Chapter 8

Construction traffic and transport

January 2020

8 Construction traffic and transport

This chapter considers the potential traffic and transport impacts from the construction of the Western Harbour Tunnel and Warringah Freeway Upgrade (the project) and identifies measures to address these impacts.

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.

The proposed environmental management measures relevant 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 requirements	Where addressed
Transport and traffic	
1. The Proponent must assess construction transport and traffic (vehicle, marine, pedestrian and cyclists) impacts, including, but not necessarily limited to: a. a considered approach to route identification and scheduling of marine and land transport movements, particularly outside standard construction hours;	Construction traffic routes are discussed 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 detailed in **Section 8.4**. 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 and sensitive road users and parking arrangements including internal Port roads and land if utilised during construction);	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.**
e. access constraints and impacts on public transport, pedestrians and cyclists;	Access constraints and impacts on public transport, pedestrians and cyclists are described in **Section 8.4**.

Secretary's requirements	Where addressed
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 in regard to public events is discussed in **Section 8.4.7**. Cumulative construction impacts are also assessed in **Section 8.4.5**.
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 marine spoil transport are discussed in **Section 8.4.2**. Potential reuse of spoil is addressed in **Chapter 24** (Resource use and waste management). 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 Sydney Harbour; and	The assessment of potential traffic impacts during construction for pedestrians and users of Sydney Harbour are detailed in **Section 8.4**. **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 and shipping channels on Sydney Harbour.	Impacts to water based traffic and shipping channels during construction are assessed in **Section 8.4.2**.

8.1 Strategic transport planning context

Details regarding the project's compatibility with key Commonwealth and State strategic planning and transport policies are provided in Chapter 3 (Strategic context and project need). More specific transport strategies relevant to 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 is 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. Generally, typical site traffic generated per hour would 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 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.	Qualitative assessment of local road changes. Estimate of number of lost parking spaces. 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.	Qualitative assessment of impacts on public transport performance (increase or decrease in travel times).
Pedestrians and cyclists (active transport)	Analysis of 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 occupation of the waterway including the number, type, frequency and duration of marine construction traffic. Simulation of marine vessels and transport of immersed tube tunnel elements.	Qualitative assessment of impacts on existing waterway navigation and commercial and recreational usage. Simulation report showing the paths of marine vessels and the area required for the transport of immersed tube tunnel elements in Sydney Harbour.

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

8.2.2 Road traffic assessment methodology

The potential impacts of the project on road network performance were assessed through strategic traffic demand 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 8-1

Strategic Travel Model (STM)

- **General description**
  Forecasts travel patterns across the Sydney, Newcastle and Illawarra regions under various land use, multi-modal transport and transport pricing scenarios
- **Project context**
  Provides forecast road traffic demands for more detailed modelling using SMPM

Sydney Motorway Planning Model (SMPM)

- **General description**
  Forecasts strategic traffic patterns for Sydney motorway projects
- **Project context**
  Provides strategic road traffic forecasts to inform project definition and evaluation, and as an input into more detailed operational traffic modelling

Operational traffic modelling

- **General description**
  Provides detailed operational road network performance modelling for more complex local and regional components of the road network relevant to the project
- **Project context**
  Predicts road network performance with and without the project

Figure 8-1 Overview of transport modelling approach

Construction traffic modelling scenarios

Based on the planned construction activities, the worst case construction traffic scenario was assumed to occur during the period of spoil removal from tunnel construction during 2022.

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 Motorways Planning Model (SMPM) to derive background traffic demand. 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 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.

Table 8-3 Construction traffic modelling scenarios

Model year	Without project	With project	Modelling scenario	Description
2022	✓		Base case 2022	The existing road network with no new projects or upgrades.
2022		✓	Construction 2022	Peak tunnelling for the project. The current road network with no new projects or upgrades, with construction traffic movements for the project in combination with Sydney Metro City & Southwest and M4–M5 Link projects.
2024		✓	Cumulative construction 2024	Peak construction year for the Western Harbour Tunnel and Beaches Link program of works. The current road network with no new projects or upgrades, with construction traffic movements for the project and the Beaches Link and Gore Hill Freeway Connection project.

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 performance

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 volume 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 PCU 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; 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	Midblock 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 signals, incidents will 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.

8.2.5 Assessment of temporary closure of the Warringah Freeway

Due to the safety risks associated with working adjacent to live traffic, full closure of some carriageways of the Warringah Freeway (primarily at night) would be beneficial for short periods, allowing for construction activities that would be carried out more efficiently and with less disruption to traffic. These activities include resheeting, installation of bridge spans and demolition of kerbs and medians. These closures would be carried out during off-peak periods generally during the evening and night.

Likely increases in traffic on surrounding roads from Warringah Freeway closures have been determined using SMPM traffic forecasts. Modelled flow differences were calculated based on observed traffic flows surveyed on the Warringah Freeway during the busiest hour of the proposed closure period (10pm to 11pm) to estimate the potential increased traffic demands on key roads impacted.

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:

- Rozelle and surrounds
- Birchgrove to Waverton (Sydney Harbour crossing)
- Warringah Freeway and surrounds
- Gore Hill Freeway and Artarmon.

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 across Sydney Harbour 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 arterial roads with posted speeds between 60 and 80km/h. Typical operating speeds during peak periods are shown to be in the range of 20 to 40km/h, indicating these corridors are operating at capacity, and resulting in congestion and delays.

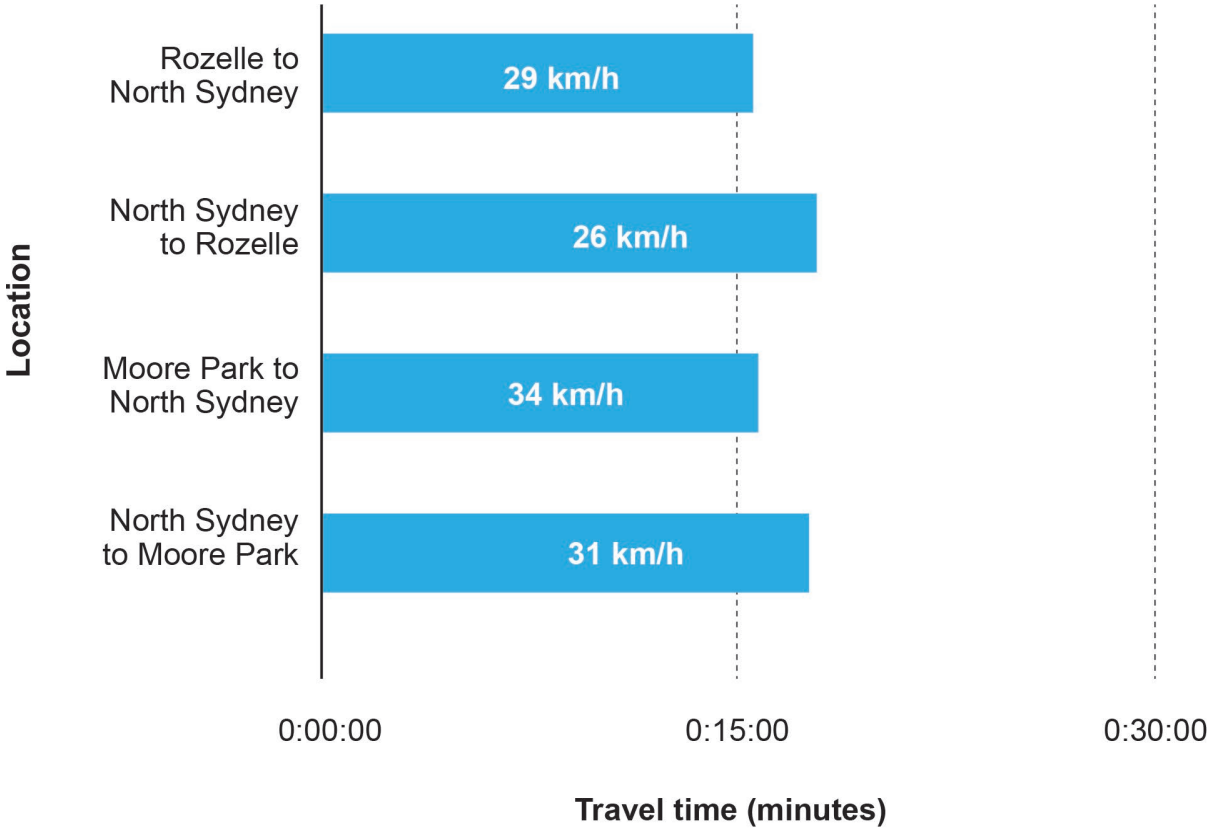


Figure 8-2 2016 AM peak travel times and average speeds along key corridors

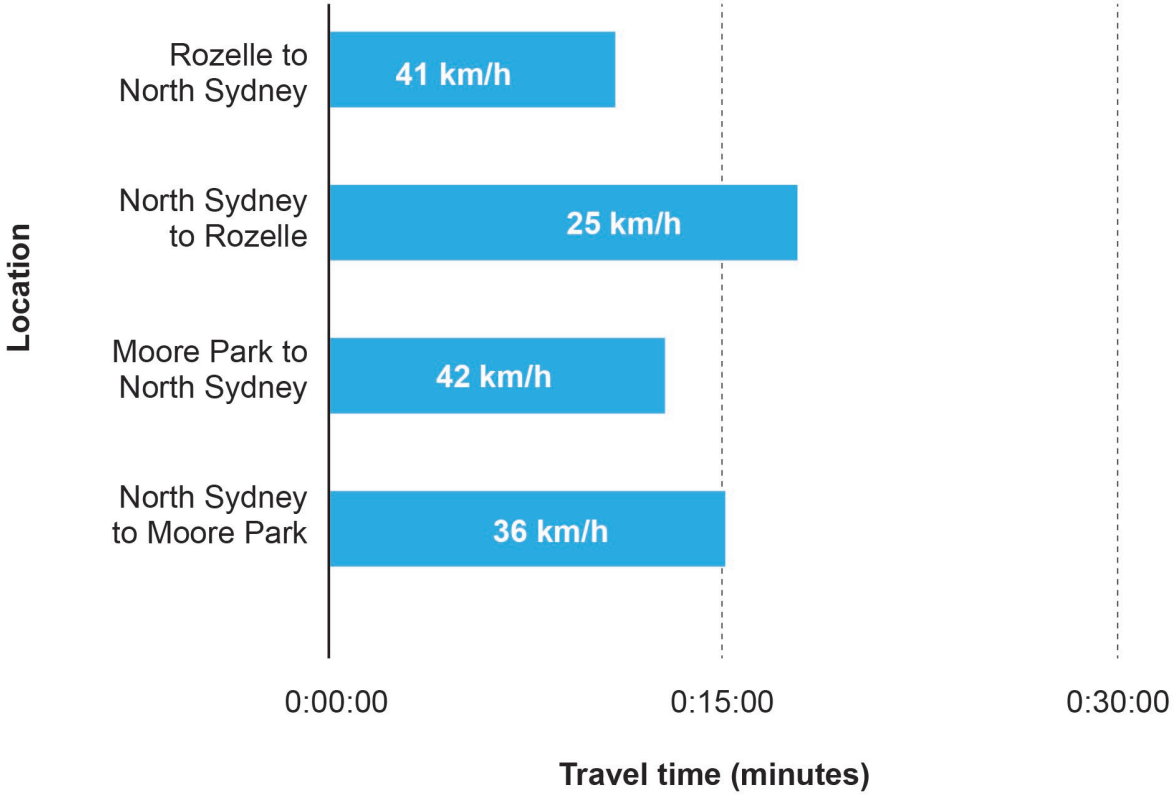


Figure 8-3 2016 PM peak travel times and average speeds along key corridors

Heavy vehicles and freight

The movement of heavy vehicles across Sydney Harbour is limited by capacity constraints and congestion, particularly during peak periods. Current freight across Sydney Harbour is limited to the following motorway and arterial roads:

- Sydney Harbour Bridge
- Sydney Harbour Tunnel
- ANZAC Bridge
- Victoria Road corridor (including the Iron Cove Bridge, Gladesville Bridge and Fig Tree Bridge).

Truck movements across Sydney Harbour in 2016 were relatively evenly distributed across the existing crossings. However, B-doubles are not permitted to travel on the Sydney Harbour Bridge and dangerous goods vehicles are not permitted through the Sydney Harbour Tunnel. Gladesville Bridge is an unrestricted B-double alternative route to these crossings. Partially due to the high traffic delays on the Sydney Harbour Bridge and through the Sydney Harbour Tunnel, the majority of heavy vehicle travel across both these routes occurs outside peak periods.

8.3.2 Rozelle and surrounds

Description

Transport network

The existing transport network within Rozelle and the surrounding areas is shown in Figure 8-4 and includes the suburbs of Balmain, Birchgrove and Rozelle.

Traffic volumes and patterns

A summary of existing peak hour traffic volumes for Rozelle 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 peak hour traffic volumes – Rozelle and surrounds

Road	Direction	AM peak		PM peak	
		Volume (vehicles)	Heavy vehicle percentage	Volume (vehicles)	Heavy vehicle percentage
Rozelle and surrounds					
City West Link west of The Crescent	Eastbound	2630	4%	2350	3%
	Westbound	1660	7%	2140	6%
James Craig Road south of The Crescent	Eastbound	260	5%	120	3%
	Westbound	140	5%	140	3%
The Crescent west of Victoria Road	Eastbound	3590	5%	2950	3%
	Westbound	2390	6%	3090	5%
Victoria Road north of The Crescent	Northbound	2090	6%	3710	5%
	Southbound	4060	6%	2930	5%

Public transport network

A summary of the public transport network that services Rozelle and surrounding areas is provided in Table 8-6.

Table 8-6 Public transport network in Rozelle and surrounding suburbs

Public transport mode	Description of services in Rozelle and surrounds
Light rail	The L1 Dulwich Hill Line provides direct connections to Pyrmont, Leichhardt, and Central and Dulwich Hill stops. The Rozelle Bay light rail stop is located near the intersection of City West Link and The Crescent. The Lilyfield light rail stop is located adjacent to the intersection of the City West Link and Catherine Street.
Ferry	Ferry services are provided from wharves located in Balmain, Balmain East and Birchgrove. These wharves are served by the F3 Parramatta River Line that provides direct connections to Circular Quay, Barangaroo, McMahons Point, Milsons Point and locations along the Parramatta River. Balmain East wharf is also served by the F4 Cross Harbour Line that provides direct connections to Circular Quay, Barangaroo, McMahons Point, Milsons Point, Pyrmont Bay, Rose Bay and Watsons Bay.
Bus	Within Rozelle and surrounding suburbs, there are 26 unique routes and about 1700 individual timetabled bus services on weekdays, 1000 services on Saturdays and 800 services on Sundays and public holidays. Bus services are operated by Sydney Buses and Transit Systems Sydney. Victoria Road and ANZAC Bridge are major bus corridors for services to the Sydney CBD, the Inner West, Ryde, Macquarie Park and Parramatta.

Legend

Road classification

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

Public transport infrastructure

- Heavy rail
- Light rail
- Sydney Metro City & Southwest – Chatswood to Sydenham (under construction)
- Train station
- Light rail stop
- Ferry wharf
- Bus stops on key routes

Figure 8-4 Existing transport network within Rozelle and surrounds

Active transport network

The pedestrian network in the Rozelle area is well developed with footpaths provided along most of the roads and controlled crossings at signalised intersections. High pedestrian activity associated with the Rozelle and Balmain local town centres occurs along Victoria Road and Darling Street, respectively. Two active transport bridges span Victoria Road; one about 90 metres north of The Crescent and the other about 70 metres east of The Crescent.

The cycle network in the Rozelle area consists of a mixture of off-road shared pedestrian and cyclist paths and on-road cycle routes on local and collector roads. The regional strategic cycle network provides connections between the area surrounding Rozelle and the Sydney CBD, North Sydney, Redfern, Green Square, Sydney Airport, Pyrmont, Surry Hills, Haberfield and Summer Hill.

Off-road shared user paths are provided at the following locations:

- Victoria Road between The Crescent and Drummoyne
- ANZAC Bridge
- Along the foreshores of Iron Cove, Rozelle Bay and Blackwattle Bay.

A shared user bridge connecting Lilyfield Road and Victoria Road with Brenan Street at Lilyfield and The Crescent at Annandale would also be provided as part of the approved M4–M5 Link.

Existing road performance

Road network performance

City West Link and Victoria Road through Rozelle are two of the busiest road corridors in Sydney, providing access to and from the Sydney CBD for people living and working in Sydney's West, Inner West and Lower North Shore. Most of the traffic travelling through this corridor is to and from the Sydney CBD or to the Lower North Shore and Northern Beaches via ANZAC Bridge, Western Distributor and the Sydney Harbour Bridge.

Due to the high traffic volumes and highly directional nature of traffic flow along Victoria Road and City West Link during peak periods, the Victoria Road corridor has active traffic management infrastructure to change traffic capacities inbound and outbound during peak periods.

Key features of the tidal flow traffic facilities along the Victoria Road corridor include:

- A moveable central median between Seymour Street in Drummoyne and Iron Cove Bridge
- A kerbside bus lane during the AM peak period between Seymour Street in Drummoyne and Iron Cove Bridge, as well as between Iron Cove Bridge and Darling Street in Rozelle
- Dynamic lane management of right turn lanes at Darling Street and The Crescent
- A right turn ban from Robert Street to Victoria Road in the AM peak.

Congestion and delays on Victoria Road and City West Link are highest during the AM peak period, with the key constraints to traffic flows headed to the Sydney CBD on Victoria Road at Terry Street, Darling Street and Robert Street in Rozelle where right turns are not permitted, and on City West Link at Balmain Road, Catherine Street and The Crescent. The two-lane grade-separated eastbound movement on The Crescent at Victoria Road is also a major constraint along with the merge arrangement for these two lanes into the accompanying two lane eastbound movement from Victoria Road, which limits the volume of eastbound traffic on the ANZAC Bridge. East of ANZAC Bridge, merging and weaving activity over a short distance to Pyrmont Bridge Road, Bathurst Street and Western Distributor results in congestion and reduced speeds.

In the PM peak, the main constraint for westbound traffic is the right turn movement from ANZAC Bridge to Victoria Road, where queues are frequently observed across the ANZAC Bridge and onto the Western Distributor. Westbound congestion and queuing is also observed on the approaches to Evans Street in Rozelle, where steep grades slow down buses travelling in the kerbside lane,

and at Darling Street. Northbound traffic on The Crescent also experiences high delays due to the limited capacity of the intersection of Johnston Street and The Crescent.

East of Rozelle, ANZAC Bridge and the Western Distributor form the main motorway network on the western side of the Sydney CBD, facilitating high traffic demands for travel both into and through the Sydney CBD and further north across Sydney Harbour to North Sydney and the Northern Beaches. The ANZAC Bridge operates close to capacity in both directions during peak periods with a high degree of weaving, merging and diverging activity occurring on the Western Distributor around the Bathurst Street and King Street exits and the weave movement from the Western Distributor to the Bradfield Highway which occurs over a short 200 metre distance, all of which generate delay and reduce capacity through this section of the motorway.

Intersection performance

Modelled intersection performance under 2016 travel demands is provided in Table 8-7. The assessment indicates that the following intersections perform at an unsatisfactory level of service (LoS E or F):

- Victoria Road and Darling Street
- Victoria Road and Gordon Street
- Victoria Road and Robert Street
- Victoria Road and The Crescent
- The Crescent and Johnson Street
- City West Link and Balmain Road.

These intersections reflect the key constraints along Victoria Road and City West Link, where high through-traffic volumes conflict with right turning or cross-street traffic. The majority of major intersections along Victoria Road are at or close to their capacity during peak periods.

Table 8-7 Modelled intersection performance in Rozelle and surrounds (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)
Victoria Road/Darling Street	F (85)	F (75)
Victoria Road/Evans Street	D (43)	D (48)
Victoria Road/Gordon Street	B (21)	E (63)
Victoria Road/Robert Street	D (49)	F (>100)
Victoria Road/The Crescent	B (27)	F (88)
The Crescent/James Craig Road	A (10)	B (25)
The Crescent/City West Link	B (21)	D (55)
The Crescent/Johnston Street	C (42)	F (89)
City West Link/Catherine Street	C (38)	B (15)
City West Link/Balmain Road	F (72)	D (52)

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

8.3.3 Birchgrove to Waverton (Sydney Harbour crossing)

The project includes the crossing of Sydney Harbour, extending from Birchgrove in the south to Waverton in the north. The two maritime areas which have been assessed for the project include the inner and outer parts of Sydney Harbour and are described as follows:

- Outer Sydney Harbour: a wide waterway between Sydney Heads, the Opera House at Bennelong Point and Admiralty House at Kirribilli Point
- Inner Sydney Harbour: a high traffic area between outer Sydney Harbour, Yurulbin Point and Manns Point. The harbour includes Circular Quay, Darling Harbour and the Bays Precinct.

The outer harbour is deep and wide with water depths exceeding 15 metres below chart datum (the zero-reference point from which tidal heights and chart soundings are calculated) between South Head and North Head, and about eight metres below chart datum between Grotto Point and Middle Head. The inner harbour is generally narrower with more variable depths. Water depths are typically between 12 and 14 metres below chart datum.

The crossing location is within a well-defined channel with relatively steep banks. The water depths along the crossing average about 15 metres below chart datum. The navigable width from Yurulbin Point to Balls Head Reserve is about 620 metres.

Balls Head Bay, Berrys Bay and Snails Bay are generally about five to 10 metres below chart datum, and increase in depth towards the head of the bays. Gore Bay provides deep-water access close to the shoreline with water depths about 10 to 15 metres below chart datum.

Users of Sydney Harbour can be divided into three main groups: recreational users, community groups and clubs; commercial operators; and government organisations. The user groups are discussed in more detail below and shown in Figure 8-5 and Figure 8-6.

Recreational users, community groups and clubs

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

- Paddle craft clubs
- Fishing clubs
- Sailing and yacht clubs
- Scout and guide groups
- Marine Rescue NSW.

Facilities supporting recreational activities include destination marinas with high quality access to services and amenities for recreational boat users, boat ramps and dry dock facilities. Key facilities are shown in Table 8-8.

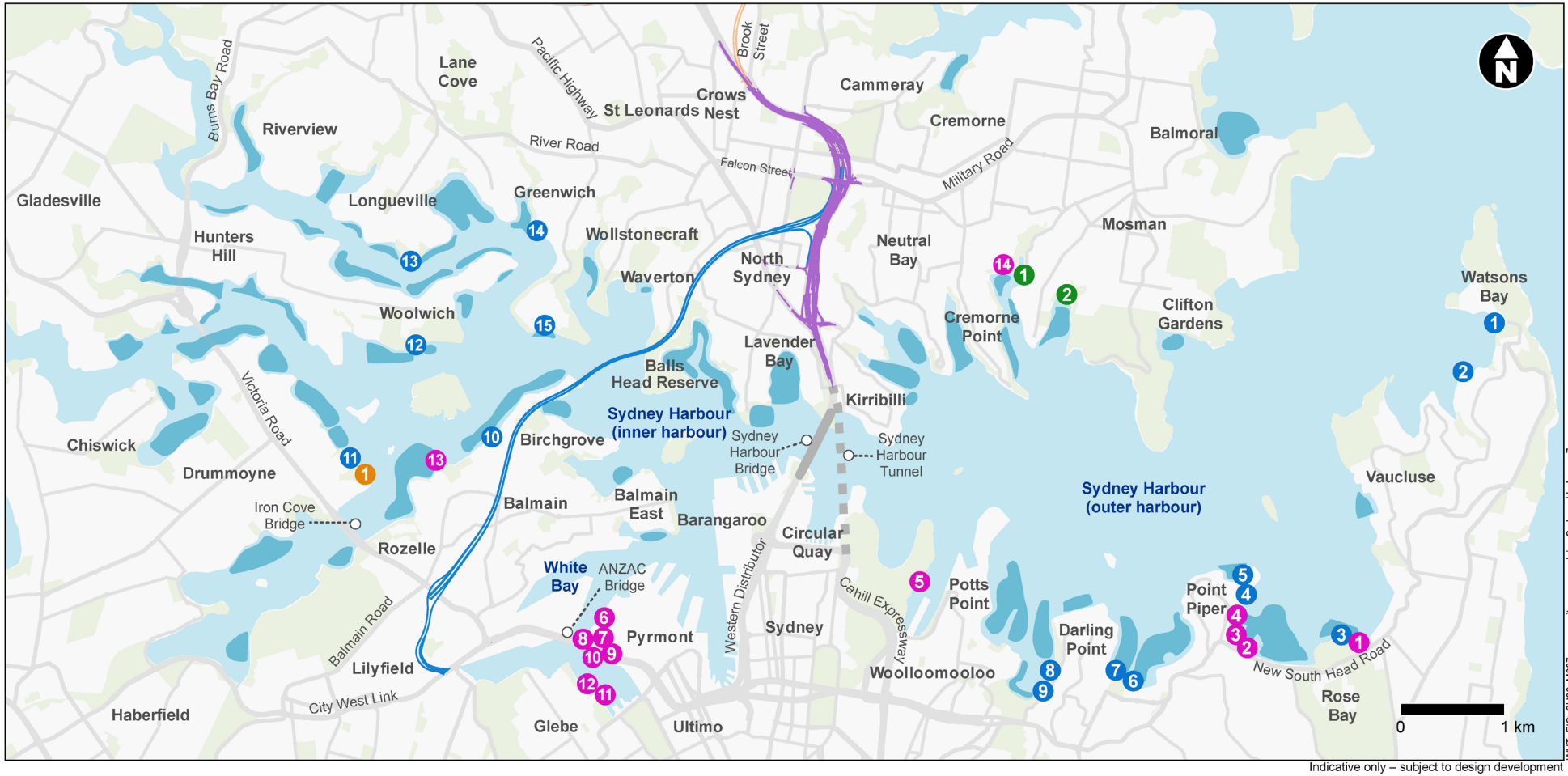
Table 8-8 Marinas, boat ramps and dry dock facilities within Sydney Harbour

Facility	Location
Marinas	• Private marinas in Birchgrove, Rozelle and Wollstonecraft • Balmain Marina and Camerons Marina in Balmain • Birkenhead Point Marina in Birkenhead • Gladesville Bridge Marina in Drummoyne • D'Albora Marinas Cabarita Point in Cabarita • Pulpit Point Marina in Hunters Hill • Woolwich Marina in Woolwich • Sydney Superyacht Marina in Rozelle • Mosman Bay Marina in Mosman • Rose Bay Marina in Rose Bay • Point Piper Marina and Royal Yacht Club Marina in Point Piper • Double Bay Marina in Double Bay • D'Albora Marina and Cruising Yacht Club of Australia (CYCA) Marina in Darling Point.
Boat ramps and dry dock facilities	• Small boat ramps in Lilyfield, Cabarita Park and Greenwich • Taplin Park boat ramp in Drummoyne • Bayview Park boat ramp in Concord • Blaxland Road boat ramp in Rhodes • Silverwater Park boat ramp in Silverwater • Wharf Road boat ramp in Ermington • Kissing Point boat ramp in Putney • Woolwich boat ramp in Woolwich • Burns Bay Reserve boat ramp in Riverview • Lyne Park boat ramp in Rose Bay • Sydney Boathouse dry boat storage in Rozelle • Sydney Harbour Boat Storage in Balmain.

Moorings are also available for recreational users as shown in Figure 8-5.

A number of major paddling, sailing and swimming events are carried out annually in Sydney Harbour and include:

- Yacht races such as the Sydney to Hobart Yacht Race on Boxing Day, Sydney Harbour Regatta, Sail Sydney and JJ Giltinan 18 foot skiff regatta
- Open water swimming events in late January including the Optus Swim Sydney Harbour and Sydney Harbour Splash
- Paddling events in late February including the Ocean Paddler and Outrigger Race.



Indicative only – subject to design development

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Legend

Operational features

- Western Harbour Tunnel
- Warringah Freeway Upgrade

Connecting projects

- Beaches Link

Sailing and yacht clubs

1. Vaucluse Yacht Club
2. Vaucluse Amateur 12ft Sailing Club
3. Woollahra Sailing Club
4. Royal Motor Yacht Club of NSW
5. Royal Prince Edward Yacht Club
6. 18 Footers Sailing Club, Double Bay
7. Double Bay Sailing Club
8. RAN Sailing Association
9. Cruising Yacht Club of Australia (CYCA)
10. Balmain Sailing Club
11. Drummoyne Sailing Club
12. Hunters Hill Sailing Club
13. Lane Cove 12 Foot Skiff Sailing Club
14. Greenwich Flying Squadron
15. Greenwich Sailing Club
16. Royal Sydney Yacht Squadron
17. Sydney Flying Squadron
18. Sydney Amateur Sailing Club

Paddle craft clubs, tours and hire centres

1. OzPaddle Rose Bay
2. Bondi Outrigger Canoe Club
3. Kayaking Tours Sydney
4. Point Piper Kayak Centre
5. OzPaddle Woolloomooloo Bay
6. Blackwattle Bay Dragon Boat Club
7. Acca Dragon Boat Racing Team
8. Sydney Tsunami Dragon Boat Club Inc.
9. NAGA Spirit Dragon Boat Club
10. Sloths Dragon Boat Club
11. Glebe Rowing Club
12. Sydney University Boat Club
13. Balmain Rowing Club
14. Mosman Rowing Club

Sea scout and guide groups

1. Mosman Sea Scouts
2. Clifton Gardens Sea Scouts

Marine rescue

1. Marine Rescue Port Jackson

Mooring locations

Figure 8-5 Community groups and clubs in Sydney Harbour

Commercial operations within Sydney Harbour

Cruise and tanker traffic

Sydney Harbour is an important destination for cruise ships and is the only port in Australia with two dedicated cruise facilities; the Overseas Passenger Terminal at Circular Quay and White Bay Cruise Terminal in Balmain. The Overseas Passenger Terminal is Sydney's primary cruise ship terminal and is supported by the White Bay Cruise Terminal when fully occupied. The White Bay Cruise Terminal also services small cruise ships that can pass under the Harbour Bridge.

Berths are also provided at Glebe Island, White Bay and Gore Cove (private facilities). The Sydney Harbour port precinct focused around Glebe Island and White Bay accommodates dry bulk imports, general cargo, the cruise industry and common user berth movements. Common user berth movements include refuelling activities, servicing marine construction, emergency and planned maintenance, and facilitating major harbour events and functions. There is also a fuel terminal at Gore Cove which is an important importation facility supplying fuel to the Sydney and NSW markets. The facility also fuels bunkering barges that service White Bay (including the cruise terminal), Glebe Island and the Overseas Passenger Terminal. About 80 tanker movements are expected at the terminal each year; however, numerous additional movements of bunkering barges may occur. Gore Bay fuel terminal has a restricted area, which includes all water within 100 metres from the wharf or 50 metres from a tanker berthed at the terminal.

White Bay and Glebe Island form part of the Bays Precinct. This precinct consists of the waterways and foreshores of Johnstons Bay, White Bay, Rozelle Bay and Blackwattle Bay. The Bays Precinct plays an important role in supporting Sydney Harbour as a working harbour, and accommodates maritime uses from the public and private sectors. These include Sydney Fish Markets, Transport for NSW, and the Sydney Superyacht Marina. All vessels access Rozelle Bay and Blackwattle Bay through the swing section of Glebe Island Bridge and underneath the ANZAC Bridge.

Captain Cook Cruises operates a Lane Cove to City ferry service, which stops at Birchgrove Wharf during private school terms only; twice in the morning and twice in the evening. This line operates within the inner harbour Monday to Friday, with six services operating in the morning and three services in the evening.

Commercial fishing

Commercial fishing is banned in Sydney Harbour, including the Parramatta River and connected tidal waterways. The commercial fishing fleet in Sydney is primarily located in Blackwattle Bay and would generally fish offshore.

Water taxis, charter companies and boat storage facilities

Water taxi and fishing charter companies operate in Sydney Harbour and its estuaries. Blackwattle Bay is a designated berthing area for a large number of charter vessels. A number of boat storage (moorings, dry dock facilities and marinas) and boat launching facilities are located around Sydney Harbour and its estuaries.

Government operations within Sydney Harbour

Harbour City Ferries

Harbour City Ferries is the operator of Sydney Ferries on behalf of the NSW Government. Two ferry routes traverse Sydney Harbour close to the proposed immersed tube tunnel crossing. Route F3 travels between Circular Quay and Parramatta, and route F8 travels between Circular Quay and Cockatoo Island. The ferries operate between 6am and 8pm, seven days a week. The F3 route (Parramatta to Circular Quay) completes 100 trips during weekdays, and the F8 route (Cockatoo Island to Circular Quay) completes 50 trips during the same period.

Royal Australian Navy

HMAS Waterhen is located on the western side of Balls Head in the inner harbour. The facility is the Royal Australian Navy's lead establishment for Mine Warfare including Australia's Mine Countermeasures Force and Clearance Diving Branch. The facility includes two wharves, a small boat jetty and boat ramp, with numerous berthed vessels. HMAS Waterhen has a restricted area demarcated by yellow buoys within Balls Head Bay.

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

The NSW Police Marine Area Command is located in Camerons Cove, immediately east of White Bay. The Marine Area Command is the primary facility in Port Jackson and services Port Jackson and NSW waters up to 200 nautical miles from the coast.

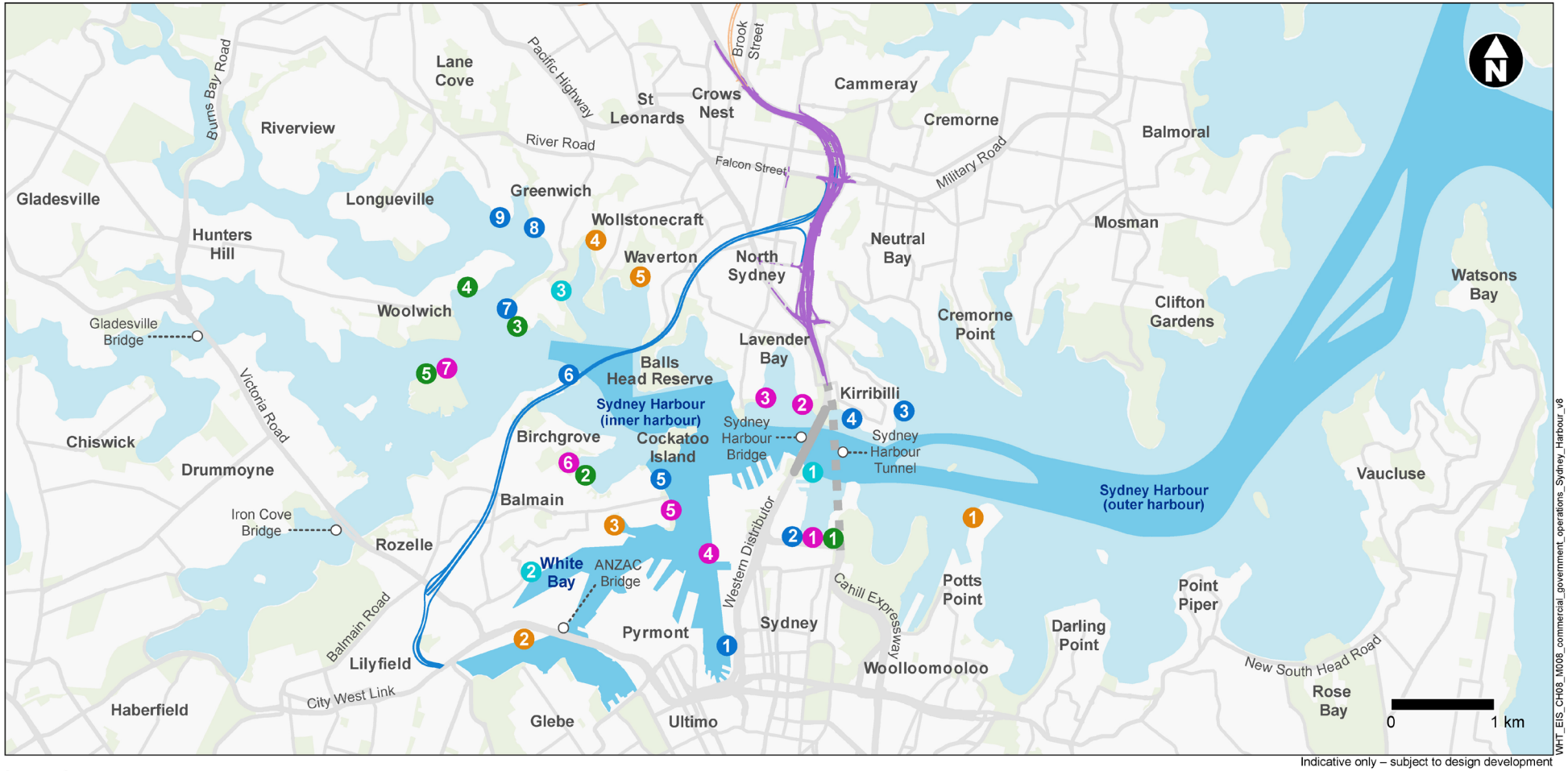
The maritime division of Transport for NSW is based at Rozelle Bay. Transport for NSW Boating Safety Officers are employed to patrol discrete regions throughout NSW to ensure compliance of waterway users with relevant legislation. The Department of Planning, Industry and Environment (Regions, Industry, Agriculture & Resources) office for the Sydney North Region is located in Wollstonecraft, on the eastern side of Gore Bay. The facility comprises a hardstand area and two small finger jetties.

Figure 8-6 shows the Sydney Harbour port precinct, the main shipping channels through the harbour and the commercial and government operations within Sydney Harbour.

Navigation restrictions

Navigation restrictions that apply to vessels travelling in the vicinity of the project include:

- Gore Cove fuel terminal – Vessels must be at least 100 metres from the wharf face or 50 metres from a tanker berthed at the terminal
- HMAS Waterhen – Vessels are required to keep clear of the facility by staying outside the marked area by yellow buoys
- All land and structures including moorings and dolphin berths at Snails Bay – Vessels travelling at more than six knots are required to maintain a distance of 30 metres from vessels, land or structures
- Sydney Harbour Bridge transit zone between Millers Point and Blues Point to the west, extending to between Kirribilli Point and Bennelong Point to the east – Vessels must not exceed 15 knots in the transit zone and they are not permitted to stop, anchor or drift
- Darling Harbour speed limit area, upstream of a line between Barangaroo Point and Balmain East Ferry Wharf – A speed limit of eight knots is imposed and is reduced to four knots upstream of ANZAC Bridge and upstream of King Street Wharf
- Waters between a line from Inner South Head to Inner North Head – A speed limit of 12 knots is imposed for vessels exceeding 30 metres
- Waters between a line from the stone pillar at Bradleys Head to Hermit Point – A speed limit of 12 knots is imposed for vessels exceeding 30 metres
- Waters between a line from Balls Head to Ballast Point – A speed limit of 10 knots is imposed for vessels exceeding 30 metres
- Waters upstream of a line between Balls Head and Ballast Point – A speed limit of six knots is imposed for vessels exceeding 30 metres
- Aquatic events – Additional restrictions may be imposed by an aquatic event such as a race, competition or exhibition, and 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.



Legend

Operational features
- Warringah Freeway Upgrade
- Western Harbour Tunnel

Connecting projects
- Beaches Link

Captain Cook Cruises Lane Cove to city ferry service wharves
1. Darling Harbour
2. Circular Quay
3. Kirribilli
4. North Sydney
5. Balmain East Wharf
6. Birchgrove
7. Greenwich Point
8. Greenwich Wharf
9. Northwood

Harbour City Ferries (F3) Parramatta River ferry service wharves
1. Circular Quay
2. Milsons Point
3. McMahons Point
4. Barangaroo
5. Balmain East
6. Balmain
7. Cockatoo Island

Harbour City Ferries (F8) Cockatoo Island Ferries
1. Circular Quay
2. Balmain
3. Greenwich Point
4. Woolwich
5. Cockatoo Island

Cruise tanker and bulk shipping terminals
1. Overseas Passenger Terminal
2. White Bay and Glebe Island
3. Gore Bay Terminal

Government organisations
1. H.M.A.S Kuttabul (Garden Island)
2. Transport for NSW
3. NSW Police Marine Area Command
4. Department of Planning, Industry and Environment (Regions, Industry, Agriculture & Resources)
5. H.M.A.S Waterhen

Shipping channel

Figure 8-6 Commercial and government operations in Sydney Harbour

8.3.4 Warringah Freeway and surrounds

Description

Transport network

The existing transport network within the Warringah Freeway and surrounds area is shown in Figure 8-7 and includes the suburbs of Cammeray, Neutral Bay, North Sydney and Waverton.

Traffic volumes and patterns

A summary of existing peak hour traffic volumes for the 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 8-9.

Table 8-9 Existing 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%

Road	Direction	AM peak		PM peak	
		Volume (vehicles)	Heavy vehicle percentage	Volume (vehicles)	Heavy vehicle percentage
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%
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 T9 Northern Lines. 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.

Active transport network

The pedestrian network in the Warringah Freeway and surrounds area is well developed with footpaths provided along most roads and controlled crossings at signalised intersections. Pedestrians are prohibited from walking along the Warringah Freeway. High pedestrian activity associated with retail and commercial activities occurs within North Sydney CBD, with schools located west of the Pacific Highway and along Miller Street, and people carrying out leisure and exercise activities in and near Balls Head Reserve.

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.

Legend

Road classification

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

Public transport infrastructure

- Heavy rail
- Tunnel
- Sydney Metro City & Southwest – Chatswood to Sydenham (under construction)
- Train stations
- Ferry wharves
- Bus stops on key routes

Figure 8-7 Existing transport network within the Warringah Freeway and surrounds area

Existing road performance

Road network performance

The Warringah Freeway is the busiest section of motorway in NSW, with congestion and delays 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 8-10. The assessment indicates that the following intersections perform at an unsatisfactory level of service (LoS F) during the AM peak:

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

The intersection of Mount and Arthur Street is the primary western access to the motorway network, where traffic heading to the Sydney Harbour Bridge main deck (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 8-10 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)

Intersection	AM peak (8am–9am) LoS (average delay in seconds)	PM peak (5pm–6pm) LoS (average delay in seconds)
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)
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	E (60)	B (18)
Mount Street/Alfred Street	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 grey denote an unsatisfactory LoS E or F

8.3.5 Gore Hill Freeway and Artarmon

Description

Transport network

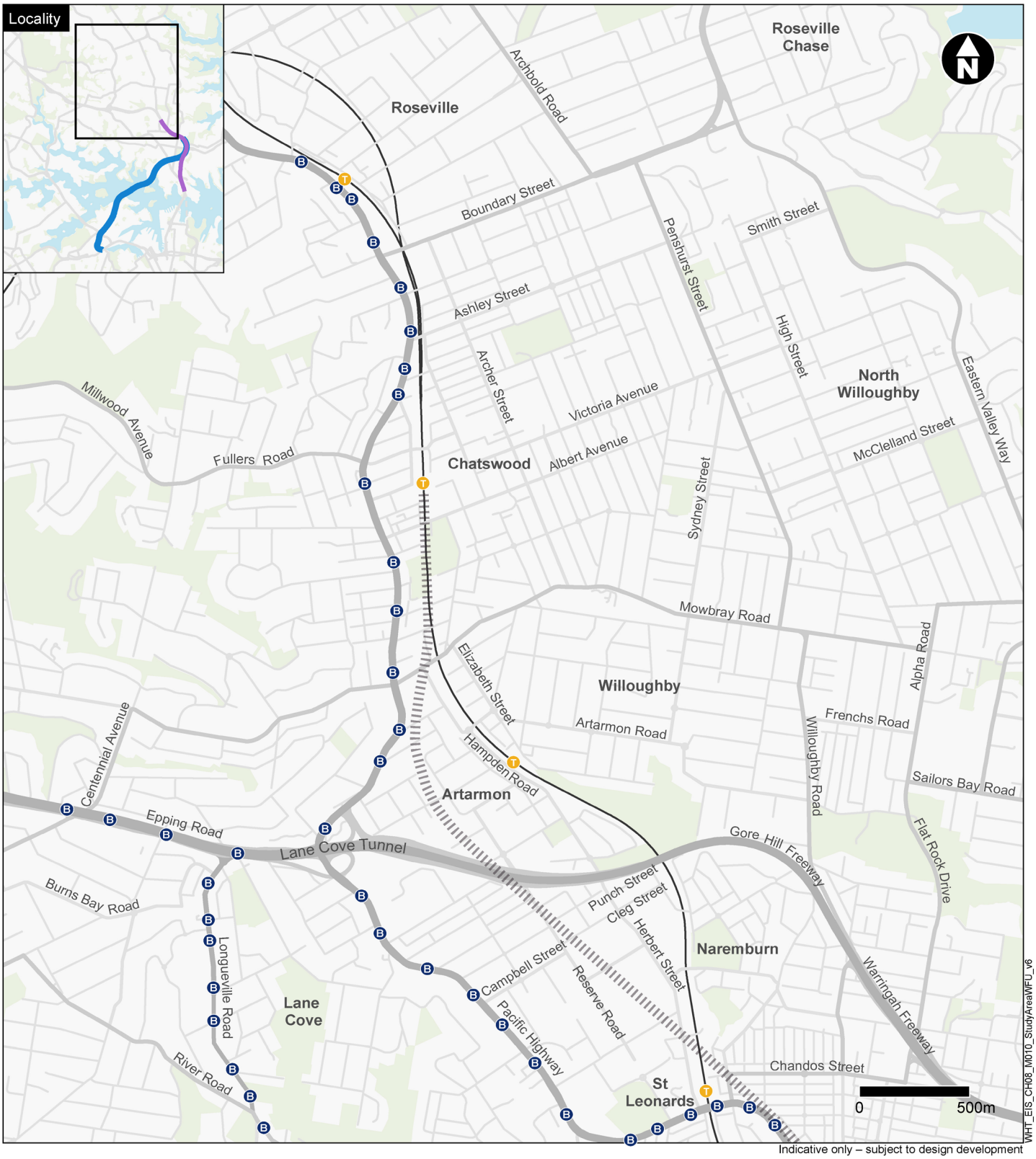
The existing transport network within the Gore Hill Freeway and Artarmon area is shown in Figure 8-8 and includes the suburbs of Artarmon, Crows Nest, St Leonards, Cammeray, Lane Cove, Naremburn and Willoughby.

Traffic volumes and patterns

A summary of existing peak hour traffic volumes for the Gore Hill Freeway and Artarmon 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 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%
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%



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

Figure 8-8 Existing transport network within the Gore Hill Freeway and Artarmon area

Public transport network

The Gore Hill Freeway and Artarmon area is readily 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.

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.

Active transport network

The pedestrian network in the Gore Hill Freeway and Artarmon area is well-developed with footpaths provided along most roads and controlled crossings provided at signalised intersections. Pedestrians are prohibited from walking along the Gore Hill Freeway and 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 central Sydney as well as local traffic from Lane Cove and Ryde.

The majority of 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 8-12. The assessment indicates that the intersection of Epping Road, Longueville Road and Parklands Avenue intersection 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 eastbound 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 8-12 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 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 8.4.2. Details of construction activities and the location and timing of construction works, including construction support site layouts and provision of construction worker parking, are presented in Chapter 6 (Construction work).

8.4.1 Rozelle and surrounds

Road network impacts

The anticipated routes to and from the construction support sites at Rozelle Rail Yards (WHT1), Victoria Road (WHT2), White Bay (WHT3) and Yurulbin Point (WHT4) are summarised in Chapter 6 (Construction work), along with the respective daily maximum construction vehicle volumes. Access to the Yurulbin Point construction support site (WHT4) would be via Sydney Harbour only, and would generate no land based construction traffic.

Intersection and midblock performance with construction traffic

The performance of intersections during AM and PM peaks within the Rozelle and surrounds area with the introduction of construction traffic would generally remain the same as under existing conditions. The following intersections would experience a temporary change in level of service:

- The Crescent/James Craig Road intersection would operate at capacity with or without construction vehicles during the AM peak. In the PM peak, the intersection operation would deteriorate from LoS D to LoS E with an increase in average vehicle delay of 13 seconds. Similar to the AM peak, the intersection is already at capacity without construction vehicles and this would experience a marginal decrease in performance with additional construction traffic
- Construction vehicles and provision of site access at Victoria Road/Wellington Street for the Victoria Road construction support site (WHT2) would have minimal impact on the overall performance of the intersection and would operate at a satisfactory level of service.

The intersection performance results for the road network operating under the worst case construction traffic scenario (2022) during the AM and PM peak periods are summarised in Table 8-13.

Table 8-13 Modelled intersection performance in Rozelle and surrounds (AM peak (8am-9am) and PM peak (5pm-6pm) during construction in 2022)

Intersection/peak period	Base case 2022 (without construction traffic)				Base case 2022 (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
City West Link/The Crescent								
AM peak	6720	90	F	>1	6860	>100	F	>1
PM peak	6380	24	B	0.8	6630	24	B	0.84
The Crescent/James Craig Road								
AM peak	6870	>100	F	>1	7000	>100	F	>1
PM peak	6270	48	D	1	6520	61	E	>1
Victoria Road/Wellington Street/Victoria Road construction support site access (WHT2)								
AM peak	5620	12	A	0.69	5660	13	A	0.69
PM peak	6180	14	A	0.67	6230	15	B	0.67

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

The midblock performance (level of service) during construction would be unchanged to the midblock performance under the base case at all locations except James Craig Road south of The Crescent in the eastbound direction, where the level of service would deteriorate during the AM and PM peaks, but 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 (2022) during the AM and PM peak periods are summarised in Table 8-14.

Table 8-14 Modelled midblock performance in Rozelle and surrounds (AM peak (8am-9am) and PM peak (5pm-6pm) during construction in 2022)

Location/ direction	Capacity (PCU)	AM peak						PM Peak					
		Base case 2022 (without construction traffic)			Construction 2022 (with construction traffic)			Base case 2022 (without construction traffic)			Construction 2022 (with construction traffic)		
		Volume (PCU)	V/C	LoS	Volume (PCU)	V/C	LoS	Volume (PCU)	V/C	LoS	Volume (PCU)	V/C	LoS
City West Link west of The Crescent													
Eastbound	1900	2830	>1	F	2950	>1	F	2440	>1	F	2630	>1	F
Westbound	1900	1940	>1	F	2030	>1	F	2330	>1	F	2470	>1	F
James Craig Road south of The Crescent													
Eastbound	900	300	0.34	B	390	0.43	C	120	0.14	A	260	0.29	B
Westbound	1900	170	0.09	A	250	0.13	A	150	0.08	A	280	0.15	A
The Crescent west of Victoria Road													
Eastbound	1900	4420	>1	F	4460	>1	F	3110	>1	F	3170	>1	F
Westbound	1900	2970	>1	F	2970	>1	F	3280	>1	F	3280	>1	F
Victoria8-32 Road north of The Crescent													
Northbound	2900	2580	0.89	E	2640	0.91	E	3990	>1	F	4060	>1	F
Southbound	3900	4600	>1	F	4660	>1	F	3220	0.83	E	3290	0.84	E

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

Impacts on local roads and parking

James Craig Road is a local road that is accessible to general traffic from The Crescent and via Robert Street for authorised vehicles only. About 270 light vehicles and 350 heavy vehicles per day would access the White Bay construction support site (WHT3) from James Craig Road and Port Access Road, with haulage vehicles travelling on the internal road network within the Sydney Ports precinct. These traffic volumes would have a minor impact, and James Craig Road would continue to operate with spare capacity during construction as shown in Table 8-14.

The Victoria Road/Wellington Street intersection would be modified during construction, with an additional approach allowing vehicles to exit the Victoria Road construction support site (WHT2) onto Victoria Road southbound. This additional traffic would have minimal impact on Wellington Street as construction vehicles would be required to give way to vehicles turning left from Wellington Street when exiting the Victoria Road construction support site (WHT2) and would not conflict with vehicles turning right.

Car parking areas for construction workers would be provided at the White Bay construction support site (WHT3). Where on-site parking is not provided or where provision of on-site parking cannot accommodate the full construction workforce, the workforce would be required to park on the surrounding road network. The construction workforce would be encouraged to use public transport where feasible and reasonable to minimise the potential parking impacts on the road network, with key bus corridors including Victoria Road and ANZAC Bridge. In addition, the construction sites are close to the Rozelle Bay light rail stop.

The Yurulbin Park car park would be temporarily closed due to the operation of the Yurulbin Point construction support site (WHT4), resulting in the loss of about ten parking spaces. The surrounding local road network, including Louisa Road, could accommodate these lost parking spaces and therefore parking impacts would be minor and manageable.

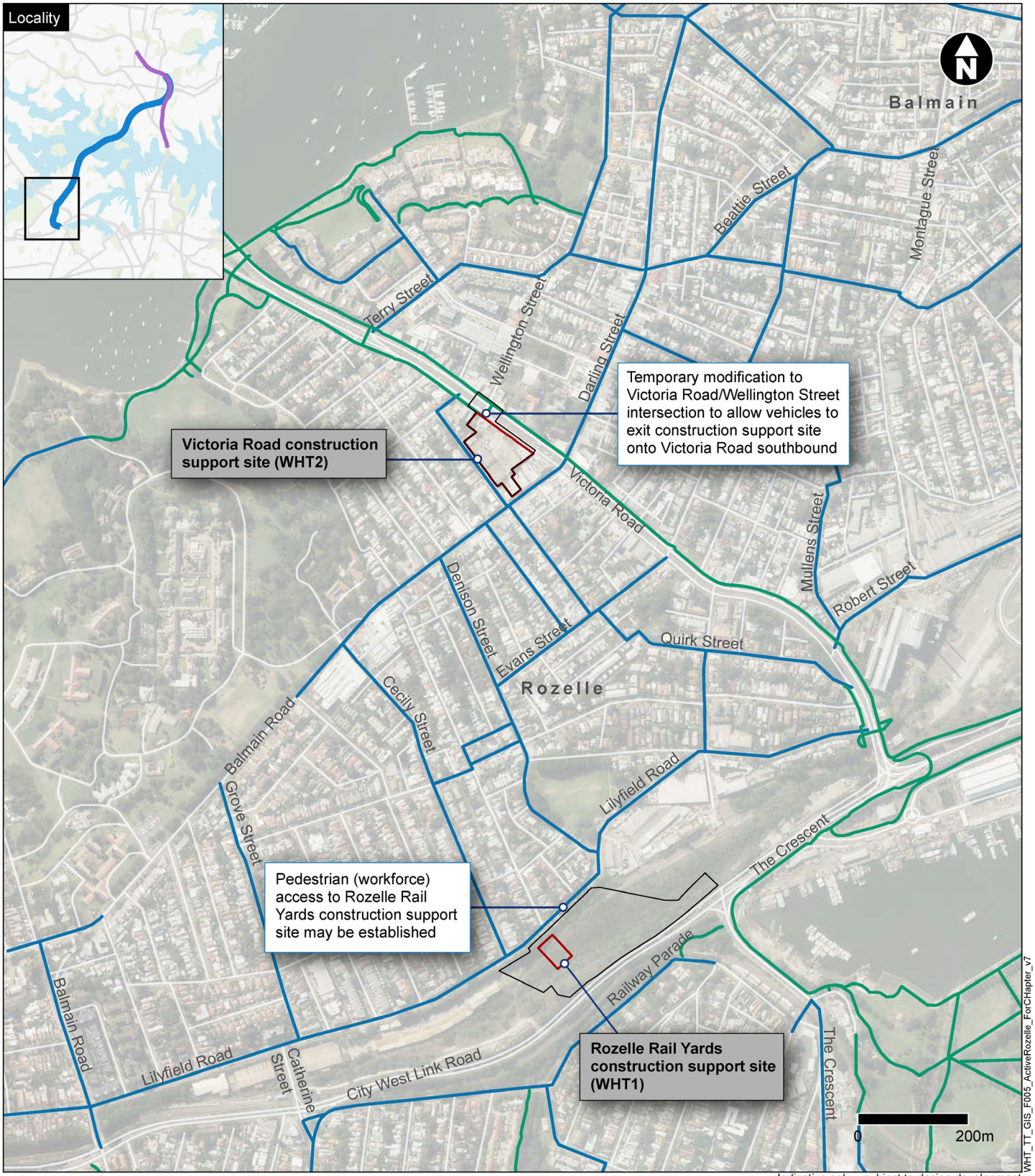
Impacts on public transport

Project construction would result in additional construction vehicles travelling on the road network around Rozelle which could increase bus travel times given the congested nature of networks in these areas. No direct or indirect impacts on light rail services are expected during construction.

Impacts on active transport

Potential impacts on the active transport network during construction are summarised in Figure 8-9.

The shared user paths on Victoria Road within the vicinity of the Victoria Road construction support site (WHT2) would be maintained throughout construction. Construction vehicles entering and exiting the site would give way to pedestrians and cyclists using the shared user path on the western side of Victoria Road. This would be facilitated through the modification of the traffic signals at the Victoria Road/Wellington Street intersection with a new south approach for construction vehicles, and controlled pedestrian and cyclist crossings across the site exit.



Legend

Construction features

- Construction support site boundary
- Construction footprint

Active transport infrastructure

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

Figure 8-9 Active transport impacts within Rozelle and surrounds during construction

8.4.2 Birchgrove to Waverton (Sydney Harbour crossing maritime movements and activities)

Overview of maritime movements and activities

During construction of the immersed tube tunnel, and establishment and operation of the construction support sites at White Bay (WHT3), Yurulbin Point (WHT4), Sydney Harbour south cofferdam (WHT5), Sydney Harbour north cofferdam (WHT6) and Berrys Bay (WHT7), there would be an increase in maritime traffic in the inner harbour. Daily maximum construction maritime traffic volumes and routes are summarised in Chapter 6 (Construction work).

The construction vessels would primarily include:

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

Construction vessel movements would be managed such that they would not interfere with port operations or the navigation of seagoing ships and ferries within Sydney Harbour, unless prior approval has been obtained from the Harbour Master.

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

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

Maritime navigation impacts

Construction activities that would impact navigation in the inner harbour are shown in Figure 8-10 and include the following:

- Temporary closure of access to Birchgrove Ferry Wharf
- Provision of temporary moorings at Snails Bay
- Establishment and operation of the Yurulbin Point (WHT4) and Berrys Bay (WHT7) construction support sites
- Installation of Sydney Harbour south cofferdam (WHT5) and Sydney Harbour north cofferdam (WHT6)
- Dredging activities in preparation for the installation of immersed tube tunnels
- Up to seven partial closures of Sydney Harbour between Birchgrove and Berrys Bay for a period of up to 48 hours
- Barge movements to and from the project construction support sites
- Boat movements transporting the construction workforce.

Exclusion zones would be set up around the cofferdams at Birchgrove and Balls Head, thereby temporarily reducing navigation width. 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 all vessels travelling within the vicinity of the cofferdams. Dredging activities would also restrict navigational movements. Impacts on vessels using Gore Cove would be minimised by ensuring that dredgers do not impede the channel during scheduled inbound and outbound trips.

The establishment of exclusion zones would reduce the operating width of Sydney Harbour at the construction location. Navigation impacts in the outer harbour would not be substantial, given 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 transportation of the immersed tube tunnel elements and to identify any restrictions and towage requirements for the safe movement of vessels to and from berths in Glebe Island, White Bay and Gore Cove, past the project work areas in Glebe Island and White Bay, and between Birchgrove and Waverton. The model found that the transportation and placement of immersed tube tunnel elements in Sydney Harbour would be feasible and could be carried out safely based on the current methodology (refer to Chapter 6 (Construction works)). The model also found that the movement of vessels to and from berths in Glebe Island, White Bay and Gore Cove, past project work areas in Glebe Island and White Bay, and between Birchgrove and Waverton would be feasible and could be carried out safely.

Impacts on recreational users, community groups and clubs

Community groups and clubs most likely to be impacted by the proposed construction activities include sailing clubs and Marine Rescue NSW.

The inner harbour (between Birchgrove and Waverton) would not be closed to community groups and clubs other than during the placement of the immersed tube tunnel. Navigation restrictions posed by construction equipment such as dredgers and cofferdams combined with the proximity and frequency of marine construction traffic, which may have limited manoeuvrability, could result in unfavourable sailing conditions. It would be possible for sailing clubs to alter their courses to maintain a competitive outcome while construction activities are underway. Sailing clubs impacted by the proposed works would be consulted and encouraged to alter sail racing courses that would be impacted by the works.

Sydney Harbour is highly congested on most weekends during summer, particularly between 12pm and 5pm when a number of clubs hold their weekly sailing races. Events held in Sydney Harbour such as paddling events in February and yacht races including the Sydney to Hobart in December generally occur in the outer harbour. Marine construction traffic in the outer harbour on weekends would be limited to the dredge transiting to and from the offshore disposal grounds about every four to five hours. This would not have any substantial impact on other outer harbour users.

Marine Rescue NSW would not be directly impacted by the construction activities. However, the construction activities may increase its emergency response time in the outer harbour or offshore. Marine Rescue NSW operates a facility at Middle Harbour in addition to Birkenhead Point. Marine Rescue NSW would be consulted about increasing patrols operating out of Middle Harbour that could service the outer harbour and offshore during periods when construction activities may impact the response time of Marine Rescue NSW located at Birkenhead Point.

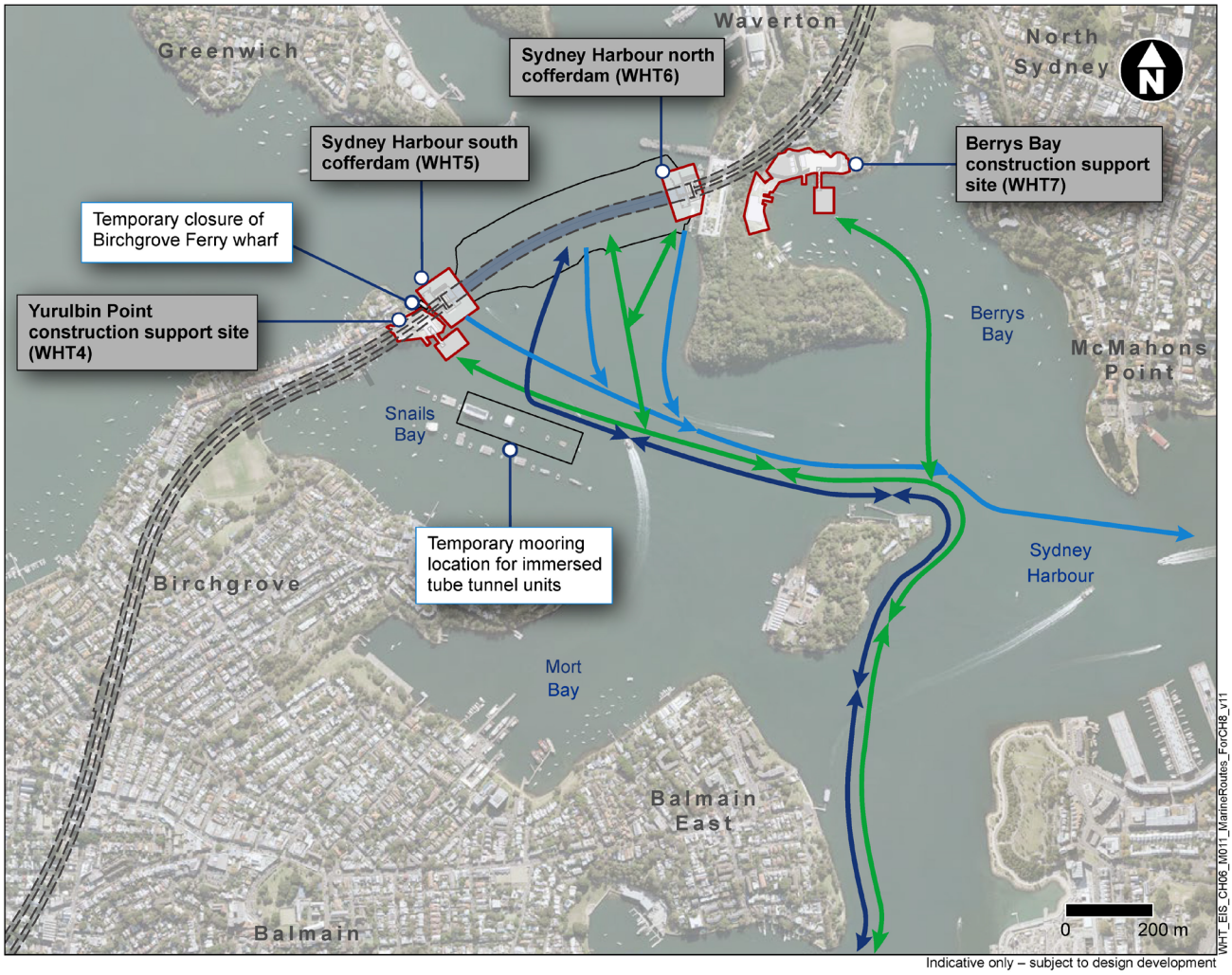


Figure 8-10 Maritime navigation impacts during construction

Impacts on commercial operations within Sydney Harbour

Cruise and tanker traffic

With the exception of White Bay Berth 3, which would be used for handling dredged material, the remaining berths at White Bay (2, 4, and 5 (Cruise Terminal and Baileys Marine Fuels)) and Glebe Island (1, 2, 7 and 8) would not be impacted by the construction activities.

Dredging of the shipping channel would result in restrictions to vessel movements. Impacts on vessels accessing Gore Cove would be minimised by ensuring that dredgers do not impede the channel during scheduled inbound and outbound trips. The delay to dredging would be about two to three hours during each movement. It would be a requirement that larger vessels accessing Gore Cove limit their maximum speed to two to three knots until the locking fill has been installed and stabilised.

Installation of the immersed tube tunnel would result in increased travel times for large vessels due to the partial closure of the inner harbour between Birchgrove and Waverton. Operators of large vessels would be consulted and notified of the planned closures to ensure that they complete their journey prior to or following the closure period. Scheduling of the partial harbour closures would be carried out in consultation with the Port Authority of NSW, Transport for NSW and all other relevant stakeholders. Construction equipment associated with the immersed tube tunnel would give way to large vessels approaching or departing White Bay and Glebe Island in the outer harbour or offshore. Harbour Master directions including the requirement that vessels would not pass between an escort vessel and a seagoing vessel, or within 30 metres of the seagoing vessel would apply to construction equipment.

Captain Cook Cruises Lane Cove to City ferry service would be directly impacted by construction activities. During construction, a speed limit of four knots would be imposed and a detour of about 300 metres may be required to avoid construction plant and equipment. Ferries would be able to pass during the 48 hour navigation restrictions with controls including escorts and speed restrictions. Impacts would include increased transit times due to speed restrictions and altered transit routes in the vicinity of construction plant and equipment. The increase in travel time is anticipated to be minor (less than a five minute increase compared to normal travel times).

Commercial fishing

Due to the primary mooring location of the commercial fishing fleet in Blackwattle Bay and the permitted fishing grounds being located offshore, there would not be a substantial impact on the commercial fishing fleet. Construction equipment associated with the immersed tube tunnel and commercial fishing vessels transiting the inner and outer harbour, would give way to one another in accordance with standard navigation rules.

Water taxis, charter companies and boat storage facilities

With the exception of increased transit time in and around the inner harbour resulting from speed restrictions in the vicinity of dredgers, construction plant and equipment, and the requirement to give way to construction plant and equipment, water taxis, charter companies and boat storage facilities are unlikely to be impacted by the proposed construction activities.

Due to the additional marine traffic anticipated during construction, charter companies would be consulted with and advised on the frequency and duration of construction activities in the harbour. Although a relatively high number of construction vessel movements are expected, the inner harbour would be maintained as a working harbour and the impact on navigation in the outer harbour is not expected to be substantial.

Impacts on government operations within Sydney Harbour

Harbour City Ferries

The temporary closure of access to Birchgrove Ferry Wharf and partial closure of the harbour between Birchgrove and Berrys Bay would impact ferry services, specifically the F3 Parramatta River line and the F8 Cockatoo Island line. Ferries would be able to pass during the 48 hour partial closure of the harbour with controls including escorts and speed restrictions. Impacts would include altered routes and an increase in travel time due to speed restrictions within the vicinity of construction plant and equipment in the inner harbour. The increase in travel time is anticipated to be minor (less than a five minute increase compared to normal travel times). In addition, ferry customers have suitable alternatives available such as the Balmain Ferry Wharf which serves the same ferry lines, as well as bus route 441, accessible from Grove Street and providing connections to Sydney CBD, and other bus services operating along Victoria Road. Opportunities to relocate the Birchgrove Ferry Wharf will be investigated during construction planning.

Royal Australian Navy

The immersed tube tunnel crosses immediately south of HMAS Waterhen defence site. The impacts of the works may include increased transit time (as a result of reduced speed limits and partial closures) past the works area. Construction vessel movements would be managed so that they would minimise interference with larger navy ship operations. The likelihood that navy vessels at HMAS Waterhen would be required for emergency deployment would be low, given that there are a number of naval bases throughout Sydney Harbour with similar capabilities.

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

Moorings within the vicinity of the Berrys Bay construction support site (WHT7) would require temporary relocation. These moorings would be relocated elsewhere in Sydney Harbour in consultation with the lease holders and therefore the impact on boat users due to the displaced moorings would be minor. Some of the Transport for NSW moorings at Snails Bay would be used to facilitate the placement of immersed tube tunnels. Given that moorings are already in use at Snails Bay, minor impacts on maritime activities are likely and would be limited to the additional construction vessel movements within Snails Bay.

Impacts on local roads and parking

The Yurulbin Park car park would be temporarily closed due to the Yurulbin Point construction support site (WHT4), resulting in the loss of about ten parking spaces. The surrounding local road network, including Louisa Road, would accommodate these lost parking spaces and therefore parking impacts would be minor and manageable.

8.4.3 Warringah Freeway and surrounds

Road network impacts

The anticipated routes to and from the construction support sites at Berrys Bay (WHT7), Berry Street north (WHT8), Ridge Street north (WHT9), Cammeray Golf Course (WHT10 and WFU8), Blue Street (WFU1), High Street south (WFU2), High Street north (WFU3), Arthur Street east (WFU4), Berry Street east (WFU5), Ridge Street east (WFU6), Merlin Street (WFU7), and Rosalind Street east (WFU9) 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 (level of service) within the Warringah Freeway and surrounds area with the introduction of construction traffic would remain the same as under existing conditions. The Ernest Street/Merlin Street signalised intersection would be modified to include a north approach, providing access to the Cammeray Golf Course construction support sites (WHT10 and WFU8). This modification would minimally impact the performance of the intersection, with average delays to increase by up to two seconds per vehicle, however level of service would not be expected to decrease. The intersection performance results for the road network operating under the worst-case construction traffic scenario (2022) 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 2022)

Intersection/peak period	Base case 2022 (without construction traffic)				Base case 2022 (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
Miller Street/Falcon Street								
AM peak	3710	50	D	0.94	3750	53	D	0.94
PM peak	3500	90	F	>1	3530	>100	F	>1
Warringah Freeway/Falcon Street interchange[1]								
AM peak	13,250	N/A	F	>1	13,310	N/A	F	>1
PM peak	13,760	N/A	F	>1	13,810	N/A	F	>1
Warringah Freeway/Ernest Street interchange[1]								
AM peak	6280	N/A	C	0.6	6550	N/A	C	0.62
PM peak	5820	N/A	D	0.57	6110	N/A	D	0.6
Ernest Street/Merlin Street - Cammeray Golf Course (WHT10 and WFU8) construction support sites secondary access (main access from Warringah Freeway)								
AM peak	2900	7	A	0.49	3090	9	A	0.5
PM peak	3180	9	A	0.77	3370	11	A	0.83
Ernest Street/Miller Street								
AM peak	3280	20	B	0.63	3380	20	B	0.68
PM peak	3530	31	C	0.76	3530	31	C	0.76
Warringah Freeway/Miller Street interchange[1]								
AM peak	5200	N/A	C	0.82	5330	N/A	C	0.88
PM peak	5110	N/A	D	0.89	5120	N/A	D	0.89

Note: Cells shaded in grey denote an unsatisfactory LoS E or F.
Note 1: Interchanges have been modelled as a network, where LoS is based on speed efficiency and not average delay.

The midblock performance (level of service) during construction would be unchanged from existing conditions at all locations except for:

- Falcon Street east of Miller Street in the westbound direction, where midblock performance would reduce from LoS B to LoS C during the AM and PM peaks
- Ridge Street east of Miller Street in the eastbound direction, where midblock performance would reduce from LoS B to LoS C during the AM peak
- Ridge Street east of Miller Street in the westbound direction, where midblock performance would reduce from LoS A to LoS B during the AM peak.

All midblock locations listed above would continue to 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 (2022) during the AM and PM peak periods 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 2022)

Location/ direction	Capacity (PCU)	AM peak						PM Peak					
		Base case 2022 (without construction traffic)			Construction 2022 (with construction traffic)			Base case 2022 (without construction traffic)			Construction 2022 (with construction traffic)		
		Volume (PCU)	V/C	LoS	Volume (PCU)	V/C	LoS	Volume (PCU)	V/C	LoS	Volume (PCU)	V/C	LoS
Pacific Highway south of Walker Street													
Northbound	4900	2380	0.49	C	2440	0.5	C	1660	0.34	B	1690	0.35	B
Southbound	2900 (AM), 1900 (PM)	490	0.17	A	510	0.18	A	660	0.35	B	670	0.35	B
Pacific Highway south of Bay Road													
Northbound	2900	850	0.29	B	880	0.3	B	1110	0.38	B	1130	0.39	B
Southbound	1900	1210	0.64	D	1220	0.65	D	1040	0.55	C	1050	0.55	C
Bay Road west of Pacific Highway													
Eastbound	900	260	0.29	B	300	0.33	B	280	0.31	B	300	0.33	B
Westbound	900	420	0.47	C	460	0.51	C	320	0.35	B	340	0.37	B

Location/ direction	Capacity (PCU)	AM peak						PM Peak					
		Base case 2022 (without construction traffic)			Construction 2022 (with construction traffic)			Base case 2022 (without construction traffic)			Construction 2022 (with construction traffic)		
		Volume (PCU)	V/C	LoS	Volume (PCU)	V/C	LoS	Volume (PCU)	V/C	LoS	Volume (PCU)	V/C	LoS
Berry Street east of Walker Street													
Eastbound	3900	1790	0.46	C	1830	0.47	C	2530	0.65	D	2540	0.65	D
Falcon Street east of Miller Street													
Eastbound	1900	1380	0.72	D	1400	0.74	D	1580	0.83	E	1600	0.84	E
Westbound	2900	1180	0.41	B	1210	0.42	C	1190	0.41	B	1210	0.42	C
Ridge Street east of Miller Street													
Eastbound	900	360	0.4	B	390	0.43	C	150	0.17	A	170	0.19	A
Westbound	900	200	0.24	A	250	0.27	B	300	0.34	B	330	0.36	B
Miller Street north of Ernest Street													
Northbound	900 (AM) 1900 (PM)	660	0.73	D	670	0.74	D	830	0.44	C	830	0.44	C
Southbound	2900 (AM) 1900 (PM)	1190	0.41	C	1320	0.45	C	1260	0.66	D	1260	0.66	D

Location/ direction	Capacity (PCU)	AM peak						PM Peak					
		Base case 2022 (without construction traffic)			Construction 2022 (with construction traffic)			Base case 2022 (without construction traffic)			Construction 2022 (with construction traffic)		
		Volume (PCU)	V/C	LoS	Volume (PCU)	V/C	LoS	Volume (PCU)	V/C	LoS	Volume (PCU)	V/C	LoS
Ernest Street west of Merlin Street													
Eastbound	1900	790	0.41	C	900	0.47	C	2100	>1	F	2220	>1	F
Westbound	2900	2100	0.72	D	2210	0.76	D	1040	0.36	B	1160	0.4	B
Blue Street south of Pacific Highway													
Northbound	900	190	0.21	A	220	0.24	A	350	0.39	B	360	0.4	B
Southbound	900	250	0.28	B	280	0.31	B	420	0.47	C	430	0.48	C
Arthur Street north of Pacific Highway													
Northbound	1900	880	0.46	C	910	0.48	C	640	0.33	B	650	0.34	B
Alfred Street north of Mount Street													
Northbound	900	40	0.04	A	40	0.05	A	30	0.03	A	30	0.04	A
Southbound	2900	1470	0.51	C	1470	0.51	C	750	0.26	A	750	0.26	A

Location/ direction	Capacity (PCU)	AM peak						PM Peak					
		Base case 2022 (without construction traffic)			Construction 2022 (with construction traffic)			Base case 2022 (without construction traffic)			Construction 2022 (with construction traffic)		
		Volume (PCU)	V/C	LoS	Volume (PCU)	V/C	LoS	Volume (PCU)	V/C	LoS	Volume (PCU)	V/C	LoS
Falcon Street west of Merlin Street													
Eastbound	3900	2520	0.64	D	2520	0.64	D	3120	0.8	D	3120	0.8	D
Westbound	5900	3440	0.58	C	3440	0.58	C	2320	0.39	B	2330	0.39	B
Walker Street north of Pacific Highway													
Northbound	1900	920	0.48	C	930	0.49	C	700	0.37	B	700	0.37	B
Southbound	900	320	0.36	B	320	0.36	B	370	0.42	C	370	0.42	C

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

Impacts on local roads and parking

A summary of potential impacts on local roads and on-street parking during construction of the project is summarised in Table 8-17.

Table 8-17 Impacts on local roads and parking during construction in the Warringah Freeway and surrounds area

Local road	Description of use during construction	Description of potential impacts
Bay Road and Balls Head Road	Construction vehicle access route in and out of the Berrys Bay construction support site (WHT7)	Tunnel spoil haulage from the Berrys Bay construction support site (WHT7) would be carried out via marine transport to reduce the number of heavy vehicle movements along the narrow Balls Head Road. Under a worst case, up to 210 light vehicle movements and 55 heavy vehicle movements per day would access this construction support site. Construction traffic is not expected to substantially impact Bay Road or Balls Head Road. There would be no loss in parking on Bay Road or Balls Head Road during construction.
Ridge Street (west of Warringah Freeway)	Primary construction vehicle access routes in and out of the Ridge Street east construction support site (WFU6). Secondary construction vehicle access route in and out of the Ridge Street north construction support site (WHT9)	About 12 parking spaces on Ridge Street at the eastern end would be removed to provide suitable access to the construction support sites. There are alternatives for parking elsewhere on local roads within North Sydney which would mitigate the loss of parking at this location. Ridge Street would be the primary construction vehicle access route in and out of the Ridge Street east construction support site (WFU6) although this site is not a major construction support site. Ridge Street would be used by construction vehicles accessing the Ridge Street north construction support site (WHT9) during early works and site establishment construction stages only. There would be limited use of this access once the site is established. Under a worst case scenario, this site would temporarily generate up to 70 light vehicle and 20 heavy vehicle movements per day. Once early works and site establishment construction stages are completed, the primary site access would be provided directly from the Warringah Freeway, so impacts on the traffic performance of Ridge Street would be low. Impacts from construction vehicles are anticipated to be minor given that Ridge Street would operate with spare capacity during construction (refer to Table 8-16).
Ernest Street/Merlin Street intersection	Secondary construction vehicle access route in and out of the Cammeray Golf Course construction support sites (WHT10 and	The Ernest Street/Merlin Street intersection would be modified during construction, with an additional north approach to enable secondary access to the Cammeray Golf Course construction support sites (WHT10 and WFU8). The intersection's modification would not impact the level of service as shown in Table 8-16. Cammeray Golf Course construction support sites (WHT10 and WFU8) primary access for heavy vehicles would be provided directly from the Warringah Freeway. Up to ten parking spaces on Ernest Street would be removed to provide suitable access to the Cammeray Golf Course

Local road	Description of use during construction	Description of potential impacts
	WFU8)	construction support site. Clearways operate on Ernest Street during peak periods, so any closure of the kerbside lane associated with the construction support site would only result in loss of parking outside of peak periods and would be mitigated by parking on nearby local roads such as Ernest Street (east of Merlin Street), Oaks Avenue and Park Avenue.
Merlin Street	Merlin Street construction support site (WFU7)	Under a worst case scenario, the site would generate up to 150 light vehicle movements per day on Merlin Street south of Falcon Street. The number of daily light vehicle movements on Merlin Street south of Falcon Street is low, so performance impacts on Merlin Street are anticipated to be minor. There would be temporary removal of up to 10 parking spaces along Merlin Street in the vicinity of the Merlin Street construction support site (WFU7). The impact of any lost parking spaces would be minor given that other local roads nearby would provide suitable alternatives.
Warringah Freeway	Various construction support sites	Up to 10 parking spaces would be removed to provide suitable access to other construction support sites established for the Warringah Freeway Upgrade such as the Rosalind Street east construction support site (WFU9). The impact of any lost parking spaces would be minor given that other local roads nearby would provide suitable alternatives.
Alfred Street North between Rose Avenue and Kurraba Road	Loss of parking spaces during works associated with the Ridge Street pedestrian bridge, Alfred Street North widening, and Mount Street interchange	Works would result in the permanent removal of about 47 parking spaces on Alfred Street North between Wyagdon Street and Ridge Street; and about 49 parking spaces on Alfred Street North between Ridge Street and Whaling Road. These would be replaced with about 23 new parking spaces following completion of works. These are on-street metered parking spaces (up to nine hours) serving commuters working in North Sydney. Their removal would result in a net loss of on-street parking in North Sydney and Neutral Bay given that there are no nearby alternatives. In addition, temporary long-term closure of sections of Alfred Street North would be required during construction. Access to properties along Alfred Street North would be maintained throughout construction via existing U-turn facilities or alternative routes on the local road network.

Car parking areas for construction workers would be provided at the Berrys Bay (WHT7), Berry Street north (WHT8), Ridge Street north (WHT9), Cammeray Golf Course (WHT10 and WFU8), Blue Street (WFU1), High Street south (WFU2), High Street north (WFU3), Arthur Street east (WFU4), Berry Street east (WFU5), Merlin Street (WFU7) and Rosalind Street east (WFU9) construction support sites. Where on-site parking is not provided or where provision of on-site parking cannot accommodate the full construction workforce, the workforce would be required to park on the surrounding road network. The construction workforce would be encouraged to use public transport where feasible and reasonable to minimise the potential parking impacts on the

road network. There are key bus corridors including Pacific Highway, Warringah Freeway, Miller Street, Falcon Street and Military Road. In addition, the T1 North Shore and T9 Northern Line are accessible from North Sydney and Waverton railway stations.

Impacts of the temporary closure of the Warringah Freeway

Forecasts of maximum detoured traffic volumes during night closures of the Warringah Freeway are detailed in Appendix F (Technical working paper: Traffic and transport) for five potential scenarios:

- Full closure
- Full northbound closure
- Outer northbound lane closure only
- Full southbound lane closure
- Outer south bound lane closure only.

Almost all roads that would be impacted by diverted traffic form part of the regional and state road network or are signposted as recommended routes to key destinations and would have sufficient capacity to accommodate additional traffic resulting from closure detours, even under a full closure scenario. For those few roads where detour volumes could exceed capacity, demand through the area could be reduced through demand management, which would also minimise additional volumes on local and collector roads. Traffic and demand management would be consistent with management measures that are currently employed to mitigate the impacts of regular closures to the Warringah Freeway and Bradfield Highway/Cahill Expressway as part of scheduled maintenance works for the Sydney Harbour Bridge. Partial or full closures of Warringah Freeway would be carried out in consultation with the Sydney Coordination Office.

Impacts on public transport

Impacts on public transport are shown in Figure 8-11.

Bus priority infrastructure and the capacity of layover facilities on the Warringah Freeway in the southbound direction would be maintained during construction. Potential strategies to be implemented include the use of temporary routes on approach to the Sydney Harbour Bridge, the utilisation of temporary bus layover facilities within Cammeray Golf Course, and a new layover facility within the existing Sydney Harbour Bridge Northern Toll Plaza area.

Potential modifications to existing bus lanes may be required for short periods during construction of the Warringah Freeway Upgrade, including:

- Temporary closure of the Mount Street on ramp bus lane
- Temporary closure of the Falcon Street on ramp bus lane
- Temporary closure of the Falcon Street off ramp bus lane.

During these short-term closures, buses would be required to use the adjacent general traffic lanes available. Impacts due to the temporary closure of the bus lanes would be minor and managed during the short periods that these bus lanes would not be in operation.

Adjustment to bus stops within the construction zone on High Street (serving bus route 263), Pacific Highway (serving bus route 200), Miller Street and Falcon Street (serving up to 20 unique bus routes) would be required. Any adjustments to these bus stops would be determined as the project progresses, with advance notification provided to affected bus customers of the changes to stopping sequences and location of bus stops. Disruption to bus customers would be minimised by relocating the bus stops to the closest practical alternative. In some instances, bus stop relocation could require some existing parking spaces to be removed. Given the potential small increase in travel distance to a relocated bus stop, impacts are anticipated to be negligible.

Given the large amount of works on existing roads on the Warringah Freeway and North Sydney road network, extensive community and stakeholder engagement would be carried out in conjunction with other Transport for NSW projects and the Sydney Coordination Office. This is likely to include a Community and Road User Campaign which would be implemented before the start of works to inform all road users including bus operators of the upcoming network changes and proposed detour routes.

Impacts on active transport

Impacts on the active transport network are shown in Figure 8-12.

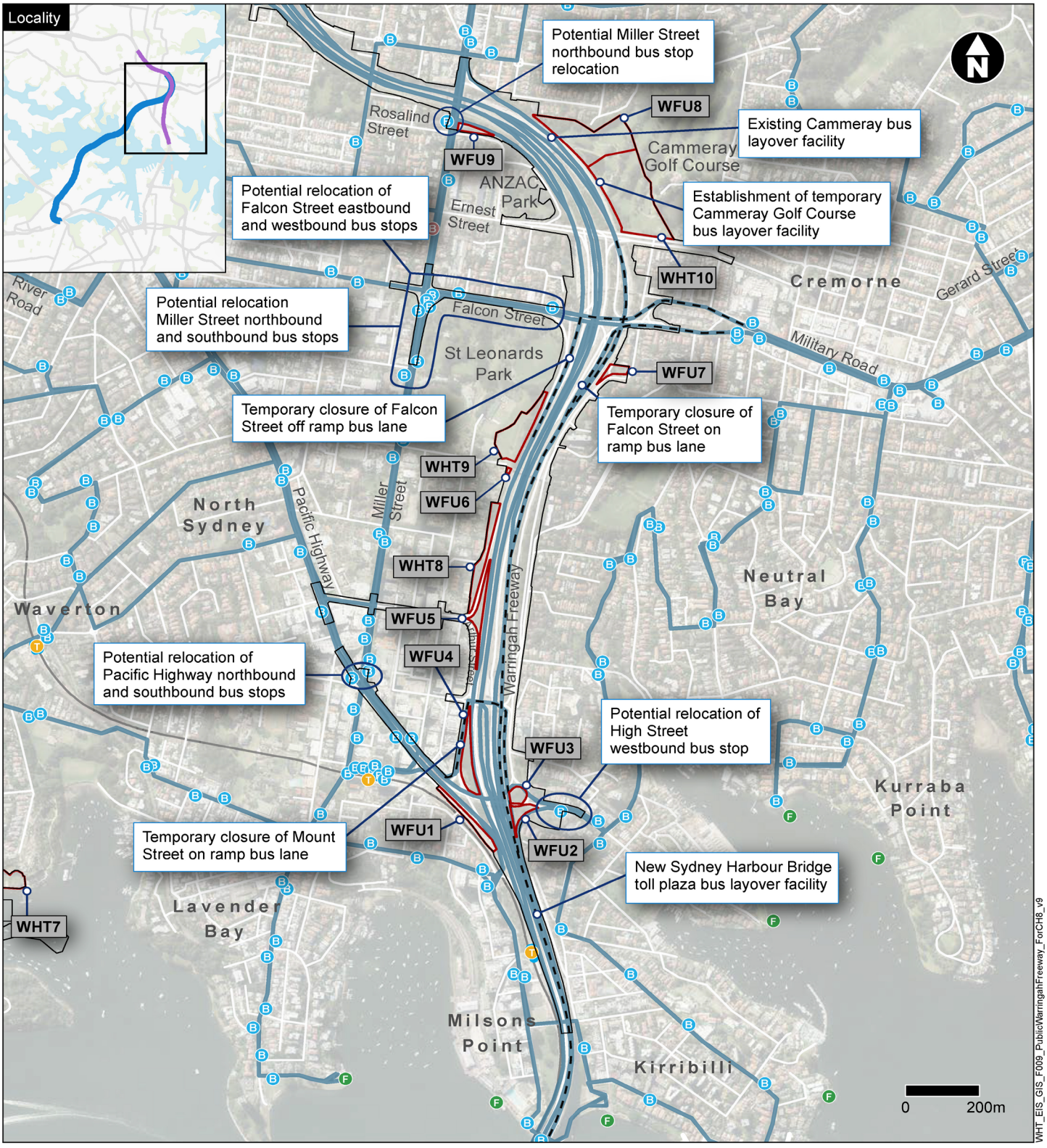
Limited vehicular access to and from the Berrys Bay construction support site (WHT7) would be provided, with about 210 light vehicle and 55 peak heavy vehicle movements per day. The construction vehicle route to this site would be via Bay Road/Balls Head Road. Bay Road/Balls Head Road provides access to Balls Head Reserve which is used by cyclists and pedestrians. Pedestrians would be separated from construction traffic along Bay Road/Balls Head Road up to Waterhen Drive, where there is a footpath provided on each side of the road. Most pedestrians and cyclists access Balls Head Reserve via Waterhen Drive and their interaction with construction traffic would be negligible.

A secondary access point to the Cammeray Golf Course construction support sites (WHT10 and WFU8) would be provided at the Ernest Street/Merlin Street intersection. Impacts on the shared user path on the northern side of Ernest Street would be minimised by directing heavy vehicles to access the site from the Warringah Freeway where feasible and reasonable, and controlling pedestrian and cyclist movements via a signalised crossing spanning the Ernest Street site entry/exit. The existing traffic lights at the Ernest Street/Merlin Street intersection would minimise interaction between pedestrians and cyclists and construction traffic.

The shared user path along Warringah Freeway near Cammeray Golf Course would be temporarily realigned to travel along the rear of the support site to the Ernest Street/Merlin Street intersection. Minor impacts on pedestrians and cyclists are anticipated given that existing connectivity would be maintained with a short additional travel distance of up to 100 metres.

Access to the Ridge Street north construction support site (WHT9) would be via the Warringah Freeway. However, during early works and site establishment, access may be required on the northern side of Ridge Street adjacent to the Ridge Street shared user bridge until the Warringah Freeway site access is operational. Given that there is no footpath on the northern side of Ridge Street, impacts on pedestrians are not expected. Pedestrian access across the Warringah Freeway would be maintained via the existing Ridge Street shared user bridge, until the new crossing is completed. Ridge Street is a difficult on-road cycle environment, and construction vehicles may interact with cyclists accessing the Ridge Street shared user bridge. Construction vehicle movements to and from the construction support site would be managed through active traffic management to control construction vehicle movements and reduce the potential interactions between these vehicles and cyclists. Impacts on sports and recreational users at St Leonards Park would also be minimal.

A new shared user bridge over the Warringah Freeway would replace the existing shared user bridge at Falcon Street. Pedestrian access across the Warringah Freeway would be maintained via the existing bridge, until the new crossing is completed. Temporary adjustments would also be required on the shared user path in Jeaffreson Jackson Reserve to accommodate the construction of the new shared user bridge. These adjustments would be short in duration and would not coincide with the temporary adjustments required to the shared user path on Ernest Street. Up to 45 pedestrians and cyclists per hour during peak periods would be detoured via Ernest Street and the existing Falcon Street shared user bridge, resulting in an additional travel distance of up to 400 metres. Impacts are anticipated to be moderate and manageable given the short-term duration of the shared user path adjustments and the low number of pedestrians and cyclists currently using this path. Advance warning signs would notify users of the temporary adjustments to the Jeaffreson Jackson Reserve shared user path and the recommended detour route.



Legend

Construction features

- Construction support site boundary
- Construction footprint

Public transport infrastructure

- Bus route
- Bus lane
- Rail
- Bus stop
- Train station
- Ferry wharf

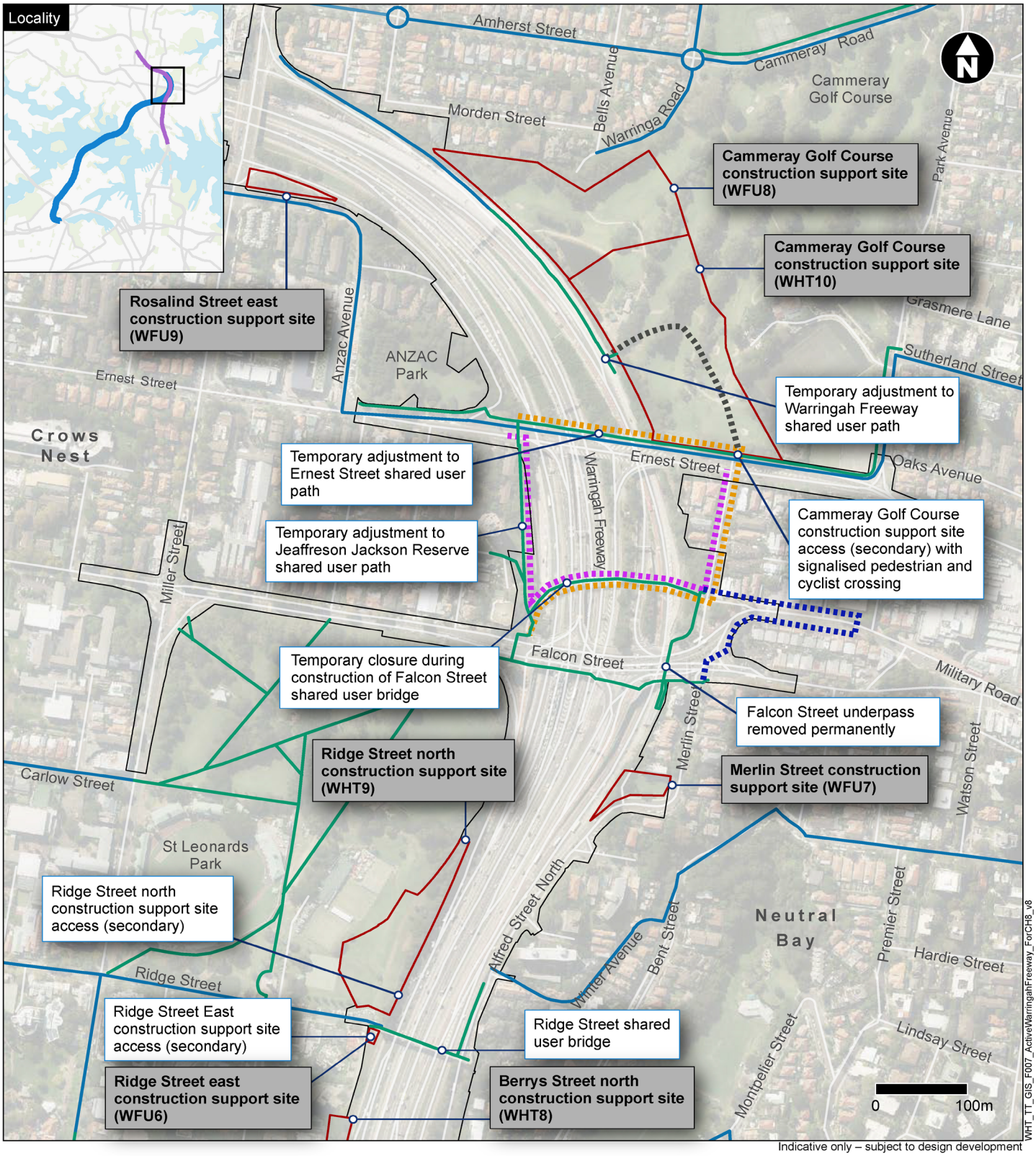
Warringah Freeway Upgrade construction support sites

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

Western Harbour Tunnel construction support sites

Berrys Bay (WHT7)
Berrys Street north (WHT8)
St Leonards Park (WHT9)
Cammeray Golf Course (WHT10)

Figure 8-11 Public transport impacts within the Warringah Freeway and surrounds area



Legend

Construction features

- Construction support site boundary
- Construction footprint

Active transport infrastructure

- Existing off-road shared user path
- Existing on-road cycle path
- Ernest Street shared user path detour
- Falcon Street underpass alternative route
- Jeaffreson Jackson Reserve shared user path detour
- Warringah Freeway shared user path detour

Figure 8-12 Active transport impacts within the Warringah Freeway and surrounds area

The cycleway underpass beneath the eastern side of the Falcon Street Bridge would be permanently removed during the initial stages of the Warringah Freeway Upgrade. Removal of the underpass would require pedestrians and cyclists to either travel an additional 380 metres via existing zebra and signalised pedestrian crossings on Falcon Street and Military Road, or travel across the Falcon Street Bridge, resulting in increased travel times. The underpass is currently under-utilised with less than 12 pedestrians and cyclists recorded using the facility during weekday and weekend peak hours. Due to the low volumes of pedestrians and cyclists using the underpass, the impact would be minor.

Temporary adjustments to the shared user path on the northern side of Ernest Street would be required during the Warringah Freeway Upgrade. Pedestrians and cyclists would be detoured via the Falcon Street pedestrian bridge, located about 140 metres south of Ernest Street. These users may be required to travel an additional 400 metres. Given the additional travel distance and possible requirement for pedestrians and cyclists to cross Ernest Street to access the Falcon Street pedestrian bridge, advance warning signs would be provided to notify these users of the temporary adjustment to the shared user path and the recommended detour route. Due to the short duration of the adjustment to the shared user path, the impact on the active transport network would be moderate and manageable.

Construction traffic volumes at all other construction support sites established for the Warringah Freeway Upgrade are also low, with minimal impacts expected to the active transport network.

8.4.4 Gore Hill Freeway and Artarmon

Road network impacts

The anticipated routes to and from the Waltham Street construction support site (WHT11) 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) near Waltham Street construction support site (WHT11) would not change during the site operation given the low volumes of construction vehicles generated (maximum 180 light vehicles and 65 heavy vehicles per day).

The midblock performance (level of service) during construction would be unchanged from the midblock performance under existing conditions at all locations except Dickson Avenue east of Reserve Road in the westbound direction, where the level of service would deteriorate during the PM peak, but 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 (2022) during the AM and PM peak periods are summarised in Table 8-18.

Table 8-18 Modelled midblock performance in Gore Hill Freeway and Artarmon (AM peak (8am-9am) and PM peak (5pm-6pm) during construction in 2022)

Location/ direction	Capacity (PCU)	AM peak						PM Peak					
		Base case 2022 (without construction traffic)			Construction 2022 (with construction traffic)			Base case 2022 (without construction traffic)			Construction 2022 (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	580	0.3	B	610	0.32	B	1150	0.61	D	1180	0.62	D
Southbound	1900	1280	0.68	D	1310	0.69	D	660	0.34	B	690	0.36	B
Dickson Avenue east of Reserve Road													
Eastbound	900	260	0.29	B	290	0.32	B	170	0.19	A	200	0.22	A
Westbound	900	140	0.15	A	160	0.18	A	230	0.25	A	260	0.29	B

Impacts on local roads and parking

Reserve Road, Dickson Avenue and Waltham Street are local roads that form part of the construction vehicle route associated with the works to be carried out at the Waltham Street construction support site (WHT11). Up to 180 light vehicles and 65 heavy vehicles per day would access the Waltham Street construction support site (WHT11) from Reserve Road. These traffic volumes would have a negligible impact as Reserve Road would operate with spare capacity and at a satisfactory level of service during construction as shown in Table 8-18.

Up to ten parking spaces may be removed temporarily on Dickson Avenue or Waltham Street to provide suitable access to the Waltham Street construction support site (WHT11). If parking spaces are lost, impacts would be minor given the low number of spaces removed and the availability of other local roads nearby to accommodate these lost parking spaces.

A car parking area for construction workers would be provided at the Waltham Street construction support site (WHT11). Where required, shuttle bus transfers between construction support sites may also be provided. Where provision of on-site parking cannot accommodate the full construction workforce, the workforce would be required to park on the surrounding road network. The construction workforce would be encouraged to use public transport where feasible and reasonable to minimise the potential parking impacts on the road network, with key bus corridors including Pacific Highway, Warringah Freeway, 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.

Impacts on public transport

No material direct or indirect impacts on public transport in the Gore Hill Freeway and Artarmon area are expected during the operation of the Waltham Street construction support site (WHT11).

Impacts on active transport

No material direct or indirect impacts on the active transport network in the Gore Hill Freeway and Artarmon area are expected during the operation of the Waltham Street construction support site (WHT11).

8.4.5 Cumulative impacts of the project and the Beaches Link and Gore Hill Freeway Connection project (Warringah Freeway and surrounds)

Peak cumulative construction traffic is expected in 2024 if construction of the Western Harbour Tunnel and Warringah Freeway Upgrade project and the Beaches Link and Gore Hill Freeway Connection project (if approved) are carried out concurrently. Peak construction activity for the project is not anticipated to overlap with peak construction activities for other major infrastructure projects including Sydney Metro City & Southwest, M4–M5 Link, and Bays Precinct Urban Renewal project. At the time of preparing this document, the program for Metro West has not been confirmed. However, the project has been working collaboratively with Metro West on this issue, through the Cumulative Traffic Working Group (refer to Section 8.4.6).

Road network performance

Analysis of network performance in the AM and PM peak periods with the project and the Beaches Link and Gore Hill Freeway Connection project indicate that when compared to forecast 2024 peak

period conditions without the project, 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.

These overall network impacts are considered minor and manageable.

General travel times

Modelled travel times during AM and PM peaks for key routes relevant to the project are presented in Table 8-19.

Under the cumulative construction 2024 scenario, travel times would increase by less than one minute for the majority of 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 8-19 Modelled AM and PM peak traffic travel times for key routes through Warringah Freeway and surrounds

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
PM peak	Northbound	03:36	03:42
	Southbound	14:27	15:05

Route/peak period	Direction	Base case 2024 (without construction traffic) (minutes : seconds)	Cumulative construction 2024 (with construction traffic) (minutes : seconds)
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

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 summarised in Appendix F (Technical working paper: Traffic and transport) for the AM and PM peak periods.

The assessment indicates that 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 reduce 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 reduce from LoS E to LoS F during the AM peak
- Amherst Street/West Street would reduce from LoS A to LoS B during the PM peak
- Amherst Street/Miller Street would reduce from LoS B to LoS C during the PM peak
- Miller Street/Warringah Freeway off ramp would reduce from LoS A to LoS C during the AM peak
- Miller Street/Falcon Street would reduce from LoS D to LoS E during the AM peak

- Military Road/Ben Boyd Road would reduce from LoS C to LoS D during the PM peak
- Mount Street/Arthur Street would reduce from LoS E to LoS F during the PM peak
- Pacific Highway/Berry Street would reduce from LoS B to LoS C during the PM peak
- Pacific Highway/Bay Road would reduce from LoS E to LoS F during the AM peak
- High Street/Alfred Street would reduce from LoS A to LoS B during the AM peak
- Ernest Street/Ben Boyd Road would reduce 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 substantial increase in average vehicle delay (around 30 to 40 seconds) during construction include Willoughby Road/Gore Hill Freeway interchange, Brook Street/Warringah Freeway ramps and Brook Street/Merrenburn Avenue.

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

Full intersection performance results are provided in Appendix F (Technical working paper: Traffic and transport).

Road network changes and access arrangements

The Cammeray Golf Course would be used as construction support sites for both the Western Harbour Tunnel and Warringah Freeway Upgrade project (WHT10 and WFU8) and the Beaches Link and Gore Hill Freeway Connection project (subject to separate assessment and approval) and would result in cumulative traffic volumes generated to and from this site. The potential for cumulative traffic impacts associated with these projects, including haulage roads and intersections traversed by construction vehicles during concurrent works, has been assessed in this section.

Impacts on public transport

In relation to bus times, cumulative construction activities in the Warringah Freeway and surrounding area have the potential to impact corridor travel times by less than one minute for the majority of routes. The results indicate that, 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 would be 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 the Western Harbour Tunnel and Warringah Freeway Upgrade project, and the Beaches Link and Gore Hill Freeway Connection project.

8.4.6 Cumulative impacts of the project and M4–M5 Link and Sydney Metro City & Southwest projects (Rozelle and surrounds)

Sydney Metro City & Southwest and M4–M5 Link construction programs would potentially overlap with the project construction in 2022. The Rozelle Rail Yards (WHT1), Victoria Road (WHT2) and White Bay (WHT3) construction support sites may be operational at the same time as construction for the M4–M5 Link and Sydney Metro City & Southwest projects. Although use of the Rozelle Rail Yards construction support site (WHT1) commences in 2023, and therefore outside of the 2022 assessment year, construction traffic volumes at this site have been included in the assessment to present a worst-case cumulative construction scenario.

Overall, the cumulative impacts in Rozelle and surrounds are moderate and manageable. The potential impacts would be mitigated by considered and tailored cumulative construction traffic planning, based on confirmed cumulative activities at the time of construction.

Cumulative Traffic Working Group

A cumulative traffic working group was established in July 2018 to investigate the potential cumulative traffic impacts associated with the concurrent traffic generating activities in the Glebe Island and White Bay area due to construction of the Rozelle Interchange, Western Harbour Tunnel and Sydney Metro West, along with an expansion of existing operations at Glebe Island by the Port Authority of NSW.

The working group includes the following stakeholders:

- Other Transport for NSW divisions and projects, including:
  - Transport for NSW (Sydney Division)
  - Transport for NSW (Rozelle Interchange project)
  - Transport for NSW (Western Harbour Tunnel)
- Urban Growth (now Infrastructure NSW)
- Sydney Coordination Office
- Sydney Metro West project
- Port Authority of NSW.

The cumulative traffic working group carried out traffic modelling to predict the potential impact of these projects and operations on the traffic network in and around the Rozelle precinct and developed a range of mitigation measures to be implemented, including:

- Implementation and incentivising bus services to transport suitable project personnel to and from site
- Avoiding tunnelling shift changeovers occurring between 7am and 9am and 4pm and 6pm Monday to Friday, to reduce peak period traffic impacts
- Offshore disposal of tunnel spoil, which is primarily crushed sandstone, when generated at harbourside construction support sites to reduce heavy haulage.

The project would adopt the first two of the aforementioned mitigation measures. An application for offshore disposal of suitable dredged material has been submitted to the Commonwealth Department of the Environment and Energy to implement offshore disposal where appropriate.

Road network performance

Analysis of network performance in the AM and PM peak periods with the project, the M4–M5 Link and Sydney Metro City & Southwest projects indicates that when compared to forecast 2022 peak

period conditions without the project, cumulative construction activities in Rozelle and surrounds area have the potential to:

- Increase traffic demand by up to three per cent
- Create up to three additional stops per trip
- Reduce average trip speeds between five per cent (during AM peaks) and 14 per cent (during PM peaks).

General travel times

Modelled travel times during AM and PM peaks for City West Link and Western Distributor and Victoria Road are presented in Table 8-20. The results show cumulative project impacts could result in:

- Travel times on City West Link westbound slowed by up to five minutes during AM peaks
- Travel times on Victoria Road northbound slowed by up to 3.5 minutes during AM peaks
- Travel times in the PM peak slowed by up to two minutes on City West Link and Victoria Road.

Table 8-20 Modelled AM and PM peaks traffic travel times for City West Link and Western Distributor and Victoria Road

Route / Peak period	Direction	Base case 2024 (without construction traffic) (minutes: seconds)	Cumulative construction 2024 (with construction traffic) (minutes : seconds)
City West Link and Western Distributor (Balmain Road to Druitt Street ramp)			
AM peak	Eastbound	14:36	12:44
	Westbound	10:29	15:50
PM peak	Eastbound	05:34	06:53
	Westbound	11:23	13:21
Victoria Road (Evans Street to ANZAC Bridge)			
AM peak	Northbound	11:00	14:24
	Southbound	03:19	03:13
PM peak	Northbound	04:54	05:50
	Southbound	04:07	03:56

Intersection performance

The intersection results for the road network under the base case 2022 (without construction vehicles) and cumulative construction 2022 (with construction vehicles) scenarios are summarised in Appendix F (Technical working paper: Traffic and transport) for the AM and PM peak periods.

The assessment indicates that the addition of construction traffic associated with the project and the M4–M5 Link and Sydney Metro City & Southwest projects on the road network would impact the level of service at the following intersections:

- Victoria Road/Evans Street would reduce from LoS E to LoS F during the PM peak
- Victoria Road/Gordon Street would reduce from LoS E to LoS F during the PM peak
- Victoria Road/Robert Street would reduce from LoS E to LoS F during the AM peak
- Victoria Road/The Crescent would reduce from LoS D to LoS E during the AM peak
- The Crescent/James Craig Road would reduce from LoS B to LoS C during the PM peak
- The Crescent/City West Link would reduce from LoS E to LoS F during the PM peak
- City West Link/Catherine Street would reduce from LoS B to LoS C during the PM peak
- City West Link/Balmain Road would reduce from LoS E to LoS F during the PM peak.

The impact to level of service at the above intersections would be primarily due to the increased demand generated by construction traffic at key capacity constrained intersections.

Full intersection performance results are provided in Appendix F (Technical working paper: Traffic and transport).

Impacts on public transport

Traffic modelling indicates that cumulative construction activities would have the potential to impact northbound bus travel times on the ANZAC Bridge-Victoria Road corridor by between 1.5 and 2.5 minutes.

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 the project and the M4–M5 Link and Sydney Metro City & Southwest projects.

8.4.7 Special events impacts

The majority of construction works would have minimal impacts on special events as the construction support sites and associated construction traffic routes would not be located in proximity to venues that regularly schedule events that require traffic or public transport event plans. Potential exceptions to this may include:

- **North Sydney Oval** – Events at North Sydney Oval typically do not require active traffic management or changes in network operation to accommodate visitors. Construction routes travelling along Miller Street would have no substantial impact on events at North Sydney Oval, however the availability of car parking, particularly at Ridge Street, would be temporarily reduced during the construction period
- **Balls Head Reserve** – Balls Head Road is typically closed to traffic during New Year's Eve. This would restrict access for light vehicles to the Berrys Bay construction support site (WHT7). Construction activity would be scheduled to avoid any conflict with special events
- **Yurulbin Park** – A popular vantage point for New Year's Eve celebrations on Sydney Harbour. After 3pm on New Year's Eve, access to Birchgrove peninsula from Victoria Road is restricted to residents, buses, taxis and authorised vehicles. The closure of the park during construction would require members of the public to seek alternative vantage points, potentially increasing pressure at other locations. Barge movements generated at the Yurulbin Point construction support site (WHT4) would be scheduled to avoid conflict with New Year's Eve celebrations
- **ANZAC Park** - Temporary occupation (about six months) of land within ANZAC Park would be required to support construction activities. Consideration of community events such as the

ANZAC Day Dawn Service at the memorial statue during the planning of major construction activities would be important to minimise potential construction impacts.

8.5 Environmental management measures

Environmental management measures relating to construction traffic and transport impacts are outlined in Table 8-21. Environmental management measures relating to cumulative impacts, including coordination of haulage routes and road occupancy, are detailed in Chapter 27 (Cumulative impacts).

Table 8-21 Environmental management measures for construction traffic and transport impacts

Ref	Phase	Impact	Environmental management measure	Location
CTT1	Pre-construction	Construction traffic	A road dilapidation report will be prepared, in consultation with relevant councils and road owners, identifying existing conditions of local roads and mechanisms to repair damage to the road network caused by heavy vehicle movements associated with the project.	WHT/WFU
CTT2	Pre-construction	Maritime construction	Moorings impacted during construction will be relocated elsewhere in Sydney Harbour in consultation with the lease holders.	WHT
CTT3	Pre-construction	Maritime construction	Opportunities to relocate the Birchgrove Ferry Wharf will be investigated during construction planning.	WHT
CTT4	Construction	Construction traffic	Ongoing consultation will be carried out with (as relevant to the location) the Sydney Coordination Office, the Port Authority of NSW, local councils, emergency services and bus operators to minimise traffic and transport impacts during construction.	WHT/WFU
CTT5	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.	WHT/WFU
CTT6	Construction	Construction traffic	Construction road traffic will be managed to minimise movements during peak periods	WHT/WFU
CTT7	Construction	Construction traffic	Vehicle access to and from construction sites will be managed to ensure pedestrian, cyclist and motorist 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.	WHT/WFU

Ref	Phase	Impact	Environmental management measure	Location
CTT8	Construction	Construction traffic	Directional signage and linemarking will be used to direct and guide drivers, cyclists and pedestrians past construction sites and on the surrounding network. This will be supplemented by Variable Message Signs to advise drivers of potential delays, traffic diversions, speed restrictions, or alternative routes.	WHT/WFU
CTT9	Construction	Construction traffic	Where provision of construction on-site parking cannot accommodate the full construction workforce, feasible and reasonable management measures that minimise impacts on parking on local roads will be identified and implemented. Depending on the location, management measures may include workforce shuttle buses and the use of public transport.	WHT/WFU
CTT10	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 will be provided to affected bus customers. Relocations will be as close as feasible and reasonable to their existing position.	WHT/WFU
CTT11	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.	WHT/WFU
CTT12	Construction	Construction traffic	Activities requiring partial and full road closures will occur outside of peak periods and/or during night time to minimise the impact of these activities on the road network where feasible and reasonable.	WHT/WFU
CTT13	Construction	Construction traffic	Partial or full closures of Warringah Freeway will be carried out in consultation with the Sydney Coordination Office.	WFU
CTT14	Construction	Construction traffic	Haulage of spoil by barge will be considered as an alternative to road based haulage.	WHT
CTT15	Construction	Maritime construction traffic	Construction vessels will be required to operate in a manner that minimises wash to areas of shoreline.	WHT

Ref	Phase	Impact	Environmental management measure	Location
CTT16	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.	WHT
CTT17	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.	WHT
CTT18	Construction	Maritime construction	Construction vessel movements will be managed so that they will not interfere with port operations or the navigation of seagoing ships and ferries, unless prior approval has been obtained from the Harbour Master.	WHT

WHT = Western Harbour Tunnel, WFU = Warringah Freeway Upgrade

Chapter 9

Operational traffic and transport

January 2020

9 Operational traffic and transport

This chapter considers the potential traffic and transport impacts arising from the operation of the Western Harbour Tunnel and Warringah Freeway Upgrade (the project) and identifies measures to address these impacts.

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.

The proposed environmental management measures relevant 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 requirements	Where addressed
Transport and traffic	
2. The Proponent must assess and model the operational transport impacts of the project including, but not necessarily limited to: 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 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**.
e. wider transport interactions (local and regional roads, cycling, public and freight transport), taking into account the Sydney City Centre Access Strategy and planned future urban	**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

Secretary's requirements	Where addressed
release areas such as the Bays Precinct;	takes into account specific transport strategies. **Section 9.4** provides an assessment of future traffic and transport interactions. Bays Precinct has been put on hold for the foreseeable future. To date, engagement has been carried out with the relevant stakeholders and would continue as required when the project recommences.
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 and access arrangements are described in **Section 9.4**. Impacts to properties and businesses is detailed in **Chapter 21** (Social and economic).
i. an explanation for the scope of the modelled area, including justification of the nominated boundaries.	The assessment methodology is outlined in **Section 9.2.**

9.1 Strategic transport planning context

Details regarding the project's compatibility with key Commonwealth 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 city-shaping multi-modal transport projects throughout the Western Harbour Tunnel and Beaches Link program of works (program of works) area present a major opportunity to develop an integrated, transport strategy that addresses a range of customer needs. The transport infrastructure investment in North Sydney is an unprecedented opportunity for the North Sydney CBD to realise place based improvements.

The *North Sydney Integrated Transport Program* (the North Sydney Program) is currently being developed by Transport for NSW in collaboration with North Sydney Council to guide transport

planning and investment in the North Sydney CBD and interconnected areas over the next 20 years and beyond. The North Sydney Program is being developed to support and facilitate the outcomes envisaged by the *Greater Sydney Region Plan* and *Future Transport 2056*. The timing for deliverables in the North Sydney Program would be cognisant of the program of works delivery timeframes.

The development of the North Sydney Program is ongoing. Consequently, the program of works has been designed to preserve opportunities for a future integrated and multi-modal transport network. Additionally, to minimise the impact of the program of works on the North Sydney precinct, 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 which 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 other stakeholders to investigate options to improve movement and place outcomes through the North Sydney Program, further leveraging the strategic benefits of the program of works.

9.1.2 Sydney City Centre Access Strategy

The *Sydney City Centre Access Strategy* (Transport for NSW, 2013a) is the NSW Government strategy to deliver a fully integrated transport network in Sydney's city centre that meets the growing demand for all transport modes. The strategy aims to prioritise and allocate road space for public transport, general traffic, pedestrians, cyclists, taxis and service vehicles.

The project addresses one of the key actions of the strategy, which is to establish traffic bypass routes to move traffic around the Sydney CBD. Bypass of the Sydney CBD by through traffic would result in reduced congestion in the Sydney CBD, reduced impact of traffic on other modes, increased reliability on designated bus corridors in the Sydney CBD and reduced likelihood of competition between different road users.

9.1.3 Sydney's Bus Future

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

By reducing network congestion, improving network resilience and increasing reliability in peak periods, a new Harbour crossing would make bus routes on the Sydney Harbour Bridge a more attractive transport option, supporting and encouraging a mode shift to public transport. The project

would also create the opportunity for new public transport routes to be developed in response to diverse travel demands and future social and economic development.

The Northern Beaches (B-Line) began operation in 2017, providing more frequent and reliable services between the Northern Beaches and Sydney CBD. The project, including the Warringah Freeway Upgrade, would support the operation of the B-Line program, as it would facilitate connections to the future Beaches Link Tunnel and enable improved bus travel time along the Warringah Freeway and across the Sydney Harbour Bridge.

9.1.4 Sydney's Cycling Future

Sydney's Cycling Future (Transport for NSW, 2013c) identifies priority cycleways to improve connections 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.

The project would improve cycle connectivity along the fragmented Warringah Freeway corridor, where the current cycle facilities are a combination of off-road and on-road paths. There is a strong community desire to fill a perceived missing link in the cycleway networks in these locations. 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, 2013d) 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 pedestrian facilities to encourage this mode for local trips.

9.2 Assessment methodology

9.2.1 Overview

The assessment methodology for 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 is 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.

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, cycleways, footpaths and pedestrian crossings.	Semi-quantitative assessment of impacts on pedestrian and cyclist networks and accessibility.
Maritime traffic	Analysis of changes in water depths in Sydney 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.

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

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 use of both regional and local scale modelling 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 Chapter 8 (Construction traffic and transport) and Appendix F (Technical working paper: Traffic and transport).

Strategic Travel Model (STM)

- **General description**
  Forecasts travel patterns across the Sydney, Newcastle and Illawarra regions under various land use, multi-modal transport and transport pricing scenarios
- **Project context**
  Provides forecast road traffic demands for more detailed modelling using SMPM

Sydney Motorway Planning Model (SMPM)

- **General description**
  Forecasts strategic traffic patterns for Sydney motorway projects
- **Project context**
  Provides strategic road traffic forecasts to inform project definition and evaluation, and as an input into more detailed operational traffic modelling

Operational traffic modelling

- **General description**
  Provides detailed operational road network performance modelling for more complex local and regional components of the road network relevant to the project
- **Project context**
  Predicts road network performance with and without the project

Figure 9-1 Overview of transport modelling approach

Operational traffic modelling scenarios

Future year networks and traffic demand were developed for 2027 (year of opening) and 2037 (year of opening plus 10 years) to assess future traffic network performance. 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 scenarios:

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

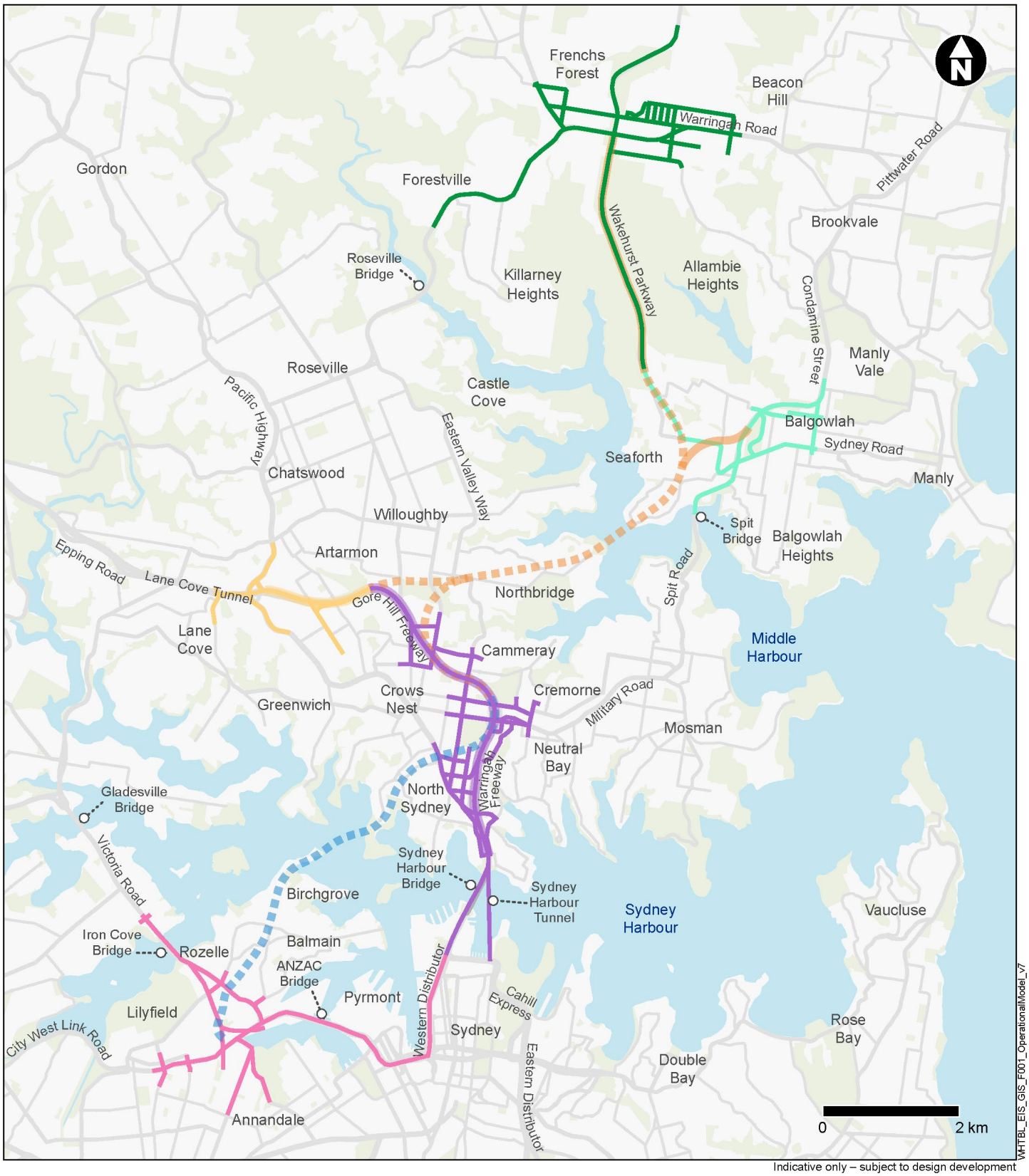
The scenarios assessed are summarised in Table 9-3.

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'	Includes approved and under construction motorway projects (NorthConnex and WestConnex) but without Western Harbour Tunnel and Warringah Freeway Upgrade, Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and F6 Extension (Stage 1) projects. Also reflects operational effects of approved and under construction public transport projects (eg Sydney Metro City & Southwest).		✓	✓
'Do something'	Includes NorthConnex, WestConnex, Western Harbour Tunnel and Warringah Freeway Upgrade projects but without Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and F6 Extension (Stage 1) projects. Also includes Sydney Metro City & Southwest.		✓	✓
'Do something cumulative'	Includes NorthConnex, WestConnex, Western Harbour Tunnel and Warringah Freeway Upgrade, Beaches Link and Gore Hill Freeway Connection, Sydney Gateway and F6 Extension (Stage 1) projects. Also includes Sydney Metro City & Southwest.		✓	✓

A tunnel model (Western Harbour Tunnel) 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. Three surface interface models (Rozelle and surrounds, Warringah Freeway Upgrade and Gore Hill Freeway Connection) 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 project. Also shown in Figure 9-2 are the operational model areas associated with the Beaches Link and Gore Hill Freeway Connection project (Balgowlah and surrounds, Frenchs Forest and surrounds, and proposed Beaches Link component of the Beaches Link and Gore Hill Freeway Connection project – not used in this assessment).



Legend

Operational features

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

Operational model areas

- Rozelle and surrounds
- Warringah Freeway and North Sydney
- 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 and corridor level – traffic demand, average speed, number of stops (that is, 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 of the following local areas:

- Rozelle and surrounds
- Birchgrove to Waverton (Sydney Harbour crossing)
- Warringah Freeway and surrounds
- Gore Hill Freeway and Artarmon.

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 Beaches Link and Gore Hill Freeway Connection project and other planned or proposed 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 substantially reduce traffic demands and improve travel times on the Sydney Harbour Bridge, the Sydney Harbour Tunnel, ANZAC Bridge, and connecting road corridors. It is expected to provide a particularly attractive alternative to the current Western Distributor and Sydney Harbour Bridge route, particularly for trips across Sydney Harbour between Rozelle, North Sydney and the Lower North Shore.

Travel times are expected to be reduced for trips via the Sydney Harbour Tunnel and from the eastern suburbs, primarily as a result of decreased congestion on this motorway corridor with longer-distance north-south trips transferring to the WestConnex-Western Harbour Tunnel corridor. The project would result in trips between strategic centres saving up to 15 minutes when crossing Sydney Harbour during peak periods.

Works for Western Harbour Tunnel and Warringah Freeway Upgrade includes provision for tolling gantries for northbound traffic should the government elect to introduce a northbound toll. The potential cost increase associated with the introduction of a northbound toll on the Sydney Harbour Bridge, the Sydney Harbour Tunnel and Western Harbour Tunnel may be offset by travel time savings created by the project. As a result, no substantial diversion of traffic to Victoria Road is predicted, with forecast traffic volumes on Gladesville Bridge and Victoria Road substantially unchanged across the day. Forecast travel times for key trips across the network in the AM peak and PM peak are shown in Figure 9-3 and Figure 9-4.

The general reduction in road vehicle congestion and travel times would result in improved travel times for buses and would increase the extent of equivalent public transport catchments and could be further extended if express buses operate through the Western Harbour Tunnel.

The project would substantially change the volume of traffic travelling on existing arterial roads at the metropolitan level. Trips through the Western Harbour Tunnel on the motorway network would be made on a higher standard of road than urban arterials; the number of crashes across the network are estimated to reduce by up to 375 incidents a year as a result of the Western Harbour Tunnel. A summary of the forecast growth at key locations for the 2027 and 2037 forecast years is provided in Table 9-4.

‘Do something cumulative’ scenario

The project combined with the proposed Beaches Link and Gore Hill Freeway Connection project would create a small increase in traffic demand across Sydney Harbour and some diversion of traffic from the Sydney Harbour Tunnel to the Western Harbour Tunnel as a result of changes to travel patterns to and from the Northern Beaches associated with Beaches Link. Traffic demand in both directions in the Sydney Harbour Tunnel would further reduce while traffic demand on the Sydney Harbour Bridge and Gladesville Bridge would not change substantially compared with the ‘Do something’ scenario.

The ‘Do something’ cumulative scenario would result in minimal changes to total heavy vehicle movements across Sydney Harbour when compared with the ‘Do something’ scenario, with the primary change being a switch from the Sydney Harbour Tunnel to the Western Harbour Tunnel as a result of direct access being provided between the Western Harbour Tunnel and Beaches Link.

The improvement in road vehicle travel times would also benefit travel times for public transport and would increase the size of equivalent public transport catchments, particularly if express buses operate through both the Beaches Link Tunnel and Western Harbour Tunnel, substantially increasing the catchment size for centres north of Sydney Harbour.

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'
Sydney Harbour Bridge	Bradfield Highway	Combined	159,500	131,500	130,500	172,500	144,500	145,000
Sydney Harbour Bridge	Cahill Expressway	Southbound	44,000	36,000	35,500	48,000	39,000	38,500
Sydney Harbour Tunnel	Sydney Harbour	Combined	111,000	88,500	77,000	120,500	96,000	85,500
Gladesville Bridge	Parramatta River	Combined	113,000	114,000	113,500	119,000	118,000	117,000
Western Harbour Tunnel	Birchgrove	Combined	N/A	67,000	87,000	N/A	83,000	106,500
ANZAC Bridge	Pyrmont	Combined	176,000	160,000	159,500	185,000	167,500	166,500
Western Distributor	Sydney CBD	Combined	109,000	68,000	67,000	117,500	74,500	73,500

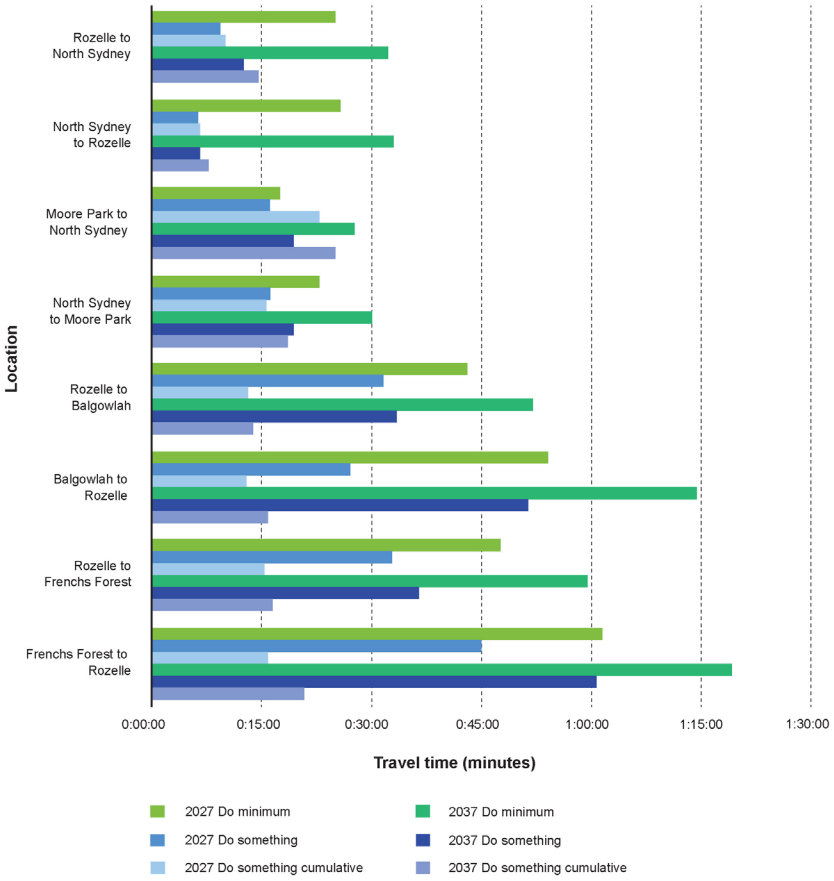


Figure 9-3 Forecast AM peak period (8am-9am) travel times along key corridors

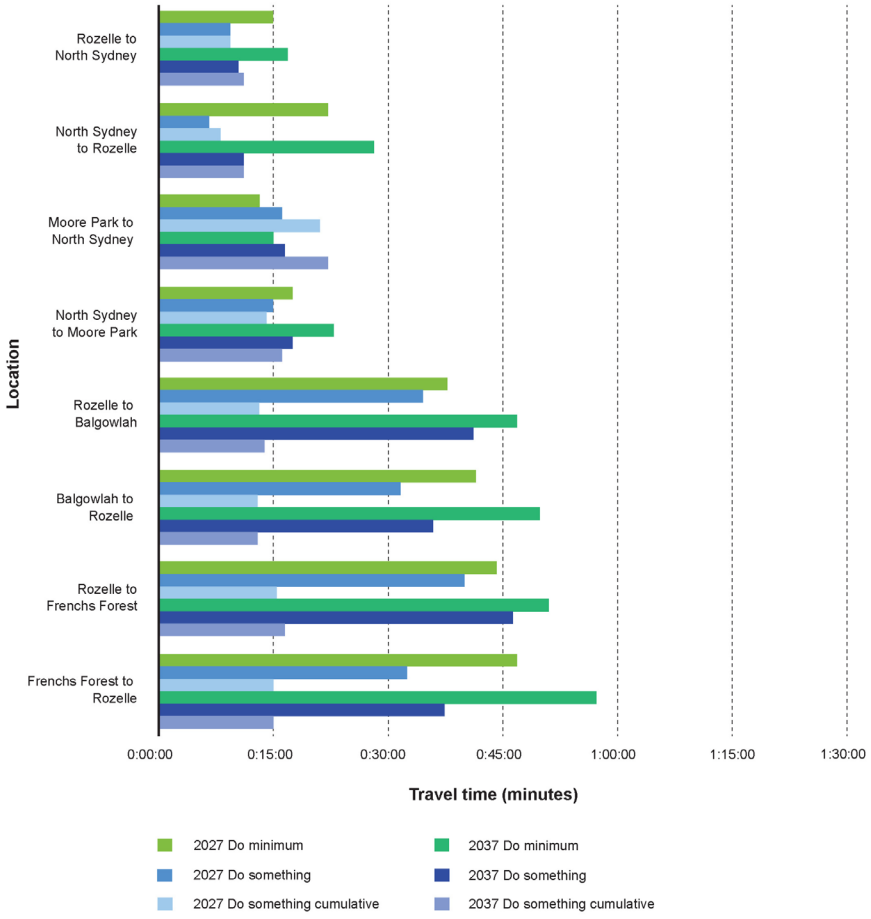


Figure 9-4 Forecast PM peak period (5pm-6pm) travel times along key corridors

Heavy vehicles and freight

Forecast heavy vehicle demands across Sydney Harbour under the 'Do something 2037' scenario shows:

- Peak period heavy vehicle demands across Sydney Harbour would increase by up to 15 per cent
- Daily heavy vehicle demands across Sydney Harbour would increase by 10 per cent

Peak period heavy vehicle demands under this scenario are predicted to decrease on the Sydney Harbour Bridge, Sydney Harbour Tunnel, ANZAC Bridge and Gladesville Bridge, with the largest peak period reduction being on Sydney Harbour Bridge (55 per cent and 28 per cent reductions in morning and evening peak periods respectively). This reflects the substantial travel time savings provided by the project, particularly for northbound trips during the morning peak, when tidal flow traffic conditions on the Sydney Harbour Bridge generally favour southbound trips at the expense of northbound trips.

The project would provide substantial travel time savings for freight vehicles, improving productivity and increasing the efficiency of the freight network, particularly for freight trips that currently use the Sydney Harbour Bridge. The movement of these trips from existing constrained corridors such as the Western Distributor and Bradfield Highway to a new high-standard motorway would also increase the safety of these trips by providing a route that has been specifically designed to meet the requirements of B-Double vehicles. This is consistent with the motorway network strategy established for the WestConnex program, which facilitates a strategic shift of freight movements from surface arterial roads to high-standard motorways. The Western Harbour Tunnel component would extend this concept of operation to the Sydney Harbour crossings and connect with motorway links north of Sydney Harbour.

9.4.2 Rozelle and surrounds

Road network performance

'Do something' scenario

Key outcomes of the road network performance assessment in Rozelle and surrounds, under the 'Do something' scenario include:

- Traffic demand through the Rozelle area is forecast to increase by up to 14 per cent as a result of the project. The project would also result in a greater amount of forecast demand being able to travel during AM and PM peaks
- Average travel speeds through the Rozelle area would improve by up to 60 per cent as a result of the project, despite the increase in demand. This is a result of the large volume of traffic that would be diverted from the ANZAC Bridge and Western Distributor to the Western Harbour Tunnel, substantially reducing delays on this part of the existing motorway network
- The number of stops through the study area would reduce by up to 40 per cent as a result of the reduction in demand and congestion on the ANZAC Bridge and Western Distributor.

Overall, forecast traffic conditions in Rozelle and surrounds would improve substantially as a result of the project due to the reduction in congestion along both ANZAC Bridge and the Western Distributor, with improved travel times and fewer delays.

'Do something cumulative' scenario

Key outcomes of the assessment of the Rozelle and surrounds area under the 'Do something cumulative' scenario (compared with the 'Do something' scenario) include:

- Forecast traffic demand would increase further, by up to eight per cent

- Average travel speeds would remain relatively unaffected in the AM and PM peaks
- The number of stops would not change materially in the AM peak but increase in the PM peak.

The cumulative scenario would result in higher traffic volumes through the Rozelle area when compared to conditions with the project only. In the AM peak, the introduction of Beaches Link and Gore Hill Freeway Connection project would reduce the traffic volumes travelling via Sydney Harbour Tunnel, with this traffic now travelling via the Western Harbour Tunnel instead. During the PM peak, the transfer of vehicles from the Western Distributor and ANZAC Bridge would result in diverted traffic exiting the Western Harbour Tunnel at The Crescent. Traffic demand on the Sydney Harbour Bridge would not change substantially compared with the 'Do something' scenario.

Traffic travel times

'Do something' scenario

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

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

- Travel times along City West Link and Western Distributor would improve substantially as a result of the project in the eastbound direction during the AM peak. This is due to the transfer of traffic from the ANZAC Bridge and Western Distributor to the Western Harbour Tunnel, which would reduce the delays generated by merging and weaving of surface traffic through this section
- Travel times on Victoria Road in the northbound direction during the AM peak are forecast to increase as a result of the project. This could occur due to increased local traffic being able to access the corridor as a result of the reduction in congestion caused by through traffic in the area, following the transfer of through traffic to the Western Harbour Tunnel. Northbound Victoria Road traffic would also merge with traffic from the M4–M5 Link at the Victoria Road off ramp south of Iron Cove Bridge, contributing to the increased travel time
- Travel times on Victoria Road southbound would improve as a result of the project, due to the reduction in downstream congestion along the ANZAC Bridge and Western Distributor.

Overall, the project is expected to generally maintain or improve travel times due to reduced congestion along existing key routes through Rozelle, resulting from substantial changes in traffic patterns with regional trips using Western Harbour Tunnel in preference to ANZAC Bridge and Western Distributor.

'Do something' cumulative scenario

Modelled travel times (Table 9-5) indicate that there would be minimal change in speeds along the main routes of City West Link/Western Distributor and Victoria Road compared with the 'Do something' scenario. This is a result of traffic signals along these routes being optimised to maintain flows along the primary arterial roads.

Table 9-5 Modelled AM peak (8am–9am) and PM peak (5pm–6pm) traffic travel times for key routes through the Rozelle area (minutes:seconds)

Route /Peak period	Direction	'Do minimum 2027'	'Do something 2027'	'Do something cumulative 2027'	'Do minimum 2037'	'Do something 2037'	'Do something cumulative 2037'
City West Link and Western Distributor (Balmain Road to Druitt Street Ramp)							
	Eastbound	21:59	12:03	12:21	21:33	14:28	13:09

Route /Peak period	Direction	'Do minimum 2027'	'Do something 2027'	'Do something cumulative 2027'	'Do minimum 2037'	'Do something 2037'	'Do something cumulative 2037'
AM peak	Westbound	04:59	05:31	04:03	05:29	05:47	05:46
PM peak	Eastbound	05:14	06:28	06:36	05:01	07:06	06:43
	Westbound	06:04	07:06	06:50	06:57	07:29	07:30
Victoria Road (Evans Street to ANZAC Bridge)							
AM peak	Northbound	02:15	07:08	04:32	02:18	07:04	06:27
	Southbound	05:38	01:57	01:49	05:58	01:48	01:44
PM peak	Northbound	02:57	02:54	02:53	03:02	03:02	03:03
	Southbound	02:00	01:59	02:02	02:07	02:07	02:08

Intersection performance

'Do something' scenario

Modelled intersection performance for key intersections in Rozelle and surrounds under the 'Do something' scenario are presented in Table 9-6, and indicate:

- The majority of intersections within the Rozelle area would perform better as a result of the project. This would be due to the substantial traffic that would be diverted from the ANZAC Bridge and Western Distributor into the Western Harbour Tunnel, which would reduce the delays generated by merging and weaving, and in turn reduce queues that would extend back to intersections
- The intersection of The Crescent and City West Link would experience relatively minor increased delays in the PM peak as a result of the project, due to the additional movements introduced by the inclusion of the Western Harbour Tunnel portal at this location
- Queuing at the intersection of City West Link and The Crescent would affect the intersections of City West Link with James Craig Road, Catherine Street and Balmain Road; however, these intersections would still perform acceptably with the project
- The intersection of Victoria Road and Darling Street would continue to perform at capacity resulting in LoS F in the AM peak both with and without the project
- The intersection of Johnston Street and The Crescent would perform substantially better with the project, due to the reduction in surface traffic and queuing in the area as a result of the project
- The intersection of Victoria Road and Robert Street would marginally improve as a result of the project; however, PM peak performance would remain at LoS F with demand exceeding capacity.

‘Do something cumulative’ scenario

Modelled intersection performance under the ‘Do something cumulative’ scenario is presented in Table 9-6. Overall, the operation of intersections in the AM peak would not materially change when compared to the ‘Do something’ scenario.

During the PM peak, the increased traffic volumes exiting the Western Harbour Tunnel at The Crescent would increase demand at intersections along The Crescent and City West Link, many of which would continue to operate at an unsatisfactory level of service. These increased traffic volumes would be managed via changes to intersection traffic signal timings, although some intersections would continue to operate at an unsatisfactory level of service.

Although traffic could be impacted by an increase in localised intersection delays due to increased traffic, compared with the ‘Do something’ scenario, modelling indicates that road users would still generally benefit from improved network capacity and substantial travel time savings on the broader network (via the Western Harbour Tunnel, ANZAC Bridge, and the Sydney Harbour Bridge). Consequently, road users who travel through the Rozelle area would still benefit from the proposed Western Harbour Tunnel and Beaches Link Tunnel program of works due to improved efficiency on the surrounding broader road network.

Table 9-6 Modelled intersection performance on Rozelle 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)
Victoria Road/Darling Street						
AM peak	F (>100)	F (>100)	F (>100)	F (>100)	F (83)	E (65)
PM peak	E (57)	D (50)	D (51)	E (62)	D (54)	E (58)
Victoria Road/Evans Street						
AM peak	C (33)	C (33)	C (33)	C (35)	C (33)	C (32)
PM peak	B (19)	B (19)	B (20)	E (58)	C (32)	D (43)
Victoria Road/Gordon Street						
AM peak	B (27)	B (27)	B (27)	B (27)	B (26)	B (25)
PM peak	B (16)	B (16)	B (16)	D (49)	C (37)	D (49)
Victoria Road/Robert Street						
AM peak	B (23)	B (21)	B (21)	B (27)	C (29)	B (28)
PM peak	B (28)	B (27)	B (28)	F (87)	F (75)	F (91)

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)
Victoria Road/The Crescent						
AM peak	B (28)	B (24)	B (24)	D (55)	C (39)	D (47)
PM peak	B (19)	B (27)	B (28)	C (37)	D (47)	D (49)
The Crescent/James Craig Road						
AM peak	C (29)	A (9)	A (9)	C (36)	B (17)	B 23)
PM peak	A (13)	B (16)	B (16)	B (28)	C (34)	C (42)
The Crescent/City West Link						
AM peak	D (43)	D (46)	D (50)	D (47)	D (46)	D (52)
PM peak	B (22)	C (41)	D (46)	B (22)	C (42)	E (58)
The Crescent/Johnston Street						
AM peak	F (>100)	B (17)	B (17)	F (>100)	B (20)	B (28)
PM peak	D (56)	B (19)	F (>100)	D (56)	B (19)	F (>100)
City West Link/Catherine Street						
AM peak	C (30)	B (25)	B (25)	C (34)	B (24)	C (29)
PM peak	C (33)	C (41)	C (38)	B (24)	D (43)	D (50)
City West Link/Balmain Road						
AM peak	D (55)	D (49)	D (47)	F (79)	D (53)	D (56)
PM peak	C (41)	C (41)	D (46)	D (46)	E (59)	F (80)
City West Link/M5 ramps						
AM peak	C (38)	B (24)	C (31)	D (51)	B (25)	C (35)
PM peak	B (20)	B (28)	C (30)	B (20)	C (30)	D (49)

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

Road network changes and access arrangements

‘Do something’ scenario

Surface road access to the project would be provided from City West Link at its intersection with The Crescent. The connection to The Crescent would be constructed as part of the approved M4–M5 Link project, and the project would carry out the fit out and commissioning of this connection. An underground connection for the project would also be provided to and from the M4–M5 Link (constructed as part of that approved project).

‘Do something cumulative’ scenario

There would be no road network changes within the Rozelle area under the ‘Do something cumulative’ scenario beyond those implemented as part of the approved M4–M5 Link project.

Impacts on public transport

‘Do something’ scenario

Modelled bus travel times for key routes through the Rozelle area during operation indicate:

- During the AM peak, southbound (towards the Sydney CBD) bus travel times would improve with the project due to reduced congestion on the ANZAC Bridge and Western Distributor, which would reduce merging and weaving and reduce queues that would block access to the Druitt Street bus lane
- During the AM peak, counter-peak northbound (away from the Sydney CBD) bus travel times along Victoria Road are forecast to increase as a result of the project. This would be due to increased local traffic being able to access the corridor, joining from side roads and merging with M4–M5 link traffic exiting to Victoria Road south of Iron Cove Bridge. As there is currently no bus lane in the northbound direction until Iron Cove Bridge, general traffic delays would also impact buses
- In the PM peak, bus travel times on Victoria Road would not change substantially as a result of the project.

‘Do something’ cumulative scenario

Modelled bus travel times for key routes through the Rozelle area under the ‘Do something cumulative’ scenario indicate that bus travel times would not change substantially as a result of the introduction of the Beaches Link and Gore Hill Freeway Connection project and other motorway projects, when compared to conditions under the ‘Do something’ scenario only.

Impacts on active transport

‘Do something’ scenario

There would be no direct impacts on the active transport network within Rozelle and surrounds.

‘Do something cumulative’ scenario

There would be no changes to the active transport network within the Rozelle area under the ‘Do something cumulative’ scenario.

9.4.3 Birchgrove to Waverton (Sydney Harbour crossing – maritime traffic)

The project would not result in a reduction in water depth at the proposed harbour crossing, and would therefore have no impact on navigation given the current depth is typically around 15 metres below chart datum at the crossing location.

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

With the reinstatement of access to the Birchgrove ferry wharf, there would be no operational impacts on maritime movements and activities as a result of the project.

9.4.4 Warringah Freeway and surrounds

Road network performance

'Do something' scenario

The assessment of the Warringah Freeway and surrounds area under the 'Do something' scenario indicates:

- Peak traffic demand through the Warringah Freeway and surrounds would increase as a result of the project by 10 per cent in the AM peak and six per cent in the PM peak by 2037
- Average travel speeds through the Warringah Freeway and surrounds would improve as a result of the project. This is due to the transfer of traffic to the Western Harbour Tunnel which would also result in reduced congestion on the Sydney Harbour Bridge and Sydney Harbour Tunnel
- The number of stops would decrease substantially as a result of the project due to the large shift in demand from the Sydney Harbour Bridge and Sydney Harbour Tunnel to the Western Harbour Tunnel, where traffic flows would be largely uninterrupted.

'Do something cumulative' scenario

Key outcomes of the assessment of the Warringah Freeway and surrounds area under the 'Do something cumulative' scenario (compared with the 'Do something' scenario) include:

- AM and PM peak travel demand through the Warringah Freeway and surrounds would increase by up to four per cent
- Average travel speeds through the Warringah Freeway and surrounds would further improve in both the AM and PM peak periods
- The number of stops would be generally unchanged in the AM peak but decrease in the PM peak.

The modelled network performance under the 'Do something cumulative' scenario shows that the introduction of the Beaches Link and Gore Hill Freeway Connection project would not substantially impact overall network performance along the Warringah Freeway and surrounds. Changes to connectivity associated with the Beaches Link and Gore Hill Freeway Connection project would result in the following localised effects:

- *Beaches Link to Western Harbour Tunnel*: The introduction of this connection would reduce traffic volumes through alternative existing corridors including Falcon Street, Ernest Street/Ourimbah Road, Brook Street and Miller Street, which have limited capacity to accommodate forecast future traffic demand. The impact of this change would be greatest in the AM peak when the southbound demand to the Western Harbour Tunnel would be highest

- *Northbound on-ramp from Berry Street to Beaches Link*: This on-ramp would provide an alternative for travel to the Warringah Road or Pittwater Road corridors, which are currently accessible via existing corridors including Falcon Street, Ernest Street, and Brook Street/Willoughby Road
- *Beaches Link southbound off-ramp to Alfred Street North*: This connection would increase traffic exiting at Alfred Street North and utilising the new upgraded intersection of Alfred Street North and High Street, reducing delays at Falcon Street and Miller Street. The impact of this change would be greatest in the AM peak when the southbound demand into North Sydney is highest.

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 9-7.

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

- Travel times for trips travelling along the Warringah Freeway between Gore Hill Freeway and Sydney Harbour Bridge and Sydney Harbour Tunnel are predicted to generally improve due to the reduction in demand for both crossings as a result of the project
- Travel times along Miller Street would experience localised delays in the PM peak of up to four minutes in the northbound direction due to changes in demands and traffic patterns
- Localised southbound travel times to the Sydney Harbour Tunnel from Falcon Street would increase marginally in the AM peak as a result of the project. This is due to changes to the configuration of the Falcon Street on ramp, which would be fed by an additional lane from the Falcon Street interchange with no additional outbound capacity
- Northbound travel times along Warringah Freeway to Falcon Street would generally improve as a result of the project. This is partially due to the increased capacity provided by the reconfiguration of the Falcon Street interchange to a diverging diamond configuration, which would reduce conflicts between traffic exiting the freeway and through-traffic on Falcon Street.

'Do something cumulative' scenario

Analysis of modelled travel times under the 'Do something cumulative' scenario (Table 9-7) indicates improved travel times along the Warringah Freeway due to the transfer of traffic from alternative routes, reducing congestion along the Warringah Freeway and its approaches. However, this would be accompanied by localised increases in travel times for some routes during the busiest peak periods as follows:

- Travel times for AM peak trips travelling along the Warringah Freeway between Gore Hill Freeway and the Sydney Harbour crossings are forecast to marginally increase in the southbound direction in some instances when compared with the 'Do something' scenario. This is due to the increase in peak direction demand for these crossings, with a greater demand for traffic travelling to the corridor from the Beaches Link Tunnel. Travel times would however be substantially lower than under the 'Do minimum' scenario
- Travel times along Miller Street would increase in the southbound direction in the AM Peak when compared with the 'Do something' scenario as a result of downstream changes to traffic demands around North Sydney (eg Pacific Highway and Berry Street) following the introduction of the Beaches Link.

Table 9-7 Modelled AM peak (8am–9am) and PM peak (5pm–6pm) traffic travel times for key routes through the Warringah Freeway and surrounds (minutes:seconds)

Route /Peak period	Direction	'Do minimum 2027'	'Do something 2017'	'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	03:39	03:33	04:51	03:31	04:12
	Southbound	04:03	04:09	04:07	04:02	04:07	04:06
PM peak	Northbound	04:02	03:23	03:25	07:51	04:12	03:28
	Southbound	06:09	04:35	04:37	05:02	04:33	04:33
Sydney Harbour Tunnel to Warringah Freeway/Falcon Street interchange							
AM peak	Northbound	03:55	03:43	03:31	04:08	03:28	04:27
	Southbound	04:03	04:33	04:27	04:02	04:22	04:26
PM peak	Northbound	03:57	06:43	03:24	07:36	03:52	03:31
	Southbound	14:54	05:28	05:28	14:59	05:37	05:35
Sydney Harbour Bridge to Gore Hill Freeway/Pacific Highway interchange							
AM peak	Northbound	06:13	05:27	05:26	06:16	05:26	05:29
	Southbound	13:35	06:59	08:02	15:22	07:36	07:54
PM peak	Northbound	05:35	05:20	05:21	06:45	05:22	05:24
	Southbound	13:56	06:08	06:10	17:31	06:07	06:10
Sydney Harbour Tunnel to Gore Hill Freeway/Pacific Highway interchange							
AM peak	Northbound	05:26	05:22	05:18	05:30	05:23	05:23
	Southbound	11:39	07:19	07:59	12:37	07:52	08:08
PM peak	Northbound	05:28	08:37	05:12	06:46	05:13	05:14
	Southbound	25:21	07:00	07:00	30:09	07:11	07:07
Berry Street to Amherst Street via Miller Street							
AM peak	Northbound	03:42	04:10	04:06	03:53	04:12	04:03
	Southbound	04:25	04:16	06:01	05:43	06:10	07:01

Route /Peak period	Direction	'Do minimum 2027'	'Do something 2017'	'Do something cumulative 2027'	'Do minimum 2037'	'Do something 2037'	'Do something cumulative 2037'
PM peak	Northbound	03:52	04:54	04:46	03:50	08:03	05:14
	Southbound	05:01	05:00	04:35	08:39	06:13	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 9-8 and indicates:

- The proposed phasing and access changes around the intersection of Miller Street and Berry Street would simplify the operation and increase the capacity of these roads to offset potential travel delays along these roads during the AM peak. During the PM peak, intersection performance would be poor under both the 'Do minimum' and ''Do something' scenarios at the Miller Street and Berry Street intersection
- Intersection performance along Brook Street in the vicinity of the Warringah Freeway would improve substantially during the AM peak as a result of the project. This would be due to reduced queuing and congestion on the Warringah Freeway, as well as the changes in access to Brook Street from the Warringah Freeway, which under the project would be limited to trips from the Sydney Harbour Bridge and Berry Street
- Intersections along the Pacific Highway would generally operate with higher delays as a result of the project. Due to the proposed removal of the right turn from Miller Street northbound into Berry Street eastbound, traffic would divert to turn right into Berry Street from the Pacific Highway, increasing delays at this intersection. The removal of a left turn lane from the Pacific Highway southbound into Berry Street would also result in increased delays on the northern approach of the Pacific Highway, which would extend past Bay Road in the AM peak
- The intersection of Ben Boyd Road and Military Road would operate with higher delays as a result of the project due to changes to access and travel patterns at the Ernest Street and Falcon Street interchanges.

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

The works in the area proposed by the project seek to maintain an appropriate level of traffic movement 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 the most equitable outcomes from the perspective of maintaining a balanced and integrated transport network through North Sydney.

Further refinements and changes to intersections with the North Sydney CBD may occur as part of the ongoing development of the North Sydney Program (see Section 9.1.1 for more information).

‘Do something’ cumulative scenario

Intersection performance in North Sydney under the ‘Do something cumulative’ scenario would be generally consistent with the ‘Do something’ scenario, albeit with increased localised demand and delays on routes that provide access to and from Beaches Link. Modelled intersection performance in the Warringah Freeway and surrounds area under the ‘Do something cumulative’ scenario is presented in Table 9-8 and indicates that some intersections would experience increased delays in some instances.

Although some traffic would be impacted by an increase in localised intersection delays, road users would still generally benefit from substantial travel time savings on the broader network (eg via Beaches Link, 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 net benefit due to the broader connectivity and efficiency improvements.

Table 9-8 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)	A (8)	A (9)	F (>100)	A (9)	A (10)
PM peak	C (38)	A (10)	A (11)	F (76)	A (9)	A (11)
Brook Street/Warringah Freeway on ramp						
AM peak	F (>100)	A (7)	A (8)	F (>100)	E (58)	E (64)
PM peak	B (14)	B (23)	A (<5)	B (17)	D (42)	B (25)
Brook Street/Warringah Freeway off ramp						
AM peak	E (61)	A (10)	A (9)	E (67)	D (49)	B (16)
PM peak	B (22)	B (18)	B (17)	B (20)	D (48)	C (29)
Brook Street/Merrenburn Avenue						
AM peak	F (>100)	B (28)	B (26)	F (>100)	D (44)	D (50)
PM peak	A (11)	D (45)	B (17)	A (13)	D (46)	C (39)
Amherst Street/West Street						
AM peak	A (5)	A (9)	D (50)	A (5)	F (>100)	F (>100)
PM peak	A (9)	F (75)	D (43)	A (14)	F (87)	F (73)

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/Miller Street						
AM peak	B (21)	C (38)	C (42)	B (20)	D (50)	D (44)
PM peak	C (29)	E (59)	D (43)	C (31)	E (63)	D (48)
Miller Street/Warringah Freeway on ramp						
AM peak	A (7)	A (6)	A (<5)	A (6)	A (9)	A (5)
PM peak	A (6)	A (7)	A (6)	A (6)	A (6)	A (7)
Miller Street/Warringah Freeway off ramp						
AM peak	A (12)	A (10)	A (8)	A (13)	A (10)	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)	D (44)	C (41)
PM peak	C (41)	C (42)	C (34)	D (43)	E (57)	C (39)
Miller Street/Falcon Street						
AM peak	C (35)	B (27)	C (30)	C (38)	C (41)	D (44)
PM peak	D (44)	E (65)	C (38)	D (49)	F (79)	D (48)
Ernest Street/Warringah Freeway on ramp						
AM peak	A (5)	B (19)	C (29)	A (5)	B (21)	C (36)
PM peak	B (15)	B (14)	A (13)	B (15)	A (14)	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)	B (21)	C (34)
PM peak	B (17)	B (23)	A (14)	B (17)	B (18)	B (15)
Falcon Street/Warringah Freeway ramps						
AM peak	C (29)	C (31)	C (42)	B (15)	D (47)	D (51)

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)
PM peak	F (72)	F (79)	D (52)	F (>100)	F (89)	E (60)
Watson Street/Military Road						
AM peak	B (18)	B (27)	C (28)	B (26)	C (36)	C (30)
PM peak	D (46)	C (31)	C (37)	E (59)	C (40)	C (38)
Military Road/Ben Boyd Road						
AM peak	B (15)	E (64)	D (47)	B (23)	F (71)	D (43)
PM peak	D (54)	F (80)	D (55)	E (70)	F (86)	F (83)
Falcon Street/Merlin Street						
AM peak	B (24)	C (35)	C (39)	C (32)	F (81)	D (54)
PM peak	F (>100)	F (>100)	F (83)	F (>100)	F (>100)	F (88)
Berry Street/Walker Street						
AM peak	C (29)	D (48)	C (41)	C (39)	D (55)	D (50)
PM peak	D (44)	F (75)	E (69)	F (73)	F (76)	F (74)
Berry Street/Miller Street						
AM peak	D (55)	D (53)	E (58)	E (69)	D (55)	E (57)
PM peak	D (46)	D (56)	D (54)	F (70)	F (>100)	E (63)
Mount Street/Arthur Street						
AM peak	D (46)	B (27)	B (18)	E (59)	C (33)	C (33)
PM peak	D (49)	C (34)	B (21)	F (92)	E (63)	F (>100)
Mount Street/Walker Street						
AM peak	C (36)	C (35)	C (35)	D (48)	D (46)	D (43)
PM peak	C (32)	F (93)	F (78)	F (75)	F (>100)	F (96)

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/High Street/Arthur Street						
AM peak	B (19)	B (23)	B (18)	C (38)	B (25)	B (19)
PM peak	D (46)	B (16)	B (16)	E (61)	B (23)	B (21)
Pacific Highway/Walker Street/Blue Street						
AM peak	C (36)	C (38)	C (33)	E (65)	C (33)	C (32)
PM peak	D (40)	F (71)	D (54)	F (80)	F (70)	E (60)
Pacific Highway/Miller Street/Mount Street						
AM peak	C (38)	E (63)	E (62)	C (41)	E (65)	E (62)
PM peak	C (41)	E (63)	D (50)	E (58)	F (>100)	E (66)
Pacific Highway/Berry Street						
AM peak	E (56)	C (35)	E (60)	D (52)	E (61)	E (60)
PM peak	B (23)	F (97)	F (85)	E (56)	F (>100)	F (87)
Pacific Highway/Bay Road						
AM peak	D (55)	B (22)	D (42)	F (77)	F (89)	F (88)
PM peak	B (15)	D (50)	B (27)	C (41)	F (96)	C (33)
Miller Street/McLaren Street						
AM peak	B (23)	C (41)	E (56)	F (72)	D (50)	E (62)
PM peak	B (21)	C (41)	C (37)	D (55)	F (76)	D (50)
Miller Street/Ridge Street						
AM peak	C (38)	D (45)	E (63)	D (53)	E (66)	E (70)
PM peak	C (40)	B (18)	B (21)	F (91)	C (38)	C (39)
Miller Street/Carlow Street						
AM peak	A (13)	A (9)	B (15)	A (13)	B (24)	C (28)

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)
PM peak	A (8)	A (7)	A (7)	B (19)	A (7)	A (7)
High Street/Clark Road						
AM peak	B (18)	C (32)	C (36)	D (55)	E (59)	C (38)
PM peak	E (61)	F (94)	D (56)	F (97)	F (82)	E (65)
High Street/Alfred Street						
AM peak	A (13)	B (18)	B (19)	E (62)	B (21)	B (18)
PM peak	F (>100)	E (58)	C (42)	F (>100)	D (53)	D (46)
Mount Street/Alfred Street						
AM peak	A (<5)	A (12)	B (14)	A (<5)	A (13)	A (14)
PM peak	A (12)	A (12)	A (12)	A (10)	A (11)	A (13)
Ernest Street/Ben Boyd Road						
AM peak	A (12)	B (17)	B (18)	A (12)	C (29)	B (26)
PM peak	D (44)	B (14)	A (10)	F (94)	D (46)	D (46)
Pedestrian crossing at Military Road						
AM peak	A (6)	A (6)	A (5)	A (5)	A (8)	A (6)
PM peak	B (27)	A (5)	A (<5)	C (34)	A (<5)	A (5)

Note: Cells shaded in 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 North Sydney via an on ramp from Berry Street for vehicles travelling southbound and an off ramp to Falcon Street (westbound only) for vehicles travelling northbound. In addition, the tunnel would connect to the Warringah Freeway at Cammeray.

The Warringah Freeway Upgrade component of the project is proposed to substantially improve the efficiency of the motorway and arterial road interfaces. The Warringah Freeway Upgrade component would involve extensive upgrades to surface roads and existing connections (refer to Chapter 5 (Project description)) that would:

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

The upgraded Warringah Freeway would simplify traffic flow and improve wayfinding by providing the following traffic lanes:

- A northbound outer carriageway which would comprise:
  - An outer western carriageway carrying northbound traffic from the Sydney Harbour Bridge to the proposed 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 the 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 which would comprise:
  - Inner eastern carriageways carrying southbound traffic to the Sydney Harbour Tunnel and facilitating distribution to local destinations such as Neutral Bay
  - An outer eastern carriageway carrying southbound traffic to the Sydney Harbour Bridge (both the Bradfield Highway and Cahill Expressway) and facilitating distribution to local destinations such as North Sydney and Kirribilli
  - A dedicated bus lane between Miller Street, Cammeray and the Sydney Harbour Bridge, which would carry southbound buses and other permitted bus lane vehicles.

Following the upgrade, connections between the upgraded Warringah Freeway and arterial road network would be provided at all existing interchange locations. However, changes to existing Warringah Freeway accesses as a result of the project 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 northbound and Falcon Street westbound. Adjacent interchanges north and south of Falcon Street would provide similar alternative connectivity
- Existing connectivity between the Sydney Harbour Tunnel in the northbound direction and Falcon Street (in the westbound direction only), and Miller Street and Brook Street would be removed. Alternative connectivity would be retained by providing a new northbound access between Sydney Harbour Tunnel and Ernest Street or Sydney Harbour Bridge/Cahill Expressway and Miller Street/Brook Street
- There would be no access from the Berry Street northbound on ramp to the Falcon Street eastbound off ramp (in addition to the Falcon Street westbound off ramp identified above) nor to the Warringah Freeway mainline. Connections to the Western Harbour Tunnel and the Miller Street and Brook Street off ramps only would be provided from the Berry Street northbound on ramp. Traffic would be required to travel via the North Sydney local road network to access the new High Street northbound on ramp, Falcon Street eastbound, or the Warringah Freeway via the Falcon Street interchange
- Access from the Falcon Street southbound on ramp to the Cahill Expressway would be removed. Access would be maintained from the Falcon Street southbound on ramp to the Sydney Harbour Bridge (Bradfield Highway) and the Sydney Harbour Tunnel, providing connectivity to the Sydney CBD and Western Suburbs, and the Eastern Suburbs, respectively
- Access between the ramps at Falcon Street and Brook Street via the Warringah Freeway would be removed. Traffic would be required to travel via the local road network to travel between these locations

- Access would be removed from the Alfred Street North southbound off ramp to Alfred Street North in the northbound direction. Traffic would be required to exit the Warringah Freeway at Falcon Street or continue onto High Street and travel via the local road network to access Alfred Street North.

'Do something cumulative' scenario

In the 'Do something cumulative' scenario, the Beaches Link and Gore Hill Freeway Connection project would connect to the Warringah Freeway at Cammeray, north of the Ernest Street Bridge. These connections would include the following:

- On and off ramps providing direct connection between the Warringah Freeway and the Beaches Link and Gore Hill Freeway Connection project
- A northbound on ramp from Berry Street to the Beaches Link and Gore Hill Freeway Connection project, providing access from North Sydney
- A southbound off ramp onto Alfred Street North from the Beaches Link and Gore Hill Freeway Connection project, providing access to North Sydney.

Impacts on public transport

'Do something' scenario

In the 'Do something' scenario, the project would provide a dedicated southbound bus lane on the Warringah Freeway between Miller Street and the Sydney Harbour Bridge, with upgraded 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, improving southbound bus operations.

Bus lanes at the Falcon Street interchange would be maintained as part of 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 project, however bus services would have the ability to access North Sydney via High Street.

The project would also relocate existing bus layover facilities on the Warringah Freeway north of Ernest Street to 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.

Modelled bus travel times for key routes through the Warringah Freeway and surrounds area during operation indicates the following:

- Travel times for buses from Gore Hill Freeway to the Sydney Harbour Bridge would improve substantially, particularly southbound during AM and PM peak periods due to the reconfiguration of the southbound bus lane between Miller Street and the Cahill Expressway, which has been separated from the general traffic lanes, 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 travelling to and from Falcon Street would improve as a result of the reconfiguration of the southbound bus lane, which removes the existing conflict with general traffic, and also as a result of the reduction in traffic demand to the Willoughby Road and Falcon Street ramps, which would otherwise block access to the northbound bus off ramp to Falcon Street
- Travel times on bus routes through North Sydney via Miller Street would generally be maintained, although some localised delays could occur during the busiest peak periods

- Travel times on bus routes through North Sydney from Pacific Highway would increase during peak periods. This is due to the increase in demand and congestion between Berry Street and Miller Street as a result of redirecting traffic from Miller Street (resulting from the removal of the existing right turn from Miller Street northbound to Berry Street eastbound).

'Do something cumulative' scenario

Under the 'Do something cumulative' scenario, the modelled bus travel times in the Warringah Freeway and surrounds area indicates the following (when compared with the 'Do something' scenario):

- Bus travel times through North Sydney and along the Warringah Freeway would not materially change as a result of the Beaches Link and Gore Hill Freeway Connection project
- Bus travel times for trips travelling between Warringah Freeway and Military Road would remain largely unchanged. The introduction of the Beaches Link and Gore Hill Freeway Connection project would not substantially change traffic conditions for these routes, which would retain the same level of priority.

Impacts on active transport

'Do something' scenario

Under the 'Do something' scenario, the following changes to the active transport network within the Warringah Freeway and surrounds area would be carried out as part of the project and are anticipated to result in improved active transport links:

- A new shared user path would be provided on the southern side of High Street bridge with signalised pedestrian crossings at the upgraded 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; this 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 pedestrian and cyclist bridge with a new structure
- Consolidating pedestrian crossings into a central median shared user path at the Falcon Street interchange as part of the diverging diamond configuration
- 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 Ernest 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

All changes to the active transport network would remain the same as the 'Do something' scenario.

9.4.5 Gore Hill Freeway and Artarmon

Road network performance

'Do something' scenario

Key outcomes of the assessment of 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 is forecast to increase in the AM peak by up to three per cent as a result of the project and remain generally unchanged in the PM peak by 2037
- Average travel speeds through the Gore Hill Freeway and Artarmon area would decrease in the 2037 AM and PM peaks as a result of the project. The AM peak average trip speed would decrease by around nine km/h to 30 km/h and the PM peak would decrease by around five km/h to 38 km/h. This would be as a result of the potential growth in traffic demand from the Pacific Highway to the Gore Hill Freeway and Warringah Freeway
- The capacity restriction of the Pacific Highway eastbound on-ramp to Gore Hill Freeway would result in increased queuing on the Pacific Highway if the increase in demand is realised.

Network performance measures for the Gore Hill Freeway and Artarmon area indicate that future demand from the Pacific Highway to Gore Hill Freeway eastbound would continue to exceed the capacity of this on ramp during peak periods, and that the inclusion of the project could further increase demands along the corridor under the 'Do something' scenario.

The traffic assessment carried out for the project assumes that all forecast traffic demand would be able to arrive at the desired time and location in the road network defined by the operational road traffic model. In other words, this demand would not be restricted by the existing capacity constraints of the broader metropolitan road network to reach the road networks represented by the operational traffic models.

However, it is recognised that in reality the growth in traffic demand along the Gore Hill Freeway corridor is constrained at either end at the Lane Cove Tunnel and the Warringah Freeway. These constraints would make realisation of the forecast demand used in modelling unlikely and the throughput would be expected to be lower than the forecast demand, leading to network performance under the project being more likely to be closer to the 'Do minimum' performance than the operational modelling would suggest. Although the forecast level of demand growth in the Gore Hill Freeway corridor is considered unlikely to be realised during peak periods without increases to broader metropolitan network capacity, it is reflected in the assessment results to represent a conservative scenario.

Road integration works associated with the Beaches Link and Gore Hill Freeway Connection could facilitate additional traffic travelling through the corridor at a generally similar or reduced level of delay than under the 'Do minimum' scenario. These works could be brought forward and carried out as part of the project scope to improve traffic conditions under the 'Do something' scenario. Consequently, a network condition monitoring approach would be carried out for this area to determine if and when the road network integration works proposed by the Beaches Link and Gore Hill Freeway Connection project should be delivered by Transport for NSW to maintain efficient road network operations in this area. Although considered unlikely, if the project did materially impact performance in this area during peak periods the conversion of existing T2 lanes to general traffic lanes along Gore Hill Freeway could be implemented over a short duration, supporting the proposed network condition monitoring approach.

'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 Gore Hill Freeway and Artarmon area would increase by up to 12 per cent by 2037 due to the additional connectivity provided by the Beaches Link tunnel
- The average travel speeds through the Gore Hill Freeway and Artarmon area during AM and PM peaks would improve by up to 56 per cent. This is a result of converting the eastbound transit lane on Gore Hill Freeway to a general traffic lane to improve utilisation. This has the greatest benefit in the AM peak when eastbound traffic demand would be highest
- Localised delays in the Artarmon area would increase, as the increased traffic volumes along the Gore Hill Freeway would require traffic signals at critical locations such as Longueville Road/Epping Road or Longueville Road/Pacific Highway to be optimised to manage throughput from the motorway, which would result in increased queues on lower order roads during peak periods.

Overall the results indicate that integration works associated with the Beaches Link Tunnel and Gore Hill Freeway connection project would facilitate additional traffic travelling through the corridor at a reduced level of delay than under the 'Do something' scenario.

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 9-9.

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

- Eastbound travel times from the Lane Cove Tunnel and Longueville Road to Gore Hill Freeway would increase with the project during the AM peak due to the increased traffic volumes from both Longueville Road and the Pacific Highway to the Gore Hill Freeway. The existing lane arrangements from Longueville Road to Gore Hill Freeway currently force a diverge for eastbound traffic west of the Lane Cove Tunnel, with transit lane traffic diverging left and general traffic diverging right. This general traffic lane merges with general traffic from Pacific Highway further east, where the combined demand would exceed the capacity of this single lane
- PM peak eastbound travel times from Longueville Road to Gore Hill Freeway would increase slightly, although not to the extent of the AM peak
- Travel times for other trips along the Gore Hill Freeway would remain largely unchanged as a result of the project.

Reallocating the existing eastbound capacity at critical network locations by removing the transit lane, would allow excess traffic to rebalance across both lanes from Longueville Road and reduce the forecast delays. In addition, although eastbound traffic would be impacted by a localised increase in travel times approaching Gore Hill Freeway, modelling of the Warringah Freeway indicates that this traffic would generally benefit from substantial travel time savings on the Warringah Freeway and Sydney Harbour crossings. Consequently, traffic impacted on the Gore Hill Freeway is still anticipated to receive a net benefit due to downstream efficiency improvements delivered by the project.

'Do something cumulative' scenario

Analysis of the modelled travel times under the 'Do something cumulative' scenario shows:

- Eastbound general travel times would improve when compared to the 'Do something' scenario as a result of the removal of the transit lane from Lane Cove Tunnel and Longueville Road to Gore Hill Freeway. This would enable the improved utilisation of existing road space, benefitting all road users in the area

- Westbound general traffic travel times would remain largely unchanged under the 'Do something cumulative' scenario when compared to the 'Do something' scenario. The additional demand associated with the introduction of the Beaches Link Tunnel would not substantially change general traffic performance in the Gore Hill Freeway corridor.

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

Route/ Peak period	Direction	'Do minimum 2027'	'Do something 2027'	'Do something cumulative 2027'	'Do minimum 2027'	'Do something 2037'	'Do something cumulative 2037'
Longueville Road to Gore Hill Freeway							
AM peak	Eastbound	01:28	06:24	01:29	01:24	05:33	01:29
	Westbound	01:24	01:26	01:23	01:28	01:28	01:23
PM peak	Eastbound	01:26	01:28	01:26	01:25	02:02	01:27
	Westbound	01:23	01:24	01:23	01:23	01:46	02:02
Lane Cove Tunnel to Gore Hill Freeway							
AM peak	Eastbound	01:18	04:42	01:16	01:24	05:55	01:17
	Westbound	01:17	01:18	01:18	02:16	01:18	01:18
PM peak	Eastbound	01:22	01:23	01:16	01:23	01:25	01:18
	Westbound	01:12	01:13	01:17	01:12	01:15	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 9-10, and indicates:

- The Longueville Road and Epping Road intersection would operate at capacity during AM and PM peaks with signal phasing and timing that would maximise traffic throughput from the motorway and ensure that queues from this location would not substantially impact operation of the Gore Hill Freeway. This would result in delays through this intersection
- The intersection of Longueville Road and Pacific Highway would continue to operate at a poor level of service in the PM peak when compared with the 'Do minimum' scenario due to the impact of queues approaching Epping Road on the short weave from Pacific Highway to Longueville Road for trips turning right into Parklands Avenue. The difficulty of this movement during AM and PM peaks is likely to result in some of these trips taking alternative routes, for example via Burley Street or Norton Lane. Diversion to alternative routes would result in delays on Longueville Road being lower than indicated by traffic modelling
- Modification of the phase arrangements at the Reserve Road interchange would reduce delays at this intersection and improve the operation of adjacent intersections, particularly at the Reserve Road/Barton Road intersection during the AM peak.

The project would facilitate additional travel through the Gore Hill Freeway and Artarmon area without substantially increasing delays at most of the critical intersections. The one exception is the intersection of Epping Road and Longueville Road, where existing constraints do not allow any scope for intersection optimisation.

'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 9-10, and indicates:

- Localised delays at the intersection of Longueville Road/Epping Road would increase when compared with the 'Do something' scenario, due to the increase in traffic through this intersection from the Beaches Link and Gore Hill Freeway Connection project, with the intersection continuing to operate beyond its capacity. The operation of this intersection would be optimised to manage traffic volumes from the motorway and ensure that queues from this location would not impact the operation of the Gore Hill Freeway
- The intersection of Longueville Road/Pacific Highway would continue to operate at a poor level of service in the PM peak by 2037, with average delays increasing by 10 seconds when compared with the 'Do something' scenario
- The Reserve Road interchange would operate with comparable delays to the 'Do something' scenario with off ramp delays managed during peak periods to ensure the efficient operation of the Gore Hill Freeway under the increased traffic demand of the cumulative scenario. This would increase localised delays at adjacent intersections along Reserve Road, with Dickson Road and Barton Road continuing to operate at an unsatisfactory LoS F during the PM peak.

Overall, intersection performance modelling under the cumulative scenario for the Gore Hill Freeway and Artarmon area shows that increased traffic demand through the area would result in some increased localised delays at intersections in the area.

Although traffic may be impacted by an increase in localised intersection delays, broader modelling indicates that road users would benefit from substantial travel time savings on the broader network (eg via Beaches Link and Gore Hill Freeway Connection project and improved efficiency of the Warringah Freeway and beyond).

Table 9-10 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)	D (51)	F (75)	F (83)	E (63)	F (77)
PM peak	F (80)	F (72)	F (81)	F (87)	F (97)	F (>100)
Longueville Road/Pacific Highway						
AM peak	C (40)	C (39)	C (39)	D (54)	D (45)	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)
PM peak	C (42)	C (37)	D (45)	D (49)	F (76)	F (86)
Pacific Highway/Howarth Road/Norton Lane						
AM peak	B (20)	B (25)	A (10)	B (28)	B (27)	A (11)
PM peak	A (13)	B (16)	A (11)	A (13)	B (24)	A (13)
Pacific Highway/Gore Hill Freeway interchange						
AM peak	B (29)	C (40)	B (25)	C (41)	C (39)	B (25)
PM peak	C (29)	B (22)	B (29)	B (23)	B (27)	B (29)
Reserve Road/Gore Hill Freeway interchange						
AM peak	E (61)	C (43)	D (52)	D (47)	D (53)	E (60)
PM peak	D (55)	C (30)	D (48)	E (57)	D (53)	D (51)
Reserve Road/Dickson Road						
AM peak	A (14)	B (17)	B (24)	B (19)	B (19)	B (27)
PM peak	F (73)	B (21)	F (87)	F (85)	C (39)	F (95)
Reserve Road/Barton Road						
AM peak	E (69)	A (10)	F (77)	F (>100)	F (>100)	F (85)
PM peak	D (49)	A (7)	F (>100)	E (66)	F (>100)	F (>100)

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

Road network changes and access arrangements

Do something scenario

The Reserve Road interchange traffic signal phasing would require minor modifications to reduce queues and delays at this intersection and to improve operation of adjacent intersections.

'Do something cumulative scenario

Under the 'Do something cumulative' scenario, with the addition of the Beaches Link and Gore Hill Freeway Connection project, the following road network connections would be in operation:

- Eastbound on ramps to the Beaches Link and Gore Hill Freeway Connection project from Epping Road/Lane Cove Tunnel and Reserve Road, providing access from Artarmon and beyond
- Westbound off ramps from the Beaches Link and Gore Hill Freeway Connection project onto Reserve Road and Lane Cove Tunnel providing access to Artarmon and beyond.

Local road changes as part of the Beaches Link and Gore Hill Freeway Connection project would include:

- 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 Beaches Link 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 Beaches Link westbound off ramp
- 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 required to use Punch Street and Herbert Street, which would not substantially increase travel time as the additional travel distance would only be up to 480 metres
- Signalisation of the Pacific Highway/Dickson Avenue intersection to increase safety and connectivity.

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

About 10 on-street parking spaces for cars and six on-street parking spaces for motorcycles would be removed at the Pacific Highway/Dickson Avenue intersection. Beaches Link operational facilities including the Motorway Control Centre would provide sufficient off-street parking and would therefore avoid creating any additional on-street parking demand. Therefore, impacts on parking would not worsen once Beaches Link is operational.

Impacts on public transport

Modelled bus travel times indicate that the removal of the existing transit lanes (proposed as part of the Beaches Link and Gore Hill Freeway Connection project) would not be expected to result in a material increase in bus travel times. Overall, there would be no substantial change in bus travel times along key routes through the Gore Hill Freeway and Artarmon area under either the 'Do something' or 'Do something cumulative' scenarios.

A southbound bus stop on Pacific Highway would be permanently relocated once the Pacific Highway/Dickson Avenue is signalised (proposed as part of the Beaches Link and Gore Hill Freeway Connection project). The bus stop would be relocated within 50 metres of its existing location so only minor impacts are anticipated given the minor increase in travel distance.

Impacts on active transport

'Do something' scenario

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

‘Do something cumulative’ scenario

As part of the Beaches Link and Gore Hill Freeway Connection project, a shared user path would be provided on the southern side of the Gore Hill Freeway between the North Shore Rail Line and Reserve Road, replacing and connecting to the existing path. Pedestrian fencing would also be installed along the northern side of the shared user path, thus improving the safety and quality of the active transport network.

9.5 Environmental management measures

Environmental management measures relating to operational traffic and transport impacts are outlined in Table 9-11.

Table 9-11 Environmental management measures for operational traffic and transport impacts

Ref	Phase	Impact	Environmental management measure	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 this assessment.	WHT/WFU
OT2	Operation	Operational traffic	Conversion of transit lanes to regular traffic lanes along Gore Hill Freeway will be considered if there is a traffic performance requirement/benefit in peak times.	WFU

WHT = Western Harbour Tunnel, WFU = Warringah Freeway Upgrade

Chapter 10

Construction noise and vibration

January 2020

10 Construction noise and vibration

This chapter considers the potential noise and vibration impacts associated with construction of the project. 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.

The proposed environmental management measures relevant to construction noise and vibration are included in Section 10.9.

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**. 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: 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 noise and vibration impacts apart thereof are outlined in **Section 10.6** and **Section 10.7**, 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 noise and vibration impacts are described in **Section 10.6** and **Section 10.7** however further detail is provided within **Appendix G** (Technical working paper: Noise and vibration). Environmental management measures related to construction fatigue are outlined in **Section 10.9**. Construction fatigue is also discussed in **Chapter**

Secretary's requirement	Where addressed in EIS
	27 (Cumulative impacts).
c. the identification of receivers, existing and likely, during the construction period;	**Section 10.5**, **Section 10.6**, **Section 10.7** and **Section 10.8** outline the identification of receivers, both existing and likely, in respect to the various elements of the project during the construction period.
d. the nature, sensitivity and impact to receivers;	**Section 10.5**, **Section 10.6**, **Section 10.7** and **Section 10.8** present information on the nature, sensitivity and impact on receivers.
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 in **Section 10.6** and **Section 10.7** 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 (DECC, 2009);	**Section 10.6**, and **Section 10.7** 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**, and **Section 10.7** 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). **Chapter 27** (Cumulative impacts) assesses the cumulative construction noise and vibration impacts generated by major projects, including the Beaches Link and Gore Hill Freeway Connection project.
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**, and **Section 10.7** 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. **Chapter 27** (Cumulative impacts) assesses the cumulative construction noise and other relevant developments in the vicinity of the proposal.

Secretary's requirement	Where addressed in EIS
i. details and analysis of the effectiveness of mitigation measures to adequately manage identified impacts, including cumulative impacts as identified in (g) and (h) and a clear identification of residual noise and vibration following application of mitigation measures; and	**Section 10.9** and **Appendix G** (Technical working paper: Noise and vibration) present details and analysis of the effectiveness of mitigation measures (as outlined in **Section 10.9**) to adequately manage identified impacts, including cumulative impacts, and a clear identification of residual noise and vibration following the application of such measures. **Chapter 27** (Cumulative impacts) details the environmental management measures relating to cumulative impacts.
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 will 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.	**Sections 10.4** and **Section 10.6** outline how blast impacts are capable of complying with respect to relevant guidelines.
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** and **Section 10.7** 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. **Chapter 11** (Operational noise and vibration) presents information with respect to the operational phase. **Chapter 14** (Non-Aboriginal heritage) presents an assessment of impacts to items of significance as a result of vibration. **Chapter 15** (Aboriginal 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 10.4** and **Section 10.6** outlines how blast impacts are capable of complying with respect to relevant guidelines.

10.1 Acoustic terminology

Common acoustic terms used throughout this chapter 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: • The specific characteristics of the noise (eg frequency, intensity, duration of the noise event) • Time of day noise events occur • Individual sensitivities and lifestyle • Reaction to an unfamiliar sound • 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.

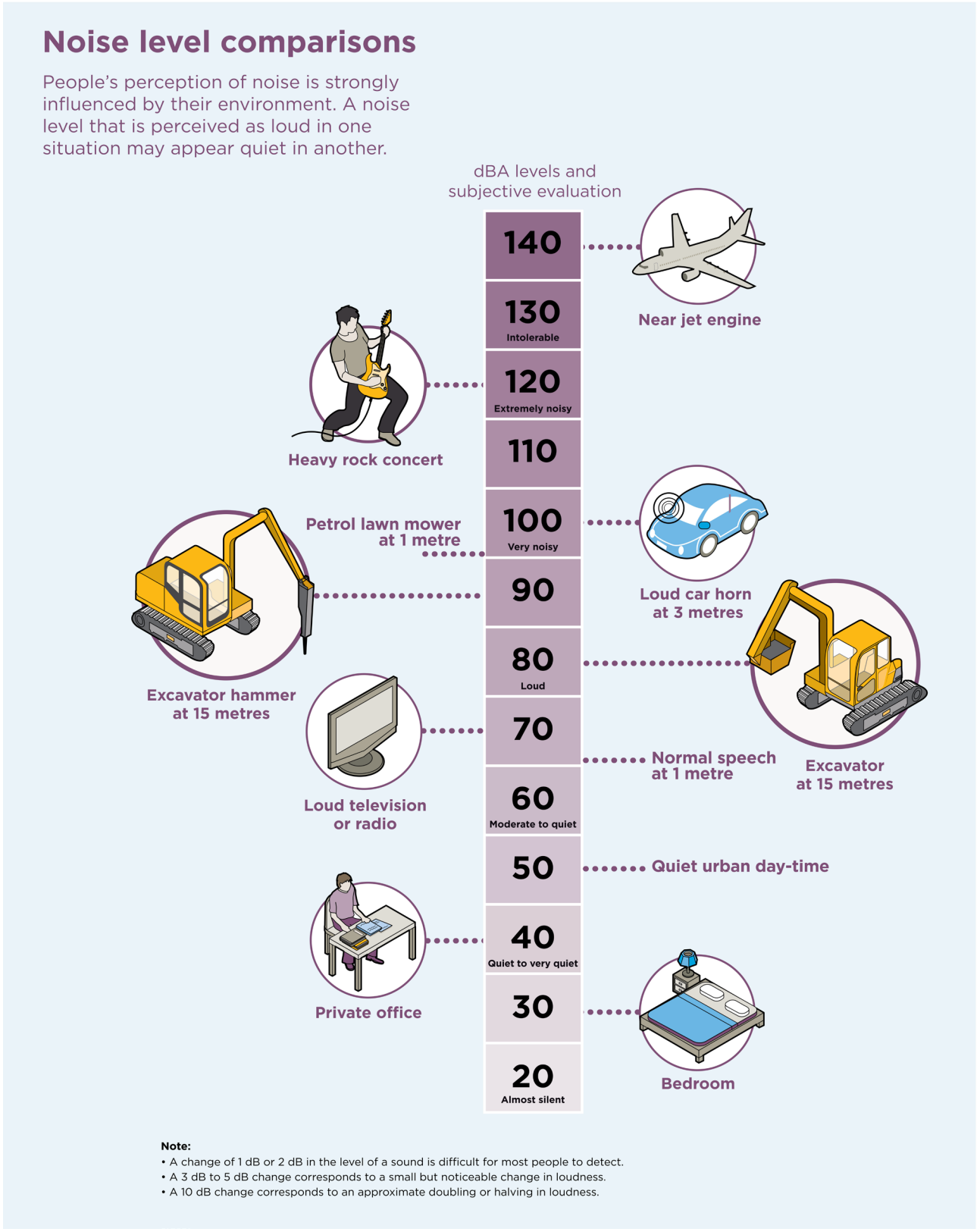


Figure 10-1 Noise level comparison

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 NSW Environment Protection Authority has issued the *Interim Construction Noise Guideline* (DECC, 2009) to provide 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 site boundary) and identifies noise management levels that guide the need to apply reasonable and feasible mitigation measures to minimise noise impacts. For construction vibration, the NSW Environment Protection Authority has issued *Assessing Vibration: a technical guideline* (DECC, 2006), which focuses managing the risk of vibration impacts on human comfort.

The *Construction Noise and Vibration Guideline* (Roads and Maritime, 2016a) integrates and adapts, for Transport for NSW roads projects, the direction and guidance provided by several other policies, guidelines and standards, including the *Interim Construction Noise Guideline* (DECC, 2009), *Assessing Vibration: a technical guideline* (DECC, 2006), and *Australian criteria for blasting* (AS 2187.2 2006). The *Construction Noise and Vibration Guideline* 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, 2015a), which provides an assessment process for construction traffic noise impacts.

10.3 Assessment methodology

The assessment of the construction noise and vibration impacts of the project included the following key steps:

- Identification of noise sensitive receivers and noise catchment areas
- Development of a study area for the assessment, including construction traffic noise
- Background noise monitoring to determine existing noise levels
- A construction noise assessment to predict noise levels that may be generated by the project; including airborne noise, ground-borne noise and vibration
- Identification of environmental management measures to avoid, minimise and manage noise and vibration impacts during construction of the project, including initial identification of potential noise barrier requirements and areas where at property treatments may need to be considered.

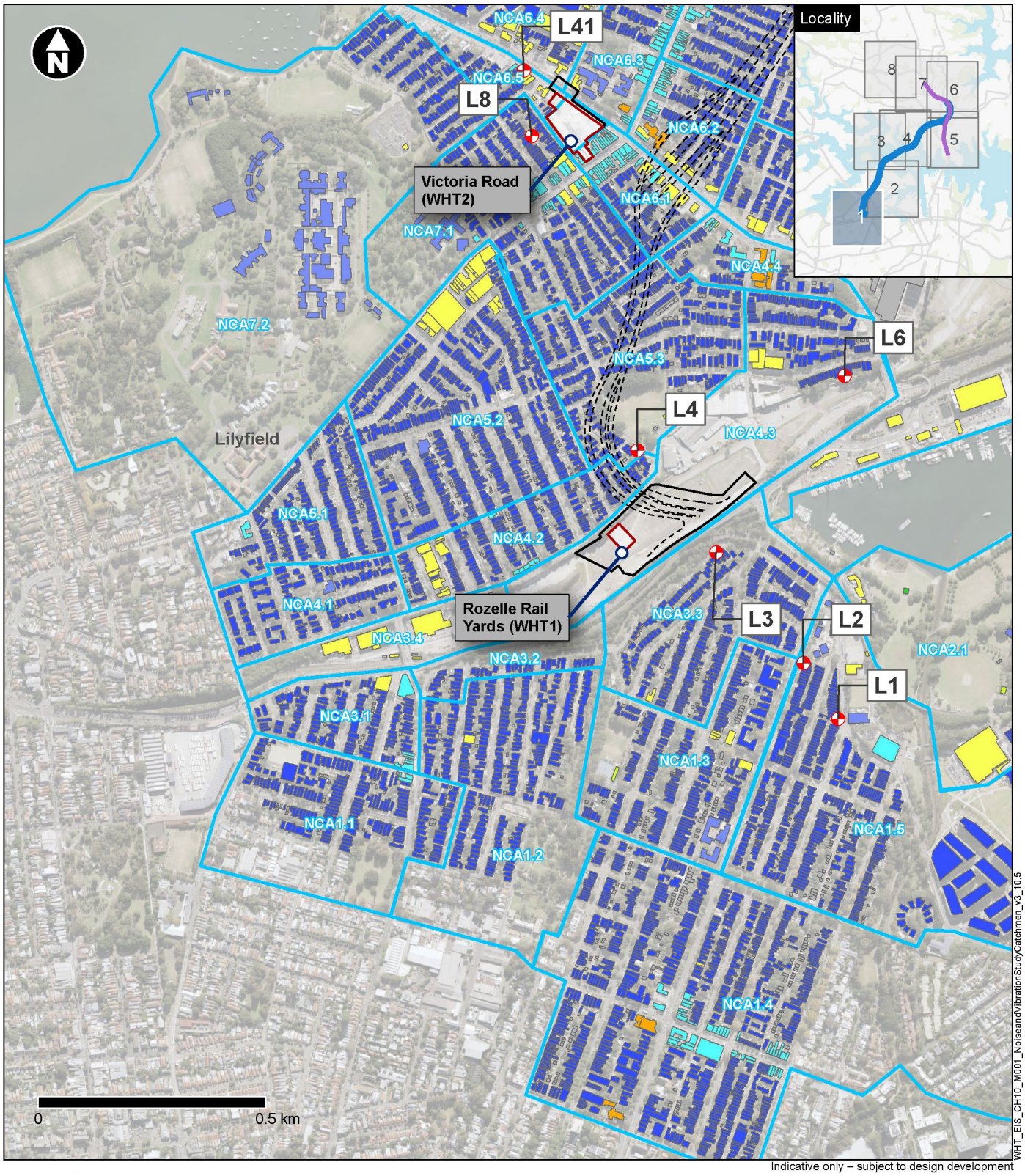
10.3.1 Noise sensitive receivers and noise catchment areas

The location and type of noise sensitive receivers near 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 along the project alignment, being areas of similar acoustic environments. The noise catchment areas are shown in Figure 10-2 to Figure 10-9.

10.3.2 Background noise monitoring

Noise monitoring was carried out at 41 locations between June 2017 and November 2017 to establish existing background and existing traffic noise levels within each of the noise catchment areas. The noise monitoring locations, receiver type and noise catchment areas are shown in Figure 10-2 to Figure 10-9.

Noise monitoring was carried out in accordance with *AS 2702–1984 – Acoustic methods of measurement of road traffic noise*. Further details of the noise monitoring are provided in Appendix G (Technical working paper: Noise and vibration).



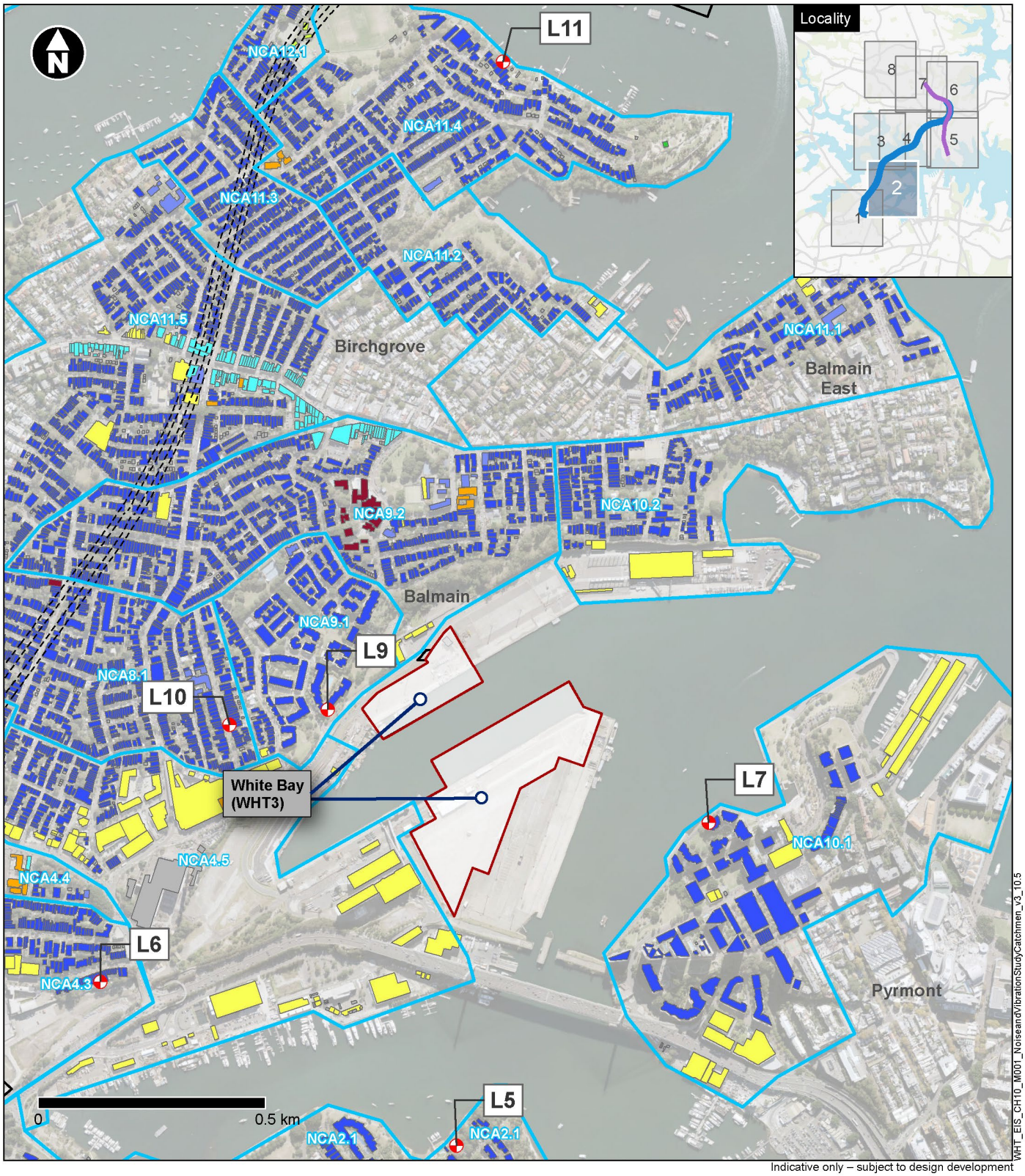
Legend

Construction features
- Construction footprint
- Construction support site
- Tunnel section

Noise assessment features
- Long-term noise monitoring location
- Noise catchment area (NCA)

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

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



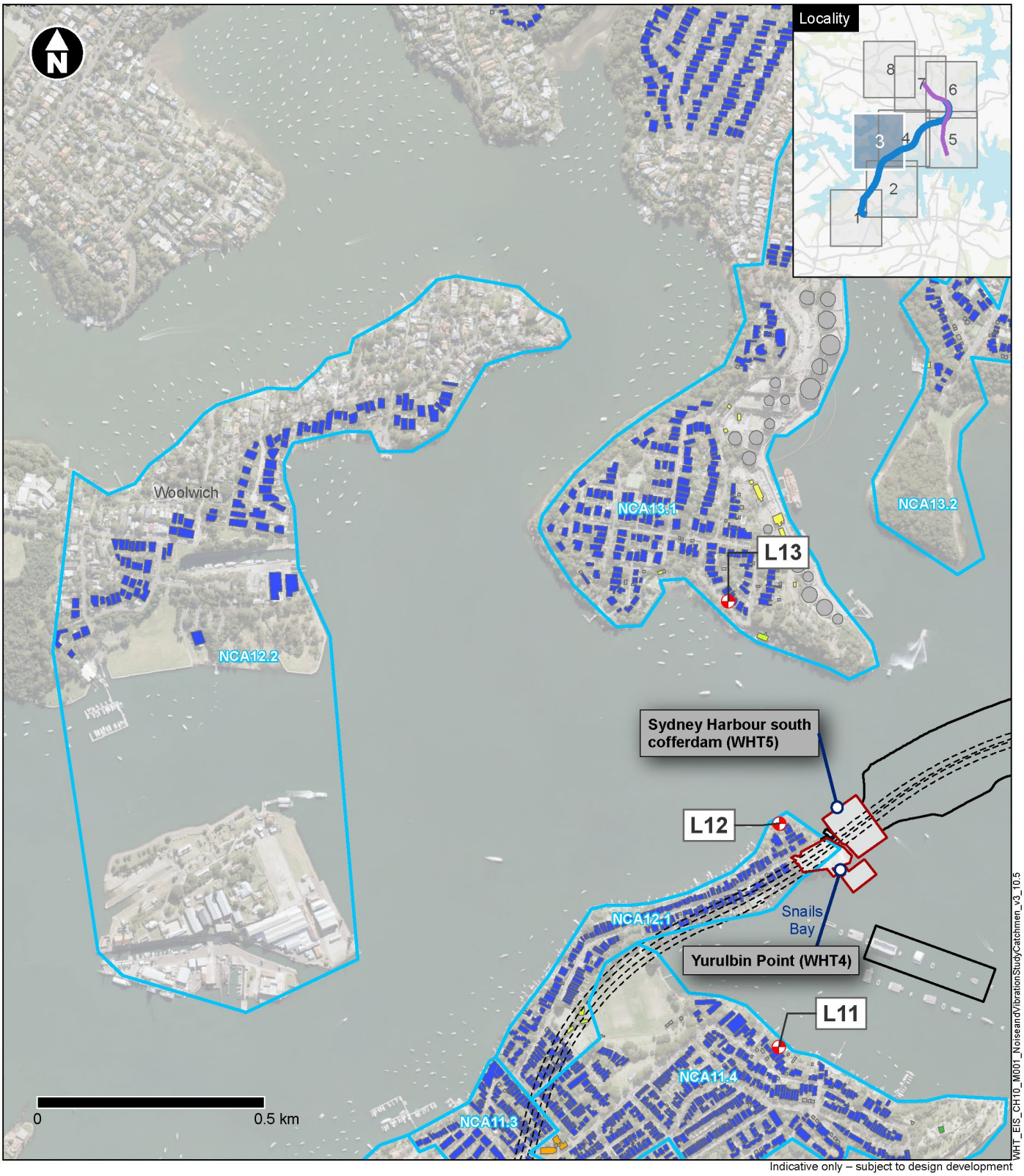
Legend

Construction features
- Construction footprint
- Construction support site
- Tunnel section

Noise assessment features
- Long-term 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 10-3 Noise catchment areas and monitoring locations (map 2)



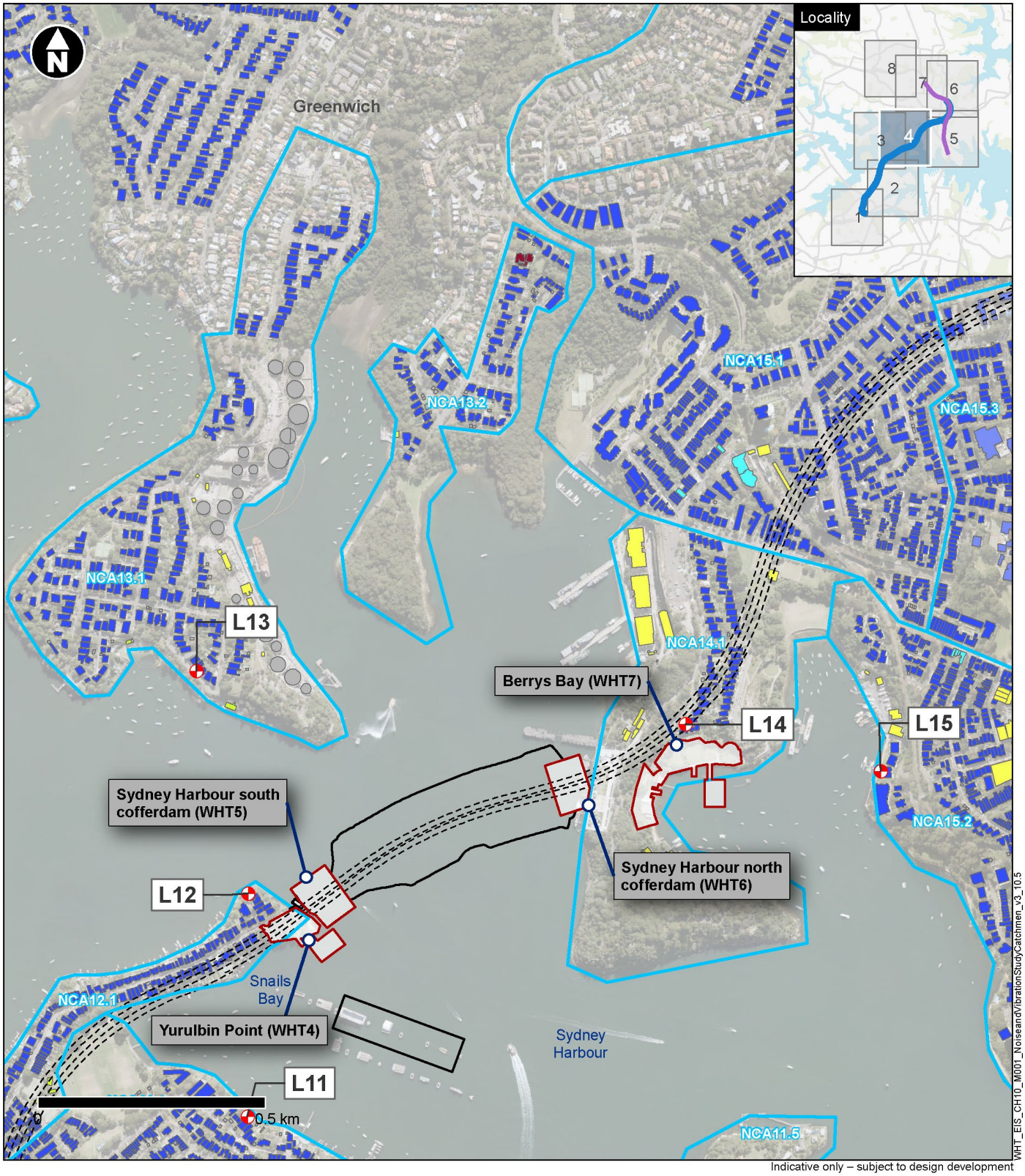
Legend

Construction features
- Construction footprint
- Construction support site
- Tunnel section

Noise assessment features
- Long-term noise monitoring location
- Noise catchment area (NCA)

Receiver type
- Commercial/industrial
- Non receiver building
- Educational/childcare
- Place of worship
- Recreational - active
- Recreational - passive
- Residential

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



Legend

Construction features

- Construction footprint
- Construction support site
- Tunnel section

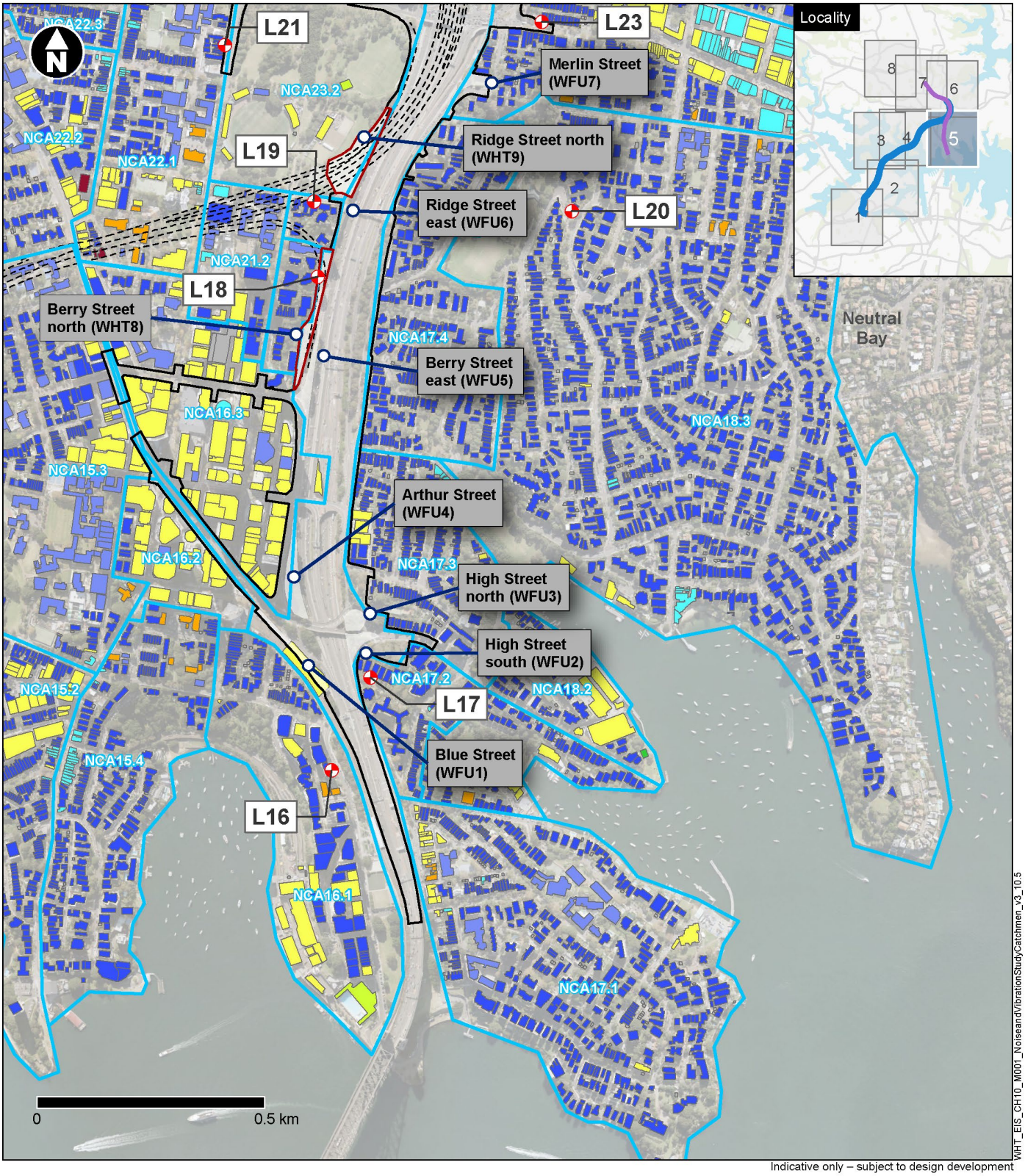
Noise assessment features

- Long-term noise monitoring location
- Noise catchment area (NCA)

Receiver type

- Commercial/industrial
- Mixed use
- Non receiver building
- Educational/childcare
- Medical
- Recreational - active
- Residential

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



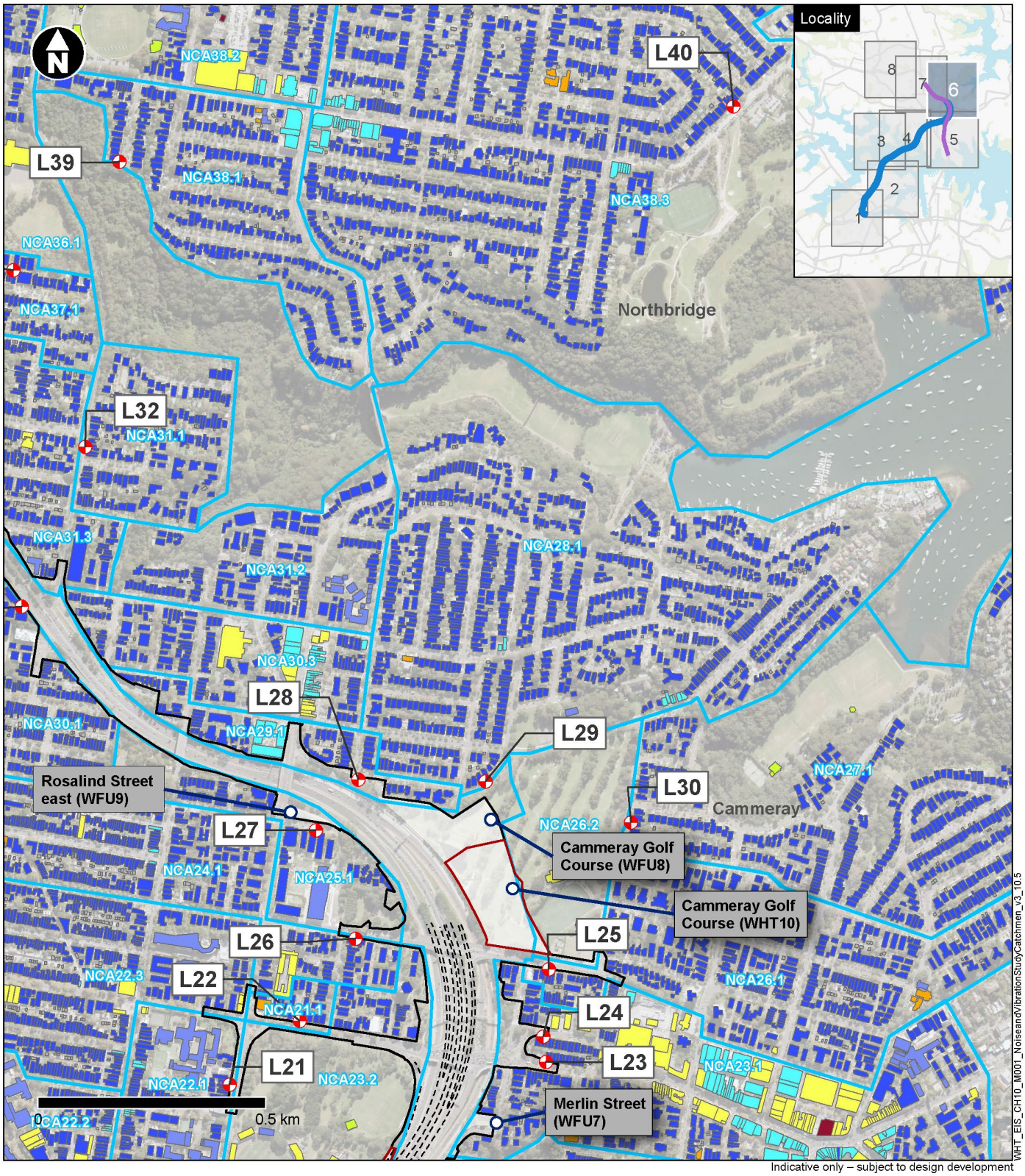
Legend

Construction features
- Construction footprint
- Construction support site
- Tunnel section

Noise assessment features
- Long-term 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 10-6 Noise catchment areas and monitoring locations (map 5)



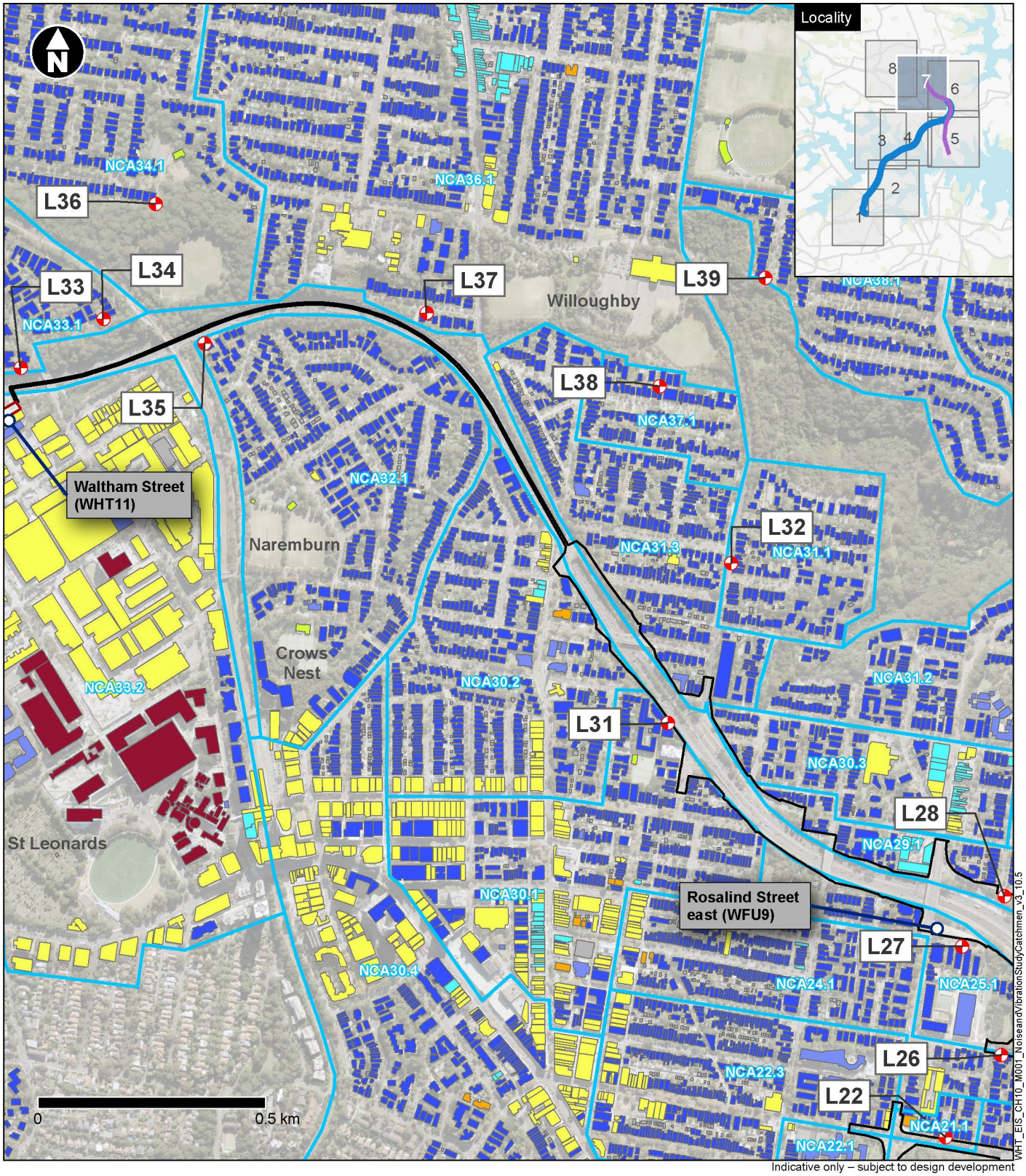
Legend

Construction features
- Construction footprint
- Construction support site
- Tunnel section

Noise assessment features
- Long-term 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 10-7 Noise catchment areas and monitoring locations (map 6)



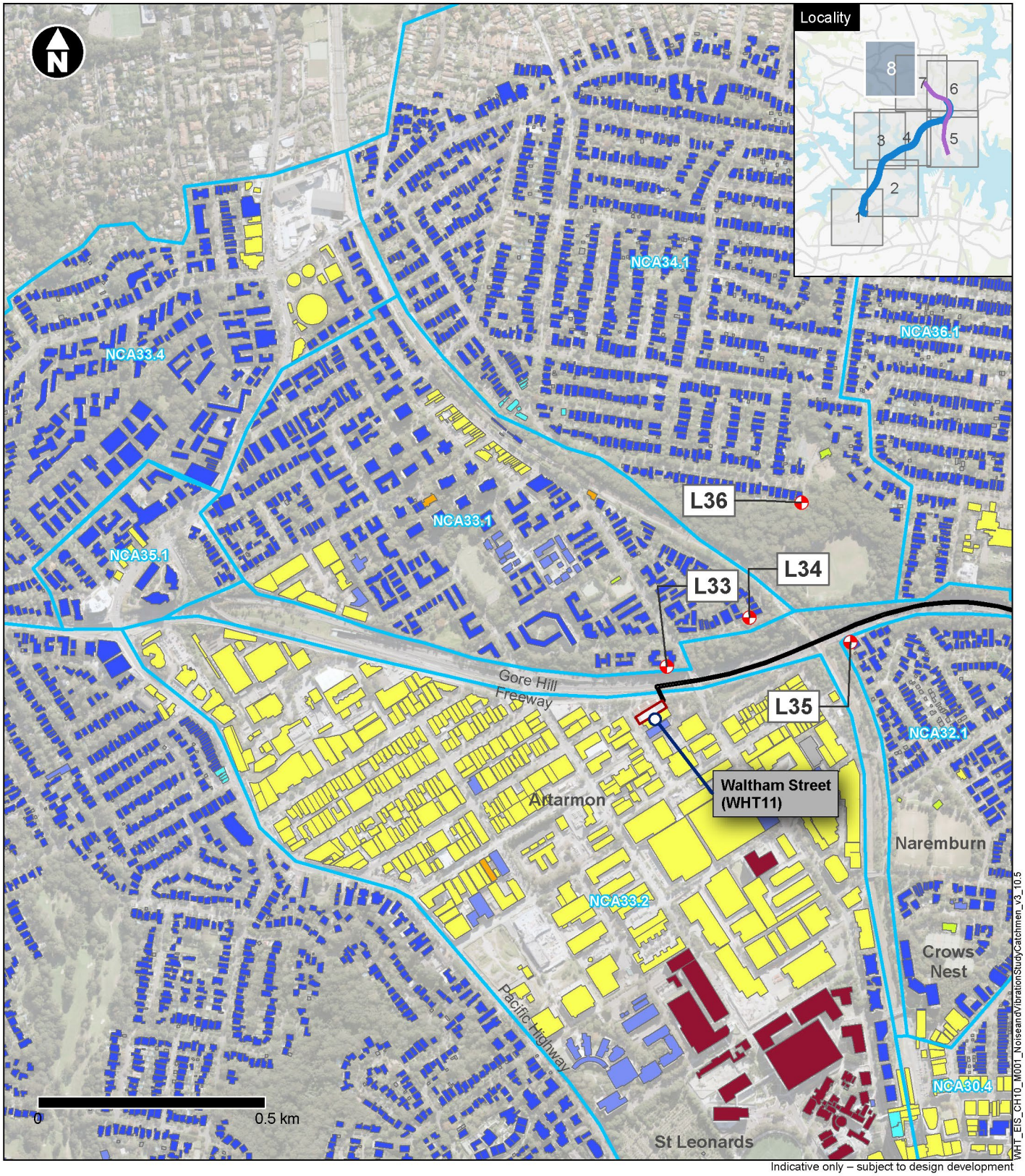
Legend

Construction features
- Construction footprint
- Construction support site

Noise assessment features
- Long-term noise monitoring location
- Noise catchment area (NCA)

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

Figure 10-8 Noise catchment areas and monitoring locations (map 7)



Legend

Construction features
- Construction footprint
- Construction support site

Noise assessment features
- Long-term noise monitoring location
- Noise catchment area (NCA)

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

Figure 10-9 Noise catchment areas and monitoring locations (map 8)

10.3.3 Construction noise and vibration assessment

The construction noise and vibration assessments for the project considered the potential impacts associated with airborne and 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 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 may contribute to cumulative noise impacts should construction activities occur at the same time
- 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 construction support sites, consideration was given to reasonable worst case construction activities as required by the *Interim Construction Noise Guideline* (DECC, 2009). The reasonable worst case scenario is conservative because it assumes all equipment expected to be used at a given site would be operating simultaneously, at a worst case intensity, and with a worst case orientation during a 15-minute period. The reasonable worst case scenario would not typically occur and therefore actual noise levels throughout the duration of construction are likely to be lower.

For the prediction of airborne noise impacts from surface road works outside construction support sites (eg surface road works in the Warringah Freeway), consideration was given to both reasonable typical and worst case construction noise impact scenarios. The typical impacts scenario was 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. Figure 10-10 provides an example of how both typical and worst case noise intensive scenarios could occur in a given period of time. The example is for utility connection works occurring at night.

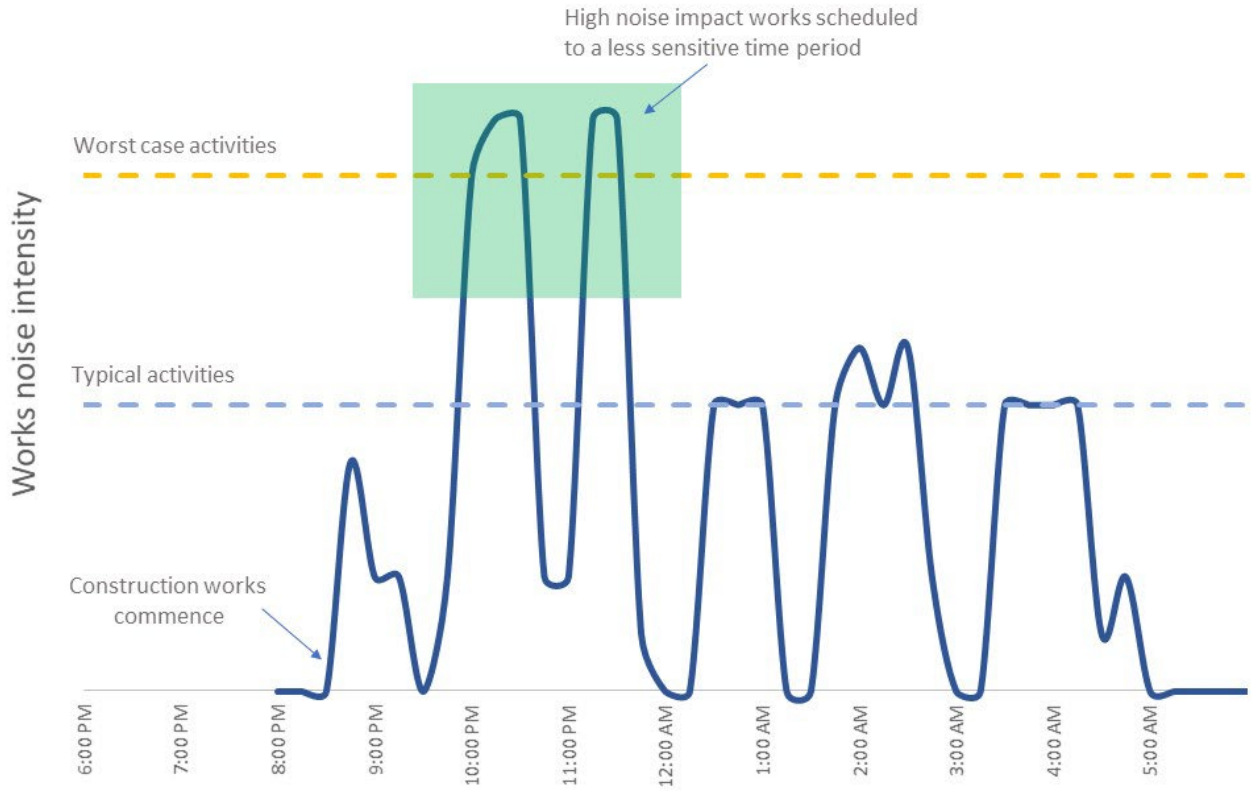


Figure 10-10 Example of variation in surface road works airborne noise impacts for typical and worst case activities

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* 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 RBL, 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 ($L_{Aeq\ (15min)}$)[1]
Recommended standard construction hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or public holidays	Noise affected RBL + 10dB(A)[2]
	Highly noise affected 75dB(A)
Outside recommended standard construction hours	Noise affected RBL + 5dB (A)

Note 1: $L_{Aeq(15min)}$ 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 Figure 10-1 for a comparison of dB(A) for various activities.

Non-residential receivers

The noise management levels for non-residential receivers set in accordance with the *Interim Construction Noise Guideline* 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 about 10dB(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 $L_{Aeq\ (15\ min)}$[1]
Classrooms at schools, and other educational institutions	Internal noise level	45dB(A)[2]
Hospital wards and operating theatres	Internal noise level	45dB(A)
Places of worship	Internal noise level	45dB(A)
Childcare centre	External noise level	50dB(A)
Active recreation areas (eg sports fields/activities which generate their own noise and are generally less sensitive to external noise)	External noise level	65dB(A)
Passive recreation areas (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	60dB(A)
Community centres	Depends on the intended use of the centre.	Refer to the 'maximum' internal levels in AS2107 for specific uses.

Land use	Where objective applies	Noise management level $L_{Aeq\ (15\ min)}$[1]
Commercial premises (including offices and retail outlets)	External noise level	70dB(A)
Industrial premises	External noise level	75dB(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: LAeq(15min) 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 Figure 10-1 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.

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 re-route due to a road closure, further assessment was completed as per the *Noise Criteria Guideline* (Roads and Maritime, 2015a).

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* are provided in Table 10-5.

Table 10-5 Ground-borne noise objectives

Receiver type	Ground-borne noise objectives ($L_{Aeq(15minute)}$)[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)

Receiver type	Ground-borne noise objectives ($L_{Aeq(15minute)}$)[1]
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: LAeq(15min) 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 Figure 10-1 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 exceeded, a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure would be done during detailed design 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. Any heritage item predicted to exceed the screening level would be investigated during detailed design, and appropriate vibration criteria for the structure adopted.

The recommended minimum working distances for construction plant in Table 10-6 considers both human comfort and impacts on structures and are referenced from the *Construction Noise and Vibration Guideline* and German Standard *DIN 4150: Part 3-1999 Structural vibration - Effects of vibration on structures*.

Where specified construction equipment is used at greater distances from receiver locations than the specified safe working distance, there is negligible risk of structural damage or impacts on human comfort outside of the construction site. Where recommended minimum working distances are not met, more detailed consideration of potential vibration impacts and construction approach would occur during detailed design.

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

Plant item	Rating description	Minimum working distance, 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 item structure)	
Vibratory roller	< 50 kN (typically 1–2t)	5	11	15–20
	< 100 kN (typically 2–4t)	6	13	20
	< 200 kN (typically 4–6t)	12	15	40
	< 300 kN (typically 7–13t)	15	31	100
	> 300 kN (typically 13–18t)	20	40	100
	> 300 kN (typically > 18t)	25	50	100
Compactor	32t (non-vibratory)	15	30	40
Bulldozer	D10 with ripper	2	10	20
Excavators	<30 tonne (travelling /digging)	10	15	15
Small hydraulic hammer	300 kg – 5 to 12 tonne excavator	2	5	7
Medium hydraulic hammer	900 kg – 12 to 18 tonne excavator	7	15	23
Large hydraulic hammer	1600 kg – 18 to 34 tonne excavator	22	30	73
Vibratory pile driver	Sheet piles	20	30	50
Impact piling	Typical driven pile[4]	20	30	110
	338kJ per stroke (23 tonne hammer with 1.5m stroke)	70	140	330
Pile boring	≤800 mm	2	5	N/A

Plant item	Rating description	Minimum working distance, 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 item structure)	
Jackhammer	Hand held	1	3	5
Roadheader	Tunnelling	5	5	10
Rockdrilling	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
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*.
Note 2: Criteria referenced from *DIN 4150 Structural Damage - Safe Limits for Short-term Building Vibration* (including heritage items).
Note 3: Criteria referenced from EPA's *Assessing Vibration: a technical guideline* (December 2006).
Note 4: Referenced to a 'typical' pile driver (impact) taken from *US Department of Transportation Federal Transit Administration Noise and Vibration manual*.

10.4.5 Blasting noise and vibration management levels

Underground blasting may be used for discrete elements of the excavation of the mainline tunnels and cross passages in the driven tunnel, along with excavation of the sandstone within the cut and cover structures leading up to the driven tunnel.

Criteria from AS 2187.2-2006 *Explosives - Storage and use - Part 2 Use of explosives* have been adopted for the project, including recommended limits for structural damage and human comfort, blasting operation hours, and underwater pressure. 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* (ANZECC, 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 project footprint and surrounds varies. The areas surrounding the project footprint are mostly residential, except for clusters of commercial and industrial receivers around White Bay, and the North Sydney central business district, and Sydney Harbour.

The acoustic environment in these residential areas is mostly influenced by noise from major roads. Traffic volumes on these main 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 arterial roads is 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 local 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 10-4. The background noise levels are typical of suburban environments with daytime noise levels ranging from 40 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 32 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.

Table 10-7 Background and ambient traffic noise monitoring

Noise monitoring location	Rating background level (dB(A))[1] (L_{A90})[2] - Day (7 am to 6 pm)	Rating background level (dB(A))[1] (L_{A90})[2] - Evening (6pm to 10 pm)	Rating background level (dB(A))[1] (L_{A90})[2] - Night (10 pm to 7 am)	Existing traffic noise level (dB(A)) - Day (7am to 10pm) ($L_{Aeq(15\text{-}hour)}$)[3]	Existing traffic noise level (dB(A)) - Night (10pm to 7am) ($L_{Aeq(9\text{-}hour)}$)[4]
Location L1	51	45	33	66	60
Location L2	50	47	36	65	59
Location L3	50	51	44	58	53
Location L4	49	46	37	61	53
Location L5	51	52	45	57	52
Location L6	52	52	45	58	55
Location L7	48	45	44	52	48
Location L8	43	41	34	57	48
Location L9	49	49	46	54	49
Location L10	42	44	38	54	48

Noise monitoring location	Rating background level (dB(A))[1] (L_{A90})[2] - Day (7 am to 6 pm)	Rating background level (dB(A))[1] (L_{A90})[2] - Evening (6pm to 10 pm)	Rating background level (dB(A))[1] (L_{A90})[2] - Night (10 pm to 7 am)	Existing traffic noise level (dB(A)) - Day (7am to 10pm) ($L_{Aeq(15\text{-}hour)}$)[3]	Existing traffic noise level (dB(A)) - Night (10pm to 7am) ($L_{Aeq(9\text{-}hour)}$)[4]
Location L11	40	42	37	52	43
Location L12	46	45	40	58	53
Location L13	41	38	32	54	43
Location L14	41	37	33	51	45
Location L15	42	41	38	52	44
Location L16	60	60	50	63	58
Location L17	55	54	45	60	56
Location L18	73	71	55	76	72
Location L19	52	52	45	57	52
Location L20	54	52	43	59	53
Location L21	52	47	36	65	58
Location L22	53	49	41	68	63
Location L23	61	54	44	69	65
Location L24	58	54	44	72	67
Location L25	58	54	41	69	62

Noise monitoring location	Rating background level (dB(A))[1] (L_{A90})[2] - Day (7 am to 6 pm)	Rating background level (dB(A))[1] (L_{A90})[2] - Evening (6pm to 10 pm)	Rating background level (dB(A))[1] (L_{A90})[2] - Night (10 pm to 7 am)	Existing traffic noise level (dB(A)) - Day (7am to 10pm) ($L_{Aeq(15\text{-}hour)}$)[3]	Existing traffic noise level (dB(A)) - Night (10pm to 7am) ($L_{Aeq(9\text{-}hour)}$)[4]
Location L26	56	52	37	68	61
Location L27	58	55	43	62	57
Location L28	64	63	47	67	64
Location L29	47	45	37	54	48
Location L30	49	48	39	59	54
Location L31	58	56	38	62	58
Location L32	56	49	37	71	65
Location L33	67	63	46	72	67
Location L34	55	53	40	59	55
Location L35	59	55	40	63	58
Location L36	44	44	37	53	46
Location L37	50	48	38	55	49
Location L38	45	44	34	53	48
Location L39	52	48	37	60	57
Location L40	43	40	36	66	58

Noise monitoring location	Rating background level (dB(A))[1] (L_{A90})[2] - Day (7 am to 6 pm)	Rating background level (dB(A))[1] (L_{A90})[2] - Evening (6pm to 10 pm)	Rating background level (dB(A))[1] (L_{A90})[2] - Night (10 pm to 7 am)	Existing traffic noise level (dB(A)) - Day (7am to 10pm) ($L_{Aeq(15\text{-}hour)}$)[3]	Existing traffic noise level (dB(A)) - Night (10pm to 7am) ($L_{Aeq(9\text{-}hour)}$)[4]
Location L41[5]	63	58	43	74	69

Note 1: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Figure 10-1 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: $L_{Aeq(15\text{-}hour)}$ 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: $L_{Aeq(9\text{-}hour)}$ 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 M4–M5 Link project environmental impact statement (AECOM, 2017).

10.6 Assessment of potential impacts – Western Harbour Tunnel

10.6.1 Overview

This section provides an assessment of the potential noise and vibration impacts associated with the construction of the Western Harbour Tunnel. Impacts associated with the Warringah Freeway Upgrade are presented in Section 10.7.

For each 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 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.

The number of buildings potentially exposed to ground-borne noise above the noise management levels during roadheader tunnelling is provided in Table 10-8. The number of buildings reported is 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 22 residential buildings could experience ground-borne noise levels between 35 and 40 dB(A) and one residential building could experience ground-borne noise levels above 40 dB(A).

Evening and night time ground-borne noise management levels have the potential to be exceeded at these receivers

- One non-residential sensitive receiver building could experience ground-borne noise levels above the noise management level
- Other commercial and industrial buildings are not predicted to experience ground-borne noise levels above their relevant ground-borne noise management level.

Roadheader progress is estimated to be 20 to 30 metres a week depending on the type and size of the tunnel section. The predicted ground-borne noise levels provided in Table 10-8 are the peak noise levels that a receiver building would be exposed to. The ground-borne noise level is expected to drop away as the tunnelling moves further away from the receiver. Variation in ground-borne noise with the progression of works is illustrated in Figure 10-11.

Rock-hammers are proposed to be used for clearing the bench of the tunnel and would follow behind the roadheader. Table 10-8 shows there are more receivers that could be impacted during rock-hammering than roadheader tunnelling. However, rock-hammering work would be programmed outside evening and night time periods to avoid or reduce ground-borne noise level exceedances on sensitive receivers' buildings where feasible and reasonable.

Table 10-8 Sensitive receiver buildings potentially affected by ground-borne noise from roadheader and 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)		
Rozelle	4.4	–	–	–	–	–	–	–	–	–	–
	4.5	–	–	–	–	–	14	–	–	–	–
	5.3	–	–	–	–	–	–	–	–	–	–
	6.1	–	–	–	–	–	52	6	–	–	–
	6.2	–	–	–	–	–	90	41	–	–	–
	6.3	–	–	–	–	–	–	–	–	–	–
	7.1	–	–	–	–	–	–	–	–	–	–
	8.1	–	–	–	–	–	64	130	–	–	–
Balmain	9.2	–	–	–	–	–	64	107	–	–	–
	11.2	–	–	–	–	–	–	–	–	–	–
	11.5	–	–	–	–	–	215	3	–	–	–

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)		
Birchgrove	11.3	–	–	–	–	–	129	41	–	–	–
	11.4	–	–	–	–	–	24	22	7	–	–
	12.1	–	–	–	–	–	28	42	105	–	–
Wollstonecraft	22.2	–	–	–	–	–	14	11	–	–	–
Waverton	14.1	4	–	–	–	–	4	8	39	–	1
	15.1	9	–	–	–	–	31	32	73	–	–
North Sydney – south west	15.3	–	–	–	–	–	15	5	6	8	–
	16.3	–	–	–	–	–	3	4	1	2	–
North Sydney – north west	19.1	1	1	–	–	–	5	–	6	1	–
	20.1	1	–	–	–	–	–	–	12	–	–
	21.2	7	–	–	1	–	1	1	8	10	–

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)		
	22.1	–	–	–	–	–	–	1	13	11	2
	23.2	–	–	–	–	–	4	1	1	–	–
Neutral Bay	17.4	–	–	–	–	–	5	2	–	–	–
	23.1	–	–	–	–	–	13	3	–	–	–
Crows Nest	24.1	–	–	–	–	–	1	–	–	–	–
Cammeray	25.1	–	–	–	–	–	–	–	–	–	–
Cremorne	26.1	–	–	–	–	–	–	–	–	–	–
Total		**22**	**1**	**0**	**1**	**0**	**776**	**460**	**271**	**32**	**3**

Note 1: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Figure 10-1 for a comparison of dB(A) for various activities.

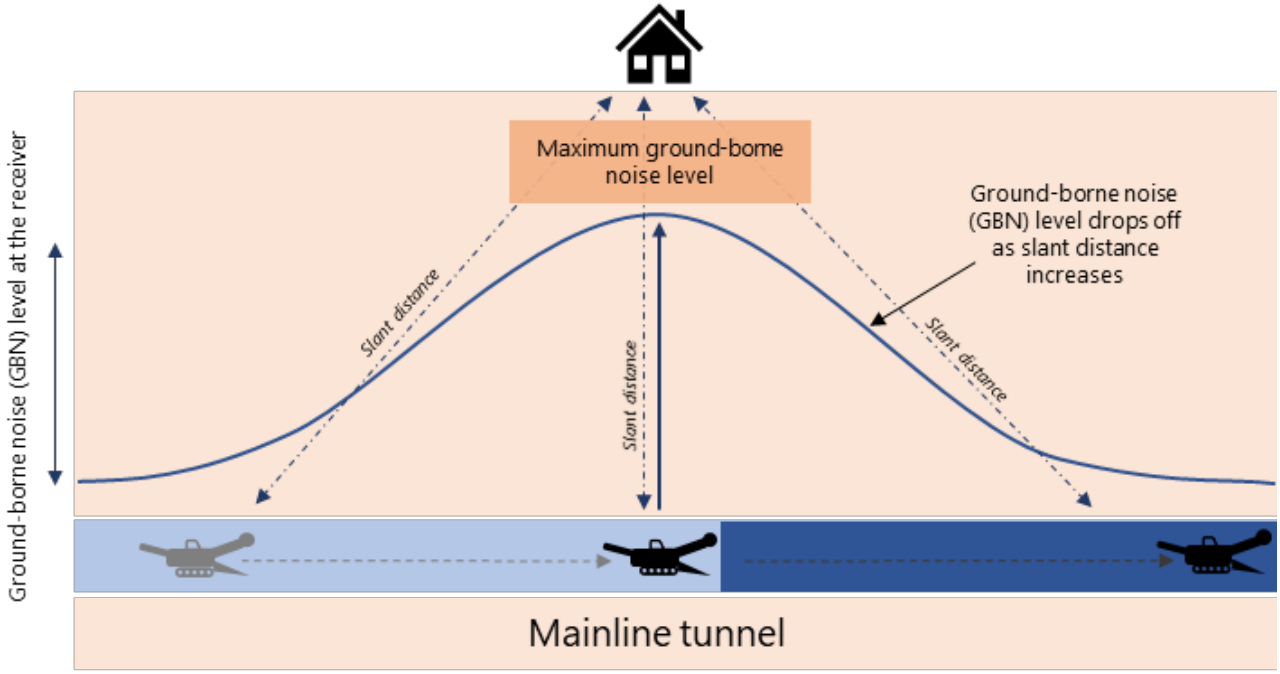


Figure 10-11 Indicative ground-borne noise impacts as tunnelling progresses

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 disturbance at all receivers.

Up to 258 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. For these receivers, standard and additional mitigation measures from the *Construction Noise and Vibration Guideline* would be implemented, which may include notification and respite. Five heritage listed items located in NCAs 14.1 and 23.2 would potentially exceed the vibration screening criterion for heritage buildings. Refer to Appendix G (Technical working paper: Noise and vibration) and Appendix J (Technical working paper: Non-Aboriginal heritage) for details on the heritage structures potentially impacted. Identified heritage items would be further investigated to determine specific vibration criteria and mitigation and management measures.

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	Number of receiver buildings affected by mainline tunnelling - Rock-hammers
Risk of structural or cosmetic damage			
	All	–	–

Suburb	Noise catchment area	Number of receiver buildings affected by mainline tunnelling - Roadheaders	Number of receiver buildings affected by mainline tunnelling - Rock-hammers
Heritage items requiring further assessment			
Waverton	14.1	–	1
North Sydney – north west	23.2	–	4
Total heritage items requiring further assessment		**0**	**5**
Buildings with screening level above risk of human disturbance			
Birchgrove	12.1	–	87
Waverton	14.1	–	42
	15.1	–	63
North Sydney – south-west	15.3	–	3
	16.3	–	1
North Sydney – north-west	19.1	–	6
	20.1	–	12
	21.2	–	16
	22.1	–	27
	23.2	–	1
Total buildings with screening level above risk of human disturbance		**0**	**258**

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 and is able to cause 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.

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 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* are achieved. A blast management strategy will be prepared in consultation with the environment protection authority to demonstrate that all blasting and associated activities will 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.

10.6.3 Rozelle Rail Yards (WHT1)

Construction works summary

The Rozelle Rail Yards construction support site is bound by Lilyfield Road to the north and the City West Link to the south. The western extent of the site borders a proposed ramp for the M4-M5 Link, and vacant, cleared land located to the east. The construction support site would support mechanical and electrical fitout of the mainline tunnels. The site would also support construction and fitout of the ventilation outlet and motorway facilities, as well as surface roads connecting the ramp tunnels to the City West Link. The works would take about three years.

Construction airborne noise

No receivers are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)).

During standard construction hours and out of hours work, residential and non-residential receiver buildings are predicted to experience noise levels below the noise management levels.

Maximum noise levels at night could exceed the sleep disturbance screening level at up to 36 receiver buildings from occasional concrete delivery trucks supporting the tunnel fitout. None of these receivers are predicted to be exposed to maximum noise levels above the awakening reaction level.

Cumulative airborne construction noise

There is potential for cumulative increases in construction noise from concurrent works with the M4–M5 Link project.

However, cumulative construction noise would be below the noise management levels. The exception would be for some receiver buildings in NCAs 3.3 and 4.2 during standard construction hours, when there is a potential for construction noise levels to increase above noise management levels if construction activities occur concurrently.

Cumulative airborne construction noise impacts would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Construction traffic noise

Construction road traffic management and vehicle movements associated with the Rozelle Yards construction support site 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.

Occasional night time heavy vehicle movements would occur to support tunnel fitout works. Road traffic related sleep disturbance impacts are not expected to occur.

Construction ground-borne noise

Ground-borne noise levels have not been assessed for the construction support site works because airborne noise levels would be dominant over ground-borne noise levels for these works. Management of the airborne noise impacts would also sufficiently manage any associated ground-borne noise impacts.

For the construction of the ventilation tunnel between Rozelle Rail Yards and the mainline tunnels, ground-borne noise levels are predicted to be between 35 and 40 dB(A) at one receiver located in NCA 4.2. This has the potential to exceed the night time ground-borne noise management level. Ventilation tunnel work would be programmed to avoid or reduce ground-borne noise impact on this sensitive receiver where feasible and reasonable.

Construction vibration

No vibration intensive work is proposed at this site. No receiver buildings are predicted to experience noise above the vibration screening level during the construction of the ventilation tunnel.

10.6.4 Victoria Road (WHT2)

Construction works summary

The Victoria Road construction support site is located within the former Balmain Leagues Club site at Rozelle. This site would be used to support excavation of the mainline tunnels. Access for plant and equipment required to excavate the tunnels would be via an access decline constructed in the south-east corner of the site within an acoustic shed. The mainline tunnels would be excavated in both directions from this site. The works would take about four years and three months.

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.

Up to 27 residential receiver buildings are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)) when rock-hammers are in use as part of the early works, site establishment, acoustic shed and decline construction and during site restoration works.

During standard construction hours, up to 208 residential receiver buildings in NCAs 6.1, 6.3, 6.5, 7.1, 7.2 and 8.1 are predicted to experience noise levels above the noise management level mostly during early and site establishment works; however, the majority of receivers (78 per cent) would experience increases of less than 10 dB(A).

Outside standard construction hours, tunnel construction and fitout works would occur. When these activities occur at night, up to three residential receiver buildings in NCA 7.1 are predicted to

experience noise levels above the noise management level; however, all three receivers would experience noise increases of less than 5 dB(A).

Maximum noise levels at night could exceed the sleep disturbance screening level at up to 210 receiver buildings from occasional concrete delivery trucks and truck unloads supporting the tunnel construction and fitout. Up to 26 of these receivers are predicted to be exposed to maximum noise levels above the awakening reaction level.

For non-residential receivers:

- Up to eight commercial receivers located in NCAs 6.2, 6.3, 6.4, 6.5, 7.1 and 7.2 are predicted to experience noise levels by up to 9 dB(A) above the noise management level during early works, site establishment, decline construction and site restoration
- Up to two childcare receivers located in NCAs 6.2 and 6.3 are predicted to experience noise levels above the noise management level by up to 11 dB(A) during various project stages
- One educational receiver with buildings located in NCA 6.3 is predicted to experience noise levels above the noise management level by up to 28 dB(A) during various project stages
- Up to two place of worship receivers located in NCAs 6.2 and 6.3 are predicted to experience noise levels above the noise management level by up to 22 dB(A) during various project stages.

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 are provided in Section 10.9.

Table 10-10 Number of residential receiver buildings over the noise management levels during construction at Victoria Road (reasonable worst case noise intensity scenario)

Stage activity	Highly noise affected (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])	
	>75 dB(A)[3]	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	**27**	**109**	**14**	**15**	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Establish site	**22**	**163**	**33**	**12**	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Establish construction facilities	0	**21**	**6**	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Piling for decline and shed	**3**	**40**	**14**	**5**	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Decline construction	**10**	**41**	**23**	**1**	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Acoustic shed construction	0	**17**	**8**	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tunnelling	0	**11**	0	0	0	0	0	0	0	0	0	0	**3**	0	0	0	**142**	**26**
Tunnel fitout	0	**6**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**210**	**21**

Stage activity	Highly noise affected (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])	
	>75 dB(A)[3]	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
Restore site	**5**	**101**	**6**	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

Cumulative airborne construction noise

There is potential for timeline overlaps with the nearby M4–M5 Link project Iron Cove construction site.

At sensitive receiver buildings not directly adjacent to the Victoria Road construction support site, there is potential for cumulative increases in construction noise from concurrent works with the M4–M5 Link project Iron Cove construction site. However, cumulative construction noise would be below the noise management levels.

Cumulative airborne construction noise impacts would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Construction traffic noise

Construction road traffic management and vehicle movements associated with the Victoria Road construction support site 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 Victoria Road or City West Link, the number of maximum noise events that could disturb sleep is not likely to increase substantially.

Construction ground-borne noise

Ground-borne noise levels have not been assessed for the works at the construction support site because airborne noise levels would be dominant over ground-borne noise levels for these works. Management of the airborne noise impacts would also sufficiently manage any associated ground-borne noise impacts.

For the construction of the access decline tunnel between the construction support site at Victoria Road and the mainline tunnel alignment, ground-borne noise levels are predicted to be between 35 and 40 dB(A) at six receivers located in NCAs 6.1 and 6.2, between 40 and 45 dB(A) at six receivers located in NCAs 6.1 and 6.3, and greater than 45 dB(A) at one receiver located in NCA 6.1. These exceedances have the potential to exceed the night time and/or evening timed ground-borne noise management levels. Access decline tunnel work would be programmed to avoid or reduce ground-borne noise level exceedances on sensitive receivers' buildings where feasible and reasonable.

Construction vibration

Table 10-11 shows one heritage structure in NCA 7.1 is 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 access decline tunnel and when rock-hammers are used. Refer to Appendix G (Technical working paper: Noise and vibration) and Appendix J (Technical working paper: Non-Aboriginal heritage) for details on the heritage structures potentially impacted.

Where vibration intensive works occur within the minimum working distances, the risk of structural damage or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Table 10-11 Number of receiver buildings within minimum working distances for vibration intensive work – Victoria Road construction support site

NCA	Number of receiver buildings within minimum working distances for vibration intensive work		
	Cosmetic damage		Human response
	Heritage item structure	Sound structure	
Access decline tunnel			
6.1	0	0	1
Construction support site vibration–intensive activities			
6.1	–	19	34
6.2	–	–	2
6.3	–	–	8
6.4	–	–	3
6.5	–	3	6
7.1	1	16	59

10.6.5 White Bay (WHT3)

Construction works summary

The White Bay construction support site is located in White Bay at Rozelle. The northern portion of the site would primarily support dredging activities for the construction of the immersed tube tunnels. The southern area of the site would be used to support the casting and fitout of the immersed tube tunnel units, and the handling and transport of spoil from the Yurulbin Point and Berrys Bay construction support sites, along with providing ancillary facilities and support to works on the southern side of the harbour, for the harbour crossing works, and the Berrys Bay site. This site would also be used to store plant and equipment until it is required at the Yurulbin Point and Berrys Bay construction support sites. The works would take about four years and six months.

Construction airborne noise

Table 10-12 shows the number of residential receiver buildings exceeding the noise management levels for the White Bay construction support site.

No receiver buildings are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)).

During standard construction hours, up to 90 residential receiver buildings in NCAs 8.1, 9.1, 9.2 and 10.2 are predicted to experience noise levels above the noise management level mostly during

early works; however, most receivers (98 per cent) would experience increases of less than 10 dB(A).

Construction works would not typically be carried out outside standard construction hours. The exception is during support of tunnel construction activities at Yurulbin Point construction support site when concrete agitators would be transported by barge between White Bay and Yurulbin Point construction support sites. No residential receiver buildings are predicted to experience noise levels above the noise management level.

Maximum noise levels at night could exceed the sleep disturbance screening level at up to five receiver buildings from the operation of concrete agitators. None of these receivers are predicted to be exposed to maximum noise levels above the awakening reaction level.

The following non-residential receivers are predicted to experience noise levels above the noise management level during early works:

- Up to three commercial receivers located in NCA 9.2 with exceedances of the noise management level by up to 5 dB(A)
- One childcare receiver located in NCA 9.2 with exceedances of the noise management level by up to 2 dB(A)
- One educational receiver with buildings located in NCA 9.2 with exceedances of the noise management level by up to 5 dB(A)
- One place of worship receiver located in NCA 9.2 with exceedances of the noise management level by up to 4 dB(A)
- One other sensitive receiver located in NCA 9.2 with exceedances of the noise management level by up to 1 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 are provided in Section 10.9.

Table 10-12 Number of residential receiver buildings over the noise management levels during construction at White Bay (reasonable worst case noise intensity scenario)

Stage activity	Highly noise affected (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])	
	>75 dB(A)[3]	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	**88**	**2**	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Establish site	0	**1**	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Establish construction facilities	0	**2**	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Piling for wharf structure	0	0	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Immersed tube tunnel production	0	0	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Immersed tube tunnel fitout	0	0	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Spoil handling	0	**1**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**5**	0

Stage activity	Highly noise affected (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])	
	>75 dB(A)[3]	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
Restore site	0	0	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

Cumulative airborne construction noise

There is potential for timeline overlaps with the nearby M4–M5 Link project White Bay civil construction site.

At sensitive receiver buildings not directly adjacent to the White Bay construction support site, there is potential for cumulative increases in construction noise from concurrent works with the M4–M5 Link project White Bay construction site.

Cumulative construction noise has the potential to increase overall duration and frequency of construction noise impacts in the same receivers.

The key noise generating activities during early works such as utility connection works are typically intermittent in nature.

Cumulative airborne construction noise impacts would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Construction traffic noise

Construction road traffic management and vehicle movements associated with the White Bay construction support site 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 City West Link/The Crescent and James Craig Road, the number of maximum noise events that could disturb sleep is not likely to increase substantially.

Construction ground-borne noise

Ground-borne noise levels have not been assessed for the works at the construction support site because airborne noise levels would be dominant over ground-borne noise levels for these works. Management of the airborne noise impacts would also sufficiently manage any associated ground-borne noise impacts.

Construction vibration

Table 10-13 shows one heritage structure in NCA 9.1 is predicted to be within the minimum working distances for major vibration-generating activities. The most vibration intensive activities at this site are likely to occur during site establishment. Refer to Appendix G (Technical working paper: Noise and vibration) and Appendix J (Technical working paper: Non-Aboriginal heritage) for details on the heritage structures potentially impacted.

Where vibration intensive works occur within the minimum working distances, the risk of structural damage or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Table 10-13 Number of receiver buildings within minimum working distances for vibration intensive work – White Bay construction support site (early works)

NCA	Number of receiver buildings within minimum working distances for vibration intensive work		
	Cosmetic damage		Human response
	Heritage item structure	Sound structure	
9.1	1	–	3
9.2	–	–	2

10.6.6 Yurulbin Point (WHT4)

Overview

The Yurulbin Point construction support site would consist of a combined land and water-based site, located at the end of Louisa Road in Yurulbin Park, Birchgrove. This site would be used to support excavation of the mainline tunnels (including for connection to the immersed tube tunnel crossing). Access for plant and equipment required to excavate the tunnels would be via an access shaft constructed on the lower portion of the site and located within an acoustic shed. The mainline tunnels would be excavated in both directions from this construction support site. The works would take about four years and six months.

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.

Up to two residential receiver buildings are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)) when rock-hammers, chainsaws and mulchers are in use as part of the early works.

During standard construction hours, up to 229 residential receiver buildings in NCAs 11.4, 12.1 and 13.1 are predicted to experience noise levels above the noise management level mostly during early and site establishment works and during piling for acoustic sheds; however, most receivers (93 per cent) would experience increases of less than 10 dB(A).

Outside standard construction hours, tunnel construction and fitout works would occur. No residential receiver buildings are predicted to experience noise levels above the noise management level.

Maximum noise levels at night could exceed the sleep disturbance screening level at up to 79 receiver buildings from occasional barge concrete unloads. Up to nine of these receivers are predicted to be exposed to maximum noise levels above the awakening reaction level.

For non-residential receivers, one recreational receiver located in NCA 13.1 is predicted to experience noise levels above the noise management level by up to 2 dB(A) during early works.

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 are provided in Section 10.9.

Table 10-14 Number of residential receiver buildings over the noise management levels during construction at Yurulbin Point (reasonable worst case noise intensity scenario)

Stage activity	Highly noise affected (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])	
	>75 dB(A)[3]	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	**2**	**212**	**12**	**5**	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Establish site	0	**113**	**15**	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Establishment of construction facilities	0	**28**	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Piling for acoustic sheds	0	**103**	**4**	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Acoustic shed construction	0	**40**	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Shaft construction	0	**11**	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tunnelling	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**79**	**9**

Stage activity	Highly noise affected (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])	
	>75 dB(A)[3]	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 fitout	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**79**	**9**
Restore site	0	**8**	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

Cumulative airborne construction noise

There is potential for timeline overlaps with the nearby Sydney Harbour south cofferdam and Sydney Harbour north cofferdam (and associated dredging), and Berrys Bay construction support sites.

Cumulative construction noise has the potential to increase overall duration and frequency of construction noise impacts in the same receivers.

During standard construction hours, noise management levels would not be exceeded from concurrent construction works at other construction support sites.

Outside standard construction hours, dredging would be the main source of construction noise. However, dredging would be short in duration and intermittent.

Cumulative airborne construction noise impacts would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Construction traffic noise

Access and deliveries to and from the site would be via water. No road traffic movements would be generated at the site.

Construction ground-borne noise

Ground-borne noise levels have not been assessed for the works at the construction support site because airborne noise levels would be dominant over ground-borne noise levels for these works. Management of the airborne noise impacts would also sufficiently manage any associated ground-borne noise impacts.

For the construction of the shaft to access the mainline tunnel, ground-borne noise levels are predicted to be between 35 and 40 dB(A) at six receivers, between 40 and 45 dB(A) at two receivers, and greater than 45 dB(A) at one receiver. All these receivers are located in NCAs 6.1. These exceedances have the potential to exceed the night time and evening timed ground-borne noise management levels. Shaft construction work would be programmed to avoid or reduce ground-borne noise level exceedances on sensitive receivers' buildings where feasible and reasonable.

Construction vibration

Table 10-15 shows three heritage structures in NCA 12.1 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 occur during early works and site establishment, piling for acoustic shed and shaft construction. Refer to Appendix G (Technical working paper: Noise and vibration) and Appendix J (Technical working paper: Non-Aboriginal heritage) for details on the heritage structures potentially impacted.

Where vibration intensive works occur within the minimum working distances, the risk of structural damage or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Table 10-15 Number of receiver buildings within minimum working distances for vibration intensive work – Yurulbin Point construction support site

NCA	Number of receiver buildings within minimum working distances for vibration intensive work		
	Cosmetic damage		Human response
	Heritage item structure	Sound structure	
12.1	4	0	21

10.6.7 Sydney Harbour crossing (WHT5 and WHT6)

Construction works summary

The Sydney Harbour south cofferdam (WHT5) and Sydney Harbour north cofferdam (WHT6) construction support sites would be located at either end of the immersed tube tunnel crossing of Sydney Harbour, at Long Nose Point, Birchgrove adjacent to Yurulbin Park in the west, and at Balls Head, Waverton next to the disused Balls Head coal loader in the east. The cofferdams are temporary structures that would facilitate construction of the underwater interface structures between the driven mainline tunnels and the immersed tube tunnel units.

Key activities that would occur on, or be supported by Sydney Harbour south cofferdam (WHT5) and Sydney Harbour north cofferdam (WHT6) construction support sites would include:

- Construction of temporary cofferdam structure, including ground treatment, piling, dewatering and excavation
- Construction of the interface structure within the cofferdams
- Removal of cofferdam structure and site rehabilitation
- Construction support from the water, including the use of moored work barges, as well as barge movements for removal and transfer of dredged marine sediment and rock, deliveries and staff transport
- Dredging and gravel placement
- Installation of immersed tube tunnel units.

The Sydney Harbour crossing works would take about four years and three months.

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 from the Sydney Harbour south cofferdam (WHT5) and the Sydney Harbour north cofferdam (WHT6) construction support sites as well as construction activities associated with the installation of the immersed tube tunnel.

Up to six residential receiver buildings are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)) during impact piling (also known as hammer piling) for the installation of the Sydney Harbour south cofferdam. Impact piling would take place one to two hours per day or five to six hours on a single day per week over three months.

During standard construction hours, up to 545 residential receiver buildings across various NCAs are predicted to experience noise levels greater than the noise management level; however, most receivers (93 per cent) would experience exceedances of less than 10 dB(A). The majority of noise affected receivers during standard construction hours result from the installation of the Sydney Harbour north and south cofferdams.

Tube tunnel units foundation preparation (ie use of trailer suction hopper dredge) and tube tunnel units immersion would be required during out of hours work. A typical immersion process for one immersed tube tunnel unit would take 24 to 48 hours. When these activities occur at night, up to 138 residential receiver buildings in NCAs 11.4, 12.1, 13.1, 13.2, 14.1 and 15.1 are predicted to exceed noise management levels; however, the majority of the exceedances (86 per cent) would be less than 5 dB(A).

Maximum noise levels at night could exceed the sleep disturbance screening level at up to 102 receiver buildings across several NCAs from the immersion of tube tunnel units. Seven of these receivers are predicted to be exposed to maximum noise levels above the awakening reaction level.

The following non-residential receivers are predicted to experience noise levels above the noise management level during the construction of the Sydney Harbour south cofferdam and Sydney Harbour north cofferdam:

- Up to three recreational receivers located in NCAs 11.4, 12.1 and 13.1 with exceedances of the noise management level by up to 15 dB(A)
- Two other sensitive receivers located in NCA 13.2 with exceedances of the noise management level by up to 6 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 are provided in Section 10.9.

Table 10-16 Number of residential receiver buildings over the noise management levels during construction at Sydney Harbour (reasonable worst case noise intensity scenario)

Stage activity	Highly noise affected (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])	
	>75 dB(A)[3]	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
Build Sydney Harbour north cofferdam	0	**416**	**4**	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Build Sydney Harbour south cofferdam	**6**	**505**	**34**	**6**	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Dewater cofferdams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Excavate cofferdams	0	**6**	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cast transition structures	0	**6**	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Remove cofferdams	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Prepare foundations	0	**6**	0	0	**6**	0	0	0	**6**	0	0	0	**46**	**7**	0	0	**6**	0

Stage activity	Highly noise affected (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])	
	>75 dB(A)[3]	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
Immerse elements	0	**1**	0	0	**18**	**1**	0	0	**22**	**3**	0	0	**119**	**19**	0	0	**102**	**7**

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

Cumulative airborne construction noise

There is potential for cumulative increases in construction noise from concurrent works with the construction support sites at Yurulbin Point and Berrys Bay, as well as with the Barangaroo construction support site for Sydney Metro Chatswood to Sydenham project.

At some sensitive receiver buildings in NCA 14.1, there is the potential for cumulative construction noise to be 3 dB(A) higher than predicted construction noise from any one site. However, cumulative noise impacts are not expected to be significant because:

- Impact piling at the Sydney Harbour Crossing would be short in duration and intermittent
- Tunnel element immersion would take place continuously over 48 hours
- Increases in cumulative construction noise is not likely to occur at the most affected receivers.

Cumulative airborne construction noise impacts would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Construction traffic noise

The Sydney Harbour crossing would be accessed by barges, usually from the construction support site at White Bay and therefore there would be no construction road traffic impacts associated with the Sydney Harbour south cofferdam (WHT5) and Sydney Harbour north cofferdam (WHT6) construction support sites.

It is expected that noise associated with barge movements would not cause substantial amenity of sleep disturbance impacts.

Construction ground-borne noise

Ground-borne noise levels have not been assessed for the works at Sydney Harbour because airborne noise levels would be dominant over ground-borne noise levels for these works. Management of the airborne noise impacts would also sufficiently manage any associated ground-borne noise impacts.

Construction vibration

Table 10-17 shows 17 heritage structures in NCAs 12.1 and 14.1 are predicted to be within the minimum working distances for major vibration-generating activities. The most vibration intensive activity is likely to be impact piling and vibratory piling for the installation of the Sydney Harbour north and Sydney Harbour south cofferdams and cofferdam excavation. Refer to Appendix G (Technical working paper: Noise and vibration) and Appendix J (Technical working paper: Non-Aboriginal heritage) for details on the heritage structures potentially impacted.

Where vibration intensive works occur within the minimum working distances, the risk of structural damage or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Table 10-17 Number of receiver buildings within minimum working distances for vibration intensive work – Sydney Harbour cofferdam construction support sites

NCA	Number of receiver buildings within minimum working distances for vibration intensive work		
	Cosmetic damage		Human response
	Heritage item structure	Sound structure	
12.1	6	–	50
14.1	14	–	22

10.6.8 Berrys Bay (WHT7)

Construction works summary

The Berrys Bay construction support site would be a combined land and water-based site at Berrys Bay, Waverton. The site would be used to establish a tunnel construction access decline located within an acoustic shed to support excavation of the mainline tunnels (including for connection to the immersed tube tunnel crossing). The mainline tunnels would be excavated in both directions from this site using roadheaders. The works would take about four years and six months.

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.

One residential receiver building is predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)) when rock-hammers are in use as part of the early works and access decline construction.

During standard construction hours, up to 92 residential receiver buildings in NCAs 14.1 and 15.1 are predicted to experience noise levels above the noise management level mostly during early works and during piling for acoustic sheds; however, the majority of receivers (80 per cent) would experience increases of less than 10 dB(A).

Outside standard construction hours, tunnel construction and fitout works would occur. When these activities occur at night, one residential receiver building is predicted to experience noise levels less than 5 dB(A) above the noise management level.

Maximum noise levels at night could exceed the sleep disturbance screening level at up to 25 receiver buildings from occasional concrete delivery trucks and truck unloads supporting the tunnel construction and fitout. Up to two of these receivers are predicted to be exposed to maximum noise levels above the awakening reaction level.

For non-residential receivers, one recreational receiver located in NCA 14.1 is predicted to experience noise levels above the noise management level during early works by up to 4 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 are provided in Section 10.9.

Table 10-18 Number of residential receiver buildings over the noise management levels during construction at Berrys Bay (reasonable worst case noise intensity scenario)

Stage activity	Highly noise affected (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])	
	>75 dB(A)[3]	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**	**74**	**14**	**4**	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Establish site	0	**18**	**5**	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Establishment of construction facilities	0	**10**	**6**	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Piling for decline and shed	0	**23**	**9**	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Decline construction	**1**	**7**	**7**	**2**	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Acoustic shed construction	0	**11**	**6**	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Tunnelling	0	**4**	0	0	0	0	0	0	0	0	0	0	**1**	0	0	0	**25**	**2**

Stage activity	Highly noise affected (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])	
	>75 dB(A)[3]	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 fitout	0	**4**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**25**	**2**
Restore site	0	**5**	**6**	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

Cumulative airborne construction noise

There is potential for timeline overlaps with the nearby Sydney Harbour south cofferdam and Sydney Harbour north cofferdam (and associated dredging), and Yurulbin Point construction support sites.

Cumulative construction noise has the potential to increase overall duration and frequency of construction noise impacts on the same receivers.

During standard construction hours and outside standard construction hours, noise management levels have the potential to be exceeded from concurrent construction works at other construction support sites.

Cumulative airborne construction noise impacts would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Construction traffic noise

Construction road traffic management and vehicle movements associated with the Berrys Bay construction support site are likely to increase road traffic noise levels by more than 2 dB(A) at receivers along Balls Head Road and Bay Road and potentially exceed the local road noise criteria by up to 6 dB(A) during the daytime period and up to 7 dB(A) for the night time period during tunnel construction and fitout.

The number of maximum noise events that could disturb sleep are predicted to exceed the sleep disturbance screening level and the awakening reaction level at receivers along Balls Head Road and Bay Road.

Construction traffic noise impacts would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Construction ground-borne noise

Ground-borne noise levels have not been assessed for the works at the construction support site because airborne noise levels would be dominant over ground-borne noise levels for these works. Management of the airborne noise impacts would also sufficiently manage any associated ground-borne noise impacts.

For the construction of the access decline tunnel between the construction support site at Berrys Bay and the mainline tunnel alignment, ground-borne noise levels are predicted to be between 35 and 40 dB(A) at two receivers located in NCA 14.1. These exceedances have the potential to exceed the night time ground-borne noise management levels. Access decline tunnel work would be programmed to avoid or reduce ground-borne noise level exceedances on sensitive receivers' buildings where feasible and reasonable.

Construction vibration

Table 10-19 shows ten heritage structures in NCA 14.1 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 site establishment when rock-hammers are used. Refer to Appendix G (Technical working paper: Noise and vibration) and Appendix J (Technical working paper: Non-Aboriginal heritage) for details on the heritage structures potentially impacted.

Where vibration intensive works occur within the minimum working distances, the risk of structural damage or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Table 10-19 Number of receiver buildings within minimum working distances for vibration intensive work – Berrys Bay construction support site (site establishment)

NCA	Number of receiver buildings within minimum working distances for vibration intensive work		
	Cosmetic damage		Human response
	Heritage item structure	Sound structure	
14.1	10	4	18

10.6.9 Berry Street North (WHT8)

The Berry Street north construction support site would be located within the Warringah Freeway corridor at North Sydney between the Berry Street on ramp and Warringah Freeway to the east and high rise residential buildings to the west. The site would be used to provide support for construction of the Berry Street on ramp to the Western Harbour Tunnel, including cut and cover structures, tunnel portal and widening of the northbound carriageway of the Warringah Freeway.

Construction noise impacts from this construction support site have been assessed as part of the Warringah Freeway Upgrade in Section 10.7.2.

10.6.10 Ridge Street north (WHT9)

The Ridge Street north construction support site would be located in the south eastern corner of St Leonards Park in North Sydney and bound by the Warringah Freeway to the east and Ridge Street to the south. The site would be used to enable construction of the cut and cover and trough portion of the Western Harbour Tunnel off ramp to Falcon Street, surface works required to integrate the Falcon Street off ramp and the Ridge Street shared user bridge.

Construction noise impacts from this construction support site have been assessed as part of the Warringah Freeway Upgrade in Section 10.7.2.

10.6.11 Cammeray Golf Course (WHT10 and WFU8)

This section assesses construction noise and vibration impacts from the Western Harbour Tunnel Cammeray Golf Course (WHT10) construction support site and the Warringah Freeway Upgrade Cammeray Golf Course (WFU8) construction support site.

Construction works summary

The Cammeray Golf Course (WHT10 and WFU8) construction support sites would be located within the south-east portion of the Cammeray Golf Course at Cammeray.

The Cammeray Golf Course (WHT10) construction support site would support the majority of tunnel excavation north of Sydney Harbour for the Western Harbour Tunnel. This would include

excavation of a tunnel construction access decline located within an acoustic shed, ramp tunnels, mainline tunnels and ventilation tunnels. The Cammeray Golf Course (WFU8) construction support site would act as the main project management construction compound for the Warringah Freeway Upgrade. It would support the use of the other Warringah Freeway Upgrade construction support sites, and would also provide a temporary bus layover area during the construction period when the existing Warringah Freeway bus layover area is removed and relocated. The works would take about four years and nine months.

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.

Up to 12 residential receiver buildings are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)) during site establishment while vegetation is being removed on the southern end of the site.

During standard construction hours, up to 253 residential receiver buildings in NCAs 23.1, 23.2, 24.1, 25.1, 26.1, 27.1, 28.1 and 29.1 are predicted to experience noise levels above the noise management level mostly during early and site establishment works; however, most receivers (94 per cent) would experience increases of less than 10 dB(A).

Outside standard construction hours, surface road works support, tunnel construction and fitout, and motorway facility works would occur. When tunnel construction and fitout activities occur at night, one residential receiver building in NCA 24.1 is predicted to experience noise levels above the noise management level. This would be an exceedance of less than 5 dB(A).

Maximum noise levels at night could exceed the sleep disturbance screening level at up to 146 receiver buildings from occasional truck movements in and out the construction support site and from occasional clangs and bangs from general site activities. Up to two of these receivers are predicted to be exposed to maximum noise levels above the awakening reaction level.

For non-residential receivers:

- Up to three childcare receivers located in NCAs 22.3, 23.2 and 28.1 are predicted to experience noise levels above the noise management level by up to 14 dB(A) during early works, site establishment and site restoration
- Up to four educational receivers with buildings located in NCAs 22.1, 22.3 and 25.1 are predicted to experience noise levels above the noise management level by up to 12 dB(A) during early works and site establishment
- Up to seven recreational receivers located in NCAs 25.1, 26.2 and 28.1 are predicted to experience noise levels above the noise management level by up to 18 dB(A) during early works, site establishment, construction of decline and shed, surface work support and restoration works
- One place of worship receiver located in NCA 28.1 is predicted to experience noise levels above the noise management level by up to 7 dB(A) during site establishment
- One other sensitive receiver located in NCA 26.1 is predicted to experience noise levels above the noise management level by up to 10 dB(A) during site establishment.

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 are provided in Section 10.9.

Table 10-20 Number of residential receiver buildings over the noise management levels during construction at Cammeray Golf Course (reasonable worst case noise intensity scenario)

Stage activity	Highly noise affected (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])	
	>75 dB(A)[3]	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	**15**	**2**	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Establish site	**12**	**237**	**16**	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Build decline and shed and surface work support	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**56**	**2**
Tunnelling and surface work support	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	0	**146**	**2**
Tunnel fitout and surface work support	0	0	0	0	0	0	0	0	0	0	0	0	**1**	0	0	0	**57**	**2**
Build operational motorway facilities and surface work support	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**56**	**2**
Motorway facilities fitout	0	0	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Stage activity	Highly noise affected (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])	
	>75 dB(A)[3]	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
Restore site	0	**14**	**3**	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

Cumulative airborne construction noise

There is potential for cumulative increases in construction noise from the concurrent delivery of the Warringah Freeway Upgrade surface road works.

At sensitive receiver buildings not directly adjacent to the Cammeray Golf Course construction support site, there is potential for cumulative increases in construction noise from concurrent works at the Warringah Freeway Upgrade surface road works. However, cumulative construction noise would be below the noise management levels.

Cumulative airborne construction noise impacts would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Construction traffic noise

Construction road traffic management and vehicle movements associated with the Cammeray Golf Course construction support site 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 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 is not likely to increase substantially.

Construction ground-borne noise

Ground-borne noise levels have not been assessed for the works at the construction support site because airborne noise levels would be dominant over ground-borne noise levels for these works. Management of the airborne noise impacts would also sufficiently manage any associated ground-borne noise impacts.

For the construction of the access decline tunnel between the construction support site at Cammeray Golf Course and the mainline tunnel alignment, ground-borne noise levels are predicted to be between 35 and 40 dB(A) at three receivers located in NCAs 23.1 and 26.1, and between 40 and 45 dB(A) at four receivers located in NCAs 23.1 and 23.2.
These exceedances have the potential to exceed the night time and/or evening timed ground-borne noise management levels. Access decline tunnel work would be programmed to avoid or reduce ground-borne noise level exceedances on sensitive receivers' buildings where feasible and reasonable.

Construction vibration

Table 10-21 shows one heritage structure in NCA 26.2 is predicted to be within the minimum working distances for major vibration-generating activities. The major activity at Cammeray Golf Course that would include vibration intensive works would be associated with the use of rock-hammers during early works, demolition during site establishment works or the construction of the acoustic shed. Refer to Appendix G (Technical working paper: Noise and vibration) and Appendix J (Technical working paper: Non-Aboriginal heritage) for details on the heritage structures potentially impacted.

Where vibration intensive works occur within the minimum working distances, the risk of structural damage or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Table 10-21 Number of receiver buildings within minimum working distances for vibration intensive work – Cammeray Golf Course construction support site (early works and site establishment)

NCA	Number of receiver buildings within minimum working distances for vibration intensive work		
	Cosmetic damage		Human response
	Heritage item structure	Sound structure	
23.1	0	0	5
26.1	0	0	9
26.2	1	0	0
28.1	0	0	18
29.1	0	6	9

10.6.12 Waltham Street (WHT11)

Construction works summary

The Waltham Street construction support site would be located within the Artarmon industrial area, between Waltham Street to the west, Gore Hill Freeway to the north, Hampden Road to the east and industrial buildings to the south. The site would be used to construct the motorway control centre for Western Harbour Tunnel, and for equipment laydown, car parking for construction workers and temporary site office buildings. The works would take about two years and three months.

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 residential receiver buildings are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)).

During standard construction hours, up to nine residential receiver buildings in NCA 33.1 are predicted to experience noise levels above the noise management level; however, all nine receivers would experience increases of less than 10 dB(A).

Outside standard construction hours, the site would support the installation of the communication cable between the Western Harbour Tunnel mainline tunnel at Cammeray and the motorway control centre. No residential receiver buildings are predicted to experience noise levels above the noise management level.

Maximum noise levels at night are not predicted to exceed the sleep disturbance screening or the awakening reaction level.

For non-residential receivers:

- Up to four commercial receivers in NCA 33.2 are predicted to experience noise levels above the noise management level by up to 18 dB(A) during early works
- Up to three childcare receivers in NCA 33.1 are predicted to experience noise levels above the noise management level by up to 2 dB(A) during early works
- One educational receiver with buildings in NCA 33.1 is predicted to experience noise levels above the noise management level by up to 4 dB(A) during early works
- One other sensitive receiver located in NCA 33.1 is predicted to experience noise levels above the noise management level by up to 1 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 are provided in Section 10.9.

Table 10-22 Number of residential receiver buildings over the noise management levels during construction at Waltham Street (reasonable worst case noise intensity scenario)

Stage activity	Highly noise affected (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])	
	> 75 dB(A)[3]	1 – 10 dB(A)	11 – 20 dB(A)	> 20 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)	1 – 5 dB(A)	6 – 15 dB(A)	16 – 25 dB(A)	> 25 dB(A)	Screening	Awakening
Build operational motorway facilities	0	**9**	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

Cumulative airborne construction noise

There is potential for cumulative increases in construction noise from concurrent works with the Gore Hill Freeway Connection surface road works which is part of the Beaches Link and Gore Hill Freeway Connection project.

Cumulative impacts during standard construction hours are likely to occur in some receivers in NCA 33.2 when noise intensive works occur concurrently.

Cumulative airborne construction noise impacts would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Construction traffic noise

Road traffic noise levels at receivers directly exposed to traffic noise on construction haulage and traffic routes are predicted to increase by less than 2 dB(A). This change represents a minor impact that is likely to be barely perceptible.

Construction vibration

Table 10-23 shows one receiver buildings falls within the minimum working distance for cosmetic damage (sound structures) and 11 for human response.

Where vibration intensive works occur within the minimum working distances, the risk of structural damage or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Table 10-23 Number of receiver buildings within minimum working distances for vibration intensive work – Waltham Street construction support site

NCA	Number of receiver buildings within minimum working distances for vibration intensive work		
	Cosmetic damage		Human response
	Heritage item structure	Sound structure	
33.1	0	0	2
33.2	0	1	9

10.7 Assessment of potential impacts – Warringah Freeway Upgrade

10.7.1 Overview

This section provides an assessment of the potential noise and vibration impacts associated with the Warringah Freeway Upgrade.

Temporary construction support sites for the Warringah Freeway Upgrade would be needed to assist with surface earthworks, bridgeworks, construction of retaining walls, installation of

stormwater drainage and pavement construction. The assessment of airborne noise impacts from these sites is provided in Section 10.7.2.

The assessment of airborne noise impacts from works in areas other than construction support sites is provided in Section 10.7.3.

Cumulative airborne construction noise, construction traffic noise, construction ground-borne noise and construction vibration assessments are presented in Section 10.7.4, Section 10.7.5, Section 10.7.7 and Section 10.7.8, respectively.

10.7.2 Airborne noise impacts from construction support sites

Construction works summary

Table 10-24 describes the key construction activities proposed at the Warringah Freeway Upgrade construction support sites.

Table 10-24 Construction works summary – Warringah Freeway Upgrade construction support sites

Support site	Construction works summary
Blue Street (WFU1)	The site would be located in North Sydney on land bound by the Pacific Highway to the east and south, North Shore railway line to west and Blue Street to the north. The site would support various construction activities at the southern end of the Warringah Freeway Upgrade, including bridgeworks and surface and pavement works.
High Street south (WFU2)	The site would be located within the Warringah Freeway corridor at North Sydney on land bound by Alfred Street North/Cahill Expressway to the west and High Street to the north, south and east. The site would be used to support construction activities for the High Street interchange upgrade, including bridge and surface works, as well as for the widening and surface works in the southern portion of the Warringah Freeway Upgrade.
High Street north (WFU3)	The site would be located in North Sydney on land bound by Alfred Street North/Cahill Expressway to the west and High Street to the north, south and east. The site would be used to support construction activities for the High Street interchange upgrade, including bridgeworks, as well as for the widening and surface works in the southern portion of the Warringah Freeway Upgrade.
Arthur Street east (WFU4)	The site would be located within the Warringah Freeway corridor at North Sydney and is bound by the Warringah Freeway to the east, Arthur Street to the west, Mount Street to the north and High Street in the south. The site would be used to support construction activities for the widening of the Warringah Freeway, and local road and intersection works along and near Arthur Street.
Berry Street east (WFU5)	The site would be located within the Warringah Freeway corridor at North Sydney on land bound by the Warringah Freeway to the east, Arthur Street and Berry Street/Warringah Freeway on ramp to the west and Doris Fitton Park to the south along Arthur Street to the west. The site would be used to support construction activities for the widening of the Warringah Freeway and surface road works associated with the Berry Street on ramp to the Western Tunnel.

Support site	Construction works summary
Berry Street north (WHT8)[1]	The Berry Street north construction support site would be located within the Warringah Freeway corridor at North Sydney between the Berry Street on ramp and Warringah Freeway to the east and high rise residential buildings to the west. The site would be used to provide support for construction of the Berry Street on ramp to the Western Harbour Tunnel, including cut and cover structures, tunnel portal and widening of the northbound carriageway of the Warringah Freeway.
Ridge Street east (WFU6)	The site would be located within the Warringah Freeway corridor at North Sydney on land bound by the Warringah Freeway to the east, residential properties on Ridge Street to the south and west and St Leonards Park to the north. The site would be used to support construction activities for the demolition of the existing Ridge Street pedestrian bridge and construction of an upgraded Ridge Street shared user bridge.
Ridge Street north (WHT9)[1]	The Ridge Street north construction support site would be located in the south-eastern corner of St Leonards Park, North Sydney and bound by the Warringah Freeway to the east and Ridge Street to the south. The site would be used to enable construction of the cut and cover and trough portion of the Western Harbour Tunnel off ramp to Falcon Street, surface works required to integrate the Falcon Street off ramp and the Ridge Street shared user bridge.
Merlin Street (WFU7)	The site would be located in Neutral Bay on the eastern side of Warringah Freeway within Merlin Street Reserve (owned by Transport for NSW) on land bound by residential properties to the north, Merlin Street to the east, Alfred Street to the south and McIntosh Lane and Warringah Freeway to the west. The site would be used to support construction activities for the realignment of Alfred Street North and construction of the new southbound bus lane bridge off Falcon Street.
Cammeray Golf Course (WFU8)	Given its proximity to the Western Harbour Tunnel Cammeray Golf Course (WHT10) construction support site, the proposed location, use and construction impacts from Cammeray Golf Course (WFU8) construction support site has been assessed in section 10.6.11.
Rosalind Street east (WFU9)	The site is located within the Warringah Freeway corridor at Cammeray on land bound by the Warringah Freeway northbound off ramp at Miller Street to the north and east, Rosalind Street to the south and Miller Street to the west. The site would be used to support the construction of the northern portion of the Warringah Freeway Upgrade, as well as local road and intersection upgrades and changes near Miller Street and Amherst Street.

Note 1: Berry Street north construction support site and Ridge Street north construction support site are Western Harbour Tunnel sites. These sites have been assessed in this section because they would support various activities within or near the Warringah Freeway corridor.

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 for the reasonable worst case noise intensity scenario.

During standard construction hours, the majority of the construction support sites are predicted to have less than seven residential receiver buildings experiencing noise levels above the noise

management level. The exception would be High Street north construction support site which would have up to 14 residential receiver buildings predicted to experience noise levels above the noise management level, and Berry Street north construction support sites which would have up to 18.

During night time activities for the Warringah Freeway Upgrade, construction support site noise levels are predicted to exceed the noise management level at various nearby receiver buildings.

Maximum noise levels could exceed the sleep disturbance screening level, including the level where there is the potential for an awakening reaction.

Where noise management levels are exceeded, there is a requirement to implement reasonable and feasible noise mitigation. The construction support sites would typically operate in conjunction with the Warringah Freeway Upgrade surface road works being carried out along the road corridor, which are often impacting the same receiver buildings. Mitigation and management measures to be implemented for the Warringah Freeway Upgrade surface road works would assist to manage construction noise impacts on these receiver locations, and further on-site mitigation in and around the construction support sites would typically not assist in reducing the overall construction noise levels at these receivers.

Measures to avoid, minimise and mitigate the potential noise impacts from construction works are provided in Section 10.9.

Table 10-25 Number of residential receiver buildings over the noise management levels during construction (reasonable worst case noise intensity scenario)

Location	Daytime (standard)	Daytime (outside standard)	Evening	Night	Sleep disturbance, awakening (L_{Amax})[1]
Blue Street (WFU1)	**6**	**6**	**6**	**9**	**6**
High Street south (WFU2)	0	0	0	**20**	**21**
High Street north (WFU3)	**14**	**14**	**22**	**57**	**51**
Arthur Street east (WFU4)	**1**	**1**	**3**	**13**	**9**
Berry Street east (WFU5)	0	0	0	**10**	**7**
Berry Street north (WHT8)[2]	**18**	**18**	**22**	**31**	**28**
Ridge Street east (WFU6)	**4**	**4**	**4**	**15**	**13**
Ridge Street north (WHT9)[2]	**3**	**3**	**3**	**18**	**15**
Merlin Street (WFU7)	**1**	**1**	**5**	**34**	**33**

Location	Daytime (standard)	Daytime (outside standard)	Evening	Night	Sleep disturbance, awakening (L_{Amax})[1]
Jeaffreson Jackson Reserve construction area[3]	3	3	10	72	44
Merlin Street north construction area[3]	1	2	10	59	24
Rosalind Street east (WFU9)	2	1	7	96	25

Note 1: L_{Amax} is the maximum A-weighted sound pressure level measured over a given period.

Note 2: Berry Street north construction support site and Ridge Street north construction support site are Western Harbour Tunnel sites. These sites have been assessed in this section because they would support various activities within or near the Warringah Freeway corridor.

Note 3: These are two small areas supporting the Falcon Street shared user bridge works. There are no formalised construction support sites.

10.7.3 Airborne noise impacts from works in areas other than construction support sites

The assessment of air-borne noise impacts from Warringah Freeway Upgrade works in areas other than construction has been carried out for the following major work areas:

- High Street interchange upgrade
- Warringah Freeway northbound widening
- Alfred Street North and Mount Street interchange modification and grade separation works
- Warringah Freeway southbound widening
- Berry Street on ramp works
- Ridge Street shared user bridge
- Falcon Street off ramp cut and cover
- Falcon Street interchange upgrade
- Falcon Street to Miller Street
- Miller Street to Willoughby Road.

High Street interchange upgrade

Construction works summary

The High Street interchange site is located at the southern end of the Warringah Freeway at North Sydney. Key construction activities would include widening of the existing bridge on the southern side and the construction of a new northbound on ramp. The works would take about one year and six months.

Construction airborne noise

Table 10-26 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels during typical construction noise intensive work scenario. Refer to Appendix G (Technical working paper: Noise and vibration) for noise predictions for the worst case construction noise intensive work scenario.

No residential receiver buildings are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)) during typical or worst case works.

During standard construction hours:

- For typical works, up to six residential receiver buildings are predicted to exceed the noise management level; however, exceedances are predicted to be below 10 dB(A)
- For worst case construction works, up to 67 residential receiver buildings are predicted to exceed the noise management level; however, the majority of these receivers (91 per cent) would experience exceedances below 10 dB(A) due to the existing high ambient noise levels controlled by the Warringah Freeway.

Outside standard construction hours, the key noise generating activities are likely to be concrete formwork construction, bored piling and road furniture installation activities. When these activities occur at night:

- For typical works, up to 53 residential receiver buildings are predicted to exceed the noise management level; however, the majority of these receivers (83 per cent) would experience exceedances below 5 dB(A). All exceedances are predicted to be below 15 dB(A)
- For worst case construction works, up to 247 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (97 per cent) would experience exceedances below 15 dB(A). Night time exceedances would occur only when bored piling activities are carried out.

The most likely source of potential sleep disturbance from night construction works would be from truck air-brakes, or metal-on-metal bangs from truck loads moving or shifting. The predicted maximum noise levels show exceedances of the sleep disturbance screening level at various receiver buildings for both typical and worst case construction works. Noise levels may exceed the awakening reaction levels for:

- Up to 26 residential receiver buildings during typical construction works
- Up to 49 residential receiver buildings during worst case construction work.

Noise management level exceedances may occur at the following non-residential receivers:

- Up to six commercial receivers located in NCA 16.3 for worst case construction works
- One childcare receiver located in NCA 16.3 for typical construction works, and up to four childcare receivers in NCAs 15.3, 16.3 and 17.1 for worst case construction works
- One educational receiver with buildings located in NCA 15.3 for worst case construction works
- Up to two recreational receivers in NCA 17.3 for worst case construction works
- Up to two place of worship receivers located in NCAs 15.4 and 16.1 for worst case construction works
- Up to two other sensitive receivers located in NCAs 16.2 and 18.1 for worst case construction works.

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 are provided in Section 10.9.

Table 10-26 Number of residential receiver buildings over the noise management levels during construction at High Street interchange (typical noise intensity scenario)

Description of construction works	Highly noise affected	Daytime (standard) (L_{Aeq}[1])			Daytime (outside standard) (L_{Aeq})				Evening (L_{Aeq})				Night (L_{Aeq})				Sleep disturbance (L_{Amax}[2])	
	>75 dB(A)[3]	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
High Street Bridge widening (Stage 1)	0	**6**	0	0	**4**	0	0	0	**6**	0	0	0	**40**	**8**	0	0	**40**	**23**
High Street Bridge widening (Stage 2)	0	**6**	0	0	**4**	0	0	0	**7**	0	0	0	**41**	**8**	0	0	**43**	**26**
Construction of the new northbound on ramp	0	**6**	0	0	**5**	**3**	0	0	**9**	**4**	0	0	**37**	**12**	0	0	**33**	**5**
Ramp modification works	0	**6**	0	0	**6**	**3**	0	0	**9**	**4**	0	0	**44**	**9**	0	0	**47**	**7**

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

Warringah Freeway northbound widening

Construction works summary

The Warringah Freeway northbound widening works are located on the western side of the Warringah Freeway, near the High Street interchange. The works would take about six months.

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 during typical construction noise intensive work scenario. Refer to Appendix G (Technical working paper: Noise and vibration) for noise predictions for the worst case construction noise intensive work scenario.

No residential receiver buildings are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)) during typical or worst case works.

During standard construction hours:

- For typical works, up to four residential receiver buildings are predicted to exceed the noise management level; however, exceedances are predicted to be below 10 dB(A)
- For worst case construction works, up to 50 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (92 per cent) would experience exceedances below 10 dB(A).

Outside standard construction hours, the key noise generating activity is likely to be road resurfacing works, when pavement profilers or pavement laying machines are in use. When this activity occurs at night:

- For typical works, up to 67 residential receiver buildings are predicted to exceed the noise management level; however, the majority of these receivers (78 per cent) would experience exceedances below 5 dB(A). All exceedances are predicted to be below 15 dB(A)
- For worst case construction works, up to 511 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (98 per cent) would experience exceedances below 15 dB(A). Night time exceedances would occur only when pavement profilers or pavement laying machines are in use.

The most likely source of potential sleep disturbance from night construction works would be from truck air-brakes, or metal-on-metal bangs from truck loads moving or shifting. The predicted maximum noise levels show:

- During typical works, up to 47 residential receiver buildings are predicted to experience noise above the sleep disturbance screening level. Noise levels may exceed the awakening reaction levels at up to six receiver buildings
- During the worst case construction activities, up to 67 residential receiver buildings are predicted to experience noise above the sleep disturbance screening level. Noise levels may exceed the awakening reaction levels at up to 23 receiver buildings.

Noise management level exceedances may occur at the following non-residential receivers:

- Two commercial receivers located in NCA 16.3 for typical construction works, and ten commercial receivers in NCAs 15.3, 16.3 and 17.1 for worst case construction works
- Two childcare receivers located in NCA 16.3 for typical construction works, and three childcare receivers in NCAs 16.3 and 17.1 for worst case construction works
- One recreational receiver located in NCA 17.3 for worst case construction works

- Two place of worship receivers located in NCAs 15.4 and 16.1 for worst case construction works
- One other sensitive receiver located in NCA 16.3 for typical construction works, and three other sensitive receivers in NCAs 16.3 and 18.1 for worst case construction works.

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 are provided in Section 10.9.

Table 10-27 Number of residential receiver buildings over the noise management levels during Warringah Freeway northbound widening works (typical noise intensity scenario)

Component of construction program	Highly noise affected (L_{Aeq}[1])	Daytime (standard) (L_{Aeq})			Daytime (outside standard) (L_{Aeq})				Evening (L_{Aeq})				Night (L_{Aeq})				Sleep disturbance (L_{Amax}[2])	
	>75 dB(A)[3]	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
New Crows Nest lane northbound on Warringah Freeway	0	**4**	0	0	**9**	0	0	0	**11**	**2**	0	0	**52**	**15**	0	0	**47**	**6**

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

Alfred Street North and Mount Street interchange modification and grade separation works

Construction works summary

The Alfred Street North and Mount Street interchange site is located on the western side of the Warringah Freeway both north and south of the Mount Street interchange.

The key construction activities required as part of the Alfred Street North and Mount Street interchange works include:

- Realignment of Alfred Street North between Merlin Street and Ridge Street footbridge
- Widening of the Warringah Freeway to the east
- Construction of a new Alfred Street North off ramp bridge
- Modifications to Mount Street interchange
- Construction of new Mount Street underpass.

The works would take about two years.

Construction airborne noise

Table 10-28 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels during typical construction noise intensive work scenario. Refer to Appendix G (Technical working paper: Noise and vibration) for noise predictions for the worst case construction noise intensive work scenario.

During typical works, up to five residential receiver buildings are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)) when utility connection work is occurring as part of the realignment of Alfred Street North between Merlin Street and Ridge Street. When worst case construction works occur, there is the potential for up to 26 residential receiver buildings to be highly noise affected.

During standard construction hours:

- For typical works, up to 25 residential receiver buildings are predicted to exceed the noise management level; however, exceedances are predicted to be below 20 dB(A)
- For worst case construction works, up to 129 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (93 per cent) would experience exceedances below 10 dB(A). The highest number of exceedances would occur during pavement and road modification works as part of the widening of the Warringah Freeway to the east.

Outside standard construction hours, the key noise generating activities are likely to be utility connection works, pavement and road modification works and clearing and grubbing works. When these activities occur at night:

- For typical works, up to 315 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (98 per cent) would experience exceedances below 15 dB(A)
- For worst case construction works, up to 2569 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (98 per cent) would experience exceedances below 15 dB(A). The highest number of night time exceedances would occur during pavement and road modification works as part of the realignment of Alfred Street North between Merlin Street and Ridge Street.

The most likely source of potential sleep disturbance from night construction works would be when rock-hammers are used for road excavation or trenching works. The predicted maximum noise levels show:

- During typical works, up to 108 residential receiver buildings are predicted to experience noise above the sleep disturbance screening level. Noise levels may exceed the awakening reaction levels at up to 68 receiver buildings
- During the worst case construction activities, up to 878 residential receiver buildings are predicted to experience noise above the sleep disturbance screening level. Noise levels may exceed the awakening reaction levels at up to 115 receiver buildings.

Noise management level exceedances may occur at the following non-residential receivers:

- Up to three commercial receivers located in NCA 17.3 for typical construction works, and up to two commercial receivers in NCAs 16.3 and 17.3 for worst case construction works
- Up to two childcare receivers located in NCA 16.3 for typical construction works; and three childcare receivers in NCAs 16.2, 16.3 and 23.2 for worst case construction works
- One educational receiver with buildings located in NCA 19.1 for typical construction works; and up to two educational receivers with buildings located in NCAs 19.1 and 21.2 for worst case construction works
- Up to two recreational receivers located in NCAs 17.4 and 23.2 for worst case construction works
- One place of worship receiver located in NCA 22.1 for worst case construction works
- One other sensitive receiver located in NCA 16.3 for typical construction works; and two other sensitive receivers in NCAs 16.3 and 21.2 for worst case construction works.

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 are provided in Section 10.9.

Table 10-28 Number of residential receiver buildings over the noise management levels during construction at Alfred Street North and Mount Street interchange modification and grade separation works (typical noise intensity scenario)

Component of construction program	Highly noise affected (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])	
	>75 dB(A)[3]	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
Realignment of Alfred Street North between Merlin Street and Ridge Street	**5**	**14**	**5**	0	**12**	**14**	**5**	0	**17**	**18**	**5**	0	**86**	**38**	**17**	**5**	**29**	**42**
Widening of the Warringah Freeway to the east (stage 1)	0	**25**	0	0	**34**	**25**	0	0	**35**	**29**	0	0	**183**	**87**	**25**	0	**84**	**68**
Widening of the Warringah Freeway to the east (stage 2)	0	**7**	0	0	**45**	**7**	0	0	**49**	**16**	0	0	**195**	**114**	**6**	0	**108**	**66**
Modifications to Mount Street Interchange	0	**2**	0	0	**9**	**3**	0	0	**11**	**5**	0	0	**38**	**17**	**3**	0	**14**	**9**
New Alfred Street North Bridge	0	**16**	0	0	**15**	**16**	0	0	**19**	**16**	0	0	**76**	**47**	**16**	0	**52**	**46**

Component of construction program	Highly noise affected (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])	
	>75 dB(A)[3]	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
New Mount Street Underpass	0	**18**	0	0	**35**	**26**	**1**	0	**44**	**29**	**2**	0	**153**	**91**	**26**	**1**	**68**	**58**

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

Warringah Freeway southbound widening

Construction works summary

The Warringah Freeway southbound widening is located on the eastern side of the Warringah Freeway north of the Mount Street interchange. The key construction activities required include:

- Construction of a new southbound bus lane bridge from Falcon Street
- Widening of Warringah Freeway to the east.

The works would take about one year.

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 during typical construction noise intensive work scenario. Refer to Appendix G (Technical working paper: Noise and vibration) for noise predictions for the worst case construction noise intensive work scenario.

During typical works, up to four residential receiver buildings are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)) when rock-hammers are used. When worst case construction works occur, there is the potential for up to 28 residential receiver buildings to be highly noise affected.

During standard construction hours:

- For typical works, up to 35 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (94 per cent) would experience exceedances below 10 dB(A). All exceedances are predicted to be below 20 dB(A)
- For worst case construction works, up to 177 residential receiver buildings are predicted to exceed the noise management level; however, the majority of receivers (83 per cent) would experience exceedances below 10 dB(A).

Outside standard construction hours, the key noise generating activities are likely to be utility connection works, pavement and road modification works and clearing and grubbing works. When these activities occur at night:

- For typical works, up to 239 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (92 per cent) would experience exceedances below 15 dB(A)
- For worst case construction works, up to 2262 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (98 per cent) would experience exceedances below 15 dB(A). These exceedances would occur only when utility connection works, pavement and road modification works or clearing and grubbing works are taking place.

The most likely source of potential sleep disturbance from night construction works would be from truck air-brakes, or metal-on-metal bangs from truck loads moving or shifting. The predicted maximum noise levels show:

- During typical works, up to 124 residential receiver buildings are predicted to experience noise above the sleep disturbance screening level. Noise levels may exceed the awakening reaction levels at up to 80 receiver buildings
- During the worst case construction activities, up to 1076 residential receiver buildings are predicted to experience noise above the sleep disturbance screening level. Noise levels may exceed the awakening reaction levels at up to 137 receiver buildings.

Noise management level exceedances may occur at the following non-residential receivers:

- One commercial receiver located in NCA 16.3 for typical construction works, and up to three commercial receivers in NCAs 16.3 and 17.3 for worst case construction works
- Two childcare receivers located in NCA 16.3 for typical construction works, and up to six childcare receivers in NCAs 16.3, 18.3, 22.3 and 23.2 for worst case construction works
- One educational receiver with buildings located in NCA 19.1 for typical construction works; and two educational receivers with buildings in NCAs 19.1 and 21.2 for worst case construction works
- One recreational receiver located in NCA 16.3 for typical construction works, and up to three recreational receivers in NCAs 16.3, 17.4 and 23.2 for worst case construction works
- Up to two place of worship receivers located in NCAs 22.1 and 23.1 for worst case construction works
- One other sensitive receiver located in NCA 16.3 for typical construction works, and up to two other sensitive receivers in NCAs 16.3 and 21.2 for worst case construction works.

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 are provided in Section 10.9.

Table 10-29 Number of residential receiver buildings over the noise management levels – Warringah Freeway southbound widening (typical noise intensity scenario)

Component of construction program	Highly noise affected (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])	
	>75 dB(A)[3]	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
Construction of new bus lane bridge	**3**	**5**	**1**	0	**8**	**4**	0	0	**9**	**8**	**2**	0	**79**	**25**	**8**	**2**	**34**	**23**
Widening Warringah Freeway southbound (north)	**1**	**3**	**1**	0	**4**	**4**	**1**	0	**7**	**6**	**1**	0	**68**	**23**	**6**	**1**	**18**	**18**
Widening Warringah Freeway southbound (middle)	**4**	**12**	**4**	0	**9**	**13**	**5**	0	**10**	**15**	**5**	0	**73**	**33**	**14**	**5**	**30**	**32**
Widening Warringah Freeway southbound (south)	0	**20**	0	0	**29**	**19**	0	0	**35**	**21**	0	0	**136**	**84**	**19**	0	**124**	**80**
Retaining wall construction	**2**	**33**	**2**	0	**15**	**6**	0	0	**18**	**6**	0	0	**55**	**40**	**6**	0	**49**	**39**

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

Berry Street on ramp works

Construction works summary

The Berry Street on ramp and southbound entry to Western Harbour Tunnel is located on the western side of the Warringah Freeway north of Berry Street. The key construction activities include realignment and pavement works and building the trough and portal structure for southbound entry to the Western Harbour Tunnel. The works would take about nine months.

Construction airborne noise

Table 10-30 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels during typical construction noise intensive work scenario. Refer to Appendix G (Technical working paper: Noise and vibration) for noise predictions for the worst case construction noise intensive work scenario.

During typical works, up to five residential receiver buildings are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)) during bulk earthworks or when rock-hammers are used as part of the construction of trough and portal structure. When worst case construction works occur, there is the potential for up to 18 residential receiver buildings to be highly noise affected.

During standard construction hours:

- For typical works, up to 24 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (94 per cent) would experience exceedances below 10 dB(A). All exceedances are predicted to be below 20 dB(A)
- For worst case construction works, up to 42 residential receiver buildings are predicted to exceed the noise management level; however, the majority of receivers (85 per cent) would experience exceedances below 20 dB(A).

Outside standard construction hours, the key noise generating activities are likely to be the use of rock-hammers during ramp realignment and pavement works and the construction of trough and portal structure. When these activities occur at night:

- For typical works, up to 664 residential receiver buildings are predicted to exceed the noise management level; however, the majority of receivers (81 per cent) would experience exceedances below 5 dB(A)
- For worst case construction works, up to 1324 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (97 per cent) would experience exceedances below 15 dB(A). Night time exceedances would occur only when rock-hammers are used.

The most likely source of potential sleep disturbance from night construction works would be from the use of rock-hammers. The predicted maximum noise levels show:

- During typical works, up to 11 residential receiver buildings are predicted to experience noise above the sleep disturbance screening level. Noise levels may exceed the awakening reaction levels at up to 35 receiver buildings
- During the worst case construction activities, up to 532 residential receiver buildings are predicted to experience noise above the sleep disturbance screening level. Noise levels may exceed the awakening reaction levels at up to 73 receiver buildings.

Noise management level exceedances may occur at the following non-residential receivers:

- One commercial receiver located in NCA 16.3 for typical construction works, and up to five commercial receivers in NCA 16.3 for worst case construction works
- Up to two childcare receivers located in NCA 16.3 for typical construction works, and up to two childcare receivers in NCAs 16.3 and 18.3 for worst case construction works
- One educational receiver with buildings located in NCA 19.1 for typical construction works, and two educational receiver with buildings in NCAs 19.1 and 21.2 for worst case construction works
- One recreational receiver located in NCA 16.3 for typical and worst case construction works
- One other sensitive receiver located in NCA 16.3 for worst case construction works.

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 are provided in Section 10.9.

Table 10-30 Number of residential receiver buildings over the noise management levels – Berry Street on ramp works (typical noise intensity scenario)

Component of construction program	Highly noise affected (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])	
	>75 dB(A)[3]	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
Ramp realignment and pavement works west	**4**	**19**	**4**	0	**9**	**14**	**13**	**3**	**10**	**16**	**13**	**3**	**536**	**98**	**21**	**9**	**6**	**30**
Ramp realignment and pavement works east	0	**15**	**1**	0	**12**	**15**	**1**	0	**13**	**16**	1	0	**7**	**25**	**7**	0	**6**	**30**
Construction of trough and portal structure	**5**	**18**	**6**	0	**9**	**14**	**6**	0	**12**	**15**	**6**	0	**12**	**25**	**10**	**3**	**11**	**35**

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

Ridge Street shared user bridge

Construction works summary

The Ridge Street pedestrian bridge site is located over the Warringah Freeway, directly south-east of St Leonards Park in North Sydney. The key construction activities required as part of the Ridge Street construction works stage include construction of a new shared user bridge south of the existing bridge and demolition of the existing shared user bridge. The works would take about one year.

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 during typical construction noise intensive work scenario. Refer to Appendix G (Technical working paper: Noise and vibration) for noise predictions for the worst case construction noise intensive work scenario.

During typical works, no residential receiver buildings are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)). When worst case construction works occur, there is the potential for up to nine residential receiver buildings to be highly noise affected while the construction works occur near these receivers.

During standard construction hours:

- For typical works, up to 13 residential receiver buildings are predicted to exceed the noise management level; however, all receivers would experience exceedances below 10 dB(A)
- For worst case construction works, up to 32 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (97 per cent) would experience exceedances below 10 dB(A).

Outside standard construction hours, the key noise generating activities are likely to be the use of rock-hammers during bridge demolition and construction. When these activities occur at night:

- For typical works, up to 55 residential receiver buildings are predicted to exceed the noise management level; however, the majority of receivers (75 per cent) would experience exceedances below 15 dB(A)
- For worst case construction works, up to 1700 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (98 per cent) would experience exceedances below 15 dB(A). Night time exceedances would occur only when rock-hammers are used.

The most likely source of potential sleep disturbance from night construction works would be from the use of rock-hammers during bridge demolition. The predicted maximum noise levels show:

- During typical works, up to 25 residential receiver buildings are predicted to experience noise above the sleep disturbance screening level. Noise levels may exceed the awakening reaction levels at up to 27 receiver buildings
- During the worst case construction activities, up to 356 residential receiver buildings are predicted to experience noise above the sleep disturbance screening level. Noise levels may exceed the awakening reaction levels at up to 71 receiver buildings.

Noise management level exceedances may occur at the following non-residential receivers:

- Two childcare receivers located in NCA 16.3 for worst case construction works

- One educational receiver with buildings located in NCA 19.1 for typical construction works, and two educational receivers with buildings in NCAs 19.1 and 21.2 for worst case construction works
- One other sensitive receiver located in NCA 21.2 for typical and worst case construction works.

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 are provided in Section 10.9.

Table 10-31 Number of residential receiver buildings over the noise management levels during construction at the Ridge Street shared user bridge (typical noise intensity scenario)

Component of construction program	Highly noise affected (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])	
	>75 dB(A)[3]	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
Construction of shared user bridge	0	**13**	0	0	**4**	**10**	0	0	**4**	**10**	0	0	**27**	**19**	**7**	0	**25**	**19**
Demolition of shared user bridge	–	–	–	–	**7**	**10**	**5**	0	**6**	**11**	**6**	0	**24**	**17**	**10**	**4**	**19**	**27**

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

Falcon Street off ramp cut and cover

Construction works summary

The North Sydney cut and cover site is located on the western side of the Warringah Freeway north of Ridge Street and within St Leonards Park. The works include construction of the Western Harbour Tunnel northbound off ramp and cut and cover structure, and the road integration works with the Warringah Freeway. The works would take about one year and six months.

Construction airborne noise

Table 10-32 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels during typical construction noise intensive work scenario. Refer to Appendix G (Technical working paper: Noise and vibration) for noise predictions for the worst case construction noise intensive work scenario.

During typical and worst case construction works, no residential receiver buildings are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)).

During standard construction hours:

- For typical works, no residential receiver buildings are predicted to exceed the noise management level
- For worst case construction works, up to six residential receiver buildings are predicted to exceed the noise management level; however, all receivers would experience exceedances below 10 dB(A).

Outside standard construction hours, the key noise generating activities are crane operations and oversized deliveries. When these activities occur at night:

- For typical works, up to 30 residential receiver buildings are predicted to exceed the noise management level; however, all receivers would experience exceedances below 15 dB(A)
- For worst case construction works, up to 1220 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (99 per cent) would experience exceedances below 15 dB(A). Night time exceedances would occur only when cranes are used or during oversized deliveries.

The most likely source of potential sleep disturbance from night construction works would be from truck air-brakes, or metal-on-metal bangs from truck loads moving or shifting. The predicted maximum noise levels show:

- During typical works, up to 18 residential receiver buildings are predicted to experience noise above the sleep disturbance screening level. Noise levels may exceed the awakening reaction levels at up to two receiver buildings
- During the worst case construction activities, up to 18 residential receiver buildings are predicted to experience noise above the sleep disturbance screening level. Noise levels may exceed the awakening reaction levels at up to five receiver buildings.

Noise management level exceedances may occur at the following non-residential receivers:

- One childcare receiver located in NCA 16.3 for worst case construction works
- One educational receiver with buildings located in NCA 21.2 for worst case construction works
- One recreational receiver located in NCA 23.2 for typical and worst case construction works
- One other sensitive receiver located in NCA 21.2 for worst case construction works.

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 are provided in Section 10.9.

Table 10-32 Number of residential receiver buildings over the noise management levels – North Sydney cut and cover (typical noise intensity scenario)

Component of construction program	Highly noise affected (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])	
	>75 dB(A)[3]	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 and structural works	0	0	0	0	0	0	0	0	0	0	0	0	**20**	**2**	0	0	0	0
Road integration works	0	0	0	0	**2**	0	0	0	**3**	0	0	0	**18**	**12**	0	0	**18**	**2**

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

Falcon Street interchange upgrade

Construction works summary

The Falcon Street interchange site is located to the immediate north-east of St Leonards Park. The key construction activities required as part of the Falcon Street interchange works include:

- Widening of the existing eastern bridge on the northern side
- Moving the Warringah Freeway northbound off ramp onto Falcon Street eastward
- Widening of the northbound off ramp from the Warringah Freeway Upgrade onto Falcon Street to accommodate the turning movements of a large semi-trailer
- Structures upgrade works for existing main bridge and ramp structures
- Construction of a new bridge to facilitate the southbound bus movement from Falcon Street onto the Warringah Freeway.

The works would take about one year.

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 typical construction noise intensive work scenario. Refer to Appendix G (Technical working paper: Noise and vibration) for noise predictions for the worst case construction noise intensive work scenario.

During typical works, up to two residential receiver buildings are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)). When worst case construction works occur, there is the potential for up to 18 residential receiver buildings to be highly noise affected while the rock-hammers or road saws are used during road modification works or demolition works.

During standard construction hours:

- For typical works, up to two residential receiver buildings are predicted to exceed the noise management level during Falcon Street shared user bridge works; however, these two receivers would experience exceedances below 10 dB(A). In addition, one residential receiver building is predicted to exceed the noise management levels between 10 and 20 dB(A) during Falcon Street Bridge works
- For worst case construction works, up to 35 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (94 per cent) would experience exceedances below 10 dB(A).

Outside standard construction hours, the key noise generating activities is likely to be road resurfacing works. When this activity occurs at night:

- For typical works, up to 227 residential receiver buildings are predicted to exceed the noise management level; however, the majority of these receivers (73 per cent) would experience exceedances below 5 dB(A)
- For worst case construction works, up to 2389 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (97 per cent) would experience exceedances below 15 dB(A). The highest exceedances would occur when rock hammers are used as part of ramp modification works.

The most likely source of potential sleep disturbance from night construction works would be from the use of rock-hammers during bridge demolition and modification, or during road excavation and trenching works. The predicted maximum noise levels show exceedances of the sleep disturbance

screening level at various receiver buildings for both typical and worst case construction works. Noise levels may exceed the awakening reaction levels for:

- Up to 36 residential receiver buildings during typical construction works
- Up to 114 residential receiver buildings during worst case construction work.

Noise management level exceedances may occur at the following non-residential receivers:

- Up to three childcare receivers located in NCAs 22.3 and 23.2 for worst case construction works
- Up to two educational receivers with buildings located in NCAs 22.1 and 25.1 for worst case construction works
- One recreational receiver in NCA 23.2 for typical works and up to three recreational receivers in NCA 23.2 for worst case construction works
- Up to two place of worship receivers located in NCAs 21.1 and 22.1 for worst case construction works
- One other sensitive receiver located in NCA 23.2 for typical works and up to three other sensitive receivers in NCAs 21.2 and 23.2 for worst case construction works.

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 are provided in Section 10.9.

Table 10-33 Number of residential receiver buildings over the noise management levels during construction the Falcon Street interchange upgrade (typical noise intensity scenario)

Component of construction program	Highly noise affected (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])	
	>75 dB(A)[3]	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
Modifications to existing Falcon Street Bridge (stage 1)	0	0	0	0	0	0	0	0	**1**	0	0	0	**6**	**1**	0	0	**17**	**9**
Modifications to existing Falcon Street Bridge (stage 2)	**2**	0	**1**	0	**1**	0	**1**	0	**11**	**2**	**1**	0	**165**	**59**	**2**	**1**	**87**	**18**
Widening of existing Falcon Street Bridge	0	0	0	0	0	0	0	0	**1**	0	0	0	**54**	**15**	0	0	**40**	**5**
Ramp modification works	0	0	0	0	0	0	0	0	**1**	0	0	0	**29**	**15**	0	0	**19**	**3**
Widening of existing Falcon Street Bridge	**2**	0	**1**	0	**3**	0	**1**	0	**13**	**4**	**1**	0	**63**	**41**	**4**	**1**	**53**	**32**
Ramp modification works	0	0	0	0	0	0	0	0	**15**	**2**	0	0	**96**	**51**	**2**	0	**84**	**28**

Component of construction program	Highly noise affected (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])	
	>75 dB(A)[3]	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
Construction of new Falcon Street shared user bridge	0	**2**	0	0	**8**	**1**	0	0	**13**	**16**	0	0	**95**	**41**	**18**	0	**70**	**30**
Demolition of existing Falcon Street shared user bridge	0	**2**	0	0	**3**	**2**	0	0	**23**	**6**	0	0	**89**	**53**	**6**	0	**58**	**36**

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

Falcon Street to Miller Street

Construction works summary

Proposed works would be located between Falcon Street and Miller Street. The key construction works include:

- Realignment of Miller Street interchange ramps
- Modification and widening works to Ernest Street Bridge
- Construction of tunnel structures for Western Harbour Tunnel
- Beaches Link tunnel structures (part of the Beaches Link and Gore Hill Freeway Connection project)
- Construction of New Brook/Miller Street on ramp bridge
- Stormwater works through ANZAC Park.

The Western Harbour Tunnel and Beaches Link cut and cover works would take about two years and three months while the Ernest Street bridge modification works would take about nine months.

Construction airborne noise

Table 10-34 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels during typical construction noise intensive work scenario. Refer to Appendix G (Technical working paper: Noise and vibration) for noise predictions for the worst case construction noise intensive work scenario.

During typical works, up to two residential receiver buildings are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)) when Warringah Freeway southbound widening works are occurring. When worst case construction works occur, there is the potential for up to ten residential receiver buildings to be highly noise affected across various construction activities.

During standard construction hours:

- For typical works, up to 44 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (97 per cent) would experience exceedances below 10 dB(A)
- For worst case construction works, up to 120 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (90 per cent) would experience exceedances below 10 dB(A). The highest number of exceedances would occur during the Warringah Freeway southbound widening.

Outside standard construction hours, the key noise generating activities are likely to be road resurfacing works, road demolition works, utility connection works, piling and concrete pours. When these activities occur at night:

- For typical works, up to 464 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (97 per cent) would experience exceedances below 15 dB(A)
- For worst case construction works, up to 2182 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (97 per cent) would experience exceedances below 15 dB(A). The highest number of night time exceedances would occur during Warringah Freeway reconfiguration works.

The most likely source of potential sleep disturbance from night construction works would be when rock-hammers are used for road tie-in works from truck air-brakes, or metal-on-metal bangs from

truck loads moving or shifting. The predicted maximum noise levels show exceedances of the sleep disturbance screening level at various receiver buildings for both typical and worst case construction works. Noise levels may exceed the awakening reaction levels for:

- Up to 33 residential receiver buildings during typical construction works
- Up to 88 residential receiver buildings during worst case construction work.

Noise management level exceedances may occur at the following non-residential receivers:

- One commercial receiver located in NCA 30.3 for worst case construction works
- One childcare receiver located in NCA 28.1 for typical and worst case construction works
- Two educational receivers with buildings located in NCA 25.1 for typical construction works, and up to three educational receivers with buildings in NCAs 25.1 and 31.2 for worst case construction works
- One recreational receiver located in NCA 26.2 for typical construction works, and up to six recreational receivers located in NCAs 23.2, 25.1 and 26.2 for worst case construction works
- One place of worship receiver located in NCA 28.1 for worst case construction works
- One other sensitive receiver located in NCA 26.1 for worst case construction works.

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 are provided in Section 10.9.

Table 10-34 Number of residential receiver buildings over the noise management levels during Military Road to Miller Street construction works (typical noise intensity scenario)

Component of construction program	Highly noise affected (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])	
	>75 dB(A)[3]	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
Ernest Street underpass	0	**1**	0	0	**1**	**2**	0	0	**3**	**3**	**1**	0	**237**	**39**	**5**	**1**	**38**	**7**
Ernest Street bridge widening	0	0	0	0	**4**	**2**	0	0	**15**	**7**	0	0	**346**	**106**	**12**	0	**98**	**17**
Warringah Freeway southbound widening	**2**	**43**	**1**	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Warringah Freeway reconfiguration works (stage 1)	0	0	0	0	**4**	0	0	0	**1**	**4**	0	0	**274**	**44**	**5**	0	**44**	**5**
Warringah Freeway reconfiguration works (stage 2)	0	0	0	0	**1**	0	0	0	**7**	0	0	0	**89**	**37**	**2**	0	**59**	**10**
Warringah Freeway reconfiguration works (stage 3)	0	0	0	0	0	0	0	0	0	0	0	0	**171**	**43**	0	0	**96**	**4**

Component of construction program	Highly noise affected (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])	
	>75 dB(A)[3]	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
Western Harbour Tunnel tunnel structure works	0	0	0	0	0	0	0	0	**5**	0	0	0	**307**	**75**	**1**	0	**70**	**4**
Excavation works	0	0	0	0	0	0	0	0	**9**	0	0	0	**207**	**75**	0	0	**69**	**6**
ANZAC Park stormwater works	0	**4**	0	0	**10**	**4**	0	0	**21**	**11**	0	0	**101**	**52**	**21**	**4**	**64**	**33**
Beaches Link tunnel structure works (stage 1)	0	0	0	0	**6**	0	0	0	**2**	**4**	0	0	**101**	**28**	**6**	0	**61**	**8**
Beaches Link tunnel structure works (stage 2)	0	0	0	0	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

Miller Street to Willoughby Road

Construction works summary

The Miller Street to Willoughby Road site is located between Miller Street and Willoughby Road, to the north of Crows Nest and North Sydney. The key construction activities include:

- Widening of Willoughby Road off ramp
- Widening of Warringah Freeway northbound and Brook Street off ramp
- Widening of Warringah Freeway northbound approach to Brook Street
- Widening for new Warringah Freeway southbound lanes
- Widening of Warringah Freeway northbound lanes.

Each of these works would take about six months, with some occurring concurrently.

Construction airborne noise

Table 10-35 provides a summary of the number of residential receiver buildings predicted to experience airborne noise levels above noise management levels during typical construction noise intensive work scenario. Refer to Appendix G (Technical working paper: Noise and vibration) for noise predictions for the worst case construction noise intensive work scenario.

During typical works, up to ten residential receiver buildings are predicted to be highly noise affected (ie predicted noise levels greater than 75 dB(A)) when works occur near these receivers. When worst case construction works occur, there is the potential for up to 60 residential receiver buildings to be highly noise affected across various construction activities.

During standard construction hours:

- For typical works, up to 25 residential receiver buildings are predicted to exceed the noise management level; however, the majority of receivers (72 per cent) would experience exceedances below 10 dB(A). All exceedances are predicted to be below 20 dB(A)
- For worst case construction works, up to 106 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (90 per cent) would experience exceedances below 10 dB(A). The highest number of exceedances would occur during south east widening works.

Outside standard construction hours, the key noise generating activities are likely to be earthworks and rock-breaking. When these activities occur at night:

- For typical works, up to 700 residential receiver buildings are predicted to exceed the noise management level; however, most receivers (92 per cent) would experience exceedances below 15 dB(A)
- For worst case construction works, up to 3708 residential receiver buildings are predicted to exceed the noise management level; however, the majority of receivers (89 per cent) would experience exceedances below 15 dB(A). The highest number of night time exceedances would occur during south-east widening works when earthworks or rock-breaking activities are taking place.

The most likely source of potential sleep disturbance from night construction works would be when rock-hammers are used for road tie-in works or excavation/trenching works. The predicted maximum noise levels show exceedances of the sleep disturbance screening level at various receiver buildings for both typical and worst case construction works. Noise levels may exceed the awakening reaction levels for:

- Up to 107 residential receiver buildings during typical construction works
- Up to 289 residential receiver buildings during worst case construction work.

Noise management level exceedances may occur at the following non-residential receivers:

- Up to 11 commercial receivers located in NCAs 30.2 and 30.3 for worst case construction works
- One childcare receiver located in NCA 30.2 for typical works and up to two childcare receivers in NCAs 23.2 and 30.2 for worst case construction works
- One educational receiver with buildings located in NCA 31.3 for typical construction works, and up to four educational receivers with buildings located in NCAs 22.3, 25.1, 30.1 and 30.2 for worst case construction works
- One recreational receiver located in NCA 25.1 for typical construction works, and up to three recreational receivers in NCAs 25.1 and 30.1 for worst case construction works
- Three place of worship receivers located in NCAs 28.1, 30.1 and 32.1 for worst case construction works
- One other sensitive receiver located in NCA 30.1 for typical and worst case construction works.

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 are provided in Section 10.9.

Table 10-35 Number of residential receiver buildings over the noise management levels during construction works between Miller Street and Willoughby Road (typical noise intensity scenario)

Component of construction program	Highly noise affected (L_{Aeq}[1])	Daytime (standard) (L_{Aeq})			Daytime (outside standard) (L_{Aeq})				Evening (L_{Aeq})				Night (L_{Aeq})				Sleep disturbance (L_{Amax}[2])	
	>75 dB(A)[3]	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
Widening works north-west area	**2**	**7**	0	0	**10**	**7**	0	0	**22**	**17**	**2**	0	**354**	**224**	**39**	**7**	**455**	**60**
Widening works south-west area	**10**	**18**	**7**	0	**20**	**18**	**7**	0	**24**	**23**	**8**	0	**340**	**213**	**35**	**25**	**418**	**107**
Widening works central area south of Brook Street	**2**	**15**	0	0	**17**	**15**	0	0	**28**	**17**	**2**	0	**369**	**272**	**44**	**15**	**402**	**68**
Widening works south-east area	**7**	**9**	0	0	**10**	**9**	0	0	**15**	**10**	**1**	0	**413**	**220**	**20**	**3**	**411**	**64**
Widening works central area north Donnelly Road	0	**3**	0	0	**3**	**2**	0	0	**16**	**6**	0	0	**139**	**83**	**13**	**2**	**160**	**19**

Note 1: L_{eq} 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 Figure 10-1 for a comparison of dB(A) for various activities.

10.7.4 Cumulative airborne construction noise

The construction timeframe for the construction sites and major work areas associated with the Warringah Freeway Upgrade overlaps with:

- The Cammeray Golf Course construction support site
- The Gore Hill Freeway Connection surface road works, and the construction support site at Punch Street which are part of the Beaches Link and Gore Hill Freeway Connection project
- Crows Nest Station and Victoria Cross Station works which are part of the Sydney Metro City and Southwest project.

When construction works are carried out in more than one major works area at the same time and the works are predicted to exceed the noise management level in the same NCA, there is potential for cumulative noise impact in that NCA.

During standard construction hours, NCAs 15.4, 16.3, 17.3, 17.4, 19.1, 20.1, 23.1, 23.2, 24.1, 25.1, 28.1, 29.1, 30.1, 30.2 and 33.2 have overlapping impacts which would be considered during further construction planning.

During out of hours work, numerous NCAs have overlapping impacts which would be considered during further construction planning.

Cumulative airborne construction noise impacts would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

10.7.5 Construction traffic noise

Construction road traffic management and vehicle movements associated with the Warringah Freeway Upgrade 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.

A reduced speed limit during traffic management arrangements along the Warringah Freeway surface road works is likely to reduce road traffic noise levels at some residential receiver buildings adjacent to the carriageway.

10.7.6 Construction traffic noise impact from the temporary closure of the Warringah Freeway

Due to the safety risks associated with working adjacent to live traffic, full closure of the Warringah Freeway would be beneficial for short periods, allowing for construction activities such as resheeting, installation of bridge spans and demolition of kerbs and medians, which would be carried out more efficiently and with less disruption to traffic. These closures would be carried out during off-peak periods, generally during the evening and night. Five closure scenarios have been considered:

- Full closure
- Full northbound closure
- Outer northbound lane closure only
- Full southbound lane closure
- Outer southbound lane closure only.

Predicted increases in road traffic noise levels at receivers adjacent to key roads and ramps where traffic would be diverted are presented in Table 10-36. The predictions show:

- Under the full closure scenario, road traffic noise levels are predicted to increase by more than 2 dB(A) at all locations except Victoria Road at Gladesville Bridge
- Under other closure scenarios, road traffic noise increases greater than 2 dB(A) are predicted at some locations only
- Road traffic noise levels increases greater than 2 dB(A) would be more frequent at two way road locations than at one way road locations.

Table 10-36 Predicted night ($L_{Aeq(9hour)}$)[1] road traffic noise level increases (dB(A))[2] on key roads and ramps – Warringah Freeway temporary closure

Location	Full closure	Full northbound closure	Outer northbound lane closure only	Full southbound lane closure	Outer south bound lane closure only
One way roads					
Mount Street southbound entry ramp to Western Suburbs (Bradfield)	7	<1	0	7	3
Mount Street southbound entry ramp to Eastern suburbs (Cahill Expressway)	3	<1	0	3	2
Arthur Street southbound (from Berry Street)	6	<1	<1	6	3
Arthur Street northbound (Pacific Highway)	5	2	<1	4	1
High Street southbound entry ramp	6	2	<1	4	3
Bent Street / Alfred Street southbound, Neutral Bay	17	5	3	16	13
Two way roads					
Pacific Highway at North Sydney	9	7	3	6	4
Cahill Expressway at Circular Quay	4	3	3	2	1
Victoria Road at Gladesville Bridge	1	<1	<1	1	<1
Miller Street at North Sydney	10	9	4	6	3

Location	Full closure	Full northbound closure	Outer northbound lane closure only	Full southbound lane closure	Outer south bound lane closure only
Clark Road at North Sydney	4	2	<1	3	2
Kurraba Road at Neutral Bay	5	2	<1	3	3
Falcon Street at North Sydney	4	3	1	1	<1
Walker Street at North Sydney	6	4	2	4	3
Ridge Street at North Sydney	10	7	4	7	5

Note 1: $L_{Aeq(9\ hour)}$ is the A-weighted equivalent noise level. It is the summation of noise events and integrated over a period of 9 hours
Note 2: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to Figure 10-1 for a comparison of dB(A) for various activities.

Should Warringah Freeway temporary closures be implemented, diverted road traffic noise impacts would be mitigated in accordance with the environmental management measures outlined in Section 10.9. An extensive communication strategy would be implemented to notify the community and affected motorists of closures and the recommended detour routes. Demand through the Warringah Freeway corridor could be reduced through demand management, which would also minimise additional volumes on local and collector roads. Traffic and demand management would be consistent with management measures that are currently employed to mitigate the impacts of regular closures to the Warringah Freeway and Bradfield Highway/Cahill Expressway as part of programmed maintenance works for the Sydney Harbour Bridge. Partial or full closures of Warringah Freeway would be carried out in consultation with the Transport for NSW, Sydney Coordination Office.

10.7.7 Construction ground-borne noise

Ground-borne noise levels have not been assessed for the Warringah Freeway Upgrade because airborne noise levels would be dominant over ground-borne noise levels for these works. Management of the airborne noise impacts would also sufficiently manage any associated ground-borne noise impacts.

10.7.8 Construction vibration

For Warringah Freeway Upgrade construction support sites, no typical vibration intensive activities are proposed. In the event vibration intensive activities are required, site-specific buffer distances for these activities would be measured on site where plant and equipment are likely to operate close to or within the typical minimum working distances.

For Warringah Freeway Upgrade work areas other than construction support sites, the predicted number of receiver buildings within minimum working distances for vibration intensive work is

presented in Table 10-37. About 38 heritage structures across various NCAs are predicted to be within the minimum working distances for major vibration-generating activities. Refer to Section 5 of Appendix G (Technical working paper: Noise and vibration) and Appendix J (Technical working paper: Non-Aboriginal heritage) for further details on the heritage structures potentially impacted. A range of vibration intensive plant and equipment such as large rock-hammers may be used as part of the freeway upgrade.

Where vibration intensive works occur within the minimum working distances, the risk of structural damage or human discomfort would be mitigated in accordance with the environmental management measures outlined in Section 10.9.

Table 10-37 Number of receiver buildings within minimum working distances for vibration intensive work – Warringah Freeway Upgrade work areas other than construction support sites

Vibration intensive works/location	NCA	Cosmetic damage - Heritage item structure	Cosmetic damage - Sound structure	Human response
Ridge Street shared user bridge	17.4	2	1	24
	20.1	1	2	8
	23.2	4	–	–
Berry Street on ramp works	16.3	–	–	8
	19.1	1	5	22
	20.1	–	–	4
Alfred Street North and Mount Street interchange modification and grade separation works	16.3	–	–	1
	17.3	1	3	54
	17.4	4	4	70
	23.1	–	–	5
Warringah Freeway northbound widening	16.1	3	–	5
	16.3	–	–	11
	17.2	–	–	1
Falcon Street interchange upgrade	23.1	–	–	28
	23.2	2	–	11
High Street interchange upgrade	16.1	3	–	12
	16.3	–	–	5
	17.2	–	–	2

Vibration intensive works/location	NCA	Cosmetic damage - Heritage item structure	Cosmetic damage - Sound structure	Human response
	17.3	–	–	3
Warringah Freeway southbound widening	16.3	–	–	1
	17.3	–	3	27
	17.4	3	4	68
	23.1	–	–	21
Military Road to Miller Street	23.1	–	2	7
	23.2	–	–	11
	24.1	–	–	12
	25.1		1	21
	26.1	–	–	1
	26.2	1	–	–
	28.1	–	–	6
	29.1	–	4	24
	30.3	–	–	1
Falcon Street off ramp cut and cover	20.1	1	3	6
	23.2	6	–	2
Miller Street to Willoughby Road	24.1	1	–	–
	25.1	–	1	30
	26.2	1	–	–
	28.1	–	–	2
	29.1	2	2	66
	30.1	1	–	88
	30.2	1	–	31
	30.3	–	–	10
	31.3	–	–	24

10.8 Assessment of potential impacts – other construction activities

10.8.1 Local area works

Local area and utility connection works may be needed as part of establishing construction support sites, such as service and utility identification works, electricity, sewer, communications and other utility adjustments, and local road integration works. While some areas of work are known and have been assessed as part of the relevant compound or surface road work area, other minor utilities requirements are still being investigated. 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 project construction support sites, residences are typically set back by about ten metres from the nearest road. Table 10-38 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 10-38 Assessment local area works noise at the nearest receiver building

Item	Utilities modification		Pavement modification		Paving or asphalting	
	Typical	Worst case	Typical	Worst case	Typical	Worst case
Distance to the highly noise affected level (metres)[1]	13	45	13	40	12	42
$L_{Aeq(15min)}$[2] noise level at 10 m (dB(A))[3]	77	88	77	87	76	88
L_{Amax}[4] noise level at 10 m (dB(A))	84	93	87	93	84	93

Note 1: This is the distance from the noise source to where the receiver building is predicted to be highly noise affected, that is, the distance at which it would be exposed to noise levels that exceed 75 dB(A). Where feasible and reasonable, high noise impact activities would be carried out during standard construction hours to limit the number of highly noise affected receivers.

Note 2: $L_{Aeq(15min)}$ is the A-weighted equivalent noise level. It is the summation of noise events and integrated over a period of 15 minutes.

Note 3: dB(A) stands for A-weighted decibel, a unit used to measure noise. Refer to section Figure 10-10 for a comparison of dB(A) for various activities.

Note 4: L_{Amax} is the maximum A-weighted equivalent noise level. It is the summation of noise events and integrated over a given period.

The results presented in Table 10-38 show that 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 25 dB(A) and in the worst case up to 35 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 40 dB(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).

10.8.2 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 further design refinement.

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.

10.9 Environmental management measures

Environmental management measures for potential noise and vibration impacts during construction are outlined in Table 10-39. Additional measures to address cumulative impacts are included in Chapter 27 (Cumulative impacts).

Table 10-39 Environmental management measures – construction noise and vibration

Ref	Phase	Impact	Environmental management measure	Location
CNV1	Pre-Construction	Construction noise and vibration impacts	A Construction Noise and Vibration Management Plan will be developed for the project. This plan will: a) Identify relevant criteria and management levels in relation to noise and vibration b) Identify noise and vibration sensitive receivers and features in the vicinity of the project c) Include standard and additional mitigation from the Construction Noise and Vibration Guideline (Roads and Maritime, 2016a) and detail how and when these will be applied in the project d) Describe the approach that will be adopted for carrying out location and activity specific constructing noise and vibration impact assessments to assist with designing and selecting of the appropriate mitigation and management measures e) Include protocols that will be adopted to manage works required outside standard construction hours f) Detail the methodology and approach for managing residual construction noise impacts g) Detail the process for managing construction vibration, including heritage structures considering all types of vibration generating works, including	WHT/WFU

Ref	Phase	Impact	Environmental management measure	Location
			blasting h) 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 i) Where feasible and reasonable, detail how construction noise impacts from concurrent or consecutive nearby construction works associated with the project will be managed. 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 Construction Noise and Vibration Impact Statements will be carried out for all construction support sites and major construction works required for the project prior to the commencement of construction. The Statements will consider the proposed site layouts and noise and vibration generating activities that will take place during all major stages of the construction support site, assess predicted noise and vibration levels against the relevant management levels, and incorporate feasible and reasonable mitigation and management measures in accordance with the requirements of the *Interim Construction Noise Guideline* (DECC, 2009) and the *Construction Noise and Vibration Guideline* (Roads and Maritime, 2016a).	WHT/WFU
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: a) Details of works required outside standard construction hours, including acceptable justifications for works outside of standard construction hours, what types of works are allowed to take place outside of construction hours, and justifications of why the activities are required outside standard construction hours b) Details of the assessment and approval process (internal and external) for works proposed outside standard construction hours c) Noise and vibration mitigation and management measures that are to be considered and implemented where	WHT/WFU

Ref	Phase	Impact	Environmental management measure	Location
			appropriate to manage potential impacts associated with works outside standard construction hours d) The noise and vibration impact assessment processes that will be followed to identify potentially affected receivers, clarify potential impacts and determine appropriate mitigation and management measures. The protocol will be prepared in consultation with the Department of Planning, Industry and Environment and the NSW Environment Protection Authority, and independently endorsed. The project protocol will be implemented during the duration of the construction of the project.	
CNV4	Construction	Construction noise and vibration impacts	Construction noise and vibration impacts will be monitored periodically throughout all stages of the construction support sites to ensure that: a) Impacts are consistent with the noise and vibration levels detailed in the relevant Construction Noise and Vibration Impact Statements b) Noise and vibration impacts are being appropriately managed c) Mitigation measures are effective.	WHT/WFU
CNV5	Construction	Construction noise and vibration 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.	WHT/WFU
CNV6	Construction	Construction vibration impacts	Vibration generating activities will be managed through the establishment of minimum buffer distances to achieve screening levels. Where vibration levels are predicted to exceed the screening levels, a more detailed assessment of the impacted structure and attended vibration monitoring will be carried out to ensure vibration levels remain below appropriate limits for that structure. For heritage items, the more detailed assessment will specifically consider the heritage values of the structure in consultation with a heritage specialist to	WHT/WFU

Ref	Phase	Impact	Environmental management measure	Location
			ensure sensitive heritage fabric is adequately monitored and managed.	
CNV7	Construction	Construction ground-borne noise impacts	Feasible and reasonable measures will be implemented to minimise ground-borne noise where exceedances are predicted.	WHT/WFU
CNV8	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: a) Carrying out works during the daytime period when near residential receivers b) Selection of plant and equipment to minimise noise and vibration impacts c) Management of plant and equipment to minimise the generation of noise and vibration impacts d) Community consultation, engagement and notification e) Detailed programming and respite protocols f) Where out of hours works are required, programming the noisiest activities to occur during the less sensitive time periods g) Out of hours works protocols h) Limiting timing of noise intensive work 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 j) Management of construction traffic to minimise movements during the night periods along local roads k) Establishing minimum vibration buffer distances for vibration intensive works l) Vibration and blasting trials and/or monitoring along with building condition surveys.	WHT/WFU
CNV9	Construction	Construction blasting impacts	A Blast Management Strategy will be prepared in consultation with the NSW Environment Protection Authority to demonstrate that all blasting and associated activities will be carried out in a manner that will not generate unacceptable noise and vibration impacts or pose a significant risk impact to structures and sensitive receivers.	WHT/WFU

Ref	Phase	Impact	Environmental management measure	Location
			The strategy will: a) Detail the blasting to be performed including location, method and justification of the need to blast b) Identify any potentially affected noise and vibration sensitive sites including heritage buildings and utilities c) Establish appropriate criteria for blast overpressure and ground vibration levels at each category of noise sensitive site d) Detail storage and handling arrangements for explosive materials and the proposed transport of those materials to the construction support site e) Identify hazardous situations that may arise from the storage and handling of explosives, the blasting process and recovery of the blast site after detonation of the explosives f) Determine potential noise and vibration and risk impacts from blasting and appropriate best management practices g) Detail community consultation procedures.	
CNV10	Construction	Cumulative construction noise impacts	Construction noise from concurrent and consecutive construction works will be managed to minimise cumulative construction noise impacts. Where feasible and reasonable the approaches that will be used include: a) Coordinating work between project construction sites and construction works to avoid cumulative noise impacts b) Consideration of additional at source or near source mitigation where construction noise levels may result in cumulative construction noise impacts, where programming is not practical to avoid cumulative noise impacts c) Community consultation throughout the project to gauge construction key noise impacts and issues and any unknown impacts from concurrent or consecutive sets of constructions works d) Incorporating additional noise mitigation and management measures with consideration of cumulative and consecutive construction noise impacts based upon coordination between projects.	WHT/WFU

Western Harbour Tunnel = WHT, Warringah Freeway Upgrade = WFU.

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