Construction Noise and Vibration Impact Assessment

Huntlee Stage 2

Huntlee Pty Ltd

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Revision Record

Revision	Date	Prepared By	Checked By	Authorised By
v1.0	6 December 2023	Shannon Harvey	Martin Davenport	Martin Davenport

Basis of Report

This report has been prepared by SLR Consulting Australia (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Huntlee Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

SLR disclaims any responsibility to the Client and others in respect of any matters outside the agreed scope of the work.

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1.0 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Swan Project Advisory Pty Ltd on behalf of Huntlee Pty Ltd to prepare a Construction Noise and Vibration Management Plan (CNVMP) for construction works associated with the proposed Huntlee Stage 2 Development Project.

The overall Development includes site preparation works including remediation, earthworks, infrastructure provision, road works and open space associated with parks and the residential neighbourhood urban design.

This CNVMP addresses the potential noise and vibration impacts associated with the bulk earthworks and upgrade of road and access infrastructure components of the construction. The CNVMP is designed to address the potential construction noise and vibration impacts on the surrounding residential receivers and to detail procedures for minimising, managing and monitoring these impacts.

Specific acoustic terminology is used in this report. An explanation of common acoustic terms is provided in **Appendix A**.

2.0 Development Overview

This report supports an Environmental Impact Statement and State Significant Development Application (SSDA) that seeks consent for the Huntlee New Town Stage 2 development, comprising the concept development for the Stage 2 sites including Villages 2 and 3, land off Old North Road and the Town Centre North area, and the detailed development for the central and southern areas of Village 2. The proposal represents the next phase of an extensive planning, assessment and consultation process completed to date for the development of the Huntlee New Town site.

Specifically, this SSDA proposes the following works for the Huntlee New Town:

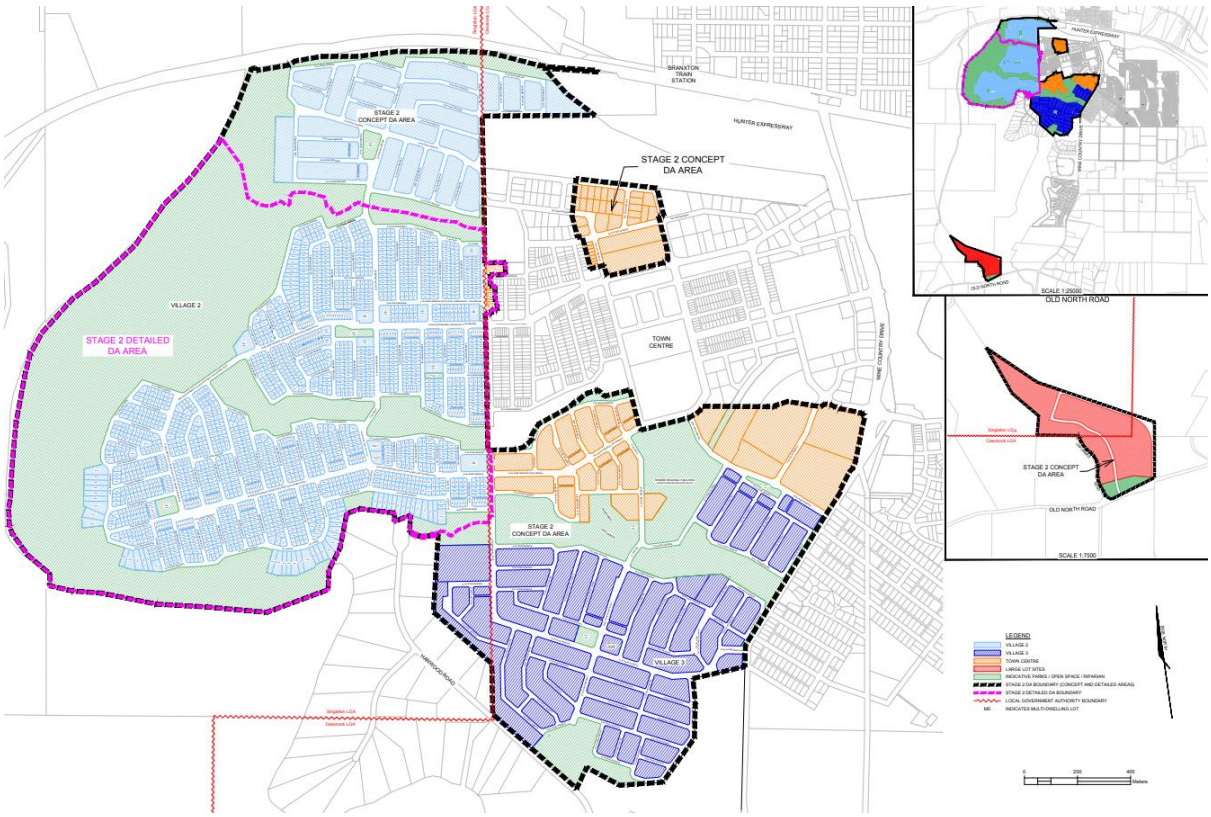
- A Concept Master plan for the Stage 2 site, comprising:
- Overall Stage 2 development footprint, including:
    - The remaining Town Centre North area,
    - Villages 2 and 3, and
    - A large lot residential area located to the south of the site on Old North Road;
- Proposed land use and development yield, including the provision for residential subdivision of approximately 5,000 lots;
- Associated new road network and required upgrades to existing network;
- Site-wide open space and riparian areas;

- Detailed development of Village 2 Central and South and eastern connection to the Town Centre, comprising:
- Demolition and clearing of existing built form structures;
- Clearing of existing vegetation within proposed development footprints;
- Open space, recreation, community and riparian areas;
- Construction of road and access infrastructure;
- Bulk earthworks;

- Stormwater and drainage works;
- Utilities and services, including
    - Sewer and potable water reticulation;
    - Electricity and communications infrastructure;
- Subdivision to facilitate approximately 1,750 lots across the Village 2 Central and South areas and Town Centre development lots, comprising approximately 1,730 residential lots, eight (8) medium density superlots, two (2) commercial/mixed use lots and open space areas; and
- Select clearing and grading to establish temporary Asset Protection Zones where development interfaces with the Concept Master plan area.

Figure 1 demonstrates the location of the Stage 2 Concept and Detailed areas, in the context of the surrounding development.

Figure 1 Proposed Concept and Detailed Area Layout



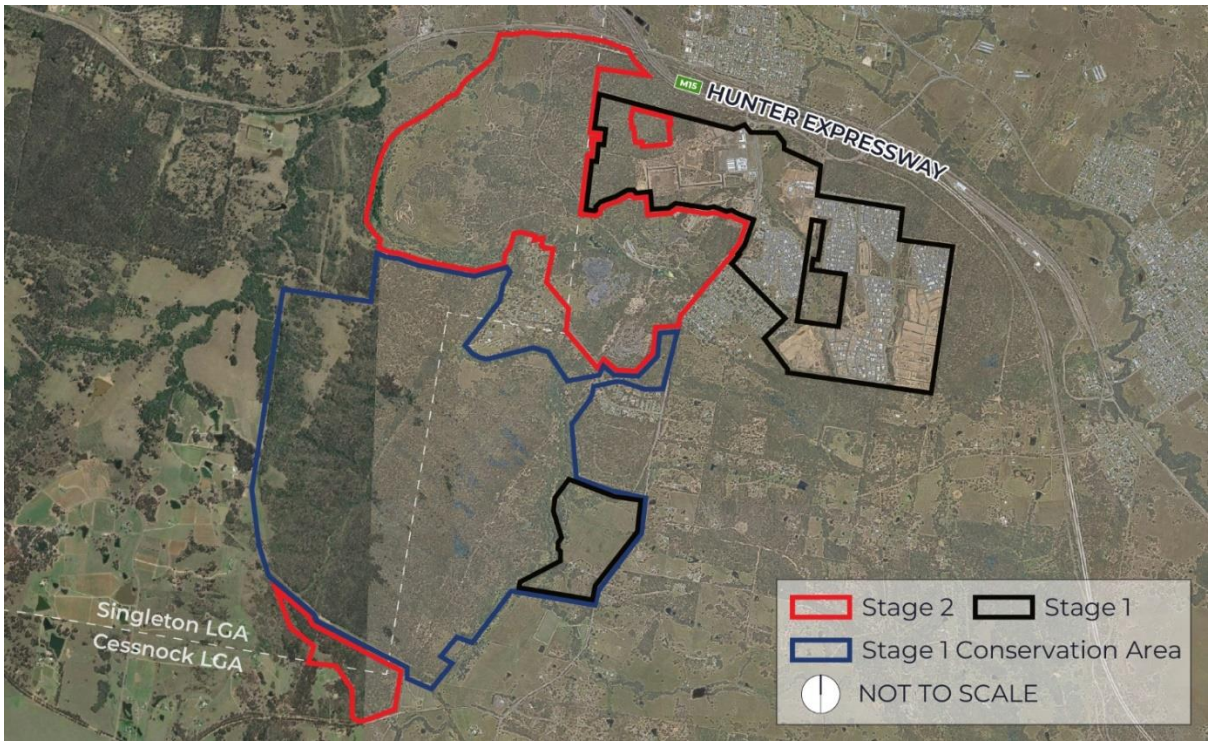
Source: Daly Smith

2.1 Subject Site

The subject site forms a large component of the 1,622 hectare Huntlee New Town, situated to the south of Branxton in the Hunter Valley. It is located approximately 20km north of Cessnock, 23 km south-east of Singleton, and 55 km north-west of Newcastle.

The subject Site comprises a number of allotments located in both Cessnock and Singleton Local Government Areas (LGAs). It has a combined area of approximately 541.71 ha, is irregular in shape and is generally extended to the west and south of the approved Huntlee Town Centre. The site is bound to the west by the Black Creek and floodplain. An aerial photo of the site is provided at **Figure 2**.

Figure 2 Site Aerial



Source: Nearmap and Ethos Urban

2.2 Working Hours

Works would be undertaken during the standard construction hours of:

- 7.00 am to 6.00 pm Monday to Friday
- 8.00 am to 1.00 pm on Saturdays
- No work on Sundays and Public Holidays

It is not expected that there would be any requirement for works during evening or night-time periods.

2.3 Plant and Equipment Noise Levels

A list of acoustically significant plant and equipment likely to be used during the stages of work have been assumed by SLR and approved by The Client. The sound power levels of the major noise generating plant and equipment are given in **Table 1**. Sound power levels

for equipment used in the assessment have been obtained from an SLR database of similar equipment.

Table 1 Acoustically Significant Equipment Sound Power Levels

Equipment	L_{Aeq} Sound Power Level (dBA)
Scraper	110
30T Excavator	110
40T Dump Truck	110
Dozer D10	112
Compactor	106
Grader	113
Pad foot roller	109
Water Cart	107
Asphalt Milling	106
Asphalt Paving	114
Smooth Drum Roller	107
33T Product Truck	108
Chainsaw	114
Mulcher	116
Front End Loader	112
10T Excavator + Rock breaker	118

2.4 Nearest Sensitive Receivers

The nearest most noise affected receivers surrounding the site (i.e those generally within 500 m of the site) and their noise catchment areas (NCAs) are described in **Table 2**. **Figure 3** and **Figure 4** shows the location of the project site and the nearest noise sensitive residential receiver areas (NCA).

Table 2 Nearest Sensitive Receivers

ID#	NCA	Address	Type	Minimum Distance from Site Boundary	Direction
Northern Area					
R1	1	2657 New England Hwy, Belford	Residential	382 m	N
R2	2	8 Station Street, Branxton	Residential	432 m	N
R3	2	Green Ridge Retirement Village	Residential	462 m	E

ID#	NCA	Address	Type	Minimum Distance from Site Boundary	Direction
R4	2	Receivers along Neves Lane, Huntlee	Residential	190 m	E
R5	2	Receivers along Harkin Road	Residential	220 m	E
R6	2	Receivers along Wine Country Drive	Residential	23 m	E
R7	3	105 Hanwood Road, North Rothbury	Residential	57 m	S
R8	3	111 Hanwood Road, North Rothbury	Residential	46 m	S
R9	3	119 Hanwood Road, North Rothbury	Residential	64 m	S
R10	3	123 Hanwood Road, North Rothbury	Residential	89 m	S
R11	3	134 Hanwood Road, North Rothbury	Residential	19 m	S
R12	3	138 Hanwood Road, North Rothbury	Residential	59 m	S
R13	3	158 Hanwood Road, North Rothbury	Residential	29 m	S
R14	3	160 Hanwood Road, North Rothbury	Residential	10 m	S
R15	3	180 Hanwood Road, North Rothbury	Residential	15 m	S
R16	3	200 Hanwood Road, North Rothbury	Residential	67 m	S
R17	3	202 Hanwood Road, North Rothbury	Residential	77 m	S
R18	3	201 Hanwood Road, North Rothbury	Residential	73 m	S
R19	3	203 Hanwood Road, North Rothbury	Residential	95 m	S
C1	-	6 Station Street, Branxton	Commercial	378 m	N
C2	-	1 Station Street, Branxton	Commercial	444 m	N
C3	-	Coles Huntlee	Commercial	445 m	E
C4	-	Huntlee Tavern	Commercial	404 m	E
E1	-	The Cottage Preschool & early Learning Centre	Educational	45 m	E
Southern Area					

ID#	NCA	Address	Type	Minimum Distance from Site Boundary	Direction
R20	4	803 Old North Road	Residential	22 m	E
R21	4	778 Old North Road	Residential	164 m	S
R22	4	728 Old North Road	Residential	166 m	S
R23	4	727 Old North Road	Residential	57 m	S
R24	4	687 Old North Road	Residential	457 m	SW
R25	4	117 Sweetwater Road	Residential	470 m	SW

The area surrounding the site can be generally categorised as follows:

- Densely populated residential receivers generally within 500 m to the north of the site in Branxton.
- Densely populated residential receivers generally within 500 m to the east of the site near the town centre of Huntlee and North Rothbury, including some isolated commercial and educational receivers.
- Sparse residential receivers to the south of the northern section of the site along Hanwood Road, generally within 100 m.
- Sparse residential receivers generally within 130 m to 260 m to the north-west, west, south-west and south of the site.
- More densely populated residential receivers generally within 200 m to 500 m to the south along Old North Road.

Due to the range in background noise levels measured in the area, SLR have used a noise catchment area (NCA) approach for grouping residential receivers.

3.0 Existing Environment

Unattended noise monitoring has been completed at four locations. Monitoring at locations NML01 and NML02 was undertaken from 11 August 2023 to 22 August 2023. Monitoring at locations NML03 and NML04 was undertaken from 14 September 2023 to 21 September 2023.

The measured noise levels have been used to determine the existing noise environment and to set the criteria used to assess the potential impacts from the project. The noise monitoring equipment continuously measured existing noise levels in 15-minute periods during the daytime, evening and night-time.

The noise monitoring locations are shown in **Figure 3** and **Figure 4** and the results are summarised in **Table 3**.

Table 3 Summary of Ambient Noise Levels

ID	Location	Measured Noise Levels (dBA)					
		Background Noise (RBL)			Average Noise (L_{Aeq})		
		Day[1]	Evening[1]	Night[1]	Day[1]	Evening[1]	Night[1]
NML01	343885 m E 6385170 m S	44	42	34	54	54	53
NML02	344568 m E 6384804 m S	53	44	34	61	58	58
NML03	202 Hanwood Road	34	34	25	50	44	48
NML04	727 Old North Road	29	40	22	53	50	46

Note 1: The assessment periods are the daytime which is 7 am to 6 pm Monday to Saturday and 8 am to 6 pm on Sundays and public holidays, the evening which is 6 pm to 10 pm, and the night-time which is 10 pm to 7 am on Monday to Saturday and 10 pm to 8 am on Sunday and public holidays. See the NSW EPA Noise Policy for Industry (NPfI).

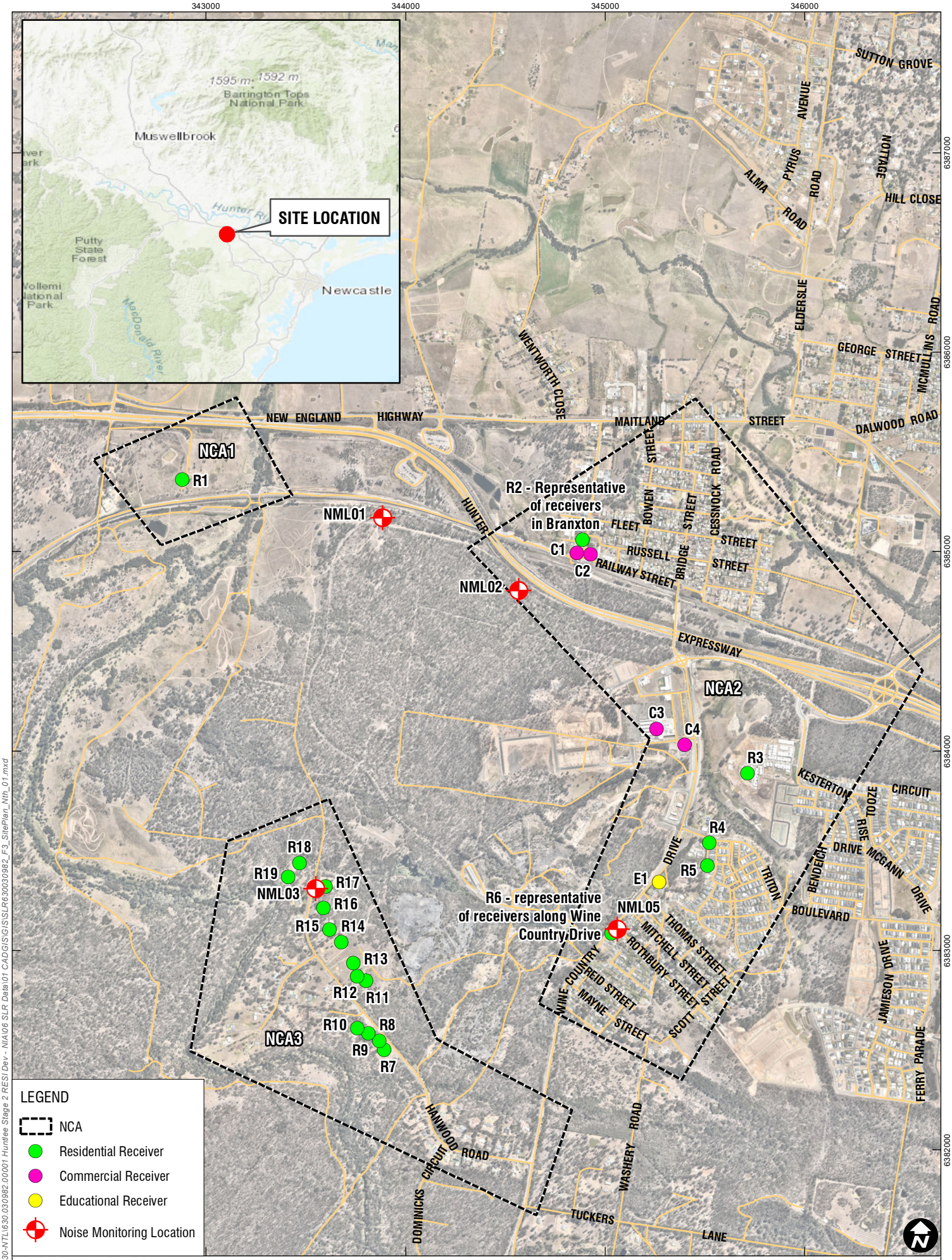
An operator attended noise measurement was also completed on 21 September 2023 during the daytime period at two noise logging locations (NML03 and NML04) and at an additional location on the corner of Rothbury Street and Wine Country drive in order to gain an understanding of the existing noise environment for receivers along Wine Country Drive in North Rothbury. Noise Monitoring locations are shown in **Figure 3** and **Figure 4**.

The attended noise measurements were performed using a Bruel & Kjaer 2250L sound level meter (Serial Number 3003389). Results from the operator attended noise survey are provided in **Table 4**.

Table 4 Operator Attended Noise Survey

Location	Date/Start Time	L_{Amax}	L_{A1}	L_{A10}	L_{A90}	L_{Aeq}	Description of Noise Emissions and Typical Maximum Noise Levels (dBA)
NML03	21/09/2023 15:47	60	51	48	41	45	Road traffic 40-60 Birdsong 44-56 Dogs barking 44-48 Aircraft 45-53 Wind in trees 40-52
NML04	21/09/2023 16:16	69	56	50	44	49	Road traffic 49-69 Birdsong 46-58 Aircraft 48-53 Wind in trees 46-53
NML05 - Cnr Rothbury St and Wine Country Drive	21/09/2023 17:00	86	78	74	51	69	Road traffic 46-86 Birdsong 45-46 Aircraft 50-52 Wind in trees 40-45

Local road traffic was observed to dominate the ambient noise levels at all locations.



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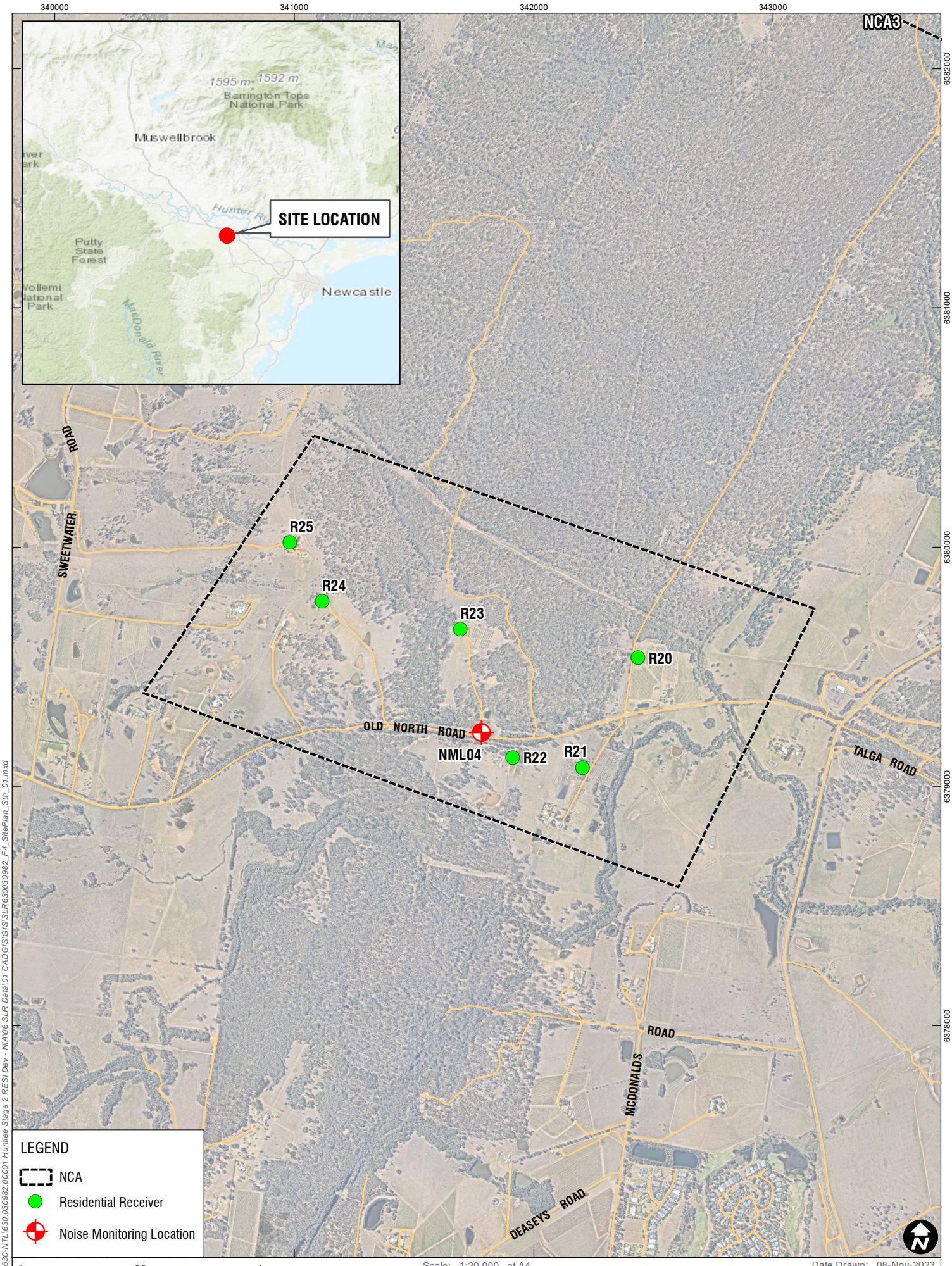
LOCALITY, RECEIVERS AND NOISE MONITORING LOCATIONS - NORTHERN

FIGURE 3



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LOCALITY, RECEIVERS AND NOISE MONITORING LOCATIONS - SOUTHERN

FIGURE 4

4.0 Assessment Criteria

4.1 Construction Noise and Vibration Guidelines

The standards and guidelines relevant to the development are listed in **Table 5**. These guidelines aim to protect the community and environment from excessive noise and vibration impacts during construction of projects.

Table 5 Construction Noise and Vibration Standards and Guidelines

Guideline/Policy Name	Where Guideline Used
Interim Construction Noise Guideline (ICNG) (DECC, 2009)	Assessment of airborne noise impacts on sensitive receivers
Construction Noise and Vibration Guideline (CNVG) (Roads and Maritime Services, 2016)	Assessment and management protocols for noise and vibration impacts
BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2, BSI, 1993	Assessment of vibration impacts (structural damage) to non-heritage sensitive structures
DIN 4150:Part 3-2016 Structural vibration – Effects of vibration on structures, Deutsches Institute fur Normung, 1999	Screening assessment of vibration impacts (structural damage) to heritage sensitive structures, where the structure is found to be unsound following an inspection by a structural engineer or other suitably qualified person.
Assessing Vibration: a technical guideline (DEC, 2006)	Assessment of vibration impacts on sensitive receivers

4.2 Interim Construction Noise Guideline

The NSW Interim Construction Noise Guideline (ICNG) is used to assess and manage impacts from construction noise on residences and other sensitive land uses in NSW.

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

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

Residential Receivers

The ICNG approach for determining NMLs at residential receivers is shown in **Table 6**.

Table 6 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	Noise affected RBL[1] + 10 dB	• The noise affected level represents the point above which there may be some community reaction to noise • Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level

Time of Day	NML $L_{Aeq(15minute)}$	How to Apply
Saturday 8:00 am to 1:00 pm No work on Sundays or public holidays		• The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details
	Highly Noise Affected 75 dBA	• The Highly Noise Affected (HNA) level represents the point above which there may be strong community reaction to noise • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restructuring the hours that the very noisy activities can occur, taking into account: ○ Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools or mid-morning or mid-afternoon for works near residences ○ If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times
Outside Standard Construction Hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours • The proponent should apply all feasible and reasonable work practices to meet the noise affected level • Where all feasible and reasonable practises 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).

'Other Sensitive' Land Uses and Commercial Receivers

The ICNG NMLs for 'other sensitive' non-residential land uses are shown in **Table 7**.

Table 7 NMLs for 'Other Sensitive' Receivers

Land Use	Noise Management Level $L_{Aeq(15minute)}$ (dBA) (Applied when the property is in use)	
	Internal	External
Classrooms at schools and other educational institutions	45	55[1]
Commercial	-	70

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

Sleep Disturbance

Works will be undertaken during standard daytime construction hours. For works required during out of hours periods, and approved by the Planning Secretary, the sleep disturbance screening level of night-time RBL plus 15 dB will be applied. No such works are considered in this assessment.

4.2.1 NML Summary

The NMLs for the project have been determined in accordance with the requirements of the ICNG and are shown in **Table 8**. The residential NMLs have been determined based on the minimum assumed RBLs of the NPfI, as discussed in **Section 3.0**.

Table 8 Project Specific Noise Management Levels (dBA)

Receiver Type	NCA	RBL	NML ($L_{Aeq(15minute)}$ – dBA)	
			Daytime Standard Construction Hours (RBL+10dB)	Highly Noise Affected (dBA)[1]
Residential	NCA01 (NML01)	44	54	75
	NCA02 (NML02)	53	63	75
	NCA3 (NML03)	35[2]	45	75
	NCA04 (NML04)	35[2]	45	75
Educational	-	-	55	-
Commercial	-	-	70	-

Note 1: The 'Highly Noise Affected' threshold only applies to residential receivers.

Note 2: Minimum RBL adopted as per NSW Nosie Policy for Industry assessment procedures

4.3 Construction Vibration Criteria

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).

4.3.1 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 9**.

Table 9 Vibration Dose Values for Intermittent Vibration

Building Type	Assessment Period	Vibration Dose Value[1] ($m/s^{1.75}$)	
		Preferred	Maximum
Critical Working Areas (eg operating theatres or laboratories)	Day or night-time	0.10	0.20

Building Type	Assessment Period	Vibration Dose Value[1] ($m/s^{1.75}$)	
		Preferred	Maximum
Residential	Daytime	0.20	0.40
	Night-time	0.13	0.26
Offices, schools, educational institutions and places of worship[2]	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.

Note 2: BAPS Temple will not be operational during the construction period applicable to the Stage 1 CNVMP.

4.3.2 Effects of 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, are located in buildings near to construction works. No such items of equipment have been identified in the project area.

4.3.3 Structural and Cosmetic Damage Vibration

4.3.3.1 British Standard 7385: Part 2 - 1993

In terms of the most recent relevant vibration damage criteria, Australian Standard AS 2187: Part 2-2006 "*Explosives - Storage and Use - Part 2: Use of Explosives*" recommends the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 "*Evaluation and measurement for vibration in buildings Part 2*" as they "are applicable to Australian conditions".

The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the Standard include demolition, piling, ground treatments (e.g. compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in **Table 10** and graphically in **Figure 5**.

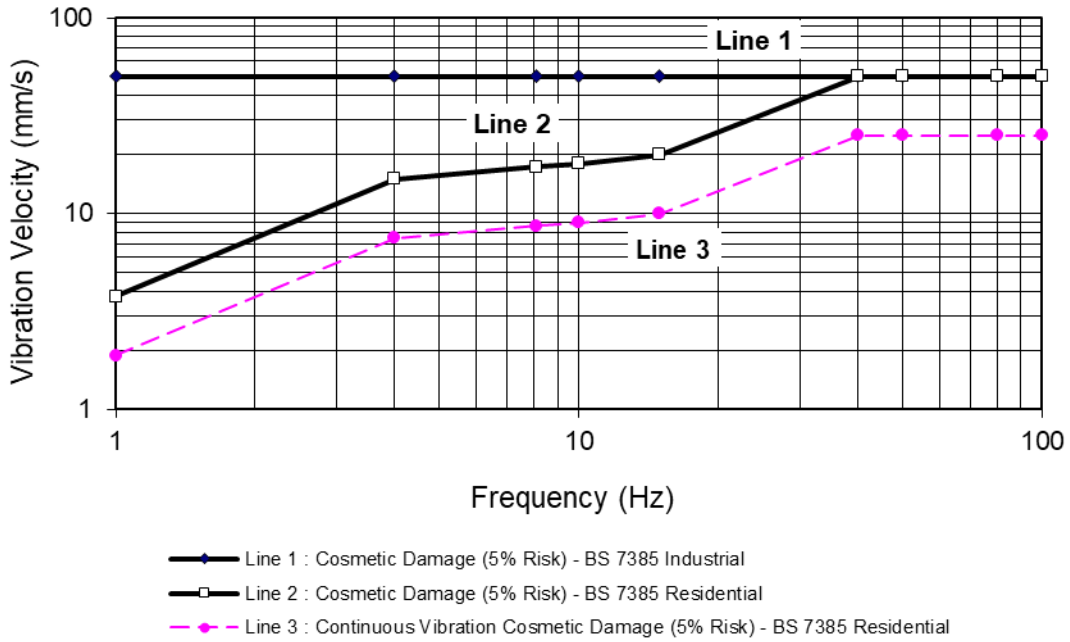
Table 10 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and Above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

The standard states that the guide values in **Table 10** relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in **Table 10** may need to be reduced by up to 50%.

Figure 5 Graph of Transient Vibration Guide Values for Cosmetic Damage



In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in **Table 10**, and major damage to a building structure may occur at values greater than four (4) times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in

respect of the fatigue life of building materials) then the guide values in **Table 10** should not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS 2187 specifies that vibration measured should be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) should be compared with the criteria curves presented in **Table 10**.

It is noteworthy that extra to the guide values nominated in **Table 10**, the standard states that:

> *"Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK."*

Also that:

> *"A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive."*

4.3.3.2 German Standard DIN 4150: Part 3-2016

For continuous long-term vibration or repetitive vibration with the potential to cause fatigue effects, DIN 4150 provides the following Peak Particle Velocity (PPV) values as safe limits, below which even superficial cosmetic damage is not to be expected:

- 2.5 mm/s for buildings of great intrinsic value (e.g. heritage listed buildings).

4.3.3.3 General Vibration Screening Criteria

The Transport for NSW Construction Noise and Vibration Strategy (CNVS) specifies general vibration screening criteria based on BS 7385: Part 2 – 1993. It notes that for most construction activities involving intermittent vibration such as rock breakers, piling rigs, vibratory rollers, excavators and the like, vibration predominantly occurs at frequencies greater than 4 Hz and therefore specifies the following conservative vibration damage screening levels:

- Reinforced or heavy frame structures: 25 mm/s
- Unreinforced or light frame structures: 7.5 mm/s

At locations where the predicted and/or measured vibration levels are greater than shown above, a more detailed analysis of the building structure, vibration source, dominant frequency and dynamic characteristics of the structure would be required to determine the applicable safe vibration levels.

4.3.3.4 Heritage

Heritage structures are also assessed against the above screening criteria as they should not be assumed to be more sensitive to vibration unless they are found to be structurally unsound following an inspection; in this case a 2.5 mm/s criterion would be considered in accordance with DIN 4150.

4.3.4 Minimum Working Distances for Vibration Intensive Works

Minimum working distances for typical vibration intensive construction equipment are provided in the Roads and Maritime Construction Noise and Vibration Guideline (CNVG) and are shown in **Table 11**. The minimum working distances are for both cosmetic damage (from BS 7385 and DIN 4150) and human comfort (from the NSW EPA Vibration Guideline).

They are based on empirical data which suggests that where works are further from receivers than the quoted minimum distances then impacts are not considered likely.

The minimum working distances for human comfort relate to continuous vibration. For most construction activities, vibration emissions are intermittent and for this reason, higher vibration levels occurring over shorter periods are allowed.

Table 11 Recommended Minimum Working Distances from Vibration Intensive Equipment

Plant Item	Rating/Description	Minimum Distance		
		Cosmetic Damage		Human Response (NSW EPA Guideline)
		Residential and Light Commercial (BS 7385)	Heritage Items (DIN 4150, Group 3)	
Vibratory Roller	<50 kN (1–2 tonne)	5 m	11 m	15 m to 20 m
	<100 kN (2–4 tonne)	6 m	13 m	20 m
	<200 kN (4–6 tonne)	12 m	15 m	40 m
	<300 kN (7–13 tonne)	15 m	31 m	100 m
	>300 kN (13–18 tonne)	20 m	40 m	100 m
	>300 kN (>18 tonne)	25 m	50 m	100 m
Small Hydraulic Hammer	300 kg (5 to 12 t excavator)	2 m	5 m	7 m
Medium Hydraulic Hammer	900 kg (12 to 18 t excavator)	7 m	15 m	23 m
Large Hydraulic Hammer	1,600 kg (18 to 34 t excavator)	22 m	44 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	5 m to 40 m	20 m
Piling Rig – Bored	≤ 800 mm	2 m (nominal)	5 m	4 m
Jackhammer	Hand held	1 m (nominal)	3 m	2 m

5.0 Construction Noise Assessment

5.1 Hours of Construction

Construction activities will be undertaken during the following hours:

- 7:00 am to 6:00 pm, Mondays to Fridays
- 8:00 am to 1:00 pm on Saturdays
- At no time on Sundays or Public Holidays

5.2 Construction Activities

Construction scenarios and corresponding items of plant have been provided by The Client.

The representative construction activities and associated items of plant that will be used during the works are detailed in **Table 12**.

Table 12 Construction Scenario Descriptions

Equipment	Scrapers	30T Excavator	40T Dump Truck	Dozer D10	Compactor	Grader	Pad Foot Roller	Water Cart	Asphalt Milling[1]	Asphalt Paving	Smooth Drum Roller	33T Product Truck	Chainsaw[1]	Mulcher[1]	Front End Loader	Rockbreaker[1]	Total LAeq Sound Power Level
L_{Aeq} Sound Power Level (dBA)	110	110	110	112	106	113	109	107	106	114	107	108	114	116	112	118	
Northern Area																	
Land Clearing and Bulk Earthworks	4	4	6	6	4	4	4					6	4	4	4	3	130
Infrastructure Works – Upgrade of Access Roads		8			4	4		4	4	4	4	4				8	129
Southern Area																	
Land Clearing and Bulk Earthworks	1	1	1	1	1	1	1					1	1	1	1	1	124
Infrastructure Works – Upgrade of Access Roads		2			1	1		1	1	1	1	1				2	123

Note 1: Equipment classed as 'annoying' in the ICNG and requires a 5 dB correction.

Note 2: Sound power level data is taken from the DEFRA Noise Database, RMS Construction and Vibration Guideline and TfNSW Construction Noise and Vibration Strategy.

Prior to commencement of the construction stages included in **Table 12**, the methodology and equipment will be reviewed and confirmation provided that the assumptions in the CNVMP remain valid. Where different methodology or equipment is proposed, further validation of the predicted noise levels will be undertaken to ensure that the proposed mitigation measures are anticipated to be sufficient.

Where feasible, validation of noise levels during high noise works must be measured in advance of commencement of the works, i.e. test measurements of the equipment undertaking the works for a short period prior full commencement of the works.

5.3 Construction Noise Predictions

Noise impacts for the construction scenarios presented in **Table 12** have been predicted at the nearby most affected receivers shown in **Figure 3** and **Figure 4**. The results are representative of the worst-case noise levels that are likely to occur during construction, and are split into two zones:

- Works that will occur in the northern part of the development.
- Works that will occur in the southern part of the development along Old North Road.

The assessment shows the predicted impacts based on the exceedance of the management levels, as per the categories in **Table 13**.

Table 13 Exceedance Bands and Impact Colouring

Exceedance of NML	Subjective Classification	Impact Colouring
No exceedance	Negligible	
1 to 10 dB	Low impact	
11 dB to 20 dB	Moderate impact	
21 dB to 30 dB	High impact	
Highly Noise Affected[1]	Extreme Impact	

Note 1: Greater than 75 dBA at residential receivers.

The predicted airborne noise impacts from construction works are summarised in **Table 14**. The predictions are representative of the highest noise levels that would likely be experienced at the surrounding receivers when the works are at the closest point of the work zone under consideration. For most construction activities, it is expected that the construction noise levels would frequently be lower than those predicted, as the noise levels presented are based on each scenario occurring at the nearest point of the site to the receiver.

Table 14 Construction Noise Predictions at Sensitive Receivers

Receiver	NML (dBA)	Predicted $L_{Aeq(15minute)}$ Construction Noise Impact (dBA)	
		Bulk Earthworks	Infrastructure works
Northern Area			
R1	52	58	57
R2	63	56	55
R3	63	55	53
R4	63	62	60
R5	63	61	60
R6	63	80	79
R7	45	77	76
R8	45	76	74
R9	45	75	73
R10	45	70	69
R11	45	79	77
R12	45	74	73
R13	45	76	75
R14	45	80	79
R15	45	76	75
R16	45	74	72
R17	45	74	73
R18	45	77	76
R19	45	70	68
C1	70	56	56

Receiver	NML (dBA)	Predicted $L_{Aeq(15minute)}$ Construction Noise Impact (dBA)	
		Bulk Earthworks	Infrastructure works
C2	70	55	54
C3	70	56	54
C4	70	56	55
E1	55	70	69
Southern Area			
R20	45	77	77
R21	45	68	67
R22	45	70	69
R23	45	70	70
R24	45	58	57
R25	45	54	54

The results represent the worst-case noise levels where all equipment in each scenario is working concurrently. For most construction activities, it is expected that the construction noise levels would frequently be lower than predicted, particularly where the works are more distant from particular receivers.

The assessment of construction noise levels presented above identifies the following:

- Worst-case noise levels of 80 dBA are predicted at receiver R6 and R14 for the northern area during the Bulk Earthworks scenario. Worst case noise levels at R6 and R14 are considered “extreme impact” in accordance with the subjective classification in **Table 13**.
- Worst-case noise levels of 77 dBA are predicted at receiver R20 for the southern section during the bulk earthworks scenarios. Worst case noise levels at R20 are considered “extreme impact” in accordance with the subjective classification in **Table 13**.
- Individual receivers would be subject to a large range of worst-case impacts, depending on how far from the works they are.

A number of identified noise sensitive receivers within the NCAs are predicted to experience high noise levels due to specific equipment being utilised throughout the construction period. The principal cause of the exceedances are rockbreaking activities. As such, these noise levels will be realised only when rockbreaking is occurring in close proximity to nearest receivers. For majority of the time, noise levels would be much less than predicted.

As the construction noise impacts exceed the NMLs at the nearest sensitive receivers, all feasible and reasonable noise mitigation measures will be required to be applied to the construction work. Construction noise mitigation measures are discussed in **Section 5.4**.

5.4 Standard Mitigation Measures

Due to the nature of construction activities and the proximity of the works to the sensitive receivers, it is inevitable that noise impacts will be apparent at certain times during the works.

Consequently, the project should apply all feasible and reasonable work practices to meet the NMLs, where possible, and inform all potentially impacted sensitive receivers of the nature of works to be carried out, the expected noise levels, duration of noise generating construction works, and contact details during construction.

The recommended construction migitaion measures are shown in **Table 15**.

Table 15 Recommended Noise Mitigation Measures

Project Stage	Measure
Project Planning	Where possible, consider the application of alternative, low-impact construction techniques to rock breaking.
	Power tools using mains power rather than by using generators.
	Use the minimum sized equipment necessary to complete the work, this is particularly relevant to compacting and hydraulic hammering / rock breaking.
Scheduling	Carry out community consultation and provide advanced warning of potential disruptions to sensitive receivers.
	Deliveries are to occur during Standard Construction Hours only.
Site Layout	Site entry and exit points will be located as far as possible from sensitive receivers, taking into account the importance of safe access.
	Compounds, refuelling areas and work areas will be designed to promote one-way traffic so that vehicle reversing movements are minimised.
	Work compounds, parking areas, equipment and material stockpile sites will be positioned away from noise-sensitive locations
	Trucks will be carefully scheduled and not queue up outside residential properties.
Training	Training will be provided to all project personnel, including relevant sub-contractors on noise requirements through inductions, toolboxes and targeted awareness training.
	All relevant staff and sub contractors will be informed of areas and work practises where potential noise impacts have been identified.
	Horn signals between drivers are not permitted.
Contractor management	Delivery vehicles should be fitted with straps rather than chains for unloading, wherever possible.
	Truck drivers should avoid compression braking as far as practicable and should use main roads where feasible.
Noise source mitigation and controlling the transmission of noise	Switch off generators/items of plant when not in use.
	Avoid dropping materials from a height.
	Shut down or throttle down machinery when not in operation.
	Avoid simultaneous operation of noisy plant within discernible range of a sensitive receiver

Project Stage	Measure
	Ensure equipment is operated in the correct manner including replacement of engine covers, repair of defective silencing equipment, tightening of rattling components, repair of leakages in compressed air lines and shutting down equipment not in use.
	Siting noisy equipment behind structures that act as barriers, or at the greatest distance from the noise-sensitive area; or orienting the equipment so that noise emissions are directed away from any sensitive areas, to achieve the maximum attenuation of noise
	Plant will be fitted with noise control devices, where practicable, including acoustic lining of engine bays and air intake / discharge silencers
	Ensure that all doors/hatches are shut during operation of plant and equipment.
	Check hatches/enclosures regularly to ensure that seals are in good working order and doors close properly against seals.
	Use residential-grade mufflers on plant.
	Use dampened bits on impulsive tools such as jackhammers to avoid 'ringing' noise.
	An acoustic shroud (skirt) can be installed on hydraulic rockbreakers and concrete saws.
	Ensure truck movements are kept to a minimum, ie that trucks are fully loaded on each trip.
	Mobile plant and trucks operating on site for a significant portion of the project will have reversing alarm noise emissions minimised, where possible, recognising the need to maintain occupational safety standards. This may potentially be achieved through restrictions on reversing activities or installation of non-tonal reversing alarms on mobile plant and equipment.
	Stationary noise sources should be enclosed or shielded where feasible and reasonable whilst ensuring that the occupational health and safety of workers is maintained. Appendix D of AS 2436:2010 lists materials suitable for shielding.
Community Consultation	Provide at least five and not more than 14 days' notice to affected receivers prior to starting works.
	Provide signage detailing who is undertaking the works and a contact number.
	Where there are complaints about noise from an identified work activity, review and implement, where feasible and reasonable, additional control measures.
Monitoring	Conduct noise monitoring in response to any complaints received to verify that levels do not substantially exceed predicted levels.
	Initial noise monitoring of plant and equipment will be undertaken to ensure the noise levels are being met.

5.5 Additional Mitigation Measures

Where the 'mitigated' construction noise levels remain above the noise management levels (NMLs), the Additional Mitigation Measures Matrix (AMMM) identified in the CNVG is to be implemented. The approach, guided by the AMMM, is primarily aimed at pro-active

engagement with affected sensitive receptors rather than additional noise reducing mitigation. The AMMM applies to all receptor types where these receptors are in-use.

The types of additional mitigation measures are listed in **Table 16** and described in the CNVG; those relevant to this project are reproduced in **Table 17** and the AMMM for construction noise are identified in **Table 18**.

Table 16 Additional Noise Mitigation Measures

Mitigation / Management Measure	Abbreviation
Alternative Accommodation	AA
Respite Period 1	R1
Respite Period 2	R2
Duration Respite	DR
Notification (letterbox drop or equivalent)	**N**
Respite offers	RO
Specific notifications	**SN**
Phone calls	PC
Individual briefings	IB
Verification	**V**

Note 1: Mitigation / Management Measures relevant to this assessment are shown in bold and described in **Table 17**.

Table 17 Relevant Additional Noise Mitigation Measures to this Assessment

Mitigation / Management Measure	Abbreviation	Description
Notification (letterbox drop or equivalent)	N	Advanced warning of works and potential disruptions can assist in reducing the impact on the community. The notification may consist of a letterbox drop (or equivalent) detailing work activities, time periods over which these will occur, impacts and mitigation measures. Notification should be a minimum of 5 working days prior to the start of works. The approval conditions for projects may also specify requirements for notification to the community about works that may impact on them.
Verification	V	Noise monitoring in accordance with the procedures detailed in **Section 5.6** and reporting in accordance with the procedures detailed in **Section 7.0**.
Specific Notification	SN	A personalised letter or phone call to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. Alternatively (or in addition to), communications representatives from the contractor would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities and provide an individual briefing. Specific notifications are used to support periodic notifications, or to advertise unscheduled works and must be approved by TfNSW prior to implementation/distribution.

Table 18 Additional Mitigation Measures Matrix - Construction Noise

Construction Hours	Receiver Perception	dB(A) above RBL	dB(A) above ANML	Additional Management Measures[1]
Standard Hours Monday to Friday (7am to 6pm) Saturday (8am to 1pm)	Noticeable	5 to 10	0	-
	Clearly Audible	> 10 to 20	< 10	-
	Moderately Intrusive	> 20 to 30	> 10 to 20	PN, V
	Highly Intrusive	> 30	> 20	PN, V
	75dBA or greater[2]	N/A	N/A	PN, V, SN

Note 1: PN = Project notification, V = Verification monitoring, SN = Specific notification.

Note 2: Applicable to residential receivers only.

What this means in practice is:

- The Notification (N) mitigation measure should be applied to all receivers that have noise impacts greater than 10 dB above the NML during the daytime.
- The Verification (V) mitigation measure should be applied for each of the activities. Measurements of the sound power level of each item shown in **Table 12** should be undertaken upon commencement of the use of that item of equipment. Monitoring should also be undertaken at the nearest sensitive receiver to the works upon the commencement of new activities and the measured levels compared with the predicted impacts in **Table 14**.
- The Specific Notification (SN) mitigation measure should be applied to all receivers that have noise impacts greater than 75 dB during the daytime.

5.6 Construction Noise Monitoring

Where feasible, validation of noise levels during high noise works must be measured in advance of commencement of the works, ie test measurements of the equipment undertaking the works for a short period prior full commencement of the works.

Attended noise monitoring will also be undertaken in response to any formal complaints. All monitoring will be completed by suitably qualified acoustic specialists. The location and extent of attended monitoring will be determined in consultation with project staff and would be dependent on the activities taking place. A noise monitoring report will be prepared after each attended monitoring survey.

It is also recommended that periodic attended noise measurements be conducted by a competent project team member at representative receiver or site boundary locations to monitor noise levels. This should be done on a monthly basis, and more frequently when significant new plant and equipment arrive on site.

The routine monitoring will take place during the expected noisiest construction periods and be representative / indicative of the impacts at the potentially affected sensitive receivers. A monthly monitoring report will be prepared summarising the measurement results and any relevant site activity observations.

All items of acoustic instrumentation utilised will be designed to comply with IEC 61672.1-2013 *Electroacoustics – Sound level meters* (AS IEC 61672) and carry current calibration certificates.

6.0 Construction Vibration Assessment

The major potential sources of vibration from the proposed construction activities would include rockbreaking during the bulk earthworks and infrastructure works stages. **Table 2** shows that the distance between the construction works and the nearest sensitive receivers is sufficient for receiver buildings to be outside of the cosmetic damage and human comfort minimum working distances for vibration intensive equipment as shown in **Table 11** for rockbreaking.

Were works are required within the safe working distances, vibration monitoring should be undertaken to confirm that the level of vibration is within acceptable tolerances. It is recommended that building condition surveys be completed before and after the works to ensure no cosmetic damage has occurred.

6.1 Construction Vibration Monitoring

Where vibration intensive works (such as rockbreaking) are required within the minimum working distances of sensitive receivers or structures (refer to **Section 4.3.4**), vibration will be monitored continuously for the duration of works within the minimum working distances.

Attended vibration measurements will be undertaken at the start of vibration intensive works within the minimum working distances to confirm the levels of vibration are below the applicable vibration limits (refer to **Section 4.3**).

Geophones will be installed by an acoustic consultant at the closest points of the sensitive structure to the vibration intensive works to continuously monitor vibration for the duration of the works. Should the works location change, the geophones will be relocated to remain at the closest point of the structure to the works.

The vibration monitoring equipment will have visible and audible alarms installed where operators of equipment can see/hear them:

- A warning vibration level of two-thirds (66%) of the applicable vibration limit will trigger a ‘warning’ alarm if exceeded.
- A ‘halt work’ alarm will trigger if vibration is measured equal to the applicable vibration limit.

Vibration monitoring data will be downloaded and reported at the following timeframes:

- Monthly during works (at a minimum)
- Within one week of an exceedance of the vibration limit alarm level
- Upon completion of vibration monitoring.

All items of vibration instrumentation will be designed to comply with applicable guidelines and carry current calibration certificates.

7.0 Monitoring Reports

Noise and/or vibration monitoring reports will be provided to the Environmental Representative (ER) and distributed in accordance with the requirements of the Consent Conditions. Monitoring reports would include the following details, at a minimum:

- Noise/vibration monitoring/measurement locations
- Date, time and length of noise monitoring/measurements
- Weather conditions during the measurements

- Name and position of personnel undertaking measurements
- Construction activities being undertaken during measurements
- Locations of construction equipment and distance from monitoring location
- Measured L_{Aeq} and LAmax noise levels during construction works (for each activity) along with a comparison to the predicted noise levels (noise monitoring only)
- Measured L_{A90} background noise level in absence of the construction works (noise monitoring only)
- Measured vibration levels during construction works (for each activity) along with a comparison to the relevant vibration criteria (vibration monitoring only)
- Measured vibration levels and relevant details of any of exceedance of the warning vibration level or vibration limits (vibration monitoring only)
- Measured background vibration level in absence of the construction works (vibration monitoring only)

Operator observations noting any extraneous noise/vibration sources or other points of relevance.

8.0 Complaint Handling

The construction contractor will adopt the following protocol for handling complaints. This protocol is intended to ensure that the issues are addressed and that appropriate corrective action is identified and implemented as necessary:

- The construction contractor will record all verbal and telephone complaints in writing and will forward all complaints to the Project Manager, together with details of the circumstance leading to the complaint and all subsequent actions.
- Complaints received by the Project Manager will, as an initial step, be referred to the construction contractor. The construction contractor will respond as described above.
- The Project Manager will investigate the complaint in order to determine whether a criterion exceedance has occurred or whether noise has occurred unnecessarily.
- If excessive or unnecessary noise/vibration have been caused, corrective action will be planned and implemented by the construction contractor.
- Complainants will be informed by the Project Manager that their complaints are being addressed, and (if appropriate) that corrective action is being taken.
- Follow up monitoring or other investigations will be carried out by the Project Manager and the construction contractor to confirm the effectiveness of the corrective action.
- Complainants will be informed of the implementation of the corrective action that has been taken to mitigate the adverse effects.

9.0 Community Consultation and Liaison

Community consultation will, if required, be undertaken via the construction contractor, including:

- Advising the community of work to be undertaken.

- Recording and managing any complaints.

These and other elements of the community consultation will be addressed under the relevant procedures for the subject works.

Appendix A Acoustic Terminology

Construction Noise and Vibration Impact Assessment

Huntlee Stage 2

Huntlee Pty Ltd

SLR Project No.: 630.030982.00002

6 December 2023

1. Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that 'noise' often refers to unwanted sound.

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

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

2. 'A' Weighted Sound Pressure Level

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

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

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

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

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

3. Sound Power Level

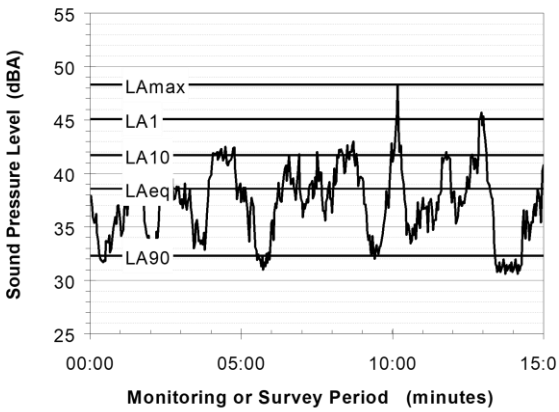
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 10^{-12} W.

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

4. Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, LA10 the noise exceeded for 10% of the time, and so on.

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



Of particular relevance, are:

LA1 The noise level exceeded for 1% of the 15 minute interval.

LA10 The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

LA90 The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

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

5. Frequency Analysis

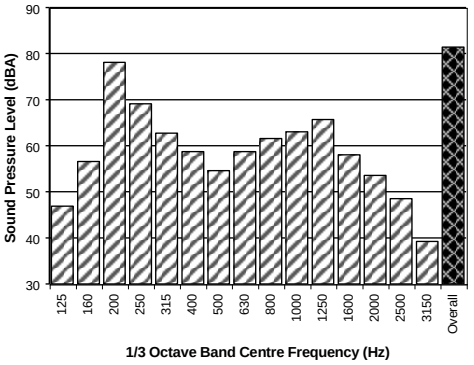
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal.

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

Frequency analysis can be in:

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

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



6. Annoying Noise (Special Audible Characteristics)

A louder noise will generally be more annoying to nearby receivers than a quieter one. However, noise is often also found to be more annoying and result in larger impacts where the following characteristics are apparent:

- **Tonality** - tonal noise contains one or more prominent tones (ie differences in distinct frequency components between adjoining octave or 1/3 octave bands), and is normally regarded as more annoying than 'broad band' noise.
- **Impulsiveness** - an impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.
- **Intermittency** - intermittent noise varies in level with the change in level being clearly audible. An example would include mechanical plant cycling on and off.
- **Low Frequency Noise** - low frequency noise contains significant energy in the lower frequency bands, which are typically taken to be in the 10 to 160 Hz region.

7. Vibration

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

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

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements (ie vertical, longitudinal and transverse).

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

8. Human Perception of Vibration

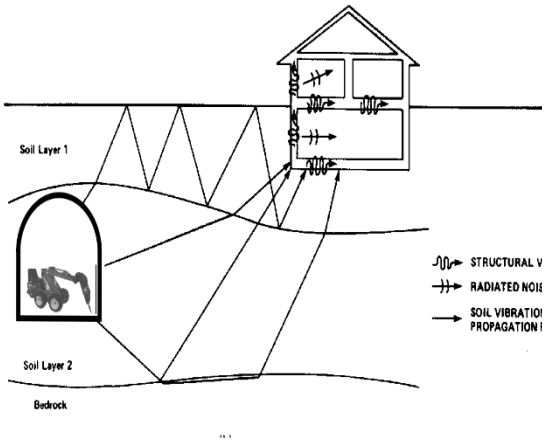
People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience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

9. Ground-borne Noise, Structure-borne Noise and Regenerated Noise

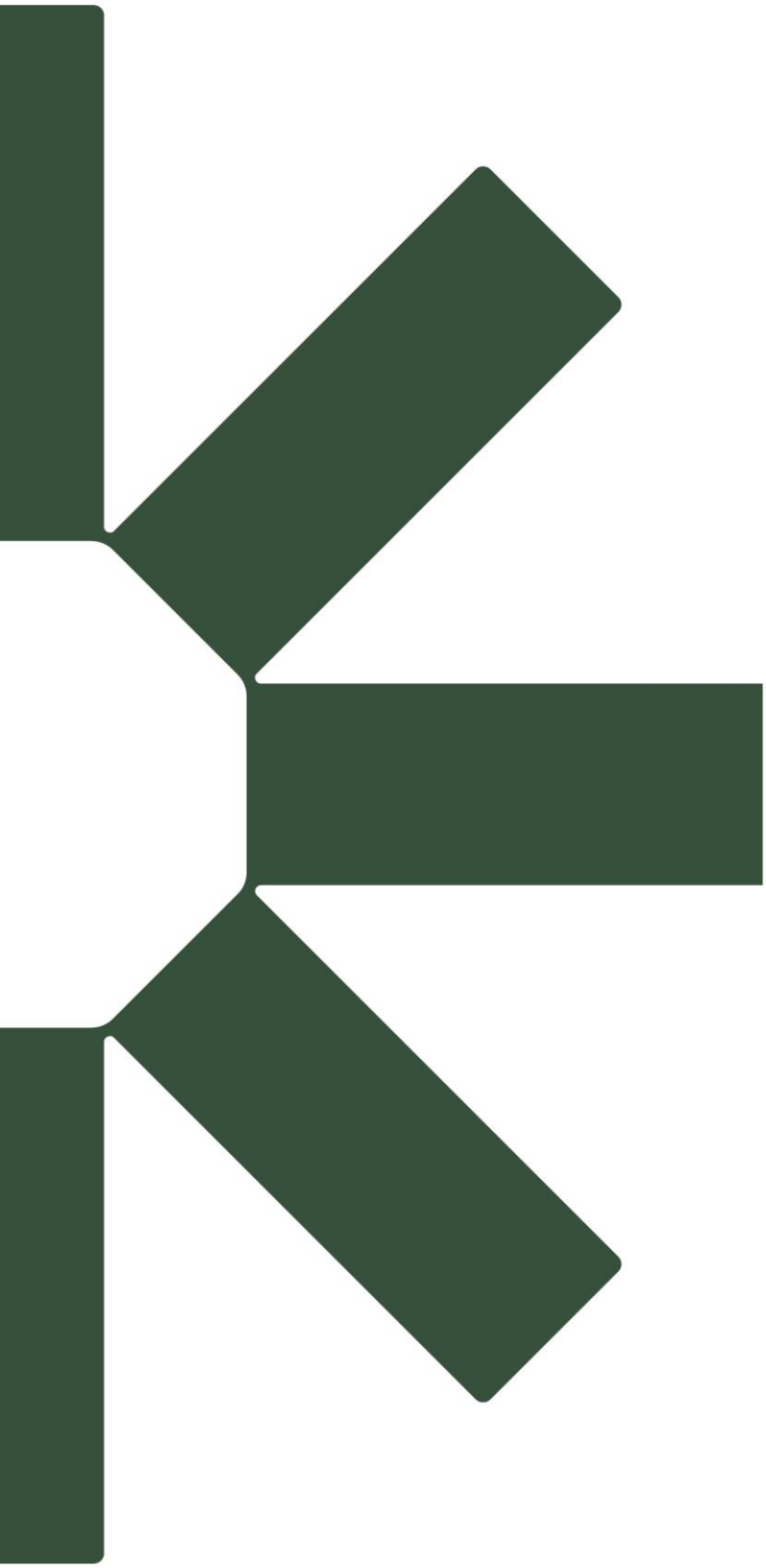
Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents an example of the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise.



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