Chapter 7

Noise and vibration

7 Noise and vibration

This chapter provides an assessment of the potential noise and vibration impacts as a result of this proposal and identifies mitigation measures to address these impacts. This chapter draws on information provided in Technical Paper 2 (Noise and vibration).

7.1 Overview

Construction noise and vibration would be managed in accordance with the Sydney Metro Construction Noise and Vibration Standard (Appendix E) which provides standard mitigation measures and additional mitigation measures for certain noise and vibration impact levels. The proposal includes a number of base case mitigation measures to minimise the potential airborne noise impacts such as bored piling, acoustic perimeter hoarding, acoustic sheds, and acoustic panels within this noise and vibration impact assessment. Proposal specific additional potential mitigation measures have also been identified to reduce noise and vibration impacts throughout construction.

The potential for noise and vibration impacts during construction vary across the study area due to a number of factors including how close the nearest receivers are to the construction sites, receiver building design and noise amenity expectation. Where receivers are close, the noise impacts during some of the work is expected to be 'high', particularly when noise intensive equipment such as rockbreakers are being used. This is consistent with most major infrastructure projects in urban areas.

There would be periods when construction airborne noise levels are much lower than the worst-case levels predicted and there would be times when no equipment is in use and no impacts would occur as noise intensive equipment would not be in use continuously. Potential construction airborne noise impacts as a result of the proposal include:

- Temporary 'high' impacts predicted at the nearest receivers to the Pyrmont Station and Hunter Street Station (Sydney CBD) construction sites during some of the noisiest scenarios (in the early stages of the proposal, where work would be completed at surface level and require noise intensive equipment to be used prior to the establishment of acoustic sheds, or where acoustic sheds are not proposed). These worst-case temporary high impacts would be limited to daytime hours and would not occur during the evening or night-time
- Receivers that are close to construction sites are predicted to be impacted at times during noise intensive work at night-time at The Bays tunnel launch and support site and Pyrmont Station construction sites.

The tunnel boring machines are expected to progress at a rate of around 20 to 30 metres per day. This means the worst-case ground-borne noise impacts from tunnelling at individual receivers would likely only be apparent for a few days for each tunnel boring machine when the tunnelling work is directly beneath. As the work progress and move away, a particular receiver's exposure to ground-borne noise would reduce accordingly. Receivers further away from the construction sites are generally predicted to comply with the ground-borne noise management levels. Potential ground-borne noise impacts as a result of the proposal include:

- Temporary 'high' or 'moderate' worst-case impacts during station shaft excavation are predicted at receivers adjacent to or opposite the excavation work at the Pyrmont Station and Hunter Street Station (Sydney CBD) construction sites. The nearest receivers at Pyrmont are generally residential, whereas at Hunter Street (Sydney CBD) are commercial or 'other sensitive' receivers
- Temporary 'high' or 'moderate' worst-case impacts are predicted at receivers above the tunnel alignment in the Pyrmont and Hunter Street (Sydney CBD) study areas where the tunnel depth is shallowest
- The tunnel alignment is sufficiently deep in most locations for ground-borne noise impacts due to tunnel boring machines to generally be compliant with the management levels or result in only 'minor' impacts.

Where vibration levels are predicted to exceed the screening criteria, a more detailed assessment of the structure (in consultation with a structural engineer) and vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for that structure and alternative less vibration intensive alternative construction methodologies, where possible. Potential construction vibration impacts as a result of the proposal include:

- Temporary exceedances of the cosmetic damage vibration screening criteria due to excavation work within the Pyrmont Station and Hunter Street Station (Sydney CBD) construction sites, and the close proximity of vibration sensitive buildings or structures to the work

- Temporary exceedances of the human comfort vibration criteria are predicted at the nearest receivers at Pyrmont and Hunter Street (Sydney CBD) as a result of excavation work within the construction sites, meaning occupants of affected buildings may be able to perceive impacts at times when vibration intensive equipment is in use nearby.

Construction traffic is unlikely to result in a noticeable increase in noise levels on the proposed construction haulage routes due to high existing traffic volumes on these roads. There is potential for increased annoyance near to entrances/exits of the construction sites where heavy vehicles accelerate/decelerate, however, this is expected to be limited to a relatively small area adjacent to each site.

7.2 Legislative and policy context

The Secretary's Environmental Assessment Requirements relating to noise and vibration, and where these requirements are addressed in this Environmental Impact Statement, are outlined in Appendix A.

The relevant assessment guidelines, standards and policies that were considered as part of the noise and vibration assessment include:

- *Interim Construction Noise Guideline* (ICNG) (Department of Environment, Climate Change and Water, 2009)
- *Noise Policy for Industry* (NPfI), (Environment Protection Authority, 2017)
- *Road Noise Policy* (RNP) (Department of Environment, Climate Change and Water, 2011)
- *Guideline for Child Care Centre Acoustic Assessment Version 2.0* (GCCCAA), (Association of Australasian Acoustical Consultant, 2013)
- AS2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors
- *Assessing Vibration: a technical guideline* (Department of Environment and Conservation, 2006)
- BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2, BSI, 1993
- DIN 4150:Part 3-2016 Structural vibration – Effects of vibration on structures, Deutsches Institute fur Normung, 1999
- *Sydney Metro Construction Noise and Vibration Standard Version 4.3*, (Sydney Metro, 2020).

7.3 Assessment methodology

7.3.1 Overview

The assessment methodology for noise and vibration impacts generally involved:

- Identifying and classifying sensitive receivers relevant to the proposal
- Characterising the existing noise environment based on attended and unattended noise measurements at specific locations across the proposal
- Determining noise and vibration management levels in accordance with relevant guidelines
- Modelling to quantify 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.

7.3.2 Study area

The study area for the noise and vibration assessment has been defined based on the likely potential impacts:

- Airborne noise has been assessed to receivers within 600 metres of the surface construction sites (including power supply route)
- Ground-borne noise and vibration from tunnelling and shaft and station cavern excavation at surface construction sites has been assessed to receivers within 150 metres of the tunnel alignment and construction sites (including the power supply route)
- Construction road traffic noise impacts on public roads have been assessed for roads between the surface construction sites and the nearest arterial road(s).

7.3.3 Construction scenarios

Representative scenarios have been developed to assess the likely potential impacts from the various phases of the proposal as listed in Table 7-1. Construction hours for construction site activities are provided in Chapter 5 (Project description). In some cases, these representative scenarios have been further separated into 'typical' and 'peak' scenarios in terms of the noise generated levels as described below.

Table 7-1 Construction scenario descriptions

Scenario - Construction site activities	Description
Enabling and site establishment work	This work is required at Pyrmont and Hunter Street (Sydney CBD) to demolish existing buildings and structures, clear or protect trees, establish access points and erect hoarding. Relocation of services or third party assets may also be required. This work may include provision of high voltage power supplies for excavation equipment, which is required early in the program. The assessed scenarios are: • 'Typical' work generally includes operation of supporting equipment such as generators, cranes, compressors, etc, and loading of heavy vehicles with equipment such as excavators • 'Peak' work includes the use of noise intensive equipment such as rockbreakers or concrete saws at times, especially during demolition of existing structures. The number of construction faces doubles during 'peak' work for most construction sites.
Piling	Piling is required at Pyrmont and Hunter Street (Sydney CBD) for the foundations of future structures and to support linings for the stations and shafts. The assessed scenarios are: • 'Typical' work would include operation of supporting equipment such as excavators and cranes, as well as concreting equipment such as concrete mixer heavy vehicles and concrete pumps • 'Peak' work would use all supporting equipment plus a piling rig. The number of piling faces doubles during 'peak' work, with most construction sites requiring up to four piling faces where there is sufficient space. Bored piling would be used as opposed to impact piling, where possible. Bored piling is significantly less noisy.
Surface construction	Following site establishment and piling, civil work and surface structures such as abutments, roads, hardstand areas, and facilities such as water treatment equipment and site offices would be constructed. This work would be required at Pyrmont and Hunter Street (Sydney CBD). Acoustic sheds over excavation and spoil handling areas would be constructed as early as possible at Pyrmont, prior to excavation and tunnelling work. The assessed scenarios are: • 'Typical' work would include the use of general construction equipment such as cranes, generators and hand tools • 'Peak' work would use all supporting equipment plus noise intensive equipment such as grinders. The number of construction faces would double during 'peak' work.
Excavation	Station shafts would need to be excavated at Pyrmont and Hunter Street (Sydney CBD) from the surface down. Excavation would begin after the piling work and surface construction work, where applicable. Excavation would be completed within acoustic sheds at Pyrmont, where 24 hours a day, seven days a week excavation work is proposed. Excavation within the Pyrmont Station eastern construction site would be staged in two phases – 'initial excavation' and 'main excavation'. 'Initial excavation' involves a smaller acoustic shed at the eastern portion of the site to allow early shaft excavation and 'main excavation' involves a longer-term and larger acoustic shed that would be in place for the majority of the excavation work.

Scenario - Construction site activities	Description
Excavation cont.	The existing acoustic shed at the Hunter Street Station (Sydney CBD) eastern construction site would remain in place (erected as part of the Sydney Metro City and Southwest construction site) for the majority of the excavation. However, this would need to be dismantled once cavern excavation is complete (see below) to allow shaft excavation, as it is currently only over part of the Hunter Street Station (Sydney CBD) eastern construction site. It is anticipated that shaft excavation would then be completed without acoustic sheds at both the Hunter Street (Sydney CBD) construction sites. This is consistent with excavation work completed at the Sydney Metro City & Southwest construction sites within the Sydney CBD, given the higher existing background levels. This is due to the minimal benefit of establishing an acoustic shed for shaft excavation only compared with the time and noise impacts to build and remove an acoustic shed to complete this activity. The assessed scenarios are: • 'Typical' excavation work would include the use of support equipment for spoil handling and a process called 'mucking out' which occurs at times when excavation work would pause so the loose spoil can be removed using excavators and transferred to heavy vehicles • 'Peak' work would involve the concurrent operation of supporting work and excavation work using rockbreakers. The number of construction faces would double during 'peak' work for most construction sites with most sites requiring concurrent use of two rockbreaking faces. Construction equipment outside the acoustic sheds would include heavy vehicles and fixed ancillary equipment such as ventilation systems and water treatment facilities.
Mined caverns	Once shafts have been excavated, areas of the underground station caverns and tunnels would be mined using road headers. This work would be required at The Bays tunnel launch and support site for the crossover cavern near the start of the tunnel alignment, Pyrmont Station construction sites and Hunter Street Station (Sydney CBD) construction sites. Mined cavern work would be launched from within acoustic sheds at all sites, with the Hunter Street Station (Sydney CBD) construction sites using the existing acoustic shed.
Tunnel boring machine launch, retrieval and support	The tunnel boring machines are proposed to be launched and supported from The Bays. Tunnel boring machine assembly and launch activities would occur 24 hours a day, seven days a week, however, the majority of the work would be completed inside an acoustic shed or at the bottom of The Bays Station box excavation (as part of major civil construction between Westmead and The Bays). Some less noisy work would be required outside the shed, such as loading and unloading of heavy vehicles. Support activities would also be required to provide tunnel ventilation, supply high voltage power and extract/stockpile spoil. Tunnel boring machine retrieval activities would also occur 24 hours a day, seven days a week, however, it is anticipated that the majority of this work would be completed at the bottom of the Hunter Street Station (Sydney CBD) box excavation. Further construction planning would determine the retrieval location of the tunnel boring machines.
Tunnelling – excavation and construction	The tunnelling work would occur 24 hours a day, seven days a week. Depending on the rate of progress, noise and vibration impacts from tunnelling would likely only be apparent for relatively short periods at most locations. At this stage, tunnel boring machines are proposed to be used for the majority of the alignment with roadheaders and rockbreakers used at stations, stub tunnels, cross passages and crossover and turnback caverns.

Scenario - Construction site activities	Description
Tunnelling – work trains	Consistent with the tunnelling methodology used on previous Sydney Metro projects, work trains would likely be used to supply materials, such as precast tunnel lining segments, and workers to the workface. Spoil would be removed via conveyor. Work trains are anticipated to operate on bespoke underground wheeled vehicles, with an alternative of a temporary narrow gauge rail with resilient mounts and/or rubber wheels. The work trains would be loaded at the launch site and unloaded at the tunnel boring machines. The operating speed of work trains is around 10 kilometres per hour and they would be required 24 hours a day, seven days a week to support tunnelling. Work trains are not expected to result in any significant noise and vibration impacts.
Spoil and materials transport	Spoil and materials transport via heavy vehicles would be required to and from all construction sites. The use of other methods of transport, such as a barge from The Bays tunnel launch and support site, may be possible subject to further investigation (refer to Chapter 5 (Project description)).
Utility work	Existing utilities would need to be adjusted, relocated and/or protected where there is a possibility they would be impacted during construction. Access to a source of electrical power would be required for the construction sites, tunnel boring machines and future metro facilities. High voltage power supply would be provided to The Bays tunnel launch and support site under existing arrangements as approved within Stage 1 of the planning approval and to Hunter Street Station (Sydney CBD) through the existing Sydney Metro City & Southwest power supply route in place. However, the Pyrmont Station construction sites would require a new power supply route to be constructed, as provided on Figure 5-18 in Chapter 5 (Project description).

The noise levels presented in the assessment are based on a realistic worst-case assessment of each work scenario, where construction equipment is at the closest point to each receiver. The proposal includes a number of base case mitigation measures to minimise the potential airborne noise impacts such as bored piling, acoustic perimeter hoarding, acoustic sheds, and acoustic panels. These measures are considered as part of the design or construction methodology in this impact assessment.

The noise impact assessment scenarios have been categorised into 'peak' and 'typical' work which have been used to define the likely range of potential noise impacts:

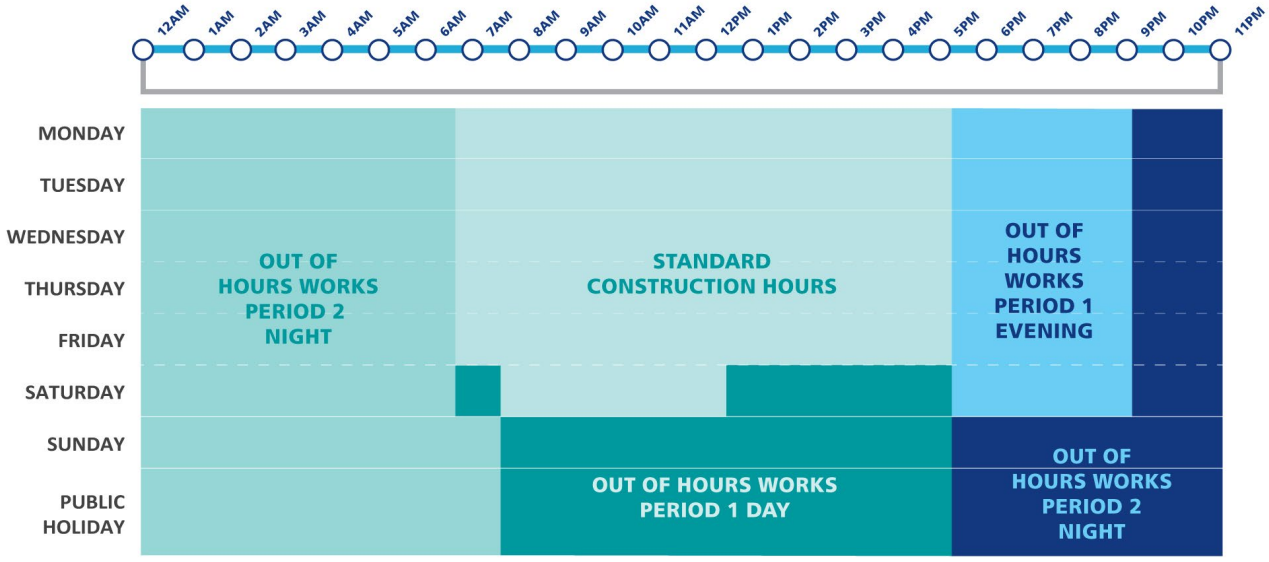
- 'Typical' work scenarios represent typical noise emissions from the proposal when noise intensive equipment is not in use. The 'typical' work generally includes items of equipment that are less noisy than the 'peak' scenario
- 'Peak' work scenarios represent the noisiest stages and can require the use of noise intensive equipment such as rockbreakers or concrete saws for some construction scenarios. While 'peak' work would be required at times in most locations, the noisiest activities would not occur over the full duration of construction. The 'peak' scenarios also include the maximum anticipated number of construction faces at each of the various construction sites. The assessment is generally considered conservative as the calculations assume several items of equipment at each construction face are in use at the same time within individual scenarios.

7.3.4 Construction program and hours

Subject to planning approval, construction of the proposal is planned to commence in 2023, with completion of work planned for the end of 2025. The total construction duration is expected to be around three years. An indicative construction program for the proposal is provided in Chapter 5 (Project description).

Standard construction hours and other work periods are identified in the ICNG. These are further defined in the Sydney Metro Construction Noise and Vibration Standard (Appendix E), shown in Table 7-2.

Table 7-2 Standard construction hours



Note 1: Work outside of Standard Construction Hours is defined as 'out of hours work' (OOHW) and can be divided into two periods of sensitivity. OOHW Period 1 which relates to evening (and weekend daytime) work, and OOHW Period 2 which relates to night-time (and weekend evening) work.

It is proposed to extend these standard construction hours for the proposal to include between 1 pm and 6 pm on Saturdays to reduce the overall program of the proposal. Earlier completion would bring considerable benefits to the community and would reduce the duration of construction related disruption. The extended construction hours on Saturdays for this proposal would also align with the Conditions of Approval for Stage 1 of the planning approval process.

The majority of above ground construction for the proposal would be carried out during these extended standard construction hours where possible, although evening and night-time work would be required during some periods. The extended standard construction hours proposed for the majority of above ground construction activities are:

- 7 am to 6 pm, Monday to Friday
- 8 am to 6 pm, Saturday
- No work on Sundays or public holidays.

Project specific constraints would require evening and night-time work at certain times, for example the tunnel boring machines operate continuously, tunnelling and associated support activities would need to be carried out on a 24 hour per day, seven day per week basis. A summary of the proposed construction hours for the construction activities of the proposal and justification for work that is required to be completed outside of standard construction hours is provided in Chapter 5 (Project description). Further detail on the approach to out of hours work is provided in the Sydney Metro Construction Noise and Vibration Standard (Appendix E).

7.3.5 Construction noise metrics

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

- Rating background level (RBL) or L_{A90} – The background noise level in the absence of proposed construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods and is used to set the $L_{Aeq(15\ minute)}$ noise management levels (NMLs) for residential receivers
- $L_{Aeq\ (period)}$ – 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 $L_{A1(1min)}$ – The 'typical maximum noise level' for an event, used in the assessment of potential sleep disturbance during night-time periods.

7.3.6 Noise catchment areas and sensitive receivers

The area surrounding each construction site is divided into one or more Noise Catchment Areas (NCAs) that reflect the ambient noise environment of that area, as well as the noise and vibration sensitivity of the surrounding land uses.

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, premises with sensitive equipment or uses are more likely to be more sensitive to vibration and ground-borne noise than residential premises, which in turn are more sensitive than typical commercial premises.

Receivers potentially sensitive to noise and vibration have been categorised into the following receiver categories:

- Residential buildings
- Commercial/industrial buildings
- 'Other sensitive' land uses, which includes educational institutions, childcare centres, medical facilities, places of worship, outdoor recreation areas.

A description of each of the NCAs is provided for each of the construction sites in Section 7.7, Section 7.8 and Section 7.9.

New developments

A review of recently approved potentially noise and vibration sensitive developments in the study area has been completed and the identified developments have been included, where appropriate.

7.3.7 Construction noise management levels

Airborne construction noise

The Sydney Metro Construction Noise and Vibration Standard (Appendix E) references the ICNG for assessing and managing construction noise impacts from Sydney Metro work.

The ICNG contains procedures for determining project specific Noise Management Levels for sensitive receivers. The 'worst-case' noise levels from construction of a project are predicted and then compared to the NMLs in a 15 minute assessment period to determine the likely impact of the proposal.

The NMLs are not mandatory limits, however where construction noise levels are predicted or measured to be above the NMLs, feasible and reasonable work practices to minimise noise emissions are to be investigated.

Residential receivers

The ICNG provides an approach for determining $L_{Aeq(15minute)}$ NMLs at residential receivers by applying the measured $L_{A90(15minute)}$ background noise levels, as described in Table 7-3. Residential NMLs for the proposal have been determined using the results from ambient noise monitoring carried out for each of the construction sites.

Table 7-3 Determination of NMLs for residential receivers

Time of day	NML $L_{Aeq(15minute)}$	How to apply
Standard Construction 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 dB	The noise affected level represents the point above which there may be some community reaction to noise: • Where the predicted or measured LAeq(15minute) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practises to meet the noise affected level • The proponent should also inform all potentially impacted residents of the nature of work to be carried out, the expected noise levels and duration, as well as contact details.
	Highly Noise Affected 75 dBA	The Highly Noise Affected (HNA) level represents the point above which there may be strong community reaction to noise: • 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: • Times identified by the community when they are less sensitive to noise (such as before and after school for work near schools or mid-morning or mid-afternoon for work near residences • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside Standard Construction Hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for work outside the recommended standard construction hours • The proponent should apply all feasible and reasonable work practices to meet the noise affected level • Where all feasible and reasonable practices have been applied and noise is more than five dB above the noise affected level, the proponent should negotiate with the community.

Other sensitive land uses and commercial receivers

Non-residential land uses have been identified in the study area. These include 'other sensitive' land uses such as educational institutes, medical facilities, outdoor recreational areas and commercial properties. The NMLs for 'other sensitive' receivers are shown in Table 7-4.

Table 7-4 NMLs for other sensitive receivers

Land use	NML $L_{Aeq(15minute)}$ (applied when the land use is in use)	
	Internal	External
ICNG 'other sensitive' receivers		
Classrooms at schools and other educational institutions	45	55[1]
Hospital wards and operating theatres	45	65[2]
Places of worship	45	55[1]
Active recreation areas (characterised by sporting activities and activities which generate noise)	-	65
Passive recreation areas (characterised by contemplative activities that generate little noise)	-	60
Commercial	-	70
Industrial	-	75
Non-ICNG 'other sensitive' receivers		
Hotel – daytime & evening[3]	50	70[2]
Hotel – night-time[3]	40	60[2]
Café/Bar/Restaurant[3]	50	70[2]

Land use	NML $L_{Aeq(15minute)}$ (applied when the land use is in use)	
	Internal	External
Child care centres – sleeping areas[4]	40	50[1]
Public building[3] (when in use)	50	60[1]
Recording studio[3] (when in use)	25	45[2]
Theatre / auditorium[3] (when in use)	30	50[2]

Note 1: It is assumed that these receivers have windows partially open for ventilation which results in internal noise levels being around 10 dB lower than the external noise level.

Note 2: It is assumed that these receivers have fixed windows which conservatively results in internal noise levels being around 20 dB lower than the external noise level.

Note 3: Taken from AS2107.

Note 4: Taken from Association of Australian Acoustical Consultants Guideline for Child Care Centre Acoustic Assessment.

Assessing airborne construction noise impacts

The assessment of predicted airborne noise impacts around construction sites is based on the exceedance of the NMLs for the identified construction scenarios. The likely subjective response of people affected by the impacts by the proposal is shown in Table 7-5 and is used at all construction sites to describe the level of impact during standard construction hours.

Table 7-5 Exceedance bands and corresponding subjective response to impacts

Exceedance of management level	Subjective classification	Impact colourings
No exceedance	Negligible	-
1 to 10 dB	Low impact	
11 dB to 20 dB	Moderate impact	
>20 dB	High impact	

Ground-borne construction noise

Construction work can cause ground-borne noise impacts in nearby buildings when vibration intensive equipment is in use, such as during tunnelling work using tunnel boring machines, roadheaders or rockbreakers. Ground-borne noise NMLs are defined in the ICNG for residential receivers and in the Sydney Metro Construction Noise and Vibration Standard (Appendix E) for commercial receivers.

The NMLs are applicable to tunnelling work and also where ground-borne noise levels are higher than airborne noise levels, which can occur during rockbreaking for example, where airborne noise levels are shielded by noise barriers or other such structures.

Ground-borne NMLs for residential and commercial receivers, based on levels provided in the ICNG or Sydney Metro Construction Noise and Vibration Standard (Appendix E), are presented in Table 7-6.

Table 7-6 Internal ground-borne NMLs for residential and commercial receivers

Time of day	Ground-borne NMLs $L_{Aeq(15\ minute)}$
Daytime 7 am–6 pm	• Residential 45 dBA • Commercial 50 dBA
Evening 6 pm–10 pm	• Residential 40 dBA
Night-time 10 pm–7 am	• Residential 35 dBA

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.

For 'other sensitive' receivers such as education institutions, hospital wards, operating theatres and places of worship, neither the ICNG nor Sydney Metro Construction Noise and Vibration Standard (Appendix E) provide guidance in relation to acceptable ground-borne noise levels. For these receivers, the ICNG internal airborne NMLs listed in Table 7-4 have been used to identify potential ground-borne noise impacts.

7.3.8 Ground-borne construction vibration

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

- Those in which the occupants of buildings are disturbed (human comfort)
- Those where the building contents may be affected (building contents)
- Those where the integrity of the building may be compromised (structural or cosmetic damage).

These are discussed further in the following sections.

Human comfort and building contents

People can sometimes perceive vibration impacts when vibration generating construction work is located close to occupied buildings. Vibration from construction work tends to be intermittent in nature and the Environment Protection Authority's *Assessing Vibration: a technical guideline* (2006) provides criteria for intermittent vibration based on the Vibration Dose Value (VDV). The VDV provides a measurement of the presence of 'jolts and jars' experienced and combines the magnitude of vibration with the time for which it occurs. The 'preferred' and 'maximum' VDVs for human comfort impacts are shown in Table 7-7.

People perceive vibration at levels well below those likely to cause damage to building contents. For most receivers, the human comfort vibration criteria are the most stringent and it is generally not necessary to set separate criteria for vibration effects on typical building contents.

Table 7-7 Vibration dose values for intermittent vibration

Building type	Assessment period	Vibration dose value[1] ($m/s^{1.75}$)	
		Preferred	Maximum
Critical work areas (e.g. operating theatres or laboratories)	Day or night-time	0.10	0.20
Residential	Daytime	0.20	0.40
	Night-time	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or night-time	0.40	0.80
Workshops	Day or night-time	0.80	1.60

Note 1: The vibration dose value accumulates vibration energy over the daytime and night-time assessment periods and is dependent on the level of vibration as well as the duration.

Exceptions to this can occur when vibration sensitive equipment, such as electron microscopes are located in buildings near to construction work. Criteria for vibration sensitive equipment are discussed below.

Cosmetic damage

If vibration from construction work is sufficiently high, it could potentially cause cosmetic damage to elements of affected buildings. Examples of potential damage include cracking or loosening of drywall surfaces, cracks in supporting columns and loosening of joints. The levels of vibration required to cause cosmetic damage tends to be at least an order of magnitude (ten times) higher than those at which people can perceive vibration (human comfort VDVs).

Industry standard cosmetic damage vibration limits are contained in Australian Standard AS 2187-2, British Standard BS 7385 and German Standard DIN 4150, which are referenced in the Sydney Metro Construction Noise and Vibration Standard (Appendix E). The Sydney Metro Construction Noise and Vibration Standard recommends limits for transient vibration which correspond to minimal risk of cosmetic damage for residential and industrial buildings.

The Sydney Metro Construction Noise and Vibration Standard notes that where dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in British Standard BS 7385:2 – 1993 may need to reduce by up to 50 per cent. On this basis, the Sydney Metro Construction Noise and Vibration Standard recommends the adoption of conservative cosmetic damage screening limits shown in Table 7-8.

Table 7-8 Transient vibration values for minimal risk of cosmetic damage

Type of building	Peak particle velocity (millimetres per second)
Reinforced or framed structures **Industrial and heavy commercial buildings**	25
Unreinforced or light framed structures **Residential or light commercial type buildings**	7.5

Heritage buildings and structures

The Sydney Metro Construction Noise and Vibration Standard (Appendix E) states that heritage buildings and structures should be assessed according to the cosmetic damage screening criteria outlined in Table 7-8 and should not be assumed to be more sensitive to vibration unless found to be structurally unsound.

Where heritage buildings or and structures are found to be structurally unsound a more conservative cosmetic damage objective of 2.5 millimetres per second peak particle velocity (from DIN 4150) would be adopted prior to more specific consideration of appropriate levels for each building or structure. The only heritage building or structure identified to require consideration of the 2.5 millimetres per second cosmetic damage screening criterion is the former White Bay Power Station in the study area around The Bays tunnel launch and support site.

Utilities and other vibration sensitive assets

Construction of the proposal could potentially affect other utilities and assets which may be sensitive to vibration. Examples include pipelines, tunnels, fibre optic cable routes and high pressure gas pipelines.

German Standard DIN 4150 provides the guideline vibration limits for buried pipework shown in Table 7-9. For other potentially affected assets, specific vibration limits should be determined on a case-by-case basis in consultation with the asset owner.

Table 7-9 Transient vibration vales for minimal risk of cosmetic damage

Pipe material	Guideline values vibration velocity at the pipe (millimetres per second)
Steel, welded	100
Vitrified clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
Masonry, plastic	50

Sensitive scientific equipment

Some scientific equipment, such as electron microscopes and microelectronics manufacturing equipment, can require more stringent vibration objectives. Other sensitive equipment used for various business requirements, such as medical equipment, may also have specific vibration goals. Vibration sensitive equipment is, however, often housed in buildings/rooms specifically designed and constructed for that purpose, which can help mitigate any potential impacts.

Vibration criterion for vibration sensitive equipment is provided in Table 13 of Technical Paper 2 (Noise and vibration). Where the criteria are exceeded all appropriate feasible and reasonable mitigation and management measures would be considered to minimise the impacts.

7.3.9 Construction traffic noise

The potential impacts from construction traffic associated with the proposal when travelling on public roads are assessed under the *NSW Road Noise Policy* (Department of Environment, Climate Change and Water, 2011a). This assessment considered the gradient, construction vehicle type, acceleration and deceleration to identify potential annoyance from traffic.

An initial screening test is first applied to evaluate if existing road traffic noise levels are expected to increase by more than two dB due to construction traffic. Where this is considered likely, further assessment is required using the following relevant road traffic noise criteria:

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

Where the criteria are exceeded Sydney Metro would consider the use of all feasible and reasonable mitigation and management measures to minimise the impacts.

7.3.10 Sleep disturbance

Where night work is located close to residential receivers there is the potential for sleep disturbance impacts.

The ICNG lists five categories of work that might be undertaken outside the standard construction hours:

- The delivery of oversized equipment or structures that require special arrangements to transport on public roads
- Emergency work to avoid the loss of life or damage to property, or to prevent environmental harm
- Maintenance and repair of public infrastructure where disruption to essential services and/or considerations of worker safety do not allow work within standard hours
- Public infrastructure work that shorten the length of the project and are supported by the affected community
- Work where a proponent demonstrates and justifies a need to operate outside the recommended standard hours.

Where construction work is planned to extend over more than two consecutive nights, the ICNG recommends an assessment of sleep disturbance impacts should be completed.

The most current method for assessing sleep disturbance from NSW transport infrastructure projects is contained in the Environment Protection Authority's *Noise Policy for Industry* (NPfI) (EPA, 2017). The NPfI defines sleep disturbance criteria as being 52 dBA L_{AFmax} or a maximum level of 15 dB above the RBL, whichever is the greater.

Where this criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.

7.4 Avoidance and minimisation of impacts

The design development of this proposal has aimed to avoid or minimise potential construction noise and vibration impacts. This included:

- Planning construction sites to adequately accommodate acoustic treatments, for example inclusion of acoustic sheds at the Pyrmont Station construction sites, and use of the existing acoustic shed at the Bligh Street construction site within the Hunter Street Station (Sydney CBD) eastern construction site. Acoustic sheds are expected to provide around 15 to 20 dB noise benefit.
- Location of Pyrmont Station construction sites on Pyrmont Bridge Road, and selection of construction traffic routes to minimise impacts on local roads and associated noise sensitive receivers
- Selection of tunnel boring machines to excavate the twin tunnels because they operate faster than other excavation machinery, resulting in a reduced construction timeframe and less disruption for the local community
- Planning the timing of construction vehicle movements at the Pyrmont Station construction sites, including haulage of excavated material, to avoid or minimise noise impacts during the night-time.

7.5 Potential tunnelling impacts

Potential construction noise and vibration impacts would be managed in accordance with the Sydney Metro Construction Noise and Vibration Standard (Appendix E) and any site specific requirements of an Environment Protection Licence, which aim to manage noise and vibration levels through feasible and reasonable measures. The Standard provides a process for the development of site or activity specific Detailed Noise and Vibration Impact Statements, standard mitigation measures and additional mitigation measures to be implemented based on noise and vibration trigger levels.

7.5.1 Potential ground-borne noise impacts

The assessment of ground-borne noise is based on the worst-case predicted ground-borne noise levels for sensitive receivers located above the proposed tunnelling work. The predictions represent the likely highest noise level inside sensitive receivers when the tunnelling work is directly below each receiver. The assessment also includes potential noise impacts from the excavation of irregular shaped tunnels such as stub tunnels, cross passages, crossover and turnback caverns and niches, by roadheaders.

The tunnel boring machines are expected to progress at a rate of around 20 to 30 metres per day. This means the worst-case ground-borne noise impacts from tunnelling at individual receivers would likely only be apparent for a few days for each tunnel boring machine when the tunnelling work is directly beneath. As the work progress and move away, a particular receiver's exposure to ground-borne noise would reduce accordingly.

A summary of the predicted ground-borne noise levels from tunnelling in each Noise Catchment Area is shown in Table 7-10. Each noise catchment area is identified in Section 7.6 to Section 7.8.

Overall, the ground-borne noise impacts during tunnelling work is predicted to comply with the daytime NMLs at most receivers. A relatively small number of the nearest receivers at the Pyrmont Station and Hunter Street Station (Sydney CBD) construction sites are predicted to have 'moderate' or 'low' impacts.

During the night-time, the impacts are more widespread due to a lower NML. The impacts are predicted to be 'high' at four receivers in each of the Pyrmont and Hunter Street Station (Sydney CBD) study areas where the tunnel depth is shallowest.

The impacted receivers are mostly residential properties in the Pyrmont study area. In the Hunter Street Station (Sydney CBD) study area the impacts are mostly at commercial receivers.

Table 7-10 Summary of tunnelling ground-borne NML exceedances – all receiver types

Construction site	Noise catchment area	Number of receivers									
		Total	With NML exceedance								
			Daytime			Evening			Night-time		
			1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
The Bays	NCA01	491	-	-	-	-	-	-	-	-	-
	NCA02	842	-	-	-	-	-	-	-	-	-
	NCA03	47	-	-	-	-	-	-	-	-	-
Pyrmont	NCA04	728	53	5	-	67	28	-	88	47	4
	NCA05	461	-	-	-	7	-	-	13	-	-
Hunter Street	NCA06	399	4	6	-	1	3	-	2	1	3
	NCA07	250	1	1	-	-	1	-	1	-	1

The above assessment shows that:

- The potential ground-borne noise impacts during tunnelling work are predicted to comply with the daytime NMLs at most receivers. A small number of the nearest receivers at the Pyrmont Station and Hunter Street Station (Sydney CBD) construction sites are predicted to have 'moderate' or 'low' impacts
- During the night-time, the impacts are more wide-spread due to a lower NML. The potential impacts are predicted to be 'high' in the Pyrmont and Hunter Street (Sydney CBD) study areas where the tunnel depth is shallowest
- The impacted receivers are mostly residential properties in the Pyrmont study area. In the Hunter Street (Sydney CBD) study area the potential impacts are mostly at commercial receivers.

7.5.2 Potential vibration impacts

The ground-borne vibration assessment is based on the worst-case predicted ground-borne vibration level for sensitive receivers above the proposed tunnelling work. The predictions represent the likely highest vibration level when tunnelling work is below each receiver. The assessment also includes potential vibration impacts from the excavation of irregular shaped tunnels such as stub tunnels, cross passages, crossover and turnback caverns and niches, by roadheaders.

Similar to ground-borne noise, worst-case vibration impacts from tunnelling at individual receivers would likely only be apparent for a few days for each tunnel boring machine, when the tunnelling work is directly beneath. As the work progresses and moves away, a particular receiver's exposure to vibration would reduce accordingly.

A summary of the predicted ground-borne vibration impacts from tunnelling in each noise catchment area is provided in Table 7-11.

Table 7-11 Summary of vibration criteria exceedances during tunnelling – all receiver types

Construction site	Noise catchment area	Number of receivers				
		Total	With vibration criteria exceedance			
			Cosmetic damage	Human comfort		Sensitive equipment
			Day / night	Day	Night	Day / night
The Bays	NCA01	491	-	-	-	-
	NCA02	842	-	-	-	-
	NCA03	47	-	-	-	-
Pyrmont	NCA04	728	-	25	43	-
	NCA05	461	-	-	-	-
Hunter Street	NCA06	399	-	7	3	-
	NCA07	250	-	1	1	3

The assessment in Table 7-11 shows:

- Vibration levels during tunnelling work are predicted to comply with the cosmetic damage criteria
- Potential exceedances of the human comfort criteria are likely in the Pyrmont and Hunter Street (Sydney CBD) study areas, meaning perceptible levels of vibration may occur when tunnelling work is beneath some receivers in those areas. These impacts are typically at receivers which surround the construction sites, as this is where the tunnel depth is shallowest. Worst-case ground-borne noise impacts from tunnelling at a receiver would likely only last for a few days for each tunnel boring machine as the tunnelling work passes beneath
- Three buildings at the Sydney Hospital are predicted to potentially have exceedances of the sensitive equipment criteria. These buildings have been identified based on an initial screening assumption that they contain vibration sensitive equipment. Vibration sensitive equipment is, however, often housed in buildings/ rooms specifically designed and constructed for that purpose, which can help mitigate any potential impacts. Potential vibration impacts would be managed in accordance with the Sydney Metro Construction Noise and Vibration Standard (Appendix E)
- No vibration impacts at the State listed heritage item, the former White Bay Power Station, are predicted as vibration intensive work during cavern mining would be around 300 metres away.

7.5.3 Work trains

Work trains would be required in the tunnels to move equipment. The speed of these trains is typically limited to 10 kilometres per hour for safety reasons and it is assumed they would have some form of resilient rubber tyres. The work trains would be used 24 hours per day, seven days a week.

Given the slow speeds and assumed rubber tyres, the potential ground-borne noise and vibration impacts from work trains are expected to be minimal. The potential impacts should be reviewed as this proposal progresses and detailed information regarding work trains becomes available.

7.6 Potential power supply route impacts

An assessment of the potential noise levels from the likely plant items associated with the Pyrmont power supply route is provided in Table 7-12. Noise levels have been predicted at various offset distances (10 to 70 metres) to give an indication of the possible impacts.

During construction, noise impacts associated with utility work would be temporary and would move progressively along the utility service corridor resulting in impacts at particular receivers for only a limited period of time. For example, the excavation work along power supply routes is anticipated to progress at about 30 metres per day and it is therefore likely that an individual receiver would be affected by the highest noise levels for up to two consecutive days at most.

Relatively high noise impacts are likely where noise intensive plant items are required near adjacent receivers. On typical streets where the closest receivers are about 10 metres from the road, noise levels between 80 to 86 dBA are possible when noise intensive plant items are in use. Where night-time work is required, worst-case exceedances of greater than 30 dB above the NML are possible where noise intensive plant items are in use. Mitigation measures, including appropriate respite, would be provided to affected receivers during power supply work in accordance with the Sydney Metro Construction Noise and Vibration Standard (Appendix E).

Table 7-12 Potential noise levels from utility work

Equipment	Predicted noise level at distance ($L_{Aeq(15\ minute)}$ dBA)				
	10 metres	15 metres	30 metres	50 metres	70 metres
Asphalt milling machine	83	79	73	69	66
Concrete saw[1]	84	80	74	70	67
Excavator	81	77	71	67	64
Excavator (breaker)[1]	90	86	80	76	73
Hand tools	69	65	59	55	52
Paver	77	73	67	63	60
Roller	78	74	68	64	61
Vacuum excavation truck	72	68	62	58	55

Note 1: Assumed to be working for 7.5 minutes in worst-case 15-minute period.

7.7 The Bays tunnel launch and support site

7.7.1 Existing environment

The impact of major civil construction work between Westmead and The Bays on noise and vibration at The Bays Station construction site is summarised in Section 11.14 of the *Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD* (Sydney Metro, 2020a). This included the use of The Bays Station construction site to:

- Carry out the excavation of The Bays Station
- Launch and support two tunnel boring machines for the drive west to the Sydney Olympic Park metro station construction site.

The Bays Station construction site is being established and surface construction and shaft excavation work would be carried out under the existing approval (Stage 1 of the planning approval process). Mitigation measures for noise and vibration impacts that apply to surface and shaft excavation work The Bays Station construction site were identified in Section 11.16 of *Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD* (Sydney Metro, 2020a) and Section 8.1 of the *Sydney Metro West Submissions Report – Westmead to The Bays and Sydney CBD* (Sydney Metro, 2020b).

Existing noise levels around The Bays tunnel launch and support site are dominated by road traffic noise from Victoria Road and Anzac Bridge, and industrial noise from White Bay and Glebe Island. The area immediately surrounding the construction site consists mainly of commercial/industrial use, with large areas of residential receivers further to the north, east and south of the site.

The Bays has been divided into three noise catchment areas: NCA01, NCA02, and NCA03 (refer to Figure 7-1).

NCA01 is located west of Victoria Road at Rozelle. This catchment is comprised of residential receivers and a mixture of commercial, places of worship (St Joseph's Catholic Church), educational facilities (Sydney Community College) and childcare facilities (Rosebud Cottage Child Care) along Victoria Road.

NCA02 is located north of the Anzac Bridge and east of Victoria Road at Rozelle. This catchment is comprised of commercial/industrial buildings associated with White Bay, Glebe Island and Rozelle Bay. A large commercial area is also located near Robert Street. Large areas of residential receivers are also located to the north west of the catchment. The Bald Rock Hotel is located around 130 metres north of the construction site on Mansfield Street.

NCA03 is located south of the Anzac Bridge and is comprised of residential areas near Glebe Point Road and recreation areas including Jubilee Park and Blackwattle Bay Park.

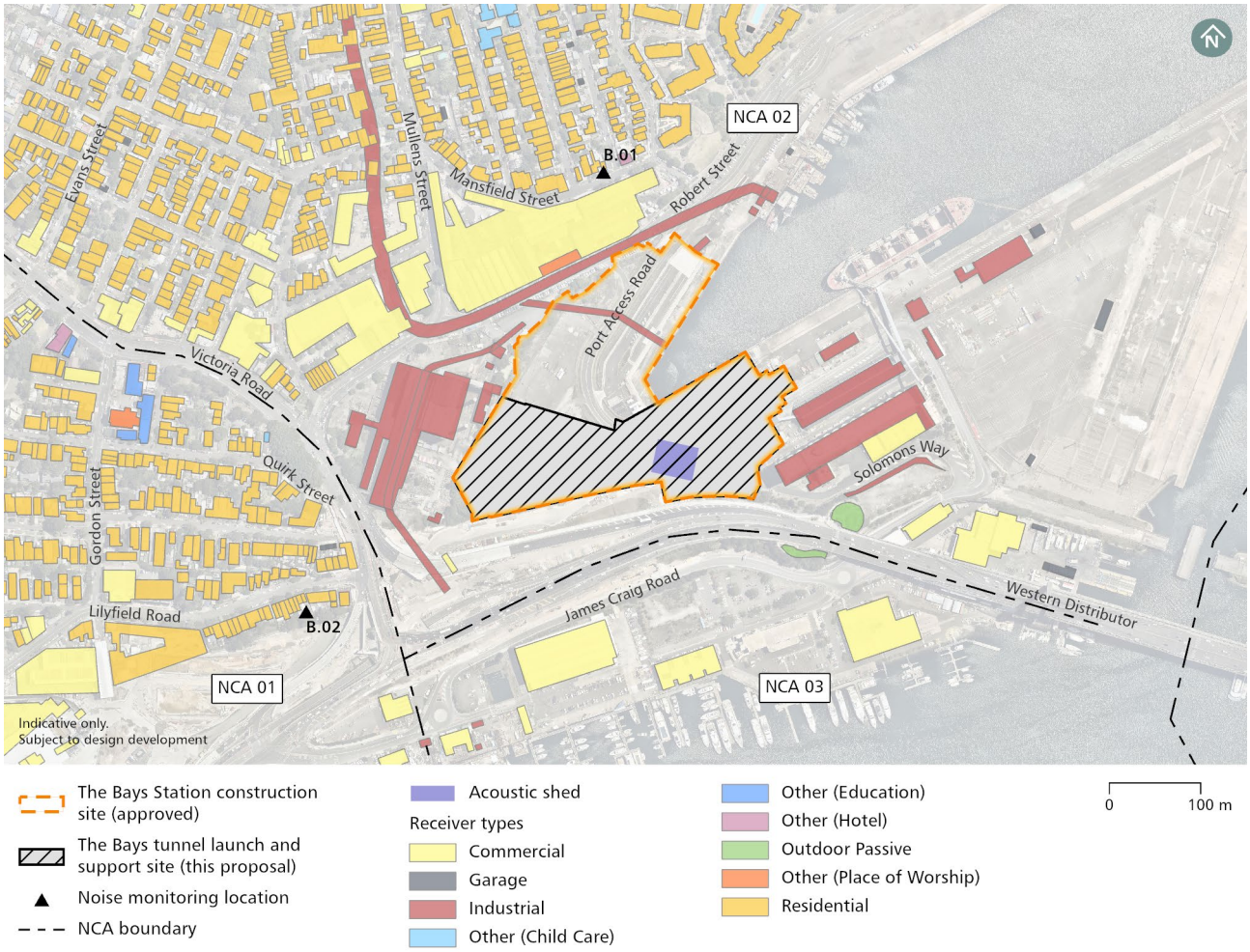


Figure 7-1 Location of sensitive receivers near The Bays tunnel launch and support site

Unattended noise monitoring was undertaken at sensitive receiver locations in the vicinity of The Bays tunnel launch and support site between March and July 2019. The results of the unattended noise surveys are summarised in Table 7-13.

Table 7-13 Summary of unattended noise monitoring – The Bays tunnel launch and support site

ID	Address	Noise level (dBA)[1]					
		Background noise (RBL)			Average noise level (LAeq)		
		Day	Eve	Night	Day	Eve	Night
B.01	21 Mansfield Street, Rozelle	43	43	35	56	54	47
B.02	22 Lilyfield Road, Rozelle	51	51	45	57	57	54
B.03	308 Glebe Point Road, Glebe	48	47	39	59	58	51

Note 1: The RBL and LAeq noise levels have been obtained using the calculation procedures documented in the Noise Policy for Industry

7.7.2 Potential impacts

As described in Section 7.7.1, The Bays tunnel launch and support site would be located entirely within the construction footprint of the approved The Bays Station construction site. The potential impacts of the proposed use of The Bays tunnel launch and support site to launch and support two tunnel boring machines for the drive east to the proposed Hunter Street Station (Sydney CBD) construction sites are assessed below.

The construction scenarios at The Bays tunnel launch and support site, and the anticipated working hours are shown in Table 7-14. The estimated duration of each activity is also provided, noting that most activities would be intermittent during this period and would not be expected to be undertaken on a continual basis. Potential noise and vibration impacts of tunnelling activity have been assessed in Section 7.5

Work associated with the proposal within The Bays tunnel launch and support site are anticipated to have a total duration of about three years.

These temporary airborne noise impacts would be managed through the implementation of standard and additional mitigation measures in accordance with the Sydney Metro Construction Noise and Vibration Standard (Appendix E).

Table 7-14 Construction activities and period of work at The Bays tunnel launch and support site

Scenario	Activity	Total indicative duration (weeks)	Maximum number of working faces	Hours of work				Comments
				Std. day	Out-of-hours work			
					Day OOH	Eve	Night	
Mined crossover cavern (in shed)	Spoil removal	28	1	✓	✓	✓	✓	
	Mining with support	28	2	✓	✓	✓	✓	OOH work would occur once the acoustic sheds (or other acoustic measures) have been constructed.
TBM launch and support (in shed)	TBM support and spoil removal	59	1	✓	✓	✓	✓	The majority of work would be conducted within the acoustic shed (or other acoustic measures) with some loading and other less noisy work being conducted outside the shed.
	TBM assembly and launch	13	2	✓	✓	✓	✓	

Note 1: Noise intensive work outside of Standard Construction Hours would only occur in acoustic sheds (constructed under existing approval).

Note 2: OOH = out of hours. During the daytime, this refers to the period on Saturday between 7 am – 8 am, and 1 pm – 10 pm.

Note 3: Durations should be regarded as indicative and represent the total estimated duration of work at a typical worksite over the entire construction period.

Airborne construction noise impacts

The predicted airborne NML exceedances from work at The Bays tunnel launch and support site are summarised in Table 7-15. The number of receivers predicted to experience exceedances of the NMLs are summarised in bands of 10 dB and are separated into day, evening and night-time periods, as appropriate.

Only residential receivers are predicted to experience exceedances of NMLs. There would be no exceedances for commercial or other sensitive receivers. The predictions are representative of the highest noise levels that would be experienced when the work is nearest to the sensitive receivers.

The noise intensive components of the proposed work at The Bays tunnel launch and support site is mostly underground and within the acoustic shed, which limits the potential impacts. The proposal would not result in any exceedances of the daytime and evening NMLs.

The night-time noise levels are predicted to result in 'low' impacts at several of the nearest residential receivers to the north of the site. This is due to their increased elevation relative to the site and increased view of the site. The 'peak' scenarios generate more noise and result in more exceedances than the 'typical' scenarios, which results from the 'peak' scenarios using noise intensive equipment.

Table 7-15 Overview of NML exceedances (all receiver types) – The Bays tunnel launch and support site

Scenario	Activity		Duration (weeks)[1]	Period[1]	Number of receivers		
					With NML exceedances		
					1-10 dB	11-20 dB	>20 dB
Mined cavern (in shed)	Typical	Spoil removal	28	Night	1	-	-
				Sleep	6	-	-
	Peak	Mining with support	28	Night	39	-	-
				Sleep	6	-	-
TBM launch and support (in shed)	Typical	TBM support and spoil removal	59	Night	1	-	-
				Sleep	6	-	-
	Peak	TBM assembly and launch	13	Night	31	-	-
				Sleep	6	-	-

Note 1: Durations should be regarded as indicative and represent a typical worksite. The duration of these impacts is less than the overall duration and depends on the rate of progress in the work areas.

Highly affected residential receivers

No receivers are predicted to be highly noise affected by work at The Bays tunnel launch and support site.

Sleep disturbance

A sleep disturbance screening assessment has been completed for the construction work and potential impacts are summarised in Table 7-15. 'Low' sleep disturbance impacts are predicted at six residential receivers to the north during night-time work. These impacts result from heavy vehicles accessing the construction site via Port Access Road and moving around the outdoor areas.

The number of potential night-time awakenings from heavy vehicles would be influenced by the number of vehicles and the way in which the vehicles are operated. Up to five trucks per hour are expected at this construction site during the night-time. The Sydney Metro Construction Traffic Management Framework (Appendix D) includes a requirement for project specific heavy vehicle driver induction training to minimise potential impacts.

Ground-borne noise and vibration impacts

Ground-borne noise and vibration impacts at this site during tunnelling work are assessed in Section 7.5.1 above.

Construction traffic noise impacts

Construction traffic related noise has the potential to temporarily increase road traffic noise levels at receivers along construction haul routes. The forecast construction traffic volumes have been used to determine that potentially noticeable increases in road traffic noise (i.e. greater than two dB increases above the existing noise level) is unlikely. No roads are anticipated to have a greater than two dB.

7.8 Pyrmont Station construction sites

7.8.1 Existing environment

Existing noise levels in this study area are dominated by road traffic noise particularly from Anzac Bridge and the Western Distributor. The areas surrounding the construction sites are mostly residential and commercial.

The area surrounding Pyrmont Station construction sites can be divided up into two noise catchment areas; NCA04 and NCA05 (refer to Figure 7-2).

NCA04 is located north of Pyrmont Bridge Road. The catchment comprises residential receivers and a mixture of commercial properties, education facilities (KU Maybanke Preschool) and childcare facilities (SDN Pyrmont Children's Education and Care Centre). The Sebel Hotel is located between the two construction sites. NCA04 also includes The Star casino and the Sydney Lyric Theatre.

NCA05 is located south of Pyrmont Bridge Road. The catchment comprises a similar mix of properties to NCA04 with both residential and commercial properties. The Ibis Hotel is located near the eastern construction site.

Figure 7-2 Location of sensitive receivers near Pyrmont Station construction sites

Unattended and attended noise monitoring was undertaken at sensitive receiver locations in the vicinity of the Pyrmont Station construction sites in June 2021. The results of the noise surveys are summarised in Table 7-16.

Table 7-16 Summary of noise monitoring – Pyrmont Station construction sites

ID	Address	Noise level (dBA)[1]					
		Background noise (RBL)			Average noise level (LAeq)		
		Day	Eve	Night	Day	Eve	Night
B.04[2]	200 Paternoster Row, Pyrmont	50	47	45	56	50	47
B.05	1-5 Harwood Street, Pyrmont	52	49	46	61	59	56

Note 1: The RBL and LAeq noise levels have been obtained using the calculation procedures documented in the Noise Policy for Industry
Note 2: Data based on several attended ambient noise measurements. See Appendix B of Technical Paper 2 (Noise and vibration) for details.

7.8.2 Potential impacts

The construction scenarios at the Pyrmont Station construction sites, and the anticipated working hours are shown in Table 7-17. The estimated duration of each activity is also provided, noting that most activities would be intermittent during this period and would not be expected to be undertaken on a continual basis.

Work within the Pyrmont Station construction sites are anticipated to have a total duration of about three years.

These temporary airborne noise impacts would be managed through the implementation of standard and additional mitigation measures in accordance with the Sydney Metro Construction Noise and Vibration Standard (Appendix E).

Table 7-17 Construction activities and period of work at Pyrmont Station construction sites

Scenario	Activity	Total indicative duration (weeks)	Maximum number of working faces	Hours of work				Comments
				Std. day	Out-of-hours work			
					Day OOH	Eve	Night	
Enabling work	Supporting and loading	17	1	✓	✓	-	-	
	Demolition using a rockbreaker	17	2	✓	✓	-	-	Rockbreaking work would only occur intermittently during a 17 week period between 7am – 6pm. Total duration of rockbreaking work would be about 15 days.
Piling	Supporting work	15	1	✓	✓	-	-	Piling work would only occur intermittently during a 15 week period between 7 am and 6 pm. Up to four piling rigs would be active at the same time.
	Bored piling with support plant	15	4	✓	✓	-	-	
Surface construction	General work	6	1	✓	✓	-	-	Civil work and construction surface structures, including acoustic shed.
	Noise intensive work	6	2	✓	✓	-	-	
Initial excavation (in sheds)	Mucking out	2	1	✓	✓	✓	✓	Early excavation work occurring with a temporary smaller acoustic shed at the eastern construction site. This work would occur 24 hours per day, seven days per week.
	Through rock using rockbreaker	2	2	✓	✓	✓	✓	
Excavation (in sheds)	Mucking out	14	1	✓	✓	✓	✓	Excavation work would occur 24 hours per day, seven days per week. OOH work would only occur once the acoustic sheds have been constructed.
	Through rock using rockbreaker	14	2	✓	✓	✓	✓	
Mined cavern (in sheds)	Spoil removal	53	1	✓	✓	✓	✓	
	Mining with support	53	2	✓	✓	✓	✓	

Note 1: Noise intensive work outside of Standard Construction Hours would only occur in acoustic sheds (constructed under existing approval).

Note 2: OOH = out of hours. During the daytime, this refers to the period on Saturday between 7 am – 8 am, and 1 pm – 10 pm.

Note 3: Durations should be regarded as indicative and represent the total estimated duration of work at a typical worksite over the entire construction period.

Airborne construction noise impacts

The predicted airborne NML exceedances at residential receivers from work at Pyrmont Station construction sites are summarised in Table 7-18 for residential receivers. The predictions are representative of the highest noise levels that would be experienced when the work is nearest to the sensitive receivers. The number of receivers predicted to experience exceedances of the NMLs are summarised in bands of 10 dB and are separated into day, evening and night-time periods, as appropriate.

The proposed work at Pyrmont Station construction sites would involve some noise intensive surface work which would be completed before construction of the acoustic sheds. This work would only be completed during the daytime. After acoustic sheds are constructed, underground excavation work would occur 24 hours per day, seven days per week.

Receivers are located close to the construction sites and impacts are predicted to be 'high' during noisy surface work when noise intensive equipment such as rockbreakers are being used. When work is underground and inside acoustic sheds, the daytime impacts are predicted to substantially reduce, with 'low' impacts predicted at the nearest receivers when rockbreaking is being completed inside the acoustic sheds (with doors closed).

During night-time, 'moderate' impacts are predicted at the nearest receivers during the nosiest work when acoustic shed doors are closed. These impacts are predicted to increase to 'high' at a small number of receivers when the doors are open. When noise intensive equipment is not in use, the impacts are substantially lower, with 'low' impacts generally predicted at the nearest receivers and compliance with the NMLs for receivers further away.

Table 7-18 Overview of NML exceedances (residential receivers) – Pyrmont Station construction sites

Scenario	Activity		Duration (weeks)[1]	Period	Number of receivers With NML exceedances		
					1-10 dB	11-20 dB	>20 dB
Enabling work	Typical	Supporting and loading	17	Day	27	8	2
				Day OOH	31	24	2
	Peak	Demolition using a rockbreaker	17	Day	135	42	33
				Day OOH	272	87	46
Piling	Typical	Supporting work	15	Day	27	3	-
				Day OOH	32	9	2
	Peak	Bored piling with support plant	15	Day	34	20	2
				Day OOH	60	33	6
Surface construction	Typical	General work	6	Day	20	2	-
				Day OOH	33	4	2
	Peak	Noise intensive work	6	Day	31	7	2
				Day OOH	35	25	2
Initial excavation (in sheds)	Typical	Mucking out (doors closed)	2	Day OOH	10	-	-
				Evening	20	-	-
				Night-time	28	1	-
				Sleep	52	16	-
	Peak	Through rock using rockbreaker (doors closed)	2	Day	34	-	-
				Day OOH	83	3	-
				Evening	88	23	-
				Night	128	35	-
				Sleep	52	16	-

Scenario	Activity		Duration (weeks)[1]	Period	Number of receivers		
					With NML exceedances		
					1-10 dB	11-20 dB	>20 dB
Excavation (in sheds)	Typical	Mucking out (doors closed)	14	Day OOH	7	-	-
				Evening	18	-	-
				Night-time	25	1	-
				Sleep	52	16	-
	Peak	Through rock using rockbreaker (doors closed)	14	Day	36	-	-
				Day OOH	84	5	-
				Evening	94	26	-
				Night	132	39	-
				Sleep	54	16	-
		Through rock using rockbreaker (doors open)	14	Day	72	15	-
				Day OOH	109	39	5
				Evening	177	53	11
				Night	229	71	19
				Sleep	72	27	-
Mined cavern (in sheds)	Typical	Spoil removal (doors closed)	53	Day OOH	8	-	-
				Evening	19	-	-
				Night-time	26	2	-
				Sleep	52	11	-
	Peak	Mining with support (doors closed)	53	Day	3	-	-
				Day OOH	32	-	-
				Evening	60	-	-
				Night	79	5	-
				Sleep	52	16	-
		Mining with support (doors open)	53	Day	31	5	-
				Day OOH	67	13	-
				Evening	93	23	-
				Night	107	35	5
				Sleep	63	21	-

Note 1: Durations should be regarded as indicative and represent a typical worksite. The duration of these impacts is less than the overall duration and depends on the rate of progress in the work areas.

Table 7-19 provides a summary of the NML exceedances for 'other' receivers near the Pyrmont Station construction sites.

The majority of nearby commercial and other sensitive receivers are predicted to experience minor exceedances. However, Bliss Early Learning, KU Maybanke Preschool, SDN Pyrmont Children's Education and Care Centre, The Sebel Hotel, the Peg Leg Inn, The Darling Hotel and Pyrmont Fire Station would experience 'moderate' exceedances during noisy outdoor activities or when acoustic shed doors are open. Sydney Lyric Theatre is predicted to experience 'high' exceedances when rockbreakers are in use outdoors (expected to be for about 15 days). Work that does not require noise intensive equipment is predicted to result in noise levels that comply with the management levels or result in 'low' exceedances at a small number of receivers.

Table 7-19 Overview of NML exceedances (other receivers) - Pyrmont Station construction sites

Scenario	Activity		Duration (weeks)[1]	Receiver type	Number of receivers With NML exceedances		
					1-10 dB	11-20 dB	>20 dB
Enabling work	Typical	Supporting and loading	17	Child care	1	-	-
				Hotel (day)	2	-	-
				Theatre	1	-	-
	Peak	Demolition using a rockbreaker	17	Commercial	11	9	-
				Child care	-	3	-
				Hotel (day)	2	3	-
				Outdoor passive	1	-	-
				Public building	1	1	-
				Theatre	4	-	1
Piling	Peak	Bored piling with support plant	15	Commercial	4	-	-
				Child care	2	-	-
				Hotel (day)	3	-	-
				Theatre	1	-	-
Surface construction	Peak	Noise intensive work	6	Commercial	1	-	-
				Child care	1	-	-
				Hotel (day)	2	-	-
				Theatre	1	-	-
Initial excavation (in sheds)	Typical	Mucking out (doors closed)	2	Hotel (night)	1	-	-
	Peak	Through rock using rockbreaker (doors closed)	2	Child care	2	-	-
				Hotel (night)	3	-	-
				Theatre	1	-	-
Excavation (in sheds)	Typical	Mucking out (doors closed)	14	Hotel (night)	1	-	-
	Peak	Through rock using rockbreaker (doors closed)	14	Child care	2	-	-
				Hotel (night)	3	-	-
				Theatre	1	-	-
		Through rock using rockbreaker (doors open)	14	Commercial	4	1	-
				Child care	2	1	-
				Hotel (day)	1	1	-
				Hotel (night)	2	2	1
				Public building	1	-	-
				Theatre	1	-	-
Mined cavern (in sheds)	Typical	Spoil removal (doors closed)	53	Hotel (night)	1	-	-

Scenario	Activity		Duration (weeks)[1]	Receiver type	Number of receivers		
					With NML exceedances		
					1-10 dB	11-20 dB	>20 dB
Mined cavern (in sheds)	Peak	Mining with support (doors closed)	53	Hotel (night)	2	-	-
		Mining with support (doors open)	53	Commercial	2	-	-
				Child care	-	1	-
				Hotel (day)	2	-	-
				Hotel (night)	1	2	-

Note 1: Durations should be regarded as indicative and represent a typical worksite. The duration of these impacts is less than the overall duration and depends on the rate of progress in the work areas.

Highly noise affected receivers

The nearest receivers to the sites are predicted to be highly noise affected during daytime work before the acoustic sheds are constructed. Work in the shed is predicted to result in highly noise affected impacts at receivers nearest to the site boundary only when shed doors are briefly opened to allow vehicles to enter or exit the site.

The predicted number of receivers likely to be highly noise affected are summarised in Table 7-20 and shown in Figure 7-3.

Table 7-20 Predicted number of highly affected residential receivers – Pyrmont Station construction sites

Scenario	Activity		NCA04			NCA05		
			Day	Eve	Night	Day	Eve	Night
Enabling work	Typical	Supporting and loading	2	n/a	n/a	-	n/a	n/a
	Peak	Demolition using a rockbreaker	32	n/a	n/a	23	n/a	n/a
Piling	Typical	Supporting work	2	n/a	n/a	-	n/a	n/a
	Peak	Bored piling with support plant	9	n/a	n/a	1	n/a	n/a
Surface construction	Typical	General work	2	n/a	n/a	-	n/a	n/a
	Peak	Noise intensive work	3	n/a	n/a	-	n/a	n/a
Initial excavation (in sheds)	Typical	Mucking out (doors closed)	-	-	-	-	-	-
	Peak	Through rock using rockbreaker (doors closed)	-	-	-	-	-	-
Excavation (in sheds)	Typical	Mucking out (doors closed)	-	-	-	-	-	-
	Peak	Through rock using rockbreaker (doors closed)	-	-	-	-	-	-
		Through rock using rockbreaker (doors open)	2	2	2	9	9	9
Mined cavern (in sheds)	Typical	Spoil removal (doors closed)	-	-	-	-	-	-
	Peak	Mining with support (doors closed)	-	-	-	-	-	-
		Mining with support (doors open)	-	-	-	2	2	2

Figure 7-3 Highly noise affected residential receivers - Pyrmont Station construction sites

Sleep disturbance

A sleep disturbance screening assessment has been completed for the construction work and potential impacts are summarised in Table 7-18. 'Moderate' sleep disturbance impacts are predicted at residential receivers adjacent to and opposite the construction sites during noisy excavation and mined cavern night-time work, with 'low' impacts at receivers which are more distant. These impacts would result from any heavy vehicles accessing the construction sites during the night where deliveries associated with night time work required for safety reasons. Sleep disturbance impacts are predicted at a small number of additional receivers if acoustic shed doors are opened during excavation work. The number of potential night-time awakenings from heavy vehicles would be influenced by the number of vehicles and the way in which the vehicles are operated. The Sydney Metro Construction Traffic Management Framework (Appendix D) includes a requirement for project specific heavy vehicle driver induction training to minimise potential impacts.

Ground-borne noise impacts

The predicted ground-borne noise impacts from station shaft excavation work inside the acoustic sheds are summarised in Table 7-21 and shown in Figure 7-4 and Figure 7-5.

Receivers are close to the western construction site and vibration intensive work is predicted to result in 'high' ground-borne noise impacts. 'Moderate' or 'low' exceedances are predicted at receivers further away from the western construction site and at the nearest receivers to the eastern construction site.

More receivers are predicted to be impacted by ground-borne noise during the evening and night-time periods due to the lower residential ground-borne NML in these periods.

'Moderate' to 'low' ground-borne noise impacts are predicted at The Sebel Hotel and Peg Leg Inn.

Vibration intensive shaft excavation work inside the acoustic shed is expected to last for around 16 weeks.

The predictions represent the worst-case scenario when shaft excavation work are at surface level and are, therefore, at the closest point to the affected buildings. As the work progresses deeper, the impacts are expected to reduce.

Table 7-21 Overview of ground-borne NML exceedance

NCA	Receiver classification	Number of receivers									
		Total	With NML Exceedance								
			Daytime			Out of hours work					
						Evening			Night-time		
			1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
NCA04	Residential	560	12	8	5	11	8	10	9	12	13
	Commercial	112	1	-	-	-	-	-	-	-	-
	Other sensitive	48	1	-	-	1	-	-	-	1	-
NCA05	Residential	396	4	-	-	7	2	-	9	4	-
	Commercial	32	-	-	-	-	-	-	-	-	-
	Other sensitive	23	1	-	-	1	-	-	-	1	-

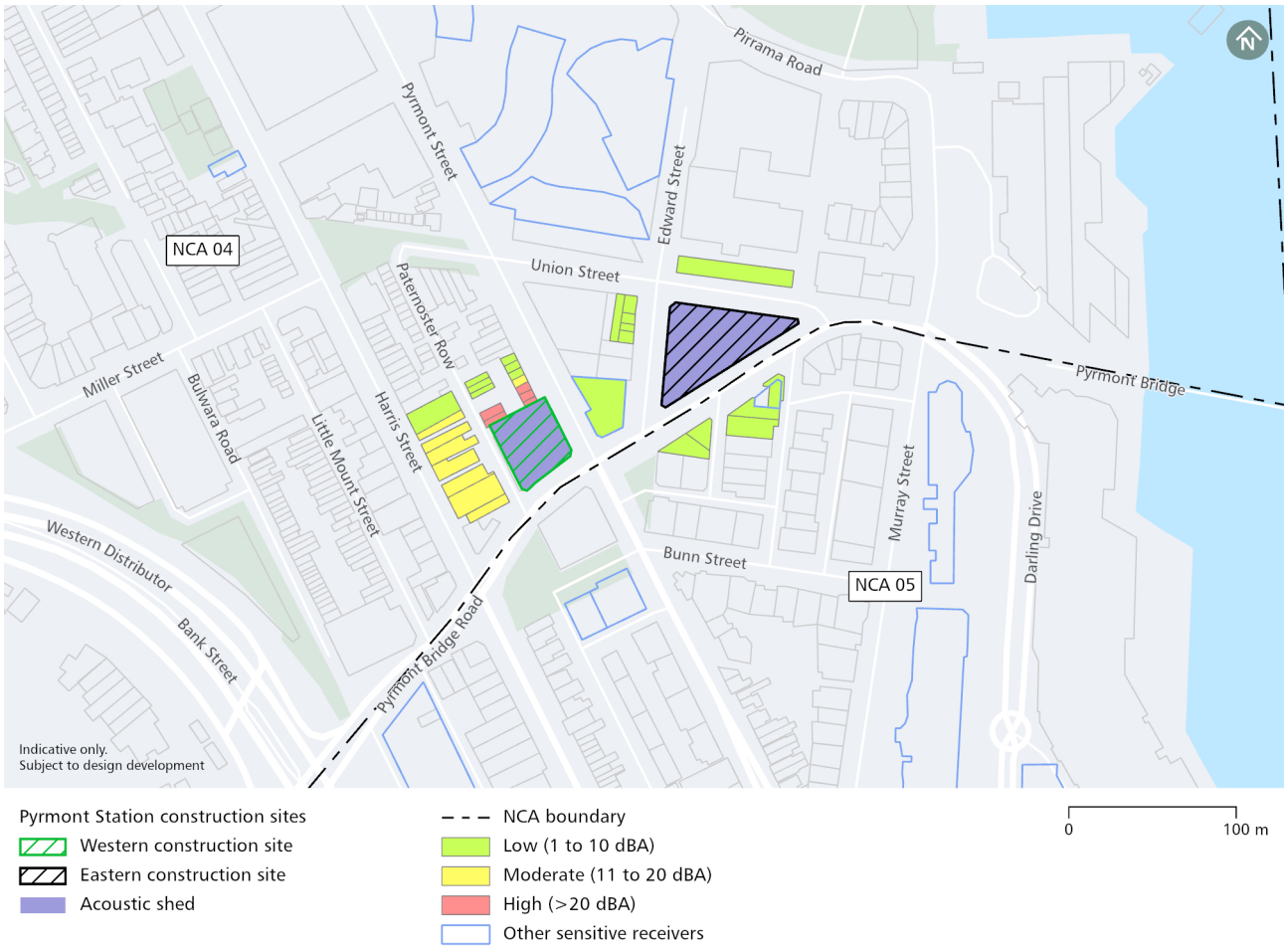


Figure 7-4 Ground borne noise impacts (daytime construction hours) - Pyrmont Station construction sites

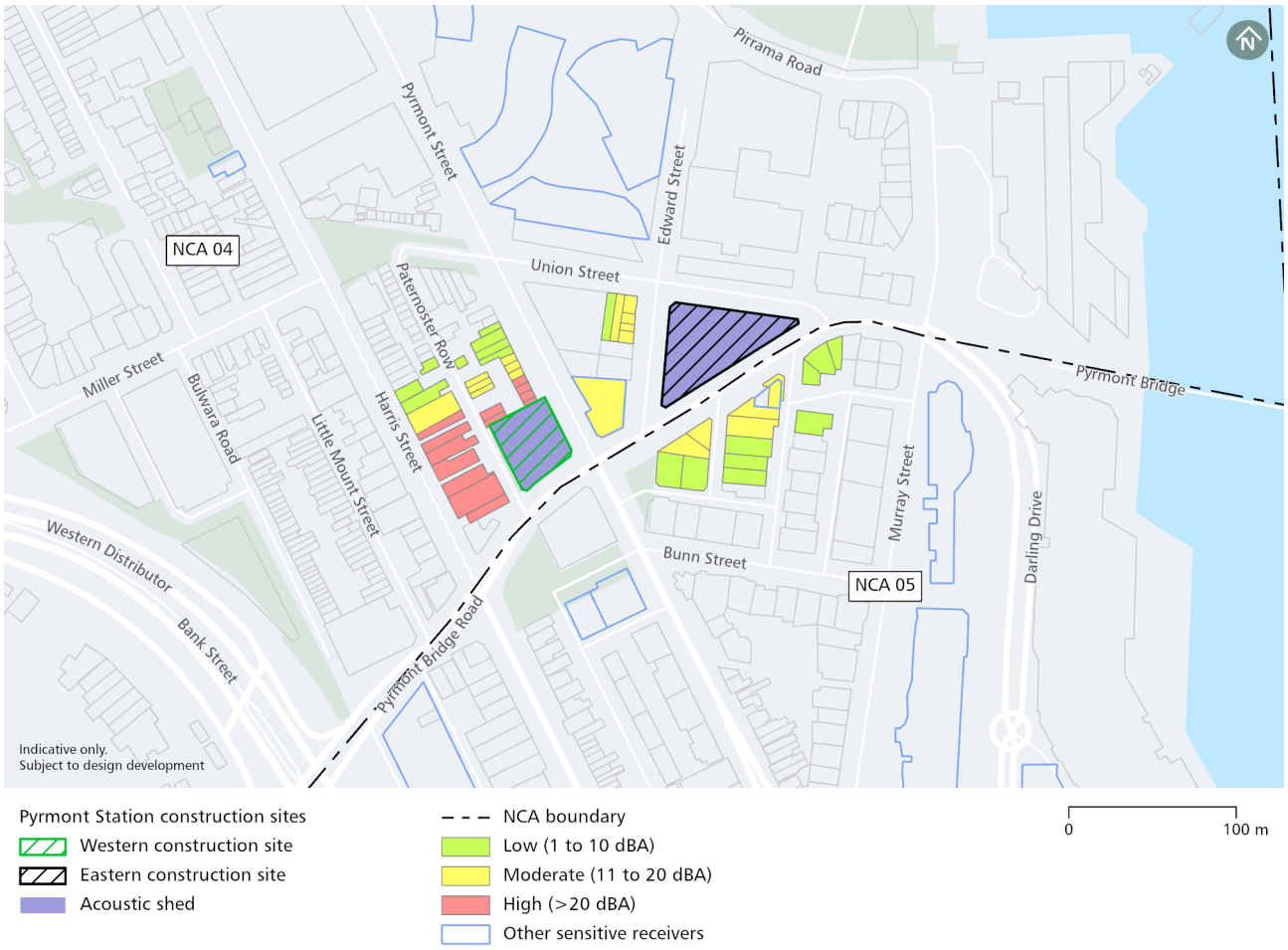


Figure 7-5 Ground borne noise impacts (night time construction hours) - Pyrmont Station construction sites

Vibration impacts

The potential predicted impacts during vibration intensive work is shown in Figure 7-6. These predictions represent a worst-case situation where a large rockbreaker is in use at the boundary of the sites and is in close proximity to the affected buildings. In reality, smaller equipment or alternative methodologies would likely be used as the work gets near to adjacent structures which would control the potential impacts.

The cosmetic damage screening criteria have the potential to be exceeded at up to four residential buildings to the north of the western construction site.

These four receivers are located within the Pyrmont Heritage Conservation Area. The potential heritage impacts on the Pyrmont Heritage Conservation Area as a result of predicted vibration levels on these receivers is presented in Chapter 8 (Non-Aboriginal heritage).

The human comfort criteria are also predicted to be exceeded at several surrounding buildings at both construction sites, meaning occupants of affected buildings may be able to perceive vibration impacts at times when vibration intensive equipment is in use nearby. Worst-case vibration intensive activities may occur over around 17 weeks during demolition and around 14 weeks during excavation. The predictions represent when work is at its closest point to each receiver and impacts would be reduced when work is more distant or further underground.

It is noted that a data centre is located at 13A-29 Union Street, Pyrmont, which is around 20 metres from both construction site boundaries. A review of the relevant guidance regarding vibration impacts on computer equipment indicates less stringent criteria than what has been used in this case, for the assessment of potential human comfort impacts on this receiver.

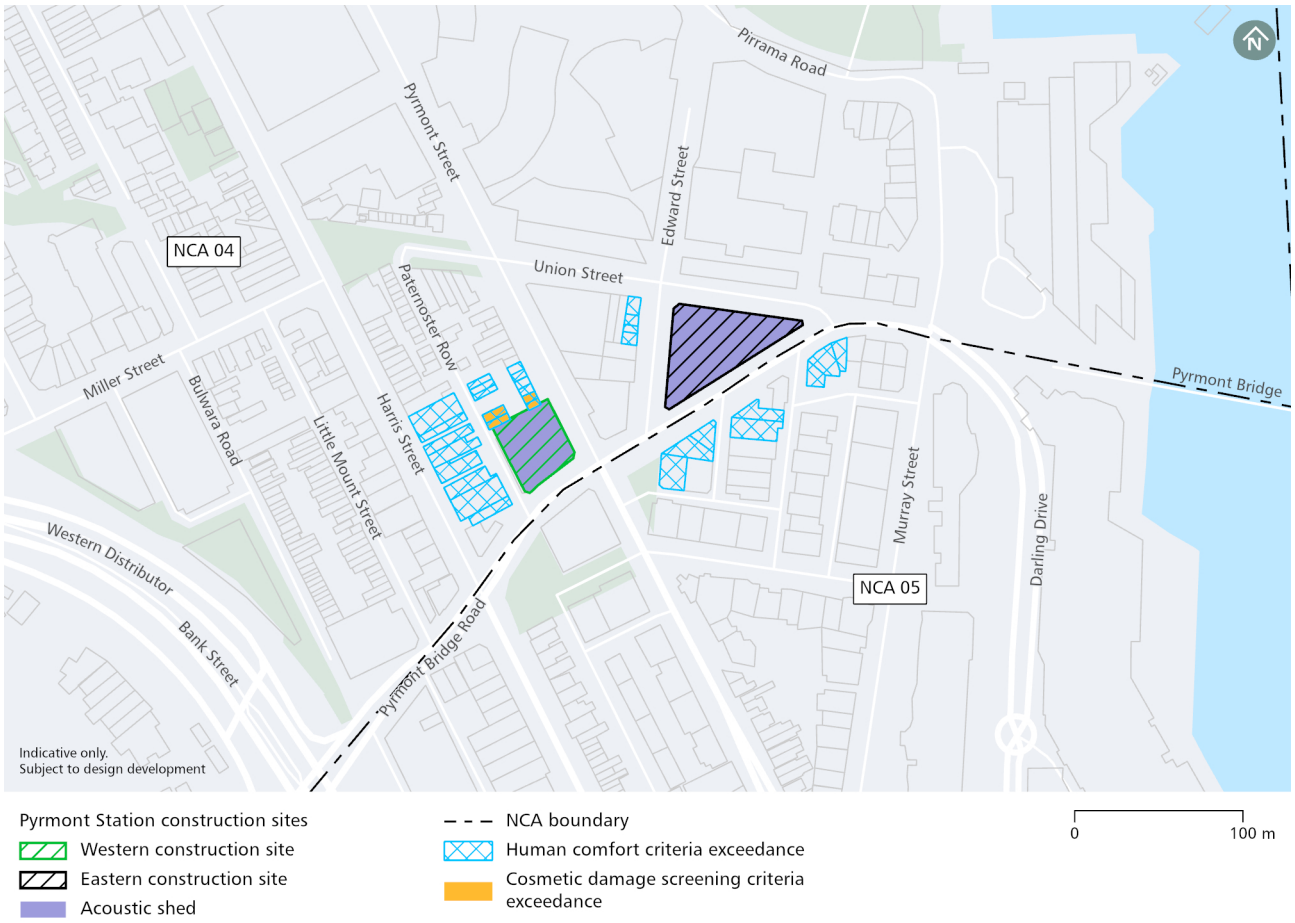


Figure 7-6 Worst-case vibration impacts – Pyrmont Station construction sites

Construction traffic noise impacts

Construction traffic related noise has the potential to temporarily increase road traffic noise levels at receivers along construction haul routes. The forecast construction traffic volumes have been used to determine that potentially noticeable increases in road traffic noise (i.e. greater than two dB increases above the existing noise level) is unlikely. No roads are anticipated to have a greater than two dB increase. This is due to the high existing volumes of traffic that use these roads compared to the relatively small volume of proposed construction vehicles.

Additional road traffic noise impacts would occur when construction heavy vehicles accelerate and decelerate at the entrances/exits of the construction sites. The potential increase would likely be limited to around 150 metres either side of the construction site access points, with the potential to result in increased annoyance at the closest receivers. However, construction heavy vehicles are not proposed to access these sites during the night-time, which would minimise the potential for annoyance. The exception would be where deliveries are required to support work required to be carried out 24 hours a day, seven days a week for safety reasons.

7.9 Hunter Street Station (Sydney CBD) construction sites

7.9.1 Existing environment

Existing noise levels in this study area are controlled by road traffic noise and general urban hum associated with the central business district. As with any central business district, existing noise levels are relatively high during all periods. The area surrounding the construction site is mainly commercial and the nearest receivers are directly adjacent to the boundary of both the western and eastern construction sites.

The area surrounding the Hunter Street Station (Sydney CBD) construction sites can be divided up into two noise catchment areas; NCA06 and NCA07 (as shown on Figure 7-7).

NCA06 is located west of Pitt Street. The catchment comprises a large number of commercial properties including a mixture of hotels (Travelodge Hotel Sydney, The Grand Hotel, The Fullerton Hotel), education facilities (Victoria University, Holmes Institute Sydney,) and places of worship (Scots Presbyterian Church Sydney) along with some residential properties.

NCA07 is located east of Pitt Street. The catchment similarly comprises a large number of commercial properties including a mixture of hotels (The Tank Stream Hotel, Radisson Blu Plaza Hotel Sydney, Comfort Hotel Sydney City, Sofitel Hotel Sydney Wentworth), public buildings (Supreme Court of NSW) and a number of residential properties.

Figure 7-7 Location of sensitive receivers near Hunter Street Station construction sites

Unattended noise monitoring was undertaken at sensitive receiver locations in the vicinity of the Hunter Street Station (Sydney CBD) construction sites in 2015. The results of the unattended noise surveys are summarised in Table 7-22.

Table 7-22 Summary of unattended noise monitoring – Hunter Street Station (Sydney CBD) construction sites

ID	Address	Noise level (dBA)[1]					
		Background noise (RBL)			Average noise level (LAeq)		
		Day	Eve	Night	Day	Eve	Night
B.06	1 Hoskings Place, Sydney	61	56	52	66	62	63

Note 1: The RBL and LAeq noise levels have been obtained using the calculation procedures documented in the Noise Policy for Industry

7.9.2 Potential impacts

The construction scenarios at the Hunter Street Station (Sydney CBD) construction sites, and the anticipated working hours are shown in Table 7-23. The estimated duration of each activity is also provided, noting that most activities would be intermittent during this period and would not be expected to be undertaken on a continual basis.

Work within the Hunter Street Station (Sydney CBD) construction sites is anticipated to have a total duration of about three years.

These temporary airborne noise impacts would be managed through the implementation of standard and additional mitigation measures in accordance with the Sydney Metro Construction Noise and Vibration Standard (Appendix E).

Table 7-23 Construction activities and period of work at Hunter Street Station (Sydney CBD) construction site

Scenario	Activity	Total indicative duration (weeks)[2]	Maximum number of working faces	Hours of work[1]				Comments
				Std. day	Out-of-hours work			
					Day OOH	Eve	Night	
Enabling work	Supporting and loading	55	1	✓	✓	-	-	
	Demolition using a rockbreaker	55	2	✓	✓	-	-	Rockbreaking work would only occur intermittently during a 55 week period between 7 am – 6 pm. Total duration of rockbreaking work would be about 50 days.
Piling	Supporting work	16	1	✓	✓	-	-	Piling work would only occur intermittently during a 16 week period between 7 am – 6 pm. Up to two and four piling rigs would be active at the same time.
	Bored piling with support plant	16	4	✓	✓	-	-	
Surface construction	General work	6	1	✓	✓	-	-	Civil work and construction surface structures
	Noise intensive work	6	2	✓	✓	-	-	
Excavation	Mucking out	39	1	✓	✓	✓	✓	This work would occur 24 hours per day, seven days per week.
	Through rock using rockbreaker	39	2	✓	✓	✓	✓	
Mined cavern	Spoil removal	116	1	✓	✓	✓	✓	This work in the eastern construction site would be completed within the existing acoustic shed.
	Mining with support	116	2	✓	✓	✓	✓	
Tunnel boring machine retrieval	Deliveries and on/off loading	4	1	✓	✓	✓	✓	This work would occur 24 hours per day, seven days per week, at the eastern construction site. Two TBMs would be retrieved.
	TBM disassembly	4	2	✓	✓	✓	✓	

Note 1: OOH = out of hours. During the daytime, this refers to the period on Saturday between 7 am – 8 am, and 1 pm – 10 pm.

Note 2: Durations should be regarded as indicative and represent the total estimated duration of work at a typical worksite over the entire construction period.

Airborne construction noise impacts

The proposed work at Hunter Street Station (Sydney CBD) construction sites involves noise intensive surface and excavation work which has been assessed within this impact assessment without acoustic sheds. This is consistent with the approach for Sydney Metro City & Southwest construction sites within Sydney CBD, given the higher existing background levels. Mined cavern excavation work would occur inside an existing acoustic shed at the eastern construction site. The existing acoustic shed would need to be dismantled once cavern excavation is complete to allow shaft excavation, as the shed is currently only over part of the eastern construction site.

Other noise mitigation measures would be in place at both construction sites (refer to Section 7.11). Through design development and construction planning, if an acoustic shed is proposed to be installed, the shed would be installed in accordance with mitigation measure NV08 as outlined within Section 7.11.3

The predicted airborne NML exceedances at residential receivers from work at the Hunter Street Station (Sydney CBD) construction sites are summarised in Table 7-24. Residential receivers are distant from the sites and the noise levels are mostly predicted to comply the management levels. 'Low' impacts are predicted at a small number of residential receivers during 'peak' enabling work and excavation activities during the day, evening and night. A 'moderate' impact is predicted at one residential receiver during 'peak' excavation work at night, which would be carried out over 39 weeks.

Table 7-24 Overview of NML exceedances (residential receivers) – Hunter Street Station (Sydney CBD) construction sites

Scenario	Activity		Duration (weeks)[1]	Period[1]	Number of receivers with NML exceedances		
					1-10 dB	11-20 dB	>20 dB
Enabling work	Typical	Supporting and loading	55	No exceedances during any period			
	Peak	Demolition using a rockbreaker	55	Day	2	-	-
				Day OOH	6	-	-
Piling	Typical	Supporting work	16	No exceedances during any period			
	Peak	Bored piling with support plant	16	No exceedances during any period			
Surface construction	Typical	General work	6	No exceedances during any period			
	Peak	Noise intensive work	6	No exceedances during any period			
Excavation	Typical	Mucking out (doors closed)	39	No exceedances during any period			
	Peak	Through rock using rockbreaker	39	Day OOH	1	-	-
				Evening	1	-	-
				Night	2	1	-
				Sleep	1	-	-
Mined cavern	Typical	Spoil removal (doors closed)	116	No exceedances during any period			
	Peak	Mining with support (doors closed)	116	No exceedances during any period			
		Mining with support (doors open)	116	No exceedances during any period			

Note 1: Durations should be regarded as indicative and represent a typical worksite. The duration of these impacts is less than the overall duration and depends on the rate of progress in the work areas.

Table 7-25 provides a summary of the NML exceedances for 'other' receivers near the Hunter Street Station (Sydney CBD) construction sites.

Commercial receivers are located close to the construction sites and impacts are predicted to be 'high' during noisy work when noise intensive equipment such as rockbreakers are being used. Rockbreakers would be used intermittently during demolition and excavation activities, which have a duration of about 55 and 39 weeks, respectively. When noise intensive equipment is not in use during 'typical' work, impacts are predicted to substantially reduce, with only 'moderate' and 'low' impacts predicted at the nearest receivers.

The nearest commercial and 'other sensitive' receivers are predicted to be impacted during some of the noisier work activities. Worst-case impacts are predicted to be 'high' at the Comfort Hotel Sydney and at 7 News Sydney, due to its relatively low NML, when rockbreakers are being used during demolition (the total duration of outdoor rockbreaker use during demolition is expected to be about 50 days). Worst case impacts are predicted to be 'moderate' at A by Adina Hotel Sydney, The Grand Hotel, the Tank Stream Hotel, Radisson Blu Plaza Hotel Sydney, City Recital Hall and Scots Presbyterian Church Sydney during noisy outdoor activities.

Work inside the acoustic shed is predicted to result in noise levels that comply with the management levels or result in 'low' exceedances at a small number of receivers.

Table 7-25 Overview of NML exceedances (other receivers) – Hunter Street Station (Sydney CBD) construction sites

Scenario	Activity		Duration (weeks)[1]	Receiver type	Number of receivers		
					With NML exceedances		
					1-10 dB	11-20 dB	>20 dB
Enabling work	Typical	Supporting and loading	55	Commercial	2	6	-
				Hotel (day)	-	1	-
				Theatre	2	-	-
	Peak	Demolition using a rockbreaker	55	Commercial	41	27	8
				Court	1	-	-
				Education	2	-	-
				Hotel (day)	3	4	1
				Outdoor passive	1	-	-
				Place of worship	-	1	-
				Theatre	-	1	1
Piling	Typical	Supporting work	16	Commercial	5	3	-
				Hotel (day)	-	1	-
				Theatre	1	-	-
	Peak	Bored piling with support plant	16	Commercial	13	8	-
				Hotel (day)	3	1	-
				Theatre	1	-	-
Surface construction	Typical	General work	6	Commercial	8	-	-
				Hotel (day)	1	-	-
	Peak	Noise intensive work	6	Commercial	12	7	-
				Hotel (day)	2	1	-
				Theatre	2	-	-
Excavation	Typical	Mucking out (doors closed)	39	Hotel (night)	1	-	-
	Peak	Through rock using rockbreaker	39	Commercial	24	15	6
				Court	1	-	-
				Hotel (day)	3	3	-
				Hotel (night)	2	3	3
				Theatre	1	1	-

Scenario	Activity		Duration (weeks)[1]	Receiver type	Number of receivers		
					With NML exceedances		
					1-10 dB	11-20 dB	>20 dB
Mined cavern	Typical	Spoil removal (doors closed)	116	Hotel (night)	1	-	-
	Peak	Mining with support (doors closed)	116	Commercial	2	-	-
				Hotel (night)	1	-	-
		Mining with support (doors open)	116	Commercial	3	-	-
				Hotel (night)	1	-	-
Tunnel boring machine retrieval	Peak	TBM disassembly	4	Commercial	3	-	-
				Hotel (night)	1	-	-
				Theatre	1	-	-

Note 1: Durations should be regarded as indicative and represent a typical worksite. The duration of these impacts is less than the overall duration and depends on the rate of progress in the work areas.

Highly affected receivers

No residential receivers are predicted to be highly noise affected by work at the Hunter Street Station (Sydney CBD) construction sites.

Sleep disturbance

A sleep disturbance screening assessment has been completed for the construction work and potential impacts are summarised in Table 7-24. 'Low' sleep disturbance impacts are predicted at one residential receiver to the north of the western construction site during the night-time work. This impact is due to the use of noise intensive equipment such as rockbreakers. The number of potential night-time awakenings would depend on several factors, including the type of equipment being used, the duration of the noisy work, and the distance of the work to nearest residential receivers. Further investigation of awakenings would be completed during detailed construction planning.

Ground-borne noise impacts

Ground-borne noise levels have been assessed at this site and the potential worst-case impacts are summarised in Table 7-26.

Shaft excavation at the Hunter Street Station (Sydney CBD) construction sites would be completed without an acoustic shed meaning airborne noise levels at the nearest receivers would likely be higher than the corresponding internal ground-borne noise levels. Where airborne noise levels are higher than ground-borne noise levels, the airborne noise levels represent the worst-case potential noise impacts and therefore it is not necessary to evaluate potential ground-borne noise impacts.

It is noted, however, that some receivers next to the construction sites may have internal spaces which do not have windows or facades facing the construction sites or may have acoustically isolated internal rooms which could result in ground-borne noise levels during vibration intensive work being audible in these spaces.

Receivers are close to both construction sites and vibration intensive work is predicted to result in 'high' ground-borne noise impacts at a small number of receivers. 'Moderate' or 'minor' exceedances are predicted at receivers further away.

During the night-time period, only the three closest hotels are predicted to be impacted by ground-borne noise.

Table 7-26 Overview of ground-borne NML exceedance

NCA	Receiver classification	Number of receivers								
		Total	With NML Exceedance							
			Daytime			Out of hours work				
						Evening			Night-time	
			1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
NCA06	Residential	42	-	-	-	-	-	-	-	-	-
	Commercial	312	2	-	5	-	-	-	-	-	-
	Other sensitive	42	-	-	1	-	-	1	1	-	1
NCA07	Residential	13	-	-	-	-	-	-	-	-	-
	Commercial	197	6	1	2	-	-	-	-	-	-
	Other sensitive	30	1	-	-	1	-	-	-	1	-

Vibration impacts

The potential predicted impacts during vibration intensive work is shown in Figure 7-8. These predictions represent a worst-case situation where a large rockbreaker is in use at the boundary of the sites and is in close proximity to the affected buildings. In reality, smaller equipment or alternative methodologies would likely be used as the work gets near to adjacent structures which would control the potential impacts.

The cosmetic damage screening criteria has the potential to be exceeded at the adjacent buildings at both construction sites. This includes the heritage listed building retained within the western construction site. These receivers include four listed heritage items. The potential heritage impacts on Non-Aboriginal heritage items as a result of predicted vibration levels on these receivers is presented in Chapter 8 (Non-Aboriginal heritage).

The human comfort criteria are also predicted to be exceeded at the nearest buildings, meaning occupants of affected buildings may be able to perceive vibration impacts at times when vibration intensive equipment is in use nearby. Worst-case vibration intensive activities may occur over around 55 weeks during demolition and around 39 weeks during excavation. The predictions represent work at its closest point to each receiver. Impacts would be reduced when work is more distant or further underground.

Figure 7-8 Predicted vibration impacts – Hunter Street Station construction site

Construction traffic noise impacts

Construction traffic related noise has the potential to temporarily increase road traffic noise levels at receivers along construction haul routes. The forecast construction traffic volumes have been used to determine that potentially noticeable increases in road traffic noise (i.e. greater than two dB increases above the existing noise level is unlikely).

Additional road traffic noise impacts may occur when construction heavy vehicles accelerate and decelerate at the entrances/exits of the construction sites. The potential increase would likely be limited to around 150 metres either side of the construction site access points, with the potential to result in increased annoyance at the closest receivers.

7.10 Cumulative construction impacts

Potential cumulative impacts were considered for assessment based on the likely interactions of this proposal with other projects that met the adopted screening criteria. The approach to assessment and the other projects considered are described further in Appendix G (Cumulative impacts assessment methodology).

Potential cumulative construction noise impacts have been considered with reference to both concurrent impacts (the combined effects of multiple projects occurring at the same time) and consecutive impacts (where projects occur consecutively and there is the potential for prolonged construction noise impacts affecting the same receivers).

The main concurrent construction noise impacts identified for the proposal are potential temporary impacts on receivers near The Bays tunnel launch and support site due to concurrent construction activities associated with the following projects:

- Major civil construction work between Westmead and The Bays (Stage 1 of the planning approval process)
- WestConnex M4-M5 Link
- Western Harbour Tunnel and Warringah Freeway Upgrade.

Concurrent impacts associated with the use of The Bays tunnel launch and support site for this proposal and use of The Bays Station construction site as approved in Stage 1 of the planning approval process would occur over a period of about six months. Potential noise impacts at the nearest residential receivers for both this proposal and the major civil construction work between Westmead and The Bays are predicted to be 'low'. However, where concurrent construction work is being completed near to a particular area, the worst-case noise levels could theoretically increase by around three decibels. The likelihood of worst-case noise levels being generated by two different work activities at the same time is considered low and rather than increase construction noise levels, the impact of concurrent work would generally be limited to a potential increase in the duration, and potential annoyance, of noise impacts on the affected receivers.

There is also potential for concurrent tunnelling work to occur between this proposal and tunnelling as part of Stage 1 of the planning approval process. The tunnelling under the Stage 1 of the planning approval process would be carried out between mid-2022 and mid-2024, to the west of the station box. The tunnelling to the east as part of this proposal would be carried out between early 2024 and early 2025. No concurrent ground-borne noise or vibration impacts are expected as the tunnelling is completed in opposite directions and would generally not affect the same receivers.

All construction work on the mainline tunnels for the WestConnex M4-M5 Link will be completed by the end of 2022. Therefore, it is anticipated that the proposal would only produce cumulative impacts with the Rozelle interchange and Iron Cove Link stage of the WestConnex M4-M5 Link which will continue until the third quarter of 2023. Work to be undertaken during this time include site rehabilitation and landscaping, demobilisation, and testing and commissioning. The overlapping work between the second quarter of 2023 and the third quarter of 2023 is unlikely to result in cumulative noise impacts.

In addition to concurrent impacts, if more than one project occurs in the same area consecutively, there may be a prolonged effect from the extended duration of construction noise impacts. This effect is typically referred to as 'construction fatigue'. Table 7-27 identifies the potential for consecutive construction noise impacts at each construction site. The need to address consecutive impacts has been identified in recent community feedback as described in Chapter 4 (Stakeholder and community engagement). These impacts would be managed through the implementation of the mitigation measures described in Section 7.11 and the Overarching Community Communications Strategy in Appendix B.

Stage 3 of the planning approval process for Sydney Metro West includes tunnel fit-out, construction of stations, ancillary facilities and station precincts, and operation and maintenance of the Sydney Metro West line. Construction would commence from about the fourth quarter of 2024 to about the third quarter of 2028, with finishing, testing and commissioning activities to be carried out between third quarter of 2028 and fourth quarter of 2029. The construction impacts from Stage 3 of the planning approval process for Sydney Metro West are currently unknown. The potential impacts from work assessed as part of Stage 3 of the planning approval process at The Bays tunnel launch and support site are, however, likely to be comparable to impacts described in *Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD* (Sydney Metro, 2020a). Both concurrent and consecutive cumulative noise and vibration impacts may occur.

The potential cumulative noise impacts (both concurrent and consecutive) from this proposal and other projects should be investigated further as the project progresses when detailed construction planning is developed. Specific management and mitigation measures designed to address potential impacts should be developed and used to minimise the impacts as far as practicable, in consultation with the affected community.

Table 7-27 Areas with potential consecutive construction noise impacts

Construction site	Potential consecutive cumulative impacts
The Bays tunnel launch and support site	• Western Harbour Tunnel and Warringah Freeway Upgrade would involve construction activities within White Bay. Construction is planned to be complete in 2024 • WestConnex M4–M5 Link is currently under construction to the south-west of the site and is expected to be complete by 2023 • Potential impacts associated with Sydney Metro West - Rail infrastructure, stations, precincts and operations (Stage 3 of the planning approval process), which involves tunnel fit-out, construction of stations, ancillary facilities and station precincts, and operation and maintenance of the Sydney Metro West line. Construction would commence from about the fourth quarter 2024 to about the third quarter 2028 • Glebe Island concrete batching plant involves the construction and operation of a new aggregate handling and concrete batching facility, with the capacity to produce up to one million cubic metres of concrete per annum. The construction program is 2021 to 2022 • Glebe Island multi-user facility is currently under construction on the eastern side of Glebe Island. The construction and operation of a ship off-loading, storage and dispatch facility for bulk construction materials such as sand, aggregates and other dry bulk construction materials.
Pyrmont Station construction sites	• A New Sydney Fish Market will be constructed at the head of Blackwattle Bay between Pyrmont Peninsula and Glebe Peninsula. Construction is planned to be complete in 2024 • Cockle Bay Wharf Mixed Use Development project is currently in planning and scheduling information is not currently available for this project • Potential impacts associated with Sydney Metro West - Rail infrastructure, stations, precincts and operations (Stage 3 of the planning approval process), which involves tunnel fit-out, construction of stations, ancillary facilities and station precincts, and operation and maintenance of the Sydney Metro West line. Construction would commence from about the fourth quarter of 2024 to about the third quarter of 2028.
Hunter Street Station (Sydney CBD) construction sites	• The existing Sydney Metro City and Southwest tunnelling support site at 33 Bligh Street would be handed over for use on Sydney Metro West and would become part of the Hunter Street Station (Sydney CBD) eastern construction site • 50-52 Phillip Street New Hotel involves the construction of a new 47 storey hotel building in Sydney's CBD. The construction program is from 2023 to 2026 • One Sydney Harbour is a skyscraper complex under construction in Sydney which includes 808 apartments in three towers. The project is part of the major urban renewal precinct of Barangaroo. The construction program is from 2019 to 2025 • Sydney Metro – Martin Place Over Station Development is a 39 storey tower under construction above the Sydney Metro City & Southwest Martin Place station. Construction is planned to be completed in 2024 • 111 &121 Castlereagh/ 65-77 Market Street, Sydney involves retention and alteration of the existing retail/commercial building and the construction of a 22-storey residential tower above (total height of 32 storeys). Construction is planned to be completed by 2023 • Potential impacts associated with Sydney Metro West - Rail infrastructure, stations, precincts and operations (Stage 3 of the planning approval process), which involves tunnel fit-out, construction of stations, ancillary facilities and station precincts, and operation and maintenance of the Sydney Metro West line. Construction would commence from about the fourth quarter 2024 to about the third quarter of 2028 • 317 and 319-321 George Street involves the redevelopment including the retention and restoration of the existing heritage listed facade and the construction and use of a new building for commercial offices and retail premises. The construction program is currently unknown • 194-204 Pitt Street a Concept building envelope for the redevelopment of the City Tattersall's Club, comprising a podium and tower containing indicative residential, retail, hotel and club land uses. The construction program is currently unknown

Construction site	Potential consecutive cumulative impacts
Hunter Street Station (Sydney CBD) construction sites cont.	• 301 and 305 Kent Street Concept Hotel Development sought consent for the establishment of a building envelope, use of the site at 301 and 305 Kent Street as a hotel with ancillary uses, pedestrian and vehicular access arrangements, and the provision of on-site bicycle and car parking. The construction program is currently unknown • 180 George Street will encompass the Salesforce Tower with a collection of new urban laneways hosting retail, dining and a major public square on George Street. The construction program is currently unknown.

7.11 Mitigation and management measures

The Construction Environmental Management Framework (Appendix C) describes the approach to environmental management, monitoring and reporting during construction. Specifically, it lists the requirements to be addressed by the construction contractor in developing the Construction Environmental Management Plans, sub-plans, and other supporting documentation for each specific environmental aspect.

The environmental management approach for the project is detailed in Chapter 23 (Synthesis of the Environmental Impact Statement). Under these broad frameworks, a series of performance outcomes have been developed to define the minimum environmental standards that would be achieved during construction of the proposal (see Section 7.11.1), and mitigation measures that would be implemented during construction to manage potential identified impacts (see Section 7.11.3).

7.11.1 Performance outcomes

Construction performance outcomes were developed for the proposal as part of the Concept approval. Performance outcomes for the proposal identify measurable, performance-based standards for environmental management. Identified performance outcomes in relation to transport and traffic for construction of the proposal include:

- Construction noise and vibration impacts on local communities are minimised by controlling noise and vibration at the source, on the source to receiver path and at the receiver
- Structural damage to buildings and heritage items from construction vibration is avoided
- Local communities are engaged during construction, including on noise mitigation in areas predicted to be affected by high noise impacts.

Chapter 23 (Synthesis of the Environmental Impact Statement) describes how the proposal addresses these performance outcomes. The proposal would manage construction noise and vibration, as well as structural damage, in accordance with the Sydney Metro Construction Noise and Vibration Standard (Appendix E). The proposal would also carry out any community consultation (where justified) to inform appropriate mitigation and management options where feasible and reasonable, as described further in Section 7.11.2.

7.11.2 Sydney Metro Construction Noise and Vibration Standard

Noise and vibration impacts would be managed in accordance with the Sydney Metro Construction Noise and Vibration Standard (Appendix E), which aims to manage all construction noise and vibration impacts from the proposal including tunnelling and utility work where feasible and reasonable using a variety of mitigation measures.

Site-specific Construction Noise and Vibration Impact Statements would be prepared for:

- All work outside standard construction hours likely to exceed the relevant NMLs
- Activities likely to result in highly noise affected receivers
- Activities likely to generate vibration levels at receivers in excess of the relevant criteria.

The Sydney Metro Construction Noise and Vibration Standard also provides:

- A list of standard mitigation measures that would be implemented where feasible and reasonable at all construction sites which includes measures such as prior notification of the work, monitoring of the impacts and offers of alternative accommodation where night-time impacts are expected to be high
- Trigger levels (based on exceedances of airborne and ground-borne NMLs) for the implementation of additional mitigation measures.

These standard and additional mitigation measures would be applied on Sydney Metro West construction sites.

7.11.3 Sydney Metro Overarching Community Communications Strategy

The Sydney Metro Overarching Community Communications Strategy (OCCS) (Appendix B) provides a framework for communication and engagement during construction on Sydney Metro projects and will be applicable to the proposal. The OCCS requires Community Communication Strategies to be developed that include a process for managing potential environmental issues during construction and outlining tailored mitigation measures to address the site specific needs of the community, stakeholders and businesses that would incorporate mitigation measures from the planning approval process.

Such measures relating to noise and vibration would include early engagement with neighbouring stakeholders and a process to respond to complaints. The OCCS and Community Communications Strategies are supported by a Construction Complaints Management System that outlines the framework for managing complaints, enquiries and escalation processes throughout the construction of the proposal. Together these documents and processes would ensure feedback from stakeholders would be taken into account in the implementation of noise and vibration mitigation measures.

7.11.4 Mitigation measures

Mitigation measures that would be implemented to address potential noise and vibration impacts are listed in Table 7-28. These measures are expected to minimise the potential impacts from the proposal as far as practicable. Alternative construction methodologies, for example, could provide noise reductions, depending on the alternative approach(es) used. Residual impacts are, however, expected to remain, particularly when noise or vibration intensive activities are being completed near to sensitive receivers. Residual impacts would be evaluated further during design development and construction planning and would be minimised using the processes defined in the Sydney Metro Construction Noise and Vibration Standard (Appendix E).

Table 7-28 Mitigation measures – Noise and vibration

Reference	Impact	Mitigation measure	Applicable location(s)
NV01	Community preference for noise mitigation and management	Where justified by the application of the Construction Noise and Vibration Standard, further engagement and consultation would be carried out in accordance with the Sydney Metro Overarching Community Communications Strategy with: • The affected communities to understand their preferences for mitigation and management measures • 'Other sensitive' receivers such as schools, medical facilities, theatres, or places of worship to understand periods in which they are more sensitive to impacts. Based on this consultation, appropriate mitigation and management options would be considered and implemented where feasible and reasonable to minimise the impacts.	All
NV02	Alternative construction methodologies	Alternative construction methodologies and measures that minimise noise and vibration levels during noise intensive work would be investigated and implemented where feasible and reasonable. This would include consideration of: • The use of hydraulic concrete shears in lieu of hammers/ rockbreakers • Sequencing work to shield noise sensitive receivers by retaining building wall elements • Locating demolition load out areas away from the nearby noise sensitive receivers • Providing respite periods to minimise impacts from prolonged periods of noise intensive work • Minimising structural-borne noise to adjacent buildings including separating the structural connection prior to demolition through saw-cutting and propping, using hand held splitters and pulverisers or hand demolition • Installing sound barrier screening to scaffolding facing noise sensitive neighbours	All

Reference	Impact	Mitigation measure	Applicable location(s)
NV02 cont.	Alternative construction methodologies	• Using portable noise barriers around particularly noisy equipment, such as concrete saws • Modifying demolition work sequencing/ hours to minimise impacts during peak pedestrian times and/or adjoining neighbour outdoor activity periods.	All
NV03	Construction noise – respite periods	Appropriate respite would be provided to affected receivers in accordance with the Sydney Metro Construction Noise and Vibration Standard. This would include consideration of impacts from utility and power supply work when determining appropriate respite periods for affected receivers. When determining appropriate respite, the need to efficiently undertake construction would be balanced against the communities' preferred noise and vibration management approach.	All
NV04	Construction noise – out of hours work	The use of noise intensive equipment at construction sites with 'moderate' and 'high' out-of-hours noise management level exceedances would be scheduled for standard construction hours, where feasible and reasonable. Where this is not feasible and reasonable, the work would be undertaken as early as possible in each work shift.	All
NV05	Night-time noise impacts	Where appropriate, air brake silencers would be used on heavy vehicles that access construction sites multiple times per night or over multiple nights.	All
NV06	Night-time noise impacts	Perimeter site hoarding would be designed with consideration of on-site heavy vehicle movements with the aim of minimising sleep disturbance impacts.	All
NV07	Noise emissions from equipment	Long term construction site support equipment and machinery would be low noise emitting and suitable for use in residential areas, where feasible and reasonable. Examples include: • Low noise water pumps for use in water treatment facilities • Low noise generators and compressors • Low noise air conditioner units for use of amenities buildings.	All
NV08	Acoustic sheds	Where acoustic sheds are installed, the internal lining and construction materials would be determined during later design stages to ensure appropriate attenuation is provided. This design of sheds would likely include the following considerations: • All significant noise producing equipment that would be used during the night-time would be inside the shed, where feasible and reasonable • Noise generating ventilation systems such as compressors, scrubbers, etc, would also be inside the shed and external air intake/ discharge ports would be appropriately acoustically treated • Acoustic shed doors would be kept closed during the night-time period, where feasible and reasonable. Where night-time vehicle access is required, the doors would be designed and constructed to minimise noise breakout.	All
NV09	Ground-borne noise	Feasible and reasonable measures would be implemented to minimise ground-borne noise where exceedances are predicted. This may require implementation of less ground-borne noise and less vibration intensive alternative construction methodologies.	All
NV10	Ground-borne noise – cross passages	The proximity of cross passages to nearby receivers and the corresponding construction ground-borne noise and vibration impacts during the excavation work would be considered when determining locations. Relocation of cross passages to be further away from sensitive receivers to mitigate potential construction impacts would be considered, where feasible and reasonable.	Metro rail tunnels

Reference	Impact	Mitigation measure	Applicable location(s)
NV11	Ground-borne noise – underground rockbreaking	Activity specific Detailed and/or General Noise and Vibration Impact Statements (in accordance with the requirements of the Construction Noise and Vibration Standard) would be developed for rockbreaking in the tunnel and at cross passages, specifically addressing the activity where it is required between 10 pm - 7 am.	Metro rail tunnels
NV12	Construction traffic noise	Further assessment of construction traffic would be completed during detailed design, including consideration of the potential for exceedances of the *NSW Road Noise Policy* base criteria (where greater than two dB increases are predicted). The potential impacts would be managed using the following approaches, where feasible and reasonable: • On-site spoil storage capacity would be maximised to reduce the need for truck movements during sensitive times • Vehicle movements would be redirected away from sensitive receiver areas and scheduled during less sensitive times • The speed of vehicles would be limited, and the use of engine compression brakes would be avoided • Heavy vehicles would not be permitted to idle near sensitive receivers.	All
NV13	Construction vibration	Where vibration levels are predicted to exceed the screening criteria, a more detailed assessment of the structure (in consultation with a structural engineer) and vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for that structure. 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.	All
NV14	Building condition surveys – construction vibration	Condition surveys of buildings and structures near to the tunnel and excavations would be undertaken prior to the commencement of excavation at each site, where appropriate. For heritage buildings and structures the surveys would consider the heritage values of the structure in consultation with a heritage specialist.	All
NV15	Cumulative construction noise impacts	The likelihood of cumulative construction noise impacts would be reviewed during detailed design when detailed construction schedules are available. Co-ordination would occur between potentially interacting projects to minimise concurrent or consecutive work in the same areas, where possible. Specific mitigation strategies would be developed to manage impacts. Depending on the nature of the impact, this could involve adjustments to construction program or activities of Sydney Metro West or of other construction projects.	All

7.11.5 Interactions between mitigation measures

Mitigation measures to control construction noise and vibration impacts generally do not overlap with other measures proposed for other environmental issues.

Measures to manage construction traffic would potentially assist in minimising road traffic noise by minimising vehicle numbers where feasible and reasonable and limiting the use of local streets.

There are no mitigation measures identified in the assessment of other environmental aspects that are likely to affect the assessment of noise and vibration impacts.

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