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.

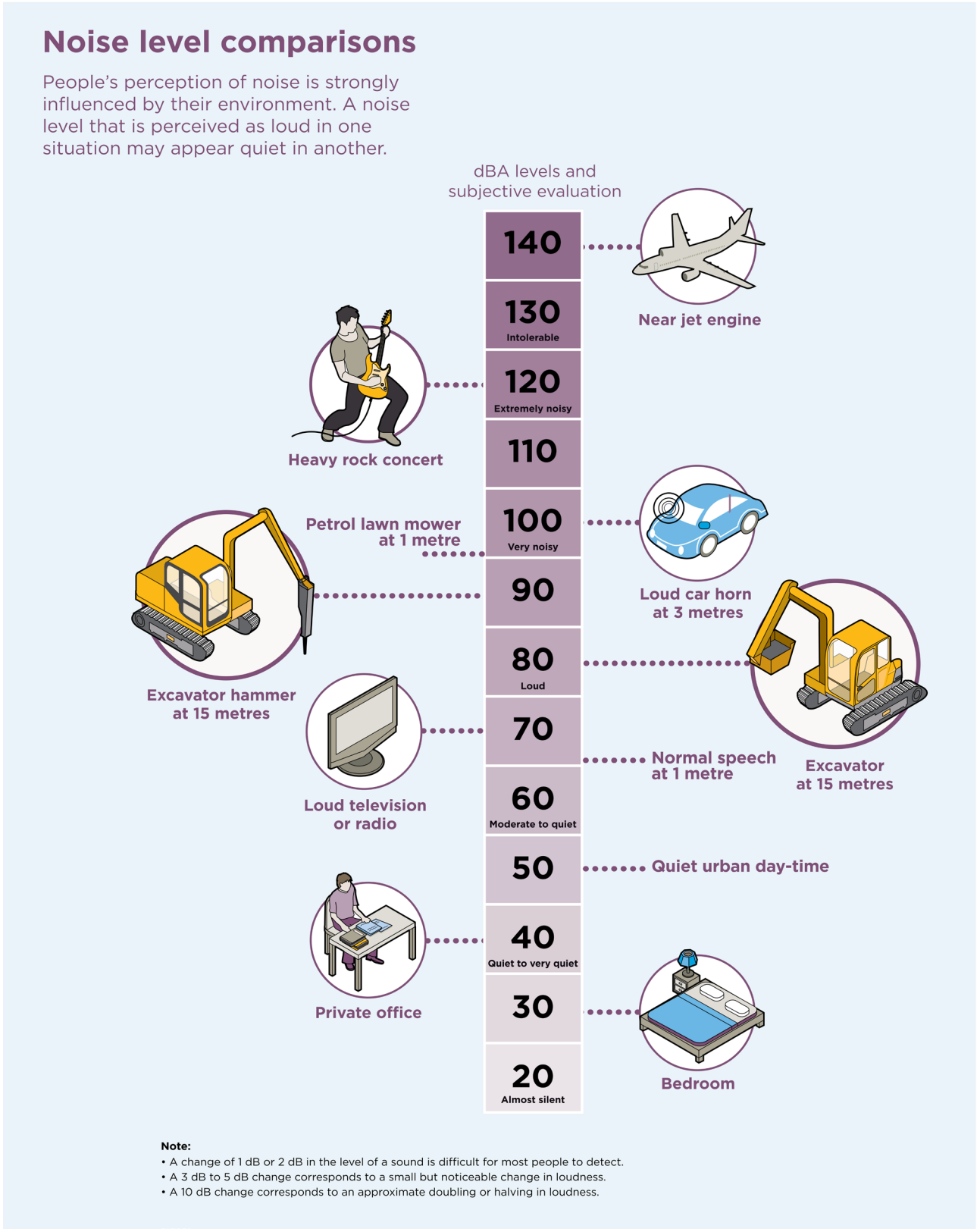


Figure 10-1 Noise level comparison

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.

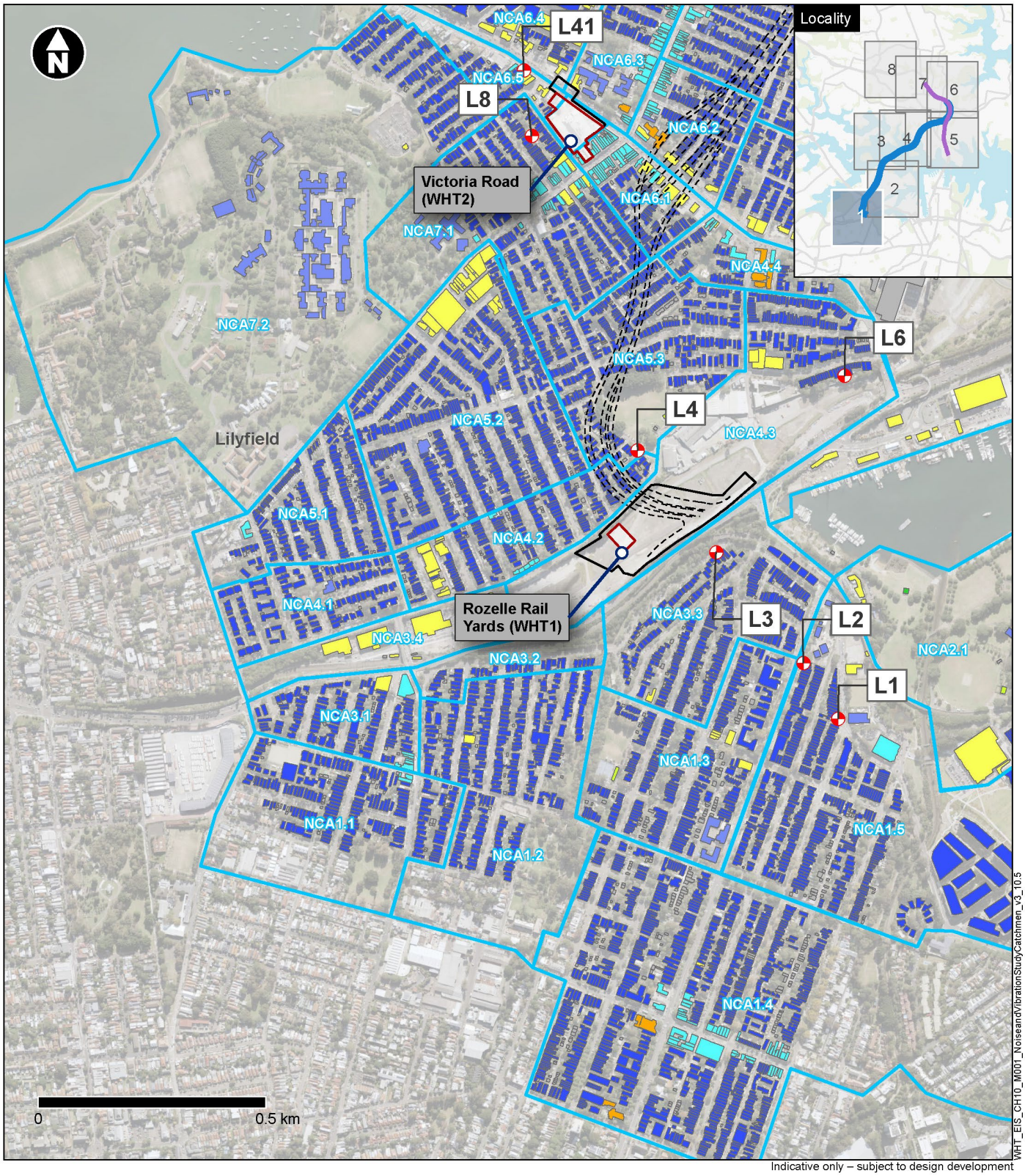
10.3.1 Noise sensitive receivers and noise catchment areas

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).



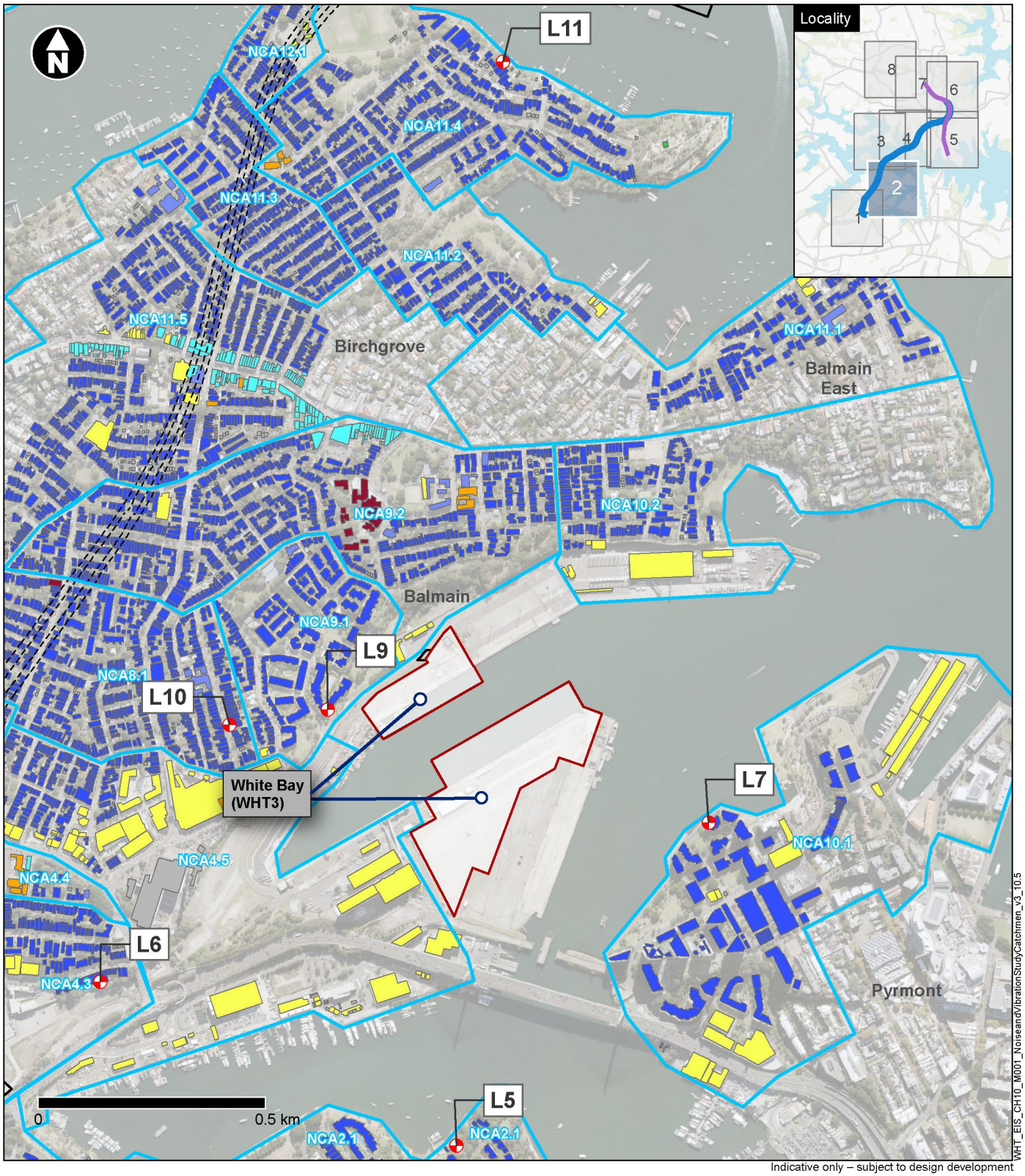
Legend

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)



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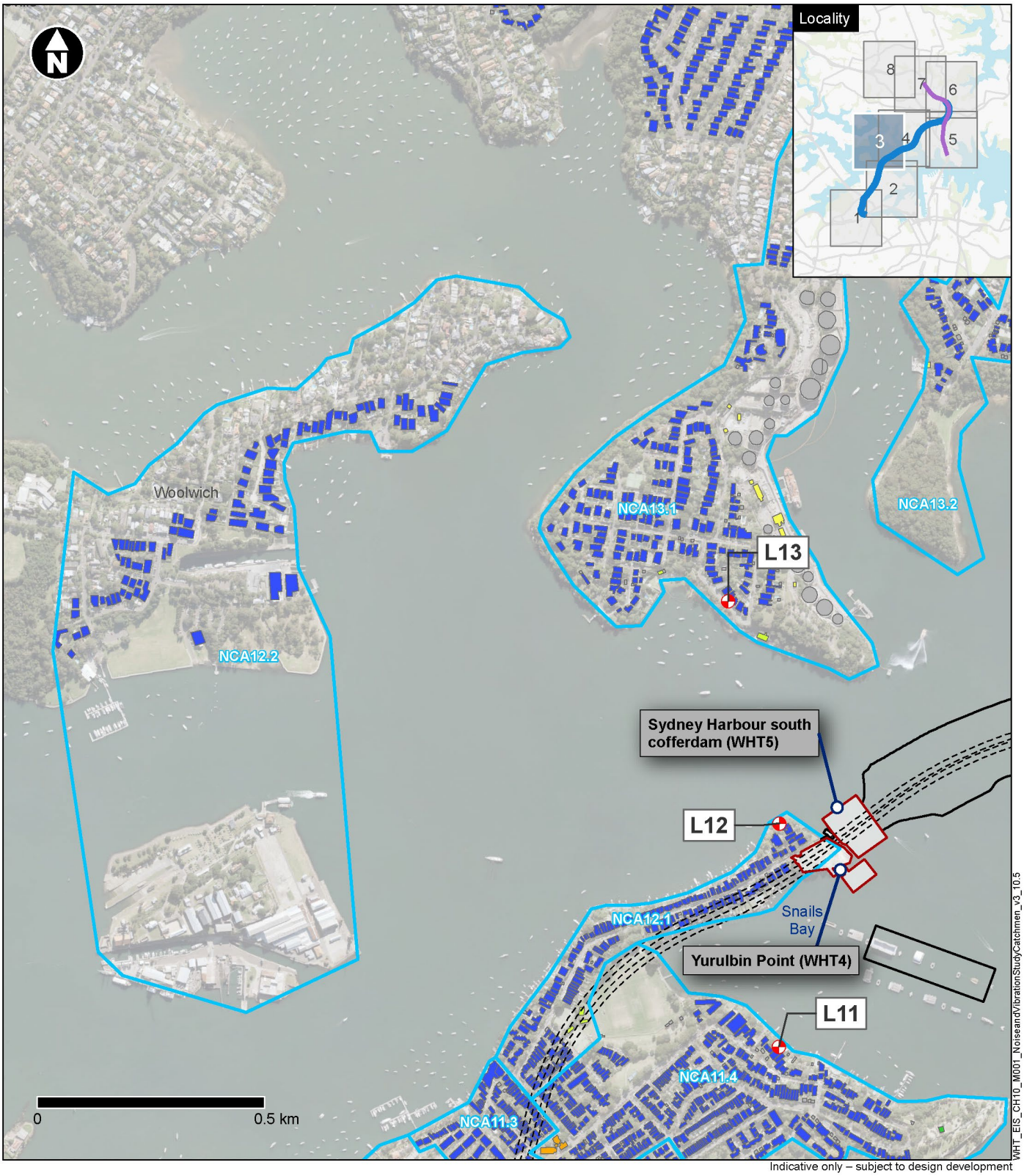
Construction features
- Construction footprint
- Construction support site
- Tunnel section

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)



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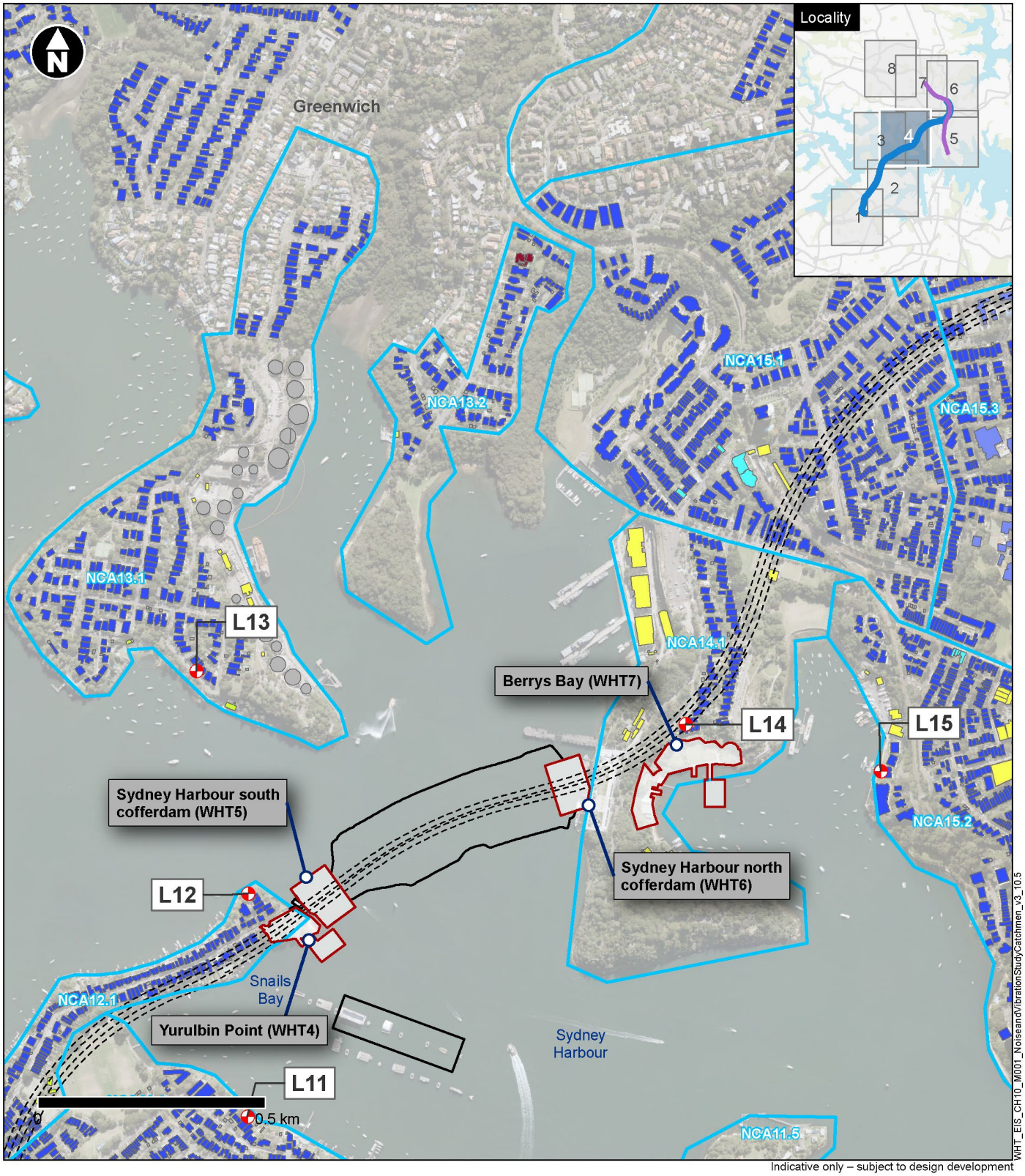
Construction features
- Construction footprint
- Construction support site
- Tunnel section

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)



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Construction features

- Construction footprint
- Construction support site
- Tunnel section

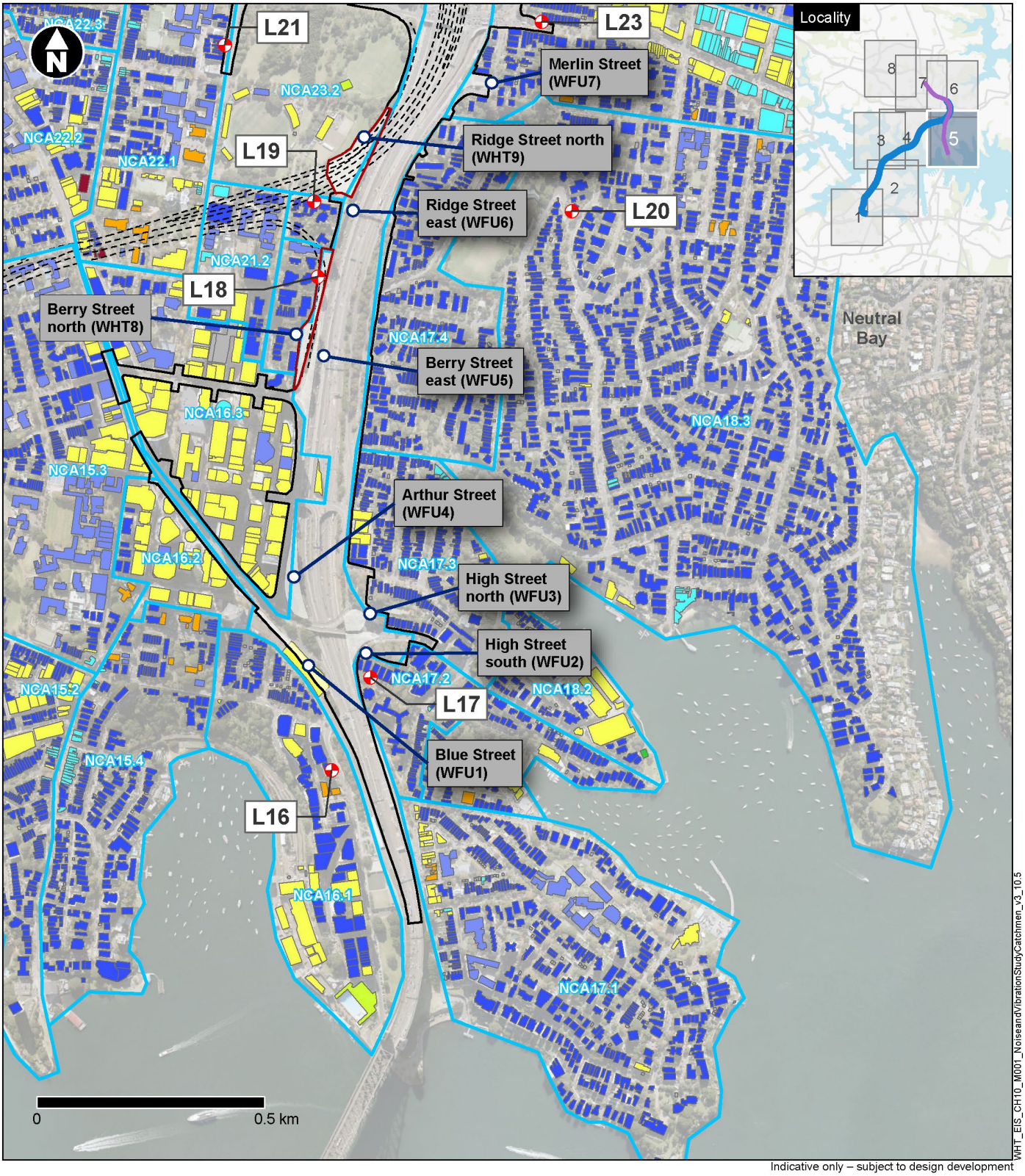
Noise assessment features

- 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)



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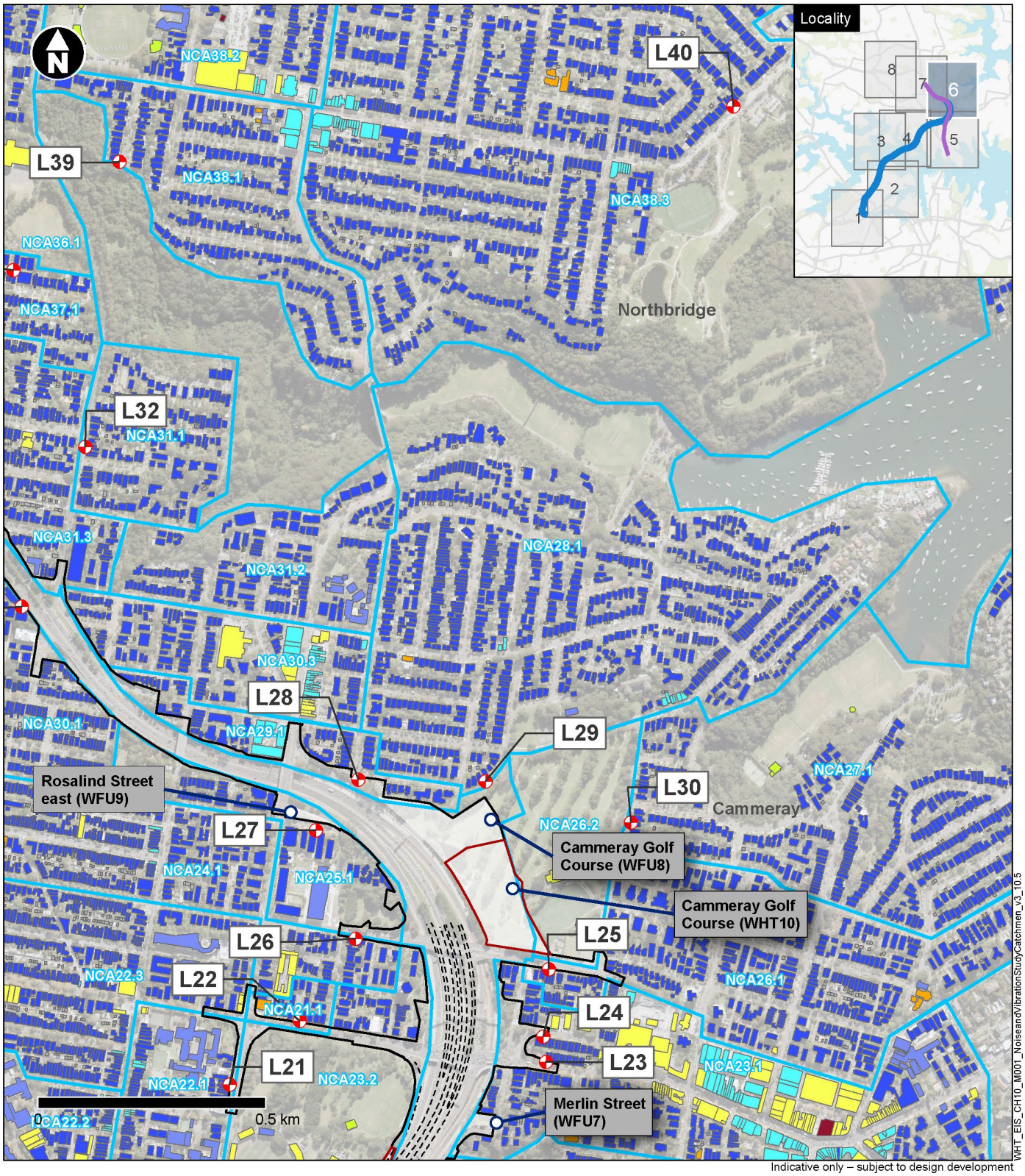
Construction features
- Construction footprint
- Construction support site
- Tunnel section

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)



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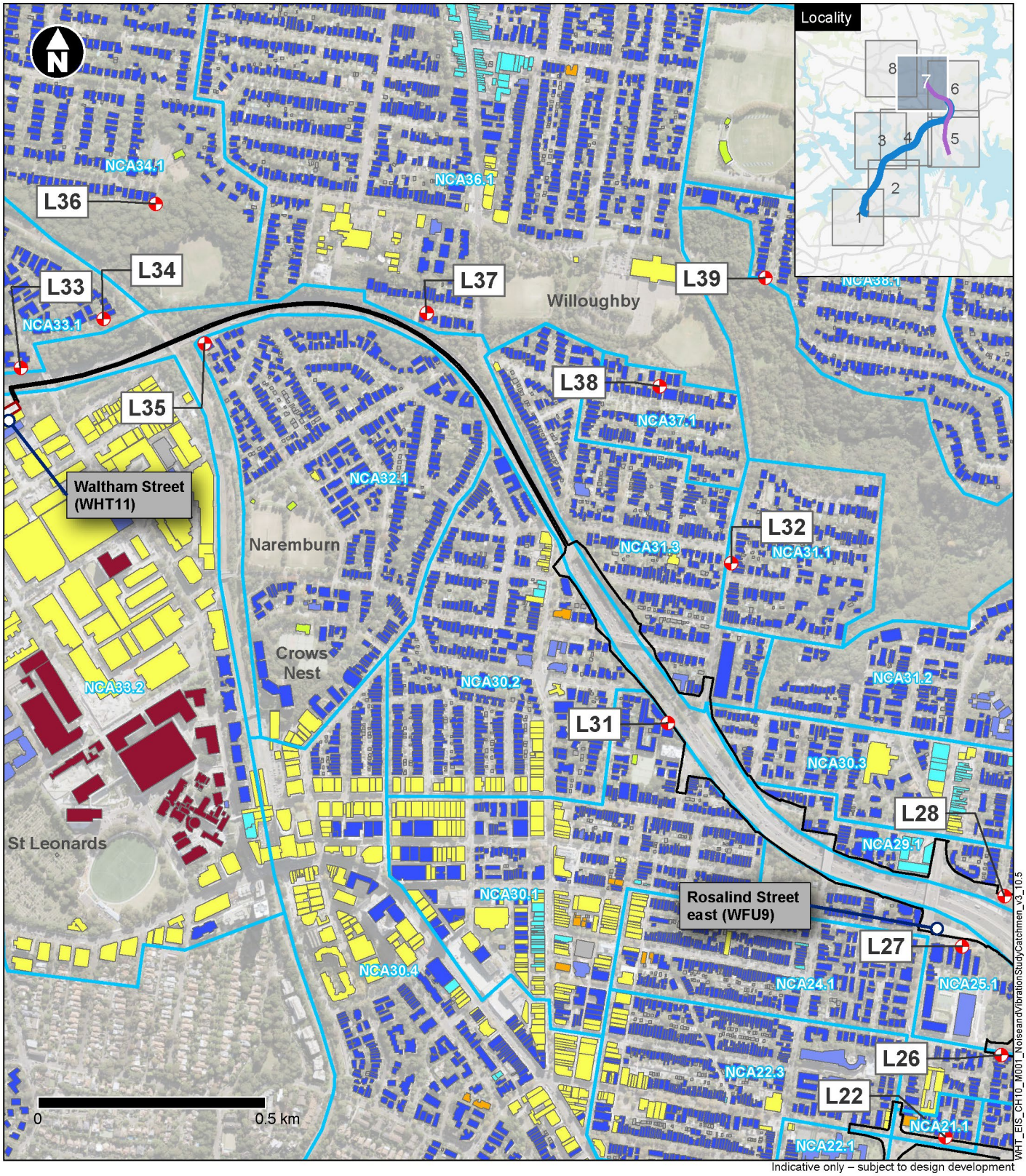
Construction features
- Construction footprint
- Construction support site
- Tunnel section

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)



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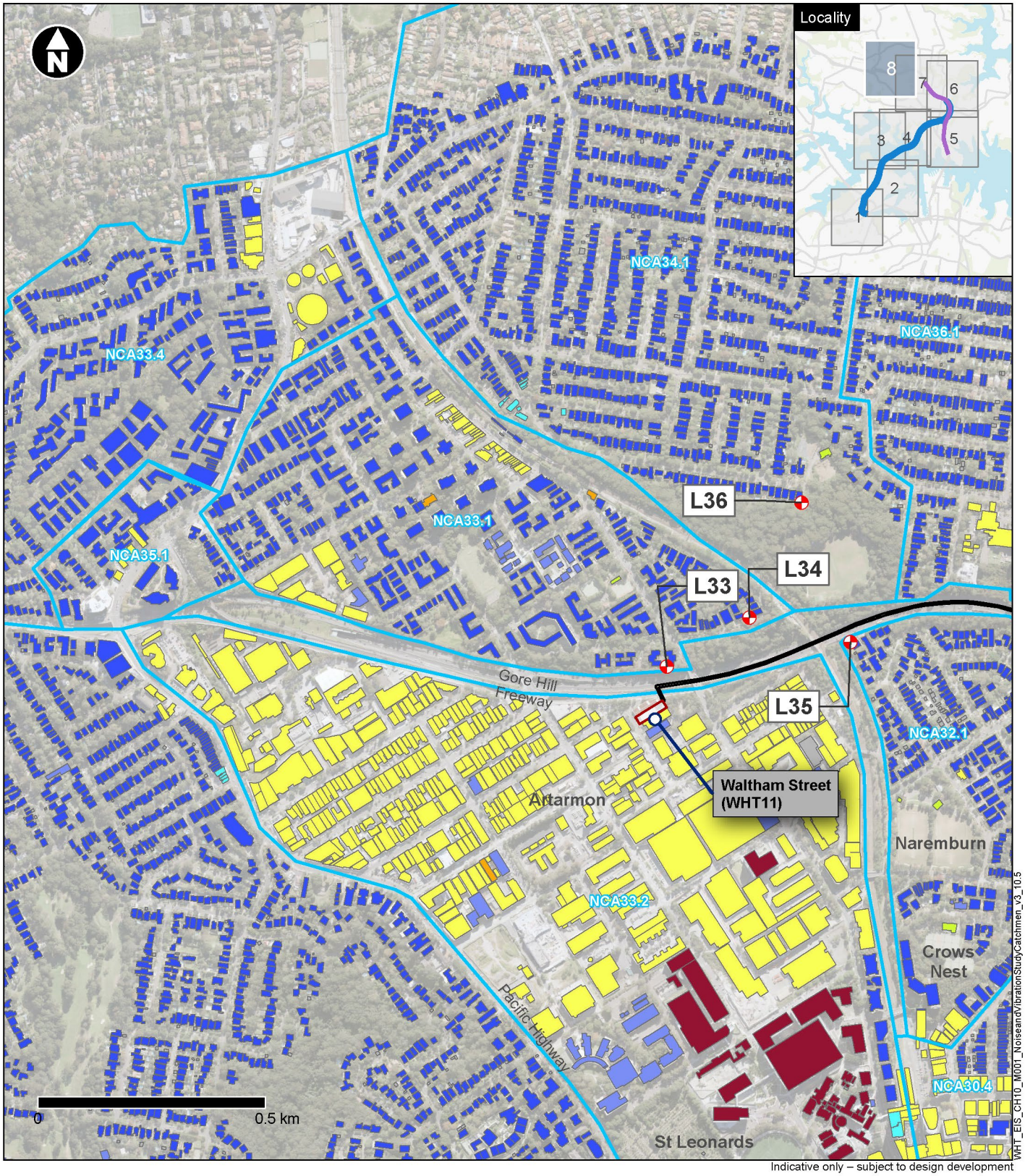
Construction features
- Construction footprint
- Construction support site

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.

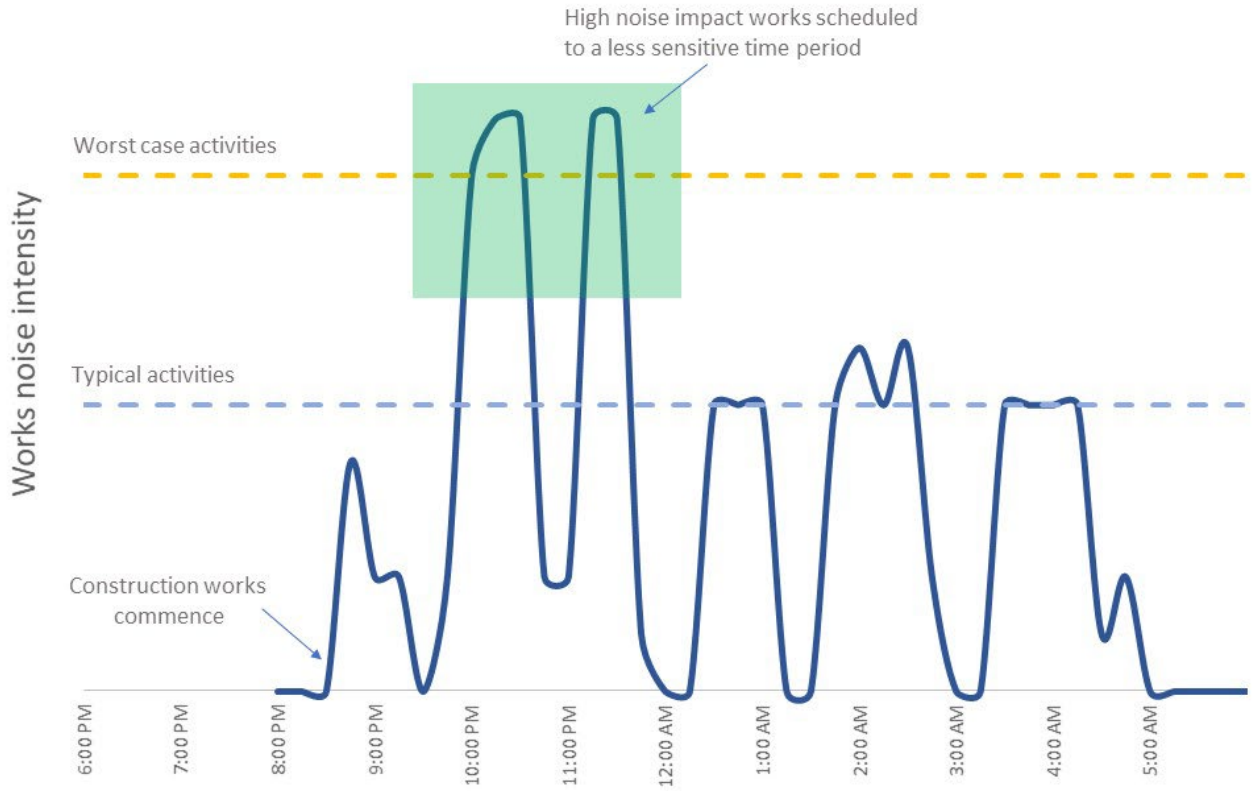


Figure 10-10 Example of variation in surface road works airborne noise impacts for typical and worst case activities

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.

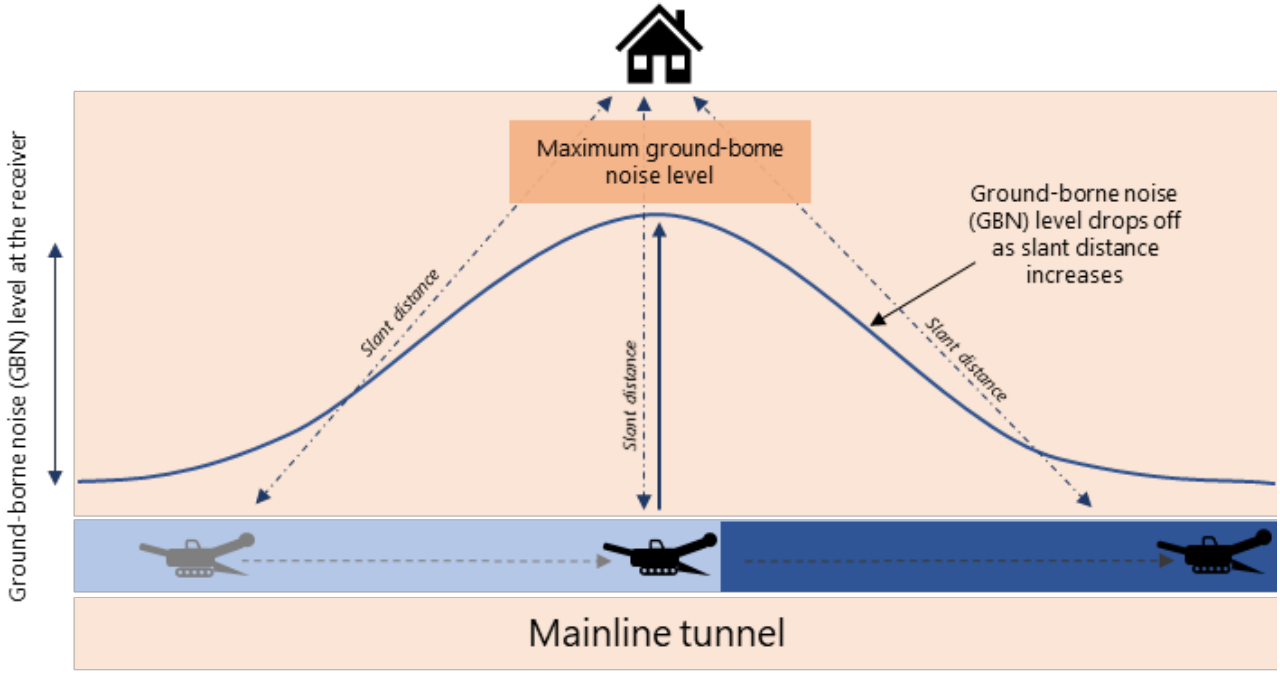


Figure 10-11 Indicative ground-borne noise impacts as tunnelling progresses

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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