Technical Paper

Construction noise and vibration

4

SYDNEY METRO WEST

Rail Infrastructure, Stations, Precincts and Operations
Technical Paper 4 - Construction Noise and Vibration

Prepared for:

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Level 43, 680 George Street
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SLR Ref: 610.30390-R01
Version No: -v1.0
March 2022

EXECUTIVE SUMMARY

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BASIS OF REPORT

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.30390-R01-v1.0	March 2022	Jordan McMahon	Antony Williams	Antony Williams

EXECUTIVE SUMMARY

Sydney Metro is proposing to construct and operate Sydney Metro West. Sydney Metro West is being assessed as a staged infrastructure application under section 5.20 of the *Environmental Planning & Assessment Act 1979* (EP&A Act). The previous Sydney Metro West planning applications included:

- The Concept and major civil construction work for Sydney Metro West between Westmead and The Bays (Stage 1 of the planning approval process, application number SSI-10038), was approved by the Minister for Planning and Public Places on 11 March 2021.
- Stage 2 of the planning approval process includes all major civil construction between The Bays and Sydney CBD. An Environmental Impact Statement for major civil construction between The Bays and Sydney CBD was exhibited between 3 November 2021 and 15 December 2021.

Stage 3 of the planning approval process is seeking planning approval to enable the approved Concept to be realised by carrying out the tunnel fit-out, construction of stations, ancillary facilities and station precincts, and operation and maintenance of the Sydney Metro West line (this proposal).

Major civil construction including station excavation and tunnelling work associated with the previous Sydney Metro West planning applications does not form part of this proposal. This proposal includes the activities required to complete construction ready for operations of Sydney Metro West.

This construction noise and vibration technical paper has been prepared to address the Secretary's environmental assessment requirements. The report describes the baseline noise environment in the study area, outlines the method used in the assessment and identifies the likely impacts from the proposal on the nearby communities and sensitive receivers. Where impacts are predicted, appropriate measures have been identified to mitigate and manage the impacts.

Construction Noise Impacts

The proposal would involve the construction and fit-out of all stations, ancillary facilities and station precincts for Sydney Metro West. Certain sites require additional earthwork and excavation activities, and some sites would provide tunnel access points for delivery of construction materials to the tunnels.

The impacts during construction vary across the study area depending on how close the nearest receivers are to the construction sites, the expected level of amenity, and the facade construction of the receiver buildings. Consistent with most major infrastructure projects in urban areas, where receivers are close, the noise impacts during some of the work are expected to be 'high' during sensitive periods, particularly when noise intensive equipment such as rockbreakers or concrete saws are being used.

Construction noise impacts are predicted to be 'high' at the nearest receivers in the Westmead, Burwood, Five Dock, The Bays, Pyrmont and Hunter Street (Sydney CBD) study areas during some of the noisiest scenarios.

The worst-case impacts are generally predicted to occur in the early stages of the work which are completed outside and require noise intensive equipment. When the station/facility structures are complete, work would move inside to complete the fit-out of the stations and impacts would generally be reduced. The requirement for noise intensive equipment is generally expected to be relatively minimal and the impacts during work that does not require noise intensive equipment are much lower. Many activities are expected to comply with the noise management levels.

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Noise intensive work at construction sites during the night-time would generally only be required for work that is necessary to be completed in or adjacent to the existing rail corridor at Westmead and North Strathfield. This work would be required to be completed during short-term rail possessions when trains are not operating. Night-time work would also be required for station/facility fit-out and activities associated with material delivery at rail system access shafts, however, the impacts from this work are generally much lower.

Noise intensive equipment would not be in use continuously. There would be periods when construction 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 occur.

Construction Ground-Borne Noise and Vibration from Construction Sites

Vibration intensive equipment is proposed to be used at Westmead during underground concourse excavation, at Parramatta during basement excavation, at Clyde stabling and maintenance facility during earthworks and at Five Dock during basement excavation.

The worst-case ground-borne noise impacts are predicted to be ‘moderate’ or ‘high’ at receivers adjacent the excavation work. Receivers which are further back are generally predicted to comply with the management levels.

Exceedances of the cosmetic damage vibration screening criteria are predicted at all sites where vibration intensive equipment is proposed. This is due to vibration sensitive buildings or structures being adjacent to the work. These predictions represent a worst-case situation where a vibration intensive equipment is in use at the boundary of the site and in close proximity to the affected buildings. In reality, smaller equipment or alternative construction methodologies would likely be used as the work gets near to adjacent structures which would control the potential impacts.

Exceedances of the human comfort vibration criteria are also predicted at the nearest receivers, meaning occupants of affected buildings may be able to perceive impacts at times when vibration intensive equipment is in use nearby.

Construction Road Traffic Noise Impacts

Construction traffic is unlikely to result in a noticeable increase in noise levels on most of the proposed construction haul routes due to high existing traffic volumes on these roads.

A number of the roads in the Westmead, Parramatta, Sydney Olympic Park, Five Dock, Clyde and Rosehill study areas are, however, predicted to have noticeable increases in some periods, particularly on roads where existing traffic volumes are low.

There is also potential for increased annoyance near to entrances/exits of the construction sites if heavy vehicles accelerate/decelerate, however, this is expected to be limited to a relatively small area adjacent to each site.

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Cumulative Impacts

Cumulative impacts may occur if the proposal is constructed at the same (or similar) time as other nearby major projects. Concurrent construction noise and vibration impacts can occur where multiple work is being completed near to a particular receiver at the same time. Additionally, if more than one project occurs in the same area consecutively, there may be a prolonged effect from the extended duration of construction impacts. This effect is termed 'construction fatigue'.

Concurrent cumulative impacts are considered unlikely to substantially alter the worst-case predictions in this report. Where concurrent construction work is being completed near to a particular area, the worst-case noise levels could theoretically increase by around 3 dB (ie a logarithmic adding of two sources of noise at the same level).

Consecutive construction impacts, or 'construction fatigue', from extended impacts may occur at the construction sites due to overlapping work as part of the previous Sydney Metro West planning applications. Construction fatigue may also occur in The Bays study area due other nearby projects, including WestConnex M4-M5 Link and Western Harbour Tunnel. Mitigation would be applied by each project which will assist in mitigating the cumulative impacts. Sydney Metro would also consult and co-ordinate with potentially interacting projects to minimise concurrent or consecutive work in the same areas, where possible. This would consider the potential impact from concurrent construction activities of other projects and this proposal.

The potential for 'construction fatigue' would be investigated further as the project progresses. Specific additional management and mitigation measures designed to address potential consecutive impacts would be developed to minimise the impacts as far as feasible and reasonable.

Management of Impacts

All feasible and reasonable work practices would be applied to reduce the potential impacts during construction. Project specific mitigation has been recommended based on the predicted impacts.

The exact mitigation strategies would be determined as the project progresses when detailed planning information becomes available. The principal contractors would be required to prepare a Construction Noise and Vibration Management Plan for their scope of work in line with the requirements of the *Interim Construction Noise Guideline* and the *Sydney Metro Construction Noise and Vibration Standard*.

Site specific Detailed and General Construction Noise and Vibration Impact Statements would also be prepared for all work outside standard construction hours likely to exceed the relevant management levels. These assessments would confirm the predicted impacts and specify the mitigation and management measures that would be used to minimise the impacts as far as practicable.

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APPENDICES

Glossary and Abbreviations

Item	Description / Definition
Attended noise monitoring	Operator attended noise monitoring which is completed to determine the various contributors to the noise environment of an area. It is usually done over a short period, such as 15 minutes.
AvaTG	*Assessing Vibration: a technical guideline*
CEMF	Construction Environmental Management Framework
CEMP	Construction Environmental Management Plan
CNVS	Sydney Metro *Construction Noise and Vibration Standard* (version 4.3, Sydney Metro, 2020b). Replaces the *Sydney Metro Construction Noise and Vibration Strategy* (Sydney Metro, 2017)
CNVMP	Construction Noise and Vibration Management Plan
Cumulative impacts	Impacts that, when considered together, have different and/or more substantial impacts than a single impact assessed on its own.
dBA	Decibel, A-weighted
DEC	Department of Environment and Conservation (now EPA)
DECC	Department of Environment and Climate Change (now EPA)
DECCW	Department of Environment, Climate Change and Water (now EPA)
DNVIS	Detailed Noise and Vibration Impact Statement
EPA	Environment Protection Authority
Existing rail corridor	The corridor within which existing rail infrastructure is located.
GNVIS	General Noise and Vibration Impact Statement
Heavy vehicles	A heavy vehicle is classified as a Class 3 vehicle (a two-axle truck) or larger, in accordance with the Austroads Vehicle Classification System.
HNA	Highly noise affected. Relates to construction noise levels of ≥75 dBA and is the point above which there may be strong community reaction to noise construction noise levels.
ICNG	*Interim Construction Noise Guideline*
INP	*Industrial Noise Policy*
L_{Aeq}	The average noise level during a measurement period, such as the daytime or night-time
L_{AFmax}	The maximum noise level measured during a monitoring period, using 'fast' weighting
LGA	Local government area
mm/s	Millimetres per second
NATA	National Association of Testing Authorities
NCA	Noise Catchment Area
NML	Noise Management Level
Noise intensive equipment	Some construction equipment can be particularly noisy and can cause excessive annoyance. This includes items such as rockbreakers and concrete saws
Npfl	*Noise Policy for Industry*
OOH	Out of Hours

Item	Description / Definition
OOHW	Out of Hours Work
PPV	Peak Particle Velocity
RBL	Rating Background Level. This is the background noise level measured at a particular location. The method for calculating the RBL is defined in the NSW *Noise Policy for Industry*.
Realistic worst-case scenarios	Realistic worst-case construction scenarios have been developed to assess the potential impacts from the proposal. These scenarios are based on the noisiest items of equipment which would likely be required to complete the work.
RMS	Root Mean Square
RNP	Road Noise Policy
Secretary's environmental assessment requirements (SEARs)	Requirements and specifications for an environmental assessment prepared by the Secretary of the Department of Planning, Industry and Environment under section 5.16 of the Environmental Planning and Assessment Act 1979 (NSW).
SLR	SLR Consulting Australia Pty Ltd
SSI	State significant infrastructure. Major transport and services infrastructure considered to have State significance as a result of size, economic value or potential impacts.
Standard construction hours	Monday to Friday 7 am to 6 pm and Saturdays from 8 am to 1 pm
Study area	The study area is defined as the wider area including and surrounding the construction sites, with the potential to be affected by noise and vibration impacts from the proposal. The actual size and extent of the study area varies relative to the potential for impacts.
SWL	Sound Power Level
Unattended noise monitoring	Noise monitoring which is typically completed over a seven day period using unattended noise monitoring equipment. The equipment is left in a certain location to measure the existing background noise levels during the daytime, evening and night-time.
VC	Vibration Criterion
VDV	Vibration Dose Value
Worst-case impacts and noise levels	The worst-case (i.e. highest) impacts or noise levels predicted in this report

1 Introduction

1.1 Context and Overview

Sydney is expanding and the NSW Government is working hard to deliver an integrated transport system that meets the needs of customers now and in the future. Sydney Metro is Australia's biggest public transport program.

Sydney Metro West is a new 24-kilometre metro line that will connect Greater Parramatta with the Sydney CBD. Confirmed stations include Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock, The Bays, Pyrmont and Hunter Street (Sydney CBD). This infrastructure investment will double the rail capacity of the Greater Parramatta to Sydney CBD corridor with a travel time target between the two centres of about 20 minutes.

The delivery of Sydney Metro West is critical to keeping Sydney moving and is identified in a number of key strategic planning documents including the Greater Sydney Region Plan: A Metropolis of Three Cities – connecting people (Greater Sydney Commission, 2018a), Building Momentum: State Infrastructure Strategy 2018-2038 (Infrastructure NSW, 2018) and Future Transport Strategy 2056 (Transport for NSW, 2018).

Sydney Metro West is being assessed as a staged infrastructure application under section 5.20 of the *Environmental Planning & Assessment Act 1979* (EP&A Act). The previous Sydney Metro West planning applications included:

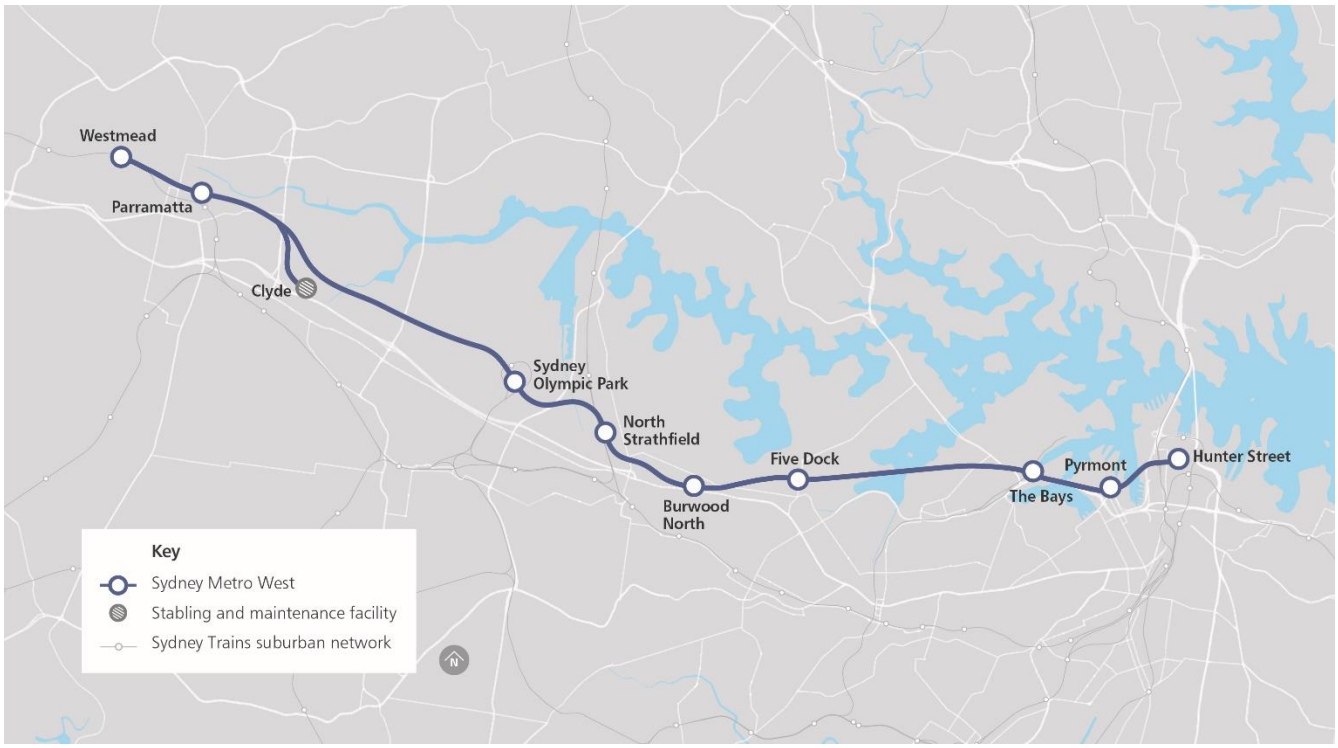
- The Concept and major civil construction work for Sydney Metro West between Westmead and The Bays (Stage 1 of the planning approval process, application number SSI-10038), was approved by the Minister for Planning and Public Places on 11 March 2021.
- Stage 2 of the planning approval process includes all major civil construction between The Bays and Sydney CBD. An Environmental Impact Statement for major civil construction between The Bays and Sydney CBD was exhibited between 3 November 2021 and 15 December 2021.

Stage 3 of the planning approval process is seeking planning approval to enable the approved Concept to be realised by carrying out the tunnel fit-out, construction of stations, ancillary facilities and station precincts, and operation and maintenance of the Sydney Metro West line (this proposal).

Major civil construction including station excavation and tunnelling work associated with the previous Sydney Metro West planning applications does not form part of this proposal. This proposal includes the activities required to complete construction ready for operations of Sydney Metro West.

The main elements of Sydney Metro West are shown in **Figure 1**.

Figure 1 Sydney Metro West



1.2 Key Features of this Proposal

This proposal would involve:

- Fit-out of tunnels including systems for metro train operations
- Construction, fit-out and operation of:
    - Metro station buildings and the surrounding metro precincts
    - A services facility and traction substations
    - A control centre, test track and stabling and maintenance facility at Clyde
- Space for non-station uses at metro stations (e.g. retail, commercial and/or community facilities)
- Provisions for over and/or adjacent station development within metro precincts
- Rail interchange support work, including work to the existing T1 Western Line at Westmead and T9 Northern Line at North Strathfield
- Transport network modifications such as new interchange facilities and changes to public transport networks to serve metro stations
- Subdivision of sites
- Operation and maintenance of the Sydney Metro West line.

Components of the proposal are subject to further design development, and changes may be made during the ongoing design which take into account the outcomes of community and stakeholder engagement and environmental investigations.

Further details of the proposal are provided in Chapter 5 (Proposal description – construction) and Chapter 6 (Proposal description – operation) of the Environmental Impact Statement

1.3 Purpose and Scope of this Technical Paper

This technical paper, Technical paper 4: Construction noise and vibration, is one of a number of technical papers that form part of the Environmental Impact Statement. The purpose of this technical paper is to identify and assess the potential impacts of the proposal in relation to construction noise and vibration. It responds directly to the Secretary's environmental assessment requirements outlined in **Section 1.3.1**.

This technical paper presents indicative construction noise and vibration impacts for the purpose of planning approval and is not intended to be used for any other purpose.

1.3.1 Secretary's Environmental Assessment Requirements

The Secretary's environmental assessment requirements were issued on 16 August 2021. The requirements specific to noise and vibration, and where these requirements are assessed in this technical paper, are outlined in **Table 1**.

The Secretary's environmental assessment requirements also make reference to the Sydney Metro West Scoping Report – Rail infrastructure, stations, precincts and operations (Sydney Metro, 2021), which identified the proposed scope of investigations and assessment. How this technical paper addresses these matters is outlined in **Table 2**.

Table 1 Secretary's Environmental Assessment Requirements – Construction Noise and Vibration

Secretary s Environmental Assessment Requirements	Where addressed
Noise and Vibration	
1. **Construction and operational noise and vibration** impacts in accordance with relevant NSW noise and vibration guidelines.	**Section 5**
2. The assessment must clearly differentiate between activities within the enclosed tunnels, activities below ground but not enclosed and activities on the surface and describe their impacts and proposed hours of work.	**Table 14** **Section 5**
3. The assessment of **construction noise and vibration** must address:	
(a) the nature of construction activities and related noise characteristics using typical and worst-case scenarios;	**Section 4.1**
(b) the intensity and duration of noise (both air and ground borne) and vibration impacts. This must include consideration of the construction program, high noise generating activities and extended construction impacts associated with ancillary facilities (and the like) and construction fatigue;	**Section 5** **Section 5.7**
(c) the identification and nature of receivers, existing and proposed, during the construction period;	**Section 2**
(d) the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage);	**Section 3.5.3.3**
(e) the nature of the impact and the sensitivity of receivers and level of impact including for out of hours work;	**Section 5**
(f) the need to balance timely conclusion of noise and vibration-generating works with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management);	**Section 6.3**
(g) statement of the proposed hours of construction. Justification must be provided where these are not consistent with standard construction hours stated in the *Interim Construction Noise Guideline*;	**Section 4.4**
(h) noise impacts of out-of-hours works (including utility works and works associated with the proposal including the potential pathway), possible locations where out-of-hours works would be undertaken, the activities that would be undertaken, the estimated duration of those activities, the relevant stage the activities are proposed and justification for these activities;	**Section 4.4** **Section 5.2**, **Section 5.5**
(i) assessment of construction traffic noise on public roads must include consideration of gradient, construction vehicle type, acceleration and deceleration and potential annoyance;	**Section 5.6**
(j) sleep disturbance (including the number of noise-awakening events);	**Section 5.2**
(k) a cumulative noise and vibration assessment inclusive of impacts from the proposal, including concurrent and consecutive construction activities within the proposal, the Sydney Metro West scheme and the construction of other relevant development in the vicinity of the proposal when considering mitigation;	**Section 5.7**
(l) qualitative assessment of the predicted effectiveness of management and mitigation measures (including, where relevant, case studies from other Sydney Metro projects) to manage identified impacts, including impacts as identified in (k); and	**Section 5,** **Section 5.3**,**6.3**
(m) any potential residual noise and vibration impacts following application of mitigation measures;	**Section 6.3**
(n) a description of how receiver feedback received during the preparation of the EIS has been taken into account (and would be taken into account post exhibition of the EIS) in the design of mitigation measures, including any tailored mitigation, management and communication strategies for sensitive receivers.	**Section 6.3**

Secretary s Environmental Assessment Requirements	Where addressed
4. The process for community engagement should be included or referenced in the noise and vibration assessment as part of the mitigation strategy and assessment.	**Section 6.3**

Table 2 Scoping Report Investigations and Assessment – Construction Noise and Vibration

Scoping Report Investigations and Assessment Noise and Vibration	Where addressed
A noise and vibration impact assessment will be carried out as part of the Environmental Impact Statement for this proposal to determine potential impact on receivers. The noise and vibration impact assessment will include:	
• Description of the existing noise environment	**Section 2**
• Explanation of the applicable standards, guidelines and environmental planning requirements	**Section 3**
• Explanation of the construction methodology, design and operational procedures relevant to noise and vibration emissions	**Section 4**
• Description of the methodology used to predict and assess the potential impacts	**Section 4**
• Consistent with the philosophy described in Case Study D5 of the NSW Environment Protection Authority's draft Construction Noise Guideline, an alternate methodology to the *Interim Construction Noise Guideline* (ICNG) (DECC, 2009) approach to assessing and managing construction noise may be proposed	n/a

• Assessment of potential construction noise and vibration impacts, including consideration of:
  • The intensity and duration of temporary construction noise and vibration impacts. This will include a 'typical level' or 'typical range' in noise levels which would be expected as construction works move around the site as well as a realistic 'peak' noise level from each activity
  • The correlation between the likely noise impacts and the anticipated duration and timing of the activity
	Section 5

• Assessment of the potential cumulative impacts with other major projects	**Section 5.7**
• Assessment of potential operational noise and vibration impacts	(see Technical Paper 3)
• Identification of feasible and reasonable construction and operational mitigation measures.	**Section 6.3**
Further consultation would be undertaken with the NSW Environment Protection Authority in preparing the noise and vibration assessment.	

1.4 Structure of this Report

This technical paper is structured as follows:

- **Section 1** – provides an introduction to the report
- **Section 2** – details the existing noise environment in the study area
- **Section 3** – presents relevant legislative and policy context to this proposal
- **Section 4** – documents the assessment methodology for this assessment

- **Section 5** – provides an assessment of the potential noise and vibration impacts of this proposal during construction, including cumulative impacts
- **Section 6** – identifies mitigation and management measures
- **Section 7** – provides a conclusion for the noise and vibration assessment of this proposal.

1.5 Terminology

The assessment has used specific acoustic terminology and an explanation of common terms is included in **Appendix A**. A glossary is also provided at the start of this document which lists the various terms used throughout this document.

2 Baseline Environment

2.1 Study Area

The proposal is located in the greater western, inner west and central regions of Sydney and crosses the Cumberland, Parramatta, Strathfield, Canada Bay, Burwood Inner West and City of Sydney local government areas (LGAs). Suburbs that would have construction sites include Westmead, Parramatta, Rosehill, Clyde, Sydney Olympic Park, North Strathfield, Burwood North, Concord, Five Dock, Rozelle, The Bays, Pyrmont and Sydney CBD. The tunnel alignment also passes beneath Silverwater, Newington, Canada Bay, Rodd Point, and Lilyfield.

The study area has been defined with reference to the requirements of the Sydney Metro *Construction Noise and Vibration Standard* (CNVS) and on the basis of the likely construction noise and vibration impacts from the proposal using the following approach:

- Airborne noise has been assessed to receivers within a distance of around 600 metres of each construction site
- Ground-borne vibration has been assessed to receivers adjacent to each construction site
- Construction road traffic noise impacts on public roads have been assessed for roads between each surface construction sites and the nearest arterial road(s).

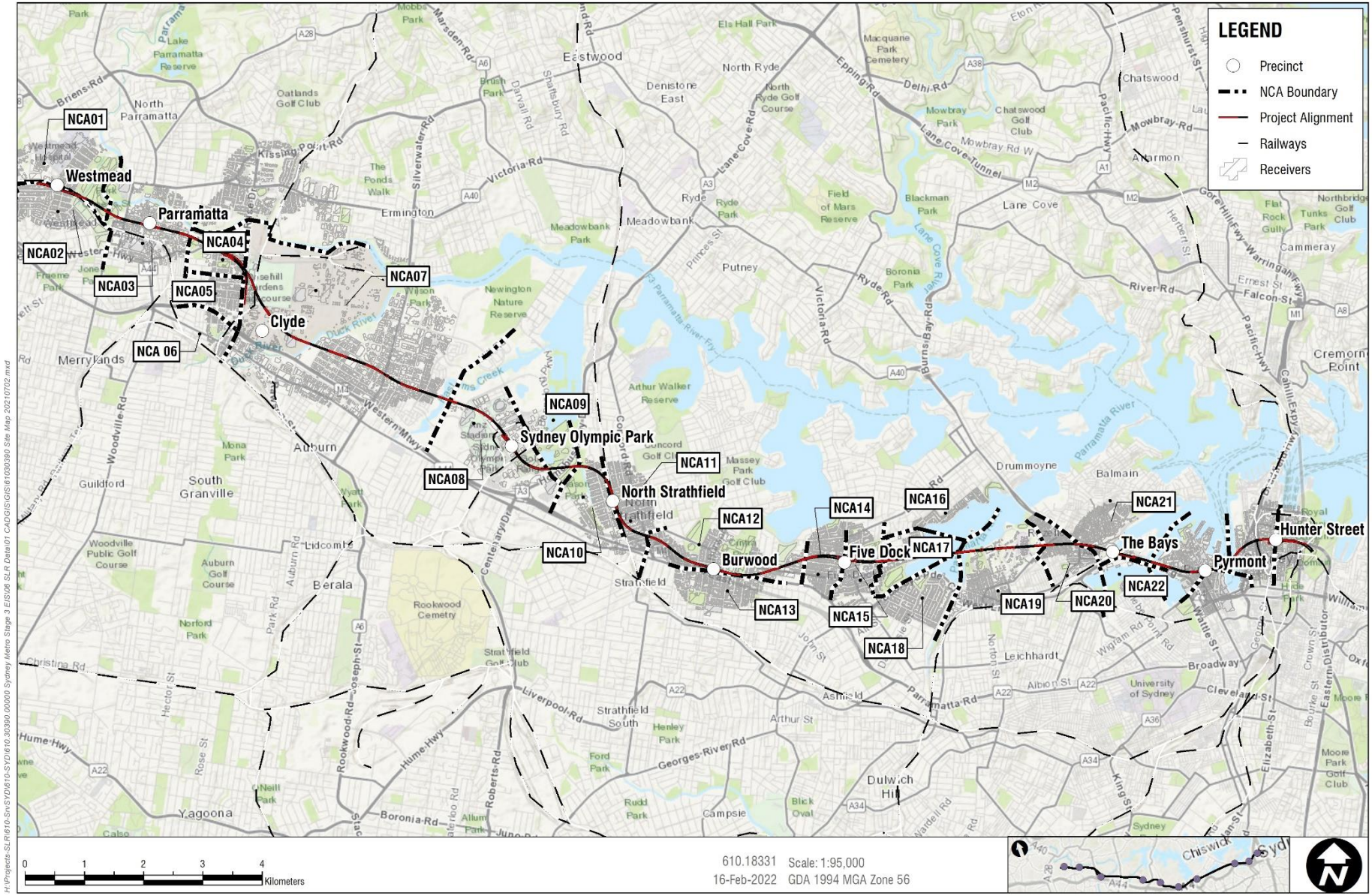
Existing noise levels vary across the study area. In some areas, the alignment is close to major sources of existing transport noise, such as the T1 Western Line near Westmead, various roads around Parramatta CBD and Sydney CBD, the M4 Motorway, the T7 Olympic Park Line near Sydney Olympic Park, the T9 Northern Line near North Strathfield, Parramatta Road in Burwood and Concord, Victoria Road in Rozelle, and Anzac Bridge near Pyrmont. Other sources of existing noise along the alignment include urban noise in Parramatta CBD, Sydney CBD and other urban centres, noise associated with events in Sydney Olympic Park, and industrial noise in areas such as Clyde, and White Bay/Glebe Island.

The tunnel alignment generally runs through areas of suburban residential receivers, with isolated industrial and/or commercial areas. Receivers surrounding the construction sites are generally a mix of residential and various commercial uses, depending on location.

The construction impacts are summarised on the basis of several study areas centred around each construction site. Each study area is divided into one or more Noise Catchment Areas (NCAs) on the basis of the general ambient noise environment of that area, the type of receivers potentially affected, and the noise and vibration sensitivity of the surrounding land uses. All NCAs are consistent with the assessments of previous Sydney Metro West planning applications.

The study areas and NCAs are shown in **Figure 2**. A detailed map of each site is provided in **Section 5.2**.

Figure 2 Study area



2.2 Sensitive Receivers

Receivers potentially sensitive to noise and vibration have been categorised as residential buildings, commercial/industrial buildings, or 'other sensitive' land uses which includes educational institutions, child care centres, medical facilities, places of worship, outdoor recreation areas, etc.

This assessment identifies the likely maximum impacts for receivers in the study area. Some buildings, however, contain more than one use, such as where residential apartments have commercial uses on the ground floor. Where this occurs, buildings have generally been categorised using the most stringent criteria.

Receiver types and locations are shown in study area maps in the discussion of impacts in **Section 5.2**.

2.2.1 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 in the assessment, where appropriate.

2.3 Noise Surveys and Monitoring Locations

Unattended ambient noise monitoring was completed in the study area between 2015 and 2021 as part of previous Sydney Metro planning applications. This baseline data was monitored prior to any Sydney Metro West construction work being undertaken at the various sites. The measured noise levels have been used to determine the existing noise environment and to set criteria to assess the potential impacts from the proposal.

The ambient noise monitoring locations were selected with reference to the procedures outline in the NSW EPA *Noise Policy for Industry* (NPfI). The measured existing noise levels are representative of receivers in each NCA that would likely be most affected by the construction of the proposal.

The noise monitoring equipment continuously measured existing noise levels in 15-minute periods during the daytime, evening and night-time. All equipment carried current National Association of Testing Authorities (NATA) calibration certificates and the calibration was checked before and after each measurement.

The results of the noise monitoring have been processed with reference to the NPfI to exclude noise from extraneous events and/or data affected by adverse weather conditions, such as strong wind or rain (measured at Observatory Hill Weather Station), to establish representative existing noise levels for each NCA.

The monitoring results are summarised in **Table 3**. Maps showing the monitoring locations are provided in the study area discussions in **Section 5.2** and in **Appendix B**. Descriptions of each monitoring location and the measured noise environment, together with graphs of the daily measured noise levels, are also in **Appendix B**.

Table 3 Summary of Noise Monitoring Results

Study area	Location ID	Address	Noise Level (dBA)[1,2]					
			Background noise (RBL)			Average noise level (L_{Aeq})		
			Day	Evening	Night	Day	Evening	Night
Westmead[3]	B.01	8-12 Alexandra Avenue, Westmead[3]	49	47	37	67	67	62
	B.02	14A Central Avenue, Westmead	48	46	41	58	53	51
Parramatta[3]	B.03	Arthur Phillip High School, Parramatta[3]	58	53	43	69	67	62
Clyde[3]	B.04	5 Hope Street, Rosehill[3]	51	48	41	61	58	57
	B.05	9 A'Beckett Street, Granville[3]	50	49	45	56	55	53
	B.06	4B Gray Street, Granville[3]	52	51	44	58	57	55
	B.07	10 Carnarvon Street, Silverwater	46	44	41	60	57	55
Sydney Olympic Park[3]	B.08	1 Herb Elliot Avenue, Sydney Olympic Park	48	48	46	55	54	52
	B.09	6 Parkview Drive, Sydney Olympic Park	48	46	41	57	58	53
North Strathfield[3]	B.10	17 George Street, North Strathfield	47	47	44	60	60	55
	B.11	131 Queen Street, North Strathfield	51	47	39	61	60	55
Burwood[3]	B.12	17 Burton Street, Concord	43	43 (47)[6]	42	56	55	50
	B.13	8 Esher Street, Burwood	48	48	44	57	56	55
Five Dock[3]	B.14	3 Henry Street, Five Dock	42	41	33	58	56	51
	B.15	8 Waterview Street, Five Dock	43	43 (44)[6]	38	57	56	50
	B.16	11 Chapel Street, Lilyfield	36	36 (39)[6]	33	60	60	53
	B.17	28 Crescent Street, Haberfield	43	43 (45)[6]	37	57	57	51
	B.18	102 Henley Marine Drive, Russell Lea	48	45	37	64	61	55
The Bays[3]	B.19	21 Mansfield Street, Rozelle	43	43	35	56	54	47
	B.20	22 Lilyfield Road, Rozelle	51	51	45	57	57	54
	B.21	308 Glebe Point Road, Glebe	48	47	39	59	58	51
Pyrmont[4]	B.22	200 Paternoster Row, Pyrmont	50	47	45	56	50	47
	B.23	1-5 Harwood Street, Pyrmont	52	49	46	61	59	56
Hunter Street[5]	B.24	1 Hosking Place, Sydney	61	56	52	66	62	63

Note 1: The RBL and L_{Aeq} noise levels have been determined with reference to the procedures in the NPfI.

Note 2: Daytime is 7am to 6pm, evening is 6pm to 10pm and night-time is 10pm to 7am.

Note 3: Data taken from Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD (Sydney Metro, 2020). See **Appendix B** for details.

Note 4: Data taken from Sydney Metro West Environmental Impact Statement – The Bays to Sydney CBD (Sydney Metro, 2021b). See **Appendix B** for details.

Note 5: Data measured as part of Sydney Metro Chatswood to Sydenham Environmental Impact Statement in 2015. Noise levels in the CBD are typically elevated due to relatively constant sources of noise and are unlikely to significantly change over time. The levels measured in 2015 are considered representative of current ambient noise conditions. See **Appendix B** for details.

Note 6: The monitored evening level was found to be higher than the daytime. In this situation the NPfI requires that the evening level be reduced to match the daytime.

Short-term attended noise monitoring was completed at each ambient monitoring location. The attended measurements allow the contributions of the various noise sources at each location to be determined. Detailed observations from the attended measurements are provided in **Appendix B**.

The attended measurements were generally found to be consistent with the results of the unattended noise monitoring and showed that the existing noise environment varies along the length of the study area. The noise sources that influence background levels include:

- Road traffic noise, which is the main source of existing noise in the study area. Most construction sites are in urban areas with busy roads either adjacent or within around 100 metres
- Noise from exiting suburban rail lines and stations is present in the Westmead, Sydney Olympic Park and North Strathfield study areas
- Aircraft noise is present in several parts of the study area that are under flight paths
- Noise generated by industrial areas in Clyde, Rozelle and White Bay
- Noise generated by commercial areas such as in Westmead, Parramatta, Five Dock, Pyrmont, and Sydney CBD areas
- Noise from sporting events at Bankwest Stadium, Rosehill Gardens racecourse, Sydney Speedway, Sydney Olympic Park, Concord Oval, Cintra Park and Leichhardt Park.

3 Legislative and Policy Context

This section summarises the guidelines and/or policies referred to in the assessment.

3.1 Relevant Construction Guidelines

The guidelines used to assess construction noise and vibration impacts from the proposal are listed in **Table 4**. The guidelines aim to protect the community and environment from excessive noise and vibration impacts as projects are constructed.

Table 4 Construction Noise and Vibration Guidelines

Guideline/Policy name	Where guideline used
Interim Construction Noise Guideline (ICNG), Department of Environment and Climate Change (DECC), 2009	Assessment of airborne noise and ground-borne noise impacts on sensitive receivers
Assessing Vibration: a technical guideline, Department of Environment and Conservation (DEC), 2006	Assessment of vibration impacts on sensitive receivers
AS2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors	Provides recommended design sound levels for internal areas of occupied spaces
Road Noise Policy (RNP), Department of Environment, Climate Change and Water (DECCW), 2011	Assessment of construction traffic impacts
BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2, BSI, 1993	Screening assessment of vibration impacts (cosmetic damage) to sensitive buildings and structures
DIN 4150:Part 3-2016 Structural vibration – Effects of vibration on structures, Deutsches Institute fur Normung, 1999	Screening assessment of vibration impacts (cosmetic damage) to vibration sensitive heritage buildings and structures, where the structure is found to be unsound
Sydney Metro Construction Noise and Vibration Standard (CNVS), Sydney Metro, 2020b (version 4.3)	Assessment and management protocols for construction of Sydney Metro projects. This Sydney Metro standard is based on the requirements of the ICNG and Transport for NSW *Construction Noise and Vibration Strategy*, as appropriate to Sydney Metro, and is the guiding strategy for assessing and managing the potential impacts during construction of the proposal.
Noise Policy for Industry (NPfI), Environmental Protection Agency (EPA), 2017	Ambient noise monitoring and analysis procedures, and assessment of sleep disturbance
Guideline for Child Care Centre Acoustic Assessment Version 2.0 (GCCCAA), Association of Australasian Acoustical Consultants (AAAC), 2013	Contains reference criteria for child care centres

3.2 Construction Airborne Noise Guidelines

The *Sydney Metro Construction Noise and Vibration Standard* (CNVS) references the NSW *Interim Construction Noise Guideline* (ICNG) for assessing and managing impacts from construction noise on Sydney Metro.

The ICNG contains procedures for determining project specific Noise Management Levels (NMLs) for sensitive receivers. The realistic '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 impacts.

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.

3.2.1 Residential Receivers

The ICNG approach for determining NMLs at residential receivers is shown in **Table 5**.

Table 5 ICNG NMLs for Residential Receivers

Time of day	NML $L_{Aeq(15minute)}$	How to apply
Standard construction hours: Monday to Friday 7:00 am to 6:00 pm Saturday 8:00 am to 1:00 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 $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

	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 works near schools or mid-morning or mid-afternoon for works near residences.
		  • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Outside standard construction hours:	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard 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 5 dB above the noise affected level, the proponent should negotiate with the community.

Note 1: The RBL is the Rating Background Level and the ICNG refers to the calculation procedures in the NSW *Industrial Noise Policy* (INP). The INP has been superseded by the NSW EPA *Noise Policy for Industry* (NPfI). The RBLs have been determined in accordance with the calculation procedures outlined in the NPfI as described in **Section 2.3**.

Note 2: The ICNG standard construction hours are proposed to be extended for this proposal. See **Section 4.4**.

Work is recommended to be completed during standard construction hours where possible. More stringent requirements are placed on work that is required to be completed outside of standard construction hours (i.e. during the evening or night-time) which reflects the greater sensitivity of communities to noise impacts during these periods.

3.2.1.1 Sleep Disturbance

Major infrastructure projects often require certain work to be completed during the night-time. Where night work is located close to residential receivers there is potential for sleep disturbance impacts.

The ICNG lists five categories of work that might be required to 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 shortens 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 that 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 EPA's *Noise Policy for Industry* (NPfI). Although the NPfI sleep disturbance criteria relate to industrial noise, they are considered relevant for reviewing potential impacts from construction noise.

The NPfI defined sleep disturbance criteria is 52 dBA L_{AFmax} or the prevailing background level plus 15 dB, whichever is the greater.

3.2.1.2 Summary of Residential NMLs

The residential NMLs for the proposal have been determined using the results from the unattended ambient noise monitoring (see **Section 2.3**) and are shown in **Table 6**.

Maps showing the monitoring locations are provided in the study area discussions in **Section 5.2** and in **Appendix B.**

Table 6 Residential Receiver Construction NMLs

Study area	NCA	Representative background monitoring location	NML ($L_{Aeq(15minute)}$ dBA)				Sleep disturbance screening criteria (52 dBA or RBL +15 dB whichever is higher)
			Standard construction (RBL +10 dB)	Out of hours (RBL +5 dB)			
			Daytime	Daytime[1]	Evening	Night time	
Westmead	NCA01	B.02	58	53	51	46	56
	NCA02	B.01	59	54	52	42	52
Parramatta	NCA03	B.03	68	63	58	48	58
Clyde	NCA04	B.04	61	56	53	46	56
	NCA05	B.05	60	55	54	50	60
	NCA06	B.06	62	57	56	49	59
	NCA07	B.07	56	51	49	46	56
Olympic Park	NCA08	B.08	58	53	53	51	61
	NCA09	B.09	58	53	51	46	56
North Strathfield	NCA10	B.10	57	52	52	49	59
	NCA11	B.11	61	56	52	44	54
Burwood	NCA12	B.12	53	48	48	47	57
	NCA13	B.13	58	53	53	49	59
Five Dock	NCA14	B.14	52	47	46	38	52
	NCA15	B.15	53	48	48	43	53
	NCA16	B.18	58	53	50	42	52
	NCA17	B.18	58	53	50	42	52
	NCA18	B.17	53	48	48	42	52
	NCA19	B.16	46	41	41	38	52
The Bays	NCA20	B.20	61	56	56	50	60
	NCA21	B.19	53	48	48	40	52
	NCA22	B.21	58	53	52	44	54
Pyrmont	NCA23	B.22	60	55	52	50	60
	NCA24	B.23	62	57	54	51	61
Hunter Street	NCA25	B.24	71	66	61	57	67
	NCA26	B.24	71	66	61	57	67

Note 1: Daytime out of hours is 7am to 8am and 1pm to 6pm on Saturday, and 8am to 6pm on Sunday and public holidays.

The noise monitoring locations were selected to measure background noise levels representative of the potentially most affected receivers in each NCA. These locations would likely be most affected during construction of this proposal and while background noise levels may be lower at receivers which are further back from the construction sites, construction noise tends to reduce at a faster rate than background noise with increasing distance. The worst-case noise impacts are, therefore, generally at the front row receivers and control the mitigation requirements.

3.2.2 '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**.

Table 7 NMLs for 'Other Sensitive' Receivers

Land Use	Noise management level $L_{Aeq(15minute)}$ (dBA) (applied when the property 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]
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]
Horse stables[5] (when in use)	-	60

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*.

Note 5: Taken from ICNG for passive recreation areas.

3.3 Construction Traffic Noise Guidelines

The potential impacts from construction traffic associated with the proposal when travelling on public roads are assessed under the NSW *Road Noise Policy* (RNP).

An initial screening test is first applied to evaluate if existing road traffic noise levels are expected to increase by more than 2.0 dB due to construction traffic. Where this is considered likely, further assessment is required using the RNP base criteria shown in **Table 8**.

Table 8 RNP Criteria for Assessing Construction Traffic on Public Roads

Road category	Type of project/land use	Assessment criteria (dBA)	
		Daytime (7 am 10 pm)	Night time (10 pm 7 am)
Freeway/ arterial/ sub-arterial roads	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq(15hour)}$ 60 (external)	$L_{Aeq(9hour)}$ 55 (external)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq(1hour)}$ 55 (external)	$L_{Aeq(1hour)}$ 50 (external)

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

3.4 Construction Ground-Borne Noise Guidelines

Construction work can cause ground-borne (or regenerated) noise impacts in nearby buildings when vibration intensive equipment is in use. Vibration can be transmitted through the ground and into nearby buildings, which can then create audible noise impacts inside the building.

Ground-borne noise NMLs are applicable where ground-borne noise levels are likely to be higher than airborne noise levels, which can occur where work is underground or where surface work is shielded by noise barriers or other structures.

Residential and Commercial Receivers

The internal ground-borne noise NMLs used in the assessment for residential and commercial receivers are shown in **Table 9**.

Table 9 Construction ground-borne NMLs

Period	Residential	Commercial
Daytime[1]	45 dBA $L_{Aeq(15minute)}$	50 dBA $L_{Aeq(15minute)}$
Evening	40 dBA $L_{Aeq(15minute)}$[2]	n/a
Night-time	35 dBA $L_{Aeq(15minute)}$[2]	n/a

Note 1: Daytime ground-borne noise NMLs taken from previous Sydney Metro planning applications for consistency. Daytime ground-borne noise NMLs are not specified in the ICNG or Sydney Metro CNVS.

Note 2: Specified in the Sydney Metro CNVS.

'Other sensitive' Land Uses

The ICNG and Sydney Metro CNVS do not provide ground-borne noise NMLs for 'other sensitive' receivers. For these receivers, the ICNG internal airborne noise NMLs listed in **Table 7** have been used to identify potential ground-borne noise impacts from the proposal.

3.5 Construction Vibration Guidelines

The effects of vibration from construction work can be divided into three categories:

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

The criteria for these categories are taken from a number of guidelines and are discussed in the following sections. It is noted that a number of assessment parameters are used to assess the various vibration impacts.

3.5.1 Human Comfort Vibration

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 EPA's *Assessing Vibration: a technical guideline* (2006) provides criteria for intermittent vibration based on the Vibration Dose Value (VDV). The 'preferred' and 'maximum' VDVs for human comfort impacts are shown in **Table 10**.

Table 10 Vibration Dose Values for Intermittent Vibration

Building type	Assessment period	Vibration dose value[1] ($m/s^{1.75}$)	
		Preferred	Maximum
Critical Working 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 VDV accumulates vibration energy over the daytime and night-time assessment periods, and is dependent on the level of vibration as well as the duration.

3.5.2 Effects on Building Contents

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.

Exceptions to this can occur when vibration sensitive equipment, such as electron microscopes, is located in buildings near to construction work. Criteria for vibration sensitive equipment are discussed in **Section 3.5.4**.

3.5.3 Cosmetic Damage Vibration

If vibration from construction work is sufficiently high it can cause cosmetic damage to elements of affected buildings. Examples of damage that can occur includes cracks 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 (10 times) higher than those at which people can perceive vibration.

Industry standard cosmetic damage vibration limits are specified in Australian Standard AS 2187-2, British Standard BS 7385 and German Standard DIN 4150, which are referenced in the Sydney Metro CNVS. Cosmetic damage vibration limits for residential and commercial buildings, heritage structures, and utilities are provided below.

3.5.3.1 General Cosmetic Damage Vibration Screening Criterion

The Sydney Metro CNVS recommends the following conservative cosmetic damage screening limits shown in **Table 11**.

Table 11 Screening Values for Minimal Risk Of Cosmetic Damage

Type of building	Peak particle velocity[1]
Reinforced or framed structures. Industrial and heavy commercial buildings	25 mm/s
Unreinforced or light framed structures. Residential or light commercial type buildings	7.5 mm/s

Note 1: Cosmetic damage vibration limits are reduced by 50 percent to account for dynamic loading caused by continuous vibration dynamic magnification due to resonance.

The CNVS recommends that a more detailed analysis of the potential vibration impacts should be completed where the predicted and/or measured vibration levels are greater than the screening values.

3.5.3.2 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 12**.

Table 12 DIN 4150 Guideline Values for Short-Term Vibration On Buried Pipework

Line	Pipe material	Guideline values vibration velocity at the pipe (mm/s)
1	Steel, welded	100
2	Vitrified clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
3	Masonry, plastics	50

For other potentially affected assets, specific vibration limits should be determined on a case-by-case basis in consultation with the asset owner.

3.5.3.3 Heritage Buildings and Structures

The Sydney Metro CNVS states that heritage buildings and structures should be assessed using the cosmetic damage screening criteria in **Table 11** 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 mm/s Peak Particle Velocity (PPV) (from DIN 4150) should be considered. The only heritage building or structure identified to require consideration of the 2.5 mm/s cosmetic damage screening criterion is the former White Bay Power Station in The Bays study area.

3.5.4 Sensitive Scientific and Medical 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 limits for the operation of sensitive scientific and medical equipment should be taken from manufacturer's data. Where this is not available the Vibration Criterion (VC) curves shown in **Table 13** can be used.

Table 13 VC Curves for Vibration Sensitive Equipment

Criterion curve	Max level (µm/sec, RMS)	Detail size (microns)	Description of use
VC-A	50	8	Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc.
VC-B	25	3	An appropriate standard for optical microscopes to 1000X, inspection and lithography equipment (including steppers) to 3 micron line widths.
VC-C	12.5	1	A good standard for most lithography and inspection equipment to 1 micron detail size.
VC-D	6	0.3	Suitable in most instances for the most demanding equipment including electron microscopes (TEMs and SEMs) and E-Beam systems, operating to the limits of their capability.
VC-E	3	0.1	A difficult criterion to achieve in most instances. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems and other systems requiring extraordinary dynamic stability.

Note: Vibration Criterion curves as published by the Society of Photo-Optical Instrumentation Engineers (Colin G. Gordon – 28 September 1999).

Where the criteria are exceeded all appropriate feasible and reasonable mitigation and management measures would be considered to minimise the impacts.

4 Methodology

This section describes the methodology used to assess the potential noise and vibration impacts from the proposal. This construction noise and vibration assessment has not considered any permanent property noise attenuation that has or will be carried out under the previous Sydney Metro West planning applications.

4.1 Construction Airborne Noise Assessment

4.1.1 Computer Noise Modelling

A noise model of the study area has been used to predict noise levels from the various construction sites to the surrounding receivers. The model uses ISO 9613 algorithms in SoundPLAN software to predict noise levels at external building facades and outdoor recreation areas.

Local terrain, receiver buildings and structures were digitised in the noise model to develop a three-dimensional representation of the construction sites and surrounding areas.

4.1.2 Assessment Approach and Construction Work Descriptions

Representative scenarios have been developed to assess the likely impacts from the construction activities. Equipment lists for each scenario and sound power level data is provided in **Appendix C**.

The assessment uses 'realistic worst-case' scenarios to predict the potential airborne noise impacts from the noisiest 15-minute period for each work scenario, as required by the ICNG. The impacts represent construction noise levels with project specific base-case mitigation applied (see **Section 4.6.1**).

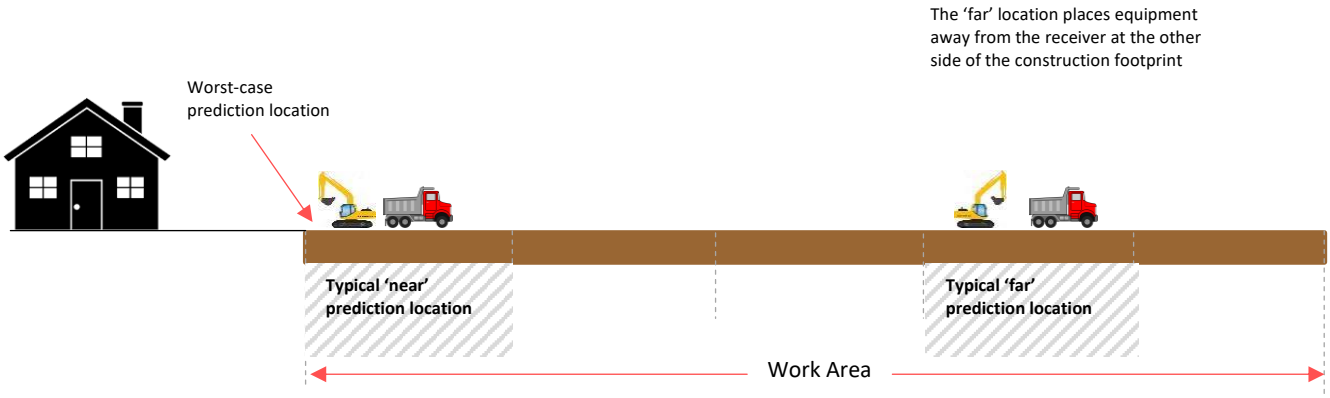
Scenarios have been categorised into 'peak' and 'typical' work which have been used to define the likely range of potential noise impacts:

- '**Peak**' work represents the noisiest stages and can require noise intensive equipment such as rockbreakers or concrete saws. While 'peak' work would be required at times in most locations, the noisiest activities would not occur for the full duration of the work.
- '**Typical**' work represents typical noise emissions when noise intensive equipment is not in use. The 'typical' work generally includes items of equipment that are less noisy than the 'peak' scenario.

Construction activities would generally occur sequentially at each site and it is expected that there would be relatively long periods where construction noise levels are much lower than the 'peak' and 'typical' worst-case levels presented in this assessment. There would also be times when work is not audible at receivers due to less noisy items of equipment being used or where work is in distant parts of the construction site.

For a particular construction site, the potential construction noise impacts can vary greatly, with a key factor being the distance of the work from the nearest receivers. For work that moves around the site, a receiver would be affected by a range of noise levels depending on how close the work is. This concept is illustrated in **Figure 3**.

Figure 3 Illustration of Work Position in Relation to Receiver



The above illustration shows that work which is close to a receiver would result in higher impacts than work which is further away. The assessment presents the expected range of impacts for each construction scenario based on work being both 'near' and 'far' from the nearest potentially affected receivers.

Work within a confined area, such as at rail systems access shafts inside acoustic sheds, would be limited to one location and no range has been presented for these scenarios.

4.1.2.1 Construction Site Work Descriptions

The representative scenarios required to construct the proposal are listed and described in **Table 14**. The scenarios represent one possible way that the proposal could be constructed and may not necessarily be the same methodology that the contractor engaged to construct the proposal would use.

Table 14 Construction Scenario Descriptions – Construction Site Activities

Scenario (work location)	Description
Site establishment and public domain work (surface work)	This work is required to establish site facilities, access points and erect hoarding. Required facilities may include toilets, meal rooms, change rooms, offices, a security hut, dangerous goods storage, workshops, site power and water treatment equipment. Similar work would be required at the end of the construction program to demobilise equipment, remove construction hoarding and complete public domain work. The work may occur over the entire construction site and the assessed scenarios are: - 'Typical' work including operation of supporting equipment and the loading/unloading of heavy vehicles - 'Peak' work including the use of multiple concurrent equipment items such as generators, forklifts, cranes, loaders, etc, and the loading/unloading of heavy vehicles. This work would include the installation and removal of site facilities and perimeter hoarding.

Scenario (work location)	Description
Piling (surface work)	Piling is potentially required at all construction sites for the foundations of future structures and to support linings for the stations. Piling is also required for the aerial concourse / footbridge to existing Sydney Trains platforms at Westmead and North Strathfield stations, and at the Clyde stabling and maintenance facility. The assessed scenarios are: - 'Typical' work including operation of supporting equipment such as excavators and cranes, as well as concreting equipment such as concrete mixers, heavy vehicles and concrete vibrators - 'Peak' work would use all supporting equipment plus a piling rig. Bored piling would be used as opposed to impact piling. Bored piling is substantially less noisy.
Station / facility construction (surface and below ground (not enclosed) work)	Following site establishment (and piling work where required) the main building support structures for the stations and facilities would be constructed. Construction of base structures would also include some of the proposed future developments on the station sites up to the height of the top of station services. This scenario includes construction of the structures for non-station use at all stations. At the Burwood North southern construction site, additional structures would be constructed above the station to provide space for future non-station uses. This has been represented in the noise model by an elevated source at the maximum height that noise intensive equipment is expected to be required for the construction of the structure. Construction of acoustic sheds would also occur over rail system access shafts at Parramatta, Rosehill, Burwood North and The Bays to allow out of hours work for this activity at those locations. The assessed scenarios are: - 'Typical' work including installation of all structural, mechanical and electrical systems at the stations and facilities. Floor finishes, glazing, facade treatment and all external cladding would also be installed using general construction equipment such as mobile cranes, elevated working platforms and hand tools. Fit-out work would occur 24/7, however the majority of this work would occur inside built structures and not include any noise intensive equipment - 'Peak 1' work including use of all supporting equipment plus tower cranes to install the framing elements of all building structures. Lift systems and emergency stairs would also be installed to enable access to the base of the excavation sites - 'Peak 2' work also includes concrete work to construct the station platforms, track pit or other cast in-situ concrete elements and would be completed with pump and supporting equipment at ground level. Concrete saws would be used for crack control where floor slabs are poured as part of the concrete work.
Rail systems access shafts (surface and below ground (enclosed) work)	Based on current construction planning, access shafts at Parramatta, Clyde stabling and maintenance facility, Rosehill services facility, Burwood North and The Bays would provide tunnel access points for delivery of all construction materials to the tunnel worksite. Work at the rail systems access shafts would occur 24/7 to support tunnel fit-out. Acoustic sheds would contain the access shafts at Parramatta, Rosehill, Burwood North and The Bays. The assessed scenarios are: - 'Typical' work including operation of supporting surface equipment such as forklifts and mobile cranes - 'Peak' work including management of deliveries and supply of major construction consumables through the access shafts. This work would use all supporting equipment plus gantry cranes and heavy vehicle deliveries. Other station sites may also be used as access points to carry out tunnel rail systems fit-out. Rail systems access may be required at all other shafts at times during construction. The impacts from this are qualitatively discussed in **Section 5.2.10**.

Scenario (work location)	Description
Earthwork (surface work)	Earthwork is required at the Clyde stabling and maintenance facility to provide a suitable level base for the track construction activities. The assessed scenarios are: - 'Typical' work including the import and stockpiling of the select fill material and construction of site drainage pits. This work would generally use excavators, loaders and dump trucks - 'Peak' work including bulk earthworks and compaction using excavators, graders, dozers and vibratory rollers.
Excavation (surface and below ground (not enclosed) work)	Excavation would be required at Westmead, Parramatta, Sydney Olympic Park and Five Dock construction sites. Work would include excavation at the existing Westmead Station during construction of the underground concourse at the Westmead metro station construction site. Excavation would be required at Parramatta metro station and Five Dock Station construction sites for basements. Excavation would also be required at Sydney Olympic Park and North Strathfield construction sites for site levelling and some minor detailed excavation beyond the excavation extent carried out as part of the previous Sydney Metro West planning application. Excavation involves removal of the upper layers of soil and rock left from the surface down. Excavation of soil and soft rock can be carried out using 'ripping' where the earth is separated using a manual pick attachment on an excavator. Initial excavation of hard rock would require noise intensive rockbreaking. 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 use of support equipment and either ripping through soft soil/rock or noise intensive rockbreaking through hard rock.
Mined tunnel (below ground (not enclosed) work)	A tunnel would be mined between the Westmead metro station construction site and the existing station platform using roadheaders. Mined tunnel work would be launched from within the excavated station box. The assessed scenarios are: - 'Typical' work would generally include operation of supporting equipment associated with spoil removal. - 'Peak' work include the concurrent use of supporting equipment and a roadheader.
Above-ground rail (surface work)	Track construction is required for all above ground rail at the Clyde stabling and maintenance facility. This includes the dive structure leading to the mainline tunnel and the above ground test and shunt track. Slewing of the existing Sydney Trains lines is proposed at Westmead to accommodate the platform widening and new aerial concourse. The assessed scenarios are: - 'Typical' work including the installation of the rail once the subgrade has been complete. This includes general construction equipment such as excavators, forklifts, welding equipment and hand tools - 'Peak' work including the preparation of the track subgrade, capping, ballast tamping and regulating. This includes the use of noise intensive equipment such ballast tampers and regulators to finalise the track level.

Scenario (work location)	Description
Brownfield work (surface work)	'Brownfield' refers to the work at the existing Westmead and North Strathfield stations related to their proposed connections to the adjacent new metro stations. Work would be required both on existing station platforms during normal working hours and within the rail corridor during rail possessions. Following the required piling work, the main building support structures for the lifts and aerial concourse / footbridge would be constructed. Delivery of materials would be by track trolleys and hi-rail equipment from the nearest corridor access gate and installed using cranes. Retaining walls for new track may be required at Westmead, along with decommissioning and demolition of the existing lift and concourse once the new concourse is complete. The assessed scenarios are: - 'Typical' work including delivery handling and support within the brownfield site. This work would generally use rail trolleys and cranes - 'Peak 1' work including use elevated working platforms and tools such as grinders and welding equipment to install the framing elements of the aerial concourse / footbridge. This scenario is also representative of the platform widening and Hawkesbury Road Bridge widening that would occur at Westmead - 'Peak 2' work would also include the removal of the existing aerial concourse at Westmead. This work would require the use of noise intensive equipment, such as a concrete saw, but would but would be relatively transient in nature.
Road work (surface work)	Road relocation work would be required at The Bays for the construction of the new precinct street / realignment of the Port Access Road to its final position. The assessed scenarios are: - 'Typical' work including supporting work such as importing and placing road base material - 'Peak' work including noise intensive equipment such as a concrete saw or rockbreaker.

4.2 Construction Ground-Borne Noise and Vibration Assessment

Ground-borne noise and vibration impacts have been predicted, where appropriate, using a three-dimensional model which includes receiver elevation data and the expected location of vibration intensive equipment.

Vibration is discussed in terms of potential ground-borne vibration and ground-borne noise impacts. Ground-borne vibration refers to vibration impacting buildings from work being completed at ground level or below ground. Ground-borne noise refers to the 'rumble-like' noise generated from the vibration of the building's internal surfaces.

Ground-borne vibration is assessed in terms of Peak Particle Velocity (PPV) and period Vibration Dose Value (VDV), and ground-borne noise is assessed in terms of the 15-minute average noise level.

Ground-borne noise is only required to be assessed where ground-borne noise levels are higher than the corresponding airborne noise levels.

4.2.1 Key Vibration Sources

The main sources of vibration generating equipment are:

- Rockbreakers – which are proposed to be used during excavation (where rock is encountered) at Westmead, Parramatta and Five Dock
- Vibratory rollers – which are proposed to be used during earthwork at Clyde stabling and maintenance facility.

Vibration from the above work has been predicted to the nearest receivers using empirically derived source vibration levels and offset distances to the nearest potentially affected receivers. The modelling also includes the following assumptions:

- Rockbreakers are 900 kilograms, have a 16 Hz drive frequency, are mounted to 12-22t tracked excavator and are in use for around 33 per cent of the assessment period
- Vibratory rollers are 20 tonnes, have a 30 Hz drive frequency and in use for around 10 per cent of the assessment period
- Tunnelling would occur 24/7 and may use rockbreakers at any point
- Large buildings with substantially greater mass than a typical residential house have conservatively been assumed to have no additional coupling loss
- A crest factor of 3.0 has been used for rockbreakers and 1.4 for vibratory rollers.

4.3 Construction Traffic Noise Assessment

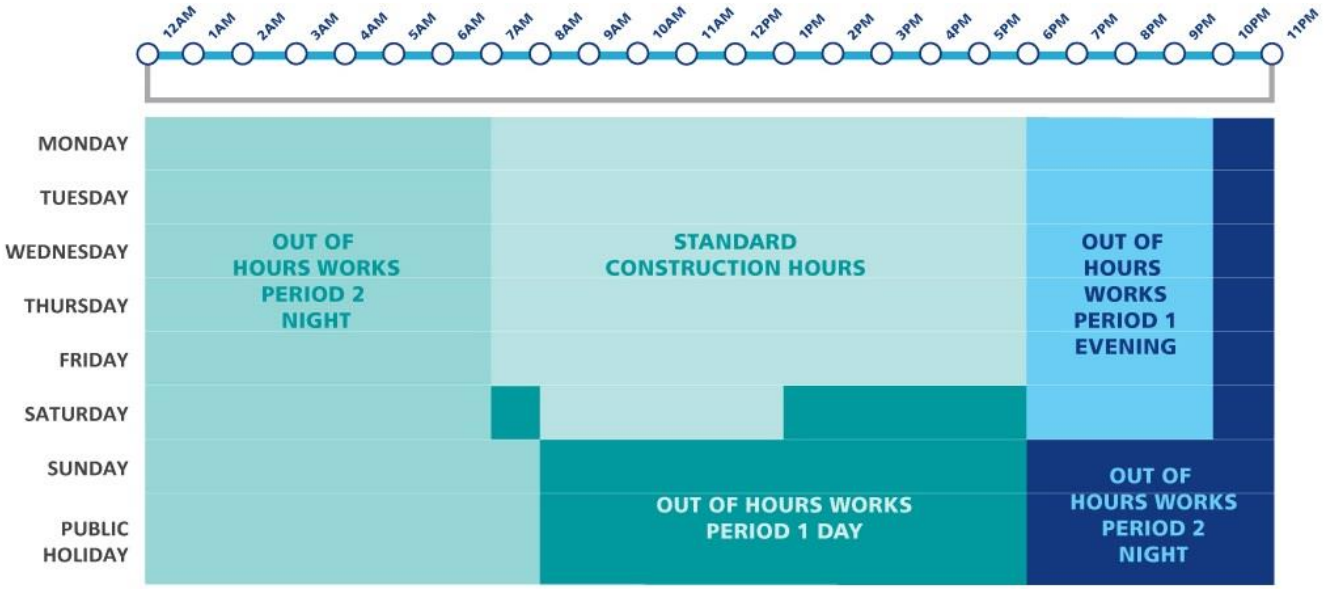
The potential impacts from construction traffic on public roads have been predicted using the *Calculation of Road Traffic Noise* (CORTN) algorithm.

Where the criteria are found to be exceeded, feasible and reasonable mitigation and management measures should be considered.

4.4 Working Hours

Construction of the proposal would be carried out during standard construction hours where practicable. Standard construction hours are defined in the ICNG and shown in **Table 15**.

Table 15 Standard construction hours[1, 2, 3]



Note 1: Taken from the Transport for NSW *Construction Noise and Vibration Strategy*.

Note 2: Standard construction hours are Monday to Friday 7 am to 6 pm and Saturdays from 8 am to 1 pm, as defined in the ICNG.

Note 3: 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.

The ICNG Standard Construction Hours are proposed to be extended to include work during the Saturday out of hours work period 1, from 1pm to 6pm, consistent with the conditions of approval for the previous Sydney Metro West planning application. Earlier completion of the proposal would bring considerable benefits to the community and would reduce the duration of construction related disruption. Appropriate acoustic mitigation measures would be in place to minimise impacts, as outlined in **Section 6**. All work scenarios have, therefore, been assessed as occurring during this period.

Project specific constraints would require evening and night-time work. A summary of the proposed construction hours for the proposal is shown in **Table 16**. Justification for out of hours work is provided in **Section 4.4.1**.

Table 16 Proposed construction hours

Scenario	Activity		Working Hours									
			Westmead	Parramatta	Sydney Olympic Pk	North Strathfield	Burwood North	Five Dock	The Bays	Pyrmont	Hunter Street	Clyde and Rosehill
Site establishment & public domain work	Typical	Deliveries and general work	Std	Std	Std	Std	Std	Std	Std	Std	Std	Std
	Peak	Construction / decommissioning of facilities and hoarding	Std	Std	Std	Std	Std	Std	Std	Std	Std	Std
Piling	Typical	Supporting work	OOH	Std	Std	OOH	Std	Std	Std	Std	Std	Std
	Peak	Bored piling with support plant	OOH	Std	Std	OOH	Std	Std	Std	Std	Std	Std
Station / facility construction	Typical	Indoor construction and fit-out	OOH	OOH	OOH	OOH	OOH	OOH	OOH	OOH	OOH	OOH
	Peak	Installation of framing and structure / concrete work	Eve	Eve	Eve	Eve	Eve	Eve	Eve	Eve	Eve	Eve
Rail system access shafts	Typical	Surface support	-	OOH	-	-	OOH	-	OOH	-	-	OOH
	Peak	Deliveries and tunnel access	-	OOH	-	-	OOH	-	OOH	-	-	OOH
Earthworks	Typical	Stockpiling and support	-	-	-	-	-	-	-	-	-	Std
	Peak	Earthworks and compacting	-	-	-	-	-	-	-	-	-	Std
Excavation	Typical	Mucking out	Std	Std	Std	Std	-	Std	-	-	-	-
	Peak	Through soft soil/rock or through rock using a rockbreaker	Std	Std	Std	Std	-	Std	-	-	-	-
Mined tunnel	Typical	Spoil removal	OOH	-	-	-	-	-	-	-	-	-
	Peak	Mining with support	OOH	-	-	-	-	-	-	-	-	-
Above-ground rail	Typical	Track installation	OOH	-	-	-	-	-	-	-	-	Std
	Peak	Track subgrade, capping and tamping	OOH	-	-	-	-	-	-	-	-	Std
Brownfield work	Typical	Deliveries and supporting work	OOH	-	-	OOH	-	-	-	-	-	-
	Peak 1	Installation of framing and structure	OOH	-	-	OOH	-	-	-	-	-	-
	Peak 2	Removal of existing structures	OOH	-	-	-	-	-	-	-	-	-
Road work	Typical	Supporting work	-	-	-	-	-	-	Std	-	-	-
	Peak	Noise intensive work	-	-	-	-	-	-	Std	-	-	-

Note 1: 'Std' refers to standard construction hours which are Monday to Friday 7am to 6pm and Saturdays 8am to 1pm. Work may also be required during Saturday daytime out of hours (ie Saturday 1pm to 6pm).

Note 2: 'Eve' refers to the evening period which is Monday to Saturday 6pm to 10pm. This work would also occur during standard construction hours and potentially Saturday daytime out of hours.

Note 3: 'OOH' refers to out of hours work that may be required to occur on a 24/7 basis.

4.4.1 Justification for Out of Hours Work

Justification for work required to be completed outside of standard construction hours is provided in **Table 17**. Further detail on the approach to out of hours work is provided in the Sydney Metro CNVS.

Table 17 Work Outside of Standard Construction Hours

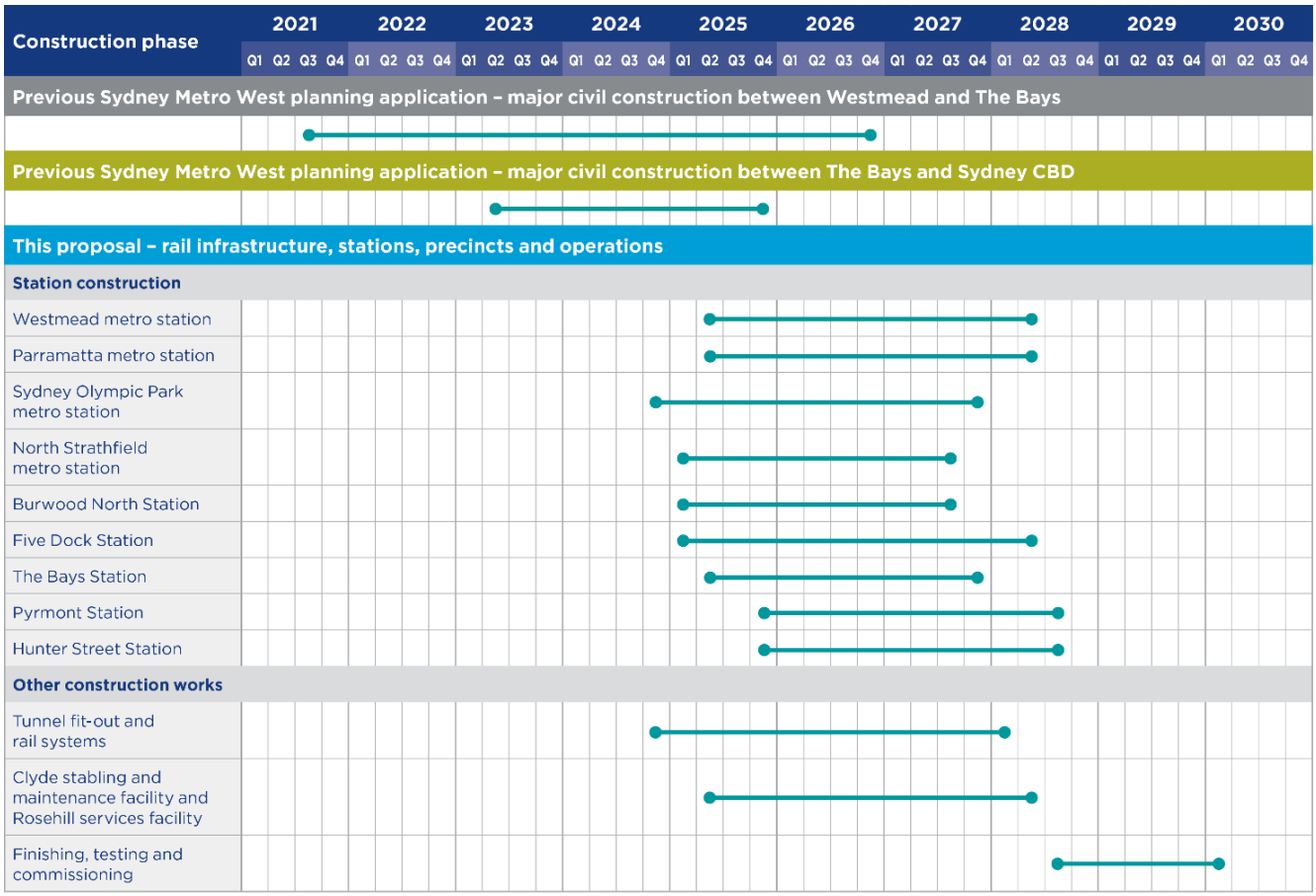
Scenario	Activity		Comments/Justification
All	All	All	Work during Saturday out of hours (i.e. Saturday 1pm to 6pm) is proposed for all construction activities. Completing work in this period would reduce the overall length of the program and the duration of construction related disruption by around three months for each site (based on the indicative construction durations). Station work (out of hours) would include: - Deliveries, including oversize loads which are required to be delivered out of hours - Finishing of concrete pours. The time to cure (harden) concrete is dependent on the weather. Achieving the desired concrete finish in the stations must be undertaken once the concrete reaches a certain hardness, which may occur out of hours. Further, concrete pours cannot be stopped once they have commenced which can lead to concrete pours being required out of hours.
Site establishment and public domain work	Typical	Deliveries and general work	Proposed to be limited to daytime periods
	Peak	Construction / decommissioning of facilities and hoarding	Proposed to be limited to daytime periods
Piling	Typical	Supporting work	Out of hours work would be required on a 24/7 basis at Westmead and North Strathfield due to certain work being in the existing rail corridor. Work would be required to be completed during short-term rail possessions at these sites when trains are not operating.
	Peak	Bored piling with support plant	
Station / facility construction	Typical	Indoor construction and fit-out	Out of hours work would be required on a 24/7 basis at all construction sites to support fit-out activities. The majority of this work would occur inside the built station structures and not require noise intensive equipment.
	Peak	Installation of framing and structure / concrete work	Evening work may be required at all construction sites to achieve interface milestones with rail systems.

Scenario	Activity		Comments/Justification
Rail system access shafts	Typical	Surface support	Out of hours work would be required on a 24/7 basis at all rail system access shafts to support tunnel fit-out and commissioning activities. Shafts at Parramatta, Rosehill, Burwood North and The Bays would be mitigated using acoustic sheds. Out of hours rail systems access shafts works would include deliveries, including oversize loads which are required to be delivered out of hours, and power isolations.
	Peak	Deliveries and tunnel access	
Earthworks	Typical	Stockpiling and support	Proposed to be limited to daytime periods
	Peak	Excavation and compacting	
Excavation	Typical	Mucking out	Proposed to be limited to daytime periods
	Peak	Through soft soil/rock or through rock using a rockbreaker	
Above-ground rail	Typical	Track installation	Out of hours work would be required on a 24/7 basis at Westmead due to certain work being in the existing rail corridor. Work would be required to be completed during short-term rail possessions at this site when trains are not operating.
	Peak	Track subgrade, capping and tamping	
Brownfield work	Typical	Deliveries and supporting work	Out of hours work would be required on a 24/7 basis at Westmead and North Strathfield due to certain work being in the existing rail corridor. Work would be required to be completed during short-term rail possessions when trains are not operating.
	Peak 1	Installation of framing and structure	
	Peak 2	Removal of existing structures	
Road work	Typical	Supporting work	Proposed to be generally limited to daytime periods
	Peak	Noise intensive work	

4.5 Work Schedule

Subject to planning approval, construction of the proposal is planned to commence in late 2024. The total duration of the proposal construction work is expected to be around four years, followed by testing and commissioning. The indicative construction program for the proposal is shown in **Table 18**.

Table 18 Indicative Construction Program



4.6 Construction Mitigation Measures

The ICNG acknowledges that due to the nature of construction work it is inevitable that there will be impacts where construction is near to sensitive receivers. Several approaches are used on major infrastructure projects to minimise the potential noise and vibration impacts as far as practicable and these are discussed below.

4.6.1 Base-Case Mitigation Measures

The proposed construction work includes a number of base-case mitigation measures to minimise the potential airborne noise impacts. These measures, detailed in **Table 19**, are included in the construction impact assessment in **Section 5** and are used prior to consideration of any 'additional mitigation measures'.

Table 19 Project Specific Base-Case Mitigation Measures

Included mitigation measures	Description
Bored piling	The construction activities assume that bored piling would be used as opposed to impact piling, wherever possible. Bored piling is significantly less noisy than impact piling.
Acoustic perimeter hoardings	For construction concentrated in a single area, such as at station and services facility construction sites, temporary acoustic hoardings around the site perimeter would be used where receivers are potentially affected and where feasible and reasonable. Acoustic hoarding of solid construction (as opposed to standard wire mesh fence) has been included in the assessment and is shown on the study area figures in **Section 5.2**. The acoustic hoarding has been assessed with a minimum height of three metres, with some areas adjacent to footpaths assessed as B-class overhead hoarding with a total height of five metres. The same noise outcome at the receivers could be achieved through a range of mitigation measures and potentially different hoarding heights.
Acoustic sheds (or other acoustic measures)	Acoustic sheds have been assumed to be used at Parramatta, Rosehill services facility, Burwood North and The Bays rail systems access shafts. At this stage, detailed designs have not been developed and a typical shed construction based on previous stages of Sydney Metro have been used with indicative shed dimensions provided by the project team. Shed ventilation would be required to be designed to maintain the integrity of the shed's acoustic performance, which indicatively would require attenuators for supply and return air ducting. Details on the acoustic properties assumed for the sheds are in **Appendix D.** When the main doors of the acoustic sheds are opened to allow heavy vehicle access, noise emissions would potentially increase. The assessment presents predicted noise levels for doors open and doors closed. The specific noise mitigation measures would be determined during detailed construction planning taking into account construction program, construction working hours and construction traffic management in accordance with the Sydney Metro CNVS and may include mitigation measures other than acoustic sheds.

4.6.2 Standard and Additional Mitigation Measures – Sydney Metro CEMF and CNVS

The Sydney Metro *Construction Environmental Management Framework* (CEMF) contains a number of 'standard mitigation measures' for mitigating and managing construction impacts on Sydney Metro projects. Where impacts remain after the use of 'standard mitigation measures', the CNVS requires 'additional mitigation measures' to be applied, where feasible and reasonable.

The mitigation measures recommended to address noise and vibration impacts from the construction of the proposal are outlined in **Section 6**.

5 Construction Impact Assessment

5.1 Overview of Impacts from Construction Sites

The following overview is based on the predicted impacts at the most affected receivers in each study area and is representative of the worst-case noise levels that are likely to occur during construction.

The assessment shows the predicted impacts based on the exceedance of the management levels, as per the categories in **Table 20**.

Table 20 Exceedance Bands and Impact Colouring

Exceedance of management level	Subjective Classification[1]	Impact colouring
No exceedance	Negligible	
1 to 10 dB	Low impact	
11 dB to 20 dB	Moderate impact	
>20 dB	High impact	

Note 1: This subjective classification is indicative and follows the approach outlined in the Sydney Metro CNVS for reporting of construction impacts in Detailed Noise and Vibration Impact Statements. The subjective response would vary and depends on the period in which the impacts occur (i.e. people are generally more sensitive to impacts during the evening and night-time). The assessment approach and subjective classification are consistent with the approach used on previous Sydney Metro West planning applications.

5.1.1 Overview of Airborne Noise Impacts from Construction Sites

The predicted construction airborne noise impacts are presented for the most affected receivers. Receivers which are further away from the work and/or shielded from view would have substantially lower impacts. The assessment is conservative as the calculations assume several items of construction equipment are in use at the same time within individual scenarios.

A summary of the predicted construction airborne noise levels (without additional mitigation) in each NCA for the various construction site activities is shown in **Table 21** for residential and commercial receivers. Results for 'other sensitive' receivers are presented in the various study area discussions in **Section 5.2**.

'Typical' and 'peak' noise impacts are predicted for each scenario, where appropriate. The noise levels are also shown as a range (e.g. 55 to 68 dBA), which represents the likely noise levels when work is 'near' to 'far' from a particular receiver, as explained in **Section 4.1.2**.

The noise levels are based on a realistic worst-case assessment of each work scenario. For most construction activities, it is expected that the construction noise levels during less intensive activities would frequently be lower than predicted.

Impacts from ground-borne vibration are summarised in **Section 5.1.2** and discussed in the study area sections. The potential impacts from fit-out work in the tunnels are in **Section 5.2.10** and impacts from construction road traffic are in **Section 5.5**.

Table 21 Predicted Worst-Case Airborne Noise Impacts from Surface Construction Sites – Residential Daytime

Study area	NCA	Predicted worst case $L_{Aeq(15minute)}$ noise level (dBA)																							
		Site establishment & public domain work				Piling				Station / facility construction						Rail system access shaft		Earthworks / Excavation				Above ground rail				Brownfield work / Road work			
		Typical		Peak		Typical		Peak		Typical		Peak 1		Peak 2		Typical	Peak	Typical		Peak		Typical		Peak		Typical		Peak	
Westmead	NCA01	48	59	54	65	51	58	56	63	46	53	52	59	63	70	n/a	n/a	59	59	73	73	44	64	59	79	45	64	54	70
	NCA02	55	67	61	73	53	64	58	69	52	59	58	65	69	76	n/a	n/a	62	62	76	76	43	65	58	80	43	59	52	66
Parramatta	NCA03	41	55	47	61	47	56	52	61	42	51	48	57	59	68	41	40	47	59	61	73	n/a		n/a		n/a		n/a	
Olympic Park	NCA08	47	56	53	62	51	57	56	62	46	52	52	58	63	69	n/a	n/a	53	62	57	66	n/a		n/a		n/a		n/a	
	NCA09	45	53	51	59	51	55	56	60	46	50	52	56	63	67	n/a	n/a	51	59	55	63	n/a		n/a		n/a		n/a	
North Strathfield	NCA10	45	62	51	68	51	61	56	66	46	56	52	62	63	73	n/a	n/a	54	63	58	67	n/a		n/a		45	66	55	55
	NCA11	47	66	53	72	53	64	58	69	48	59	54	65	65	76	n/a	n/a	57	64	61	68	n/a		n/a		43	55	58	58
Burwood North	NCA12	54	75	60	81	53	74	58	79	48	69	54	75	65	86	46	57	n/a		n/a		n/a		n/a		n/a		n/a	
	NCA13	52	72	58	78	54	74	59	79	49	69	55	75	66	86	39	43	n/a		n/a		n/a		n/a		n/a		n/a	
Five Dock	NCA14	48	68	54	74	50	68	55	73	45	63	51	69	62	80	n/a	n/a	65	69	79	83	n/a		n/a		n/a		n/a	
	NCA15	60	76	66	82	62	72	67	77	57	67	63	73	74	84	n/a	n/a	65	67	79	81	n/a		n/a		n/a		n/a	
The Bays	NCA20	39	57	45	63	47	50	52	55	42	45	48	51	59	62	36	48	n/a		n/a		n/a		n/a		42	54	62	74
	NCA21	40	55	46	61	47	50	52	55	42	45	48	51	59	62	36	48	n/a		n/a		n/a		n/a		40	68	60	88
	NCA22	<30	42	34	48	32	43	37	48	<30	38	33	44	44	55	30	41	n/a		n/a		n/a		n/a		<30	40	47	60
Pyrmont	NCA23	45	80	51	86	46	83	51	88	41	78	47	84	58	95	n/a	n/a	n/a		n/a		n/a		n/a		n/a		n/a	
	NCA24	56	69	62	75	58	70	63	75	53	65	59	71	70	82	n/a	n/a	n/a		n/a		n/a		n/a		n/a		n/a	
Hunter Street	NCA25	31	52	37	58	34	55	39	60	<30	50	35	56	46	67	n/a	n/a	n/a		n/a		n/a		n/a		n/a		n/a	
	NCA26	34	39	40	45	37	42	42	47	32	37	38	43	49	54	n/a	n/a	n/a		n/a		n/a		n/a		n/a		n/a	
Clyde and Rosehill	NCA04	<30	57	33	63	32	56	37	61	<30	33	33	39	44	50	44	45	36	62	38	64	<30	52	43	67	n/a		n/a	
	NCA05	33	62	39	68	36	65	41	70	35	46	41	52	52	63	59	59	42	71	44	73	33	61	48	76	n/a		n/a	
	NCA06	<30	47	34	53	31	47	36	52	32	41	38	47	49	58	37	44	37	54	39	56	<30	43	42	58	n/a		n/a	
	NCA07	<30	49	35	55	32	50	37	55	32	42	38	48	49	59	35	46	38	58	40	60	<30	46	43	61	n/a		n/a	

Legend

No Exceedance | 1 - 10 dB above NML | 11 - 20 dB above NML | >20 dB above NML

Table 22 Predicted worst-case airborne noise impacts from surface construction sites – residential night-time

Study area	NCA	Predicted worst case $L_{Aeq(15minute)}$ noise level (dBA)															
		Site establishment & public domain work		Piling		Station / facility construction			Rail system access shaft		Earthworks / Excavation		Above ground rail		Brownfield work / Road work		
		Typical	Peak	Typical	Peak	Typical	Peak 1	Peak 2	Typical	Peak	Typical	Peak	Typical	Peak	Typical	Peak	
Westmead	NCA01	n/a	n/a	51 to 57	56 to 62	46 to 53	n/a	n/a	n/a	n/a	n/a	n/a	44 to 64	59 to 79	45 to 64	54 to 70	
	NCA02	n/a	n/a	53 to 58	58 to 63	52 to 59	n/a	n/a	n/a	n/a	n/a	n/a	43 to 65	58 to 80	43 to 59	52 to 66	
Parramatta	NCA03	n/a	n/a	n/a	n/a	42 to 51	n/a	n/a	41	40	n/a	n/a	n/a	n/a	n/a	n/a	
Olympic Park	NCA08	n/a	n/a	n/a	n/a	46 to 52	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	NCA09	n/a	n/a	n/a	n/a	46 to 50	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
North Strathfield	NCA10	n/a	n/a	52 to 52	57 to 57	46 to 56	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	45 to 66	55 to 55	
	NCA11	n/a	n/a	55 to 55	60 to 60	48 to 59	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	43 to 55	58 to 58	
Burwood North	NCA12	n/a	n/a	n/a	n/a	48 to 69	n/a	n/a	46	57	n/a	n/a	n/a	n/a	n/a	n/a	
	NCA13	n/a	n/a	n/a	n/a	49 to 69	n/a	n/a	39	43	n/a	n/a	n/a	n/a	n/a	n/a	
Five Dock	NCA14	n/a	n/a	n/a	n/a	45 to 63	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	NCA15	n/a	n/a	n/a	n/a	57 to 67	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
The Bays	NCA20	n/a	n/a	n/a	n/a	42 to 45	n/a	n/a	36	48	n/a	n/a	n/a	n/a	n/a	n/a	
	NCA21	n/a	n/a	n/a	n/a	42 to 45	n/a	n/a	36	48	n/a	n/a	n/a	n/a	n/a	n/a	
	NCA22	n/a	n/a	n/a	n/a	<30 to 38	n/a	n/a	30	41	n/a	n/a	n/a	n/a	n/a	n/a	
Pyrmont	NCA23	n/a	n/a	n/a	n/a	41 to 78	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	NCA24	n/a	n/a	n/a	n/a	53 to 65	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Hunter Street	NCA25	n/a	n/a	n/a	n/a	<30 to 50	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
	NCA26	n/a	n/a	n/a	n/a	32 to 37	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	
Clyde and Rosehill	NCA04	n/a	n/a	n/a	n/a	<30 to 33	n/a	n/a	44	45	n/a	n/a	n/a	n/a	n/a	n/a	
	NCA05	n/a	n/a	n/a	n/a	35 to 46	n/a	n/a	59	59	n/a	n/a	n/a	n/a	n/a	n/a	
	NCA06	n/a	n/a	n/a	n/a	32 to 41	n/a	n/a	37	44	n/a	n/a	n/a	n/a	n/a	n/a	
	NCA07	n/a	n/a	n/a	n/a	32 to 42	n/a	n/a	35	46	n/a	n/a	n/a	n/a	n/a	n/a	

Legend

No Exceedance | 1 - 10 dB above NML | 11 - 20 dB above NML | >20 dB above NML

Table 23 Predicted worst-case airborne noise impacts from surface construction sites – commercial

Study area	NCA	Predicted worst case $L_{Aeq(15minute)}$ noise level (dBA)																					
		Site establishment & public domain work		Piling		Station / facility construction			Rail system access shaft		Earthworks / Excavation		Above ground rail		Brownfield work / Road work	
		Typical	Peak	Typical	Peak	Typical	Peak 1	Peak 2	Typical	Peak	Typical	Peak	Typical	Peak	Typical	Peak
Westmead	NCA01	41 to 52	47 to 58	44 to 65	49 to 70	39 to 49	45 to 55	56 to 66	n/a	n/a	64 to 64	78 to 78	45 to 57	60 to 72	49 to 59	58 to 78
	NCA02	36 to 50	42 to 56	32 to 51	37 to 56	36 to 46	42 to 52	53 to 63	n/a	n/a	41 to 41	55 to 55	31 to 39	46 to 54	<30 to 41	35 to 45
Parramatta	NCA03	53 to 76	59 to 82	55 to 78	60 to 83	50 to 73	56 to 79	67 to 90	51	65	58 to 82	72 to >90	n/a	n/a	n/a	n/a
Olympic Park	NCA08	50 to 69	56 to 75	55 to 72	60 to 77	50 to 67	56 to 73	67 to 84	n/a	n/a	56 to 75	60 to 79	n/a	n/a	n/a	n/a
	NCA09	<30 to 40	34 to 46	37 to 42	42 to 47	32 to 37	38 to 43	49 to 54	n/a	n/a	33 to 45	37 to 49	n/a	n/a	n/a	n/a
North Strathfield	NCA10	53 to 67	59 to 73	55 to 70	60 to 75	50 to 57	56 to 63	67 to 74	n/a	n/a	59 to 63	63 to 67	n/a	n/a	51 to 75	73 to 73
	NCA11	52 to 70	58 to 76	57 to 69	62 to 74	52 to 64	58 to 70	69 to 81	n/a	n/a	61 to 69	65 to 73	n/a	n/a	47 to 56	65 to 65
Burwood North	NCA12	45 to 59	51 to 65	47 to 56	52 to 61	42 to 51	48 to 57	59 to 68	41	43	n/a	n/a	n/a	n/a	n/a	n/a
	NCA13	51 to 71	57 to 77	51 to 64	56 to 69	46 to 63	52 to 69	63 to 80	40	42	n/a	n/a	n/a	n/a	n/a	n/a
Five Dock	NCA14	47 to 57	53 to 63	53 to 58	58 to 63	48 to 53	54 to 59	65 to 70	n/a	n/a	60 to 61	74 to 75	n/a	n/a	n/a	n/a
	NCA15	58 to 62	64 to 68	57 to 60	62 to 65	52 to 55	58 to 61	69 to 72	n/a	n/a	60 to 63	74 to 77	n/a	n/a	n/a	n/a
The Bays	NCA20	<30 to 48	31 to 54	44 to 47	49 to 52	39 to 42	45 to 48	56 to 59	33	44	n/a	n/a	n/a	n/a	<30 to 40	48 to 60
	NCA21	41 to 73	47 to 79	48 to 56	53 to 61	43 to 51	49 to 57	60 to 68	40	55	n/a	n/a	n/a	n/a	57 to 77	77 to >90
	NCA22	<30 to 51	31 to 57	37 to 47	42 to 52	32 to 42	38 to 48	49 to 59	36	44	n/a	n/a	n/a	n/a	<30 to 41	44 to 61
Pyrmont	NCA23	49 to 69	55 to 75	49 to 68	54 to 73	44 to 63	50 to 69	61 to 80	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	NCA24	55 to 69	61 to 75	57 to 70	62 to 75	52 to 65	58 to 71	69 to 82	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Hunter Street	NCA25	57 to 81	63 to 87	59 to 84	64 to 89	54 to 79	60 to 85	71 to >90	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	NCA26	53 to 81	59 to 87	56 to 84	61 to 89	51 to 79	57 to 85	68 to >90	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Clyde and Rosehill	NCA04	<30 to 50	<30 to 56	<30 to 51	31 to 56	<30 to <30	30 to 35	41 to 46	33	36	<30 to 57	30 to 59	<30 to 47	39 to 62	n/a	n/a
	NCA05	31 to 54	37 to 60	34 to 53	39 to 58	32 to 43	38 to 49	49 to 60	39	48	40 to 61	42 to 63	30 to 49	45 to 64	n/a	n/a
	NCA06	32 to 51	38 to 57	35 to 52	40 to 57	35 to 43	41 to 49	52 to 60	39	47	41 to 59	43 to 61	31 to 48	46 to 63	n/a	n/a
	NCA07	32 to 73	38 to 79	36 to 76	41 to 81	37 to 52	43 to 58	54 to 69	55	55	41 to 82	43 to 84	32 to 72	47 to 87	n/a	n/a

Legend

No Exceedance | 1 - 10 dB above NML | 11 - 20 dB above NML | >20 dB above NML

The above assessment of the worst-case impacts shows that:

- The airborne noise impacts from the construction sites vary depending on how close the nearest receivers are and the type of work required. Sites with adjacent residential receivers such as Burwood North, Five Dock and Pyrmont are predicted to have 'moderate' to 'high' worst-case impacts during the noisiest work activities.
- The highest impacts are seen in the 'peak' scenarios, particularly where noise intensive equipment such as rockbreakers, concrete saws or rail tampers are used during outdoor surface work. For most scenarios, the 'peak' work would only be required for relatively short periods of the total duration and noise impacts during 'typical' work, which do not require noise intensive equipment, are considerably lower. Further information on the relative duration of the use of this equipment at each of the relevant sites is provided in **Section 5.2**.
- During the daytime, the nearest residential receivers are predicted to be impacted in most study areas to some degree. Noise levels are, however, expected to comply with the noise management levels during many of the less noisy works.
- Most of the work requiring noise intensive equipment would be completed during the daytime. Some noise intensive work is required during the evening and night-time at Westmead and North Strathfield to construct connections between the proposed metro stations and existing Sydney Trains stations. This work would be relatively short in duration and generally limited to a number of isolated two day rail possession periods.
- Individual receivers would be subject to a range of impacts. The highest impacts are seen when work is 'near' to receivers. Impacts are generally much lower when the work is 'far', due to the increased separation distance.
- Noise levels at commercial receivers are generally predicted to comply with the noise management levels. 'Moderate' to 'high' impacts are, however, predicted at some of the nearest receivers when noisy work is being completed without acoustic sheds at sites in commercial areas such as Parramatta and Hunter Street (Sydney CBD).

The predicted noise levels represent the worst-case potential impacts without any additional mitigation measures. The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

5.1.2 Overview Of Ground-Borne Noise and Vibration Impacts from Construction Sites

Vibration intensive equipment is proposed to be used at Westmead during underground concourse excavation, at Parramatta during basement excavation, at Clyde stabling and maintenance facility during earthworks and at Five Dock during basement excavation. This work would occur during only the daytime in all cases except for the underground excavation at Westmead, where work would continue during the night-time. The predicted ground-borne noise and vibration impacts in each NCA are shown in **Table 24** and **Table 25** for all receiver types.

The predictions represent the likely highest vibration levels at nearby sensitive structures during the use of vibration intensive equipment from any of the nominated work activities. The predicted ground-borne noise and vibration impacts are assessed against the appropriate management levels, with the number of exceedances presented.

Airborne construction noise levels at Clyde and Five Dock would be higher than the ground-borne noise level. Where this occurs, it is not necessary to evaluate potential ground-borne noise impacts.

Table 24 Overview of Ground-Borne Noise Exceedances – All Receiver Types

Study area	NCA	Number of Receivers									
		Total	With Ground borne NML Exceedance[1]								
			Daytime[2]			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
Westmead	NCA01	340	-	1	-	-	-	-	-	-	-
	NCA02	806	-	-	-	-	-	-	-	-	-
Parramatta[3]	NCA03	509	18	3	7	n/a	n/a	n/a	n/a	n/a	n/a

Note 1: Based on worst-case predicted ground-borne noise levels.

Note 2: Daytime ground-borne noise NMLs taken from previous Sydney Metro planning applications for consistency. Daytime ground-borne noise NMLs are not specified in the ICNG or Sydney Metro CNVS.

Note 3: Airborne noise levels are likely to be higher than ground-borne noise level at most receivers during excavation at Parramatta. The presented ground-borne noise impacts may be dominant at internal spaces which do not have windows or facades facing the construction site.

The above assessment shows that:

- Ground-borne noise from the underground tunnelling at Westmead is predicted to comply with the management levels for all receivers except for the existing Westmead station building.
- 'Moderate' to 'high' ground-borne noise impacts are predicted at the nearest receivers to the Parramatta metro station construction site due to receivers being relatively near to the basement excavation work. These impacts are generally at commercial and 'other sensitive' receivers.
- While daytime exceedances are predicted, neither the ICNG nor CNVS specify daytime NMLs for ground-borne noise. The assessment has used daytime ground-borne noise NMLs from previous Sydney Metro planning applications for consistency.
- The ground-borne noise predictions are based on the nearest receivers at ground floor. The ground-borne noise impacts would reduce for sensitive receivers which are further away from the work or for receivers on higher floors in multistorey buildings.
- The impacts are predicted for work being near surface level. The impacts would be expected to reduce as the excavation work progresses deeper.

Table 25 Overview of Ground-Borne Vibration Exceedances – All Receiver Types

Study area	NCA	Number of Receivers				
		Total	With Vibration Criteria Exceedance[1]			
			Cosmetic Damage	Human Comfort		Sensitive Equipment
			Day / Night	Day	Night	Day / Night
Westmead	NCA01	340	1	1	-	-
	NCA02	809	-	-	-	-
Parramatta	NCA03	513	9	11	n/a	1
Clyde	NCA04	392	-	-	n/a	-
	NCA05	482	-	16	n/a	-
	NCA06	207	-	-	n/a	-
	NCA07	2,060	5	11	n/a	-
Five Dock	NCA14	1,243	1	4	n/a	-
	NCA15	966	-	-	n/a	-

Note 1: Based on worst-case predicted vibration levels. The criteria are 25 mm/s and 7.5 mm/s for commercial buildings and residential properties, respectively (see **Table 11**).

The above assessment shows that:

- Exceedances of the cosmetic damage screening criteria and human comfort criteria are predicted at each site due to vibration sensitive structures being directly adjacent to the boundary of the sites.
- One potential exceedance of the sensitive equipment screening criteria is predicted in Parramatta where a medical clinic has been identified as potentially having vibration sensitive equipment.
- These predictions represent a worst-case situation where a large rockbreaker or vibratory roller is in use at the boundary of the site and in close proximity to certain adjacent 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.

5.2 Detailed Noise and Vibration Impacts from Construction Sites

The following sections present a detailed assessment of the likely worst-case predicted noise and vibration impacts from each of the proposed construction sites.

The predictions represent the highest impacts when the work is closest to sensitive receivers. The assessment in **Section 5.1.1** indicates that when work is further away from receivers in the 'far' scenarios, the noise levels would generally be around 10 dB to 20 dB lower than the worst-case levels.

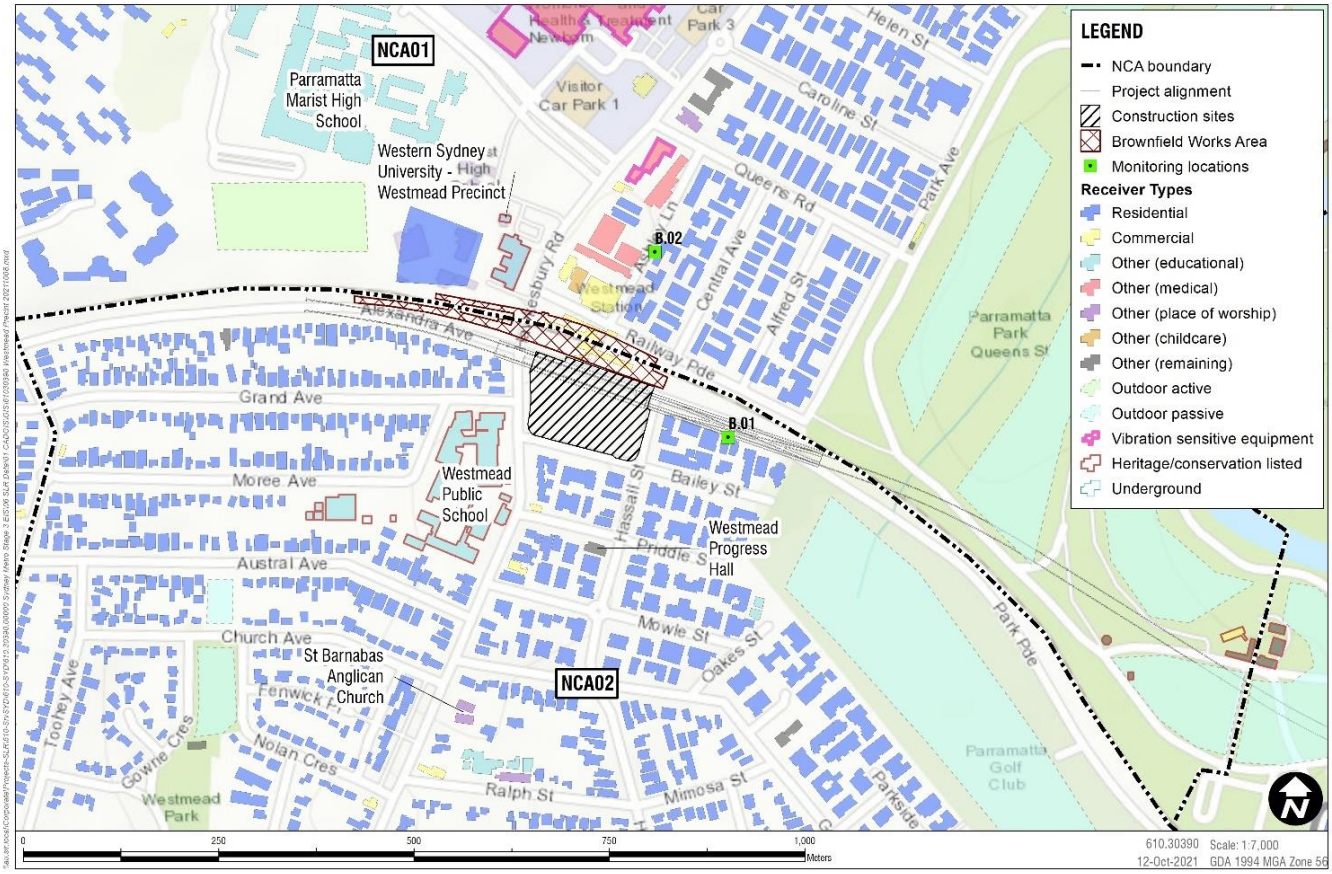
5.2.1 Westmead (NCA01 – NCA02)

The Westmead metro station construction site is generally bound by Hawkesbury Road, Bailey Street and Hassall Street. The site is mostly located to the south of the existing Westmead Station. Part of the existing Westmead Station, rail corridor and Hawkesbury Road bridge is also included where 'brownfield work' is required to widen the existing platforms, construct a new Sydney Trains aerial concourse and upgrade the western side of the bridge. This work would require slewing of the existing Sydney Train lines and demolition of the existing Westmead Station aerial concourse. Work in the rail corridor would need to be completed out of hours during short-term rail possessions when trains are not operating.

Mined excavation would also be required to construct an underground pedestrian concourse between the proposed metro station and the existing Westmead Station. Mined tunnelling work would be launched from within the metro station box and additional excavation would be required north of Alexandra Avenue within the rail corridor to complete the connection.

Existing noise levels in this study area are generally controlled by transportation noise from the surrounding road network and existing rail line. The area surrounding the construction site is generally suburban and the nearest receivers are a mixture of residential, commercial and education facilities. The site and NCAs are shown in **Figure 4**.

Figure 4 Westmead Site Map and Sensitive Receivers



5.2.1.1 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 26**. The estimated duration of each activity is also provided, noting that most activities would be intermittent and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

The proposed work is anticipated to have a total duration of around four years.

Table 26 Westmead Construction Activities and Working Hours

Scenario	Activity		Total indicative duration (months)[2]	Hours of work[1]			
				Std. day	Out of hours		
					Day OOH	Eve	Night
Sydney Metro West station construction site work							
Site establishment and public domain work	Typical	Deliveries and general work	15	✓	✓	-	-
	Peak	Construction / decommissioning of facilities and hoarding		✓	✓	-	-
Piling	Typical	Supporting work	1	✓	✓	-	-
	Peak	Bored piling with support plant		✓	✓	-	-
Station / facility construction	Typical	Indoor construction and fit-out	24	✓	✓	✓	✓
	Peak 1	Installation of framing and structure		✓	✓	✓	-
	Peak 2	Concrete work		✓	✓	✓	-
Mined tunnel	Typical	Spoil removal	6	✓	✓	✓	✓
	Peak	Mining with support		✓	✓	✓	✓
Brownfield / other off-site work							
Piling	Typical	Supporting work	Possession[3]	✓	✓	✓	✓
	Peak	Bored piling with support plant		✓	✓	✓	✓
Above-ground rail	Typical	Track installation	Possession[3]	✓	✓	✓	✓
	Peak	Track subgrade, capping and tamping		✓	✓	✓	✓
Brownfield work	Typical	Deliveries and supporting work	Possession[3]	✓	✓	✓	✓
	Peak 1	Installation of framing and structure		✓	✓	✓	✓
	Peak 2	Removal of existing structures		✓	✓	✓	✓
Excavation	Typical	Mucking out	Possession[3]	✓	✓	-	-
	Peak 1	Through soft soil/rock		✓	✓	-	-
	Peak 2	Through rock using a rockbreaker		✓	✓	-	-

Note 1: OOH = out of hours.

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.

Note 3: Work would be completed during short-term rail possessions. Two day rail possessions would likely occur four times per year, plus an additional five-day shutdown between 26-30 December.

The majority of *Piling*, *Above-ground rail, Brownfield work* and *Excavation* within the existing corridor would be completed during short-term rail possessions that run from Friday evening to early Monday morning. It is currently anticipated that about 16 individual weekend rail possessions would be required. Work would also likely occur during five-day shutdowns between December 26 and 30 in 2024, 2025 and 2026.

Sydney Metro is continuing to investigate options for the layout and use of Alexandra Avenue between Hawkesbury Road and Hassall Street, including the potential for this section of road to be regraded (to provide an accessible connection from the bus stops to the station entry) and narrowed and used for bus and emergency services only.

5.2.1.2 Overview of Airborne Noise Impacts from Construction Site

Number of NML Exceedances

The predicted airborne noise impacts from construction site work in this study area are summarised in **Table 27**, **Table 28** and **Table 29** for all receiver types, residential receivers, and commercial/'other sensitive' receivers, respectively. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding 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.

Table 27 Westmead Overview of NML Exceedances – All Receiver Types

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Sydney Metro West station construction site work																			
Site establishment & public domain work	Typical	15	943	-	12	-	-	22	4	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		943	-	26	5	-	47	11	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	1	943	-	6	-	-	21	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		943	-	24	-	-	50	4	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	24	943	-	-	-	-	4	-	-	11	-	-	40	8	-	11	-	-
	Peak 1		943	-	10	-	-	27	1	-	34	1	-	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		943	1	54	16	-	109	34	1	146	41	2	n/a	n/a	n/a	n/a	n/a	n/a
Mined tunnel	Typical	6	943	-	-	-	-	2	-	-	4	-	-	26	4	-	8	-	-
	Peak		943	-	12	-	-	31	2	-	32	3	-	119	21	3	27	4	-
Brownfield / other off-site work																			
Piling	Typical	Possession	943	-	1	1	-	5	1	-	7	-	-	32	5	-	14	-	-
	Peak		943	-	5	1	-	12	1	-	13	2	-	78	14	1	32	5	-
Above-ground rail	Typical	Possession	943	-	13	-	-	21	5	-	21	7	-	80	21	4	35	13	-
	Peak		943	11	79	20	6	193	34	12	247	44	14	389	218	48	371	103	29
Brownfield work	Typical	Possession	943	-	4	-	-	11	1	-	11	2	-	45	7	-	42	9	2
	Peak 1		943	-	17	4	-	37	9	-	42	11	1	217	36	7	49	12	2
	Peak 2		943	-	10	2	-	17	5	-	24	5	-	160	18	3	64	15	2
Excavation	Typical	Possession	943	-	3	1	-	7	1	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 1		943	-	7	1	-	12	2	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		943	1	35	7	1	83	12	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 28 Westmead Overview of NML Exceedances – Residential Receivers

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Sydney Metro West station construction site work																			
Site establishment & public domain work	Typical	15	854	-	10	-	-	20	4	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		854	-	22	4	-	43	10	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	1	854	-	4	-	-	19	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		854	-	19	-	-	45	4	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	24	854	-	-	-	-	4	-	-	11	-	-	40	8	-	11	-	-
	Peak 1		854	-	7	-	-	24	1	-	34	1	-	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		854	1	51	11	-	106	29	1	144	41	2	n/a	n/a	n/a	n/a	n/a	n/a
Mined tunnel	Typical	6	854	-	-	-	-	2	-	-	4	-	-	26	4	-	8	-	-
	Peak		854	-	8	-	-	27	2	-	32	3	-	119	21	3	27	4	-
Brownfield / other off-site work																			
Piling	Typical	Possession	854	-	-	-	-	4	-	-	7	-	-	32	5	-	14	-	-
	Peak		854	-	4	-	-	11	-	-	13	2	-	78	14	1	32	5	-
Above-ground rail	Typical	Possession	854	-	11	-	-	19	5	-	21	7	-	80	21	4	38	13	-
	Peak		854	11	65	19	5	179	33	11	245	44	14	388	218	48	371	103	29
Brownfield work	Typical	Possession	854	-	2	-	-	9	1	-	11	2	-	45	7	-	42	9	2
	Peak 1		854	-	16	2	-	36	7	-	42	11	1	217	36	7	49	12	2
	Peak 2		854	-	7	1	-	14	4	-	24	5	-	160	18	3	64	15	2
Excavation	Typical	Possession	854	-	2	-	-	6	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 1		854	-	5	-	-	10	1	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		854	1	28	5	-	76	10	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 29 Westmead Overview of Commercial and 'Other Sensitive' Receiver NML Exceedances

Scenario	Activity	No. months[1]	Number of receivers								
			Commercial			Child care			Educational		
			1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	1 10 dB	1 10 dB
Sydney Metro West station construction site work											
Site establishment & public domain work	Typical	15	-	-	-	1	-	-	1	-	-
	Peak		-	-	-	1	-	-	3	1	-
Piling	Typical	1	-	-	-	1	-	-	1	-	-
	Peak		-	-	-	1	-	-	4	-	-
Station / facility construction	Typical	24	-	-	-	-	-	-	-	-	-
	Peak 1		-	-	-	1	-	-	2	-	-
	Peak 2		-	-	-	-	1	-	1	4	-
Mined tunnel	Typical	6	-	-	-	-	-	-	-	-	-
	Peak		-	-	-	1	-	-	3	-	-
Brownfield / other off-site work											
Piling	Typical	Possession	-	-	-	-	1	-	1	-	-
	Peak		-	-	-	-	1	-	1	-	-
Above-ground rail	Typical	Possession	-	-	-	1	-	-	1	-	-
	Peak		1	-	-	-	1	-	11	-	1
Brownfield work	Typical	Possession	-	-	-	1	-	-	1	-	-
	Peak 1		-	-	-	-	1	-	1	1	-
	Peak 2		1	-	-	-	1	-	2	-	-
Excavation	Typical	Possession	-	-	-	-	1	-	1	-	-
	Peak 1		-	-	-	-	1	-	2	-	-
	Peak 2		2	-	-	-	-	1	4	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.

Daytime scenarios

The highest daytime construction noise impacts are predicted during *Above-ground rail*, *Excavation* and *Station / facility construction* work when noise intensive equipment such as a rail tamper, rockbreaker or concrete saw is in use. The worst-case range of predicted daytime impacts during this work are shown in:

- **Figure 5** – *Above-ground rail – Track subgrade, capping and tamping (peak)*
- **Figure 6** – *Above-ground rail – Track installation (typical).*

The highest impact work is expected to last for:

- *Above-ground rail – Track subgrade, capping and tamping (peak)* – four days actual rail tamper use
- *Excavation – Through rock using a rockbreaker (peak 2)* – 12 weeks actual rockbreaker use.

Figure 5 Worst-Case Daytime Airborne Noise – *Above-Ground Rail – Track Subgrade, Capping and Tamping (peak)*

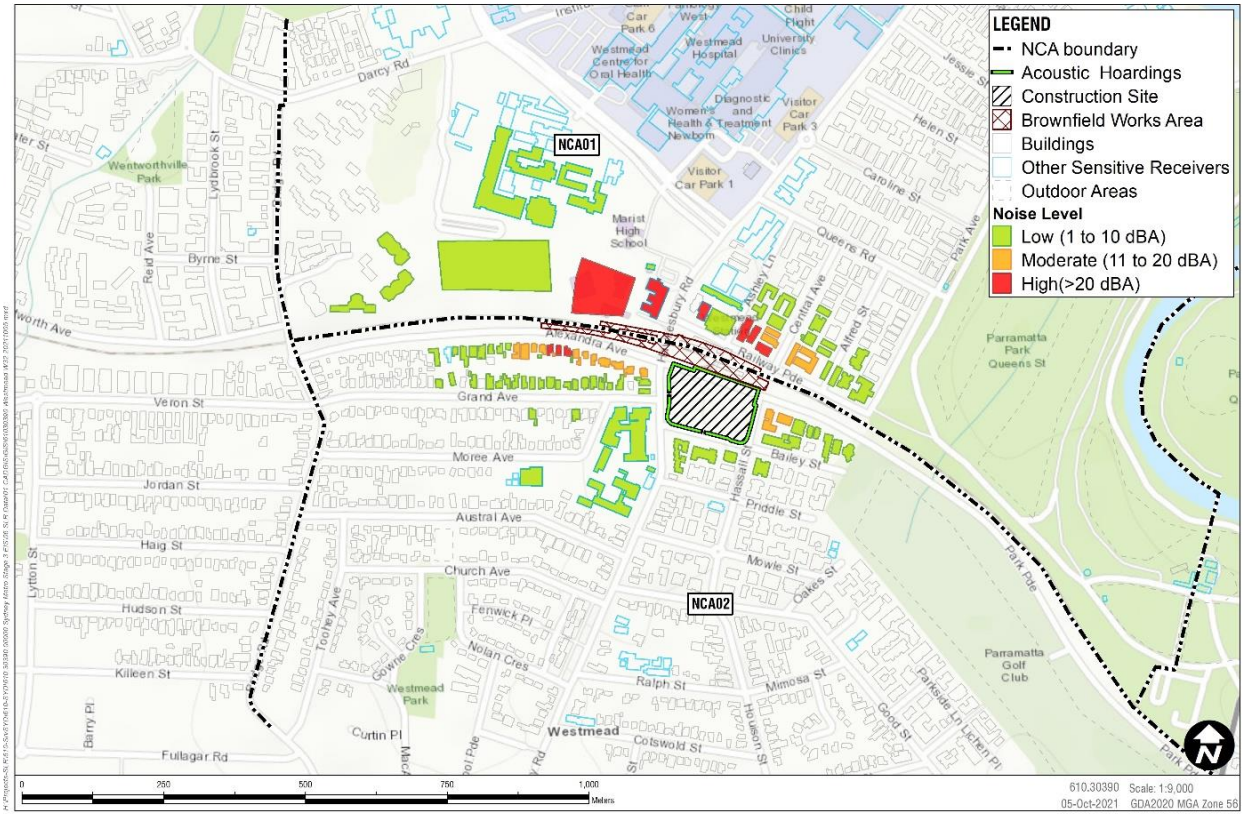
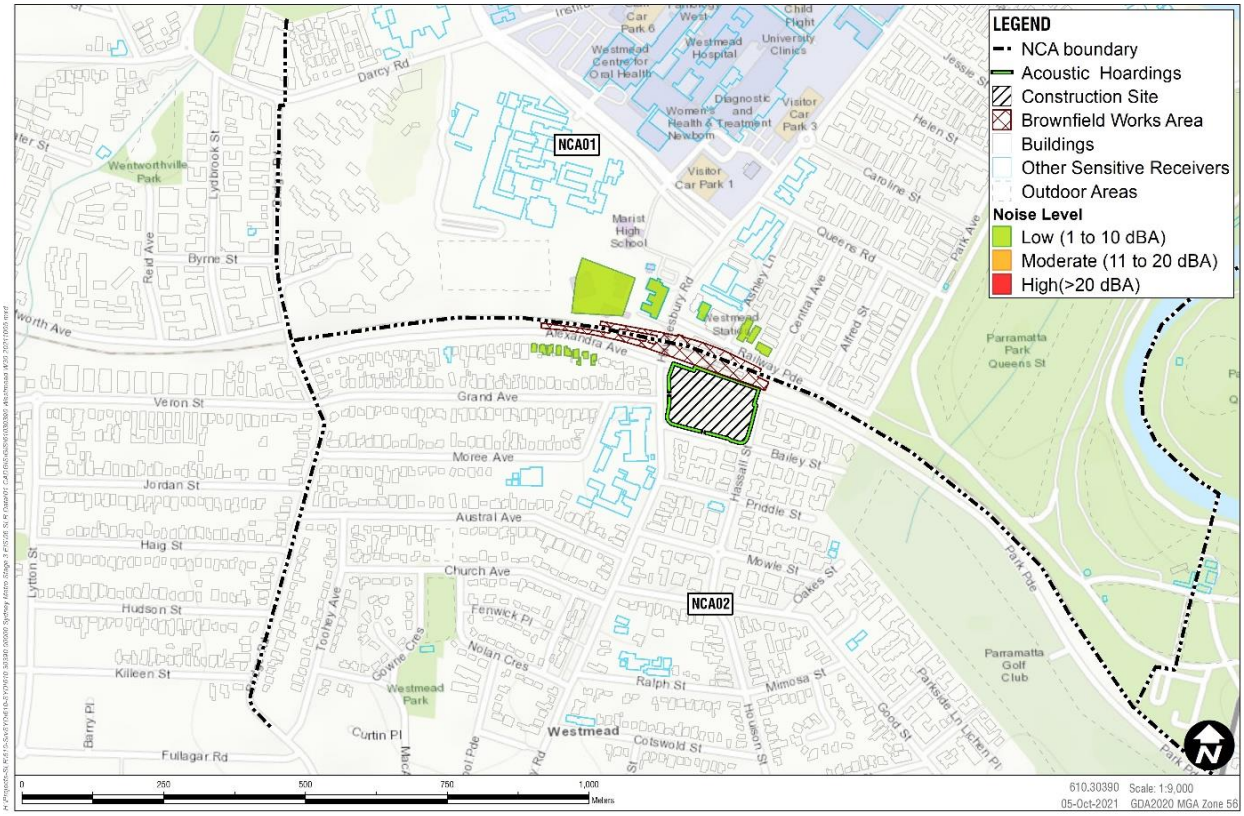


Figure 6 Worst-Case Daytime Airborne Noise – *Above-Ground Rail – Track Installation (Typical)*



The proposed work at Westmead metro station construction site would involve outdoor activities during construction of the station, along with work at the existing station platform and aerial concourse to connect the existing station to the new metro station. Track slewing is also required to accommodate platform widening. When the station structure is complete, work would move inside to complete the fit-out of the station.

The above assessment during the worst-case daytime impacts shows the following:

- Receivers are located relatively close to the construction site and impacts are predicted to be 'moderate' to 'high' during noisy outside work, particularly when noise intensive equipment such as ballast tampers, rockbreakers or concrete saws are being used as part of *Above-ground rail*, *Excavation* and *Station / facility construction* work, respectively. The total duration of ballast tamping is expected to be about four days, while rockbreakers could be used during excavation for around 12 weeks. Concrete saws are expected to be infrequently used throughout a 24 month construction period. The impacts during 'typical' work at the Westmead metro station which does not require noise intensive equipment or are inside the station are predicted to substantially reduce, with noise levels generally predicted to comply with the noise management levels or result in only 'low' impacts.
- Work at the brownfield construction site is generally predicted to result in more impacts than work within the Westmead metro station construction site. This is due to the brownfield work areas being closer to the surrounding receivers. This work would, however, be limited to short-term rail possessions.
- The 'peak' scenarios generate more noise and result in more exceedances than the 'typical' scenarios, which results from the 'peak' scenarios using noise intensive (or noisier) equipment.
- The nearest commercial and 'other sensitive' receivers are predicted to be impacted during some of the noisier outdoor work activities. Some of this work would, however, be completed at weekends under rail possessions when 'other sensitive' receivers such as child care centres and educational facilities are unlikely to be in use. 'High' or 'moderate' worst-case impacts are predicted at:
- Western Sydney University – Westmead Precinct ('high')
- Mounika's Family Day Care ('high')
- Westmead Public School ('moderate').

The highest impacts at these receivers are predicted when ballast tamping, rockbreaking or concrete saws are being used as part of *Above-ground rail*, *Excavation* and *Station / facility construction* work, respectively.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would frequently be periods when construction 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 occur.

Night-Time Scenarios

Night-time work at the Westmead metro station construction site would involve outdoor activities in the existing rail corridor during *Piling*, *Above-ground rail* and *Brownfield work* work. This work would need to be completed during short-term rail possessions when trains are not operating. It is currently anticipated that about 16 individual weekend rail possessions would be required, as well as extended five day rail possessions between December 26 to 30 in 2024, 2025 and 2026.

Station / facility construction – Indoor construction and fit-out would also occur during the night-time, however, the majority of this work would occur inside the built station structure and does not require noise intensive equipment. *Mined tunnel* work would also be completed during the night-time period.

The highest night-time construction noise impacts during rail possessions are predicted during *Above-ground rail*, *Brownfield work, Excavation* and *Piling* work when noise intensive equipment such as a rail tamper, rockbreaker or concrete saw is in use. The worst-case predicted range of night-time impacts during this work are shown in:

- **Figure 7 –** *Above-ground rail – Track subgrade, capping and tamping (peak)*
- **Figure 8** – *Above-ground rail – Track installation (typical).*

The highest impact work is expected to last for:

- *Above-ground rail – Track subgrade, capping and tamping (peak)* – four days actual rail tamper use
- *Brownfield work – Removal of existing structures (peak 2)* – two short-term weekend rail possessions.

Figure 7 Worst-Case Night-Time Airborne Noise – *Above-Ground Rail – Track Subgrade, Capping and Tamping (Peak)*

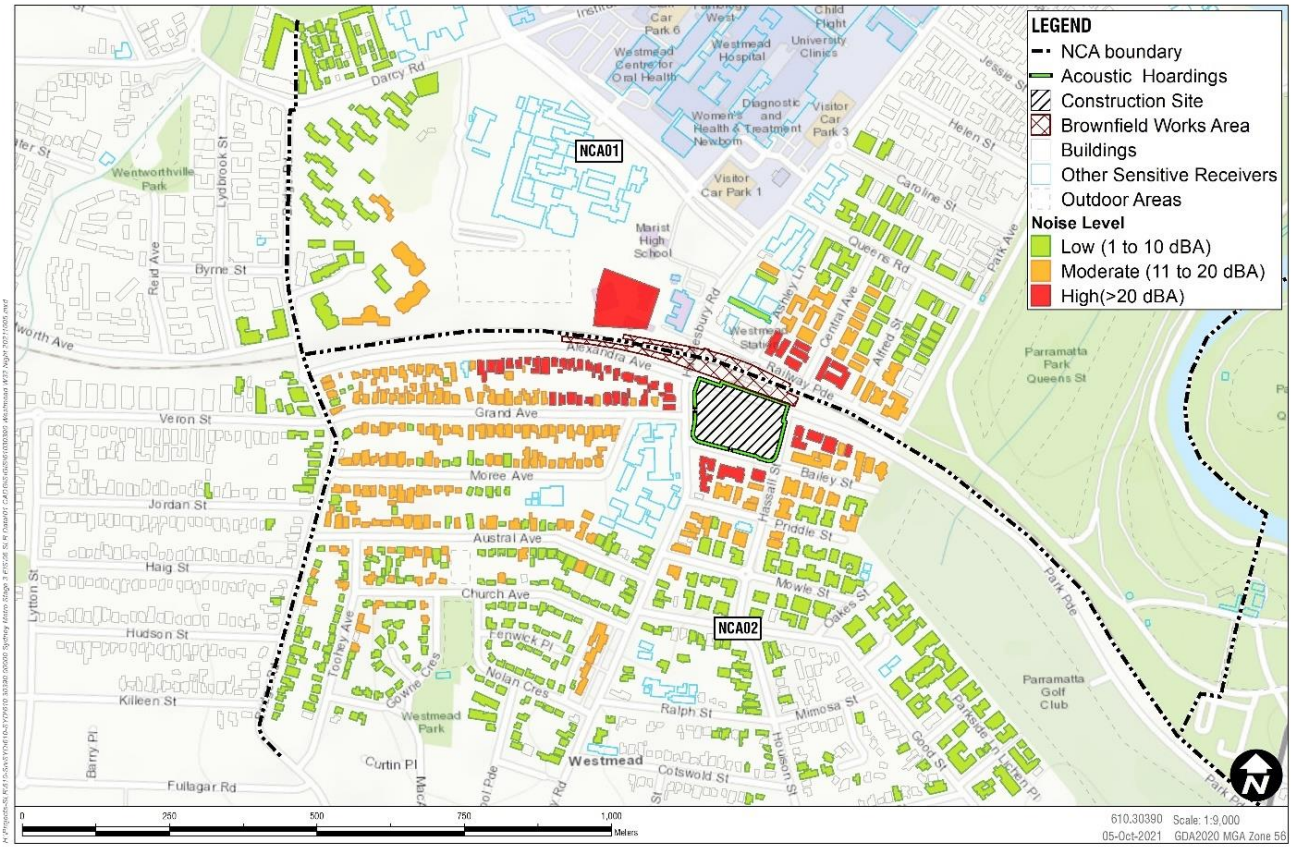
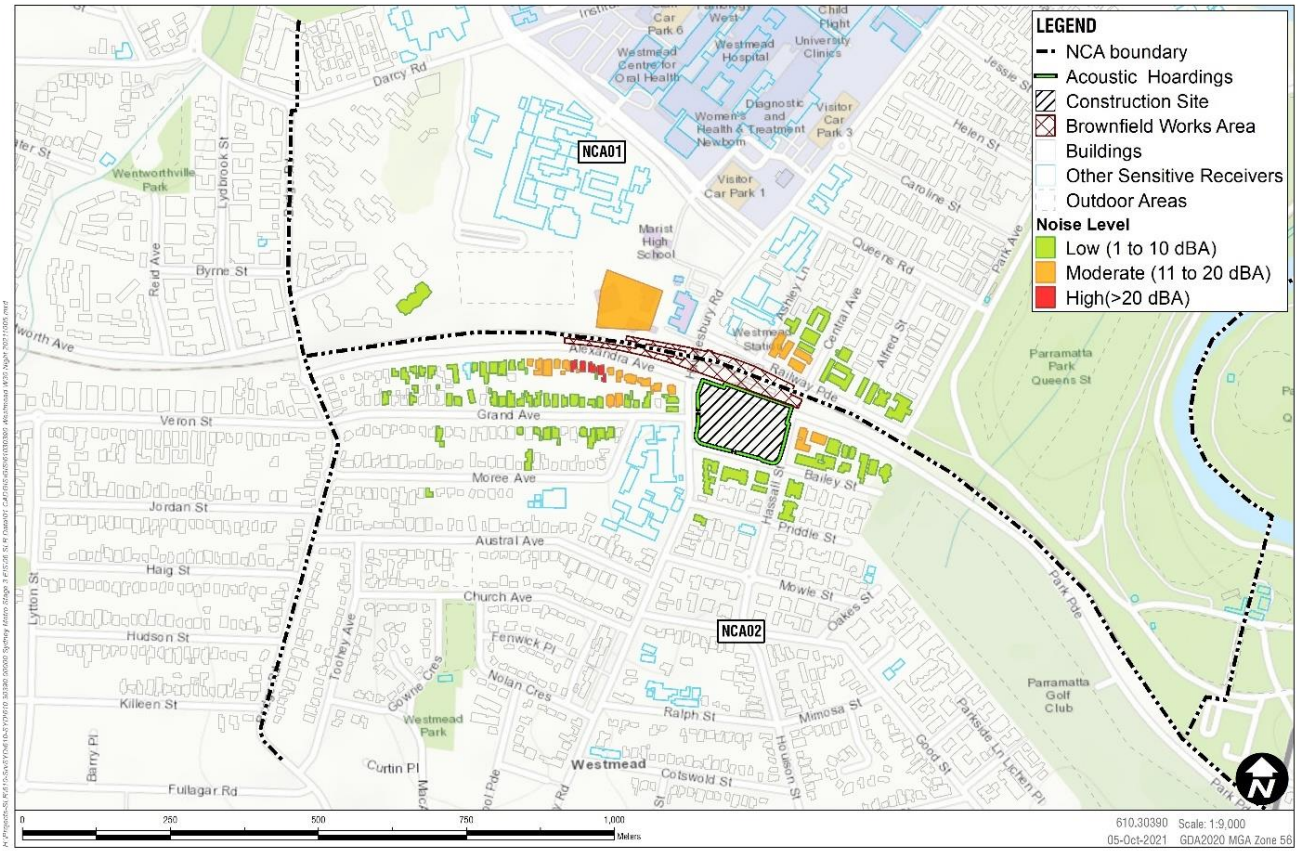


Figure 8 Worst-Case Night-Time Airborne Noise – *Above-Ground Rail – Track Installation (Typical)*



The highest night-time construction noise impacts from work within the Westmead metro station construction site are predicted during *Mined tunnel* when noise intensive equipment such as roadheaders are in use. *Station / facility construction – Indoor construction and fit-out* is also proposed during the night-time, however, the majority of this work would occur inside the built station structure and does not require noise intensive equipment during the night-time. The worst-case range of predicted night-time impacts during this work is shown in:

- **Figure 9** – *Mined tunnel – Mining with support (peak)*
- **Figure 10** – *Mined tunnel – Spoil removal (typical).*

The highest impact work is expected to last for:

- *Mined Tunnel – Mining with support (peak)* – six months, however, worst-case impacts would be limited to when work is being launched and close to the surface.

Figure 9 Worst-Case Night-Time Airborne Noise – *Mined Tunnel – Mining with Support (Peak)*

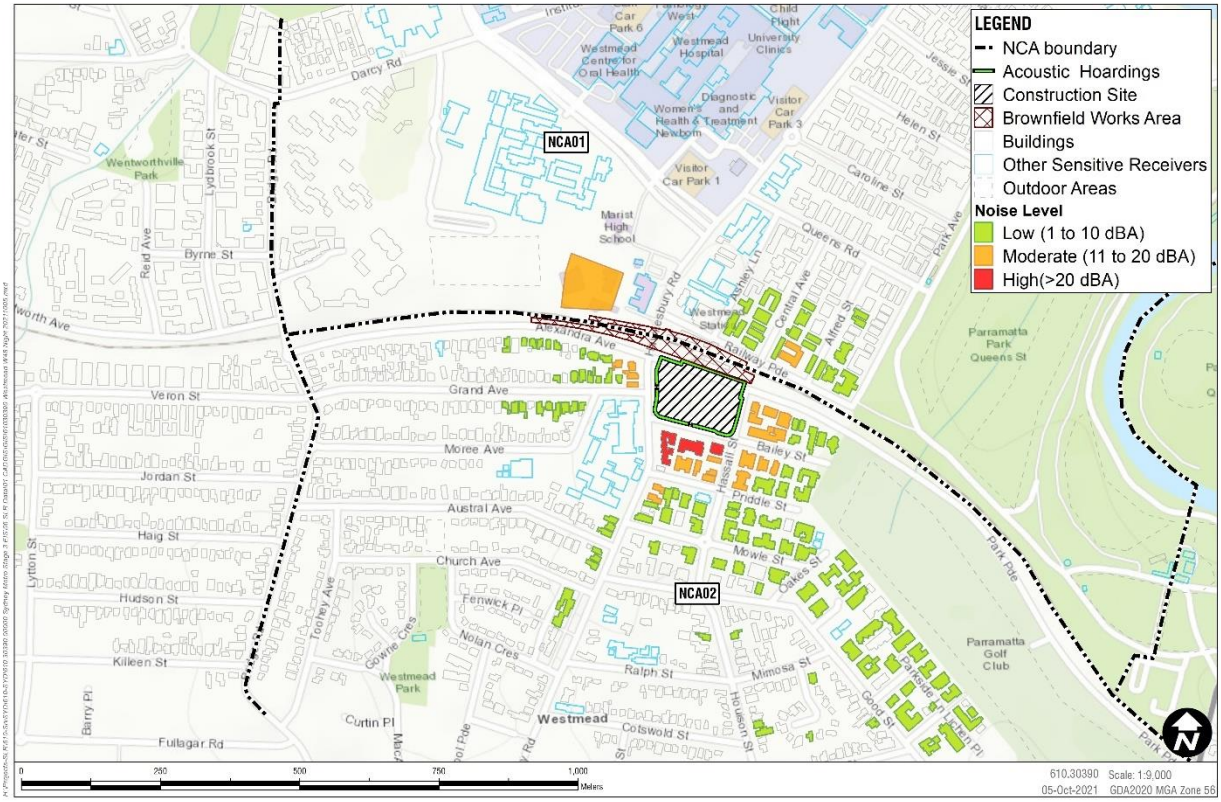
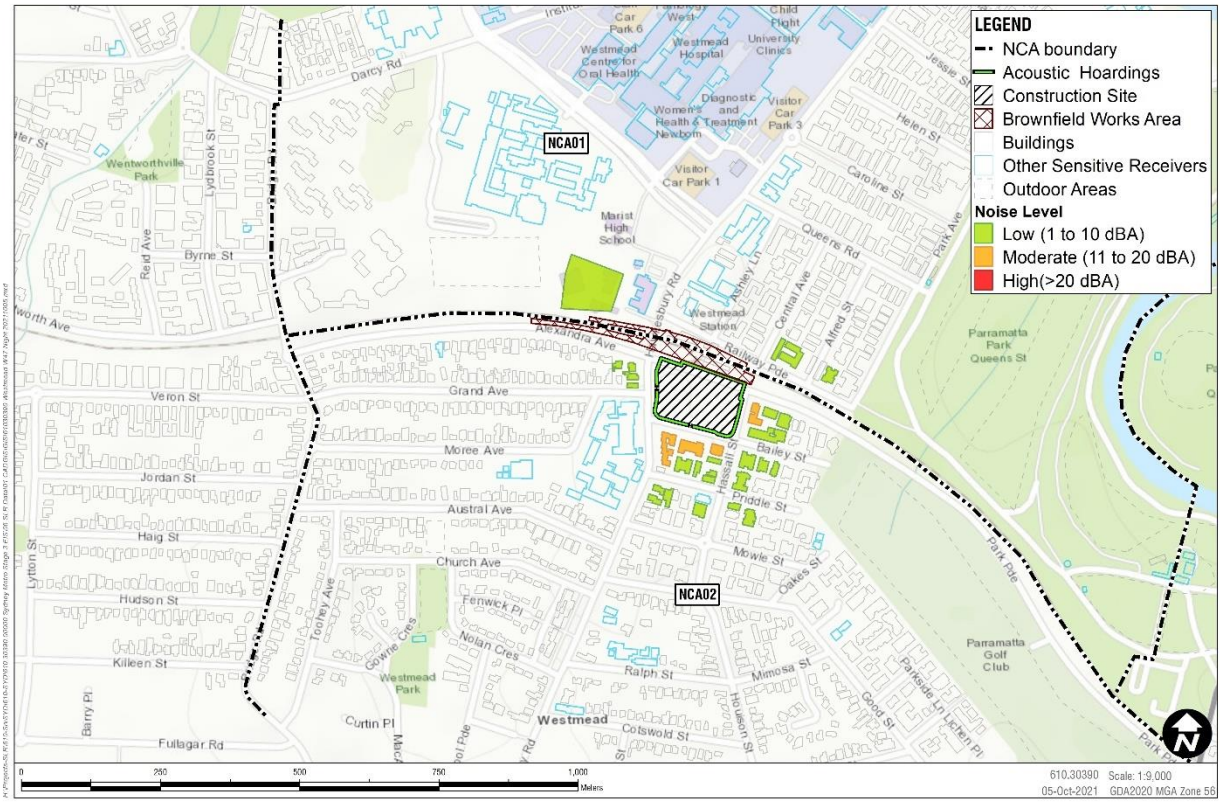


Figure 10 Worst-Case Night-Time Airborne Noise – *Mined Tunnel – Spoil Removal (Typical)*



The above assessment during the worst-case night-time impacts shows the following:

- Outdoor work during rail possessions is predicted to result in 'moderate' to 'high' impacts at the nearest residential receivers during the noisiest work, when ballast tampers or concrete saws are being used. The requirement for night-time rail possessions would be relatively minimal and the rail possessions would generally only occur over isolated weekend periods. It is expected that about 16 individual weekend rail possessions would be required, plus extended five day rail possessions between December 26 to 30 in 2024, 2025 and 2026. The total duration of ballast tamping is expected to be about four days. Concrete saws are expected to only be required at night-time during two short-term rail possessions when the existing Westmead Station concourse is demolished. The impacts are generally reduced to 'low' or 'moderate' at the nearest receivers when noise intensive equipment is not in being used during these activities, and fewer receivers are predicted to be impacted.
- 'Moderate' to 'high' impacts are predicted during the *Mined Tunnel* work within the Westmead metro station construction site when work is near the surface. 'Low' impacts are generally predicted during internal *Station / facility construction* work, with a small number of the nearest receivers are predicted to have 'moderate' impacts during the noisiest activities.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would be periods when construction 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 occur.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed and is summarised in **Table 27**. 'Moderate' to 'high' sleep disturbance impacts are predicted at several of the nearest residential receivers when noise intensive equipment is being used during rail possessions for *Above ground rail*, *Brownfield work* and *Excavation*. The 'high' impacts are generally limited to receivers on Alexandra Avenue and Railway Parade which are directly adjacent to the rail corridor.

The number of potential night-time awakenings would depend on several factors, including the type of equipment being used and the duration of the noisy work. The requirement for night-time rail possessions would be relatively minimal and the rail possessions would generally only occur over isolated weekend periods.

Further investigation of awakenings would be completed during the next stages of the proposal when detailed construction planning information becomes available.

Highly Noise Affected Residential Receivers

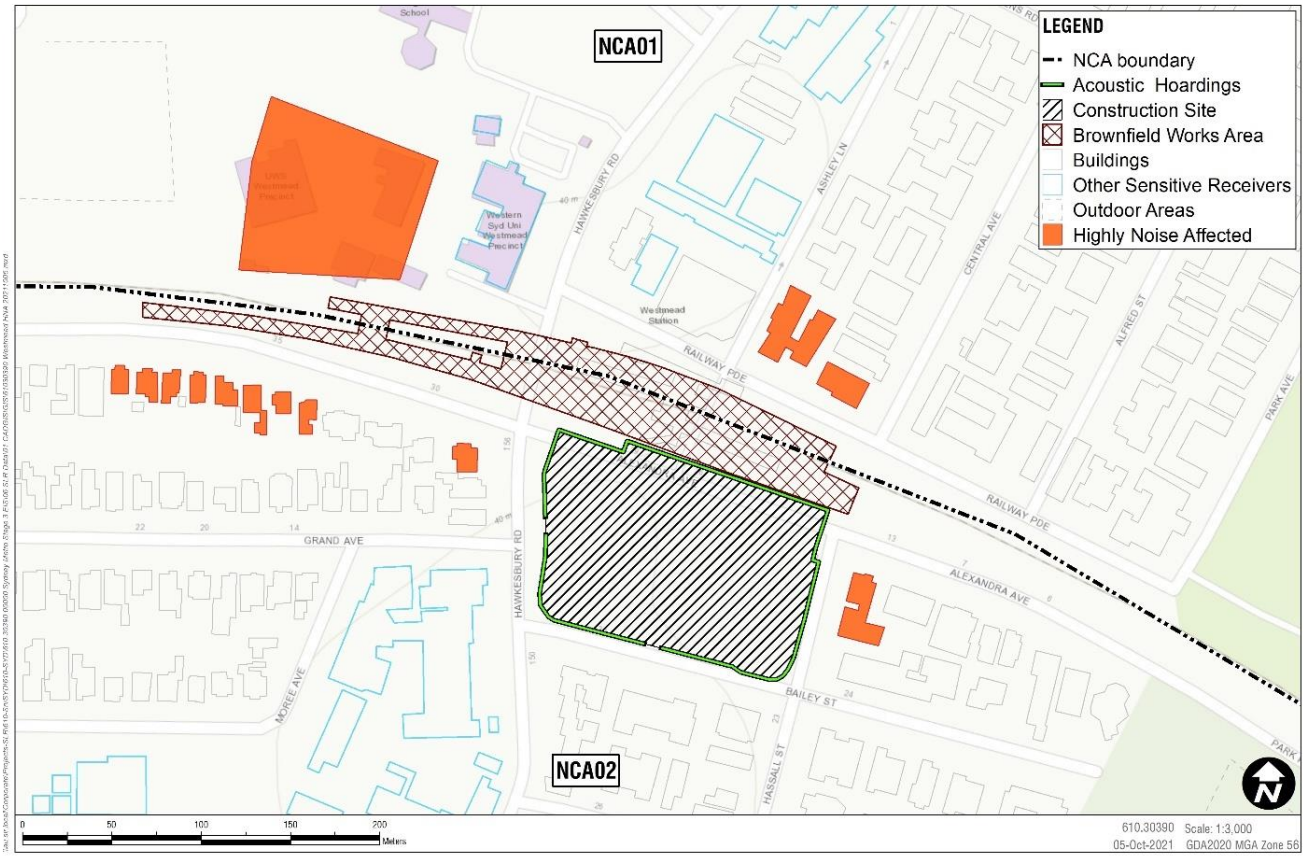
The receivers predicted to be highly noise affected are summarised in **Table 30** and shown in **Figure 11**.

Table 30 Westmead Predicted Number of Highly Noise Affected Residential Receivers

Scenario	Activity		NCA01			NCA02		
			Day	Eve	Night	Day	Eve	Night
Sydney Metro West station construction site work								
Site establishment and public domain work	Typical	Deliveries and general work	-	n/a	n/a	-	n/a	n/a
	Peak	Construction / decommissioning of facilities and hoarding	-	n/a	n/a	-	n/a	n/a
Piling	Typical	Supporting work	-	n/a	n/a	-	n/a	n/a
	Peak	Bored piling with support plant	-	n/a	n/a	-	n/a	n/a
Station / facility construction	Typical	Indoor construction and fit-out	-	-	-	-	-	-
	Peak 1	Installation of framing and structure	-	-	n/a	-	-	n/a
	Peak 2	Concrete work	-	-	n/a	1	1	n/a
Mined tunnel	Typical	Spoil removal	-	-	-	-	-	-
	Peak	Mining with support	-	-	-	-	-	-
Brownfield / other off-site work								
Piling	Typical	Supporting work	-	-	-	-	-	-
	Peak	Bored piling with support plant	-	-	-	-	-	-
Above-ground rail	Typical	Track installation	-	-	-	-	-	-
	Peak	Track subgrade, capping and tamping	3	3	3	8	8	8
Brownfield work	Typical	Deliveries and supporting work	-	-	-	-	-	-
	Peak 1	Installation of framing and structure	-	-	-	-	-	-
	Peak 2	Removal of existing structures	-	-	-	-	-	-
Excavation	Typical	Mucking out	-	-	-	-	-	-
	Peak 1	Through soft soil/rock	-	-	-	-	-	-
	Peak 2	Through rock using a rockbreaker	-	-	-	1	1	1

Note 1: 'n/a' represents where work would not be performed during the evening or night-time periods.

Figure 11 Westmead Highly Noise Affected Residential Receivers (From Any Work Scenario)



The assessment shows that some of the nearest residential receivers on Alexandra Avenue and Railway Parade with line of sight to the work areas are predicted to be highly noise affected when ballast tampers, rockbreakers or concrete saws are being used outside.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

5.2.1.3 Ground-Borne Noise Impacts from Construction Site

Vibration intensive work at the Westmead metro station construction site would include mined tunnelling and excavation work.

The existing Westmead Station is the only receiver predicted to be impacted by ground-borne noise from the excavation and tunnelling work. 'Moderate' worst-case exceedances are predicted at commercial spaces within the station due to their close proximity to the work.

It is noted that neither the ICNG nor CNVS specify daytime NMLs for ground-borne noise. The assessment has used daytime ground-borne noise NMLs from previous Sydney Metro planning applications for consistency.

5.2.1.4 Vibration Impacts from Construction Site

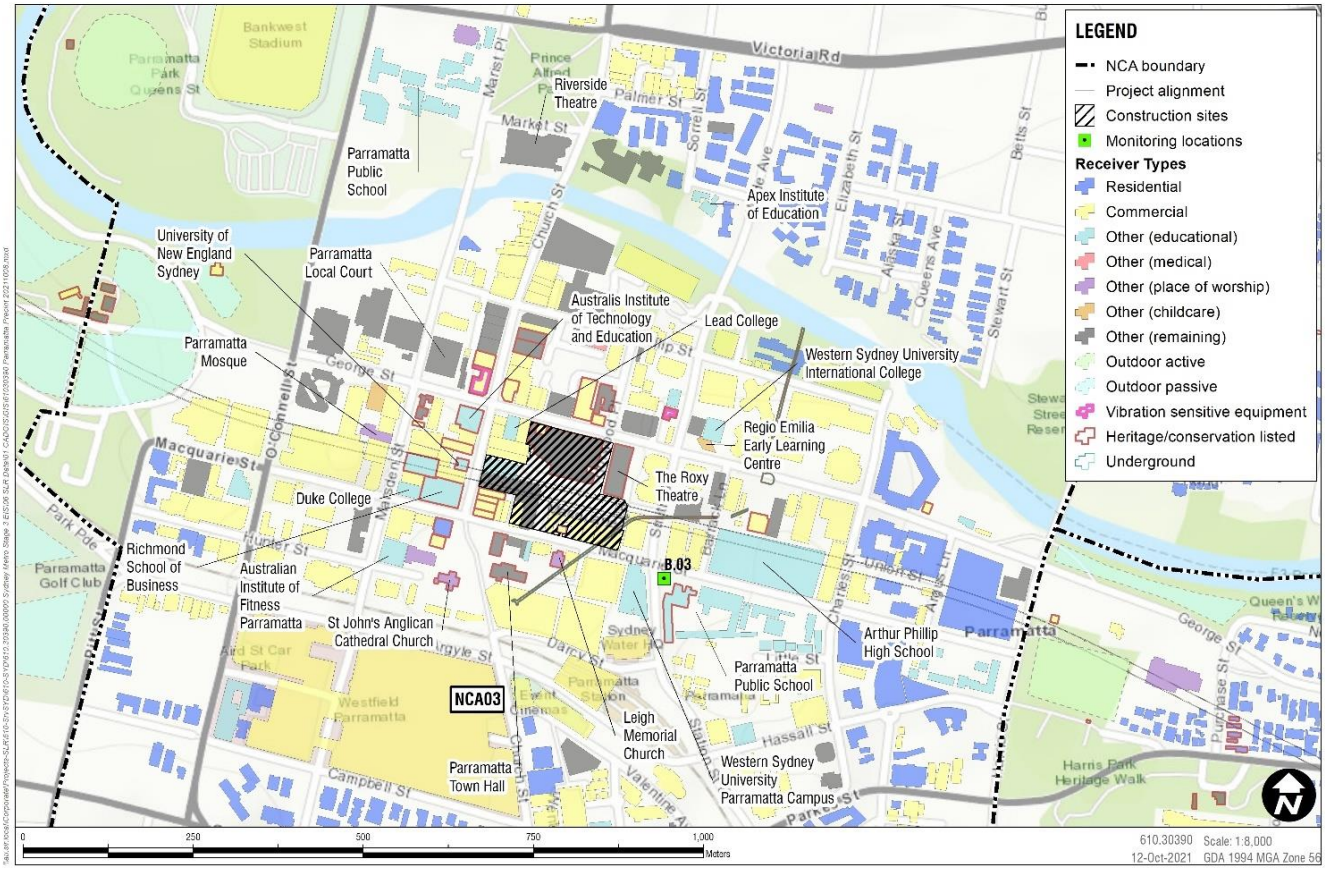
Vibration from excavation and tunnelling work at the Westmead metro station construction site is predicted to comply with the management levels at all receivers except for the existing Westmead Station, where the cosmetic damage and human comfort criteria are predicted to be exceeded.

5.2.2 Parramatta (NCA03)

The Parramatta metro station construction site is between George Street to the north, Smith Street to the east, Macquarie Street to the south and Church Street to the west. The site would have an access shaft to provide a tunnel access point for delivery of construction materials. This would occur up to 24 hours per day and seven days per week to support tunnel fit-out. The access shaft would be within an acoustic shed to mitigate impacts. Additional excavation would be required across the majority of the site beyond the extent of work under the previous Sydney Metro West planning application.

Existing noise levels in this study area are controlled by road traffic noise and general urban hum associated with the CBD. As with any CBD, existing noise levels and are relatively high during all periods. The area surrounding the construction site is mainly commercial and the nearest receivers (general office or retail) are close to the boundary of the site. The site and NCAs are shown in **Figure 12**.

Figure 12 Parramatta Site Map and Sensitive Receivers



5.2.2.1 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 31**. The estimated duration of each activity is also provided, noting that most activities would be intermittent and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

The proposed work is anticipated to have a total duration of around four years.

Table 31 Parramatta Construction Activities and Working Hours

Scenario	Activity		Total indicative duration (months)[2]	Hours of work[1]			
				Std. day	Out of hours		
					Day OOH	Eve	Night
Site establishment and public domain work	Typical	Deliveries and general work	18	✓	✓	-	-
	Peak	Construction / decommissioning of facilities and hoarding		✓	✓	-	-
Piling	Typical	Supporting work	6	✓	✓	-	-
	Peak	Bored piling with support plant		✓	✓	-	-
Station / facility construction	Typical	Indoor construction and fit-out	27	✓	✓	✓	✓
	Peak 1	Installation of framing and structure		✓	✓	✓	-
	Peak 2	Concrete work		✓	✓	✓	-
Rail systems access shafts	Typical	Surface support	9	✓	✓	✓	✓
	Peak	Deliveries and tunnel access		✓	✓	✓	✓
Excavation	Typical	Mucking out	9	✓	✓	-	-
	Peak 1	Through soft soil/rock		✓	✓	-	-
	Peak 2	Through rock using a rockbreaker		✓	✓	-	-

Note 1: OOH = out of hours.

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.

5.2.2.2 Overview of Airborne Noise Impacts from Construction Site

Number of NML Exceedances

The predicted airborne noise impacts from construction site work in this study area are summarised in **Table 32**, **Table 33** and **Table 34** for all receiver types, residential receivers, and commercial/'other sensitive' receivers, respectively. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding 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.

Table 32 Parramatta Overview of NML Exceedances – All Receiver Types

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	481	-	9	3	-	9	3	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		481	-	27	10	-	27	10	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	6	481	-	9	3	-	9	3	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		481	-	14	8	1	14	8	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	27	481	-	8	1	-	8	1	-	-	-	-	1	-	-	-	-	-
	Peak 1		481	-	9	4	-	9	4	-	3	-	-	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		481	-	41	10	4	42	10	4	4	4	-	n/a	n/a	n/a	n/a	n/a	n/a
Rail systems access shafts	Typical	9	481	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak		481	-	1	-	-	1	-	-	1	-	-	-	-	-	1	-	-
Excavation	Typical	9	481	-	15	8	-	15	8	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 1		481	-	28	9	2	28	9	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		481	-	49	28	11	50	28	11	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 33 Parramatta Overview of NML Exceedances – Residential Receivers

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	161	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		161	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	6	161	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		161	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	27	161	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
	Peak 1		161	-	-	-	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		161	-	-	-	-	1	-	-	2	-	-	n/a	n/a	n/a	n/a	n/a	n/a
Rail systems access shafts	Typical	9	161	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak		161	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Excavation	Typical	9	161	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 1		161	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		161	-	1	-	-	2	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 34 Parramatta Overview of Commercial and 'Other Sensitive' Receiver NML Exceedances

Scenario	Activity	No. Months[1]	Number of Receivers																				
			Commercial			Café/bars			Child Care			Educational			Public Building			Place of Worship			Passive Recreation		
			1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	5	-	-	-	-	-	-	-	-	4	1	-	-	1	-	-	1	-	-	-	-
	Peak		11	3	-	5	-	-	2	-	-	5	5	-	1	1	-	2	1	-	1	-	-
Piling	Typical	6	4	-	-	-	-	-	-	-	-	5	1	-	-	1	-	-	1	-	-	-	-
	Peak		5	2	-	-	-	-	1	-	-	4	5	-	1	-	1	2	1	-	1	-	-
Station / facility construction	Typical	27	2	-	-	-	-	-	-	-	-	5	-	-	-	1	-	1	-	-	-	-	-
	Peak 1		5	-	-	-	-	-	-	-	-	4	2	-	-	1	-	-	1	-	-	-	-
	Peak 2		16	6	-	4	-	-	2	-	-	10	4	2	3	-	1	3	-	1	2	-	-
Rail systems access shafts	Typical	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak		-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
Excavation	Typical	9	6	3	-	1	-	-	1	-	-	6	3	-	-	1	-	1	1	-	-	-	-
	Peak 1		12	4	-	3	-	-	2	-	-	7	5	-	1	-	1	2	-	1	1	-	-
	Peak 2		20	12	4	4	3	-	-	2	-	15	7	5	4	1	1	2	2	1	1	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.

Daytime Scenarios

The highest daytime construction noise impacts are predicted during *Excavation* and *Station / facility construction* when rockbreakers or concrete saws are in use. The worst-case range of predicted daytime impacts during this work are shown in:

- **Figure 13** – *Excavation – Through rock using a rockbreaker (peak 2)*
- **Figure 14** – *Excavation – Mucking out (typical).*

The highest impact work is expected to last for:

- *Excavation – Through rock using a rockbreaker (peak 2)* – 20 weeks actual rockbreaker use
- *Station / facility construction – Concrete work (peak 2)* – 27 months, however, concrete saws would only be used intermittently as required for crack control when slabs are poured.

Figure 13 Worst-Case Daytime Airborne Noise – *Excavation – Through Rock using a Rockbreaker (peak 2)*

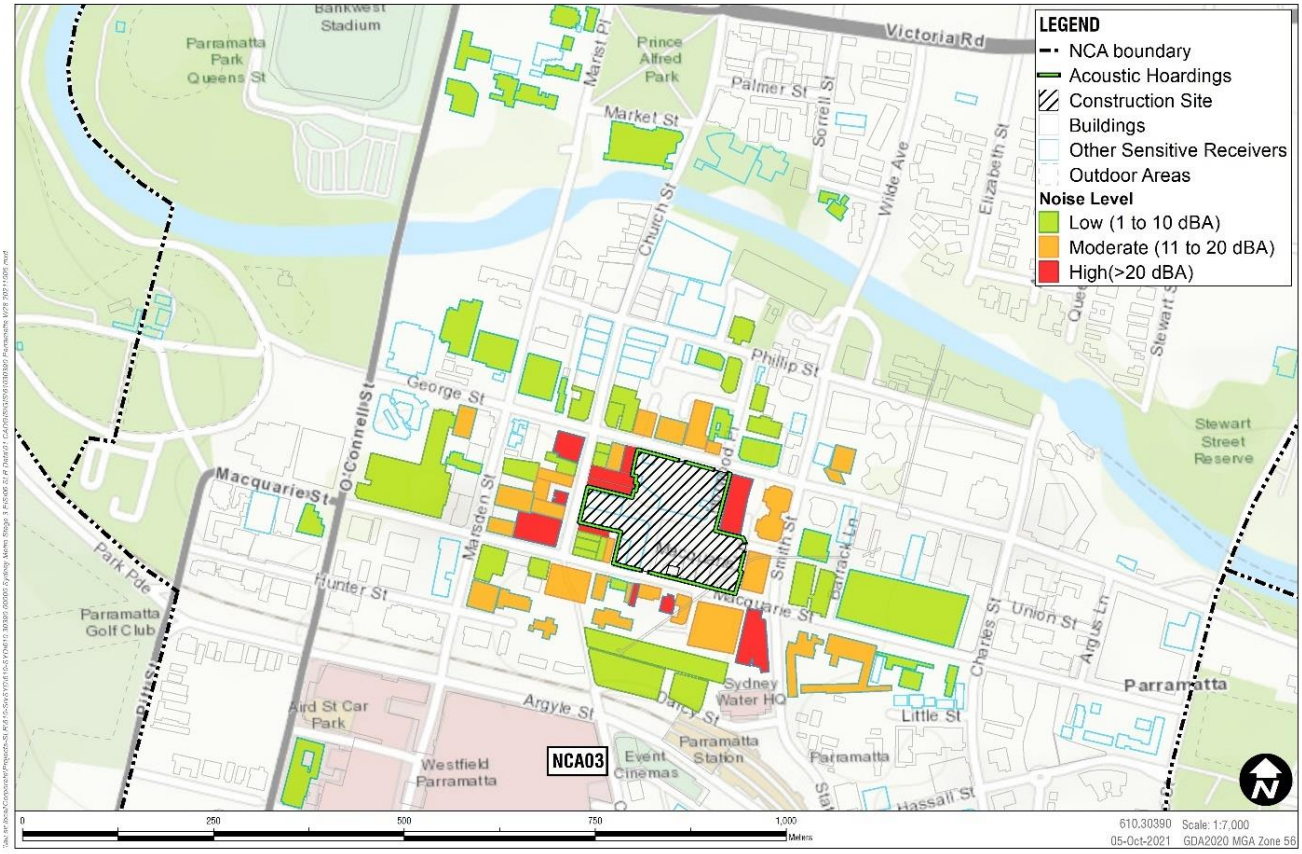
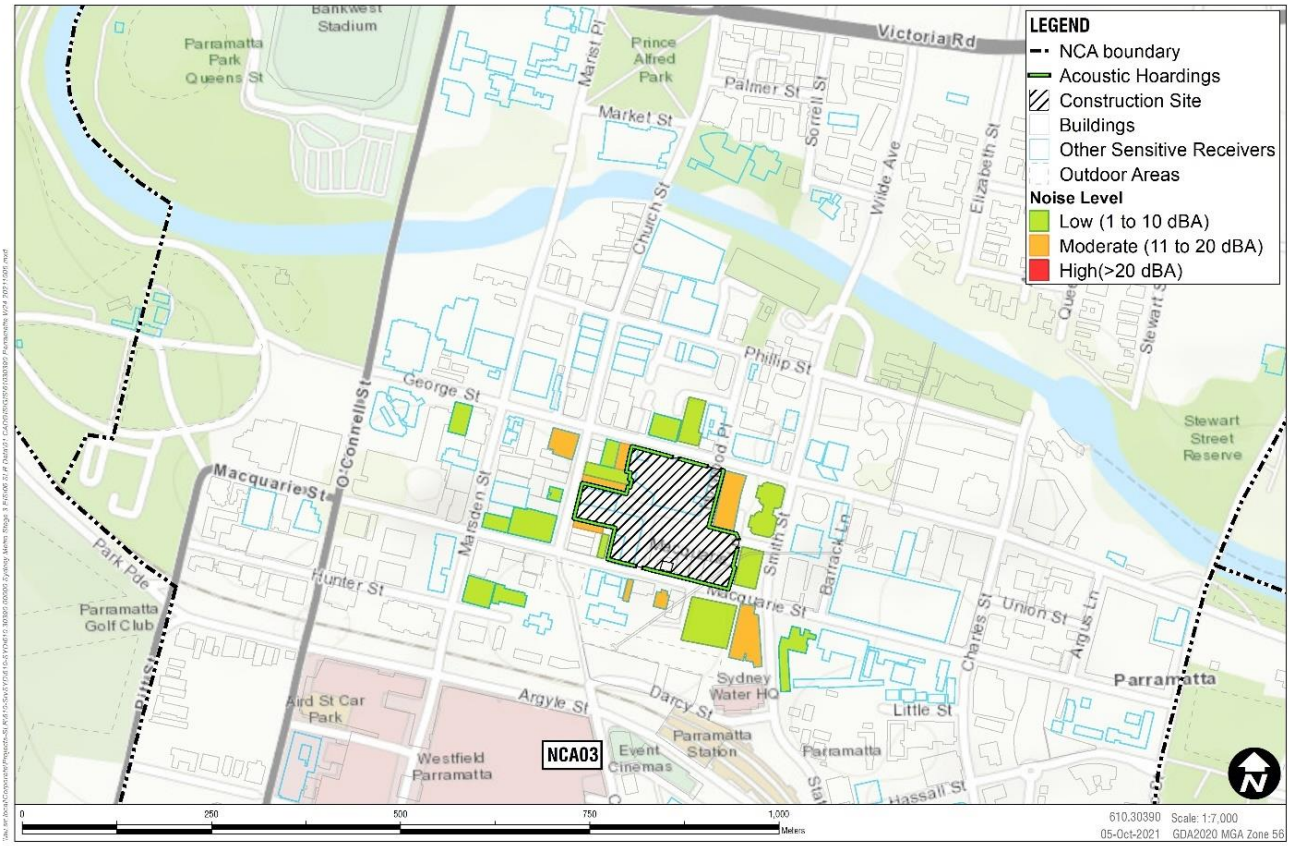


Figure 14 Worst-Case Daytime Airborne Noise – *Excavation – Mucking Out (Typical)*



The proposed work at Parramatta metro station construction site would involve excavation work and outdoor activities during construction of the station. When the station structure is complete, work would move inside to complete the fit-out of the station. The site would also have an access shaft to provide a tunnel access point for delivery of construction materials.

The above assessment during the worst-case daytime impacts shows the following:

- Residential receivers are distant from the site and the closest surrounding receivers are generally commercial and 'other sensitive'. 'Moderate' to 'high' impacts are predicted at the nearest receivers when noise intensive equipment such as rockbreakers or concrete saws are being used as part of *Excavation* and *Station / facility construction* work. The total duration of rockbreaking is expected to be about 20 weeks. Concrete saws are expected to be infrequently used throughout a 27 month construction period. The impacts during 'typical' work which does not require noise intensive equipment or are inside the station are predicted to substantially reduce, with noise levels predicted to result in 'moderate' or 'low' impacts at the nearest receivers.
- The noise levels during work associated with *Rail systems access shafts* are generally expected to comply with management levels.
- The 'peak' scenarios generate more noise and result in more exceedances than the 'typical' scenarios, which results from the 'peak' scenarios using noise intensive (or noisier) equipment.
- The nearest 'other sensitive' receivers are predicted to impacted during some of the noisier work activities. 'High' or 'moderate' worst-case impacts are predicted at:

- University of New England Sydney, Leigh Memorial Church, Roxy Theatre (noting this receiver is not currently in use), Richmond School of Business, Australis Institute of Technology and Western Sydney University Parramatta Campus ('high')
- St John's Anglican Cathedral Church, Parramatta Town Hall, Lead College, Australian Institute of Fitness Parramatta, Duke College, Western Sydney University International College, Blue Bay College, Regio Emilia Early Learning Centre, Arthur Philip High School, Centenary Square and Parramatta Early Childhood Centre ('moderate').

The highest impacts at these receivers are predicted when rockbreakers or concrete saws are being used as part of *Excavation* and *Station / facility construction* work.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would frequently be periods when construction 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 occur.

Night-Time Scenarios

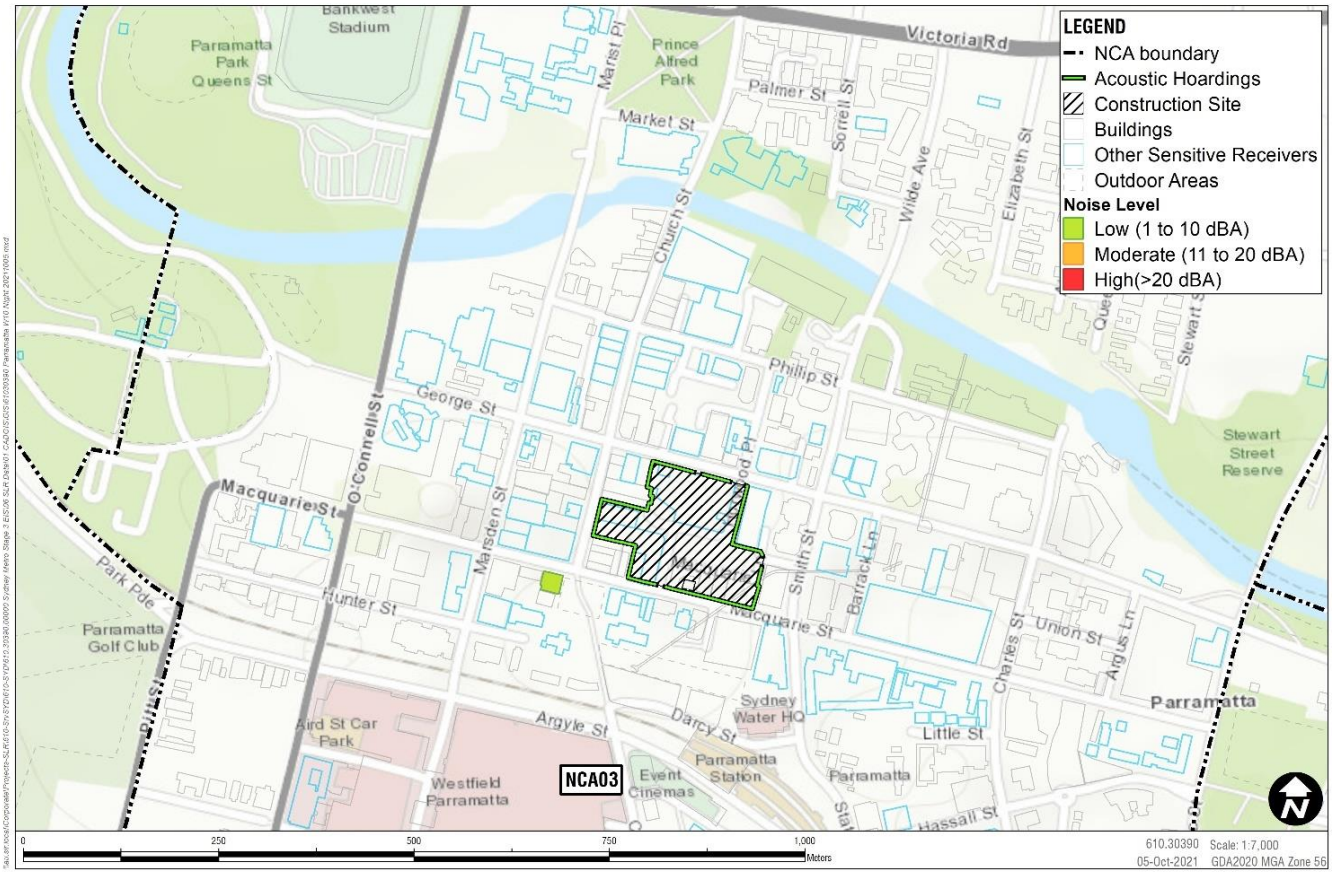
Night-time work at the Parramatta Station construction site would involve *Rail systems access shafts* and *Station / facility construction – Indoor construction and fit-out*. The majority of this work would occur inside an acoustic shed or the built station structure and does not require noise intensive equipment. The worst-case predicted night-time impacts during this work are shown in:

- **Figure 15** – *Station / facility construction – Indoor construction and fit-out (typical)*.

The work is expected to last for:

- *Station / facility construction* – 27 months.

Figure 15 Worst-Case Night-Time Airborne Noise – *Station / Facility Construction – Indoor Construction and Fit-Out (Typical)*



The above assessment during the worst-case night-time impacts shows the following:

- Noise levels at the majority of receivers are predicted to comply with the noise management levels. 'Low' impacts are predicted at one residential receiver during noisy internal *Station / facility construction* activities.
- Noise levels during *Rail systems access shaft* work inside the acoustic shed are predicted to comply with the noise management levels.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would be periods when construction 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 occur.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed and is summarised in **Table 32**. 'Low' sleep disturbance impacts are predicted at one residential receiver during *Rail system access shafts – Deliveries and tunnel access* work. This results from heavy vehicle movements within the site.

The number of potential night-time awakenings would depend on the number of heavy vehicles accessing the site during the night-time and the way in which the vehicles are operated. The number of night-time heavy vehicles at this construction site time is expected to be around to four trucks per hour.

Further investigation of awakenings would be completed during the next stages of the proposal when detailed construction planning information becomes available.

Highly Noise Affected Residential Receivers

No receivers are predicted to be highly noise affected in this study area.

5.2.2.3 Ground-Borne Noise Impacts from Construction Site

Basement excavation at the Parramatta metro station construction site would be completed outdoors, 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 it is not necessary to evaluate potential ground-borne noise impacts.

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

On this basis, ground-borne noise levels have been assessed at this site and the potential worst-case impacts are summarised in **Table 35**. The excavation would only take place during the daytime and the predicted impacts are shown in **Figure 16**. The predictions are representative of the highest ground-borne noise levels that would likely be experienced by the nearest receivers when excavation work is close.

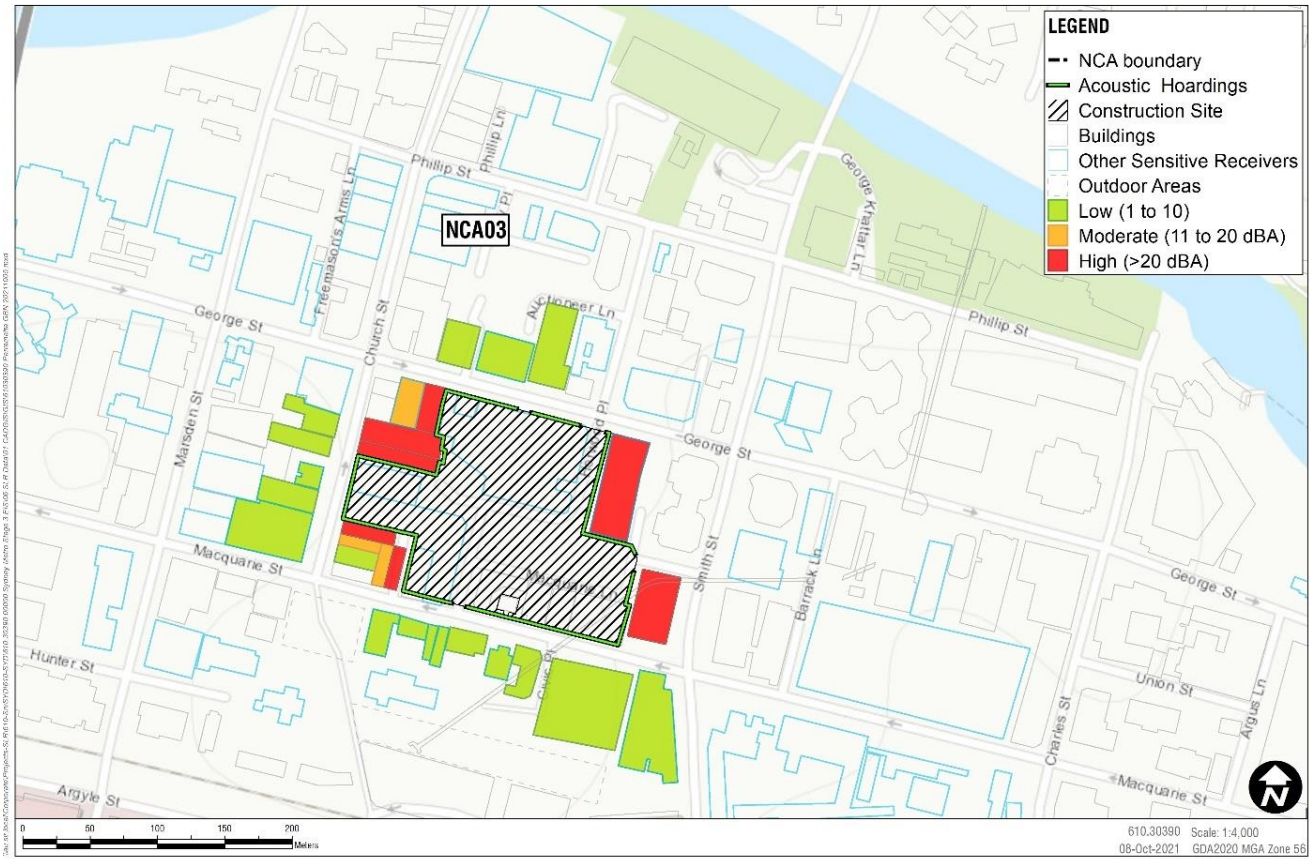
Table 35 Parramatta Overview of Ground-Borne NML Exceedances

NCA	Receiver Classification	Number of Receivers									
		Total	With NML Exceedance[1]								
			Daytime[2]			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	167	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a
	Commercial	222	9	2	6	n/a	n/a	n/a	n/a	n/a	n/a
	Other Sensitive	117	9	1	1	n/a	n/a	n/a	n/a	n/a	n/a

Note 1: Based on worst-case predicted noise levels.

Note 2: Daytime ground-borne noise NMLs taken from previous Sydney Metro planning applications for consistency. Daytime ground-borne noise NMLs are not specified in the ICNG or Sydney Metro CNVS.

Figure 16 Parramatta Predicted Ground-Borne Noise Impacts – Daytime



The above assessment during the worst-case impacts shows the following:

- Receivers that are adjacent to the construction site boundaries, where excavation is required, are predicted to result in 'high' ground-borne noise impacts. 'Low' to 'moderate' exceedances are predicted at a small number of more distant receivers.
- While exceedances are predicted during the daytime, it is noted that neither the ICNG nor CNVS specify daytime NMLs for ground-borne noise. The assessment has used daytime ground-borne noise NMLs from previous Sydney Metro planning applications for consistency.

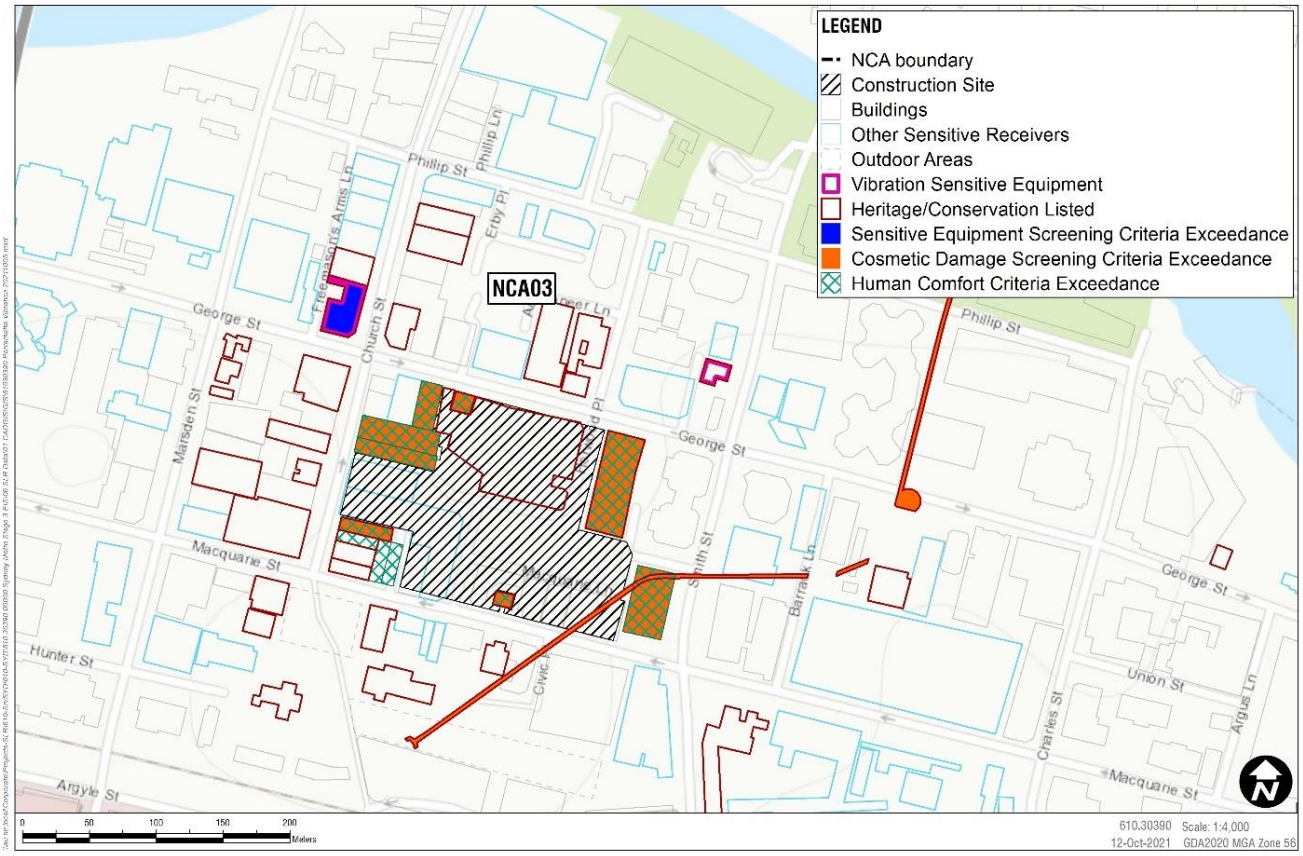
Vibration intensive excavation work is expected to last for around 20 weeks.

The predictions assume the work is relatively near surface level. As progress is made further underground the impacts would be expected to reduce.

5.2.2.4 Vibration Impacts from Construction Site

The predicted impacts during vibration intensive excavation are shown in **Figure 17**. The predictions are representative of the highest vibration levels that would likely be experienced by the nearest receivers when work is close.

Figure 17 Parramatta predicted vibration impacts – daytime



The above assessment during the worst-case impacts shows the following:

- The cosmetic damage screening criteria are predicted to be exceeded at the nine nearest buildings to the site. This includes the Roxy Theatre to the east, two heritage listed buildings being retained within the site, and one heritage listed structure (underground services) underneath the basement excavation footprint.
- The human comfort criteria are also predicted to be exceeded at some of 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.
- An exceedance of the vibration sensitive equipment screening criteria is predicted at the SunDoctors Skin Cancer Clinic, which is identified as potentially having vibration sensitive equipment with a VC-A criterion.
- These predictions represent a worst-case situation where a large rockbreaker is in use at the boundary of the site 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 proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

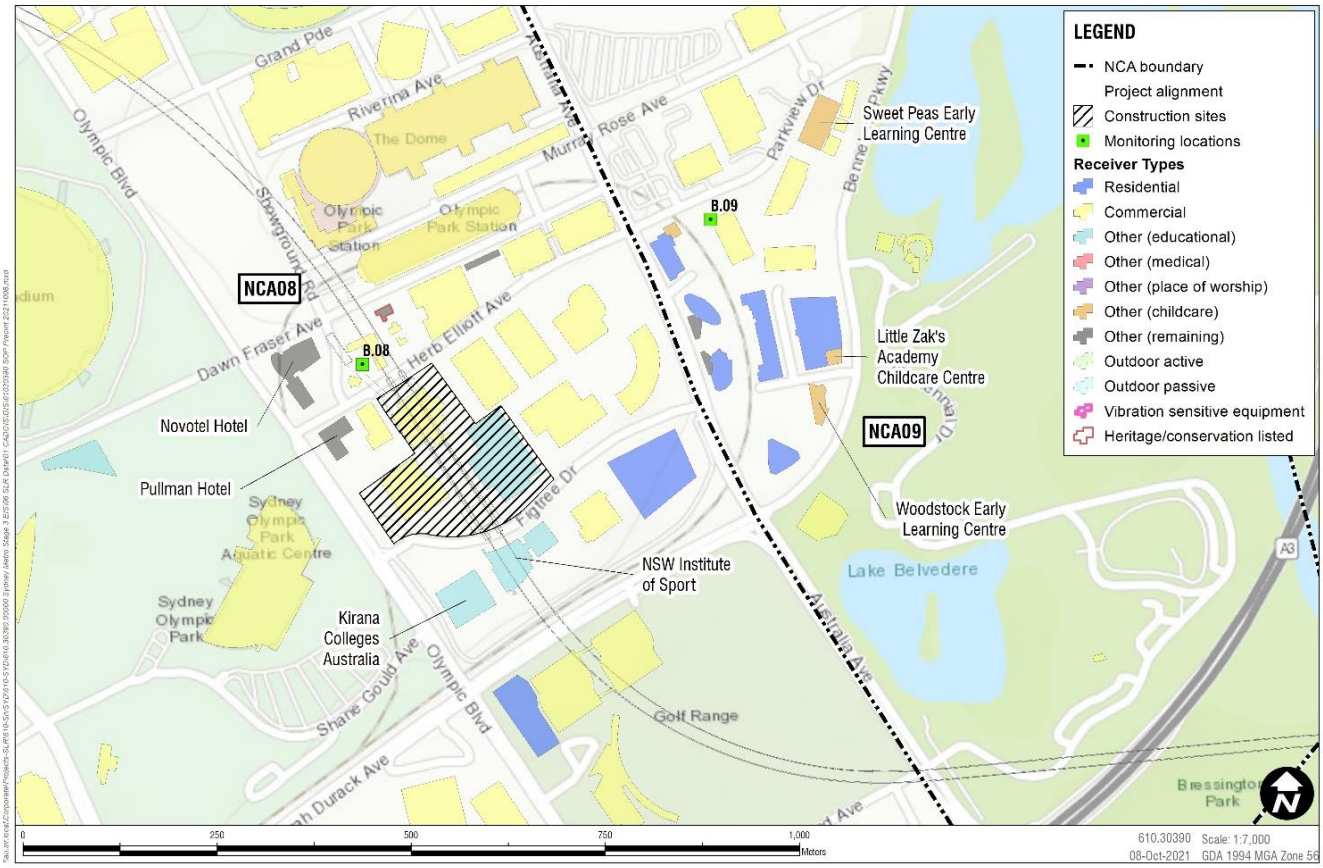
5.2.3 Sydney Olympic Park (NCA08 – NCA09)

The Sydney Olympic Park metro station construction site is close to Olympic Boulevard, and between Herb Elliot Avenue and Figtree Drive. Additional minor excavation would be required at this site beyond the extent of work under the previous Sydney Metro West planning application.

Existing noise levels in this study area are controlled by distant road traffic noise, some rail noise, and general noise from the sports and entertainment complex. Sydney Olympic Park has several open-air stadiums and various bars and restaurants. High levels of sporting/spectator noise are a regular feature of the area during events and when crowds disperse afterwards.

The area surrounding the construction site is mainly commercial with receivers typically being of office or retail use. The site and NCAs are shown in **Figure 18**.

Figure 18 Sydney Olympic Park Site Map and Sensitive Receivers



5.2.3.1 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 36**. The estimated duration of each activity is also provided, noting that most activities would be intermittent and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

The proposed work is anticipated to have a total duration of around four and a half years.

Table 36 Sydney Olympic Park Construction Activities and Working Hours

Scenario	Activity		Total indicative duration (months)[2]	Hours of work[1]			
				Std. day	Out of hours		
					Day OOH	Eve	Night
Site establishment and public domain work	Typical	Deliveries and general work	18	✓	✓	-	-
	Peak	Construction / decommissioning of facilities and hoarding		✓	✓	-	-
Piling	Typical	Supporting work	9	✓	✓	-	-
	Peak	Bored piling with support plant		✓	✓	-	-
Station / facility construction	Typical	Indoor construction and fit-out	30	✓	✓	✓	✓
	Peak 1	Installation of framing and structure		✓	✓	✓	-
	Peak 2	Concrete work		✓	✓	✓	-
Excavation	Typical	Mucking out	9	✓	✓	-	-
	Peak 1	Through soft soil/rock		✓	✓	-	-

Note 1: OOH = out of hours.

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.

5.2.3.2 Overview of Airborne Noise Impacts from Construction Site

Number of NML Exceedances

The predicted airborne noise impacts from construction site work in this study area are summarised in **Table 37**, **Table 38** and **Table 39** for all receiver types, residential receivers, and commercial/'other sensitive' receivers, respectively. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding 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.

Table 37 Sydney Olympic Park Overview of NML Exceedances – All Receiver Types

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	99	-	2	-	-	3	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		99	-	7	1	-	10	1	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	9	99	-	2	1	-	4	1	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		99	-	5	1	-	8	1	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	30	99	-	1	-	-	1	-	-	-	-	-	2	-	-	-	-	-
	Peak 1		99	-	2	1	-	5	1	-	3	-	-	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		99	-	14	3	1	15	5	1	4	4	-	n/a	n/a	n/a	n/a	n/a	n/a
Excavation	Typical	9	99	-	6	1	-	9	1	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 1		99	-	9	2	-	9	3	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 38 Sydney Olympic Park Overview of NML Exceedances – Residential Receivers

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	10	-	-	-	-	1	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		10	-	2	-	-	5	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	9	10	-	-	-	-	2	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		10	-	2	-	-	5	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	30	10	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
	Peak 1		10	-	-	-	-	3	-	-	3	-	-	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		10	-	4	1	-	5	3	-	4	4	-	n/a	n/a	n/a	n/a	n/a	n/a
Excavation	Typical	9	10	-	2	-	-	5	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 1		10	-	4	-	-	4	1	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 39 Sydney Olympic Park Overview of Commercial and 'Other Sensitive' Receiver NML Exceedances

Scenario	Activity	No. Months[1]	Number of receivers								
			Commercial			Child Care			Educational		
			1 10 dB	11 20 dB	>20 dB	1 10 dB	1 10 dB	1 10 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	-	-	-	-	-	-	2	-	-
	Peak		4	-	-	-	-	-	1	1	-
Piling	Typical	9	1	-	-	-	-	-	1	1	-
	Peak		2	-	-	-	-	-	1	1	-
Station / facility construction	Typical	30	-	-	-	-	-	-	1	-	-
	Peak 1		1	-	-	-	-	-	1	1	-
	Peak 2		6	1	-	4	-	-	-	1	1
Excavation	Typical	9	3	-	-	-	-	-	1	1	-
	Peak 1		5	-	-	-	-	-	-	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.

Daytime Scenarios

The highest daytime construction noise impacts are predicted during *Station / facility construction* when noise intensive equipment such as a concrete saw is in use. The worst-case range of predicted daytime impacts during this work are shown in:

- **Figure 19** – *Station / facility construction – Concrete work (peak 2)*
- **Figure 20** – *Station / facility construction – Installation of framing and structure (peak 1).*

The highest impact work is expected to last for:

- *Station / facility construction – Concrete work (peak 2)* – 30 months, however, concrete saws would only be used intermittently as required for crack control when slabs are poured.

Figure 19 Worst-Case Daytime Airborne Noise – *Station / Facility Construction – Concrete Work (Peak 2)*

Figure 20 Worst-case daytime airborne noise – *Station / facility construction – Inst. of framing & structure (peak 1)*

The proposed work at Sydney Olympic Park metro station construction site would involve minor excavation work and outdoor activities during construction of the station. When the station structure is complete, work would move inside to complete the fit-out of the station.

The above assessment during the worst-case daytime impacts shows the following:

- The nearest residential receivers are distant from the site and the surrounding receivers are generally commercial or educational facilities. 'Moderate' to 'high' impacts are predicted at a small number of the nearest receivers during noisy outside work, particularly when noise intensive equipment such as concrete saws are being used as part of *Station / facility construction* work. Concrete saws are expected to only be infrequently used throughout a 30 month construction period. When work is inside the station the daytime impacts are predicted to substantially reduce, with noise levels predicted to comply with the noise management levels at most receivers.
- The 'peak' scenarios generate more noise and result in more exceedances than the 'typical' scenarios, which results from the 'peak' scenarios using noise intensive (or noisier) equipment.
- The nearest commercial and 'other sensitive' receivers are predicted to be impacted during some of the noisier outdoor work activities. 'High' or 'moderate' worst-case impacts are predicted at:
    - The NSW Institute of Sport ('high')
    - Kirana Colleges Australia and adjacent commercial building ('moderate').

The highest impacts at these receivers are predicted when concrete saws are being used as part of *Station / facility construction*. Concrete saws are expected to be infrequently used throughout a 30 month construction period.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would frequently be periods when construction 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 occur.

Night-Time Scenarios

Station / facility construction is the only activity proposed during the night-time at Sydney Olympic Park metro station construction site. The majority of this work would occur inside the built station structure and does not require noise intensive equipment. The worst-case predicted night-time impacts during this work are shown in:

- **Figure 21** – *Station / facility construction – Indoor construction and fit-out (typical)*.

The work is expected to last for:

- *Station / facility construction* – 30 months.

Figure 21 Worst-Case Night-Time Airborne Noise – *Station / Facility Construction – Indoor Construction and Fit-Out (Typical)*

The above assessment during the worst-case night-time impacts shows the following:

- Noise levels at the majority of receivers are predicted to comply with the noise management levels. 'Low' impacts are predicted at two residential receivers during noisy internal *Station / facility construction* activities.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would be periods when construction 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 occur.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed and is summarised in **Table 37**. No sleep disturbance impacts are predicted from the proposed work.

Highly Noise Affected Residential Receivers

No receivers are predicted to be highly noise affected in this study area.

5.2.4 North Strathfield (NCA10 – NCA11)

The North Strathfield metro station construction site is mostly on the eastern side of the rail corridor, adjacent to Queen Street. Part of the existing North Strathfield Station and rail corridor is also included where 'brownfield work' is required to construct a new aerial footbridge and associated upgraded entries. Work in the rail corridor would need to be completed out of hours during short-term rail possessions when trains are not operating. Additional minor excavation would be required at this site beyond the extent of work under the previous Sydney Metro West planning application.

Existing noise levels in this study area are controlled by transportation noise from the surrounding road network and existing rail line. The area surrounding the construction site is generally suburban and includes residential, commercial and educational receivers. The site and NCAs are shown in **Figure 22**.

Figure 22 North Strathfield Site Map and Sensitive Receivers

5.2.4.1 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 40**. The estimated duration of each activity is also provided, noting that most activities would be intermittent and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

The proposed work is anticipated to have a total duration of around four and a half years.

Table 40 North Strathfield Construction Activities and Working Hours

Scenario	Activity		Total indicative duration (months)[2]	Hours of work[1]			
				Std. day	Out of hours		
					Day OOH	Eve	Night
Sydney Metro West station construction site work							
Site establishment and public domain work	Typical	Deliveries and general work	18	✓	✓	-	-
	Peak	Construction / decommissioning of facilities and hoarding		✓	✓	-	-
Piling	Typical	Supporting work	2	✓	✓	-	-
	Peak	Bored piling with support plant		✓	✓	-	-
Station / facility construction	Typical	Indoor construction and fit-out	30	✓	✓	✓	✓
	Peak 1	Installation of framing and structure		✓	✓	✓	-
	Peak 2	Concrete work		✓	✓	✓	-
Excavation	Typical	Mucking out	4	✓	✓	-	-
	Peak 1	Through soft soil/rock		✓	✓	-	-
Brownfield / other off-site work							
Piling	Typical	Supporting work	Possession[3]	✓	✓	✓	✓
	Peak	Bored piling with support plant		✓	✓	✓	✓
Brownfield work	Typical	Deliveries and supporting work	Possession[3]	✓	✓	✓	✓
	Peak 1	Installation of framing and structure		✓	✓	✓	✓

Note 1: OOH = out of hours.

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.

Note 3: Work would be completed during short-term rail possessions. A total of 17 two day rail possessions would likely be required at this site.

The majority of *Piling*, and *Brownfield work* within the existing rail corridor would be completed during short-term rail possessions that run from Friday evening to early Monday morning. It is currently anticipated that about 17 individual weekend rail possessions would be required.

5.2.4.2 Overview of Airborne Noise Impacts from Construction Site

Number of NML Exceedances

The predicted airborne noise impacts from construction site work in this study area are summarised in **Table 41**, **Table 42** and **Table 43** for all receiver types, residential receivers, and commercial/'other sensitive' receivers, respectively. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding 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.

Table 41 North Strathfield Overview of NML Exceedances – All Receiver Types

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Sydney Metro West station construction site work																			
Site establishment & public domain work	Typical	18	1388	-	18	-	-	31	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1388	-	50	3	-	76	18	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	2	1388	-	10	-	-	20	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1388	-	28	1	-	77	5	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	30	1388	-	1	-	-	5	-	-	10	-	-	37	5	-	9	-	-
	Peak 1		1388	-	12	-	-	29	-	-	31	3	-	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		1388	2	120	16	-	306	37	1	394	40	5	n/a	n/a	n/a	n/a	n/a	n/a
Excavation	Typical	4	1388	-	12	-	-	29	1	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 1		1388	-	30	1	-	83	5	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Brownfield / other off-site work																			
Piling	Typical	Possession	1388	-	4	1	-	4	1	-	5	-	-	49	1	-	8	-	-
	Peak		1388	-	5	2	-	20	2	-	30	-	-	184	12	-	49	1	-
Brownfield work	Typical	Possession	1388	-	8	1	-	6	4	-	5	3	-	44	4	-	36	8	1
	Peak 1		1388	-	5	2	-	11	2	-	16	-	-	112	7	-	40	8	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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 42 North Strathfield Overview of NML Exceedances – Residential Receivers

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Sydney Metro West station construction site work																			
Site establishment & public domain work	Typical	18	1255	-	12	-	-	25	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1255	-	27	2	-	53	17	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	2	1255	-	4	-	-	14	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1255	-	14	-	-	63	4	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	30	1255	-	-	-	-	4	-	-	10	-	-	37	5	-	9	-	-
	Peak 1		1255	-	6	-	-	23	-	-	31	3	-	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		1255	2	103	8	-	289	29	1	394	40	5	n/a	n/a	n/a	n/a	n/a	n/a
Excavation	Typical	4	1255	-	6	-	-	23	1	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 1		1255	-	20	-	-	73	4	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Brownfield / other off-site work																			
Piling	Typical	Possession	1255	-	-	-	-	-	-	-	5	-	-	49	1	-	8	-	-
	Peak		1255	-	-	-	-	15	-	-	30	-	-	184	12	-	49	1	-
Brownfield work	Typical	Possession	1255	-	3	-	-	1	3	-	5	3	-	44	4	-	36	8	1
	Peak 1		1255	-	-	-	-	6	-	-	16	-	-	112	7	-	40	8	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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 43 North Strathfield Overview of Commercial and 'Other Sensitive' Receiver NML Exceedances

Scenario	Activity	No. Months[1]	Number of receivers											
			Commercial			Café/Bar			Child care			Educational		
			1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	1 10 dB	1 10 dB	1 10 dB	11 20 dB	>20 dB
Sydney Metro West station construction site work														
Site establishment & public domain work	Typical	18	-	-	-	-	-	-	1	-	-	5	-	-
	Peak		16	-	-	1	-	-	-	1	-	6	-	-
Piling	Typical	2	-	-	-	-	-	-	-	-	-	6	-	-
	Peak		6	-	-	1	-	-	2	-	-	5	1	-
Station / facility construction	Typical	30	-	-	-	-	-	-	-	-	-	1	-	-
	Peak 1		-	-	-	-	-	-	-	-	-	6	-	-
	Peak 2		15	1	-	1	-	-	1	1	-	-	6	-
Excavation	Typical	4	-	-	-	-	-	-	-	-	-	6	-	-
	Peak 1		3	-	-	-	-	-	2	-	-	5	1	-
Brownfield / other off-site work														
Piling	Typical	Possession	-	-	-	-	-	-	-	-	-	4	1	-
	Peak 1		1	-	-	-	-	-	-	-	-	4	2	-
Brownfield work	Typical	Possession	1	-	-	-	-	-	1	-	-	3	1	-
	Peak 1		1	-	-	-	-	-	-	-	-	4	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.

Daytime Scenarios

The highest daytime construction noise impacts are predicted during *Station / facility construction* when noise intensive equipment such as a concrete saw is in use. The worst-case range of predicted daytime impacts during this work are shown in:

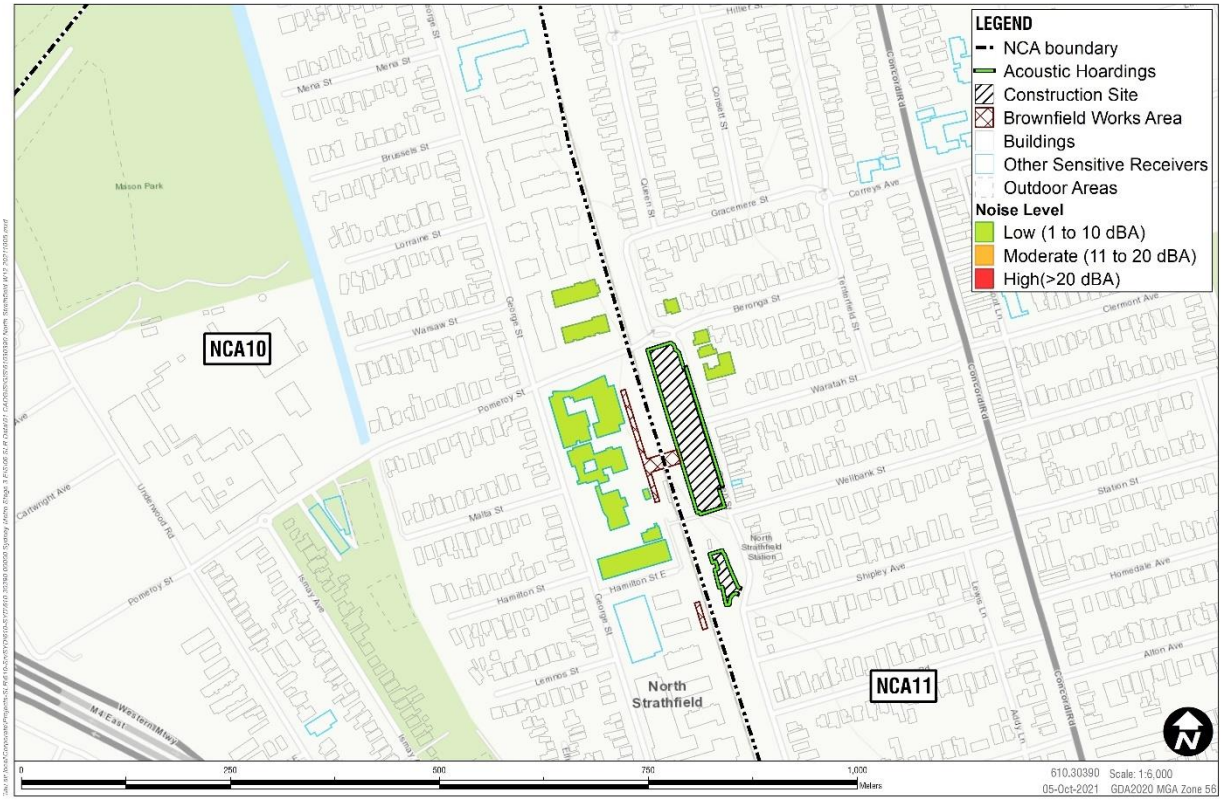
- **Figure 23** – *Station / facility construction – Concrete work (peak 2)*
- **Figure 24** – *Station / facility construction – Installation of framing and structure (peak 1).*

The highest impact work is expected to last for:

- *Station / facility construction – Concrete work (peak 2)* – 30 months, however, concrete saws would only be used intermittently as required for crack control when slabs are poured.

Figure 23 Worst-Case Daytime Airborne Noise – *Station / Facility Construction – Concrete Work (Peak 2)*

Figure 24 Worst-case daytime airborne noise – *Station / facility construction – Inst. of framing & structure (peak 1)*



The proposed work at North Strathfield metro station construction site would involve minor excavation work. Outdoor activities also include construction of the station, and work at the existing station and aerial footbridge to connect the existing station to the new metro station. When the station structure is complete, work would move inside to complete the fit-out of the station.

The above assessment during the worst-case daytime impacts shows the following:

- Receivers are located relatively close to the construction site and impacts are predicted to be 'low' to 'moderate' during noisy outside work, particularly when noise intensive equipment such as concrete saws are being used as part of *Station / facility construction* work. Concrete saws are expected to be infrequently used throughout a 30 month construction period. The impacts during 'typical' work which does not require noise intensive equipment or are inside the station are predicted to substantially reduce, with noise levels generally predicted to comply with the noise management levels or result in only 'low' impacts.
- The 'peak' scenarios generate more noise and result in more exceedances than the 'typical' scenarios, which results from the 'peak' scenarios using noise intensive (or noisier) equipment.
- The nearest commercial and 'other sensitive' receivers are predicted to impacted during some of the noisier outdoor work activities. Some of this work would, however, be complete at weekends under rail possessions when 'other sensitive' receivers such as child care centres and educational facilities are unlikely to be in use. 'Moderate' worst-case impacts are predicted at:
    - Lighthouse Childcare, The McDonald College and Our Lady of the Assumption Catholic Primary School
    - An adjacent commercial building.

The highest impacts at these receivers are predicted when concrete saws are being used as part of *Station / facility construction*. Concrete saws are expected to be infrequently used throughout a 30 month construction period.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would frequently be periods when construction 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 occur.

Night-Time Scenarios

Night-time work at North Strathfield metro station construction site would involve outdoor activities in the existing rail corridor during *Piling* and *Brownfield work*. This work would need to be completed during short-term out of hours rail possessions when trains are not operating. It is currently anticipated that about 17 individual weekend rail possessions would be required.

Station / facility construction – Indoor construction and fit-out would also occur during the night-time, however, the majority of this work would occur inside the built station structure and does not require noise intensive equipment.

The highest night-time construction noise impacts are predicted during *Piling* and *Brownfield work* when noise intensive equipment such as grinders are in use. This work would, however, be relatively short and is only expected to take up to 17 two day rail possessions. The worst-case range of predicted night-time impacts during this work are shown in:

- **Figure 25** – Brownfield work – Installation on framing and structure (peak 1)
- **Figure 26** – Brownfield work – Deliveries and supporting work (typical).

Figure 25 Worst-Case Night-Time Airborne Noise – *Brownfield Work – Inst. of Framing and Structure (Peak 1)*

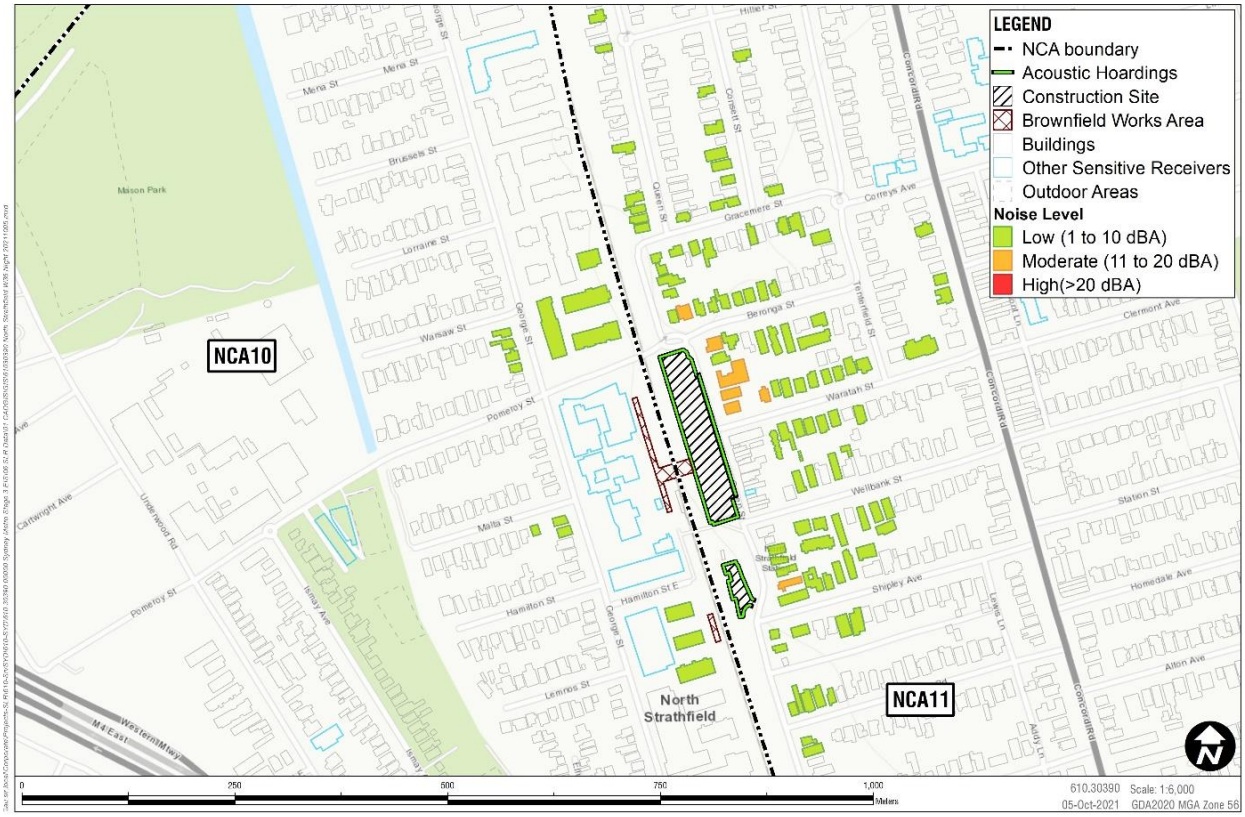
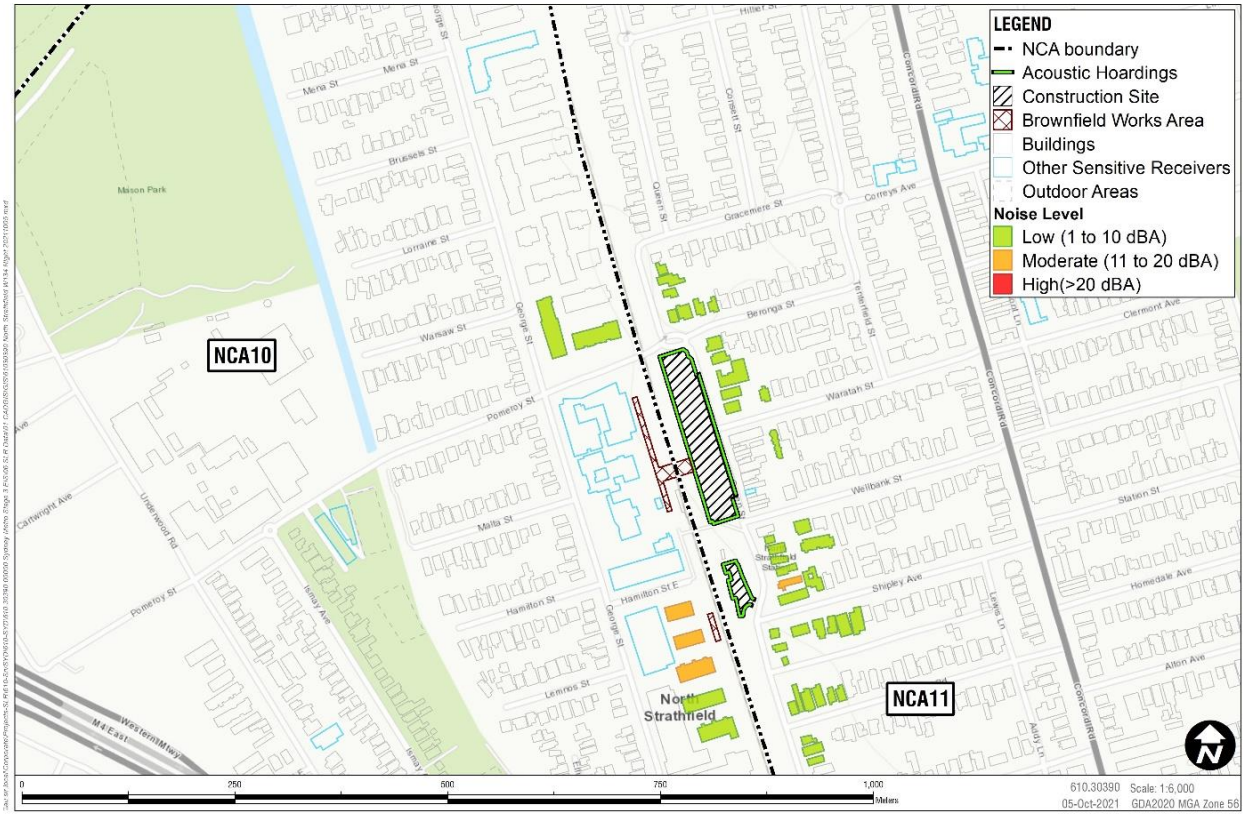


Figure 26 Worst-Case Night-Time airborne noise – *Brownfield Work – Deliveries & Supporting Work (Typical)*



The above assessment during the worst-case night-time impacts shows the following:

- Outdoor work during rail possessions is predicted to result in 'low' to 'moderate' impacts at the nearest residential receivers during noisy work, when equipment such as grinders are being used. The requirement for night-time rail possessions would be relatively minimal and the rail possessions would generally only occur over isolated weekend periods. A total of 17 rail possessions are expected to be required. The impacts are generally reduced to 'low' when noise intensive equipment is not in being used during these activities, and fewer receivers are predicted to be impacted.
- 'Low' impacts are generally predicted during *Station / facility construction – Indoor construction and fit-out* work. A small number of the nearest receivers are predicted to have 'moderate' impacts during the noisiest activities.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would be periods when construction 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 occur.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed and is summarised in **Table 41**. 'High' sleep disturbance impacts are predicted at one residential receiver with 'moderate' impacts predicted at several other nearby residential receivers during rail possessions. These impacts mainly result from heavy vehicles accessing the rail possession site via Queen Street and Hamilton Street.

'Low' impacts are predicted at a small number of receivers during *Station / facility construction – Indoor construction and fit-out* work.

The number of potential night-time awakenings would depend on several factors, including the number of heavy vehicles accessing the site during the night-time and the way in which vehicles are operated. The number of night-time heavy vehicles at this construction site is expected to be around to four trucks per hour.

The requirement for night-time rail possessions would be relatively minimal and the rail possessions would generally only occur over isolated weekend periods.

Further investigation of awakenings would be completed during the next stages of the proposal when detailed construction planning information becomes available.

Highly Noise Affected Residential Receivers

The receivers predicted to be highly noise affected are summarised in **Table 44** and shown in **Figure 27**.

Table 44 North Strathfield Predicted Number of Highly Noise Affected Residential Receivers

Scenario	Activity		NCA10			NCA11		
			Day	Eve	Night	Day	Eve	Night
Sydney Metro West station construction site work								
Site establishment and public domain work	Typical	Deliveries and general work	-	n/a	n/a	-	n/a	n/a
	Peak	Construction / decommissioning of facilities and hoarding	-	n/a	n/a	-	n/a	n/a
Piling	Typical	Supporting work	-	n/a	n/a	-	n/a	n/a
	Peak	Bored piling with support plant	-	-	-	-	-	-
Station / facility construction	Typical	Indoor construction and fit-out	-	-	-	-	-	-
	Peak 1	Installation of framing and structure	-	-	n/a	-	-	n/a
	Peak 2	Concrete work	-	-	n/a	2	2	n/a
Excavation	Typical	Mucking out	-	n/a	n/a	-	n/a	n/a
	Peak 1	Through soft soil/rock	-	n/a	n/a	-	n/a	n/a
Brownfield / other off-site work								
Piling	Typical	Supporting work	-	-	-	-	-	-
	Peak	Bored piling with support plant	-	-	-	-	-	-
Brownfield work	Typical	Deliveries and supporting work	-	-	-	-	-	-
	Peak	Installation of framing and structure	-	-	-	-	-	-

Note 1: 'n/a' represents where work would not be performed during the evening or night-time periods.

Figure 27 North Strathfield Highly Noise Affected Residential Receivers (From any Work Scenario)

The assessment shows that two of the nearest residential receivers to the north east are predicted to be highly noise affected when concrete saws are being used outside. Concrete saws are expected to be infrequently used throughout a 30 month construction period.

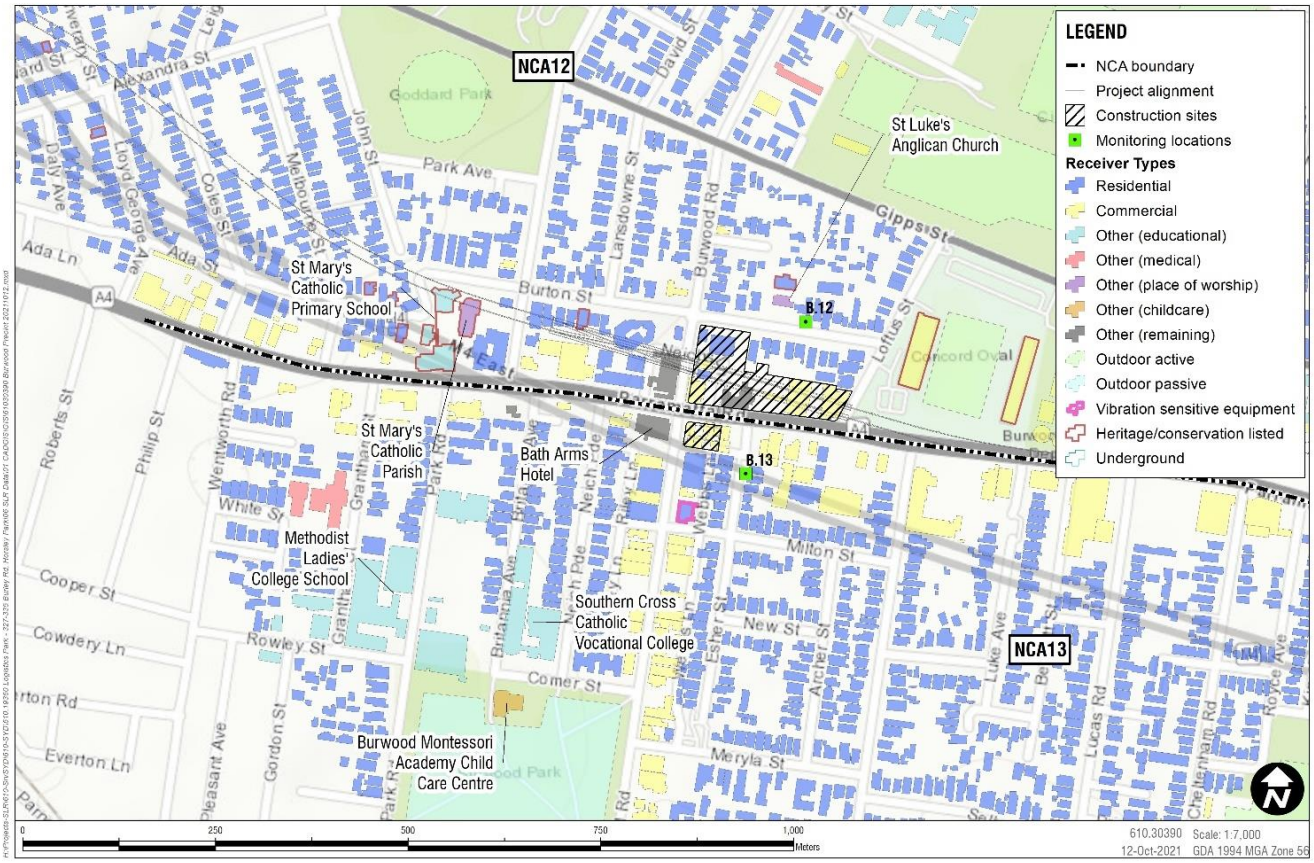
The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

5.2.5 Burwood North (NCA12 – NCA13)

Burwood North includes the use of two construction sites. The Burwood North Station northern construction site is on Parramatta Road, bound by Burwood Road and Loftus Street. The Burwood North Station southern construction site is on Parramatta Road, bound by Burwood Road and Esher Lane. The site would have an access shaft to provide a tunnel access point for delivery of construction materials. This would occur up to 24 hours per day and seven days per week to support tunnel fit-out. The access shaft would be within an acoustic shed to mitigate impacts.

Existing noise levels in this study area are controlled by road traffic noise on the surrounding road network. The area surrounding the construction sites is mostly residential. The nearest receivers are close to the northern boundary of the northern construction site and the southern boundary of the southern construction site. The sites and NCAs are shown in **Figure 28**.

Figure 28 Burwood North Site Map and Sensitive Receivers



5.2.5.1 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 45**. The estimated duration of each activity is also provided, noting that most activities would be intermittent and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

The proposed work is anticipated to have a total duration of around four years.

Table 45 Burwood North Construction Activities and Working Hours

Scenario	Activity		Total indicative duration (months)[2]	Hours of work[1]			
				Std. day	Out of hours		
					Day OOH	Eve	Night
Site establishment and public domain work	Typical	Deliveries and general work	18	✓	✓	-	-
	Peak	Construction / decommissioning of facilities and hoarding		✓	✓	-	-
Piling	Typical	Supporting work	2	✓	✓	-	-
	Peak	Bored piling with support plant		✓	✓	-	-
Station / facility construction	Typical	Indoor construction and fit-out	27	✓	✓	✓	✓
	Peak 1	Installation of framing and structure		✓	✓	✓	-
	Peak 2	Concrete work		✓	✓	✓	-
Rail systems access shafts	Typical	Surface support	21	✓	✓	✓	✓
	Peak	Deliveries and tunnel access		✓	✓	✓	✓

Note 1: OOH = out of hours.

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.

5.2.5.2 Overview of Airborne Noise Impacts from Construction Site

Number of NML Exceedances

The predicted airborne noise impacts from construction site work in this study area are summarised in **Table 46**, **Table 47** and **Table 48** for all receiver types, residential receivers, and commercial/'other sensitive' receivers, respectively. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding 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.

Table 46 Burwood North Overview of NML Exceedances – All Receiver Types

Scenario	Activity	No. Months[1]	Number of receivers															
			Total	HNA[2]	With NML exceedance[3]													
					Standard construction hours daytime			Out of hours work[4]										
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	1455	1	20	12	1	41	14	3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1455	5	48	17	4	92	20	14	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	2	1455	-	22	4	1	48	11	4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1455	3	49	11	4	86	22	5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	27	1455	-	16	4	-	31	6	1	31	6	1	52	8	1	15	3	-
	Peak 1		1455	2	39	8	1	111	19	4	111	19	4	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		1455	11	367	41	14	676	138	28	660	138	28	n/a	n/a	n/a	n/a	n/a	n/a
Rail systems access shafts	Typical	21	1455	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak		1455	-	1	-	-	4	-	-	4	-	-	5	-	-	21	5	-

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 47 Burwood North Overview of NML Exceedances – Residential Receivers

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	1300	1	18	12	1	39	14	3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1300	5	44	17	4	88	20	14	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	2	1300	-	22	4	1	48	11	4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1300	3	48	11	4	85	22	5	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	27	1300	-	16	4	-	31	6	1	31	6	1	51	8	1	15	3	-
	Peak 1		1300	2	39	8	1	111	19	4	111	19	4	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		1300	11	349	39	14	658	136	28	658	136	28	n/a	n/a	n/a	n/a	n/a	n/a
Rail systems access shafts	Typical	21	1300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak		1300	-	1	-	-	4	-	-	4	-	-	5	-	-	21	5	-

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 48 Burwood North Overview of Commercial and 'Other Sensitive' Receiver NML Exceedances

Scenario	Activity	No. Months[1]	Number of Receivers																				
			Commercial			Café/bars			Child Care			Educational			Hotel			Place of Worship			Active Recreation		
			1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
	Peak		1	-	-	1	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-
Piling	Typical	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Station / facility construction	Typical	27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak 1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak 2		5	-	-	1	-	-	1	-	-	9	-	-	-	1	-	1	1	-	1	-	-
Rail systems access shafts	Typical	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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.

Daytime Scenarios

The highest daytime construction noise impacts are predicted during *Station / facility construction* when noise intensive equipment such as a concrete saw is in use. The worst-case range of predicted daytime impacts during this work are shown in:

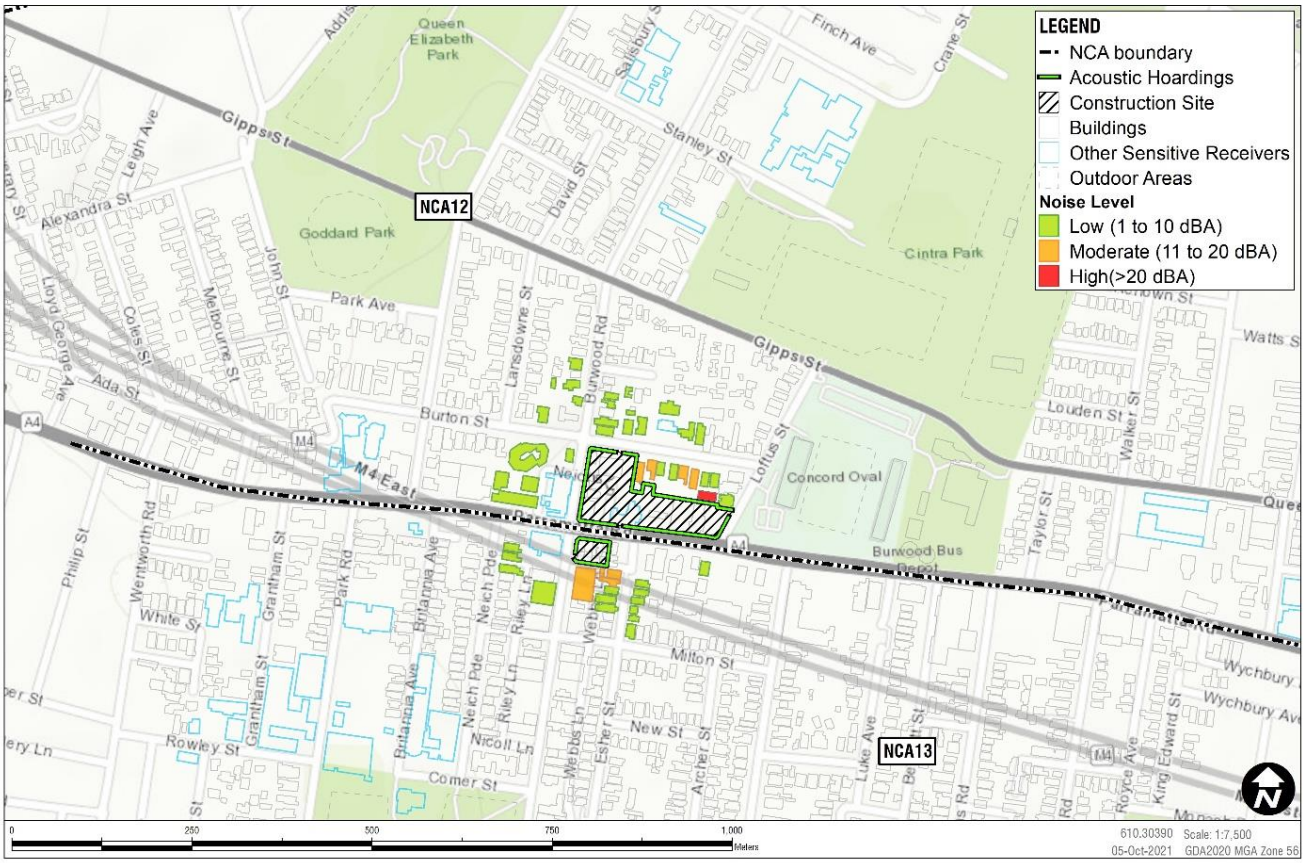
- **Figure 29** – *Station / facility construction – Concrete work (peak 2)*
- **Figure 30** – *Station / facility construction – Installation of framing and structure (peak 1).*

The highest impact work is expected to last for:

- *Station / facility construction – Concrete work (peak 2)* – 27 months, however, concrete saws would only be used intermittently as required for crack control when slabs are poured.

Figure 29 Worst-Case Daytime Airborne Noise – *Station / Facility Construction – Concrete Work (Peak 2)*

Figure 30 Worst-Case Daytime Airborne Noise – *Station / Facility Construction – Installation of Framing & Structure (Peak 1)*



The proposed work at Burwood North Station construction site would involve outdoor activities during construction of the station. When the station structure is complete, work would move inside to complete the fit-out of the station.

The above assessment during the worst-case daytime impacts shows the following:

- Residential receivers are located relatively close to the construction site and impacts are predicted to be 'moderate' to 'high' during noisy outside work, particularly when noise intensive equipment such as concrete saws are being used as part of *Station / facility construction* work. Concrete saws are expected to be infrequently used throughout a 27 month construction period. The impacts during 'typical' work which does not require noise intensive equipment or are inside the station are predicted to substantially reduce. 'Moderate' to 'high' impacts are, however, still predicted at certain nearby receivers due their proximity to 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 (or noisier) equipment.
- The nearest commercial and 'other sensitive' receivers are predicted to impacted during some of the noisier work activities. 'Moderate' worst-case impacts are predicted at:
    - St Luke's Anglican Church
    - Bath Arms Hotel.

The highest impacts at these receivers are predicted when concrete saws are being used as part of *Station / facility construction*. Concrete saws are expected to be infrequently used throughout a 27 month construction period.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would frequently be periods when construction 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 occur.

Night-time scenarios

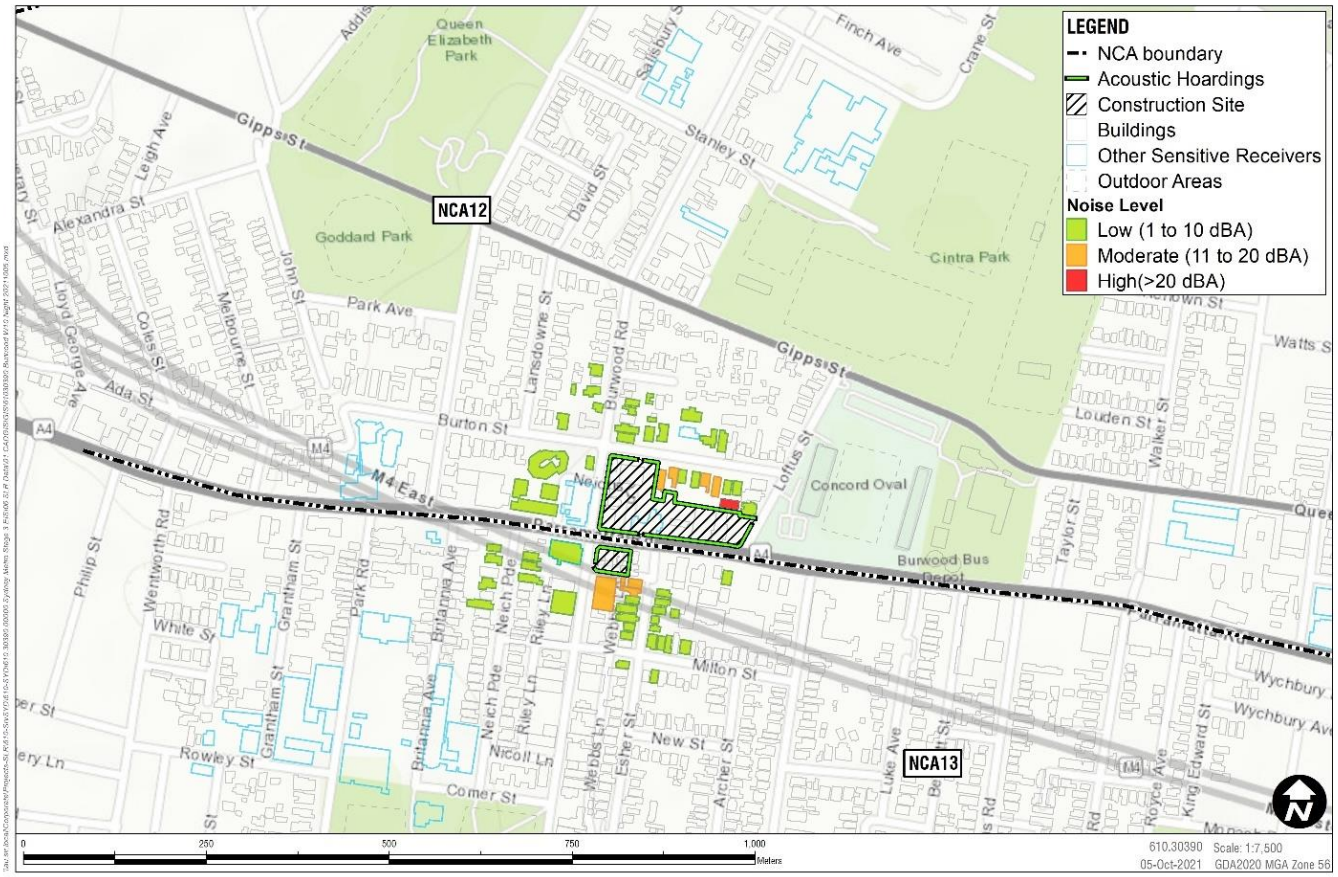
Night-time work at the Burwood North Station construction site would involve *Rail systems access shafts* and *Station / facility construction – Indoor construction and fit-out*. The majority of this work would occur inside an acoustic shed or the built station structure and does not require noise intensive equipment. The worst-case predicted night-time impacts during this work are shown in:

- **Figure 31** – *Station / facility construction – Indoor construction and fit-out (typical).*

The work is expected to last for:

- *Station / facility construction* – 27 months.

Figure 31 Worst-Case Night-Time Airborne Noise – *Station / Facility Construction – Indoor Construction and Fit-Out (Typical)*



The above assessment during the worst-case night-time impacts shows the following:

- 'Moderate' to 'low' impacts are generally predicted at the nearest residential receivers. More distant receivers are predicted to have 'low' impacts or comply with the noise management levels.
- The proposed work at Burwood North Station construction site would also include the *Rail systems access shaft* in an acoustic shed at the western end of the station box. 'Low' impacts are predicted at a small number of the nearest receivers.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would be periods when construction 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 occur.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed and is summarised in **Table 46**. 'Moderate' sleep disturbance impacts are predicted at the nearest residential receivers. These impacts mainly result from heavy vehicles accessing the site via Burton Street and movements within the site. Outdoor equipment used during *Station / facility construction – Indoor construction and fit-out* also contributes to the predicted sleep disturbance impacts.

The number of potential night-time awakenings would depend on several factors, including the number of heavy vehicles accessing the site during the night-time, the way in which vehicles are operated, the type of equipment being used and the duration of the noisy work. The number of night-time heavy vehicles at this construction site is expected to be around to four trucks per hour.

Further investigation of awakenings would be completed during the next stages of the proposal when detailed construction planning information becomes available.

Highly Noise Affected Residential Receivers

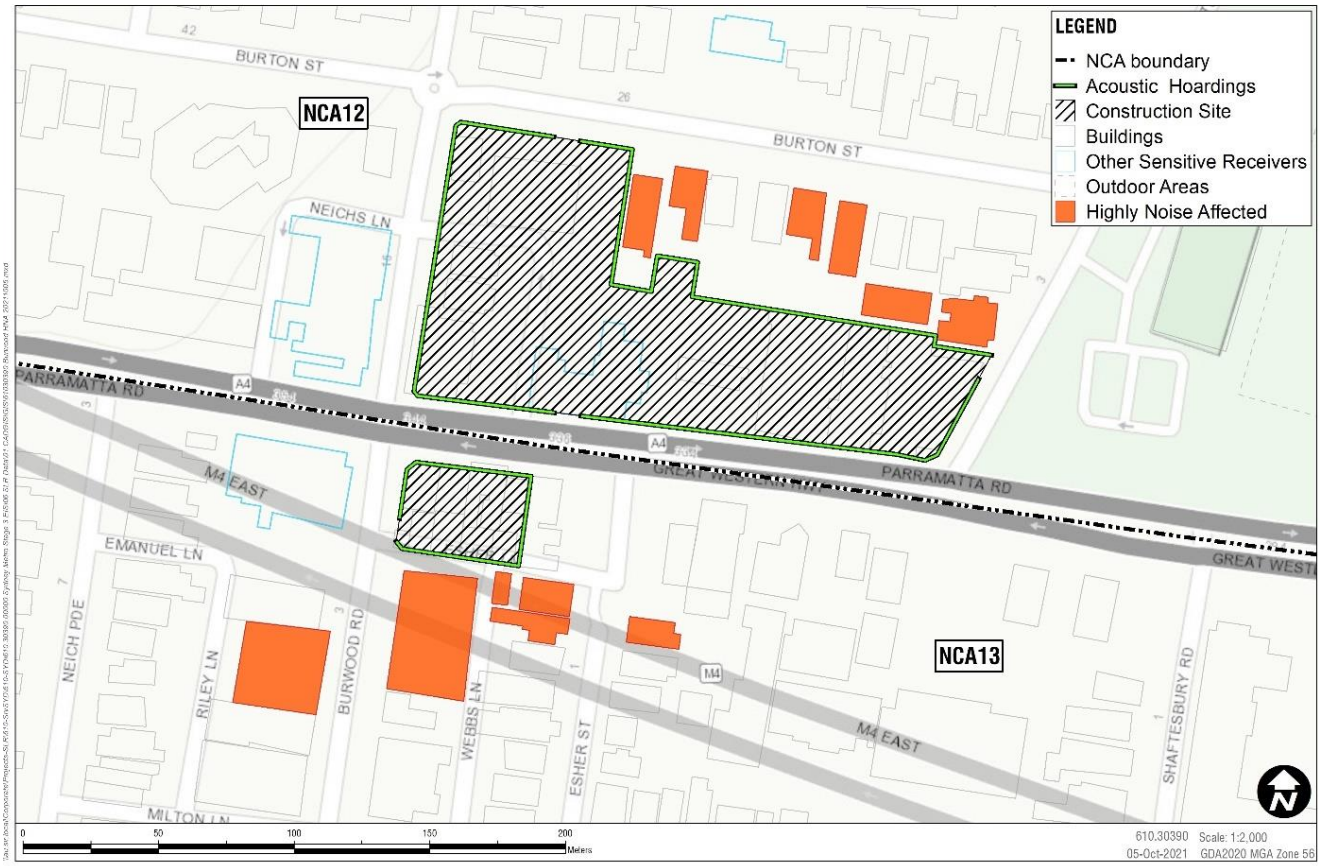
The receivers predicted to be highly noise affected are summarised in **Table 49** and shown in **Figure 32**.

Table 49 Burwood North Predicted Number of Highly Noise Affected Residential Receivers

Scenario	Activity		NCA12			NCA13		
			Day	Eve	Night	Day	Eve	Night
Site establishment and public domain work	Typical	Deliveries and general work	1	n/a	n/a	-	n/a	n/a
	Peak	Construction / decommissioning of facilities and hoarding	3	n/a	n/a	2	n/a	n/a
Piling	Typical	Supporting work	-	n/a	n/a	-	n/a	n/a
	Peak	Bored piling with support plant	2	n/a	n/a	1	n/a	n/a
Station / facility construction	Typical	Indoor construction and fit-out	-	-	-	-	-	-
	Peak 1	Installation of framing and structure	1	1	n/a	1	1	n/a
	Peak 2	Concrete work	5	5	n/a	6	6	n/a
Rail systems access shaft	Typical	Surface support	-	n/a	n/a	-	n/a	n/a
	Peak	Deliveries and tunnel access	-	n/a	n/a	-	n/a	n/a

Note 1: 'n/a' represents where work would not be performed during the evening or night-time periods.

Figure 32 Burwood North Highly Noise Affected Residential Receivers (From Any Work Scenario)



The assessment shows that a small number of the nearest residential receivers with line of sight to the work areas in each construction site are predicted to be highly noise affected, particularly when noise intensive equipment such as concrete saws are being used outside. Concrete saws are expected to be infrequently used throughout a 27 month construction period.

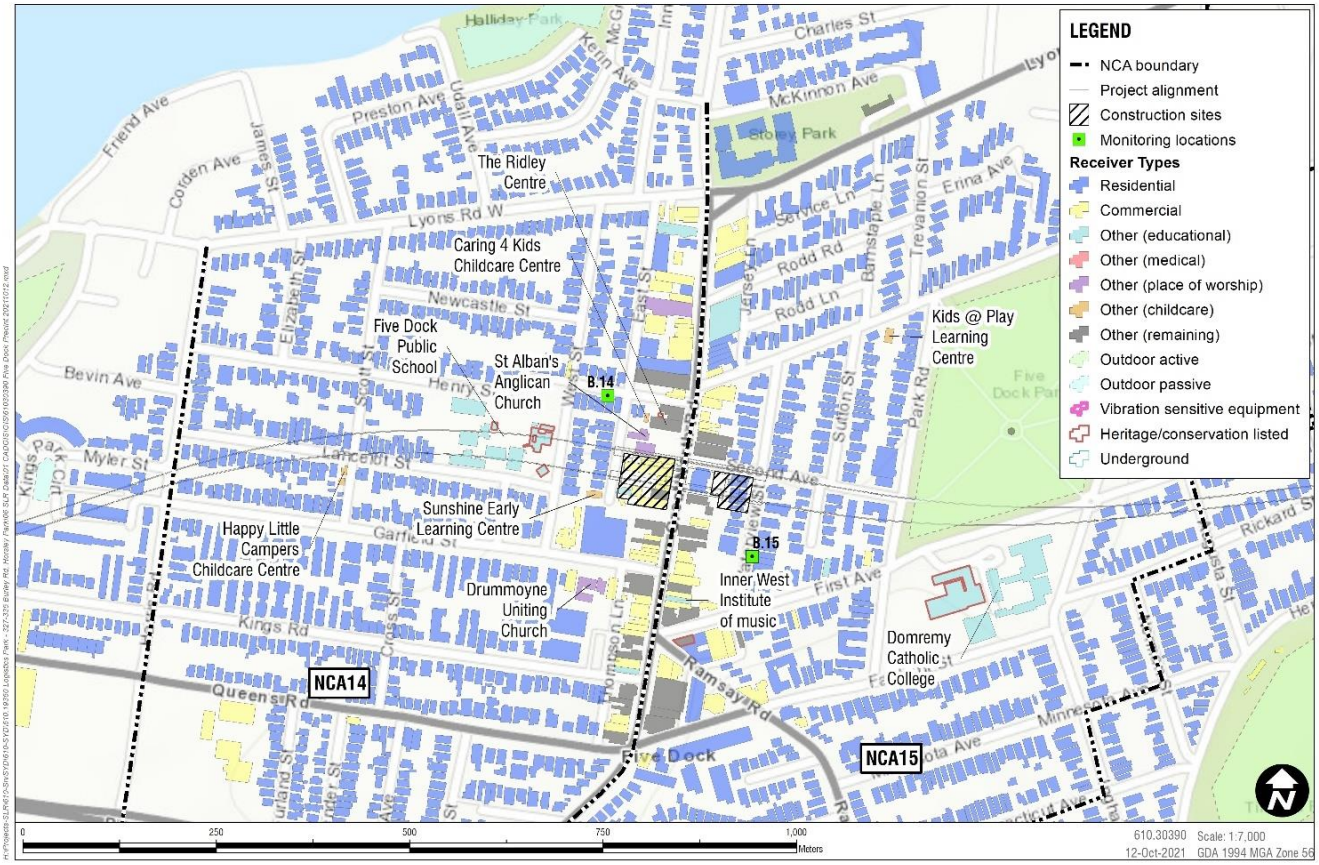
The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

5.2.6 Five Dock (NCA14 – NCA19)

Five Dock Station includes the use of two construction sites. The Five Dock Station western construction site is between Great North Road and East Street, to the north of Fred Kelly Place and south of St Albans Anglican Church. The Five Dock Station eastern construction site is on the corner of Second Avenue and Waterview Street. Additional minor excavation would be required at the western construction site beyond the extent of work under the previous Sydney Metro West planning application.

Existing noise levels in this study area are generally controlled by road traffic noise on the surrounding road network. The area surrounding the construction sites is a mixture of commercial, 'other sensitive' and residential receivers, with the nearest receivers at both sites being close to the boundary. The sites and NCAs are shown in **Figure 33**.

Figure 33 Five Dock Site Map and Sensitive Receivers



5.2.6.1 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 50**. The estimated duration of each activity is also provided, noting that most activities would be intermittent and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

The proposed work is anticipated to have a total duration of around four years.

Table 50 Five Dock Construction Activities and Working Hours

Scenario	Activity		Total indicative duration (months)[2]	Hours of work[1]			
				Std. day	Out of hours		
					Day OOH	Eve	Night
Site establishment and public domain work	Typical	Deliveries and general work	18	✓	✓	-	-
	Peak	Construction / decommissioning of facilities and hoarding		✓	✓	-	-
Piling	Typical	Supporting work	2	✓	✓	-	-
	Peak	Bored piling with support plant		✓	✓		--
Station / facility construction	Typical	Indoor construction and fit-out	30	✓	✓	✓	✓
	Peak 1	Installation of framing and structure		✓	✓	✓	-
	Peak 2	Concrete work		✓	✓	✓	-
Excavation	Typical	Mucking out	3	✓	✓	-	-
	Peak 1	Through soft soil/rock		✓	✓	-	-
	Peak 2	Through rock using a rockbreaker		✓	✓	-	-

Note 1: OOH = out of hours.

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.

5.2.6.2 Overview of Airborne Noise Impacts from Construction Site

Number of NMLExceedances

The predicted airborne noise impacts from construction site work in this study area are summarised in **Table 51**, **Table 52** and **Table 53** for all receiver types, residential receivers, and commercial/'other sensitive' receivers, respectively. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding 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.

Table 51 Five Dock Overview of NML Exceedances – All Receiver Types

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	1815	1	33	16	2	68	26	4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1815	2	86	25	8	181	34	17	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	2	1815	-	39	11	-	83	22	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1815	1	86	22	3	208	34	10	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	30	1815	-	22	3	-	34	10	-	37	11	-	96	20	7	26	5	-
	Peak 1		1815	-	48	12	1	92	25	3	92	22	6	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		1815	10	297	56	13	581	107	33	622	113	32	n/a	n/a	n/a	n/a	n/a	n/a
Excavation	Typical	3	1815	-	37	10	-	90	11	4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 1		1815	-	67	13	5	267	24	9	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		1815	10	592	67	18	722	267	33	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 52 Five Dock Overview of NML Exceedances – Residential Receivers

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	1660	1	28	13	2	63	23	4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1660	2	75	23	6	170	32	15	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	2	1660	-	32	9	-	76	20	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1660	1	76	20	2	198	32	9	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	30	1660	-	20	2	-	32	9	-	36	10	-	96	20	7	26	5	-
	Peak 1		1660	-	40	11	-	84	24	2	88	22	5	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		1660	10	278	47	11	562	98	31	621	109	31	n/a	n/a	n/a	n/a	n/a	n/a
Excavation	Typical	3	1660	-	27	8	-	80	9	4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 1		1660	-	56	10	3	256	21	7	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		1660	10	559	56	13	689	256	28	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 53 Five Dock Overview of Commercial and 'Other Sensitive' Receiver NML Exceedances

Scenario	Activity	No. Months[1]	Number of Receivers																							
			Commercial			Café/bars			Child Care			Educational			Public Building			Place of Worship			Recording Studio			Passive Recreation		
			1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	1	-	-	1	-	-	1	1	-	-	-	-	1	-	-	1	1	-	-	-	-	-	1	-
	Peak		1	-	-	4	-	-	1	-	1	3	-	-	2	-	-	-	1	1	-	-	-	-	1	-
Piling	Typical	2	1	-	-	1	-	-	-	1	-	1	-	-	2	-	-	1	1	-	-	-	-	1	-	-
	Peak		1	-	-	2	-	-	1	1	-	3	-	-	2	-	-	-	1	1	-	-	-	1	-	-
Station / facility construction	Typical	30	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
	Peak 1		1	-	-	1	-	-	1	1	-	1	-	-	2	-	-	1	-	1	-	-	-	1	-	-
	Peak 2		2	1	-	5	1	-	2	1	1	9	2	-	-	2	-	-	1	1	1	-	-	-	1	-
Excavation	Typical	3	1	-	-	2	-	-	1	1	-	2	-	-	2	-	-	1	1	-	-	-	-	1	-	-
	Peak 1		-	1	-	2	-	-	2	-	1	5	-	-	2	-	-	-	1	1	-	-	-	-	1	-
	Peak 2		12	-	1	8	2	-	1	2	1	9	5	-	-	2	-	2	-	2	1	-	-	-	-	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.

Daytime Scenarios

The highest daytime construction noise impacts are predicted during *Excavation* and *Station / facility construction* when rockbreakers or concrete saws are in use. The worst-case range of predicted daytime impacts during this work are shown in:

- **Figure 34** – *Excavation – Through rock using a rockbreaker (peak 2)*
- **Figure 35** – *Excavation – Mucking out (typical).*

The highest impact work is expected to last for:

- *Excavation – Through rock using a rockbreaker (peak 2)* – 80 days of intermittent rockbreaker use
- *Station / facility construction – Concrete work (peak 2)* – 30 months, however, concrete saws would only be used intermittently as required for crack control when slabs are poured.

Figure 34 Worst-Case Daytime Airborne Noise – *Excavation – Through Rock using a Rockbreaker (Peak 2)*

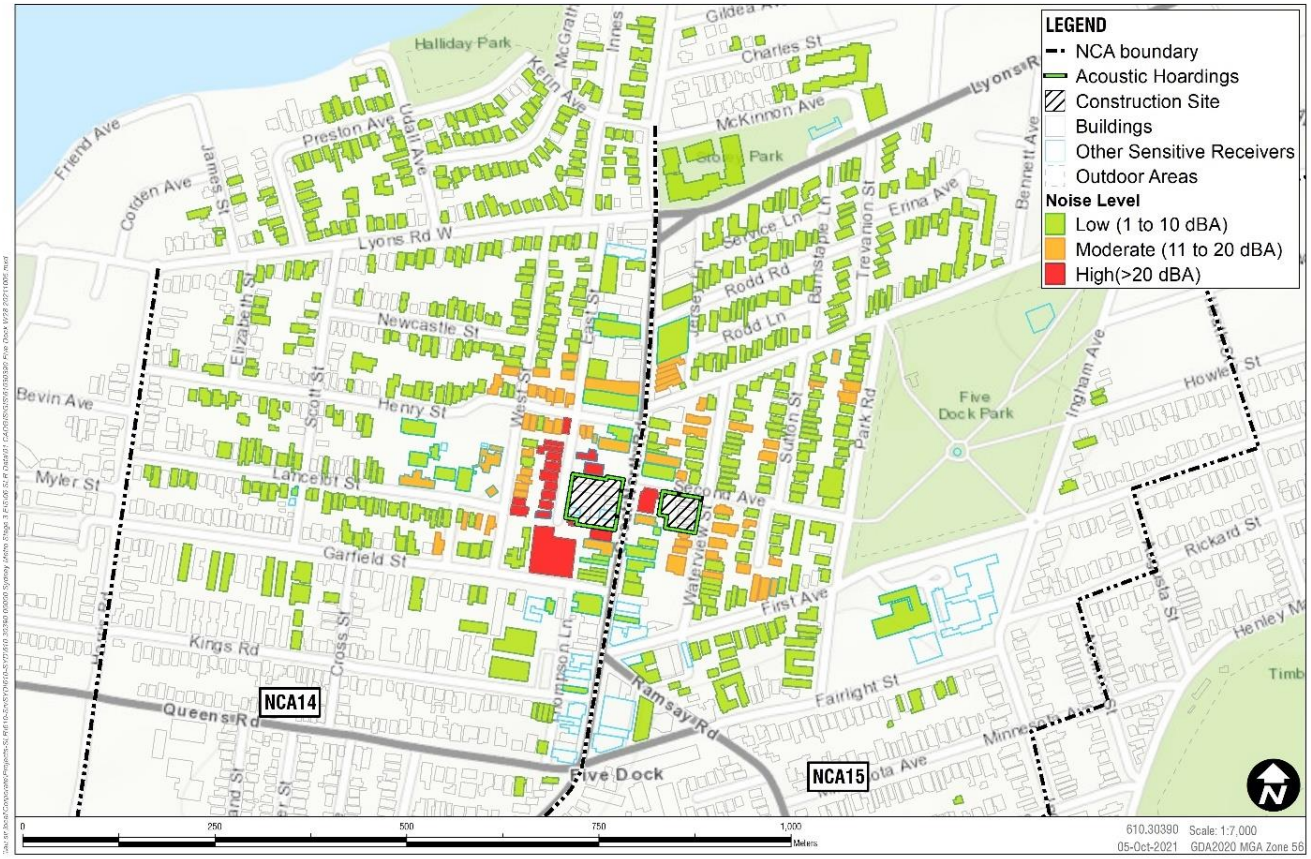
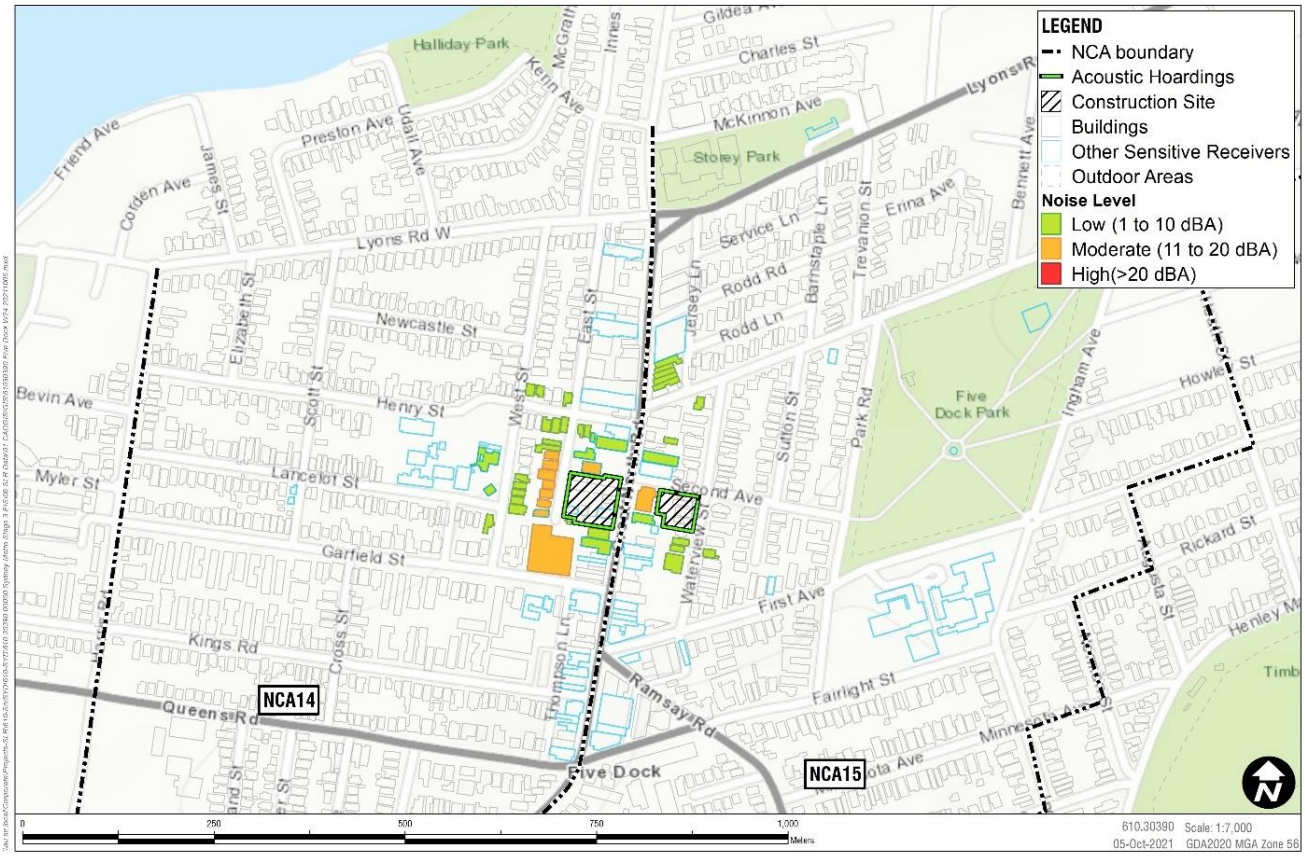


Figure 35 Worst-Case Daytime Airborne Noise – *Excavation – Mucking Out (Typical)*



The proposed work at Five Dock Station construction site would involve excavation work and outdoor activities during construction of the station. When the station structure is complete, work would move inside to complete the fit-out of the station.

The above assessment during the worst-case daytime impacts shows the following:

- Residential receivers are located relatively close to the construction site and impacts are predicted to be 'moderate' to 'high' during noisy outside work, particularly when noise intensive equipment such as rockbreakers are being used as part of *Excavation* work. Rockbreakers are expected to be used intermittently throughout a three month excavation period. The impacts during 'typical' work which does not require noise intensive equipment or are inside the station are predicted to substantially reduce. 'Moderate' to 'high' impacts are, however, still predicted at certain nearby receivers due their proximity to 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 (or noisier) equipment.
- The nearest commercial and 'other sensitive' receivers are predicted to impacted during some of the noisier work activities. 'High' or 'moderate' worst-case impacts are predicted at:
    - St Alban's Anglican Church, Sunshine Early Learning Centre and Fred Kelly Place ('high')
    - The Ridley Centre, Five Dock Public School, Caring 4 Kids Child Care and Kids @ Play Learning Centre ('moderate').

The highest impacts at these receivers are predicted when rockbreakers or concrete saws are being used as part of *Excavation* and *Station / facility construction*, respectively.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would frequently be periods when construction 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 occur.

Night-Time Scenarios

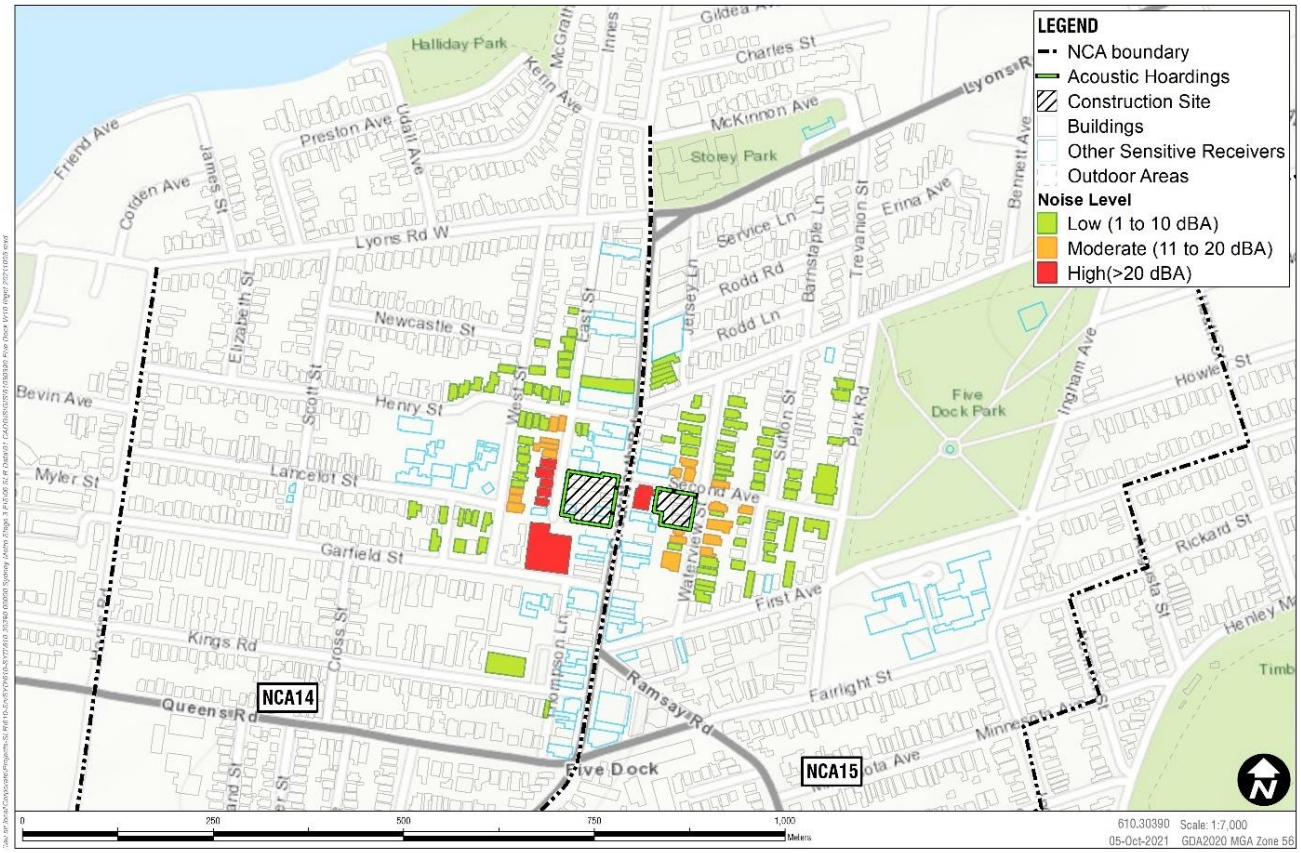
Night-time work at the Five Dock Station construction site would involve *Rail systems access shafts* and *Station / facility construction – Indoor construction and fit-out*. The majority of this work would occur inside the built station structure and does not require noise intensive equipment. The worst-case predicted night-time impacts during this work are shown in:

- **Figure 36** – *Station / facility construction – Indoor construction and fit-out (typical)*.

The work is expected to last for:

- *Station / facility construction* – 30 months.

Figure 36 Worst-Case Night-Time Airborne Noise – *Station / Facility Construction – Indoor Construction and Fit-Out (Typical)*



The above assessment during the worst-case night-time impacts shows the following:

- 'High' to 'moderate' impacts are predicted at the nearest residential receivers, particularly those on East Street which are multistorey and overlook the site. More distant receivers are predicted to have 'low' impacts or to comply with the noise management levels. These worst-case impacts are expected to occur only during external fit-out activities, such as during the installation of cladding.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would be periods when construction 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 occur.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed and is summarised in **Table 51**. 'Moderate' and sleep disturbance impacts are predicted at the nearest residential receivers during *Station / facility construction*.

The number of potential night-time awakenings would depend on several factors, including the type of equipment being used and the duration of the noisy work.

Further investigation of awakenings would be completed during the next stages of the proposal when detailed construction planning information becomes available.

Highly Noise Affected Residential Receivers

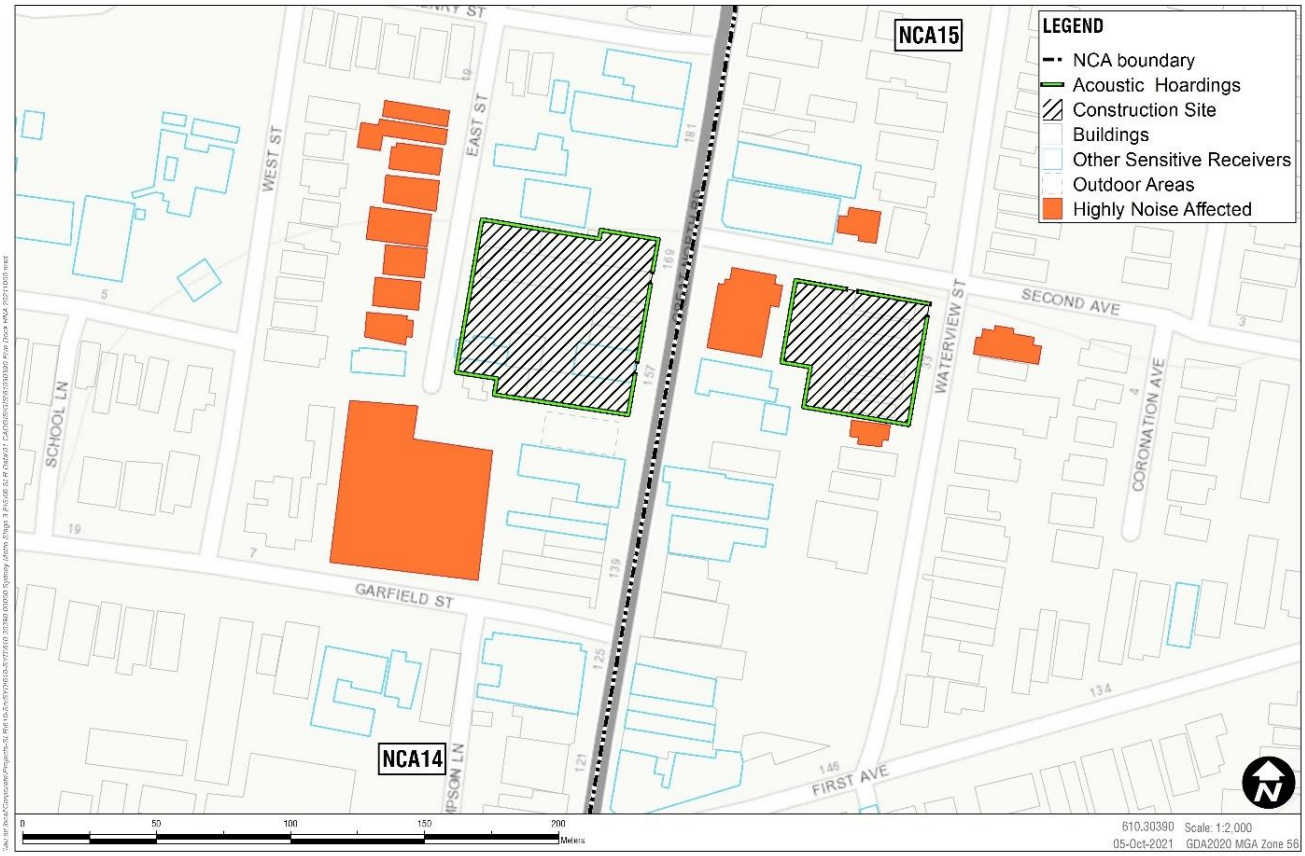
The receivers predicted to be highly noise affected are summarised in **Table 54** and shown in **Figure 37**.

Table 54 Five Dock Predicted Number of Highly Noise Affected Residential Receivers

Scenario	Activity		NCA14			NCA15		
			Day	Eve	Night	Day	Eve	Night
Site establishment and public domain work	Typical	Deliveries and general work	-	n/a	n/a	1	n/a	n/a
	Peak	Construction / decommissioning of facilities and hoarding	-	n/a	n/a	2	n/a	n/a
Piling	Typical	Supporting work	-	n/a	n/a	-	n/a	n/a
	Peak	Bored piling with support plant	-	n/a	n/a	1	n/a	n/a
Station / facility construction	Typical	Indoor construction and fit-out	-	-	-	-	-	-
	Peak 1	Installation of framing and structure	-	-	n/a	-	-	n/a
	Peak 2	Concrete work	6	6	n/a	4	4	n/a
Excavation	Typical	Mucking out	-	n/a	n/a	-	n/a	n/a
	Peak 1	Through soft soil/rock	-	n/a	n/a	-	n/a	n/a
	Peak 2	Through rock using a rockbreaker	9	n/a	n/a	1	n/a	n/a

Note 1: 'n/a' represents where work would not be performed during the evening or night-time periods.

Figure 37 Five Dock Highly Noise Affected Residential Receivers (From Any Work Scenario)



The assessment shows that a small number of the nearest residential receivers with line of sight to the work areas in each construction site are predicted to be highly noise affected, particularly when rockbreakers or concrete saws are being used outside. Concrete saws are expected to be infrequently used throughout a 30 month construction period. Rockbreakers would be used intermittently over an 80 day period.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

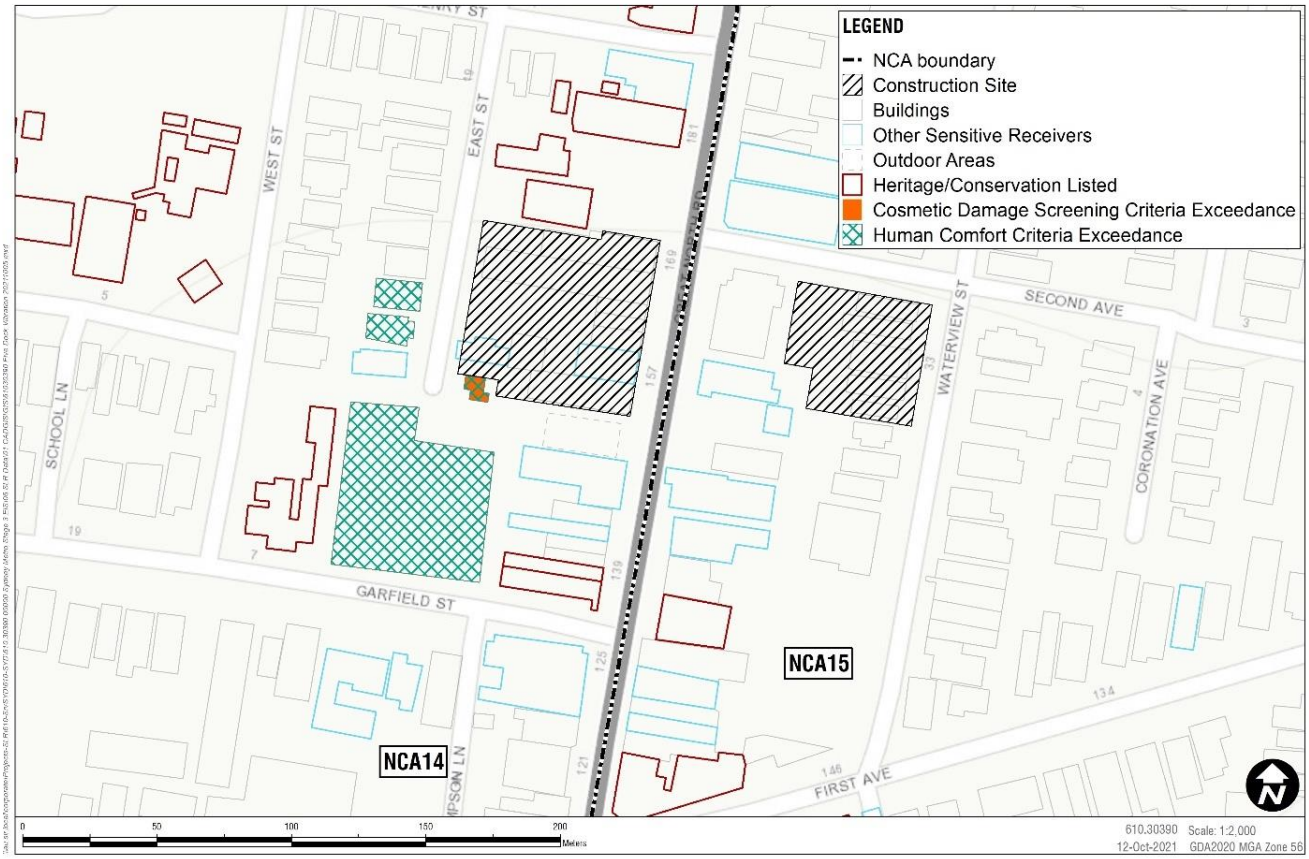
5.2.6.3 Ground-Borne Noise Impacts from Construction Site

Basement excavation at the Five Dock Station construction site would be completed outdoors, 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 it is not necessary to evaluate potential ground-borne noise impacts and they have not been considered further for this site.

5.2.6.4 Vibration Impacts from Construction Site

The predicted impacts during vibration intensive excavation are shown in **Figure 38**. The predictions are representative of the highest vibration levels that would likely be experienced by the nearest receivers when work is close.

Figure 38 Predicted Vibration Impacts – Daytime



The above assessment during the worst-case impacts shows the following:

- The cosmetic damage screening criteria is predicted to be exceeded at one industrial structure directly adjacent to the southwest boundary of the site.
- The human comfort criteria are also predicted to be exceeded at three of the nearest residential buildings, meaning occupants of affected buildings may be able to perceive vibration impacts at times when vibration intensive equipment is in use nearby.
- These predictions represent a worst-case situation where a large rockbreaker is in use at the boundary of the site 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.

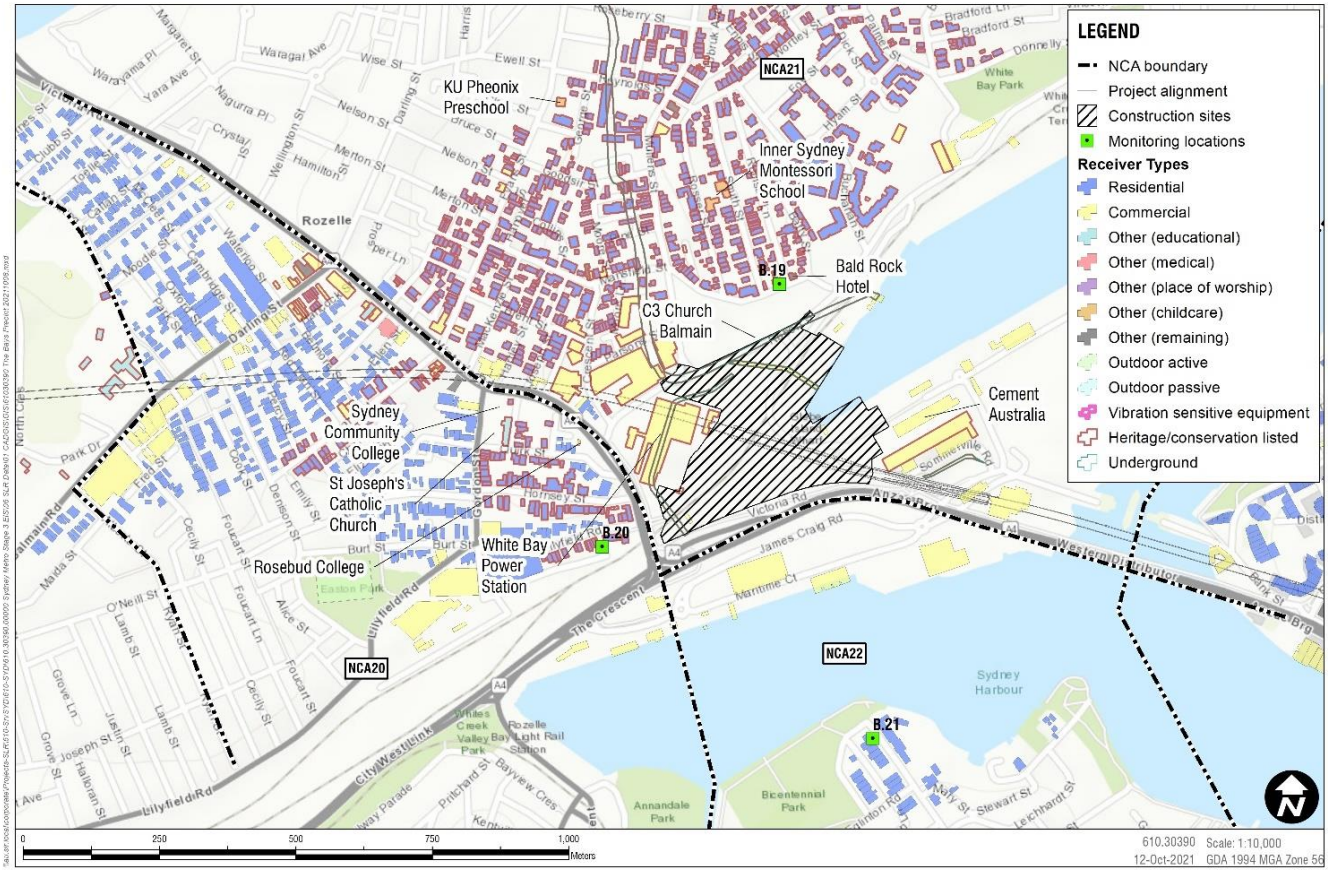
The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

5.2.7 The Bays (NCA20 – NCA22)

The Bays Station construction site is between Roberts Street on the northern side, White Bay on the eastern side, Anzac Bridge approach on the southern side, and the former White Bay Power Station on the western side. The site would have an access shaft to provide a tunnel access point for delivery of construction materials. This would occur up to 24 hours per day and seven days per week to support tunnel fit-out. The access shaft would be within an acoustic shed to mitigate impacts.

Existing noise levels in this study area are controlled by road traffic noise on the surrounding road network, and industrial noise from White Bay and Glebe Island. The area surrounding the construction site is mainly commercial/industrial and the nearest receivers are close to the boundary of the site. Residential receivers are located to the north and west of the construction site, however, they are generally behind existing buildings. The site and NCAs are shown in **Figure 39**.

Figure 39 The Bays Site Map and Sensitive Receivers



5.2.7.1 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 55**. The estimated duration of each activity is also provided, noting that most activities would be intermittent and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

The proposed work is anticipated to have a total duration of around four years.

Table 55 The Bays Construction Activities and Working Hours

Scenario	Activity		Total indicative duration (months)[2]	Hours of work[1]			
				Std. day	Out of hours		
					Day OOH	Eve	Night
Site establishment and public domain work	Typical	Deliveries and general work	18	✓	✓	-	-
	Peak	Construction / decommissioning of facilities and hoarding		✓	✓	-	-
Piling	Typical	Supporting work	9	✓	✓	-	-
	Peak	Bored piling with support plant		✓	✓	-	-
Station / facility construction	Typical	Indoor construction and fit-out	27	✓	✓	✓	✓
	Peak 1	Installation of framing and structure		✓	✓	✓	-
	Peak 2	Concrete work		✓	✓	✓	-
Rail systems access shafts	Typical	Surface support	21	✓	✓	✓	✓
	Peak	Deliveries and tunnel access		✓	✓	✓	✓
Road work	Typical	Supporting work	9	✓	✓	-	-
	Peak	Noise intensive work		✓	✓	-	-

Note 1: OOH = out of hours.

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.

5.2.7.2 Overview of Airborne Noise Impacts from Construction Site

Number of NML Exceedances

The predicted airborne noise impacts from construction site work in this study area are summarised in **Table 56**, **Table 57** and **Table 58** for all receiver types, residential receivers, and commercial/'other sensitive' receivers, respectively. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding 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.

Table 56 The Bays Overview of NML Exceedances – All Receiver Types

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	1121	-	2	1	-	17	1	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1121	-	33	-	1	128	1	1	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	9	1121	-	-	-	-	2	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1121	-	4	-	-	94	-	-	15	-	-	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	27	1121	-	-	-	-	-	-	-	558	28	-	45	-	-	-	-	-
	Peak 1		1121	-	-	-	-	15	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		1121	-	178	-	-	562	28	-	1	-	-	n/a	n/a	n/a	n/a	n/a	n/a
Rail systems access shafts	Typical	21	1121	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak		1121	-	1	-	-	1	-	-	1	-	-	76	-	-	9	-	-
Road work	Typical	9	1121	-	15	4	-	29	8	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1121	11	413	99	19	372	295	37	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 57 The Bays Overview of NML Exceedances – Residential Receivers

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	1025	-	1	-	-	16	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1025	-	25	-	-	120	1	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	9	1025	-	-	-	-	2	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1025	-	2	-	-	92	-	-	15	-	-	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	27	1025	-	-	-	-	-	-	-	556	28	-	45	-	-	-	-	-
	Peak 1		1025	-	-	-	-	15	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		1025	-	170	-	-	554	28	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a
Rail systems access shafts	Typical	21	1025	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak		1025	-	-	-	-	-	-	-	15	-	-	76	-	-	9	-	-
Road work	Typical	9	1025	-	11	3	-	25	7	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1025	11	405	92	14	364	288	32	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 58 The Bays Overview of Commercial and 'Other Sensitive' Receiver NML Exceedances

Scenario	Activity	No. Months[1]	Number of Receivers														
			Commercial			Child Care			Educational			Place of Worship			Passive Recreation		
			1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment and public domain work	Typical	18	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-
	Peak		5	-	-	3	-	-	-	-	-	-	-	1	-	-	-
Piling	Typical	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak		-	-	-	1	-	-	-	-	-	1	-	-	-	-	-
Station / facility construction	Typical	27	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak 1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak 2		1	-	-	5	-	-	-	-	-	1	-	-	1	-	-
Rail systems access shafts	Typical	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak		-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Road work	Typical	9	3	-	-	1	-	-	-	-	-	-	1	-	-	-	-
	Peak		3	2	3	1	4	1	2	1	-	1	-	1	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.

Daytime Scenarios

The highest daytime construction noise impacts are predicted from *Road work* when noise intensive equipment such as a concrete saw or rockbreaker is in use. The predicted range of daytime impacts during this work is shown in:

- **Figure 40** – *Road work – Noise intensive work (peak)*
- **Figure 41** – *Road work – Supporting work (typical).*

The highest impact work is expected to last for:

- *Road work – Noise intensive work (peak)* – nine months however, concrete saws and rockbreakers would only be used intermittently as required.

Figure 40 Worst-Case Daytime Airborne Noise – *Road Work – Noise Intensive Work (Peak)*

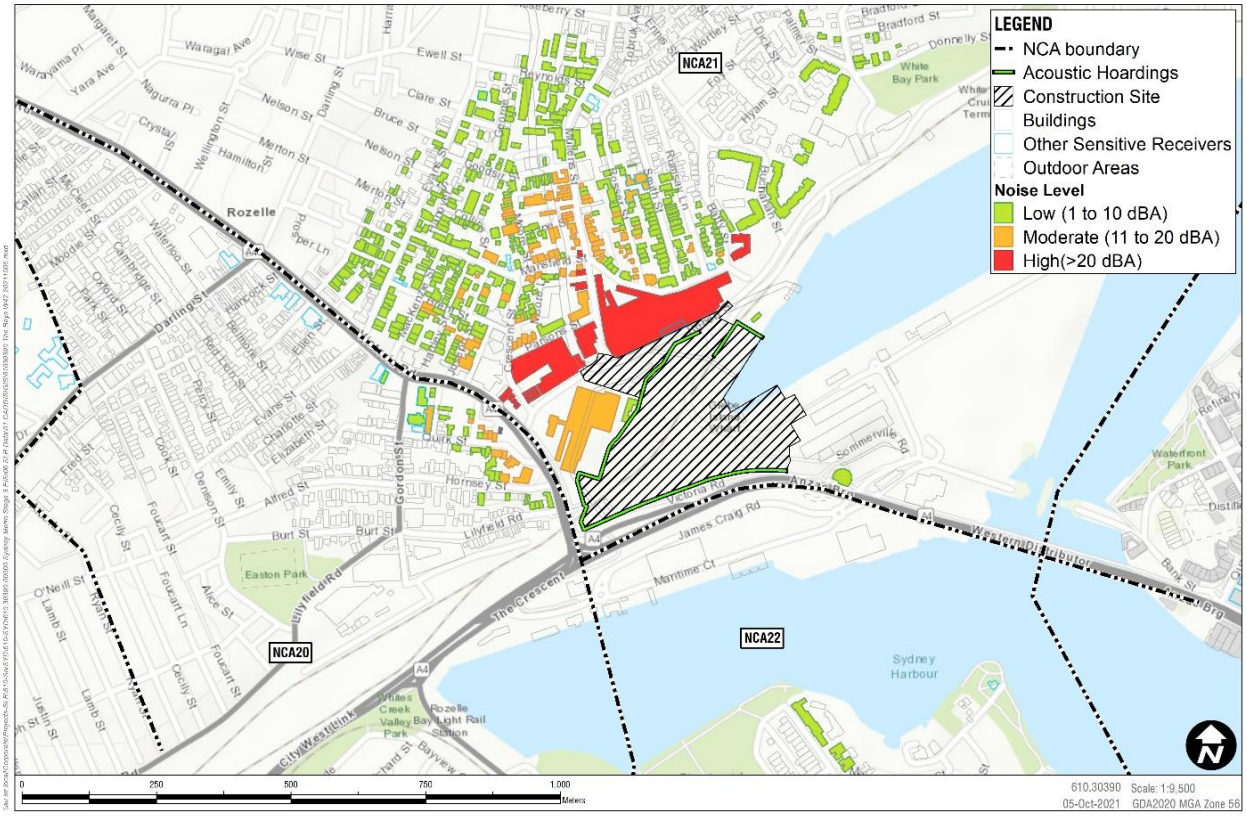
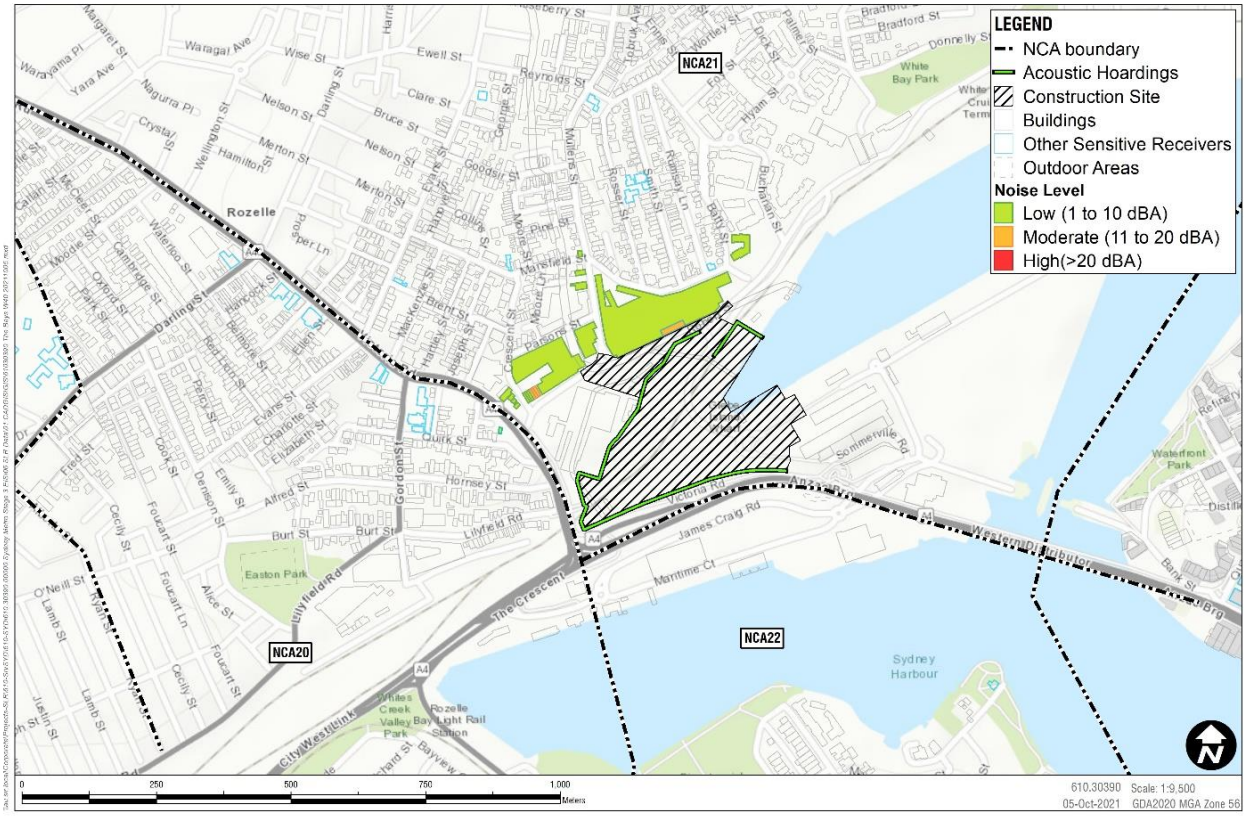


Figure 41 Worst-Case Daytime Airborne Noise – R*oad Work – Supporting Work (Typical)*



The proposed work at The Bays Station construction site would involve outdoor activities during construction of the station, including road work for the construction of the new precinct street and realignment of the Port Access Road. When the station structure is complete, work would move inside to complete the fit-out of the station. The site would also have an access shaft to provide a tunnel access point for delivery of construction materials.

The above assessment during the worst-case daytime impacts shows the following:

- The nearest residential receivers are distant from the site and the surrounding receivers are generally commercial or industrial. 'Moderate' to 'high' impacts are predicted at a small number of the nearest receivers during noisy outside work, particularly when noise intensive equipment such as concrete saws or rockbreakers are being used as part of *Road work*. Concrete saws and rockbreakers are expected to only be infrequently throughout a nine month construction period. Noise levels during the other construction activities are predicted to comply with the noise management levels at most receivers or result in only 'low' impacts.
- The 'peak' scenarios generate more noise and result in more exceedances than the 'typical' scenarios, which results from the 'peak' scenarios using noise intensive (or noisier) equipment.
- The nearest commercial and 'other sensitive' receivers are predicted to be impacted during some of the noisier outdoor work activities. 'High' or 'moderate' worst-case impacts are predicted at:
    - C3 Church Balmain ('high')
    - Rosebud College Child Care('high')
    - Inner Sydney Montessori School ('moderate').

The highest impacts at these receivers are predicted when rockbreaker or concrete saws are being used as part of *Road work*. Concrete saws and rockbreakers are expected to be infrequently used as part of this scenario throughout a nine month construction period.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would frequently be periods when construction 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 occur.

Night-Time Scenarios

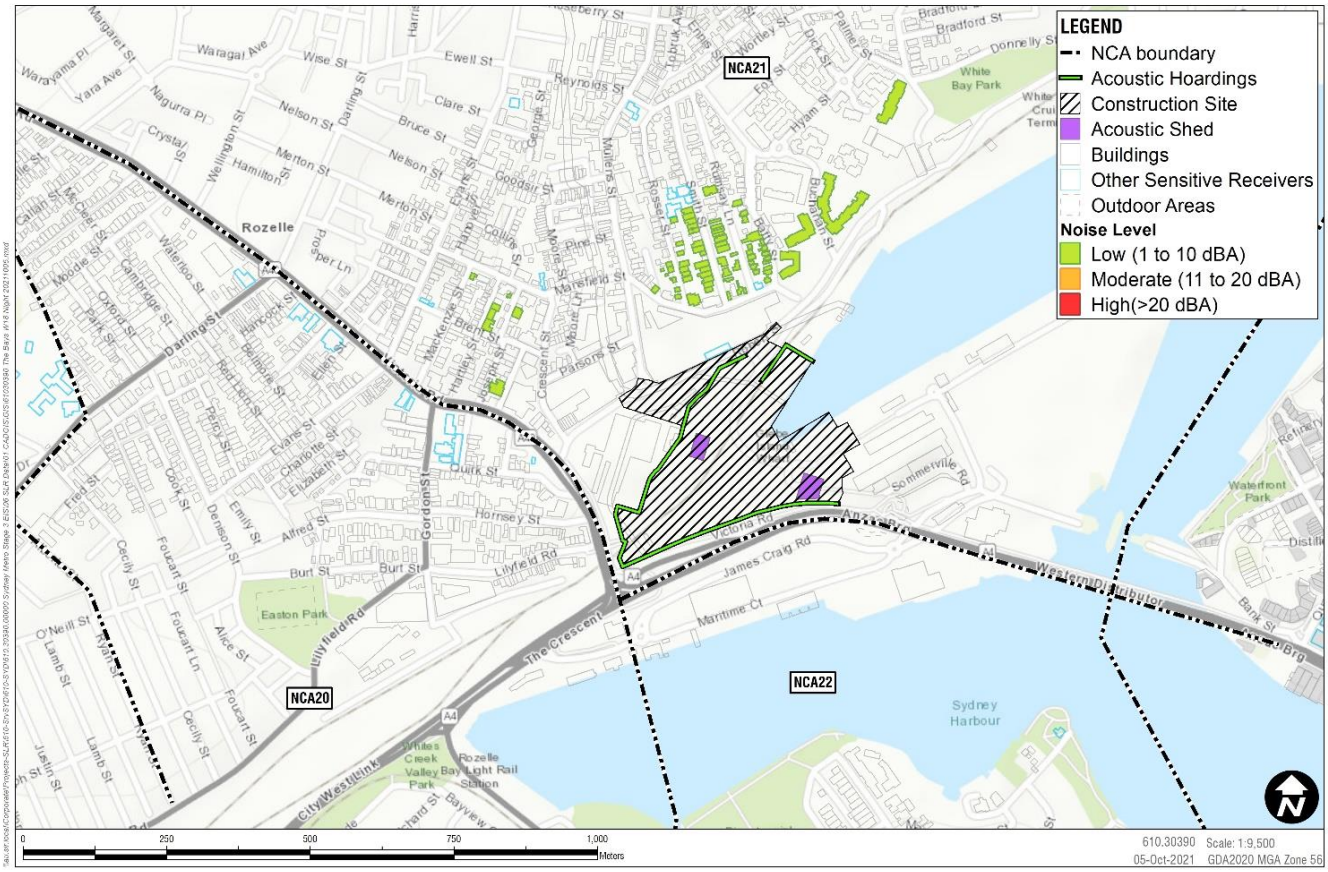
Night-time work at The Bays Station construction site would involve *Rail systems access shafts* and *Station / facility construction – Indoor construction and fit-out*. The majority of this work would occur inside the built station structure and does not require noise intensive equipment. The worst-case predicted night-time impacts during this work are shown in:

- **Figure 42** – *Rail system access shafts – Deliveries and tunnel access (peak)*
- *Rail system access shafts – Surface support (typical)* – noise levels predicted to comply with noise management levels.

The work is expected to last for:

- *Rail system access shafts* – 21 months.

Figure 42 Worst-Case Night-Time Airborne Noise – *Rail System Access Shafts – Deliveries and Tunnel Access (Peak)*



The above assessment during the worst-case night-time impacts shows the following:

- Noise levels at the majority of receivers are predicted to comply with the noise management levels. 'Low' impacts are predicted at the nearest residential receivers during *Rail system access shafts – Deliveries and tunnel access*..

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would be periods when construction 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 occur.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed and is summarised in **Table 56**. 'Low' sleep disturbance impacts are predicted at some of the nearest residential receivers to the north of the site. These impacts mainly result from heavy vehicle movements within the site.

The number of potential night-time awakenings would depend on several factors, including the number of heavy vehicles accessing the site during the night-time and the way in which vehicles are operated. The number of night-time heavy vehicles at this construction site is expected to be around to four trucks per hour.

Further investigation of awakenings would be completed during the next stages of the proposal when detailed construction planning information becomes available.

Highly Noise Affected Residential Receivers

The receivers predicted to be highly noise affected are summarised in **Table 59** and shown in **Figure 43**.

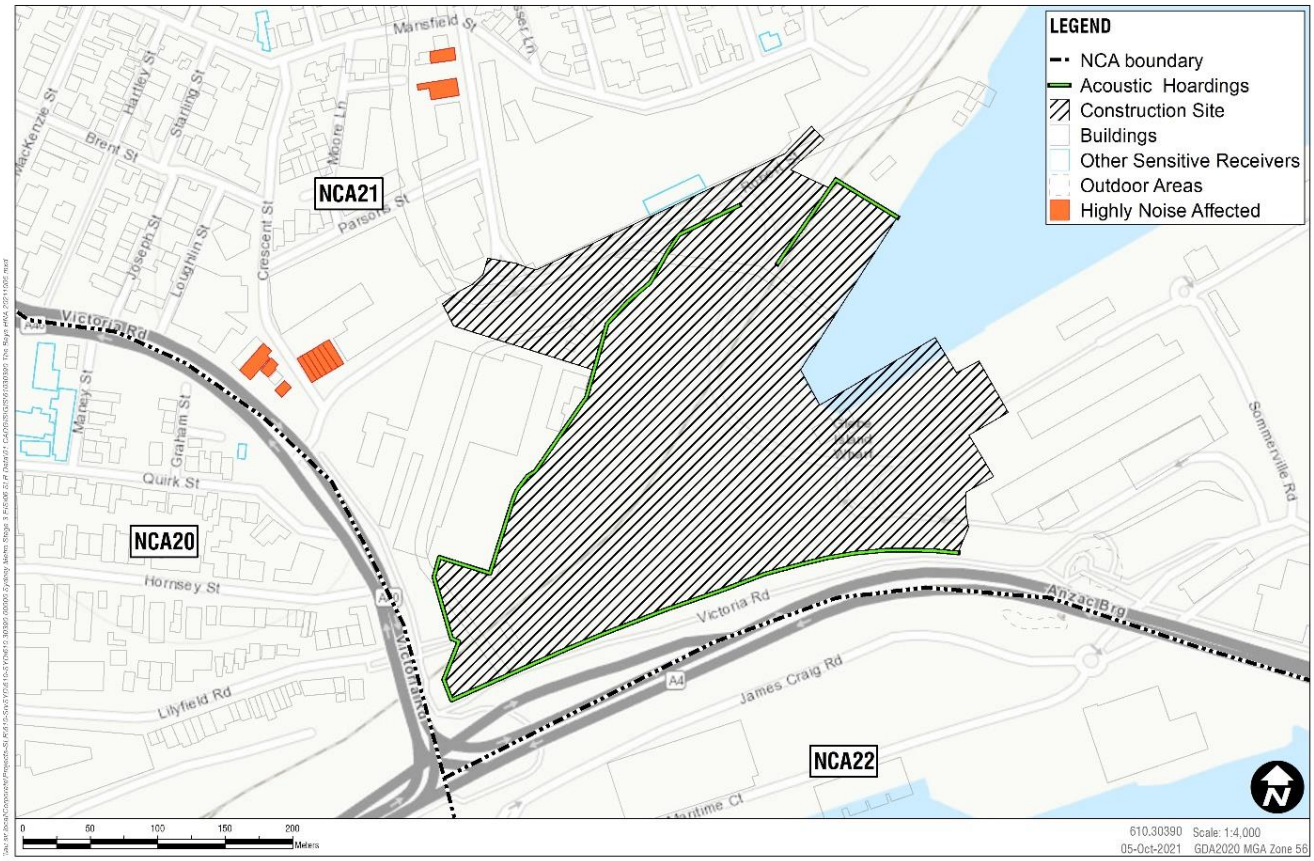
Table 59 The Bays Predicted Number of Highly Noise Affected Residential Receivers

Scenario	Activity		NCA21[2]		
			Day	Eve	Night
Site establishment and public domain work	Typical	Deliveries and general work	-	n/a	n/a
	Peak	Construction / decommissioning of facilities and hoarding	-	n/a	n/a
Piling	Typical	Supporting work	-	n/a	n/a
	Peak	Bored piling with support plant	-	n/a	n/a
Station / facility construction	Typical	Indoor construction and fit-out	-	-	-
	Peak 1	Installation of framing and structure	-	-	n/a
	Peak 2	Concrete work	-	-	n/a
Rail systems access shafts	Typical	Surface support	-	-	-
	Peak	Deliveries and tunnel access	-	-	-
Road work	Typical	Supporting work	-	n/a	n/a
	Peak	Noise intensive work	11	n/a	n/a

Note 1: 'n/a' represents where work would not be performed during the evening or night-time periods.

Note 2: No receivers in NCA020 or NCA22 are predicted to be highly noise affected.

Figure 43 The Bays Highly Noise Affected Residential Receivers (From Any Work Scenario)



The assessment shows that some of the nearest residential receivers on Crescent Street and Mullens Street with line of sight to the work areas are predicted to be highly noise affected when noise intensive equipment is being used as part of *Road work*. Concrete saws and rockbreakers are expected to be infrequently used during this scenario throughout a nine month construction period.

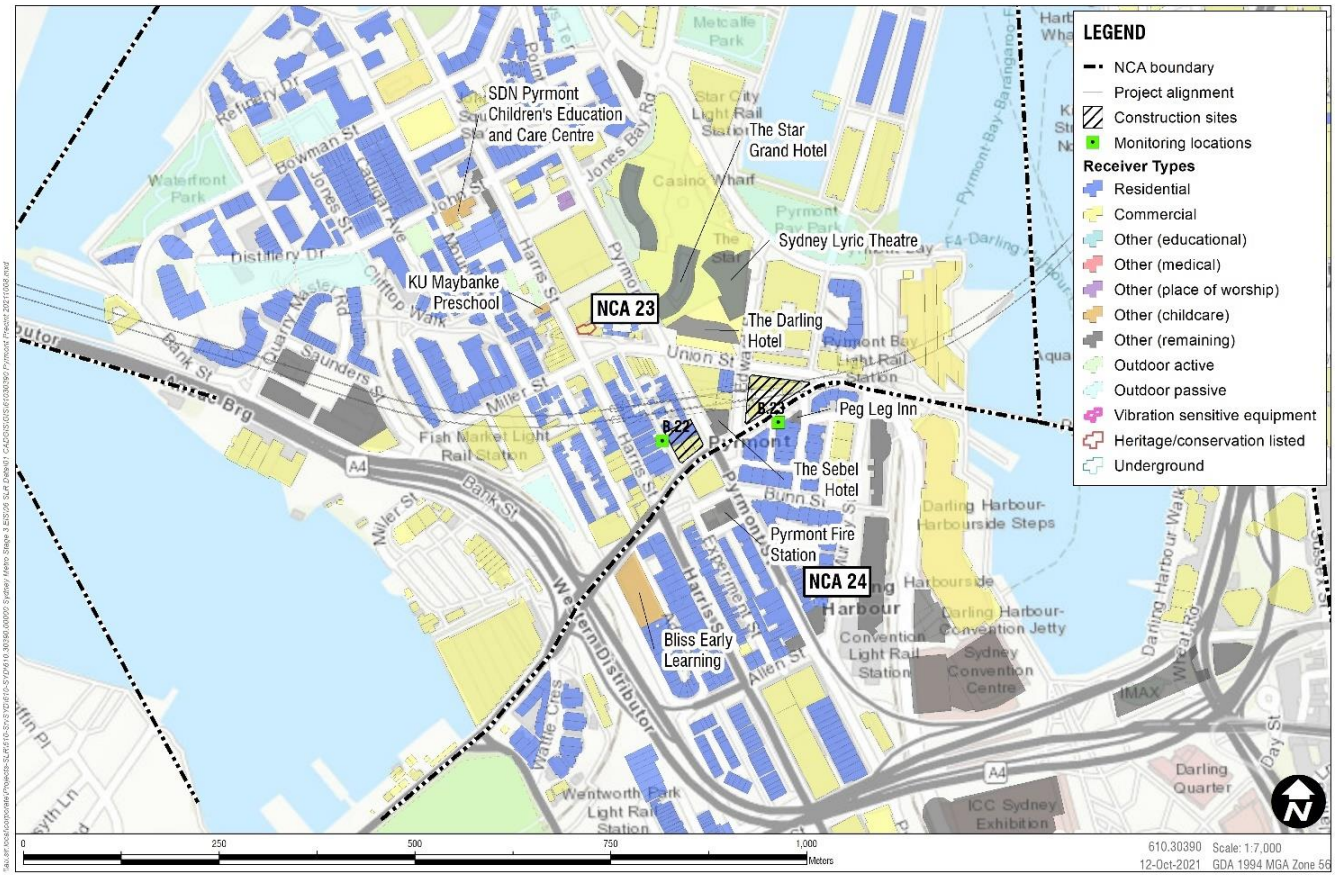
The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

5.2.8 Pyrmont (NCA23 – NCA24)

Pyrmont Station would involve the use of two construction sites. The Pyrmont Station western construction site is located between Paternoster Row and Pyrmont Street, immediately north of Pyrmont Bridge Road. The Pyrmont Station eastern construction site is located between Edward Street, Union Street and Pyrmont Bridge Road.

Existing noise levels in this study area are controlled by road traffic noise on the surrounding road network. The area surrounding the construction sites is mostly residential and commercial. The nearest receivers are close to the boundary of sites. The sites and NCAs are shown in **Figure 44**.

Figure 44 Pyrmont Site Map and Sensitive Receivers



5.2.8.1 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 60**. The estimated duration of each activity is also provided, noting that most activities would be intermittent and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

The proposed work is anticipated to have a total duration of around four years.

Table 60 Pyrmont Construction Activities and Working Hours

Scenario	Activity		Total indicative duration (months)[2]	Hours of work[1]			
				Std. day	Out of hours		
					Day OOH	Eve	Night
Site establishment and public domain work	Typical	Deliveries and general work	18	✓	✓	-	-
	Peak	Construction / decommissioning of facilities and hoarding		✓	✓	-	-
Piling	Typical	Supporting work	1	✓	✓	-	-
	Peak	Bored piling with support plant		✓	✓	-	-
Station / facility construction	Typical	Indoor construction and fit-out	24	✓	✓	✓	✓
	Peak 1	Installation of framing and structure		✓	✓	✓	-
	Peak 2	Concrete work		✓	✓	✓	-

Note 1: OOH = out of hours.

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.

5.2.8.2 Overview of Airborne Noise Impacts from Construction Site

Number of NML Exceedances

The predicted airborne noise impacts from construction site work in this study area are summarised in **Table 61**, **Table 62** and **Table 63** for all receiver types, residential receivers, and commercial/'other sensitive' receivers, respectively. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding 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.

Table 61 Pyrmont Overview of NML Exceedances – All Receiver Types

Scenario	Activity	No. Months[1]	Number of receivers															
			Total	HNA[2]	With NML exceedance[3]													
					Standard construction hours daytime			Out of hours work[4]										
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	1155	2	27	9	-	30	21	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1155	14	45	24	2	69	27	10	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	1	1155	2	36	4	2	37	20	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1155	10	43	20	2	65	33	6	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	24	1155	2	20	2	-	33	4	2	31	14	2	39	21	2	28	3	-
	Peak 1		1155	3	36	7	2	40	25	2	50	31	5	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		1155	37	90	38	10	149	41	29	228	59	39	n/a	n/a	n/a	n/a	n/a	n/a

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 62 Pyrmont Overview of NML Exceedances – Residential Receivers

Scenario	Activity	No. Months[1]	Number of receivers															
			Total	HNA[2]	With NML exceedance[3]													
					Standard construction hours daytime			Out of hours work[4]										
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	939	2	25	9	-	28	21	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		939	14	31	24	2	55	27	10	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	1	939	2	33	4	2	34	20	2	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		939	10	34	20	2	56	33	6	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	24	939	2	20	2	-	33	4	2	31	14	2	36	21	2	28	3	-
	Peak 1		939	3	31	7	2	35	25	2	47	31	5	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		939	37	75	33	10	134	36	29	225	56	39	n/a	n/a	n/a	n/a	n/a	n/a

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 63 Pyrmont Overview of Commercial and 'Other Sensitive' Receiver NML Exceedances

Scenario	Activity	No. Months[1]	Number of Receivers																	
			Commercial			Child Care			Hotel			Hotel (Night)			Public Building			Theatre		
			1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-	1	-	-
	Peak		8	-	-	2	-	-	3	-	-	1	3	-	-	-	-	1	-	-
Piling	Typical	1	-	-	-	1	-	-	1	-	-	2	1	-	-	-	-	1	-	-
	Peak		4	-	-	1	-	-	3	-	-	2	3	-	-	-	-	1	-	-
Station / facility construction	Typical	24	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-
	Peak 1		1	-	-	1	-	-	2	-	-	1	2	-	-	-	-	1	-	-
	Peak 2		10	1	-	2	1	-	1	2	-	3	1	2	1	-	-	1	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.

Daytime Scenarios

The highest daytime construction noise impacts are predicted during *Station / facility construction* when noise intensive equipment such as a concrete saw is in use. The worst-case range of predicted daytime impacts during this work are shown in:

- **Figure 45** – *Station / facility construction – Concrete work (peak 2)*
- **Figure 46** – *Station / facility construction – Installation of framing and structure (peak 1).*

The highest impact work is expected to last for:

- *Station / facility construction – Concrete work (peak 2)* – 24 months, however, concrete saws would only be used intermittently as required for crack control when slabs are poured.

Figure 45 Worst-Case Daytime Airborne Noise – *Station / Facility Construction – Concrete Work (Peak 2)*

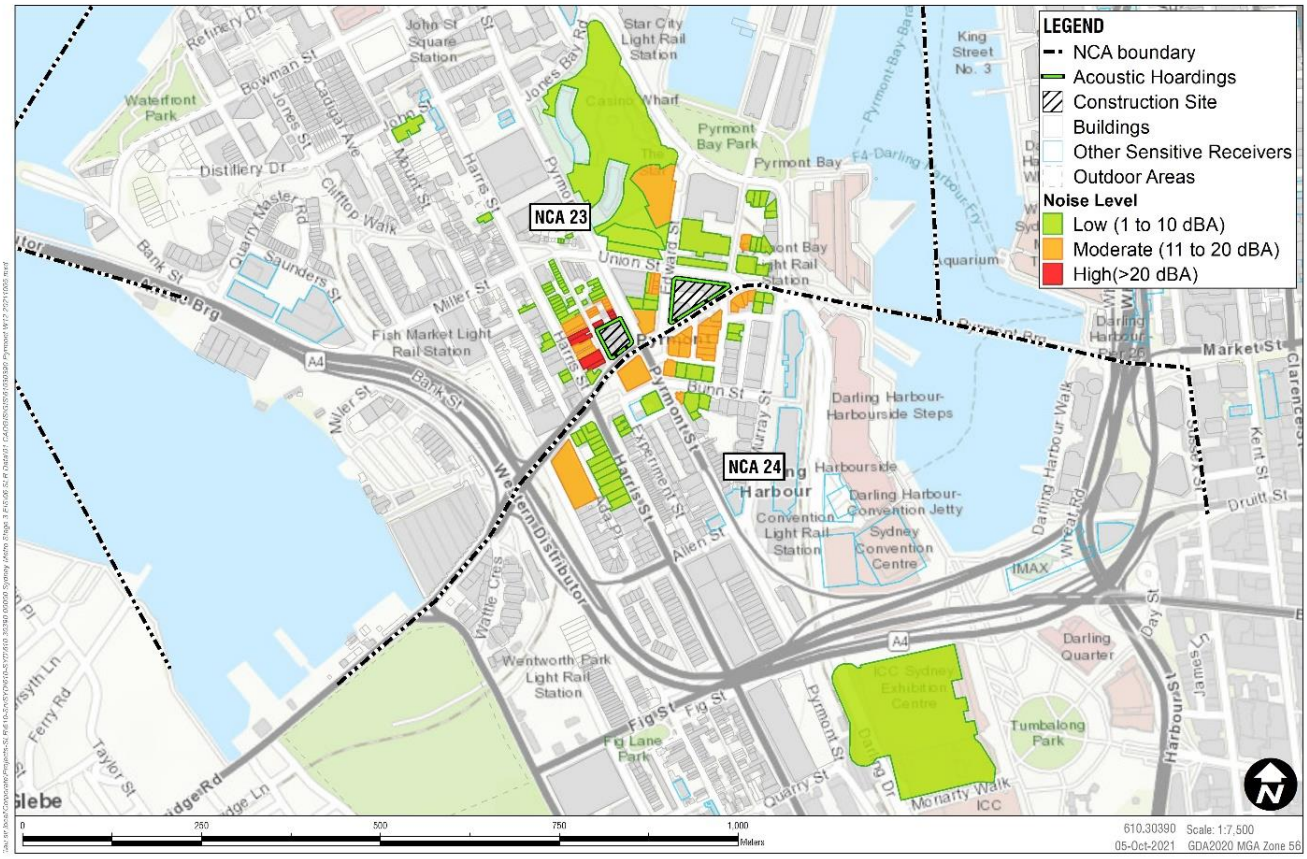
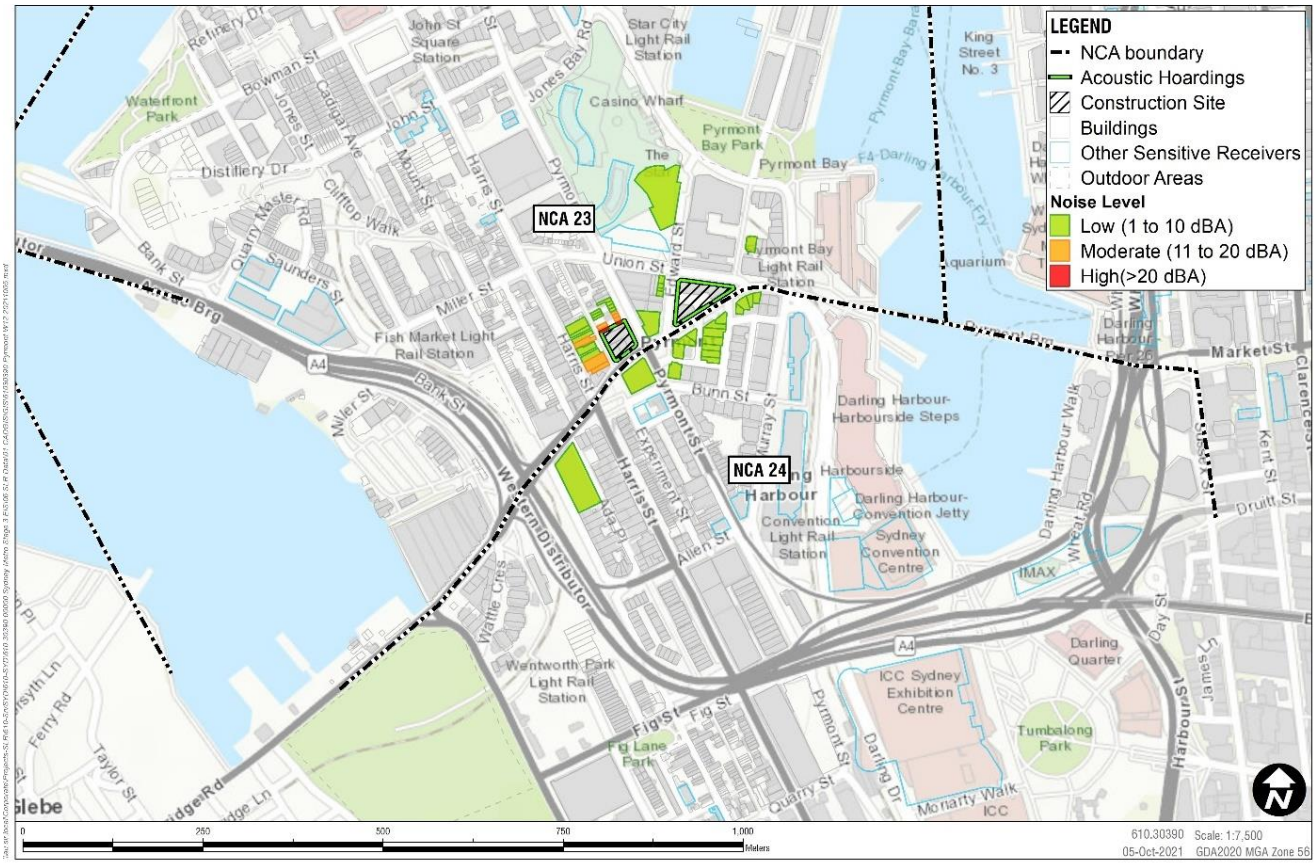


Figure 46 Worst-Case Daytime Airborne Noise – *Station / Facility Construction – Inst. of Framing & Structure (Peak 1)*



The proposed work at Pyrmont Station construction site would involve outdoor activities during construction of the facility. When the facility structure is complete, work would move inside to complete the fit-out of the facility.

The above assessment during the worst-case daytime impacts shows the following:

- Residential receivers are located relatively close to the construction site and impacts are predicted to be 'moderate' to 'high' during noisy outside work, particularly when noise intensive equipment such as concrete saws are being used as part of *Station / facility construction* work. Concrete saws are expected to be infrequently used throughout a 24 month construction period. The impacts during 'typical' work which does not require noise intensive equipment or are inside the station are predicted to substantially reduce, with noise levels generally predicted to result in 'moderate' or 'low' impacts at the nearest receivers.
- The 'peak' scenarios generate more noise and result in more exceedances than the 'typical' scenarios, which results from the 'peak' scenarios using noise intensive (or noisier) equipment.
- The nearest commercial and 'other sensitive' receivers are predicted to impacted during some of the noisier outdoor work activities. 'Moderate' worst-case impacts are predicted at:
    - Sydney Lyric Theatre
    - Sebel Hotel
    - Pegg Legg Inn
    - Bliss Early Learning.

The highest impacts at these receivers are predicted when concrete saws are being used as part of *Station / facility construction*. Concrete saws are expected to be infrequently used throughout a 24 month construction period.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would frequently be periods when construction 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 occur.

Night-Time Scenarios

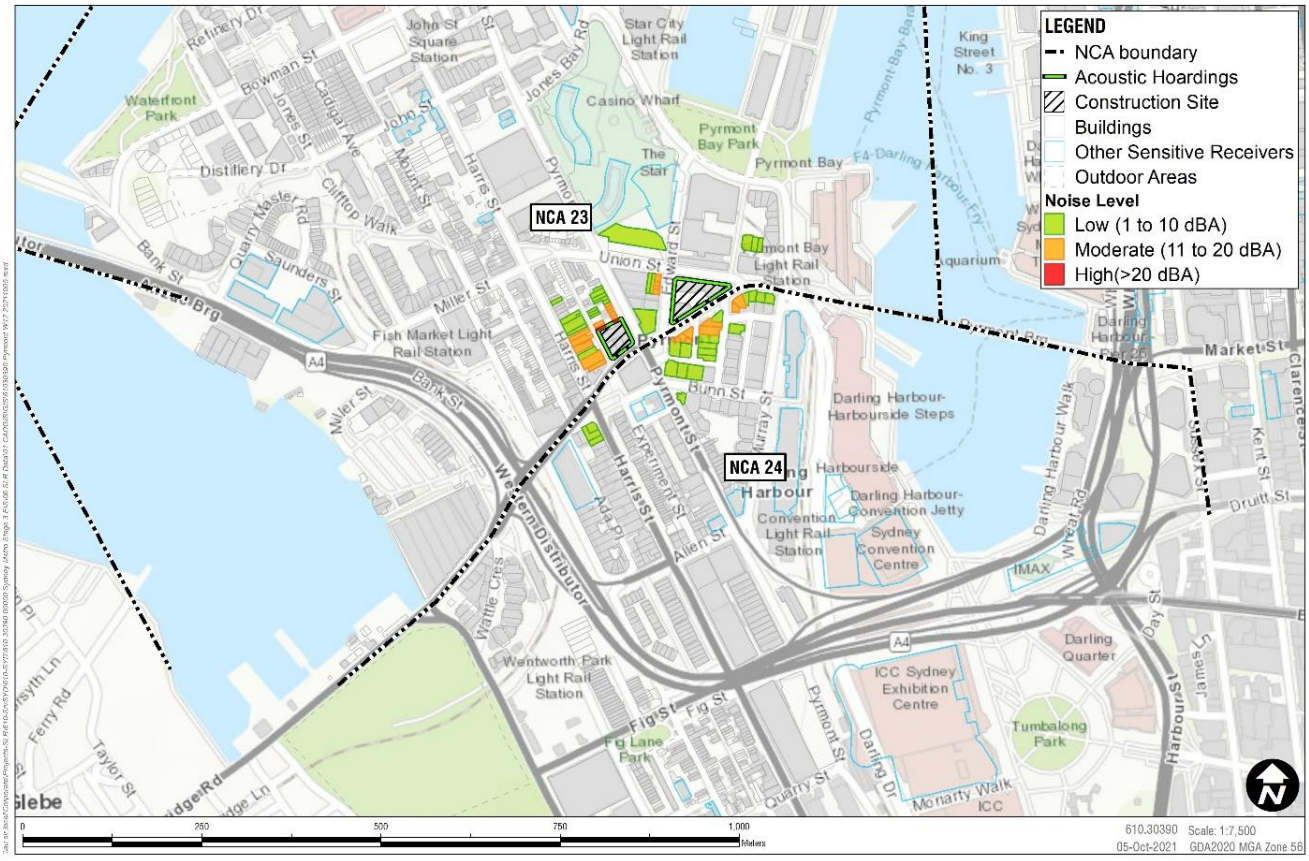
Night-time work at the Pyrmont Station construction site would involve *Station / facility construction – Indoor construction and fit-out*. The majority of this work would occur inside the built station structure and does not require noise intensive equipment. The worst-case predicted night-time impacts during this work are shown in:

- **Figure 47** – *Station / facility construction – Indoor construction and fit-out (typical)*.

The work is expected to last for:

- *Station / facility construction* – 24 months.

Figure 47 Worst-Case Night-Time Airborne Noise – *Station / Facility Construction – Indoor Construction and Fit-Out (Typical)*



The above assessment during the worst-case night-time impacts shows the following:

- 'High' to 'moderate' impacts are predicted at the nearest residential receivers, particularly surrounding the western construction site. More distant receivers are predicted to have 'moderate' to 'low' impacts. These worst-case impacts are expected to occur only during external fit-out activities, such as during the installation of cladding.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would be periods when construction 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 occur.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed and is summarised in **Table 61**. 'Moderate' sleep disturbance impacts are predicted at a small number of the nearest residential receivers during *Station / facility construction*.

The number of potential night-time awakenings would depend on several factors, including the type of equipment being used and the duration of the noisy work.

Further investigation of awakenings would be completed during the next stages of the proposal when detailed construction planning information becomes available.

Highly Noise Affected Residential Receivers

The receivers predicted to be highly noise affected are summarised in **Table 64** and shown in **Figure 48**.

Table 64 Pyrmont Predicted Number of Highly Noise Affected Residential Receivers

Scenario	Activity		NCA23			NCA24		
			Day	Eve	Night	Day	Eve	Night
Site establishment and public domain work	Typical	Deliveries and general work	2	n/a	n/a	-	n/a	n/a
	Peak	Construction / decommissioning of facilities and hoarding	13	n/a	n/a	1	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
Station / facility construction	Typical	Indoor construction and fit-out	2	2	2	-	-	-
	Peak 1	Installation of framing and structure	3	3	n/a	-	-	n/a
	Peak 2	Concrete work	24	24	n/a	13	13	n/a

Note 1: 'n/a' represents where work would not be performed during the evening or night-time periods.

Figure 48 Pyrmont Highly Noise Affected Residential Receivers (From Any Work Scenario)

The assessment shows that a some of the nearest residential receivers with line of sight to the work areas in each construction site are predicted to be highly noise affected, particularly when concrete saws are being used outside. Concrete saws are expected to be infrequently used throughout a 24 month construction period.

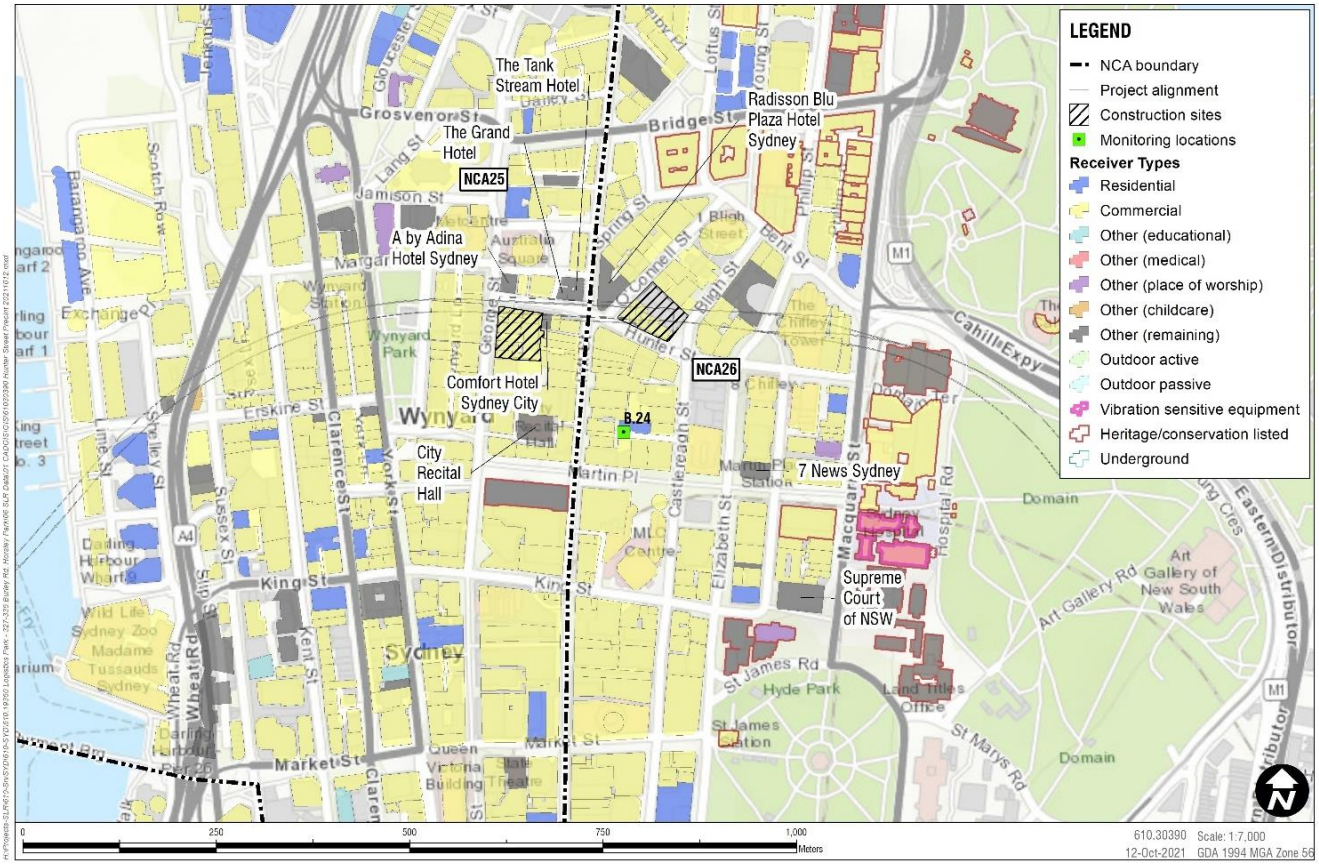
The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

5.2.9 Hunter Street (Sydney CBD) (NCA25 – NCA26)

Hunter Street Station (Sydney CBD) would involve the use of two construction sites. The Hunter Street Station (Sydney CBD) western construction site is located on the south-east corner of Hunter Street and George Street and would also contain DeMestre Place. The Hunter Street Station (Sydney CBD) eastern construction site is bound by O'Connell Street, Hunter Street and Bligh Street

Existing noise levels in this study area are controlled by road traffic noise and general urban hum associated with the CBD. As with any CBD, existing noise levels and are relatively high during all periods. The area surrounding the construction sites is mainly commercial and the nearest receivers are close to the boundary of the sites. The sites and NCAs are shown in **Figure 49**.

Figure 49 Hunter Street (Sydney CBD) Site Map and Sensitive Receivers



5.2.9.1 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 65**. The estimated duration of each activity is also provided, noting that most activities would be intermittent and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

The proposed work is anticipated to have a total duration of around four years.

Table 65 Hunter Street (Sydney CBD) Construction Activities and Working Hours

Scenario	Activity		Total indicative duration (months)[2]	Hours of work[1]			
				Std. day	Out of hours		
					Day OOH	Eve	Night
Site establishment and public domain work	Typical	Deliveries and general work	18	✓	✓	-	-
	Peak	Construction / decommissioning of facilities and hoarding		✓	✓	-	-
Piling	Typical	Supporting work	1	✓	✓	-	-
	Peak	Bored piling with support plant		✓	✓		-
Station / facility construction	Typical	Indoor construction and fit-out	24	✓	✓	✓	✓
	Peak 1	Installation of framing and structure		✓	✓	✓	-
	Peak 2	Concrete work		✓	✓	✓	-

Note 1: OOH = out of hours.

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.

5.2.9.2 Overview of Airborne Noise Impacts from Construction Site

Number of NML Exceedances

The predicted airborne noise impacts from construction site work in this study area are summarised in **Table 66**, **Table 67** and **Table 68** for all receiver types, residential receivers, and commercial/'other sensitive' receivers, respectively. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding 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.

Table 66 Hunter Street (Sydney CBD) Overview of NML Exceedances – All Receiver Types

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	624	-	5	5	-	5	5	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		624	-	16	9	-	16	9	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	1	624	-	6	8	-	6	8	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		624	-	17	9	-	17	9	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	24	624	-	9	-	-	9	-	-	1	-	-	3	1	-	-	-	-
	Peak 1		624	-	11	8	-	11	8	-	2	1	-	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		624	-	29	13	9	30	13	9	5	3	1	n/a	n/a	n/a	n/a	n/a	n/a

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{Aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 67 Hunter Street (Sydney CBD) Overview of NML Exceedances – Residential Receivers

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment & public domain work	Typical	18	54	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		54	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	1	54	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		54	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	24	54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak 1		54	-	-	-	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		54	-	-	-	-	1	-	-	1	-	-	n/a	n/a	n/a	n/a	n/a	n/a

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 68 Hunter Street (Sydney CBD) Overview of Commercial and 'Other Sensitive' Receiver NML Exceedances

Scenario	Activity	No. Months[1]	Number of Receivers														
			Commercial			Court			Hotel			Hotel (Night)			Theatre		
			1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment and public domain work	Typical	18	4	4	-	-	-	-	-	1	-	n/a	n/a	n/a	1	-	-
	Peak		13	8	-	-	-	-	2	1	-	n/a	n/a	n/a	1	-	-
Piling	Typical	1	5	7	-	-	-	-	-	1	-	n/a	n/a	n/a	1	-	-
	Peak		13	8	-	-	-	-	3	1	-	n/a	n/a	n/a	1	-	-
Station / facility construction	Typical	24	8	-	-	-	-	-	1	-	-	3	1	-	-	-	-
	Peak 1		9	7	-	-	-	-	1	1	-	n/a	n/a	n/a	1	-	-
	Peak 2		25	10	8	1	-	-	2	2	1	n/a	n/a	n/a	1	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.

Daytime scenarios

The highest daytime construction noise impacts are predicted during *Station / facility construction* when noise intensive equipment such as a concrete saw is in use. The worst-case range of predicted daytime impacts during this work are shown in:

- **Figure 50** – *Station / facility construction – Concrete work (peak 2)*
- **Figure 51** – *Station / facility construction – Installation of framing and structure (peak 1).*

The highest impact work is expected to last for:

- *Station / facility construction – Concrete work (peak 2)* – 24 months, however, concrete saws would only be used intermittently as required for crack control when slabs are poured.

Figure 50 Worst-Case Daytime Airborne Noise – *Station / Facility Construction – Concrete Work (Peak 2)*

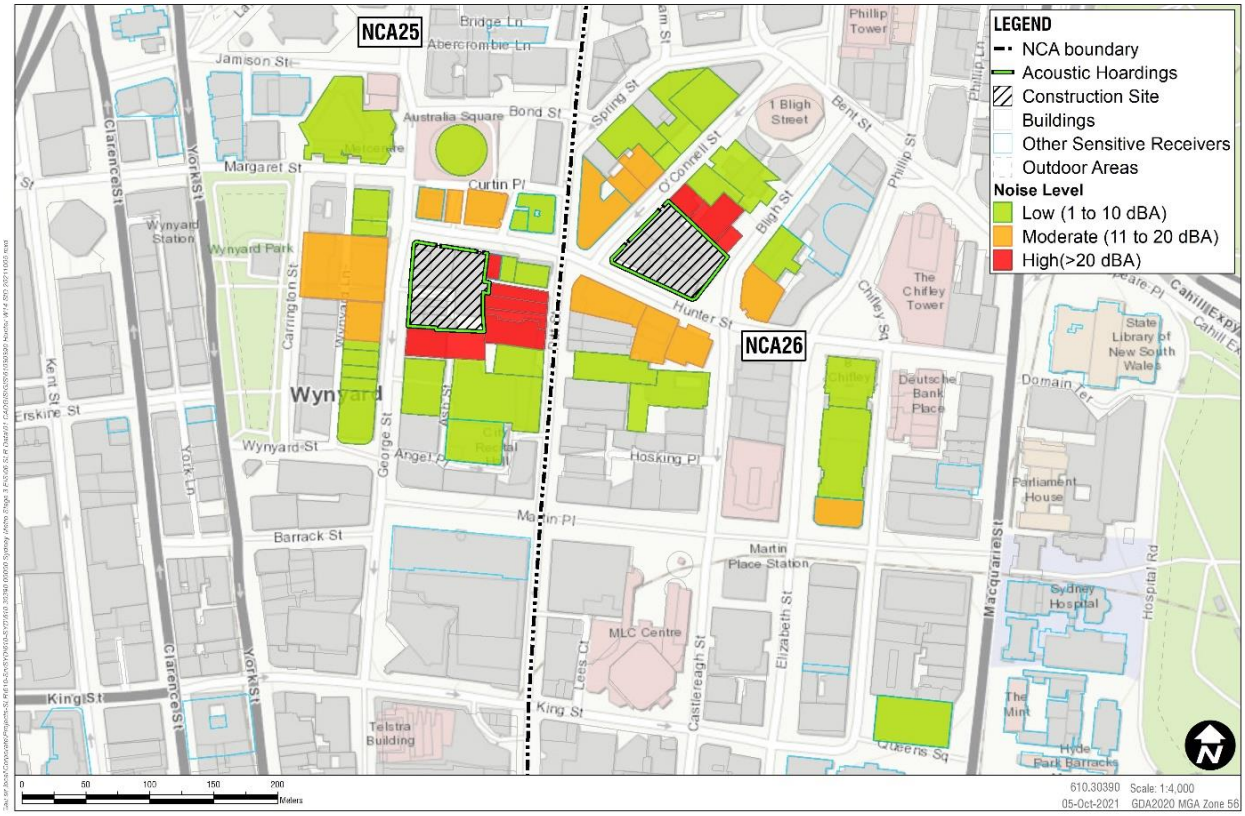
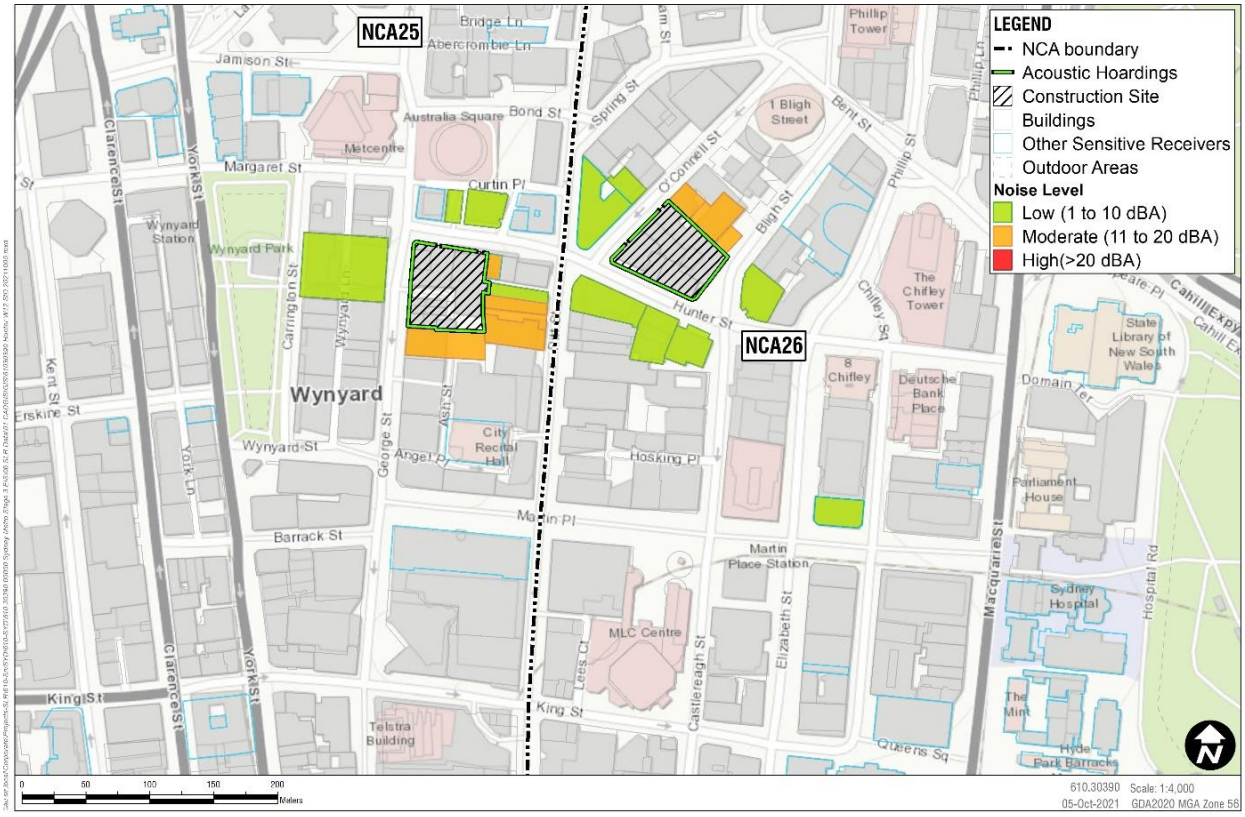


Figure 51 Worst-Case Daytime Airborne Noise – *Station / Facility Construction – Inst. Of Framing & Structure (Peak 1)*



The proposed work at Hunter Street Station (Sydney CBD) construction site would involve outdoor activities during construction of the facility. When the facility structure is complete, work would move inside to complete the fit-out of the facility.

The above assessment during the worst-case daytime impacts shows the following:

- Residential receivers are distant from the site and the surrounding receivers are generally commercial and 'other sensitive'. 'Moderate' to 'high' impacts are predicted during noisy outside work, particularly when noise intensive equipment such as concrete saws are being used as part of *Station / facility construction* work. Concrete saws are expected to be infrequently used throughout a 24 month construction period. The impacts during 'typical' work which does not require noise intensive equipment or are inside the station are predicted to substantially reduce, with noise levels predicted to result in 'moderate' or 'low' impacts at a small number of the nearest receivers.
- The 'peak' scenarios generate more noise and result in more exceedances than the 'typical' scenarios, which results from the 'peak' scenarios using noise intensive (or noisier) equipment.
- The nearest commercial and 'other sensitive' receivers are predicted to impacted during some of the noisier outdoor work activities. 'High' or 'moderate' worst-case impacts are predicted at:
    - The Comfort Hotel Sydney ('high')
    - A by Adina Hotel Sydney ('moderate')
    - Radisson Blu Plaza Hotel Sydney ('moderate')
    - 7 News Sydney ('moderate').

The highest impacts at these receivers are predicted when concrete saws are being used as part of *Station / facility construction*. Concrete saws are expected to be infrequently used throughout a 24 month construction period.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would frequently be periods when construction 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 occur.

Night-Time Scenarios

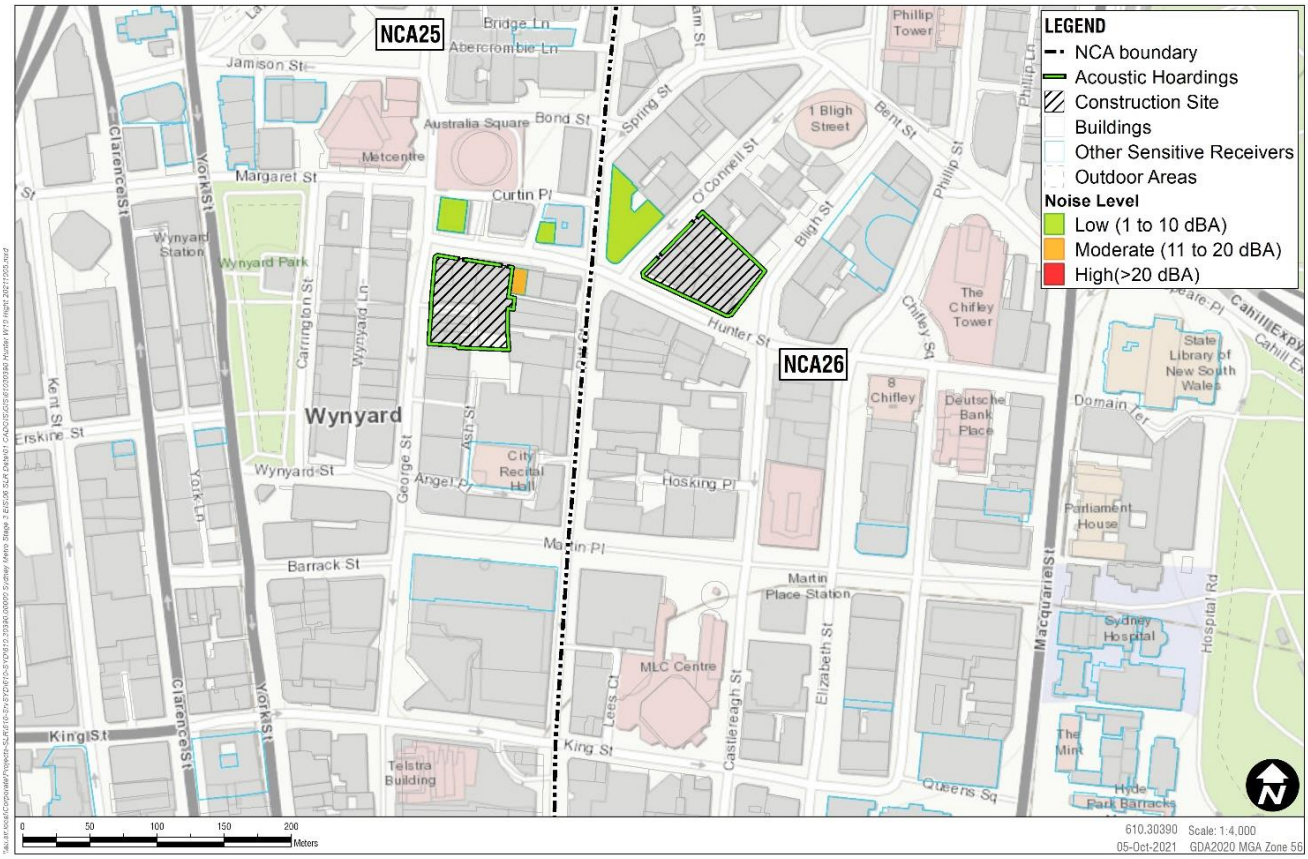
Night-time work at the Hunter Street Station (Sydney CBD) construction site would involve *Station / facility construction – Indoor construction and fit-out*. The majority of this work would occur inside the built station structure and does not require noise intensive equipment. The worst-case predicted night-time impacts during this work are shown in:

- **Figure 52** – *Station / facility construction – Indoor construction and fit-out (typical)*.

The work is expected to last for:

- *Station / facility construction* – 24 months.

Figure 52 Worst-Case Night-Time Airborne Noise – *Station / Facility Construction – Indoor Construction and Fit-Out (Typical)*



The above assessment during the worst-case night-time impacts shows the following:

- Noise levels at the majority of receivers are predicted to comply with the noise management levels. 'Moderate' impacts are predicted the closest hotel receiver and 'low' impacts are predicted at three more distant hotels.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**

Sleep Disturbance

A sleep disturbance screening assessment has been completed and is summarised in **Table 66**. No sleep disturbance impacts are predicted from the proposed work.

Highly Noise Affected Residential Receivers

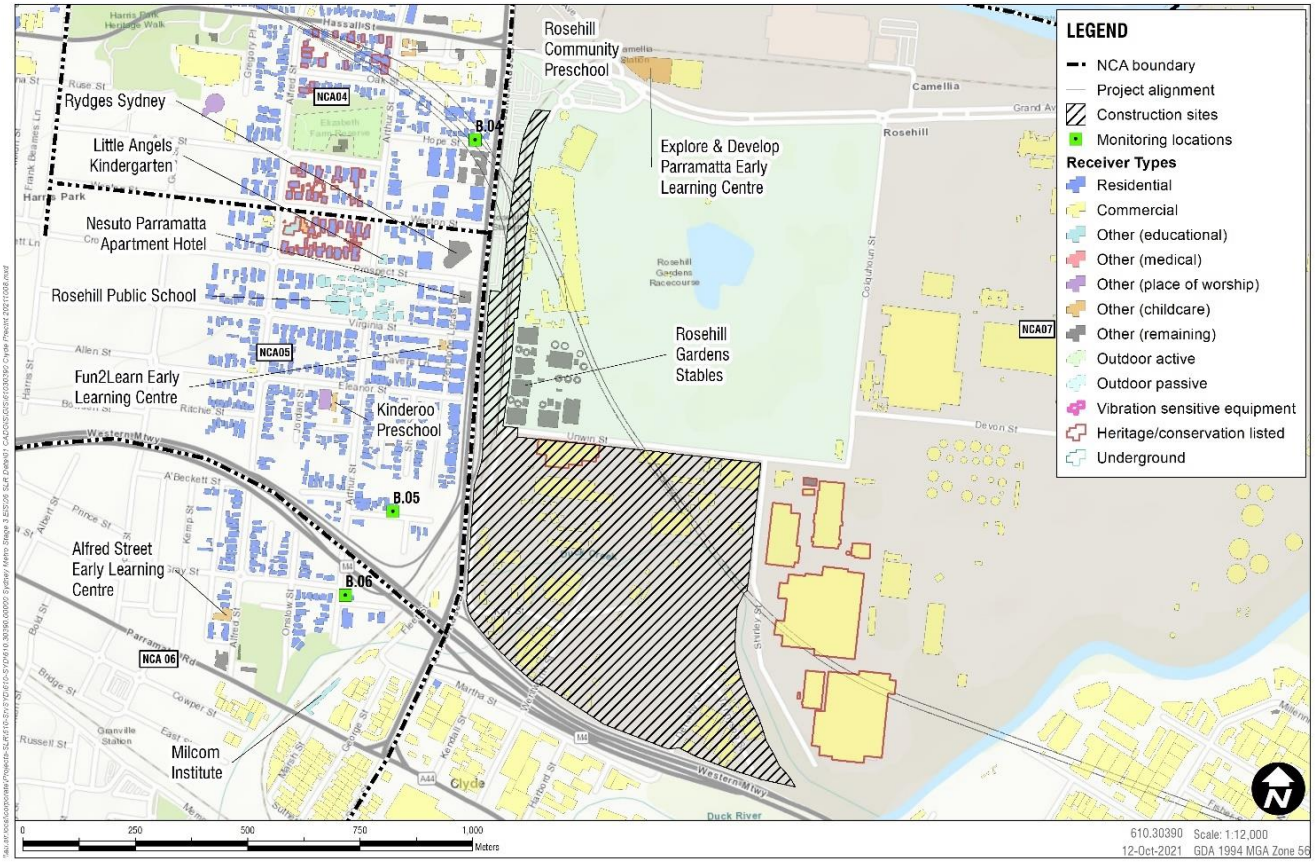
No receivers are predicted to be highly noise affected in this study area.

5.2.10 Clyde and Rosehill (NCA04 – NCA07)

The Clyde stabling and maintenance facility and Rosehill services facility construction site is between the M4 Motorway, James Ruse Drive and Rosehill Gardens racecourse, and is the location of the proposed stabling and maintenance facility. The site would have an access shaft at the tunnel portal and Rosehill services facility to provide a tunnel access point for delivery of construction materials. This would occur up to 24 hours per day and seven days per week to support tunnel fit-out. The access shaft at Rosehill would be within an acoustic shed to mitigate impacts.

Existing noise levels in this study area are generally controlled by road traffic noise on the surrounding road network. The area surrounding the construction site is generally suburban residential to the west and commercial/industrial to the east. The site and NCAs are shown in **Figure 53**.

Figure 53 Clyde and Rosehill Site Map and Sensitive Receivers



Note: B.07 monitoring location is at 10 Carnarvon Street, Silverwater, to the southeast of the map view.

5.2.10.1 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 69**. The estimated duration of each activity is also provided, noting that most activities would be intermittent and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

The proposed work is anticipated to have a total duration of around four and a half years.

Table 69 Clyde and Rosehill Construction Activities and Working Hours

Scenario	Activity		Total indicative duration (months)[2]	Hours of work[1]			
				Std. day	Out of hours		
					Day OOH	Eve	Night
Site establishment and public domain work	Typical	Deliveries and general work	6	✓	✓	-	-
	Peak	Construction / decommissioning of facilities and hoarding		✓	✓	-	-
Piling	Typical	Supporting work	6	✓	✓	-	-
	Peak	Bored piling with support plant		✓	✓	-	-
Station / facility construction	Typical	Indoor construction and fit-out	21	✓	✓	✓	✓
	Peak 1	Installation of framing and structure		✓	✓	✓	-
	Peak 2	Concrete work		✓	✓	✓	-
Rail systems access shafts	Typical	Surface support	36	✓	✓	✓	✓
	Peak	Deliveries and tunnel access		✓	✓	✓	✓
Earthwork	Typical	Stockpiling and support	18	✓	✓	-	-
	Peak	Excavation and compacting		✓	✓	-	-
Above-ground rail	Typical	Track installation	33	✓	✓	-	-
	Peak	Track subgrade, capping and tamping		✓	✓	-	-

Note 1: OOH = out of hours.

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.

5.2.10.2 Overview of Airborne Noise Impacts from Construction Site

Number of NML Exceedances

The predicted airborne noise impacts from construction site work in this study area are summarised in **Table 70**, **Table 71** and **Table 72** for all receiver types, residential receivers, and commercial/'other sensitive' receivers, respectively. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding 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.

Table 70 Clyde and Rosehill Overview of NML Exceedances – All Receiver Types

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment and public domain work	Typical	6	2765	-	18	-	-	27	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		2765	-	34	2	-	64	7	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	6	2765	-	16	-	-	25	1	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		2765	-	35	2	-	73	6	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	21	2765	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak 1		2765	-	-	-	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		2765	-	17	-	-	62	-	-	78	-	-	n/a	n/a	n/a	n/a	n/a	n/a
Rail systems access shafts	Typical	36	2765	-	-	-	-	5	-	-	5	-	-	10	-	-	5	-	-
	Peak		2765	-	1	-	-	6	-	-	8	-	-	15	-	-	12	-	-
Earthwork	Typical	18	2765	-	42	5	-	100	9	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		2765	-	55	12	-	131	20	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Above-ground rail	Typical	33	2765	-	5	-	-	8	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		2765	4	119	18	-	212	28	4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 71 Clyde and Rosehill Overview of NML Exceedances – Residential Receivers

Scenario	Activity	No. Months[1]	Number of receivers																
			Total	HNA[2]	With NML exceedance[3]														
					Standard construction hours daytime			Out of hours work[4]											
								Daytime OOH			Evening			Night time			Sleep disturbance		
					1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment and public domain work	Typical	6	1574	-	5	-	-	14	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1574	-	16	-	-	46	5	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Piling	Typical	6	1574	-	5	-	-	14	1	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1574	-	14	1	-	52	5	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Station / facility construction	Typical	21	1574	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak 1		1574	-	-	-	-	-	-	-	-	-	-	n/a	n/a	n/a	n/a	n/a	n/a
	Peak 2		1574	-	9	-	-	54	-	-	75	-	-	n/a	n/a	n/a	n/a	n/a	n/a
Rail systems access shafts	Typical	36	1574	-	-	-	-	5	-	-	5	-	-	10	-	-	10	-	-
	Peak		1574	-	-	-	-	5	-	-	7	-	-	14	-	-	14	-	-
Earthwork	Typical	18	1574	-	18	4	-	76	8	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1574	-	31	5	-	107	13	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Above-ground rail	Typical	33	1574	-	4	-	-	7	-	-	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Peak		1574	4	70	7	-	163	17	4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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.

Note 2: Highly noise affected, based on ICNG definition (i.e. predicted $L_{aeq(15minute)}$ noise at residential receiver is 75 dBA or greater).

Note 3: Based on worst-case predicted noise levels.

Note 4: OOH = out of hours.

Table 72 Clyde and Rosehill Overview of Commercial and 'Other Sensitive' Receiver NML Exceedances

Scenario	Activity	No. Months[1]	Number of Receivers														
			Commercial			Child Care			Educational			Hotel			Stables		
			1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
Site establishment and public domain work	Typical	6	4	-	-	1	-	-	-	-	-	-	-	-	8	-	-
	Peak		7	-	-	2	-	-	-	-	-	-	-	-	9	2	-
Piling	Typical	6	4	-	-	2	-	-	-	-	-	-	-	-	5	-	-
	Peak		5	1	-	3	-	-	1	-	-	-	-	-	12	-	-
Station / facility construction	Typical	21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak 1		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak 2		-	-	-	4	-	-	1	-	-	-	-	-	3	-	-
Rail systems access shafts	Typical	36	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak		-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Earthwork	Typical	18	5	1	-	3	-	-	1	-	-	-	-	-	15	-	-
	Peak		4	3	-	4	1	-	1	-	-	1	-	-	14	3	-
Above-ground rail	Typical	33	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Peak		7	4	-	8	2	-	11	-	-	2	-	-	21	5	-

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.

Daytime Scenarios

The highest daytime construction noise impacts are predicted from *Above-ground rail* when noise intensive equipment such as a rail saw is in use. The worst-case range of predicted daytime impacts during this work are shown in:

- **Figure 54** – *Above-ground rail – Track subgrade, capping and tamping (peak)*
- **Figure 55** – *Above-ground rail – Track installation (typical)*.

The highest impact work is expected to last for:

- *Above-ground rail – Track subgrade, capping and tamping (peak)* – eight months, however, ballast tampers would only be used intermittently as required.

Figure 54 Worst-Case Daytime Airborne Noise – *Above-Ground Rail – Track Subgrade, Capping & Tamping (Peak)*

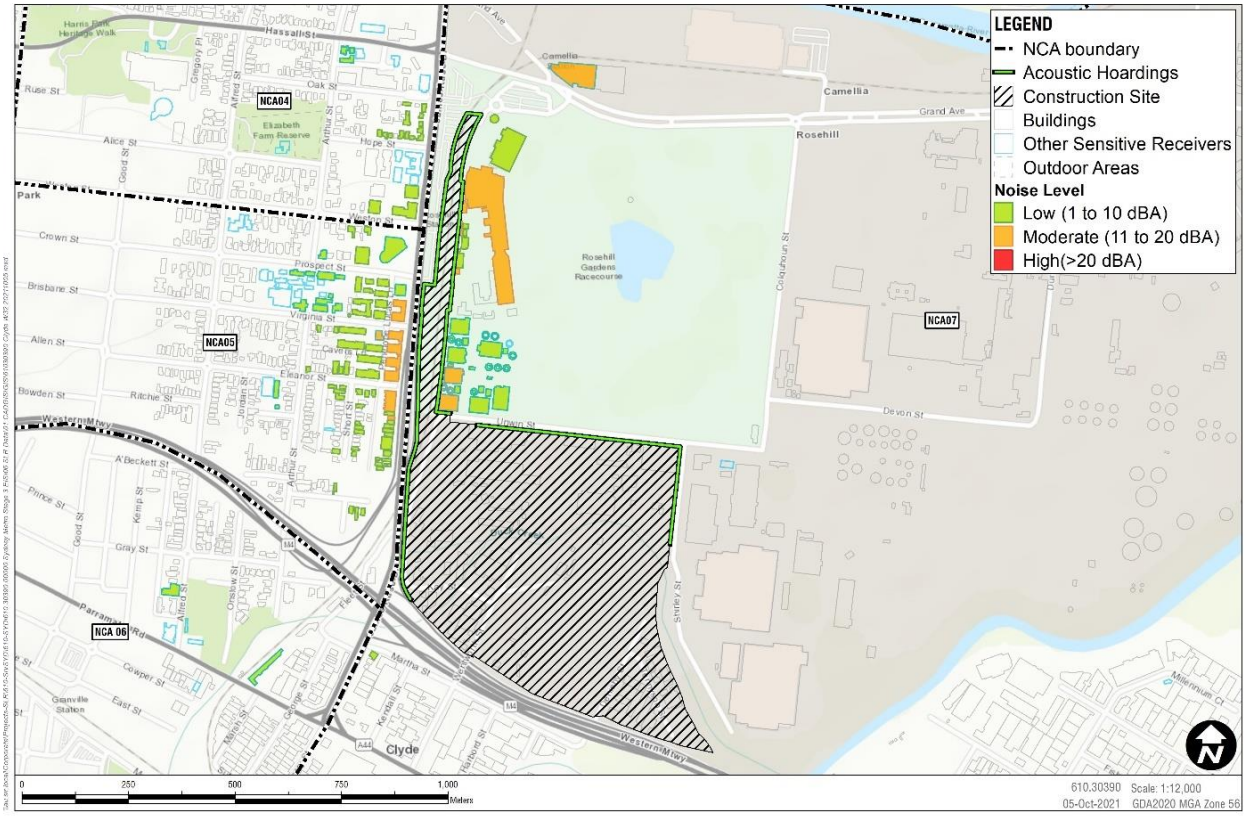
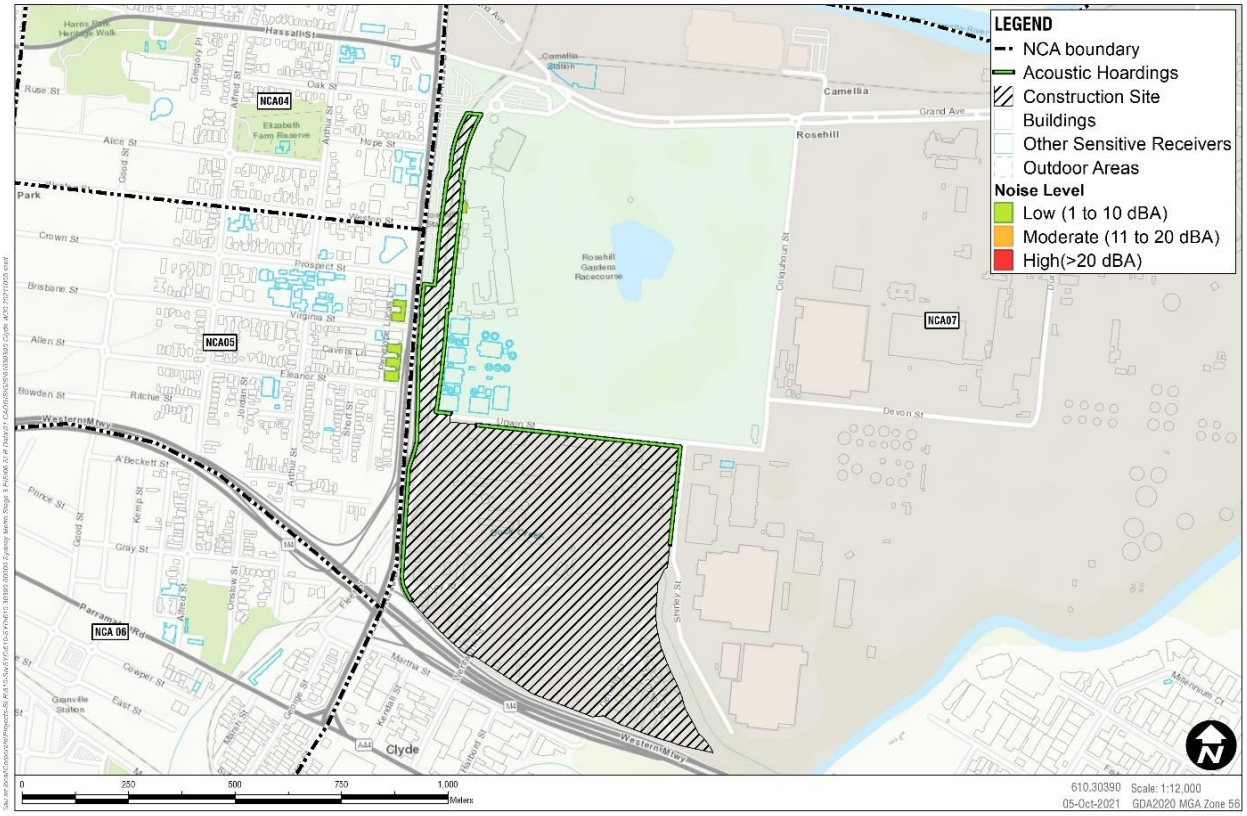


Figure 55 Worst-Case Daytime Airborne Noise – *Above-Ground Rail – Track Installation (Typical)*



The proposed work at Clyde stabling and maintenance facility and Rosehill services facility construction site would involve outdoor piling, earthwork and rail construction work. The site would also have an access shaft at the tunnel portal and Rosehill services facility to provide a tunnel access point for delivery of construction materials.

The above assessment during the worst-case daytime impacts shows the following:

- The nearest receivers to the site are generally residential (across James Ruse Drive) and 'other sensitive' receivers at Rosehill Gardens racecourse (i.e. stables). 'Moderate' impacts are predicted when noise intensive equipment such as rail tampers and vibratory rollers are being used as part of *Above-ground rail* and *Earthworks*. The impacts during 'typical' work which does not require noise intensive equipment or are inside the station are predicted to substantially reduce, with noise levels generally predicted to comply with the noise management levels or result in only 'low' impacts.
- The noise levels during work associated with *Rail systems access shafts* are generally expected to comply with management levels.
- The 'peak' scenarios generate more noise and result in more exceedances than the 'typical' scenarios, which results from the 'peak' scenarios using noise intensive (or noisier) equipment.
- The nearest 'other sensitive' receivers are predicted to impacted during some of the noisier work activities. 'Moderate' worst-case impacts are predicted at:
    - Rosehill Gardens racecourse stables
    - Explore & Develop Parramatta Early Learning Centre.

The highest impacts at these receivers are predicted when ballast tampers or other noisy items of equipment are being used as part of *Site establishment and public domain work*, *Earthwork* and *Above-ground rail* work.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would frequently be periods when construction 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 occur.

Night-Time Scenarios

Night-time work at the Clyde and Rosehill construction site would involve *Rail systems access shafts* and *Station / facility construction – Indoor construction and fit-out*. The majority of this work would occur inside an acoustic shed or the built facility structure and does not require noise intensive equipment. The worst-case range of predicted night-time impacts during this work are shown in:

- **Figure 56** – *Rail system access shafts – Deliveries and tunnel access (peak)*
- **Figure 57** – *Rail system access shafts – Surface support (typical).*

The work is expected to last for:

- *Rail system access shafts* – 36 months.

Figure 56 Worst-Case Night-Time Airborne Noise – *Rail System Access Shafts – Deliveries & Tunnel Access (Peak)*

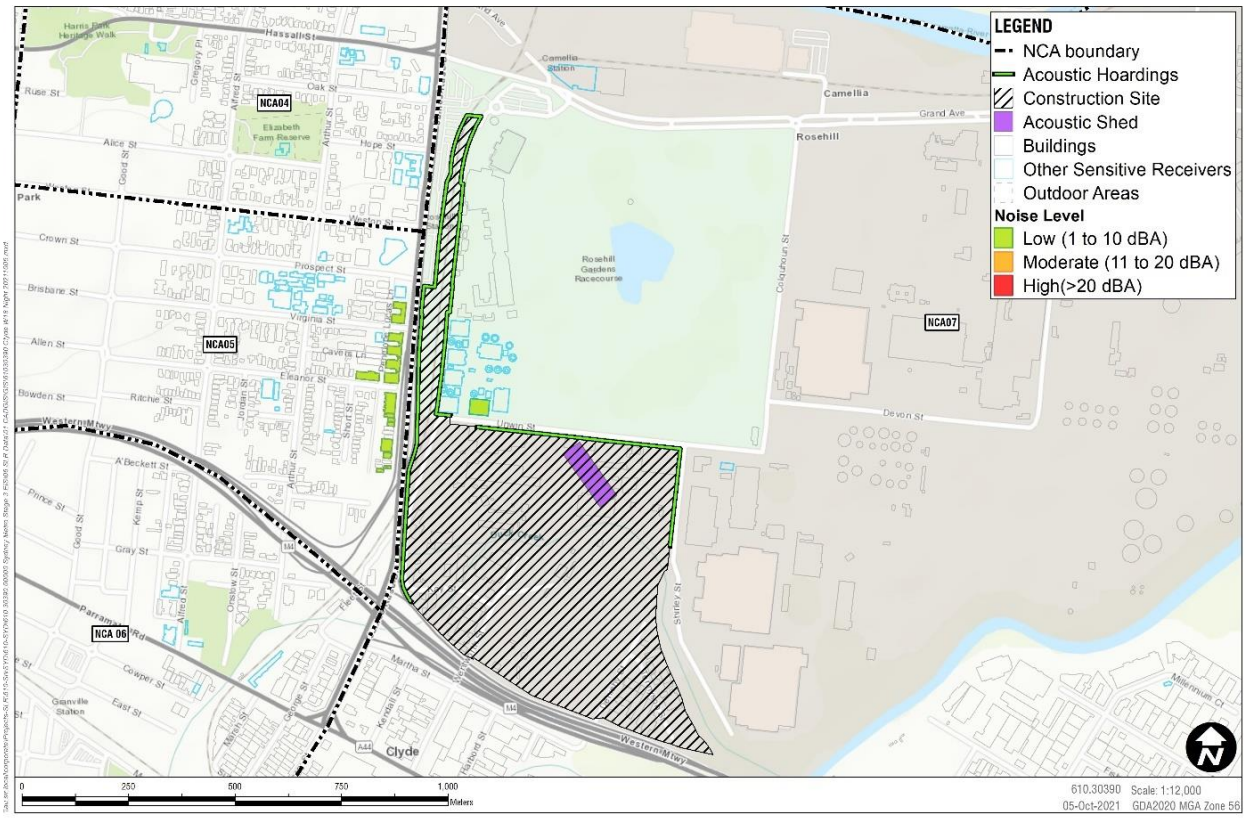
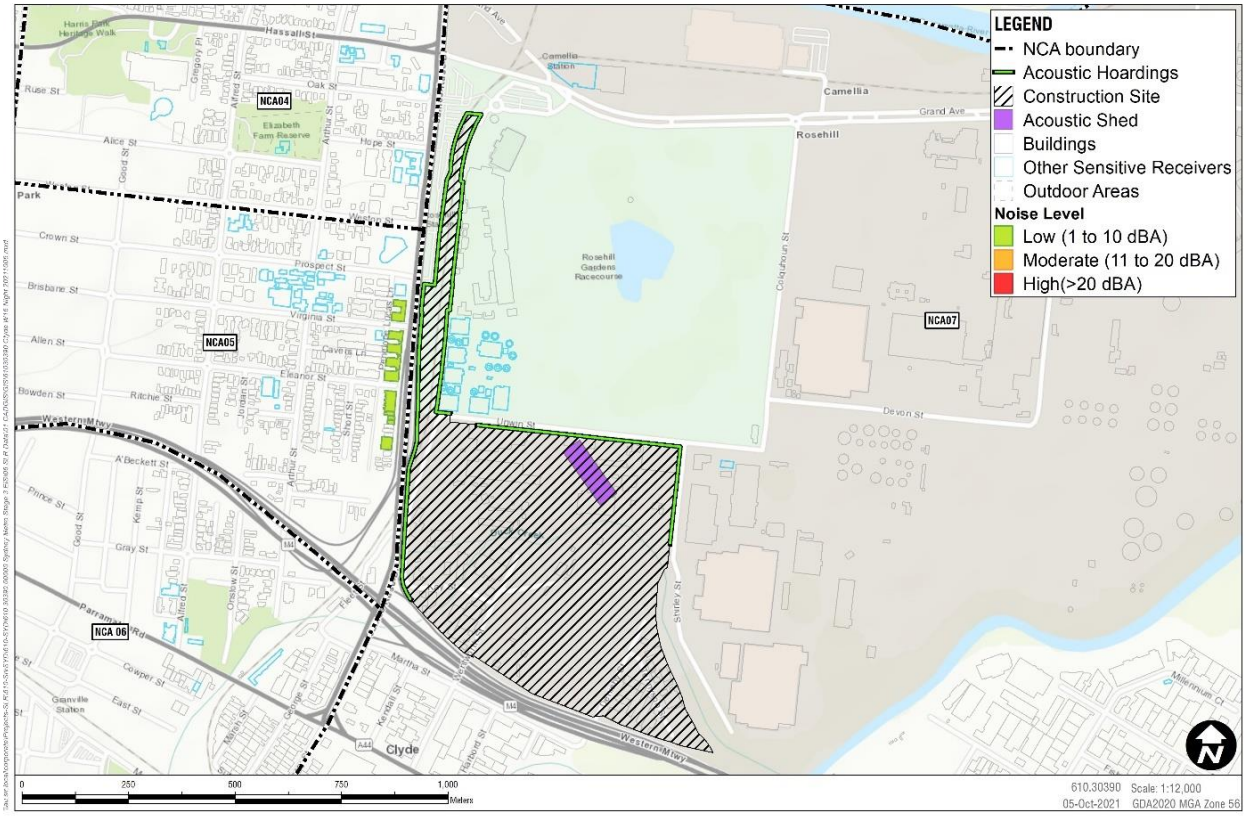


Figure 57 Worst-Case Night-Time Airborne Noise – *Rail System Access Shafts – Surface Support (Typical)*



The above assessment during the worst-case night-time impacts shows the following:

- Noise levels at the majority of receivers are predicted to comply with the noise management levels. 'Low' impacts are predicted at the nearest residential receivers during *Rail system access shafts*, when material is being supplied through the tunnel portal of the outdoor dive structure.
- 'Low' impacts are also predicted at one stable at Rosehill Gardens racecourse that is adjacent to a gap in the acoustic hoarding to allow for the realigned Unwin Street.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would be periods when construction 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 occur.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed and is summarised in **Table 70**. 'Low' sleep disturbance impacts are predicted at the nearest residential receivers to the west of James Ruse Drive. These impacts mainly result from heavy vehicle movements within the site and supply of materials for rail systems fit-out through the dive structure within the Clyde stabling and maintenance facility construction site.

The number of potential night-time awakenings would depend on several factors, including the number of heavy vehicles accessing the site during the night-time, the way in which vehicles are operated, the type of equipment being used and the duration of the noisy work. The number of night-time heavy vehicles at this construction site is expected to be around to four trucks per hour.

Further investigation of awakenings would be completed during the next stages of the proposal when detailed construction planning information becomes available.

Highly Noise Affected Residential Receivers

The receivers predicted to be highly noise affected are summarised in **Table 73** and shown in **Figure 58**.

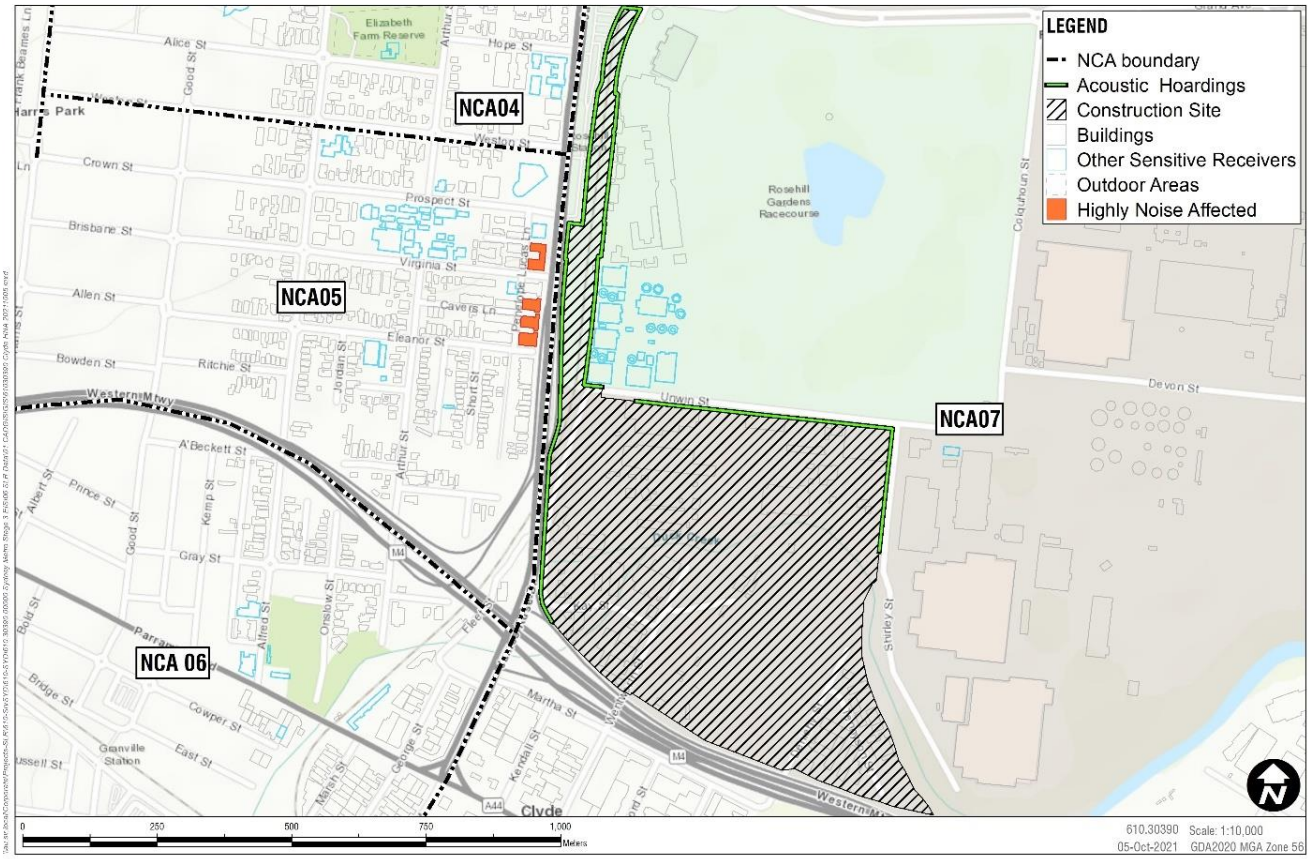
Table 73 Clyde and Rosehill Predicted Number of Highly Noise Affected Residential Receivers

Scenario	Activity		NCA05[2]		
			Day	Eve	Night
Site establishment and public domain work	Typical	Deliveries and general work	-	n/a	n/a
	Peak	Construction / decommissioning of facilities and hoarding	-	n/a	n/a
Piling	Typical	Supporting work	-	n/a	n/a
	Peak	Bored piling with support plant	-	n/a	n/a
Station / facility construction	Typical	Indoor construction and fit-out	-	-	-
	Peak 1	Installation of framing and structure	-	-	n/a
	Peak 2	Concrete work	-	-	n/a
Rail systems access shafts	Typical	Surface support	-	-	-
	Peak	Deliveries and tunnel access	-	-	-
Earthwork	Typical	Stockpiling and support	-	n/a	n/a
	Peak	Excavation and compacting	-	n/a	n/a
Above-ground rail	Typical	Track installation	-	-	-
	Peak	Track subgrade, capping and tamping	4	4	4

Note 1: 'n/a' represents where work would not be performed during the evening or night-time periods.

Note 2: No receivers in NCA04, NCA06 or NCA07 are predicted to be highly noise affected.

Figure 58 Clyde and Rosehill Highly Noise Affected Residential Receivers (From Any Work Scenario)



The assessment shows that a four of the nearest residential receivers to the west are predicted to be highly noise affected when ballast tampers are being used. These are multistorey receivers overlooking the site.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

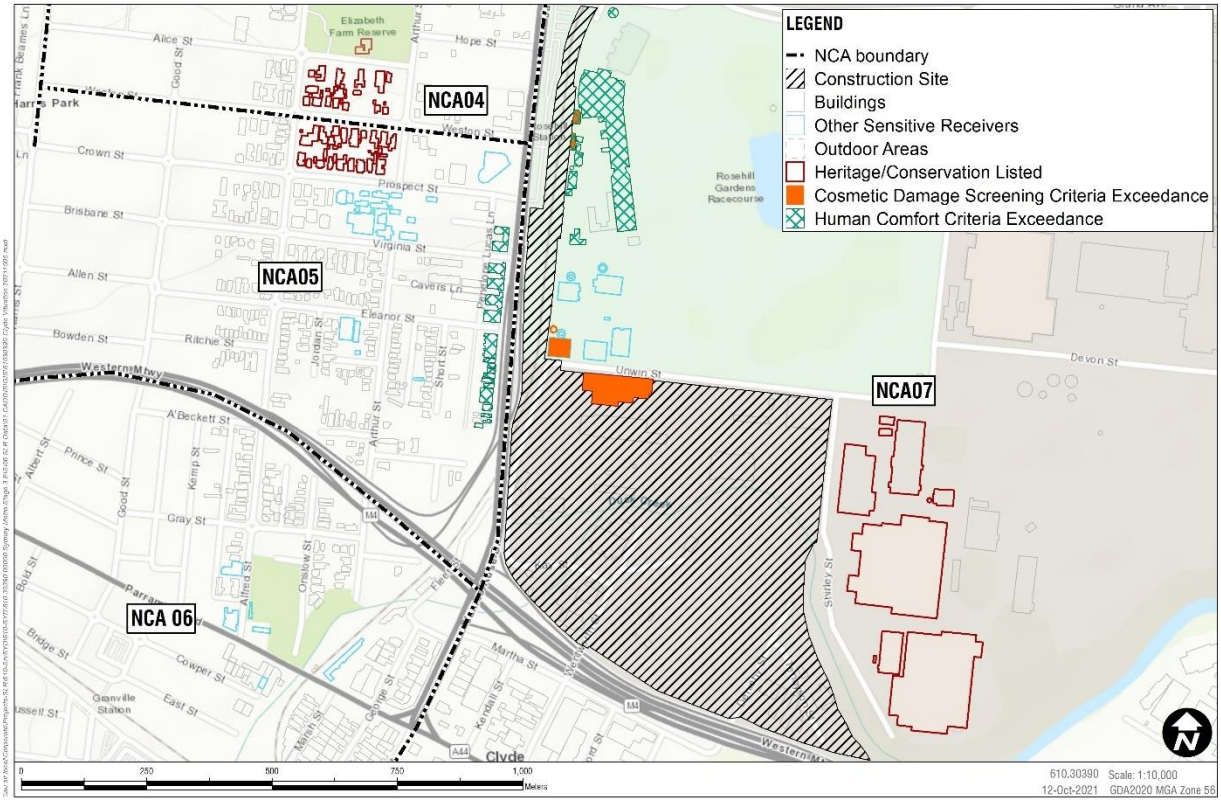
5.2.10.3 Ground-Borne Noise Impacts from Construction Site

Vibration intensive earthwork at the Clyde stabling and maintenance facility construction site would be completed outdoors, 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 it is not necessary to evaluate potential ground-borne noise impacts and they have not been considered further for this site.

5.2.10.4 Vibration Impacts from Construction Site

The predicted impacts during vibration intensive earthwork are shown in **Figure 59**. The predictions are representative of the highest vibration levels that would likely be experienced by the nearest receivers when work is close.

Figure 59 Clyde and Rosehill Predicted Vibration Impacts – Daytime



The above assessment during the worst-case impacts shows the following:

- The cosmetic damage screening criteria are predicted to be exceeded at:
  - One heritage listed structure within the site boundary at 1 Unwin Street, Rosehill.
  - Two stables and two commercial buildings at Rosehill Gardens racecourse.
- The human comfort criteria are also predicted to be exceeded at the nearest commercial buildings located to the north of the site and the nearest residential buildings opposite James Ruse Drive. Occupants of affected buildings may be able to perceive vibration impacts at times when vibration intensive equipment is in use nearby.
- There are no predicted exceedances of the sensitive equipment screening criteria.
- These predictions represent a worst-case situation where a large vibratory roller is in use at the boundary of the site 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 proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

5.3 Rail System Access Shafts

The potential impacts from material delivery, support and supply of major construction consumables at rail system access shafts have been quantitatively assessed at Parramatta, Clyde stabling and maintenance facility, Rosehill services facility, Burwood North and The Bays in **Section 5.2**.

There is potential for rail access to be required at times from all other construction site shafts to support rail systems fit-out work. The noise sources required would likely be similar to those quantitively assessed at the primary access sites (see **Table 14**), however, acoustic sheds would not necessarily be constructed over shafts where access is expected to be relatively short-term or intermittent.

The potential worst-case impacts from 'peak' rail system access work are qualitatively described at the nearest residential and commercial receivers in **Table 74**. It is assumed that access could occur up to 24 hours per day and seven days per week at each site.

Table 74 Rail System Access Shafts – Qualitative Assessment

Construction site	Receivers	Potential impacts	
		No acoustic shed	With acoustic shed[1]
Westmead	Residential (daytime)	Moderate	Negligible
	Residential (night-time)	High	Low
	Commercial	Negligible	Negligible
Parramatta	See **Section 5.2.2**		
Sydney Olympic Park	Residential (daytime)	Low	Negligible
	Residential (night-time)	Moderate	Negligible
	Commercial	Low	Negligible
North Strathfield	Residential (daytime)	Moderate	Negligible
	Residential (night-time)	High	Low
	Commercial	Low	Negligible
Burwood North	See **Section 5.2.5**		
Five Dock	Residential (daytime)	High	Low
	Residential (night-time)	High	Moderate
	Commercial	Low	Negligible
The Bays	See **Section 5.2.7**		
Pyrmont	Residential (daytime)	High	Low
	Residential (night-time)	High	Moderate
	Commercial	Low	Negligible
Hunter Street	Residential (daytime)	Negligible	Negligible
	Residential (night-time)	Negligible	Negligible
	Commercial	Moderate	Negligible
Clyde and Rosehill	See **Section 5.2.10**		

Note 1: Assessment assumes an indicative benefit typically achieved with an acoustic shed. Other equivalent mitigation measures may be used.

The above assessment shows that:

- If acoustic sheds (or other equivalent acoustic measures) are used, the potential noise levels are likely to comply the noise management levels or result in only 'low' impacts at the nearest receivers at most sites. 'Moderate' impacts are, however, predicted at the Five Dock and Pyrmont Station construction sites due to residential receivers being immediately adjacent.
- If acoustic sheds (or other equivalent acoustic measures) are not used, 'high' or 'moderate' impacts are likely at sites with nearby residential receivers.
- The potential impacts at residential receivers are substantially higher during the night-time period, due to lower background noise levels and corresponding lower noise management levels in this period.
- The highest impacts would occur when rail saws are being used. Noise impacts during typical material handling activities are likely to be substantially lower than presented.
- Materials would be delivered by heavy vehicle. There is potential for sleep disturbance impacts where this occurs during the night-time at sites with nearby residential receivers.

Rail Systems Fit-Out – Sydney Metro City & Southwest Waterloo Station Case Study

Sydney Metro City & Southwest used the Waterloo Station site for rail welding and delivery for around a two month period in August and September 2020. This included out of hours work in both the evening and night-time. This work involved:

- Delivery of rail to the site and into the station box using cranes
- Welding of short rail sections together with the station box
- Grinding of the rail to profile within the station box
- Delivery of the welded rail sections into the tunnels.

The area surrounding Waterloo Station is residential in nature, with the closest residential receivers located directly adjacent to the east and north of the site. The NMLs at the site are 52 dB for the evening and 44 dB for the night-time. Compared to residential sites along the Sydney Metro West alignment, these NMLs are:

- Comparable to Westmead and North Strathfield
- Marginally higher than Five Dock
- Marginally lower than Burwood and Pyrmont.

As such, a case study of this activity at Waterloo Station provides a useful comparison to consider the nature of impacts which could occur from this work.

The work at Waterloo Station resulted in exceedances of the applicable NMLs of:

- Around 6 dB during the evening (a 'low' impact)
- Around 14 during the night-time (a 'moderate' impact).

The following measures were used at Waterloo Station to mitigate and manage the potential for noise impacts (in addition to the acoustic hoarding that was present at the site):

- Out of hours work at the surface and within the open station box was minimised as far as feasible and reasonable, particularly beyond 10 pm

- Metal-on-metal 'clanging' during rail lifts was minimised using a specialised hydraulic rail clamp
- Administrative controls included toolbox talks and instructions to drivers and workers to reduce the potential for noisy events that could result in sleep disturbance impacts
- The additional mitigation measures matrix was implemented in accordance with the Sydney Metro CNVS, which included regular community notifications prior to and during the work
- Noise monitoring was completed to verify the airborne noise predictions.

During the works, a total of six community complaints were received over the two month period. This shows that this work can be successfully undertaken in residential environments with the use of appropriate noise mitigation measures.

Appropriate mitigation measures for Sydney Metro West rail system access shaft work would be applied to minimise and manage the potential impacts. The measures would be determined in accordance with the Sydney Metro CNVS as detailed construction planning information becomes available for each site. The proposed mitigation measures are discussed in **Section 6**.

5.4 Tunnels

Fit-out of the tunnels would occur up to 24 hours per day and seven days per week. The depth of the tunnel is sufficient for the potential ground-borne noise and vibration impacts during fit-out to be negligible.

5.5 Utilities Adjustments

The majority of utility adjustments would be carried out as part of the previous Sydney Metro West planning applications, however, there may be some minor utility adjustments required as part of this proposal, including work along the existing rail corridor at Westmead and North Strathfield.

An assessment of the potential noise levels from utility work is provided in **Table 75**. Noise levels have been predicted at various offset distances from typical items of equipment to determine the potential impacts.

Table 75 Potential Noise Levels from Utility Work

Equipment	Predicted Noise Level at Distance ($L_{Aeq(15minute)}$ 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.

The above table shows that relatively high noise levels are likely where noise intensive equipment is required to be used near to adjacent receivers. On typical streets surrounding the construction sites, the closest receivers are around 10 to 15 metres from the road. In this situation, worst-case noise levels in the region of 80 to 90 dBA are possible during noisy phases of the work.

Night-time NMLs in the vicinity of most sites are in the region of 40 to 50 dBA (see **Table 6**), meaning worst-case exceedances at residential receivers of greater than 30 dB above the NML are possible if noise intensive equipment is used during the night-time. Utility work would be temporary and the duration of impacts at would be limited.

5.6 Construction Road Traffic Noise Impacts

Construction related traffic has the potential to temporarily increase road traffic noise levels at receivers which are adjacent to construction haul routes.

The forecast construction traffic volumes in the study area have been used to determine where potentially noticeable increases in road traffic noise (i.e. a greater than 2.0 dB increase above the existing noise level) is likely.

A summary of the predicted impacts from construction traffic is provided in **Table 76**. The predicted traffic noise for all construction haul routes is shown in **Appendix E**.

Table 76 Construction Traffic Impacts

Study area	Roads predicted to have a >2.0 dB increase[1]	Reason for increase
Westmead	• Hassall Street south of Alexandra Avenue (predicted increase of 5 dB during the night) • Hassall Street south of Bailey Street (predicted increase of 5 dB during the day) • Bailey Street east of Hawkesbury Road (predicted increase of 9 dB during the day) • Priddle Street east of Hawkesbury Road (predicted increase of 8 dB during the day) • Hawkesbury Road south of Alexandra Avenue (predicted increase of 5 dB during the day) • Hawkesbury Road south of Bailey Street (predicted increase of 3 dB during the night)	Road reconfiguration diverting traffic from Alexandra Avenue during the period that Alexandra Avenue is temporarily closed between Hassall Street and Hawkesbury Road

Study area	Roads predicted to have a >2.0 dB increase[1]	Reason for increase
Parramatta	• Macquarie Street east of O'Connell Street (predicted increase of 4 dB during the night)	Construction traffic entering the site increases night-time traffic and noise levels. Around 30% increase in night-time traffic volumes with 10% increase in the proportion of heavy vehicles. The increase is primarily due to low existing heavy vehicle volumes.
Sydney Olympic Park	• Figtree Drive east of Olympic Boulevard (predicted increase of 2 dB during the day)	Construction traffic exiting the site increases daytime traffic and noise levels. Around 10% increase in daytime traffic volumes with 5% increase in the proportion of heavy vehicles. The noise increase is primarily due to low existing heavy vehicle volumes.
North Strathfield	-	-
Burwood North	-	-
Five Dock	• Second Avenue east of Great North Road (predicted increase of 3 dB during the day)	Increased daytime and night-time construction traffic exiting the site. Up to around 30% increase in traffic volumes with 10% increase in the proportion of heavy vehicles. The noise increase is primarily due to low existing heavy vehicle volumes.
The Bays	-	-
Pyrmont	-	-
Hunter Street	-	-
Clyde and Rosehill	• Wentworth Street north of Parramatta Road (predicted increase of 3 dB during the day) • Martha Street east of Wentworth Street (predicted increase of 4 dB during the day)	Increased daytime and night-time construction traffic for site access. Up to around 30% increase in traffic volumes with 10% increase in the proportion of heavy vehicles. The noise increase is primarily due to low existing heavy vehicle volumes.

Note 1: The increase represents the worst-case predicted increase in any period. Local roads are assessed against 1-hour criteria.

The above assessment indicates that construction traffic is unlikely to result in a noticeable increase in noise levels on most of the proposed construction haul routes. This results from the high existing volumes of traffic that currently use these routes compared to the relatively small volume of construction vehicles.

Certain roads near to the Parramatta, Sydney Olympic Park, Five Dock, and the Clyde and Rosehill construction sites are, however, predicted to have noticeable increases in traffic noise during some periods, which is mostly due to construction related heavy vehicles using roads with relatively low existing traffic volumes. Temporary road reconfigurations in the Westmead study area that divert traffic from Alexandra Avenue through Hassall Street, Bailey Street, Priddle Street and Hawkesbury Road are also likely to result in noticeable increases on these roads during the period that Alexandra Avenue is temporarily closed.

The assessment assumes free flowing traffic on the haul routes. Additional road traffic noise impacts may occur when construction heavy vehicles accelerate and decelerate at the entrances/exits of the construction sites. The requirement for vehicles to accelerate and decelerate would depend on the size/type of heavy vehicle, their loaded weight and the local traffic conditions at the time, all of which are currently unknown. The following is noted with respect to the potential for increased noise impacts:

- The potential increase would likely be limited to around 150 metres either side of the construction site access points (based on a typical acceleration rate for a cat 3 semi-trailer heavy vehicle to reach 60 km/h)
- Heavy vehicles would be required to accelerate and decelerate more on roads with notable gradients. This would affect both existing heavy vehicles and construction related heavy vehicles
- The increased noise levels may result in increased annoyance at the closest receivers. Pyrmont has the closest residential receivers, however, construction heavy vehicles are generally not proposed to access these sites during the night-time (infrequent deliveries of concrete by truck would be required to support station lining pours for safety reasons) which would minimise the potential for annoyance.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 6**.

5.7 Cumulative Construction Impacts

Cumulative impacts are a result of incremental, sustained and combined effects of human action and natural variations over time and can be both positive and negative. They can be caused by the compounding effects of a single project or multiple projects in an area, and by the accumulation of effects from past, current and future activities as they arise impacts (Department of Planning, Industry and Environment, 2021). Work covered by this proposal has the possibility of interacting with the construction activities of a number of other projects along the planned corridor or at proposed construction sites. Key projects to be considered are described below.

Concurrent cumulative construction noise and vibration impacts can occur where multiple work activities are being completed near to a particular receiver at the same time. Additionally, if more than one project occurs in the same area consecutively, there may be a prolonged effect from the extended duration of construction impacts. This effect is termed ‘construction fatigue’.

5.7.1 Sydney Metro West Previous Planning Applications

The Sydney Metro West Concept and major civil construction work between Westmead and The Bays (Stage 1 of the planning approval for Sydney Metro West) was approved on 11 March 2021. This work involves the major civil construction work at all construction sites from Westmead to The Bays. Construction will start in 2021 and is planned to be complete in 2026.

The proposed major civil construction work between Pyrmont and Sydney CBD (Stage 2 of the planning approval process) Environmental Impact Statement was exhibited between 3 November 2021 and 15 December 2021. Subject to approval, construction would commence from around quarter two 2023 and be complete by the end of 2025.

The majority of the major civil construction work associated with the previous Sydney Metro West planning applications at each construction site (demolition, utility relocations and construction of station boxes) would be complete before construction work associated with this proposal starts. However, there could be a period of overlap when the contractor(s) undertaking construction work associated with the previous Sydney Metro West planning applications are on site at the same time as the contractor(s) engaged to construct this proposal. Concurrent cumulative noise impacts could occur during this period depending on the type of construction work being competed by separate contractors. At the majority of sites, the potential overlap of construction work would be limited to a short period (a few months) and would typically involve the demobilisation of one contractor and the mobilisation of another.

Where concurrent construction work is being completed near to a particular area, the worst-case noise levels could theoretically increase by around 3 dB (i.e. a logarithmic adding of two sources of noise at the same level). The likelihood of worst-case noise levels being generated by two different work activities at the same time is, however, considered low and rather than increase construction noise levels, the impact of concurrent construction work would generally be limited to a potential increase in the duration, and annoyance, of noise impacts on the affected receivers.

The use of the various construction sites by overlapping or successive contractors may also result in consecutive impacts (i.e. 'construction fatigue') at the surrounding receivers due to construction work being in the area for an extended period.

Mitigation measures aimed at short-term construction work may be less effective where receivers are affected by longer duration impacts from several projects, especially where extensive night-time work is required. Where receivers are affected by 'construction fatigue', it may be necessary to consider specific mitigation and management measures to minimise the impacts.

5.7.2 The Bays Construction Site

The Bays Station construction site would be used by all stages of Sydney Metro West. The construction work under the previous Sydney Metro West planning applications is expected to occur through to around quarter three 2024. The proposed major civil construction work between The Bays and Sydney CBD would occur on a portion of the construction site through to around quarter three 2025. Construction work associated with this proposal would start in quarter two 2025. Concurrent cumulative noise impacts may occur during the period of the handover to the contractor(s) engaged to construct this proposal.

Several other major projects are also located nearby, including WestConnex M4-M5 Link and Western Harbour Tunnel and Warringah Freeway Upgrade. Construction of these projects are, however, expected to be complete prior to construction work starting on this proposal, meaning concurrent cumulative noise impacts are unlikely.

The presence of construction work from several overlapping or consecutive major projects in the wider area surrounding The Bays Station construction site may result in consecutive impacts (i.e 'construction fatigue') at the surrounding receivers. Specific additional mitigation and management measures may need to be considered to minimise the impacts.

5.7.3 Other Projects

The proposal is near to a number of projects that have recently been constructed, are currently under construction or are planned for construction. These projects are listed in **Table 77**.

Table 77 Nearby Major Developments

Project	Details and construction activities
Parramatta Leagues Club Hotel	The proposal involves the demolition of existing buildings and the construction of a 17-storey hotel building. The proposal includes public domain works and service upgrades surrounding the building to integrate the building with the surrounding area and infrastructure. The construction program is currently unknown.
Clyde Terminal Conversion Project	The project involves the removal of redundant crude oil refinery and import facilities at the Clyde Terminal and upgrade of existing facilities. Construction started in 2015 is expected to finish in 2025.
Site 2A and Site 2B Australia Avenue, Sydney Olympic Park	The development comprises a State significant development application for the construction of two buildings including a tower (around 45 storeys) that provides serviced apartments, plus a podium on Site 2A and a commercial building (around 12 storeys) on Site 2B. The construction program is currently unknown.
Site 43/44, Sydney Olympic Park – Stage 1 and 2 (6 Australia Avenue and 2 Herb Elliot Avenue)	The project involves the staged development of two mixed-use buildings for commercial and retail spaces, associated basement car parking, landscaping and driveway access. The construction program is currently unknown.
MLC Senior School Centre – modification	The project involves the redevelopment of the MLC Senior School Centre, including: • Demolition of existing structures and vegetation • Construction of two new buildings • Alterations, additions and refurbishment of two existing buildings • Landscaping works. The construction program is currently unknown.
Western Harbour Tunnel and Warringah Freeway Upgrade	The Western Harbour Tunnel and Warringah Freeway Upgrade project form part of the Western Harbour Tunnel and Beaches Link Program and comprise a new motorway tunnel connection across Sydney Harbour, and an upgrade of the Warringah Freeway to integrate the new motorway infrastructure with the existing road network, with a connection to the Beaches Link and Gore Hill Freeway Connection project. Components of the proposal relevant to this assessment include: • Construction activities at Rozelle Rail Yards • Construction activities at White Bay. Construction is expected to start in 2023 and finish in 2024.
Sydney Metro City & Southwest (Chatswood to Sydenham)	The Chatswood to Sydenham component of Sydney Metro City & Southwest involves the construction and operation of a 15.5 km metro line from Chatswood, under Sydney Harbour and through Sydney's CBD out to Sydenham. Components of the project relevant to this assessment include tunnelling/construction of stations at Barangaroo and Martin Place. Construction started in 2017 and is expected to be complete in 2024.

Project	Details and construction activities
The new Sydney Fish Market	The project involves building a new Sydney Fish Market which will be set within an improved public domain including the creation of a waterfront promenade. The site is located at the head of Blackwattle Bay between Pyrmont Peninsula and Glebe Peninsula. Construction started in 2020 and is expected to be complete in 2024.
Cockle Bay Wharf mixed use development	A State significant development application was approved by the NSW Independent Planning Commission on 13 May 2019 for the Concept Proposal and Stage 1 works which include demolition works. The current proposal would include: • Construction of a landbridge across part of the Western Distributor • The design, construction and use of a 43 storey mixed-use development • At least 6500 m^2 of publicly accessible open space • Site interface works and subdivision. The construction program is currently unknown.
50-52 Phillip Street New Hotel	The proposal involves the construction of a new 47 storey hotel building in Sydney's CBD. Construction is expected to start in 2023 and last for around 2.5 years.
One Sydney Harbour	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. Construction is planned to be completed in 2025.
Sydney Metro – Martin Place Over Station Development	The project includes two over station development commercial towers above the northern and southern entrances of the yet to be constructed Martin Place Metro Station. The Concept Proposal is intended to be delivered as a single, integrated project along with the delivery of rail, station, concourse infrastructure and public domain work associated with the Martin Place Metro Station. The construction of the different elements is likely to be staged so as not to interrupt the Sydney Metro construction program. Construction is planned to be completed in 2024.
301 and 305 Kent Street Concept Hotel Development	The proposal is a Concept State significant development application which seeks consent for the establishment of a building envelope up to a height of RL 96.2m, to be used as a hotel. A future detailed State significant development application will be lodged for the detailed design and construction of the development. The construction program is currently unknown.

Concurrent construction noise impacts may occur if construction activities for these projects is carried out at the same time as this proposal. There is also potential for consecutive impacts if certain receivers are affected by construction noise from two or more projects occurring in succession near the same area.

The potential cumulative impacts (both concurrent and consecutive) from this proposal and other projects would continue to be considered as the project progresses when detailed construction planning is developed. This would consider the potential impact from concurrent construction activities of other projects and this proposal. Specific management and mitigation measures designed to address potential impacts would be developed and used to minimise the impacts as far as practicable, in consultation with the affected community, as outlined in **Section 6**.

6 Mitigation and Management Measures

This section provides a summary of the mitigation and management measures that would be implemented to minimise, avoid or mitigate the noise and vibration impacts of the proposal. The ICNG acknowledges that due to the nature of construction work it is inevitable that there will be impacts where construction is near to sensitive receivers.

6.1 Construction Environmental Management Framework

The *Sydney Metro Construction Environmental Management Framework* (CEMF) was developed and successfully implemented as part of the Sydney Metro Northwest and Sydney Metro City & Southwest projects and will be implemented during work under the previous Sydney Metro West planning applications. This framework has been reviewed and amended to be applicable to this proposal. The *Sydney Metro Construction Environmental Management Framework* is provided in Appendix F to the Environmental Impact Statement.

The CEMF details environmental, management systems and processes for this proposal. Specifically, it details the requirements in relation to the content of the construction environmental management plan, sub-plans and other supporting documentation for each specific environmental aspect.

The CEMF would require the principal contractors to prepare a Construction Noise and Vibration Management Plan (CNVMP) for their scope of work in line with the requirements of the ICNG (see **Section 2**) and the Sydney Metro CNVS (see **Section 6.2**).

The CNVMP would be prepared before any work begins and would define how the predicted impacts would be mitigated and managed. The CNVMP would include:

- Identification of nearby sensitive receivers
- Description of work, construction equipment and hours the work would be completed in
- Criteria for the project and relevant licence and approval conditions
- Requirements for noise and vibration monitoring
- Details of how community consultation would be completed
- Procedures for handling complaints
- Details on how respite would be applied where ongoing high impacts are seen at certain receivers.

The CNVMP would also consider cumulative concurrent construction impacts and the likelihood for ‘construction fatigue’ from consecutive projects in the areas which have substantial night-time work.

6.1.1 Standard Mitigation Measures

The CEMF contains a number of ‘standard mitigation measures’ related to construction noise and vibration. These measures are provided in Appendix F to the Environmental Impact Statement and would be applied to the work at all construction sites to minimse the impacts from the work as far as practicable and where feasible and reasonable.

The standard measures include items such as:

- Ongoing engagement with the affected community and other sensitive receivers to understand their preference for mitigation measures
- Consideration of alternative construction methods to reduce construction noise and vibration impacts, particularly for noise intensive works
- Provision of appropriate respite periods
- Consideration for scheduling of noise intensive works during the daytime construction hours where feasible and reasonable
- Measures to manage construction traffic noise exceedances
- Further assessment of structures where exceedances of the cosmetic damage screening criteria are predicted, and further investigation of receivers identified as potentially having vibration sensitive equipment
- Requirements for construction contractors to complete site inductions to make workers aware of any noise and vibration specifics
- Requirements for undertaking regular monitoring to check noise and vibration levels are as expected and checking that noise emission levels for construction equipment remains within allowed CNVS and manufacturers specifications.

6.2 Sydney Metro Construction Noise and Vibration Standard

The *Construction Noise and Vibration Standard* (CNVS) establishes a consistent strategy for the assessment, mitigation and monitoring of noise and vibration generated by construction activities across Sydney Metro. It defines a minimum standard for managing noise and vibration impacts that considers currently best practice guidelines and other regulatory requirements, and adopts strategic objectives to understand and manage potential noise and vibration impacts.

The Sydney Metro CNVS is provided as Appendix H to the Environmental Impact Statement.

6.2.1 Additional Noise Mitigation Measures

Where impacts remain after the use of ‘standard mitigation measures’, the Sydney Metro CNVS requires ‘additional mitigation measures’ to be applied, where feasible and reasonable. The ‘additional mitigation measures’ are described in **Table 78**.

Table 78 Additional Management Measures

Measure	Description	Abbreviation[1]
Alternative accommodation	Alternative accommodation options may be provided for residents living in close proximity to construction works that are likely to incur unreasonably high impacts over an extended period of time. Alternative accommodation will be determined on a case-by-case basis.	AA
Monitoring	Where it has been identified that specific construction activities are likely to exceed the relevant noise or vibration goals, noise or vibration monitoring may be conducted at the affected receiver(s) or a nominated representative location (typically the nearest receiver where more than one receiver have been identified). Monitoring can be in the form of either unattended logging or operator attended surveys. The purpose of monitoring is to inform the relevant personnel when the noise or vibration goal has been exceeded so that additional management measures may be implemented.	M
Individual briefings	Individual briefings are used to inform stakeholders about the impacts of high noise activities and mitigation measures that will be implemented. Communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project.	IB
Letter box drops	For each Sydney Metro project, a newsletter is produced and distributed to the local community via letterbox drop and the project mailing list. These newsletters provide an overview of current and upcoming works across the project and other topics of interest. The objective is to engage and inform and provide project-specific messages. Advanced warning of potential disruptions (e.g. traffic changes or noisy works) can assist in reducing the impact on the community. Content and newsletter length is determined on a project-by-project basis. Most projects distribute notifications on a monthly basis. Each newsletter is graphically designed within a branded template	LB
Project specific respite offer	The purpose of a project specific respite offer is to provide residents subjected to lengthy periods of noise or vibration respite from an ongoing impact.	RO
Phone calls and emails	Phone calls and/or emails detailing relevant information would be made to identified/affected stakeholders within 7 days of proposed work. Phone calls and/or emails provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and specific needs etc.	PC
Specific notifications	Specific notifications would be letterbox dropped or hand distributed to identified stakeholders no later than 7 days ahead of construction activities that are likely to exceed the noise objectives. This form of communication is used to support periodic notifications, or to advertise unscheduled works	SN

The CNVS defines how and when 'additional mitigation measures' are applied to airborne noise impacts, ground-borne noise and potential human comfort vibration impacts. The approach for each is shown in **Table 79, Table 80** and **Table 81**, respectively.

The airborne noise mitigation requirements in the CNVS are defined by the predicted exceedance of the NML. Ground-borne noise and vibration mitigation requirements are defined by the predicted exceedance of the management or maximum levels.

Table 79 Additional Mitigation Measures – Airborne Construction Noise

Time period		Mitigation measure			
		Predicted $L_{Aeq(15minute)}$ noise level above NML			
		0 to 10 dB	10 to 20 dB	20 to 30 dB	>30 dB
Standard	Mon-Fri (7am - 6pm)	-	LB	LB, M, SN	LB, M, SN
	Sat (8am - 1pm)				
	Sun/Pub Hol. (Nil)				
OOHW Period 1	Mon-Fri (6pm - 10pm)	LB	LB, M	LB, M, SN, RO	LB, M, SN, RO, IB, PC, RO
	Sat (1pm - 10pm)				
	Sun/Pub Hol. (8am - 6pm)				
OOHW Period 2	Mon-Fri (10pm - 7am)	LB	LB, M, SN, RO	LB, M, SN, RO, IB, PC, RO, AA	LB, M, SN, RO, IB, PC, RO, AA
	Sat (10pm - 8am)				
	Sun/Pub Hol. (6pm - 7am)				

Note: The following abbreviations are used: Alternative accommodation (AA), Monitoring (M), Individual briefings (IB), Letter box drops (LB), Project specific respite offer (RO), Phone calls and emails (PC), Specific notifications (SN). See **Table 78** for descriptions of the measures.

Table 80 Additional Mitigation Measures – Ground-Borne Noise

Time Period		Mitigation Measure		
		Predicted $L_{Aeq(15minute)}$ Noise Level above NML		
		0 to 10 dB	10 to 20 dBA	>20 dBA
Standard	Mon-Fri (7am - 6pm)	No NML for GBN during standard hours		
	Sat (8am - 1pm)			
	Sun/Pub Hol. (Nil)			
OOHW Period 1	Mon-Fri (6pm - 10pm)	LB	LB, M, SN	LB, M, SN, IB, PC, RO
	Sat (1pm - 10pm)			
	Sun/Pub Hol. (8am - 6pm)			
OOHW Period 2	Mon-Fri (10pm - 7am)	LB, M, SN	LB, M, SN, IB, PC, RO, AA	LB, M, SN, IB, PC, RO, AA
	Sat (10pm - 8am)			
	Sun/Pub Hol. (6pm - 7am)			

Note: See **Table 78** for descriptions of the measures.

Table 81 Additional Mitigation Measures – Human Comfort Vibration

Time period		Mitigation measure
		Predicted vibration levels exceed maximum levels
Standard	Mon-Fri (7am - 6pm)	LB, M, RO
	Sat (8am - 1pm)	
	Sun/Pub Hol. (Nil)	
OOHW Period 1 (Evening)	Mon-Fri (6pm - 10pm)	LB, M, IB, PC, RO, SN
	Sat (1pm - 10pm)	
	Sun/Pub Hol. (8am - 6pm)	
OOHW Period 2 (Night)	Mon-Fri (10pm - 7am)	LB, M, IB, PC, RO, SN, AA
	Sat (10pm - 8am)	
	Sun/Pub Hol. (6pm - 7am)	

Note: See **Table 78** for descriptions of the measures.

The specific 'additional noise mitigation' requirements would be determined at a later stage of the proposal in construction noise and vibration assessments when detailed construction data is available.

6.2.2 Construction Noise and Vibration Impact Statements

The contractor(s) engaged to construct the proposal would complete site specific Detailed Construction Noise and Vibration Impact Statements (DNVIS) and General Construction Noise and Vibration Impact Statements (GNVIS) in accordance with the Sydney Metro CNVS for all work outside standard construction hours likely to exceed the relevant NMLs, activities likely to result in highly noise affected receivers and/or activities likely to generate vibration levels at receivers which exceed the relevant criteria.

- **DNVIS** – these are detailed quantitative assessments undertaken by contractors when they have a better understanding of the exact equipment list and construction methodology to be used in carrying out their work. They are typically focused on specific activities or locations and consider work carried out inside and outside of standard construction hours. Work described in a DNVIS cannot proceed until it is approved by an Acoustic Advisor appointed under an SSI approval or other delegate approved by Sydney Metro.
- **GNVIS** – these are secondary assessments that have the same purpose as a DNVIS except that the assessment process is simplified. Work described in a GNVIS cannot proceed until the GNVIS is approved by Sydney Metro.

The DNVIS and/or GNVIS assessments would be completed prior to the work starting and would assess the potential impacts at nearby receivers and determine appropriate measures to minimise the impacts as far as practicable.

The mitigation and management measures would be determined based on the magnitude and duration of the predicted impacts and would be consistent with the 'standard' and 'additional mitigation measures' defined in the Sydney Metro CNVS, or any relevant conditions of approval.

6.3 Proposal Specific Construction Mitigation Measures

In addition to the measures outlined in the Sydney Metro CEMF and CNVS, one proposal specific mitigation measure has been identified and is presented in **Table 82**.

This would be supplemented by mitigation measures detailed in Chapter 20 (Synthesis) of the Environmental Impact Statement with respect to cumulative impacts.

The Sydney Metro Overarching Community Communications Strategy (OCCS) (Appendix C of the Environmental Impact Statement) 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 Communication 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.

Table 82 Summary of Specific Construction Noise and Vibration Mitigation Measures

ID	Impact	Mitigation measure	Applicable Location(s)
EIS-NV4	Noise impacts to horses at Rosehill Racecourse Stables	Consultation with the owners and operators of the horse stables near the Clyde stabling and maintenance facility construction site would be carried out so that potential impacts to horses are appropriately managed.	Clyde and Rosehill

Community Feedback

Community feedback received as part of the exhibition of the *Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD* (Sydney Metro, 2020) has been reviewed as part of the development of mitigation measures for this proposal. The feedback received and how this has informed or is already considered in the relevant management framework and mitigation measures is discussed in **Table 83**.

As outlined in the CNVS and the OCCS, Sydney Metro would continue to consult with the nearby community prior to and during construction of this proposal. This would include engagement and consultation with:

- The affected communities to understand their preferences for mitigation and management measures
- 'Other sensitive' receivers such as schools, medical facilities 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 applied where feasible and reasonable to minimise the potential impacts.

Table 83 Community Feedback and Noise and Vibration Mitigation

Feedback	Response
Restrictions on works during night-time periods	Where possible, work would be carried out during the daytime period. Some work, however, would be required to be carried out during out of hours periods and at night-time. Further details are outlined in **Section 4.4**.
Schedule work outside operating hours of educational and places of workshop	The standard mitigation measures outlined in the CNVS include scheduling work outside of key periods for educational receivers and places of worship, where feasible and reasonable.
Respite measures	The standard mitigation measures outlined in the CNVS include respite periods for high noise and vibration generating activities.
24/7 phoneline	Sydney Metro will maintain a 24/7 community information line as outlined in Chapter 3 of the Environmental Impact Statement and the Overarching Community Communication Strategy.
Ongoing community information and notifications	Sydney Metro will provide ongoing community information and notifications as outlined in Chapter 3 of the Environmental Impact Statement and the Overarching Community Communication Strategy.
Temporary relocation of residents	The additional mitigation measures outlined in the CNVS include provision of alternative accommodation for residents based on certain exceedances of the applicable noise management levels.
At-property treatments	The CNVS provides a comprehensive list of standard and additional mitigation measures to avoid and minimise potential construction noise impacts, as far as feasible and reasonable.
Scheduling works during school holiday periods	The standard mitigation measures outlined in the CNVS include scheduling work outside of key periods for educational receivers where feasible and reasonable. For example, at Westmead extended rail possession work is scheduled for the period between December 26 and December 30. This would result in these high noise generating activities being carried out during school holiday periods, minimising impacts to the nearby Westmead Public School.
Rectification of building damage	The CNVS outlines a process to be followed so that vibration levels from construction work remain below potential damage levels for individual buildings. The CNVS also outlines the process for pre and post condition surveys of adjacent buildings. Any buildings damage attributable to Sydney Metro work would be rectified at no cost to the owner.

Residual Impacts

The above measures are expected to control the potential impacts from the proposal as far as practicable. 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 later design stages and would be mitigated using the processes defined in the CNVS.

6.4 Performance Outcomes

Performance outcomes for Sydney Metro West were established as part of the concept assessment in the Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD (Sydney Metro, 2020). The performance outcomes related to construction noise and vibration are:

- 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.

Further detail regarding how this proposal would achieve the performance outcomes is provided in Chapter 20 (Synthesis) of the Environmental Impact Statement.

7 Conclusion

Construction noise and vibration impacts from work at the proposed construction sites have been assessed, together with impacts from construction road traffic and utility work. The potential cumulative impacts from concurrent and consecutive work of the proposal and other major interfacing projects have also been identified.

Consistent with other major infrastructure projects in suburban/urban areas, noise impacts during construction are inevitable, particularly where work requires the use of noise intensive equipment near to sensitive receivers.

The assessment identifies that mitigation measures are required to be considered to minimise the potential noise and vibration impacts. Several mitigation strategies have been recommended with reference to the *Interim Construction Noise Guideline* and the *Sydney Metro Construction Noise and Vibration Standard*, as required by the *Sydney Metro Construction Environmental Management Framework*.

8 References

Association of Australasian Acoustical Consultants. (2020). Guideline for Child Care Centre Acoustic Assessment.

British Standards Institution. (1993). Evaluation and Measurement for Vibration in Buildings - Guide to Damage Levels from Ground Borne Vibration. BS 7385-2:1993.

Department of Environment and Climate Change NSW. (2009). Interim Construction Noise Guideline.

Department of Environment and Conservation. (2006). Assessing Vibration: a technical guideline.

Department of Environment, Climate Change and Water NSW. (2011). NSW Road Noise Policy.

Environment Protection Authority. (2017). Noise Policy for Industry.

Environmental Planning and Assessment Act 1979. (NSW).

German Institute for Standardisation. (2016). Vibration in Buildings - Part 3: Effects on Structures. DIN 4150-3:2016.

Standards Australia. (2006). Explosives - Storage and use of explosives. AS 2187.2-2006.

Standards Australia and Standards New Zealand. (2016). Acoustics - Recommended design sound levels and reverberation times for building interiors. AS/NZS 2107:2016.

Sydney Metro. (2015). Sydney Metro City & Southwest Chatswood to Sydenham Environmental Impact Statement.

Sydney Metro. (2020). Sydney Metro West Environmental Impact Statement – Westmead to The Bays and Sydney CBD.

Sydney Metro. (2020b). Construction Noise and Vibration Standard.

Sydney Metro. (2021). Sydney Metro West Scoping Report – Rail infrastructure, stations, precincts and operations.

Sydney Metro. (2021b). Sydney Metro West Environmental Impact Statement – The Bays to Sydney CBD.

Sydney Metro. (2021c). Construction Environmental Management Framework.

APPENDIX A

Acoustic Terminology

1 Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that in common usage 'noise' is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-5} Pa.

2 'A' Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an 'A-weighting' filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4,000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dB or 2 dB in the level of a sound is difficult for most people to detect, whilst a 3 dB to 5 dB change corresponds to a small but noticeable change in loudness. A 10 dB change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels.

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as 'linear', and the units are expressed as dB(lin) or dB.

3 Sound Power Level

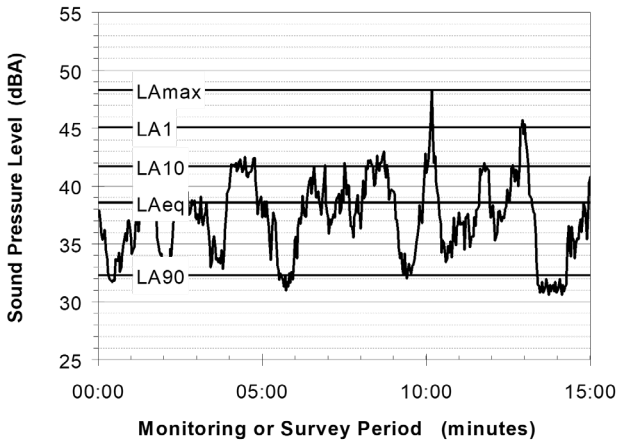
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

L_{Aeq} The A-weighted equivalent noise level (basically, the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the 'repeatable minimum' L_{A90} noise level over the daytime and night-time measurement periods, as required by the EPA. In addition, the method produces mean or 'average' levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc).

5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than 'broad band' noise.

6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

7 Frequency Analysis

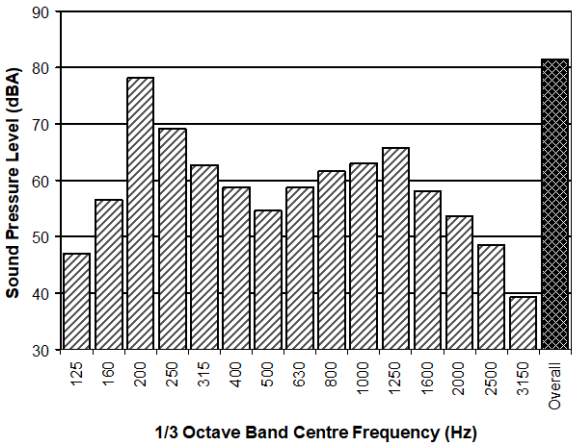
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



8 Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of 'peak' velocity or 'rms' velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/V_o), where V_o is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organisations.

9 Human Perception of Vibration

People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as 'normal' in a car, bus or train is considerably higher than what is perceived as 'normal' in a shop, office or dwelling.

10 Over-Pressure

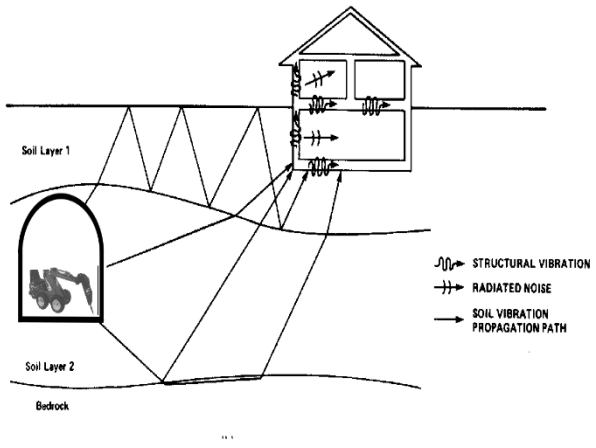
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents an example of the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise