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West

Westmead to The Bays and Sydney CBD

Environmental Impact Statement

Concept and Stage 1

Technical Paper 2
Noise and vibration

SYDNEY METRO WEST

Stage 1 Environmental Impact Statement Technical Paper 2
Noise and Vibration

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BASIS OF REPORT

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EXECUTIVE SUMMARY

Sydney Metro is proposing to construct and operate Sydney Metro West. Stage 1 of Sydney Metro West involves the major civil construction works between Westmead and The Bays Precinct and is the subject of this technical paper. Future stage(s) would include the remaining major civil construction works from The Bays Precinct to the Sydney CBD, rail systems fit-out, station fit-out and aboveground building construction, and operation of the metro line (future application(s)).

This Noise and Vibration Technical Paper has been prepared to address the Secretary's Environmental Assessment Requirements. The report describes the existing noise environment in the Stage 1 study area, outlines the method used in the assessment and identifies the likely impacts from Stage 1 on the nearby communities and sensitive receivers. Where impacts are predicted, appropriate measures have been identified to mitigate and manage the impacts.

Construction Noise from Construction Sites

Stage 1 would involve excavation of future metro stations and services facilities, and civil works for a future stabling and maintenance facility at several construction sites. The impacts during construction vary across the Stage 1 study area depending on how close the nearest receivers are to the various construction sites. Consistent with most major infrastructure projects in urban areas, where receivers are close to construction sites the noise impacts during some of the works are expected to be 'high', particularly when noise intensive equipment such as rockbreakers are in use close to receivers.

Construction noise impacts are predicted to be 'high' at the nearest residential receivers in the Westmead, Clyde, North Strathfield, Burwood North and Five Dock Station study areas during some of the noisiest scenarios. Residential receivers in the other study areas are typically further away and/or shielded from view, meaning impacts are generally lower. Acoustic sheds (or other acoustic measures) would be implemented to mitigate the noise impacts at construction sites with nearby receivers and where night-time works are proposed.

The worst-case impacts are generally predicted to occur in the early stages of the works, such as during *Enabling works*, *Piling* and *Initial excavation*, which require noise intensive equipment to be used prior to the construction acoustic sheds. At most construction sites these works would progressively move around the construction site over the course of the works. The impacts when these works are 'near' to a particular receiver are likely to be 'moderate' or 'high' for the nearest receivers in most study areas, but when works are 'far' the impacts are substantially lower with many catchments predicted to be compliant with the management levels or result in only 'minor' worst-case impacts. These early stage works are limited to daytime hours and would not occur during the evening or night-time.

Noise intensive works within the construction sites during the night-time would generally only be completed inside acoustic sheds. The impacts from works in sheds are reduced substantially, however, some construction sites with very close receivers are predicted to have 'moderate' worst-case night-time impacts.

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.

Most construction sites have nearby commercial receivers or 'other sensitive' receivers, which includes educational facilities, places of worship, medical facilities and outdoor recreation areas and 'high' impacts are likely at these some of these receivers when noise intensive equipment is in use.

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Construction Ground-borne Noise and Vibration from Construction Sites

The main potential sources of construction ground-borne noise and vibration during shaft excavation at construction sites are roadheaders and rockbreakers.

The worst-case predicted ground-borne noise impacts during station shaft excavation are generally compliant with the management levels or result in only 'minor' impacts for most receivers. 'Moderate' or 'high' impacts are, however, predicted in the Westmead, Parramatta, Burwood North and Five Dock Station study areas, due to sensitive receivers being near the excavation works in these locations. In the Parramatta study area, these impacts are generally at commercial and 'other sensitive' receivers, whereas in the other study areas the impacts are mostly at residential receivers.

Exceedances of the cosmetic damage vibration screening criteria are predicted in Parramatta, Clyde, Silverwater, Burwood North, Five Dock and The Bays, due to vibration sensitive structures being adjacent to the boundary of these sites. Exceedances of the human comfort vibration criteria are also predicted at the nearest receivers in all study areas, meaning occupants of affected buildings may be able to perceive the impacts at times when vibration intensive equipment is in use nearby.

The vibration predictions represent the worst-case scenario when vibration intensive works are at surface level and are, therefore, at the closest point to the affected buildings. As the works progress deeper, the impacts are expected to reduce.

Construction Ground-borne Noise and Vibration from Tunnelling

The tunnel alignment would mostly be excavated using Tunnel Boring Machines (TBMs). The ground-borne noise impacts during tunnelling would depend on the depth of the tunnel and the alignment is sufficiently deep in most locations for ground-borne noise impacts to generally be compliant with the management levels or result in only 'minor' impacts.

'Moderate' impacts are predicted in the shallower sections, including in the Westmead, Parramatta, Clyde, North Strathfield, and Five Dock study areas. These impacts are generally at receivers near to future metro station construction sites, as this is where the tunnel depth is shallowest. The worst-case tunnelling impacts are predicted to be 'high' in North Strathfield at receivers to the north of the North Strathfield metro station construction site.

The TBMs are expected to progress at a rate of between 20 to 50 metres per day. This means the worst-case ground-borne noise impacts at a receiver would likely only be apparent for a few days for each TBM as the tunnelling works pass beneath.

No cosmetic damage vibration impacts are expected during tunnelling, although vibration impacts may be perceptible at times.

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Cross passages would be excavated between the tunnels at spacings of around 240 metres. They would likely be excavated using roadheaders and rockbreakers. The location of cross passages has not yet been confirmed. 'Moderate' exceedances of the night-time management level are expected where residential receivers have a slant distance of around 30 metres or less from the nearest cross passage. 'High' exceedances are expected where the slant distance is less than around 17 metres. Each cross passage may take up to several months to excavate.

Consecutive Impacts

Consecutive construction impacts, or 'construction fatigue', from extended impacts from Stage 1 and other major projects may occur in some areas of the Stage 1 study area where construction projects are close to each other. While each project would apply mitigation measures that are suitable for controlling impacts from that project in isolation, the measures may not be sufficient to address prolonged impacts from multiple projects.

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.

Operational Road Traffic Noise

Road reconfigurations at intersections around the Westmead metro station construction site and a proposed new bridge at Clyde trigger the requirement to assess the potential impact of changed road traffic noise due from the project.

Receivers near to the proposed Westmead road reconfigurations are predicted to have exceedances of the operational road traffic noise criteria and have been identified as being eligible for consideration of additional noise mitigation.

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 for Stage 1 based on the predicted impacts.

The exact mitigation strategies would be determined as the project progresses when detailed planning information becomes available. The Stage 1 principal contractors would be required to prepare a Construction Noise and Vibration Management Plan for their scope of works in line with the requirements of the *Interim Construction Noise Guideline* and the *Sydney Metro Construction Noise and Vibration Standard*. Site specific Construction Noise and Vibration Impact Statements would also be prepared for all works outside Standard Construction Hours likely to exceed the relevant management levels. These assessments would confirm the predicted impacts at the nearby receivers to aid the selection of appropriate management measures.

The operational road traffic noise mitigation strategy would also be determined as the project progresses. It is likely that at-property treatment would be the only feasible approach to mitigating the impacts.

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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.
At-property treatments	Acoustic treatment of individual properties used to mitigate internal noise levels. Individual treatment packages depend on the level of exceedance of the criteria but can include mechanical ventilation, upgraded glazing, window and door seals, sealing of vents and underfloor areas, etc.
CEMF	Construction Environmental Management Framework
CEMP	Construction Environmental Management Plan
CNVIS	Construction Noise and Vibration Impact Statement
CNVS	Sydney Metro *Construction Noise and Vibration Standard*. 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)
EIS, the	Sydney Metro West Stage 1 Environmental Impact Statement
EPA	Environment Protection Authority
Existing rail corridor	The corridor within which existing rail infrastructure is located.
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_{AE} or SEL	Sound Exposure Level – used to characterise events and is normalised to one second
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

Item	Description / Definition
Noise intensive equipment	Construction equipment that is particularly noisy and causes annoyance. Includes items such as rockbreakers and concrete saws
NPfI	Noise Policy for Industry
OOH	Out of Hours
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 Stage 1. These scenarios are based on the noisiest items of equipment which would likely be required to complete the works.
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 and Environment under section 115Y 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
Stage 1 study area, the	The Stage 1 study area is defined as the wider area including and surrounding the construction sites, with the potential to be directly or indirectly affected by Stage 1 (e.g. by noise and vibration, visual or traffic impacts). The actual size and extent of the Stage 1 study area varies according to the nature and requirements of each assessment and the relative potential for impacts but which is sufficient to allow for a complete assessment of the proposed project impacts to be undertaken.
SWL	Sound Power Level
Sydney Metro West Stage 1	Stage 1 of Sydney Metro West would involve the major civil construction work between Westmead and The Bays Precinct, as described in **Section 1** of this report.
TBM	Tunnel boring machine
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 Sydney Metro West

Sydney Metro West is a critical step in the delivery of Future Transport Strategy 2056. It would provide fast, reliable and frequent rail service between Greater Parramatta and the Sydney CBD.

Sydney Metro (as 'the proponent') is seeking planning approvals as follows:

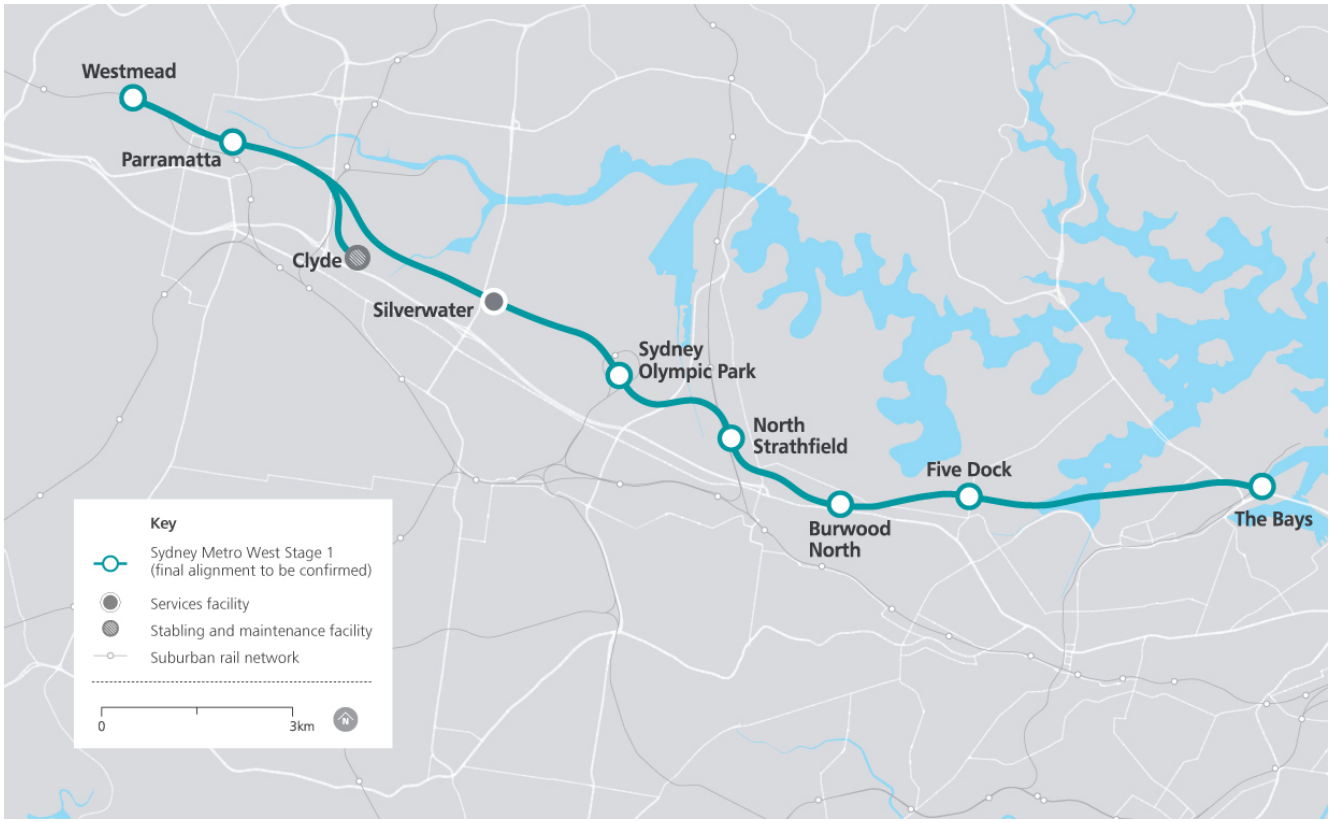
- Approval for the whole Sydney Metro West (at concept level) concurrent with Stage 1. Stage 1 involves the major civil construction works between Westmead and The Bays Precinct (and is the subject of this technical paper)
- Future stage(s) would include the remaining major civil construction works from The Bays Precinct to the Sydney CBD, rail systems fit-out, station fit-out and aboveground building construction, and operation of the metro line (future application(s)).

Sydney Metro is seeking a specific declaration for Sydney Metro West to be declared as State significant infrastructure and critical State significant infrastructure under sections 5.12(4) and 5.13 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), respectively.

1.1.1 Location

Sydney Metro West would mainly be underground in twin tunnels. Stage 1, which is the subject of this assessment, extends from Westmead to The Bays Precinct as shown in **Figure 1**.

Figure 1 Sydney Metro West overview



1.1.2 Overview of Stage 1

Stage 1 would involve the major civil construction work for Sydney Metro West (Westmead to The Bays Precinct), including:

- Enabling works such as demolition, utility supply to construction sites, utility adjustments and modifications to the existing transport network
- Tunnel excavation including tunnel support activities
- Station excavation for new metro stations at Westmead, Parramatta, Sydney Olympic Park, North Strathfield, Burwood North, Five Dock and The Bays
- Shaft excavation for services facilities at Rosehill (within the Clyde stabling and maintenance facility construction site), Silverwater and between Five Dock Station and The Bays Station construction sites
- Civil work for the stabling and maintenance facility at Clyde including earthworks and structures
- A concrete segment facility for use during construction located at the Clyde stabling and maintenance facility construction site
- Road reconfiguration around Westmead metro station and at the Clyde stabling and maintenance facility
- Excavation of a tunnel dive structure and associated tunnels at Rosehill to support a connection between the Clyde stabling and maintenance facility and the mainline metro tunnels.

The Stage 1 is further described in Chapter 9 (Stage 1 Project description) of the Environmental Impact Statement.

The location of the services facility between Five Dock Station and The Bays Station is currently being investigated, and is not assessed within this technical paper. Further detail on the locational and design criteria that would be used as part of determining the preferred location is detailed in Chapter 9 (Stage 1 description) of the Environmental Impact Statement.

1.2 Purpose and Scope of This Report

This technical paper, Technical Paper 2: 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 noise and vibration impacts of Stage 1. In doing so, this technical paper responds directly to the Secretary's Environmental Assessment Requirements outlined in **Section 1.2.1**.

This report:

- Describes the existing environment with respect to noise and vibration
- Assesses the noise and vibration impacts of Stage 1 on the nearby communities and receivers
- Evaluates the potential cumulative impact of Stage 1 with other major infrastructure projects
- Identifies measures to mitigate and manage the predicted impacts.

The purpose of this report is to present indicative environmental impacts for the purpose of project approval and is not intended to be used for any other purpose.

1.2.1 Secretary's Environmental Assessment Requirements

The Secretary's Environmental Assessment Requirements were issued for Stage 1 on 11 December 2019. The requirements specific to noise and vibration, and where these requirements are assessed in this technical paper, are outlined in **Table 1**.

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

Secretary's Environmental Assessment Requirements	Where Addressed
Sydney Metro West Stage 1 - Noise and Vibration	
1. Commitments made in Section 9.2.2 of the Scoping Report.	**Table 2**
2. The assessment of construction noise and vibration must address:	
(a) the nature of construction activities and related noise characteristics;	**Section 4.1.2**
(b) the intensity and duration of noise (both air and ground borne) and vibration impacts. This must include consideration of extended construction impacts associated with ancillary facilities (and the like) and construction fatigue;	**Section 5**
(c) the identification and nature of receivers, existing and proposed, during the construction period;	**Section 2**
(d) the nature of the impact and the sensitivity of receivers and level of impact including for out of hours works;	**Section 5**
(e) the need to balance timely conclusion of noise and vibration-generating works with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management);	**Section 8.3**
(f) noise impacts of out-of-hours works (including utility works and works associated with the SSI including those undertaken under another assessment pathway), possible locations where out-of-hours works would be undertaken, the activities that would be undertaken, the estimated duration of those activities and justification for these activities in terms of the Interim Construction Noise Guideline (DECCW, 2009);	**Section 5.2, Section 5.5**
(g) sleep disturbance (including the number of noise-awakening events);	
(h) a cumulative noise and vibration assessment inclusive of impacts from Stage 1, including concurrent construction activities within Stage 1 and the construction of other relevant development in the vicinity of Stage 1;	**Section 5.2, 7.1 Section 6**
(i) details and analysis of the predicted effectiveness of mitigation measures to adequately manage identified impacts, including impacts as identified in (h);	**Section 5, 5.2, 8.3**
(j) any potential residual noise and vibration impacts following application of mitigation measures; and	**Section 5.2, 8.3**
(k) 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 8.3**
3. The assessment must include consideration of impacts to the structural integrity and heritage significance of items (including Aboriginal places and items of environmental heritage).	**Section 3.5.3.3, 5.1.2, 5.2, 5.3, 8.3**
4. Blast impacts (if required) can comply with current guidelines.	**Section 4.1.2.3**

Secretary's Environmental Assessment Requirement 1 in **Table 1** refers to commitments made in Section 9.2.2 of the *Sydney Metro West Scoping Report*. These commitments and where they are assessed in this technical paper are outlined in **Table 2**.

Table 2 Sydney Metro West Scoping Report Section 9.2.2 Commitments

Proposed Investigations and Assessment – Noise and Vibration	Where Addressed
The following government guidelines will be considered as relevant during the preparation of the noise and vibration assessment:	
• Sydney Metro City & Southwest Construction Noise and Vibration Strategy (Sydney Metro, 2017)	**Section 3.1, 3.2, 3.4, 3.5, 3.6, 4.4, 4.6.2**
• Interim Construction Noise Guideline (Department of Environment, Climate Change and Water, 2009)	**Section 3.1, 3.2, 3.4, 3.6, 4.1.2, 4.4**
• Noise Policy for Industry (Environment Protection Authority, 2017)	**Section 2.3, 3.1, 3.2**
• NSW Road Noise Policy (Department of Environment, Climate Change and Water, 2011)	**Section 3.1, 3.3, 3.7**
• Assessing Vibration: A Technical Guideline (Department of Environment and conservation, 2006)	**Section 3.5**
• Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration (Australian and New Zealand Environment Council, 1990).	**Section 3.6**
The construction noise and vibration impact assessment for Stage 1 will include:	
• The nature of construction activities	**Section 4.1.2**
• The intensity and duration of noise and vibration impacts. This will include a 'typical level' or 'typical range' in noise levels which would be expected as construction work move around the site as well as a realistic 'worst-case' noise level from each activity	**Section 5**
• The correlation between the likely noise impacts and the anticipated duration and timing of the activity	**Section 5**
• The nature, sensitivity and impact on potentially affected receivers, including consideration of particularly sensitive receivers if present within the vicinity (such as schools, hospitals, aged care facilities) and sensitive structures (particularly heritage structures and key utilities/infrastructure)	**Section 2.2, 3, 4, 5, 7**
• Impacts associated with any work proposed to be undertaken outside standard daytime construction hours	**Section 5**
• The potential impacts associated with long term construction noise	**Section 6**
• Explanation of how the extent of potential impacts on sensitive receivers have been balanced against the duration of impacts	**Section 8.3**
• Other factors that may influence the timing and duration of construction activities (such as traffic management)	**Section 4.1.2, 8.3**
• Feasible and reasonable mitigation and management measures to address identified construction noise impacts.	**Section 8**

1.3 Structure of this report

The structure of the report is outlined below.

- **Section 1** – provides an introduction to the report
- **Section 2** – describes the existing noise environment in the Stage 1 study area
- **Section 3** – defines the criteria relevant to Stage 1
- **Section 4** – outlines the methodology used to predicted and assess the potential impacts
- **Section 5** – summarises the construction noise and vibration assessment
- **Section 6** – assesses the potential cumulative impacts from Stage 1 and other major projects
- **Section 7** – summarises the operational road traffic noise assessment
- **Section 8** – discusses the recommended mitigation and management measures for Stage 1
- **Section 9** – provides a conclusion for the Stage 1 assessment.

1.4 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 Existing Environment

2.1 Study Area

Stage 1 is located in the inner west and greater western regions of Sydney and crosses the Cumberland, Parramatta, Strathfield, Canada Bay, Burwood and Inner West local government areas (LGAs). Suburbs that would have Stage 1 construction sites include Westmead, Parramatta, Rosehill, Clyde, Silverwater, Sydney Olympic Park, North Strathfield, Burwood, Concord, Five Dock and Rozelle. The tunnel alignment also passes beneath Newington, Canada Bay, and Rodd Point.

Existing noise levels vary across the Stage 1 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, 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, and City West Link near Lilyfield. Other sources of existing noise along the alignment include urban noise in Parramatta CBD and other urban centres, noise associated with sporting events in Sydney Olympic Park, and industrial noise in areas such as Clyde, Silverwater 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 surface construction sites are generally a mix of residential and various commercial uses, depending on location.

The Stage 1 study area has been defined on the basis of the likely noise and vibration impacts from Stage 1 using the following approach:

- Ground-borne noise and vibration from tunnelling and station excavation at surface construction sites has been assessed to all receivers within 150 metres of the tunnel alignment and construction sites
- Airborne noise has been assessed to receivers within 600 metres of the surface construction sites
- Construction road traffic noise impacts on public roads have been assessed for receivers adjacent to roads between the surface construction sites and the nearest arterial roads
- Operational road traffic noise impacts from road reconfigurations have been assessed at receivers adjacent to roads with changed configurations or traffic conditions.

The Stage 1 construction impacts are summarised on the basis of several study areas centred around each surface construction site. Each study area is divided into one or more Noise Catchment Areas (NCAs) that reflect the ambient noise environment of that area, as well as the noise and vibration sensitivity of the surrounding land uses.

The study areas and NCAs are shown in **Figure 2** and described **Table 3**. A detailed map of each study area is provided in **Section 5.2**.

Figure 2 Stage 1 Study Area

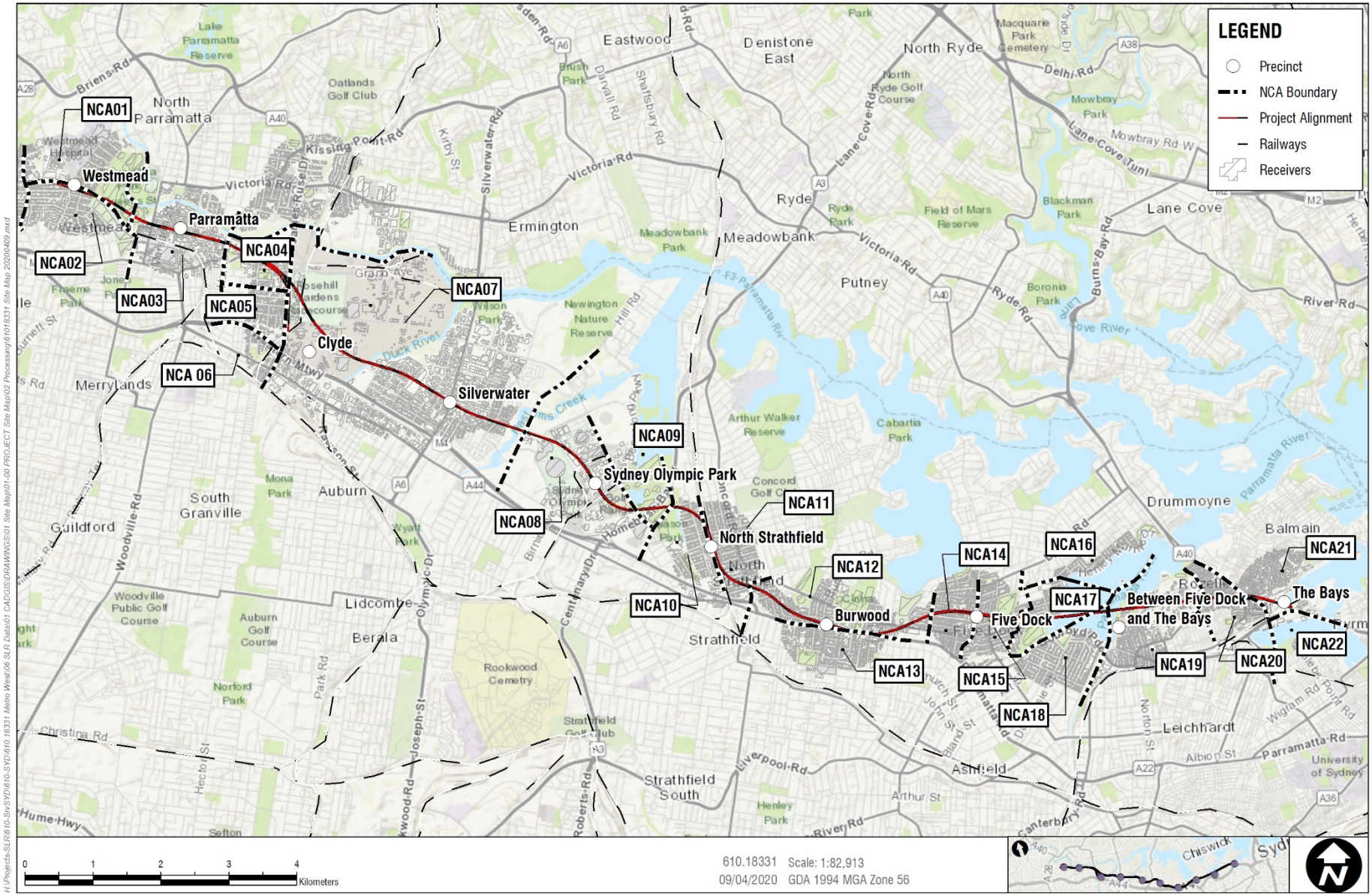


Table 3 Noise Catchment Areas and Surrounding Land Uses

Study area	NCA	Minimum distance (metres)[1]	Description
Westmead	NCA01	65	North of the existing rail corridor in Westmead and mainly residential. 'Other sensitive' receivers include Westmead Hospital, Western Sydney University – Westmead, and Parramatta Marist High School. A child care centre and a number of medical facilities are to the north of the existing Westmead Station.
	NCA02	25	South of the existing rail corridor and mainly residential. Westmead Primary School is in the north of the catchment on Hawksbury Road.
Parramatta	NCA03	5	Covers Parramatta CBD and is mainly commercial. Residential receivers are generally on the outskirts of the catchment. There are many 'other sensitive' receivers in this catchment, including Western Sydney University – Parramatta, Arthur Phillip High School, Parramatta Public School, and a number of nearby hotels and places of worship.
Clyde and Silverwater	NCA04	60	South of the Parramatta River and west of James Ruse Drive. The catchment is mainly residential with small areas of commercial receivers.
	NCA05	60	North of the M4 Motorway and west of James Ruse Drive. The catchment is mainly residential. 'Other sensitive' receivers include Rosehill Public School and a number of hotels and child care centres.
	NCA06	200	South of the M4 Motorway in Granville. The catchment is mostly residential adjacent to the motorway, with some commercial use in the south-east.
	NCA07	200	East of James Ruse Drive, this catchment is mostly commercial and covers Rosehill Gardens racecourse, the Clyde commercial/industrial area, and Silverwater and Newington. Residential receivers and Newington Public School are in the south-east. This catchment is included in both the Clyde and Silverwater precincts.
Olympic Park	NCA08	70	Covers the western portion of Olympic Park near the existing Olympic Park Station. This catchment is mainly of commercial and sporting related uses, with some 'other sensitive' receivers including hotels and educational facilities. Residential apartment blocks are in the south, east and west.
	NCA09	300	Covers the eastern portion of Olympic Park and is a mixture of commercial and residential. There are several high-rise residential apartment buildings near Australia Avenue.
North Strathfield	NCA10	50	West of the existing above ground rail corridor in North Strathfield and mainly residential. Commercial receivers are in the south near the M4 Motorway and in the west. 'Other sensitive' receivers include McDonald College and Our Lady of the Assumption Catholic Primary School.
	NCA11	20	East of the existing rail corridor and mainly residential, with areas of commercial receivers along Queen Street and Concord Road. Strathfield North Public School is in the north.

Study area	NCA	Minimum distance (metres)[1]	Description
Burwood	NCA12	10	North of Parramatta Road and mainly residential, with some commercial areas along Parramatta Road. 'Other sensitive' receivers include Concord High School, St Mary's Catholic Primary School, St Marys Catholic Church and St Luke's Anglican Church.
	NCA13	5	South of Parramatta Road and mainly residential, with commercial areas along Parramatta Road and Burwood Road. 'Other sensitive' receivers include Bath Arms Hotel, Southern Cross Catholic College and Methodist Ladies College.
Five Dock	NCA14	5	West of Great North Road in Five Dock and mainly residential. Commercial receivers are along Great North Road. 'Other sensitive' receivers include Five Dock Public School, St Albans Anglican Church, Drummoyne Uniting Church and Awesome Church.
	NCA15	5	East of Great North Road and mainly residential. Commercial receivers are along Great North Road and 'other sensitive' receivers include Domremy Catholic Church.
Between Five Dock and The Bays	NCA16	700	North of Parramatta River in Russell Lea and Iron Cove. This catchment is mainly residential and is relatively far from Stage 1.
	NCA17	300	North of City West Link in Rodd Point. This catchment is mainly residential.
	NCA18	30	South of City West Link in Haberfield. This catchment is mainly residential. Dobroyd Point Public School is in the west and Robson Park is in the north.
	NCA19	10	North of City West Link in Lilyfield. This catchment is mainly residential. 'Other sensitive' receivers include the University of Tasmania, NSW/Ambulance, Sydney University College of the Arts, Orange Grove Public School, and several outdoor recreation areas.
The Bays	NCA20	90	West of Victoria Road in Rozelle. This catchment is mainly residential with some commercial receivers along Victoria Road and Lilyfield Road. 'Other sensitive' receivers include Sydney Community College, St Joseph's Catholic Church and Rosebud Cottage child care centre.
	NCA21	50	East of Victoria Road in Rozelle and Balmain, and includes White Bay, the former White Bay Power Station and Glebe Island. This catchment is mainly residential, with various commercial areas surrounding White Bay and Glebe Island. 'Other sensitive' receivers include Inner Sydney Montessori School and C3 Church Balmain.
	NCA22	500	South of Victoria Road/Western Distributor in Glebe. Commercial areas associated with Rozelle Bay are to the south of Victoria Road/Western Distributor and the more distant areas across Rozelle Bay are residential.

Note 1: Approximate minimum horizontal distance from Stage 1 site to nearest sensitive receiver.

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 each receiver in the Stage 1 study area. Some buildings, however, contain more than one use, such as where residential apartments have commercial uses on ground floor. Where this occurs, the building is categorised using the most stringent criteria.

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

2.2.1 New Developments

A review of recently approved potentially noise and vibration sensitive developments in the Stage 1 study area has been completed and the identified developments have been included in the assessment, where appropriate.

2.3 Noise Surveys and Monitoring Locations

2.3.1 Unattended Ambient Noise Monitoring Results

Unattended ambient noise monitoring was completed in the Stage 1 study area between March and July 2019. Ambient noise data measured on other recent projects has also been used, resulting in a total of 21 representative monitoring locations across the study area. The measured noise levels have been used to determine the existing noise environment and to set criteria to assess the potential impacts from Stage 1.

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 Stage 1.

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 Sydney Olympic Park and Observatory Hill Weather Stations), to establish representative existing noise levels for each NCA.

The monitoring results are summarised in **Table 4**. Maps showing the monitoring locations in relation to Stage 1 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 level, are also in **Appendix B**.

Table 4 Summary of Unattended Noise Monitoring Results

Study area	Location ID	Address	Noise Level (dBA)[1]					
			Background Noise (RBL)			Average Noise Level (LAeq)		
			Day	Evening	Night	Day	Evening	Night
Westmead	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	B.03	Arthur Phillip High School, Parramatta[3]	58	53	43	69	67	62
Clyde	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	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	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	B.12	17 Burton Street, Concord	43	43 (47)[4]	42	56	55	50
	B.13	8 Esher Street, Burwood	48	48	44	57	56	55
Five Dock	B.14	3 Henry Street, Five Dock	42	41	33	58	56	51
	B.15	8 Waterview Street, Five Dock	43	43 (44)[4]	38	57	56	50
Between Five Dock and The Bays	B.16	11 Chapel Street, Lilyfield	36	36 (39)[4]	33	60	60	53
	B.17	28 Crescent Street, Haberfield	43	43 (45)[4]	37	57	57	51
	B.18	102 Henley Marine Drive, Russell Lea	48	45	37	64	61	55
The Bays	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

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

Note 2: Daytime is 7.00 am to 6.00 pm, evening is 6.00 pm to 10.00 pm and night-time is 10.00 pm to 7.00 am.

Note 3: Data measured on other recent project. See **Appendix B** for details.

Note 4: 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.

2.3.2 Unattended Road Traffic Noise Monitoring Results

To validate the operational road traffic noise model, measurements of existing road traffic noise levels in the Stage 1 study area were completed in July and August 2019. The survey used the same methodology as the unattended ambient noise monitoring detailed in **Section 2.3.1**.

The monitoring results are summarised in **Table 5**. Maps showing the monitoring locations are provided in **Section 4.7.2** and in **Appendix C**. Descriptions of each monitoring location and the measured noise environment, together with graphs of the daily measured noise level, are also in **Appendix C**.

Table 5 Measured Road Traffic Noise Levels

Validation Monitoring Location	Address	Measured Noise Level (dBA)	
		Daytime $L_{Aeq(15hour)}$[1]	Night-time $L_{Aeq(9hour)}$[1]
V.01	1-7 Alexandra Avenue, Westmead	66.9	60.7
V.02	57 Alexandra Avenue, Westmead	61.5	57.3
V.03	47 Grand Avenue, Westmead	53.0	48.6
V.04	150 Hawkesbury Road, Westmead	65.0	60.6

Note 1: Operational road traffic noise is assessed during the RNP defined daytime which is 7 am to 10 pm and night-time which is 10 pm to 7 am.

2.3.3 Attended Noise Measurements

Short-term attended noise monitoring was completed at each ambient and operational road traffic noise 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** and **Appendix C**.

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 Stage 1 study area. The noise sources that influence background levels include:

- Road traffic noise, which is the main source of existing noise in the Stage 1 study area. Most construction surface 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, Rosehill, Sydney Olympic Park and North Strathfield study areas.
- Aircraft noise is present in several parts of the Stage 1 study area that are under flight paths, including the 'Between Five Dock and The Bays' study area.
- Noise generated by industrial areas in Clyde, Rozelle and White Bay.
- Noise generated by commercial areas such as in Westmead, Parramatta, Silverwater, Five Dock, and Sydney CBD areas.
- Noise from sporting events at Parramatta Stadium, Rosehill Gardens racecourse, Sydney Speedway, Sydney Olympic Park, Concord Oval, Cintra Park and Leichhardt Park.

3 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 Stage 1 are listed in **Table 6**. The guidelines aim to protect the community and environment from excessive adverse noise and vibration impacts as projects are constructed.

Table 6 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
Construction Noise and Vibration Strategy, Transport for NSW, 2016	Assessment and management protocols for airborne noise, ground-borne noise and vibration impacts for construction of rail infrastructure projects
Sydney Metro Construction Noise and Vibration Standard (CNVS), Sydney Metro, 2020	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 CNVS, as appropriate to Sydney Metro and is the guiding strategy for assessing and managing the potential impacts during construction of Stage 1. This Sydney Metro standard replaces the *Sydney Metro Construction Noise and Vibration Strategy* (Sydney Metro, 2017)
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 7**.

Table 7 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	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 practises 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.

Time of Day	NML LAeq(15minute)	How to Apply
Outside Standard Construction Hours:	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**.

Works are recommended to be completed during Standard Construction Hours where possible. More stringent requirements are placed on works that are 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 works to be completed during the night-time. Where night works are located close to residential receivers there is potential for sleep disturbance impacts.

The ICNG lists five categories of works 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 works** that shorten the length of the project and are supported by the affected community
- Works where a proponent demonstrates and justifies a need to operate outside the recommended standard hours.

Where construction works are 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 Stage 1 have been determined using the results from the unattended ambient noise monitoring (see **Section 2.3**) and are shown in **Table 8**.

Table 8 Residential Receiver Construction NMLs

Study area	NCA	Representative Background Monitoring Location	NML (LAeq(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	59	54	53	49	59
	NCA06	B.06	62	57	56	49	59
	NCA07	B.07	56	51	49	46	56
Silverwater	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
Between Five Dock and The Bays	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

Note 1: Daytime out of hours is 7 am to 8 am and 1 pm to 6 pm on Saturday, and 8 am to 6 pm 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 Stage 1 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 Stage 1 study area. These include 'other sensitive' land uses such as educational institutes, medical facilities, outdoor recreational areas and commercial properties. The ICNG NMLs for 'other sensitive' receivers are shown in **Table 9**.

Table 9 ICNG NMLs for 'Other Sensitive' Receivers

Land Use	Noise Management Level LAeq(15minute) (dBA) (Applied when the property is in use)	
	Internal	External
Classrooms at schools and other educational institutions	45	55[1]
Hospital wards and operating theatres	45	65[1]
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

Note 1: The criteria is specified as an internal noise level for this receiver category. As the noise model predicts external noise levels, it has been conservatively assumed that all schools and places of worship have openable windows and external noise levels are 10 dB higher than the corresponding internal level, which is representative of windows being partially open to provide ventilation. Hospitals are assumed to have fixed windows with 20 dB higher external levels.

Rosehill Gardens racecourse stables have been included in the assessment and are assessed as 'other sensitive' active recreation areas. This is consistent with the CBD and South East Light Rail Environmental Impact Statement (Transport for NSW, 2013).

The ICNG references *AS2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors* for criteria for 'other sensitive' receivers which are not listed in the guideline. Neither the ICNG nor AS2107 provide criteria for child care centres so the Association of Australian Acoustical Consultants *Guideline for Child Care Centre Acoustic Assessment* (GCCCAA) has been referenced. The NMLs for 'other sensitive' receivers are shown in **Table 10**.

Table 10 NMLs for 'Other Sensitive' Receivers

Use	Period	NML Derived From	Noise Management Level LAeq(15minute) (dBA)	
			Internal	External
Hotel	Daytime & evening	AS2107: Bars and lounges	50	70[1]
	Night-time	AS2107: Sleeping areas, Hotels near major roads	40	60[1]
Café	When in use	AS2107: Coffee bar	50	70[1]
Bar/Restaurant	When in use	AS2107: Bars and Lounges / Restaurant	50	70[1]

Use	Period	NML Derived From	Noise Management Level $L_{Aeq(15minute)}$ (dBA)	
			Internal	External
Child care centres	Daytime	GCCCAA: Outdoor play areas	-	55
		GCCCAA: Sleeping areas	40	50[2]
Public building	When in use	AS2107: Public space	50	60[2]
Recording studio	When in use	AS2107: Music recording studios	25	45[1]
Theatre / auditorium	When in use	AS2107: Drama theatres	30	50[1]
Stables	When in use	ICNG: Outdoor passive recreation	-	60

Note 1: It is assumed that these receiver types have fixed windows with a conservative 20 dB reduction for external to internal noise levels.

Note 2: Receiver conservatively assumed to have openable windows and a 10 dB outside to inside facade performance.

3.3 Construction Traffic Noise Guidelines

The potential impacts from construction traffic associated with Stage 1 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 11**.

Table 11 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 Stage 1 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 works can cause ground-borne (or regenerated) noise impacts in nearby buildings when vibration intensive equipment is in use, such as during tunnelling or excavation works using tunnel boring machines (TBMs), roadheaders or rockbreakers. Vibration can be transmitted through the ground and into nearby buildings, which can then create audible noise impacts inside the building. Ground-borne NMLs are defined in the ICNG for residential receivers and in the Sydney Metro CNVS for commercial receivers.

The NMLs are applicable to tunnelling and excavation works where ground-borne noise levels are likely to be higher than airborne noise levels. This can occur during rockbreaking if, for example, airborne noise levels are shielded by noise barriers or other such structures.

Residential and Commercial Receivers

The internal ground-borne noise criteria for residential and commercial receivers are shown in **Table 12**.

Table 12 Construction Ground-borne Noise Criteria

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

Other Sensitive Land Uses

For 'other sensitive' receivers, neither the ICNG nor Sydney Metro CNVS provide guidance in relation to acceptable ground-borne noise levels. For these receivers, the ICNG internal airborne noise NMLs listed in **Table 9** and **Table 10** have been used to identify potential ground-borne noise impacts from Stage 1.

3.5 Construction Vibration Guidelines

The effects of vibration from construction works 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 works are located close to occupied buildings.

Vibration from construction works 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 13**.

Table 13 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 works. Criteria for vibration sensitive equipment are discussed in **Section 3.5.4**.

3.5.3 Cosmetic Damage Vibration

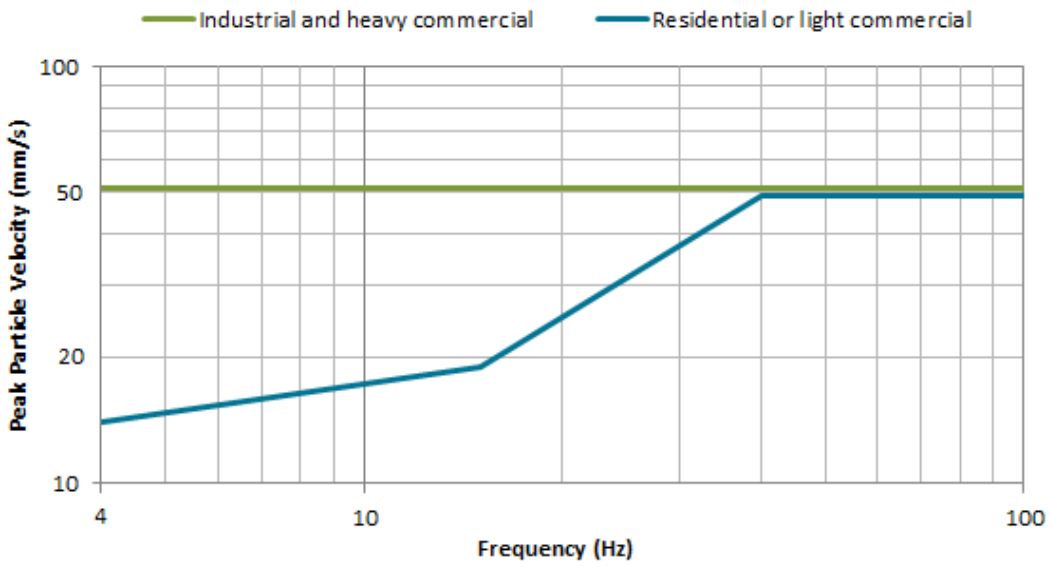
If vibration from construction works is sufficiently high it can cause cosmetic damage to elements of affected buildings. Examples of damage that can occur includes cracks or loosening of drywall surfaces, cracks in supporting columns and loosening of joints. The levels of vibration required to cause 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 limits for transient vibration which correspond to minimal risk of cosmetic damage for residential and industrial buildings. The limits are shown in **Figure 3**.

Figure 3 Transient Vibration Values for Minimal Risk of Cosmetic Damage



The Sydney Metro CNVS notes that where dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at lower frequencies where lower guide values apply, then the guide values in **Figure 3** may need to be reduced by up to 50 percent. On this basis, the Sydney Metro CNVS recommends the following conservative cosmetic damage screening limits shown in **Table 14**.

Table 14 Transient Vibration 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.

3.5.3.2 Utilities and Other Vibration Sensitive Assets

Construction of Stage 1 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 15**.

Table 15 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 according to the cosmetic damage screening criteria in **Table 14** and **Table 15** and should not be assumed to be more sensitive to vibration unless found to be structurally unsound.

Where heritage buildings 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) would be considered.

Sydney Metro West would complete condition surveys of potentially affected buildings and structures near to the tunnel and excavations prior to the commencement of excavation in consultation with a structural engineer, where appropriate. For heritage buildings and structures the surveys would consider the heritage nature of the structure in consultation with a heritage specialist to ensure suitably stringent vibration criteria are applied and the items are adequately monitored and managed. Consideration would also be given to information from any recent condition surveys.

Based on a review of currently available information, the only heritage buildings and structures 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.

No vibration sensitive Aboriginal places or environmental heritage items have been identified in the Stage 1 study area and are not considered further in this assessment.

3.5.4 Sensitive Scientific Equipment

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

Where vibration sensitive equipment is potentially affected by construction works, vibration limits for the operation of the equipment should be taken from manufacturer's data. Where this is not available, generic Vibration Criterion (VC) curves can be used. These VC curves are shown in **Table 16**.

Table 16 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.

3.6 Vibration and Overpressure from Blasting

Blasting is often used where deep excavation of rock is required and can be used as an alternative to rockbreaking. Blasting events have the potential to result in brief ground vibration and air overpressure impacts at nearby receivers.

Blasting has the benefit of substantially reducing the duration of noise and vibration impacts when compared to rockbreaking alone.

The ICNG recommends the following hours for blasting:

- Monday to Friday (9:00 am to 5:00 pm)
- Saturday (9:00 am to 1:00 pm)
- No blasting on Sundays or public holidays.

The ICNG requires vibration and overpressure from blasting to be assessed against the Australian and New Zealand Environment Council (ANZECC) *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration,* ANZECC, 1990.

The criteria in the ANZECC standard are, however, applicable to long-term operations, such as those at mining sites and are targeted to protect human comfort from vibration. As a result, the vibration levels are conservative and can introduce overly stringent constraints when applied to construction projects, which typically occur for much shorter time periods.

The Sydney Metro CNVS recognises the restrictive nature of the ANZECC criteria and recommends the following vibration and overpressure limits:

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

As noted earlier, heritage buildings and structures should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound. Where heritage buildings and structures are found to be structurally unsound, a more conservative cosmetic damage objective of 2.5 mm/s PPV (from DIN 4150) would be considered (see **Section 3.5.3.3**).

3.7 Operational Road Traffic Noise Guidelines

The guidelines used to assess the potential operational road traffic impacts from Stage 1 are listed in **Table 17**. The guidelines aim to protect the community and environment from excessive noise impacts from the long-term operation of road projects.

Table 17 Operational Road Traffic Noise Guidelines

Guideline/Policy Name	When Guideline is Used
Road Noise Policy (RNP) (DECCW, 2011)	Operational road traffic noise assessment
Noise Criteria Guideline (NCG) (Roads and Maritime, 2015)	Defines Roads and Maritime's interpretation of the RNP and details how criteria is applied to sensitive receivers
Noise Mitigation Guideline (NMG) (Roads and Maritime, 2015)	Details how additional mitigation measures are to be applied to road projects
Environmental Noise Management Manual (ENMM) (Roads and Traffic Authority, 2001)	Additional information for operational road traffic noise assessment, including maximum noise assessments

3.7.1 Airborne Noise – Road Noise Policy and Noise Criteria Guideline

The NSW *Road Noise Policy* (RNP) is used to assess and manage potential airborne noise impact from new and redeveloped road projects.

This assessment has been undertaken with guidance from the *Noise Criteria Guideline* (NCG) which is Roads and Maritime's interpretation of the RNP and provides a consistent approach to identifying road noise criteria for road infrastructure projects.

The RNP and NCG provide non-mandatory criteria for residential and 'other sensitive' land uses. Where a project results in road traffic noise levels which are predicted to be above the criteria, feasible and reasonable noise mitigation measures should be investigated to minimise the impacts.

The assessment uses the following terms to describe and assess the impacts from road projects:

- '**No Build**' – the assessment scenario used to predict noise levels if Stage1 were not to go ahead
- '**Build**' – the assessment scenario used to predict noise levels including the road reconfigurations that are proposed as part of Stage 1.

The difference between the 'Build' and the 'No Build' noise levels is used to determine the impact of a project.

Residential Receivers

The Stage 1 road reconfiguration works are a mixture of both 'redeveloped' roads and 'new' roads. A road is 'redeveloped' where works are in an existing road corridor and the existing road is not substantially realigned. Roads are classed as 'new' where the road construction is in an undeveloped corridor, where an existing road is substantially realigned or where the functional class of a road changes, such as where a road that was previously local becomes a larger collector road. The relevant noise criteria for residential receivers are shown in **Table 18**.

Table 18 NCG Criteria for Residential Receivers

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	1. Existing residences affected by noise from **new** freeway/arterial/sub-arterial road corridors	$L_{Aeq(15\ hour)}$ 55 (external)	$L_{Aeq(9\ hour)}$ 50 (external)
	2. Existing residences affected by noise from **redevelopment** of existing freeway/arterial/sub-arterial roads	$L_{Aeq(15\ hour)}$ 60 (external)	$L_{Aeq(9\ hour)}$ 55 (external)
	3. Existing residences affected by **additional traffic** on existing freeways/arterial/sub-arterial roads generated by land use developments		
	4. Existing residences affected by both new roads and the redevelopment of existing freeway/arterial/sub-arterial roads in a **transition zone**[1]	Between $L_{Aeq(15hour)}$ 55-60 (external)	Between $L_{Aeq(9hour)}$ 50-55 (external)
	5. Existing residences affected by increases in traffic noise of 12 dB or more from redevelopment of existing freeway/arterial/sub-arterial roads[2]	Between $L_{Aeq(15hour)}$ 42-55 (external)	Between $L_{Aeq(9hour)}$ 42-50 (external)
	6. Existing residences affected by increases in traffic noise of 12 dB or more from redevelopment of existing freeway/arterial/sub-arterial roads[2]	Between $L_{Aeq(15hour)}$ 42-60 (external)	Between $L_{Aeq(9hour)}$ 42-55 (external)
Local roads	7. Existing residences affected by noise from **new** local road corridors	$L_{Aeq(1\ hour)}$ 55 (external)	$L_{Aeq(1\ hour)}$ 50 (external)
	8. Existing residences affected by noise from **redevelopment** of existing local roads		
	9. Existing residences affected by **additional traffic** on existing local roads generated by land use developments		

Note 1: The criteria assigned to the entire residence depend on the proportion of noise coming from the new and redeveloped roads.

Note 2: The criteria at each facade are determined from the existing traffic noise level plus 12 dB.

The criteria are lower for the night-time due to the greater sensitivity of communities to noise impacts during this period.

The RNP and NCG require noise to be assessed at project opening and for a future design year, which is typically ten years after opening. The Stage 1 road reconfigurations are not expected to increase traffic carrying capacity of the affected roads at either project opening or in the future design year, and for this reason only the opening year (2023) has been assessed.

'Other Sensitive' Land Uses

Several 'other sensitive' non-residential land uses have been identified in the Stage 1 study area. The noise criteria for these receivers are shown in **Table 19**. The NCG does not consider commercial and industrial receivers as being sensitive to operational road traffic noise impacts.

Table 19 NCG Criteria for Other Sensitive Receivers

Existing Sensitive Land Use	Assessment Criteria (dB)		Additional Considerations
	Daytime (7 am – 10 pm)	Night-time (10 pm – 7 am)	
1. School classrooms	$L_{Aeq(1\ hour)}$ 40 (internal)[1]	-	In the case of buildings used for education or health care, noise level criteria for spaces other than classrooms and wards may be obtained by interpolation from the 'maximum' levels shown in Australian Standard 2107:2000 (Standards Australia 2000).
2. Hospital wards	$L_{Aeq(1\ hour)}$ 35 (internal)	$L_{Aeq(1\ hour)}$ 35 (internal)	
3. Places of worship	$L_{Aeq(1\ hour)}$ 40 (internal)[1]	$L_{Aeq(1\ hour)}$ 40 (internal)[1]	The criteria are internal, ie the inside of a church. Areas outside the place of worship, such as a churchyard or cemetery, may also be a place of worship. Therefore, in determining appropriate criteria for such external areas, it should be established what is in these areas that may be affected by road traffic noise.
4. Open space (active use)	$L_{Aeq(15\ hour)}$ 60 (external)	-	Active recreation is characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion.
5. Open space (passive use)	$L_{Aeq(15\ hour)}$ 55 (external)	-	Passive recreation is characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion (eg playing chess, reading).
6. Child care facilities	Sleeping rooms $L_{Aeq(1\ hour)}$ 35 (internal)[1] Indoor play areas $L_{Aeq(1\ hour)}$ 40 (internal)[1] Outdoor play areas $L_{Aeq(1\ hour)}$ 55 (internal)	-	Multipurpose spaces (eg shared indoor play/sleeping rooms) should meet the lower of the respective criteria. Measurements for sleeping rooms should be taken during designated sleeping times for the facility, or if these are not known, during the highest hourly traffic noise level during the opening hours of the facility.
7. Aged care facilities	-	-	The criteria for residential land uses should be applied to these facilities.

Note 1: The criteria are specified as an internal noise level for this receiver category. As the noise model predicts external noise levels, it has been conservatively assumed that all schools and places of worship have openable windows and external noise levels are 10 dB higher than the corresponding internal level, which is representative of windows being partially open to provide ventilation.

4 Methodology

This section describes the methodology used to assess the potential noise and vibration impacts from Stage 1.

4.1 Construction Airborne Noise Assessment

4.1.1 Computer Noise Modelling

A noise model of the Stage 1 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 Works Descriptions

The proposed Stage 1 construction works include the following:

- Site clearing of currently occupied construction sites (including demolition of existing structures) and site establishment
- Excavation of stations and station shafts
- Excavation of shafts for ancillary infrastructure such as services facilities
- Excavation of a dive structure at Rosehill in the Clyde study area
- Excavation of the tunnels between Westmead and The Bays Study area
- Civil works for the stabling and maintenance facility
- Road reconfigurations around Westmead Metro Station and at the Clyde stabling and maintenance facility.

Representative scenarios have been developed to assess the likely impacts from the various construction activities. The scenarios required at the surface constructions sites are discussed in **Section 4.1.2.1** with the remaining construction activities, including blasting, tunnelling and ancillary works, discussed in **Section 4.1.2.2**. Equipment lists for each scenario and sound power level data is provided in **Appendix D**.

The assessment uses ‘realistic worst-case’ scenarios to determine 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’ works which have been used to define the likely range of potential noise impacts:

- ‘**Peak**’ works represent the noisiest stages and can require noise intensive equipment, such as rockbreakers or concrete saws. While ‘Peak’ works would be required at times in most locations, the noisiest works would not occur for the full duration of the works.

- '**Typical**' works represent typical noise emissions when noise intensive equipment is not in use. The 'Typical' works generally include most items of equipment for a given activity except for the loudest item. These items generally support the 'Peak' works activity and are referred to as 'supporting equipment'.

An example of 'Peak' and 'Typical' works scenarios in presented in **Table 20**.

Table 20 'Peak' and 'Typical' Works Example

Activity	Equipment	Individual Item Sound Power Level (dBA)	Number of Items	
			'Peak'	'Typical'
Example works	**Number of Construction Faces**		**2**	**1**
	Excavator (22 tonne)	105	2	1
	Excavator (Breaker)	121	2	0
	Dozer	112	2	1
	Rock Anchor Drill	108	2	1
	Truck	108	2	1
Resultant Sound Power Level			**125**	**115**

The above shows that the 'Peak' activity sound power level represents the noisiest period of the works when all equipment, including two rockbreakers, are being used. The 'Typical' activity is 10 dB lower than the 'Peak' when rockbreakers are not being used and there is less supporting equipment.

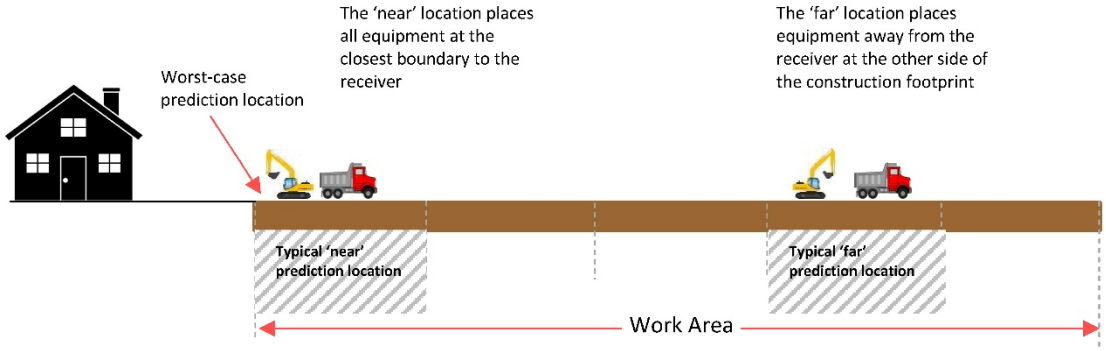
The ICNG requires that activities identified as particularly annoying (such as jackhammering, rockbreaking and power saw operation) have a 5 dB 'penalty' added to predict noise levels when using the quantitative method. Construction equipment that requires an annoyance penalty are shown in **Appendix D**.

Certain construction scenarios would require the concurrent operation of several construction teams (or 'construction faces') performing the same works in different areas of the site. The 'Peak' scenarios include the maximum anticipated number of construction faces at each construction site. The assessment is generally considered conservative as the calculations assume several items of equipment at each construction face are in use at the same time.

Construction activities would 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 works are not audible at receivers due to no noisy items of equipment being used.

For a particular construction site, the potential construction noise impacts can vary greatly, with a key factor being the distance of the works from the nearest receivers. For works that move around the site (such as site clearing and piling), a receiver would be affected by a range of noise levels depending on how close the works are. This concept is illustrated in **Figure 4**.

Figure 4 Illustration of Works Position in Relation to Receiver



The above illustration shows that works which are closest to a receiver would result in higher impacts than works which are further away. The assessment of the proposed Stage 1 construction works presents the expected range of impacts for each construction scenario based on works being both 'near' and 'far' from the nearest potentially affected receivers.

Works within a confined area, such as excavation works inside the acoustic sheds, would be limited to one location and no range has been presented for these scenarios.

4.1.2.1 Construction Site Works Descriptions

The works involved in the construction of stations, services facilities, the Clyde stabling and maintenance facility and the launch/retrieval/support of TBMs are listed and described in **Table 21**. The construction scenarios represent one possible way that Stage 1 could be constructed and may not necessarily be the same methodology that the contractor engaged to construct Stage 1 would use.

Table 21 Construction Scenario Descriptions – Construction Site Activities

Scenario	Description
Enabling and site establishment works	These works are required to demolish existing buildings and structures, clear or protect trees, establish access points and erect hoarding. Relocation of services or third party assets may also be required. These works may include provision of high voltage power supplies for excavation equipment, which is required early in the program at some sites. The works are: - 'Typical' works generally include operation of supporting equipment such as generators, cranes, compressors, etc, and loading of heavy vehicles with equipment such as excavators. - 'Peak' works include the use of noise intensive equipment such as rockbreakers and concrete saws at times, especially during demolition of existing structures. The number of construction faces would double during 'Peak' works for most construction sites. The North Strathfield and Silverwater construction sites have been cleared by previous activities and would not require site clearing works prior to Stage 1 construction. At these sites the *Enabling and site establishment* works would involve the following less noise intensive activities: - 'Typical' works would generally involve delivery of equipment and facilities to the site. - 'Peak' works include the assembly of site facilities including perimeter hoarding and amenities buildings.

Scenario	Description
Piling	Piling is required at all construction sites for the foundations of future structures and to support linings for the stations and shafts. The works are: - 'Typical' works would include operation of supporting equipment such as excavators and cranes, as well as concreting equipment such as concrete mixer heavy vehicles and concrete pumps. - 'Peak' works would use all supporting equipment plus a piling rig. The number of piling faces would double during 'Peak' works with most construction sites requiring up to four piling faces where there is sufficient space. Bored piling would be used as opposed to impact piling, where possible. Bored piling is significantly less noisy.
Surface construction	Following site establishment and piling, civil works and surface structures such as abutments, roads, hardstand areas, and facilities such as water treatment equipment and site offices would be constructed. Acoustic shed(s) (or other acoustic measures) would be constructed over excavation and most spoil handling areas as early as possible for sites where 24/7 excavation and tunnelling works are proposed. The works are: - 'Typical' works would include the use of general construction equipment such as cranes, generators and hand tools. - 'Peak' works would use all supporting equipment plus noise intensive equipment such as grinders. The number of construction faces would double during 'Peak' works for most sites.
Excavation	Stations as well as services facility shafts, tunnel dives and TBM launch shafts would need to be excavated from the surface down. Excavation would begin after the piling works. Excavation at each site would be separated into two phases – 'initial excavation' and 'main excavation'. Definitions of these phases are provided below. **Initial excavation** Initial excavation involves removal of the upper layers of soil and rock to a depth suitable for the construction of an acoustic shed (or other acoustic measures) or acoustic panels (which are covers placed over the top of the excavation pit to minimise noise emissions). Initial excavation would take around two months to complete (varies according to construction site) and would be performed during the daytime. Initial excavation of soil and soft rock can be undertaken using 'ripping' where the earth is separated using a manual pick attachment on an excavator. Initial excavation of hard rock would require rockbreaking, which is noise intensive. The time required for ripping versus rockbreaking would vary at each site depending on the depth of rock. Indicative durations for initial excavation at each construction site are provided in **Section 5.2**. The works are: - 'Typical' initial excavation works would include the use of support equipment for spoil handling and a process called 'mucking out' which is described below. - 'Peak' works would involve the concurrent use of support equipment and either ripping through soft soil/rock or noise intensive rockbreaking through hard rock. The number of construction faces would double during 'Peak' works for most construction sites. Initial excavation works are not required at construction sites without acoustic sheds. At these sites only 'main excavation' would occur.

Scenario	Description
	Main excavation Main excavation (referred to as 'excavation' hereon) involves excavation to a depth where blasting can be performed, if it is suitable for that site. Excavation would be completed within acoustic sheds or below acoustic panels (or other acoustic measures) at sites where 24/7 excavation works are proposed including Westmead metro station, Olympic Park metro station, Burwood North Station, Five Dock Station and The Bays Station construction sites. At sites without acoustic sheds or panels, noisy excavation works would typically be restricted to the daytime. The works are: - 'Typical' excavation works would include the use of supporting equipment for spoil handling and a process called 'mucking out' which is described below. - 'Peak' works would involve the concurrent operation of supporting works and rockbreakers. The number of construction faces would double during 'Peak' works for most construction sites with most sites requiring concurrent use of two rockbreaking faces. Construction equipment outside the acoustic sheds would include heavy vehicles and fixed ancillary equipment such as ventilation systems and water treatment facilities.
Mucking out	At times during excavation, works would pause so the loose spoil can be removed using excavators and transferred to heavy vehicles. This is referred to as 'mucking out'. - Mucking out is part of the 'Typical' works activity for the initial excavation and excavation scenarios.
Mined caverns	Once the shafts have been excavated, areas of the underground station caverns can be mined using roadheaders. These works would be required at Burwood North and Five Dock. The works are: - 'Typical' works would generally include operation of supporting equipment associated with spoil removal. - 'Peak' works include the concurrent use of supporting equipment and roadheaders. The number of construction faces would double during 'Peak' works for some construction sites with up to two roadheaders operating at the same time. Excavation of stub tunnels, connecting tunnels, and crossover and turnback caverns are included in the tunnelling noise and vibration assessment in **Section 5.3**.
TBM launch, extraction, and support	TBMs are proposed to be launched and supported from the Westmead metro station construction site and The Bays Station construction site. At each site, TBM support activities would be required to provide tunnel ventilation, supply high voltage power and extract/stockpile spoil. TBMs would be extracted at the Sydney Olympic Park metro station construction site. TBM assembly, launch and extraction would occur 24/7, however, the majority of these works would be completed inside acoustic sheds (or other acoustic measures). Some less noisy works would be required outside the shed, such as loading and unloading of heavy vehicles. Once the TBMs are operational, spoil handling and removal would occur 24/7 at TBM launch and support sites. The works require heavy vehicles, spoil conveyors, loading activities, tunnel ventilation fans, dust collectors, materials and equipment deliveries and onsite stockpiling. Where 24/7 tunnelling or excavation works are required near sensitive receivers, an acoustic shed (or other acoustic measures) would be erected to mitigate the noise impacts.

Scenario	Description
Concrete batching plant and segment production facility	A concrete segment production facility would be established at the Clyde stabling and maintenance facility construction site. This would include a concrete batching plant, a pre-cast production facility and storage yard. The concrete batching plant and segment production facility would operate on a 24/7 basis and would be operational for the duration of the TBM tunnelling works. The concrete production operations are included in the *Concrete batch plant* construction scenario, which is representative of the facility operating in the absence of other construction equipment, and also in the *Excavation* scenario, which includes the concurrent operation of the concrete plant and excavation equipment. 'Typical' and 'Peak' works scenarios for the concrete batching plant and pre-cast facility would generally include use of concrete processing equipment such as concrete pumps, agitators, and vibrators, as well as the loading of heavy vehicles and stockpiles with concrete and tunnel lining segments. The facility is assumed to operate as follows: - 50 percent capacity during the 'Typical' scenario. - 100 percent capacity during the 'Peak' scenario.
Clyde earthworks and civil works	The Clyde stabling and maintenance facility construction site would include earthwork and civil works required to prepare the site for construction of the facility, road reconfigurations, road bridges, and construction of associated structures. The works are: - 'Typical' works would include operation of supporting equipment such as excavators and heavy vehicles. - 'Peak' works would use all supporting equipment plus noise intensive equipment such as concrete saws and jackhammers. The number of working faces would double during 'Peak' works.

4.1.2.2 Tunnelling, Ancillary, and Alternative Construction Activities

The Stage 1 tunnelling and ancillary activities that are required outside of the surface construction sites are listed and described in **Table 22**.

Table 22 Construction Scenario Descriptions – Tunnelling and Ancillary Activities

Scenario	Description
Tunnelling – excavation and construction	The tunnelling works would occur 24/7. Depending on the rate of progress, noise and vibration impacts from tunnelling would likely only be apparent for relatively short periods at most locations. At this stage, TBMs are proposed to be used for the majority of the alignment with roadheaders and rockbreakers used at stations, stub tunnels, cross passages and crossover and turnback caverns. Roadheaders would also be used to excavate the tunnels that connect the stabling and maintenance facility to the main alignment.
Tunnelling – work trains	Consistent with the tunnelling methodology used on previous Sydney Metro projects, work trains would be used to supply materials, such as precast tunnel lining segments, and workers to the workface. Spoil would be removed via conveyor. Work trains are anticipated to operate on a temporary narrow gauge rail with resilient mounts and/or rubber wheels. The work trains would be loaded at the TBM launch site and unloaded at the TBM. The operating speed of work trains is around 10 km/h and they would be required 24/7 to support tunnelling. On the basis of the above, work trains are not expected to result in any significant noise and vibration impacts.

Scenario	Description
Spoil and materials transport	Spoil and materials transport via heavy vehicles would be required to and from all construction sites. The possibility of bulk removal of spoil from The Bays Station construction site via barge is being investigated as an alternative option that may reduce the need for road transportation.
Road intersection modification	Road works would be required to modify intersections near the Westmead metro station construction site. These works would likely occur during the evening and night-time to minimise disruption on the road network. The works are: - 'Typical' works would include operation of supporting equipment such as excavators, trucks and lighting towers. - 'Peak' works would use all supporting equipment plus noise intensive equipment such as concrete saws and rockbreakers. Additional road works would also be required to complete the works, however, they would mostly consist of less noisy activities, such as line marking and installing street furniture, and have not been considered further in this assessment.
Utility works	Utilities would need to be adjusted, relocated and/or protected where there is a possibility they would be impacted during construction. Access to a source of electrical power would be required for the construction sites, TBMs and future metro facilities. Generally, these utilities are located close to the construction sites (such as the adjacent footpath). However, there would be occasions where a utility needs to be relocated within the construction site or in some instances outside the construction site footprint. The details of each utility relocation are currently being determined as the design develops. The management of utility protection, adjustment or relocation is detailed in Chapter 9 (Stage 1 description) of the Environmental Impact Statement, including the management of construction noise and amenity impacts. An assessment of the potential noise levels from the likely equipment associated with these activities is provided in **Section 5.5**.

4.1.2.3 Alternative Construction Methodologies – Controlled Blasting

A potential alternative to continuous rockbreaking is to use controlled blasting to excavate shafts. This excavation method can greatly reduce the duration of noise and vibration impacts by limiting the need for rockbreaking to 'trimming' works only. Trimming involves shaping the face of the rock with a rockbreaker after blasting.

Blasting can be used after the shaft has been excavated using rockbreakers/ripping to a suitable depth, and when the shaft is sufficiently far away from nearby structures (based on complying with the cosmetic damage screening criteria in **Section 3.6**).

The charge size can be increased as the shafts become deeper and the offset distances to nearest receivers increases. In all cases, maximum instantaneous blast charges would be monitored so that the vibration and blast over-pressure criteria are complied with.

The indicative suitable depths for blasting at each site are shown in **Table 23**. The anticipated reduction in continuous rockbreaking is also shown in the table, if blasting was to be used.

As blasting events are instantaneous, the duration of potential ground-borne noise and human comfort vibration impacts are generally minimal. Additionally, the blast events are only expected to occur, at most, once a day, and up to two or three times a week.

Table 23 Potential Reduction in Continuous Rockbreaking and Construction Program from using Blasting

Study area	Construction Site	Suitable Controlled Blasting Depth (metres)[1]	Reduction in Days of Continuous Rockbreaking[2]	Reduction in Days of Excavation Program
Westmead	Station box	15	143	8%
Parramatta	Station box	20	56	7%
Clyde	Tunnel dive	15	71	0%
	Services facility shaft	20	18	44%
Silverwater	Services facility shaft	15	45	44%
Sydney Olympic Park	Station box	15	130	8%
North Strathfield	Northern end of cut and cover station box	15	42	38%
Burwood	Station box	15	159	8%
	Southern shaft	15	30	63%
Five Dock	Eastern shaft	15	37	62%
	Western shaft	15	155	45%
The Bays	Station box	20	41	0%

Note 1: Suitable controlled drill and blast depth based solely on depth to competent rock. In addition to this depth, the drill and blast area would also need to be sufficiently distant from nearby structures to meet cosmetic damage criteria (see **Section 3.6**).

Note 2: Rockbreaking would still be required for occasional trimming operations for excavation using controlled blasting. Trimming works are only estimated to be required for a relatively short duration and is not accounted for in **Table 23**.

4.2 Construction Ground-borne Noise and Vibration Assessment

Ground-borne noise and vibration impacts at receivers above the proposed tunnelling works or near to station excavation works have been predicted using a three-dimensional model which includes receiver elevation data and the shaft locations/tunnel alignment.

Vibration is discussed in terms of potential ground-borne vibration and ground-borne noise impacts. Ground-borne vibration refers to vibration impacting buildings from works 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

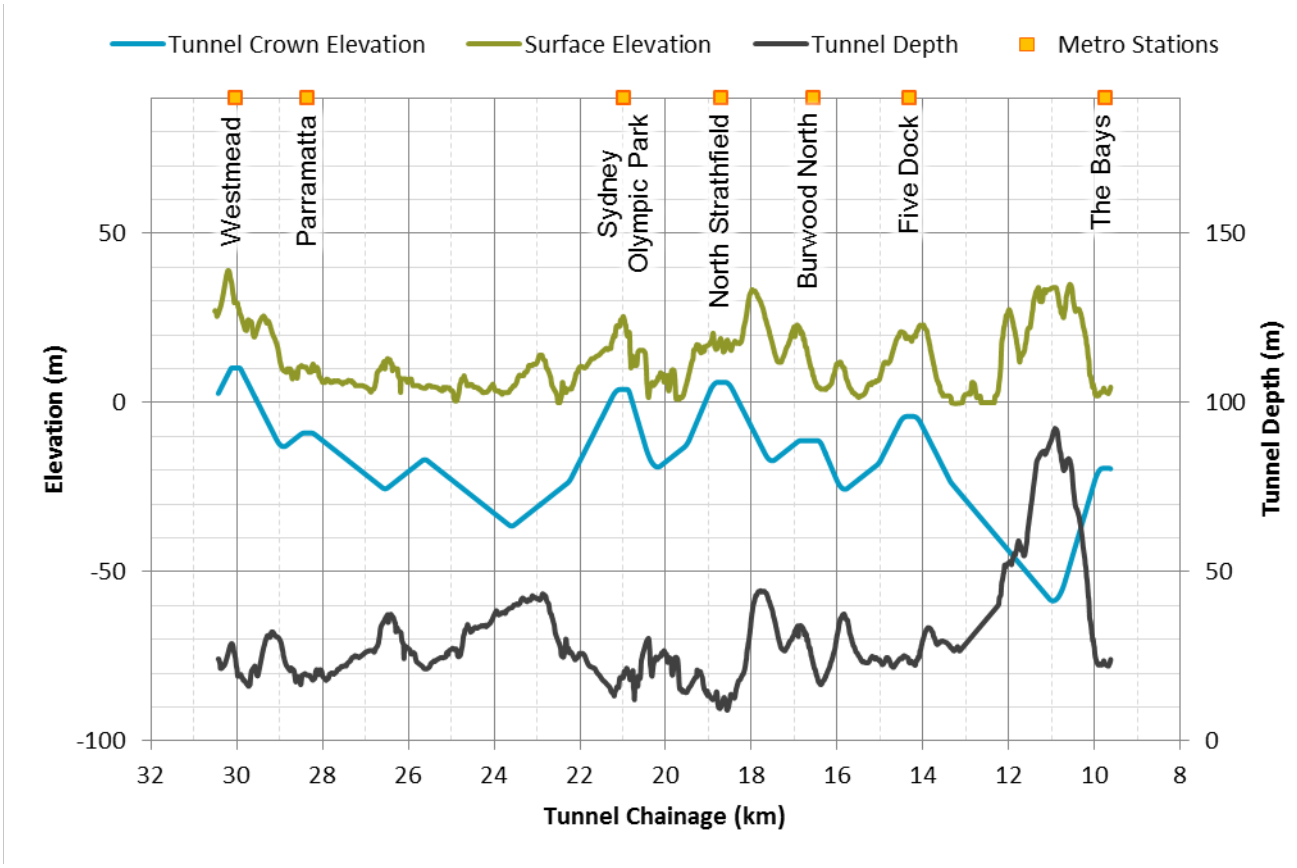
The main sources of vibration generating equipment are:

- Tunnel boring machines (TBMs), which excavate rock and construct the tunnel exterior structure
- Roadheaders (which scrape/grind rock) and rockbreakers which are used to excavate stations, station shafts and cross passages.

At this early stage, the location of cross passage has not been confirmed and the assessment conservatively assumes they could be located anywhere along the tunnel alignment. Excavation of each cross passage is expected to take around three weeks and is assumed to be completed using rockbreakers, which would result in the potential worst-case impacts.

The proposed tunnel depth is shown in **Figure 5**. The figure shows that the depth generally varies between 20 to 50 metres for most of the alignment. The shallowest parts are near to North Strathfield metro station and Sydney Olympic Park metro station, which are around 10 to 20 metres below the surface. The maximum tunnel depth is around 90 metres between Five Dock Station and The Bays Station where the tunnels pass beneath the Rozelle Interchange.

Figure 5 Proposed Tunnel Depth and Existing Ground Elevation



4.2.2 Modelling Approach

The prediction of ground-borne noise and vibration from underground construction sites is a complex and developing technical field. While much research has been undertaken into the various aspects, there is currently no universally accepted modelling approach.

The modelling has been carried out using a combination of theoretical and empirical relationships which use the 3D slant distance from the potentially affected receivers to the closest section of the tunnels or excavation works. The modelling also includes the following assumptions:

- The TBM is seven metres in diameter, has a double shield configuration and is in use for 25 to 50 percent of the assessment period (the rest of the time is spent assembling the tunnel lining and repositioning the TBM)
- The TBM would typically progress at a rate of between 20 to 50 metres per day
- Rockbreakers are 900 kilograms in size, have a 16 Hz drive frequency, are mounted to 12-22t tracked excavator and in use for 33 percent of the assessment period
- The in-tunnel work trains use rubber tyres (ie work trains have effective resilient mounts or wheels), resulting in minimal impacts
- Spoil would be transported from the TBM to the surface via conveyor
- Tunnelling would occur 24/7
- Large buildings with substantially greater mass than a typical residential house have conservatively been assumed to have no additional coupling loss
- A conservative crest factor of 3.0 has been used for rockbreakers and 3.5 for TBMs.

Predictions have been made to all sensitive receivers within a horizontal distance of around 150 metres of the tunnel alignment.

4.2.3 Source Levels versus Distance

The PPV and ground-borne noise levels used in the modelling are shown in **Figure 6** and **Figure 7** for TBMs and rockbreakers, respectively. Reference information sources are provided for comparison. The figures show that rockbreakers have higher levels in close proximity compared to the TBMs, but similar levels at larger distances.

Figure 6 Modelled Levels versus Distance for TBMs – Vibration (left), Ground-borne Noise (right)

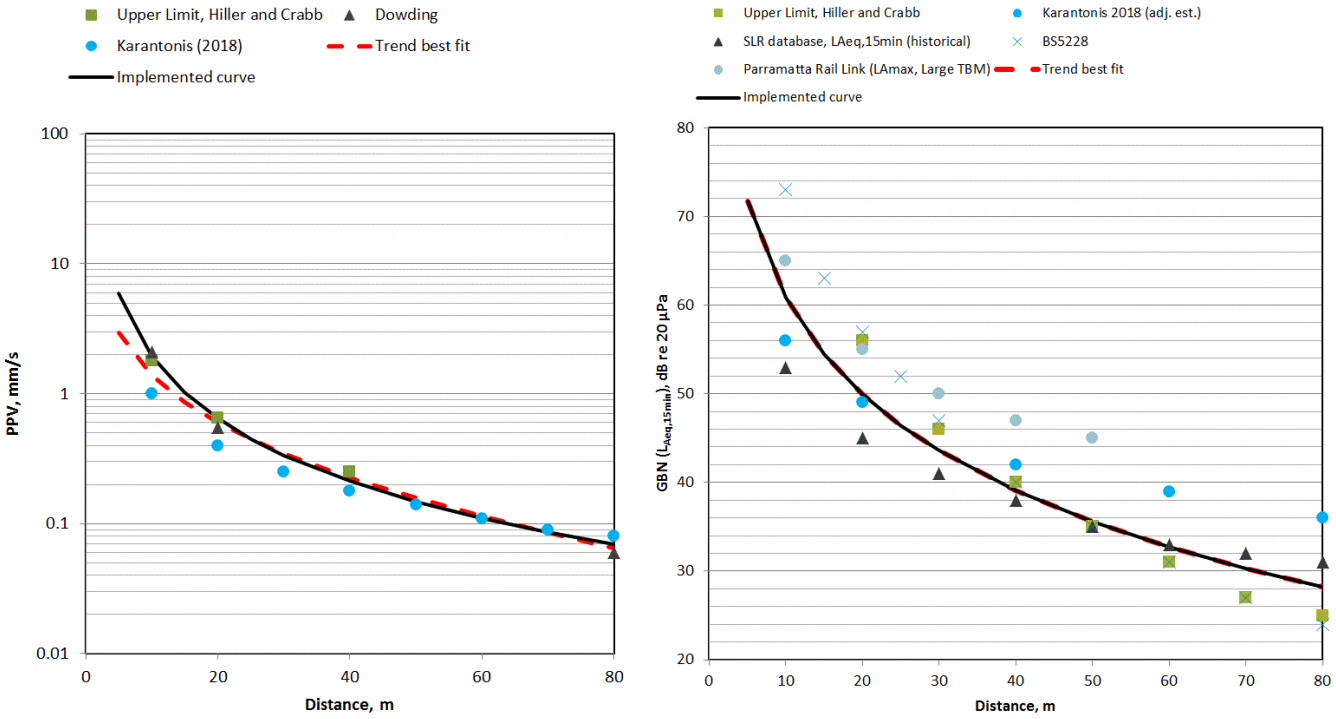
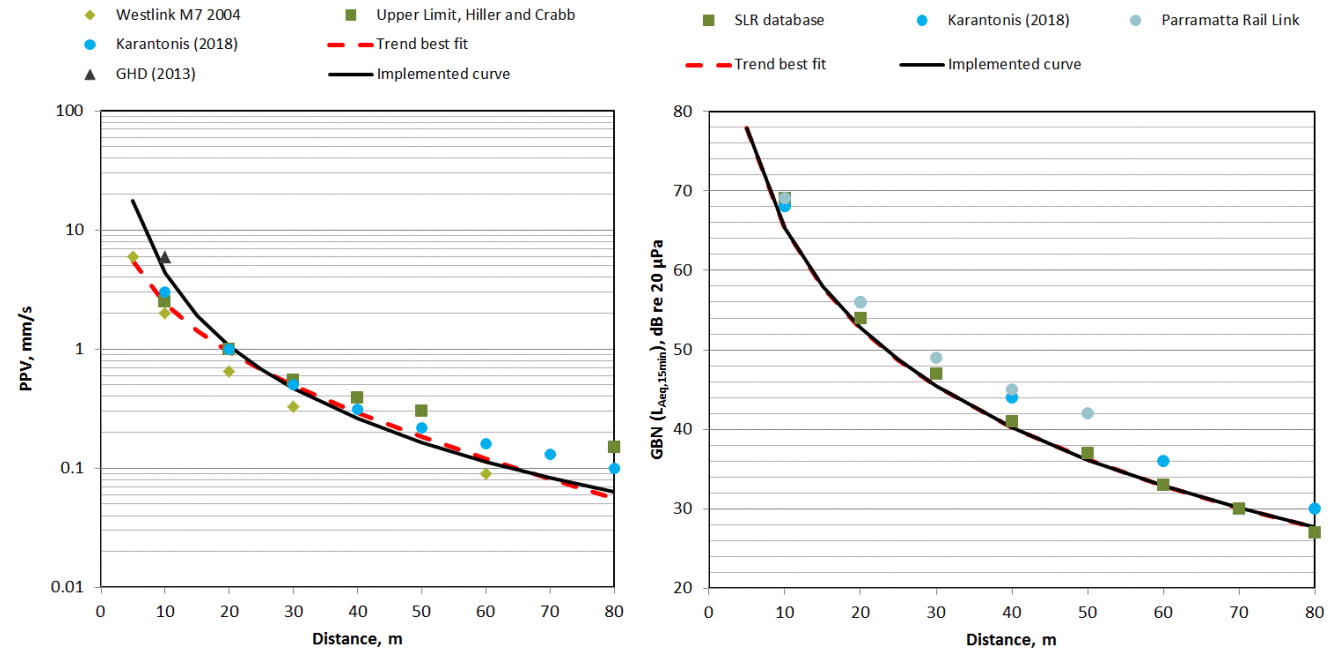


Figure 7 Modelled Levels versus Distance for Rockbreakers – Vibration (left), Ground-borne Noise (right)



4.3 Construction Traffic Noise Assessment

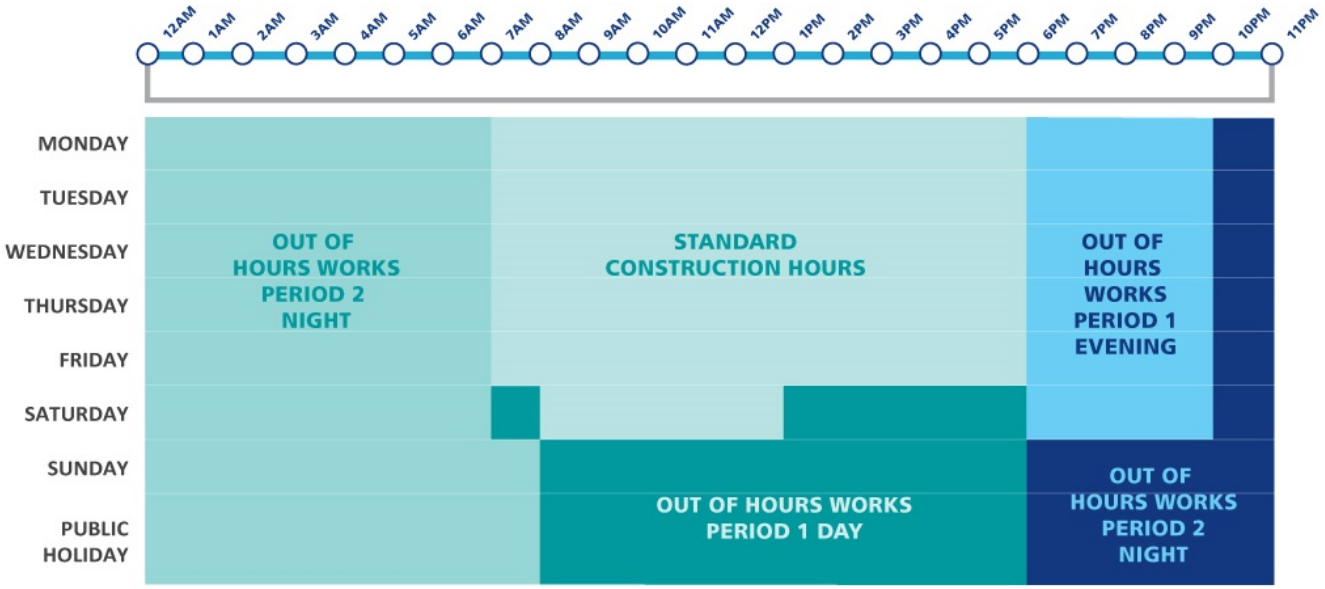
The potential impacts from construction traffic on public roads have been predicted using the Calculation of Road Traffic Noise (CORTN) algorithm.

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

4.4 Working Hours

Construction of Stage 1 would be carried out during Standard Construction Hours where practicable. Standard Construction Hours are defined in the ICNG and shown in **Table 24.**

Table 24 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 Wok' (OOHW) and can be divided into two periods of sensitivity. OOHW Period 1 is defined as Monday to Saturday 6:00 pm to 10:00 pm (evenings), Saturday 7: am to 8:00 pm and 1:00 pm to 10:00 pm (day and evening), and Sunday and public holidays 8:00 am to 6:00 pm (days). OOHW Period 2 is defined as Monday to Sunday 10:00 pm to 7:00 am (night-time) and public holidays 6:00 pm to 8:00 am (night-time).

Project specific constraints would require evening and night-time work at certain times. A summary of the proposed construction hours for Stage 1 is shown in **Table 25**.

As the TBMs operate continuously, tunnelling and associated support activities would need to be carried out on a 24/7 basis. The majority of the construction site activities would, however, be carried out during daytime hours including Standard Construction Hours and OOHW Period 1 Day.

Acoustic sheds (or other acoustic measures) would be constructed before evening and night-time works begin at all sites where noisy works are required outside of daytime hours and have the potential to impact nearby receivers.

Table 25 Proposed Construction Hours

Activity	Construction hours[1,2]	Comments or exceptions
Aboveground construction activities		
Enabling works	ICNG Standard Construction Hours and Daytime OOHW Period 1 at some sites	Noisy works restricted to Standard Construction Hours with the exception of Parramatta, Silverwater and The Bays construction sites (refer **Table 26**). Non-disruptive preparatory work, repairs or maintenance may be carried out on Saturday afternoons between 1:00 pm and 5:00 pm or Sundays between 8:00 am and 5:00 pm.
Piling		
Surface construction		
Clyde civil and earthworks		
Initial excavation		
TBM launch, support and extraction	24 hours per day, seven days per week	Restrictions would be in place during sensitive periods.
Concrete batching plant and segment production facility		
Construction traffic for material supply to and spoil removal from tunnelling and underground excavation (station and ancillary facility sites)		
Westmead intersection modifications		
Utility works		
Underground construction activities		
Controlled blasting	ICNG Standard Construction Hours	Drill and blast, if required, would be carried out during periods anticipated to have the least impact on receivers. This is expected to be during Standard Construction Hours for most sites.
Tunnelling works	24 hours per day, seven days per week	Activities that support tunnelling may need to occur 24 hours per day, up to seven days per week. Rockbreaking in the tunnel and cross passages between 10:00 pm and 7:00 am would not occur except where appropriate mitigation measures have been assessed and applied in accordance with the CNVS.
Underground excavation at station and ancillary sites		

Note 1: 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 2: Work outside of Standard Construction Hours is defined as 'Out-of-Hours Wok' (OOHW) and can be divided into two periods of sensitivity. OOHW Period 1 is Monday to Saturday 6:00 pm to 10:00 pm (evening), Saturday 7:00 am to 8:00 pm and 1:00 pm to 10:00 pm (day and evening), and Sunday and public holidays 8:00 am to 6:00 pm (day). OOHW Period 2 is Monday to Sunday 10:00 pm to 7:00 am (night-time) and public holidays 6:00 pm to 8:00 am (night-time).

Justification for Out of Hours Works

Justification for works that are required to be completed outside of Standard Construction Hours is provided in **Table 26**. Further detail on the approach to out of hours work is provided in the Sydney Metro CNVS.

Table 26 Works Outside of Standard Construction Hours

Activity	Justification for Out of Hours Activities
Tunnelling (including cross passages) and tunnelling support activities (including tunnel boring machine launch/retrieval and spoil handling).	Tunnelling and excavation works would define the overall Stage 1 duration. Earlier completion would bring considerable benefits to the community and would reduce the duration of construction related disruption. Other aspects of the justification for out of hours tunnelling and support operations include: • Need to install ground support systems immediately following excavation • Need to construct cross passages closely following the progress of the TBMs to provide a critical secondary egress for people to evacuate and access for emergency services in the event of an incident • Reducing peak demand on the electricity network • Need to handle the spoil produced by the 24/7 operation of the tunnel boring machines and the proposed out of hours transport of spoil.
Precast concrete segment production	The production of precast concrete tunnel segments is needed to support the construction of the tunnel following TBM excavation. The production facility needs to operate outside Standard Construction Hours to achieve the precast segment production rates required by 24/7 tunnelling.
Construction traffic for material supply to and spoil removal from tunnelling and underground excavation (station and ancillary facility sites)	Tunnelling and excavation works would require materials deliveries and the transport by road of substantial quantities of spoil. To avoid impacting the operation of the road network, construction vehicle movements during the AM and PM peak periods are to be minimised. Given the volumes of spoil and space constraints at construction sites, which limit the extent of on-site spoil storage, transport of materials and spoil cannot be limited to the hours between 10 am and 3 pm, meaning night-time vehicle movements are necessary.
Underground excavation at station and ancillary sites	For mined excavations, temporary support in the form of shotcrete, steel sets and rockbolts must be installed immediately to ensure stability of the works and to minimise any potential ground movement or settlement. Grouting is required to transfer load directly to the adjacent rock and needs to occur immediately after bolt installation for safety and quality reasons. Out of hours works would allow for the completion of the entire support system following excavation.
Intersection modifications at Westmead	These works would require lane closures and, in some cases, total closure of roads. Intersection modification works would, therefore, likely be required occur during the evening and night-time period when traffic volumes are lower to minimise disruption to local traffic.
Daytime Out-of-Hours Works	Enabling works, Pilling, Surface construction, and Initial excavation works are proposed during Saturday Daytime Out-of-Hours Works Period 1 at Parramatta, Silverwater and The Bays construction sites. Residential receivers are generally around 100 metres or further away from these construction sites and are screened from view by intervening non-residential buildings, meaning impacts would be low.

4.5 Works Schedule

Subject to planning approval, construction of Stage 1 is planned to commence in 2021, with completion expected in 2026. The total duration of Stage 1 construction works is expected to be around five years. The indicative construction program is shown in **Table 27**.

Table 27 Indicative Construction Program

Works Phase	Indicative Construction Program – Stage 1																							
	2021				2022				2023				2024				2025				2026			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Tunnelling																								
Westmead metro station to Sydney Olympic Park metro station												■	■	■	■	■	■	■	■	■	■			
The Bays Station to Sydney Olympic Park metro station							■	■	■	■	■	■	■	■										
Construction sites																								
Westmead metro station				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Parramatta metro station				■	■	■	■	■	■	■	■													
Clyde stabling and maintenance facility				■	■	■	■	■	■	■	■	■	■	■	■	■								
Silverwater services facility				■	■	■																		
Sydney Olympic Park metro station				■	■	■	■	■	■	■	■	■	■	■	■	■	■							
North Strathfield metro station					■	■	■	■	■	■														
Burwood North Station				■	■	■	■	■	■	■	■	■												
Five Dock Station				■	■	■	■	■	■	■	■													
The Bays Station			■	■	■	■	■	■	■	■	■	■	■	■										

4.6 Construction Mitigation Measures

The ICNG acknowledges that due to the nature of construction works 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 Included in Design

The Stage 1 construction works include a number of base-case mitigation measures to minimise the potential airborne noise impacts. These measures are included in the construction impact assessment in **Section 5** and are used prior to consideration of any 'additional mitigation measures'.

Table 28 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. On this basis, three metre high 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**. However, in practice the same noise outcome at the receivers could be achieved through a range of mitigation measures and potentially different barrier heights.
Acoustic sheds (or other acoustic measures)	Acoustic sheds have been assumed to be used for construction sites where station excavation would occur on a 24/7 basis in close proximity to sensitive receivers. Typically the sheds are designed to cover all excavation and spoil handling activities with the exception of The Bays Station construction site where spoil handling would be outside the acoustic shed. 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 E.** 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. Where opening the shed doors during the night-time is predicted to result in NML exceedances, a two-stage 'airlock' door may be required to provide additional mitigation. 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.
Acoustic panels	Where acoustic sheds are constructed over part of a cut and cover station, the remainder of the excavated pit would be covered by acoustic panels to minimise noise emissions. This assessment assumes that the panels would be consistent with those used in previous stages of Sydney Metro and would not allow a significant transfer of construction noise through the system.

4.6.2 Standard and Additional Mitigation Measures – Sydney Metro CNVS

The Sydney Metro CNVS 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 Stage 1 are outlined in **Section 8**.

4.7 Operational Road Traffic Noise Assessment

4.7.1 Key Operational Features of Project

Stage 1 has the potential to change operational road traffic noise impacts due to the following works:

- **Road upgrades at Westmead** – this includes realignment of Alexandra Avenue east of Hawkesbury Road to join the eastern end of Grand Avenue. Existing east-west traffic which current uses Alexandra Avenue (west of Hawkesbury Road) would be redistributed down Grand Avenue, which results in a functional class change of Grand Avenue from a local road to a collector road.
- **A new bridge at Clyde** – the new Clyde stabling and maintenance facility would be constructed on land to the south of Rosehill industrial estate. Access to the industrial estate from Parramatta Road is currently via Unwin Street, Kay Street and Wentworth Street. A new bridge would be constructed over the proposed stabling and maintenance facility to retain this access.

Neither of these changes would increase the traffic carrying capacity of the affected roads. The key features of the works are shown in **Figure 8**.

4.7.2 Noise Model

A noise model of the study area has been used to predict operational road traffic noise levels to the surrounding receivers. The model uses *Calculation of Road Traffic Noise* (CoRTN) (UK Department of Transport, 1988) algorithms in SoundPLAN software.

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

The '**No Build**' scenarios use the existing road alignment geometry, including existing structures and features within the road corridor.

The '**Build**' scenarios use the proposed road designs, which includes the proposed road reconfigurations.

Project and Non-Project Roads

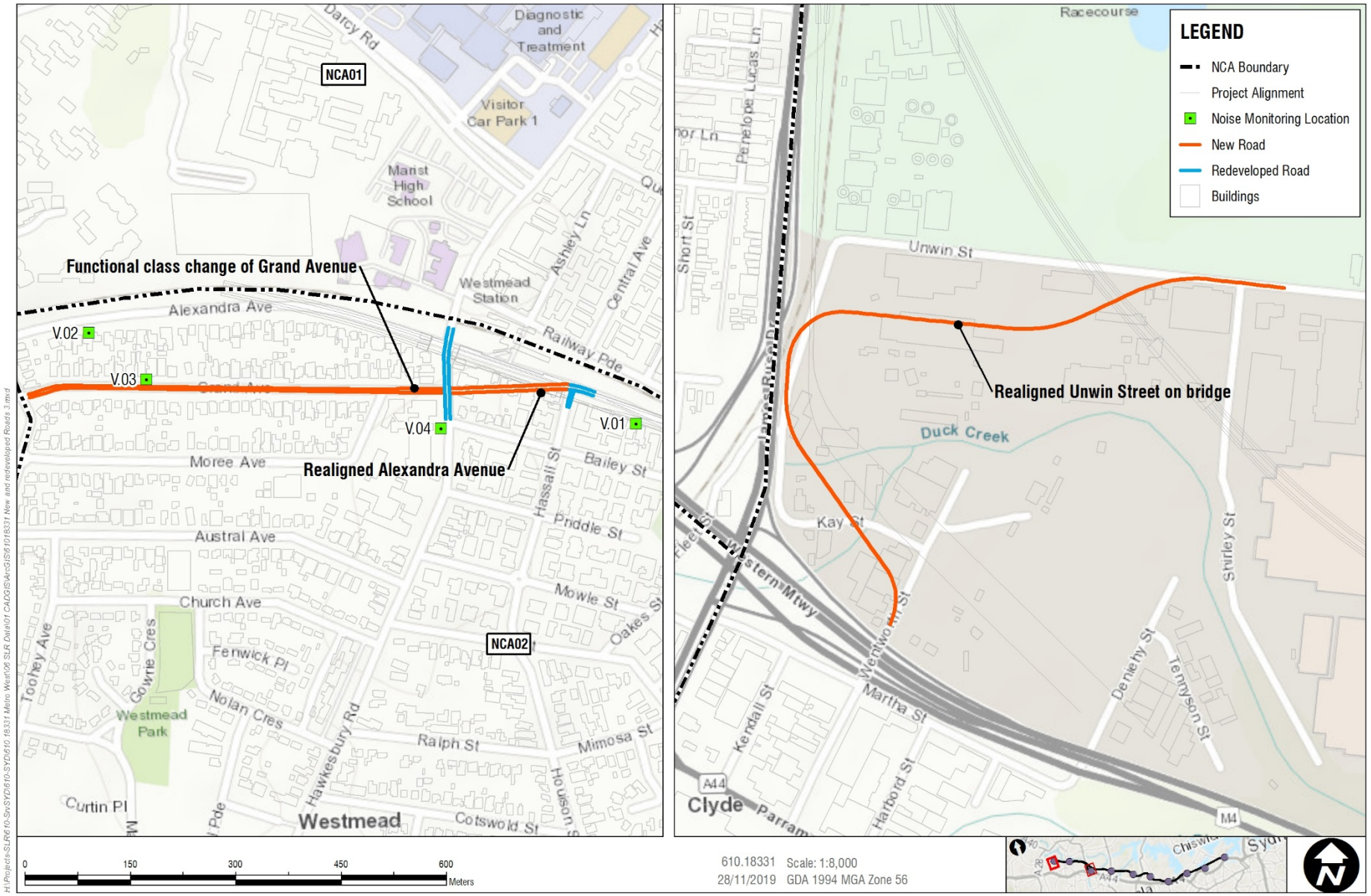
Roads where design or engineering changes are proposed are considered as 'project' roads. Existing roads with no works are considered 'non-project'.

All major roads in the study area have been modelled together with major roads on the surrounding road network to determine the contributions from 'project' and 'non-project' roads at individual receivers, as required by the NCG.

Road Types

The NCG classifies project roads as either 'new' or 'redeveloped'. The road classifications used in the assessment are shown in **Figure 8**.

Figure 8 Key Operational Road Traffic Features and Road Classification



Noise Modelling Parameters

Further details on the noise modelling parameters used in the assessment are provided in **Table 29**.

Table 29 Summary of Noise Model Inputs and Parameters

Input Parameter	Source of Data
Ground topography	The noise model includes a 'digital ground model' which is an accurate 3D representation of the terrain in the study area. The ground model was constructed from a combination of surveyed road corridor data and LIDAR point cloud data.
Buildings, receiver locations and floors	Buildings can provide screening to more distant locations of the study area. The buildings in the noise model were generated from a combination of aerial photography and site inspections, with heights derived from LIDAR data. The model predicts noise to every facade of every identified receiver in the assessment area.
Study area	The area extends 600 m from the project roads.
Assessment timeframes	The works would not result in a change to traffic volumes, so only the 'at-opening' year (2023) has been assessed.
Traffic volumes	Existing traffic volumes in Westmead were measured at the same time as the noise monitoring survey. This data was used to model the existing situation and validate the operational model. The forecast traffic volumes including the road reconfigurations were provided by the project team. Traffic volumes on some of the surrounding roads were taken from other projects, including WestConnex M4 Widening.
Vehicle speed	Existing vehicle speeds were measured during the noise monitoring survey and used to validate the noise model. Existing and future posted vehicle speeds were used in the operational assessment.
Source heights and source correction	Vehicles generally emit road traffic noise at four source heights. These are represented in the noise model by the following: • Cars (at 0.5 m height with a source correction of 0.0 dB) • Truck tyres (at 0.5 m height with a source correction of -5.4 dB) • Truck engines (at 1.5 m height with a source correction of -2.4 dB) • Truck exhausts (at 3.6 m height with a source correction of -8.5 dB).
Road surface corrections	The existing and proposed future road surface in the study area is Dense Grade Asphalt (DGA), which has a 0 dB surface correction factor.
Ground absorption	Noise levels at receivers can be influenced by the type of ground between the source of noise and the receiver. A ground absorption factor of 50% has been used in the noise model, as per the Roads and Maritime *Model Validation Guideline* specification for residential areas[1].
General corrections	The model also includes the following corrections to convert the noise model outputs to the appropriate assessment noise levels: • Facade reflections +2.5 dB[1] • L_{A10} to L_{Aeq} -3 dB[1]

Note 1: Taken from the Roads and Maritime *Model Validation Guideline.*

Noise Model Validation

To validate the operational road traffic noise model, the 2019 existing scenario at Westmead was modelled and compared to existing road traffic noise measurements in the study area (refer **Section 2.3.2**). The validation measurement sites are shown in **Figure 8**. A summary of the noise model validation is shown in **Table 30**.

Table 30 Comparison of Measured and Predicted Operational Road Traffic Noise Levels

Location	Noise Level (dBA)					
	Daytime LAeq(15hour)			Night-time LAeq(9hour)		
	Measured	Predicted	Difference	Measured	Predicted	Difference
V.01 – 1-7 Alexandra Avenue, Westmead	66.9	68.4	1.5	60.7	62.1	1.4
V.02 – 57 Alexandra Avenue, Westmead	61.5	62.9	1.4	57.3	57.2	-0.1
V.03 – 47 Grand Avenue, Westmead	53.0	55.2	2.2	48.6	48.6	0.0
V.04 – 150 Hawkesbury Road, Westmead	65.0	67.2	2.2	60.6	62.4	1.8
		Median	**1.9**		**Median**	**0.7**

The Roads and Maritime *Environmental Noise Management Manual* (ENMM) notes that *"it should be recognised that noise prediction modelling has some accuracy limitations and will commonly produce acceptable errors of around 2 dBA"*.

The above predictions show that the noise model is generally slightly conservative at the validation sites and the difference between the measured and predicted noise levels is within the anticipated random error at all locations. The results of the validation do not indicate calibration of the noise model is required. On this basis, the model is considered valid for predicting operational road traffic noise levels for the project.

4.7.3 Noise Mitigation

The Roads and Maritime *Noise Mitigation Guideline* (NMG) provides guidance in managing and controlling road traffic noise and describes the principles to be applied when reviewing noise mitigation. The NMG recognises that the NCG criteria are not always practicable and that it is not always feasible or reasonable to expect that they are achieved.

Site specific 'additional noise mitigation measures' are required to be investigated for receivers which have residual exceedances of the criteria. The NMG provides three triggers where a receiver may qualify for consideration of 'additional noise mitigation'. These are:

- **Trigger 1** – the predicted 'Build' noise level exceeds the NCG controlling criterion and the noise level increase due to the works (ie the noise predictions for the 'Build' minus the 'No Build') is greater than 2.0 dB
- **Trigger 2** – the predicted 'Build' noise level is 5 dB or more above the NCG controlling criterion (ie exceeds the cumulative limit) and the receiver is significantly influenced by project road noise, regardless of the incremental impact of the works
- **Trigger 3** – the noise level contribution from the road project is acute (daytime $L_{Aeq(15hour)}$ 65 dBA or higher, or night-time $L_{Aeq(9hour)}$ 60 dBA or higher) even if noise levels are controlled by a non-project road.

For receivers that qualify for consideration of 'additional noise mitigation', potential noise mitigation measures are to be considered in the following order of preference:

- At-source mitigation (i.e. quieter road pavement surfaces)
- In-corridor mitigation (i.e. noise mounds or noise barriers)
- At-receiver mitigation (i.e. at-property treatments).

4.7.4 Maximum Noise Levels

Maximum noise levels near roads are generally controlled by noise from trucks. Where new or redeveloped roads are located close to residential receivers there is potential for sleep disturbance impacts from altered maximum noise level events.

The potential for changes in maximum noise levels near to the proposed road reconfigurations has been evaluated at the potentially affected sensitive receivers.

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 31**. The likely subjective response of people affected by the impacts is also shown in the table, noting that the subjective response would vary and depends on the period in which the impacts occur (i.e. people are generally less sensitive to impacts during the daytime and more sensitive in the evening and night-time).

Table 31 Exceedance Bands and Corresponding Subjective Response to Impacts

Exceedance of Management Level	Likely Subjective Response	Impact Colouring
No exceedance	Negligible to low	
1 to 10 dB	Minor to marginal	
11 dB to 20 dB	Moderate	
>20 dB	High	

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 works and/or shielded from view would have substantially lower impacts. The assessment is generally considered 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 (including works at stations, the tunnel dive at Rosehill, services facilities, and the stabling and maintenance facility) is shown in **Table 32** 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 (i.e. 55 to 68 dBA), which represents the likely noise levels when works are 'near' to 'far' from a particular receiver, as explained in **Section 4.1.2**.

The noise levels presented in this report are based on a realistic worst-case assessment of each works 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 noise and vibration are summarised in **Section 5.1.2** and discussed in detail in the study area sections. Impacts from tunnelling are in **Section 5.3** and impacts from construction road traffic are in **Section 5.4**.

Table 32 Predicted Worst-Case Airborne Noise Impacts from Surface Construction Sites – All Works and All NCAs

Study area	NCA	NML	Predicted Worst-case $L_{Aeq(15minute)}$ Noise Level (dBA)																			
			Enabling works		Piling		Surface construction		Initial excavation / Excavation (without shed)			Excavation (with shed)		Mined cavern (with shed)		TBM launch/ retrieval/ support		Intersection modification		Civil and earthworks	
			'Typical'	'Peak'	'Typical'	'Peak'	'Typical'	'Peak'	'Typical'	'Peak'	'Peak'	'Typ.'	'Pk.'	'Typ.'	'Pk.'	'Typ.'	'Pk.'	'Typ.'	'Pk.'	'Typ.'	'Pk.'
			Supporting and loading or, Delivery of equipment	Demolition using a rockbreaker or, Assembly of site facilities	Supporting works	Bored piling with supporting plant	General works	Noise intensive works	Mucking out	Through soft soil/rock	Through rock using rockbreaker	Mucking out	Through rock using rockbreaker (doors closed)	Spoil removal	Mining with support	TBM support and spoil removal or, Deliveries and on/off loading	TBM assembly and launch/disassembly	Supporting works	Noise intensive works	Supporting works	Noise intensive works
Residential – Daytime																						
Westmead	NCA01	58	48 to 59	66 to 77	52 to 60	56 to 64	44 to 52	51 to 59	54 to 62	58 to 66	68 to 76	37	46	-	-	38	41	56	76	-	-
	NCA02	59	56 to 67	74 to 85	58 to 65	62 to 69	52 to 60	59 to 67	60 to 67	64 to 71	74 to 81	53	56	-	-	56	62	71	91	-	-
Parramatta	NCA03	68	44 to 55	62 to 73	48 to 55	52 to 59	40 to 49	47 to 56	50 to 57	54 to 61	64 to 71	-	-	-	-	-	-	-	-	-	-
Clyde	NCA04	61	* to 51	46 to 69	35 to 53	39 to 57	* to 45	* to 52	49 to 54	50 to 55	65 to 65	-	-	-	-	-	-	-	-	42	57
	NCA05	59	35 to 63	53 to 81	41 to 66	45 to 70	31 to 59	38 to 66	63 to 69	64 to 70	81 to 81	-	-	-	-	-	-	-	-	56	71
	NCA06	62	34 to 47	52 to 65	38 to 48	42 to 52	* to 42	36 to 49	50 to 51	51 to 52	59 to 59	-	-	-	-	-	-	-	-	39	54
	NCA07	56	34 to 50	52 to 68	37 to 51	41 to 55	30 to 46	37 to 53	50 to 52	51 to 53	57 to 57	-	-	-	-	-	-	-	-	43	58
Silverwater	NCA07	56	35 to 40	41 to 46	42 to 48	46 to 52	-	-	42 to 42	48 to 54	56 to 56	-	-	-	-	-	-	-	-	-	-
Olympic Park	NCA08	58	49 to 54	67 to 72	52 to 56	56 to 60	45 to 50	52 to 57	54 to 58	58 to 62	68 to 72	42	48	42	47	42	45	-	-	-	-
	NCA09	58	47 to 53	65 to 71	52 to 54	56 to 58	44 to 48	51 to 55	54 to 56	58 to 60	68 to 70	41	47	41	45	41	44	-	-	-	-
North Strathfield	NCA10	57	41 to 58	47 to 64	52 to 62	56 to 66	42 to 55	49 to 62	54 to 64	58 to 68	68 to 78	-	-	-	-	-	-	-	-	-	-
	NCA11	61	43 to 62	49 to 68	57 to 67	61 to 71	44 to 60	51 to 67	59 to 69	63 to 73	73 to 83	-	-	-	-	-	-	-	-	-	-
Burwood	NCA12	53	55 to 75	73 to 93	56 to 73	60 to 77	49 to 71	56 to 78	58 to 75	62 to 79	72 to 89	62	65	59	62	-	-	-	-	-	-
	NCA13	58	53 to 73	70 to 90	54 to 74	58 to 78	48 to 67	55 to 74	57 to 77	61 to 81	71 to 91	51	62	48	58	-	-	-	-	-	-
Five Dock	NCA14	52	49 to 68	67 to 86	50 to 67	54 to 71	44 to 62	51 to 69	53 to 70	57 to 74	67 to 84	41	54	40	50	-	-	-	-	-	-
	NCA15	53	61 to 75	78 to 92	63 to 74	67 to 78	57 to 70	63 to 76	66 to 77	69 to 80	79 to 90	51	57	51	54	-	-	-	-	-	-
The Bays	NCA20	61	43 to 51	61 to 69	48 to 51	52 to 55	39 to 47	46 to 54	50 to 53	54 to 57	64 to 67	44	48	-	-	38	45	-	-	-	-
	NCA21	53	44 to 55	62 to 73	49 to 51	53 to 55	40 to 50	47 to 57	51 to 53	55 to 57	65 to 67	51	54	-	-	46	50	-	-	-	-
	NCA22	58	32 to 42	50 to 60	39 to 44	43 to 48	* to 38	35 to 45	41 to 46	45 to 50	55 to 60	38	42	-	-	33	41	-	-	-	-

Note * Results marked with an asterisk (*) represent predicted noise levels of less than 30 dBA.

Legend

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

Study area	NCA	NML	Predicted Worst-case $L_{Aeq(15minute)}$ Noise Level (dBA)																			
			Enabling works		Piling		Surface construction		Initial excavation / Excavation (without shed)			Excavation (with shed)		Mined cavern (with shed)		TBM launch/ retrieval/ support		Intersection modification		Civil and earthworks	
			'Typical'	'Peak'	'Typical'	'Peak'	'Typical'	'Peak'	'Typical'	'Peak'	'Peak'	'Typ.'	'Pk.'	'Typ.'	'Pk.'	'Typ.'	'Pk.'	'Typ.'	'Pk.'	'Typ.'	'Pk.'
			Supporting and loading or, Delivery of equipment	Demolition using a rockbreaker or, Assembly of site facilities	Supporting works	Bored piling with supporting plant	General works	Noise intensive works	Mucking out	Through soft soil/rock	Through rock using rockbreaker	Mucking out	Through rock using rockbreaker (doors closed)	Spoil removal	Mining with support	TBM support and spoil removal or, Deliveries and on/off loading	TBM assembly and launch/disassembly	Supporting works	Noise intensive works	Supporting works	Noise intensive works
Residential – Night-time																						
Westmead	NCA01	46	-	-	-	-	-	-	-	-	-	37	46	-	-	38	41	56	76	-	-
	NCA02	42	-	-	-	-	-	-	-	-	-	53	56	-	-	56	62	71	91	-	-
Parramatta	NCA03	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clyde	NCA04	46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	42	-
	NCA05	49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	56	-
	NCA06	49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	39	-
	NCA07	46	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43	-
Silverwater	NCA07	46										-	-	-	-	-	-	-	-	-	-
Olympic Park	NCA08	51	-	-	-	-	-	-	-	-	-	42	48	42	47	42	45	-	-	-	-
	NCA09	46	-	-	-	-	-	-	-	-	-	41	47	41	45	41	44	-	-	-	-
North Strathfield	NCA10	49	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	NCA11	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Burwood	NCA12	47	-	-	-	-	-	-	-	-	-	42	54	42	47	-	-	-	-	-	-
	NCA13	49	-	-	-	-	-	-	-	-	-	49	62	47	58	-	-	-	-	-	-
Five Dock	NCA14	38	-	-	-	-	-	-	-	-	-	41	54	40	50	-	-	-	-	-	-
	NCA15	43	-	-	-	-	-	-	-	-	-	51	57	51	54	-	-	-	-	-	-
The Bays	NCA20	50	-	-	-	-	-	-	-	-	-	44	48	-	-	38	45	-	-	-	-
	NCA21	40	-	-	-	-	-	-	-	-	-	51	54	-	-	46	50	-	-	-	-
	NCA22	44	-	-	-	-	-	-	-	-	-	38	42	-	-	33	41	-	-	-	-

Note * Results marked with an asterisk (*) represent predicted noise levels of less than 30 dBA.

Legend

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

Study area	NCA	NML	Predicted Worst-case $L_{Aeq(15minute)}$ Noise Level (dBA)																	
			Enabling works		Piling		Surface construction		Initial excavation / Excavation (without shed)			Excavation (with shed)		Mined cavern (with shed)		TBM launch/ retrieval/ support		Intersection modification		Civil and earthworks	
			'Typical'	'Peak'	'Typical'	'Peak'	'Typical'	'Peak'	'Typical'	'Peak'	'Peak'	'Typ.'	'Pk.'	'Typ.'	'Pk.'	'Typ.'	'Pk.'	'Typ.'	'Pk.'	'Typ.'	'Pk.'
			Supporting and loading or, Delivery of equipment	Demolition using a rockbreaker or, Assembly of site facilities	Supporting works	Bored piling with supporting plant	General works	Noise intensive works	Mucking out	Through soft soil/rock	Through rock using rockbreaker	Mucking out	Through rock using rockbreaker (doors closed)	Spoil removal	Mining with support	TBM support and spoil removal or, Deliveries and on/off loading	TBM assembly and launch/disassembly	Supporting works	Noise intensive works	Supporting works	Noise intensive works
Commercial																						
Westmead	NCA01	70	43 to 53	61 to 71	45 to 56	49 to 60	39 to 48	46 to 55	47 to 58	51 to 62	61 to 72	34	46	-	-	31	37	56	76	-	-
	NCA02	70	39 to 51	57 to 69	40 to 52	44 to 56	34 to 45	41 to 52	42 to 54	46 to 58	56 to 68	36	41	-	-	38	41	56	76	-	-
Parramatta	NCA03	70	54 to 75	72 to 93	58 to 77	62 to 81	50 to 71	57 to 78	60 to 79	64 to 83	74 to 93	-	-	-	-	-	-	-	-	-	-
Clyde	NCA04	70	* to 40	38 to 58	30 to 40	34 to 44	* to 33	* to 40	42 to 45	43 to 46	56 to 56	-	-	-	-	-	-	-	-	30	45
	NCA05	70	34 to 55	52 to 73	39 to 54	43 to 58	* to 48	35 to 55	52 to 55	53 to 56	59 to 59	-	-	-	-	-	-	-	-	45	60
	NCA06	70	36 to 52	54 to 70	40 to 52	44 to 56	32 to 47	39 to 54	51 to 53	52 to 54	60 to 60	-	-	-	-	-	-	-	-	44	59
	NCA07	70	36 to 64	54 to 82	40 to 66	44 to 70	32 to 60	39 to 67	59 to 65	60 to 66	77 to 77	-	-	-	-	-	-	-	-	57	72
Silverwater	NCA07	70	64 to 71	70 to 77	72 to 79	76 to 83	-	-	82 to 82	78 to 85	88 to 88	-	-	-	-	-	-	-	-	-	-
Olympic Park	NCA08	70	53 to 69	71 to 87	57 to 68	61 to 72	49 to 65	56 to 72	59 to 70	63 to 74	73 to 84	57	62	57	60	57	60	-	-	-	-
	NCA09	70	* to 40	47 to 58	37 to 42	41 to 46	* to 35	32 to 42	39 to 44	43 to 48	53 to 58	*	36	*	33	*	*	-	-	-	-
North Strathfield	NCA10	70	49 to 64	55 to 70	57 to 68	61 to 72	49 to 61	56 to 68	59 to 70	63 to 74	73 to 84	-	-	-	-	-	-	-	-	-	-
	NCA11	70	48 to 64	54 to 70	59 to 71	63 to 75	48 to 64	55 to 71	61 to 73	65 to 77	75 to 87	-	-	-	-	-	-	-	-	-	-
Burwood	NCA12	70	45 to 60	63 to 78	48 to 59	52 to 63	41 to 52	48 to 59	50 to 61	54 to 65	64 to 75	45	49	42	46	-	-	-	-	-	-
	NCA13	70	53 to 63	70 to 80	54 to 62	58 to 66	48 to 58	55 to 65	57 to 65	61 to 69	71 to 79	49	55	45	51	-	-	-	-	-	-
Five Dock	NCA14	70	49 to 75	67 to 93	50 to 64	54 to 68	40 to 59	47 to 66	53 to 67	57 to 71	67 to 81	40	51	37	48	-	-	-	-	-	-
	NCA15	70	59 to 63	76 to 80	57 to 61	61 to 65	51 to 55	57 to 61	60 to 64	63 to 67	73 to 77	40	49	38	46	-	-	-	-	-	-
The Bays	NCA20	70	41 to 46	59 to 64	46 to 47	50 to 51	37 to 40	44 to 47	48 to 49	52 to 53	62 to 63	42	46	-	-	36	44	-	-	-	-
	NCA21	70	46 to 64	64 to 82	50 to 57	54 to 61	42 to 58	49 to 65	52 to 59	56 to 63	66 to 73	54	57	-	-	48	53	-	-	-	-
	NCA22	70	38 to 47	56 to 65	43 to 48	47 to 52	33 to 42	40 to 49	45 to 50	49 to 54	59 to 64	41	45	-	-	36	43	-	-	-	-

Note * Results marked with an asterisk (*) represent predicted noise levels of less than 30 dBA.

Legend

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

The above assessment shows that:

- The airborne noise impacts from Stage 1 construction sites vary across the study area depending on the proximity of the nearest receivers. Where receivers are close to construction sites, 'high' worst-case impacts are likely at times during noisy works.
- The highest impacts are predicted at the Westmead metro station, Clyde stabling and maintenance facility, North Strathfield metro station, Burwood North Station and Five Dock Station construction sites, which is due to sensitive receivers being adjacent to the boundaries of these sites. Receivers in the other study areas are generally further away or less sensitive to construction noise resulting in lower impacts.
- The highest impacts are predicted for Enabling works and Initial excavation/Excavation without shed which occur prior to the acoustic shed(s) being constructed or at sites without sheds. These works are, however, limited to daytime hours and would not occur during the evening or night-time. 'High' impacts are also predicted during Intersection modification works in Westmead.
- Worst-case noise levels in study areas with close receivers are predicted to be around 80 to 90 dBA. Worst-case noise levels in study areas with distant receivers are around 50 to 70 dBA.
- The highest impacts are seen in the 'Peak' scenarios, which require the use of noise intensive equipment such as rockbreakers. For most scenarios, the 'Peak' works would, however, only be required for a relatively short period of the total duration. Noise levels and impacts during 'Typical' works which do not require noise intensive equipment are considerably lower.
- Individual receivers would be subject to a range of worst-case impacts, depending on how far from the works they are. The highest impacts are seen when works are 'near' to receivers and are generally much lower when works are 'far', due to the increased separation distance.
- Construction works during Enabling works, Piling, Surface construction, Initial excavation and Excavation without shed are required to move around the various construction sites and a large variation in worst-case noise levels of around 10 dB to 20 dB is predicted during these activities. The impacts when works are 'near' to a particular receiver are likely to be 'moderate' or 'high' for the nearest receivers in most study areas, but when works are 'far' the impacts are substantially lower with many catchments predicted to be compliant with the management levels or result in only 'minor' worst-case impacts.
- 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 be compliant during many of the less noisy works. The worst-case daytime impacts are typically associated with noise intensive equipment such as rockbreakers.
- At residential receivers during the night-time, 'high' worst-case impacts are predicted in the Westmead study area, with 'moderate' impacts in Burwood, Five Dock and The Bays study areas. The highest impacts are in the 'Peak' scenarios, which use noise intensive equipment such as rockbreakers. 'Typical' scenarios generally result in 'minor' or compliant noise levels in most study areas. The worst-case night-time impacts are associated with:
    - *Excavation* – (Peak) *Through rock using rockbreaker (doors closed)*
    - *Mined Cavern* – (Peak) *Mining with support*
    - *Intersection Modification* – (Peak) *Noise intensive works*, which is only required in Westmead.
- The impacts at commercial receivers are mostly predicted to be compliant with the management levels. Impacts during noisy works are predicted in study areas with close commercial receivers, however, the number of affected receivers in these study areas is relatively small.

5.1.2 Overview of Ground-borne Noise and Vibration Impacts from Construction Sites

Ground-borne noise and vibration impacts can occur when vibration intensive equipment, such as a rockbreaker, is being used at the construction sites. The predicted ground-borne noise and vibration impacts in each NCA during station excavation works are shown in **Table 33** for all receiver types.

The assessment presents the predicted ground-borne noise levels at receivers surrounding the various construction sites during station shaft or ancillary facility shaft excavation works. The predictions represent the likely highest noise level inside sensitive receivers when excavation works using rockbreakers are being completed near surface level.

The predicted construction vibration impacts are assessed against the applicable human comfort, cosmetic damage and sensitive equipment criteria, with the number of criteria exceedances presented. 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.

Table 33 Overview of Ground-borne and Vibration Exceedances – All Receiver Types

Study area	NCA	Number of Receivers												
		Total	With Ground-borne NML Exceedance[1,2]									With Vibration Criteria Exceedance[3]		
			Excavation of Station Shafts / Ancillary Facility Shafts									All Vibration Intensive Works (w. rockbreaker)		
			Daytime			Evening			Night-time			Cosmetic Damage	Human Comfort		Sensitive Equipment
			1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	Day / Night	Day	Night	Day / Night
Westmead	NCA01	340	1	-	-	-	-	-	-	-	-	-	-	-	-
	NCA02	806	2	-	-	4	-	-	3	2	-	-	1	1	-
Parramatta[2]	NCA03	509	3	3	2	-	-	-	-	-	-	9	11	-	2
Clyde[2]	NCA04	392	-	-	-	-	-	-	-	-	-	-	-	-	-
	NCA05	477	-	-	-	-	-	-	-	-	-	-	-	-	-
	NCA06	207	-	-	-	-	-	-	-	-	-	-	-	-	-
	NCA07	553	-	-	-	-	-	-	-	-	-	5	1	-	-
Silverwater[2]	NCA07	1,389	1	-	-	-	-	-	-	-	-	1	2	-	-
Olympic Park	NCA08	95	1	-	-	-	-	-	-	-	-	2	4	-	-
	NCA09	32	-	-	-	-	-	-	-	-	-	-	-	-	-
North Strathfield[2]	NCA10	614	-	-	-	-	-	-	-	-	-	-	-	-	-
	NCA11	1,280	11	-	-	-	-	-	-	-	-	-	17	1	-
Burwood	NCA12	1,200	5	1	1	10	2	1	9	4	2	3	9	5	-
	NCA13	957	3	1	-	3	1	-	4	3	-	4	5	3	1
Five Dock	NCA14	1,242	7	1	-	5	2	-	3	6	-	2	8	5	-
	NCA15	966	5	1	1	6	2	1	4	3	1	4	12	4	-
The Bays	NCA20	873	-	-	-	-	-	-	-	-	-	-	-	-	-
	NCA21	844	-	-	-	-	-	-	-	-	-	3	4	-	-
	NCA22	46	-	-	-	-	-	-	-	-	-	-	-	-	-

Note 1: Based on worst-case predicted noise levels.
Note 2: Noise levels from construction sites without acoustic sheds would likely be airborne noise dominant for most receivers.
Note 3: Based on worst-case predicted vibration levels.

The above assessment shows that:

Ground-borne noise

- The worst-case predicted ground-borne noise impacts during station shaft excavation are generally compliant with the NMLs or result in only 'minor' impacts for most receivers.
- 'Moderate' or 'high' impacts are, however, predicted in the Westmead, Parramatta, Burwood and Five Dock study areas, due to sensitive receivers being near the excavation works in these locations. In the Parramatta study area, these impacts are generally at commercial and 'other sensitive' receivers, whereas in the other study areas the impacts are mostly at residential receivers.
- During the night-time, the number of 'moderate' and 'high' impacts increases due to lower (i.e. more stringent) residential ground-borne NMLs.
- The worst-case night-time impacts are predicted to be 'high' at residential receivers within around 20 metres of the station shaft excavation works.
- The ground-borne noise predictions are based on the nearest sensitive receivers and most exposed floor. The ground-borne noise impacts would reduce for sensitive receivers which are further away from the works or for receivers higher up in multistorey buildings.
- As the excavation works progress underground, ground-borne noise impacts would also be expected to reduce.

Ground-borne Vibration

- Exceedances of the cosmetic damage screening criteria are predicted in Parramatta, Clyde, Silverwater, Burwood, Five Dock and The Bays, due to vibration sensitive structures being adjacent to the boundary of these sites.
- Exceedances of the human comfort criteria are also predicted in all study areas as sensitive receivers are relatively close to the boundary of all construction sites.
- During the night-time, there are fewer human comfort exceedances in study areas with nearby residential receivers due to vibration intensive works being restricted to shaft excavation areas which are further away from sensitive receiver buildings than some of the works completed during the daytime.
- The construction activity with the greatest potential for vibration impacts is *Enabling works – Demolition using a rockbreaker* as this scenario requires the use of a rockbreaker in relatively close proximity to some of the structures surrounding the various construction sites.
- Exceedances of the sensitive equipment screening criteria are predicted in Parramatta and in Burwood where receivers have been identified as potentially having vibration sensitive equipment with a VC-A criterion. Exceedances of the sensitive equipment screening criteria are predicted at:
    - SunDoctors Skin Cancer Clinic, Parramatta
    - Orthodontics Sydney Wide, Parramatta
    - Central Sydney ENT, Burwood.

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 Stage 1 construction sites in each study area. The predictions are representative of the highest impacts when the works are at their closest to sensitive receivers.

The predicted noise levels in **Section 5.1.1** indicate that when works are 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 at the most affected receivers.

5.2.1 Westmead Study Area (NCA01 – NCA02)

The Westmead study area is centred on the Westmead metro station construction site. This study area contains two Noise Catchments Areas (NCA01 and NCA02) which are to the north and south of the existing Westmead Station.

The construction site is located to the south of the existing Westmead Station and is bound by Hawkesbury Road to the west, Hassall Street to the east and Baily Street to the south.

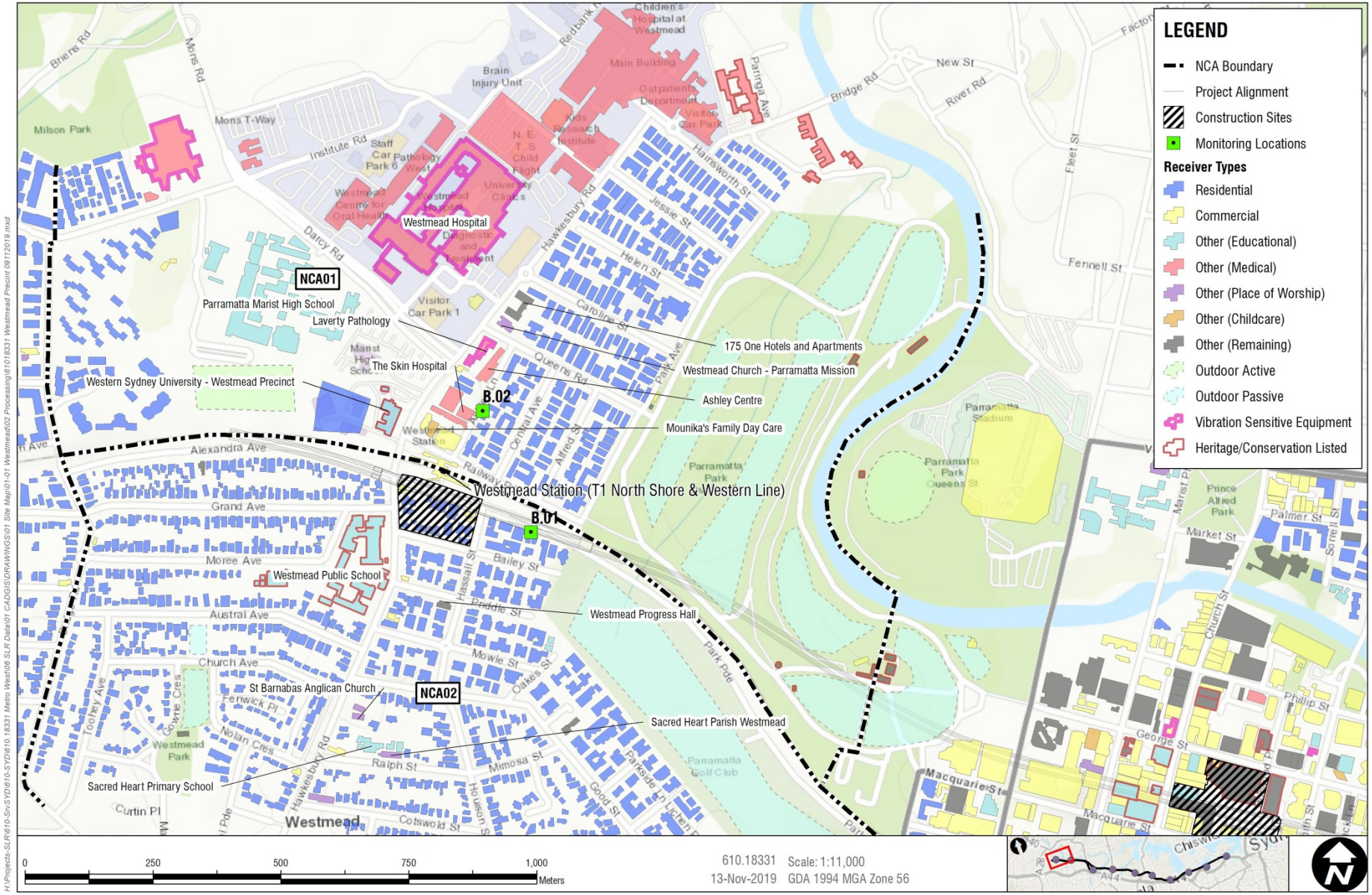
Existing noise levels in this study area are generally controlled by transportation noise from the surrounding road network and existing rail line. The area surrounding the construction site is generally suburban and the nearest receivers are residential.

The NCAs in the Westmead study area are described below and a map is shown in **Figure 9**.

NCA01 and NCA02

- The nearest receivers are residential properties which surround the site to the west, east and south on Hawkesbury Road, Hassall Street and Baily Street respectively.
- A number of educational facilities are located relatively close to site, including Westmead Public School which is around 30 metres to the south-west, across Hawkesbury Road. Western Sydney University – Westmead and Parramatta Marist High School are further to the north-west.
- An area of commercial receivers is to the north of the existing Westmead Station, which includes 'other sensitive' receivers such as Mounika's Family Day care and a number of medical facilities adjacent to Hawkesbury Road.
- The Westmead Medical Precinct, which includes Westmead Hospital and various other medical institutes, is located around 400 metres to the north of the site.

Figure 9 Site Map, Works and Sensitive Receivers



5.2.1.2 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 34**. The estimated duration of each activity is also provided, noting that most activities would be intermittent during this period and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

This site is proposed to be used as a TBM launch and support site. The main excavation works at this construction site would be completed in an acoustic shed. Modifications to the various road intersections surrounding the site would also be required. The turnback cavern at Westmead is assessed as part of the tunnelling assessment in **Section 5.3**.

The Stage 1 works in this study area are anticipated to have a total duration of approximately five years.

5.2.1.3 Airborne Noise Impacts from Construction Sites

Number of NML Exceedances

The predicted airborne noise impacts from construction site works in this study area are summarised in **Table 35**, **Table 36** and **Table 37** 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 when the works are at their closest.

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 34 Surface construction Activities and Period of Works

Scenario	Activity		Total Indicative Duration (Weeks)[3]	Maximum Number of Working Faces	Hours of Works[1,2]				Comments
					Std. Day	Out-of-Hours Works			
						Day OOH	Eve	Night	
Enabling works	'Typical'	Supporting and loading	15	1	✓	-	-	-	-
	'Peak'	Demolition using a rockbreaker	15	2	✓	-	-	-	Rockbreaking works would only occur intermittently during a 15 week period between 7am – 6pm. Total duration of rockbreaking works would be approximately 10 days.
Piling	'Typical'	Supporting works	36	2	✓	-	-	-	-
	'Peak'	Bored piling with support plant	36	4	✓	-	-	-	Piling works would only occur intermittently during a six week period between 7am – 6pm. Up to four piling rigs would be active at the same time.
Surface construction	'Typical'	General works	12	1	✓	-	-	-	-
	'Peak'	Noise intensive works	12	2	✓	-	-	-	-
Initial excavation	'Typical'	Mucking out	8	1	✓	-	-	-	-
	'Peak'	Through soft soil/rock	4	2	✓	-	-	-	Excavation through soil and soft rock using excavator ripper attachment, before construction of the acoustic shed.
		Through rock using rockbreaker	4	2	✓	-	-	-	Excavation through rock using rockbreaker, before construction of the acoustic shed. Works restricted to daytime hours only.
Excavation with shed	'Typical'	Mucking out	23	1	✓	✓	✓	✓	Out of hours works would only occur once the acoustic shed and acoustic panels (where appropriate) have been installed.
	'Peak'	Through rock using rockbreaker	23	2	✓	✓	✓	✓	
TBM launch and support	'Typical'	TBM support and spoil removal	78	1	✓	✓	✓	✓	The majority of works would be completed in the acoustic shed. Loading of TBM components and other less noisy works would occasionally occur outside the shed.
	'Peak'	TBM assembly and launch	2	1	✓	✓	✓	✓	
Intersection modifications	'Typical'	Supporting works	2	1	✓	✓	✓	✓	
	'Peak'	Noise intensive works	2	1	✓	✓	✓	✓	

Note 1: Noise intensive works outside of Standard Construction Hours would only be undertaken within the acoustic shed.

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

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

Table 35 Overview of NML Exceedances – All Receiver Types

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Supporting and loading	15	941	-	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	15	941	12	141	31	10	-	-	-	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	36	941	-	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	36	941	-	26	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	12	941	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	12	941	-	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial excavation	'Typical'	Mucking out	8	941	-	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	4	941	-	34	3	-	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	4	941	10	151	34	3	-	-	-	-	-	-	-	-	-	-	-	-
Excavation with shed	'Typical'	Mucking out (Doors Closed)	23	941	-	-	-	-	-	-	-	1	-	-	12	1	-	38	10	2
	'Peak'	Through rock using rockbreaker (Doors Closed)	23	941	-	-	-	-	2	-	-	3	-	-	22	3	-	38	10	2
		Through rock using rockbreaker (Doors Open)	23	941	-	8	-	-	14	1	-	16	1	-	63	16	1	39	10	2
TBM launch and support	'Typical'	TBM support and spoil removal	78	941	-	-	-	-	2	-	-	2	-	-	14	2	-	38	10	2
	'Peak'	TBM assembly and launch	2	941	-	3	-	-	7	-	-	11	-	-	48	11	-	38	10	2
Intersection modifications	'Typical'	Supporting works	2	941	-	14	6	-	20	9	-	24	10	-	68	22	10	51	12	7
	'Peak'	Noise intensive works	2	941	24	164	39	20	347	85	29	415	99	34	351	376	100	449	89	43

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

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

Table 36 Overview of NML Exceedances – Residential Receivers

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Supporting and loading	15	854	-	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	15	854	12	130	27	8	-	-	-	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	36	854	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	36	854	-	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	12	854	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	12	854	-	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial excavation	'Typical'	Mucking out	8	854	-	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	4	854	-	30	1	-	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	4	854	10	136	30	1	-	-	-	-	-	-	-	-	-	-	-	-
Excavation with shed	'Typical'	Mucking out (Doors Closed)	23	854	-	-	-	-	-	-	-	1	-	-	12	1	-	38	10	2
	'Peak'	Through rock using rockbreaker (Doors Closed)	23	854	-	-	-	-	2	-	-	3	-	-	22	3	-	38	10	2
		Through rock using rockbreaker (Doors Open)	23	854	-	7	-	-	13	1	-	16	1	-	63	16	1	39	10	2
TBM launch and support	'Typical'	TBM support and spoil removal	78	854	-	-	-	-	2	-	-	2	-	-	14	2	-	38	10	2
	'Peak'	TBM assembly and launch	2	854	-	2	-	-	6	-	-	11	-	-	48	11	-	38	10	2
Intersection modifications	'Typical'	Supporting works	2	854	-	10	5	-	16	8	-	24	10	-	68	22	10	51	12	7
	'Peak'	Noise intensive works	2	854	24	146	37	15	329	83	24	406	98	34	347	376	100	449	89	43

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

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

Table 37 Overview of Commercial and Other Sensitive Receiver NML Exceedances

Scenario	Activity		No. Weeks[1]	Number of Receivers																								
				Commercial			Child Care			Educational			Public Building			Place of Worship			Passive Recreation			Medical (Daytime)			Medical (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	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
Enabling works	'Typical'	Supporting and loading	15	-	-	-	1	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	15	1	-	-	-	-	1	3	4	1	1	-	-	2	-	-	1	-	-	3	-	-	-	-	-	-
Piling	'Typical'	Supporting works	36	-	-	-	1	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	36	-	-	-	-	1	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	12	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	12	-	-	-	1	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial excavation	'Typical'	Mucking out	8	-	-	-	1	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	4	-	-	-	-	1	-	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	4	1	-	-	-	-	1	6	4	1	2	-	-	2	-	-	1	-	-	3	-	-	-	-	-	-
Excavation with shed	'Typical'	Mucking out (Doors Closed)	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through rock using rockbreaker (Doors Closed)	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker (Doors Open)	23	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TBM launch and support	'Typical'	TBM support and spoil removal	78	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	TBM assembly and launch	2	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Intersection modifications	'Typical'	Supporting works	2	-	-	-	1	-	-	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	2	4	-	-	-	-	1	5	1	4	-	1	-	4	-	-	1	-	-	4	-	-	4	-	-	-

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

The above shows the following:

- The Stage 1 construction works are predicted to result in 'high' worst-case noise impacts at the nearest receivers during higher noise generating activities. The nearest receivers to the site are generally residential and educational buildings. Some of the worst-case impacts are predicted during *Enabling works* and *Initial excavation* which would occur before the acoustic shed is constructed. These works are, however, limited to Standard Construction Hours and would not occur during the evening or night-time.
- The highest impacts are during 'Peak' scenarios which use noise intensive equipment such as rockbreakers. Rockbreakers would, however, only be used outdoors intermittently and the duration is around 10 days during *Enabling works* and four weeks during *Initial excavation* works. When noise intensive equipment is not in use during 'Typical' works, the worst-case impacts are predicted to generally be reduced to 'minor' or 'moderate' at the nearest receivers.
- *Piling* and *Surface construction* works generate less noise and the worst-case impacts at the nearest receivers are predicted to be 'minor'. These works would also be completed during Standard Construction Hours, prior to the acoustic shed being built.
- Noise intensive works outside of Standard Construction Hours would only be completed in the acoustic shed once it is built (except for *Intersection modification* works). The worst-case impacts from works in the shed during the night-time are generally predicted to be 'minor' or 'moderate' during *Excavation with shed* when rockbreakers are in use and the shed doors are closed. When rockbreakers are in use and the doors are open the impacts are increased for receivers near to the doors of the shed.
- 'High' impacts are also predicted during *Intersection modifications* which are required on certain roads surrounding the construction site. These works are required during all periods, including some works during the evening and night-time period, however, they are only expected to last for two weeks.
- Works requiring noise intensive equipment outside of the acoustic shed are predicted to result in Highly Noise Affected impacts at the nearest residential receivers.
- 'High' sleep disturbance impacts are also predicted for the nearest residential receivers. These impacts result from occasional high noise levels from heavy vehicle movements around the outdoor areas of the site.

Impacts during Standard Construction Hours

The worst-case impacts during Standard Construction Hours are predicted when noise intensive works occur before construction of the acoustic shed. The predicted worst-case daytime impacts in this study area are shown in:

- **Figure 10** – All outdoor construction site works, including rockbreakers
- **Figure 11** – All outdoor construction site works, not including rockbreakers
- **Figure 12** – Works involving rockbreakers within the acoustic shed (Doors Closed)
- **Figure 13** – *Intersection modifications*, including rockbreakers.

The highest impact works are expected to last for:

- *Enabling works – Demolition using a rockbreaker* – 10 days (actual rockbreaker use)
- *Initial excavation – Through rock using rockbreaker* – four weeks
- *Intersection modifications – Noise intensive works* – two weeks.

Figure 10 Worst-case Daytime Airborne Noise Impacts – All Outdoor Construction Site Works, including Rockbreakers

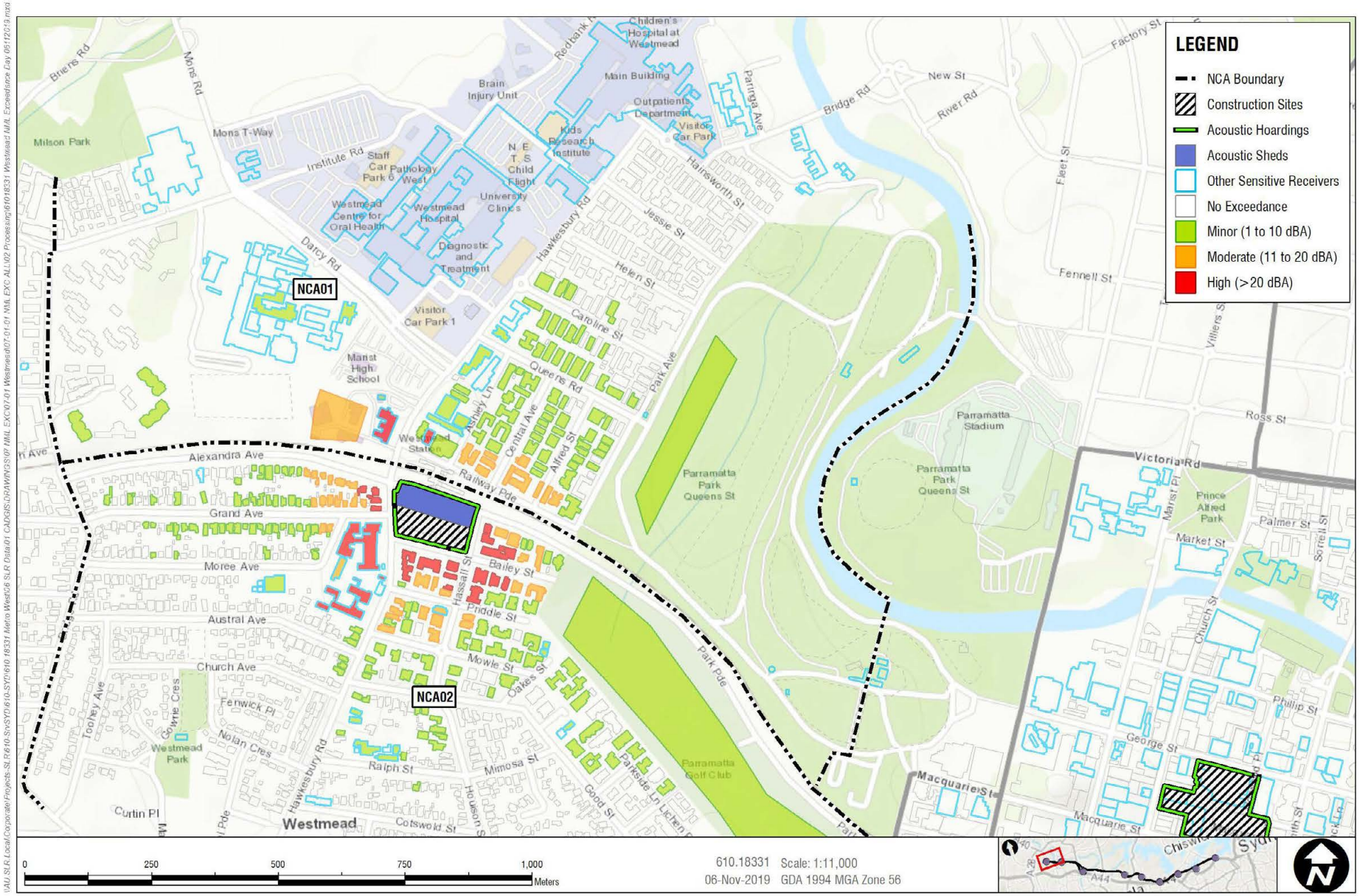


Figure 11 Worst-case Daytime Airborne Noise Impacts – All Outdoor Construction Site Works, not including Rockbreakers

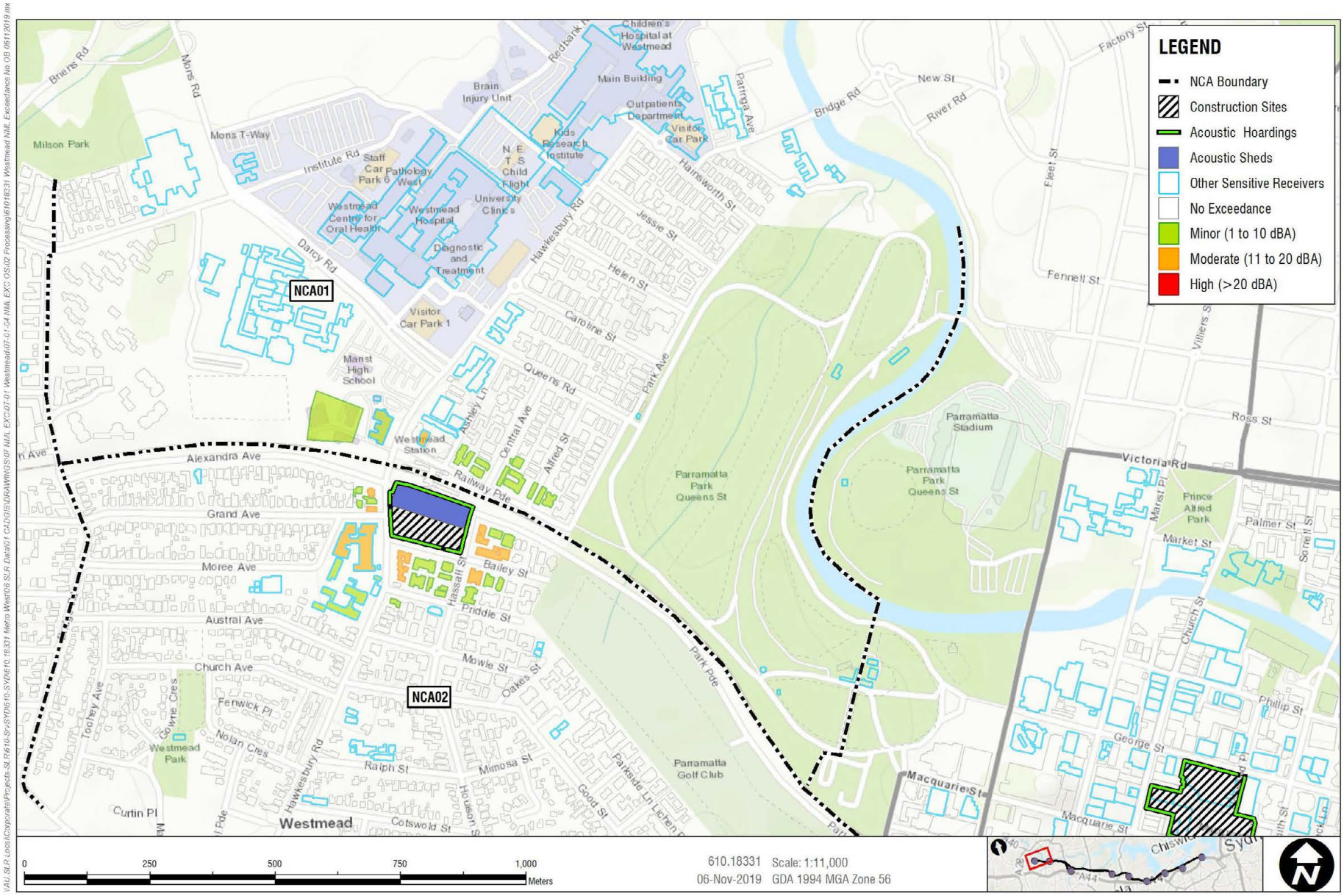


Figure 12 Worst-case Daytime Airborne Noise Impacts – Works involving rockbreakers within the Acoustic Shed (Doors Closed)

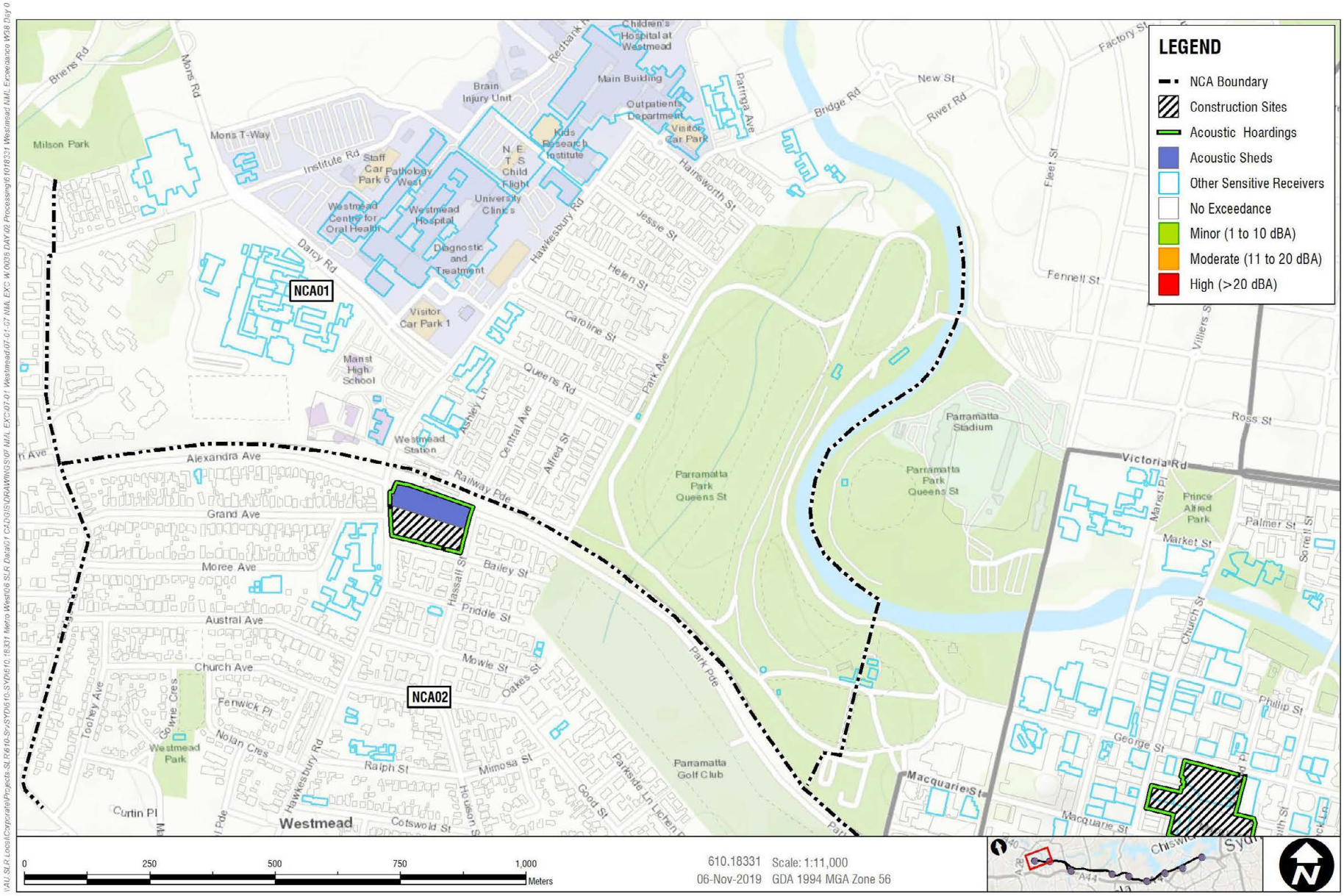
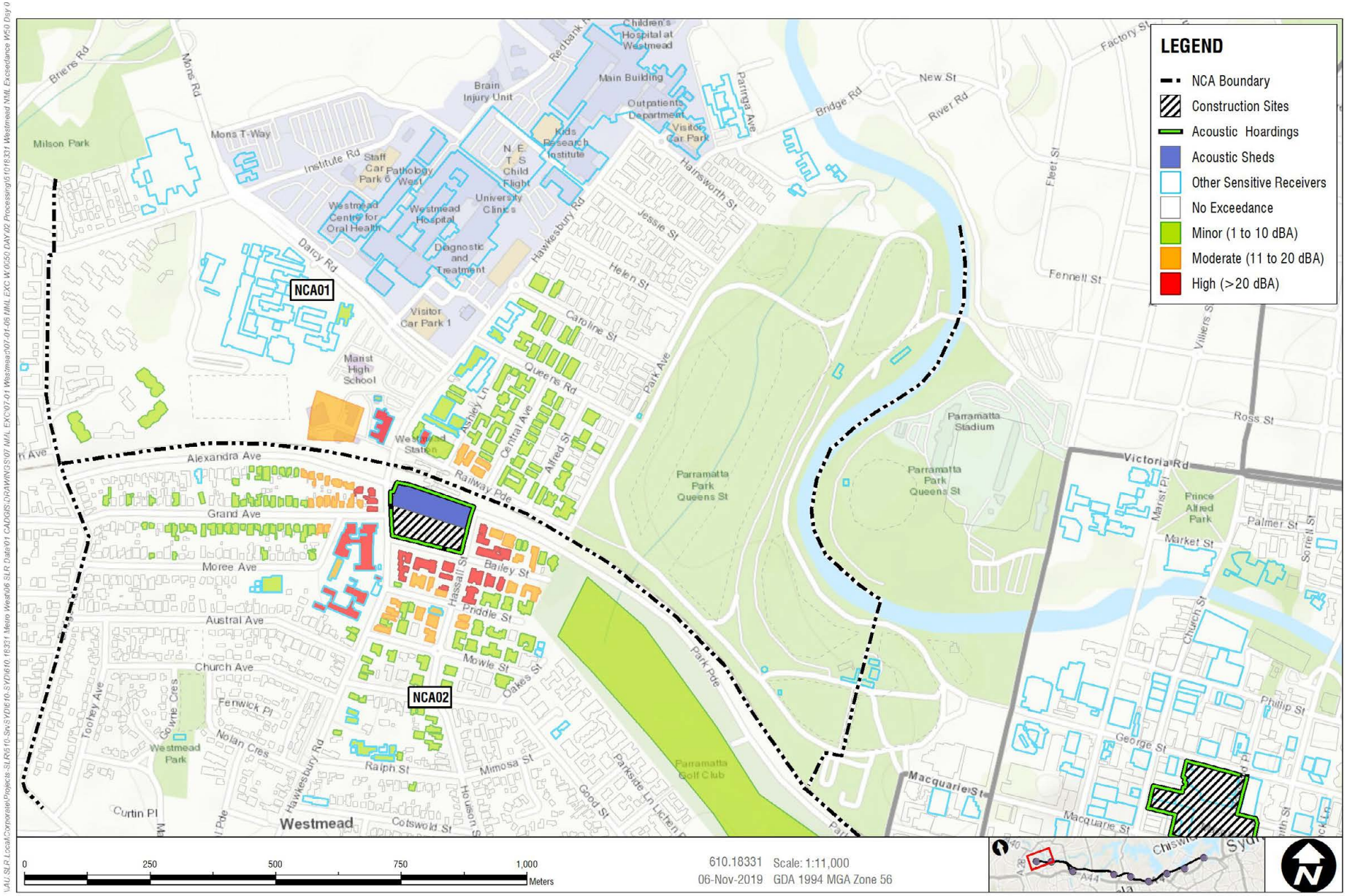


Figure 13 Worst-case Daytime Airborne Noise Impacts – Intersection Modifications, including Rockbeakers



The above shows the following:

- The worst-case daytime impacts are predicted during noise intensive works, such as rockbreaking, which occur prior to construction of the acoustic shed and during *Intersection modifications*. The impacts are expected to be 'high' at receivers adjacent the site and 'moderate' or 'minor' for receivers which are more distant. The nearest receivers are a mixture of residential and educational.
- The worst-case daytime impacts at 'other sensitive' receivers are predicted to be:
    - 'High' at Westmead Public School, Western Sydney University – Westmead Precinct and Mounika's Family Day Care.
    - 'Moderate' at the Westmead Progress Hall.
- When rockbreakers are not in use during outdoor works or *Intersection modifications*, the noise levels are predicted to be substantially lower, with the worst-case impacts being 'moderate' at the closest receivers and 'minor' or compliant in the rest of the study area.
- When rockbreakers are being used inside the acoustic shed and doors are closed, no daytime impacts are predicted.

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.

Impacts during the Night-time

Noise intensive works during the night-time at this construction site would only be completed inside the acoustic shed (with the exception of *Intersection modification* works). Some less noisy *TBM assembly* related works would be required outside the shed at times, such as loading and unloading of heavy vehicles. The worst-case impacts are predicted during *Excavation with shed* when rockbreakers are in use, and also during *Intersection modifications* which are required at the intersections near the construction site. The predicted worst-case night-time impacts from the assessed scenarios in this study area are shown in:

- **Figure 14** – *Excavation with shed – Through rock using rockbreaker (Doors Open)*
- **Figure 15** – *Excavation with shed – Through rock using rockbreaker (Doors Closed)*
- **Figure 16** – *Excavation with shed – Mucking out (Doors Closed)*, which has no requirement for noise intensive equipment
- **Figure 17** – *Intersection modifications – Noise intensive works*.

The highest impact works are expected to last for:

- *Excavation with shed – Through rock using rockbreaker* – 23 weeks
- *Excavation with shed – Mucking out* – 23 weeks.
- *Intersection modifications – Noise intensive works* – two weeks.

Figure 14 Worst-case Night-time Airborne Noise Impacts – Excavation in Shed using Rockbreaker (Doors Open)

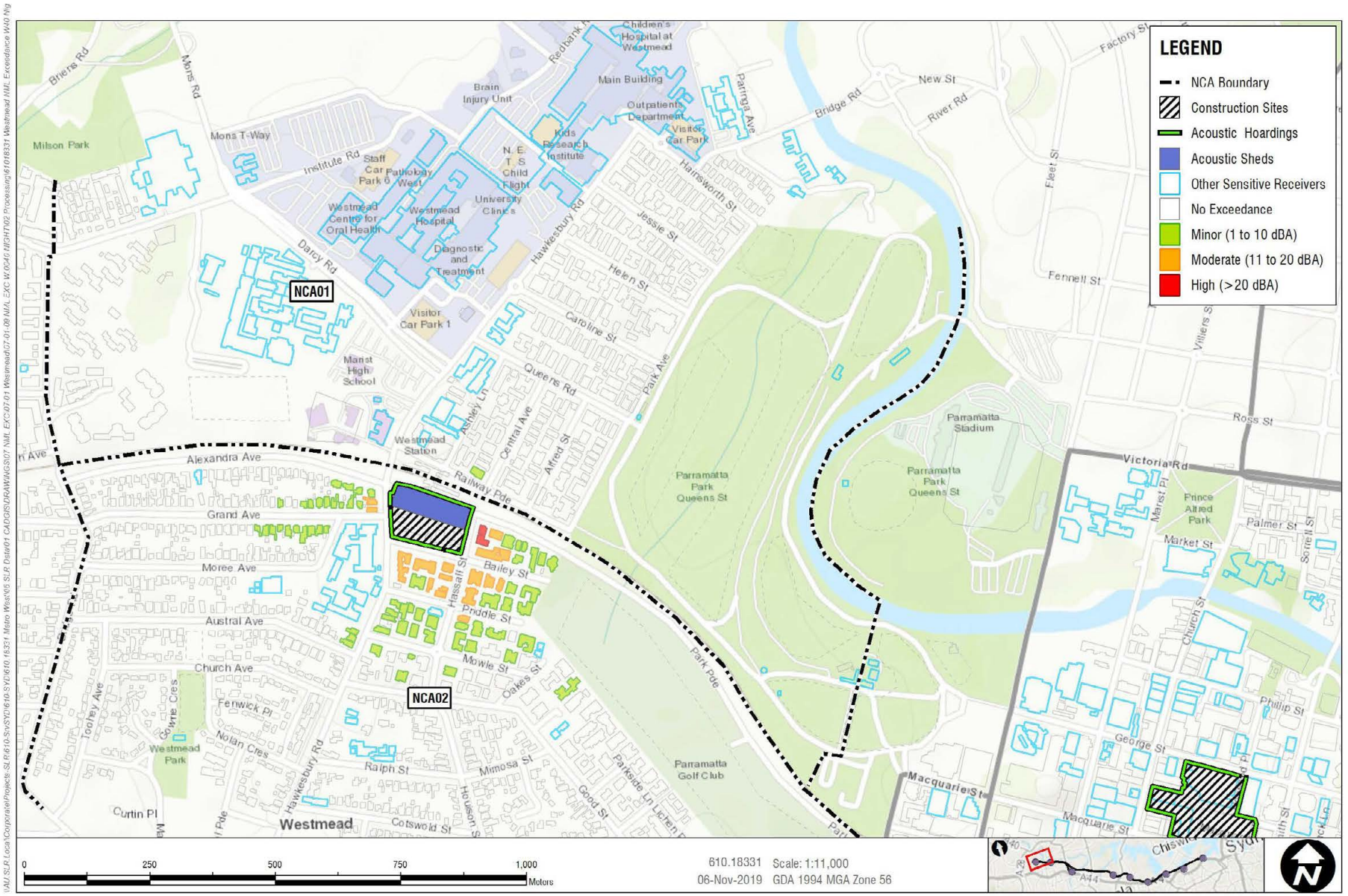


Figure 15 Worst-case Night-time Airborne Noise Impacts – Excavation in Shed using Rockbreaker (Doors Closed)

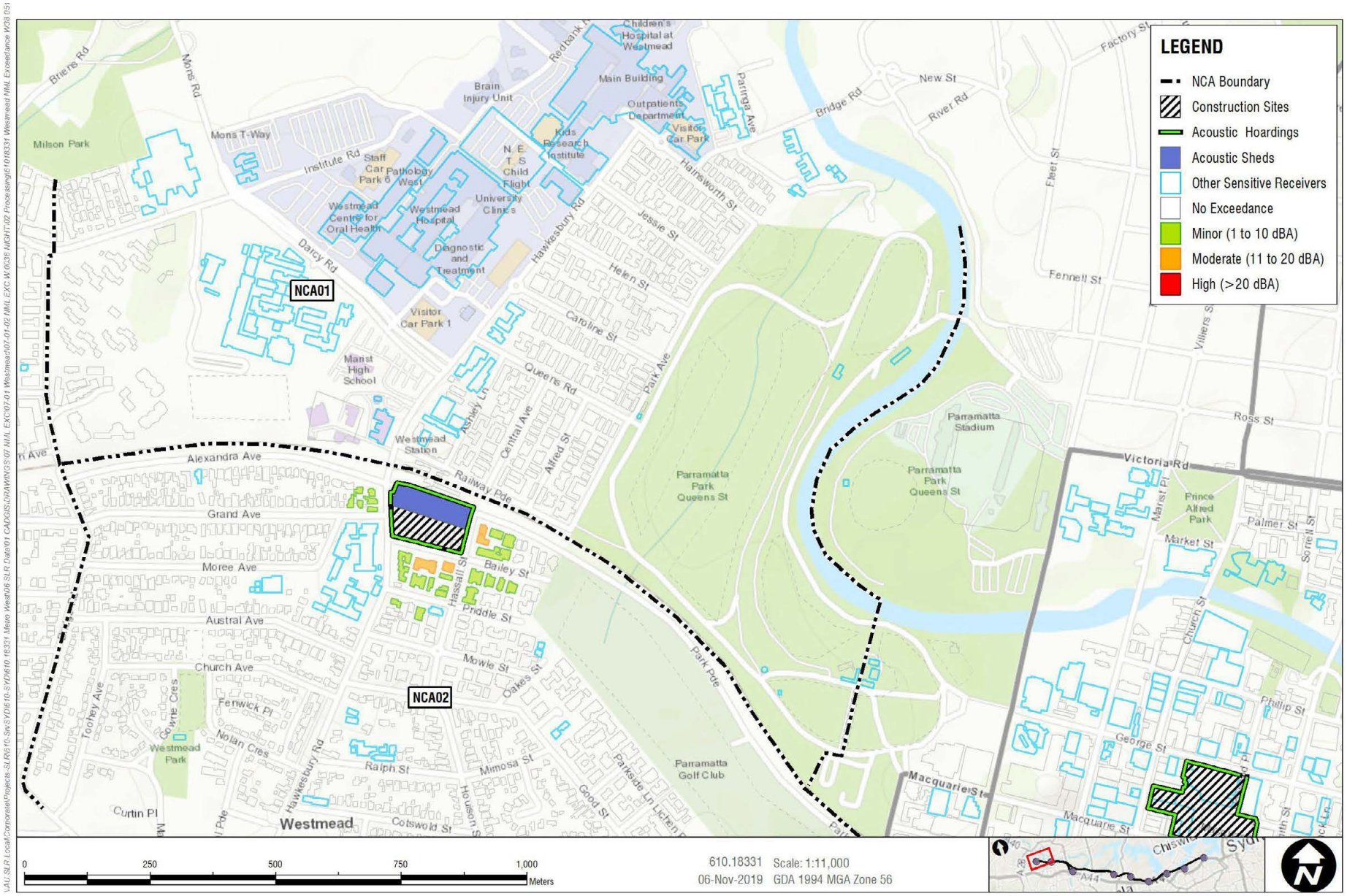


Figure 16 Worst-case Night-time Airborne Noise Impacts – Mucking Out (Doors Closed)

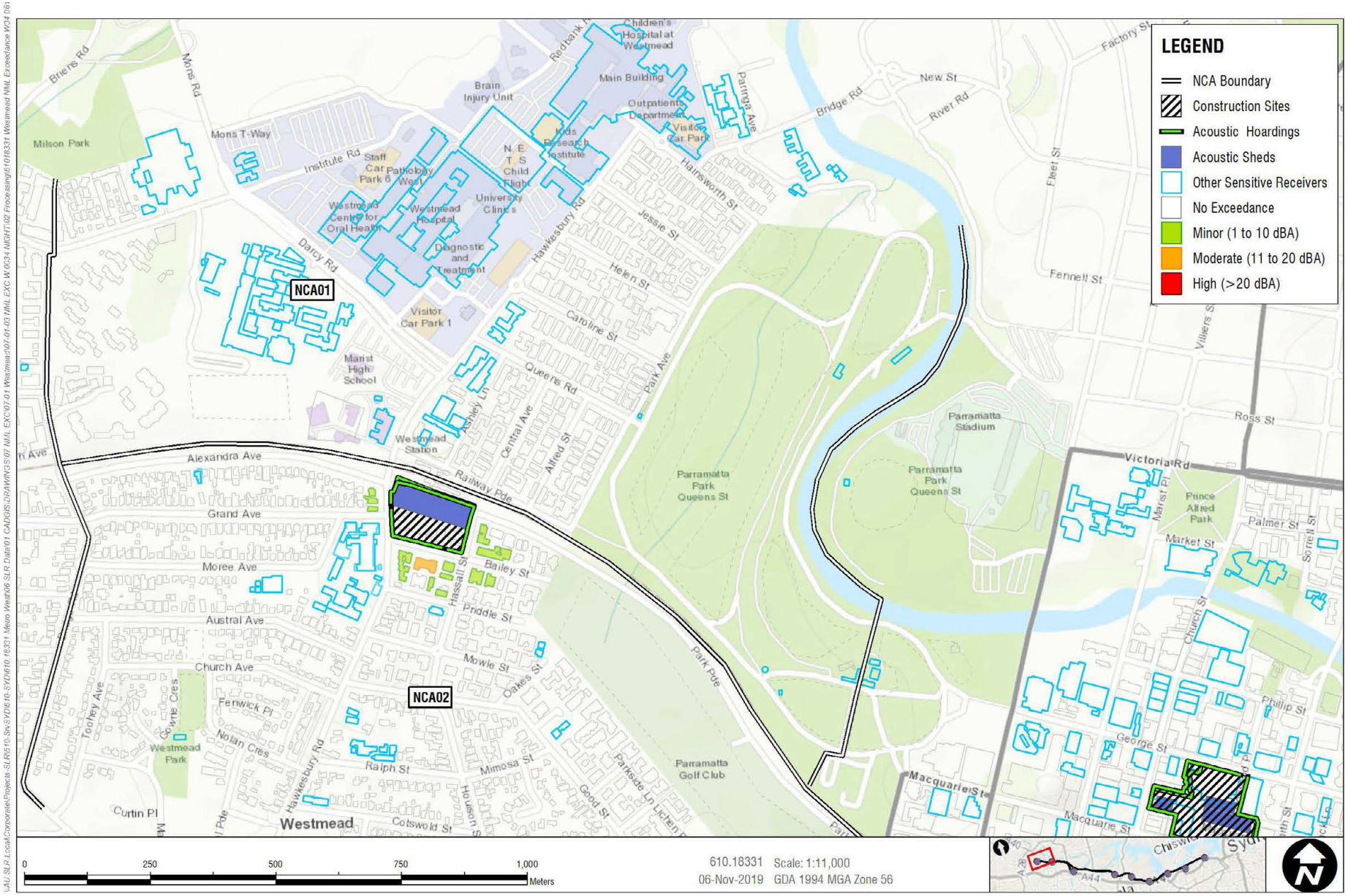
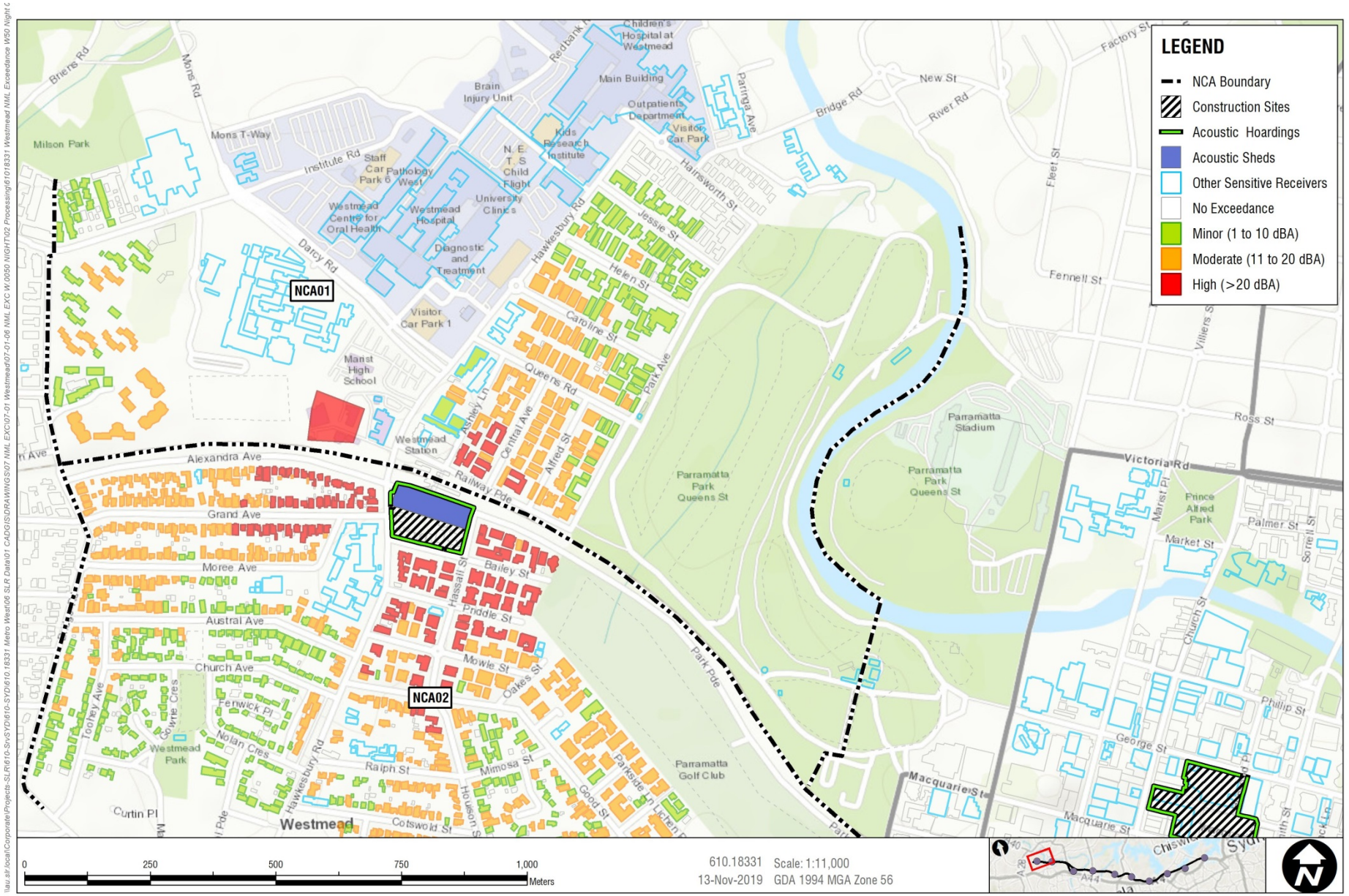


Figure 17 Worst-case Night-time Airborne Noise Impacts – Intersection modifications (Noise intensive works)



The above shows the following:

- The worst-case night-time noise levels from works in the acoustic shed are expected to occur when rockbreakers are used and the shed doors are open. These works are predicted to result in 'high' impacts at one residential receiver to the east of the site. 'Moderate' impacts are predicted for the other receivers which are near to the site, with 'minor' impacts at more distant receivers.
- When the acoustic shed doors are closed, the impacts during rockbreaking are reduced substantially and the nearest receivers are predicted to have 'moderate' or 'minor' worst-case impacts. More distant receivers in the study area are compliant with the management levels.
- When rockbreakers are not in use during *Mucking out* in the acoustic shed, noise levels are reduced further and the extent of the predicted exceedances is mostly reduced to 'minor' impacts at the nearest receivers.
- 'High' impacts are predicted at many of the surrounding receivers when noise intensive equipment is used during *Intersection modifications*. When noise intensive equipment is not being used during these works the extent of the exceedances would be substantially less, however, 'high' impacts remain at the nearest receivers. While widespread impacts are predicted during these works, they are expected to only last for two weeks.

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 8**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed for the construction works and is summarised in **Table 35**.

'High' sleep disturbance impacts are predicted at the nearest residential during noisy works as part of *Excavation with shed*, *TBM launch and support* and *Intersection modifications*.

Sleep disturbance impacts from within the construction site are generally controlled by heavy vehicle movements in the outdoor areas of the site during *Excavation with shed* and *TBM launch* scenarios. Sleep disturbance impacts associated with intersection modifications are generally from use of noise intensive equipment such as concrete saws and rockbreakers.

The potential awakenings from heavy vehicles would be influenced by the number of trucks accessing the site during the night-time and the way in which the vehicles are operated. The number of heavy vehicles at the construction site during the night-time is expected to be around 25 heavy vehicles per hour.

The number of night-time awakenings during *Intersection modifications* would depend on several factors, including the type of equipment being used, the duration of the noisy works and the distance of the works to nearest residential receivers. At this early stage in the project the currently available information does not allow for accurate prediction of the extent of night-time awakenings. Further investigation of awakenings would be completed during the next stages of Stage 1 when detailed construction planning information becomes available.

Highly Noise Affected Residential Receivers

The receivers predicted to be Highly Noise Affected during the worst-case impacts are summarised in **Table 38** and shown in **Figure 18**. The table shows the number of residential receivers separated by works activity and NCA.

Table 38 Predicted Number of Highly Noise Affected Residential Receivers by Works and NCA

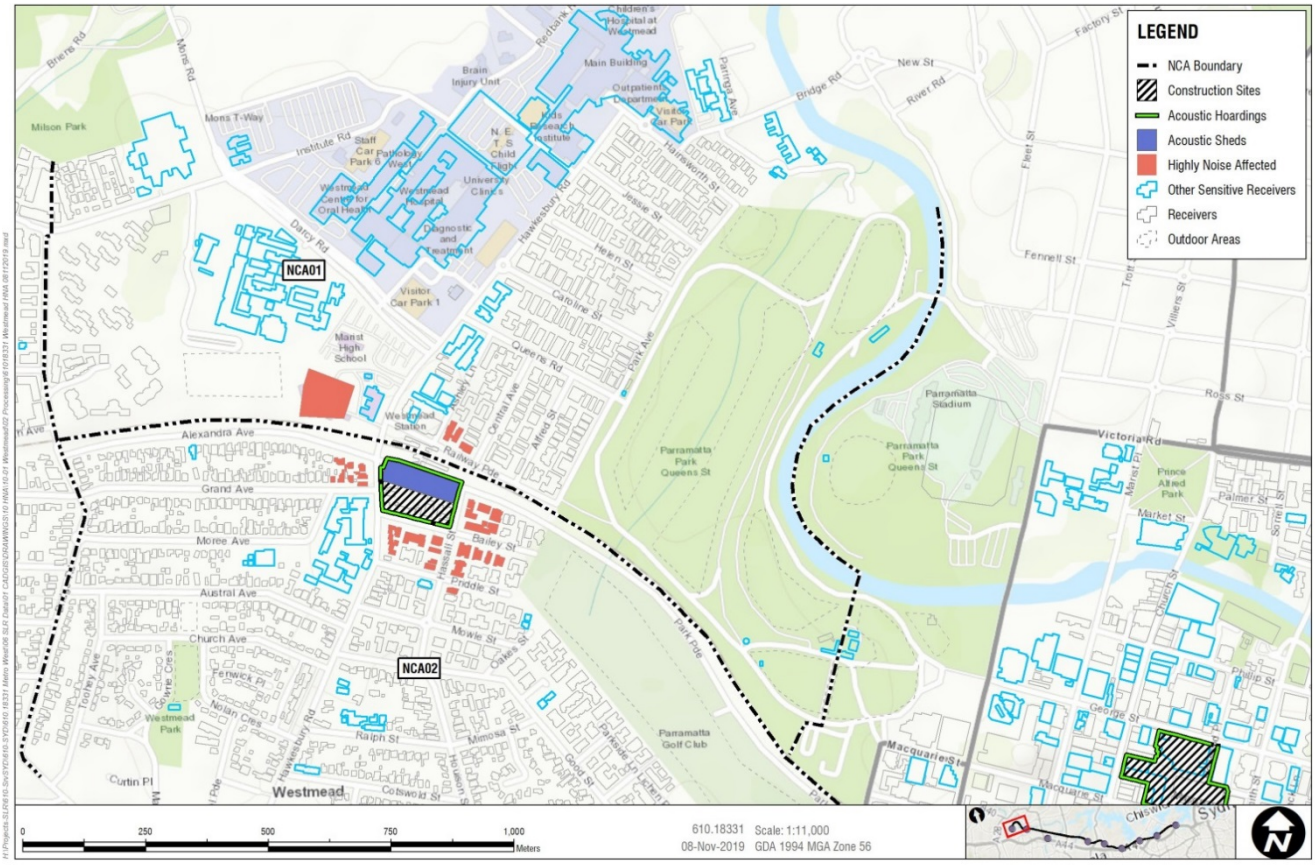
Scenario	Activity		NCA01			NCA02		
			Day	Eve	Night	Day	Eve	Night
Enabling works	'Typical'	Supporting and loading	-	n/a	n/a	-	n/a	n/a
	'Peak'	Demolition using a rockbreaker with supporting plant	1	n/a	n/a	11	n/a	n/a
Piling	'Typical'	Supporting works	-	n/a	n/a	-	n/a	n/a
	'Peak'	Bored piling with support plant	-	n/a	n/a	-	n/a	n/a
Surface construction	'Typical'	General works	-	n/a	n/a	-	n/a	n/a
	'Peak'	Noise intensive works	-	n/a	n/a	-	n/a	n/a
Initial excavation	'Typical'	Mucking out	-	n/a	n/a	-	n/a	n/a
	'Peak'	Through soft soil/rock	-	n/a	n/a	-	n/a	n/a
		Through rock using rockbreaker	2	n/a	n/a	8	n/a	n/a
Excavation with shed	'Typical'	Mucking out (Doors Closed)	-	-	-	-	-	-
	'Peak'	Through rock using rockbreaker (Doors Closed)	-	-	-	-	-	-
		Through rock using rockbreaker (Doors Open)	-	-	-	-	-	-
TBM launch and support	'Typical'	TBM support and spoil removal	-	-	-	-	-	-
	'Peak'	TBM assembly and launch	-	-	-	-	-	-
Intersection modifications	'Typical'	Supporting works	-	-	-	-	-	-
	'Peak'	Noise intensive works	1	1	1	23	23	23

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

The assessment shows that the nearest receivers to the site are predicted to be Highly Noise Affected during daytime works involving rockbreakers before the acoustic shed is constructed. Works in the shed are not predicted to result in any Highly Noise Affected impacts.

Intersection modifications are also likely to result in Highly Noise Affected impacts at the surrounding receivers when noise intensive equipment such as concrete saws and rockbreakers are being used. These works are expected to be required during all periods, but only last for two weeks.

Figure 18 Highly Noise Affected Residential Receivers (During Any Works)



5.2.1.4 Ground-borne Noise Impacts from Construction Sites

The predicted ground-borne impacts from vibration intensive station shaft excavation works inside the acoustic shed are summarised in **Table 39**. The results are shown in **Figure 19** and **Figure 20** for the daytime and night-time, respectively. The predictions are representative of the highest ground-borne noise levels that would likely be experienced by the nearest receivers when excavation works are at their closest.

Table 39 Overview of Ground-borne NML Exceedances

NCA	Receiver Classification	Number of Receivers									
		Total	With NML Exceedance[1]								
			Daytime			Out-of-Hours Works					
						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
NCA01	Residential	261	-	-	-	-	-	-	-	-	-
	Commercial	9	1	-	-	-	-	-	-	-	-
	Other Sensitive	62	-	-	-	-	-	-	-	-	-
NCA02	Residential	655	2	-	-	4	-	-	3	2	-
	Commercial	9	-	-	-	-	-	-	-	-	-
	Other Sensitive	26	-	-	-	-	-	-	-	-	-

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

Figure 19 Ground-borne Noise Impacts – Daytime Construction Hours

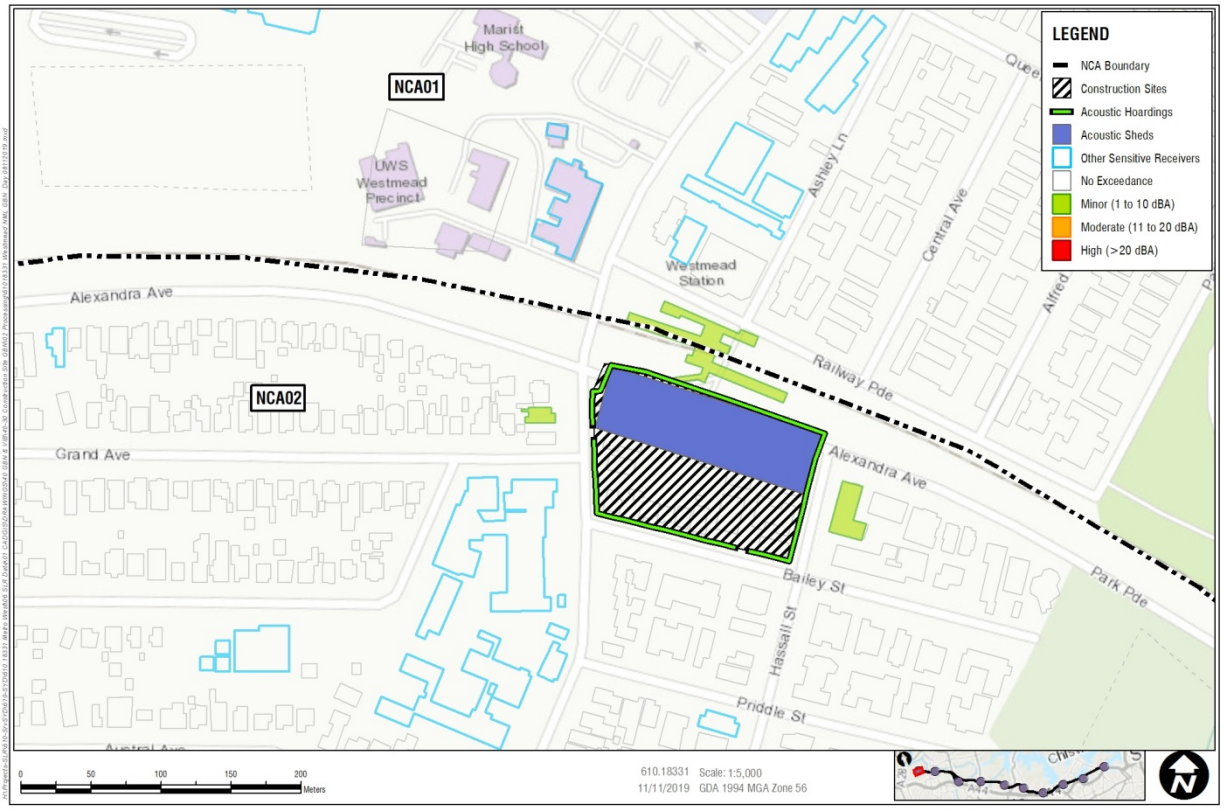
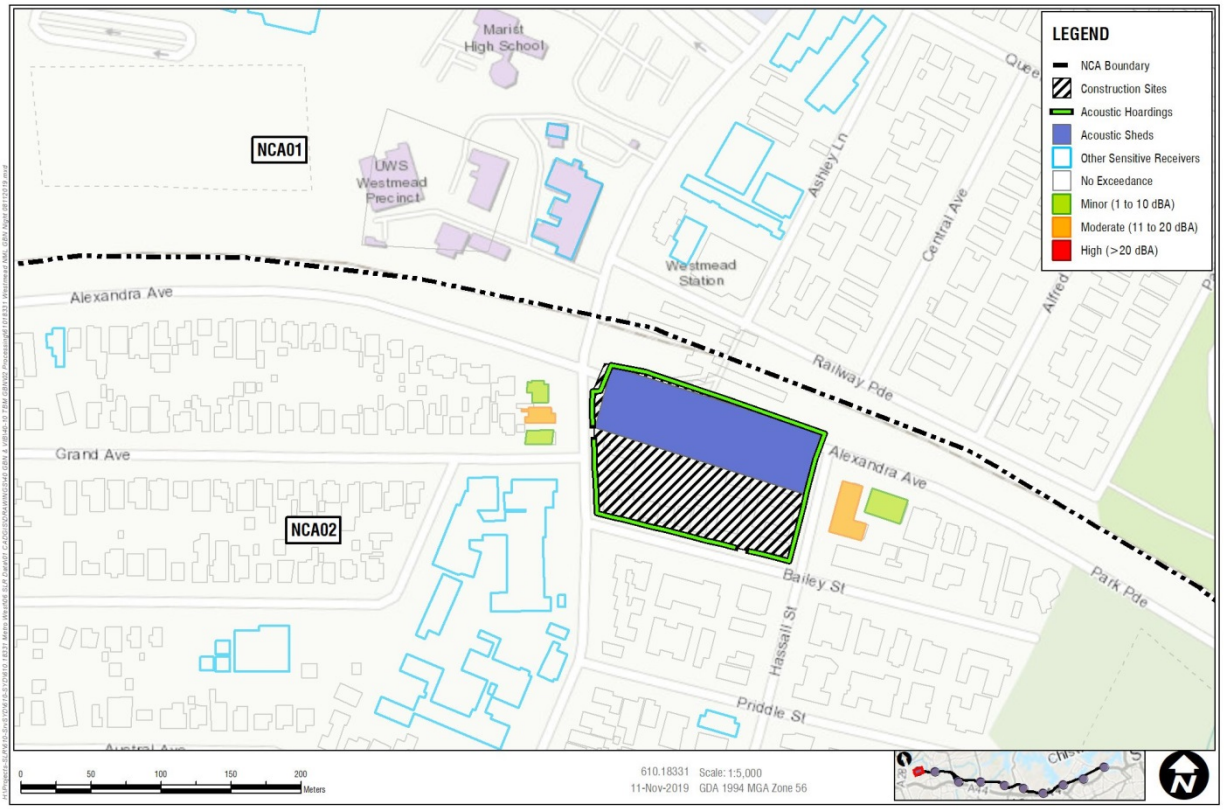


Figure 20 Ground-borne Noise Impacts – Night-time



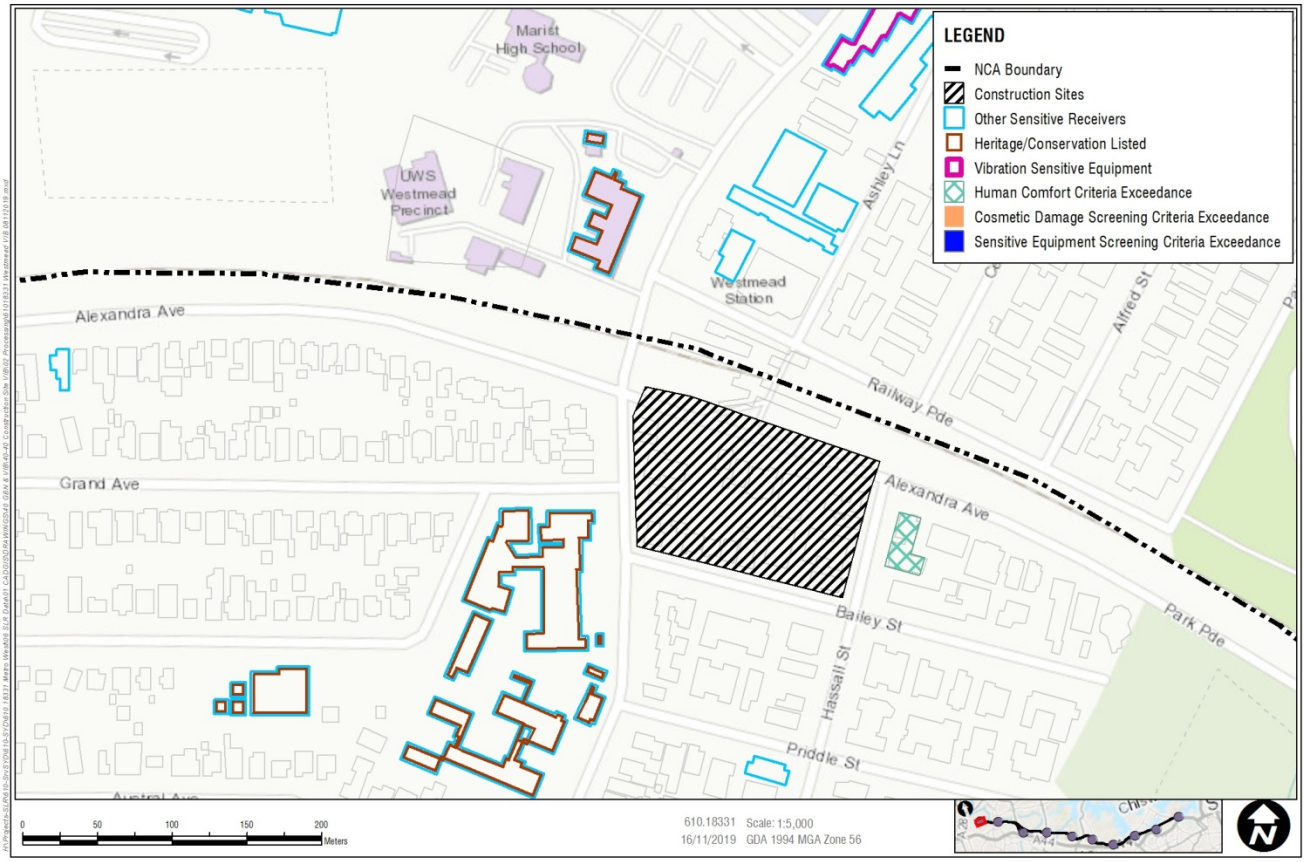
The above shows the following:

- Vibration intensive works are predicted to result in 'minor' worst-case ground-borne noise impacts during the daytime at the two nearest residential receivers and at one existing commercial building at Westmead Station.
- The worst-case impacts during the night-time are predicted to be 'moderate' at the two nearest residential receivers.
- Vibration intensive shaft excavation works inside the acoustic shed are anticipated to occur for 23 weeks. The predictions represent the worst-case scenario when excavation works are at surface level and are, therefore, at the closest point to the affected buildings. As the works progress deeper, the impacts are expected to reduce.

5.2.1.5 Vibration Impacts from Construction Sites

The predicted impacts during vibration intensive works are shown in **Figure 21**. The predictions are representative of the highest vibration levels that would likely be experienced by the nearest receivers when works are at their closest.

Figure 21 Worst-case Vibration Impacts



The above shows the following:

- There are no predicted exceedances of the cosmetic damage screening criteria or the sensitive equipment screening criteria at this site.
- The human comfort criteria are predicted to be exceeded at one residential receiver to the east of the site, meaning occupants of affected buildings may be able to perceive vibration impacts at times when vibration intensive equipment is in use nearby.

5.2.2 Parramatta Study Area (NCA03)

The Parramatta study area is centred on the Parramatta metro station construction site. This study area contains one Noise Catchment Area (NCA03) which includes most of Parramatta CBD.

The construction site is located between George Street and Macquarie Street, and between Church Street and Smith Street.

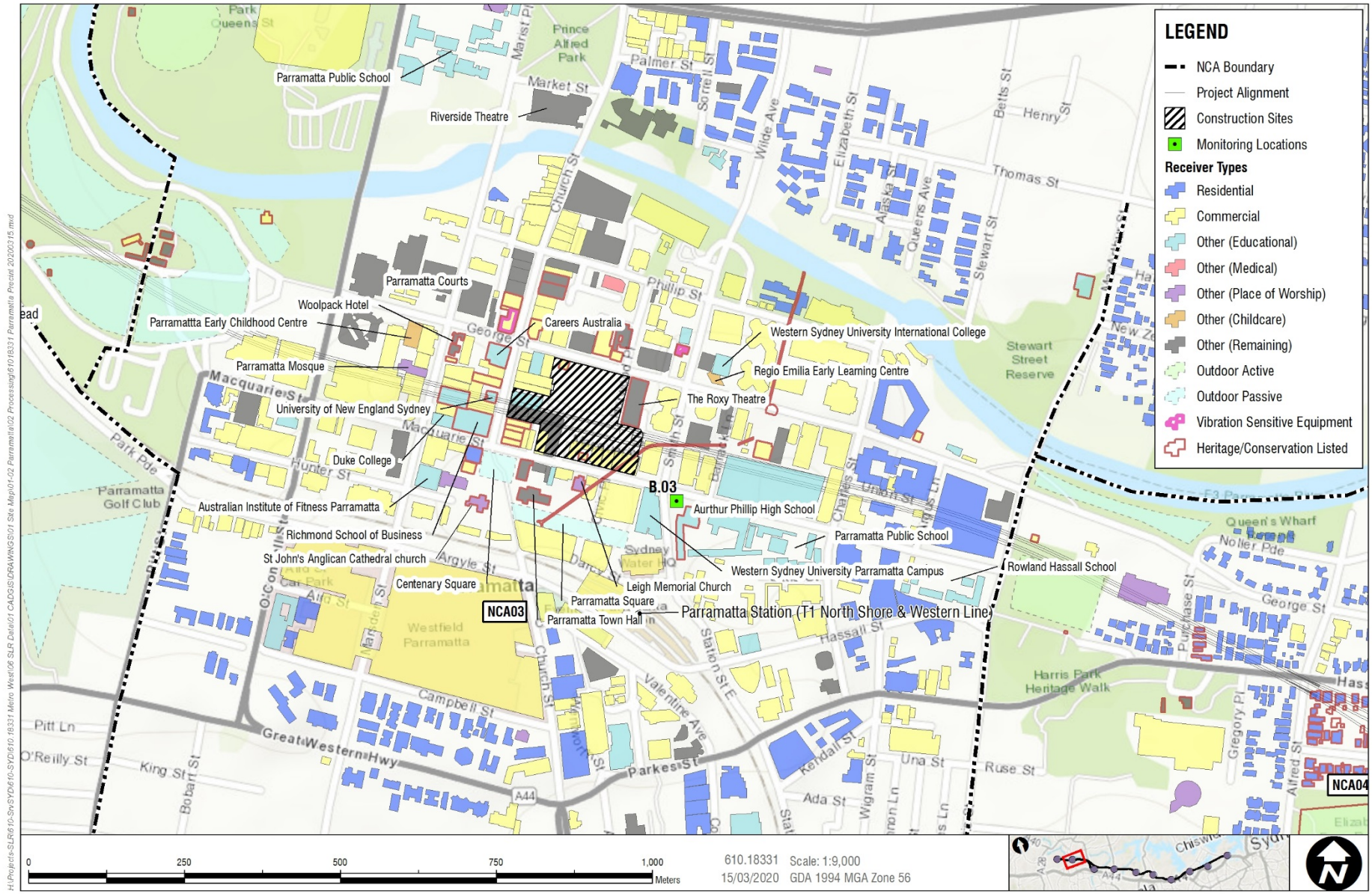
Existing noise levels in this study area are controlled by road traffic noise and general urban hum associated with the CBD. As with any CBD, existing noise levels and are relatively high during the daytime, evening and night-time. The area surrounding the construction site is mainly commercial and the nearest receivers are close to the boundary of the site. The nearest receivers are typically of general office or retail use.

The NCAs in the Parramatta study area are described below and a map is shown in **Figure 22**.

NCA03

- The nearest receivers to the site are several commercial buildings on George Street, Macquarie Street, Church Street and Smith Street. These buildings are located immediately adjacent the site boundary. While some of these buildings have windows that overlook the construction site, several buildings do not.
- The Roxy Theatre is the immediate east of the site, however, this receiver is currently not in use and unlikely to be considered sensitive at the time of Stage 1 works.
- Several educational receivers are located near the site, including a number to the west of the construction site across on Church Street, the University of Western Sydney Parramatta Campus which is on the corner of Macquarie Street and Smith Street, and Arthur Phillip High School which is around 100 metres to the south-east.
- Parramatta Town Hall and Leigh Memorial Church are around 60 metres south of the site, on the opposite side of Macquarie Street. Parramatta Courts are located around 100 metres northwest of the site.
- Centenary Square and the approved Parramatta Square (currently under construction) are two outdoor passive recreation areas located around 80 metres south of the site.
- The nearest residential receiver is located approximately 80 metres southwest of the construction site on Macquarie Street.

Figure 22 Site Map, Works and Sensitive Receivers



5.2.2.2 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 during this period and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

The Stage 1 works within this study area are anticipated to have a total duration of about two years.

5.2.2.3 Airborne Noise Impacts from Construction Sites

Number of NML Exceedances

The predicted airborne noise impacts from construction site works 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 when the works are at their closest.

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 40 Surface construction Activities and Period of Works

Scenario	Activity		Total Indicative Duration (Weeks)[2]	Maximum Number of Working Faces	Hours of Works[1]				Comments
					Std. Day	Out-of-Hours Works			
						Day OOH[1]	Eve	Night	
Enabling works	'Typical'	Supporting and loading	24	1	✓	✓	-	-	-
	'Peak'	Demolition using a rockbreaker	24	2	✓	✓	-	-	Rockbreaking works would only occur intermittently during a 24 week period between 7am – 6pm. Total duration of rockbreaking works would be approximately 20 days.
Piling	'Typical'	Supporting works	36	2	✓	✓	-	-	-
	'Peak'	Bored piling with support plant	36	4	✓	✓	-	-	Piling works would only occur intermittently during a 36 week period between 7am – 6pm. Up to four piling rigs would be active at the same time.
Surface construction	'Typical'	General works	12	1	✓	✓	-	-	-
	'Peak'	Noise intensive works	12	2	✓	✓	-	-	-
Excavation	'Typical'	Mucking out	30	1	✓	✓	✓	✓	Mucking out would occur during standard daytime and out-of-hours daytime periods only. Spoil haulage would occur during all periods including the evening and night-time.
	'Peak'	Through soft soil/rock	6	2	✓	✓	-	-	Excavation through soil and soft rock using excavator ripper attachment.
		Through rock using rockbreaker	24	2	✓	✓	-	-	Excavation through rock using rockbreaker. Works restricted to daytime only.

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

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

Table 41 Overview of NML Exceedances – All Receiver Types

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Supporting and loading	24	478	-	9	3	-	9	3	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	24	478	-	50	29	10	50	29	10	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	36	478	-	10	1	-	10	1	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	36	478	-	13	5	1	13	5	1	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	12	478	-	7	-	-	7	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	12	478	-	8	4	-	8	4	-	-	-	-	-	-	-	-	-	-
Excavation	'Typical'	Mucking out	30	478	-	9	3	-	9	3	-	2	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	6	478	-	15	6	1	15	6	1	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	24	478	-	56	15	7	56	15	7	-	-	-	-	-	-	-	-	-

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

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

Table 42 Overview of NML Exceedances – Residential Receivers

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Supporting and loading	24	161	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	24	161	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	36	161	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	36	161	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	12	161	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	12	161	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Excavation	'Typical'	Mucking out	30	161	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	6	161	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	24	161	-	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 in the works areas.

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

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

Scenario	Activity		No. Weeks[1]	Number of Receivers																										
				Commercial			Café/bars			Child Care			Educational			Public Building			Place of Worship			Passive Recreation			Medical (Daytime)			Medical (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	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
Enabling works	'Typical'	Supporting and loading	24	5	-	-	-	-	-	-	-	-	4	1	5	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	24	20	13	3	2	5	-	-	2	-	16	5	20	6	1	1	2	2	6	1	1	-	5	1	-	-	-	-
Piling	'Typical'	Supporting works	36	3	-	-	-	-	-	-	-	-	6	-	3	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	36	4	1	-	-	-	-	1	-	-	5	3	4	1	-	1	2	1	1	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	12	1	-	-	-	-	-	-	-	-	4	-	1	1	-	-	1	-	1	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	12	3	-	-	-	-	-	-	-	-	5	2	3	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-
Excavation	'Typical'	Mucking out	30	4	-	-	-	-	-	-	-	-	5	1	4	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	6	7	1	-	-	-	-	1	-	-	4	4	7	1	-	1	2	1	1	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	24	24	7	1	6	-	-	1	1	-	14	4	24	4	1	1	2	2	4	2	-	-	4	1	-	-	-	-

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

The above shows the following:

- The Stage 1 construction works are predicted to result in 'high' worst-case noise impacts at the nearest receivers during higher noise generating activities. The nearest receivers to the site are generally commercial. The worst-case impacts are predicted during *Enabling works* and *Excavation*. These works are, however, limited to the daytime and would not typically occur during the evening or night-time.
- The highest impacts are during 'Peak' scenarios which use noise intensive equipment such as rockbreakers. When noise intensive equipment is not in use during 'Typical' works, the worst-case impacts are predicted to be reduced to 'moderate' or 'minor' at the nearest receivers.
- *Piling* and *Surface construction* works generate less noise and the worst-case impacts at the nearest receivers are generally predicted to be 'minor' or 'moderate'. These works would also only be undertaken during the daytime.
- The majority of the works are proposed to occur during the daytime. Spoil haulage (as part of *Mucking Out*) would be required during the evening and night-time, however, noise levels from this activity are relatively low and only predicted to result in two 'minor' exceedances during the evening.
- No receivers are predicted to be Highly Noise Affected during the works.
- No sleep disturbance impacts are predicted during the works.

Impacts during Standard Construction Hours

The worst-case impacts during Standard Construction Hours are predicted during noise intensive works. The predicted worst-case daytime impacts in this study area are shown in:

- **Figure 23** – All works, including rockbreakers
- **Figure 24** – All works, not including rockbreakers.

The highest impact works are expected to last for:

- *Enabling works – Demolition using a rockbreaker* – 20 days (actual rockbreaker use)
- *Excavation – Through rock using rockbreaker* – 24 weeks.

Figure 23 Worst-case Daytime Airborne Noise Impacts – All Works, including Rockbreakers

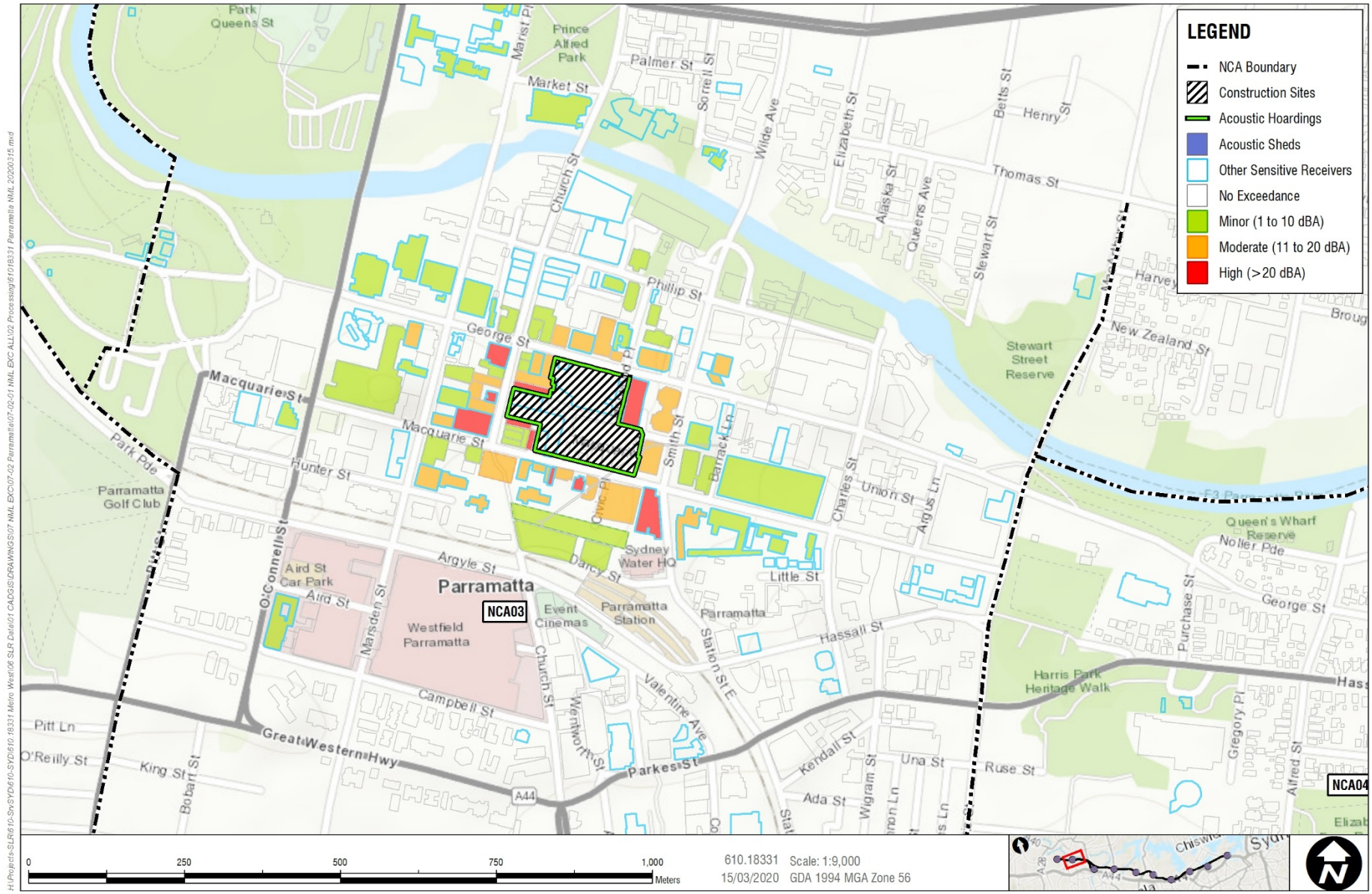
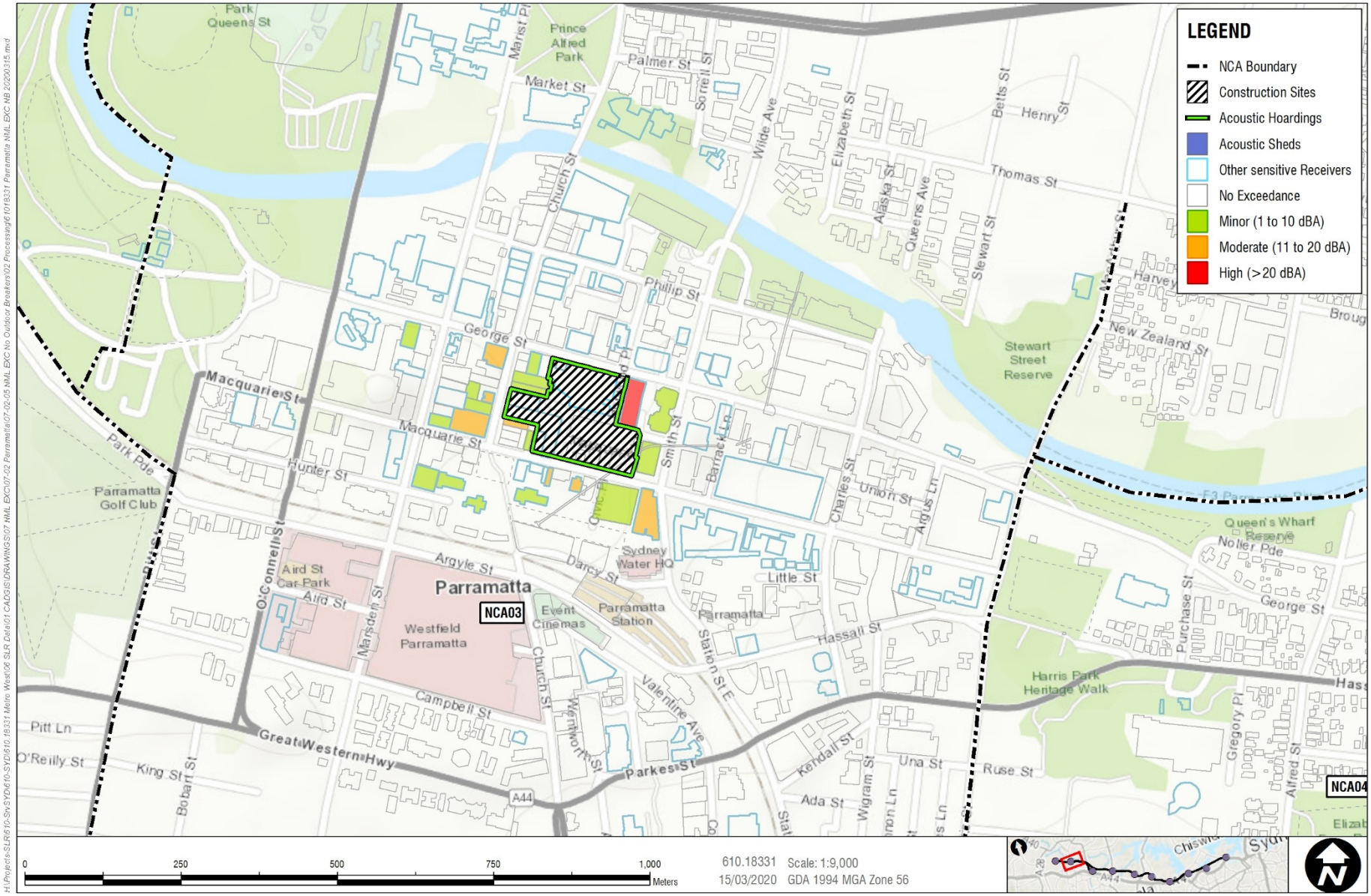


Figure 24 Worst-case Daytime Airborne Noise Impacts – All Works, not including Rockbreakers



The above shows the following:

- The worst-case impacts during Standard Construction Hours are predicted during noise intensive works, such as rockbreaking. The impacts are expected to be 'high' at receivers immediately adjacent the site and 'moderate' or 'minor' for more distance receivers. Most of the nearest receivers are commercial and in some cases overlook the worksite.
- The worst-case impacts at 'other sensitive' receivers are predicted to be:
    - 'High' at University of New England Sydney, Leigh Memorial Church, Roxy Theatre (noting this receiver is not currently operational), Richmond School of Business, Australis Institute of Technology and Western Sydney University Parramatta Campus.
    - 'Moderate' at two buildings of St John's Anglican Cathedral Church, Parramatta Town Hall, Lead College, Australian Institute of Fitness Parramatta, Duke College, Western Sydney University International College, Regio Emilia Early Learning Centre, Arthur Philip High School, Centenary Square, Parramatta Early Childhood Centre and several café/bars on George Street and Macquarie Street.
- When rockbreakers are not in use, the impacts are predicted to be substantially lower and only the former Roxy Theatre is predicted to have 'high' worst-case impacts. The impacts at the other receivers near the site are reduced to 'moderate' or 'minor'.

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.

Impacts during Daytime Out of Hours

The results in **Table 42** show that the predicted impacts during Daytime Out of Hours periods are the same as for Standard Construction Hours, with only one residential receiver having 'minor' worst-case impacts.

Impacts during the Night-time and Sleep Disturbance

Only spoil haulage (as part of *Mucking Out*) would occur during the night-time. No impacts are predicted during this activity.

Highly Noise Affected Residential Receivers

No receivers are predicted to be Highly Noise Affected in this study area by the works.

5.2.2.4 Ground-borne Noise Impacts from Construction Sites

Vibration intensive works during shaft excavation at this construction site would not be completed in an acoustic shed meaning airborne noise levels at the nearest receivers would likely be higher than the corresponding internal ground-borne noise levels. Where airborne noise levels are higher than ground-borne noise levels it is not necessary to evaluate potential ground-borne noise impacts.

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

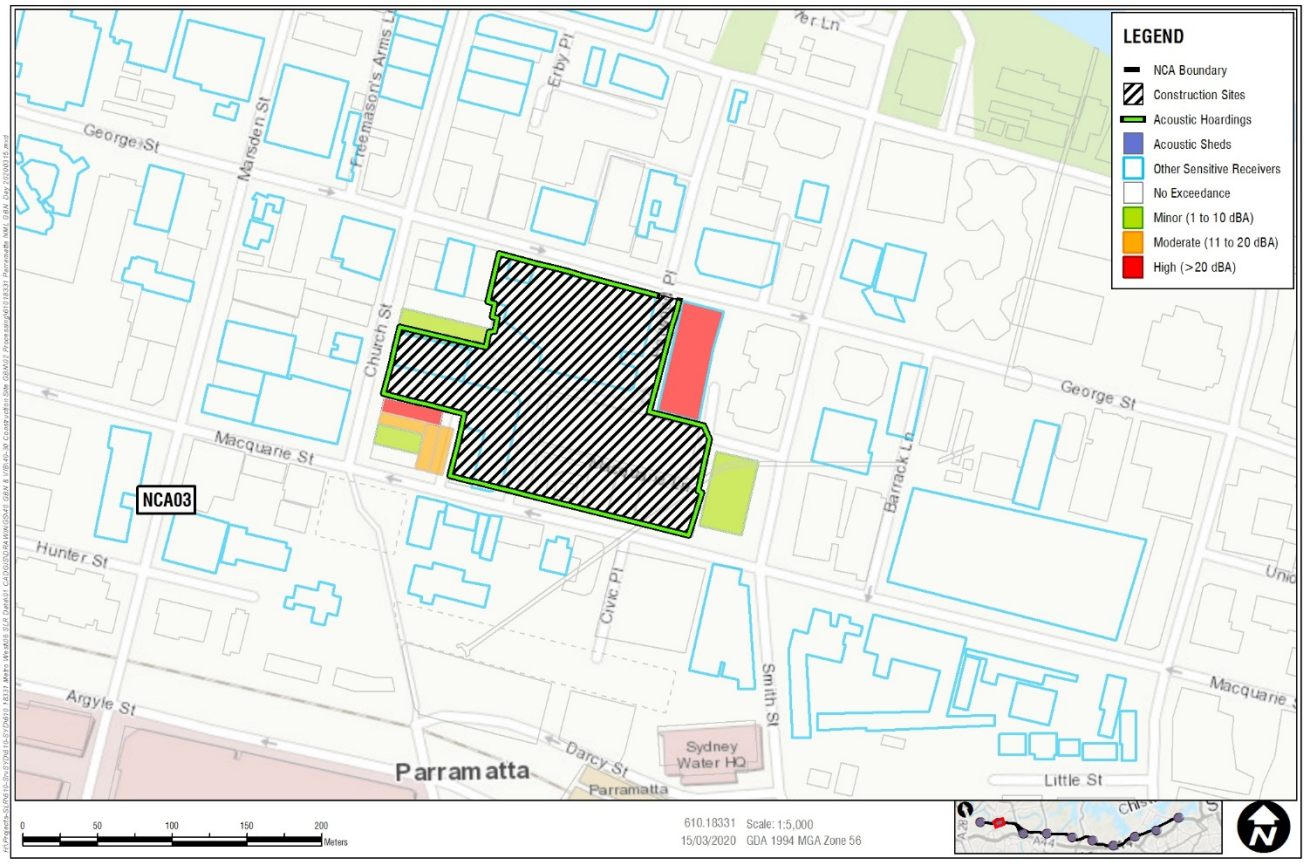
On this basis, ground-borne noise levels have been assessed at this site and the potential worst-case impacts are summarised in **Table 44** and shown in **Figure 25**. The predictions are representative of the highest ground-borne noise levels that would likely be experienced by the nearest receivers when excavation works are at their closest.

Table 44 Overview of Ground-borne NML Exceedances

NCA	Receiver Classification	Number of Receivers									
		Total	With NML Exceedance[1]								
			Daytime			Out-of-Hours Works					
						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
NCA03	Residential	167	-	-	-	-	-	-	-	-	-
	Commercial	217	3	3	1	-	-	-	-	-	-
	Other Sensitive	118	-	-	1	-	-	-	-	-	-

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

Figure 25 Ground-borne Noise Impacts – Daytime Construction Hours



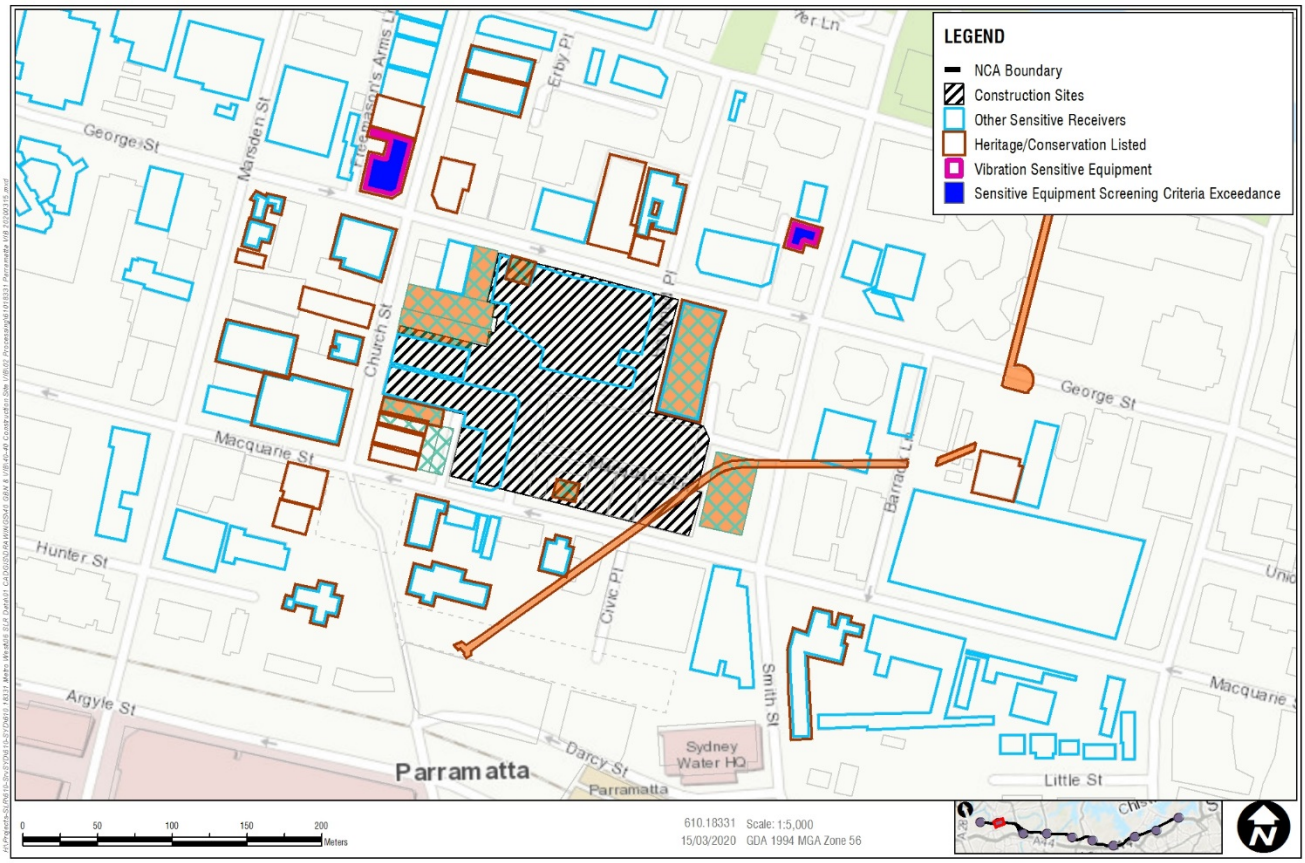
The above shows the following:

- Vibration intensive works are predicted to result in 'high' worst-case ground-borne noise impacts during the daytime at the two nearest receivers to the site boundary, which are within 5 metres of the excavation areas. This includes one commercial building to the south-west of the site and the Roxy Theatre to the east, however, this building is not currently in use.
- 'Moderate' or 'minor' exceedances are predicted at a number of the surrounding commercial buildings.
- Vibration intensive shaft excavation works inside the acoustic shed are anticipated to occur for 24 weeks. The predictions represent the worst-case scenario when shaft excavation works are at surface level and are, therefore, at the closest point to the affected buildings. As the works progress deeper, the impacts are expected to be reduce.

5.2.2.5 Vibration Impacts from Construction Sites

The predicted impacts during vibration intensive works are shown in **Figure 26**. The predictions are representative of the highest vibration levels that would likely be experienced by the nearest receivers when works are at their closest.

Figure 26 Worst-case Vibration Impacts



The above shows the following:

- The cosmetic damage screening criteria are predicted to be exceeded at the nine nearest buildings and structures to the site. This includes the Roxy Theatre to the east as well as two heritage listed buildings and one heritage listed structure (underground services) within the construction site footprint.
- The human comfort criteria are also predicted to be exceeded at some of the nearest commercial buildings, meaning occupants of affected buildings may be able to perceive vibration impacts at times when vibration intensive equipment is in use nearby.
- Exceedances of the vibration sensitive equipment screening criteria are predicted at the following two locations identified as potentially having vibration sensitive equipment with a VC-A criterion:
    - SunDoctors Skin Cancer Clinic, Parramatta
    - Orthodontics Sydney Wide, Parramatta.

5.2.3 Clyde Study Area (NCA04 to NCA07)

The Clyde study area is centred on the Clyde stabling and maintenance facility. This study area contains four Noise Catchments Areas (NCA04 and NCA07) which are generally to the west and east of James Ruse Drive.

The construction site is located to the east of James Ruse Drive, to the north of the M4 Motorway and to the south of Rosehill Gardens racecourse. A section of the redundant T6 Carlingford Line to the north of the construction site would be required for the construction of future stages of Sydney Metro West.

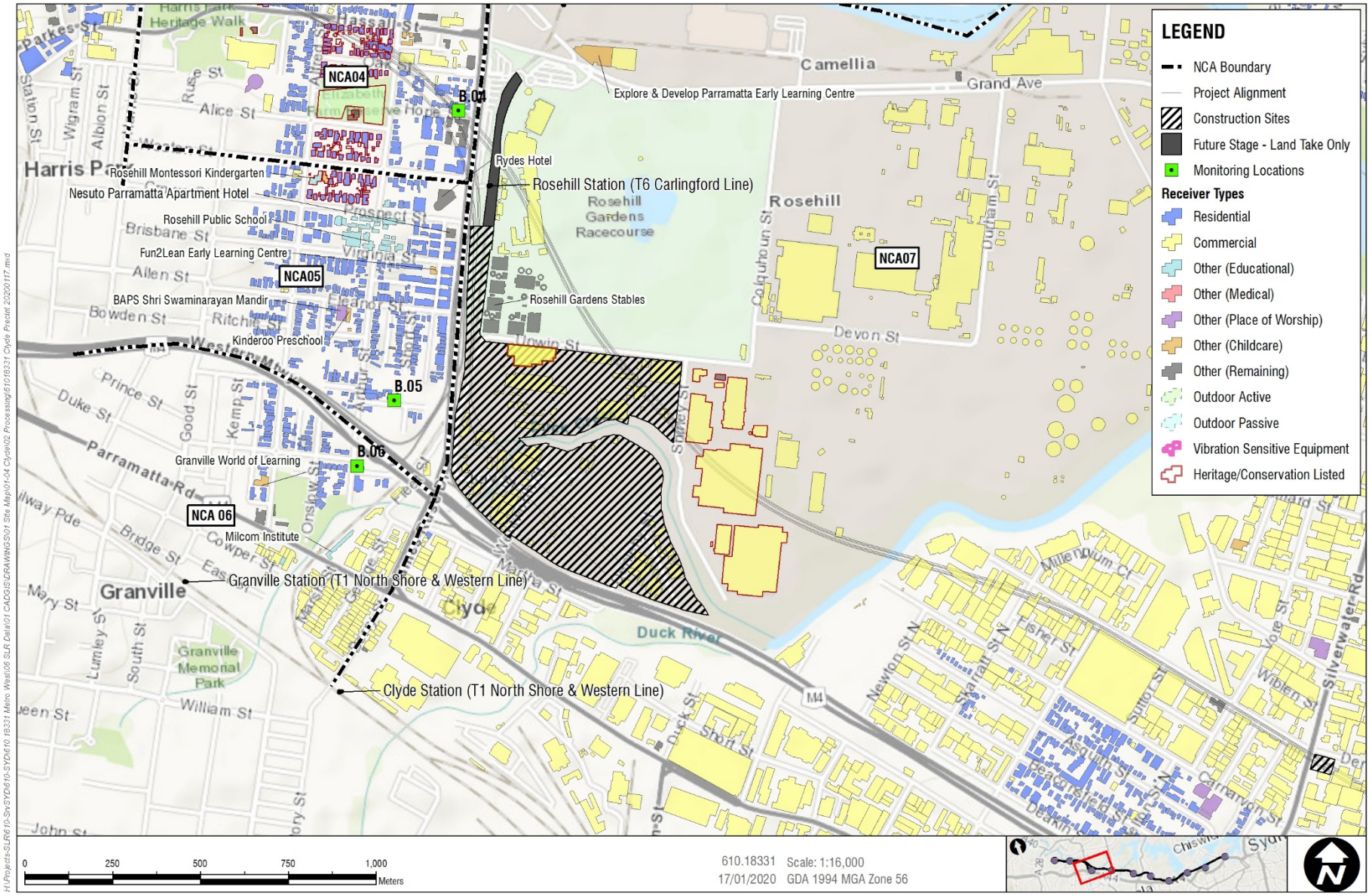
Existing noise levels in this study area are generally controlled by road traffic noise on the surrounding road network. The area surrounding the construction site is generally suburban residential to the west and commercial/industrial to the east.

The NCAs in the Clyde study area are described below and a map is shown in **Figure 27**.

NCA04 to NCA07

- The nearest receivers are residential properties to the west of the site, across James Ruse Drive, and stables associated with Rosehill Gardens racecourse to the north.
- Rosehill Public School is located around 200 metres to the west of the site.
- Various commercial and industrial receivers associated with the Clyde and Rosehill Industrial Estates are to the east and south.
- The commercial and residential areas of Silverwater and Newington are in the south-east, however, these are distant from the construction site.

Figure 27 Site Map, Works and Sensitive Receivers



5.2.3.2 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 during this period and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

Works at this are associated with construction of the stabling and maintenance facility and include earthwork and civil works required to prepare the site for construction of the facility, road reconfigurations, road bridges, and construction of associated structures. Excavation of a services facility shaft at the eastern side of the construction site and a tunnel dive in the northern extent of the construction site would also be required.

A concrete batching plant and segment production facility would operate on a 24/7 basis for the duration of the TBM tunnelling works. The operation of these facilities is included in the *Concrete batch plant* construction scenario, which is representative of the facilities operating in the absence of other construction equipment, and also in the *Excavation scenario*, which includes the concurrent operation of the concrete plant facilities and excavation equipment.

The Stage 1 works within this study area are anticipated to have a total duration of approximately three years.

5.2.3.3 Airborne Noise Impacts from Construction Sites

Number of NML Exceedances

The predicted airborne noise impacts from construction site works 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 when the works are at their nearest.

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 45 Surface Construction Activities and Period of Works

Scenario	Activity		Total Indicative Duration (Weeks)[2]	Maximum Number of Working Faces	Hours of Works[1]				Comments
					Std. Day	Out-of-Hours Works			
						Day OOH	Eve	Night	
Enabling works	'Typical'	Supporting and loading	19	1	✓	-	-	-	-
	'Peak'	Demolition using a rockbreaker	19	2	✓	-	-	-	Rockbreaking works would only occur intermittently during a 19 week period between 7am – 6pm. Total duration of rockbreaking works would be approximately 15 days.
Piling	'Typical'	Supporting works	5	1	✓	-	-	-	-
	'Peak'	Bored piling with support plant	5	2	✓	-	-	-	Piling works would only occur intermittently during a five week period between 7am – 6pm. Up to two piling rigs would be active at the same time.
Earthworks and civil works	'Typical'	General works	38	1	✓	✓	✓	✓	Delivery and stockpiling of spoil would be undertaken on a 24-hour basis. No noise intensive equipment would be used during out of hours periods.
	'Peak'	Noise intensive works	38	2	✓	-	-	-	-
Surface construction	'Typical'	General works	13	1	✓	-	-	-	-
	'Peak'	Noise intensive works	13	2	✓	-	-	-	-
Excavation	'Typical'	Mucking out	35	1	✓	-	-	-	Includes concrete batching plant.
	'Peak'	Through soft soil/rock	5	2	✓	-	-	-	Excavation through soil and soft rock using excavator ripper attachment. Includes concrete batching plant.
		Through rock using rockbreaker	30	2	✓	-	-	-	Excavation through rock using rockbreaker. Works restricted to Standard Construction Hours only. Includes concrete batching plant.
Concrete batch plant	'Typical'	50 percent capacity	143	1	✓	✓	✓	✓	-
	'Peak'	100 percent capacity	143	1	✓	✓	✓	✓	-

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

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

Table 46 Overview of NML Exceedances – All Receiver Types

Scenario		Activity	No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Supporting and loading	19	2764	-	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	19	2764	9	212	37	10	-	-	-	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	5	2764	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	5	2764	-	22	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Earthworks and civil works	'Typical'	General works	38	2764	-	-	-	-	3	-	-	5	-	-	6	-	-	1	-	-
	'Peak'	Noise intensive works	38	2764	-	31	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	13	2764	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	13	2764	-	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Excavation	'Typical'	Mucking out	35	2764	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	5	2764	-	21	1	-	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	30	2764	5	84	14	3	-	-	-	-	-	-	-	-	-	-	-	-
Concrete batch plant	'Typical'	50 percent capacity	143	2764	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-
	'Peak'	100 percent capacity	143	2764	-	-	-	-	-	-	-	3	-	-	25	-	-	-	-	-

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

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

Table 47 Overview of NML Exceedances – Residential Receivers

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Supporting and loading	19	1574	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	19	1574	9	153	20	5	-	-	-	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	5	1574	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	5	1574	-	11	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Earthworks and civil works	'Typical'	General works	38	1574	-	-	-	-	3	-	-	5	-	-	6	-	-	1	-	-
	'Peak'	Noise intensive works	38	1574	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	13	1574	-	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	13	1574	-	9	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Excavation	'Typical'	Mucking out	35	1574	5	39	5	3	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	5	1574	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	30	1574	-	14	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Concrete batch plant	'Typical'	50 percent capacity	143	1574	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-
	'Peak'	100 percent capacity	143	1574	-	-	-	-	-	-	-	3	-	-	25	-	-	-	-	-

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

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

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

Scenario	Activity		No. Weeks[1]	Number of Receivers																				
				Commercial			Child Care			Educational			Place of Worship			Stables			Hotel (Daytime)			Hotel (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	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
Enabling works	'Typical'	Supporting and loading	19	-	-	-	1	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	19	20	3	-	5	2	-	19	2	-	1	-	-	12	10	5	2	-	-	-	-	-
Piling	'Typical'	Supporting works	5	-	-	-	1	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	5	-	-	-	1	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-	-	-
Earthworks and civil works	'Typical'	General works	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	38	1	-	-	2	-	-	1	-	-	-	-	-	13	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	13	-	-	-	1	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-
Excavation	'Typical'	Mucking out	35	-	-	-	1	-	-	-	-	-	-	-	-	11	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	5	-	-	-	1	-	-	-	-	-	-	-	-	11	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	30	6	-	-	4	1	-	14	-	-	-	-	-	19	8	-	2	-	-	-	-	-
Concrete batch plant	'Typical'	50 percent capacity	143	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	100 percent capacity	143	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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

The above shows the following:

- The Stage 1 construction works are predicted to result in 'high' worst-case noise impacts at the nearest receivers during the higher noise generating activities. The nearest receivers to the site are generally residential and 'other sensitive' receivers at Rosehill Gardens racecourse (ie stables). The worst-case impacts are predicted during *Enabling works* and *Excavation*. These works are, however, limited to Standard Construction Hours and would not occur during the evening or night-time.
- The highest impacts are during 'Peak' scenarios which use noise intensive equipment such as rockbreakers. Rockbreakers would, however, only be used intermittently during demolition works, and the total duration is around 15 days. Excavation works would also require intermittent use of rockbreakers over approximately 30 weeks. When noise intensive equipment is not in use during 'Typical' works, the worst-case impacts are predicted to be reduced to 'minor' or be compliant with the management levels.
- *Piling, Earthworks and civil works* and *Surface construction* works generate less noise and the worst-case impacts at the nearest receivers are predicted to be 'moderate' or 'minor'.
- Works associated with delivery and stockpiling of spoil would occur outside of Standard Construction Hours. The worst-case impacts during the night-time are predicted to be 'minor' at the nearest receivers.
- Works associated with the concrete batch plant and segment production facility would occur outside Standard Construction Hours. The worst-case impacts during the night-time are predicted to be 'minor' at the nearest receivers if the facility operates at 100 percent capacity during, as represented by the 'peak' scenario. The number of 'minor' night-time NML exceedances is substantially reduced when the facility operates at 50 percent capacity.
- Works requiring noise intensive equipment such as rockbreakers are predicted to result in Highly Noise Affected impacts at the nearest residential receivers.
- 'Minor' sleep disturbance impacts are predicted for the nearest residential receivers.

Impacts during Standard Construction Hours

The worst-case impacts during Standard Construction Hours are predicted during noise intensive works. The predicted worst-case daytime impacts in this study area are shown in:

- **Figure 28** – All works, including rockbreakers
- **Figure 29** – All works, not including rockbreakers.

The highest impact works are expected to last for:

- *Enabling works – Demolition using a rockbreaker* – 15 days (actual rockbreaker use)
- *Excavation – Through rock using rockbreaker* – 30 weeks.

Figure 28 Worst-case Daytime Airborne Noise Impacts – All Works, including Rockbreakers

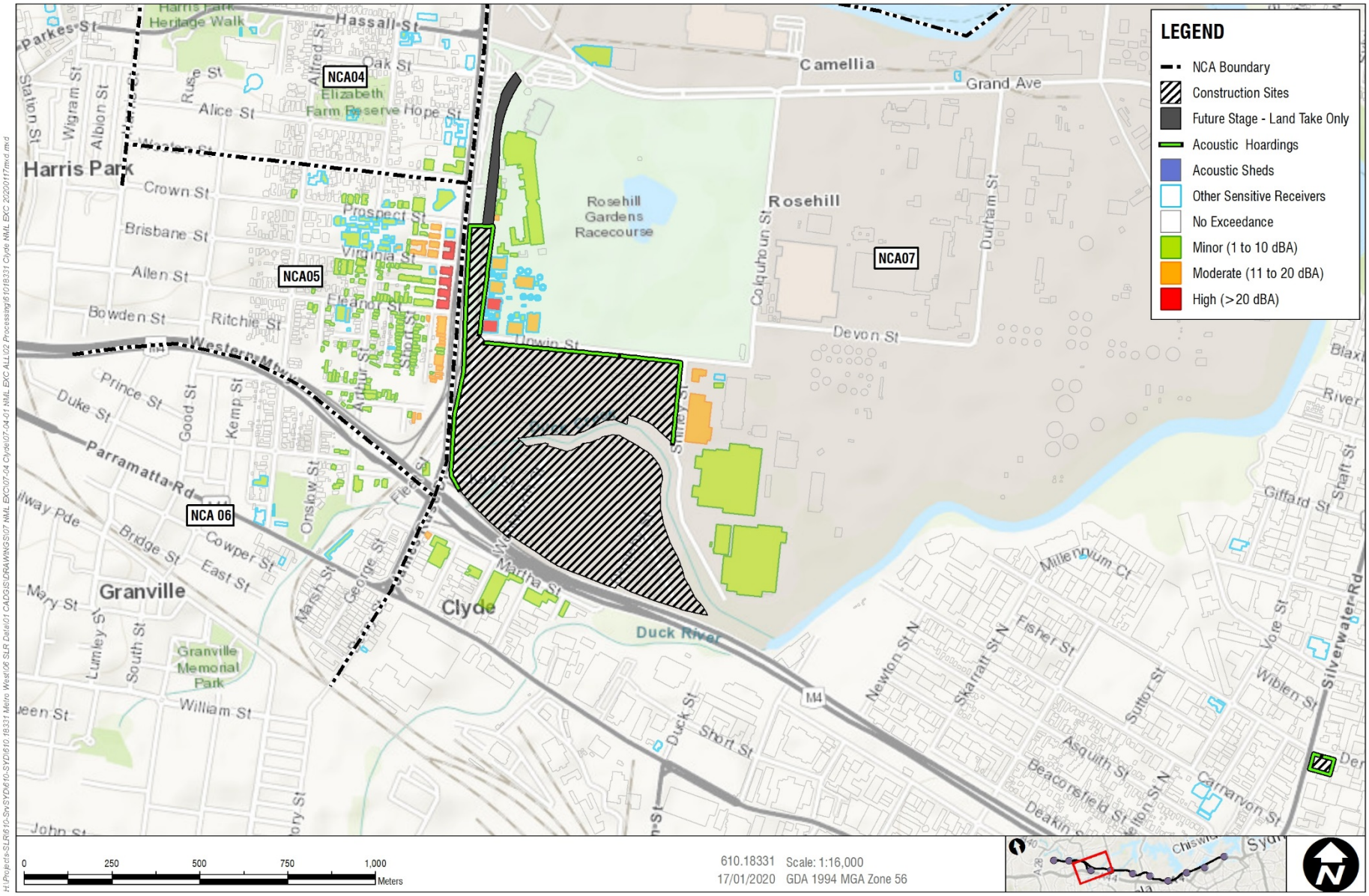
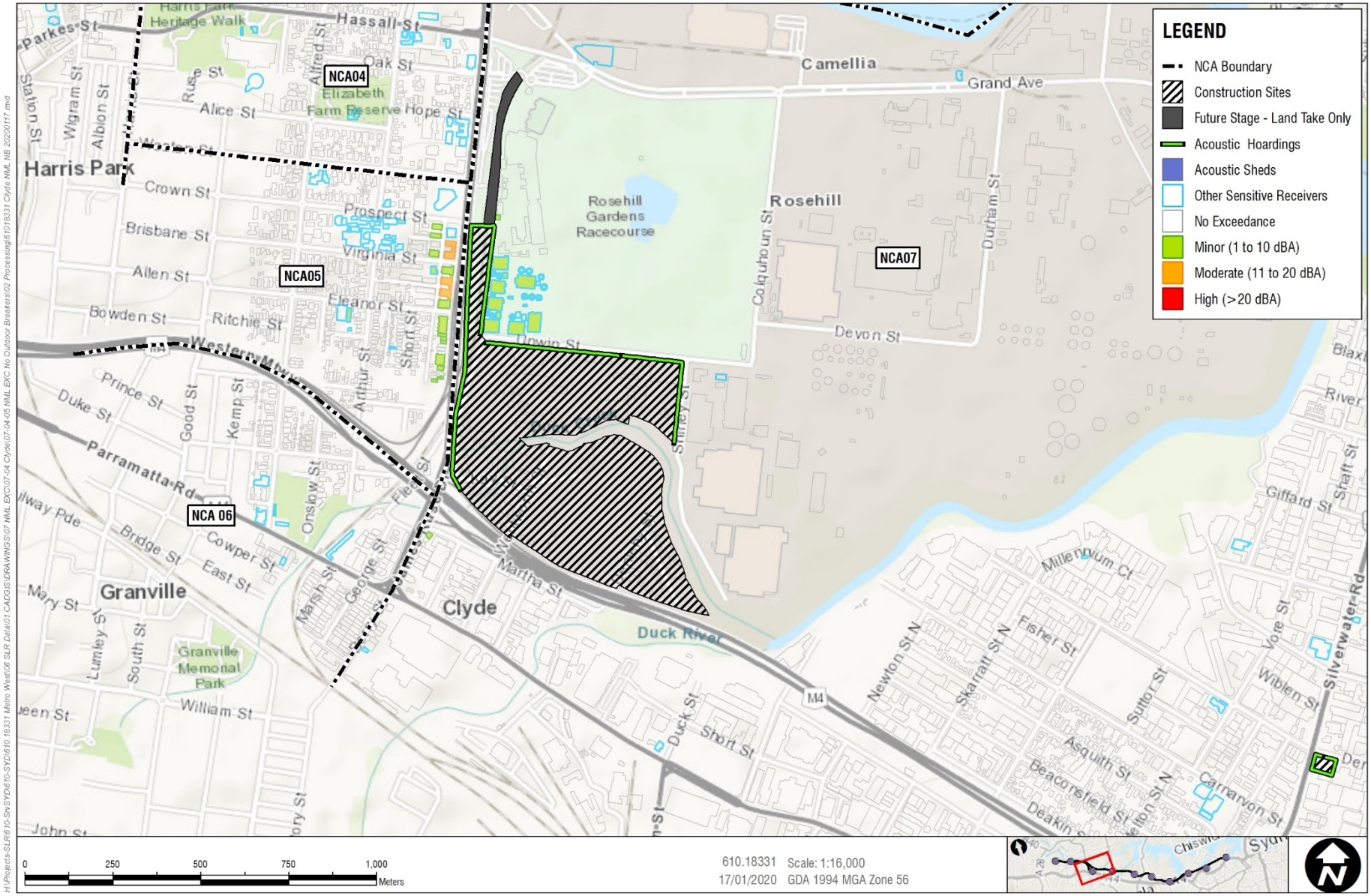


Figure 29 Worst-case Daytime Airborne Noise Impacts – All Works, not including Rockbreakers



The above shows the following:

- The worst-case daytime impacts are predicted during noise intensive works, such as rockbreaking. The impacts are expected to be 'high' at receivers adjacent the site and 'moderate' or 'minor' for receivers which are more distant. The nearest receivers are a mixture of residential and 'other sensitive' and are concentrated around the tunnel dive site.
- The worst-case impacts at 'other sensitive' receivers are predicted to be:
    - 'High' or 'moderate' at several stables at Rosehill Gardens
    - 'Moderate' at Fun2Learn Early Learning Centre and Kinderoo Preschool.
- When rockbreakers are not in use, the impacts are predicted to be substantially lower, with the worst-case impacts being 'moderate' at the closest receivers and 'minor' or compliant in the rest of the study area.

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.

Impacts during the Night-time

Works during the night-time at this construction site would only be associated with delivery and stockpiling of spoil and operation of the concrete batching plant and segment production facility. The predicted worst-case night-time impacts from the assessed scenarios in this study area are shown in:

- **Figure 30** – *Earthworks and civil works – General works* (delivery and stockpiling of spoil)
- **Figure 31** – *Earthworks and civil works – Concrete batch plant* (100 percent capacity)
- **Figure 32** – *Earthworks and civil works – Concrete batch plant* (50 percent capacity).

The delivery and stockpiling works are expected to last for 38 weeks and the concrete batching plant and segment production facility is expected to operate for 143 weeks.

Figure 30 Worst-case Night-time Airborne Noise Impacts – Earthworks and Civil Works, General works (Delivery and Stockpiling of Spoil)

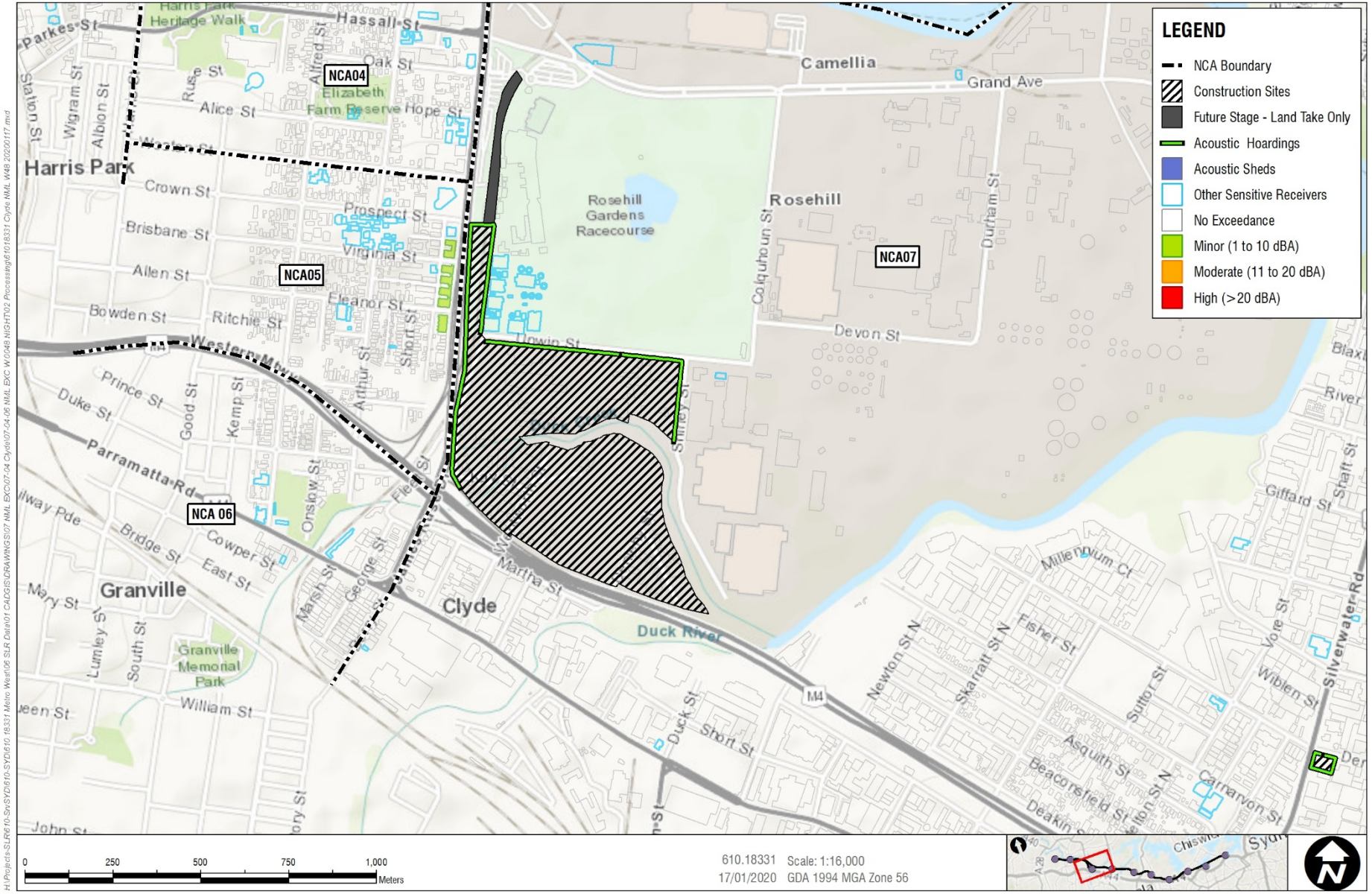


Figure 31 Worst-case Night-time Airborne Noise Impacts – Concrete batch plant (100 percent capacity)

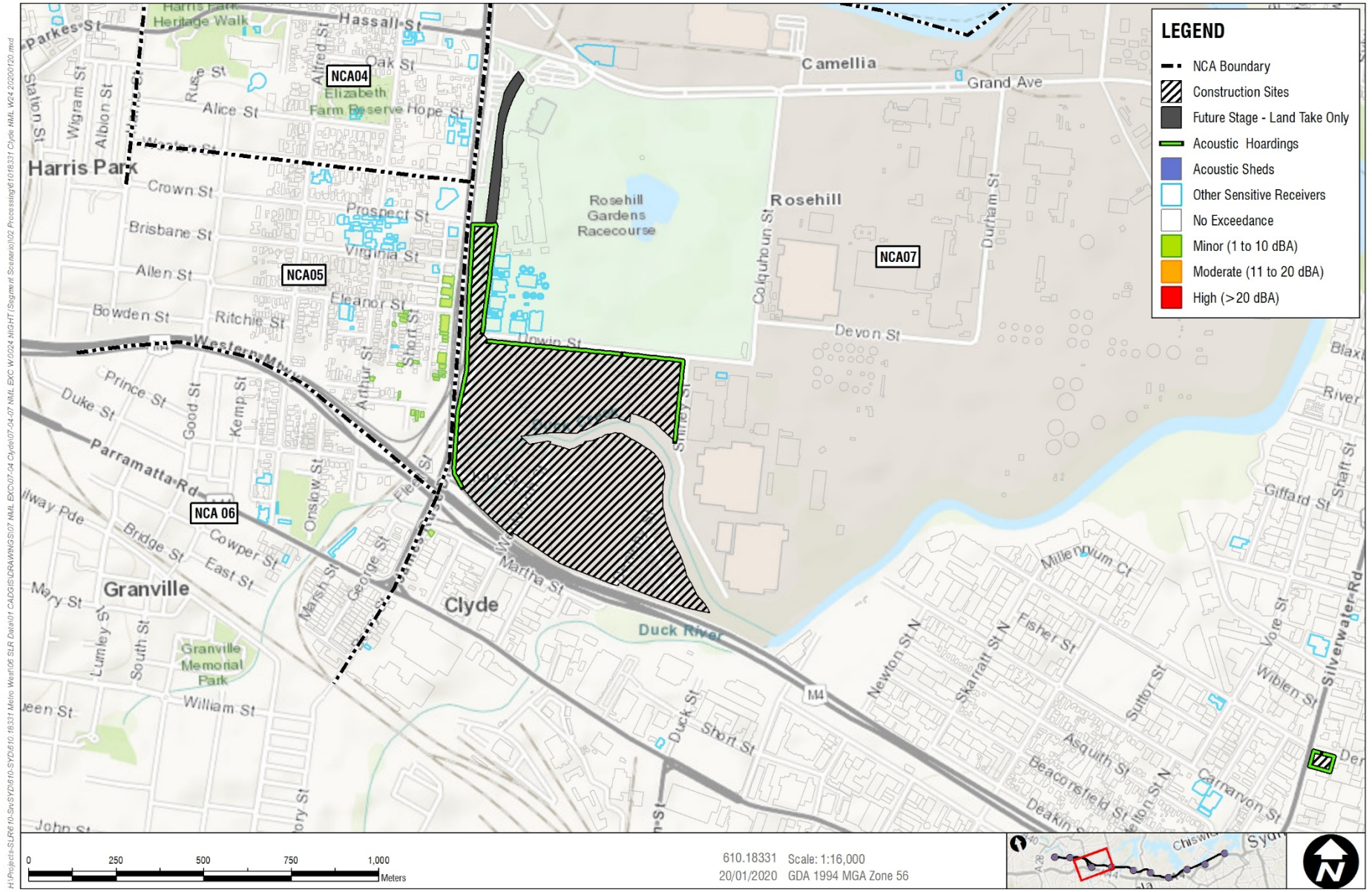
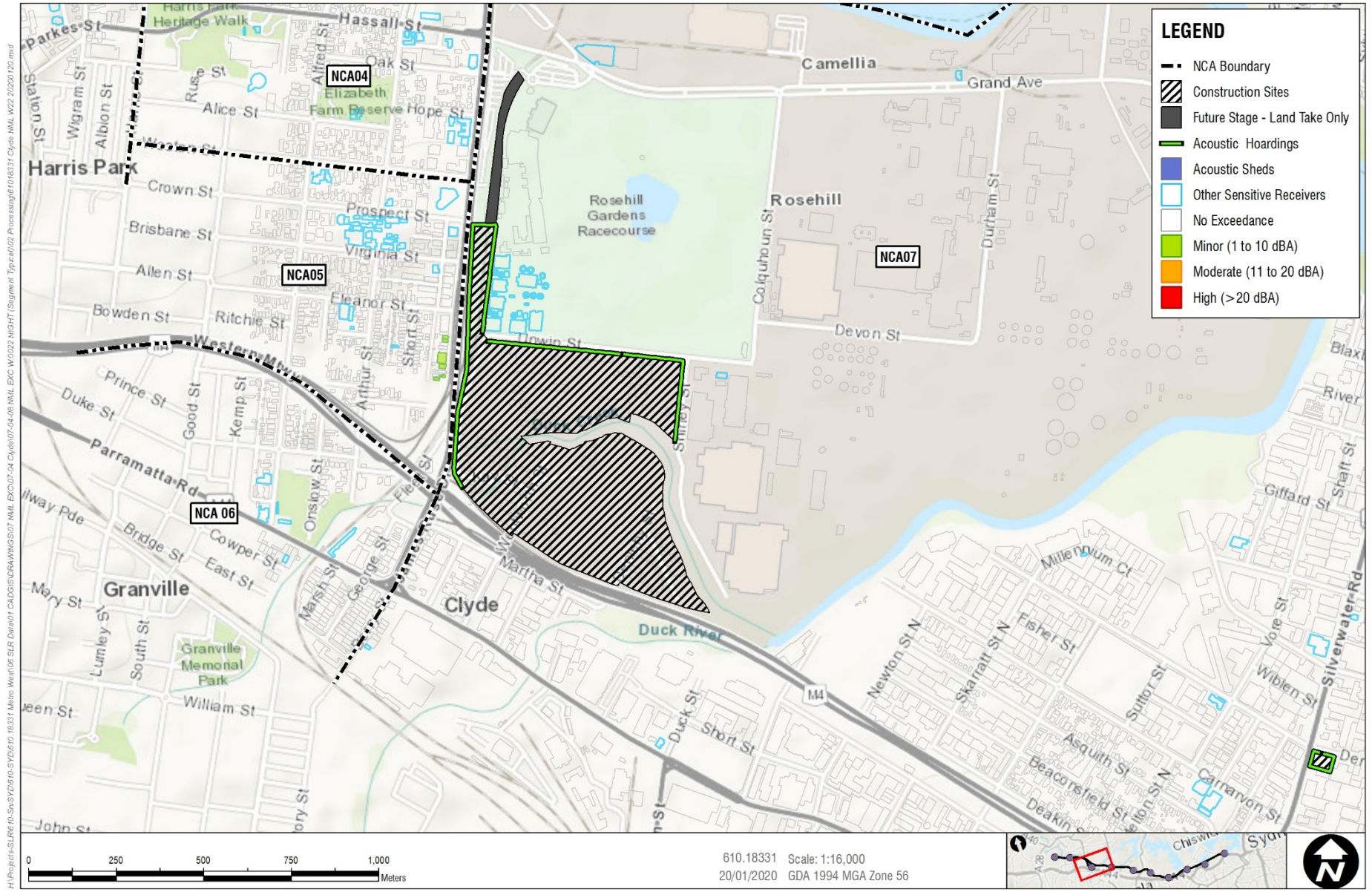


Figure 32 Worst-case Night-time Airborne Noise Impacts – Concrete batch plant (50 percent capacity)



The above shows the following:

- The worst-case night-time noise levels during delivery and stockpiling of spoil are expected to be 'minor' at the residential receivers to the west of the site. Noise levels at the more distant receivers are predicted to comply with management levels.
- The worst impacts during operation of the concrete batch plant and segment production facility are predicted to be 'minor' at the nearest receivers if the facility operates at 100 percent capacity during the night-time period as represented by the 'peak' scenario. The number of exceeding receivers is substantially reduced when the facility operates at 50 percent capacity.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would be periods when 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 8**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed for the construction works and is summarised in **Table 46**.

'Minor' sleep disturbance impacts are predicted at one residential receiver to the west during delivery and stockpiling of spoil.

Sleep disturbance impacts from within the construction site are generally controlled by heavy vehicle movements. It is noted that existing maximum noise levels from heavy vehicles on James Ruse Drive would likely be higher than maximum noise events from the Stage 1 construction site.

The potential awakenings from heavy vehicles would be influenced by the number of heavy vehicles accessing the site during the night-time and the way in which the vehicles are operated. The number of heavy vehicles at the construction site during the night-time is expected to be around 22 heavy vehicles per hour with vehicles accessing the site via the southern entrance on Wentworth Street.

The number of night-time awakenings during construction works would depend on several factors, including the type of vehicles and equipment being used, the duration of the noisy works and the distance of the works to nearest residential receivers. At this early stage in the project the currently available information does not allow for accurate prediction of the extent of night-time awakenings. Further investigation of awakenings would be completed during the next stages of the project when detailed construction planning information becomes available.

Highly Noise Affected Residential Receivers

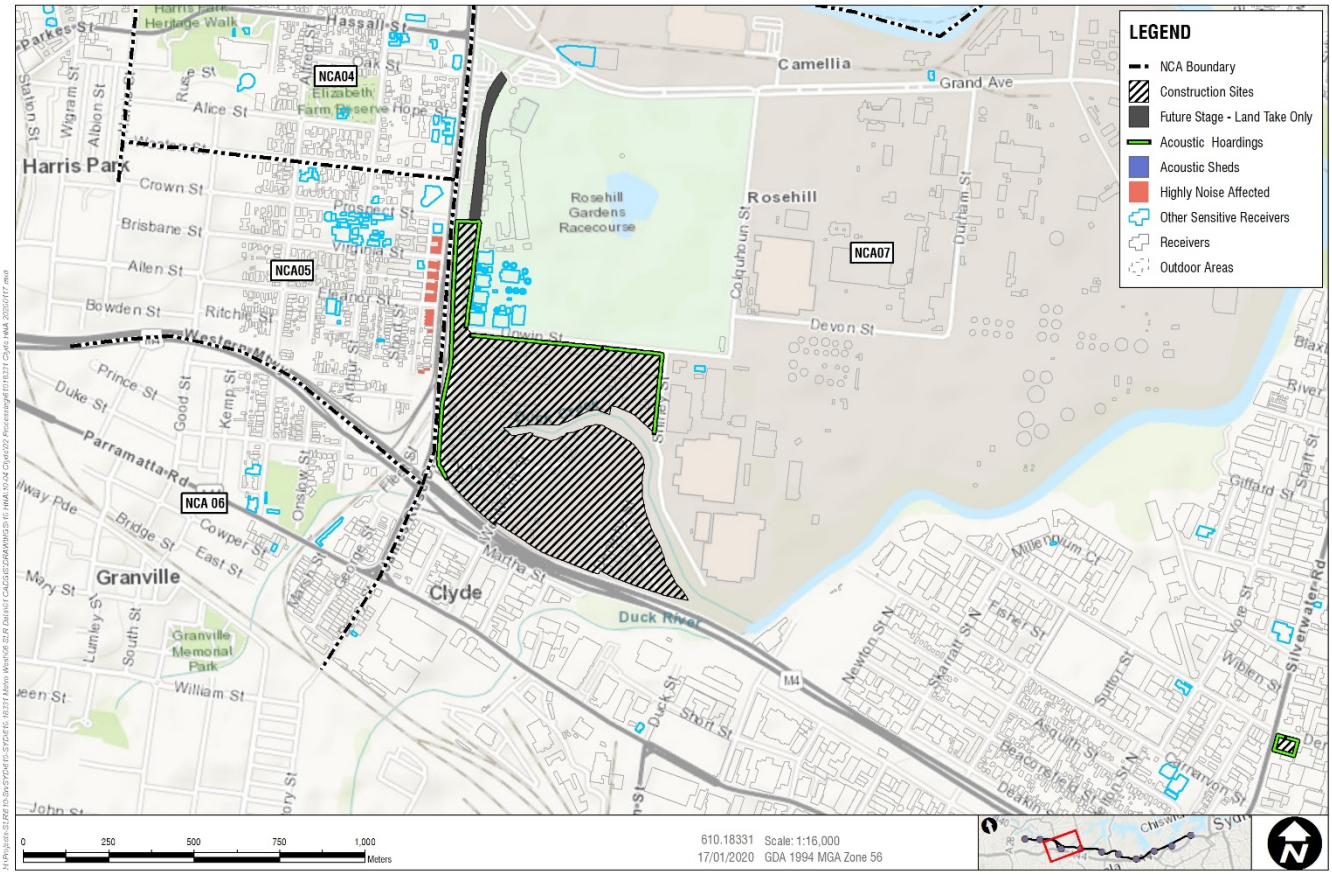
The receivers predicted to be Highly Noise Affected during the worst-case impacts are summarised in **Table 49** and shown in **Figure 33**. The table shows the number of residential receivers separated by works activity and NCA.

Table 49 Predicted Number of Highly Noise Affected Residential Receivers by Works

Scenario	Activity		NCA04, NCA05, NCA06 and NCA07		
			Day	Eve	Night
Enabling works	'Typical'	Supporting and loading	-	n/a	n/a
	'Peak'	Demolition using a rockbreaker	9	n/a	n/a
Piling	'Typical'	Supporting works	-	n/a	n/a
	'Peak'	Bored piling with support plant	-	n/a	n/a
Civil and Earthworks	'Typical'	General works	-	-	-
	'Peak'	Noise intensive works	-	n/a	n/a
Surface Construction	'Typical'	General works	-	n/a	n/a
	'Peak'	Noise intensive works	-	n/a	n/a
Excavation	'Typical'	Mucking out	-	n/a	n/a
	'Peak'	Through soft soil/rock	-	n/a	n/a
		Through rock using rockbreaker	5	n/a	n/a
Concrete batch plant	'Typical'	50 percent capacity	-	-	-
	'Peak'	100 percent capacity	-	-	-

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

Figure 33 Highly Noise Affected Residential Receivers (During Any Works)



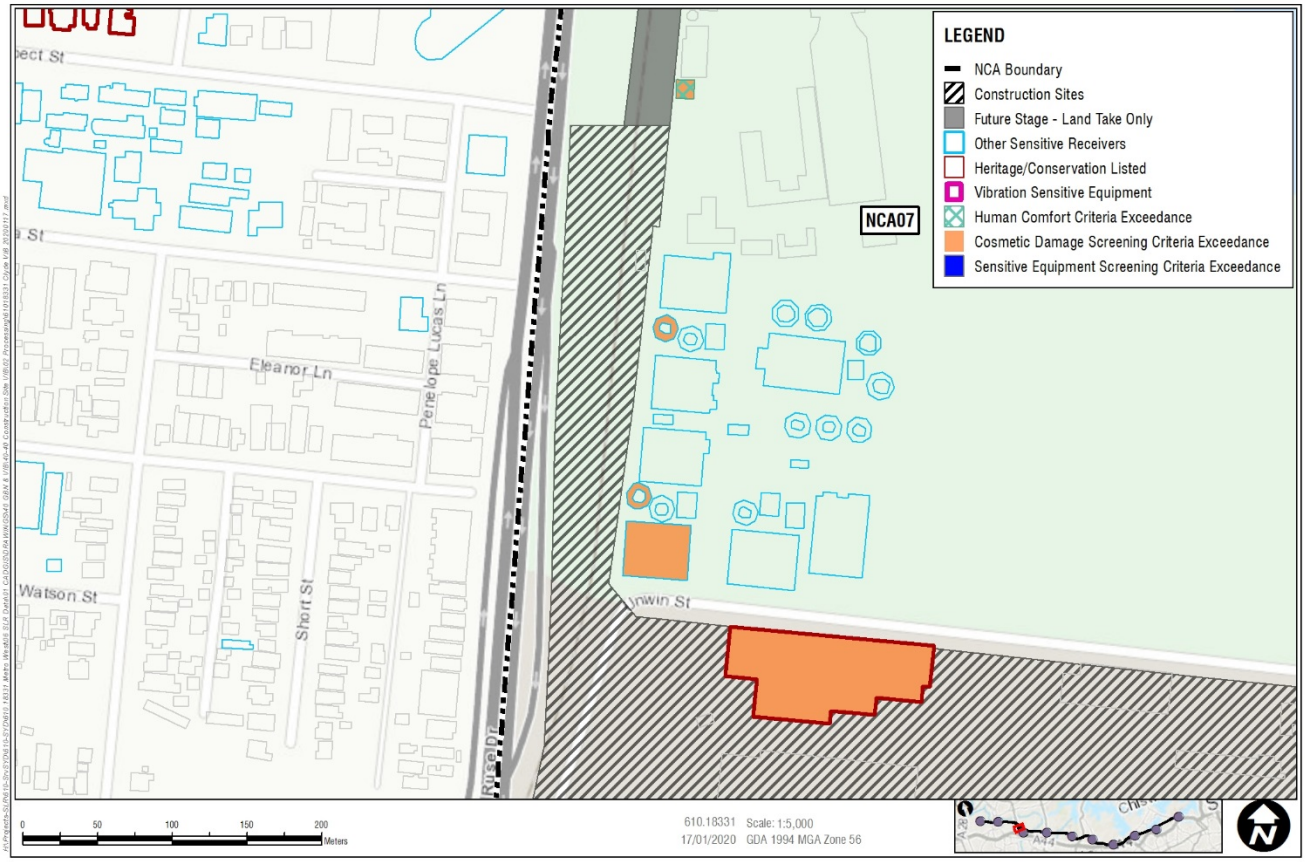
5.2.3.4 Ground-borne Noise Impacts from Construction Sites

Vibration intensive works during shaft excavation at this construction site would not be completed in an acoustic shed (as the works would only be undertaken during the daytime period) 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.

5.2.3.5 Vibration Impacts from Construction Sites

The predicted impacts during vibration intensive works are shown in **Figure 34**. The predictions are representative of the highest vibration levels that would likely be experienced by the nearest receivers when works are at their closest.

Figure 34 Worst-case Vibration Impacts



The above shows the following:

- The cosmetic damage screening criteria are predicted to be exceeded at:
  - One heritage listed building at 1 Unwin Street, Rosehill, located to the north of the site. This building is a heritage listed free-standing building facade and is not occupied.
  - Four commercial buildings at Rosehill Gardens racecourse located east of the existing rail corridor section of the site.

- The human comfort criteria are also predicted to be exceeded at one of the nearest commercial buildings located to the north of the site, meaning 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.

5.2.4 Silverwater Study Area (NCA07)

The Silverwater study area is centred on the Silverwater services facility construction site. Services facilities are shafts which are used to supply future operational services to the tunnels. This study area contains one Noise Catchment Area (NCA07) which covers the area to the north of the M4 Motorway.

The construction site is located in the Silverwater industrial estate, near the intersection of Silverwater Road and Derby Street.

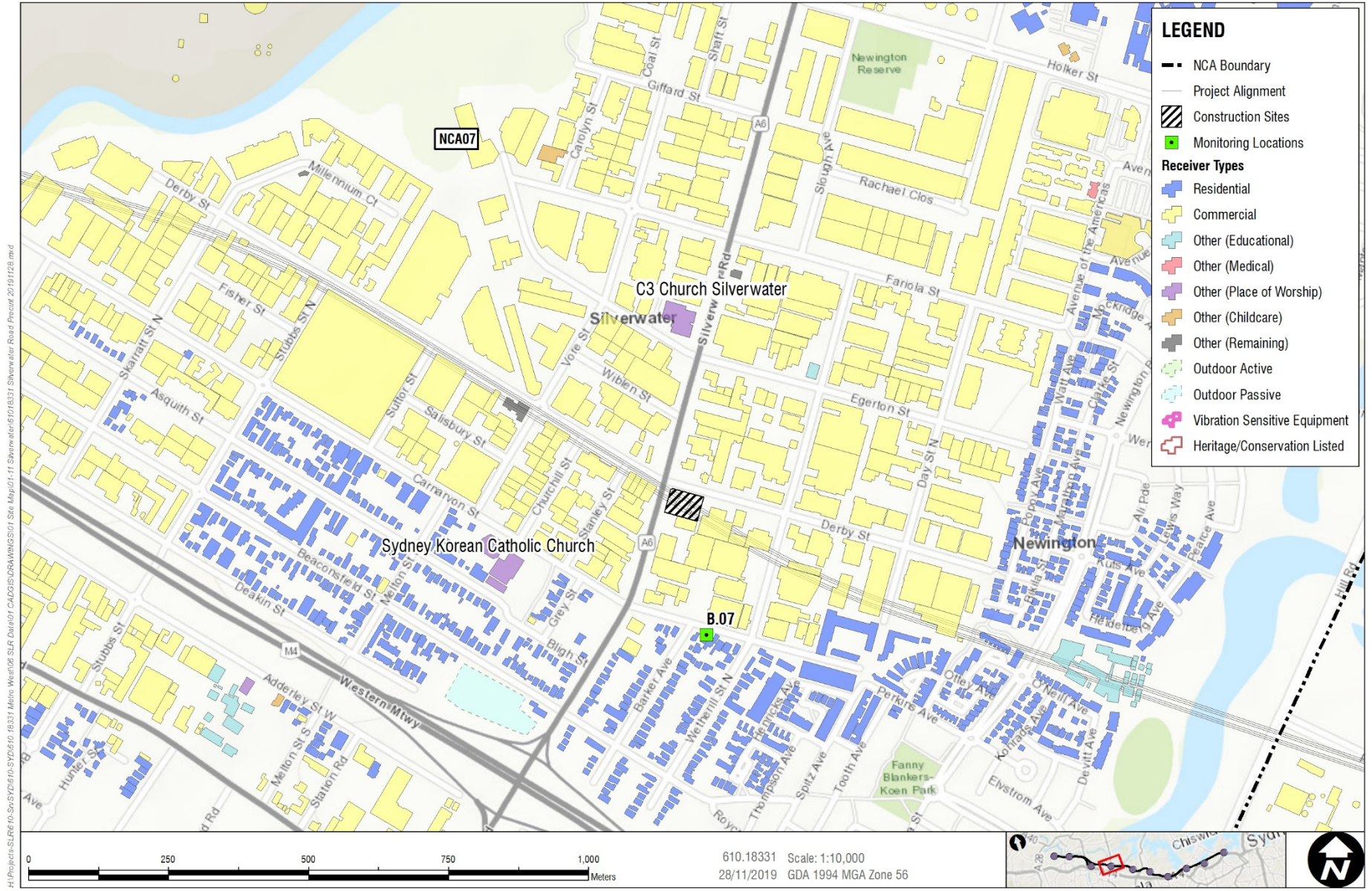
Existing noise levels in this study area are generally controlled by road traffic noise on the surrounding road network and commercial/industrial noise. The area surrounding the construction site is largely commercial.

The NCAs in the Silverwater study area are described below and a map is shown in **Figure 35**.

NCA07

- The nearest receivers are commercial buildings on Silverwater Road and Derby Street. The nearest commercial building is immediately adjacent to the southern boundary of the construction site.
- The nearest residential receivers are around 200 metres to the south, on Carnarvon Street.
- The C3 Church Silverwater is around 270 metres to the north and the Sydney Korean Catholic Church is 300 metres to the south-west.

Figure 35 Site Map, Works and Sensitive Receivers



5.2.4.2 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 during this period and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

Works in this study area would generally only occur during daytime hours. The Stage 1 works within this study area are anticipated to have a total duration of approximately 39 weeks.

5.2.4.3 Airborne Noise Impacts from Construction Sites

Number of NML Exceedances

The predicted airborne noise impacts from construction site works 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 when the works are at their nearest.

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 50 Surface construction Activities and Period of Works

Scenario	Activity		Total Indicative Duration (Weeks)[2]	Maximum Number of Working Faces	Hours of Works[1]				Comments
					Std. Day	Out-of-Hours Works			
						Day OOH	Eve	Night	
Enabling works	'Typical'	Delivery of equipment	4	1	✓	✓	-	-	The construction site is currently vacant meaning no site clearing or demolition works would be required. Enabling works would be limited to general site mobilization activities.
	'Peak'	Assembly of site facilities	4	1	✓	✓	-	-	
Piling	'Typical'	Supporting works	4	1	✓	✓	-	-	-
	'Peak'	Bored piling with support plant	4	2	✓	✓	-	-	Piling works would only occur intermittently during a four week period between 7am – 6pm. Up to two piling rigs would be active at the same time.
Excavation	'Typical'	Mucking out	10	1	✓	✓	-	-	-
	'Peak'	Through soft soil/rock	4	2	✓	✓	-	-	Excavation through soil and soft rock using excavator ripper attachment.
		Through rock using rockbreaker	6	2	✓	✓	-	-	Excavation through rock using rockbreaker. Works restricted to daytime hours only.

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

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

Table 51 Overview of NML Exceedances – All Receiver Types

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Delivery of equipment	4	2761	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Assembly of site facilities	4	2761	-	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	4	2761	-	2	-	-	2	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	4	2761	-	2	1	-	3	1	-	-	-	-	-	-	-	-	-	-
Excavation	'Typical'	Mucking out	10	2761	-	1	1	-	1	1	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	4	2761	-	7	1	-	8	1	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	6	2761	-	14	3	-	28	3	-	-	-	-	-	-	-	-	-	-

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

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

Table 52 Overview of NML Exceedances – Residential Receivers

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Delivery of equipment	4	1571	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Assembly of site facilities	4	1571	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	4	1571	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	4	1571	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Excavation	'Typical'	Mucking out	10	1571	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	4	1571	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	6	1571	-	-	-	-	14	-	-	-	-	-	-	-	-	-	-	-

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

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

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

Scenario	Activity		No. Weeks[1]	Number of Receivers								
				Commercial			Child Care			Place of Worship		
				1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
Enabling works	'Typical'	Delivery of equipment	4	1	-	-	-	-	-	-	-	-
	'Peak'	Assembly of site facilities	4	2	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	4	2	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	4	2	1	-	-	-	-	-	-	-
Excavation	'Typical'	Mucking out	10	1	1	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	4	6	1	-	-	-	-	1	-	-
		Through rock using rockbreaker	6	13	3	-	-	-	-	1	-	-

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

The above shows the following:

- The Stage 1 construction works are predicted to result in 'moderate' worst-case noise impacts at the nearest receivers during higher noise generating activities. The nearest receivers to the site are commercial and the worst-case impacts are predicted during *Excavation*. These works are would only be completed during the daytime.
- The highest impacts are during 'Peak' scenarios which use noise intensive equipment such as rockbreakers. When noise intensive equipment is not in use during 'Typical' works, the worst-case impacts are predicted to be reduced with much fewer exceeding receivers.
- *Enabling works* and *Piling* generate less noise and the worst-case impacts at the nearest receivers are generally predicted to be 'minor'.
- The nearest residential receivers are predicted to have 'minor' worst-case impacts during the noisiest scenario.
- No works are proposed at this site during the evening or night-time.
- No residential receivers are predicted to be Highly Noise Affected during the works.

Impacts during Standard Construction Hours

The worst-case impacts during Standard Construction Hours are predicted during noise intensive works. The predicted worst-case daytime impacts in this study area are shown in:

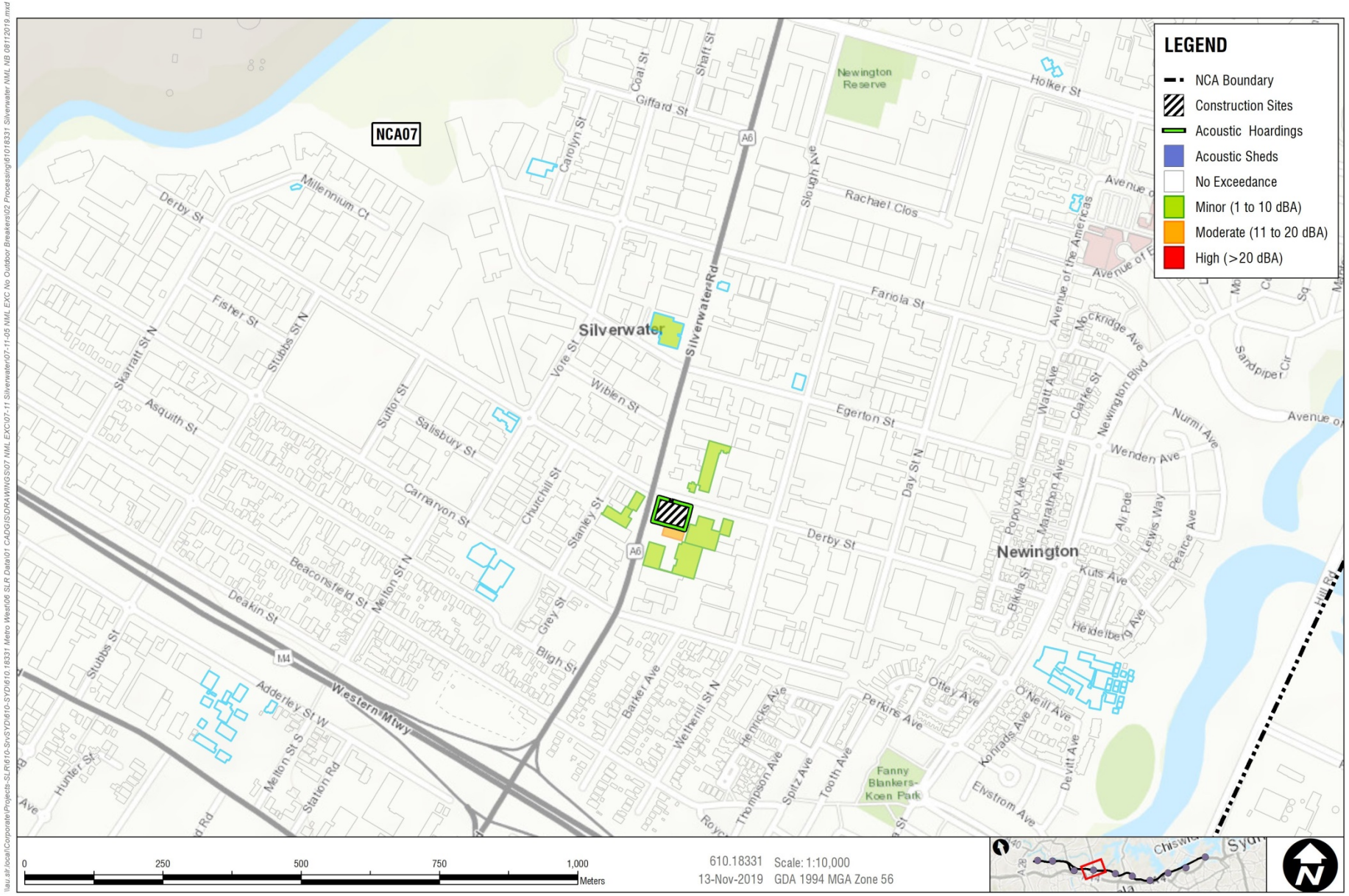
- **Figure 36** – All works, including rockbreakers
- **Figure 37** – All works, not including rockbreakers.

The highest impact works are expected to last for:

- *Excavation – Through rock using rockbreaker* – six weeks.

Figure 36 Worst-case Daytime Airborne Noise Impacts – All Works, including Rockbreakers

Figure 37 Worst-case Daytime Airborne Noise Impacts – All Works, not including Rockbreakers



The above shows the following:

- The worst-case daytime impacts are predicted during noise intensive works, such as rockbreaking. The impacts are expected to be 'moderate' at the nearest receivers to the site and 'minor' at the more distant receivers. The nearest receivers are commercial.
- The worst-case impacts at 'other sensitive' receivers are predicted to be 'minor' at C3 Church Silverwater, north of the site.
- When rockbreakers are not in use, the noise levels are predicted to be substantially lower, with the worst-case impacts generally predicted to reduce to 'minor' or compliant with the management levels at the surrounding 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.

Impacts during Daytime Out of Hours

The results in **Table 52** show that the predicted impacts during Daytime Out of Hours periods affect a wider area of receivers but are generally comparable to those for Standard Construction Hours. The impacts affect more receivers due to the Daytime Out of Hours criteria being 5 dB more stringent.

Impacts during the Night-time and Sleep Disturbance

No works are proposed at this construction site during the night-time.

Highly Noise Affected Residential Receivers

No receivers are predicted to be Highly Noise Affected in this study area by the works.

5.2.4.4 Ground-borne Noise Impacts from Construction Sites

Vibration intensive works during shaft excavation at this construction site would not be completed in an acoustic shed (as the works would only be undertaken during the daytime period) 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 the ground-borne noise levels it is not necessary to evaluate potential ground-borne noise impacts.

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

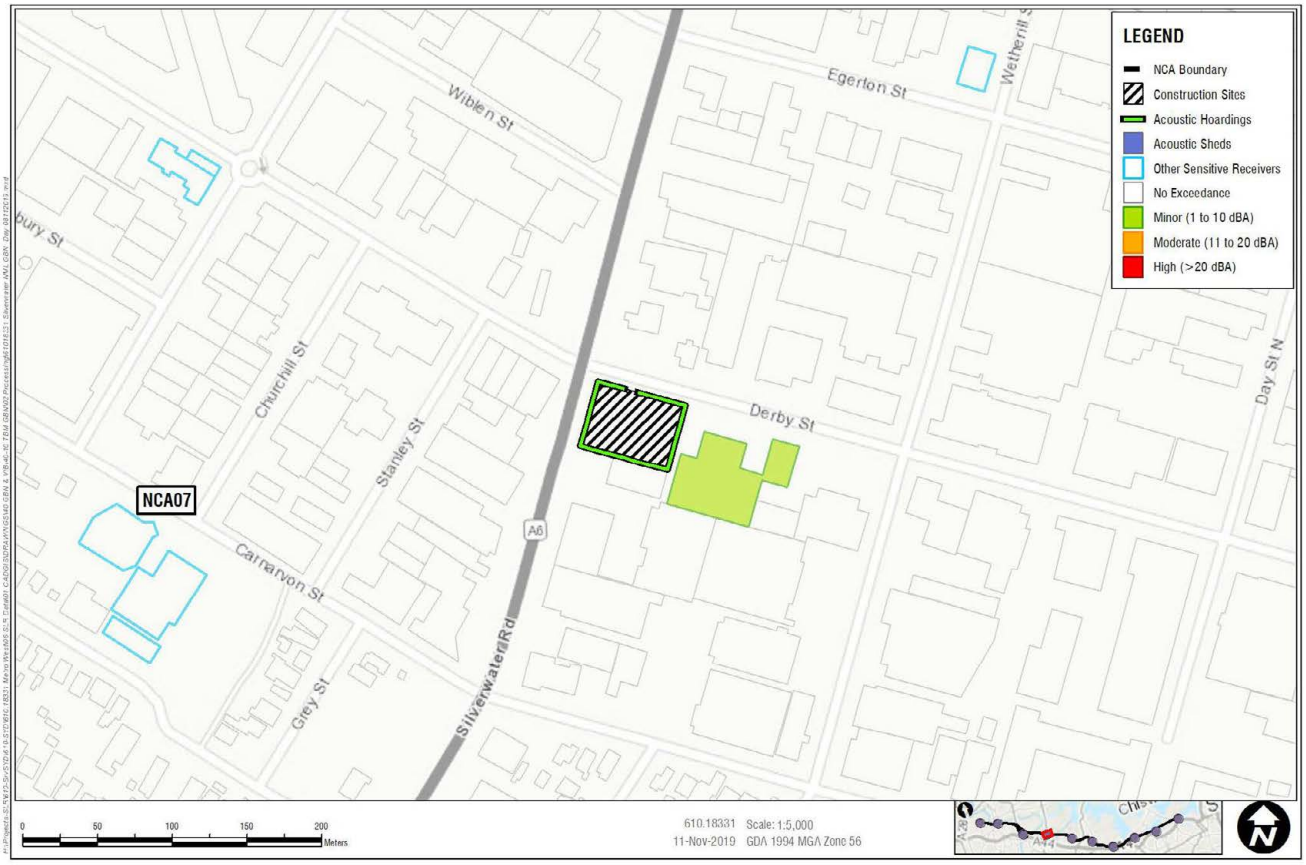
On this basis, ground-borne noise levels have been assessed at this site and the worst-case impacts are summarised in **Table 54** and shown in **Figure 38**. The predictions are representative of the highest ground-borne noise levels that would likely be experienced by the nearest receivers when excavation works are at their closest.

Table 54 Overview of Ground-borne NML Exceedances

NCA	Receiver Classification	Number of Receivers									
		Total	With NML Exceedance[1]								
			Daytime			Out-of-Hours Works					
						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
NCA07	Residential	167	-	-	-	-	-	-	-	-	-
	Commercial	217	1	-	-	-	-	-	-	-	-
	Other Sensitive	44	-	-	-	-	-	-	-	-	-

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

Figure 38 Ground-borne Noise Impacts – Daytime Construction Hours



The above shows the following:

- Vibration intensive works are predicted to result in 'minor' worst-case ground-borne noise impacts during the daytime at one commercial building located to the east of the site.
- Vibration intensive shaft excavation works inside the acoustic shed are anticipated to occur for six weeks. The predictions represent the worst-case scenario when shaft excavation works are at surface level and are, therefore, at the closest point to the affected buildings. As the works progress deeper, the impacts are expected to be reduce.

5.2.4.5 Vibration Impacts from Construction Sites

The predicted impacts during vibration intensive works are shown in **Figure 39**. The predictions are representative of the highest vibration levels that would likely be experienced by the nearest receivers when works are at their closest.

Figure 39 Worst-case Vibration Impacts

The above shows the following:

- The cosmetic damage screening criteria are predicted to be exceeded at the nearest commercial building located to the south of the site.
- The human comfort criteria are also predicted to be exceeded at the two nearest buildings, meaning 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.

5.2.5 Olympic Park Study Area (NCA08 and NCA09)

The Olympic Park study area is centred on the Sydney Olympic Park metro station construction site. This study area contains two noise catchments (NCA08 and NCA09).

The construction site is located off Olympic Boulevard, to the south of the existing Olympic Park Rail Station. The existing T7 Olympic Park Line circles around the construction site. The line is in tunnels under Dawn Fraser Avenue and Olympic Boulevard but is above ground alongside Sarah Durack Avenue and near to residential receivers on Australia Avenue.

Existing noise levels in this study area are controlled by distant road traffic noise from the M4 Motorway and Homebush Bay Drive, some rail noise, and general noise from the sports and entertainment complex.

Sydney Olympic Park has a number of open-air sports 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 stadiums are also used for special events such as music festivals and concerts, which can also result in high levels of noise during the daytime, evening and parts of the night-time.

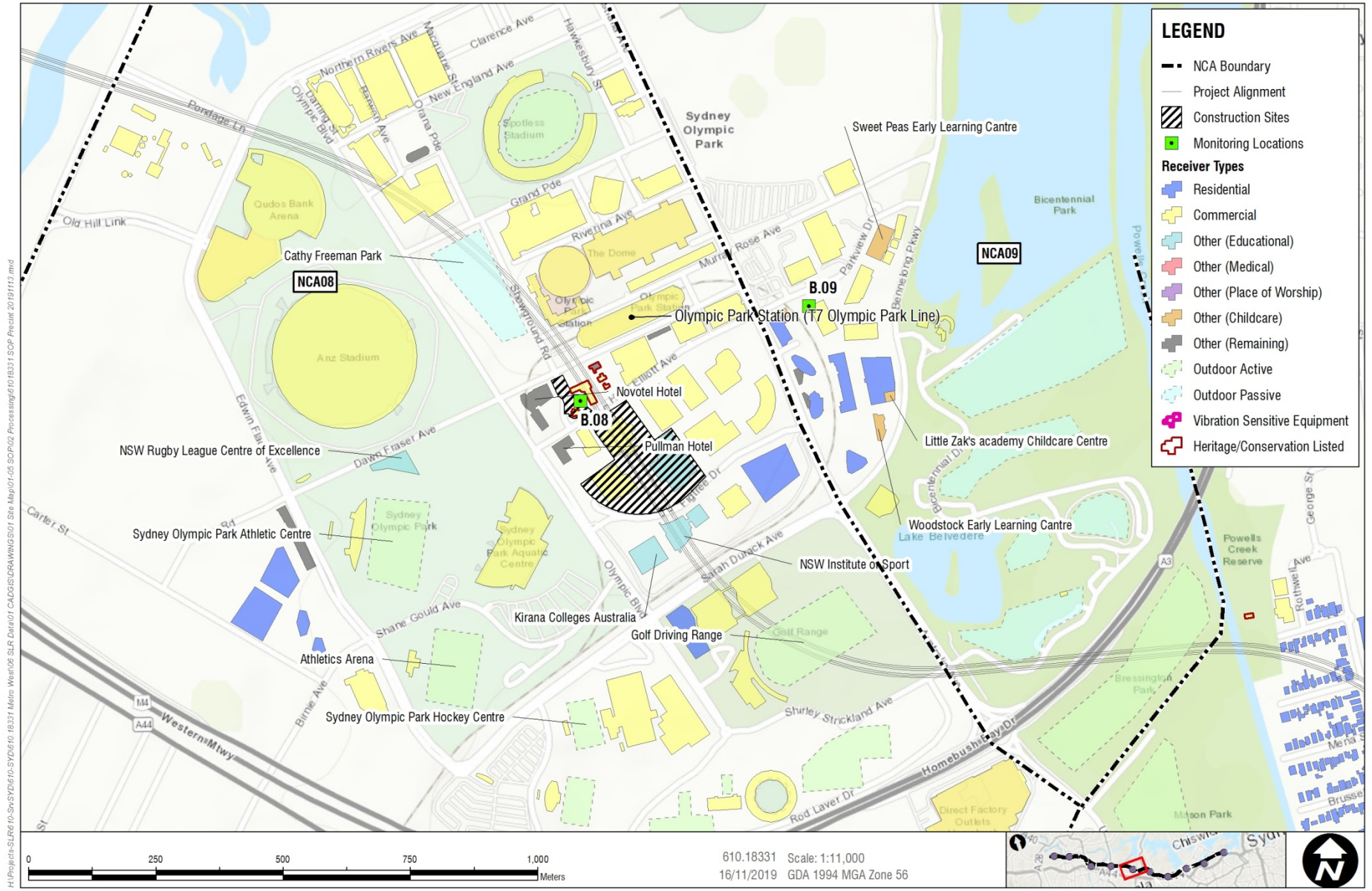
The area surrounding the construction site is mainly commercial with receivers typically being of office or retail use.

The NCAs in the Olympic Park study area are described below and a map is shown in **Figure 40**.

NCA08 and NCA09

- The nearest receivers to the site are several commercial buildings on Dawn Fraser Avenue, Olympic Boulevard, Herb Elliott Avenue and Figtree Drive. The buildings to the east and south are generally offset by at least 20 metres, however, two commercial buildings to north and west are adjacent the site boundary.
- Two hotels (Novotel Sydney Olympic Park and Pullman at Sydney Olympic Park) are located close to the western boundary.
- The nearest resident receivers are an apartment building that is around 70 metres to the south-east on Sarah Durack Avenue. Further residential towers are to east, however, these are over 200 metres away.
- Four outdoor sporting fields are located within around 500 metres of the site, including Sydney Olympic Park Athletic Centre, an athletics arena, Sydney Olympic Park Hockey Centre and a golf driving range.
- The Cathy Freeman Park outdoor passive recreation area is located around 150 metres north-west of the construction site between Showground Road and Olympic Boulevard.
- The New South Wales Rugby League Centre of Excellence educational building is located 350 metres west of the construction site on Dawn Fraser Avenue.
- The Australian College of Physical Education and the NSW Institute of Sport educational facilities are around 50 metres and 25 metres to the south of the construction site, respectively.

Figure 40 Site Map, Works and Sensitive Receivers



5.2.5.2 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 during this period and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

This site is proposed to be used as a TBM retrieval site. The main excavation works at this construction site would be completed in acoustic sheds.

The Stage 1 works within this study area are anticipated to have a total duration of approximately three and a half years.

5.2.5.3 Airborne Noise Impacts from Construction Sites

Number of NML Exceedances

The predicted airborne noise impacts from construction site works 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 when the works are at their nearest.

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 55 Surface Construction Activities and Period of Works

Scenario	Activity		Total Indicative Duration (Weeks)[3]	Maximum Number of Working Faces	Hours of Works[1,2]				Comments
					Std. Day	Out-of-Hours Works			
						Day OOH	Eve	Night	
Enabling works	'Typical'	Supporting and loading	13	1	✓	-	-	-	-
	'Peak'	Demolition using a rockbreaker	13	2	✓	-	-	-	Rockbreaking works would only occur intermittently during a 13 week period between 7am – 6pm. Total duration of rockbreaking works would be approximately 10 days.
Piling	'Typical'	Supporting works	28	2	✓	-	-	-	-
	'Peak'	Bored piling with support plant	28	4	✓	-	-	-	Piling works would only occur intermittently during a 28 week period between 7am – 6pm. Up to four piling rigs would be active at the same time.
Surface construction	'Typical'	General works	20	1	✓	-	-	-	-
	'Peak'	Noise intensive works	20	2	✓	-	-	-	-
Initial excavation	'Typical'	Mucking out	4	1	✓	-	-	-	-
	'Peak'	Through soft soil/rock	2	2	✓	-	-	-	Excavation through soil and soft rock using excavator ripper attachment, before construction of the acoustic sheds.
		Through rock using rockbreaker	2	2	✓	-	-	-	Excavation through rock using rockbreaker, before construction of the acoustic sheds. Works restricted to Standard Construction Hours only.
Excavation with sheds	'Typical'	Mucking out	33	1	✓	✓	✓	✓	Out of hours works would only occur once the acoustic sheds and acoustic panels (where appropriate) have been constructed.
	'Peak'	Through rock using rockbreaker	33	2	✓	✓	✓	✓	
TBM retrieval	'Typical'	Deliveries and on/off loading	7	1	✓	✓	✓	✓	Four TBMs would be retrieved from the Sydney Olympic Park metro station construction site within a period of around one year.
	'Peak'	TBM disassembly	7	2	✓	✓	✓	✓	

Note 1: Noise intensive works outside of Standard Construction Hours would only occur after construction of the acoustic sheds.

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

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

Table 56 Overview of NML Exceedances – All Receiver Types

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Supporting and loading	13	99	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	13	99	-	21	8	1	-	-	-	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	28	99	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	28	99	-	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	20	99	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	20	99	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial excavation	'Typical'	Mucking out	4	99	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	2	99	-	6	1	-	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	2	99	-	21	6	1	-	-	-	-	-	-	-	-	-	-	-	-
Excavation with sheds	'Typical'	Mucking out (Doors Closed)	33	99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through rock using rockbreaker (Doors Closed)	33	99	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
		Through rock using rockbreaker (Doors Open)	33	99	-	6	-	-	8	-	-	4	-	-	7	-	-	1	-	-
TBM retrieval	'Typical'	Deliveries and on/off loading	7	99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	TBM disassembly	7	99	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

Table 57 Overview of NML Exceedances – Residential Receivers

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Supporting and loading	13	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	13	10	-	5	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	28	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	28	10	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	20	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Initial excavation	'Typical'	Mucking out	4	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	2	10	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	2	10	-	5	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Excavation with sheds	'Typical'	Mucking out (Doors Closed)	33	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through rock using rockbreaker (Doors Closed)	33	10	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
		Through rock using rockbreaker (Doors Open)	33	10	-	-	-	-	2	-	-	4	-	-	6	-	-	1	-	-
TBM retrieval	'Typical'	Deliveries and on/off loading	7	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	TBM disassembly	7	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

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

Scenario	Activity		No. Weeks[1]	Number of Receivers																				
				Commercial			Café/bar			Child Care			Educational			Passive Recreation			Hotel (Daytime)			Hotel (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	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
Enabling works	'Typical'	Supporting and loading	13	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	13	7	4	-	1	-	-	4	-	-	1	1	1	1	-	-	2	-	-	-	-	-
Piling	'Typical'	Supporting works	28	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	28	2	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	20	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	20	1	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
Initial excavation	'Typical'	Mucking out	4	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	2	2	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	2	7	2	-	1	-	-	4	-	-	1	1	1	1	-	-	2	-	-	-	-	-
Excavation with sheds	'Typical'	Mucking out (Doors Closed)	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through rock using rockbreaker (Doors Closed)	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker (Doors Open)	33	5	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
TBM retrieval	'Typical'	Deliveries and on/off loading	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	TBM disassembly	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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

The above shows the following:

- The Stage 1 construction works are generally predicted to result in 'moderate' or 'high' worst-case noise impacts at the nearest receivers during the higher noise generating activities. The nearest receivers to the site are generally commercial and the worst-case impacts are predicted during *Enabling works* and *Initial excavation* which would occur before the acoustic sheds are constructed. These works are, however, limited to Standard Construction Hours and would not occur during the evening or night-time.
- The highest impacts are during 'Peak' scenarios which use noise intensive equipment such as rockbreakers. Rockbreakers would, however, only be used outdoors intermittently and the duration is around 10 days during *Enabling works* and two weeks during *Initial excavation* works. When noise intensive equipment is not in use during 'Typical' works, the worst-case impacts are predicted to generally be reduced to 'minor' or 'moderate' at the nearest receivers.
- *Piling, Surface construction* and *Excavation with sheds* works generate less noise and the worst-case impacts at the nearest receivers are predicted to be 'moderate' or 'minor', but affecting much fewer receivers. These works would also be completed prior to the acoustic sheds being built during Standard Construction Hours.
- *TBM retrieval* works are predicted to be compliant with the management levels during all periods.
- Noise intensive outside of Standard Construction Hours would only be completed in the acoustic sheds once built. The worst-case impacts from works in the sheds during the night-time are predicted to be 'minor' at one receiver during *Excavation with shed* when rockbreakers are in use and the shed doors are closed. When rockbreakers are in use and the doors are open seven receivers are predicted to have 'minor' impacts.
- No residential receivers are predicted to be Highly Noise Affected during the works.
- 'Minor' sleep disturbance impacts are predicted at the nearest residential receiver during the noisiest scenario.

Impacts during Standard Construction Hours

The worst-case impacts during Standard Construction Hours are predicted when noise intensive works occur before construction of the acoustic sheds. The predicted worst-case daytime impacts in this study area are shown in:

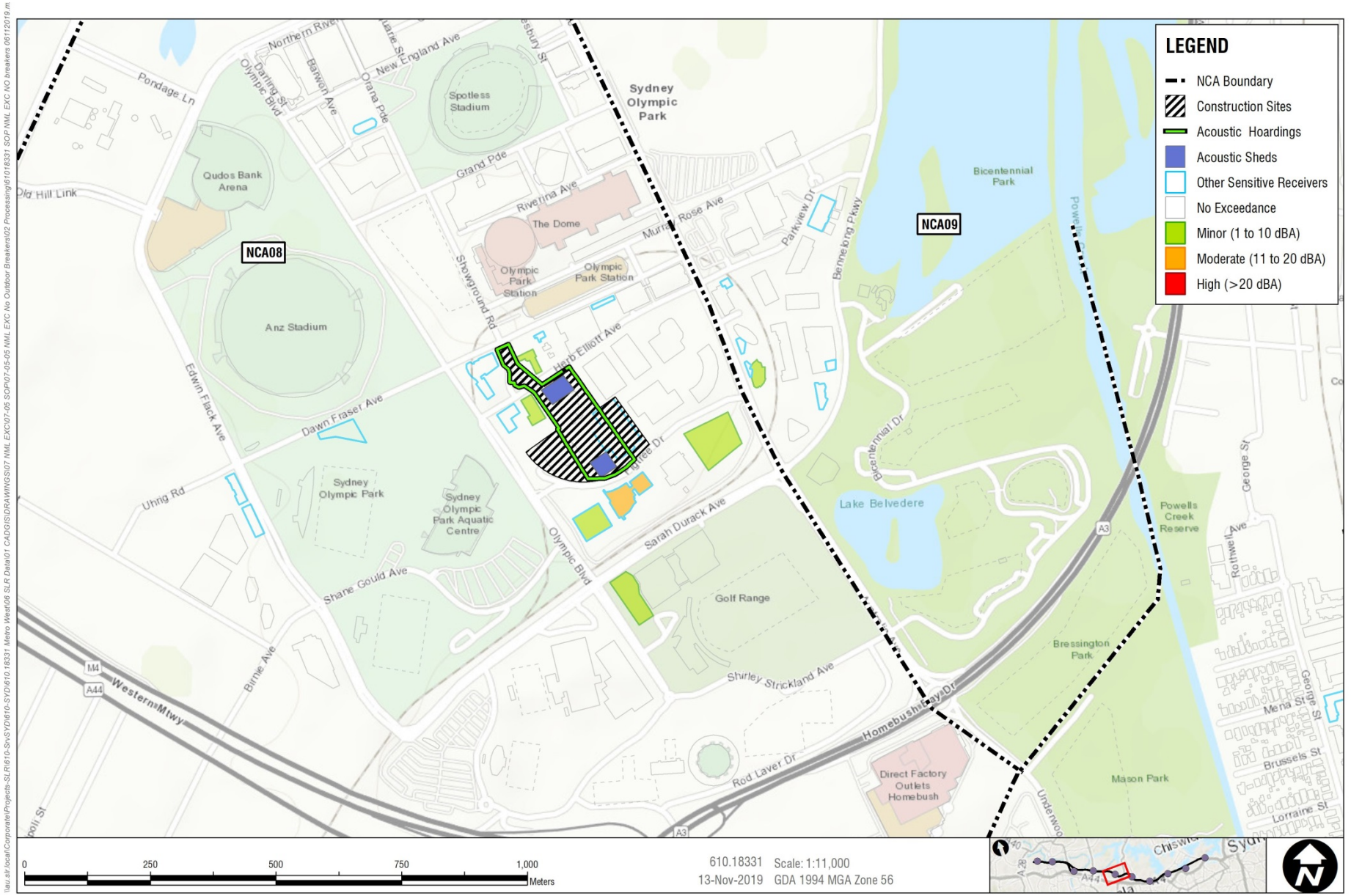
- **Figure 41** – All outdoor works, including rockbreakers
- **Figure 42** – All outdoor works, not including rockbreakers.

The highest impact works are expected to last for:

- *Enabling works – Demolition using a rockbreaker with supporting plant* – 10 days (actual rockbreaker use)
- *Initial excavation – Through rock using rockbreaker* – two weeks.

Figure 41 Worst-case Daytime Airborne Noise Impacts – All Outdoor Works, including Rockbreakers

Figure 42 Worst-case Daytime Airborne Noise Impacts – All Outdoor Works, not including Rockbreakers



The above shows the following:

- The worst-case daytime impacts are predicted during noise intensive works, such as rockbreaking, which occur prior to construction of the acoustic sheds. The impacts are expected to be 'high' at the nearest receiver to the site, and 'moderate' or 'minor' at the more distant receivers. The receivers surrounding the site are a mixture of commercial, hotels and educational facilities.
- The worst-case impacts at 'other sensitive' receivers are predicted to be:
    - 'High' for the NSW Institute of Sport educational facility directly south of the construction site.
    - 'Moderate' for the Kirana Colleges Australia educational facility located south of the construction site and a café/bar on Dawn Fraser Avenue.
    - 'Minor' at the Novotel Sydney Olympic Park hotel and Pullman at Sydney Olympic Park hotel near the western boundary of the site.
- When rockbreakers are not in use during outdoor works, the noise levels are predicted to be substantially lower, with the worst-case impacts generally being 'minor' at the closest receivers and compliant in the rest of the study area.
- When rockbreakers are being used inside the acoustic sheds and doors are closed, no daytime impacts are predicted.

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.

Impacts during the Night-time

Noise intensive works during the night-time at this construction site would only be completed inside the acoustic sheds. The worst-case impacts are predicted during *Excavation with sheds* when rockbreakers are in use. The predicted worst-case night-time impacts from the assessed scenarios in this study area are shown in:

- **Figure 43** – *Excavation with sheds – Through rock using rockbreaker (Doors Closed)*
- **Figure 44** – *Excavation with shed – Mucking out (Doors Closed)*, which has no requirement for noise intensive equipment.

The highest impact works are expected to last for:

- *Excavation with sheds – Through rock using rockbreaker* – 33 weeks
- *Excavation with sheds – Mucking out* – 33 weeks.

Figure 43 Worst-case Night-time Airborne Noise Impacts – Excavation in Sheds using Rockbreaker (Doors Closed)

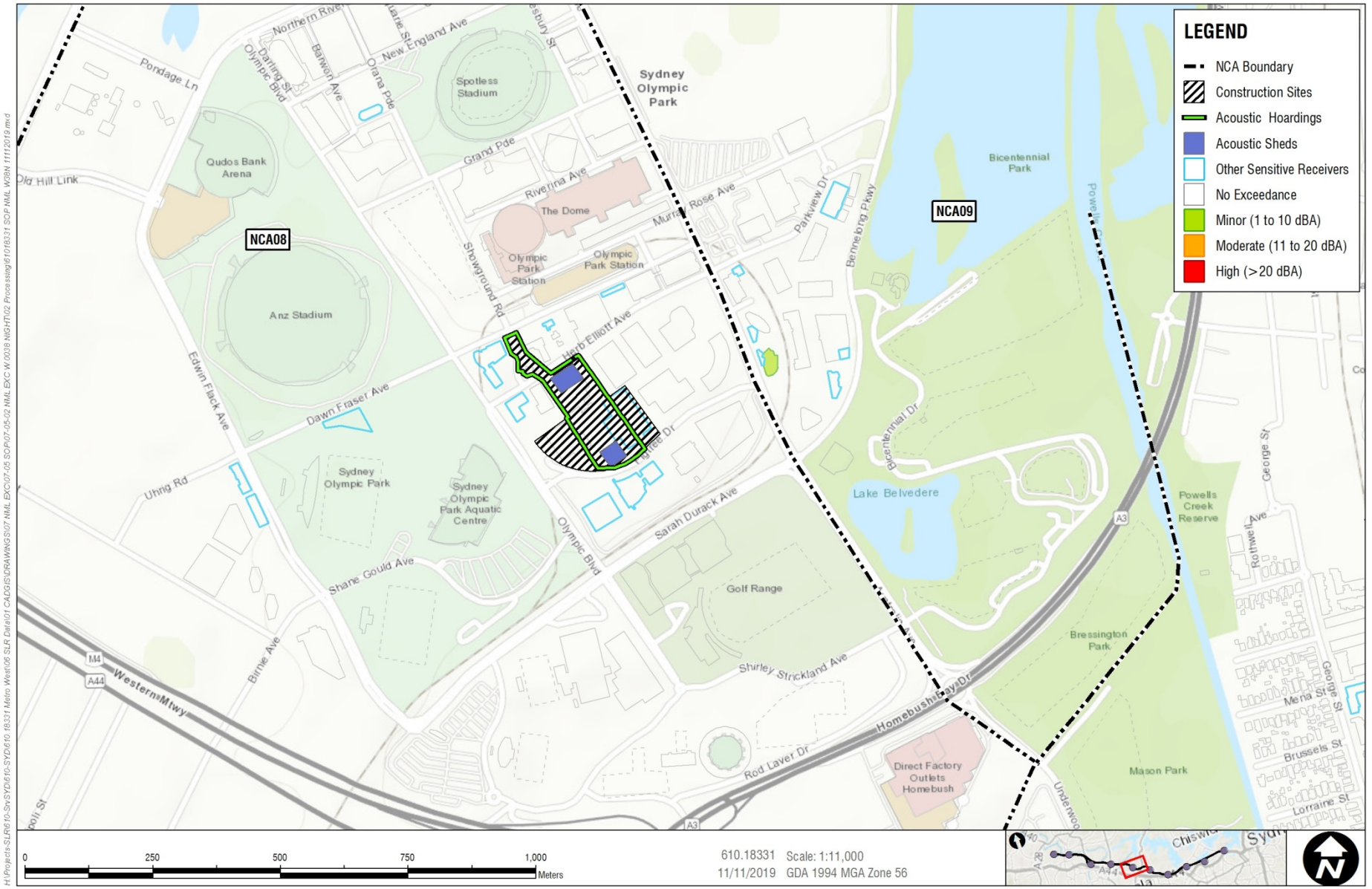


Figure 44 Worst-case Night-time Airborne Noise Impacts – Mucking Out (Doors Closed)

The above shows the following:

- The worst-case night-time noise levels from works in the acoustic sheds are expected to occur when rockbreakers are used and the shed doors are open. These works are predicted to result in 'minor' impacts at residential receivers to the east of the site.
- When the acoustic shed doors are closed, the impacts during rockbreaking are reduced substantially and only one receivers is predicted to have 'minor' worst-case impacts. More distant receivers in the study area are compliant with the management levels.
- When rockbreakers are not in use during *Mucking out* in the acoustic shed, noise levels are reduced further and are predicted to be compliant with the 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 8**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed for the construction works and is summarised in **Table 56**.

'Minor' sleep disturbance impacts are predicted at one residential receiver to the east during the noisiest works. These impacts result from heavy vehicles accessing the site via Herb Elliott Avenue and from movements in the outdoor areas of the site.

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

Further investigation of awakenings would be completed during the next stages of Stage 1 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 by the works.

5.2.5.4 Ground-borne Noise Impacts from Construction Sites

The predicted ground-borne impacts from vibration intensive station shaft excavation works inside the acoustic sheds are summarised in **Table 59**. The results are shown in **Figure 45** for the daytime period. The predictions are representative of the highest ground-borne noise levels that would likely be experienced by the nearest receivers when excavation works are at their closest.

Table 59 Overview of Ground-borne NML Exceedances

NCA	Receiver Classification	Number of Receivers									
		Total	With NML Exceedance[1]								
			Daytime			Out-of-Hours Works					
						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
NCA08	Residential	6	-	-	-	-	-	-	-	-	-
	Commercial	55	-	-	-	-	-	-	-	-	-
	Other Sensitive	33	1	-	-	-	-	-	-	-	-
NCA09	Residential	6	-	-	-	-	-	-	-	-	-
	Commercial	15	-	-	-	-	-	-	-	-	-
	Other Sensitive	10	-	-	-	-	-	-	-	-	-

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

Figure 45 Ground-borne Noise Impacts – Daytime Construction Hours

The above shows the following:

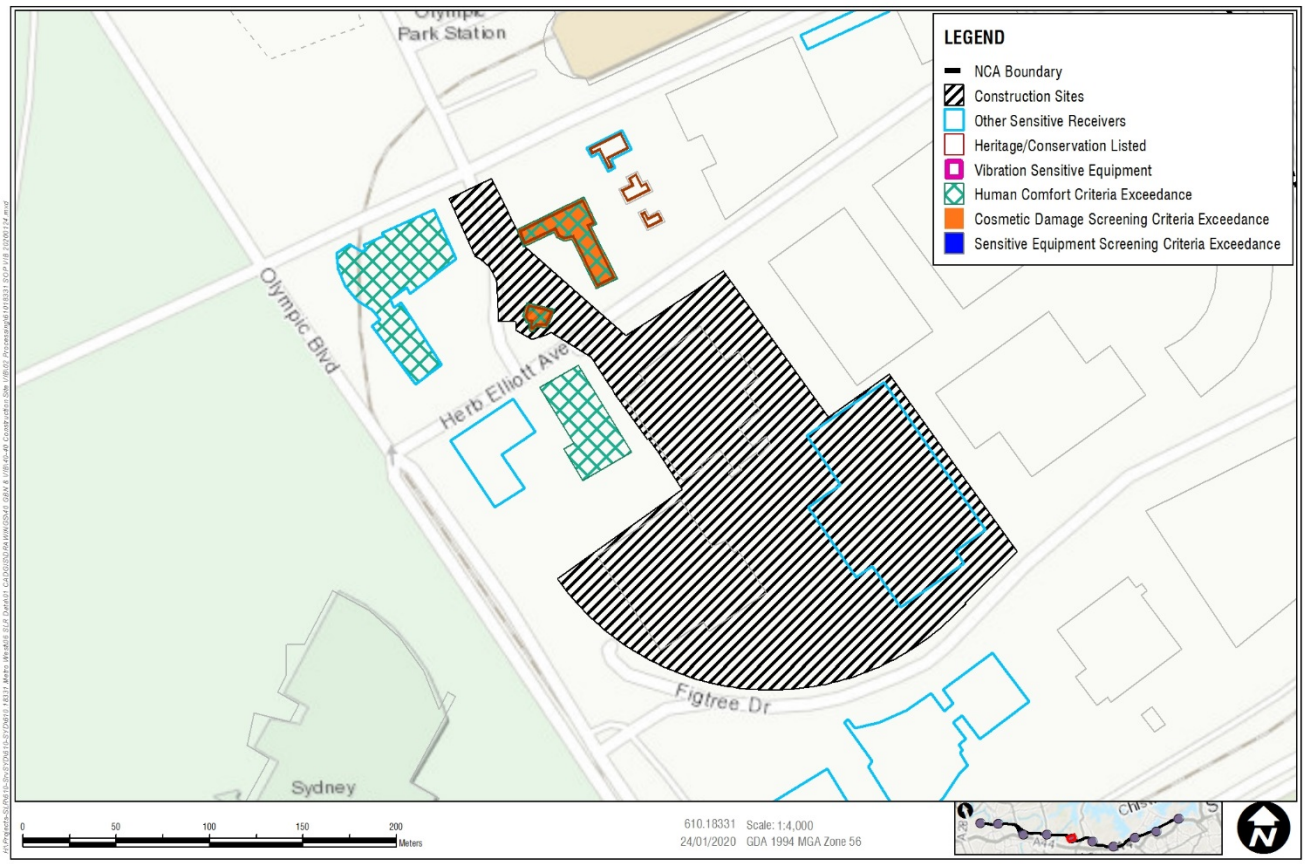
- Vibration intensive works are predicted to result in 'minor' worst-case ground-borne noise impacts during the daytime at one educational receiver to the south of the construction site (NSW Institute of Sport).

- Vibration intensive shaft excavation works inside the acoustic shed are anticipated to occur for 33 weeks. The predictions represent the worst-case scenario when shaft excavation works are at surface level and are, therefore, at the closest point to the affected buildings. As the works progress deeper and further away from this receiver, the exceedances are expected to be reduce or eliminated.

5.2.5.5 Vibration Impacts from Construction Sites

The predicted impacts during vibration intensive works are shown in **Figure 46**. The predictions are representative of the highest vibration levels that would likely be experienced by the nearest receivers when works are at their closest.

Figure 46 Worst-case Vibration Impacts



The above shows the following:

- There are no predicted exceedances of the sensitive equipment screening criteria.
- The cosmetic damage screening criteria are predicted to be exceeded at the two nearest heritage listed buildings. This includes one building immediately adjacent the north eastern boundary of the site and one building within the construction site boundary.

- The human comfort criteria are predicted to be exceeded at four of the nearest receivers, including two heritage listed buildings as well as a commercial building and hotel to the west, meaning occupants of affected buildings may be able to perceive vibration impacts at times when vibration intensive equipment is in use nearby.

5.2.6 North Strathfield Study Area (NCA10 and NCA11)

The North Strathfield study area is centred on the North Strathfield metro station construction site. This study area contains two noise catchments (NCA10 and NCA11) which are to the west and east of the existing rail line.

The construction site is located to the east of the existing North Strathfield Station and is adjacent to Queen Street.

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 with a mixture of residential, commercial and educational receivers. The nearest receivers are opposite the site, across Queen Street. The commercial receivers adjacent to the site are typically of retail use.

The NCAs in the North Strathfield study area are described below and a map is shown in **Figure 47**.

NCA10 and NCA11

- The nearest receivers to the site are residential and commercial buildings to the north and east on Queen Street. The nearest of these buildings are located around 10 to 20 metres from the site boundary.
- The McDonald College Campus is located around 50 metres to the west of the site.
- Lighthouse Child Care is located around 150 metres south-west of the construction site on George Street.
- Our Lady of The Assumption Catholic Church is located about 500 metres south-west of the construction site on Underwood Road.
- Outdoor recreation areas, including Ismay Reserve and Allen Street Reserve, are located around 400 metres to the south-west, between Allen Street and Pomeroy Street.
- More distant educational facilities include Strathfield North Public School and Integricare Early Learning Centre which are around 400 metres to the east.

Figure 47 Site Map, Works and Sensitive Receivers

5.2.6.2 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 during this period and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

Works in this study area would generally only occur during daytime hours.

The Stage 1 works within this study area are anticipated to have a total duration of approximately 18 months.

5.2.6.3 Airborne Noise Impacts from Construction Sites

Number of NML Exceedances

The predicted airborne noise impacts from construction site works 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 when the works are at their nearest.

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 60 Surface construction Activities and Period of Works

Scenario	Activity		Total Indicative Duration (Weeks)[2]	Maximum Number of Working Faces	Hours of Works[1]				Comments
					Std. Day	Out-of-Hours Works			
						Day OOH	Eve	Night	
Enabling works	'Typical'	Delivery of equipment	4	1	✓	-	-	-	The construction site is currently vacant meaning no site clearing or demolition works would be required. Enabling works would be limited to general site mobilization activities.
	'Peak'	Assembly of site facilities	4	2	✓	-	-	-	
Piling	'Typical'	Supporting works	20	2	✓	-	-	-	-
	'Peak'	Bored piling with support plant	20	4	✓	-	-	-	Piling works would only occur intermittently during a 20 week period between 7am – 6pm. Up to four piling rigs would be active at the same time.
Surface construction	'Typical'	General works	12	1	✓	-	-	-	-
	'Peak'	Noise intensive works	12	2	✓	-	-	-	-
Excavation	'Typical'	Mucking out	29	1	✓	-	-	-	-
	'Peak'	Through soft soil/rock	10	2	✓	-	-	-	Excavation through soil and soft rock using excavator ripper attachment.
		Through rock using rockbreaker	19	2	✓	-	-	-	Excavation through rock using rockbreaker. Works restricted to Standard Construction Hours only.

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

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

Table 61 Overview of NML Exceedances – All Receiver Types

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Delivery of equipment	4	1388	-	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Assembly of site facilities	4	1388	-	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	20	1388	-	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	20	1388	-	48	3	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	12	1388	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	12	1388	-	23	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Excavation	'Typical'	Mucking out	29	1388	-	32	1	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	10	1388	-	63	7	-	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	19	1388	15	392	63	7	-	-	-	-	-	-	-	-	-	-	-	-

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

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

Table 62 Overview of NML Exceedances – Residential Receivers

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Delivery of equipment	4	1255	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Assembly of site facilities	4	1255	-	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	20	1255	-	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	20	1255	-	27	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	12	1255	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	12	1255	-	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Excavation	'Typical'	Mucking out	29	1255	-	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	10	1255	-	43	3	-	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	19	1255	15	380	43	3	-	-	-	-	-	-	-	-	-	-	-	-

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

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

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

Scenario	Activity		No. Weeks[1]	Number of Receivers																	
				Commercial			Café/bar			Child Care			Educational			Public Building			Place of Worship		
				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
Enabling works	'Typical'	Delivery of equipment	4	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-
	'Peak'	Assembly of site facilities	4	-	-	-	-	-	-	1	-	-	6	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	20	3	-	-	1	-	-	-	-	-	6	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	20	15	-	-	1	-	-	2	-	-	3	3	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	12	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	12	3	-	-	1	-	-	1	-	-	6	-	-	-	-	-	-	-	-
Excavation	'Typical'	Mucking out	29	10	-	-	1	-	-	1	-	-	5	1	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	10	15	-	-	1	-	-	2	-	-	2	4	-	-	-	-	-	-	-
		Through rock using rockbreaker	19	4	15	-	-	1	-	1	2	-	3	2	4	1	-	-	3	-	-

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

The above shows the following:

- The Stage 1 construction works are predicted to result in 'high' worst-case noise impacts at the nearest receivers during higher noise generating activities. The nearest receivers to the site are a mixture of residential, commercial and educational buildings. The worst-case impacts are predicted during *Excavation* works. These works are, however, limited to Standard Construction Hours and would not occur during the evening or night-time
- The highest impacts are during 'Peak' scenarios which use noise intensive equipment such as rockbreakers. When noise intensive equipment is not in use during 'Typical' works, the worst-case impacts are predicted to be reduced to 'minor' or 'moderate' at the nearest receivers.
- *Enabling Works, Piling* and *Surface construction* works generate less noise and the worst-case impacts at the nearest receivers are predicted to be 'minor' or 'moderate'. These works would also be completed during Standard Construction Hours.
- *Excavation* works requiring rockbreakers are predicted to result in Highly Noise Affected impacts at the nearest residential receivers.
- No works are proposed at this site during the evening or night-time.

Impacts during Standard Construction Hours

The worst-case impacts during Standard Construction Hours are predicted during noise intensive works. The predicted worst-case daytime in this study area are shown in:

- **Figure 48** – All works, including rockbreakers
- **Figure 49** – All works, not including rockbreakers.

The highest impact works are expected to last for:

- *Excavation – Through rock using rockbreaker* – 19 weeks.

Figure 48 Worst-case Daytime Airborne Noise Impacts – All Works, including Rockbreakers

Figure 49 Worst-case Daytime Airborne Noise Impacts – All Works, not including Rockbreakers

The above shows the following:

- The worst-case daytime impacts are predicted during noise intensive works, such as rockbreaking. The impacts are expected to be 'high' at receivers adjacent the site and 'moderate' or 'minor' for receivers which are more distant. The nearest receivers are a mixture of residential, commercial and educational.
- The worst-case impacts at 'other sensitive' receivers are predicted to be:
    - 'High' or 'moderate' at several buildings at the McDonald College Campus and Our Lady of the Assumption Catholic Primary School adjacent to the site to the west.
    - 'Moderate' at Lighthouse Child Care and a café/bar on Queen Street.
- When rockbreakers are not in use, the noise levels are predicted to be substantially lower, with the worst-case impacts being 'moderate' at the closest receivers and 'minor' or compliant in the rest of the study area.

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.

Impacts during the Night-time and Sleep Disturbance

No works are proposed at this construction site during the night-time.

Highly Noise Affected Residential Receivers

The receivers predicted to be Highly Noise Affected during the worst-case impacts are summarised in **Table 64** and shown in **Figure 50.** The table shows the number of residential receivers separated by works activity and NCA.

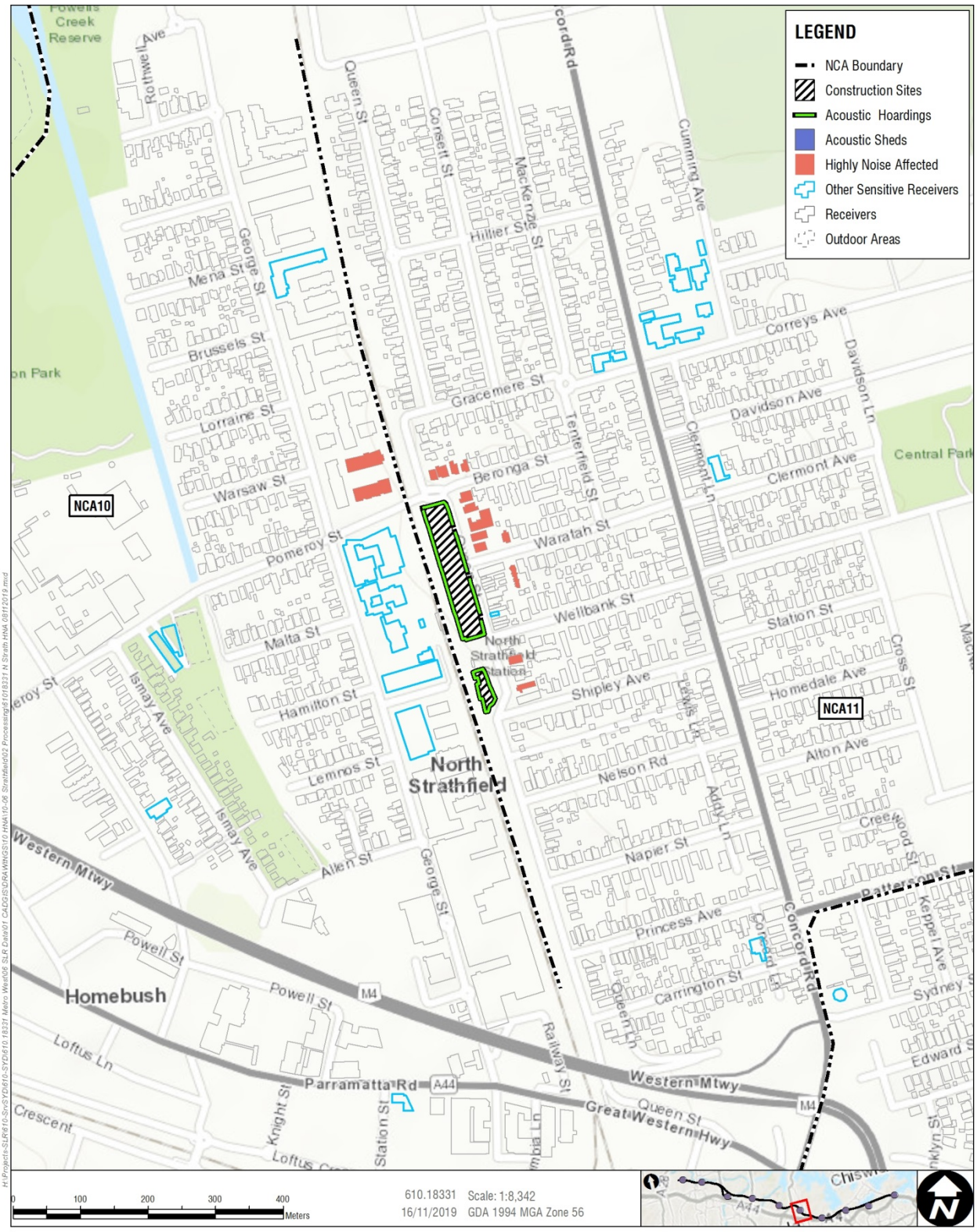
Table 64 Predicted Number of Highly Noise Affected Residential Receivers by Works and NCA

Scenario	Activity		NCA10			NCA11		
			Day	Eve	Night	Day	Eve	Night
Enabling works	'Typical'	Delivery of equipment	-	n/a	n/a	-	n/a	n/a
	'Peak'	Assembly of site facilities	-	n/a	n/a	-	n/a	n/a
Piling	'Typical'	Supporting works	-	n/a	n/a	-	n/a	n/a
	'Peak'	Bored piling with support plant	-	n/a	n/a	-	n/a	n/a
Surface construction	'Typical'	General works	-	n/a	n/a	-	n/a	n/a
	'Peak'	Noise intensive works	-	n/a	n/a	-	n/a	n/a
Excavation	'Typical'	Mucking out	-	n/a	n/a	-	n/a	n/a
	'Peak'	Through soft soil/rock	-	n/a	n/a	-	n/a	n/a
		Through rock using rockbreaker	2	n/a	n/a	13	n/a	n/a

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

The assessment shows that the nearest receivers to the site are predicted to be Highly Noise Affected during daytime works involving rockbreakers.

Figure 50 Highly Noise Affected Residential Receivers (During Any Works)



5.2.6.4 Ground-borne Noise Impacts from Construction Sites

Vibration intensive works during shaft excavation at this construction site would not be completed in an acoustic shed meaning airborne noise levels at the nearest receivers would likely be higher than the corresponding internal ground-borne noise levels. Where airborne noise levels are higher than ground-borne noise levels it is not necessary to evaluate potential ground-borne noise impacts.

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

On this basis, ground-borne noise levels have been assessed at this site and the worst-case impacts are summarised in **Table 65** and shown in **Figure 51**. The predictions are representative of the highest ground-borne noise levels that would likely be experienced by the nearest receivers when excavation works are at their closest.

Table 65 Overview of Ground-borne NML Exceedances

NCA	Receiver Classification	Number of Receivers									
		Total	With NML Exceedance[1]								
			Daytime			Out-of-Hours Works					
						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
NCA10	Residential	415	-	-	-	-	-	-	-	-	-
	Commercial	55	-	-	-	-	-	-	-	-	-
	Other Sensitive	16	-	-	-	-	-	-	-	-	-
NCA11	Residential	876	5	-	-	-	-	-	-	-	-
	Commercial	53	5	-	-	-	-	-	-	-	-
	Other Sensitive	13	1	-	-	-	-	-	-	-	-

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

Figure 51 Ground-borne Noise Impacts – Daytime Construction Hours

The above shows the following:

- Vibration intensive works are predicted to result in 'minor' worst-case ground-borne noise impacts during the daytime at the nearest receivers on the eastern side of Queen Street, which includes residential and commercial and 'other sensitive' (café) buildings.
- Vibration intensive shaft excavation works inside the acoustic shed are anticipated to occur for 19 weeks. The predictions represent the worst-case scenario when shaft excavation works are at surface level and are, therefore, at the closest point to the affected buildings. As the works progress deeper, the impacts are expected to be reduce.

5.2.6.5 Vibration Impacts from Construction Sites

The predicted impacts during vibration intensive works are shown in **Figure 52**. The predictions are representative of the highest vibration levels that would likely be experienced by the nearest receivers when works are at their closest.

Figure 52 Worst-case Vibration Impacts

The above shows the following:

- There are no predicted exceedances of the cosmetic damage screening criteria or the sensitive equipment screening criteria.
- The human comfort criteria are predicted to be exceeded the nearest residential, commercial and 'other sensitive' (café) receivers to the east, meaning occupants of affected buildings may be able to perceive vibration impacts at times when vibration intensive equipment is in use nearby.

5.2.7 Burwood Study Area (NCA12 and NCA13)

The Burwood study area is centred on the Burwood North Station construction site. This study area includes two noise catchments (NCA12 and NCA13) which are to the north and south of Parramatta Road.

The Stage 1 works would use two separate sites. The main construction site would be to the north of Parramatta Road and a smaller site would be to the south.

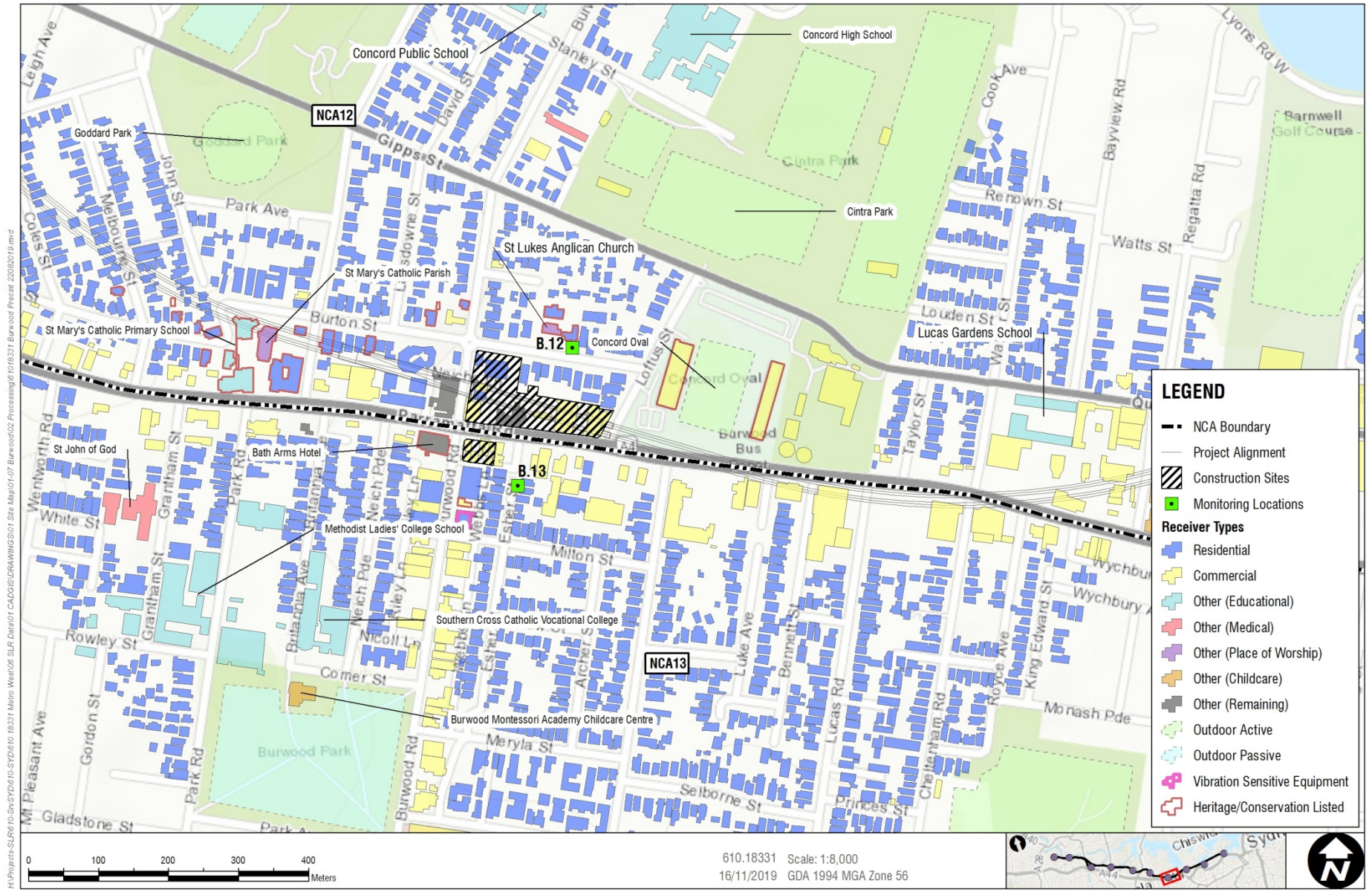
Existing noise levels in this study area are controlled by road traffic noise. The area surrounding the construction site is mostly residential and the nearest receivers are in close proximity to the northern boundary of the northern construction site and the southern boundary of the southern construction site. Commercial receivers are also adjacent to the site, along Parramatta Road, and are of general retail use.

The NCAs in the Burwood study area are described below and a map is shown in **Figure 53**.

NCA12 and NCA13

- The nearest receivers to the northern construction site are residential buildings on Burton Street. These receivers are within around five to 20 metres of the site.
- Several commercial receivers are also located opposite the northern construction site, on the southern side of Parramatta Road.
- The nearest receivers to the southern construction site are residential buildings on Burwood Road and Esher Street. These receivers are around five metres from the southern site boundary.
- The Bath Arms Hotel is 20 metres to the west of the southern construction site.
- Various educational facilities are located within around 300 metres of the construction sites, including Southern Cross Catholic Vocational College, St Mary's Catholic Primary School, Concord High School, Concord Public School, Methodist Ladies' College School and Lucas Special School
- Concord Oval is located around 100 metres east of the northern construction site. Three other sporting fields are located further from the site, including Cintra Park, Saint Lukes Park and Goddard Park.
- St Mary's Catholic Parish is located 300 metres west of the northern construction site, on the southern side of Burton Street.
- The more distant parts of the study area are generally areas of suburban residential receivers.

Figure 53 Site Map, Works and Sensitive Receivers



5.2.7.2 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 66**. The estimated duration of each activity is also provided, noting that most activities would be intermittent during this period and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

The main excavation works at this construction site would be completed in acoustic sheds. The crossover cavern at Burwood North is assessed as part of the tunnelling assessment in **Section 5.3**.

The Stage 1 works within this study area are anticipated to have a total duration of approximately two years.

5.2.7.3 Airborne Noise Impacts from Construction Sites

Number of NML Exceedances

The predicted airborne noise impacts from construction site works in this study area are summarised in **Table 67**, **Table 68** and **Table 69** 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 when the works are at their nearest.

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 Surface construction Activities and Period of Works

Scenario	Activity		Total Indicative Duration (Weeks)[3]	Maximum Number of Working Faces		Hours of Works[1,2]				Comments
				Northern site	Southern site	Std. Day	Out-of-Hours Works			
							Day OOH	Eve	Night	
Enabling works	'Typical'	Supporting and loading	16	1	1	✓	-	-	-	-
	'Peak'	Demolition using a rockbreaker	16	2	1	✓	-	-	-	Rockbreaking works would only occur intermittently during a 16 week period between 7am – 6pm. Total duration of rockbreaking works would be approximately 10 days.
Piling	'Typical'	Supporting works	22	2	1	✓	-	-	-	Piling works would only occur intermittently during a 22 week period between 7am – 6pm. Up to two and four piling rigs would be active at the same time at the southern and northern sites, respectively.
	'Peak'	Bored piling with support plant	22	4	2	✓	-	-	-	
Surface construction	'Typical'	General works	10	1	1	✓	-	-	-	-
	'Peak'	Noise intensive works	10	2	2	✓	-	-	-	-
Initial excavation	'Typical'	Mucking out	9	1	1	✓	-	-	-	-
	'Peak'	Through soft soil/rock	4	2	2	✓	-	-	-	Excavation through soil and soft rock using excavator ripper attachment, before construction of the acoustic shed.
		Through rock using rockbreaker	5	2	2	✓	-	-	-	Excavation through rock using rockbreaker, before construction of the acoustic sheds. Works restricted to Standard Construction Hours only.
Excavation with shed	'Typical'	Mucking out	32	1	1	✓	✓	✓	✓	Out of hours works would only occur once the acoustic sheds and acoustic panels (where appropriate) have been constructed.
	'Peak'	Through rock using rockbreaker	32	2	2	✓	✓	✓	✓	
Mined cavern with shed	'Typical'	Spoil removal	34	1	1	✓	✓	✓	✓	
	'Peak'	Mining with support	34	1	1	✓	✓	✓	✓	

Note 1: Noise intensive works outside of Standard Construction Hours would only occur after construction of the acoustic shed and acoustic panels.

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

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

Table 67 Overview of NML Exceedances – All Receiver Types

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Supporting and loading	16	1455	1	24	9	1	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	16	1455	27	463	65	26	-	-	-	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	22	1455	-	24	6	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	22	1455	3	45	14	3	-	-	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	10	1455	-	13	3	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	10	1455	2	29	7	2	-	-	-	-	-	-	-	-	-	-	-	-
Initial excavation	'Typical'	Mucking out	9	1455	2	33	9	2	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	4	1455	4	65	17	4	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	5	1455	24	487	65	21	-	-	-	-	-	-	-	-	-	-	-	-
Excavation with shed	'Typical'	Mucking out (Doors Closed)	32	1455	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through rock using rockbreaker (Doors Closed)	32	1455	-	7	1	-	8	-	-	8	-	-	15	1	-	1	-	-
		Through rock using rockbreaker (Doors Open)	32	1455	-	61	13	2	76	16	3	73	16	3	145	21	5	27	5	-
Mined cavern with shed	'Typical'	Spoil removal (Doors Closed)	34	1455	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Mining with Support (Doors Closed)	34	1455	-	3	-	-	1	-	-	1	-	-	2	-	-	1	-	-
		Mining with Support (Doors Open)	34	1455	-	14	2	-	17	2	-	17	2	-	23	5	-	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 in the works areas.

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

Table 68 Overview of NML Exceedances – Residential Receivers

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Supporting and loading	16	1300	1	23	9	1	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	16	1300	27	433	62	26	-	-	-	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	22	1300	-	24	6	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	22	1300	3	43	14	3	-	-	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	10	1300	-	13	3	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	10	1300	2	28	7	2	-	-	-	-	-	-	-	-	-	-	-	-
Initial excavation	'Typical'	Mucking out	9	1300	2	32	9	2	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	4	1300	4	62	17	4	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	5	1300	24	454	62	21	-	-	-	-	-	-	-	-	-	-	-	-
Excavation with shed	'Typical'	Mucking out (Doors Closed)	32	1300	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through rock using rockbreaker (Doors Closed)	32	1300	-	7	1	-	8	-	-	8	-	-	15	1	-	1	-	-
		Through rock using rockbreaker (Doors Open)	32	1300	-	56	13	2	72	16	3	72	16	3	145	20	5	27	5	-
Mined cavern with shed	'Typical'	Spoil removal (Doors Closed)	34	1300	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Mining with Support (Doors Closed)	34	1300	-	3	-	-	1	-	-	1	-	-	2	-	-	1	-	-
		Mining with Support (Doors Open)	34	1300	-	14	2	-	17	2	-	17	2	-	22	5	-	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 in the works areas.

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

Table 69 Overview of Commercial and 'Other Sensitive' Receiver NML Exceedances

Scenario	Activity		No. Weeks[1]	Number of Receivers																								
				Commercial			Café/bar			Child Care			Educational			Active Recreation			Place of Worship			Hotel (Daytime)			Hotel (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	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
Enabling works	'Typical'	Supporting and loading	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	16	15	-	-	-	1	-	1	-	-	12	-	-	1	-	-	1	1	-	-	1	-	-	-	-	-	-
Piling	'Typical'	Supporting works	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
Initial excavation	'Typical'	Mucking out	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	4	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-
		Through rock using rockbreaker	5	16	-	-	-	1	-	1	-	-	14	-	-	1	-	-	1	1	-	-	1	-	-	-	-	-	-
Excavation with shed	'Typical'	Mucking out (Doors Closed)	32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through rock using rockbreaker (Doors Closed)	32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker (Doors Open)	32	2	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	1	-	-	-
Mined cavern with shed	'Typical'	Spoil removal (Doors Closed)	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Mining with Support (Doors Closed)	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		Mining with Support (Doors Open)	34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-

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

The above shows the following:

- The Stage 1 construction works are predicted to result in 'high' worst-case noise impacts at the nearest receivers during higher noise generating activities. The nearest receivers to the site are generally residential receivers on Burton Street, which are immediately adjacent to the northern construction site boundary. The worst-case impacts are predicted during *Enabling works*, *Piling*, *Surface construction* and *Initial excavation* which would occur before the acoustic shed is constructed. These works are, however, limited to Standard Construction Hours and would not occur during the evening or night-time.
- The highest impacts are during 'Peak' scenarios which generally require noise intensive equipment such as rockbreakers. Rockbreakers would, however, only be used intermittently and the duration is around 10 days for *Enabling works* and five weeks for *Initial excavation* works. When noise intensive equipment is not in use during 'Typical' works, the worst-case impacts are predicted to be reduced, however, 'high' or 'moderate' worst-case impacts remain at the nearest receivers.
- Noise intensive works outside of Standard Construction Hours would only be completed in the acoustic sheds once built. The worst-case impacts from works in the sheds during the night-time are predicted to be 'moderate' at one receiver during *Excavation with shed* when rockbreakers are in use and the shed doors are closed. When rockbreakers are in use and the doors are open five receivers are predicted to have 'high' impacts with 21 having 'moderate' impacts.
- Works requiring noise intensive equipment outside of the acoustic sheds before they are constructed are predicted to result in Highly Noise Affected impacts at the nearest residential receivers.
- 'Moderate' sleep disturbance impacts are also predicted for the nearest residential receivers when the acoustic shed doors are open. This impact is reduced with the acoustic shed doors closed where only one 'minor' impact is predicted.

Impacts during Standard Construction Hours

The worst-case impacts during Standard Construction Hours are predicted when noise intensive works occur before construction of the acoustic sheds. The predicted worst-case daytime impacts in this study area are shown in:

- **Figure 54** – All outdoor works, including rockbreakers
- **Figure 55** – All outdoor works, not including rockbreakers.
- **Figure 56** – Works involving rockbreakers within the acoustic shed (Doors Closed).

The highest impact works are expected to last for:

- *Enabling works – Demolition using a rockbreaker* – 10 days (actual rockbreaker use)
- *Initial excavation – Through rock using rockbreaker* – five weeks.

Figure 54 Worst-case Daytime Airborne Noise Impacts – All Outdoor Works, including Rockbreakers

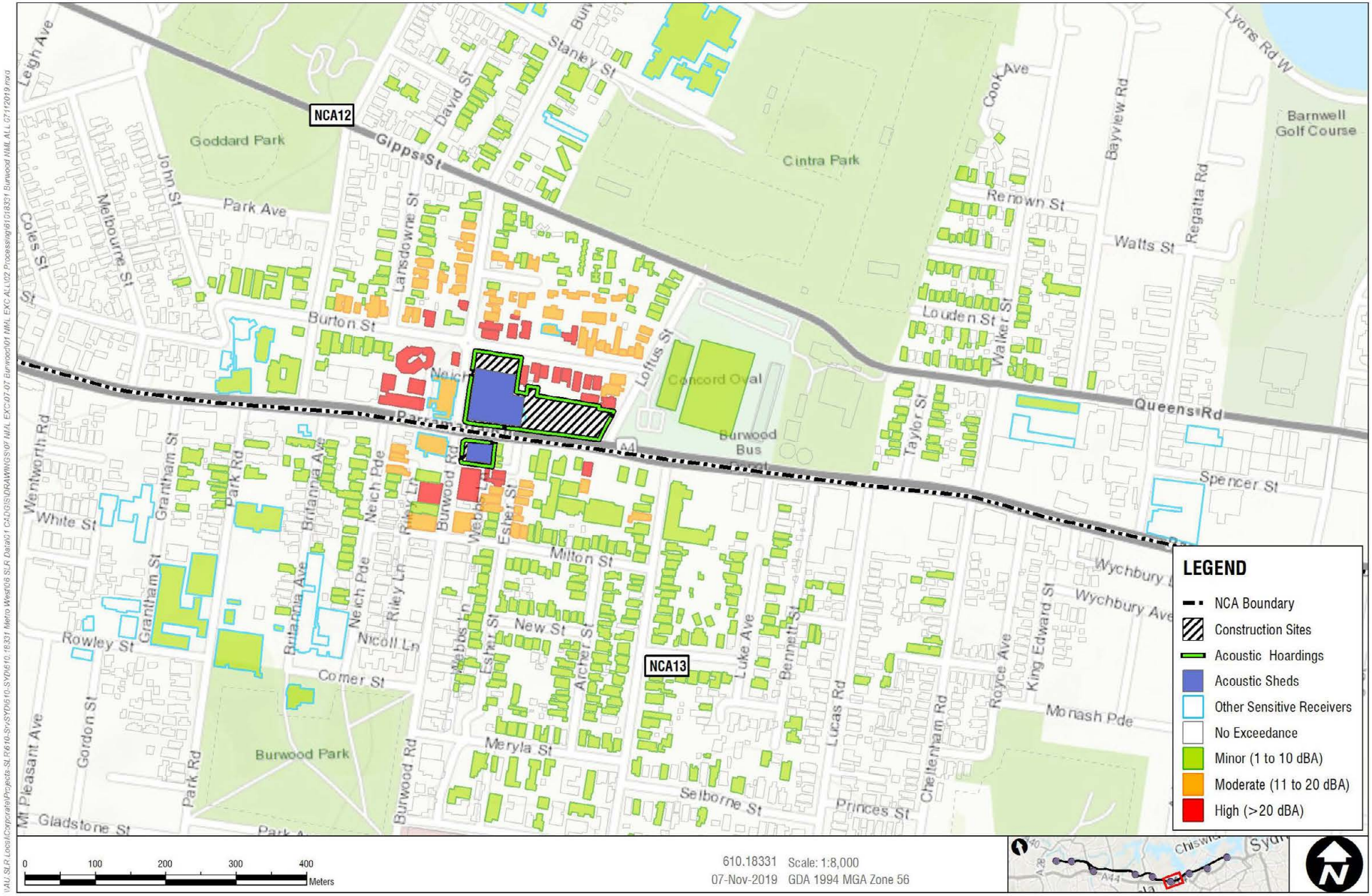


Figure 55 Worst-case Daytime Airborne Noise Impacts – All Outdoor Works, not including Rockbreakers

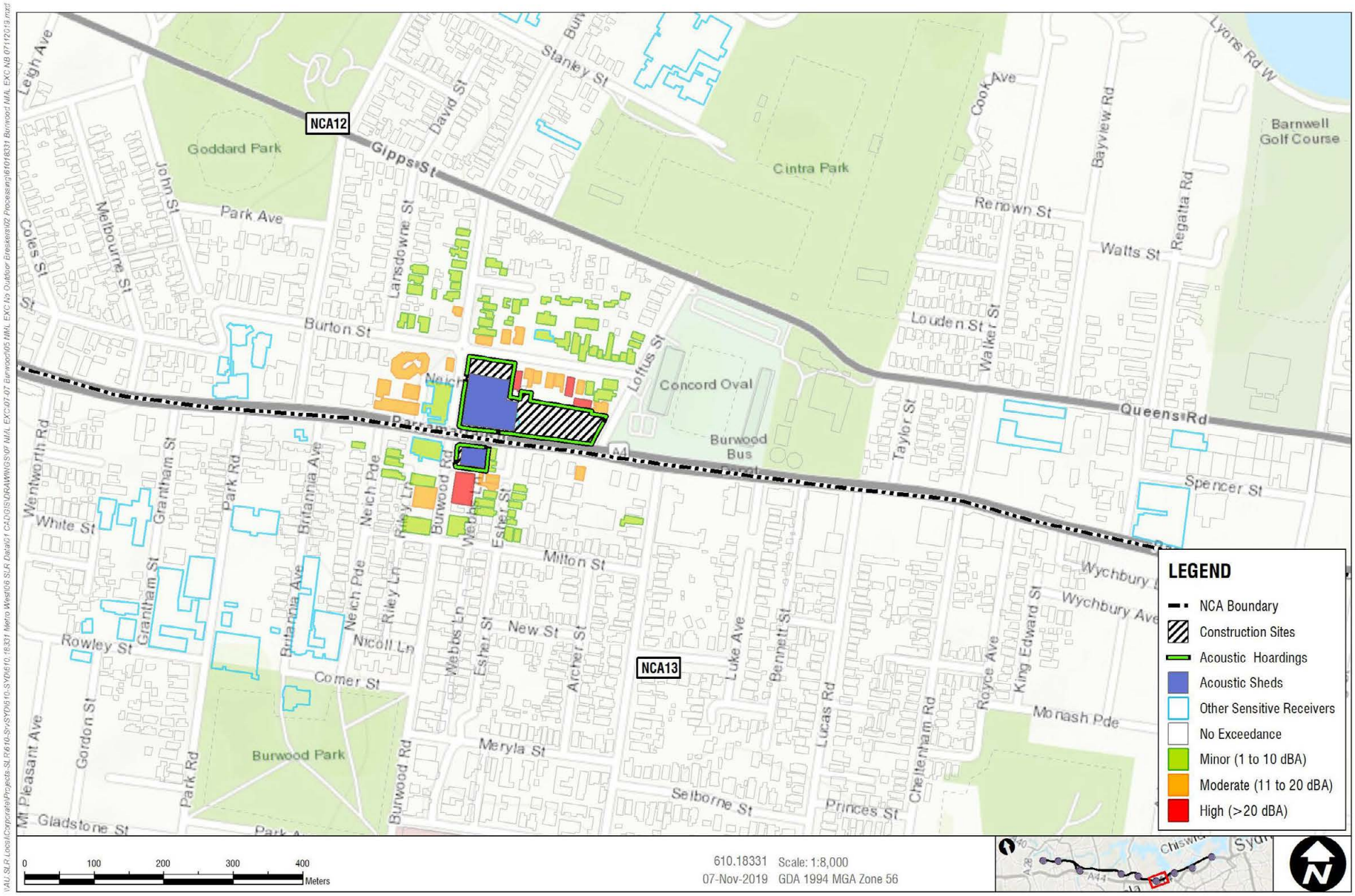
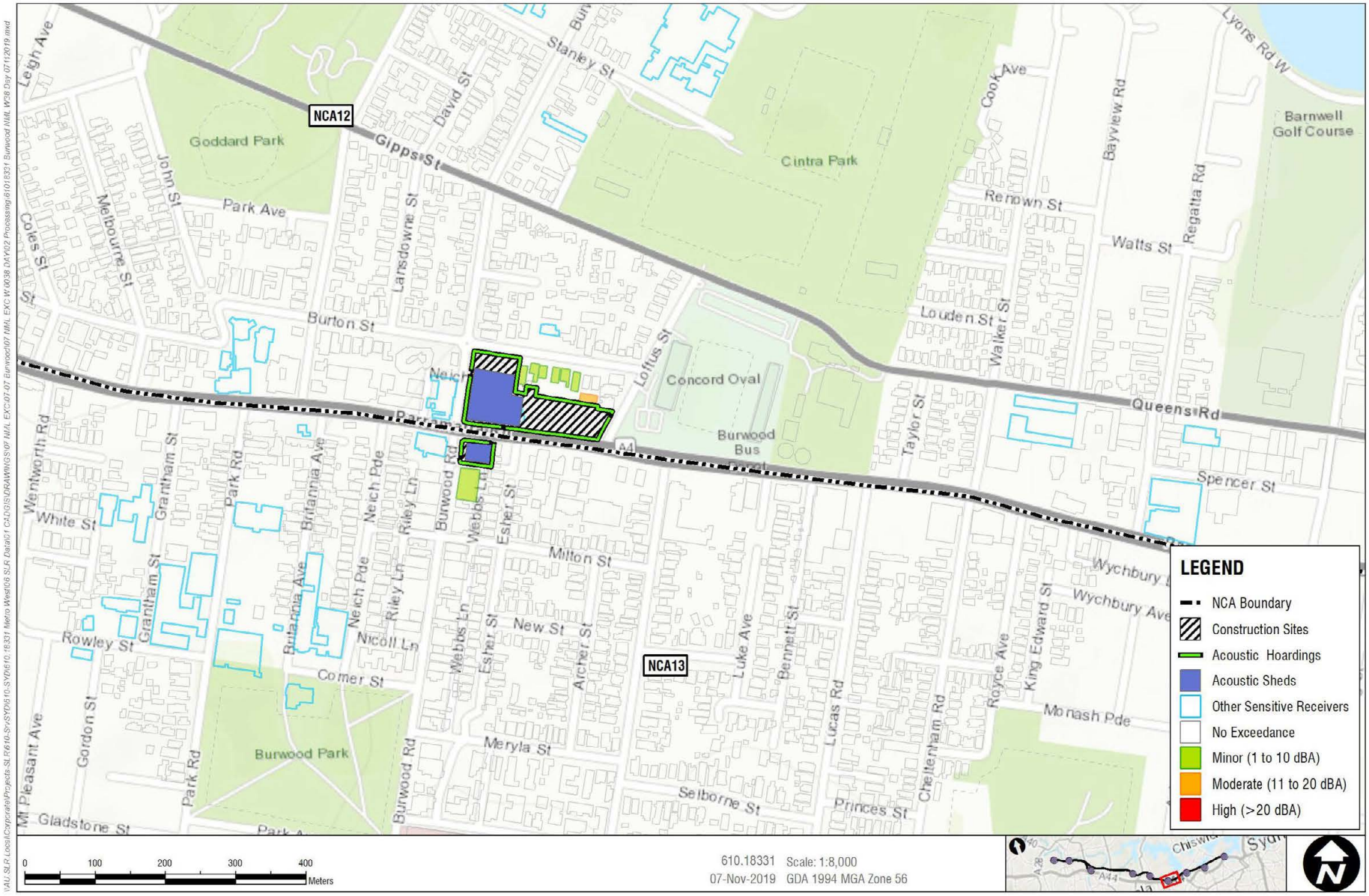


Figure 56 Worst-case Daytime Airborne Noise Impacts – Excavation in Shed using Rockbreaker (Doors Closed)



The above shows the following:

- The worst-case daytime impacts are predicted during noise intensive works, such as rockbreaking, which occur prior to construction of the acoustic sheds. The impacts during these works are expected to be 'high' at receivers near the site and 'moderate' or minor' for receivers which are more distant. Most of the nearest receivers are residential.
- The worst-case impacts at 'other sensitive' receivers are predicted to be:
    - 'Moderate' at St Luke's Anglican Church to the north of the site, the Bath Arms Hotel directly west of the southern site area, and a café/bar on Burwood Road.
- When rockbreakers are not in use during outdoor works, the impacts are predicted to be substantially lower, however, 'high' worst-case impacts remain at receivers adjacent to the site boundary, with the other receivers which surround the site being subject to 'moderate' or 'minor' impacts.
- When rockbreakers are being used inside the acoustic shed and doors are closed, the impacts are reduced further still. 'Moderate' impacts remain at one residential receiver immediately north of the construction site, with 'minor' impacts at the remaining adjacent receivers. Receivers in the rest of the study area are predicted to comply with the 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.

Impacts during the Night-time

Noise intensive works during the night-time at this construction site would only be completed inside the acoustic sheds. The worst-case impacts are predicted during *Excavation with shed* when rockbreakers are in use. The predicted worst-case night-time impacts from the assessed scenarios in this study area are shown in:

- **Figure 57** – *Excavation with shed – Through rock using rockbreaker (Doors Open)*
- **Figure 58** – *Excavation with shed – Through rock using rockbreaker (Doors Closed)*
- **Figure 59** – *Excavation with shed – Mucking out (Doors Closed)*, which has no requirement for noise intensive equipment.

The highest impact works are expected to last for:

- *Excavation with shed – Through rock using rockbreaker* – 32 weeks
- *Excavation with shed – Mucking out* – 32 weeks.

Figure 57 Worst-case Night-time Airborne Noise Impacts – Excavation in Shed using Rockbreaker (Doors Open)

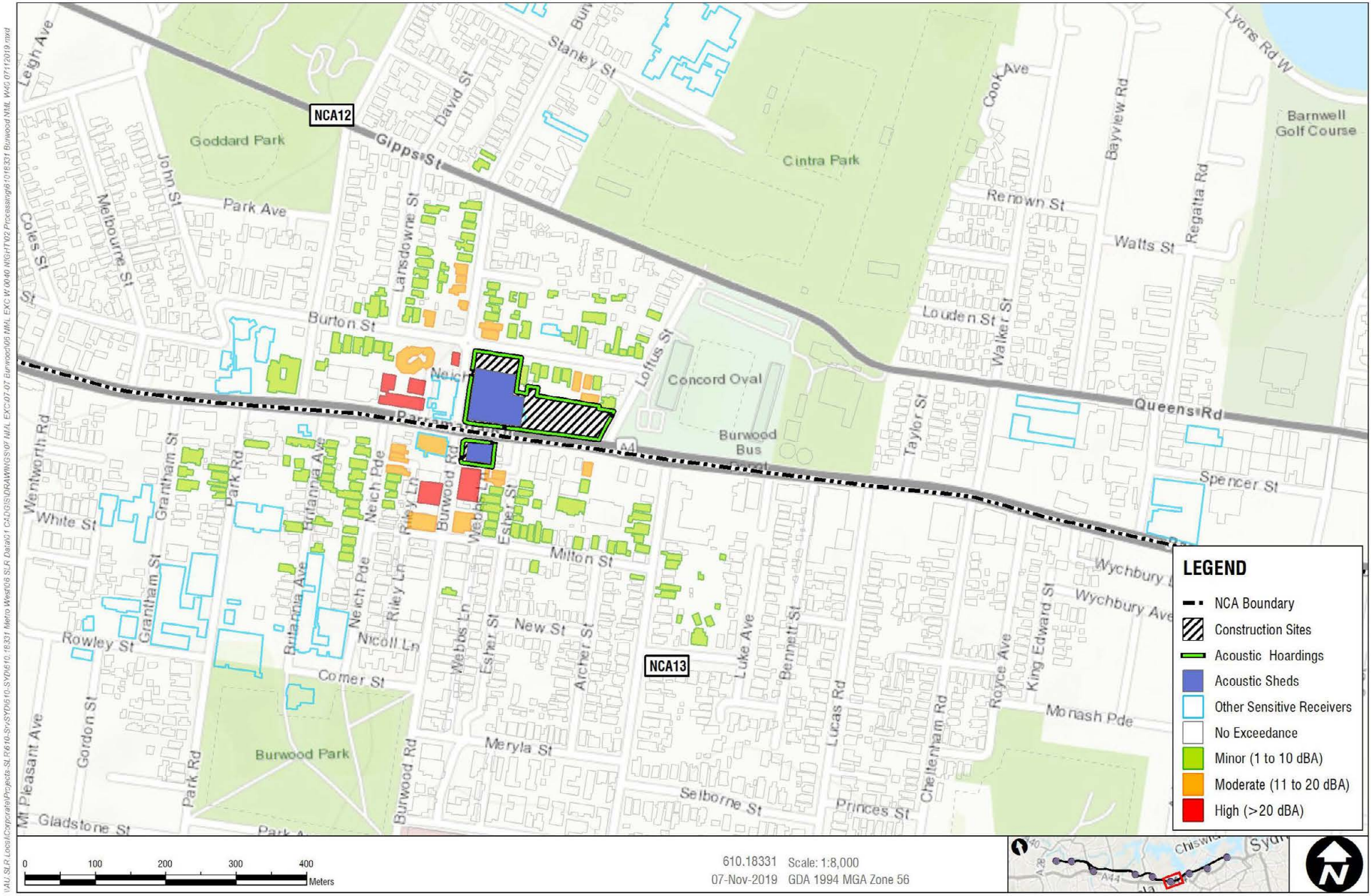


Figure 58 Worst-case Night-time Airborne Noise Impacts – Excavation in Shed using Rockbreaker (Doors Closed)

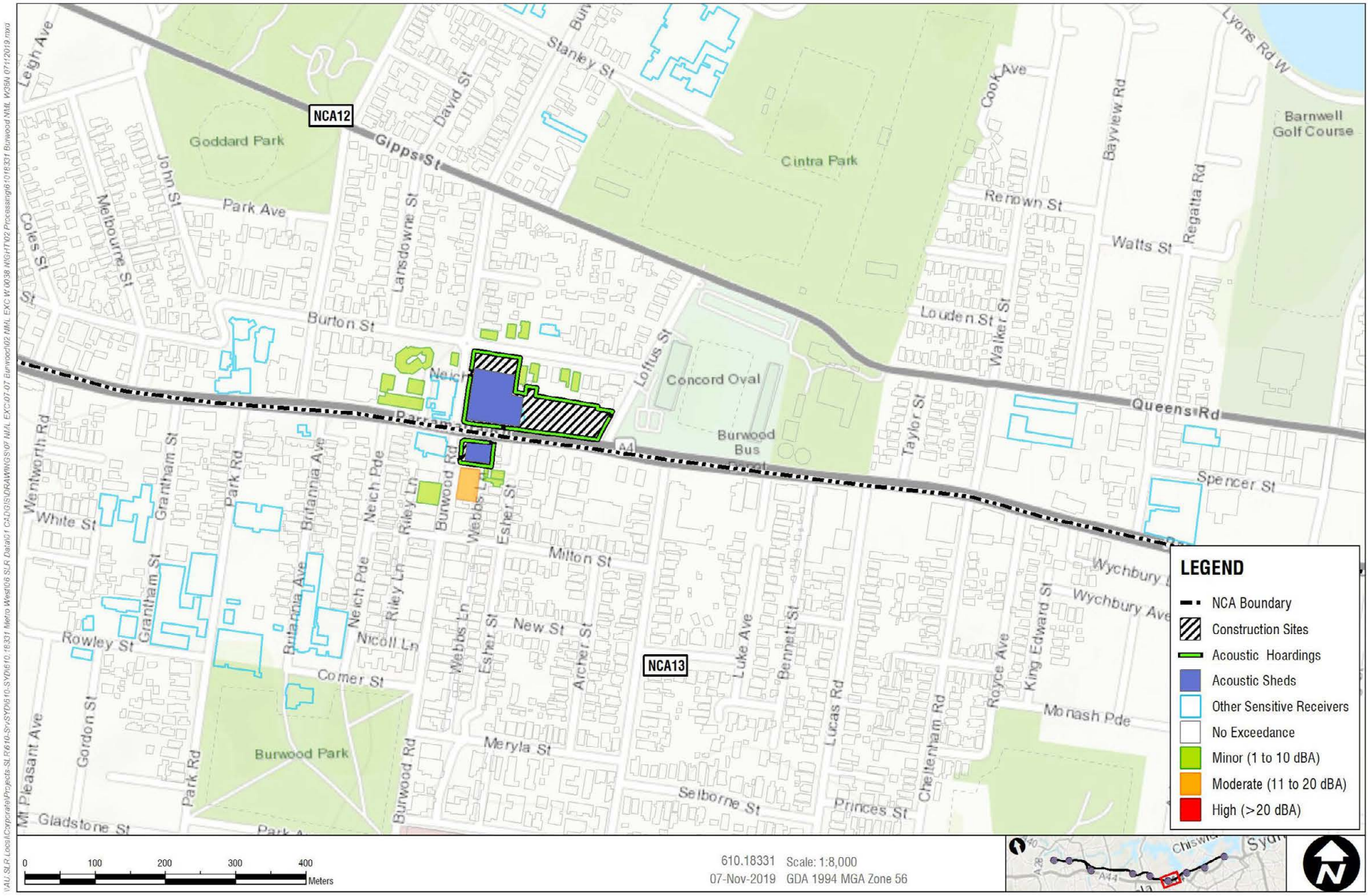
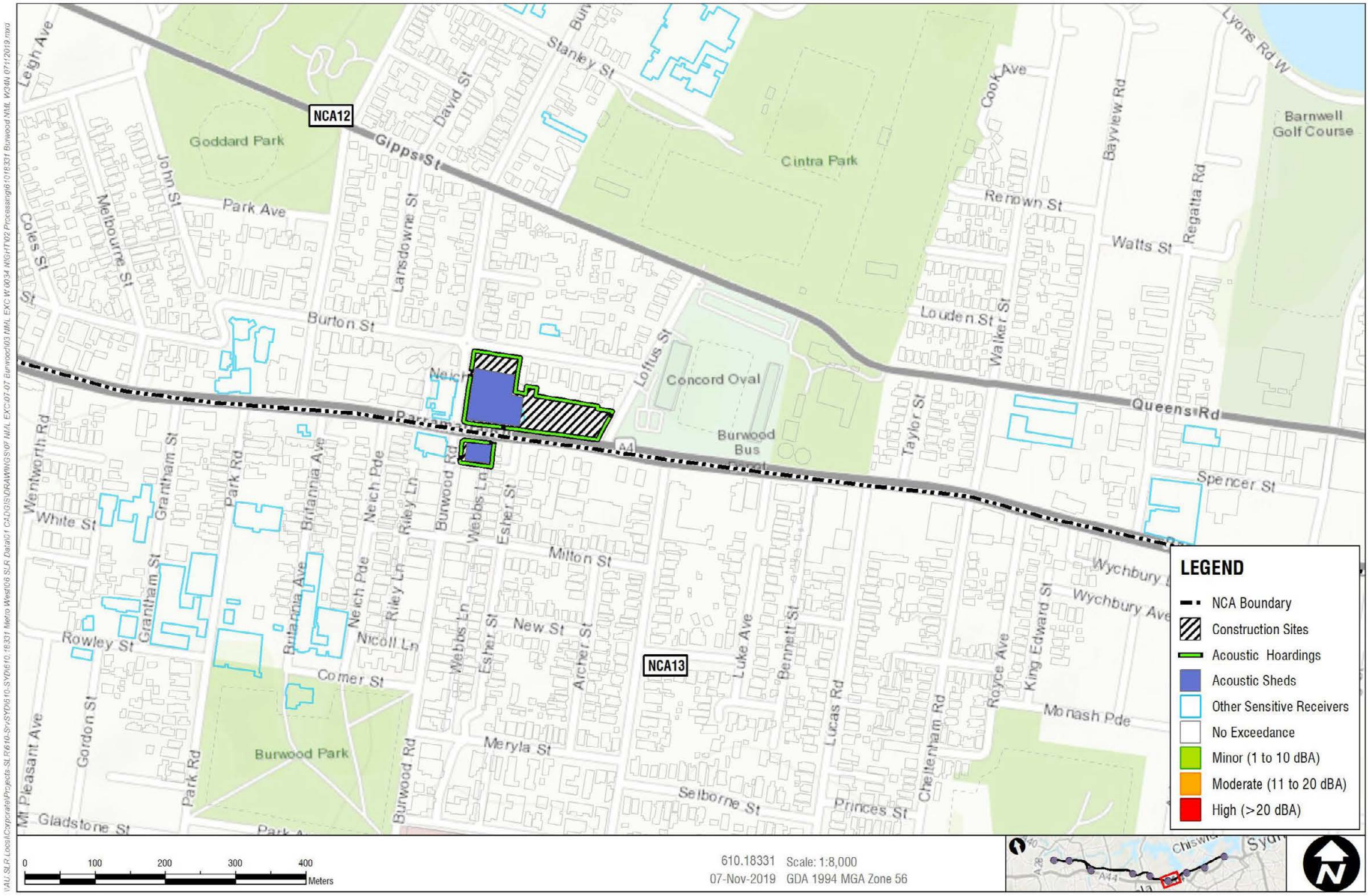


Figure 59 Worst-case Night-time Airborne Noise Impacts – Mucking Out (Doors Closed)



The above shows the following:

- The worst-case night-time noise levels from works in the acoustic sheds are expected to occur when rockbreakers are used and the shed doors are open. These works are predicted to result in 'high' impacts at the nearest receivers to the west of the site, which have line of sight to the doors. 'Moderate' impacts are predicted for the other receivers which are near to the site, with 'minor' impacts at more distant receivers.
- When the acoustic shed doors are closed, the impacts during rockbreaking are reduced substantially. One receiver to the south of the southern construction site is predicted to have 'moderate' worst-case impacts, with the other surrounding receivers at both sites having 'minor' impacts. More distant receivers in the study area are predicted to be compliant with the management levels.
- When rockbreakers are not in use during *Mucking out* in the acoustic shed, noise levels are reduced further and are predicted to be compliant with the management levels at all 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 8**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed for the construction works and is summarised in **Table 67.**

'Moderate' sleep disturbance impacts are predicted at the nearest residential receivers during noisy works as part of Excavation with shed. These impacts are generally controlled by the use of noise intensive equipment, such as rockbreakers inside the acoustic sheds.

The number of night-time awakenings during construction works would depend on several factors, including the type of equipment being used, the duration of the noisy works and the distance of the works to residential receivers. At this early stage in the project the currently available information does not allow for accurate prediction of the extent of night-time awakenings. Further investigation of awakenings would be completed during the next stages of Stage 1 when detailed construction planning information becomes available.

Highly Noise Affected Residential Receivers

The receivers predicted to be Highly Noise Affected during the worst-case impacts are summarised in **Table 70** and shown in **Figure 60**. The table shows the number of residential receivers separated by works activity and NCA.

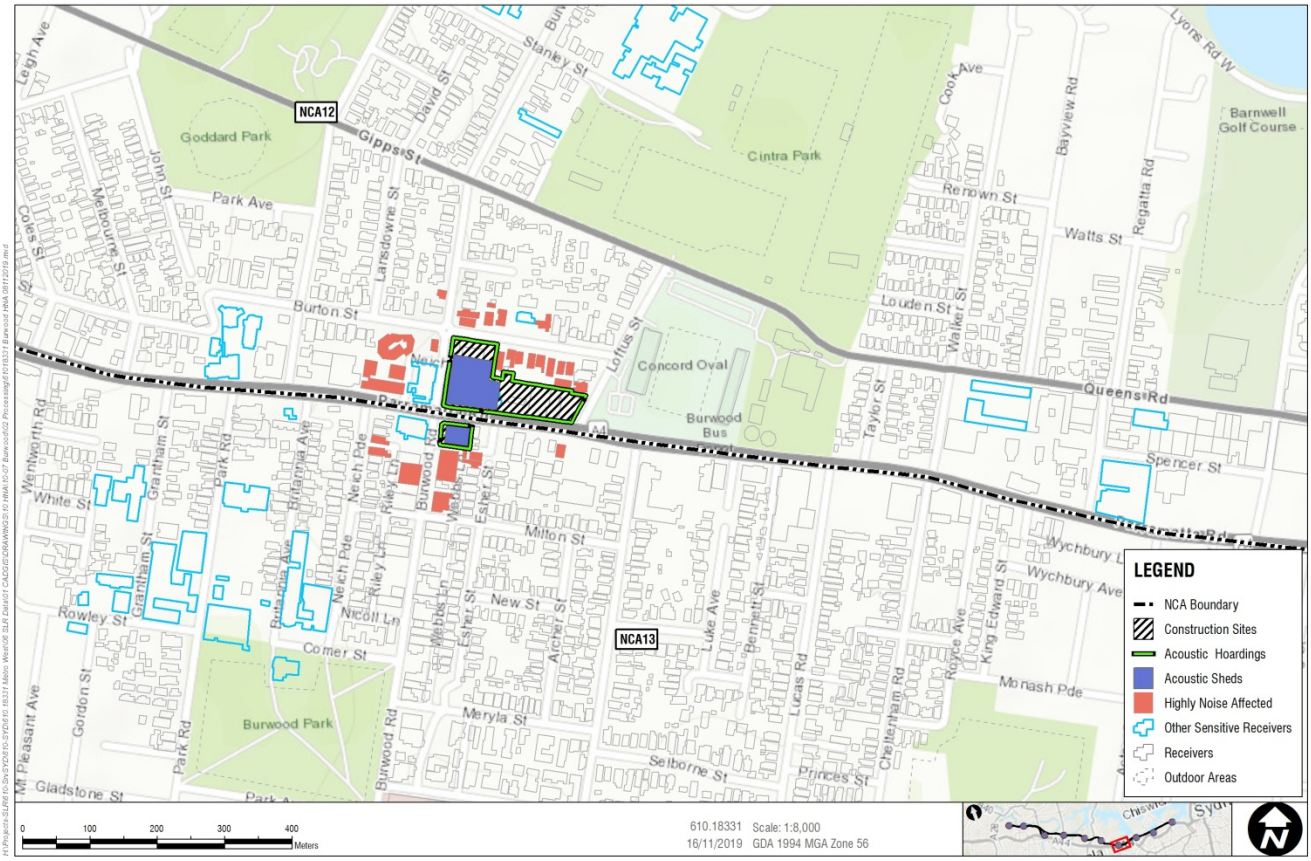
Table 70 Predicted Number of Highly Noise Affected Residential Receivers by Works and NCA

Scenario	Activity		NCA12			NCA13		
			Day	Eve	Night	Day	Eve	Night
Enabling works	'Typical'	Supporting and loading	1	n/a	n/a	-	n/a	n/a
	'Peak'	Demolition using a rockbreaker with supporting plant	21	n/a	n/a	6	n/a	n/a
Piling	'Typical'	Supporting works	-	n/a	n/a	-	n/a	n/a
	'Peak'	Bored piling with support plant	2	n/a	n/a	1	n/a	n/a
Surface construction	'Typical'	General works	-	n/a	n/a	-	n/a	n/a
	'Peak'	Noise intensive works	2	n/a	n/a	-	n/a	n/a
Initial excavation	'Typical'	Mucking out	1	n/a	n/a	1	n/a	n/a
	'Peak'	Through soft soil/rock	3	n/a	n/a	1	n/a	n/a
		Through rock using rockbreaker	15	n/a	n/a	9	n/a	n/a
Excavation with shed	'Typical'	Mucking out (Doors Closed)	-	-	-	-	-	-
	'Peak'	Through rock using rockbreaker (Doors Closed)	-	-	-	-	-	-
		Through rock using rockbreaker (Doors Open)	-	-	-	-	-	-
Mined cavern with shed	'Typical'	Spoil removal (Doors Closed)	-	-	-	-	-	-
	'Peak'	Mining with Support (Doors Closed)	-	-	-	-	-	-
		Mining with Support (Doors Open)	-	-	-	-	-	-

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

The assessment shows that the nearest receivers to the site are predicted to be Highly Noise Affected during daytime works involving rockbreakers before the acoustic sheds are constructed. Works in the sheds are not predicted to result in any Highly Noise Affected impacts.

Figure 60 Highly Noise Affected Residential Receivers (During Any Works)



5.2.7.4 Ground-borne Noise Impacts from Construction Sites

The predicted ground-borne impacts from vibration intensive station shaft excavation works inside the acoustic sheds are summarised in **Table 71**. The results are shown in **Figure 61** and **Figure 62** for the daytime and night-time periods, respectively. The predictions are representative of the highest ground-borne noise levels that would likely be experienced by adjacent receivers when excavation works are at their closest.

Table 71 Overview of Ground-borne NML Exceedances

NCA	Receiver Classification	Number of Receivers									
		Total	With NML Exceedance[1]								
			Daytime			Out-of-Hours Works					
						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
NCA12	Residential	903	3	1	1	7	2	1	8	3	2
	Commercial	86	-	-	-	-	-	-	-	-	-
	Other Sensitive	37	1	-	-	1	-	-	-	-	-
NCA13	Residential	741	3	-	-	3	1	-	3	3	-
	Commercial	79	-	1	-	-	-	-	-	-	-
	Other Sensitive	19	-	-	-	-	-	-	1	-	-

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

Figure 61 Ground-borne Noise Impacts – Daytime Construction Hours

Figure 62 Ground-borne Noise Impacts – Night-time

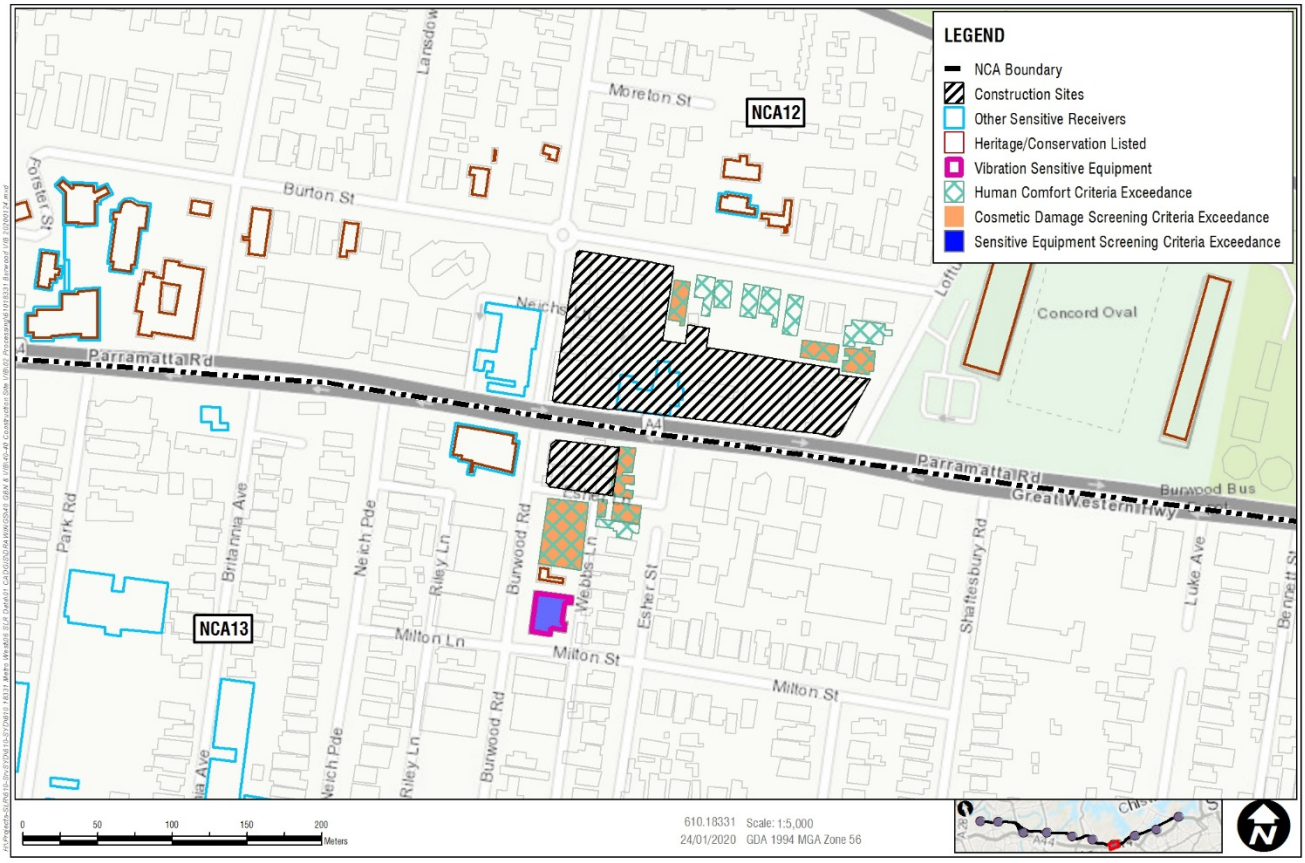
The above shows the following:

- Vibration intensive works are predicted to result in 'high' worst-case ground-borne noise impacts during the daytime at the nearest residential receiver to the north of the northern construction site. 'Moderate' or 'minor' exceedances are also predicted at a number of the other receivers surrounding both sites.
- The worst-case impacts during the night-time are predicted to be 'high' at the two nearest residential receivers to the north of the northern construction site. 'Moderate' or 'minor' exceedances are also predicted at the other surrounding receivers at both sites.
- Vibration intensive shaft excavation works inside the acoustic shed are anticipated to occur for 32 weeks. The predictions represent the worst-case scenario when shaft excavation works are at surface level and are, therefore, at the closest point to the affected buildings. As the works progress deeper, the impacts are expected to be reduce.

5.2.7.5 Vibration Impacts from Construction Sites

The predicted impacts during vibration intensive works are shown in **Figure 63**. The predictions are representative of the highest vibration levels that would likely be experienced by the nearest receivers when works are at their closest.

Figure 63 Worst-case Vibration Impacts



The above shows the following:

- The cosmetic damage screening criteria are predicted to be exceeded at the nearest residential buildings to the north of the northern construction site and to the south of the southern construction site.
- The human comfort criteria are also predicted to be exceeded at several of the nearest residential and commercial buildings, meaning occupants of affected buildings may be able to perceive vibration impacts at times when vibration intensive equipment is in use nearby.
- Exceedances of the vibration sensitive equipment screening criteria are predicted at Central Sydney ENT in Burwood, which was identified as potentially having vibration sensitive equipment with a VC-A criterion.

5.2.8 Five Dock Study Area (NCA14 and NCA15)

The Five Dock study area is centred on the Five Dock construction site. This study area contains two noise catchments (NCA14 and NCA15) which are to the west and east of Great North Road, respectively.

The Stage 1 works would use two separate sites located opposite each other on either side of Great North Road, near to the intersection with Second Avenue.

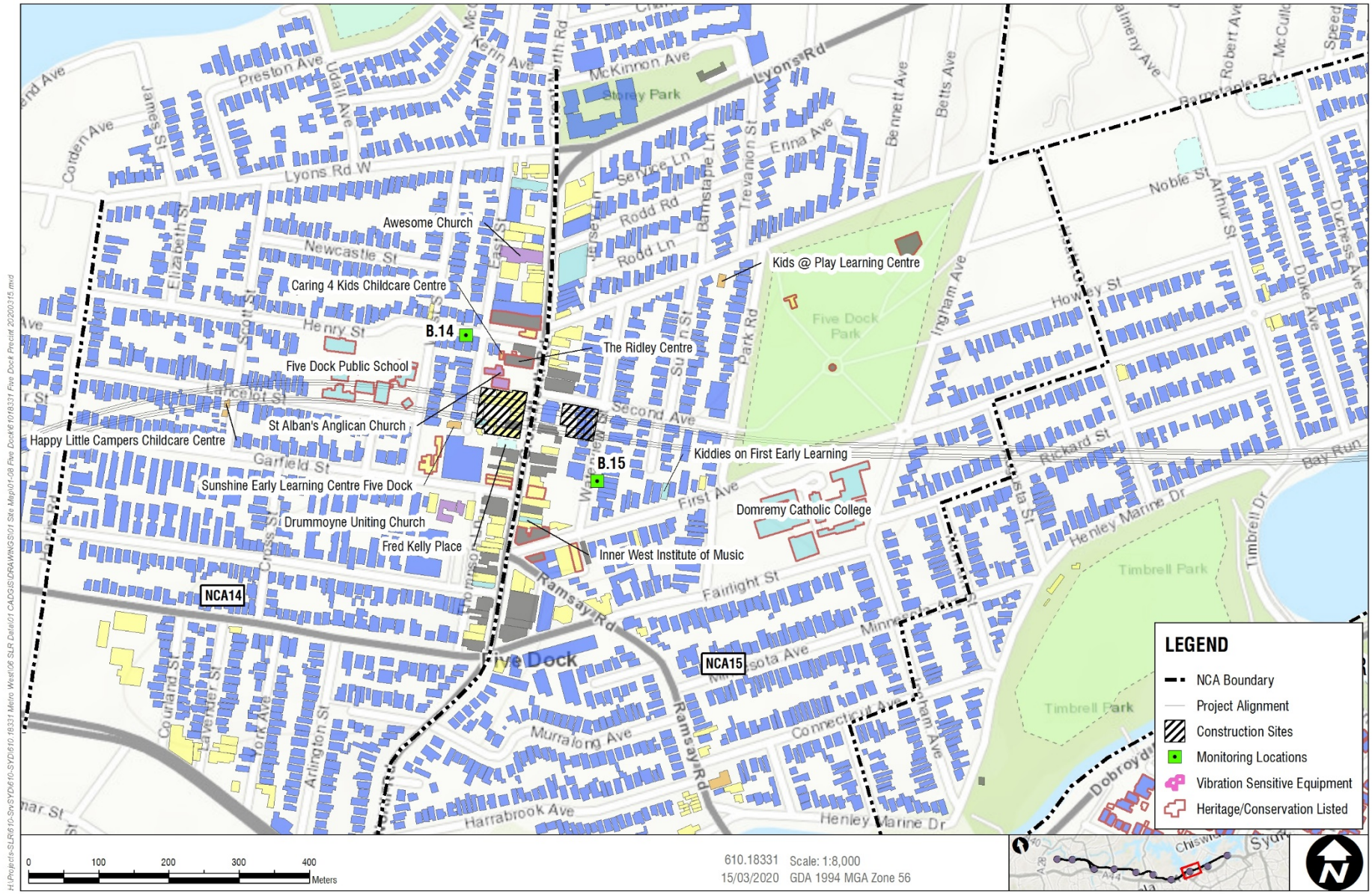
Existing noise levels in this study area are generally controlled by road traffic noise on the surrounding road network. The area surrounding the construction site is a mixture of commercial, 'other sensitive' and residential receivers, with the nearest receivers being close to the boundary of both the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

The NCAs in the Five Dock study area are described below and a map is shown in **Figure 64**.

NCA14 and NCA15

- The nearest receivers to the western construction site are residential buildings and the Caring4Kids Child Care centre on East Street, which are around 20 metres from the site boundary.
- St Albans Anglican Church is to the immediate north of the western construction site and Five Dock Public School is around 100 metres to the west.
- The nearest receivers to the eastern construction site are residential buildings to the immediate east, west and south of the site, near Waterview Street. These receivers are around five to 20 metres from the site boundary.
- Domremy Catholic College is around 300 metres to the east of the eastern construction site.
- Fred Kelly Place passive recreation area is located immediately south of the western construction site.
- Receivers further away on Great North Road are generally commercial and some 'other sensitive' uses, including hotels, cafés, bars and public buildings. The more distant parts of the study area are generally suburban residential receivers.

Figure 64 Site Map, Works and Sensitive Receivers



5.2.8.2 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 72**. The estimated duration of each activity is also provided, noting that most activities would be intermittent during this period and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

The main excavation works at this construction site would be completed in acoustic sheds.

The Stage 1 works within this study area are anticipated to have a total duration of approximately two years.

5.2.8.3 Airborne Noise Impacts from Construction Sites

Number of NML Exceedances

The predicted airborne noise impacts from construction site works in this study area are summarised in **Table 73**, **Table 74** and **Table 75** 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 when the works are at their nearest.

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 72 Surface construction Activities and Period of Works

Scenario	Activity		Total Indicative Duration (Weeks)[3]	Maximum Number of Working Faces		Hours of Works[1,2]				Comments
				Eastern site	Western site	Std. Day	Out-of-Hours Works			
							Day OOH	Eve	Night	
Enabling works	'Typical'	Supporting and loading	13	1	1	✓	-	-	-	Rockbreaking works would only occur intermittently during a 13 week period between 7am – 6pm. Total duration of rockbreaking works would be approximately 10 days.
	'Peak'	Demolition using a rockbreaker	13	1	2	✓	-	-	-	
Piling	'Typical'	Supporting works	26	1	2	✓	-	-	-	Piling works would only occur intermittently during a 10 week period at the eastern construction shaft and a 26 week program at the western construction site between 7am – 6pm. Up to two and four piling rigs would be active at the same time at the eastern and western sites, respectively.
	'Peak'	Bored piling with support plant	26	2	4	✓	-	-	-	
Surface construction	'Typical'	General works	5	1	1	✓	-	-	-	-
	'Peak'	Noise intensive works	5	2	2	✓	-	-	-	-
Initial excavation	'Typical'	Mucking out	10	1	1	✓	-	-	-	-
	'Peak'	Through soft soil/rock	4	2	2	✓	-	-	-	Excavation through soil and soft rock using excavator ripper attachment, before construction of the acoustic sheds.
		Through rock using rockbreaker	6	2	2	✓	-	-	-	Excavation through rock using rockbreaker, before construction of the acoustic sheds. Works restricted to Standard Construction Hours only.
Excavation with sheds	'Typical'	Mucking out	30	1	1	✓	✓	✓	✓	Out of hours works would only occur once the acoustic sheds and acoustic panels (where appropriate) have been constructed.
	'Peak'	Through rock using rockbreaker	30	2	2	✓	✓	✓	✓	
Mined cavern with shed	'Typical'	Spoil removal	30	1	1	✓	✓	✓	✓	-
	'Peak'	Mining with support	30	1	1	✓	✓	✓	✓	-

Note 1: Noise intensive works outside of Standard Construction Hours would only occur after construction of the acoustic sheds.

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

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

Table 73 Overview of NML Exceedances – All Receiver Types

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Supporting and loading	13	1814	1	35	17	1	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	13	1814	33	574	122	42	-	-	-	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	26	1814	-	42	13	1	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	26	1814	1	81	25	2	-	-	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	5	1814	-	26	2	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	5	1814	1	48	13	2	-	-	-	-	-	-	-	-	-	-	-	-
Initial excavation	'Typical'	Mucking out	10	1814	1	69	24	1	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	4	1814	1	115	27	6	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	6	1814	26	543	115	33	-	-	-	-	-	-	-	-	-	-	-	-
Excavation with sheds	'Typical'	Mucking out (Doors Closed)	30	1814	-	-	-	-	2	-	-	1	-	-	13	-	-	61	20	4
	'Peak'	Through rock using rockbreaker (Doors Closed)	30	1814	-	9	-	-	32	-	-	26	-	-	112	16	-	61	20	4
		Through rock using rockbreaker (Doors Open)	30	1814	1	81	15	2	183	34	7	172	29	6	375	88	17	108	22	6
Mined cavern with shed	'Typical'	Spoil removal (Doors Closed)	30	1814	-	-	-	-	1	-	-	1	-	-	9	-	-	61	20	4
	'Peak'	Mining with Support (Doors Closed)	30	1814	-	3	-	-	14	-	-	12	-	-	62	8	-	61	20	4
		Mining with Support (Doors Open)	30	1814	-	25	4	-	55	9	1	60	7	1	164	28	4	61	20	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 in the works areas.

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

Table 74 Overview of NML Exceedances – Residential Receivers

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Supporting and loading	13	1660	1	30	14	1	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	13	1660	33	540	107	37	-	-	-	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	26	1660	-	37	11	1	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	26	1660	1	72	23	1	-	-	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	5	1660	-	24	1	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	5	1660	1	41	12	1	-	-	-	-	-	-	-	-	-	-	-	-
Initial excavation	'Typical'	Mucking out	10	1660	1	60	21	1	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	4	1660	1	102	25	5	-	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	6	1660	26	507	102	30	-	-	-	-	-	-	-	-	-	-	-	-
Excavation with sheds	'Typical'	Mucking out (Doors Closed)	30	1660	-	-	-	-	2	-	-	1	-	-	13	-	-	61	20	4
	'Peak'	Through rock using rockbreaker (Doors Closed)	30	1660	-	7	-	-	30	-	-	25	-	-	112	16	-	61	20	4
		Through rock using rockbreaker (Doors Open)	30	1660	1	71	14	2	173	33	7	167	29	6	375	88	17	108	22	6
Mined cavern with shed	'Typical'	Spoil removal (Doors Closed)	30	1660	-	-	-	-	1	-	-	1	-	-	9	-	-	61	20	4
	'Peak'	Mining with Support (Doors Closed)	30	1660	-	2	-	-	13	-	-	11	-	-	62	8	-	61	20	4
		Mining with Support (Doors Open)	30	1660	-	21	4	-	51	9	1	57	7	1	164	28	4	61	20	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 in the works areas.

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

Table 75 Overview of Commercial and 'Other Sensitive' Receiver NML Exceedances

Scenario	Activity		No. Weeks[1]	Number of Receivers																								
				Commercial			Café/bar			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
Enabling works	'Typical'	Supporting and loading	13	-	-	-	1	-	-	1	1	-	-	-	-	2	-	-	1	1	-	-	-	-	-	1	-
	'Peak'	Demolition using a rockbreaker	13	14	1	-	5	5	-	2	2	1	10	6	-	-	1	1	2	-	2	1	-	-	-	-	1
Piling	'Typical'	Supporting works	26	-	-	-	1	-	-	-	1	-	-	-	-	2	-	-	1	1	-	-	-	-	1	-	-
	'Peak'	Bored piling with support plant	26	-	-	-	2	-	-	1	1	-	3	-	-	2	-	-	-	1	1	-	-	-	1	-	-
Surface construction	'Typical'	General works	5	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	5	-	-	-	1	-	-	1	1	-	1	-	-	2	-	-	1	-	1	-	-	-	1	-	-
Initial excavation	'Typical'	Mucking out	10	-	-	-	2	-	-	1	1	-	3	-	-	2	-	-	-	2	-	-	-	-	1	-	-
	'Peak'	Through soft soil/rock	4	-	-	-	3	-	-	2	1	-	5	-	-	2	-	-	-	1	1	-	-	-	1	-	-
		Through rock using rockbreaker	6	13	-	-	7	3	-	3	2	1	10	5	-	-	2	-	2	-	2	1	-	-	-	1	-
Excavation with sheds	'Typical'	Mucking out (Doors Closed)	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through rock using rockbreaker (Doors Closed)	30	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
		Through rock using rockbreaker (Doors Open)	30	-	-	-	2	-	-	2	1	-	1	-	-	2	-	-	2	-	-	-	-	-	1	-	-
Mined cavern with shed	'Typical'	Spoil removal (Doors Closed)	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Mining with Support (Doors Closed)	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
		Mining with Support (Doors Open)	30	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	2	-	-	-	-	-	-	-	-

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

The above shows the following:

- The Stage 1 construction works are predicted to result in 'high' worst-case noise impacts at the nearest receivers during higher noise generating activities. The nearest receivers to the site are generally residential and 'other sensitive' receivers. The worst-case impacts are predicted during *Enabling works* and *Initial excavation* which would occur before the acoustic sheds are constructed. These works are, however, limited to Standard Construction Hours and would not occur during the evening or night-time.
- The highest impacts are during 'Peak' scenarios which use noise intensive equipment such as rockbreakers. Rockbreakers would, however, only be used intermittently and the duration is around 10 days for *Enabling works* and around six weeks for *Initial excavation* works. When noise intensive equipment is not in use during 'Typical' works, the worst-case impacts are predicted to be reduced, however, 'high' or 'moderate' worst-case impacts remain at the nearest receivers
- Noise intensive works outside of Standard Construction Hours would only be completed in the acoustic sheds once built. The worst-case impacts from works in the sheds during the night-time are generally predicted to be 'moderate' at the nearest receivers during *Excavation with sheds* and *Mined cavern with sheds* when rockbreakers are in use and the shed doors are closed. When rockbreakers and roadheaders are in use and the doors are open several of the nearest receivers are predicted to have 'high' impacts with many surrounding receivers having 'moderate' impacts.
- Works requiring noise intensive equipment outside of the acoustic sheds before they are constructed are predicted to result in Highly Noise Affected impacts at the nearest residential receivers.
- 'High' sleep disturbance impacts are predicted for the nearest residential receivers. These impacts result from noise intensive rockbreaking in the acoustic sheds when doors are open and occasional high noise levels from heavy vehicles moving around the outdoor areas of the site.

Impacts during Standard Construction Hours

The worst-case impacts during Standard Construction Hours are predicted when noise intensive works occur before construction of the acoustic sheds. The predicted worst-case daytime impacts in this study area are shown in:

- **Figure 65** – All outdoor works, including rockbreakers
- **Figure 66** – All outdoor works, not including rockbreakers.

The highest impact works are expected to last for:

- *Enabling works – Demolition using a rockbreaker* – 10 days (actual rockbreaker use)
- *Initial excavation – Through rock using rockbreaker* – six weeks.

Figure 65 Worst-case Daytime Airborne Noise Impacts – All Outdoor Works, including Rockbreakers

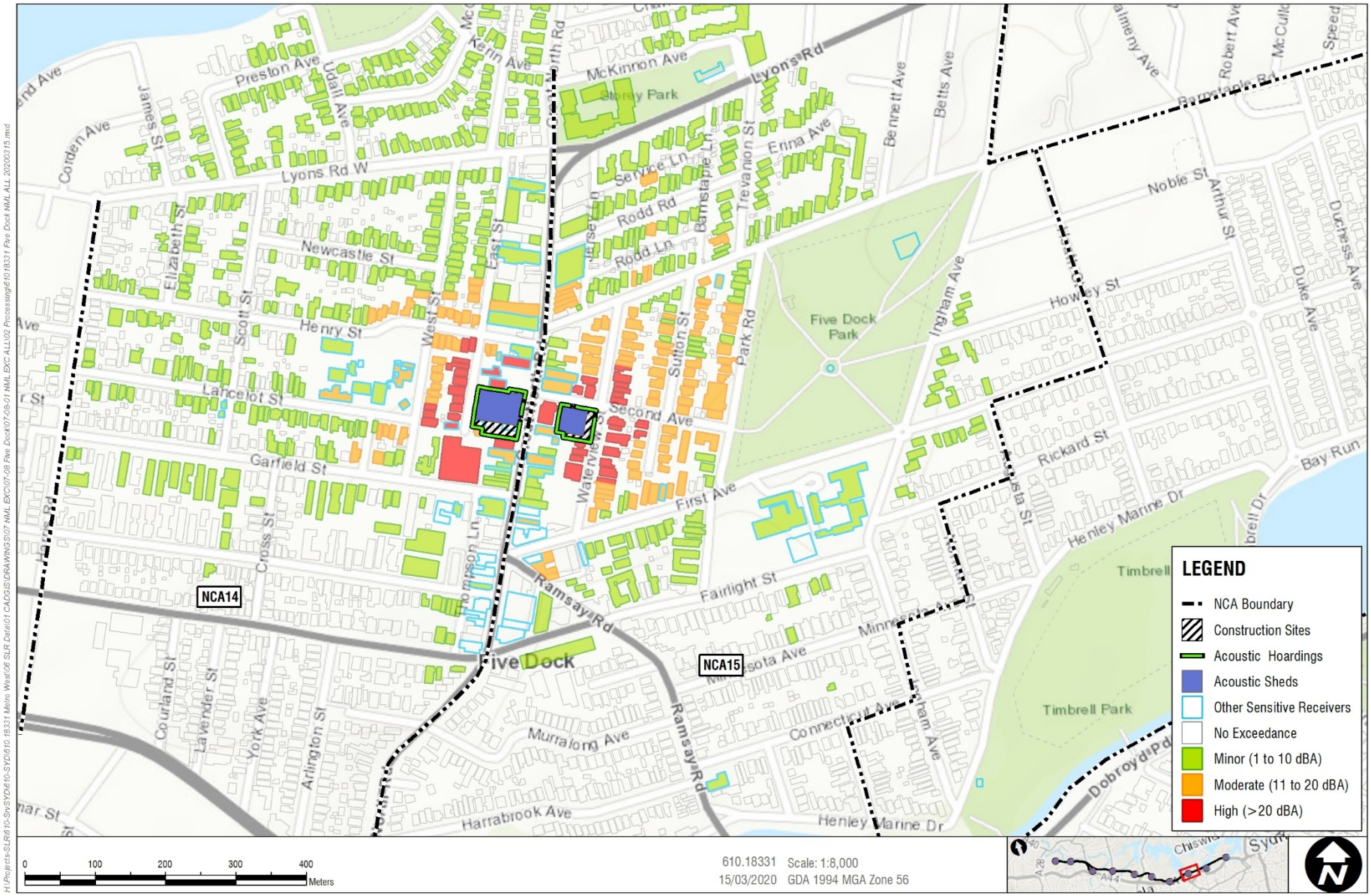
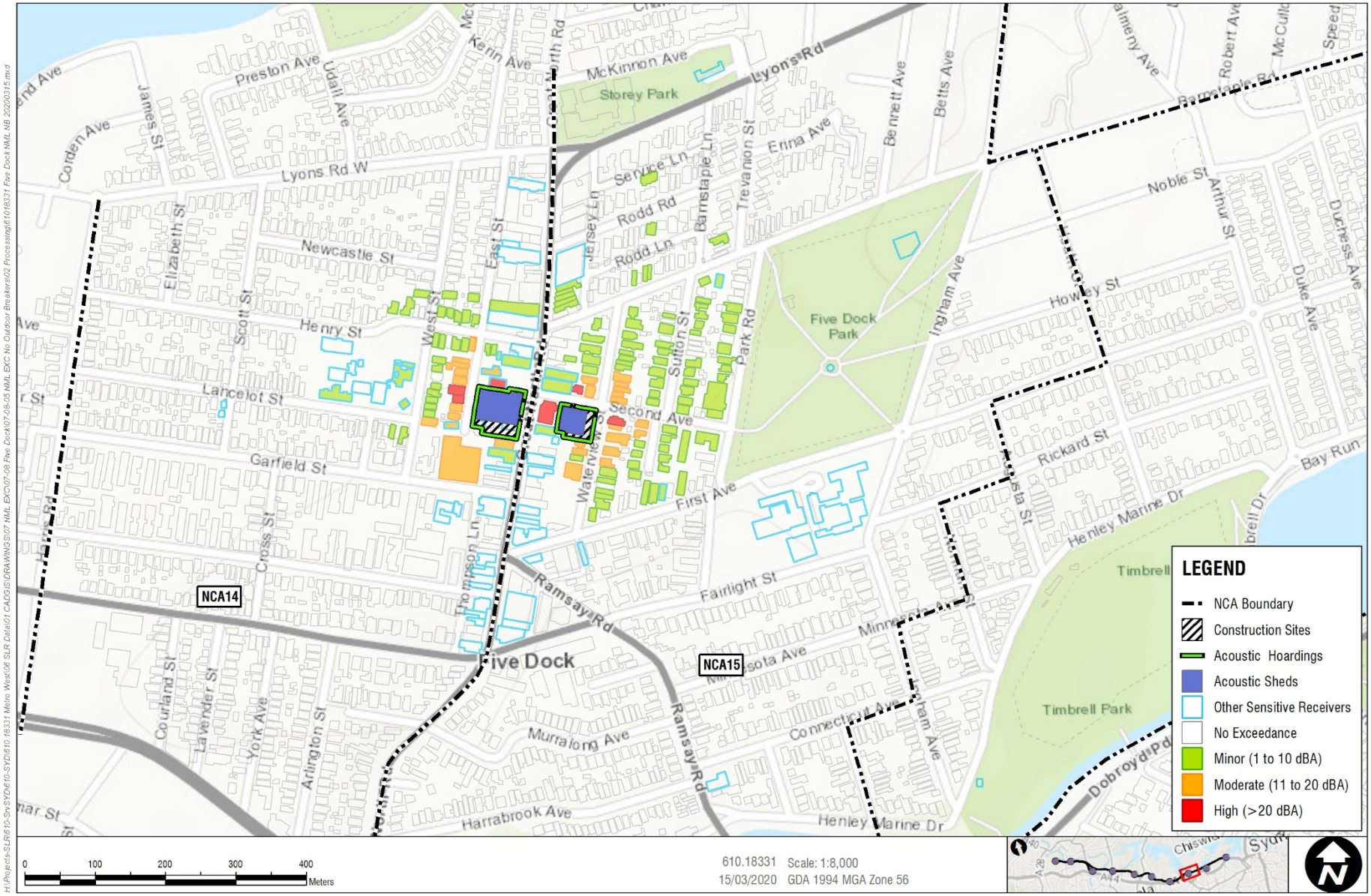


Figure 66 Worst-case Daytime Airborne Noise Impacts – All Outdoor Works, not including Rockbreakers



The above shows the following:

- The worst-case daytime impacts are predicted during noise intensive works, such as rockbreaking, which occur prior to construction of the acoustic sheds. The impacts are expected to be 'high' at receivers near the site and 'moderate' or 'minor' for receivers which are more distant. The nearest receivers are a mixture of residential, commercial and 'other sensitive'.
- The worst-case impacts at 'other sensitive' receivers are predicted to be:
    - 'High' at St Ablan's Anglican Church, Sunshine Early Learning Centre, Fred Kelly Place and The Ridley Centre mixed use hall, which are adjacent to the western site.
    - 'Moderate' at Caring 4 Kids Child Care, Ottimo House venue hire, Inner West Institute of Music, several buildings at Five Dock Public School, Da Vinci Hub Learning Centre, Kids @ Play Learning Centre, Kiddies on First Early Learning and several café/bars on Great North Road.
- When rockbreakers are not in use during outdoor works, the noise levels are predicted to be substantially lower, however, 'high' worst-case impacts remain at receivers adjacent to the site boundary, with the other receivers which surround the site being subject to 'moderate' or 'minor' impacts.
- When rockbreakers are being used inside the acoustic sheds and doors are closed, the impacts at the nearest receivers are predicted to be 'minor' or compliant with the 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.

Impacts during the Night-time

Noise intensive works during the night-time at this construction site would only be completed inside the acoustic sheds. The worst-case impacts are predicted during *Excavation with sheds* when rockbreakers are in use. The predicted worst-case night-time impacts from the assessed scenarios in this study area are shown in:

- **Figure 67** – *Excavation with sheds – Through rock using rockbreaker* (Doors Open)
- **Figure 68** – *Excavation with sheds – Through rock using rockbreaker* (Doors Closed)
- **Figure 69** – *Excavation with shed – Mucking out (Doors Closed)*, which has no requirement for noise intensive equipment.

The highest impact works are expected to last for:

- *Excavation with sheds – Through rock using rockbreaker* – 30 weeks
- *Excavation with shed – Mucking out* – 30 weeks.

Figure 67 Worst-case Night-time Airborne Noise Impacts – Excavation in Sheds using Rockbreaker (Doors Open)

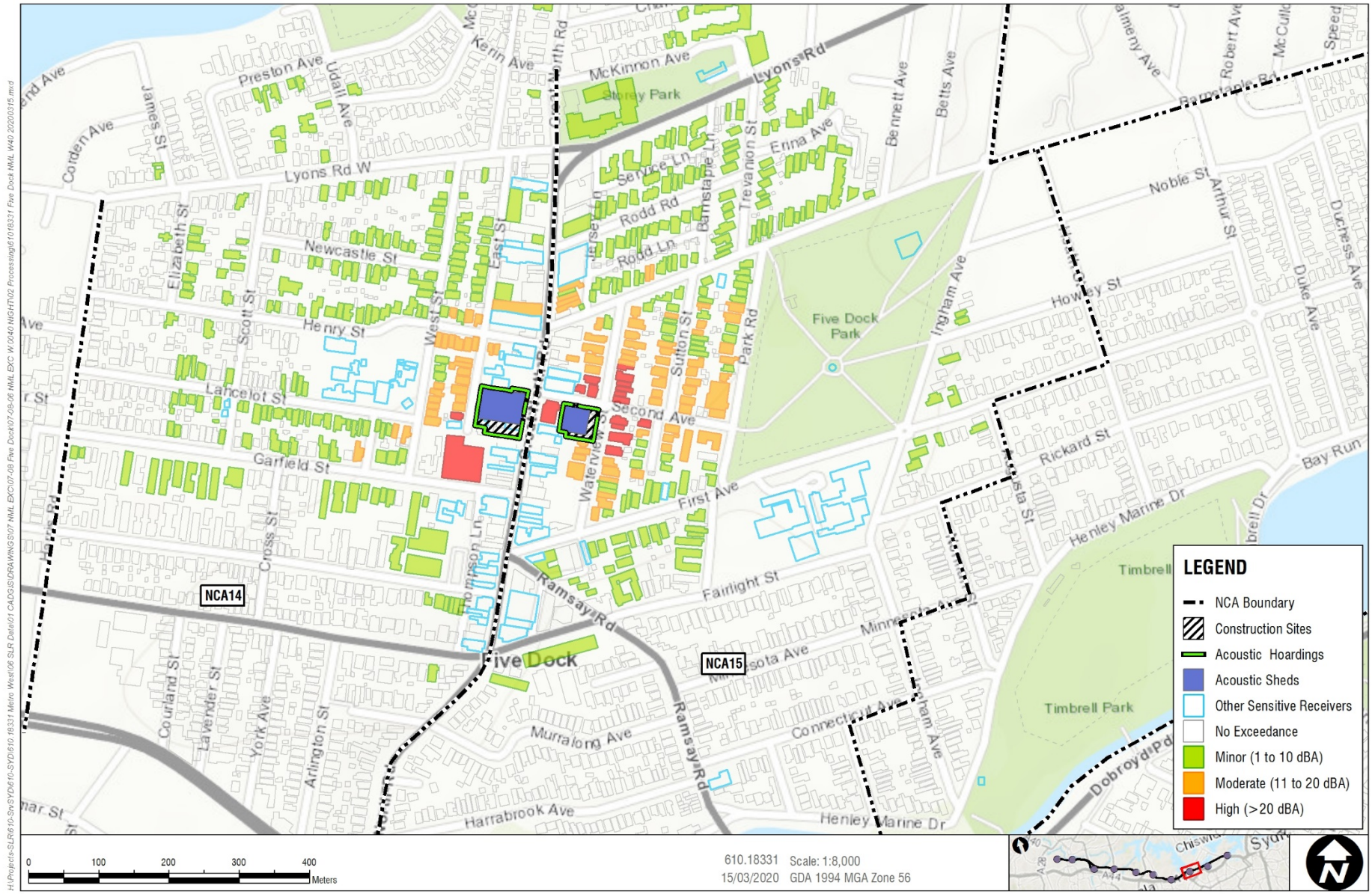


Figure 68 Worst-case Night-time Airborne Noise Impacts – Excavation in Sheds using Rockbreaker (Doors Closed)

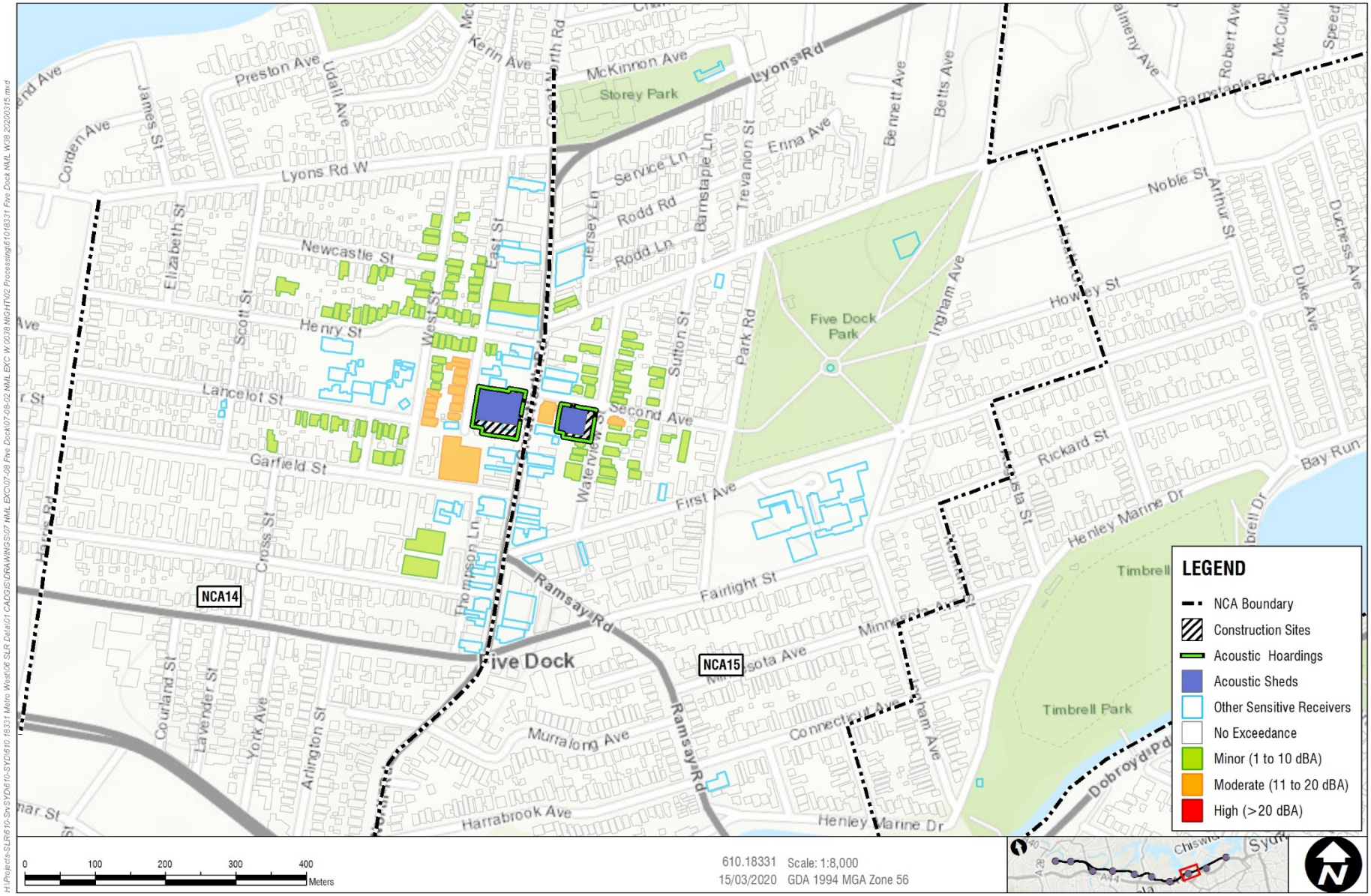
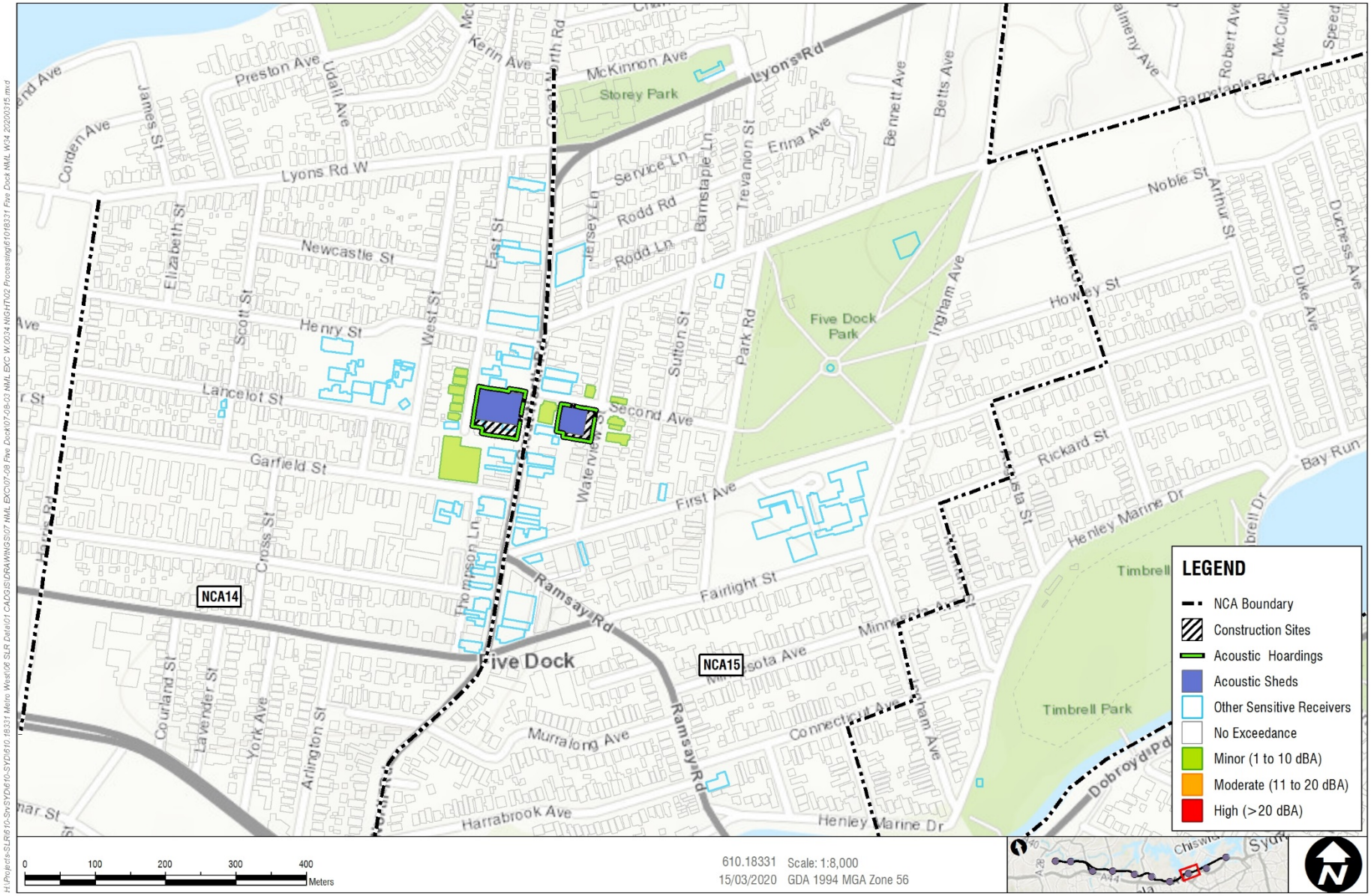


Figure 69 Worst-case Night-time Airborne Noise Impacts – Mucking Out (Doors Closed)



The above shows the following:

- The worst-case night-time noise levels from works in the acoustic sheds are expected to occur when rockbreakers are used and the shed doors are open. These works are predicted to result in 'high' impacts at residential receivers which surround the two sites. 'Moderate' impacts are predicted for the other receivers which are near to the site, with 'minor' impacts at more distant receivers.
- When the acoustic shed doors are closed, the impacts during rockbreaking are reduced substantially. The receivers adjacent both sites are predicted to have 'moderate' worst-case impacts, with the other surrounding receivers having 'minor' impacts. More distant receivers in the study area are predicted to be compliant with the management levels.
- When rockbreakers are not in use during *Mucking out* in the acoustic sheds, noise levels are reduced further and the extent of the predicted exceedances is mostly reduced to 'minor' impacts at 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 8**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed for the construction works and is summarised in **Table 73**.

'High' sleep disturbance impacts are predicted at the adjacent residential receivers during noisy works as part of *Excavation with shed* and *Mined Cavern with shed*, with 'moderate' impacts at receivers which are more distant. These impacts result from heavy vehicles accessing the site and movements in the outdoor areas of the site. Sleep disturbance impacts are predicted to increase if acoustic shed doors are opened during excavation works.

The potential awakenings from heavy vehicles would be influenced by the number of heavy vehicles accessing the eastern and western construction sites during the night-time and the way in which the vehicles are operated. The number of heavy vehicles at these construction site during the night-time are expected to be around five trucks per hour per site.

Further investigation of awakenings would be completed during the next stages of Stage 1 when detailed construction planning information becomes available.

Highly Noise Affected Residential Receivers

The receivers predicted to be Highly Noise Affected during the worst-case impacts are summarised in **Table 76** and shown in **Figure 70**. The table shows the number of residential receivers separated by works activity and NCA.

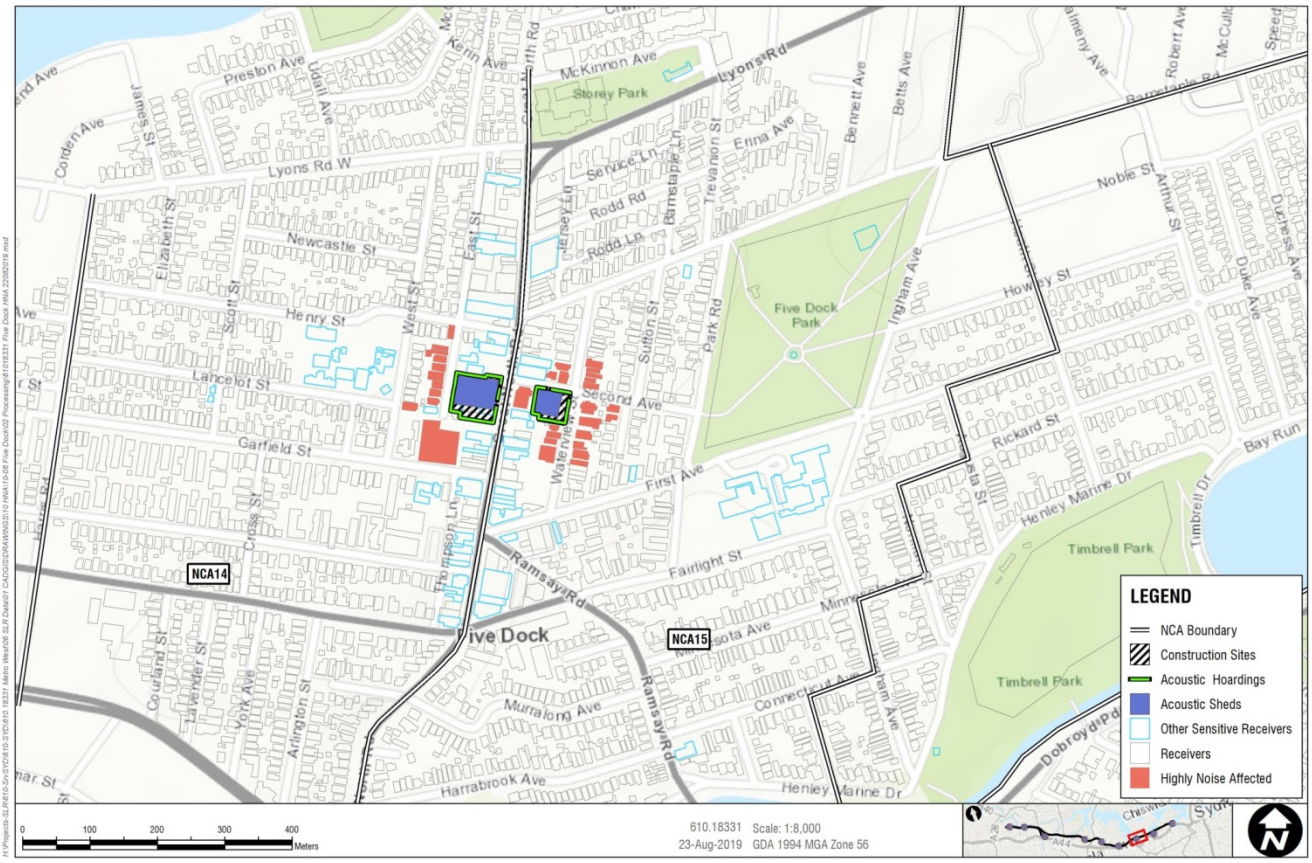
Table 76 Predicted Number of Highly Noise Affected Residential Receivers by Works and NCA

Scenario	Activity		NCA14			NCA15		
			Day	Eve	Night	Day	Eve	Night
Enabling works	'Typical'	Supporting and loading	-	n/a	n/a	1	n/a	n/a
	'Peak'	Demolition using a rockbreaker with supporting plant	11	n/a	n/a	22	n/a	n/a
Piling	'Typical'	Supporting works	-	n/a	n/a	-	n/a	n/a
	'Peak'	Bored piling with support plant	-	n/a	n/a	1	n/a	n/a
Surface construction	'Typical'	General works	-	n/a	n/a	-	n/a	n/a
	'Peak'	Noise intensive works	-	n/a	n/a	1	n/a	n/a
Initial excavation	'Typical'	Mucking out	-	n/a	n/a	1	n/a	n/a
	'Peak'	Through soft soil/rock	-	n/a	n/a	1	n/a	n/a
		Through rock using rockbreaker	9	n/a	n/a	17	n/a	n/a
Excavation with shed	'Typical'	Mucking out (Doors Closed)	-	-	-	-	-	-
	'Peak'	Excavation through rock using rockbreaker (Doors Closed)	-	-	-	-	-	-
		Excavation through rock using rockbreaker (Doors Open)	-	-	-	1	1	1
Mined cavern with shed	'Typical'	Spoil removal (Doors Closed)	-	-	-	-	-	-
	'Peak'	Mining with Support (Doors Closed)	-	-	-	-	-	-
		Mining with Support (Doors Open)	-	-	-	-	-	-

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

The assessment shows that the nearest receivers to the site are predicted to be Highly Noise Affected during the noisiest daytime works before the acoustic shed is constructed. Works in the shed are predicted to result in Highly Noise Affected impacts at one receiver which is adjacent to the site boundary of the western construction site.

Figure 70 Highly Noise Affected Residential Receivers (During Any Works)



5.2.8.4 Ground-borne Noise Impacts from Construction Sites

The predicted ground-borne impacts from vibration intensive station shaft excavation works inside the acoustic sheds are summarised in **Table 77**. The results are shown in **Figure 71** and **Figure 72** for the daytime and night-time periods, respectively. The predictions are representative of the highest ground-borne noise levels that would likely be experienced by adjacent receivers when excavation works are at their closest.

Table 77 Overview of Ground-borne NML Exceedances

NCA	Receiver Classification	Number of Receivers									
		Total	With NML Exceedance[1]								
			Daytime			Out-of-Hours Works					
						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
NCA14	Residential	877	6	-	-	5	2	-	3	6	-
	Commercial	55	-	-	-	-	-	-	-	-	-
	Other Sensitive	39	1	1	-	-	-	-	-	-	-
NCA15	Residential	736	3	-	1	4	1	1	4	3	1
	Commercial	44	-	-	-	-	-	-	-	-	-
	Other Sensitive	25	2	1	-	2	1	-	-	-	-

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

Figure 71 Ground-borne Noise Impacts – Daytime Construction Hours

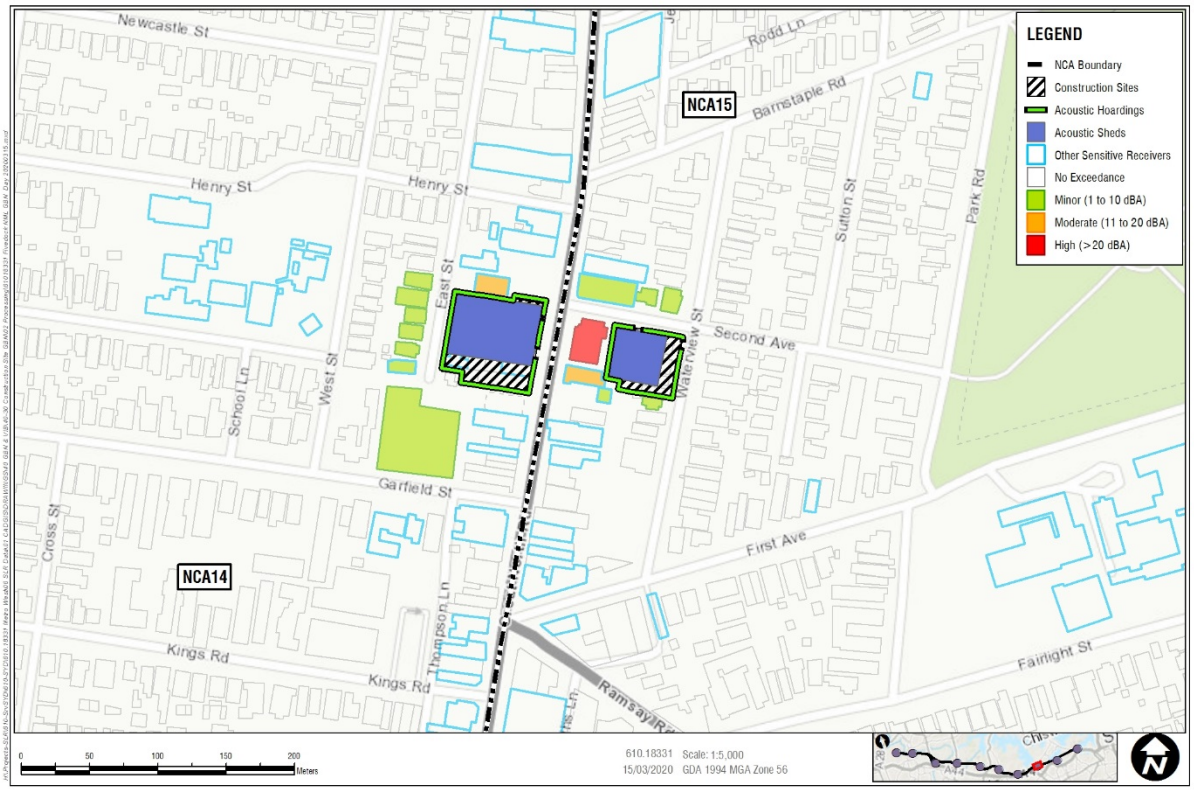
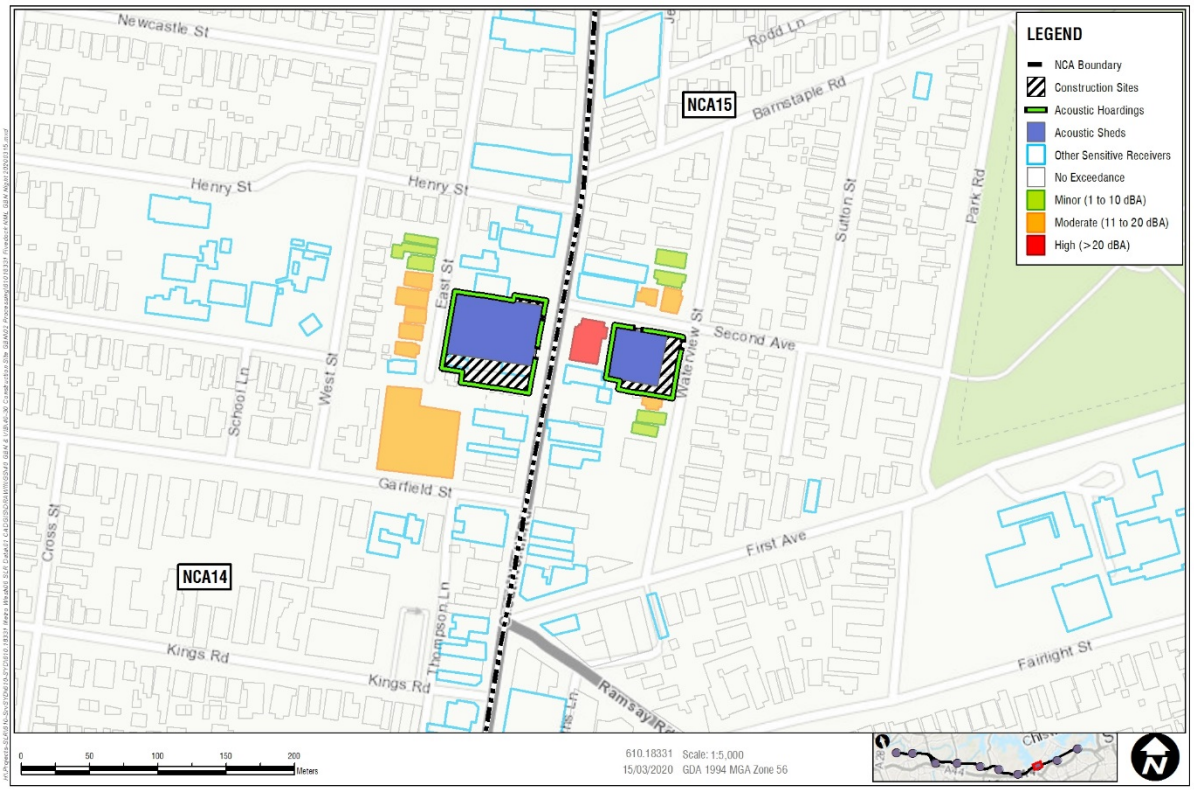


Figure 72 Ground-borne Noise Impacts – Night-time



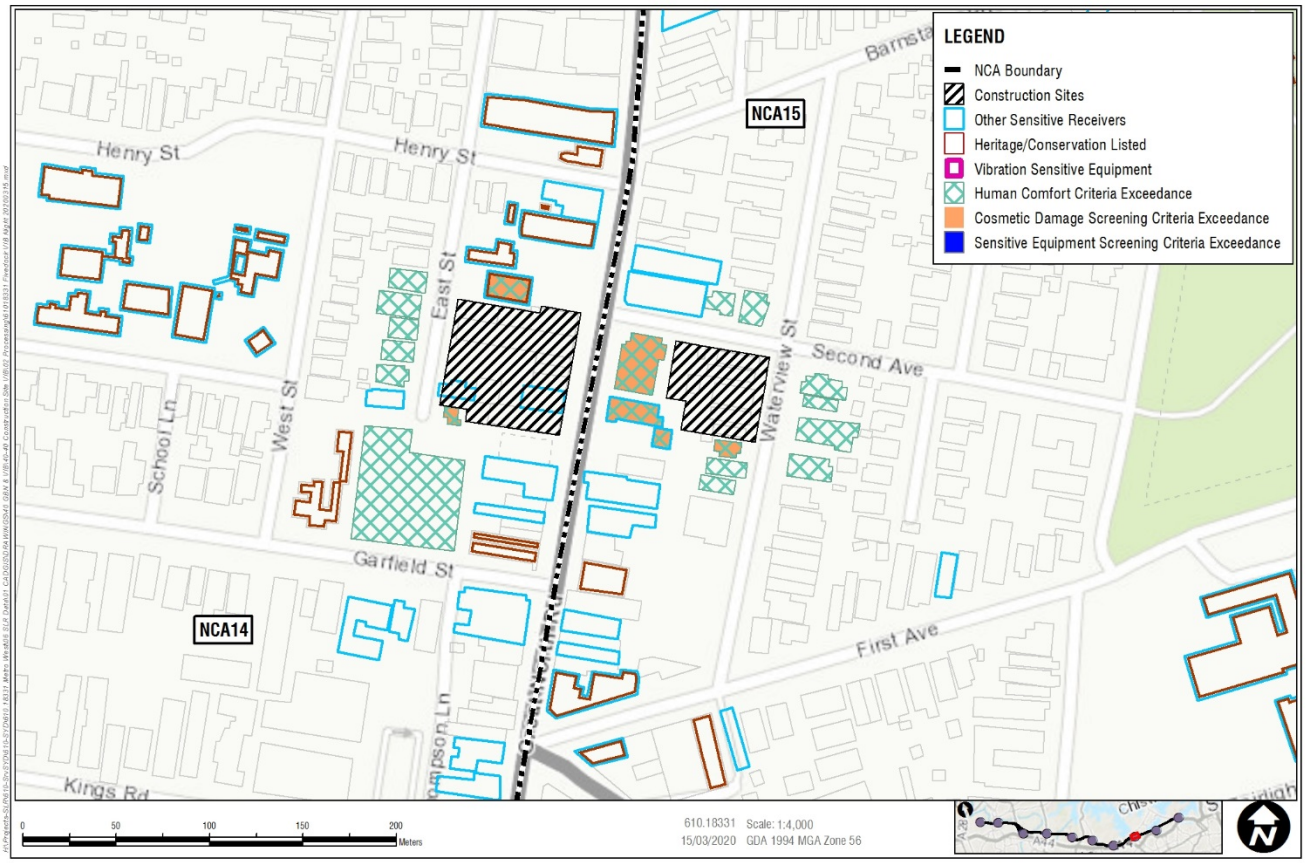
The above shows the following:

- Vibration intensive works are predicted to result in 'high' worst-case ground-borne noise impacts during the daytime at the nearest residential receiver to the west of the eastern construction site. 'Moderate' or 'minor' exceedances are also predicted at several other receivers surrounding both sites.
- The worst-case impacts during the night-time are predicted to be 'high' at the same residential receiver to the west of the eastern construction site. 'Moderate' or 'minor' exceedances are also predicted at the receivers surrounding the sites.
- Vibration intensive shaft excavation works inside the acoustic shed are anticipated to occur for 30 weeks. The predictions represent the worst-case scenario when shaft excavation works are at surface level and are, therefore, at the closest point to the affected buildings. As the works progress deeper, the impacts are expected to be reduce.

5.2.8.5 Vibration Impacts from Construction Sites

The predicted impacts during vibration intensive works are shown in **Figure 73**. The predictions are representative of the highest vibration levels that would likely be experienced by the nearest receivers when works are at their closest.

Figure 73 Worst-case Vibration Impacts



The above shows the following:

- The cosmetic damage screening criteria are predicted to be exceeded at the nearest buildings to both sites. This includes St. Alban's Anglican Church that is located to the north of the western construction site.
- 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.
- There are no predicted exceedances of the sensitive equipment screening criteria.

5.2.9 The Bays Study Area (NCA20 to NCA22)

The Bays study area is centred on The Bays Station construction site. This study area contains three noise catchments (NCA20 to NCA22) which cover Rozelle, Balmain and Glebe.

The construction site is located to the east of the former White Bay Power Station and north of Anzac Bridge.

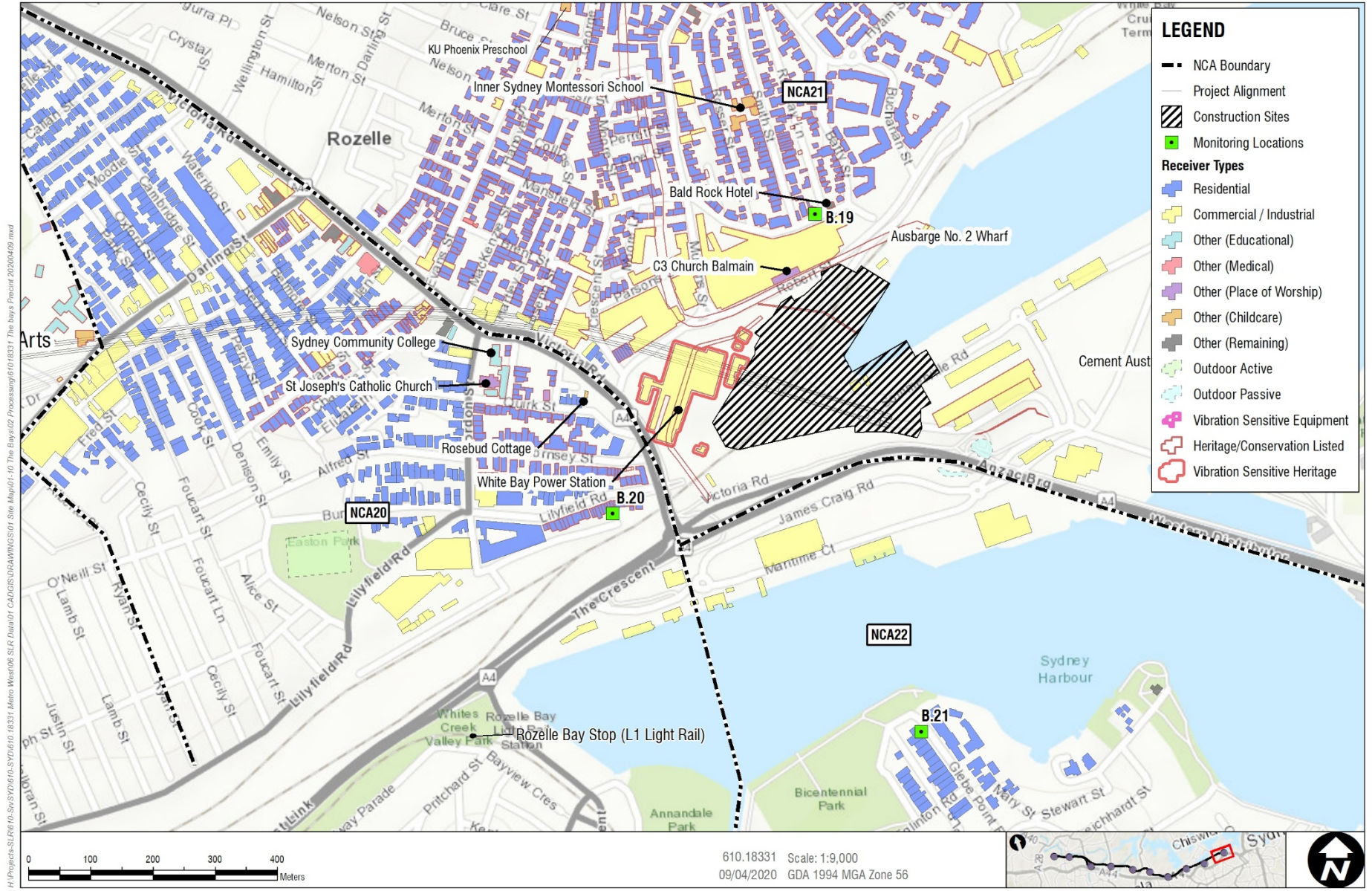
Existing noise levels in this study area are controlled by road traffic noise from Victoria Road and the Western Distributor, and industrial noise from White Bay and Glebe Island. The area surrounding the construction site is mainly commercial/industrial. The nearest receivers are close to the boundary of the site, however, they are not considered particularly sensitive to noise impacts given their industrial use.

The NCAs in the Bays study area are described below and a map is shown in **Figure 74**.

NCA20 to NCA22

- The nearest receivers to the site are commercial/industrial buildings associated with White Bay, Glebe Island and Rozelle Bay. A large commercial area is also located to the north-west of the site across Robert Street.
- The nearest residential receivers are located around 150 metres to the west, near Victoria Road. Further residential areas are to the north in Rozelle and to the south in Glebe. Receivers in NCA21 generally rise in elevation the further north that are from the construction site. This means that these receivers have very little noise shielding from the construction site due to their tiered positioning.
- C3 Church Rozelle is around 40 metres to the north of the construction site. St Joseph's Catholic Church and Sydney Community College are also located around 350 metres west of the site.
- The Bald Rock Hotel is located around 130 metres north of the construction site on Mansfield Street.
- Rosebud Cottage Child Care is located around 180 metres west of the construction site on Quirk Street.

Figure 74 Site Map, Works and Sensitive Receivers



5.2.9.2 Construction Site Activities

The construction scenarios required in this study area and proposed working hours are shown in **Table 78**. The estimated duration of each activity is also provided, noting that most activities would be intermittent during this period and would not be expected to be undertaken on a continual basis during every day of the scheduled activity.

This site is proposed to be used as a TBM launch site. The main excavation works at this construction site would be completed in acoustic sheds. Spoil handling activities at this site would be completed outside the acoustic sheds, noting that the shed doors would not need to open and closed regularly as spoil would be fed from the shed to the stockpiling are via conveyer.

The Stage 1 works within this study area are anticipated to have a total duration of approximately three years.

5.2.9.3 Airborne Noise Impacts from Construction Sites

Number of NML Exceedances

The predicted airborne noise impacts from construction site works in this study area are summarised in **Table 79**, **Table 80** and **Table 81** 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 when the works are at their nearest.

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 78 Surface construction Activities and Period of Works

Scenario	Activity		Total Indicative Duration (Weeks)[3]	Maximum Number of Working Faces	Hours of Works[1,2]				Comments
					Std. Day	Out-of-Hours Works			
						Day OOH	Eve	Night	
Enabling works	'Typical'	Supporting and loading	4	1	✓	✓	-	-	-
	'Peak'	Demolition using a rockbreaker	4	2	✓	✓	-	-	Rockbreaking works would only occur intermittently during a four week period between 7am – 6pm. Total duration of rockbreaking works would be approximately 10 days.
Piling	'Typical'	Supporting works	30	2	✓	✓	-	-	-
	'Peak'	Bored piling with support plant	30	4	✓	✓	-	-	Piling works would only occur intermittently during a 30 week period between 7am – 6pm. Up to four piling rigs would be active at the same time.
Surface construction	'Typical'	General works	12	1	✓	✓	-	-	-
	'Peak'	Noise intensive works	12	2	✓	✓	-	-	-
Initial excavation	'Typical'	Mucking out	8	1	✓	✓	-	-	-
	'Peak'	Through soft soil/rock	1	2	✓	✓	-	-	Excavation through soil and soft rock using excavator ripper attachment, before construction of the acoustic sheds.
		Through rock using rockbreaker	7	2	✓	✓	-	-	Excavation through rock using rockbreaker, before construction of the acoustic sheds. Works restricted to daytime hours only.
Excavation with shed	'Typical'	Mucking out	26	1	✓	✓	✓	✓	Out of hours (evening / night-time) works would only occur once the acoustic sheds and acoustic panels (where appropriate) have been constructed.
	'Peak'	Through rock using rockbreaker	26	2	✓	✓	✓	✓	
TBM launch and support	'Typical'	TBM support and spoil removal	78	1	✓	✓	✓	✓	The majority of works would be completed within the acoustic sheds with some loading and other less noisy works being outside the sheds.
	'Peak'	TBM assembly and launch	2	1	✓	✓	✓	✓	

Note 1: Noise intensive works outside of daytime hours would only occur after construction of the acoustic shed and acoustic panels.

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

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

Table 79 Overview of NML Exceedances – All Receiver Types

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Supporting and loading	4	1126	-	2	-	-	13	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	4	1126	-	554	44	1	636	186	6	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	30	1126	-	-	-	-	15	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	30	1126	-	4	-	-	93	-	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	12	1126	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	12	1126	-	6	-	-	40	-	-	-	-	-	-	-	-	-	-	-
Initial excavation	'Typical'	Mucking out	8	1126	-	-	-	-	39	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	1	1126	-	30	-	-	158	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	7	1126	-	510	30	-	633	158	-	-	-	-	-	-	-	-	-	-
Excavation with shed	'Typical'	Mucking out (Doors Closed)	26	1126	-	-	-	-	1	-	-	1	-	-	118	1	-	3	-	-
	'Peak'	Through rock using rockbreaker (Doors Closed)	26	1126	-	2	-	-	21	-	-	21	-	-	333	2	-	3	-	-
TBM launch and support	'Typical'	TBM support and spoil removal	78	1126	-	-	-	-	-	-	-	-	-	-	21	-	-	3	-	-
	'Peak'	TBM assembly and launch	2	1126	-	-	-	-	3	-	-	3	-	-	182	-	-	3	-	-

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

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

Table 80 Overview of NML Exceedances – Residential Receivers

Scenario	Activity		No. Weeks[1]	Number of Receivers																
				Total	HNA[2]	With NML Exceedance[3]														
						Standard Construction Hours – Daytime			Out-of-Hours Works [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
Enabling works	'Typical'	Supporting and loading	4	1024	-	1	-	-	12	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Demolition using a rockbreaker	4	1024	-	536	40	-	618	182	5	-	-	-	-	-	-	-	-	-
Piling	'Typical'	Supporting works	30	1024	-	-	-	-	15	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	30	1024	-	2	-	-	91	-	-	-	-	-	-	-	-	-	-	-
Surface construction	'Typical'	General works	12	1024	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	12	1024	-	5	-	-	39	-	-	-	-	-	-	-	-	-	-	-
Initial excavation	'Typical'	Mucking out	8	1024	-	-	-	-	39	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	1	1024	-	26	-	-	154	-	-	-	-	-	-	-	-	-	-	-
		Through rock using rockbreaker	7	1024	-	500	26	-	623	154	-	-	-	-	-	-	-	-	-	-
Excavation with shed	'Typical'	Mucking out (Doors Closed)	26	1024	-	-	-	-	1	-	-	1	-	-	118	1	-	3	-	-
	'Peak'	Through rock using rockbreaker (Doors Closed)	26	1024	-	1	-	-	20	-	-	20	-	-	333	2	-	3	-	-
TBM launch and support	'Typical'	TBM support and spoil removal	78	1024	-	-	-	-	-	-	-	-	-	-	21	-	-	3	-	-
	'Peak'	TBM assembly and launch	2	1024	-	-	-	-	3	-	-	3	-	-	182	-	-	3	-	-

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

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. During the daytime, this refers to the period on Saturday between 7am – 8am, and 1pm – 10pm.

Table 81 Overview of Commercial and 'Other Sensitive' Receiver NML Exceedances

Scenario	Activity		No. Weeks[1]	Number of Receivers														
				Commercial			Child Care			Educational			Passive Recreation			Place of Worship		
				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
Enabling works	'Typical'	Supporting and loading	4	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
	'Peak'	Demolition using a rockbreaker	4	8	2	-	4	2	-	3	-	-	1	-	-	2	-	1
Piling	'Typical'	Supporting works	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Bored piling with support plant	30	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
Surface construction	'Typical'	General works	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Noise intensive works	12	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Initial excavation	'Typical'	Mucking out	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through soft soil/rock	1	-	-	-	3	-	-	-	-	-	-	-	-	1	-	-
		Through rock using rockbreaker	7	2	-	-	3	3	-	3	-	-	1	-	-	1	1	-
Excavation with shed	'Typical'	Mucking out (Doors Closed)	26	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	Through rock using rockbreaker (Doors Closed)	26	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
TBM launch and support	'Typical'	TBM support and spoil removal	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	'Peak'	TBM assembly and launch	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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

The above shows the following:

- The Stage 1 construction works are predicted to result in 'moderate' or 'high' worst-case noise impacts at the nearest receivers during higher noise generating activities. The nearest receivers to the site are a mixture of commercial/industrial and residential. The worst-case impacts are predicted during *Enabling works* and *Initial excavation* which would occur before the acoustic sheds are constructed. These works are, however, limited to the daytime and would not occur during the evening or night-time
- The highest impacts are predicted during 'Peak' scenarios which use noise intensive equipment such as rockbreakers. Rockbreakers would, however, only be used intermittently and the duration is only for around 10 days during *Enabling works* and for up to seven weeks during *Initial excavation* works. When noise intensive equipment is not in use during 'Typical' works, the worst-case impacts are predicted to be reduced to 'minor' or be compliant with the management levels.
- *Piling* and *Surface construction* works generate less noise and the worst-case impacts at the nearest receivers are predicted to be 'minor'.
- Noise intensive works outside of daytime hours would only be completed in the acoustic sheds once built. The worst-case impacts during the night-time are predicted to be 'minor' at most surrounding residential receivers with 'moderate' impacts at two of the nearest receivers.
- No residential receivers are predicted to be Highly Noise Affected.
- 'Minor' sleep disturbance impacts are predicted for the nearest residential receivers.

Impacts during Standard Construction Hours

The worst-case impacts during Standard Construction Hours are predicted when noise intensive works occur before construction of the acoustic shed. The predicted worst-case daytime impacts in this study area are shown in:

- **Figure 75** – All outdoor works, including rockbreakers
- **Figure 76** – All outdoor works, not including rockbreakers.

The highest impact works are expected to last for:

- *Enabling works – Demolition using a rockbreaker with supporting plant* – 10 days (actual rockbreaker use)
- *Initial excavation – Through rock using rockbreaker* – seven weeks.

Figure 75 Worst-case Daytime Airborne Noise Impacts – Outdoor Works, including Rockbreakers

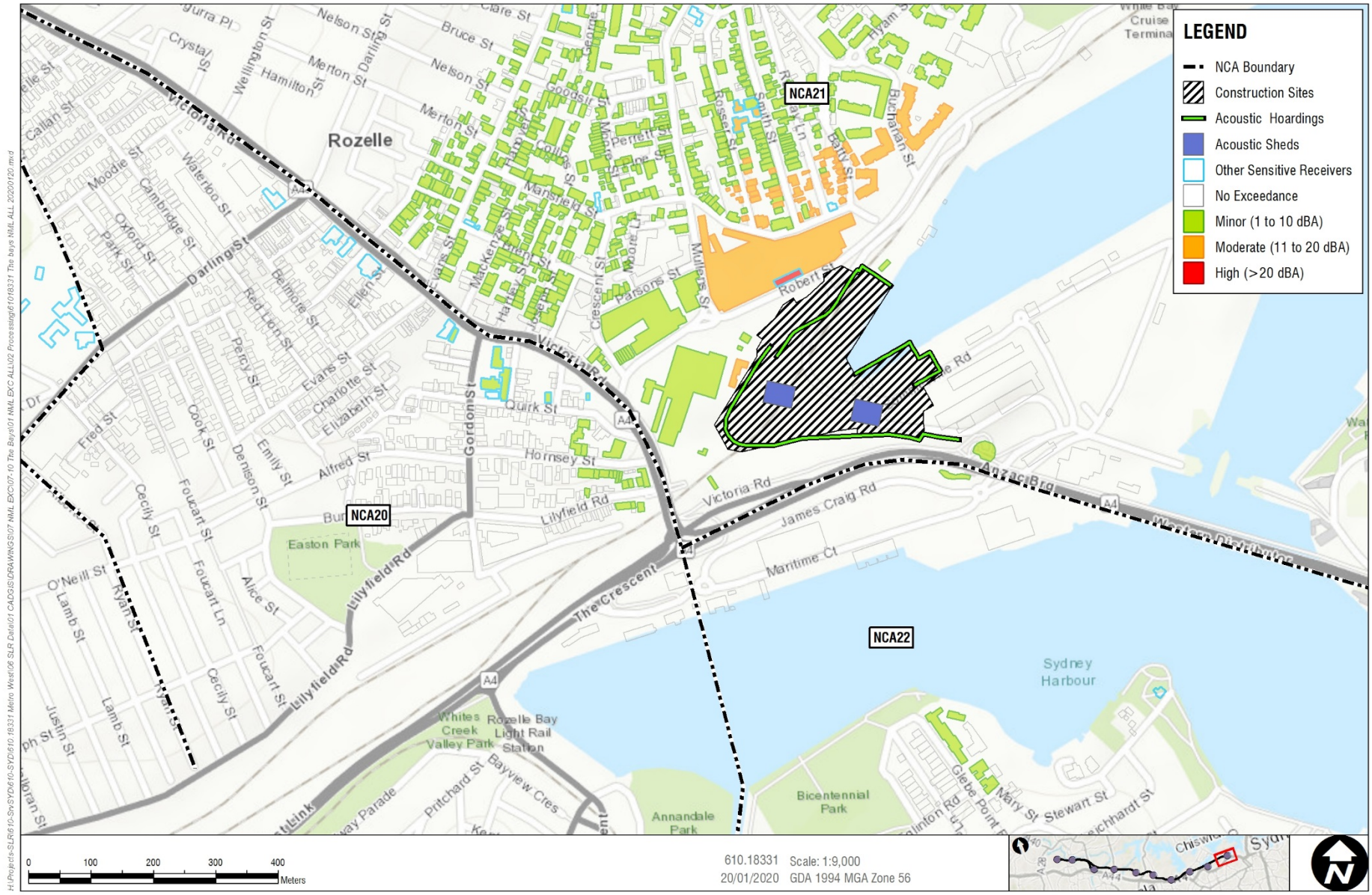
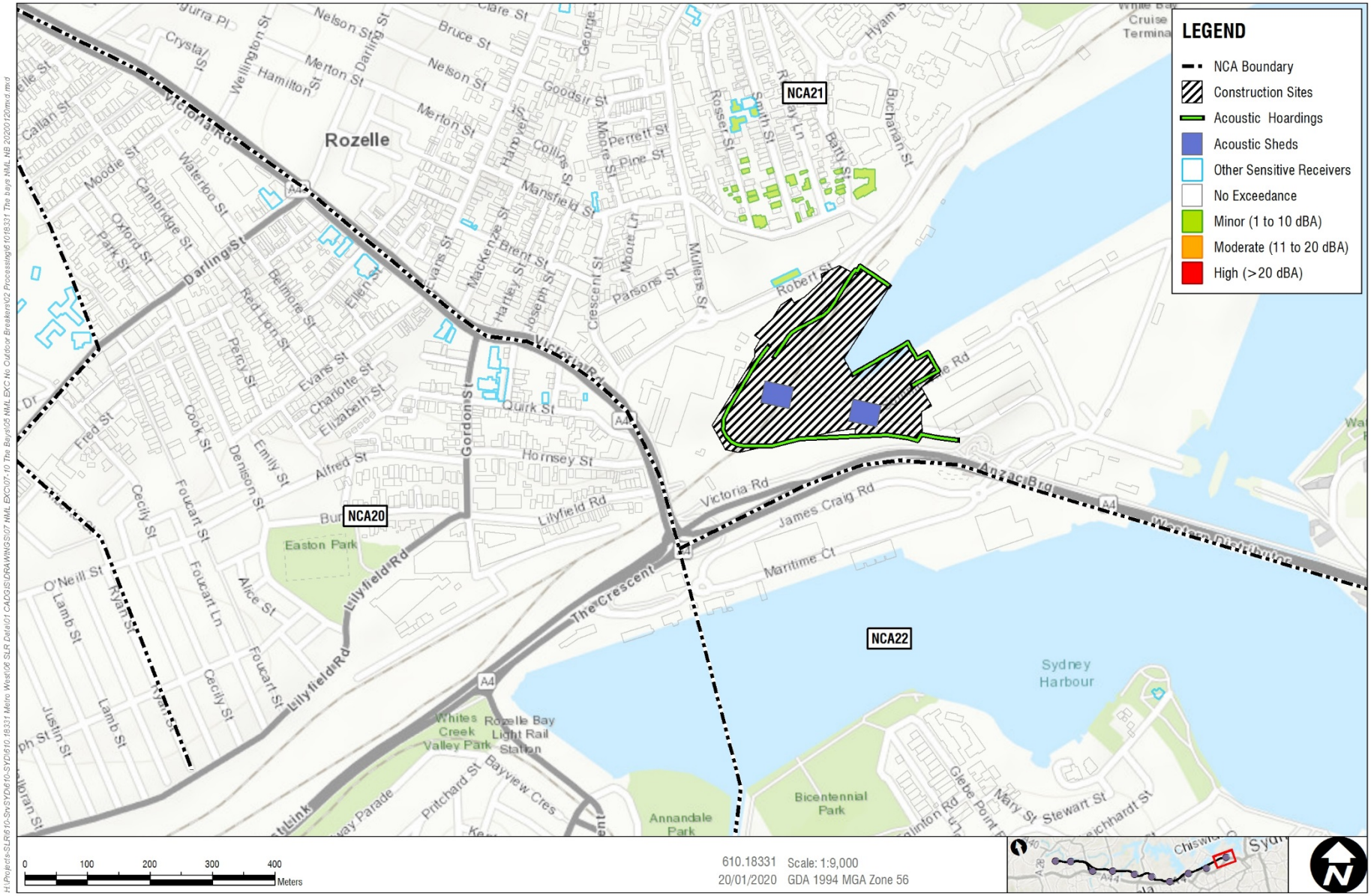


Figure 76 Worst-case Daytime Airborne Noise Impacts – All Outdoor Works, not including Rockbreakers



The above shows the following:

- The worst-case daytime impacts are predicted during noise intensive works, such as rockbreaking, which occur prior to construction of the acoustic sheds. The impacts are generally expected to be 'moderate' at the nearest receivers and 'minor' for receivers which are more distant. Most of the nearest receivers are commercial/industrial or residential.
- The worst-case impacts at 'other sensitive' receivers are predicted to be:
    - 'High' at C3 Church Rozelle, directly north of the site.
    - 'Moderate' at three buildings of Inner Sydney Montessori and one industrial building at the former White Bay Power Station.
- When rockbreakers are not in use during outdoor works, the impacts are predicted to be substantially lower, with the worst-case impacts being 'minor' at a relatively small number of receivers to the north.

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.

Impacts during the Night-time

Noise intensive works during the night-time at this construction site would only be completed inside the acoustic sheds. The worst-case impacts are predicted during *Excavation with shed* when rockbreakers are in use. The predicted worst-case night-time impacts from the assessed scenarios in this study area are shown in:

- **Figure 77** – *Excavation with shed – Through rock using rockbreaker (Doors Closed)*
- **Figure 78** – *Excavation with shed – Mucking out (Doors Closed)*, which has no requirement for noise intensive equipment.

The highest impact works are expected to last for:

- *Excavation with shed – Through rock using rockbreaker* – 26 weeks
- *Excavation with shed – Mucking out* – 26 weeks.

Figure 77 Worst-case Night-time Airborne Noise Impacts – Excavation in Shed using Rockbreaker (Doors Closed)

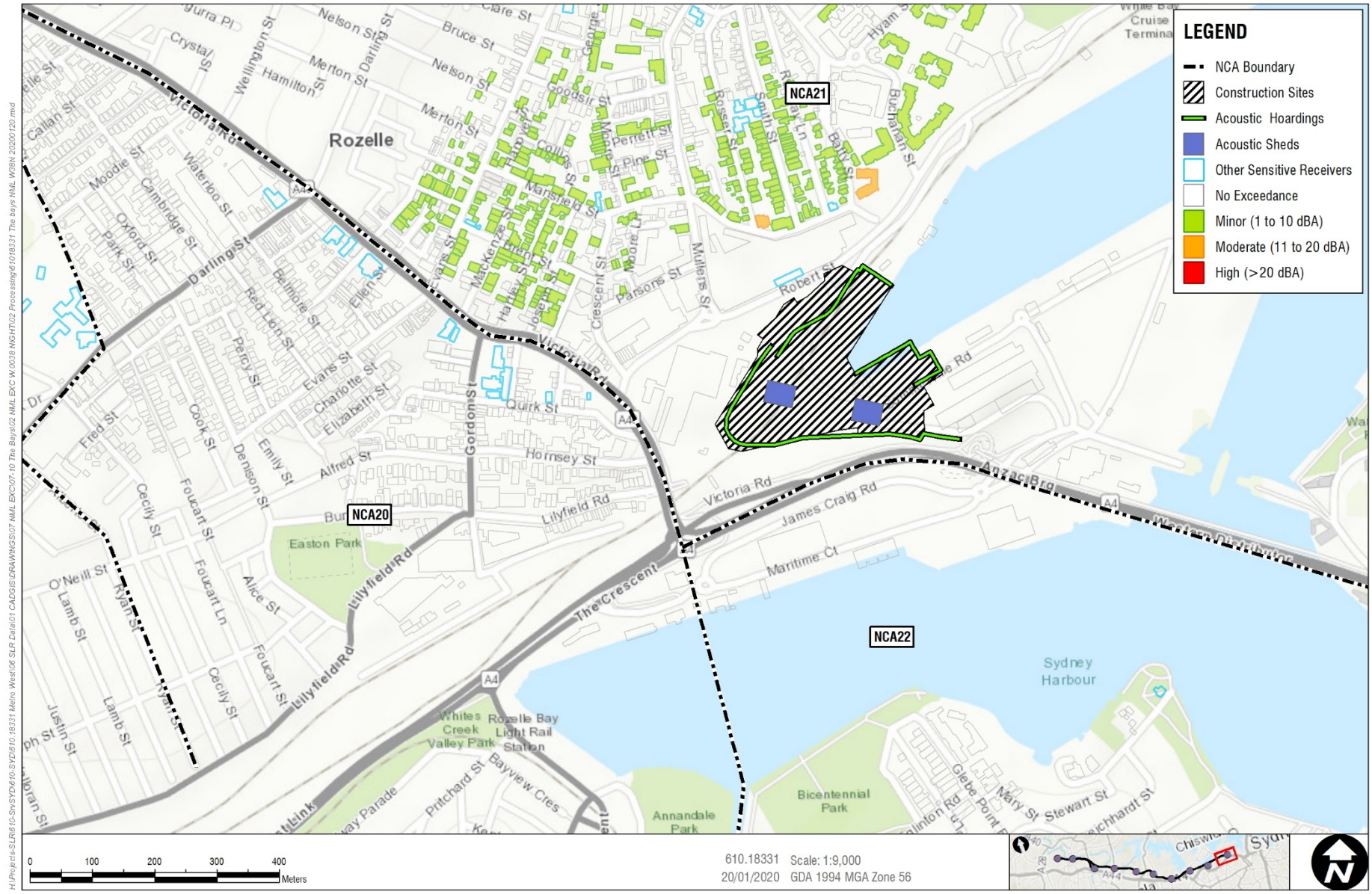
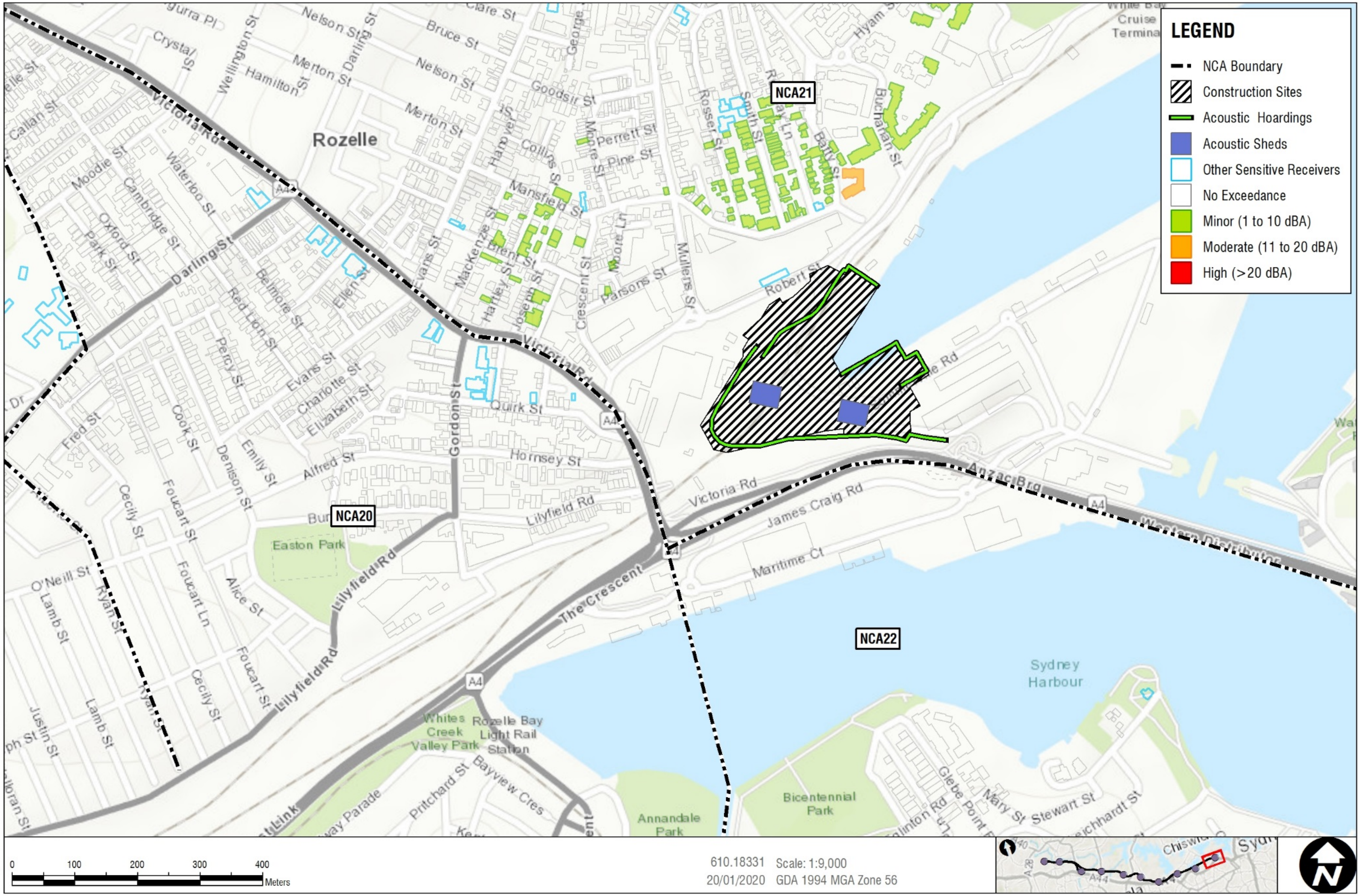


Figure 78 Worst-case Night-time Airborne Noise Impacts – Mucking Out (Doors Closed)



The above shows the following:

- The worst-case night-time noise levels from works in the acoustic shed are expected to occur when rockbreakers are used and the acoustic shed doors are closed. These works are predicted to result in 'moderate' impacts at two residential receivers to the north of the site, with 'minor' impacts for the more distant receivers further to the north.
- When rockbreakers are not in use during *Mucking out* in the acoustic shed, the impacts are predicted to reduce. Only one receiver is predicted to have 'moderate' impacts and much fewer receivers have 'minor' impacts. More distant receivers in the study area are predicted to be compliant with the 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 8**.

Sleep Disturbance

A sleep disturbance screening assessment has been completed for the construction works and is summarised in **Table 79**.

'Minor' sleep disturbance impacts are predicted three residential receivers to the north during noisy works as part of *Excavation with shed and TBM launch and support*. These impacts result from heavy vehicles movements in the outdoor areas of the site as well as from spoil loading activities located immediately north-east of the acoustic sheds.

The potential awakenings from heavy vehicles would be influenced by the number of heavy vehicles accessing the site during the night-time. The number of heavy vehicles at the construction site during the night-time is expected to be around 25 heavy vehicles per hour with vehicles accessing the site via the southern entrance off James Craig Road. The spoil loading facilities would be on the north-eastern side of the acoustic sheds which is around 260 metres from the nearest residential receivers on Mansfield Street.

The number of night-time awakenings during construction works would depend on several factors, including the type of vehicles and spoil loading equipment being used, the duration of the noisy works and the distance of the works to nearest residential receivers. At this early stage in the project the currently available information does not allow for accurate prediction of the extent of night-time awakenings. Further investigation of awakenings would be completed during the next stages of Stage 1 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 by the works.

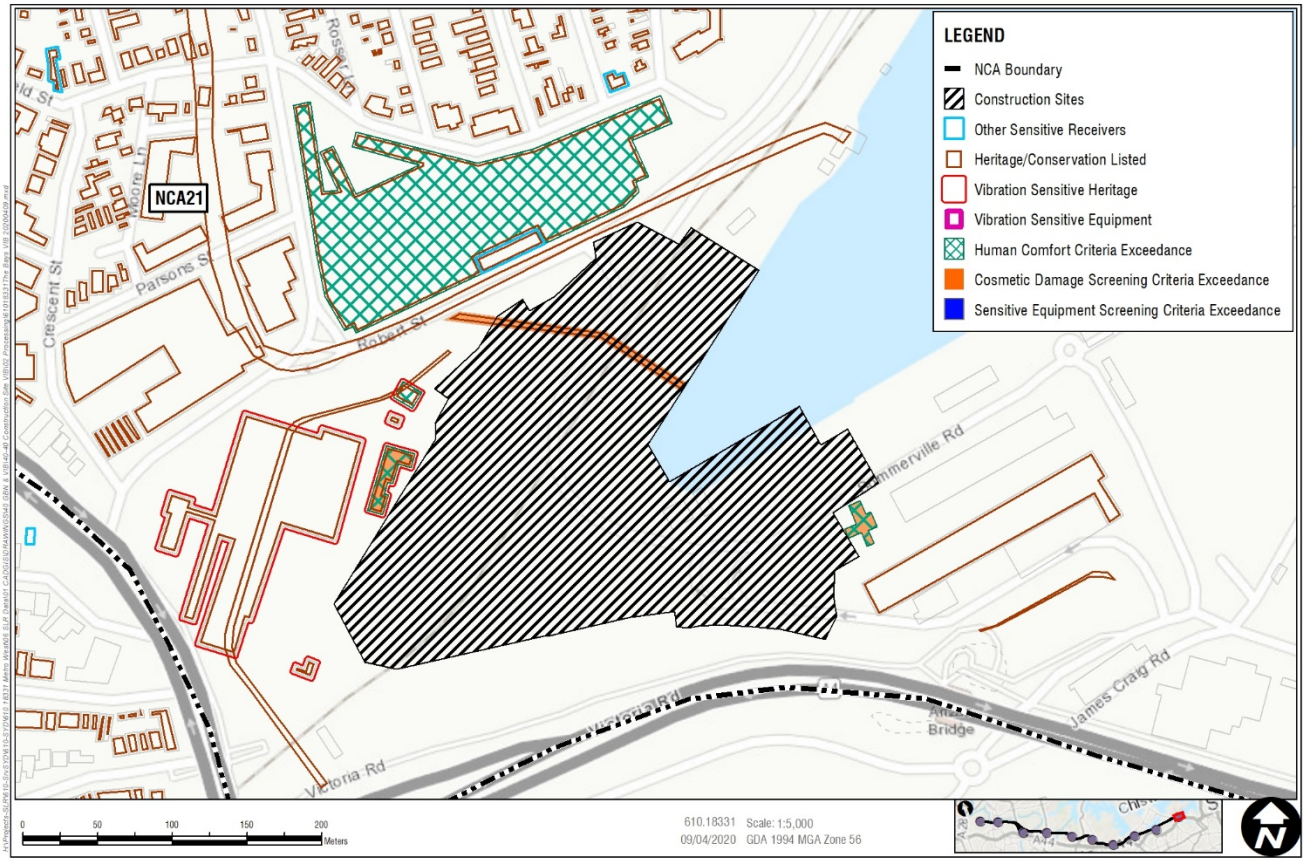
5.2.9.4 Ground-borne Noise Impacts from Construction Sites

The offset distances from the shaft excavation areas to the nearest receivers are large enough for there to be no predicted exceedances of the ground-borne noise criteria in this study area.

5.2.9.5 Vibration Impacts from Construction Sites

The predicted impacts during vibration intensive works are shown in **Figure 79**. The predictions are representative of the highest vibration levels that would likely be experienced by the nearest receivers when works are at their closest.

Figure 79 Worst-case Vibration Impacts



The above shows the following:

- The cosmetic damage screening criteria are predicted to be exceeded at the following buildings:
  - One heritage listed building at the former White Bay Power Station
  - One heritage listed underground canal structure crossing the construction site between the former White Bay Power Station and the bay
  - One commercial building at Gypsum Resources Australia located east of the construction site.
- The human comfort criteria are also predicted to be exceeded at some of the nearest commercial buildings, meaning occupants of affected buildings may be able to perceive vibration impacts at times when vibration intensive equipment is in use nearby. This includes two buildings on the former White Bay Power Station site which are expected to be disused but are included in this assessment for completeness.
- There are no predicted exceedances of the sensitive equipment screening criteria.

5.3 Tunnelling

The following sections present an assessment of the predicted ground-borne noise and vibration impacts from the Stage 1 tunnelling works.

5.3.1 Ground-borne Noise Impacts from TBMs

The ground-borne noise assessment is based on the worst-case predicted internal ground-borne noise levels for sensitive receivers above the proposed tunnel alignment. The predictions represent the likely highest noise levels when the TBM tunnelling works are directly below each receiver.

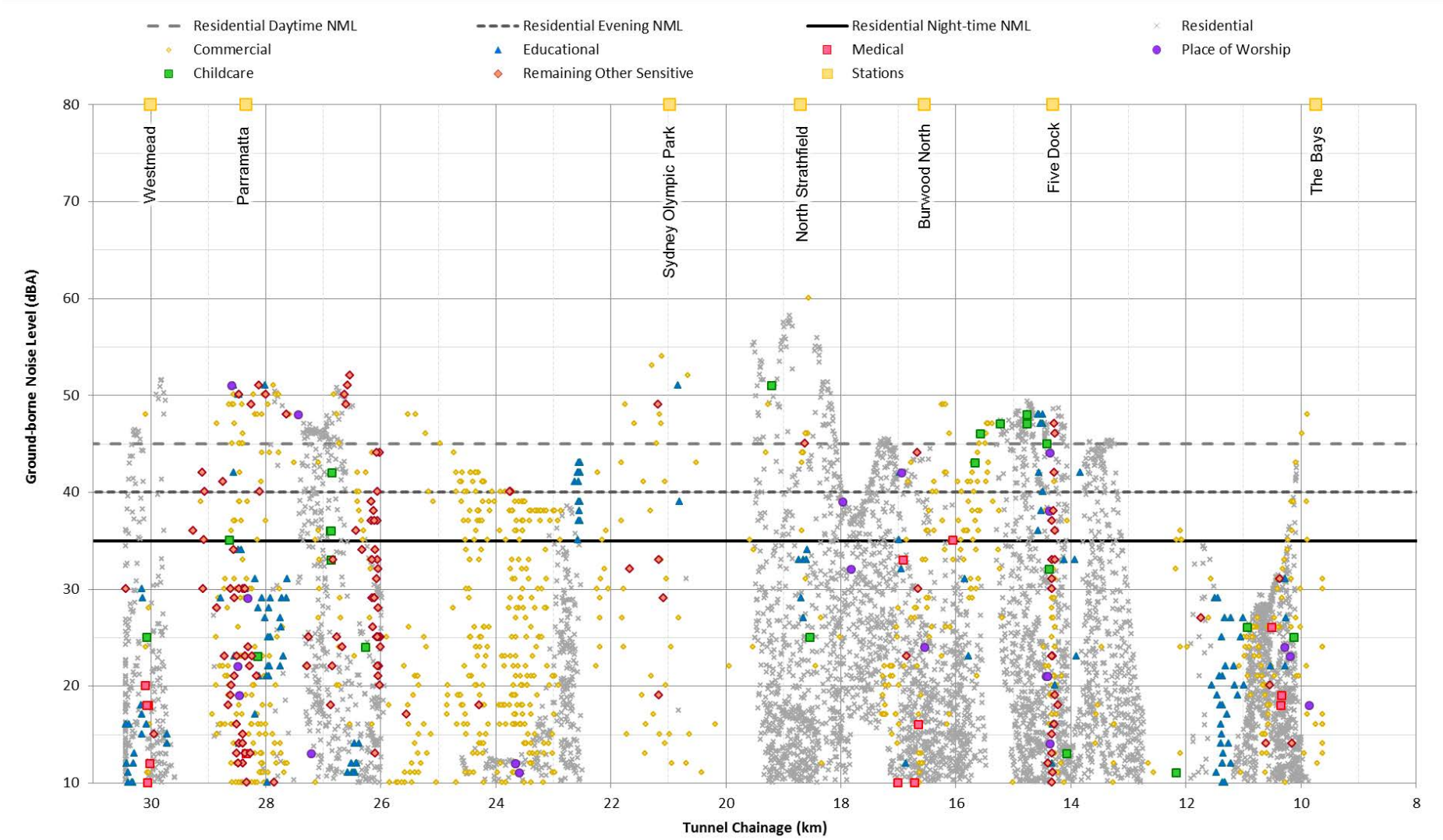
A summary of the predicted ground-borne noise levels from TBM tunnelling in each NCA is shown in **Table 82**. The results are also presented in a scatter graph in **Figure 80** which shows the highest predicted ground-borne noise level at each receiver and in **Appendix F** which shows the highest predicted NML exceedance for each receiver building.

Table 82 Overview of TBM Tunnelling Ground-borne NML Exceedances – All Receiver Types

Study area	NCA	Number of Receivers									
		Total	With NML Exceedance[1]								
			Tunnelling with TBM								
			Daytime			Evening			Night-time		
			1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
Westmead	NCA01	340	-	-	-	-	-	-	2	-	-
	NCA02	806	15	-	-	24	3	-	23	15	-
Parramatta	NCA03	509	13	-	-	8	-	-	4	5	-
Clyde	NCA04	392	51	-	-	91	1	-	80	49	-
	NCA05	477	-	-	-	-	-	-	-	-	-
	NCA06	207	-	-	-	-	-	-	-	-	-
	NCA07	553	-	-	-	-	-	-	-	-	-
Silverwater	NCA07	1,389	-	-	-	-	-	-	8	-	-
Olympic Park	NCA08	95	4	-	-	-	-	-	-	-	-
	NCA09	32	-	-	-	-	-	-	-	-	-
North Strathfield	NCA10	614	20	1	-	13	13	-	19	20	-
	NCA11	1,280	39	11	-	57	27	-	69	39	11
Burwood	NCA12	1,200	14	-	-	94	-	-	168	11	-
	NCA13	957	-	-	-	1	-	-	3	-	-
Five Dock	NCA14	1,242	71	-	-	93	-	-	54	61	-
	NCA15	966	14	-	-	43	-	-	47	14	-
Between Five Dock and The Bays	NCA16	389	-	-	-	-	-	-	-	-	-
	NCA17	679	-	-	-	41	-	-	60	-	-
	NCA18	921	-	-	-	-	-	-	-	-	-
	NCA19	962	-	-	-	-	-	-	-	-	-
The Bays	NCA20	873	-	-	-	-	-	-	-	-	-
	NCA21	844	-	-	-	6	-	-	12	-	-
	NCA22	46	-	-	-	-	-	-	-	-	-

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

Figure 80 TBM Tunnelling Ground-borne Noise Predictions



The above assessment shows that:

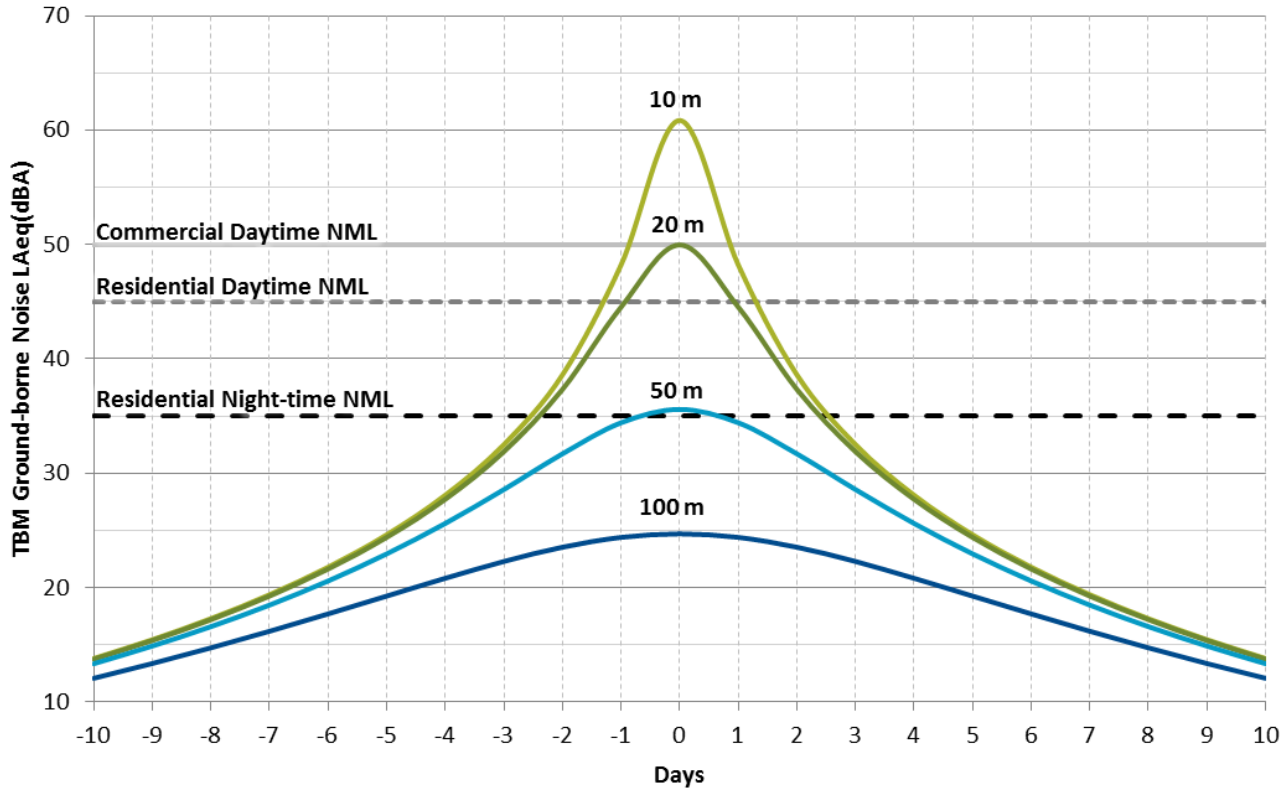
- The worst-case ground-borne noise impacts from TBM tunnelling during the daytime are predicted to generally be compliant with the NML or result in only 'minor' impacts. 'Moderate' impacts are predicted at twelve receivers in the North Strathfield study area, which is due to this location being the shallowest section of the tunnel. The 'moderate' impacts are generally at residential receivers on Queen Street, to the north to the North Strathfield metro station construction site.
- During the night-time, the worst-case impacts are more wide-spread due to a lower and more stringent NML. The worst-case impacts are predicted to be 'high' in the North Strathfield study area, at receivers to the north of the North Strathfield metro station construction site, with 'moderate' impacts also predicted at certain receivers in the Westmead, Parramatta, Clyde, North Strathfield, and Five Dock study areas. These impacts are generally at receivers near to the construction sites, as this is where the tunnel depth is shallowest.
- The majority of the impacted receivers are residential properties. Several 'other sensitive' receivers are also predicted to impacted to various degrees along the alignment.
- The ground-borne noise predictions are based on the nearest sensitive receivers and most exposed floor (ie ground floor for commercial and assumed lowest habitable floor for residential). The ground-borne noise impacts would reduce for sensitive receivers which are further away from the alignment or for receivers higher up in buildings.

The TBMs are expected to progress at a rate of between 20 to 50 metres per day. This means the worst-case ground-borne noise impacts from tunnelling at a receiver would likely only be apparent for a few days for each TBM as the tunnelling works pass beneath.

As the works progress and move away, a receiver's exposure to ground-borne noise would reduce as illustrated in **Figure 81**. The figure shows the indicative worst-case internal ground-borne noise levels from TBM tunnelling as works progresses towards and past a particular location.

Short sections of stub tunnels would be excavated next to the main tunnels in the Westmead study area, below Alexandra Avenue and in the Clyde study area, between the main tunnels and the Rosehill dive. The stub tunnels are expected to be excavated by roadheaders and the works would likely generate lower ground-borne noise levels than produced by the TBMs. The predicted impacts from stub tunnel excavation are included in the tunnelling predictions in **Table 82**, **Appendix F** and **Figure 80**.

Figure 81 Example TBM Ground Borne Noise Levels (Progress = 20m/day)



The above figure shows that where a residential receiver has a 20 metres slant distance from the nearest tunnel (ie the three dimensional distance which takes into account the tunnel depth and the horizontal offset distance), internal ground-borne noise levels are likely to exceed the 35 dB night-time ground-borne NML for around five days.

If the rate of progress increased to 50 metres per day, the exceedance of the night-time NML decreases to around 2.5 days. The actual rate of progress would depend on several factors and may vary along the alignment based on the local geology.

Where residential receivers have a slant distance of greater than around 50 metres, exceedances of the night-time NML are not considered likely.

5.3.2 Vibration Impacts from TBMs

The ground-borne vibration assessment is based on the worst-case predicted ground-borne vibration level for sensitive receivers above the proposed tunnel alignment. The predictions represent the likely highest vibration level when the tunnelling works are directly below each receiver.

A summary of the predicted ground-borne vibration levels from TBM tunnelling in each NCA is shown in **Table 83**.

Table 83 Overview of Vibration Criteria Exceedances – All Receiver Types

Study area	NCA	Number of Receivers				
		Total	With Vibration Criteria Exceedance[1]			
			Tunnelling with TBM			
			Cosmetic Damage	Human Comfort		Sensitive Equipment
			Day / Night	Day	Night	Day / Night
Westmead	NCA01	340	-	-	-	-
	NCA02	806	-	2	8	-
Parramatta	NCA03	509	-	-	5	-
Clyde	NCA04	392	-	-	17	-
	NCA05	477	-	-	-	-
	NCA06	207	-	-	-	-
	NCA07	553	-	-	-	-
Silverwater	NCA07	1389	-	-	-	-
Olympic Park	NCA08	95	-	-	-	-
	NCA09	32	-	-	-	-
North Strathfield	NCA10	614	-	11	19	-
	NCA11	1280	-	26	45	-
Burwood	NCA12	1200	-	-	6	-
	NCA13	957	-	-	-	-
Five Dock	NCA14	1242	-	-	43	-
	NCA15	966	-	-	9	-
Between Five Dock and The Bays	NCA16	389	-	-	-	-
	NCA17	679	-	-	-	-
	NCA18	921	-	-	-	-
	NCA19	962	-	-	-	-
The Bays	NCA20	873	-	-	-	-
	NCA21	844	-	-	-	-
	NCA22	46	-	-	-	-

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

The above shows the following:

- No receivers are predicted to be subject to vibration levels during TBM tunnel which exceed the cosmetic damage or sensitive equipment screening criteria.
- Potential exceedances of the human comfort criteria are likely in the Westmead, Parramatta, Clyde, North Strathfield, Burwood and Five Dock study areas, meaning perceptible levels of vibration may occur when tunnelling works are below these areas. These impacts are typically at receivers which surround the construction sites, as this is where the tunnel depth is shallowest.
- The above predictions assume the TBM is in use for 50 percent of the assessment period. If this is reduced to 20 percent, the number of human comfort criteria exceedances would notably decrease. The TBM boring duty would depend on several factors and may vary throughout the alignment.

The location of all human comfort vibration criteria exceedances are shown in **Appendix G**.

5.3.3 Cross Passages

Cross passages between tunnels are anticipated to be spaced at around 240 metre intervals along the tunnel alignment and would be excavated with roadheaders. Niches and rooms would be excavated using rockbreakers. At this early stage, the location of cross passage has not been confirmed and the assessment conservatively assumes they could be located anywhere along the alignment.

Ground-borne Noise

The potential ground-borne noise impacts during excavation of each cross passage would depend on the depth of the alignment in that area. Ground-borne noise levels during rockbreaking are expected to be around 3 dB higher than during TBM tunneling. The night-time NML is likely to be exceeded during excavation of cross passages at the distances shown in **Table 84**.

Table 84 Minimum Slant Distance which Results in Exceedance of Night-time NML

Receiver Type	Criteria (dBA)	Minimum Slant Distance which Results in Exceedance of NML (metres)		
		Minor (1-10 dB)	Moderate (11-20 dB)	High (>20 dB)
Residential (daytime)	45	30	17	10
Residential (night-time)	35	52	30	17
Educational	45	30	17	10
Medical	45	30	17	10
Place of worship	45	30	17	10
Child care	40	39	23	13
Commercial	50	23	13	7

The above shows the following:

- ‘Moderate’ exceedances of the night-time NML are expected where residential receivers have a slant distance of around 30 metres or less from the nearest cross passage.
- ‘High’ exceedances at residential receivers are likely where the slant distance is less than around 17 metres. The tunnel alignment depth is less than 17 metres from the surface elevation in the Olympic Park and North Strathfield study areas.

The duration of excavation for each cross passage is expected to vary between sites but may take up to several months in some areas.

Vibration

Vibration levels from the excavation of cross passages using roadheaders and rockbreakers would be similar to the levels from excavation of the tunnels using TBMs. The tunnel alignment is sufficiently distant from nearby buildings for the risk of exceedances of the cosmetic damage criteria to be low.

Exceedances of the daytime human comfort criteria are, however, likely at residential receivers with a slant distance of less than 20 metres from cross passages and at commercial receivers with a slant distance of less than 15 metres.

Exceedances of the night-time human comfort criteria are likely at residential receivers with a slant distance of less than 30 metres from cross passages.

No identified vibration sensitive receivers are predicted to be subject to cross passage excavation vibration levels which exceed the appropriate sensitive equipment criteria.

5.3.4 Work Trains

Work trains would be required in the tunnels to move equipment. The speed of these trains is typically limited to 10 km/h for safety reasons and it is assumed they would have some form of resilient rubber tyres. The work trains would be used on a 24/7 basis.

Given the slow speeds and assumed rubber tyres, the potential ground-borne noise and vibration impacts from work trains are expected to be minimal. The potential impacts should be reviewed as Stage 1 progresses and detailed information regarding work trains becomes available.

5.4 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 haulage routes.

The forecast construction traffic volumes in the study area have been used to determine where potentially noticeable increases in road traffic noise (ie a greater than 2.0 dB increase above the existing noise level) is likely. The assessment is summarised in **Figure 82** and **Figure 83**.

Figure 82 Construction Traffic Assessment – Predicted Change in Road Traffic Noise Levels (Westmead Study Area to Olympic Park Study Area)

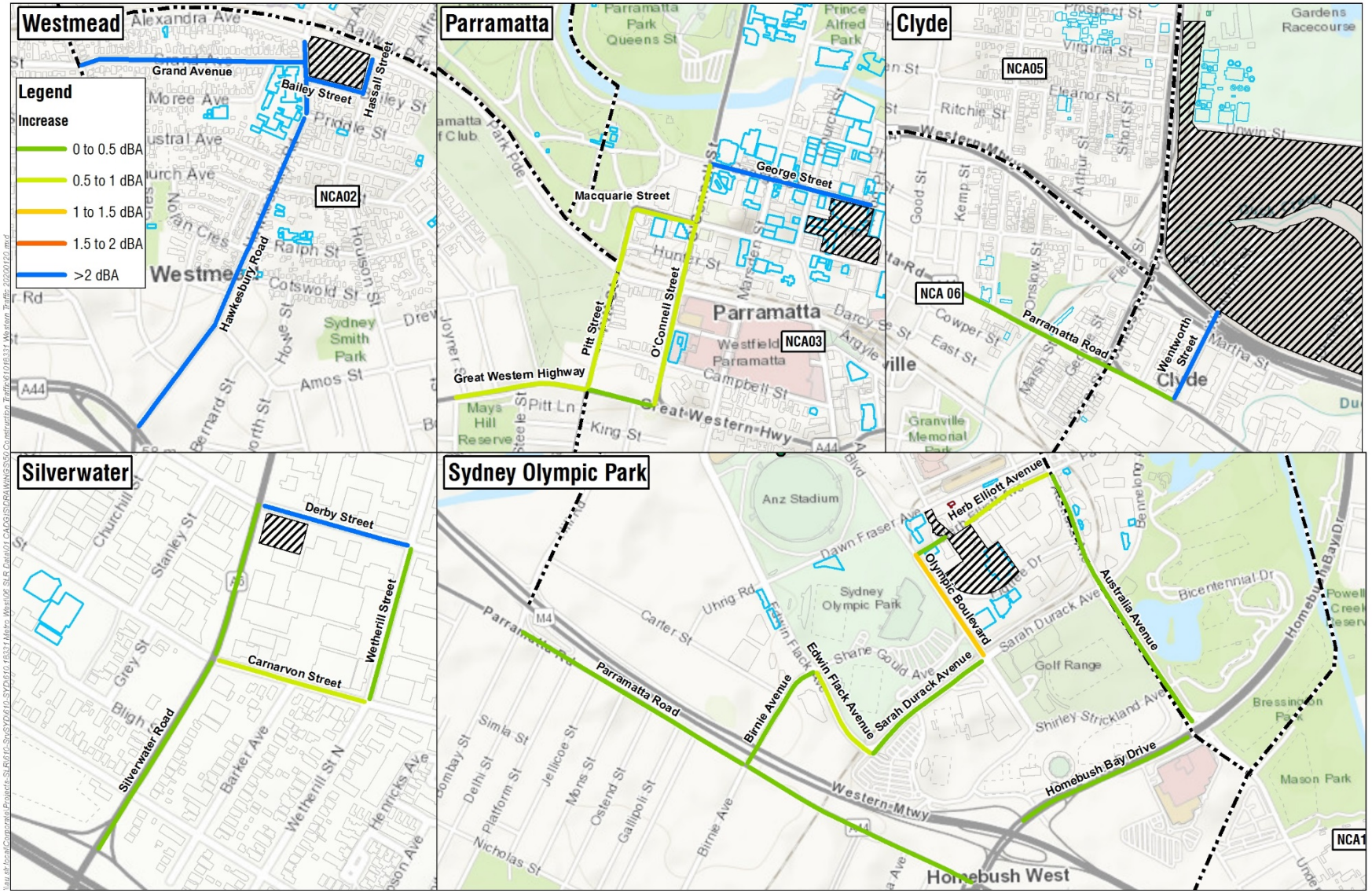
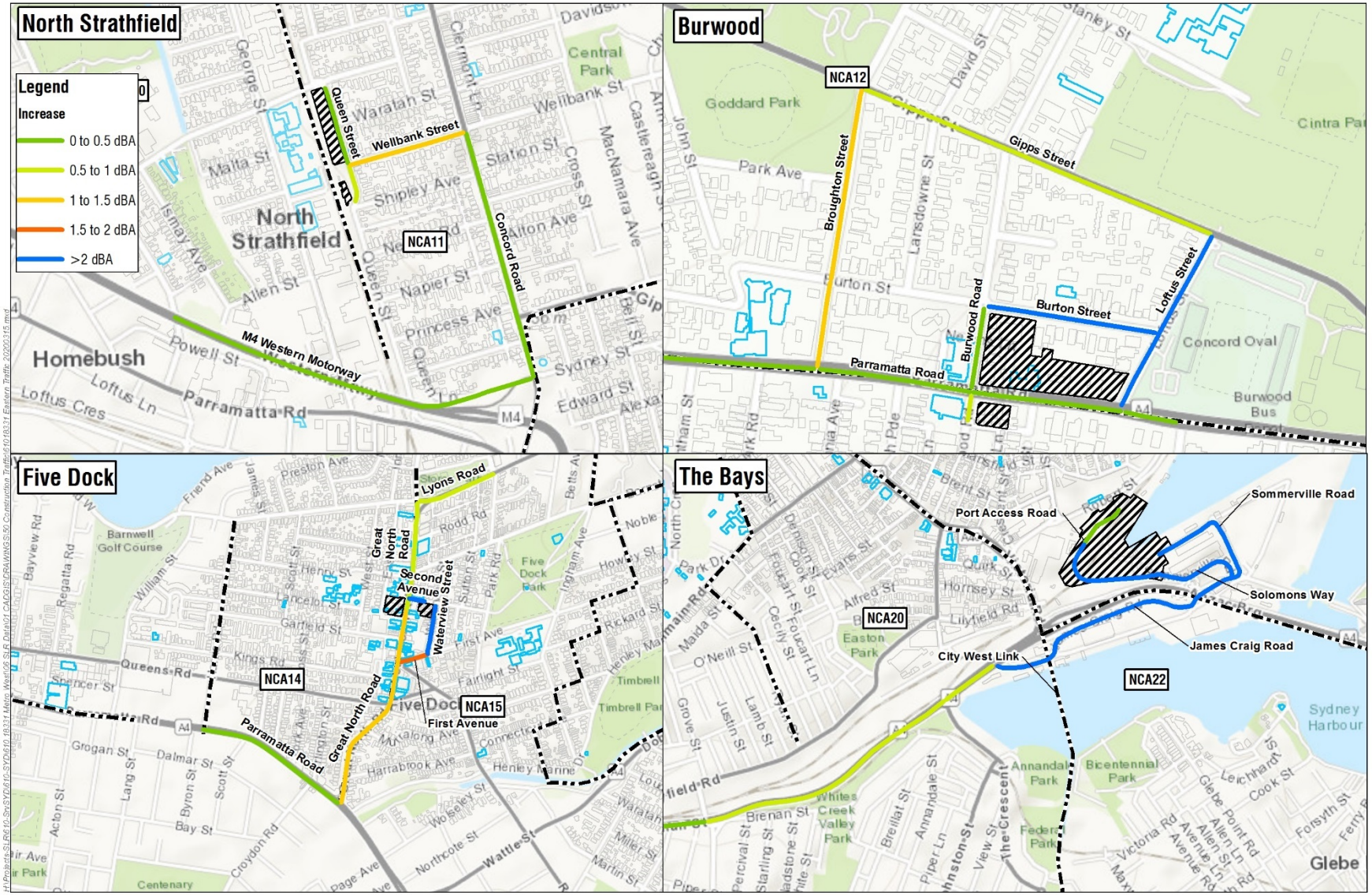


Figure 83 Construction Traffic Assessment – Predicted Change in Road Traffic Noise Levels (North Strathfield Study Area to The Bays Study Area)



A summary of the predicted impacts from construction traffic is provided in **Table 85**.

Table 85 Construction Traffic Impacts

Study Area[1]	Roads Predicted to have a >2.0 dB Increase[2]	Reason for Increase
Westmead	Hawkesbury Road to the south of the construction site and Bailey Street	Increased heavy vehicles
	Hassall Street, Bailey Street to the south east and Grand Avenue to the west of the construction site	Road reconfiguration diverting vehicles from Alexandra Avenue
Parramatta	George Street to the west of the construction site	Increased heavy vehicles
Clyde	Wentworth Street to the south of the construction site	Increased heavy vehicles
Silverwater	Derby Street to the north-east of the construction site	Increased heavy vehicles
Sydney Olympic Park	-	-
North Strathfield	Queen Street and Wellbank Street, which are both east of the construction site	Increased heavy vehicles
Burwood	Loftus Street to the east of the construction site	Increased heavy vehicles
	Burton Street to the east of the construction site	Increased light vehicles
Five Dock	Second Avenue to the east of the construction site	Increased heavy vehicles
	Waterview Street to the east of the construction site	Increased light and heavy vehicles
The Bays	James Craig Road, Port Access Road, Sommerville Road and Solomons Way, generally to the south of the construction site	Increased heavy vehicles

Note 1: Traffic volumes and distributions for some roads have been assuming using the data provided.

Note 2: 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 haulage routes. This results from the high existing volumes of traffic that currently use these routes compared to the relatively small volume of construction vehicles.

A number of the smaller roads near to the various construction sites are, however, predicted to have noticeable increases, 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 and Grand Avenue are likely to result in noticeable increases on these roads.

The proposed mitigation measures to minimise and manage the predicted impacts are discussed in **Section 8**.

5.5 Utility Works

An assessment of the potential noise levels from the likely equipment associated with utility works and construction power supply routes is provided in **Table 86**. Noise levels have been predicted at various offset distances to give indicative impacts from these works.

Table 86 Potential Noise Levels from Utility Works

Equipment	Predicted Noise Level at Distance ($L_{Aeq(15minute)}$ dBA)			
	15 m	30 m	50 m	70 m
Asphalt milling machine	79	73	69	66
Concrete saw[1]	80	74	70	67
Excavator	77	71	67	64
Excavator (breaker)[1]	86	80	76	73
Hand tools	65	59	55	52

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 near to adjacent receivers. On typical streets surrounding the Stage 1 work, the closest residential receivers are likely to be situated around 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 works.

Night-time NMLs in the vicinity of most sites would be expected to be in the region of 40 to 50 dBA (see **Table 8**), depending on the specific location of the works, meaning worst-case exceedances of greater than 30 dB above NML are possible if noise intensive equipment is required during the night-time.

Noise impacts from utility works would be temporary and the duration of impacts at particular receivers would be limited.

6 Cumulative Construction Impacts

Cumulative construction impacts can occur where multiple works are being completed near to a particular location at the same time concurrently or if more than one project occurs in the same area consecutively. The potential cumulative impacts from Stage 1 and other major projects are discussed in the following sections.

6.1 Major Developments

Stage 1 is near to a number of major projects that have recently been constructed, are currently under construction or are planned for construction. These projects are listed in **Table 87**.

Table 87 Nearby Major Developments

Project	Details
Parramatta Light Rail Stages 1 and 2	Parramatta Light Rail involves the construction of a new light rail network. Stage 1 of the project is between Westmead and Carlingford, via Parramatta CBD and Camellia, and is currently under construction. Enabling works for Stage 1 began in late-2018 and construction is expected to be complete by early 2023. Stage 2 is proposed to connect Parramatta CBD to Ermington, Melrose Park, Wentworth Point and Sydney Olympic Park. Stage 2 is currently in the planning phase.
Western Sydney University Westmead Campus Upgrade	Western Sydney University is upgrading its four-hectare Westmead campus into a retail, business and residential hub to support the Westmead study area. Construction of a 19-storey building, landscaping and public domain works are currently occurring in the south-west portion of the campus.
Westmead Medical Precinct Redevelopment	Upgrade and redevelopment of various health services, education and medical research facilities will occur across the 75 hectare Westmead Medical Precinct over the coming years. These works are anticipated to extend to 2036.
Parramatta North Urban Transformation Area	UrbanGrowth NSW is creating new public domain spaces which will preserve the site's existing parkland character. The proposed recreational amenities will service new residents and visitors with new play spaces, open spaces, river walks, BBQ and outdoor dining areas as well as new high quality streetscapes with generous tree planting. The project is in the planning stages and construction timeframes are not currently known.
New Powerhouse Museum	The new Powerhouse Precinct at Parramatta will feature the largest museum in NSW and be home to Australia's largest planetarium. Early works are planned to commence in 2019 with completion expected in 2023.
Central City District Plan	This Central City District Plan is a 20-year plan to manage growth in the context of economic, social and environmental matters to achieve the 40-year vision of Greater Sydney. The plan covers Blacktown, Cumberland, Parramatta and The Hills.
Camellia Town Centre	A strategy for renewal of Camellia is being developed. It would provide for a new riverside town centre positioned on the Parramatta Light Rail, as well as a proposed new primary school, 13 hectares of new open space and affordable housing. The project is in the planning stages and construction timeframes are not currently known.
Clyde Terminal Conversion Project	Viva Energy Australia is converting what was an operating refinery into a more efficient fuel import and storage terminal. The project includes demolition and removal of redundant refining infrastructure as well as works to improve the environmental and operational performance of the facility. Construction is expected to last for five to 10 years from project approval (which was in 2015).

Project	Details
WestConnex M4 Widening	WestConnex M4 Widening involved building an additional lane in each direction on the M4 Motorway between Parramatta and Homebush. The project was constructed between 2015 and mid-2017 and is now complete.
	Transport for NSW is proposing to modify the project by building a westbound off-ramp from the M4 Motorway onto Hill Road and Parramatta Road at Lidcombe. The project is in the planning stages and construction timeframes are not currently known.
Sydney Olympic Park Masterplan 2030	The Sydney Olympic Park Masterplan aims to develop a sustainable and active Sydney Olympic Park. The Master Plan 2030 includes: • 10,700 homes for 23,500 residents • 34,000 job opportunities • Retail space increased to 100,000m^2 • More local parks • Possibilities for new primary and secondary schools.
North Strathfield Station Upgrade	Upgrade of accessibility at North Strathfield Station was delivered as part of the Transport Access Program. The upgrade works included three new lifts, platform resurfacing, utilities works, station building upgrades and adjustments to ancillary infrastructure. The works were conducted between January and December 2019.
Concord Oval Redevelopment	The Redevelopment of Concord Oval includes a new facility to deliver a range of community services including a new indoor recreation centre, open spaces for passive recreation, rooms for community use, new match day facilities for local sporting clubs and a new High Performance Centre for the Wests Tigers. Construction is anticipated to be early 2020 to mid-2021.
Parramatta Road Corridor Urban Transformation Strategy	The Parramatta Road Corridor Urban Transformation Strategy is the NSW Government's 30-year plan to drive and inform land use planning and development decisions as well as long-term infrastructure delivery programs in the Parramatta Road Corridor.
WestConnex M4 East	The M4 East is the first underground section of WestConnex. It connects to the widened M4 Motorway and extends it via twin motorway tunnels from Homebush to Haberfield with three lanes in each direction. Construction began in 2016 and was completed in mid-2019.
WestConnex M4–M5 Link	Stage one of WestConnex M4–M5 Link involves construction of tunnels between the M4 East at Haberfield and the New M5 at St Peters. Stage two involves the construction of the Rozelle Interchange and Iron Cove Link. The Rozelle Interchange and Iron Cove Link will provide a new underground motorway interchange to City West Link and provide an underground bypass of Victoria Road between Iron Cove Bridge and Anzac Bridge, with links to the future Western Harbour Tunnel. The interchange in Rozelle will be mostly underground and located at the site of the old Rozelle Rail Yards. Construction of Stage one began in late 2018 and is due for completion in late-2022. Stage two also began in late 2018 and is planned for completion in late-2023.
Western Harbour Tunnel and Warringah Freeway Upgrade	Transport for NSW is proposing to construct a new tunnel from the Rozelle Interchange, under Sydney Harbour to the Warringah Freeway. Upgrades to the Warringah Freeway are also proposed. Construction sites would be located at the Rozelle Rail Yards and White Bay. The project is currently in the planning stages with construction planned to begin in late 2020 and be complete in early 2026.

Project	Details
Sydney Metro City & Southwest (Chatswood to Sydenham), White Bay truck marshalling yard	Sydney Metro has established a truck marshalling yard at White Bay for the Sydney Metro City & Southwest project. The marshalling yard would be operated in two stages. Stage 1 would involve a temporary site in White Bay used for a period of up to six months. Stage 2, located opposite the temporary site, would be the main truck marshalling facility and is expected to be used for around two years until completion of spoil haulage activities. The yard is expected to be in use until the end of 2020.
Glebe Island Multi-User Facility	The Port Authority of NSW are proposing the construction of a multi-user facility for the import, storage and distribution of dry bulk materials at Glebe Island. The project was approved in 2019 and construction is anticipated to commence in March 2020.
Glebe Island Concrete Batching Plant	The Glebe Island Concrete Batching Plant will supply concrete and aggregate to a range of concrete intensive projects around Central Sydney using Glebe Island Berth 1. The construction program for this project is not currently known.
The Bays Precinct Urban Transformation Plan	The project sets out a strategy for the transformation of The Bays Precinct. It identifies eight destinations within The Bays Precinct including: • Bays Market District • Bays Waterfront Promenade • Wentworth Park • Glebe Island • White Bay • White Bay Power Station • Rozelle Rail Yards • Rozelle Bay and Bays Waterways Some areas are immediate priorities, such as the White Bay Power Station and the Bays Market District, while others represent longer-term opportunities to be developed over the next 20 to 30 years.
New Sydney Fish Market	A new fish market will be developed at Blackwattle Bay on a site adjacent the current Sydney Fish Market. Construction is planned to be complete in 2023.
Eastern City District Plan	This Eastern City District Plan is a 20-year plan to manage growth in the context of economic, social and environmental matters to achieve the 40-year vision of Greater Sydney. The plan covers the Bayside, Burwood, City of Canada Bay, City of Sydney, Inner West, Randwick, Strathfield, Waverley and Woollahra local government areas.

Concurrent construction noise impacts may occur if construction of these projects is carried out at the same time as Stage 1. 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. Indicative construction schedules for the nearby approved major projects (where available) are provided in **Table 88** in relation to Stage 1.

The location of these major projects is shown in **Figure 84** to **Figure 87**.

Table 88 Indicative Construction Schedule for Major Projects

Project and Work Phase	2018				2019				2020				2021				2022				2023				2024				2025				2026			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Metro West Stage 1																																				
Tunnelling																																				
Westmead metro station																																				
Parramatta metro station																																				
Clyde stabling and maintenance facility																																				
Silverwater services facility																																				
Sydney Olympic Park metro station																																				
North Strathfield metro station																																				
Burwood North Station																																				
Five Dock Station																																				
The Bays Station																																				
Other Major Developments																																				
Parramatta Light Rail – Stage 1																																				
New Powerhouse Museum																																				
Clyde Terminal Conversion																																				
North Strathfield Station Upgrade																																				
Concord Oval Redevelopment																																				
WestConnex M4–M5 Link																																				
Sydney Metro City & Southwest, White Bay truck marshalling yard																																				
Western Harbour Tunnel and Warringah Freeway																																				

Figure 84 Other Major Construction Projects – NCA01 to NCA07

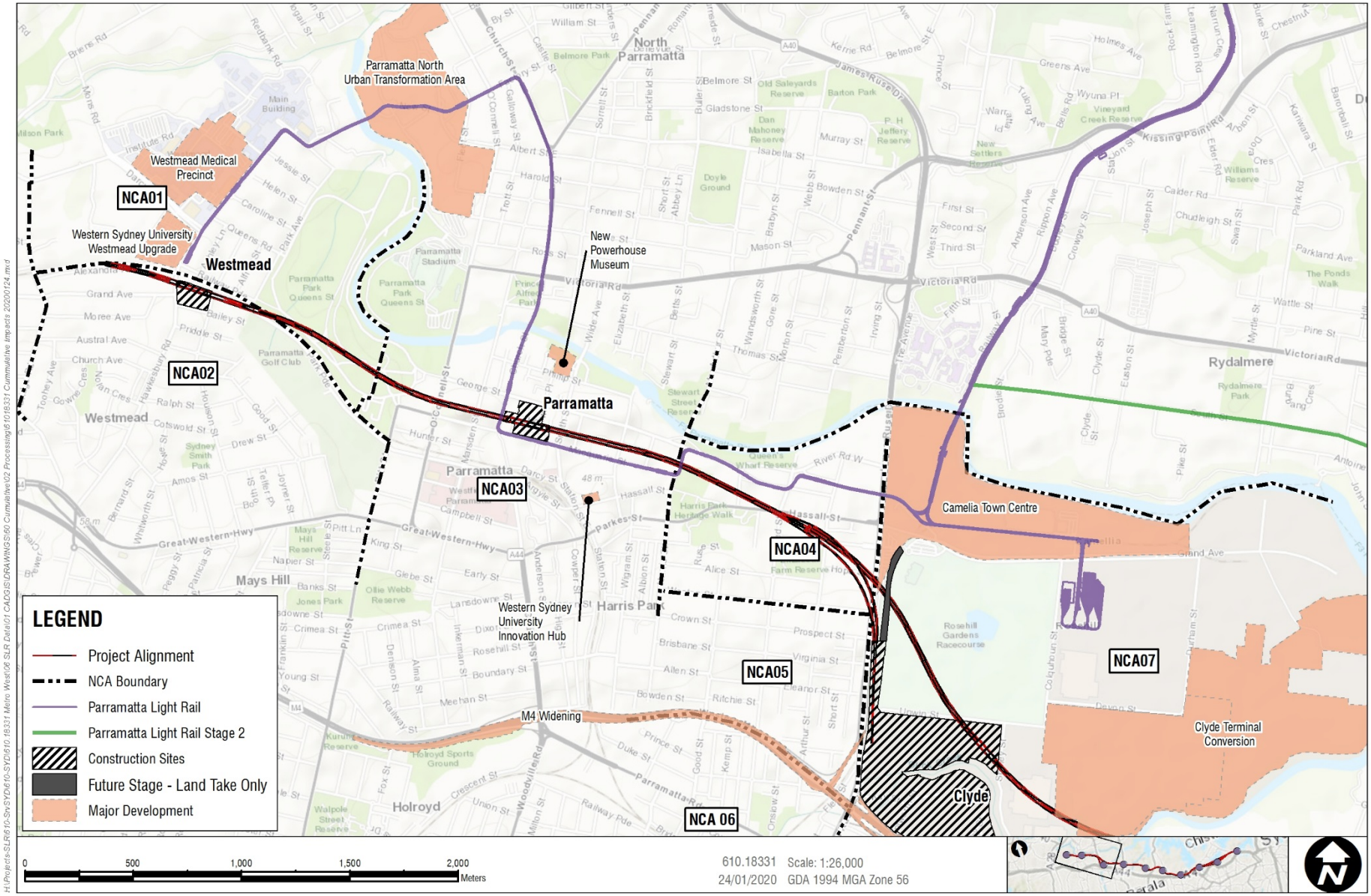


Figure 85 Other Major Construction Projects – NCA07 to NCA10

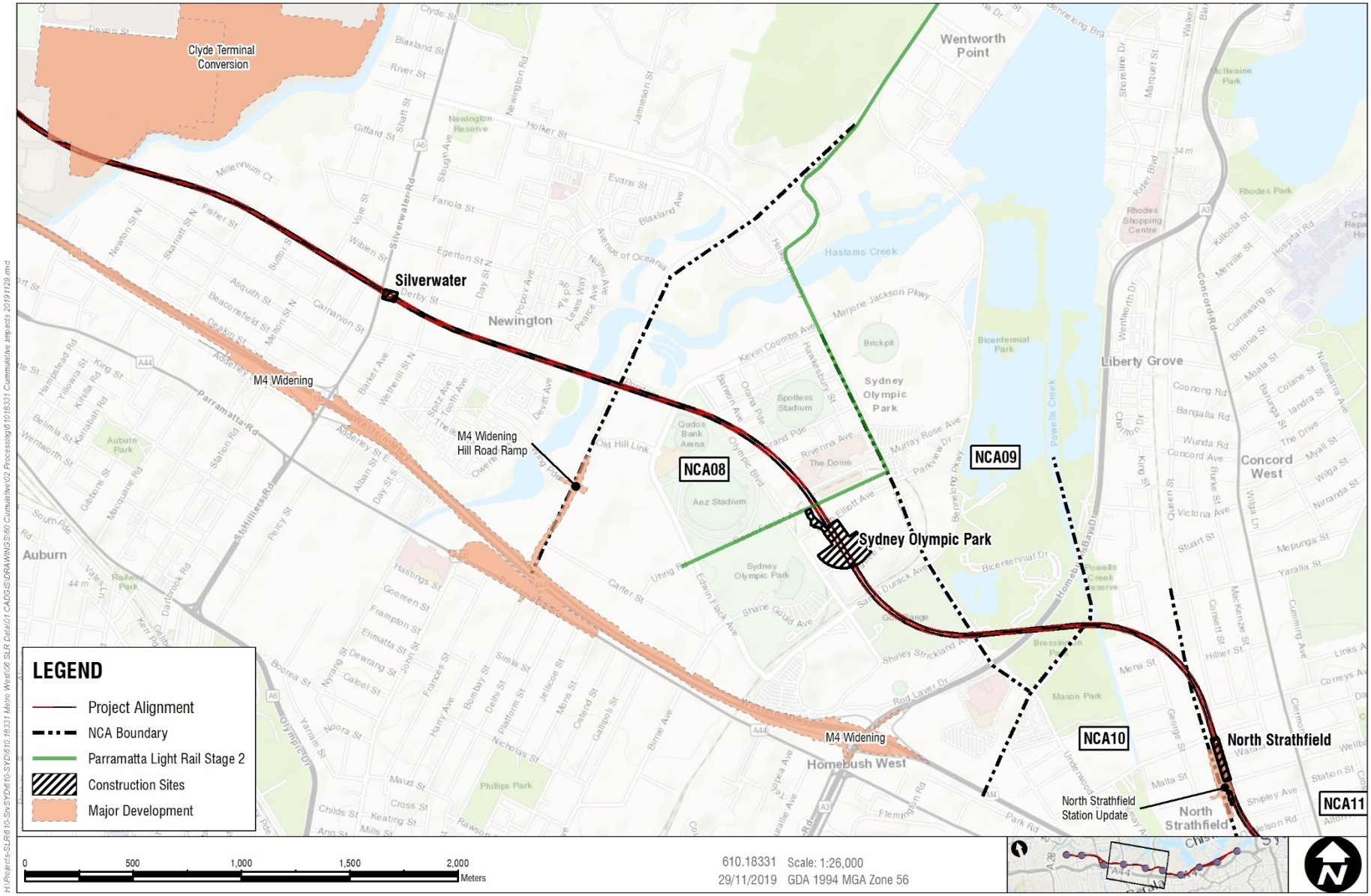


Figure 86 Other Major Construction Projects – NCA10 to NCA15

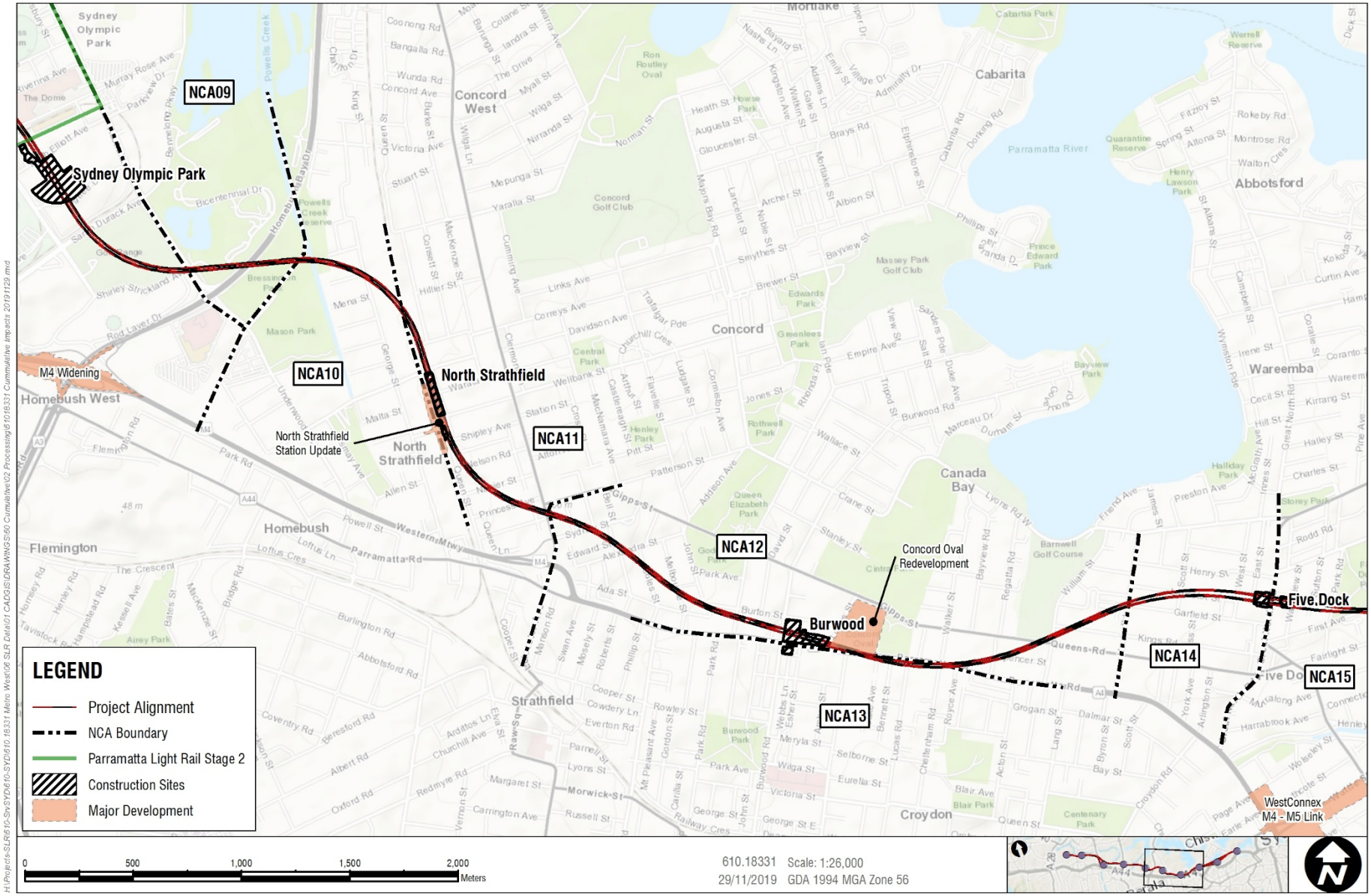
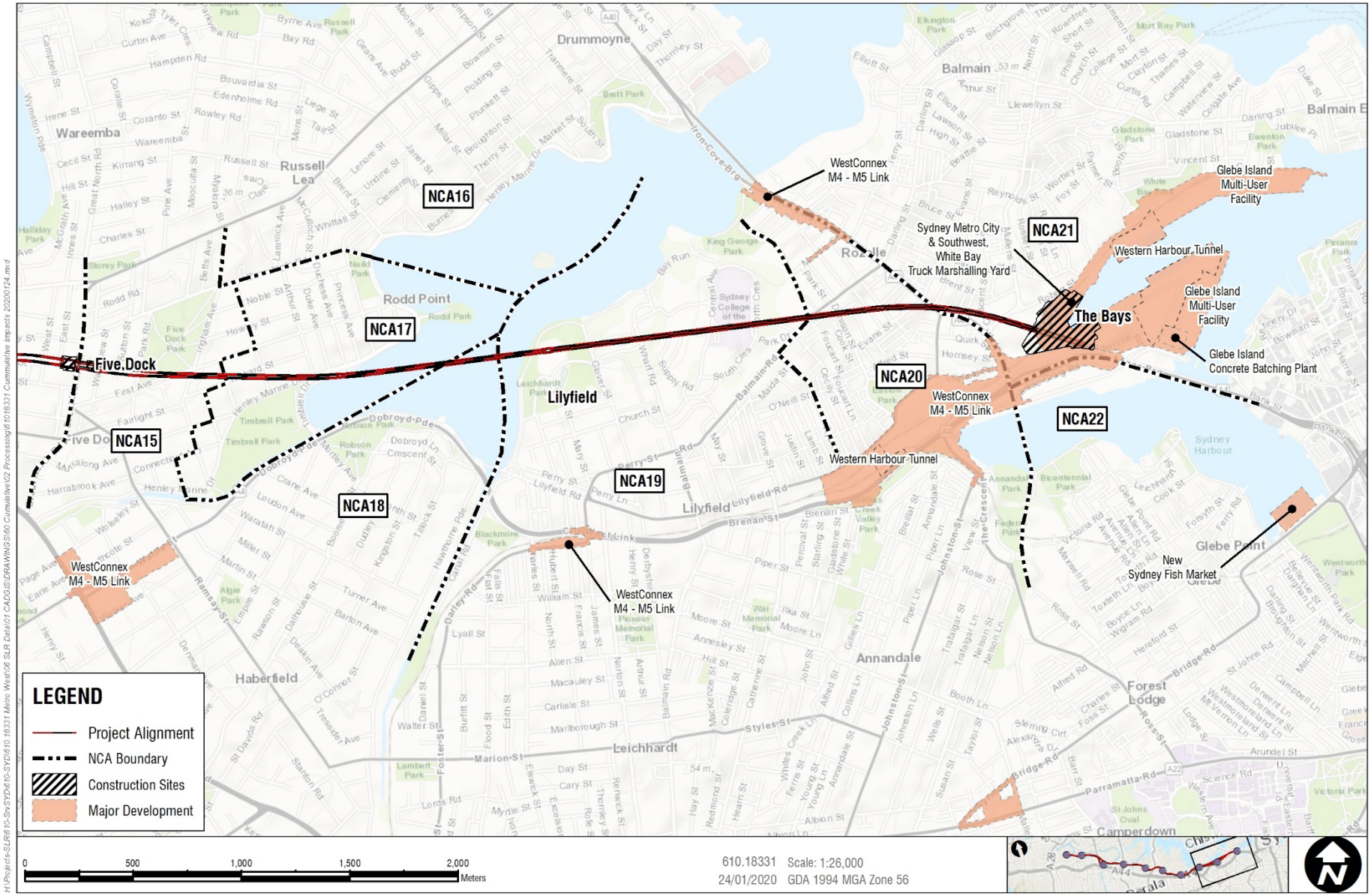


Figure 87 Other Major Construction Projects – NCA15 to NCA22



6.2 Concurrent Construction Noise Impacts

Concurrent construction noise impacts can occur where multiple works are being completed near to a particular receiver at the same time.

Many of the identified projects near to Stage 1 are in the early planning stages and detailed construction information is not available. Notwithstanding, there is potential for concurrent works to occur on several projects at the same time as Stage 1. Based on a review of the currently available information, concurrent impacts may occur in the locations identified in **Table 89**.

Table 89 Areas Identified for Potential Concurrent Impacts

Study area	Cumulative Impact Details
Westmead	**Parramatta Light Rail Stage 1 –** the light rail alignment runs along Hawkesbury Road in Westmead, which is to the north of the Westmead metro station construction site. Parramatta Light Rail Stage 1 is currently in construction and is expected to be complete in 2023. Receivers near to Westmead metro station construction site in NCA01 and NCA02 would potentially be affected by concurrent noise impacts from the construction of both projects.
Parramatta	**Parramatta Light Rail Stage 1 –** the light rail alignment also passes the Parramatta metro station construction site on Church Street and Macquarie Street in Parramatta. Receivers near to Parramatta metro station construction site in NCA03 would potentially be affected by concurrent noise impacts from the construction of both projects.
Clyde	**Clyde Terminal Conversion and Remediation Projects –** works at the terminal are to the east of the Clyde stabling and maintenance facility construction site and concurrent noise impacts may affect receivers in Silverwater that would be between both projects. These receivers are, however, largely commercial with relatively low sensitivity to construction noise. **Parramatta Light Rail Stage 1 –** the light rail alignment passes through the north section of the Clyde precinct along Tramway Avenue and to the north of Grand Avenue. A stabling and maintenance facility forms part of Parramatta Light Rail Stage 1 is located to the east of Rosehill Gardens racecourse. The projects are separated by around 850 metres meaning concurrent impacts are unlikely.
Sydney Olympic Park	**Sydney Olympic Park Masterplan 2030 –** various projects at Sydney Olympic Park may be in construction at the same time as construction of Sydney Olympic Park construction site and concurrent noise impacts may affect receivers around this construction site. Most of the receivers surrounding Stage 1 are commercial. Details of other projects that would be constructed near Stage 1 are not currently known.

Study area	Cumulative Impact Details
The Bays	**WestConnex M4–M5 Link –** works at Rozelle interchange are scheduled to occur at the same time as Stage 1 works at The Bays Station construction site meaning concurrent construction noise impacts may affect receivers near to both projects. WestConnex works at Rozelle interchange are expected to last until late-2023. The **Sydney Metro City & Southwest (Chatswood to Sydenham), White Bay truck marshalling yard** is also next to The Bays Station construction site. The nearest receivers to the site are, however, commercial or industrial, with the nearest residential receivers being over 130 metres away. The **Bays Precinct Urban Transformation Plan** and **Glebe Island Multi-User Facility** are proposed projects which are also close to this area. Timing for the various stages of these projects is currently unknown. **Western Harbour Tunnel and Warringah Freeway Upgrade** would be a new tunnel from the Rozelle interchange, under Sydney Harbour to the Warringah Freeway. Construction sites are proposed on the northern and southern sides of Glebe Island and in the disused rail yard north of the City West Link. This project is currently in the planning stages.

WestConnex M4-M5 Link

Of the projects identified in **Table 87**, WestConnex M4–M5 Link is considered to have the greatest potential for concurrent impacts with Stage 1. The Conditions of Approval for WestConnex M4-M5 Link identified areas of receivers near that project that are likely to be impacted by long-term, high impact works (in Condition E87). One area is to the west of Victoria Road and is located between WestConnex M4-M5 Link and The Bays Station construction site. The location is shown in **Figure 88**.

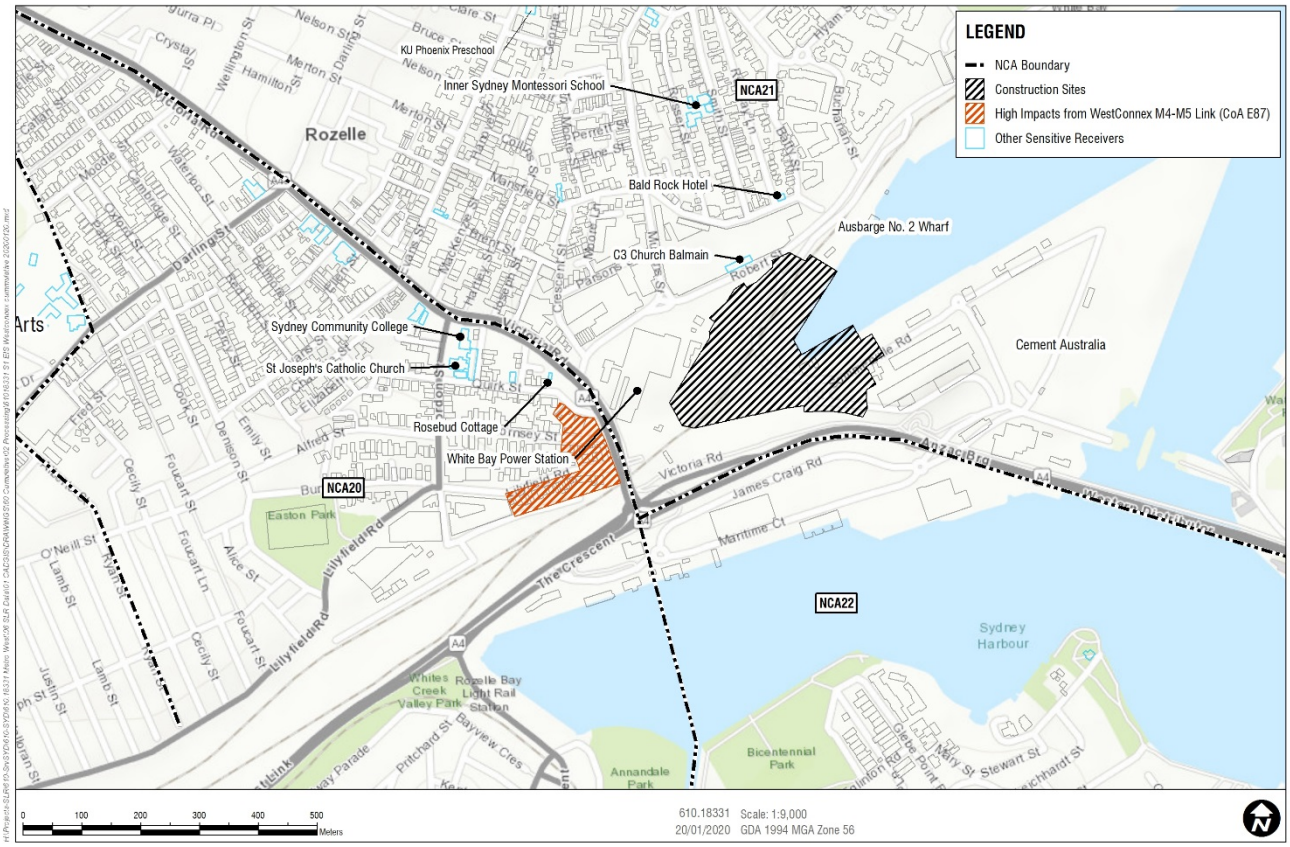
Reference to the predictions in **Section 5.2.9** show that Stage 1 works would only result in 'minor' worst-case daytime impacts at receivers near to the area identified in **Figure 88**. These impacts would occur during the noisiest scenarios which are *Enabling works – Demolition using a rockbreaker* and *Initial excavation – Through rock using rockbreaker* when noise intensive equipment such as rockbreakers are in use.

These noise intensive works are expected to last for four and seven weeks, respectively, with noise levels in this area during the longer-term Stage 1 works predicted to be compliant with the management levels.

On this basis, the potential concurrent impacts from Stage 1 and WestConnex M4-M5 Link works are considered minimal. If works were occurring on both projects at the same time near this area, construction noise levels at these receivers would generally be controlled by the much closer WestConnex M4-M5 Link works.

Other areas to south of Victoria Road in Rozelle Bay may also be affected by concurrent impacts, however, these areas are commercial/industrial with relatively low sensitivity to noise impacts.

Figure 88 WestConnex M4-M5 Link – High Impact Location



Western Harbour Tunnel and Warringah Freeway Upgrade

Western Harbour Tunnel and Warringah Freeway Upgrade would include the White Bay construction support site and the Rozelle Rail Yards construction support site which are to the north-east and south-west of The Bays construction site respectively, as shown in **Figure 87**. The Rozelle Rail Yards construction support site is within the footprint for the Rozelle Interchange, which forms part of the M4-M5 Link site and is over 800 m to the south-west of Stage 1 and sufficiently far for concurrent impacts to be unlikely at receivers surrounding The Bays construction site. The White Bay construction support site is, however, only 400 m to the north-east of The Bays Station construction sites and noise from works at this site may affect receivers impacted by Stage 1 works.

The highest impacts during works at the White Bay construction support site are expected to occur during spoil handling activities which would be undertaken during Standard Construction Hours[1]. 'Minor' noise impacts from the Western Harbour Tunnel and Warringah Freeway Upgrade works are predicted at receivers to the north of Robert Street in Rozelle, between Rumsay Street and Stephen Street, and also at receivers to east of the site across White Bay in Pyrmont.

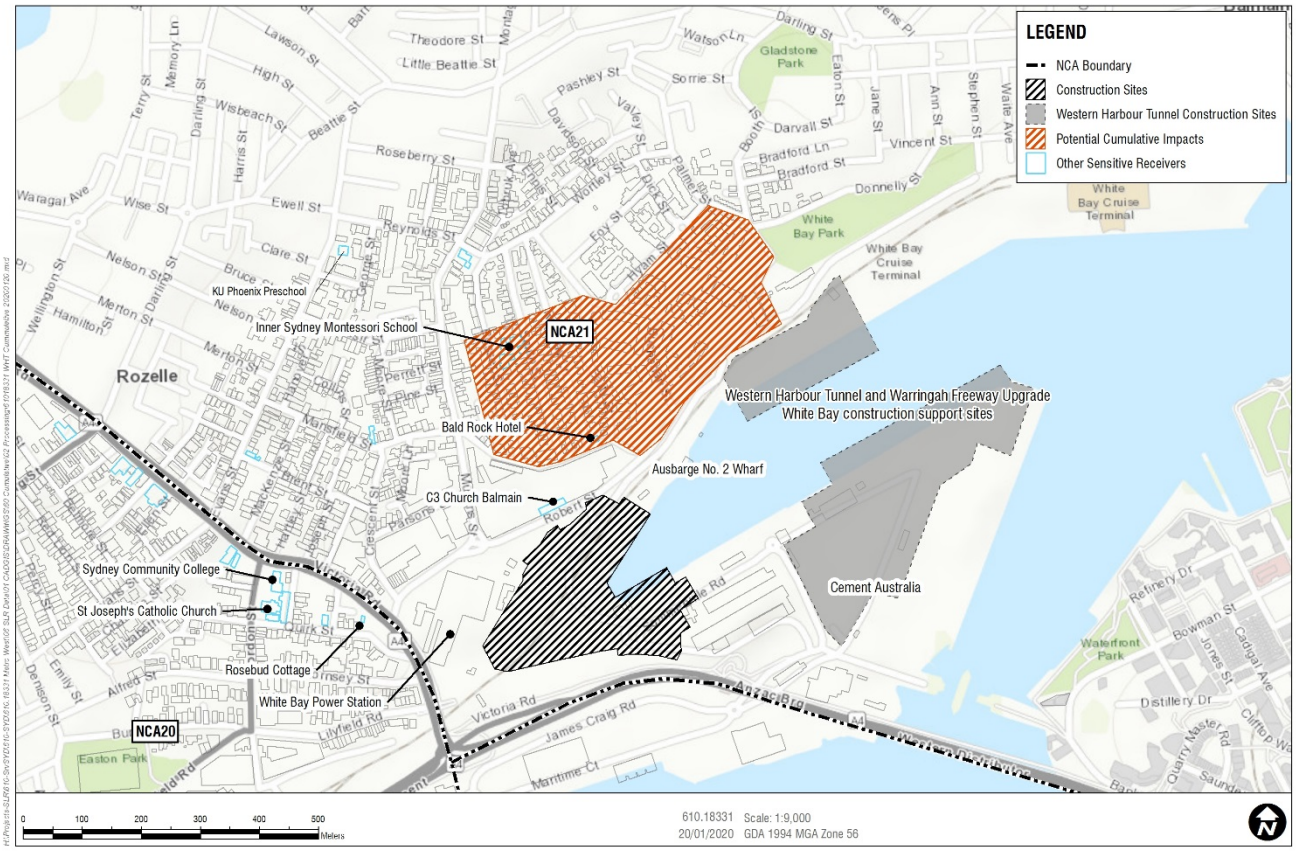
[1] *Western Harbour Tunnel and Warringah Freeway Upgrade Environmental Impact Statement – Appendix G*, Roads and Maritime, 2020.

Reference to the predictions in **Section 5.2.9** show that Stage 1 works not involving noise intensive equipment would also result in 'minor' worst-case daytime NML exceedances at receivers impacted by Western Harbour Tunnel and Warringah Freeway Upgrade works between Smith Street and Buchanan Street in Rozelle. For Stage 1 works involving rockbreakers, noise levels at the surrounding receivers would generally be dominated by Stage 1 works meaning concurrent impacts are unlikely.

On this basis, concurrent impacts from Stage 1 works and Western Harbour Tunnel and Warringah Freeway Upgrade works may occur at receivers situated between both sites as shown in **Figure 89**. Concurrent construction works on both projects (not involving Stage 1 noise intensive works) could theoretically increase the noise levels in this report by around 3 dB (ie a logarithmic adding of two sources of noise at the same level). This may result in 'minor' standard daytime NML exceedances at some receivers in this area that were previously predicted to be compliant, along with marginally higher 'minor' NML exceedances at some receivers already predicted to have exceedances.

The likelihood of worst-case noise levels being generated by two different projects at the same time is, however, considered low and rather than increase construction noise levels, the impact of concurrent works in this area would generally be expected to be an increase in the duration and potential annoyance of noise impacts at the nearest receivers.

Figure 89 Western Harbour Tunnel and Warringah Freeway Upgrade – Potential Concurrent Impacts



Other Major Projects

Concurrent noise Impacts from the remaining projects identified in **Table 89** may occur where construction works occur at the same time as Stage 1. Since the construction works for these projects would generally require similar items of equipment to Stage 1, concurrent construction works could theoretically increase the worst-case noise levels in this report by around 3 dB (ie a logarithmic adding of two sources of noise at the same level) where works on two projects are near to a particular receiver.

The likelihood of worst-case noise levels being generated by two different works at the same time is, however, considered low and rather than increase construction noise levels, the impact of concurrent works would generally be expected to be an increase in the duration and potential annoyance of noise impacts at the nearest receivers.

In practice, construction noise levels in any one location would vary and would be frequently much lower than worst-case due to construction phasing moving works around and in many cases only a few items of equipment being used at any one time.

Where works on multiple projects are occurring outside of Standard Construction Hours in similar areas there is potential for increased impacts (including sleep disturbance) at nearby affected receivers. It is important that coordination occurs between the various major projects regarding evening and night-time works so that appropriate respite is provided to affected receivers in accordance with the CNVS and/or the project's conditions of approval, as outlined in **Section 8**.

6.3 Consecutive Construction Noise Impacts

In addition to concurrent impacts, if more than one project occurs in the same area consecutively, there may be a prolonged effect from the extended duration of construction noise impacts. This effect is termed 'construction fatigue'.

Mitigation measures aimed at short-term construction works may be less effective where receivers are affected by longer duration impacts from several projects, especially where extensive night-time works are required. Where receivers are affected by 'construction fatigue', it may be necessary to consider specific mitigation and management measures to minimise the impacts. Based on the currently available information, 'construction fatigue' from consecutive projects may occur in the locations identified in **Table 90**.

Table 90 Areas Identified for Potential Consecutive Impacts

Construction site	Consecutive Impact Details[1]
Westmead metro station	• Parramatta Light Rail Stage 1 is to north of the construction site. Construction works are currently being undertaken. • Western Sydney University Westmead Campus Upgrade is to the north-west of the site. Construction works are currently occurring. • Westmead Medical Precinct Redevelopment is located to the north of the site, although this is over 300 metres away. • A mixed use development is proposed at 24-26 Railway Parade, Westmead, which is next to the future light rail Westmead stop.

Construction site	Consecutive Impact Details[1]
Parramatta metro station	• Three local development projects are proposed on or adjacent to the Parramatta Station construction site, including 61B George Street, 69 George Street and 220 Church Street/48 Macquarie Street. • The New Powerhouse Museum is located to the north of the site, however, this is over 170 metres away with many intervening buildings.
Clyde stabling and maintenance facility	• Parramatta Light Rail Stage 1 light rail alignment and stabling yard is to north of the construction site. • Camelia Town Centre is to the north of the site. • Clyde Terminal Conversation is to the east of the site. • WestConnex M4 Widening was constructed to the south of the site between 2015 and mid-2017.
Sydney Olympic Park metro station	• There are several local development projects near to the construction site. Some of these are currently under construction with other being proposed. • Sydney Olympic Park Masterplan 2030 sets out the strategy for future development in the area. • WestConnex M4 Widening was constructed to the south of the site between 2015 and mid-2017. • WestConnex M4 Widening, Hill Road Modification is proposed to the south of the site. • WestConnex M4 East was constructed to the south-east of the site between 2016 and mid-2019.
North Strathfield metro station	• North Strathfield Station Upgrade was completed in late 2019. • WestConnex M4 East was construction to the south-east of the site between 2016 and mid-2019.
Burwood North	• WestConnex M4 East was construction to the east of the site between 2016 and mid-2019. • Concord Oval Redevelopment is proposed immediately next to the site.
The Bays Station	• WestConnex M4–M5 Link is currently under construction to the south-west of the site and is expected to be complete by 2023. • The Sydney Metro City & Southwest (Chatswood to Sydenham), White Bay truck marshalling yard is currently in use to the north of the site and expected to be in use until 2020. • Glebe Island Multi-User Facility is proposed to the north and east of the site. • The Bays Precinct Urban Transformation Plan surrounds the site. • Western Harbour Tunnel and Warringah Freeway Upgrade is proposed to the north-east and south-west of the site. Construction scheduling information is not currently available for this project.

Note 1: Several of these construction projects are located relatively distant from Stage 1, however, they are considered relevant as they may add to the perception of the extended nature of construction works in some areas.

The potential consecutive impacts from Stage 1 and other major projects in these areas should be investigated further as the project progresses when detailed construction planning is developed. Specific management and mitigation measures designed to address potential consecutive impacts should be developed and used to minimise the impacts as far as practicable, in consultation with the affected community as outlined in **Section 8**.

7 Operational Road Traffic Noise Assessment

Operational road traffic noise impacts 'without mitigation' have been predicted for all sensitive receivers in the study area near to proposed road reconfigurations.

The predicted operational road noise levels at residential receivers are summarised in **Table 91**. The table shows the worst-case impacts in each NCA, which typically correspond to receivers nearest the roadworks. 'Other sensitive' receivers with predicted exceedances of the trigger levels are shown in **Table 92**. The locations of the receivers which are above the noise trigger levels are shown in **Figure 90**.

Table 91 Predicted Road Traffic Noise Levels at Most Affected Residential Receivers in each NCA

NCA	Predicted Noise Level (dBA)[1]				Number of Triggered Buildings[2]			
	At Opening (2023)							
	No Build (without project)		Build (with project)					
	Day	Night	Day	Night	Trigger 1 >2.0 dB	Trigger 2 Cumulative	Trigger 3 Acute	Total
Westmead								
NCA01	70	64	70	63	-	-	-	-
NCA02	68	63	70	65	68	69	4	71
Clyde								
NCA05	70	66	70	66	-	-	-	-

Note 1: Daytime and night-time are $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ noise levels, respectively.

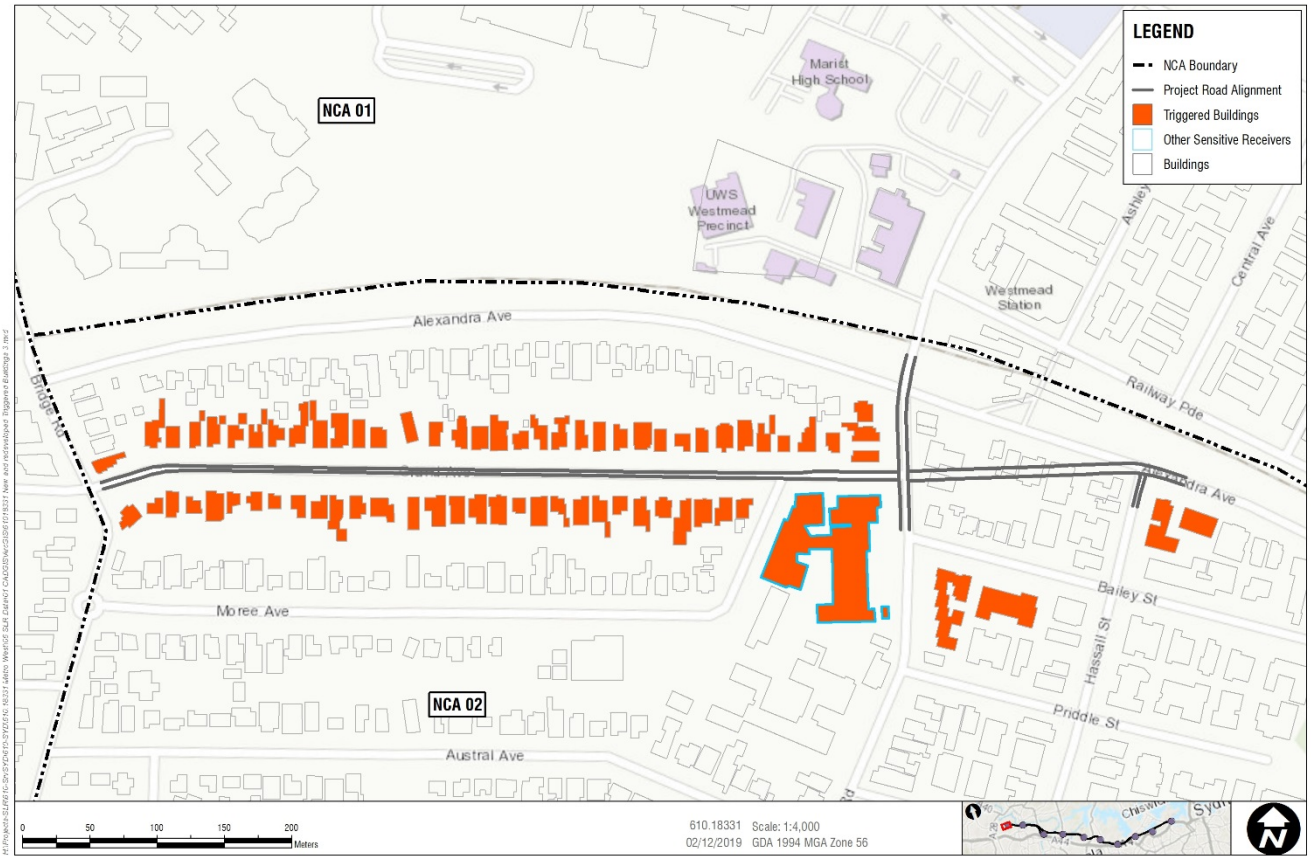
Note 2: The NMG triggers are discussed in **Section 4.7.3**.

Table 92 'Other Sensitive' Receivers Triggers

NCA	Receiver	Type	NMG Triggers[1]		
			Trigger 1 >2.0 dB	Trigger 2 Cumulative	Trigger 3 Acute
Westmead					
NCA01	-	-	-	-	-
NCA02	Westmead Public School	Educational	Y	Y	Y
Clyde					
NCA05	-	-	-	-	-

Note 1: The NMG triggers are discussed in **Section 4.7.3**

Figure 90 Locations of Triggered Receivers



The above results show the following:

Westmead

- Residential receivers are predicted to be above the trigger levels in Westmead adjacent to the realignment of Alexandra Avenue and also along Grand Avenue. The triggers near Baily Street are due to Alexandra Avenue moving closer to these receivers and the triggers along Grand Avenue are due to the functional class change of Grand Avenue which means the impacts here are required to be assessed against 'new' road criteria.
- Noise levels at residential receivers to the south on Bailey Street are predicted to increase by around 3 dB due to the realigned section of Alexandra Avenue. Noise levels along Grand Avenue are predicted to increase by around 5 to 6 dB which is due to the increased volume of traffic on this road.
- Exceedances of the NCG cumulative limit criteria (ie 5 dB or more above the NCG controlling criterion) are predicted at the receivers which have noticeable increases in noise.
- The works are predicted to result in acute noise levels (ie daytime noise levels are 65 dBA or higher, or night-time noise levels are 60 dBA or higher) at four residential receivers.
- Westmead Public School is predicted to be above the trigger levels.
- In total, 71 receivers that are predicted to have exceedances of the operational road traffic noise criteria.

Clyde

- Existing noise levels are not predicted to be altered by the road reconfigurations at Clyde. This is due to the relatively small contribution that the revised location of Unwin Street has to the noise levels at the nearest receivers. Existing and future noise levels at the nearest receivers are expected to be controlled by James Ruse Drive.

7.1 Maximum Noise Levels

While average noise levels are expected to increase at receivers on Grand Avenue during the night-time due to increased traffic, the road reconfigurations are not expected to result in any noticeable changes in the magnitude of existing maximum noise levels, as maximum noise levels are typically controlled by heavy vehicle movements on the nearest roads or occasional noisy light vehicles or motorbikes, which is unlikely to be altered by the works.

The frequency of maximum noise level events on Grand Avenue is, however, likely to increase in line with the general increase in night-time traffic, noting that the increased traffic is limited to a higher volume of light vehicles, with the number of night-time heavy vehicles remaining low after the road reconfiguration works are complete.

8 Management of Impacts

The ICNG acknowledges that due to the nature of construction works it is inevitable that there will be impacts where construction is near to sensitive receivers. Mitigation and management measures which could be applied to Stage 1 to minimise the impacts are provided below.

8.1 Construction Environmental Framework

The Construction Environmental Management Framework (CEMF) is a Sydney Metro project framework which sets out the environmental, stakeholder and community management requirements for construction of Stage 1. Stage 1 principal contractors would be required to implement and adhere to the requirements of the CEMF. The CEMF is provided as Appendix D of the Environmental Impact Statement.

The CEMF would require the principal contractors to prepare a Construction Noise and Vibration Management Plan (CNVMP) for their scope of works in line with the requirements of the ICNG (see **Section 3**) and the Sydney Metro CNVS (see **Section 8.2**).

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

- Identification of nearby sensitive receivers
- Description of works, construction equipment and hours works 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 works.

8.2 Sydney Metro Construction Noise and Vibration Standard

The Sydney Metro CNVS contains assessment and management protocols for construction of Sydney Metro projects. The strategy is based on the requirements of the ICNG and Transport for NSW CNVS, as appropriate to Sydney Metro and is the guiding strategy for mitigating and managing all construction noise and vibration impacts from Stage 1 including tunnelling and utility works. The Sydney Metro CNVS is provided as Appendix E to the Environmental Impact Statement.

8.2.1 Standard Mitigation Measures

The CNVS contains a number of ‘standard mitigation measures’. These measures are summarised in **Appendix H** and would be applied to the works at all Stage 1 construction sites to minimse the impacts from the works as far as practicable and where feasible and reasonable.

The standard measures include items such as requiring construction contractors to complete site inductions to make workers aware of any noise and vibration specifics, completing 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.

8.2.2 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 93**.

Table 93 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 has 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 Stage 1.	IB
Letter box drops	A newsletter would be 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 Stage 1 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 seven 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

Measure	Description	Abbreviation[1]
Specific notifications	Specific notifications would be letterbox dropped or hand distributed to identified stakeholders no later than seven 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 impacts and potential human comfort vibration impacts. The approach for each is shown in **Table 94, Table 95** and **Table 96**, respectively.

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

Table 94 Additional Mitigation Measures Matrix – Airborne Construction Noise

Time Period		Mitigation Measure			
		$L_{Aeq(15minute)}$ Noise Level above Background (RBL)			
		0 to 10 dBA	10 to 20 dBA	20 to 30 dBA	>30 dBA
Standard	Mon-Fri (7am - 6pm)	-	-	M, LB	M, LB
	Sat (8am - 1pm)				
	Sun/Pub Hol. (Nil)				
OOHW Period 1	Mon-Fri (6pm - 10pm)	-	LB	M, LB	M, IB, LB, PC, RO, SN
	Sat (7am - 8am) & (1pm - 10pm)				
	Sun/Pub Hol. (8am - 6pm)				
OOHW Period 2	Mon-Fri (10pm - 7am)	-	M, LB	M, IB, LB, PC, RO, SN	AA, M, IB, LB, PC, RO, SN
	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 (PC), Specific notifications (SN).

Table 95 Additional Mitigation Measures Matrix – Ground-borne Noise

Time Period		Mitigation Measure		
		$L_{Aeq(15minute)}$ Noise Level above Noise Management Level (NML)		
		0 to 10 dB	10 to 20 dBA	>20 dBA
Standard	Mon-Fri (7am - 6pm)	LB	LB	LB, M
	Sat (8am - 1pm)			
	Sun/Pub Hol. (Nil)			
OOHW Period 1	Mon-Fri (6pm - 10pm)	LB	M, LB, SN	M, IB, LB, RO, PC, SN
	Sat (7am - 8am) & (1pm - 10pm)			
	Sun/Pub Hol. (8am - 6pm)			
OOHW Period 2	Mon-Fri (10pm - 7am)	M, LB, SN	AA, M, IB, LB, PC, RO, SN	AA, M, IB, LB, PC, RO, SN
	Sat (10pm - 8am)			
	Sun/Pub Hol. (6pm - 7am)			

Note: The abbreviations are defined in **Table 94.**

Table 96 Additional Mitigation Measures Matrix – Human Comfort Vibration

Time Period		Mitigation Measure
		Predicted Vibration Levels Exceed Maximum Levels
Standard	Mon-Fri (7am - 6pm)	M, LB, SN
	Sat (8am - 1pm)	
	Sun/Pub Hol. (Nil)	
OOHW Period 1	Mon-Fri (6pm - 10pm)	LB
	Sat (7am - 8am) & (1pm - 10pm)	
	Sun/Pub Hol. (8am - 6pm)	
OOHW Period 2	Mon-Fri (10pm - 7am)	M, LB, SN
	Sat (10pm - 8am)	
	Sun/Pub Hol. (6pm - 7am)	

Note: The abbreviations are defined in **Table 94.**

The specific 'additional noise mitigation' requirements would be determined at a later stage of Stage 1 in CNVIS assessments when detailed construction data is available.

8.2.3 Construction Noise and Vibration Impact Statements

Site specific Construction Noise and Vibration Impact Statements (CNVIS) would be prepared for all works 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.

The CNVIS assessments would be completed prior to the works starting and would assess the potential impacts at receivers near the works 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.

8.3 Project Specific Construction Mitigation Measures

The noise and vibration impacts from all works associated with Stage 1 would generally be controlled using the approaches defined in the CEMF, CNVMP and Sydney Metro CNVS as detailed above. Several base-case mitigation measures would be included to minimise the potential airborne noise impacts as outlined in **Section 4.6.1**.

On the basis of the predictions, **Table 97** lists the project-specific mitigation measures which would also be used in addition to the CEMF, CNVMP and Sydney Metro CNVS to minimise the impacts. Items where further investigation has been recommended in later stages of Stage 1 are also listed.

Table 97 Stage 1 Specific Construction Noise and Vibration Mitigation Measures

ID	Impact	Mitigation measure
NV01	Community preference	Further engagement and consultation would be carried out 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 would be consulted to understand periods in which they are more sensitive to impacts. Based on this consultation, appropriate feasible and reasonable mitigation and management options would be considered and implemented where feasible and reasonable to minimise the impacts.
NV02	Alternative construction methodologies	Alternative construction methodologies and measures minimise the impacts during noise intensive works would be investigated and implemented where feasible and reasonable. This would include consideration of alternative techniques that have been effective on previous similar projects such as: • The use of hydraulic concrete shears in lieu of rockbreakers • Sequencing works to shield noise sensitive receivers by retaining building wall elements • Locating demolition load out areas away from nearby noise sensitive receivers • Providing respite periods for noise intensive works • Minimising structure-borne noise to adjacent buildings by separating the structural connection prior to demolition using less vibration intensive means such as saw-cutting and propping, using hand splitters and pulverisers or hand demolition • Installing of acoustic screening on areas of scaffolding facing noise sensitive receivers • Using portable noise barriers around particularly noisy equipment such as concrete saws • Modifying demolition works sequencing / hours to minimise impacts during peak pedestrian times and / or adjoining neighbour outdoor activity periods.

ID	Impact	Mitigation measure
NV03	Respite and duration of construction noise exceedances	Appropriate respite would be provided to affected receivers in accordance with the CNVS. This would include consideration of impacts from Stage 1 utility and power supply works when determining appropriate respite periods for affected receivers When determining appropriate respite, the need to efficiently undertake construction would be balanced against the communities' preferred noise and vibration management approach.
NV04	Out of hours construction noise exceedances	The use of noise intensive equipment at construction sites with 'moderate' or 'high' out of hours noise management level exceedances would be scheduled for Standard Construction Hours, where feasible and reasonable. Where this is not feasible and reasonable, the works would be undertaken as early as possible in the work shift.
NV05	Heavy vehicle pneumatic release noise	Air brake silencers would be used on heavy vehicles that access the construction sites multiple times per night or over multiple nights.
NV06	Sleep disturbance impacts from heavy vehicles	Perimeter site hoarding would be designed with consideration of on-site heavy vehicle movements with the aim of minimising sleep disturbance impacts.
NV07	Long-term stationary equipment	Long-term stationary construction site support equipment and machinery would be specified to be low noise emitting and suitable for use in residential areas, where feasible and reasonable. Examples include: • Low noise water pumps in water treatment facilities • Low noise generators and compressors • Low noise air conditioner units for use of amenities buildings.
NV08	Acoustic sheds	For all sites where acoustic sheds are determined to be suitable, the sheds would be sufficiently designed and constructed to minimise noise emissions. This would include the following considerations: • All significant noise producing equipment that would be used during the night-time would be inside the sheds, where feasible and reasonable • Noise generating ventilation systems such as compressors, scrubbers, etc, would be located inside the sheds and external air intake/discharge ports would be appropriately acoustically treated • The doors of acoustic sheds would be kept closed during the night-time period, where feasible and reasonable. Where night-time vehicle access is required at sites with nearby residences, the shed entrances would be designed and constructed to minimise noise breakout.
NV09	Construction ground-borne noise at construction sites	Feasible and reasonable measures would be used to minimise ground-borne noise where exceedances are predicted. This could include measures such as using alternative less ground-borne noise and vibration intensive construction methodologies.
NV10	Ground-borne noise – cross passages	The proximity of cross passages to nearby receivers and the corresponding construction ground-borne noise and vibration impacts during the excavation works would be considered when determining locations. Relocation of cross passages to be further away from sensitive receivers to mitigate potential construction impacts would be considered, where feasible and reasonable.

ID	Impact	Mitigation measure
NV11	Ground-borne noise – underground rockbreaking	An activity specific Construction Noise and Vibration Impact Statement (in accordance with the requirements of the CNVS) would be developed for rockbreaking in the tunnel and at cross passages, specifically addressing the activity between 10:00 pm and 7:00 am.
NV12	Blast Management	Blasting would be planned during hours that would cause the least disruption and disturbance to the nearest receivers. Notification protocols prior to blasting for the nearest sensitive receivers would be established.
NV13	Blast monitoring	Attended vibration and overpressure measurements would be completed at the start of any blasting activities to confirm that vibration levels are within the blasting criteria.
NV14	Construction traffic noise	Further assessment of construction traffic would be completed during detailed design, including consideration of the potential for exceedances of the RNP base criteria (where >2.0 dB increases are predicted). The potential impacts would be managed using the following approaches, where feasible and reasonable: • On-site spoil storage capacity would be maximised to reduce the need for truck movements during sensitive times • Vehicle movements would be redirected away from sensitive receiver areas and scheduled during less sensitive times • The speed of vehicles would be limited and the use of engine compression brakes would be avoided • Heavy vehicles would be restricted from idling near to sensitive receivers.
NV15	Rosehill Gardens 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.
NV16	Construction vibration at construction sites	Where vibration levels are predicted to exceed the screening criteria, a more detailed assessment of the structure (in consultation with a structural engineer) and attended vibration monitoring would be carried out to ensure vibration levels remain below appropriate limits for that structure. For heritage items, the more detailed assessment would specifically consider the heritage values of the structure in consultation with a heritage specialist to ensure sensitive heritage fabric is adequately monitored and managed.
NV17	Building condition surveys	Condition surveys of buildings and structures near to the tunnel and excavations would be undertaken before and after the works, where appropriate. For heritage buildings and structures the surveys would consider the heritage values of the structure in consultation with a heritage specialist.
NV18	Cumulative construction impacts	The likelihood of cumulative construction noise impacts would be reviewed during detailed design when detailed construction schedules are available. Co-ordination would occur between potentially interacting projects to minimise concurrent or consecutive works in the same areas, where possible. Specific mitigation strategies would be developed to manage impacts. Depending on the nature of the impact, this could involve adjustments to construction program or activities of Sydney Metro West or of other construction projects.

8.4 Operational Road Traffic Mitigation

Where operational road traffic noise levels exceed the criteria, the impacts should be reduced using feasible and reasonable mitigation. For receivers that qualify for consideration of noise mitigation, potential measures are to be considered in the following order of preference:

- At-source mitigation (ie quieter road pavement surfaces)
- In-corridor mitigation (ie noise barrier or mounds)
- At-receiver mitigation (at-property treatments).

8.4.1 At-Source Mitigation – Low Noise Pavements

The type of road surface can significantly affect road traffic noise levels at nearby receivers. Concrete pavements tend to be the noisiest with low noise pavements such as open grade asphalt (OGA) being the quietest.

Low noise pavements are generally most effective where vehicle speeds are high, such as on motorways, and less effective where traffic speeds are slower or where traffic is required to slow down or stop. As the speeds on roads affected by the Stage 1 works would be 50 km/h, low noise pavements are not considered an appropriate mitigation option.

8.4.2 In-Corridor Mitigation – Noise Barriers

After at-source mitigation has been investigated, the next approach is to consider in-corridor mitigation which aims to block line of sight from the source of noise to nearby receivers. Noise barriers (in the form of walls or mounds) can provide significant noise reductions and also have the benefit of reducing both external and internal noise levels.

The receivers in Westmead which are predicted to be impacted by Stage 1 are accessed from the roads which are predicted to results in increased noise levels. This means noise barriers are not a feasible and reasonable option as they would require gates for every property access.

8.4.3 At-Property Mitigation – Architectural Treatment

Where residual impacts remain after the use of at-source and in-corridor mitigation, the final approach is to use at-property mitigation. This typically involves using architectural treatments such as thicker glazing and doors, or upgraded facade constructions to achieve appropriate internal noise levels.

Architectural treatments are more effective when they are applied to masonry buildings compared to lightly clad timber framed structures, and caution should be taken before providing treatments to buildings with poor facade acoustic performance as they may not be effective.

The architectural treatments are typically limited to:

- Fresh air ventilation systems that meet the National Construction Code of Australia requirements with the windows and doors shut
- Upgraded windows and glazing and solid core doors on the exposed facades of the substantial structures only (eg masonry or insulated weather board cladding with sealed underfloor). These techniques would be unlikely to produce any noticeable benefit for light frame structures with no acoustic insulation in the walls

- Upgrading window or door seals and appropriately treating sub-floor ventilation
- The sealing of wall vents
- The sealing of the underfloor below the bearers
- The sealing of eaves.

The final operational road traffic noise mitigation strategy for receivers identified as being eligible for consideration of treatment would be determined as the project progresses. It is likely that at-property treatment would be the most appropriate approach to mitigating the impacts.

Receivers that are identified as requiring at-receiver noise mitigation should be identified and offered treatment prior to the start of construction works, which have the potential to affect them.

Some of the receivers triggered for consideration of mitigation are recently built and would have been constructed in accordance with the requirements of the *NSW Infrastructure State Environmental Planning Policy* (ISEPP) and as they are near to existing sources of road and rail noise, would likely already have increased performance facades.

9 Conclusion

Noise and vibration impacts from works specific to construction sites in each of the eleven study areas have been assessed, together with impacts from tunnelling, construction road traffic and utility works. The potential cumulative impacts from concurrent and consecutive works of Sydney Mero West 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 as works require the use of noise intensive equipment near to sensitive receivers.

The assessment indicates a requirement to consider mitigation measures to minimise the potential noise and vibration impacts from the project. Several mitigation strategies have been recommended which are informed by the *Interim Construction Noise Guideline* (ICNG) and the *Sydney Metro Construction Noise and Vibration Standard* (CNVS), as required by the Sydney Metro Construction Environmental Management Framework (CEMF). These measures are considered appropriate to minimise noise and vibration impacts from the project as far as reasonably practicable and in a manner consistent with recent approved major infrastructure projects in NSW.

The project would also reconfigure road intersections at some construction sites. The operational road traffic noise assessment indicates that 71 receivers in Westmead are above the appropriate criteria and are eligible for consideration of mitigation.