

CONSTRUCTION NOISE AND VIBRATION

CHAPTER TEN

10 Construction noise and vibration

This chapter assesses the potential impact of noise and vibration during the construction stage of the project. It describes the existing noise and vibration environment and identifies the potential significance of impacts to sensitive receivers. Mitigation measures to address the potential impacts are also identified. Technical paper 2 – Noise and vibration provides further details.

10.1 Secretary environmental assessment requirements

The Secretary’s environmental assessment requirements relating to construction noise and vibration, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Table 10-1.

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

Ref.	Secretary’s environmental assessment requirements	Where addressed
8. Noise and vibration – amenity		
8.1	The Proponent must assess construction and operational noise and vibration impacts in accordance with relevant NSW noise and vibration guidelines. The assessment must include consideration of impacts to sensitive receivers including commercial premises, and include consideration of sleep disturbance and, as relevant, the characteristics of noise and vibration (for example, low frequency noise).	Construction noise and vibration impacts are assessed in this chapter. Operational noise and vibration impacts are assessed in Chapter 11 (Operational noise and vibration).
8.2	If blasting is required, the relevant requirements of Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration are to be assessed.	Consideration and assessment of blasting scenarios is provided in Section 10.4.
9. Noise and vibration – structural		
9.1	The Proponent must assess construction and operational 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).	Construction noise and vibration impacts, including potential structural damage impacts are assessed in this chapter. Potential vibration impacts to heritage items are assessed in Chapter 14 (Non-Aboriginal heritage) and Chapter 15 (Aboriginal heritage).
9.2	The proponent must demonstrate that blast impacts are capable of complying with the current guidelines, if blasting is required.	Consideration and assessment of blasting scenarios is provided in Section 10.4.

10.2 Assessment methodology

The assessment methodology for noise and vibration impacts generally involved:

- Identifying and classifying of sensitive receivers
- Characterising the existing noise environment based on attended and unattended noise measurements at specific locations across the project area
- Determining noise and vibration management levels in accordance with relevant guidelines
- Modelling to quantify the potential noise and vibration impacts
- Assessing the significance of potential impacts identified
- Examining the proposed construction methodologies and identifying mitigation measures that are likely to be required to minimise construction noise and vibration impacts
- Preparing and documenting mitigation measures that would be implemented during construction.

The construction noise and vibration assessment has been carried out in accordance with:

- The *Interim Construction Noise Guideline* (Department of Climate Change, 2009a) for airborne and ground-borne construction noise
- The NSW *Road Noise Policy* (Department of Environment, Climate Change and Water, 2011a) for construction road traffic noise
- *Assessing Vibration: a technical guideline* (Department of Environment and Conservation, 2006a) for construction vibration.

10.2.1 Construction noise metrics

Noise parameters most relevant to construction noise are described below and were evaluated for daytime (7 am to 6 pm), evening (6 pm to 10 pm) and night-time (10 pm to 7 am) periods:

- RBL – Rating Background Level – 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 $L_{Aeq(15\text{ minute})}$ Noise Management Levels (NMLs) for residential receivers
- $L_{Aeq(\text{period})}$ – the Energy Average Noise Level evaluated over a defined measurement period (typically 15 minutes for construction noise or the relevant daytime, evening or night-time period for ambient noise monitoring)
- L_{Amax} or $L_{A1(1\text{min})}$ – the ‘typical maximum noise level’ for an event, used in the assessment of potential sleep disturbance during night-time periods.

10.2.2 Sensitive receivers

The sensitivity of occupants to noise and vibration varies according to the nature of the occupancy and the activities performed within the affected premises. For example, recording studios are more sensitive to vibration and ground-borne noise than residential premises, which in turn are more sensitive than typical commercial premises.

Properties within about 100 metres of the metro corridor and about 200 metres from construction sites have been classified into one of the following receiver categories:

- Commercial
- Educational
- Industrial
- Mixed commercial / residential
- Residential
- Place of worship
- Child care
- Recreation (passive and active)
- Special sensitive (eg hospital, precision laboratories, recording studios).

Receivers greater than these distances are unlikely to hear any construction noise. Commercial and industrial receivers are generally considered to be less sensitive to noise and vibration compared to residential receivers.

10.2.3 Construction noise management levels

Airborne construction noise

Airborne noise would occur at all construction sites and would primarily be associated with surface activities or underground activities where there is an airborne noise path between the source and receiver (ie not fully shielded).

The *Interim Construction Noise Guideline* (ICNG) (Department of Environment and Climate Change, 2009a) sets out ways to deal with the impacts of construction noise on residential receivers and other sensitive land uses by presenting assessment approaches that are tailored to the scale of construction projects.

The ICNG sets out a quantitative assessment method involving predicting noise levels at sensitive receivers and comparing them with the proposal specific NMLs established for noise affected receivers. In the event that construction noise levels are predicted to be above the NMLs, all feasible and reasonable mitigation and work practices are required to be investigated to minimise noise emissions.

Residential receivers

The ICNG provides an approach for determining $L_{Aeq}(15\text{minute})$ NMLs at residential receivers by applying the measured $L_{A90}(15\text{minute})$ background noise levels, as described in Table 10-2.

Table 10-2 Determination of NMLs for residential receivers

Time of Day	Noise Management Level $L_{Aeq}(15\text{minute})$	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dBA	<p>The noise affected level represents the point above which there may be some community reaction to noise.</p> <p>Where the predicted or measured $L_{Aeq}(15\text{minute})$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level.</p> <p>The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.</p>
	Highly noise affected 75 dB(A)	<p>The highly noise affected level represents the point above which there may be strong community reaction to noise.</p> <p>Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restructuring the hours that the very noisy activities can occur, taking into account:</p> <ul style="list-style-type: none"> ○ Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools or mid-morning or mid-afternoon for works near residences) ○ If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dBA	<p>A strong justification would typically be required for works outside the recommended standard hours.</p> <p>The proponent should apply all feasible and reasonable work practices to meet the noise affected level.</p> <p>Where all feasible and reasonable practice have been applied and noise is more than 5 dB above the noise affected level, the proponent should negotiate with the community.</p>

Other sensitive land uses

The project specific $L_{Aeq}(15\text{minute})$ NMLs for other non-residential noise sensitive receivers from the ICNG are provided in Table 10-3.

Table 10-3 NMLs for other sensitive receivers

Land use	NML $L_{Aeq}(15\text{minute})$ (Applied when the land use is in use)
Classrooms at schools and other education institutions	Internal noise level 45 dBA
Hospital wards and operating theatres	Internal noise level 45 dBA
Places of worship	Internal noise level 45 dBA
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dBA

Land use	NML LAeq(15minute) (Applied when the land use is in use)
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, e.g. reading, meditation)	External noise level 60 dBA
Community centres	Depends on the intended use of the centre. Refer to the recommended 'maximum' internal levels in <i>Australian Standard 2107 – Acoustics – Recommended design sound levels and reverberation times for building interiors</i> for specific uses.

Other noise-sensitive businesses require separate project specific noise goals. The *Interim Construction Noise Guidelines* recommends that the internal construction noise levels at these premises are determined based on the 'maximum' internal levels presented in *AS 2107*. These recommended 'maximum' internal noise levels are provided in Table 10-4.

Table 10-4 NMLs for other receivers

Description	Time period	AS 2107 Classification	Recommended 'Maximum' Internal LAeq (dBA)
Hotel	Daytime and evening	Bars and lounges	50
	Night-time	Sleeping areas (hotels near major roads)	40
Café	When in use	Coffee bar	50
Bar / restaurant	When in use	Bars and lounges / restaurant	50
Library	When in use	Reading areas	45
Recording studio	When in use	Music recording studios	25
Theatre / auditorium	When in use	Drama theatres	30

The *Interim Construction Noise Guidelines* and *AS 2107* do not provide specific guideline noise levels for childcare centres. Childcare centres generally have internal play areas and sleep areas. The *Technical Guideline Child Care Centre Noise Assessment* (Association of Australian Acoustical Consultants, 2008) provides criteria for road, rail traffic and industry. This guideline recommends a LAeq(1hour) of 55 dBA for external play areas and a LAeq(1hour) of 40 dBA for indoor play areas and sleeping areas. For internal play areas an internal NML of LAeq(15minute) 55 dBA has been adopted and for sleeping areas an internal NML of LAeq(15minute) 40 dBA (when in use) has been adopted. On the assumption that windows and doors of childcare centres may be opened, an external NML of LAeq(15minute) 65 dBA for play areas has been applied at the facade and would also be applicable to external play areas. For sleeping areas on the assumption that windows are open, the external NML of LAeq(15minute) 50 dBA has been applied.

Commercial and industrial premises

NMLs for commercial and industrial premises have been set based on the *Interim Construction Noise Guidelines*. For commercial premises, including offices, retail outlets and small commercial premises an external NML of LAeq(15minute) 70 dBA has been adopted. An external NML of LAeq(15minute) 75 dBA has been adopted for industrial premises. For both land use types, the external noise levels should be assessed at the most affected occupied point on the premises.

Ground-borne construction noise

Ground-borne noise during construction may be experienced by sensitive receivers located close to tunnels or other underground excavations (including stations and service facilities). Whilst ground-borne noise may also be audible during construction activities on the surface, the airborne noise levels are likely to be higher and more prominent.

Ground-borne NMLs for residential receivers, based on levels provided in the ICNG, are presented in Table 10-5.

Ground-borne noise is usually not a significant disturbance to building occupants during the day due to high ambient levels which mask the audibility of ground-borne noise emissions. For daytime periods, the ICNG does not provide NMLs, but instead specifies that the human comfort vibration guidelines are applicable.

During evening and night-time periods however, when ambient noise levels are lower, ground-borne noise is more prominent and may result in adverse comment from building occupants.

Table 10-5 Ground-borne NMLs for residential receivers

Time of day	Ground-borne NMLs $L_{Aeq}(15 \text{ minute})$
Daytime 7 am to 6 pm	45 dBA – internal
Evening 6 pm to 10 pm	40 dBA – internal
Night-time 10 pm to 7 am	35 dBA – internal

At locations where the construction noise levels are predicted to exceed the NMLs, consideration must be given to applying all feasible and reasonable work practices for each site and activity to minimise potential noise impacts.

10.2.4 Construction ground-borne vibration

The effects of vibration in buildings can be divided into three main categories:

- Those in which the occupants or users of the building are inconvenienced or possibly disturbed
- Those where the building contents may be affected
- Those in which the integrity of the building or the structure itself may be compromised.

People are able to “feel” vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). Relevant vibration dose values for human comfort are provided in *Technical paper 2 – Noise and vibration*. People tend to hear vibration before they feel vibration; that means that if the ground-borne noise criteria are exceeded then the human comfort criteria for vibration would also be exceeded. This assessment has taken a conservative approach by assessing ground-borne noise impacts to determine exceedances and the requirement to implement mitigation measures.

In relation to structural and cosmetic damage, *Australian Standard AS 2187:2 – 2006* recommends use of the guidelines values and assessment methods provided in *British Standard BS 7385:2 – 1993*. The guidelines values for minimal risk of cosmetic damage from the BS 7385:2 – 1993 are provided in Table 10-6.

Table 10-6 BS 7385 cosmetic damage guideline values

Type of building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Where dynamic loading caused by continuous vibration may result in magnification of vibration through a building structure the guideline values may need to be reduced by up to 50 per cent. Rock breaking, rock hammering and sheet piling activities are considered to have the potential to cause dynamic loading in some structures (eg residences).

For construction activities involving intermittent vibration sources such as rock breakers, piling rigs, vibratory rollers, excavators and the like, the predominant vibration energy occurs at frequencies greater than 4 Hz (and usually in the 10 Hz to 100 Hz range). On this basis, and consistent with the guidance from *BS 7385*, the following conservative vibration damage screening level per receiver type have been adopted for the project:

- Reinforced or framed structures: 25.0 mm/s
- Unreinforced or light framed structures: 7.5 mm/s.

Heritage items

Heritage listed structures should not be assumed to be more sensitive to vibration. Notwithstanding, a conservative vibration screening criterion of 7.5 mm/s has been adopted for heritage structures.

10.2.5 Blasting

The ICNG recommends that vibration and overpressure from blasting be assessed against the levels presented in the *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration* (Australia and New Zealand Environment Council, 1990).

The criteria set by this standard are targeted for operations that occur for long periods of time such as those at mining sites and hence are targeted to protect human comfort from vibration. As a result the vibration levels are conservative and can introduce unnecessary constraints when applied to construction projects which typically occur for much shorter time periods.

Recent NSW infrastructure project approvals have recognised the restrictive nature of these blasting criteria when applied to construction projects and have allowed higher limits. Consistent with these recent approvals, the vibration and overpressure limits for blasting applied to this project are:

- Vibration (PPV): 25 mm/s
- Overpressure: 125 dBL.

These upper limits of vibration and overpressure are intended to target the protection of building structures from cosmetic damage rather than human comfort criteria as construction works are considered short-term. Since these criteria are analogous to the cosmetic damage screening criteria it is appropriate to add an additional conservative criteria which is specific to heritage buildings. A vibration (PPV) of 7.5 mm/s would be used to screen potential vibration impacts from blasting at heritage buildings.

The blasting scenarios developed for consideration in this assessment have been designed (based on preliminary information) to comply with the above criteria. The assessment then considers the potential reduction in periods of ground-borne noise impacts associated with the adoption of blasting as an excavation method.

10.2.6 Construction traffic noise

During construction, spoil removal and product deliveries would result in additional heavy vehicle movements on public roads. Whilst specific guidance on acceptable noise levels associated with construction traffic is not provided by the Environment Protection Authority, the potential noise impacts have been identified using guidance in the *NSW Road Noise Policy (RNP)* (Department of Environment, Climate Change and Water, 2011a).

One of the objectives of the RNP is to protect against excessive reduction in amenity as the result of a project by comparing traffic noise levels to the following relevant road traffic noise criteria:

- Existing freeway / arterial / sub-arterial roads:
 - ◆ $L_{Aeq}(15\text{hour})$ 60 dBA day
 - ◆ $L_{Aeq}(9\text{hour})$ 55 dBA night
- Existing local roads:
 - ◆ $L_{Aeq}(1\text{hour})$ 55 dBA day
 - ◆ $L_{Aeq}(1\text{hour})$ 50 dBA night.

Where traffic noise levels from the existing traffic plus the additional traffic generated by the project exceeds the criteria, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'no project option'.

In considering feasible and reasonable mitigation measures where the relevant noise increase is greater than 2 dB, consideration is also given to the actual noise levels associated with construction traffic.

10.2.7 Sleep disturbance

Sleep disturbance is considered as the emergence of the maximum level ($LA_{1(1\text{minute})}$ or LA_{max}) above the $LA_{90(15\text{minute})}$ background level at the time. The appropriate screening criterion for sleep disturbance is determined to be a maximum level 15 dB above the RBL, normally during the night-time period (10 pm to 7 am). Where this criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.

Additional guidance is provided in the RNP which concludes that:

- Maximum internal noise levels below 50 dBA to 55 dBA are unlikely to cause awakening reactions
- One or two events per night, with maximum internal noise levels of 65 dBA to 70 dBA, are not likely to affect health and wellbeing significantly.

On the basis of the above guidance, a sleep disturbance NML of 55 dBA (internal) has been adopted, which equates to an external noise level of 65 dBA (assuming open windows).

10.3 Existing environment

The project would cross a well-established urban environment that contains a wide range of commercial, residential and industrial land uses of varying densities interspersed with recreational areas and community facilities (such as schools, childcare centres, places of worship and medical facilities).

The existing noise environment varies considerably along the length of the project. The dominant noise sources that are likely to influence background noise levels include:

- Road traffic noise
- Suburban rail line operations and associated station activities
- Industrial activities occurring within existing industrial areas (such as at Artarmon and Marrickville)
- Other construction activities (such as the CBD and South East Light Rail, building redevelopments, road and housing construction)
- Sydney Harbour maritime traffic
- Aircraft noise.

10.3.1 Ambient noise surveys and monitoring locations

To characterise the existing ambient noise environment across the project area and to establish ambient noise levels on which to base the construction NMLs, noise monitoring was carried out at 25 representative locations during June to July and August to September 2015. This information has been supplemented with ambient noise data collated during the investigations for other recent projects, resulting in a database for a total of 29 representative locations across the project area.

Unattended noise monitors were placed at sensitive receiver locations in the vicinity of all construction sites for a minimum period of one week. The location of unattended noise surveys are shown on the respective figures in Section 10.4. The results of the unattended noise survey are summarised in Table 10-7.

Table 10-7 Summary of unattended noise monitoring

Location ID	Noise Level (dBA) ^{1,2}					
	Daytime 7 am to 6 pm		Evening 6 pm to 10 pm		Night-time 10 pm to 7 am	
	RBL	LAeq	RBL	LAeq	RBL	LAeq
Chatswood dive site (northern)						
B.22	42	55	41	50	34	48
B.23	63	71	60	70	45	67
B.24	50	59	47	58	39	55
B.25	41	54	40	53	35	49
Artarmon substation						
B20	45	56	45 (46) ³	54	38	50
B.21	49	55	46	50	41	48
Crows Nest Station						
B.19	59	68	55	67	50	62

Location ID	Noise Level (dBA) ^{1,2}					
	Daytime 7 am to 6 pm		Evening 6 pm to 10 pm		Night-time 10 pm to 7 am	
	RBL	LAeq	RBL	LAeq	RBL	LAeq
Victoria Cross Station						
B.16	65	68	63	65	52	62
B.17	55	61	50	55	44	51
B.18	65	74	57	71	51	66
Blues Point temporary site						
B.14	51	62	49	61	40	54
B.15	38	51	38	47	36	45
Sydney Harbour ground improvement works						
B.13	62	66	62	65	52	63
Barangaroo Station						
B.12	50	61	45	64	40	51
B.28 (2014)	51	56	46	52	41	47
B.29 (2013)	49	55	49	55	41	49
Martin Place Station						
B.11	61	66	56	62	52	63
Pitt Street Station						
B.27 (2009)	66	71	64	70	61	68
Central Station						
B.09	56	68	53	66	45	64
B.10	51	65	50	64	49	62
B.26 (2009)	58	70	56	69	52	66
Waterloo Station						
B.06	54	65	47	62	39	58
Marrickville dive site (southern)						
B.01	59	71	53	69	41	65
B.02	58	69	52	66	38	62
B.03	52	66	43	64	38	58
B.04	47	61	47	59	47	53

1 The RBL and LAeq noise levels have been obtained using the calculation procedures documented in the Industrial Noise Policy (INP) (Environment Protection Authority, 2000)

2 In accordance with the INP, where the RBL is found to be less than 30 dBA, then it is set to 30 dBA

3 Evening RBL reduced to equal daytime RBL in accordance with INP application notes

10.4 Potential impacts

The noise modelling scenarios are based on the construction methods described in Chapter 7 (Project description – construction). Chapter 7 (Project description – construction) also provides indicative timeframes for each of the construction activities at each construction site. Notwithstanding, the following sections provide a brief description of the construction noise scenarios modelled and the anticipated durations of each activity.

Construction planning has identified the need for measures at construction sites to manage potential noise impacts. Based on this the following has been included as part of the project and within the noise modelling:

- Standard attenuation acoustic sheds at Chatswood dive site, Crows Nest Station, Victoria Cross Station, Barangaroo Station, Martin Place Station, Pitt Street Station, Waterloo Station and Marrickville dive site to manage out of hours underground construction works. The same noise outcome may be achieved through alternative measures, such as acoustic panels over the station excavations. The specific noise mitigation measures would be determined during detailed construction planning taking into account construction program, construction working hours and construction traffic management in accordance with the Construction Noise and Vibration Strategy
- Noise barriers (indicatively three metres high) around all construction sites. The same noise outcome may be achieved through a range of noise barrier heights and the specific height of construction noise barriers would be identified during detailed construction planning through the implementation of the Construction Noise and Vibration Strategy.

The above measures are included in the noise predictions in the following sections.

10.4.1 Chatswood dive site (northern) and northern surface works

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-1.

The construction scenarios at the Chatswood dive site and northern surface works, and the anticipated timeframes, include:

- Demolition and site establishment (about 12 months) – the demolition of buildings on the site, demolition of the Nelson Street bridge, constructing site access and egress points, delivery and placement of site sheds and establishment of site compound facilities
- Track works (periodic over about four and a half years) – modifications to the T1 North Shore Line between Brand Street, Artarmon and Chatswood Station and the laying of metro tracks from the tunnel portal to Chatswood Station
- Earthworks (about 12 months) – initial surface excavation and excavation of the dive structure
- Acoustic shed construction (about one month) – piling and erection of the acoustic shed
- Tunnelling (about one and a half years) – excavation of the main tunnels and associated support services including spoil handling and removal
- Fit-out (about one and a half years) – fit of the track and the rail systems in the tunnels.

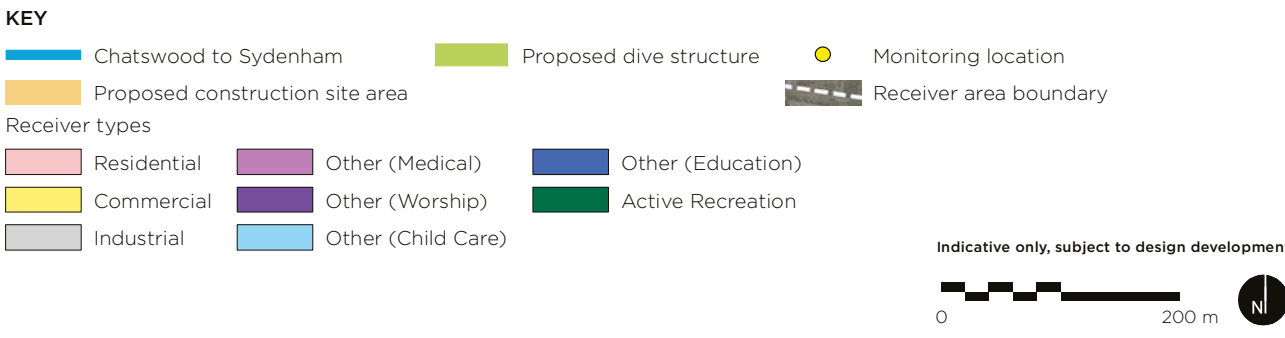
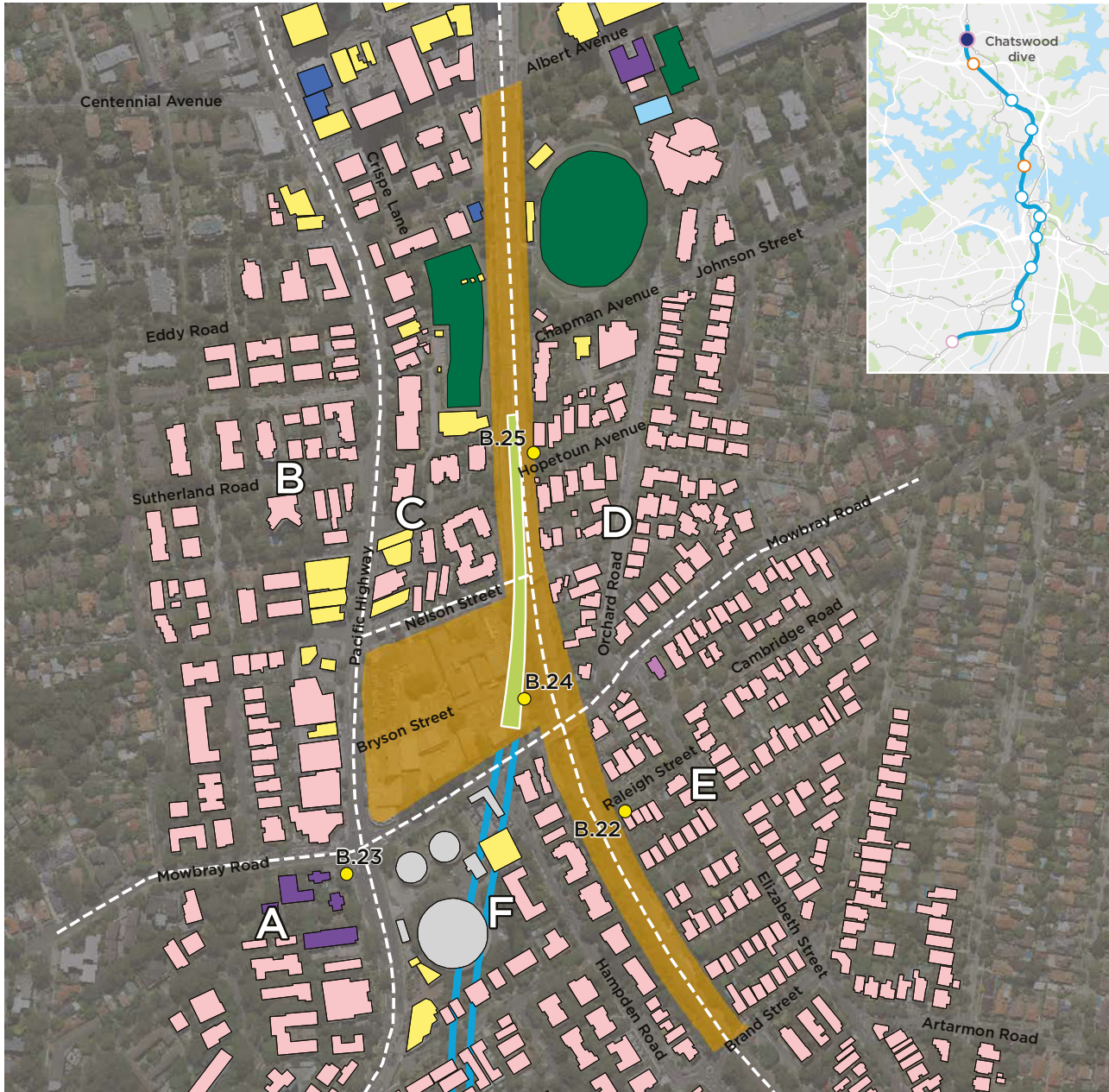


Figure 10-1 Location of sensitive receivers near Chatswood dive site (northern) and northern surface works

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-8 for each construction scenario.

Table 10-8 Predicted airborne noise level exceedances at Chatswood dive site (northern) and northern surface works

Receiver area	Noise modelling scenario													
	Demolition and site establishment	Track works	Earthworks	Acoustic shed construction	Tunnelling					Fit-out				
	Day	Day	Day	Day	Day	DOOH ¹	Evening	Night	Sleep	Day	DOOH ¹	Evening	Night	Sleep
A Church to the south west on Pacific Highway	●	●	●	●	●	●	●	●	●	●	●	●	●	●
B Residential to the west on Pacific Highway	●	●	●	●	●	●	●	●	●	●	●	●	●	●
B Commercial to the west on the Pacific Highway	●	●	●	●	●	●	●	●	●	●	●	●	●	●
C Residential to the north on Nelson Street	●	●	●	●	●	●	●	●	●	●	●	●	●	●
C Commercial to the north on Nelson Street	●	●	●	●	●	●	●	●	●	●	●	●	●	●
C Active recreation to the north, west of the T1 North Shore Rail Line	●	●	●	●	●	●	●	●	●	●	●	●	●	●
D Active recreation to the north, east of the T1 North Shore Rail Line	●	●	●	●	●	●	●	●	●	●	●	●	●	●
D Residential to the east, east of the T1 North Shore Rail Line	●	●	●	●	●	●	●	●	●	●	●	●	●	●
E Residential to the east, east of the T1 North Shore Rail Line	●	●	●	●	●	●	●	●	●	●	●	●	●	●
F Residential to the south on Mowbray Road	●	●	●	●	●	●	●	●	●	●	●	●	●	●
F Commercial to the south on Mowbray Road	●	●	●	●	●	●	●	●	●	●	●	●	●	●
F Industrial receivers to the south on Mowbray Road	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

¹ DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)

The preliminary findings of the construction noise impact assessment at Chatswood dive site indicate:

- For demolition and site establishment works during the daytime high exceedances of more than 20 dB of the NMLs are predicted at residential receivers in Area C, D, E and F and at the commercial receivers and active recreation in Area C. Moderate exceedances of more than 10 dB are predicted for the church in Area A, and at the residential and commercial receivers in Area B. Minor exceedances are predicted at the active recreation Area D. These are a direct result of the relative close proximity of receivers to the construction activities and the absence of any appreciable shielding between sites and receivers
- For track works during the daytime high exceedances of more than 20 dB of the NMLs are predicted at residential receivers in Area C, D, E and F and at the commercial receivers and active recreation of Area C. Moderate exceedances of more than 10 dB are predicted at the church and at the active recreation Area D
- For earthworks during the daytime high exceedances of more than 20 dB of the NMLs are predicted at residential receivers in Area C, D, E and F. Moderate exceedances of more than 10 dB are predicted at the commercial receivers in Area C and at the active recreation Area C
- For acoustic shed construction during the daytime minor exceedances of less than 10 dB are predicted at the residential receivers in Areas C, D, E and F
- During tunnelling a high exceedance of the NMLs by more than 20 dB is predicted at the residential receivers in Area C, D, and F, and a moderate exceedance is predicted in Area E during the daytime, from activities outside the shed. During the night-time moderate exceedances of more than 10 dB are predicted at the residential receivers in Area C, D, E, and F, and minor exceedances in Area A. An acoustic shed with higher noise insulation (such as a double wall construction) would be required to reduce night-time non-compliance
- During fitout compliance is generally predicted during daytime and evening, with minor exceedances at residences in Areas C (during the night time) and F (during the evening and night time).

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site exceed the sleep disturbance screening level during tunnelling at residential receivers in Areas C, E and F.

Opportunities to minimise noise from heavy vehicles, such as consideration of site layouts and screening, would be considered during detailed construction site planning.

Ground-borne noise

Rock breaking and dive excavation works are proposed to be carried out during the daytime period at this site. The ground-borne noise assessment indicated that:

- Three residences located to the east of the dive structure, would exceed the NML by 20 dB to 25 dB
- Seven residences, located to the east and west of the dive structure, would exceed the NML by 10 dB to 20 dB. This includes Mowbray House which would form part of the construction site but be retained
- Nine residences, located east and south of the dive structure, would exceed the NML by up to 10 dB
- One commercial receiver, located to the west of the dive structure, would exceed the NML by 10 dB to 20 dB.

These exceedances are a direct result of the relative close proximity of receivers to the construction activities and the use of large rock breakers. The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Ground-borne vibration

The heritage listed Mowbray House is located on the construction site, and predicted vibration levels exceed the vibration screening level for an unreinforced or light framed structure. A more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for that structure.

Construction vibration levels are anticipated to remain well below the vibration screening levels associated with minor cosmetic building damage at all other receivers.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Chatswood dive site and are presented in Table 10-9.

On the Pacific Highway and Mowbray Road construction traffic exceeds the base criteria, however the predicted noise level increase complies with the 2 dB allowance. Whilst there is an exceedance of the sleep disturbance screening criterion (of up to 10 dB) and external sleep disturbance NML of 65 dBA (by up to 10 dB), the L_{Amax} levels would be similar to other heavy vehicles using the Pacific Highway and Mowbray Road. Therefore sensitive receivers on these roads are not likely to notice an increase in the average road traffic noise levels during construction.

On Nelson Street baseline noise levels of 58 dBA (daytime) and 52 dBA (night-time) have been predicted. These levels exceed the RNP base criteria of 55 dBA (daytime) and 50 dBA (night-time) for local roads. There is an exceedance of the sleep disturbance screening criterion (of up to 16 dB) and external sleep disturbance NML of 65 dBA (by up to 5 dB) resulting in a sleep disturbance risk. Unless compliance with the road traffic noise criteria can be achieved on Nelson Street, night time heavy vehicle movements at the Chatswood dive site would be restricted to the Pacific Highway and Mowbray Road.

Table 10-9 Chatswood dive site (northern) – road traffic noise

Road	Base criteria (dB) day / night ($L_{Aeq}(15hr/9hr)$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
Pacific Highway	60 / 55	74 / 68	0.1 / 0.2	65	65	74
Mowbray Road	60 / 55	73 / 67	0.1 / 0.2	65	65	75
Nelson Street	55 / 50	58 / 52	N/A ¹	54	65	70

¹ Existing traffic flows are not available for Nelson Street

10.4.2 Artarmon substation construction site

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-2.

The construction scenarios at the Artarmon substation, and the anticipated timeframes, include:

- Site establishment (about one month) – vegetation clearing and establishment of the site compound
- Earthworks (about one month) – initial surface excavation and site levelling
- Excavation (about nine months) – excavation of the shaft to the tunnels below
- Building construction (about 12 months) – construction and fit-out of the aboveground substation building.

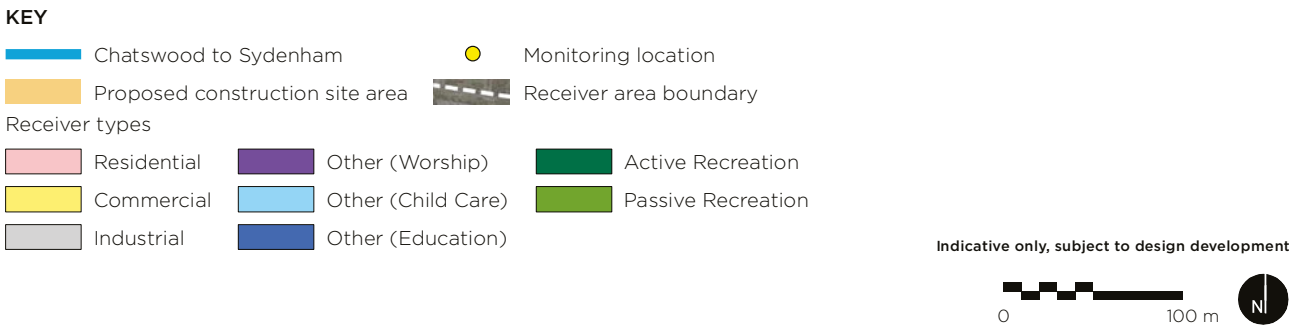


Figure 10-2 Location of sensitive receivers near Artarmon substation construction site

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-10 for each construction scenario.

Table 10-10 Predicted airborne noise level exceedances at Artarmon substation construction site

Receiver area	Noise modelling scenario			
	Site establishment	Earthworks	Excavation	Building construction
	Day	Day	Day	Day
A Residential to the north of Butchers Lane	●	●	●	●
B Residential to the north east on Reserve Road	●	●	●	●
C Residential to the east on Barton Road	●	●	●	●
D Commercial to the south on Hotham Parade	●	●	●	●

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

The preliminary findings of the construction noise impact assessment at Artarmon Substation indicate:

- For site establishment works high exceedances of more than 20 dB of the NMLs are predicted at residential receivers in area A and B and moderate exceedances of more than 10 dB in Area C. There are minor exceedances of less than 10 dB on the commercial receivers in Area D. These are a direct result of the relative close proximity of receivers to the construction activities and the absence of any appreciable shielding between sites and receivers
- For earthworks and shaft excavation high exceedances of more than 20 dB are predicted at the residential receivers in Area A and moderate exceedances of more than 10 dB are predicted at Area B. There are minor exceedances at the residential receivers in Area C and at the commercial receivers in Area D
- For building construction moderate exceedances of more than 10 dB are predicted at the residential receivers in Area A and B and minor exceedances in Area C. At the commercial receivers in Areas D, compliance is predicted.

On site night-time L_{Amax} truck noise

No night-time L_{Amax} truck noise impacts are predicted at the Artarmon substation construction site as construction would occur during the daytime.

Ground-borne noise

Rock breaking and excavation works are proposed to be carried out during the daytime period at this site. The ground-borne noise assessment indicated that minor exceedances minor of the NML of up 10 dB would occur at the nearest receivers.

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Ground-borne vibration

During rock breaker activities at the Artarmon substation construction site, vibration levels may be perceptible at the nearest residential receivers. As the nearest buildings are around 25 metres from the proposed shaft, vibration levels are anticipated to remain below the vibration screening levels associated with minor cosmetic building damage.

Construction traffic noise

The predicted L_{Aeq} increase noise levels have been assessed for the access routes to the Artarmon substation construction site. As no night-time works are proposed at this site, a sleep disturbance assessment has not been carried out.

Reserve Road has significant daytime flows, and the predicted traffic noise increase is 0.2 dB which complies with the 2 dB increase criteria.

Barton Road is a cul-de-sac which does not provide access to any residences and, as such, has negligible existing flows. Therefore traffic noise levels from site traffic movements have been predicted for comparison with the RNP baseline criteria (presented in Table 10-11). Traffic noise levels from the project comply with the baseline criteria on Barton Road.

Table 10-11 Artarmon substation – road traffic noise

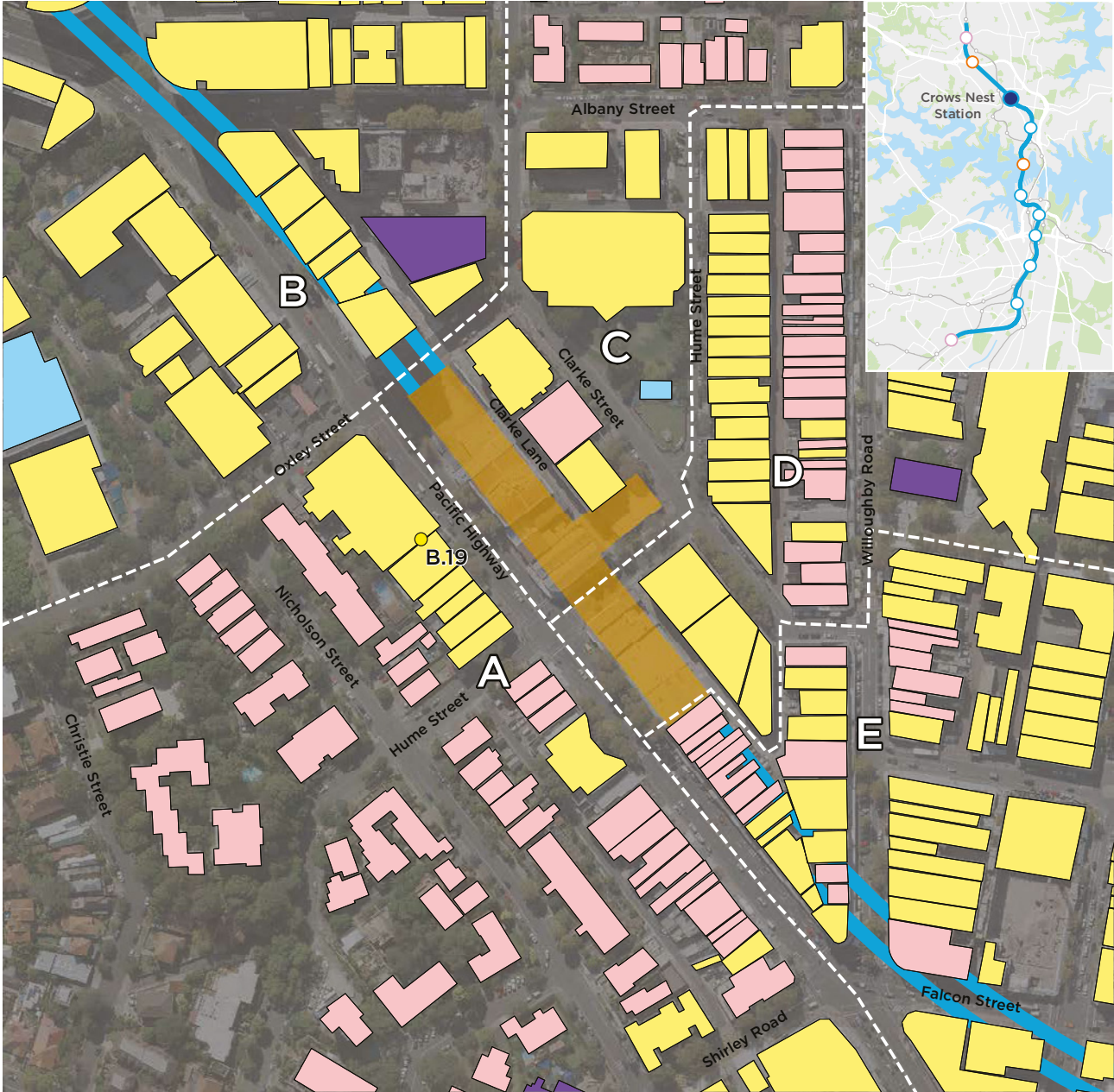
Road	Base criteria daytime (dB)	Predicted project daytime traffic noise (dB)
Barton Road	55	51

10.4.3 Crows Nest Station





The nearest sensitive receivers to the proposed construction site are shown in Figure 10-3.

The construction scenarios at the Crows Nest Station construction site, and the anticipated timeframes, include:





- Demolition and site establishment (about 12 months) – the demolition of buildings on the site and establishment of the site compound facilities
- Earthworks (about two months) – initial surface excavation
- Acoustic shed construction (about one month) – piling and erection of the acoustic shed
- Excavation and structural works (about three years) – excavation of the station and structural works
- Building construction (about one and a half years) – aboveground station and services building construction and fit-out.



KEY

 Chatswood to Sydenham	 Monitoring location
 Proposed construction site area	 Receiver area boundary

Receiver types

 Residential	 Other (Worship)
 Commercial	 Other (Child Care)

Indicative only, subject to design development



Figure 10-3 Location of sensitive receivers near Crows Nest Station

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-12 for each construction scenario.

Table 10-12 Predicted airborne noise level exceedances at Crows Nest Station

Receiver area	Noise modelling scenario								
	Demolition and site establishment	Earthworks	Acoustic shed construction	Excavation and structural works				Building construction	
				Day	DOOH ¹	Evening	Night		Sleep
Day	Day	Day	Day	DOOH ¹	Evening	Night	Sleep	Day	
A Residential to the west on Pacific Highway	●	●	●	●	●	●	●	●	●
A Commercial to the west on Pacific Highway	●	●	●	●	●	●	●	●	
B Commercial to the north on Oxley Street	●	●	●	●	●	●	●	●	●
B Church to the north on Oxley Street	●	●	●	●	●	●	●	●	●
C Residential to the north east on Clarke Street	●	●	●	●	●	●	●	●	●
C Commercial to the north east on Clarke Street	●	●	●	●	●	●	●	●	●
C Active recreation to the north on Hume Street	●	●	●	●	●	●	●	●	●
D Residential to the north east on Clarke Street	●	●	●	●	●	●	●	●	●
D Commercial to the north east on Clarke Street	●	●	●	●	●	●	●	●	●
E Residential to the south on Pacific Highway	●	●	●	●	●	●	●	●	●
E Commercial to the south on Pacific Highway	●	●	●	●	●	●	●	●	●

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

¹ DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)

The preliminary findings of the construction noise impact assessment at Crows Nest Station indicate:

- For demolition and site establishment during the daytime high exceedances of more than 20 dB of the NMLs are predicted at residential receivers in Area C and E. Moderate exceedances of more than 10 dB are predicted at residential receivers in Area A, at the church in Area B and the active recreation in Area C. At residential receivers in Area D minor exceedances are predicted.

High exceedances of more than 20 dB of the NMLs are predicted at the nearest commercial receivers in Areas C and D, moderate exceedances of more than 10 dB are predicted at commercial receivers in Areas A and B, and minor exceedances are predicted at commercial receivers in Area E

- For earthworks during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the residential receivers in Area C. Moderate exceedances are predicted at the church in Area B, the residential receivers in Area E and the active recreation in Area C. Minor exceedances are predicted at the residential receivers in Area A and D.

High exceedances of more than 20 dB of the NMLs are predicted at the nearest commercial receivers in Areas C and D, and moderate exceedances of more than 10 dB are predicted at commercial receivers in Areas A and B

- For acoustic shed construction during the daytime moderate exceedances are predicted at commercial receivers in Area C, and minor exceedances are predicted at the church in Area B, the residential in Area C and the commercial in Area D
- For station excavation and structural works minor exceedances of up to 10 dB of the NMLs are predicted at the commercial receivers in Area C, and the church in Area B during daytime. During the night-time period moderate exceedances are predicted at residences in Area C, and minor exceedances are predicted at residences in Area A. An acoustic shed with higher noise insulation (such as a double wall construction) would be required to reduce night-time non compliance
- During station building construction during the daytime moderate exceedances of more than 10 dB of the NMLs are predicted at the residential receivers in Area C and E, commercial receivers at Area C and D, and at the church in Area B. Minor exceedances are predicted at residential receivers in Area A, and at commercial receivers in Area A and B and the active recreation in Area C.

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site exceed the sleep disturbance screening level by up to 10 dB during excavation. Opportunities to minimise noise from heavy vehicles, such as consideration of site layouts and screening, would be considered during detailed construction site planning.

Ground-borne noise

The ground-borne noise assessment indicated:

- During the daytime period seven buildings (four commercial buildings located to the east of the site, one residential building located to the east of the site and two residential buildings located to the south of the site) are predicted to have ground-borne noise levels potentially higher than 75 dBA for several floors in each building
- During the night-time period 15 residential buildings, located to the east, south and west of the site, are predicted to have ground-borne noise levels potentially higher than 45 dBA on one or more floors.

Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted. Where exceedances of ground-borne noise levels are predicted, mitigation measures would be implemented in accordance with the Sydney Metro Construction Noise and Vibration Strategy (Appendix E).

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Blasting

Due to the level and duration of ground-borne noise exceedances associated with rock breaking, consideration has been given to blasting as an alternative excavation method. Table 10-13 shows the anticipated reduction in the number of periods when the NML would be exceeded. The table shows three scenarios: no blasting, blasting plus a large rock breaker, blasting plus a medium rock breaker.

Table 10-13 Crows Nest Station blasting scenarios

Scenario	Number of periods above NMLs			
	Residential			Commercial
	Day	Evening	Night	Day
No blasting	80	136	185	67
Blasting plus large rock breaker	30	45	60	27
Blasting plus medium rock breaker	15	29	49	8

The potential change in duration of impacts is:

- **Residential day:** the use of large rock breakers with no blasting generates 80 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 30 daytime periods. The inclusion of blasting combined with medium rock breakers reduces the duration of impacts to 15 daytime periods
- **Residential evening:** the use of large rock breakers with no blasting generates 136 evening periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 45 evening periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 29 evening periods
- **Residential night:** the use of large rock breakers with no blasting generates 185 night-time periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 60 night-time periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 49 night-time periods
- **Commercial day:** the use of large rock breakers with no blasting generates 67 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 27 daytime periods. The inclusion of blasting combined with medium rock breakers reduces the duration of impacts to eight daytime periods.

Further detailed construction planning, through the development of Construction Noise Impact Statements (as required by the *Sydney Metro Construction Noise and Vibration Strategy* in Appendix E) would determine the exact construction activities with the aim of reducing ground-borne noise impacts to receivers. For example, this could involve the consideration of different sized rock breakers at different periods, and the positioning of rock breakers within the site during different periods.

With careful planning and positioning of the rock breakers it may be possible to avoid consecutive periods of NML exceedances to any one receiver, effectively providing respite periods. For any residual exceedances of the NMLs, additional mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

Ground-borne vibration

During excavation, vibration levels are anticipated to exceed the cosmetic damage vibration screening criteria at three buildings adjacent to the site (one building located to the east on Clarke Street and two building located to the south of the Pacific Highway). A more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for those structures.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Crows Nest Station construction site and are presented in Table 10-14. No sensitive receivers are located on the sections of Oxley Street and Hume Street proposed to be used as haul routes.

On the Pacific Highway predicted noise level exceed the base criteria, however the increase associated with construction traffic complies with the 2 dB allowance. Whilst there is an exceedance of the sleep disturbance screening criterion (of up to 14 dB) and external sleep disturbance NML of 65 dBA (by up to 14 dB), the L_{Amax} levels would be similar to other heavy vehicles using the Pacific Highway. Therefore sensitive receivers are not likely to notice an increase in the average road traffic noise levels during construction.

On Clarke Street noise levels of 59 dBA (daytime) and 56 dBA (night-time) have been predicted. These levels exceed the RNP baseline criteria of 55 dBA (daytime) and 50 dBA (night-time) for local roads. There is an exceedance of the sleep disturbance screening criterion (of up to 9 dB) and external sleep disturbance NML of 65 dBA (of up to 10 dB), resulting in a sleep disturbance risk. Unless compliance with the road traffic noise criteria can be achieved on Clarke Street, night time heavy vehicle movements at the Crows Nest Station construction site would be restricted to the Pacific Highway, Hume Street and Oxley Street.

Table 10-14 Crows Nest Station – road traffic noise

Road	Base criteria (dB) day / night ($L_{Aeq}(15hr/9hr)$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
Pacific Highway	60 / 55	75 / 68	0.2 / 0.5	65	65	79
Clarke Street	55 / 50	59 / 56	N/A ¹	66	65	75

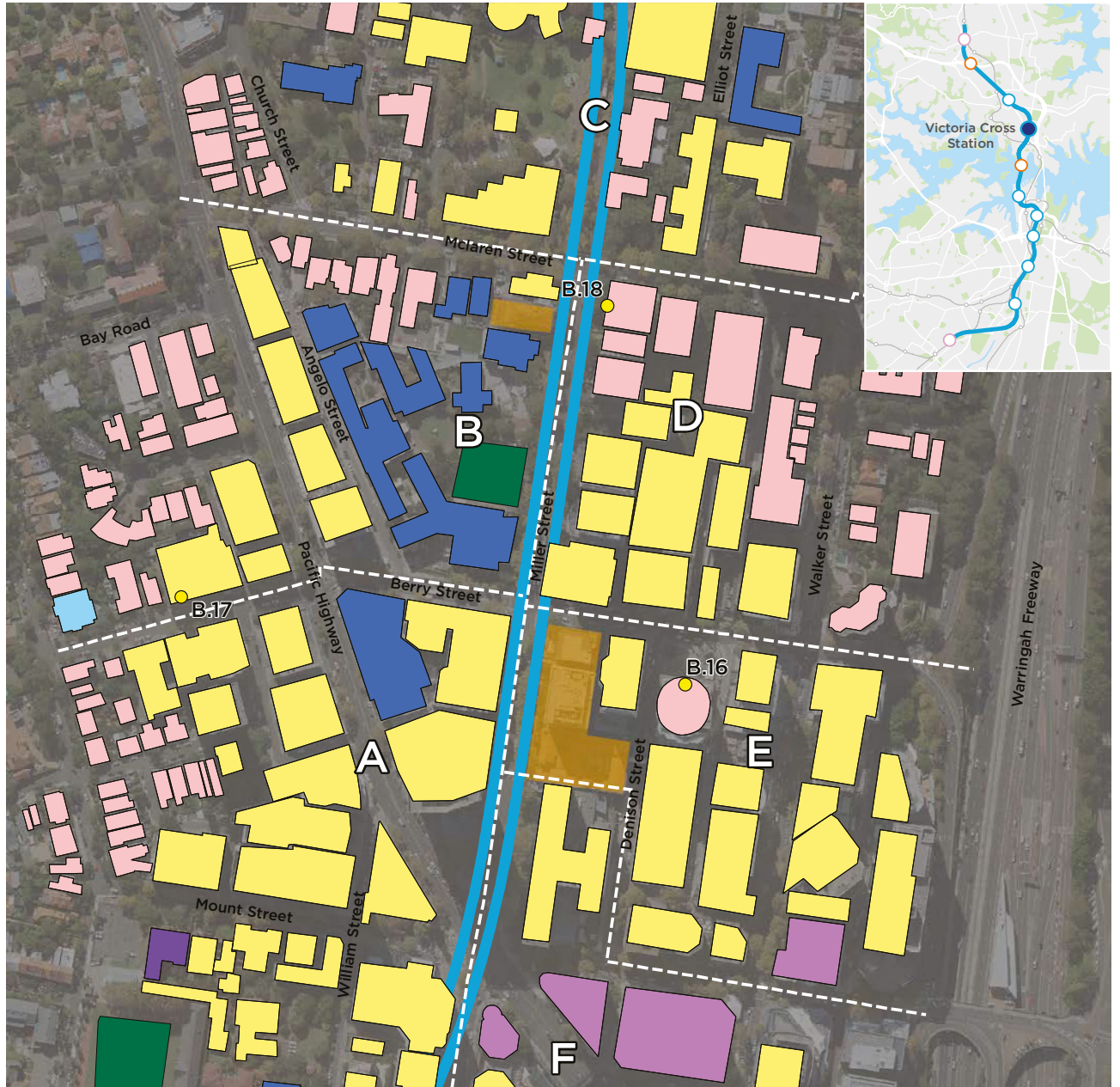
¹ Existing traffic flows are not available for Clarke Street

10.4.4 Victoria Cross Station

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-4.

The construction scenarios at the Victoria Cross Station construction site, and the anticipated timeframes, include:

- Demolition and site establishment (about 12 months) – the demolition of buildings on the site and establishment of the site compound facilities
- Earthworks (about two months) – initial surface excavation
- Acoustic shed construction (about one month) – piling and erection of the acoustic shed
- Excavation and structural works (about three years) – excavation of the station and structural works
- Building construction (about one a half years) – aboveground station and services building construction and fit-out.



KEY

- Chatswood to Sydenham
 - Proposed construction site area
 - Receiver area boundary
 - Monitoring location
- Receiver types
- | | | |
|--|---|--|
| Residential | Other (Worship) | Active Recreation |
| Commercial | Other (Child Care) | |
| Other (Medical) | Other (Education) | |

Indicative only, subject to design development



Figure 10-4 Location of sensitive receivers near Victoria Cross Station

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-15 for each construction scenario.

Table 10-15 Predicted airborne noise level exceedances at Victoria Cross Station

Receiver area	Noise modelling scenario								
	Demolition and site establishment	Earthworks	Acoustic shed construction	Excavation and structural works				Building construction	
	Day	Day	Day	Day	DOOH ¹	Evening	Night	Sleep	Day
A Commercial to the west on Miller Street	●	●	●	●	●	●	●	●	●
A Educational to the west on Pacific Highway	●	●	●	●	●	●	●	●	●
B Commercial to the west on Miller Street	●	●	●	●	●	●	●	●	●
B Residential to the west on McLaren Street	●	●	●	●	●	●	●	●	●
B Educational to the west on Miller Street	●	●	●	●	●	●	●	●	●
C Residential to the north on McLaren Street	●	●	●	●	●	●	●	●	●
C Commercial to the north on McLaren Street	●	●	●	●	●	●	●	●	●
D Residential to the east on Miller Street	●	●	●	●	●	●	●	●	●
D Commercial to the east on Miller Street	●	●	●	●	●	●	●	●	●
E Residential to the east on Miller Street	●	●	●	●	●	●	●	●	●
E Commercial to the east on Miller Street	●	●	●	●	●	●	●	●	●
F Commercial adjacent to the south	●	●	●	●	●	●	●	●	●

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

¹ DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)

The preliminary findings of the construction noise impact assessment at Victoria Cross Station indicate:

- For demolition and site establishment works during the daytime high exceedances of more than 20 dB of the NMLs are predicted at educational receivers in Area B and at the commercial receivers in Areas B, E and F. Moderate exceedances of more than 10 dB are predicted at commercial receivers in Areas A and D, at residential receivers in Area B and educational receivers in Area in A. At residential receivers in Area D and E and commercial receivers in Area C minor exceedances are predicted
- For earthworks during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the educational receivers in Area B and commercial receivers in Areas E and F. Moderate exceedances are predicted at the educational receivers in Area A, and the commercial receivers in Areas B and D.

At the nearest residential receivers moderate exceedances are predicted in Area B and minor exceedances are predicted in Areas D and E

- For acoustic shed construction during the daytime high exceedances of more than 20 dB are predicted at educational receivers in Area B and moderate exceedances of more than 10 dB at commercial receivers in Areas E and F
- For excavation during the daytime moderate exceedances are predicted at the educational receivers in Area B. For night-time excavation moderate exceedances are predicted at residential receivers in Area B and a minor exceedance is predicted at residential receivers in Areas D and E. An acoustic shed with higher noise insulation (such as a double wall construction) would be required to reduce night-time non compliance
- For station building construction during the daytime high exceedances of more than 20 dB are predicted at the educational receivers in Area B, and moderate exceedances of more than 10 dB of the NMLs are predicted at the commercial receivers at Areas B and E. Minor exceedances are predicted at residential receivers in Areas B and D, educational receivers in Area A and at commercial receivers in Areas A, D and F.

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site exceed the sleep disturbance screening level by up to 10 dB during excavation. Opportunities to minimise noise from heavy vehicles, such as consideration of site layouts and screening, would be considered during detailed construction site planning.

Ground-borne noise

The ground-borne noise assessment indicated:

- During the daytime the three buildings immediately adjacent to the northern site to the south, west and north and one building to the east of the southern site are predicted to have ground-borne noise levels potentially higher than 75 dBA on several floors in each building
- During night-time the five residential buildings near the northern site (to the east and west) and one residential building to the east of the southern site have ground-borne noise levels potentially higher than 45 dBA on several floors.

Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted. Where exceedances of ground-borne noise levels are predicted, mitigation measures would be implemented in accordance with the Sydney Metro Construction Noise and Vibration Strategy (Appendix E).

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Blasting

Due to the level and duration of ground-borne noise exceedances associated with rock breaking, consideration has been given to blasting as an alternative excavation method. Table 10-16 shows the anticipated reduction in the number of periods when the NML would be exceeded. The table shows three scenarios: no blasting, blasting plus a large rock breaker, blasting plus a medium rock breaker.

Table 10-16 Victoria Cross Station blasting scenarios

Scenario	Number of periods above NMLs			
	Residential			Commercial
	Day	Evening	Night	Day
Northern site				
No blasting	62	172	268	283
Blasting plus large rock breaker	32	71	101	131
Blasting plus medium rock breaker	9	31	77	111
Southern site				
No blasting	0	16	55	37
Blasting plus large rock breaker	0	8	22	22
Blasting plus medium rock breaker	0	0	7	8

The potential change in duration of impacts is:

- Residential day:** the use of large rock breakers with no blasting generates 62 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 32 daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to nine daytime periods
- Residential evening:** the use of large rock breakers with no blasting generates 192 evening periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 79 evening periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 31 evening periods
- Residential night:** the use of large rock breakers with no blasting generates 323 night-time periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 123 night-time periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 84 night-time periods
- Commercial day:** the use of large rock breakers with no blasting generates 324 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 153 daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 119 daytime periods.

Further detailed construction planning, through the development of Construction Noise Impact Statements (as required by the *Sydney Metro Construction Noise and Vibration Strategy* in Appendix E) would determine the exact construction activities with the aim of reducing ground-borne noise impacts to receivers. For example, this could involve the consideration of different sized rock breakers at different periods, and the positioning of rock breakers within the site during different periods.

With careful planning and positioning of the rock breakers it may be possible to avoid consecutive periods of NML exceedances to any one receiver, effectively providing respite periods. For any residual exceedances of the NMLs, additional mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

Ground-borne vibration

During excavation of the shafts vibration levels are anticipated to remain below the cosmetic damage vibration screening criteria, except for:

- The three buildings immediately adjacent to the northern site to the south, west and north
- One commercial building to the east of the southern site.

A more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for these structures.

The use of road headers to excavate a low level pedestrian walkway from the southern site to the mined station cavern is predicted to remain below the cosmetic damage vibration screening criteria screening levels.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Victoria Cross Station construction site and are presented in Table 10-17.

On McLaren Street, Miller Street and Berry Street the predicted noise level exceeds the base criteria, however the increase associated with construction traffic complies with the 2 dB allowance. Whilst there is an exceedance of the sleep disturbance screening criterion (of up to 10 dB) and external sleep disturbance NML of 65 dBA (of up to 11 dB), the L_{Amax} levels would be similar to other heavy vehicles using McLaren Street, Miller Street and Berry Street. Therefore sensitive receivers are not likely to notice an increase in the average road traffic noise levels during construction.

On Denison Street baseline noise levels of 54 dBA (daytime) and of 50 dBA (night-time) have been predicted. These levels comply with the RNP baseline criteria of 55 dBA (daytime) and 50 dBA (night-time) for local roads. However, there is an exceedance of the sleep disturbance screening criteria and, as there are limited existing heavy vehicles using this road, there is a risk of sleep disturbance impacts. Unless compliance with the road traffic noise criteria can be achieved on Denison Street, night time heavy vehicle movements at the Victoria Cross Station construction site would be restricted to McLaren Street, Miller Street and Berry Street.

Table 10-17 Victoria Cross Station – road traffic noise

Road	Base criteria (dB) day / night ($L_{Aeq}(15hr/9hr)$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
McLaren Street	60 / 55	66 / 62	0.6 / 0.8	66	65	76
Miller Street	60 / 55	66 / 59	0.3 / 0.7	66	65	72

Road	Base criteria (dB) day / night (L _{Aeq} (15hr/9hr))	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L _{Amax} NML Level (dBA)	Predicted L _{Amax} Noise Level (dBA)
Berry Street	60 / 55	69 / 62	0.3 / 0.8	67	65	76
Denison Street	55 / 50	54 / 50	N/A ¹	67	65	72

¹ Existing traffic flows are not available for Denison Street

10.4.5 Blues Point temporary site

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-5.

The construction scenarios at the Blues Point temporary site, and the anticipated timeframes, include:

- Site establishment (about one month) – stripping to grass and topsoil and establishment of site compound facilities
- Earthworks (about one month) – initial surface excavation and site levelling
- Excavation (about 12 months) – excavation of the shaft to tunnel level
- Site rehabilitation (about six months) – rehabilitation of Blues Point Reserve including re-contouring of the site and landscaping.



KEY

- Chatswood to Sydenham
- Proposed construction site area
- Receiver area boundary
- Monitoring location
- Residential
- Commercial
- Passive Recreation

Indicative only, subject to design development



Figure 10-5 Location of sensitive receivers near Blues Point temporary site

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-18 for each construction scenario.

Table 10-18 Predicted airborne noise level exceedances at Blues Point temporary site

Receiver area	Noise modelling scenario			
	Site establishment	Earthworks	Excavation	Site rehabilitation
	Day	Day	Day	Day
A Residential to the west in Blues Point Tower	●	●	●	●
A Passive recreation to the south west	●	●	●	●
B Residential to the north, east of Blues Point Road	●	●	●	●
C Residential to the north on Warung Street	●	●	●	●
D Commercial to the east on Henry Lawson Avenue	●	●	●	●
D Passive recreation to the east	●	●	●	●

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

The preliminary findings of the construction noise impact assessment at Blues Point temporary site indicate:

- For site establishment works high exceedances of more than 20 dB of the NMLs are predicted at residential receivers in Area C, and moderate exceedances of more than 10 dB are predicted in at residential receivers in Areas A and B and at the commercial and recreation receivers in Area D. A moderate exceedance is also predicted in the passive recreation in Areas A and D, and at the commercial receiver in Area D. These are a direct result of the relative close proximity of receivers to the construction activities and the absence of any appreciable shielding between sites and receivers
- For earthworks and excavation high exceedances of more than 20 dB are predicted at the residential receivers in Area C, a moderate exceedance at residences in Areas A and B and minor exceedances of less than 10 dB at the passive recreation in Areas A and D, and the commercial receiver in Area D
- For site rehabilitation moderate exceedances of more than 10 dB are predicted at the residential receivers in Area C. There are minor exceedances in the residential receivers in Areas A and B and the passive recreation in Areas A and D.

On site night-time L_{Amax} truck noise

With the exception of the four occasions when transport of the tunnel boring machine cutter heads would be carried out, no night-time L_{Amax} truck noise impacts are predicted at the Blues Point temporary site as construction would generally occur during the daytime.

Ground-borne noise

Rock breaking and excavation works are proposed to be carried out during the daytime period at this site. The ground-borne noise assessment indicated that:

- One receiver, located on Warung Street, is predicted to have a high exceedance of the NML (of between 20 dB to 25 dB)
- Three receivers, located on Warung Street, are predicted to have a moderate exceedance of the NML (of up to 10 dB).

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Ground-borne vibration

During excavation of the shafts vibration levels are anticipated to remain below the cosmetic damage vibration screening criteria.

Construction traffic noise

The predicted L_{Aeq} increase noise levels have been assessed for the access routes to the Blues Point temporary site. As no night-time works are proposed at this site (with the exception of the four occasions when transport of the tunnel boring machine cutter heads would be carried out), a sleep disturbance assessment has not been carried out. Traffic noise levels from the project comply with the baseline criteria on Henry Lawson Avenue and exceed by 1 dB on Blues Point Road.

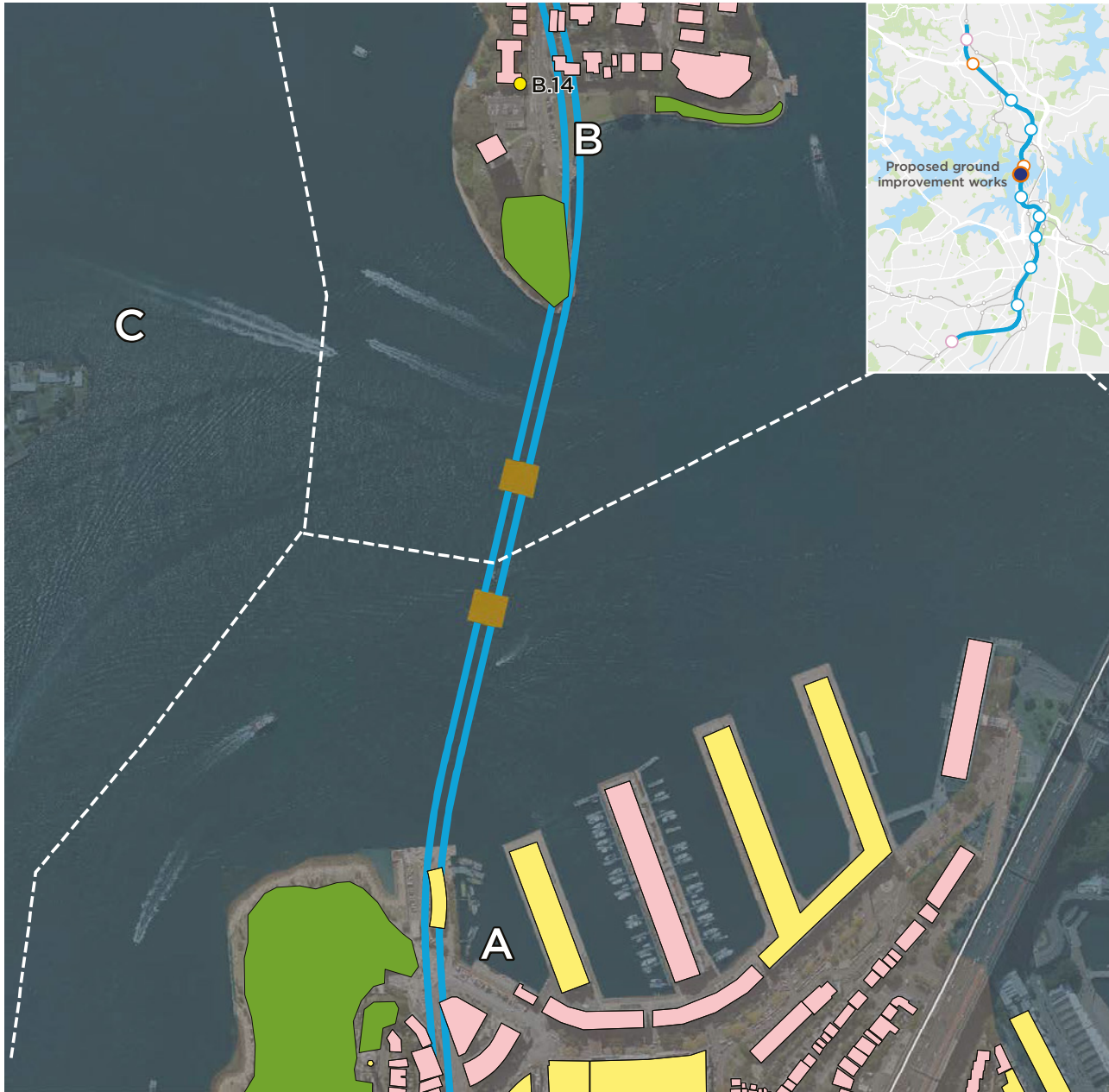
Table 10-19 Blues Point temporary site – road traffic noise

Road	Base criteria daytime (dB)	Predicted project daytime traffic noise (dB)
Blues Point Road	55	56
Henry Lawson Avenue	55	52








10.4.6 Sydney Harbour ground improvement works

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-6. Due to the nature of works at this site, the assessment has considered potential airborne noise impacts only.

The construction scenario for the ground improvement work involves the use of the grout barge on the harbor in two location. The works are anticipated to occur for about 12 months.



KEY

	Chatswood to Sydenham		Monitoring location
	Proposed ground improvement works		Receiver area boundary
Receiver types			
	Residential		Commercial
	Passive Recreation		

Indicative only, subject to design development



Figure 10-6 Location of sensitive receivers near Sydney Harbour ground improvement works

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-20 for the construction scenario.

Table 10-20 Predicted airborne noise level exceedances – ground improvement work

Receiver area	Noise modelling scenario				
	Day	DOOH	Evening	Night	Sleep
A Residential to the west in Blues Point Tower	●	●	●	●	●
A Passive recreation to the south west	●	●	●	●	●
B Residential to the north, east of Blues Point Road	●	●	●	●	●
C Residential to the north on Warung Street	●	●	●	●	●
D Commercial to the east on Henry Lawson Avenue	●	●	●	●	●
D Passive recreation to the east	●	●	●	●	●

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

¹ DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)

The preliminary findings of the construction noise impact assessment of the Sydney Harbour ground improvement works predicts compliance for the daytime at evening periods at all receiver areas. During night-time there is a minor exceedance of up to 10 dB at residential receivers in Area A.

10.4.7 Barangaroo Station

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-7.

The construction scenarios at the Barangaroo Station construction site, and the anticipated timeframes, include:

- Site establishment (about 12 months) – establishment of site compound facilities
- Earthworks (about two months) – initial surface excavation
- Acoustic shed construction (about one month) – piling and erection of the acoustic shed
- Station excavation and tunnelling works (about 12 months for station excavation and one and half years for tunnelling) – excavation of the station, excavation of the main tunnel beneath Sydney Harbour and associated support services such as spoil handling and removal
- Building construction (about one and a half years) – aboveground station and services building construction and fit-out.



KEY

- Chatswood to Sydenham
 - Proposed construction site area
 - Receiver area boundary
 - Monitoring location
- Receiver types
- Residential
 - Other (Worship)
 - Passive Recreation
 - Commercial
 - Other (Education)

Indicative only, subject to design development



Figure 10-7 Location of sensitive receivers near Barangaroo Station

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-21 for each construction scenario.

Table 10-21 Predicted airborne noise level exceedances at Barangaroo Station

Receiver area	Noise modelling scenario								
	Site establishment	Earthworks	Acoustic shed construction	Station excavation and tunnelling works				Building construction	
	Day	Day	Day	Day	DOOH ¹	Evening	Night	Sleep	
A Commercial (future) to the west and south	●	●	●	●	●	●	●	●	●
A Residential (future) to the west and south	●	●	●	●	●	●	●	●	●
B Residential to the north on Bettington Street	●	●	●	●	●	●	●	●	●
B Passive recreation to the north at Barangaroo Reserve	●	●	●	●	●	●	●	●	●
C Residential to the east on High Street	●	●	●	●	●	●	●	●	●
D Residential to the south on High Street	●	●	●	●	●	●	●	●	●
D Commercial to the south on Hickson Road	●	●	●	●	●	●	●	●	●
E Residential to the west in Balmain East	●	●	●	●	●	●	●	●	●

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

Note 1: DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)

The preliminary findings of the construction noise impact assessment at Barangaroo Station indicate:

- For site establishment works high exceedances of more than 20 dB of the NMLs are predicted at residential receivers in Area C and commercial receivers in Area A. Moderate exceedances of more than 10 dB are predicted at residential receivers in Areas B and D. Minor exceedances are predicted at residential receivers in Area A, commercial receivers in Area D and passive recreation in Area B. These are a direct result of the relative close proximity of receivers to the construction activities and the absence of any appreciable shielding between sites and receivers
- For earthworks a moderate exceedance is predicted at residential receivers in Areas C and D. Minor exceedances are predicted at residential receivers in Areas A and B, commercial receivers in Areas A and D and passive recreation in Area B
- For construction of the acoustic shed minor exceedances are predicted at the residential receivers in Areas C and D
- For excavation and tunnelling during the daytime a moderate exceedance of more than 10 dB is predicted at residences in Area C, and a minor exceedance of up to 10 dB at residential receivers in Areas B and D. For excavation and tunnelling outside standard construction hours moderate exceedances are predicted at residential receivers in Areas C and D and minor exceedances in Areas A and B. An acoustic shed with higher noise insulation (such as a double wall construction) would be required to reduce night-time non compliance
- For station building construction moderate exceedances are predicted at residential receivers in Areas C and D, and minor exceedances at residences in Areas A and B, commercial receivers in Area A and passive recreation in Area B.

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site exceed the sleep disturbance screening level by up to 10 dB during excavation with an acoustic shed at residential receivers in Areas C and D. Opportunities to minimise noise from heavy vehicles, such as consideration of site layouts and screening, would be considered during detailed construction site planning.

Ground-borne noise

The ground-borne noise assessment indicated:

- During the daytime one commercial building, located on Hickson Road to the north of the site, is predicted to have high exceedances of the NML (of 20 dB to 25 dB). The remaining commercial and residential buildings, located on High Street and within the Barangaroo development, are predicted to have a moderate exceedance of the NML (of 10 dB to 20 dB)
- During night-time 14 residential buildings, located on High Street and Kent Street to the east of the excavation, are predicted to have ground-borne noise levels potentially higher than 45 dBA on several floors.

Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted. Where exceedances of ground-borne noise levels are predicted, mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Blasting

Due to the level and duration of ground-borne noise exceedances associated with rock breaking, consideration has been given to blasting as an alternative excavation method. Table 10-22 shows the anticipated reduction in the number of periods when the NML would be exceeded. The table shows three scenarios: no blasting, blasting plus a large rock breaker, blasting plus a medium rock breaker.

Table 10-22 Barangaroo Station blasting scenarios

Scenario	Number of periods above NMLs			
	Residential			Commercial
	Day	Evening	Night	Day
No blasting	358	>365	>365	9
Blasting plus large rock breaker	171	277	>365	6
Blasting plus medium rock breaker	63	174	295	1

The potential change in duration of impacts is:

- Residential day:** the use of large rock breakers with no blasting generates 358 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 171 daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 63 daytime periods
- Residential evening:** the use of large rock breakers with no blasting generates +365 evening periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 277 evening periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 174 evening periods
- Residential night:** the use of large rock breakers with no blasting generates greater than 365 night-time periods with exceedances of the NMLs. The inclusion of blasting with large rock breakers would still result in greater 365 night-time periods with exceedances of the NMLs. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts to 295 night-time periods
- Commercial day:** the use of large rock breakers with no blasting generates nine daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to six daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to one daytime period.

Further detailed construction planning, through the development of Construction Noise Impact Statements (as required by the *Sydney Metro Construction Noise and Vibration Strategy* in Appendix E) would determine the exact construction activities with the aim of reducing ground-borne noise impacts to receivers. For example, this could involve the consideration of different sized rock breakers at different periods, and the positioning of rock breakers within the site during different periods.

With careful planning and positioning of the rock breakers it may be possible to avoid consecutive periods of NML exceedances to any one receiver, effectively providing respite periods. For any residual exceedances of the NMLs, additional mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

Ground-borne vibration

During excavation of the station vibration levels are anticipated to remain below the cosmetic damage vibration screening criteria, except for one commercial building to the north of the site on Hickson Road. A more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for this structure.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Barangaroo Station construction site and are presented in Table 10-23.

The predicted noise level increase associated with construction traffic exceeds the base criteria, however the increase complies with the 2 dB allowance. Whilst there is an exceedance of the sleep disturbance screening criterion (of up to 22 dB) and external sleep disturbance NML of 65 dBA (by up to 12 dB), the L_{Amax} levels would be similar to other heavy vehicles using Hickson Road. Therefore sensitive receivers are not likely to notice an increase in the average road traffic noise levels during construction.

Table 10-23 Barangaroo Station – road traffic noise

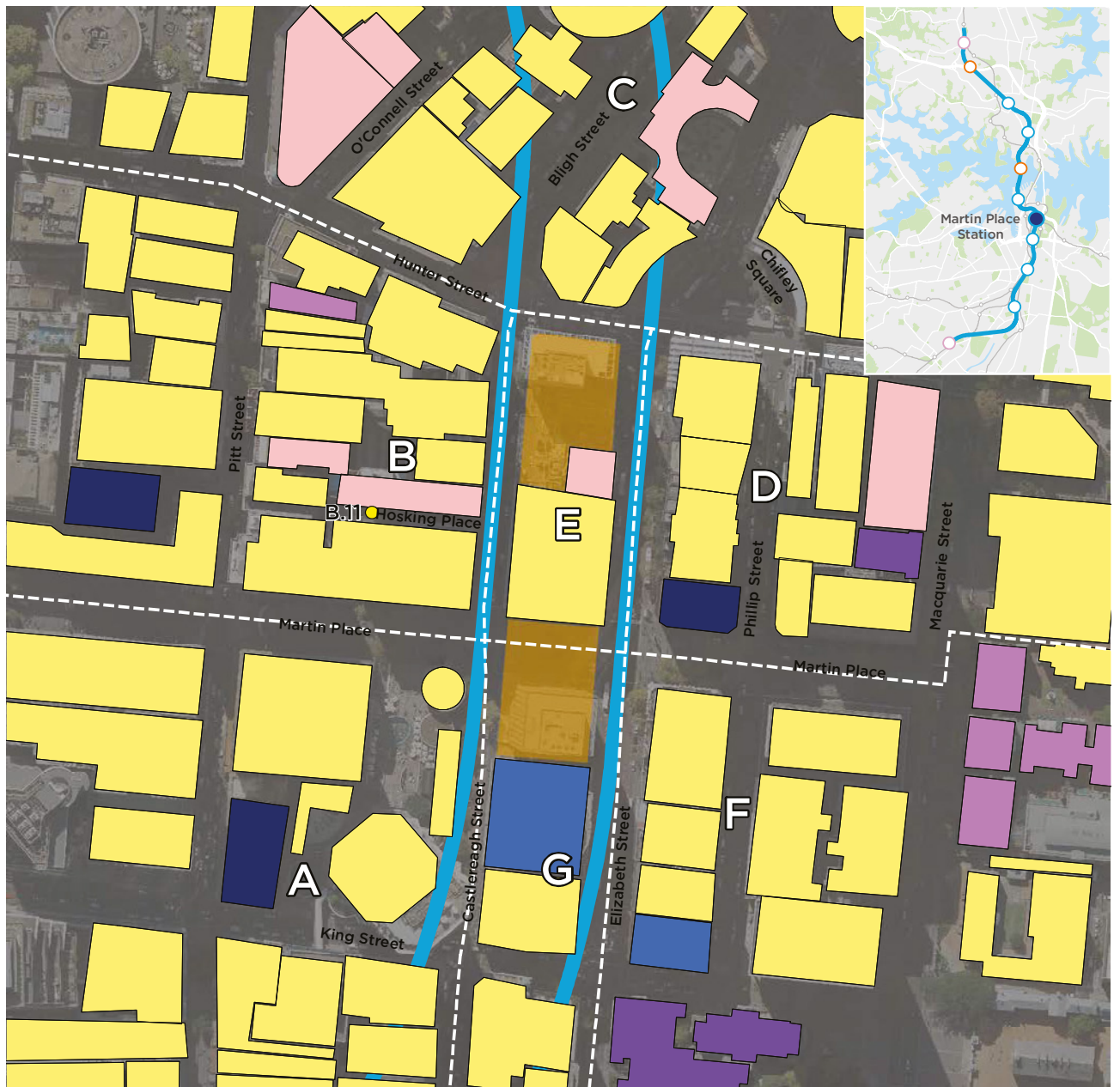
Road	Base criteria (dB) day / night ($L_{Aeq}(15hr/9hr)$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
Hickson Road	60 / 55	70 / 64	0.6 / 1.2	55	65	77

10.4.8 Martin Place Station

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-8.

The construction scenarios at the Martin Place Station construction site, and the anticipated timeframes, include:

- Demolition and site establishment (about 12 months) – the demolition of buildings on the site and establishment of site compound facilities
- Earthworks (about two month) – initial surface excavation
- Acoustic shed construction (about one month) – piling and erection of the acoustic shed
- Excavation and structural works (about three years) – excavation of the station and structural works
- Building construction (about one and a half years) – aboveground station and services building construction and fit-out.



KEY

- Chatswood to Sydenham
 - Proposed construction site area
 - Receiver area boundary
 - Monitoring location
- Receiver types
- | | |
|---|---|
| Residential | Other (Worship) |
| Commercial | Other (Education) |
| Other (Medical) | Other (Theatre) |

Indicative only, subject to design development



Figure 10-8 Location of sensitive receivers near Martin Place Station

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-24 for each construction scenario.

Table 10-24 Predicted noise level exceedances at Martin Place Station

Receiver area	Noise modelling scenario								
	Demolition and site establishment	Earthworks	Acoustic shed construction	Excavation and structural works				Building construction	
				Day	DOOH ¹	Evening	Night		Sleep
Day	Day	Day	Day	DOOH ¹	Evening	Night	Sleep	Day	
A Commercial to the west, west of Pitt Street and south of Martin Place	●	●	●	●	●	●	●	●	●
B Residential to the west, west of Pitt Street and north of Martin Place	●	●	●	●	●	●	●	●	●
B Commercial to the west, west of Pitt Street and north of Martin Place	●	●	●	●	●	●	●	●	●
C Residential to the north, north of Hunter Street	●	●	●	●	●	●	●	●	●
C Commercial to the north, north of Hunter Street	●	●	●	●	●	●	●	●	●
D Residential to the east, between Hunter Street and Martin Place	●	●	●	●	●	●	●	●	●
D Commercial to the east, between Hunter Street and Martin Place	●	●	●	●	●	●	●	●	●
E Residential receivers between the two construction sites	●	●	●	●	●	●	●	●	●
E Commercial between the two construction sites	●	●	●	●	●	●	●	●	●
F Commercial to the east, between King Street and Martin Place	●	●	●	●	●	●	●	●	●
F Educational to the east, between King Street and Martin Place	●	●	●	●	●	●	●	●	●
G Educational to the south, between Castlereagh Street and Elizabeth Street	●	●	●	●	●	●	●	●	●
G Commercial to the south, between Castlereagh Street and Elizabeth Street	●	●	●	●	●	●	●	●	●

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

¹ DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)

The preliminary findings of the construction noise impact assessment at Martin Place Station indicate:

- For site establishment works during the daytime high exceedances of more than 20 dB of the NMLs are predicted at educational receivers in Area G and the residential receivers in Area E. Moderate exceedances of more than 10 dB are predicted at residential receivers in Area B and educational receivers in Area F. At residential receivers in Area C minor exceedances of less than 10 dB are predicted.

At the nearest commercial receivers in Area E high exceedances of more than 20 dB of the NMLs are predicted, and at commercial receivers in Areas A, B, C and D moderate exceedances of more than 10 dB are predicted. Minor exceedances are predicted at commercial receivers in Area F

- For earthworks during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the educational receivers in Area G. At the educational receivers in Area F and residences in Area E moderate exceedances are predicted. At residences in Area B and C minor exceedances are predicted.

At the nearest commercial receivers in Areas A, B, C, D and E moderate exceedances of the NMLs are predicted, with minor exceedances at the commercial receivers in Area F

- For acoustic shed construction during the daytime a moderate exceedance is predicted at educational receivers in Area G and minor exceedances at educational receivers in Area F, the residential receivers in Area E, and commercial receivers in Area B
- For excavation during the daytime a moderate exceedance of more than 10 dB is predicted the educational receivers in Area G. Compliance is predicted at all other receivers during daytime. During night-time works minor exceedances are predicted at residences in Areas B and E
- For station building construction during the daytime major exceedances are predicted at the educational receivers in Area G, and moderate exceedances are predicted at residences in Area E and commercial receivers at Area E. Minor exceedances are predicted at educational receivers in Area F, at residential receivers in Area B and at commercial receivers in Areas A, B, C, D and F
- At the Channel Seven studio on Martin Place noise levels are predicted to be up to 79 dBA, and at the Theatre Royal up to 69 dBA. At both locations these levels would be similar to external noise levels from heavy vehicles on Castlereagh Street, and Pitt Street respectively, and general city noise. The building external to internal noise reduction would therefore adequately attenuate noise from the works to the news room and theatre respectively.

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site comply with the sleep disturbance screening level.

Ground-borne noise

The ground-borne noise assessment indicated:

- During the daytime two commercial buildings (one to the south of the northern site and one to the south of the southern site) are predicted to have ground-borne noise levels potentially higher than 75 dBA for several floors, which correlates to very high NML exceedances of greater than 25 dB. A further five commercial buildings, located to the west of both sites, are predicted to have high exceedances of the NML of 20 dB to 25 dB. The nearest residential receiver, located to the west on Castlereagh Street between Hunter Street and Martin Place, is predicted to have a moderate exceedance of the NML of 10 dB to 20 dB
- During night-time one residential building to the west on Castlereagh Street between Hunter Street and Martin Place is predicted to have ground-borne noise levels potentially higher than 45 dBA on one or more floors
- The Theatre Royal (located around 100 metres from the proposed station excavation works) is predicted to have ground-borne noise levels up to L_{Aeq(15minute)} 30 dBA within the theatre during rock breaker works, which complies with the 30 dBA criteria.

Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted. Where exceedances of ground-borne noise levels are predicted, mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Blasting

Due to the level and duration of ground-borne noise exceedances associated with rock breaking, consideration has been given to blasting as an alternative excavation method. Table 10-25 shows the anticipated reduction in the number of periods when the NML would be exceeded. The table shows three scenarios: no blasting, blasting plus a large rock breaker, blasting plus a medium rock breaker.

Table 10-25 Martin Place Station blasting scenarios

Scenario	Number of periods above NMLs			
	Residential			Commercial
	Day	Evening	Night	Day
Northern site				
No blasting	2	5	9	225
Blasting plus large rock breaker	0	1	1	42
Blasting plus medium rock breaker	0	0	1	22
Southern site				
No blasting	0	0	0	32
Blasting plus large rock breaker	0	0	0	18
Blasting plus medium rock breaker	0	0	0	9

The potential change in duration of impacts is:

- Residential day:** the use of large rock breakers with no blasting generates two daytime periods with exceedances of the NMLs. The inclusion of blasting eliminates the potential exceedances during the daytime period
- Residential evening:** the use of large rock breakers with no blasting generates five evening periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to one evening period
- Residential night:** the use of large rock breakers with no blasting generates nine night-time periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to one night-time period
- Commercial day:** the use of large rock breakers with no blasting generates 257 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 60 daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 31 daytime periods.

Further detailed construction planning, through the development of Construction Noise Impact Statements (as required by the *Sydney Metro Construction Noise and Vibration Strategy* in Appendix E) would determine the exact construction activities with the aim of reducing ground-borne noise impacts to receivers. For example, this could involve the consideration of different sized rock breakers at different periods, and the positioning of rock breakers within the site during different periods.

With careful planning and positioning of the rock breakers it may be possible to avoid consecutive periods of NML exceedances to any one receiver, effectively providing respite periods. For any residual exceedances of the NMLs, additional mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

Ground-borne vibration

During excavation of the station shafts vibration levels are anticipated to remain below the cosmetic damage vibration screening criteria, except for one commercial building located immediately to the south of the southern site. A more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for this structure.

At the Commonwealth Bank building the more stringent 7.5 mm/s screening criterion was applied. Vibration levels at the Commonwealth Bank building are predicted to comply with this screening criterion.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Martin Place Station construction site and are presented in Table 10-26.

The predicted noise level associated with construction traffic exceeds the base criteria, however the increase complies with the 2 dB allowance. Whilst there is an exceedance of the sleep disturbance screening criterion (of up to 11 dB) and external sleep disturbance NML of 65 dBA (by up to 13 dB), the L_{Amax} levels would be similar to other heavy vehicles using Hunter Street, Castlereagh Street and Elizabeth Street. Therefore sensitive receivers are not likely to notice an increase in the average road traffic noise levels during construction.

Table 10-26 Martin Place Station – road traffic noise

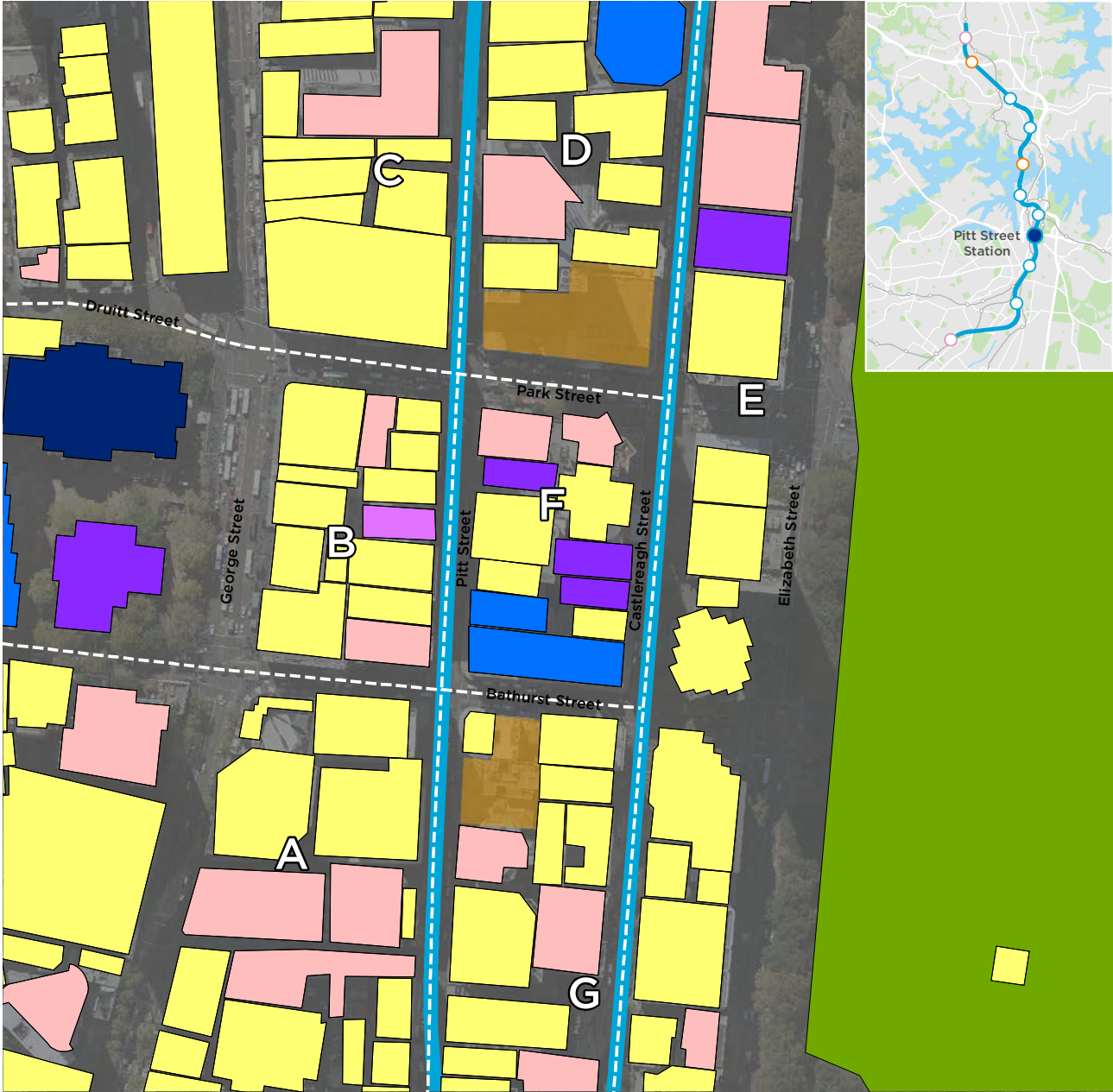
Road	Base criteria (dB) day / night ($L_{Aeq}(15hr/9hr)$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
Hunter Street	60 / 55	70 / 66	0.3 / 0.4	67	65	78
Castlereagh Street	60 / 55	69 / 64	0.4 / 0.6	67	65	78
Elizabeth Street	60 / 55	73 / 69	0.2 / 0.2	67	65	78

10.4.9 Pitt Street Station

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-9.

The construction scenarios at the Pitt Street Station construction site, and the anticipated timeframes, include:

- Demolition and site establishment (about 12 months) – the demolition of buildings on the site and establishment of site compound facilities
- Earthworks (about two months) – initial surface excavation
- Acoustic shed construction (about one month) – piling and erection of the acoustic shed
- Excavation and structural works (about three years) – excavation of the station and structural works
- Building construction (about one and a half years) – aboveground station and services building construction and fit-out.



- KEY**
- Chatswood to Sydenham
 - Proposed construction site area
 - Receiver area boundary
 - Monitoring location
- Receiver types
- Residential
 - Commercial
 - Other (Medical)
 - Other (Worship)
 - Other (Education)
 - Other (Theatre)
 - Passive Recreation

Indicative only, subject to design development



Figure 10-9 Location of sensitive receivers near Pitt Street Station

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-27 for each construction scenario.

Table 10-27 Predicted airborne noise level exceedances at Pitt Street Station

Receiver area	Noise modelling scenario									
	Demolition and site establishment	Earthworks	Acoustic shed construction	Excavation and structural works				Building construction		
	Day	Day	Day	Day	DOOH ¹	Evening	Night	Sleep	Day	
A Residential to the west, west of Pitt Street and south of Bathurst Street	●	●	●	●	●	●	●	●	●	●
A Commercial to the west, west of Pitt Street and south of Bathurst Street	●	●	●	●	●	●	●	●	●	●
B Residential to the west, west of Pitt Street and north of Bathurst Street	●	●	●	●	●	●	●	●	●	●
B Commercial to the west, west of Pitt Street and north of Bathurst Street	●	●	●	●	●	●	●	●	●	●
C Residential to the west, west of Pitt Street and north of Park Street	●	●	●	●	●	●	●	●	●	●
C Commercial to the west, west of Pitt Street and north of Park Street	●	●	●	●	●	●	●	●	●	●
D Commercial to the north, between Pitt Street and Castlereagh Street	●	●	●	●	●	●	●	●	●	●
E Residential to the east	●	●	●	●	●	●	●	●	●	●
E Commercial to the east	●	●	●	●	●	●	●	●	●	●
F Residential between Park Street and Bathurst Street	●	●	●	●	●	●	●	●	●	●
F Commercial between Park Street and Bathurst Street	●	●	●	●	●	●	●	●	●	●
F Educational between Park Street and Bathurst Street	●	●	●	●	●	●	●	●	●	●
G Residential to the south between Pitt Street and Castlereagh Street	●	●	●	●	●	●	●	●	●	●
G Commercial to the south between Pitt Street and Castlereagh Street	●	●	●	●	●	●	●	●	●	●

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

¹ DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)

The preliminary findings of the construction noise impact assessment at Pitt Street Station indicate:

- For site establishment works during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the residential receivers in Area G and at educational receivers in Area F. At residential receivers in Areas B and F, minor exceedances are predicted.

At the nearest commercial receivers in Areas D and G high exceedances of more than 20 dB of the NMLs are predicted, and at commercial receivers in Areas A, C and E moderate exceedances of more than 10 dB are predicted. Minor exceedances are predicted at commercial receivers in Areas B and F

- For earthworks during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the educational receivers in Area F. Minor exceedances of more than 10 dB are predicted at residential receivers in Area G. At residential receivers in Areas B and F minor exceedances are predicted.

At the nearest commercial receivers in Area G high exceedances of more than 20 dB of the NMLs are predicted, and at commercial receivers in Areas A, C, D and E moderate exceedances of more than 10 dB are predicted. Minor exceedances are predicted at commercial receivers in Areas B, and F

- For acoustic shed construction during the daytime a moderate exceedance is predicted at educational receivers in Area F and commercial receivers in Area G. Minor exceedances at residential receivers in Area G and commercial receivers in Areas C and D are predicted
- For excavation during the daytime a minor exceedance of less than 10 dB is predicted at educational receivers in Area F. During the night-time, a minor exceedance of less than 10 dB is predicted at residential receivers in Area G
- For station building construction during the daytime major exceedances are predicted at residential receivers in Area G, the educational receivers in Area F and the commercial receivers in Area G. Moderate exceedances are predicted at commercial receivers at Area D. Minor exceedances are predicted at the residential receivers in Area F, and at commercial receivers in Areas A, B, C, E and F
- At Town Hall external noise levels are predicted to be up to 68 dBA. These levels would be similar to existing noise from heavy vehicles on George Street and other city noise. The buildings external to internal noise reduction would adequately attenuate noise from the works to the performance space.

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site comply with the sleep disturbance screening level.

Ground-borne noise

The ground-borne noise assessment indicated:

- During the daytime one building adjacent to the northern site (to the north on Pitt Street) and the four buildings immediately adjacent to the southern site are predicted to have ground-borne noise levels potentially higher than 75 dBA on several floors in each building
- During night-time three residential buildings near the northern site (one to the north on Pitt Street, and two to the south on Park Street) and four residential buildings near the southern site (one to the south on Pitt Street, one to the south on Castlereagh Street and two to the west on Pitt Street) have ground-borne noise levels potentially higher than 45 dBA on several floors in each building.

Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted. Where exceedances of ground-borne noise levels are predicted, mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Blasting

Due to the level and duration of ground-borne noise exceedances associated with rock breaking, consideration has been given to blasting as an alternative excavation method. Table 10-28 shows the anticipated reduction in the number of periods when the NML would be exceeded. The table shows three scenarios: no blasting, blasting plus a large rock breaker, blasting plus a medium rock breaker.

Table 10-28 Pitt Street Station blasting scenarios

Scenario	Number of periods above NMLs			
	Residential			Commercial
	Day	Evening	Night	Day
Northern site				
No blasting	48	123	181	41
Blasting plus large rock breaker	25	52	69	22
Blasting plus medium rock breaker	4	24	54	12
Southern site				
No blasting	76	129	212	116
Blasting plus large rock breaker	33	53	83	60
Blasting plus medium rock breaker	23	35	56	36

The potential change in duration of impacts is:

- **Residential day:** the use of large rock breakers with no blasting generates 124 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 58 daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 27 daytime periods
- **Residential evening:** the use of large rock breakers with no blasting generates 252 evening periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 105 evening periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 59 evening periods
- **Residential night:** the use of large rock breakers with no blasting generates greater than 365 night-time periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 152 night-time periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 60 night-time periods
- **Commercial day:** the use of large rock breakers with no blasting generates 157 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 82 daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 48 daytime periods.

Further detailed construction planning, through the development of Construction Noise Impact Statements (as required by the *Sydney Metro Construction Noise and Vibration Strategy* in Appendix E) would determine the exact construction activities with the aim of reducing ground-borne noise impacts to receivers. For example, this could involve the consideration of different sized rock breakers at different periods, and the positioning of rock breakers within the site during different periods.

With careful planning and positioning of the rock breakers it may be possible to avoid consecutive periods of NML exceedances to any one receiver, effectively providing respite periods. For any residual exceedances of the NMLs, additional mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

Ground-borne vibration

During excavation of the station shafts vibration levels are anticipated to exceed the cosmetic damage vibration screening criteria at five buildings near the southern site (the buildings immediately adjacent on Bathurst, Pitt and Castlereagh streets) and one building adjacent to the northern site (to the north on Pitt Street). A more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for these structures.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Pitt Street Station construction site and are presented in Table 10-29.

The predicted noise level increase associated with construction traffic exceeds the base criteria, however the increase complies with the 2 dB allowance. Whilst there is compliance with the sleep disturbance screening criterion, there is an exceedance of the external sleep disturbance NML of 65 dBA (by up to 11 dB). The L_{Amax} levels would be similar to other heavy vehicles using Pitt Street, Castlereagh Street and Bathurst Street. Therefore sensitive receivers are not likely to notice an increase in the average road traffic noise levels during construction.

Table 10-29 Pitt Street Station – road traffic noise

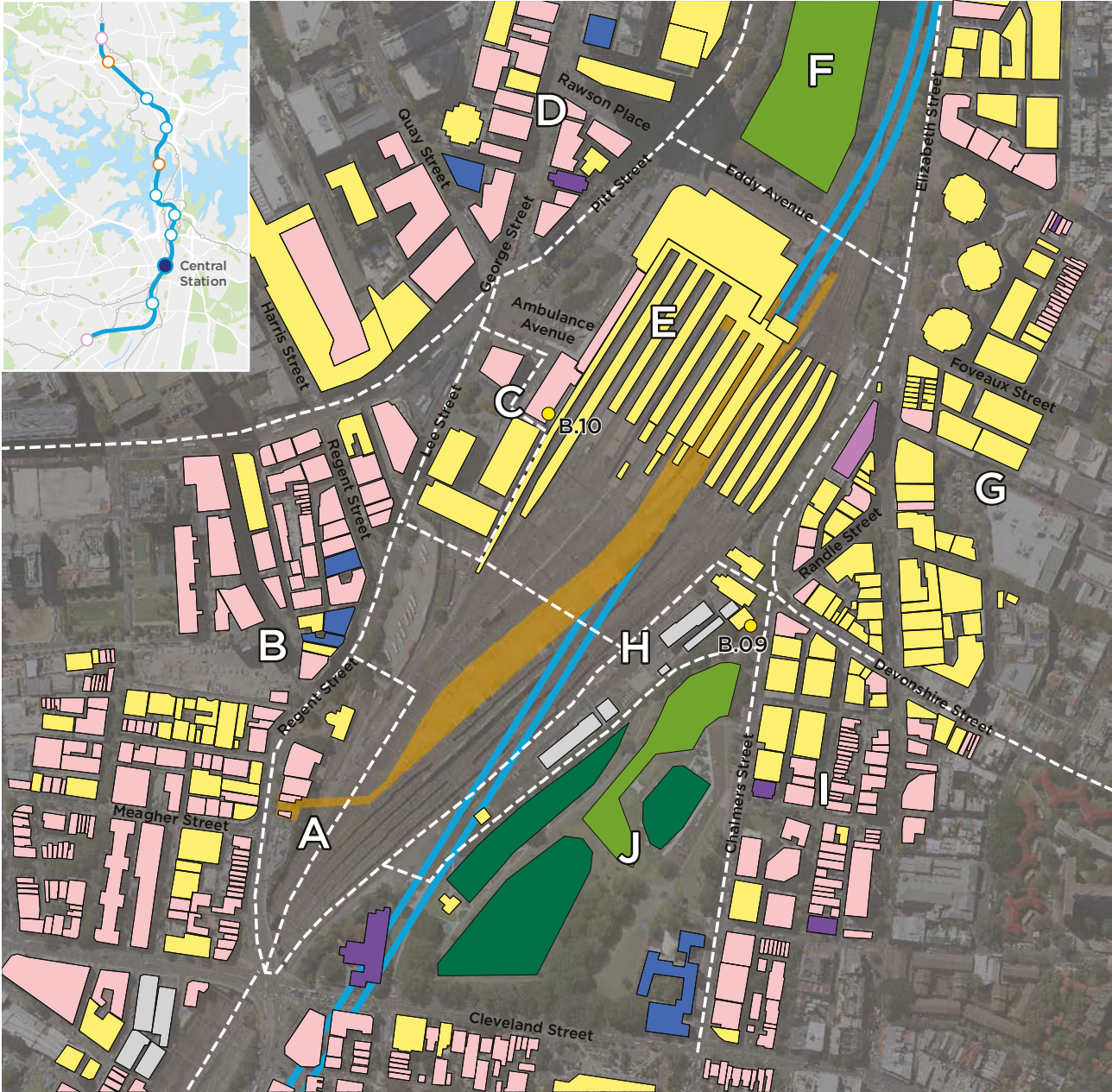
Road	Base criteria (dB) day / night ($L_{Aeq}(15hr/9hr)$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
Pitt Street south	60 / 55	67 / 62	0.5 / 0.7	76	65	76
Pitt Street north	60 / 55	65 / 61	0.5 / 0.4	76	65	76
Castlereagh Street	60 / 55	67 / 61	0.2 / 0.4	76	65	76
Bathurst Street	60 / 55	70 / 67	0.2 / 0.2	76	65	76

10.4.10 Central Station

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-10.

The construction scenarios at the Central Station construction site, and the anticipated timeframes, include:

- Demolition and site establishment (about one a half years) – the demolition of buildings on the site, construction of the Sydney Yard Access Bridge and the temporary pedestrian bridge, establishment of site compound facilities and construction of the combined services ring
- Earthworks (about two months) – initial surface excavation
- Excavation and structural works (about three and a half years) – excavation of the station and structural works
- Building construction (about 12 months) – aboveground station and services building construction and fit-out.



- KEY**
- Chatswood to Sydenham
 - Proposed construction site area
 - Receiver area boundary
 - Monitoring location
- Receiver types
- | | | |
|---|---|--|
| Residential | Other (Medical) | Active Recreation |
| Commercial | Other (Worship) | Passive Recreation |
| Industrial | Other (Education) | |

Indicative only, subject to design development



Figure 10-10 Location of sensitive receivers near Central Station

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-30 for each construction scenario.

Table 10-30 Predicted airborne noise level exceedances at Central Station

Receiver area	Noise modelling scenario								
	Demolition and site establishment	Earthworks	Acoustic shed construction	Excavation and structural works				Building construction	
				Day	DOOH ¹	Evening	Night		Sleep
Day	Day	Day	Day	DOOH ¹	Evening	Night	Sleep	Day	
A Residential receivers to the west, east of Regent Street.	●	●	●	●	●	●	●	●	●
B Residential receivers to the east, west of Regent Street	●	●	●	●	●	●	●	●	●
B Commercial receivers to the west, east of Lee Street	●	●	●	●	●	●	●	●	●
C Residential receivers to the east, east of Regent Street	●	●	●	●	●	●	●	●	●
C Commercial receivers to the east, east of Regent Street	●	●	●	●	●	●	●	●	●
D Residential receivers to the west, west of Lee Street	●	●	●	●	●	●	●	●	●
D Commercial receivers to the west, west of Lee Street	●	●	●	●	●	●	●	●	●
E Commercial receivers surrounding at Central Station	●	●	●	●	●	●	●	●	●
F Passive recreation at Belmore Park to the north	●	●	●	●	●	●	●	●	●
G Residential receivers to the east, east of Chalmers Street	●	●	●	●	●	●	●	●	●
G Commercial receivers to the east, east of Chalmers Street	●	●	●	●	●	●	●	●	●
H Commercial receivers to the east, west of Prince Alfred Park	●	●	●	●	●	●	●	●	●
I Residential receivers to the east, south of Devonshire Street	●	●	●	●	●	●	●	●	●
I Commercial receivers to the east, south of Devonshire Street	●	●	●	●	●	●	●	●	●
J Passive and active recreation at Prince Alfred Park	●	●	●	●	●	●	●	●	●

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

¹ DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)

The preliminary findings of the construction noise impact assessment at Central Station indicate:

- For site establishment during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the residential receivers in Area A and at the recreation receivers in Area J (Prince Alfred Park). Moderate exceedances of more than 10 dB are predicted at residential receivers in Areas B, C, D and I. At residential receivers in Area G, and at recreation receivers in Area F (Belmore Park) minor exceedances are predicted.

At the nearest commercial receivers in Areas C, E and H high exceedances of more than 20 dB of the NMLs are predicted, and at commercial receivers in Areas B, D and I moderate exceedances of more than 10 dB are predicted. Minor exceedances are predicted at commercial receivers in Areas D and G

- For earthworks during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the residential receivers in Area A. Moderate exceedances of more than 10 dB are predicted at residential receivers in Area G. At residential receivers in Area B minor exceedances are predicted.

At the nearest commercial receivers in Area E high exceedances of more than 20 dB of the NMLs are predicted. Minor exceedances are predicted at commercial receivers in Areas B, G and H.

Compliance is predicted at residential receivers in Areas C, D, I, at recreation receivers at Area F (Belmore Park) and Area J (Prince Alfred Park), and at commercial receivers in Areas C, D, and I

- For excavation during daytime a moderate exceedance of more than 10 dB is predicted at commercial receivers in Area E. Compliance is predicted at all other locations. For excavation during the 'day out of hours' period and evenings a minor exceedance of up to 10 dB is predicted for residences in Areas G and I.

For night-time excavation works moderate exceedances of more than 10 dB are predicted at residences in Areas G and I and minor exceedances of up to 10 dB at residences in Areas A and C

- For station building construction during the daytime a major exceedance is predicted at commercial receivers in Area E. Compliance is predicted at all other locations.

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site exceed the sleep disturbance screening level (by up to 10 dB) during excavation. Opportunities to minimise noise from heavy vehicles, such as consideration of site layouts and screening, would be considered during detailed construction site planning.

Ground-borne noise

The ground-borne noise assessment indicated:

- During the daytime ground-borne noise levels inside the adjacent station buildings and on platforms has the potential to exceed 75 dBA during rock breaking activities. These areas would be subject to existing high ambient noise levels from the operation of the station and, as such, no mitigation measures are deemed necessary
- During the daytime three commercial buildings, located to the east around the northern corner of Prince Alfred Park, are predicted to have ground-borne noise levels potentially higher than 75 dBA on several floors in each building
- During night-time one residential building, located on the corner of Devonshire and Chalmers streets, is predicted to have ground-borne noise levels potentially higher than 45 dBA on several floors.

Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted. Where exceedances of ground-borne noise levels are predicted, mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Ground-borne vibration

During excavation of the station vibration levels are anticipated to exceed the cosmetic damage vibration screening criteria at two station platforms and three commercial buildings (located to the east around the northern corner of Prince Alfred Park). A more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for these structures.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Central Station construction site and are presented in Table 10-31.

The predicted noise level increase associated with construction traffic exceeds the base criteria, however the increase complies with the 2 dB allowance. Whilst there is an exceedance of the sleep disturbance screening criterion (of up to 18 dB) and external sleep disturbance NML of 65 dBA (by up to 13 dB), the L_{Amax} levels would be similar to other heavy vehicles using Regent Street and Chalmers Street. Therefore sensitive receivers are not likely to notice an increase in the average road traffic noise levels during construction.

Table 10-31 Central Station – road traffic noise

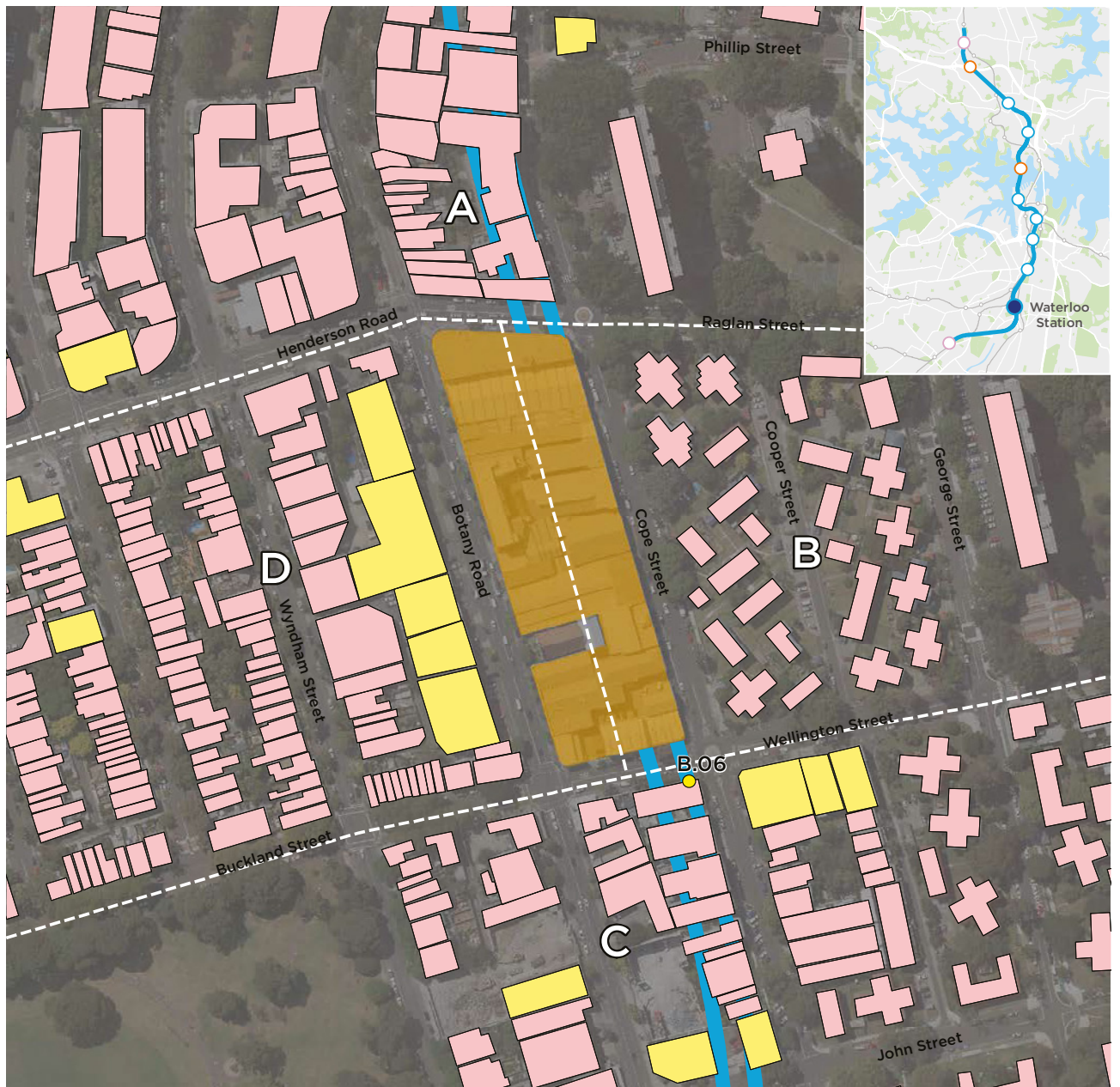
Road	Base criteria (dB) day / night ($L_{Aeq}(15hr/9hr)$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
Regent Street	60 / 55	74 / 70	0.1 / 0.2	67	65	78
Chalmers Street	60 / 55	72 / 67	0.2 / 0.3	60	65	78

10.4.11 Waterloo Station

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-11.

The construction scenarios at the Waterloo Station construction site, and the anticipated timeframes, include:

- Demolition and site establishment (about 12 months) – the demolition of buildings on the site and establishment of site compound facilities
- Earthworks (about two months) – initial surface excavation
- Acoustic shed construction (about one month) – piling and erection of the acoustic shed
- Excavation and structural works (about three years) – excavation of the station and structural works
- Building construction (about one and a half years) – aboveground station and services building construction and fit-out.



KEY

- Chatswood to Sydenham
- Proposed construction site area
- Receiver area boundary
- Monitoring location
- Residential
- Commercial

Indicative only, subject to design development



Figure 10-11 Location of sensitive receivers near Waterloo Station

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-32 for each construction scenario.

Table 10-32 Predicted airborne noise level exceedances at Waterloo Station

Receiver area	Noise modelling scenario								
	Demolition and site establishment	Earthworks	Acoustic shed construction	Excavation and structural works				Building construction	
	Day	Day	Day	Day	DOOH ¹	Evening	Night	Sleep	Day
A Residential to the north of Raglan Street	●	●	●	●	●	●	●	●	●
B Residential to the east of Cope Street	●	●	●	●	●	●	●	●	●
C Residential to the south of Buckland Street	●	●	●	●	●	●	●	●	●
C Commercial to the south of Buckland Street	●	●	●	●	●	●	●	●	●
D Residential to the west	●	●	●	●	●	●	●	●	●
D Church adjacent to the west on Botany Road	●	●	●	●	●	●	●	●	●
D Commercial to the west of Botany Road	●	●	●	●	●	●	●	●	●

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

¹ DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)

The preliminary findings of the construction noise impact assessment at Waterloo Street Station indicate:

- For site establishment works during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the residential receivers in Areas A and D, and at the church in Area D. Moderate exceedances of more than 10 dB are predicted at residential receivers in Areas B and C.

At the nearest commercial receivers in Area D, moderate exceedances of more than 10 dB of the NMLs are predicted. Minor exceedances of less than 10 dB are predicted at commercial receivers in Area C
- For earthworks during the daytime high exceedances of more than 20 dB of the NMLs are predicted at the church in Area D. Moderate exceedances of more than 10 dB are predicted at residential receivers in Areas A, B, C and D.

At the nearest commercial receivers in Areas C and D, minor exceedances of less than 10 dB of the NMLs are predicted
- For acoustic shed construction during the daytime a moderate exceedance is predicted at the church in Area D. Minor exceedances are predicted at residential receivers in Areas A, B, C and D
- For excavation during the daytime a minor exceedance of less than 10 dB is predicted at the church in Area D. During the night-time moderate exceedances are predicted at residences in Areas A, B, C and D. An acoustic shed with higher noise insulation would be required to reduce night-time non compliance
- For station building construction during the daytime high exceedances are predicted at the church in Area D. Moderate exceedances are predicted at residential receivers at Areas B and C. Minor exceedances are predicted at residences in Areas A and D, and commercial receivers in Areas C and D.

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site exceed the sleep disturbance screening level during excavation by more than 10 dB at residential receivers in Area D and up to 10 dB at residential receivers in Areas A, B and C. Opportunities to minimise noise from heavy vehicles, such as consideration of site layouts and screening, would be considered during detailed construction site planning.

Ground-borne noise

The ground-borne noise assessment indicated:

- During the daytime, moderate exceedances of the NMLs (of 10 to 20 dB) are predicted at the church on Botany Road and residential receivers on Raglan, Cope and Wellington streets
- During night-time 10 residential buildings on Raglan, Cope and Wellington streets are predicted to have ground-borne noise levels potentially higher than 45 dBA on several floors in each building.

Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted. Where exceedances of ground-borne noise levels are predicted, mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Blasting

Due to the level and duration of ground-borne noise exceedances associated with rock breaking, consideration has been given to blasting as an alternative excavation method. Table 10-33 shows the anticipated reduction in the number of periods when the NML would be exceeded. The table shows three scenarios: no blasting, blasting plus a large rock breaker, blasting plus a medium rock breaker.

Table 10-33 Waterloo Station blasting scenarios

Scenario	Number of periods above NMLs			
	Residential			Commercial
	Day	Evening	Night	Day
No blasting	251	>365	>365	14
Blasting plus large rock breaker	139	275	>365	8
Blasting plus medium rock breaker	13	131	294	3

The potential change in duration of impacts is:

- Residential day:** the use of large rock breakers with no blasting generates 251 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 139 daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 13 daytime periods
- Residential evening:** the use of large rock breakers with no blasting generates greater than 365 evening periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to 275 evening periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to 131 evening periods
- Residential night:** the use of large rock breakers with no blasting generates greater than 365 night-time periods with exceedances of the NMLs. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts 294 night-time periods
- Commercial day:** the use of large rock breakers with no blasting generates 14 daytime periods with exceedances of the NMLs. The inclusion of blasting reduces the duration of impacts to eight daytime periods. The inclusion of blasting and the use of medium rock breakers reduces the duration of impacts even further to three daytime periods.

Further detailed construction planning, through the development of Construction Noise Impact Statements (as required by the *Sydney Metro Construction Noise and Vibration Strategy* in Appendix E) would determine the exact construction activities with the aim of reducing ground-borne noise impacts to receivers. For example, this could involve the consideration of different sized rock breakers at different periods, and the positioning of rock breakers within the site during different periods.

With careful planning and positioning of the rock breakers it may be possible to avoid consecutive periods of NML exceedances to any one receiver, effectively providing respite periods. For any residual exceedances of the NMLs, additional mitigation measures would be implemented in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (Appendix E).

Ground-borne vibration

During excavation of the station vibration levels are anticipated to remain below the cosmetic damage vibration screening criteria.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Waterloo Station construction site and are presented in Table 10-34.

The predicted noise level increase associated with construction traffic exceeds the base criteria, however the increase complies with the 2 dB allowance. Whilst there is an exceedance of the sleep disturbance screening criterion (by up to 24 dB) and external sleep disturbance NML of 65 dBA (by up to 13 dB), the L_{Amax} levels would be similar to other heavy vehicles using Botany Road and Henderson Road. Therefore sensitive receivers are not likely to notice an increase in the average road traffic noise levels during construction.

Table 10-34 Waterloo Station – road traffic noise

Road	Base criteria (dB) day / night ($L_{Aeq}(15hr/9hr)$)	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External L_{Amax} NML Level (dBA)	Predicted L_{Amax} Noise Level (dBA)
Botany Road	60 / 55	73 / 68	0.1 / 0.2	54	65	78
Henderson Road	60 / 55	72 / 66	0.1 / 0.3	54	65	76

10.4.12 Marrickville dive site (southern)

The nearest sensitive receivers to the proposed construction site are shown in Figure 10-12.

The construction scenarios at the Marrickville dive site, and the anticipated timeframes, include:

- Demolition and site establishment (about 12 months) – the demolition of buildings on the site and establishment of site compound facilities
- Track works (about 12 months) – laying of metro track in the dive structure
- Earthworks (about six months) – initial surface excavation and excavation of the dive structure
- Acoustic shed construction (about one month) – piling and erection of the acoustic shed
- Tunnelling and pre-cast factory (about one and a half years) – excavation of the main tunnels and associated support services and operation of the concrete pre-cast factory
- Fit-out (about one and a half years) – fit of the track and the rail systems in the tunnels.

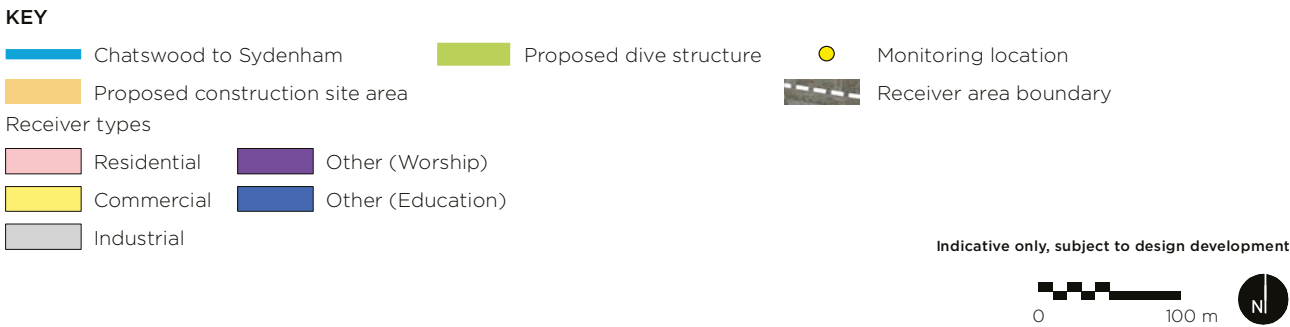


Figure 10-12 Location of sensitive receivers near Marrickville dive site (southern)

Airborne construction noise

A summary of the predicted noise level exceedances at the nearest sensitive receivers is provided in Table 10-35 for each construction scenario.

Table 10-35 Predicted noise level exceedances at Marrickville dive site (southern)

Receiver area	Noise modelling scenario														
	Demolition and site establishment	Track works	Earthworks	Acoustic shed construction	Tunnelling and pre-cast facility					Fit-out					
	Day	Day	Day	Day	Day	DOOH ¹	Evening	Night	Sleep	Day	DOOH ¹	Evening	Night	Sleep	
A Industrial to the north east	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
B Commercial to the north	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
B Educational to the north	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
B Residential to the north on Edinburgh Road	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
C Residential to the north, east of Edgeware Road	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
D Active recreation to the east at Camdenville Park	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
D Residential to the east, on May Street	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
E Residential to the south east on Unwins Bridge Road	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
F Industrial to the south east	●	●	●	●	●	●	●	●	●	●	●	●	●	●	
G Residential to the south east on Burrows Avenue	●	●	●	●	●	●	●	●	●	●	●	●	●	●	

Legend

- NML compliance
- NML exceedance of less than 10 dB
- NML exceedance between 10 dB and 20 dB
- NML exceedance of more than 20 dB

¹ DOOH = Daytime out of hours (i.e Saturdays 1pm to 6pm and Sundays 7am to 6pm)

The preliminary findings of the construction noise impact assessment at the Marrickville dive site indicate:

- For site establishment works during the daytime moderate exceedances of between 10 dB to 20 dB of the NMLs are predicted at the educational receiver in Area B and industrial receivers in Area A. Minor exceedances are predicted at residential receivers in Areas B and C, and commercial and industrial receivers in Areas B and F. These are a direct result of the relative close proximity of receivers to the construction activities and the absence of any appreciable shielding between sites and receivers
- For track works and earthworks during the daytime a moderate exceedance of between 10 dB to 20 dB of the NML is predicted at the educational receiver in Area B. At residential receivers in Area C a minor exceedance at receivers is predicted.
- At commercial and industrial receivers a minor exceedance of up to 10 dB is predicted at the industrial Area F to the south east. Compliance is predicted at other locations
- For acoustic shed construction during the daytime compliance is predicted at all receivers
- For tunnelling and precast factory use during the daytime a minor exceedance is predicted at the educational receiver in Area B. During the night-time a minor exceedance is predicted at the residential receivers in Areas B, C, D, E and G
- For fitout during the daytime compliance is predicted at all receivers.

On site night-time L_{Amax} truck noise

The L_{Amax} noise levels associated with individual truck movements on site comply with the sleep disturbance screening level.

Ground-borne noise

Rock breaking and dive excavation works are proposed to be carried out during the daytime period at this site. The ground-borne noise assessment indicated all receivers would comply with the ground-borne noise NMLs.

The potential ground-borne noise impacts associated with excavation of the tunnels is discussed in Section 10.4.13.

Ground-borne vibration

Construction vibration levels are anticipated to remain well below the vibration screening levels associated with minor cosmetic building damage at all receivers.

Construction traffic noise

The predicted L_{Aeq} increase and sleep disturbance noise levels have been assessed for the access routes to the Marrickville dive site and are presented in Table 10-36.

The predicted noise level increase associated with construction traffic exceeds the base criteria. The increase complies with the 2 dB allowance for the daytime period and on Bedwin Road for the night-time period. On May Street the increase marginally exceeds the 2 dB allowance (by 0.4 dB).

Whilst there is an exceedance of the sleep disturbance screening criterion (by up to 23 dB) and external sleep disturbance NML of 65 dBA (by up to 14 dB), the L_{Amax} levels would be similar to other heavy vehicles using Bedwin Road and May Street. Therefore sensitive receivers are not likely to notice an increase in the average road traffic noise levels during construction.

Table 10-36 Marrickville dive site – road traffic noise

Road	Base criteria (dB) day / night (LAeq(15hr/9hr))	Predicted Road Traffic Noise (dB) day / night	Predicted Road Traffic Noise Increase (dB) day / night	RBL + 15 dB Screening Criterion (dBA)	External LAmax NML Level (dBA)	Predicted LAmax Noise Level (dBA)
Bedwin Road	60 / 55	68 / 62	0.5 / 1.8	53	65	69
May Street	60 / 55	72 / 68	0.9 / 2.4	56	65	79

10.4.13 Tunnel excavation

Ground-borne noise

The potential impacts of ground-borne noise from the excavation of the main tunnels using tunnel boring machines is discussed in Table 10-37. Ground-borne noise from tunnel excavation during the daytime is expected to be well below background noise levels. As such, the assessment considers the evening and night-time periods.

The ground-borne noise assessment is based on the worst-case predicted internal ground-borne noise level when the tunnelling works are directly below each receiver and the tunnelling works are at their closest point. Given the progression rate of the tunnel boring machines, it is anticipated that this worst-case ground-borne noise impact would only be apparent for a relatively short period of time (ie a few days for each tunnel burning machine) whilst the tunnelling works are directly beneath a particular receiver.

Table 10-37 Ground-borne noise main tunnel excavation

Location	Potential impacts
Chatswood portal to Crows Nest Station	Predicted exceedances of the night-time NML of: <ul style="list-style-type: none"> Up to 10dB at residential receivers between the Chatswood portal and Artarmon substation Up to 6 dB at the few residential receivers between Artarmon substation and Crows Nest Station.
Crows Nest Station to Blues Point temporary site	Predicted exceedances of the night-time NML of: <ul style="list-style-type: none"> Up to 5 dB at residential receivers between Crows Nest and Victoria Cross stations Up to 3 dB from North Sydney Station to around Princess Street Up to 8 dB in the area around Blues Point.
Barangaroo Station to Central Station	Predicted exceedances of the night-time NML of: <ul style="list-style-type: none"> Up to 5 dB in the area around Barangaroo Station Up to 5 dB in the area around Martin Place Station Up to 10 dB in the area around Pitt Street Station.
Central Station to Marrickville portal	Predicted exceedances of the night-time NML of: <ul style="list-style-type: none"> Up to 10 dB in the area around Waterloo Station Up to 3 dB in the area between Maddox Street and the Princes Highway Greater than 10 dB just north of the Marrickville portal.

Ground-borne noise impacts may also arise from the excavation of other features and the use of other equipment within the tunnels. This includes:

- **Cross passages** – expected to be excavated mainly by roadheaders with the anticipated duration being 80 days at each cross passage. The night-time NML would be complied with when the tunnel depth is greater than 30 metres (which generally occurs near the tunnel portals and around Crows Nest Station, Barangaroo Station, Martin Place Station, Pitt Street Station, Central Station and Waterloo Station). Works between 10 pm and 7 am would be precluded where residential receivers are located with a slant distance (the straight line distance between the tunnel and receiver) of less than 30 metres from the tunnels
- **Stub tunnels** – expected to be excavated using roadheaders to the north of Victoria Cross Station and to the north of the Marrickville portal. In these two locations, the depths to the tunnels are around 50 metres and 40 metres respectively. At this depth, there is not expected to any exceedances of the night-time NMLs from roadheader use
- **Use of rock breakers** – rock breakers may be required to excavate cross passages and stub tunnels where hard rock is encountered. Rock hammering works may result in exceedances of the night-time NMLs to a slant distance of less than 70 metres from the excavation site (which would be the case for the majority of the tunnel alignment). Rock hammering would be precluded between 10 pm and 7 am except where there would be no exceedance of the NMLs
- **Use of work trains** – work trains may be used during construction to deliver materials and construction workers within the tunnels. In the event that these are used, they would be designed with the aim of achieving the noise trigger levels in the *Rail Infrastructure Noise Guidelines* (RING) (Environment Protection Authority, 2013). Alternatives may also be considered including the use of rubber tyred vehicles in lieu of work trains.

Ground-borne vibration

During main tunnelling works, it is anticipated that ground-borne vibration would be lower than the 7.5 mm/s screening level (the threshold at which cosmetic damage may occur) at all locations.

Vibration levels may, however be noticeable within surface buildings located close to the main tunnel alignment. The impact at these locations would only be apparent for a relatively short period of time (one or two days) as the tunnel boring machines pass by a particular location. Human comfort vibration impacts would be managed in accordance with the *Sydney Metro Construction Noise and Vibration Strategy* (refer to Appendix E).

10.4.14 Power supply routes

The *Interim Construction Noise Guidelines* (Department of Environment and Climate Change, 2009), suggest a qualitative noise assessment method for works which are unlikely to affect an individual or sensitive land use for more than three weeks in total. As the construction work associated with the power supply routes are not expected to affect any individual receivers for more than three weeks, and these receivers would be minimally impacted by the long term construction works for the project, a qualitative noise assessment has been carried out for these works.

Work along the power supply routes would take place generally within the road corridor and therefore would be close to receivers. In some cases the closest residential receiver would be within 10 metres of the proposed works. The following sections provide a qualitative discussion in relation to the types of activities and potential noise impacts.

Trenching

Receivers along the power supply route are expected to experience elevated noise levels during periods when the trenching work is in their vicinity. The initial phase of trenching is likely to involve the use of a concrete saw to remove road pavement. This would be followed by excavation using a small excavator or bobcat.

During these works, especially during the use of concrete saws, the closest receivers could experience noise levels in excess of 75 dB(A). Additionally, as the works are located within road reserves, a substantial portion of the works may be required to be carried out outside of standard daytime construction hours. The excavation work is anticipated to progress at about 30 metres per day and it is likely that a receiver would be affected for up to two consecutive days at most.

Due to these potential high noise levels, feasible and reasonable mitigation measures would be implemented to minimise impacts to receivers. This would include:

- Carrying out works during the daytime period when in the vicinity of residential receivers, where feasible and reasonable
- Where out of hours works are required, scheduling the noisiest activities to occur in the evening period (up to 10 pm)
- Use of portable noise barriers around particularly noisy equipment such as concrete saws
- Provision of additional mitigation measures in accordance with the Construction Noise and Vibration Strategy (Appendix E).

Under-boring

Where works cross major roads or other infrastructure under-boring may be used instead of trenching. Drilling equipment would typically result in elevated noise levels which, at some receivers, could exceed 75 dB(A). It is anticipated that under boring would generally be restricted to daytime works and would be carried out for up to two weeks in any single location.

Cable installation

Cable installation work is expected to be carried out during standard daytime construction hours and is not expected to cause significant noise impacts. The estimated work rate is around 500 metres per day and therefore any single receivers would only be affected for about one day.

Road and footpath re-instatement

Road and footpath re-instatement works have the potential to cause elevated noise levels in the vicinity of sensitive receivers. Additionally, these works are likely to occur outside of standard daytime construction hours to minimise traffic and pedestrian impacts. Re-instatement works are expected to progress at about 30 metres per day and therefore any single receiver would likely be affected for up to about two days.

10.5 Mitigation measures

10.5.1 Construction noise and vibration strategy

The *Construction Noise and Vibration Strategy* (CNVS) (Appendix E) has been developed to identify how Sydney Metro proposes to manage construction noise and vibration for the City & Southwest project. It is anticipated that construction of City & Southwest would be developed under a number of separate construction contracts. The CNVS defines the strategies by which construction noise and vibration impacts are to be minimised on Sydney Metro projects and aims to provide a consistent approach to management and mitigation across the Sydney Metro projects.

Specifically the CNVS identifies:

- The requirements and methodology to develop Construction Noise Impact Statements. These are prepared prior to specific construction activities and are based on a more detailed understanding of the construction methods, including the size and type of construction equipment. Construction Noise Impact Statement would include:
 - ◆ A more detailed understanding of surrounding receivers including particularly sensitive receivers such as education and child care, and vibration sensitive medical, imaging and scientific equipment
 - ◆ Application of appropriate noise and vibration criteria for each receiver type
 - ◆ An assessment of the potential noise and vibration impacts as a result of the construction activities.

Two different types of Construction Noise Impact Statements may be developed:

- ◆ General – for construction activities that are consistently the same and progressively move along the alignment, eg tunnelling
- ◆ Location specific – for activities that are specific to a location. This also includes out of hours works and to support applications for variations to the project Environment Protection Licence
- The minimum requirements in relation to standard noise and vibration mitigation measures
- Noise and vibration auditing and monitoring requirements
- Additional mitigation measures to be implemented when exceedances to the NMLs are likely to occur. These measures are primarily aimed at pro-active engagement with potentially affected receivers, and the provision of respite periods and alternative accommodation for defined exceedance levels.

10.5.2 Site specific mitigation measures

The mitigation measures that would be implemented to address potential construction noise and vibration impacts are listed in Table 10-38.

Mitigation measures relevant to driver training and limiting the use of compression braking is provided in Chapter 8 (Construction traffic and transport).

Table 10-38 Mitigation measures – construction noise and vibration

Ref	Mitigation measure	Applicable location(s) ¹
NV1	<p>The Construction Noise and Vibration Strategy would be implemented with the aim of achieving the noise management levels where feasible and reasonable.</p> <p>This would include the following example standard mitigation measures where feasible and reasonable:</p> <ul style="list-style-type: none"> ○ Provision of noise barriers around each construction site ○ Provision of acoustic sheds at Chatswood dive site, Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street, Waterloo and Marrickville dive site ○ The coincidence of noisy plant working simultaneously close together would be avoided ○ Offset distances between noisy plant and sensitive receivers would be increased ○ Residential grade mufflers would be fitted to all mobile plant ○ Dampened rock hammers would be used ○ Non-tonal reversing alarms would be fitted to all permanent mobile plant ○ High noise generating activities would be scheduled for less sensitive period considering the nearby receivers ○ The layout of construction sites would consider opportunities to shield receivers from noise. 	All
NV2	<p>Unless compliance with the relevant traffic noise criteria can be achieved, night time heavy vehicle movements at the Chatswood dive site, Crows Nest Station and Victoria Cross Station sites would be restricted to:</p> <ul style="list-style-type: none"> ○ The Pacific Highway and Mowbray Road at the Chatswood dive site ○ The Pacific Highway, Hume Street and Oxley Street at the Crows Nest Station construction site ○ McLaren Street, Miller Street and Berry Street at the Victoria Cross station construction site. 	CDS, CN, VC
NV3	<p>Where vibration levels are predicted to exceed the screening criteria, a more detailed assessment of the structure and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for that structure.</p> <p>For heritage items, the more detailed assessment would specifically consider the heritage values of the structure in consultation with a heritage specialist to ensure sensitive heritage fabric is adequately monitored and managed.</p>	All except metro rail tunnels
NV4	Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted.	All
NV5	<p>Feasible and reasonable mitigation measures would be implemented where power supply works would result in elevated noise levels at receivers. This would include:</p> <ul style="list-style-type: none"> ○ Carrying out works during the daytime period when in the vicinity of residential receivers ○ Where out of hours works are required, scheduling the noisiest activities to occur in the evening period (up to 10 pm) ○ Use of portable noise barriers around particularly noisy equipment such as concrete saws. 	PSR

¹ STW: Surface track works; CDS: Chatswood dive site; AS: Artarmon substation; CN: Crows Nest Station; VC: Victoria Cross Station; BP: Blues Point temporary site; GI: Ground improvement works; BN: Barangaroo Station; MP: Martin Place Station; PS: Pitt Street Station; CS: Central Station; WS: Waterloo Station; MDS: Marrickville dive site; Metro rail tunnels: Metro rail tunnels not related to other sites (eg TBM works); PSR: Power supply routes.

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