42-52 RAYMOND AVENUE, MATRAVILLE

Construction Noise and Vibration Management Plan

Prepared for:

Vaughan Constructions Pty Ltd
9a Commercial Road
Kingsgrove, NSW 2208

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Vaughan Constructions 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.

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
610.31125.00000-R01-v1.0	19 December 2022	Jonathan Caine	Martin Davenport	Aaron Miller

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1 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Vaughan Constructions Ptd Ltd to prepare a Construction Noise and Vibration Management Plan (CNVMP) for construction works associated with the development at 42 Raymond Avenue, Matraville, NSW, to satisfy the Condition B24 of Development Consent SSD-31552370. It is anticipated that this CNVMP will be incorporated into an overarching Construction Environmental Management Plan (CEMP).

This CNVMP addresses the potential noise and vibration impacts associated with the construction, which involves:

- Construction, fit out and operation of a two-storey warehouse and distribution centre comprising approximately 19,460 m^2 GFA including:
  - 17,789 m^2 of warehouse and distribution GFA; and
  - 1,671 m^2 GFA ancillary office space.
- Provision of 11 bicycle parking spaces and 101 car parking spaces at ground.
- Approximately 2,250 m^2 of hard and soft landscaping at ground.
- Provision of one additional access crossover from Raymond Avenue.
- Provision of internal vehicle access route and loading docks.
- Upgrades to existing on-site infrastructure.
- Building identification signage.

SLR has prepared this CNVMP in accordance with the conditions of consent, the SEARs requirements and industry best-practice.

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

SLR is suitably qualified to produce this CNVMP and SLR staff are members of the Australian Acoustical Society (AAS). SLR is also a member firm of the Association of Australasian Acoustical Consultants (AAAC).

2 Development Overview

2.1 Site Description

42-52 Raymond Avenue, Matraville (the project) is legally described as Lot 1 in DP 369888, Lot 32 Section B DP 8313 and Lot 1 DP 511092, which is located on the south-west side of Raymond Avenue, Matraville, with an area of approximately 1.8 hectares (ha) within the Randwick Local Government Area.

The estate has around 40 m of direct frontage to Raymond Avenue where access to the project will be provided.

The site is located approximately 2 km south-east of the Sydney Airport, and 9 km south of the Sydney CBD.

The layout of the warehouses are shown in **Figure 1** and **Figure 2**. The site location, surrounding receivers and unattended monitoring locations are shown in **Figure 3**.

Figure 1 Proposed Development – Ground Floor

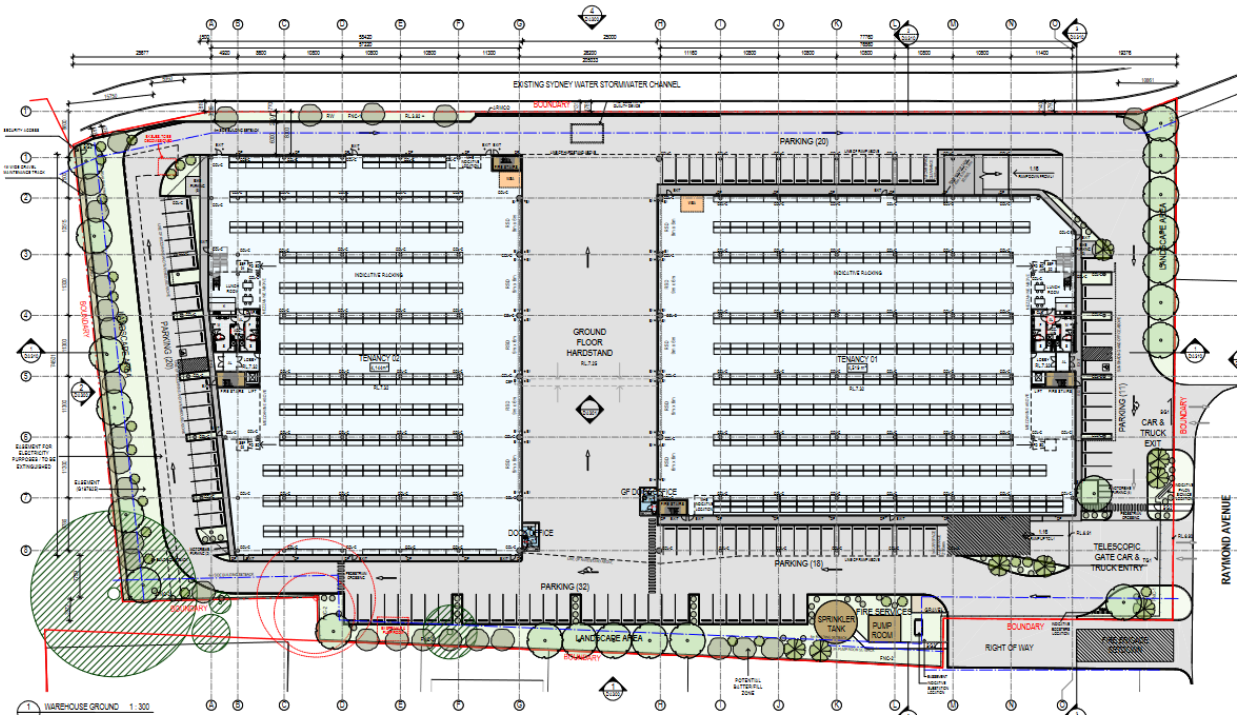


Figure 2 Proposed Development – First Floor

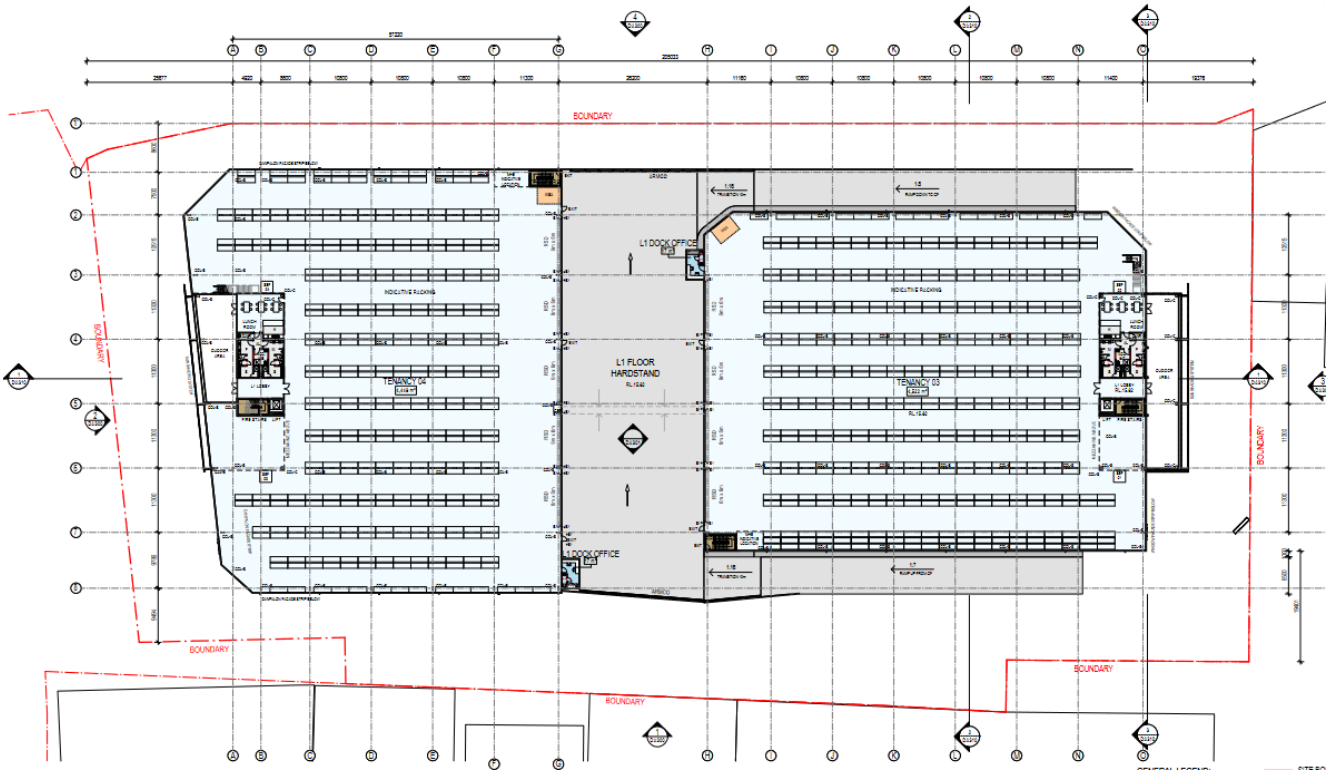


Figure 3 Site Location, Logging Locations and Surrounding Sensitive Receivers Areas

2.2 Nearest Sensitive Receivers

The nearest receivers are commercial developments located 10 m to the north and east of the site. Industrial developments are located 20 m to the north-west of the site. The nearest residential receivers are located around 170 m to north-east of the site. The nearest receivers are shown in **Table 1**.

Table 1 Nearest Sensitive Receivers

ID#	Address[1]	Type	Distance from Site Boundary	Direction	Notes
R01	40 McCauley Street, Matraville	Commercial	10	East	R01
R02	33 Raymond Avenue, Matraville	Commercial	30	North-east	R02
R03	17 McCauley Street, Matraville	Residential	170	North-east	R03
R04	40 Raymond Avenue, Matraville	Commercial	10	North	R04
R05	73-79 Beauchamp Road, Banksmeadow	Industrial	20	North-west	R05

It is understood that the Sydney Water Drainage Canal located on the western boundary of the site is a heritage listed structure.

3 Development Consent

Condition B24 of the Development Consent states the DPE requirements for a Construction Noise and Vibration Management Plan, reproduced in **Table 2** below.

Table 2 Construction Noise and Vibration Management Plan Requirements

Comments / Requirements	Addressed in Section
B24. The Applicant must prepare a Construction Noise and Vibration Management Plan for the development to the satisfaction of the Planning Secretary. The Plan must form part of the CEMP required by condition C2 and must:	This report
a) be prepared by a suitably qualified and experienced noise expert(s);	**Section 1**
b) describe procedures for achieving the noise management levels in the Interim Construction Noise Guideline (DECC, 2009) (as may be updated or replaced from time to time);	**Section 7**
c) describe the measures to be implemented to manage high noise generating works such as utilising vibratory rollers, in close proximity to sensitive receivers;	**Section 7.1**
d) include strategies that have been developed with the community for managing high noise generating works;	**Section 7.2**
e) describe the community consultation undertaken to develop the strategies in condition B24(d)	**Section 7.2**
f) include a complaints management system that would be implemented for the duration of the development.	**Section 7.4**

The Development Consent conditions outline the restriction of construction hours to:

- 7:00 am to 6:00 pm Monday to Friday
- 8:00 am to 1:00 pm on Saturdays
- No work on Sundays or Public Holidays

And that works outside of these hours would only be permitted under the following circumstances:

- Works that are inaudible at the nearest sensitive receivers;
- Works agreed to in writing by the Planning Secretary;
- For the delivery of materials required outside of these hours by the NSW Police Force or other authorities for safety reasons; or
- Where it is required in an emergency to prevent the loss of lives, property or to prevent environmental harm.

4 Existing Environment

Unattended noise monitoring has been completed at one location at the nearest residential receivers shown in **Figure 3**. 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 proposal. The noise monitoring equipment continuously measured existing noise levels in 15-minute periods during the daytime, evening and night-time.

The noise monitoring location is shown in **Figure 3** and the results are summarised in **Table 3**.

Table 3 Summary of Ambient Noise Levels

ID	Address	Measured Noise Levels (dBA)					
		Background Noise (RBL)			Average Noise (L_{Aeq})		
		Day[1]	Evening[1]	Night[1]	Day[1]	Evening[1]	Night[1]
L01	15 McCauley Street, Matraville	44	42	42	56	52	50

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).

The works for this project are proposed to occur only during standard construction hours, which are only within the daytime period of the NSW Environment Protection Authority's (EPA's) *Noise Policy for Industry* (NPfI). Short-term attended noise monitoring was also completed as a part of the *42-52 Raymond Avenue, Matraville SSDA Noise Impact Assessment* prepared by SLR Consulting Pty Ltd (refer to report 610.30618-R02) dated July 2022. The attended measurements allow the contributions of the various noise sources at each location to be determined.

The attended measurements were generally found to be consistent with the results of the unattended noise monitoring and show that existing ambient noise levels are typically dominated by industrial noise from existing industrial developments and road traffic noise from the surrounding road network.

5 Assessment Criteria

5.1 Construction Noise and Vibration Guidelines

The standards and guidelines relevant to the development are listed in **Table 4**. These guidelines aim to protect the community and environment from excessive noise and vibration impacts during construction of projects.

Table 4 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
Road Noise Policy (RNP) (DECCW, 2011)	Assessment of construction traffic 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

5.2 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 proposal are predicted and then compared to the NMLs in a 15-minute assessment period to determine the likely impact of the proposal.

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

Residential Receivers

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

Table 5 ICNG NMLs for Residential Receivers

Time of Day	NML $L_{Aeq(15minute)}$	How to Apply
Standard Construction Hours Monday to Friday 7:00 am to 6:00 pm Saturday 8:00 am to 1:00 pm No work on Sundays or public holidays	Noise affected RBL[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 • 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 6**.

Table 6 NMLs for 'Other Sensitive' Receivers

Land Use	Noise Management Level $L_{Aeq(15minute)}$ (dBA) (applied when the property is in use)	
	Internal	External
ICNG 'Other Sensitive' Receivers		
Classrooms at schools and other educational institutions	45	55[1]
Hospital wards and operating theatres	45	65[2]
Places of worship	45	55[1]
Active recreation areas (characterised by sporting activities and activities which generate noise)	-	65

Land Use	Noise Management Level $L_{Aeq(15minute)}$ (dBA) (applied when the property is in use)	
	Internal	External
Passive recreation areas (characterised by contemplative activities that generate little noise)	-	60
Commercial	-	70
Industrial	-	75
Non-ICNG 'Other Sensitive' Receivers		
n/a	-	-

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

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

5.2.2 NML Summary

The construction NMLs for the proposal have been determined using the results from the unattended noise monitoring and are shown in **Table 7**.

Table 7 Project Specific Noise Management Levels (dBA)

Receiver Type	Monitoring Location	Noise Management Level ($L_{Aeq(15minute)}$ – dBA)			
		Standard Construction (RBL +10 dB)[1]	Out of Hours (RBL +5 dB)		
		Daytime	Daytime[1]	Evening	Night-time
Residential (R03)	L01	54	49	47	47
Commercial (R01, R02, R04)	-	70 (when in use)	-	-	-
Industrial (R05)	-	75 (when in use)	-	-	-

Note 1: RBL = Rating Background Level.

Note 2: 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.

Sleep Disturbance

A method for assessing sleep disturbance is contained in the NPfI. Although the NPfI sleep disturbance criteria relates to industrial noise, it is also considered relevant for reviewing potential impacts from construction noise as a screening criteria to identify the need for further assessment. The NPfI notes that a detailed maximum noise level assessment should be undertaken where a project results in night-time noise levels which exceed 52 dBA L_{AFmax} or the prevailing background level plus 15 dB, whichever is the greater.

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.

5.3 Construction Road Traffic Noise Guidelines

The potential impacts from construction traffic on public roads are assessed under the NSW EPA *Road Noise Policy* (RNP) and Roads and Maritime (now Transport for NSW) *Construction Noise and Vibration Guideline* (CNVG).

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 as a result of construction traffic. Where this is considered likely, further assessment is required using the RNP base criteria shown in **Table 8**.

Table 8 RNP Criteria for Assessing Construction Vehicles 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)

The majority of traffic associated with the development is expected to enter and exit the development from the south via McCauley Street and Botany Road. The potential noise impacts from development related traffic on public roads are expected to be negligible given there are no sensitive receivers on this route and Botany Road is a major arterial road with high existing traffic volumes. It is anticipated that construction traffic will result in a minimal increase (i.e. less than 2 dB) in the overall traffic noise levels along the construction haulage routes. As such, construction traffic noise impacts have not been assessed further.

5.4 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).

5.4.1 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
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.

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

5.4.3 Structural and Cosmetic Damage Vibration

5.4.3.1 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 4**.

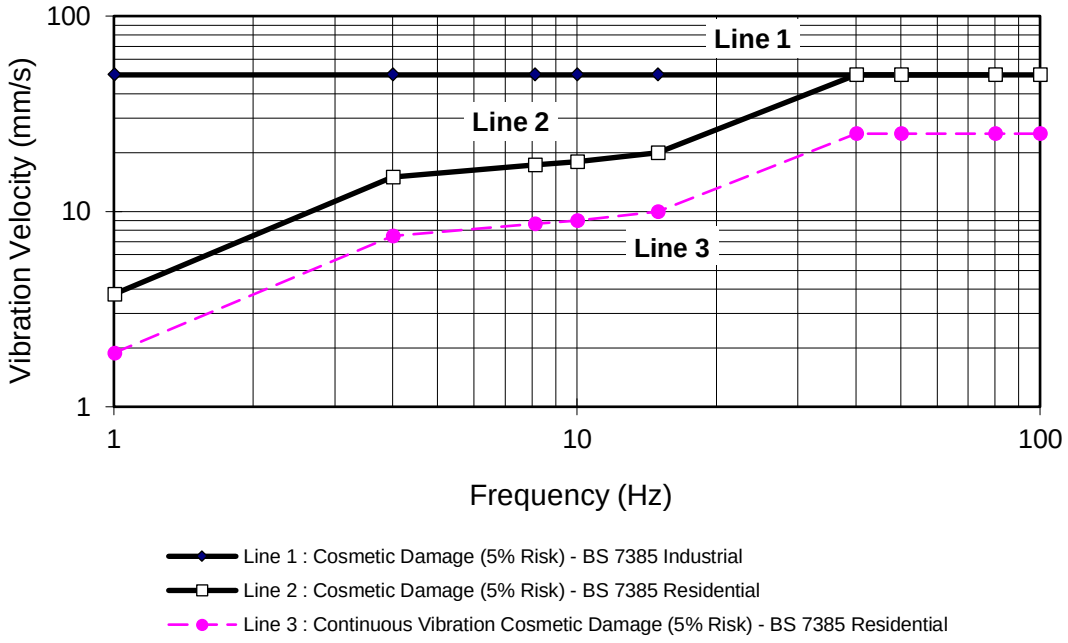
Table 10 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

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 4 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."*

5.4.3.2 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).

5.4.3.3 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.

5.4.3.4 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.

If upon inspection the Sydney Water Drainage Canal is found to be in good condition (i.e not found to be structurally unsound) DIN 4150-3 provides guideline values for short term vibration levels for masonry of 50 mm/s, reducing to 25 mm/s for long term effects. These thresholds are significantly higher (i.e. less stringent) than the limits for heritage structures.

In any case appropriate criteria will be developed in consultation with the asset manager (Sydney Water) and implemented in this CNVMP.

Notwithstanding the above, in the absence of specific Sydney Water criteria and inspection, given the heritage listing of the canal a default 2.5 mm/s criterion would be considered in accordance with DIN 4150.

5.4.4 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	25 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

It should be noted that these minimum working distances are indicative and will vary depending on the particular item of equipment and local geotechnical conditions.

6 Construction Noise and Vibration Assessment

6.1 Hours of Construction

As discussed in **Section 3**, construction activities are only to 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.

With the exception of the following circumstances:

- Works that are inaudible at the nearest sensitive receivers
- Works agreed to in writing by the Planning Secretary
- For the delivery of materials required outside these hours by the NSW Police Force or other authorities for safety reasons

- Where it is required in an emergency to avoid the loss of lives, property or to prevent environmental harm.

None of the works proposed in this assessment are expected to be inaudible at the nearest sensitive receivers. Therefore, where works are required out of hours a construction noise impact statement (CNIS) must be prepared detailing the proposed out of hours works activities, predicted noise and vibration impacts, and proposed mitigation and management measures. CNIS for out of hours works will be provided to the Planning Secretary for approval. This work must be agreed to in writing by the Planning Secretary. Consequently, this assessment therefore only considers works that will occur during the assumed hours of construction.

6.2 Construction Activities

Construction scenarios and corresponding items of plant have been approved by Vaughan Constructions Pty Ltd

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		35T Excavator	110t piling rig	Bogey Trucks	Bulldozer	Grader	Truck (Deliveries)	Concrete Pump	Concrete Vibration Machines	200t Crane	Total L_{Aeq} Sound Power Level (dBA)
L_{Aeq} Sound Power Level (dBA)		109	108	102	113	108	101	106	102	105	
Scenario	Earthworks/ Site Establishment	2	2	2	2	2		1			119
	Infrastructure Works			2			2	2	6	2	116

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, ie test measurements of the equipment undertaking the works for a short period prior full commencement of the works.

6.3 Construction Noise Predictions

Noise impacts for the construction scenarios presented in **Table 12** have been predicted at the nearby sensitive receivers shown in **Table 1** using the CONCAWE algorithm implemented in SoundPLAN 8.2 software. A three-dimensional digital terrain map providing relevant topographic information was used in the modelling process, together with noise source data, shielding by barriers and/or adjacent buildings and atmospheric information to predict noise levels at the nearest potentially affected receivers.

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 and during noise enhancing weather conditions with wind flowing from source to receiver.

Table 14 Construction Noise Predictions at Sensitive Receivers

Receiver and Type	NML (dBA)	Predicted $L_{Aeq(15minute)}$ Construction Noise Impact (dBA)		NML Exceedance	
		Earthworks / Site Establishment	Infrastructure Works	Earthworks / Site Establishment	Infrastructure Works
R01 – Commercial	70	80	76	10	6
R02 – Commercial	70	75	71	5	1
R03 – Residential	54	52	48	-	-
R04 – Commercial	70	79	76	9	6
R05 – Industrial	75	77	73	2	-

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

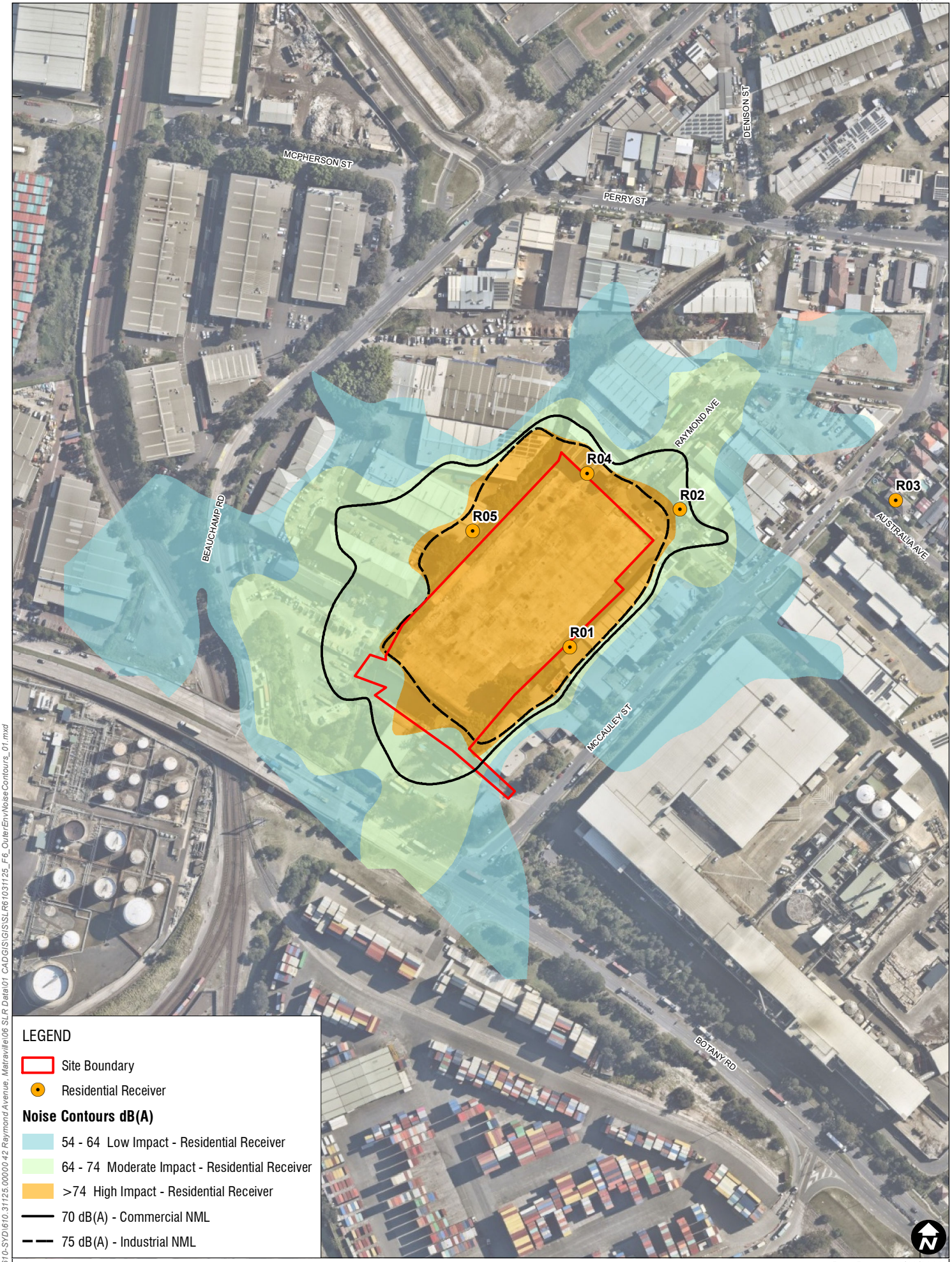
- Noise levels of 80 dBA are predicted at receiver R01 and 79 dBA at receiver R04. These are considered "Low impact" in accordance with the subjective classification in **Table 13**.

- Noise levels at residential receivers are predicted to be 52 dBA at receiver R03 for earthworks and below the relevant NML. As such construction noise impacts are deemed "negligible" in accordance with the subjective classification in **Table 13** for the nearest residential receivers.

A contour plot showing outer envelope construction noise predictions is provided in **Figure 5**. These represent the noise impacts for the loudest construction works over the total construction works period.

As no receivers are expected to experience noise levels deemed above "Low Impact" in accordance with the subjective classification in **Table 13** it is not expected that high noise generating works would occur as a part of construction noise impacts from the project.

As the construction noise impacts exceed the NMLs at the nearest commercial and industrial receivers, all feasible and reasonable noise mitigation measures will be required to be applied to the construction work. Construction noise measures are discussed in **Section 7**.



Scale: 1:3,500 at A4
Coordinate System: GDA 1994 MGA Zone 56

Date Drawn: 9/12/2022
Project Number: 610.31125

H:\Projects-SLR\610-SnySYD\610-SYD\610.31125.00000 42 Raymond Avenue, Matraville\06 SLR Data\01 CADGIS\GIS\SLR61031125_F6_OuterEnvNoiseContours_01.mxd

SLR

OUTER ENVELOPE NOISE CONTOURS

FIGURE 5

6.4 Construction Vibration

Figure 3 and **Table 1** show that the distance between the construction work and the nearest sensitive residential receivers is generally sufficient for most receiver buildings to be outside of the cosmetic damage working distance for proposed construction equipment in the absence of any vibratory rolling. However the nearest commercial/industrial buildings are likely to be within the minimum working distances shown in **Table 11** when vibratory rollers are in use nearby.

The Sydney Water Drainage Canal is located on the western boundary and within safe working distances shown in **Table 11**.

As such feasible and reasonable construction vibration mitigation measures should be applied where vibration intensive works are required within the minimum working distances. Construction mitigation and management measures are discussed further in **Section 7.**

7 Mitigation and Management 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. The worst-case noise impacts during construction of the project are predicted to be 'low' at the nearest commercial and industrial receivers immediately surrounding the site and 'negligible' at the other residential receivers identified in **Figure 3**. Works are also generally limited to daytime hours only.

All appropriate feasible and reasonable mitigation measures will be applied to the work to minimise the potential impacts, as far as practicable.

7.1 Standard Mitigation and Management Measures

The mitigation and management measures that would be applied to the project are detailed in **Table 15**.

Table 15 Environmental Management Controls for Construction Noise and Vibration

Measure	Person Responsible	Timing / Frequency	Reference / Notes
Project Planning			
Use quieter and less vibration emitting construction methods where feasible and reasonable.	Project Manager	Ongoing	Best practice
Works will be completed during standard daytime construction hours outlined in **Section 6.1**.			
Truck routes to site will be limited to major roads.			
Scheduling for High Noise or Vibration Generating Works			
High-noise or vibration generating works will be carried out in continuous blocks no longer than three hours in length, with a minimum respite period of one hour between each block. 'Continuous' includes any period during which there is less than a one hour respite between ceasing and recommencing these works.	Project Manager/ Communications and Community Liaison Representative	Ongoing	Best practice

Measure	Person Responsible	Timing / Frequency	Reference / Notes
Site Layout			
Compounds and worksites will be designed to promote one-way traffic and minimise the need for vehicle reversing.	Project Manager	Ongoing	Best practice
Where practicable, work compounds, parking areas, and equipment and material stockpiles will be positioned away from noise-sensitive locations and take advantage of existing screening from local topography.			
Documentation of how site layout has been considered to reduce noise impacts must be provided to the Contractor's Project Manager. This must occur any time there are significant changes to the site layout.			
Equipment that is noisy will be started away from sensitive receivers			
Training			
Training will be provided to all personnel on noise and vibration requirements for the project. Inductions and toolbox talks to be used to inform personnel of the location and sensitivity of surrounding receivers.	Project Manager	Ongoing	Best practice
Plant and Equipment Source Mitigation			
All plant and equipment must be maintained in a proper and efficient condition, operated in a proper and efficient manner, and feature standard noise amelioration measures where applicable.	Project Manager	Ongoing	Best practice
Where practicable, tonal reversing alarms (beepers) will be replaced with non-tonal alarms (squawkers) on all equipment in use (subject to occupational health and safety requirements).			
Noisy equipment will be sited behind structures that act as barriers, or at the greatest distance from the noise-sensitive area. Equipment will be oriented so that noise emissions are directed away from any sensitive areas, where possible.			
Noise generating equipment will be regularly checked and effectively maintained, including checking of hatches/enclosures regularly to ensure that seals are in good condition and doors close properly against seals.			
Noise monitoring spot checks of equipment will be completed to ensure individual items are operating as expected			
Dropping materials from a height will be avoided.			
Loading and unloading will be carried out away from noise sensitive areas, where practicable.			
Trucks will not queue outside residential properties. Truck drivers will avoid compression braking as far as practicable.			
Truck movements will be kept to a minimum, ie trucks are fully loaded on each trip.			
Screening			

Measure	Person Responsible	Timing / Frequency	Reference / Notes
Where possible, install purpose-built screening or enclosures will be used around long-term fixed plant that has the potential to impact nearby receivers	Project Manager	Ongoing	Best practice
The layout of the site will take advantage of existing screening from local topography, where possible. Site huts, maintenance sheds and/or containers will be positioned between noisy equipment and the affected receivers.			
Complaints Management			
Where complaints are received, work practices will be reviewed and feasible and reasonable practices implemented to minimise any further impacts. Refer to **Section 7.4**.	Communications and Community Liaison Representative	Ongoing	Best practice
Monitoring			
Noise and/or vibration monitoring will be conducted (as appropriate) when noise/vibration intensive works are being undertaken in close proximity to sensitive receivers.	Environmental Coordinator	Ongoing	Best practice
Noise and/or vibration monitoring will be conducted (as appropriate) in response to any complaints received to verify that levels are not substantially above the predicted levels.			
Refer to **Section 7.3** for full details of monitoring requirements.			
Vibration			
If vibration generating works are required within the minimum cosmetic damage working distances and considered likely to exceed the criteria: • Different construction methods with lower source vibration levels will be investigated and implemented, where feasible. • Attended vibration measurements will be undertaken at the start of the works to determine actual vibration levels at the item. Works will cease if the monitoring indicates vibration levels are likely to, or do, exceed the relevant criteria.	Environmental Coordinator	Ongoing	Best practice
Where works are required within the cosmetic damage minimum working distances, building condition surveys will be completed before and after the works to ensure no cosmetic damage has occurred.			

7.2 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**. 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.

Table 18 Additional Mitigation Measures Matrix - Construction Noise

Construction Hours	Receiver Perception	Noise Level above RBL (dBA)	Noise Level above NML (dBA)	Additional Measures
Standard Hours Mon-Fri (7am - 6pm) Saturdays (8am - 1pm)	Noticeable	5 to 10	0	-
	Clearly Audible	>10 to 20	<10	-
	Moderately intrusive	>20 to 30	>10 to 20	N, V
	Highly Intrusive	>30	>20	N, V
	75 dBA or greater[1]	N/A	N/A	N, V, PC, RO
Out-of-Hours Work (OOHW) Period 1 Mon-Fri (6pm - 10pm)	Noticeable	5 to 10	<5	-
	Clearly Audible	>10 to 20	5 to 15	N, R1, DR
	Moderately intrusive	>20 to 30	>15 to 25	V, N, R1, DR

Construction Hours	Receiver Perception	Noise Level above RBL (dBA)	Noise Level above NML (dBA)	Additional Measures
Saturdays (7am-8am) and (1pm-10pm) Sundays/Public Holidays (8am-6pm)	Highly Intrusive	>30	>25	V, IB, N, R1, DR, PC, SN
Out-of-Hours Work (OOHW) Period 2 Mon-Fri (10pm - 7am) Saturdays (10pm - 8am) Sundays/Public Holidays (6pm - 7am)	Noticeable	0 to 10	<5	N
	Clearly Audible	>10 to 20	5 to 15	V, N, R2, DR
	Moderately intrusive	>20 to 30	>15 to 25	V, IB, N, PC, SN, R2, DR
	Highly Intrusive	>30	>25	AA, V, IB, N, PC, SN, R2, DR

Note 1: Only applies at residential receivers.

For the commercial and industrial receivers near the site, the NSW Environment Protection Authority's (EPA's) *Interim Construction Noise Guideline* (ICNG) notes that:

> *The proponent should assess construction noise levels for the project, and consult with occupants of commercial and industrial premises prior to lodging an application where required.*
>
> *During construction, the proponent should regularly update the occupants of the commercial and industrial premises regarding noise levels and hours of work.*

Additionally, the TfNSW *Construction Noise and Vibration Strategy* (CNVS) notes regarding commercial and industrial premises that:

> *Community consultation will be required during the assessment and planning phase of a project (prior to construction) to confirm the location of other sensitive receivers including collecting information on specialised requirements for each receiver (for example education or community facilities that provide Autism-specific services or identifying to location of vibration sensitive equipment in medical facilities). This may be achieved by completing a door-knock exercise or completing specific notifications prior to construction.*

The following consultation procedure is therefore recommended for commercial and industrial receivers where noise levels are predicted to exceed the NML or where vibration intensive activities will occur within the minimum working distances provided in **Table 11**:

- Specific notifications in the form of a personalised letter should be provided to these receivers at least seven days prior to the commencement of works. In addition to providing the likely noise/vibration impacts and proposed hours (including respite periods), the letter should provide an opportunity to comment on the project as well as a point of contact for complaints.
- The construction contractor should continue to provide notifications to the above receivers in the form of a letterbox drop at monthly intervals, and when new activities are likely to commence. The letterbox drop should indicate the likely noise/vibration impacts and proposed hours (including respite periods) for the upcoming works.

The contractor has door knocked and liaised with the nearest commercial and industrial businesses to inform them of upcoming construction works and left business cards with relevant personnel detailing relevant contact details. Prior to construction commencing the contractor will provide the neighbouring businesses with the timing of upcoming works and detail any high noise generating works. Any feedback from the neighbouring receivers regarding any potential additional noise and vibration management measures will be implemented, where reasonable and feasible.

7.3 Monitoring

7.3.1 Construction Noise Monitoring

Attended noise monitoring will 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.

The monitoring will take place during the expected noisiest construction periods and be representative / indicative of the impacts at the potentially affected sensitive receivers. All items of acoustic instrumentation utilised will be designed to comply with AS IEC 61672.1-2019 *Electroacoustics – Sound level meters* (AS IEC 61672) and carry current calibration certificates.

A noise monitoring report will be prepared after each attended monitoring survey.

7.3.2 Construction Vibration Monitoring

Where vibration intensive works (such as impact hammering, vibratory rolling or piling) are required within the minimum working distances of sensitive receivers or structures (refer to **Section 5.4.4**), 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 5.4.4**).

Geophones will be installed by appropriately qualified personnel 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. Actions to be carried out if the exceedance alarms are triggered are detailed in **Section 7.5**.

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.

7.3.3 Monitoring Reports

Noise and/or vibration monitoring reports will be provided to the relevant regulatory authorities after review, unless otherwise agreed by the relevant regulatory authorities. 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 L_{Amax} 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.

7.4 Complaints Management

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.

7.5 Contingency Plan

The following contingency management plan, shown in **Table 19**, would be used to manage noise and vibration impacts that are higher than expected.

Any incident or non-compliance shall be handled and reported in accordance with the CEMP.

The following events constitute an incident in terms of noise and vibration:

- Trigger of Condition Red for noise impacts during the standard construction hours detailed in **Section 3**.
- Any works occurring outside the standard construction hours detailed in **Section 3**, where those works do not meet the allowable circumstances, including being agreed in writing by the Planning Secretary.
- Trigger of Condition Red for vibration impacts at sensitive receivers.

Table 19 Contingency Management Plan

Key Element	Trigger / Response	Condition Green	Condition Amber	Condition Red
Noise impacts at sensitive receiver locations	Trigger	Noise levels do not exceed applicable NMLs	Noise levels exceed applicable NMLs	Noise levels exceed Highly Noise Affected criteria (75 dBA)
	Response	On-going best practice management measures to minimise noise emissions	Undertake all feasible and reasonable mitigation and management measures to minimise noise impacts (aiming to achieve NMLs)	Works exceeding the Highly Noise Affected criteria will be managed in accordance with the strategies for high-noise generating works determined through community consultation, as detailed in **Section 7.2**.
Vibration impacts at sensitive receiver locations	Trigger	Vibration intensive works undertaken outside minimum working distance for the specific equipment in use	Vibration intensive works undertaken within minimum working distance for the specific equipment in use	Vibration levels exceed applicable vibration limits
	Response	On-going best practice management measures to minimise vibration emissions	Undertake vibration monitoring for the duration of the works to confirm vibration levels.	Stop work. Undertake all feasible and reasonable mitigation and management measures to ensure vibration levels are below applicable limits. If vibration levels cannot be kept below applicable limits then a different construction method or equipment must be utilised.

7.6 Internal Audits

Periodic internal audits will be conducted to ensure that the development consent conditions and commitments and environmental management controls outlined in this CNVMP are being properly implemented. Audit reports will be used to inform of any corrective actions.

7.7 Roles and Responsibilities

Overall roles and responsibilities relating to the project are expected to be outlined in the CEMP. The key responsibilities specifically for noise and vibration management are as follows:

7.7.1 Contractor's Project Manager

- Ensuring appropriate resources are available for the implementation of this CNVMP
- Assessing data from inspections and providing project-wide advice to ensure consistent approach and outcomes are achieved
- Providing necessary training for project personnel to cover noise and vibration management
- Reviewing and update of this CNVMP, where necessary

- Commissioning suitably qualified consultants to complete noise and vibration monitoring. Ensuring environmental coordinators appropriately undertake attended noise and vibration measurements required by this CNVMP
- Assessing and (as required) mitigating risks of high noise and vibration levels before commencing works and ensuring that the appropriate controls are implemented
- Ceasing works in the event of excessive noise and vibration generation
- In the event that a noise or vibration complaint is received, implementing the procedure outlined in **Section 7.4**.

7.7.2 Environmental Coordinator

- Coordinating noise and/or vibration monitoring program, where required
- Review control measures in accordance with the CNVMP
- Identifying and reporting any high or non-compliant noise and vibration emissions.

7.7.3 All Workers on Site

- Observing any noise and vibration emission control instructions and procedures that apply to their work
- Taking action to prevent or minimise noise and vibration emission incidents
- Identifying and reporting noise and vibration emission incidents.

8 Review and Improvement of Noise Management Plan

Reviews, investigations, and improvements to this plan and the environmental performance shall be undertaken in accordance with the CEMP.

This CNVMP will be reviewed, and if necessary, updated in the following circumstances:

- Significant changes to the equipment, machinery and plant operated within the site
- Any feedback regarding potential additional mitigation measures obtained from further consultation with the neighbouring commercial and industrial receivers.
- Where it is identified via monitoring that the performance of the project is not meeting the objectives of the CNVMP
- At the request of the relevant regulatory authority or other relevant government agency.

All employees and contractors will be informed of any revisions to the CNVMP by Site Management during toolbox talks. The most recent version of the CNVMP as approved by the Planning Secretary, will be implemented for the duration of construction works.

APPENDIX A

Acoustic Terminology

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 2×10^{-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

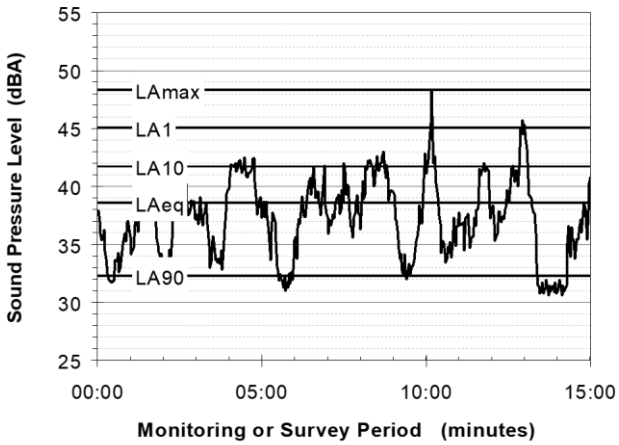
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 10^{-12} W.

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 L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

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



Of particular relevance, are:

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

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

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

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

5. Frequency Analysis

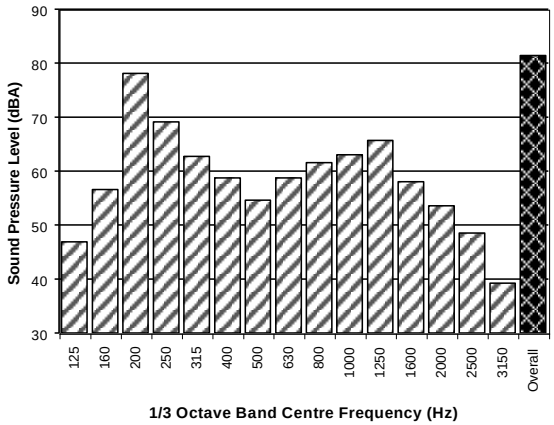
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal.

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

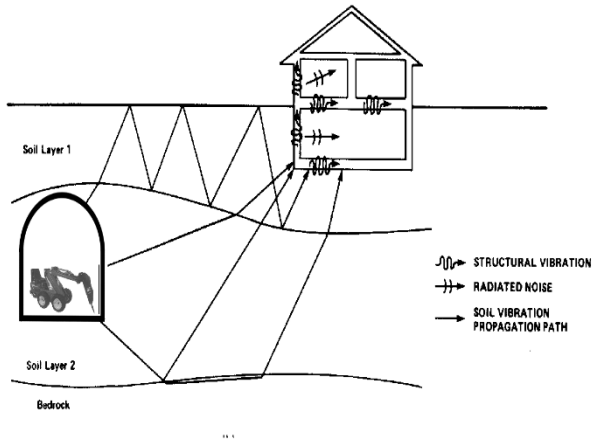
People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience 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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