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STATION ST MENANGLE

Noise and Vibration Impact Assessment - Pedestrian Bridge Crossing

23 June 2023

Mirvac C/- Calibre Group

TL970-03F02 Menangle Rail Bridge Pedestrian Overpass NVIA (r1)

Document details

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1 Introduction

1.1 Project overview

Renzo Tonin & Associates (RTA) has been engaged by Mirvac to prepare a Review of Environmental Factors (REF) noise and vibration assessment for the Environmental Impact Assessment for the Pedestrian Bridge Crossing project (the Proposal).

Renzo Tonin & Associates previously prepared a Noise and Vibration Impact Assessment Report in 2021 and 2022 in support of the draft REF for the Menangle Pedestrian Bridge at Station Street Menangle, linking the two sides of Mirvac's development together and allowing safe access to the railway station.

The REF has now come under Transport for NSW (TfNSW) as the approving entity and requires amendment to reflect this change and also to note the standards that TfNSW requires as Council is no longer the approving entity. Operational and construction noise and vibration impacts from the associated proposal are subsequently addressed in this report in accordance with the TfNSW requirements and guidelines.

1.2 Report objectives

The objectives of the noise and vibration assessment are to:

- Identify the existing acoustic environment and relevant noise and vibration objectives for construction and operations.
- Assess potential construction noise and vibration impacts.
- Recommend feasible and reasonable mitigation and management measures to limit the impact of the construction works.

The assessment is based on the status of design and construction information available and provided by Calibre Group at the time of preparing this assessment.

1.3 Project description and aim of study

This project is to construct a pedestrian foot bridge over the rail line & immediately to the north of Station Street.

The bridge will provide a pedestrian corridor between the subdivision that is being constructed to the east of the rail line & the Menangle township & Rail Station.

The location of the Proposal and site plan is shown in Figure 1-1.

The Proposal would include the following key features:

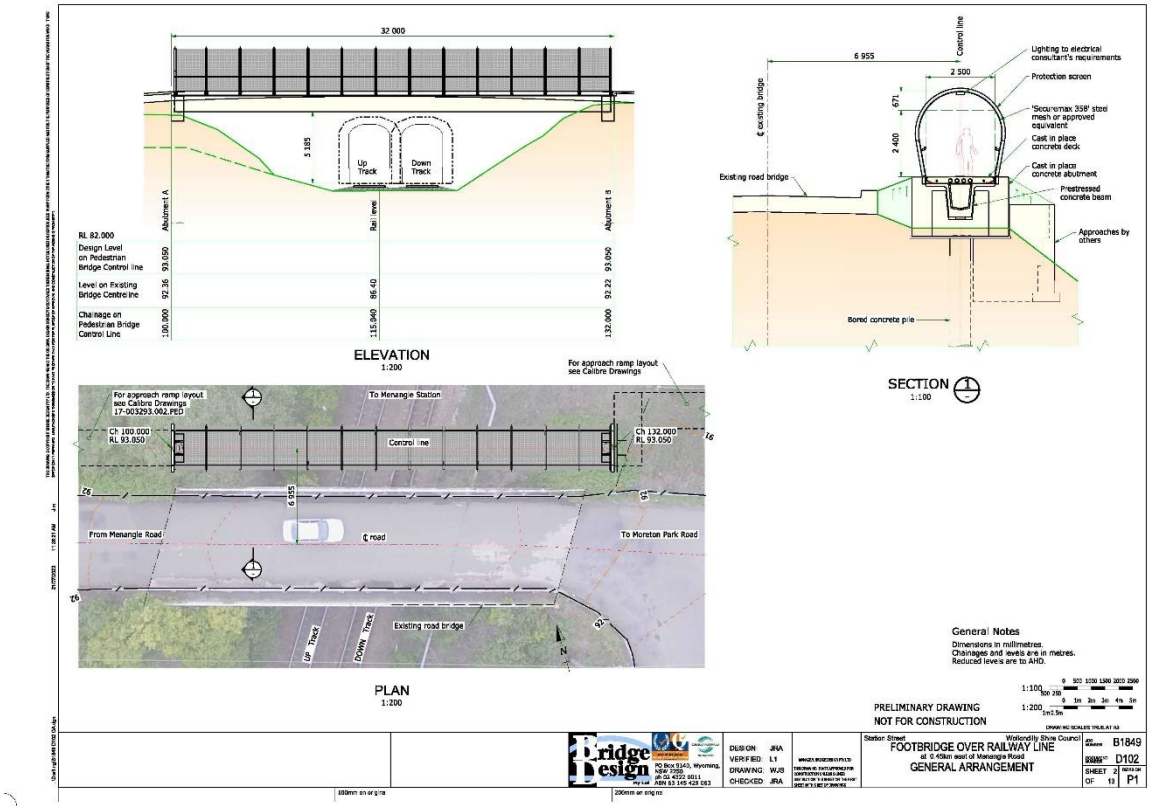
- Preconstruction site investigations

- Site establishment and enabling works including mobilisation of temporary compound facilities and staging areas
- Piling platform and insitu concrete bridge abutment works
- Installation of the bridge beams
- Testing and commissioning
- Site demobilisation works.

Temporary compound facilities and storage and laydown areas would be provided during construction works to accommodate site offices, amenities, storage of plant and equipment, stockpiling of materials, and limited parking for construction personnel.

Access to and egress from the temporary site compound and staging areas would be via Station Street and along Stevens Road and extension of Moreton Park Road to the north on the east side of the bridge. This area is located within the rail corridor as shown in Figure 1-1. The ancillary storage and laydown area would remain for the duration of the construction program. Construction of the Proposal is scheduled to occur between July and October 2023. Site works for the foundation, bridge and frame are proposed to be undertaken in about 15 weeks with up to 3 track possession periods.

Figure 1-1: Key features of the Proposal



1.4 Relevant policies and guidelines and assessment objectives

This study aims to quantify the potential noise and vibration impact associated with the construction of the Proposal, in particular in relation to out of hours construction work during rail possessions.

In regard to the operation of the Proposal, Renzo Tonin and Associates does not envisage any ongoing noise and vibration emissions once the pedestrian bridge is operational. The decking will be constructed out of in-situ concrete so any noise and vibration associated with footfall will be minimal. Accordingly, operational noise is not addressed further in the report.

The assessment objectives are to determine the levels of noise and vibration impact on sensitive receivers located near to the project and determine the levels of mitigation that will be required to enable compliance with the current NSW requirements.

Table 1-1 presents the policies, guidelines and standards considered in this assessment.

Table 1-1: Relevant noise and vibration policies, guidelines and standards

Guideline/policy document	Assessment aspect
Construction Noise and Vibration Strategy (Transport for NSW, 2019)	Airborne noise, ground-borne noise and vibration impacts (including construction traffic within the construction support site boundary)
Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009)	Airborne noise and ground-borne noise impacts (including construction traffic within the construction support site boundary)
Assessing Vibration: a technical guideline (Department of Environment and Climate Change, 2006)	Vibration amenity - construction and operations
British Standard BS 7385: Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from groundborne vibration (BSI, 1993)*	Vibration impacts to structures and blasting impacts
German Standard DIN 4150-3 (2016) *Structural vibration – Effects of vibration on structures (Deutsches Institut für Normung, 2016)*	Vibration impacts to structures and blasting impacts
*NSW Road Noise Policy (*Department of Environment, Climate Change and Water, *2011)*	Construction road traffic noise impacts (on public roads)
Noise Policy for Industry (Environment Protection Authority, 2017)	Establishing the existing noise environment

The Transport for NSW *Construction Noise and Vibration Strategy* (2019) (DMS-ST-157, Revision 4.2 with revised Table 8 and 9) (CNVS) provides practical guidance on how to minimise, to the fullest extent practicable, the impacts on the community from airborne noise, ground-borne noise and vibration generated during the construction of infrastructure projects through the application of all feasible and reasonable mitigation measures. The TfNSW CNVS will be adopted by the project to assist in managing the impacts from construction noise and vibration.

1.5 Acoustic concepts, terminology & quality

This report is technical in nature and uses acoustic terminology throughout. A summary and explanation of the common acoustic terms that has been used in this report is presented in Section A.1.

Some of the key acoustic concepts used in this report are further explained in Section A.2.

2 Existing noise environment

2.1 Noise and vibration-sensitive receivers

A desktop land use survey was carried out to identify the receiver types and land uses surrounding the proposal that could potentially be impacted by noise or vibration from the project. At detailed design further review of potentially impacted noise-sensitive receivers should be undertaken to confirm that impacts are mitigated and managed appropriately.

The noise and vibration-sensitive receivers are generally separated into different classifications based upon their differing sensitivities to noise and vibration impacts. They are generally separated into the following major categories; however, these can differ and expand depending upon the review of surrounding sensitive receivers undertaken during detailed design:

- Residential receivers (including mixed use buildings and aged care facilities)
- Other noise and vibration-sensitive receivers, including:
    - Classrooms at schools and other educational institutions
    - Hospital wards and operating theatres
    - Places of worship
    - Childcare centres
    - Active recreation areas (eg. sports fields/activities which generate their own noise and are generally less sensitive to external noise)
    - Passive recreation areas (eg. areas used for low intensity and low noise producing activities which have the potential to be impacted by external noise such as reading or meditation)
    - Community centres
    - Special noise and/or vibration-sensitive receivers (eg. laboratories, recording studios)
- Commercial premises (including offices and retail outlets)
- Industrial premises.

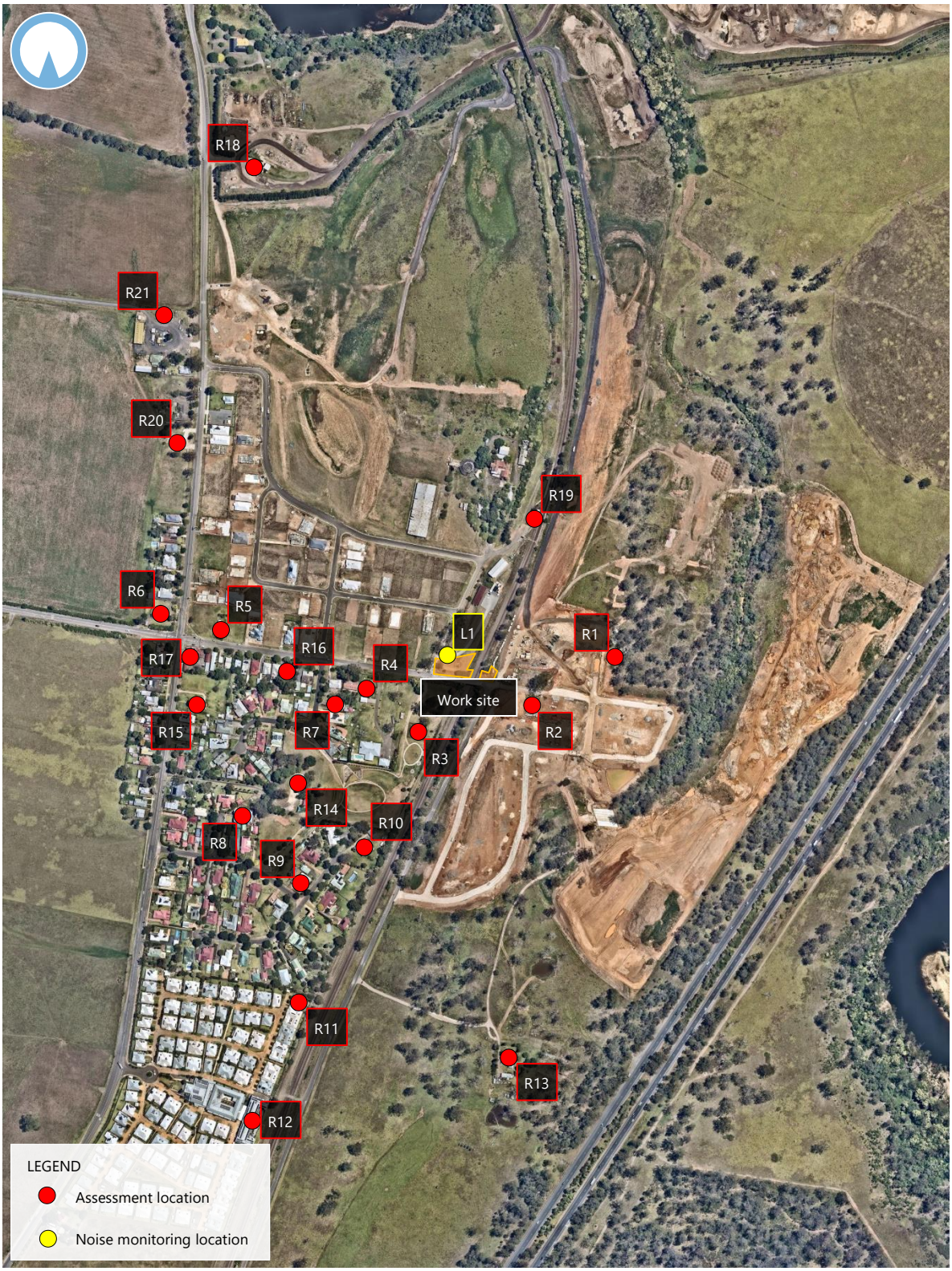
All assessed noise and vibration-sensitive receiver types for the Proposal are shown in Figure 2-1. No heritage listed item has been identified by the client.

A number of the nearest representative noise sensitive receivers surrounding the Proposal have been identified for the purposes of reporting noise levels at nearby noise sensitive receivers. These selected receivers are detailed in Table 2-1 below and identified in Figure 2-1. Note that the new lots currently developed by Mirvac are not expected to be completed prior to the Proposal and also since all these works are under Mirvac, no assessment has been carried out to these unoccupied lots.

Table 2-1: Nearest and representative noise sensitive receivers

Receiver type	Description / NCA	Address	Approximate closest distance to the Proposal, metres	Receiver ID
Residential	Low density suburban residential area along either side of the rail corridor	1390 Moreton Park Road, Menangle	173	R1
		42 Station Street, Menangle	58	R2
		28 Station Street, Menangle	85	R3
		26A Station Street, Menangle	99	R4
		27 Station Street, Menangle	317	R5
		110 Menangle Road, Menangle	404	R6
		1 Riversford Close, Menangle	142	R7
		4 Sulman Place, Menangle	338	R8
		13 St James Avenue, Menangle	356	R9
		7 Haines Place, Menangle	264	R10
		Villa 701/153 Menangle Road, Menangle	517	R11
		Durham Green Lodge, Menangle	677	R12
		1370 Moreton Park Road, Menangle	546	R13
Place of Worship	St James Anglican Church Menangle	131 Menangle Road, Menangle	250	R14
	St Patrick's Catholic Church	119 Menangle Road, Menangle	341	R15
Recreational Active	Dean McGrath Park (Playground)	18 Station Street, Menangle	198	R16
Commercial	The Menangle Store	2 Station Street, Menangle	342	R17
Industrial	Benedict Sands Menangle	31 Menangle Road, Menangle	760	R18
Infrastructure	Menangle Station	Stevens Road, Menangle	210	R19
	Menangle Rural Fire Brigade	90 Menangle Road, Menangle	486	R20
	Elizabeth Macarthur Agricultural Institute	60 Woodbridge Road, Menangle	634	R21

Figure 2-1:Construction works areas, assessed nearby noise and vibration-sensitive receiver, representative receiver locations and monitoring locations



2.2 Existing background noise levels

Background noise varies over the course of any 24-hour period, typically from a minimum at 3:00 am in the morning, to a maximum during morning and afternoon traffic peak hours. Therefore, the NPfI, referenced by the ICNG for determining the Rating Background Level (RBL), requires that the level of background and ambient noise be assessed separately for the daytime, evening and night-time periods. The NPfI defines these periods as follows:

- **Day** is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.
- **Evening** is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.
- **Night** is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays.

2.3 Noise monitoring

2.3.1 Unattended noise monitoring

Fact Sheet B of the NSW EPA NPfI outlines two methods for determining the background noise level of an area, being '*B1 – Determining background noise using long-term noise measurements*' and '*B2 – Determining background noise using short-term noise measurements*'. This assessment has used long-term noise monitoring to determine background noise levels.

Long term unattended noise monitoring was conducted at one location for a continuous period from 1 to 10 August 2018, to measure ambient and background noise levels in the vicinity of residential receivers around the proposed construction works areas. The equipment used for noise measurements were NTi Audio Type XL2 precision sound level analysers which are a Class 1 instruments having accuracy suitable for field and laboratory use and is summarised in Table 2-2. All instrumentation complies with IEC 61672 (parts 1-3) '*Electroacoustics - Sound Level Meters*' and IEC 60942 '*Electroacoustics - Sound calibrators*' and carries current NATA certification (or if less than 2 years old, manufacturers certification). The equipment calibration was field checked prior and subsequent to the measurement period using a Brüel & Kjær Type 4231 calibrator, with no significant calibration drift observed. The noise monitoring was undertaken in the free field, and representative of the ambient noise environment for the associated residential receivers.

The unattended noise monitoring location [L1] and observed noise environment are summarised in Table 2-3 below and shown on the map Figure 2-1. The existing measured background and ambient noise levels are presented in Appendix B.

Table 2-2: Unattended noise monitoring equipment

Reference location	Address	Instrument	Logger reference	Monitoring period
L1	Stevens Road, Menangle	NTi Audio XL2	RTA06	01/08/2018 - 10/08/2018

Note: All meters comply with AS IEC 61672.1 2004 "Electroacoustics - Sound Level Meters" and designated Type 1, and are suitable for field use.

A summary of the unattended noise monitoring results along with a graphical recorded output from the long-term noise monitoring are included in Appendix B. The graphs in Appendix B were analysed in accordance with the procedure outlined in the NPfI to determine an Assessment Background Level (ABL) for each day, evening and night period in each 24-hour period of noise monitoring. Based on the median of individual ABLs an overall single Rating Background Level (RBL) for the day, evening and night period is determined over the entire monitoring period in accordance with the NPfI.

Table 2-3: Unattended noise monitoring location

Noise logger #	Location	Observed noise environment
L1	Stevens Road	The noise monitor was located in the free-field, approximately 60m to the west of the Southern Highlands Rail Line. The noise environment was dominated by distant traffic from the Hume Highway to the east, with occasional noise from passing passenger and freight trains.

The existing background noise levels adopted for the assessments are presented in Table 2-4 below.

Table 2-4: Measured existing background noise levels, dB(A)

Ref	Location	Rating background noise levels (RBL), $L_{A90,\ 15\ minute}$		
		Day	Evening	Night
L1	Stevens Road	41	43	40

Residential receivers nearby to works areas are generally located in a suburban environment, with the Main South line rail corridor, the Hume Motorway and Menangle Road, contributing to the background noise levels at these receivers during day, evening and night periods.

3 Noise and vibration objectives

3.1 Construction noise objectives

3.1.1 Noise metrics

For the assessment of construction noise, which is typically temporary in nature and highly variable, the EPA's Interim Construction Noise Guideline (ICNG) uses three noise metrics to determine the potential construction noise impact.

L_{Aeq} - To protect against long-term repeated noise exposure, the indicator for assessing the cumulative noise exposure level over a specific time interval is the equivalent sound pressure level, denoted as L_{Aeq}. The L_{Aeq} indicator accounts for the total energy content from all sources of sound under consideration. The fact that the L_{Aeq} is a cumulative measure means that louder activities have greater influence of the L_{Aeq} level than do quieter ones, and activities that last longer in time have greater L_{Aeq} than do shorter ones. An increase in the number of events also increases the L_{Aeq}. Further, people react to the duration of noise events, judging longer events to be more annoying than shorter ones, assuming equal maximum noise levels.

L_{Amax} - It is important to note that even though L_{Aeq} levels are numerically lower than maximum noise levels (denoted as L_{Amax}). None of the noise is ignored, just as all the rain that falls in the rain gauge in one hour counts toward the total. In the case of noisy but short-lived maximum noise events, which can sometime result in immediate short-term awakening reaction, potential impact is assessed using the LAmax indicator in which its emergence above the background noise environment is evaluated.

L_{A90} - The L_{A90} is the level of noise that is present almost constantly, or for 90 percent of the time and is commonly referred to as the background noise. Typical examples of what types of noise may contribute to the background noise levels are continuously flowing traffic or air conditioner noise.

3.1.2 Noise management levels (NMLs)

The ICNG provides guidelines for assessing noise generated during the construction phase of developments. There are two methods described for the assessment of construction noise, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement and prediction of noise levels, and assessment against set criteria. A qualitative assessment is recommended for small projects with duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification.

Given the scale of the construction works proposed, a quantitative assessment is carried out herein, consistent with the ICNG and CNVS requirements.

Table 3-1 reproduced from the ICNG, sets out the airborne noise management levels and how they are to be applied for residential receivers.

Table 3-1: Noise management levels at residential receivers

Time of day	Management level $L_{Aeq\ (15\ min)}$ [1]	How to apply
Recommended standard 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 + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq\ (15\ min)}$ 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 dB(A)	The highly noise affected 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 restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before/ after school for works near schools, or mid-morning or mid-afternoon for works near residences 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see *ICNG* section 7.2.2.

Note: 1. Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 metre above ground level. If the property boundary is more than 30 metres from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 metres of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Table 3-2 sets out the ICNG noise management levels for other noise sensitive receiver locations. Where premises are noise-sensitive and cannot be suitably classified by the categories in this table, it is recommended that the recommended 'maximum' internal noise levels presented in AS/NZS 2107:2016 are adopted.

Table 3-2: Noise management levels at other noise sensitive land uses, dB(A)

Land use	Time of day	Where objective applies	Management level $L_{Aeq\ (15\ min)}$
Childcare centre[2]	When in use	Outdoor noise level	50 [2]
Classrooms at schools and other educational institutions	When in use	Indoor noise level Outdoor noise level[1]	45 55[1]
Hospital wards and operating theatres	When in use	Indoor noise level Outdoor noise level	45 65[7]
Places of worship	When in use	Indoor noise level Outdoor noise level[1]	45 55
Hotel/Motel/Hostel	When in use	Indoor noise level Outdoor noise level [5]	40 60
Community centres	When in use	Indoor noise level Outdoor noise level [6]	40 [6] 60 [6]
Active recreation areas [4]	When in use	Outdoor noise level	65
Passive recreation areas [3]	When in use	Outdoor noise level	60
Commercial premises	When in use	Outdoor noise level	70
Industrial premises	When in use	Outdoor noise level	75

Notes:
1. Outdoor noise level based on internal noise level in ICNG and assumes 10 dB loss through an open window
2. An external screening level of 50 dB(A) is adopted for assessing childcare centres, based upon the recommended noise levels in the Association of Australian Acoustical Consultants (AAAC) Guideline for Child Care Centre Acoustics Assessment (2020). This considers the centre has sleeping areas.
3. Passive recreation - Areas used for low intensity and low noise producing activities which could be impacted by external noise such as reading or meditation
4. Active recreation - Sports fields/activities which generate their own noise and are generally less sensitive to external noise
5. Based upon AS2107 (Sleeping areas: Hotels near major roads), and 20 dB(A) outside to inside difference (closed windows)
6. Community centres have been assessed to an external noise level of 60 dB(A). Depending on the intended use of the centre, the noise management level may vary.
7. Outdoor noise level based on internal noise level in ICNG and assumes 20 dB loss through a closed window as the building is assumed to have fresh air supplied internally (ie. mechanical ventilation).

3.1.3 Sleep disturbance

The ICNG recommends that where construction works are planned to extend over two or more consecutive nights, the Proposal should consider maximum noise levels and the extent and frequency of maximum noise level events exceeding the RBL. The potential for both sleep disturbance and awakenings should be considered in the assessment.

To assess the likelihood of sleep disturbance, an initial screening level of $L_{Amax} < L_{A90(15min)} + 15$ dB(A) is used. This is an external noise level, while receivers will be located inside when there is potential for sleep disturbance impacts. Typically when considering internal noise impacts using a conservative 10 dB(A) reduction from external noise levels to internal noise levels is assumed considering an open window in line with the ICNG, which is not always the case and could be greater especially in the case that the receivers have a closed windows/facade. Sealed facades or facades with windows closed can provide external to internal noise reductions much greater than 10 dB(A). Noise reductions greater than 20–25 dB(A) are achievable where facades consist of standard to thick glazing and heavy facade construction (eg. brick construction).

Where there are noise events found to exceed the initial screening level, further analysis is made to identify:

- The likely number of events that might occur during the night assessment period
- Whether events exceed an 'awakening reaction' level of L_{Amax} 65 dB(A) (assumed equivalent to L_{Amax} 55 dB(A) internal).

The sleep disturbance assessment levels for the project are presented in Table 3-3.

3.1.4 Summary of construction noise management levels

Table 3-3 presents the construction noise management levels established for the nearest noise sensitive residential receivers based upon the noise monitoring outlined in Section 2.3.

Table 3-3: Construction noise management levels at residential receivers, dB(A)

Rating background level (RBL)			Noise management level $L_{Aeq(15min)}$				Sleep disturbance[3] L_{Amax}	
Day	Evening	Night	Day (Standard)[1]	Day (OOH)[2]	Evening (OOH)[2]	Night (OOH)[2]	Screening level	Awakening reaction
41	43	40	51	46	48	45	55	65

Notes:
1. Standard construction hours, as defined in Section 4.1.
1. OOH = outside standard construction hours, as defined in Section 4.1
2. Assessed during the night period only (10:00 pm to 7:00 am)
3. See Table 2-4 for more information.

3.2 Construction-related road traffic noise

When trucks and other vehicles are operating within the boundary of a construction site, road vehicle noise contributions are included in the overall predicted $L_{Aeq(15minute)}$ construction site noise emissions. When construction-related traffic moves onto the public road network a different noise assessment methodology is appropriate, as vehicle movements would be regarded as 'additional road traffic' rather than as part of the construction site.

Construction-related traffic operating on the public road network, especially heavy vehicle movements travelling on roads located immediately adjacent to construction sites are likely to be associated to the Proposal by the community. However, once the heavy vehicles move further from the Proposal construction site onto major sub-arterial or arterial roads, the noise may be perceived as being part of the general road traffic.

Noise from construction traffic on public roads is not assessed under the ICNG, although the guideline does reference the *Environmental Criteria for Road Traffic Noise* (EPA 1999), which has been superseded by the RNP. The RNP states that in assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person. For existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments (in this case the construction area), any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'without construction' scenario.

Where the road traffic noise levels are predicted to increase by more than 2 dB as a result of construction traffic, consideration would be given to applying feasible and reasonable noise mitigation measures to reduce the potential noise impacts and preserve acoustic amenity.

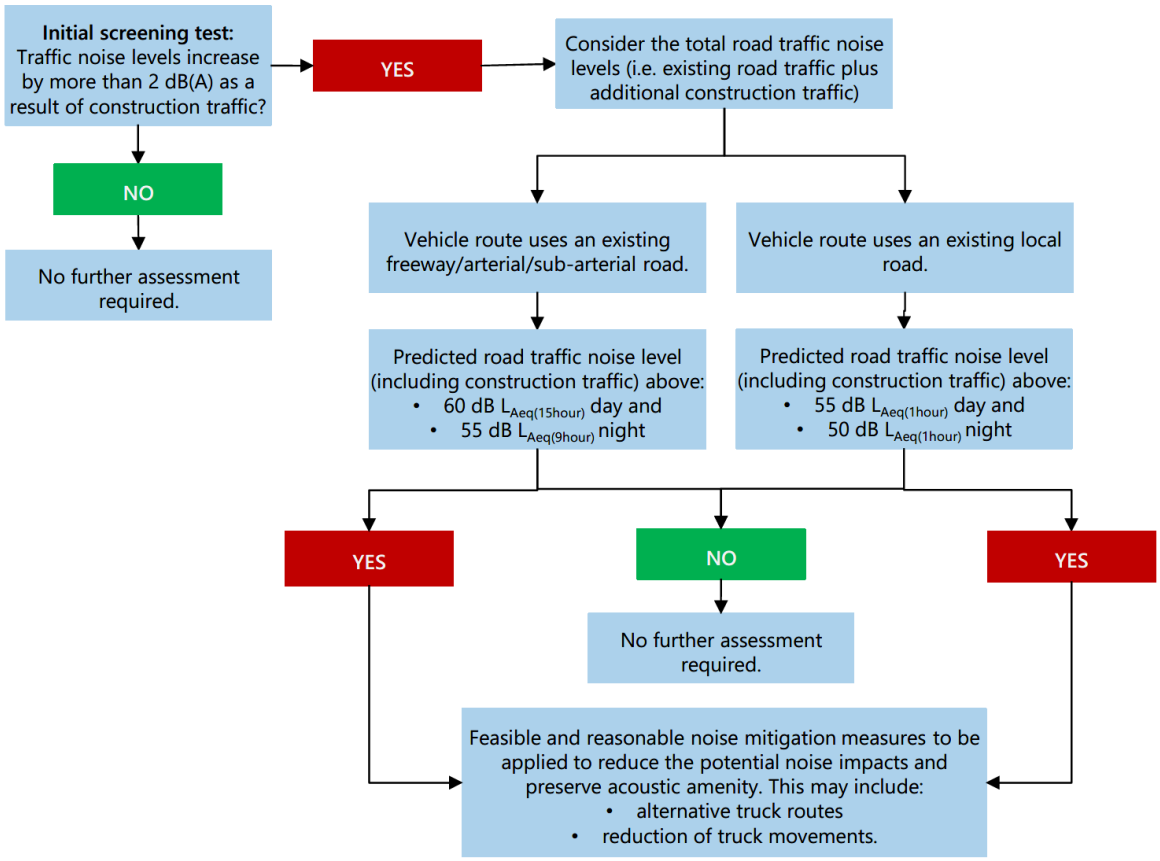
In considering feasible and reasonable mitigation measures where the relevant noise increase is greater than 2 dB, consideration should be given to the actual noise levels associated with construction traffic and whether these levels comply with the road traffic noise criteria in the RNP presented in Table 3-4.

Table 3-4: Construction-related road traffic noise assessment criteria

Road type	Day criteria (7:00am – 10:00pm)	Night criteria (10:00pm – 7:00am)
Freeway/ arterial/ sub-arterial roads	60 $L_{Aeq\ 15\ hour}$	55 $L_{Aeq\ 9\ hour}$
Local roads	55 $L_{Aeq\ 1\ hour}$	50 $L_{Aeq\ 1\ hour}$

The process that should be used to assess and manage potential noise impacts from construction traffic is presented in Figure 3-1.

Figure 3-1:Construction traffic noise assessment process



3.3 Construction vibration objectives

Construction vibration is associated with three main types of impact:

- disturbance to building occupants
- potential damage to buildings
- potential damage to sensitive equipment in a building.

Generally, if disturbance to building occupants is controlled, there is limited potential for structural damage to the buildings.

Construction vibration management levels have been determined in accordance with Section A.3 of CNVS.

3.3.1 Disturbance to buildings occupants

The acceptable vibration values to assess the potential for human annoyance from vibration are set out in the *Environmental Noise Management Assessing Vibration: A Technical Guideline* (AVTG) (DEC, 2006).

To assess the potential for vibration impact on human comfort, an initial screening test will be done based on peak velocity units, as this metric is also used for the cosmetic damage vibration assessment. The screening test is based on the continuous vibration velocity (ie. vibration that continues uninterrupted for a defined period). If the predicted vibration exceeds the initial screening test, the total estimated Vibration Dose Value (ie. eVDV) will be determined based on the level and duration of the vibration event causing exceedance.

The initial screening test values and VDVs recommended in BS 6472-1992 for which various levels of adverse comment from occupants may be expected are presented in Table 3-5. The 'Low probability of adverse comment eVDV' represent the preferred and maximum value presented in the AVTG.

Table 3-5: Vibration management levels for disturbance to building occupants

Place and Time	Initial screening test Velocity, PEAK, mm/s (>8Hz)	Low probability of adverse comment eVDV $m/s^{1.75}$	Adverse comment possible eVDV $m/s^{1.75}$	Adverse comment probable eVDV $m/s^{1.75}$
Critical areas (day or night)[1]	0.28	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Residential buildings 16 hr day[2]	0.56	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hr night[2]	0.40	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Offices, schools, educational institutions and places of worship (day or night)	1.10	0.4 to 0.8	0.8 to 1.6	1.6 to 2.4
Workshops (day or night)	2.20	0.8 to 1.6	1.6 to 3.2	3.2 to 6.4

1. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specified above.
2. Daytime is 7:00 am to 10:00 pm and night-time is 10:00 pm to 7:00 am

3.3.2 Damage to buildings or structures

Potential structural damage of buildings as a result of vibration is typically managed by ensuring vibration induced into the structure does not exceed certain limits and standards, such as British Standard *BS 7385 Part 2 – 1993 Evaluation and measurement for vibration in buildings* and German Standard *DIN 4150-3: 2016 Structural Vibration – Part 3: Effects of vibration on structures*. There is no Australian Standard for assessment of structural building damage caused by vibration energy.

It is noted that vibration levels required to cause minor cosmetic damage are typically 10 x higher than levels that will cause disturbance to building occupants. Many building occupants assume that building damage is occurring when they feel vibration or observe rattling of loose objects, however, the level of vibration at which people perceive vibration or at which loose objects may rattle is far lower than vibration levels that can cause damage to structures.

BS 7385-2 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.

The recommended limits (guide values) from *BS 7385-2* for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 3-6.

Table 3-6: BS 7385 structural damage criteria

Group	Type of structure	Damage level	Peak component particle velocity, mm/s		
			4Hz to 15Hz	15Hz to 40Hz	40Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic	50		
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50

Notes:
1. Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.
2. PPV values increase between specified frequencies as detailed in BS7385-2
3. Values referred to are at the base of the building, as per Section 6.3 of BS7385-2

BS 7385-2 states that the guide values in Table 3-6 relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to 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 3-6 may need to be reduced by up to 50%.

BS 7385-2 goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 3-6 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 3-6 should not be reduced for fatigue considerations. It is noteworthy that, extra to the guide values nominated in Table 3-6, 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."*.

3.3.3 Heritage structures and items

Heritage items are considered on a case by case basis, and care should be taken as these structures can be difficult to repair in the case of damage. It should be noted that British Standard BS 5228-2:2009 states that *'a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive'* (p.39) when compared to other structures.

As part of the identification of noise and vibration sensitive receivers discussed in Section 2.1, potentially impacted heritage receivers should be identified nearby to the construction works areas. Included in the vibration assessment in Section 4.5 are the nearby identifies nearby heritage items and structures that are subject to heritage conservation as designated by the relevant NSW environmental planning instrument (EPI) under the *Environmental Planning and Assessment Act 1979*. Heritage conservation areas are not included in the assessment. At detailed design a further review of potentially impacted vibration-sensitive heritage receivers should be undertaken to ensure that vibration intensive construction activities are appropriately mitigated and managed.

Where a structure is found to have defects, or is structurally unsound following an inspection, maximum vibration criteria are to be established for that specific structure for works to not further damage the structure. As stated previously, German Standard DIN 4150: Part 3 provides guidance for structures that are sensitive to vibration (eg. structurally unsound).

A conservative vibration damage screening level of 2.5 mm/s has been adopted as a screening level for heritage structures. This does not necessarily reflect that there would be a vibration impact on the structure if this level is exceeded, instead it is a suitable vibration level that is used as part of the construction vibration management process to trigger further investigation.

Any heritage structure predicted to exceed the screening level would be further investigated during detailed design, and appropriate vibration criteria for the structure adopted. If a heritage building or structure is found to be structurally unsound (following inspection), the conservative cosmetic damage objective of 2.5 mm/s peak component particle velocity (from DIN 4150) would be considered, and appropriate protections put in place.

The general approach to manage potential vibration impacts on heritage items would be to:

1. Identify heritage items where the 2.5 mm/s peak component particle velocity objective may be exceeded during specific construction activities

2. Carry out a structural engineering report on identified heritage items, to confirm structural integrity of the building and confirm if item is 'structurally sound'
3. Adopt the appropriate screening level from BS7385 Part 2 if the item was confirmed as 'structurally sound', or
4. Adopt the more conservative cosmetic damage level of 2.5 mm/s (long-term impacts) or 3 mm/s (short term impacts, with additional consideration for frequency as outlined in DIN 4150-3: 2016) peak component particle velocity if the item was confirmed as 'structurally unsound'.

3.3.4 General vibration (building damage) screening criterion

In accordance with *BS 7385-2* and *DIN 4150-3*, a conservative vibration damage screening level (peak component particle velocity) per receiver type is detailed in the CNVS and outlined below:

- reinforced or framed structures: 25.0 mm/s
- unreinforced or light framed structures: 7.5 mm/s
- heritage structures (structurally unsound): 2.5 mm/s.

Where the predicted and/or measured vibration is greater than shown above, a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure will be completed to determine the applicable vibration limit.

3.3.5 Damage to vibration sensitive equipment

Some high technology manufacturing facilities, hospitals and laboratories utilise equipment that is highly sensitive and susceptible to vibration, for example scanning electron microscopes and micro-electronic manufacturing facilities. In addition, buildings housing sensitive computer or telecommunications equipment may require assessment against stricter criteria than those nominated for building damage.

There is no explicit guidance on acceptable vibration levels for such equipment, so recommended vibration levels should be obtained from instrument manufacturers. In the absence of equipment specific data provided by manufacturers, there are generic vibration criteria that can be used to assess the impact of vibration generating activities on buildings housing vibration sensitive equipment. For example, the Vibration Criteria (VC) curves are often referred to as they are generic and apply to all tools/ equipment types within each category. The VC curves are defined over the frequency range 8 to 100 Hz.

Table 3-7 below summarises a range of suitable and conservatively stringent vibration limits that are applicable to buildings housing vibration sensitive equipment which may potentially be affected by construction vibration.

Table 3-7: Acceptable vibration limits for vibration measured on building structure housing sensitive equipment

Equipment Requirements	Vibration Limit[1] mm/s,		Description of Use[3]
	RMS[4]	Peak [5]	
Computer Areas[2]	0.7	1.0	Barely perceptible vibration. Adequate for computer equipment accommodation environments.
Medical[2, 3]	0.1	0.14	Vibration not perceptible. Suitable in most instances for microscopes to 100X and for other equipment of low sensitivity.
VC-A[3]	0.05	0.07	Vibration not perceptible. Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc

Notes:
1. As measured in one-third octave bands of frequency over the frequency range 8 to 100 Hz. Vibration measured on the building structure near vibrating equipment or in areas containing sensitive equipment.
2. Based on AS 2834 Computer Accommodation
3. Gordon CG Generic Vibration Criteria for Vibration Sensitive Equipment
4. Root Mean Square value representing the average value of a signal
5. In the absence of Peak limits, RMS limits are converted to Peak by conservatively assuming the vibration signal is sinusoidal and random with a nominal crest factor of 1.414

3.3.6 Damage to buried services

Section 5.3 of DIN 4150-3 also sets out guideline values for vibration velocity to be used when evaluating the effects of vibration on buried pipework. These values, which apply at the wall of the pipe, are reproduced and presented in Table 3-8 below.

Table 3-8: DIN 4150-3 Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on buried pipework

Line	Pipe Material	Guideline values for vibration velocity measured on the pipe, mm/s
1	Steel (including welded pipes)	100
2	Vitrified clay, concrete, reinforced concrete, prestressed concrete, metal (with or without flange)	80
3	Masonry, plastics	50

For long-term vibration the guideline levels presented in Table 3-8 should be halved.

Recommended vibration goals for electrical cables and telecommunication services such as fibre optic cables range from between 50 mm/s and 100 mm/s. It is noted however that although the cables may sustain these vibration levels, the services they are connected to, such as transformers and switch blocks, may not.

It is recommended that should such equipment and pipework be encountered during the construction process an individual vibration assessment should be carried out. This may include a specific noise and vibration assessment addressing impact on the utility and consultation with the utility provider to confirm specific vibration requirements.

4 Construction noise and vibration assessment

4.1 Construction hours

4.1.1 Standard construction hours

The recommended standard hours for construction are defined in the ICNG and the CNVS. Whilst the standard construction hours are not mandatory, limiting construction works to within standard construction hours as much as practicable assists in managing noise or vibration impact and provides a lengthy respite period whilst people are most likely to be relaxing or sleeping.

4.1.2 Works outside standard construction hours

The ICNG identifies five categories of works that might be undertaken outside the recommended standard hours (OOH or OOHW):

1. the **delivery of oversized plant or structures** that police or other authorities determine require special arrangements to transport along public roads
2. **emergency work** to avoid the loss of life or damage to property, or to prevent environmental harm
3. **maintenance and repair of public infrastructure** where disruption to essential services and/or considerations of worker safety do not allow work within standard hours
4. **public infrastructure works** that shorten the length of the project and are supported by the affected community
5. works where a proponent demonstrates and justifies a **need to operate outside the recommended standard hours**.

All of the above categories may apply to the Proposal at different stages of the works. Mostly the last two categories will apply, and for these works clear justification for working outside standard hours for reasons other than convenience is required.

Construction hours, including OOH work periods are defined in Table 4-1. Construction work for the Proposal would be completed during standard construction hours wherever reasonable and feasible and can be undertaken under work site protection measures. As the proposed works are to be undertaken within the rail corridor. the existing rail traffic would impose major risks to construction workers due to the extremely close proximity between all parties involved. Safe work areas will be established to ensure the proposed construction activities have minimal impact on the safety of commuters whilst keeping construction workers a safe distance from rail traffic.

Notwithstanding this, some activities due to their location and plant/equipment requirements will need to occur during rail shutdown possessions to minimise the risks of rail traffic, commuter and work site interaction.

4.1.3 Summary of construction hours and work periods

Table 4-1: Construction hours

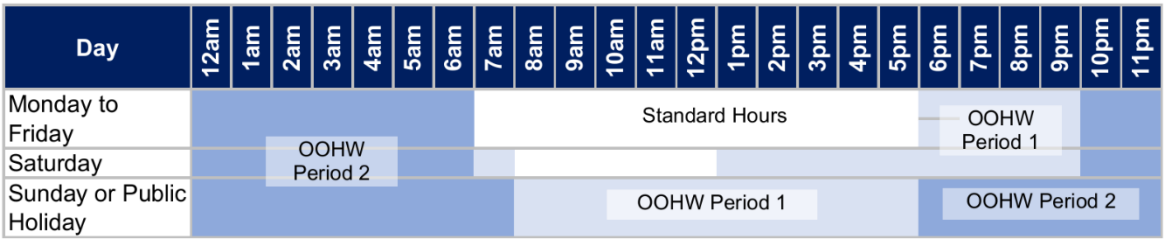
Construction hours	Monday to Friday	Saturday	Sunday/ Public holiday
Recommended standard construction hours			
Standard hours	7:00 am to 6:00 pm	8:00 am to 1:00 pm	No work
Activities with special audible characteristics[1]	8:00 am to 6:00 pm	9:00 am to 1:00 pm	No work
Outside standard construction hours			
Out of Hours Day (OOH(D))	N/A	1:00 pm to 6:00 pm	8:00 am to 6:00 pm
Out of Hours Evening (OOH(E))	6:00 pm to 10:00 pm	6:00 pm to 10:00 pm	6:00 pm to 10:00 pm
Out of Hours Night (OOH(N))	10:00 pm to 7:00 am	10:00 pm to 8:00 am	10:00 pm to 8:00 am

Note: 1. Special audible characteristics includes particularly annoying construction noise sources that may generate high noise impact, impulsive or tonal noise emissions, such as rock hammering. Where applicable, such activities should be limited to continuous blocks not exceeding three hours each with a minimum respite from those activities and works of not less than one hour between each block, unless otherwise approved by TfNSW.

The CNVS provides a hierarchy of OOH work periods. The impact of OOH works may be reduced by scheduling work and activities with greater impact during the preferred periods when receivers are likely to be less sensitive to noise and vibration, such as in the OOH(D) and OOH(E) periods. Table 4-2 presents the construction work periods as:

- Standard Hours
- OOHW Period 1
- OOHW Period 2.

Table 4-2: Construction work periods



1. Standard construction hours are defined in the CNVS as: Monday to Friday 7:00am to 6:00pm and Saturdays from 8:00am to 1:00pm.
2. Work outside of standard construction hours is defined as Out-of-Hours Work (OOHW) and can be divided into 2 periods of sensitivity. **OOHW Period 1** is the least sensitive OOH period and is defined as Monday to Friday 6:00pm to 10:00pm (evenings), Saturday 7:00am to 8:00am and 1:00pm to 10:00pm (day & evening) and Sunday and public holidays 8:00am to 6:00pm (days). **OOHW Period 2** is the most sensitive OOH period and is defined as Monday to Saturday 10:00pm to 7:00am (nights) and Sundays and public holidays 6:00pm to 8:00am (nights).

4.2 Construction noise and vibration activities and assumptions

4.2.1 Construction activities

The construction works associated with the Proposal are anticipated to take place about 15 weeks with up to 3 track possession periods (currently programmed for July to October 2023). Piling rig will be needed for bored piers and crane for bridge install.

As some of the proposed works are to be undertaken within the rail corridor, the existing rail traffic would impose major risks to rail users and construction workers due to the extremely close proximity between all parties involved. Safe work areas will be established to ensure the proposed construction activities have minimal impact on the safety of commuters whilst keeping construction workers a safe distance from rail traffic. Notwithstanding this, construction work is proposed during scheduled track possessions to minimise the risks of rail traffic and work site interaction, which are generally outside the standard construction working hours. This will require works during both standard and outside of standard hours including some night works.

Mobilisation and demobilisation of the temporary compound facilities located adjacent to the rail corridor will typically be undertaken during standard construction hours: however, access into this facility work may be required outside of standard hours (ie. delivery of structural bridge members) if restrictions on truck size and movements are applicable. An assessment of potential construction noise and vibration impact has been carried out to determine whether mitigation will be required and identify appropriate management controls. Specific construction equipment requirements are not yet known.

The construction staging and methodology, presented in Table 4-3, is indicative and is based on the current concept design. This would be further developed during the detailed design of the Proposal by the nominated Construction Contractor in consultation with Mirvac and Calibre Group. The construction assessment scenarios and the type and number of plant and equipment associated with the proposed works was assumed based upon the proposed construction details and activities provided by Calibre Group and from the Methodology Report (Document reference: *Footbridge over Main Southern Railway at Station Street, Menangle*, Methodology 1.0, Christie Civil Pty Ltd).

Further assessment may be required when final construction detail becomes available.

Table 4-3: Indicative construction staging for key activities and associated construction hours

Phase	Construction activities	Approximate duration[2]	Work hours[1]			
			Std.	OOHW		
				Day	Eve	Ngt
Preconstruction site investigation works	• Complete a dial before you dig (DBYD) search and engage an underground service locator to locate any utilities prior to the site investigation commencing • Collection of samples for geotechnical and contamination analysis as required	3 weeks (Weeks 4-6)	♦	-	-	-
Mobilisation and demobilisation of the temporary site compound and staging areas and enabling works+ temporary site compound support activities	• Establishment of compound facilities and staging areas (erect fencing, site offices, amenities and plant/material storage areas, demarcate the live rail corridor, etc.) • Establishment of environmental control measures such as erosion and sediment controls • Removal of temporary site facilities • Removal of environmental control measures • Completion of site clean-up, waste removal, and reinstatement works. • Investigations / identification of existing services and utilities and the relocation and/or protection of any affected services and/or utilities in the Proposal footprint • Site investigation works to inform the detailed design	*(Mobilisation and demobilisation)* 2 weeks (Weeks 2-3) and 4 weeks (Weeks 12-15)	♦	-	-	-
		(Temporary site compound support activities)	♦	-	-	-
Piling	• Piling platforms • Piling	5 weeks (Weeks 6-10)	♦	-	-	-
Form, reo & pour abutment	• Cast insitu concrete bridge abutment	3 weeks (Weeks 11-13)	♦	-	-	-
Installation of the bridge beams	• Receive and prepare bridge beam • Install bridge beam • Prepare & install bridge deck • Complete frames & mesh	5 weeks (Weeks 6-10) 1 possession	♦	♦	♦	♦

Notes: 1. Standard (Std.) construction hours is 7.00am to 6.00pm Monday to Friday and 8.00 am to 1.00 pm Saturday
OOHW (D) - Out-of-Hours Work (Day) is 1.00 pm to 6.00 pm Saturday and 8.00am to 6.00 pm Sunday/ Public holiday
OOHW (E) - Evening is 6.00 pm to 10.00 pm Monday to Friday and 6.00 pm to 10.00 pm Saturday/Sunday/ Public holiday
OOHW (N) - Night is 10.00 pm to 7.00 am Monday to Friday and 10.00 pm to 8.00 am Saturday/ Sunday/ Public holiday
2. Timeframes are indicative and may change.

4.2.2 Construction noise sources

Table 4-4 following summarises the likely plant and equipment and the assumed sound power levels for construction activities associated with the Proposal for the anticipated staging presented in in Table 4-3. This is not a comprehensive list of all potential plant and equipment but covers the key likely plant and equipment items. A further assessment will be required once final construction detail becomes available with progress of the detailed design. The sound power levels for the majority of activities presented in Table 4-4 are based on maximum levels given in Table A1 of Australian Standard 2436 - 2010 '*Guide to Noise Control on Construction, Demolition and Maintenance Sites*', ICNG, information from past projects and information held in the Renzo Tonin & Associates library files.

Table 4-4: Noise modelling assumptions for construction - activities and equipment

		Construction equipment	Concrete pump	Concrete vibrators	Daymaker	Generator	Elevated work platform	Excavator with bucket	Franna crane	Front end loader	Forklift	Hand tools	Vibratory roller	Truck (medium rigid)	Dump truck	Semi-trailer truck	Water truck	Plate compactor	Piling rig - bored	Vacuum truck	Regulator	Rail saw[3]	Rail profile grinder[3]	Ballast tamper	Mobile crane	Welding equipment	Concrete agitator	Drill rig (borehole)
		Sound Power level (Lw) (L_{Aeq})	103	106	93	94	102	105	98	110	103	104	109	103	108	108	103	108	112	108	114	118	114	111	110	105	108	106
		Assumed usage time (min)	15	15	15	15	15	7.5	15	7.5	7.5	15	15	15	15	15	7.5	7.5	15	15	15	5	7.5	15	15	15	15	7.5
		Sound Power level (Lw) (L_{Amax})	-	-	95	-	105	108	102	113	-	108	-	117	117	117	117	-	115		-	121	117	-	114	-	-	108
Ref.	Stage	Construction activity	Activity Lw, dB(A) $L_{Aeq15min}$[1]	Activity Lw, dB(A) L_{Amax}																								
S1	Preconstruction site investigation works	Site investigation (utilities), validation of detailed site survey	112	117				•		•			•				•				•							
S2	Temporary site compound and staging area	Site preparation/ demobilisation *(standard hours only)*	110	117						•	•		•				•											
S3		Site compound activities (ie. laydown)	106	117				•			•		•		•													
S4	Piling	Civil related (footings excavation works)	114	117				•	•	•	•		•						•	•								
S5	Form, reo & pour abutment	Civil related (concreting, installation works)	110	117	•	•	•	•		•	•		•				•											•	
S6	Installation of the bridge beams	OHW works - A 300T crane (estimated) will be used for the installation of the bridge beams	112	117			•	•	•		•		•		•		•								•		•	

Notes:
1. Activity $L_{Aeq15min}$ sound power levels (L_W) are based upon the loudest 3 items of plant/equipment operating simultaneously in the same location. Number of units operating at any one time may change on site.
2. Assumptions in table are for modelling purposes, based on a conservative, but realistic estimate of equipment operating concurrently for each activity.
3. Activity L_{Amax} sound power levels (L_W) is based upon the loudest item of plant/equipment for equipment potentially used during the night period with high noise events.
4. In accordance with the ICNG and the TfNSW CNVS, a 5 dB(A) 'penalty' is applied for activities identified as particularly annoying, such as rock hammers, power saws and grinding operations.

4.3 Construction airborne noise assessment

Construction noise levels were predicted by modelling the noise sources, receiver locations, and operating activities across 6 different construction scenarios based on the information presented in Section 4.2.1.

4.3.1 Noise prediction methodology

A noise model was developed for the Proposal using the CadnaA computer modelling program and noise levels were predicted using the noise propagation algorithm ISO 9613-2 (1996), which incorporates moderately adverse meteorological conditions, implemented in accordance with ISO/TR 17534-3 (2015).

The noise prediction model considers:

- Location of noise sources and sensitive receiver building locations
- Height of sources and receivers referenced to digital ground contours for the site and surrounding area
- Sound Power Levels (L_W) of plant and equipment likely to be used during the various construction activities
- Each noise-sensitive building in the project has been assessed separately, considering all facades
- Separation distances between sources and receivers
- Acoustic shielding, potential reflections and attenuation from intervening structures, barriers and topography (natural and purpose built)
- Ground absorption between the source and receiver, typically assuming 0.5.

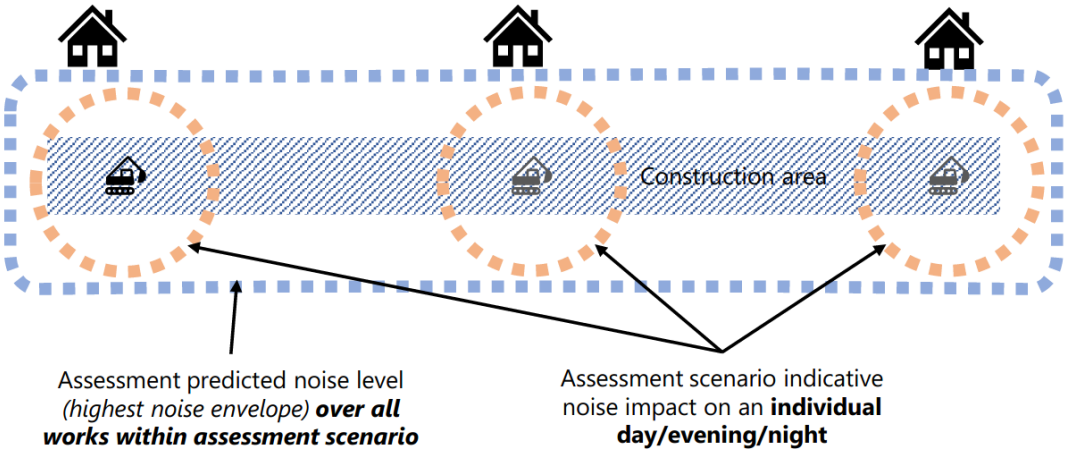
Construction noise levels are assessed at the most noise affected facade and floor level of a receiver building. Construction noise levels experienced at other points on the building may be lower.

The predicted levels are conservative and represent the equipment/plant operating simultaneously in any 15-minute period. Where plant items are not operating simultaneously, or for reduced times in a 15-minute period, noise impacts could be lower than predicted.

A 5 dB(A) penalty in accordance with the ICNG has been factored into the noise modelling levels where applicable to allow for particularly annoying activities, such as rock hammering, saw cutting and jack hammering.

Additionally, these noise levels assume that the assessed activities could occur anywhere within the assessed construction works area, with the predicted level based upon when works are at the closest point to each receiver. While in practice, noise intensive construction works would occur at different locations throughout the work area, resulting in differing noise levels at each receiver. This means that predicted noise levels are only likely to occur when works are at the closest point to each receiver. The noise impacts may be lower than predicted as the construction activities move around or progress around the construction site. This concept is demonstrated in Figure 4-1, and should be considered when reviewing the predicted noise levels in this assessment.

Figure 4-1:Predicted level are based works at the closest point of the entire works area, which differs from individual day/evening/night periods



The following sections colour code the predicted impact based upon Table 4-5 so that the amount the predicted noise level is over the NML can be reviewed directly against the categories presented in the TfNSW CNVS provided in Section 4.6.5.

Table 4-5: Key to the predicted construction noise results tables

Assessment	Time of day	Key			
$L_{Aeq(15min)}$	Standard hours[1]	0-10 dB(A) over NML (light blue) Clearly audible	11-20 dB(A) over NML (mid blue) Moderately intrusive	>20 dB(A) above NML (dark blue) Highly intrusive	
	Outside standard hours	1-5 dB(A) above NML (green) Noticeable	6-15 dB(A) above NML (yellow) Clearly audible	16-25 dB(A) above NML (orange) Moderately intrusive	>25 dB(A) above NML (purple) Highly intrusive
Sleep disturbance	Night only	L_{Amax} above sleep disturbance screening criterion (yellow)		L_{Amax} above awakening level (>65 dB(A), purple)	

Note: 1. Highly noise affected (HNA) which is greater than 75dB(A) is shown with **Bold** text and applies to residential receiver buildings only during standard construction hours.

4.3.1.1 Standard construction hours

A summary of the overall number of noise sensitive receivers predicted to potentially experience construction noise levels above the noise management level is presented in Table 4-6 for residential receivers.

The number of noise sensitive receivers identified in Table 4-6 are based upon the number of unique property addresses identified. As such, where there are multiple noise sensitive receivers within a unique property address, such as a receiver building with multiple apartments, or multiple buildings located on the one address (eg. townhouses), this will be counted only as one receiver for the purposes of the number of noise sensitive receiver properties. Where impacts are identified at properties with multiple dwellings during detailed design, a further review of the potential noise sensitive receivers within the property may be required to properly mitigate and manage construction noise impacts.

The construction works are next to the rail alignment. As such, where highly intrusive noise levels at receivers are identified, these may only be experienced by the nearest receiver locations, and as the works move further away, the noise levels experienced would be lower. As such, the indicated noise levels may only be experienced during a shorter period of the overall program. This concept can also be demonstrated in Figure 4-1, and should be considered when reviewing the predicted noise levels in this assessment.

Residential receivers

During standard construction hours, the assessment found that residential receivers located near to the construction work area have the potential to be noise affected (ie. > NML) during all construction stages. The highest impacts are during piling works, loud site investigation works, and civil related services works when they occur close to a residence.

Residences with direct line of site to works areas will be the most noise affected.

No receiver is predicted to be highly noise affected [ie. > 75 dB(A)] during the construction works.

For the main construction area, at the nearby sensitive receivers the noise predictions indicate that during typical loud works construction noise levels may be up to 20 dB of the NML which can be considered moderately intrusive.

Where possible, arrangements to the site layout of the temporary compound to provide acoustic shielding (ie. temporary site sheds, site storage containers, etc.) should be considered in the worksite design development.

Non-residential receivers

The predicted noise levels indicate that during the loud construction works, all non-residential receivers will be below NML and are not predicted to be noise affected.

It is important to note that the noise management levels for these facilities only apply when the facility is in use. As such it is unlikely that the places of worship will be impacted even though they will be used for services during potential weekend possession periods.

Impacts on other non-residential receivers are generally based upon conservative assumptions (ie. 10 dB(A) outside to inside noise reduction through an open window). As such, further mitigation and management measures are to be investigated during detailed design to identify when works are above the NML at individual non-residential receivers, and identify feasible and reasonable mitigation and management measures to reduce noise impacts as detailed in Section 4.6.

4.3.1.2 Outside of standard construction hours

As discussed in Section 4.1.2, works will need to be completed outside standard construction hours during rail possession periods. Table 4-6 presents a summary of the overall number of receivers predicted to potentially experience construction noise levels above the noise management level during the construction stages. Predicted levels at nearby residential receivers are less than 20 dB above the NML (ie. moderately intrusive) for all main construction works if loud activities are to occur during the night period (OOHW period 2).

Due to the very close proximity of residences, care will need to be taken during the OOHW periods to ensure that loud construction work that cannot be undertaken during the daytime period, occurs behind close fitting site hoardings or temporary noise barriers, where practicable. This will provide 5 to 10 dB(A) noise reduction, where line of sight is broken between the noise source and receiver. In addition, works should be scheduled such that loud plant and equipment (eg. rail saw, grinding, loaders, tipper trucks, rollers or equipment with prominent bangs/clangs) are minimised at night. For rail possession and non-possession periods these activities could be scheduled to take place during the daytime or evening period (prior to 10:00pm or not beyond midnight, where practicable).

Noise mitigation measures are described in Section 4.6 to further reduce noise levels, where reasonable and feasible, or to manage impacts where they occur. Where all reasonable and feasible mitigation measures have been applied and noise levels are still above the relevant noise objectives, additional noise management measures are provided to manage the impact on the community surrounding the construction works as detailed in Section 4.6.5.

The potential for sleep disturbance at night has also been considered. The predicted noise levels indicate that without noise mitigation, there is potential for noise levels from instantaneous noise events at the residential receivers closest to the work areas to be above the sleep disturbance screening level; however, predicted instantaneous noise levels do not exceed the awakening reaction external noise level of 65 dB(A) L_{Amax} for the residences.

Identified noise events with the potential to disturb sleep are high instantaneous noise events such as metal-on-metal clangs/bangs (ie. excavator buckets), air-releases from equipment with compressed air or high instantaneous noise events caused by hand tools. Where these events can be managed or the items are not required during the night period, noise levels from instantaneous noise events are less likely to disturb sleep.

Across each of the construction works it will be important to implement management measures as detailed in Section 4.6.2 to minimise the number and level of maximum noise events associated with the construction works. Management measures should be implemented where feasible and reasonable such as arranging the temporary site compound sites sheds and structures to shield noise generating works from nearby receivers, limiting acceleration/engine revving on site, use of broadband reversing alarms on heavy vehicles/equipment and managing works to prevent metal-on-metal bangs for works where this could occur. Construction mitigation and management measures are provided in Section 4.6 to assist in reducing OOHW construction noise impacts to receivers.

Table 4-6: Number of receiver properties over the noise management level - residential receivers

Stage	Construction activity	Assessment reference	Highly noise affected[2] L_{Aeq}	Day (standard hours) L_{ea}			Day (outside standard hours) L_{Aeq}				Evening L_{Aeq}				Night L_{Aeq}				Sleep disturbance L_{Amax}	
			> 75 dB(A)	1 – 10 dB(A)	11 – 20 dB(A)	> 20 dB(A)	1 – 5 dB(A)	6 – 15 dB(A)	16 – 25 dB(A)	> 25 dB(A)	1 – 5 dB(A)	6 – 15 dB(A)	16 – 25 dB(A)	> 25 dB(A)	1 – 5 dB(A)	6 – 15 dB(A)	16 – 25 dB(A)	> 25 dB(A)	Screening	Awakening
Pre-construction site investigation works	Site investigation (utilities), validation of detailed site survey,	S1	**0**	27	0	0	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]
Temporary site compound and staging area	Site preparation/ demobilisation *(standard hours only)*	S2	**0**	14	0	0	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]
	Site compound activities (ie. laydown)	S3	**0**	1	0	0	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]
Piling	Civil related (footings excavation works)	S4	**0**	32	1	0	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]
Form, reo & pour abutment	Civil related (concreting, installation works)	S5	**0**	14	0	0	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]	-[3]
Installation of the bridge beams	OHW works - A 300T crane (estimated) will be used for the installation of the bridge beams	S6	**0**	27	0	0	28	27	0	0	27	14	0	0	32	28	0	0	10	0

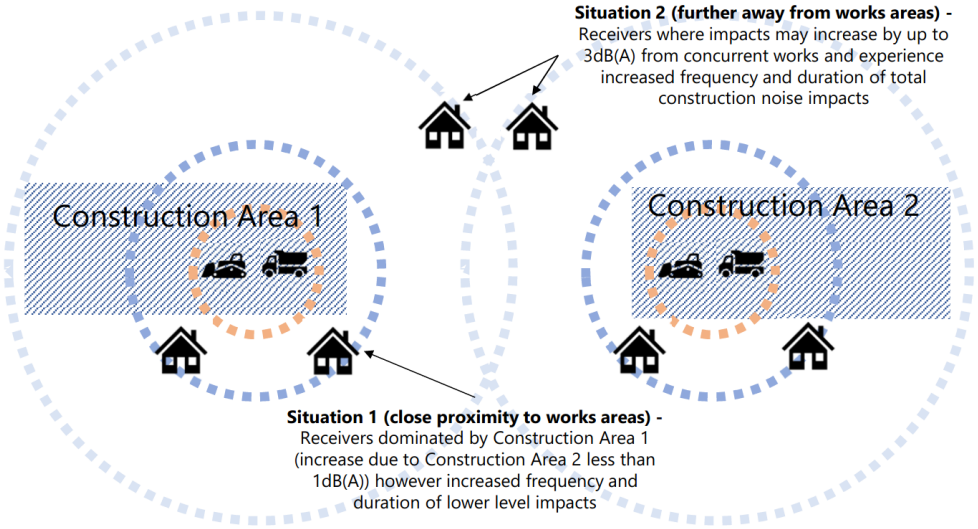
Notes:
1. Construction noise level cells are shaded based upon the predicted worst case NML exceedance of the controlling time period in accordance with the key presented in Table 4-5.
2. Highly noise affected applies during standard hours, as per the ICNG.
3. No typical work is proposed outside standard construction hours.

4.3.1.3 Cumulative major project construction noise

Currently the other known construction projects in the nearby vicinity are the construction of the new dwellings on the subdivided lots by Mirvac, directly west and south from the works area.

Typically, while impacts from one project or one construction site may be relatively short-term or noise intensive periods intermittent, when multiple construction projects are occurring at the same time near to a particular receiver cumulative construction noise impacts can occur. This can mean that construction noise impacting a sensitive receiver may be louder than from an individual set up works (by up to 3 dB(A)), the overall duration of construction impacts may be overall longer or impacts more frequent. Typically, concurrent projects can impact nearby receiver locations in one of two ways, as also shown in Figure 4-2.

Figure 4-2: Cumulative construction noise impacts



In the case that there is potential for cumulative noise impacts from the Proposal combined with other concurrent construction projects it is recommended that mitigation and management measures are implemented to minimise cumulative impacts, as detailed in Section 4.6.3.

4.4 Construction-related road traffic

The proposed construction packages do not include a large number of associated heavy vehicles movements.

The majority of the proposed construction would be for deliveries to the site temporary laydown areas for items such as accommodate site offices, amenities, plant and equipment, and stockpiling of materials.

Materials and goods for the works will come by truck to the temporary site compound and staging areas. Access to and egress to the temporary site compound and staging areas would be via the local Station Street up along Stevens Road and the access way north of Moreton Park Road.

During peak construction periods, the highest levels of traffic generated during construction works is expected to be up to four heavy vehicle movements per hour during the day period.

It is estimated that up to four heavy vehicle movements (ie. two movement each way) along each of the proposed access routes, this would comply with the local road daytime criteria of 55 dB(A) $L_{Aeq,1hr}$. Based on the proposed traffic volumes, exceedances of the local road noise goals are not generally expected, however there may be minor exceedances if greater than this volume of movements is required during peak periods.

Construction heavy vehicles and delivery vehicles should be scheduled during standard construction hours where feasible and reasonable to minimise the likelihood of sleep disturbance. In addition, heavy vehicles use of local roads to access the construction sites should be avoided.

Considering the existing high traffic volumes of the major arterial roads, including heavy vehicles, and expected low number of construction vehicles associated with the project, it is unlikely that traffic noise levels would increase by more than 2 dB as a result of the project on these roads if appropriately managed.

4.5 Construction vibration assessment

The pattern of vibration radiation is very different to the pattern of airborne noise radiation and is very site specific as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver.

Accordingly, based on a database containing vibration measurements from past projects and library information, Table 4-7 presents the indicative minimum working distances for most vibration intensive plant proposed.

Table 4-7: Recommended minimum working distances for vibration intensive plant

Plant item	Rating/ description	Minimum working distance (metres)		
		Cosmetic damage		Human response
		Unreinforced or light framed structures (sound structure)	Structurally unsound heritage structures (unsound structure)	
Smooth drum roller	< 300 kN (typically 7-13 tonne)	15 metres[1]	31 metres	100 metres[1]
Plate compactor/ Wacker packer	Handheld	1 metres (nominal)	5 metres	15 metres
Jackhammer	Handheld[1]	1 metres (nominal) [1]	5 metres	Avoid contact with structure[1]

Note 1: Source: TfNSW Construction Noise and Vibration Strategy (Appendix D)

As a screening assessment, items potentially impacted by vibration were identified if they were located within the relevant minimum working distances from the various proposed vibration intensive activities. Non-heritage structures of heritage items or heritage curtilages were classified as unsound heritage structures for this review to identify heritage items within the minimum works distances.

As the nearest structures are located more than 31 metres away, it is unlikely that any of the identified receivers will be affected by vibration intensive works.

The vibration sensitive items are based on safe working distances for plant and equipment listed in Table 4-7 and could be subject to change based on the detailed design and construction methodology.

4.5.1 Cosmetic damage

No building or structure has been identified as within the cosmetic damage minimum working distances for sound or unsound structures during use of a vibration intensive equipment during that works.

4.5.2 Human response

The use of a vibratory rollers (compactor / smooth drum roller) would occur only for limited durations as part of the works. Therefore, the risk of human annoyance is considered low. However, occupants of up to 3 potentially occupied properties may be able to feel vibration when vibratory rollers are being used at some point during the works. Sensitive receivers, other than those directly adjacent to the works, are unlikely to feel vibration from other vibration intensive equipment.

The extent of mitigation and management required to limit potential impacts to receivers would be determined by not only the level of vibration, but also the duration that receivers are likely to be exposed to vibration above the perception level. This could be managed by, for example providing respite periods for the vibratory roller or limiting its use during the night period (OOHW Period 2), where practicable.

After applying all feasible and reasonable vibration mitigation measures, if vibration monitoring still identifies that measured vibration levels exceed the perception level, appropriate additional mitigation measures would be provided (see Section 4.6.5).

4.5.3 Vibration assessment summary

A review of the works areas and nearby sensitive buildings indicates there is generally a low risk of vibration impact as a result of the works considering the type of works and the distance offset to nearby vibration sensitive items/buildings/receivers. Additionally, vibration intensive activities are proposed for only one construction activity during the Proposal construction works, and so will be used minimally. However, where vibration intensive activities are required such as vibratory rollers, then vibration impacts should be managed. Measures for managing vibration impacts are described in Section 4.6.4.

4.6 Construction mitigation and management measures

4.6.1 Highly noise affected receivers

Due to the distance from the works to the nearby residential receivers, no residential receiver to the Proposal construction areas has been identified to be 'highly noise affected' [ie. exposed to noise levels that exceed 75 dB(A)] from any one assessment scenario.

To limit the impact, high noise impact activities will be carried out with respite periods, such that:

- high noise impact activities will only carried out between:
  - 8:00 am and 6:00 pm Monday to Friday; and
  - 8:00 am and 1:00 pm Saturday (noting that most works would occur during weekend possession periods, this time period should be preferred).
- high noise impact activities will be carried out in continuous blocks of up to 3 hours. Respite from high noise impact activities will be provided between each block for at least 1 hour. No high noise impact activities will be carried out during this 1-hour respite period.

Alternatively, potentially impacted receivers should be consulted to assist with identifying times identified when they are less sensitive to noise, and consideration for suitable periods of respite and restrictions on construction times. This should then be used to provide suitable periods of respite for these receivers.

It is recommended that works should be scheduled so that high noise generating plant and equipment is not required during the night period (OOHW Period 2), where feasible and reasonable.

Where high noise generating plant and equipment are required to be used during the night period (OOHW Period 2), respite periods would be implemented and/or duration reduction considered in consultation with the affected community to reduce the overall duration of impacts in accordance with the TfNSW CNVS.

4.6.2 Noise and vibration control measures

The assessment has determined that there could be a large number of receivers impacted, especially during the OOHW periods. Considering this, it will be important that a further assessment be undertaken once final construction details becomes available with progress of the detailed design as previously noted. As part of this assessment, reasonable and feasible considering the information detailed in this section, to ensure that the construction noise impacts are properly mitigated and managed.

Table 4-8 summarises actions that can be applied to manage the potential for noise and vibration to impact on sensitive receivers near the Proposal construction works, consistent with the standard mitigation and management measures detailed in Section 8.1 of the CNVS, which are to be applied where reasonable and feasible.

These should be considered and implemented where feasible and reasonable where there is potential for the noise and vibration management levels presented in Section 3 to be exceeded by the construction works either individually or cumulatively with other nearby projects.

Table 4-8: Noise and vibration mitigation and management measures

Action required	Applies to	Details	Estimated noise benefit
At-source mitigation measures			
Equipment selection	Airborne noise Vibration	Use quieter and less noise/vibration emitting construction methods where feasible and reasonable. Where loud plant and/or equipment are being used in construction works, where feasible and reasonable the selection of alternative quieter plant and/or equipment should be considered for tasks.	Variable. Minimise noise impact and reduce risk of annoyance.
Maximum noise levels	Airborne noise	The noise levels of plant and equipment (including rental plant) must have operating Sound Power or Sound Pressure Levels compliant with the allowable noise levels in Appendix C of the TfNSW CNVS.	Variable. Minimise noise impact and reduce risk of annoyance.
Rental plant and equipment	Airborne noise	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the allowable noise levels in Appendix C of the TfNSW CNVS.	Variable. Minimise noise impact and reduce risk of annoyance.
Use and siting of plant	Airborne noise Vibration	Simultaneous operation of noisy plant within discernible range of a sensitive receiver is to be avoided. - The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. - Plant used intermittently to be throttled down or shut down. - Noise-emitting plant to be directed away from sensitive receivers.	Up to 20 dB reduction + reduce vibration
Non-tonal and ambient sensitive reversing alarms	Airborne noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work. This should include delivery vehicles for OOHW where feasible and reasonable. Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level.	5-10 dB reduction
Minimise disturbance arising from delivery of goods	Airborne noise	Loading and unloading of materials/deliveries is to occur as far away as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible.	Variable. Reduce noise/ vibration impact + risk of annoyance.

Action required	Applies to	Details	Estimated noise benefit
Silencers on Mobile Plant	Airborne noise	Where possible reduce noise from mobile plant through additional fittings including: - Residential grade mufflers - Air Parking brake engagement is silenced. Ensure plant including the silencer is well maintained.	0-20 dB reduction Reduce annoyance + sleep disturbance.
Prefabrication of materials off-site	Airborne noise	Where practicable, pre-fabricate and/or prepare materials off-site to reduce noise with special audible characteristics occurring on site. Materials can then be delivered to site for installation.	5-20 dB reduction Reduce noise/ vibration impact + risk of annoyance
Engine compression brakes	Airborne noise	Limit the use of engine compression brakes at night and in residential areas. Ensure vehicles are fitted with a maintained original equipment manufacturer exhaust silencer or a silencer that complies with the National Transport Commission's 'In-service test procedure' and standard.	5-20 dB reduction
Path mitigation measures			
Construction hoarding as noise barrier	Airborne noise	Any construction hoarding shall be installed on each worksite shall be constructed as a noise barrier, where practicable to provide shielding to the nearest affected receivers.	Receiver **with** line of site of the works area: 5-10 dB reduction Receiver **without** line of site of the works area: 0-5 dB reduction
Temporary site sheds and storage containers	Airborne noise	Site sheds or storage containers are to be located within the temporary site compound so that they will provide acoustic shielding to nearby residences from the noise generating works.	Receiver **with** line of site of the ancillary facility works area: 5-10 dB reduction
Laydown and stockpiling	Airborne noise	Locate laydown and staging areas within the temporary site compound or construction area as far from residences as practicably possible.	Variable. Minimise noise impact and reduce risk of annoyance.
Shield stationary noise sources such as pumps, compressors, etc.	Airborne noise	Stationary noise sources should be enclosed or shielded whilst ensuring that the occupational health and safety of workers is maintained. Appendix F of AS 2436: 1981 lists materials suitable for shielding.	5-10 dB reduction
Use temporary noise barriers around work area	Airborne noise	Where works are to be completed as OOHW outside the construction hoarding area, relocatable noise barriers e.g. acoustic blankets hung from temporary construction fencing would be used, where practicable.	Receiver **with** line of site of the works area: 5-10 dB reduction Receiver **without** line of site of the works area: 0-5 dB reduction
Mobile noise screens	Airborne noise	Where practicable, a mobile noise screen/tent would be used to reduce noise from moving plant items. Mobile noise screens utilise aluminium mobile scaffold (or similar), with acoustic blanket/ quilt (eg. Echo-barrier, FlexShield or similar) attached on up to 4 sides (including the top, where no solid platform). Mobile noise screens can provide 5 to 10 dB noise reduction, where they can break line of sight between the source and the receiver.	Receiver **with** line of site of the works area: 5-10 dB reduction Receiver **without** line of site of the works area: 0-5 dB reduction

Action required	Applies to	Details	Estimated noise benefit
Management measures			
Construction Environmental Management Plan update	Airborne noise Vibration	The CEMP including at minimum relevant section for construction noise and vibration management must be prepared prior to the commencement of construction and regularly updated to account for changes in noise management issues and strategies.	-
Implement stakeholder consultation measures	Airborne noise	Periodic notification (monthly letterbox drop and website notification) detailing all upcoming construction activities delivered to sensitive receivers at least 7 days prior to commencement of relevant works. In addition to Periodic Notification, the following strategies may be adopted to notify the community of upcoming works: • Project Specific Website • Project Infoline • Email Distribution List • Web-based Surveys • Social Media • Community and Stakeholder Meetings.	Keeps stakeholders informed of the likely impact. Community may identify solution to assist in managing impacts.
Register of noise and vibration sensitive receivers	Airborne noise Vibration	A register of most affected noise and vibration sensitive receivers (NVSRs) would be kept on site. The register would include the following details for each NVSR: • Address of receiver • Category of receiver (eg. Residential, Commercial, etc.) • Contact name and phone number. The register may be included as part of the Project's Community Liaison Plan or similar document.	Assists with keeping stakeholders informed of the likely impact. Assists with planning and reducing potential noise/ vibration impact + risk of annoyance
Construction hours and scheduling	Airborne noise Vibration	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise levels and vibration intensive plant identified within minimum working distances for human response should be scheduled during less sensitive time periods, such as after 8 am and before 6 pm. If the work cannot be undertaken during the day, it should be completed before 11 pm.	Minimise noise and vibration impact and reduce risk of annoyance.

Action required	Applies to	Details	Estimated noise benefit
Receiver respite for highly noise affected receivers	Airborne noise	Where feasible and reasonable, limit the impact, high noise impact activities will be carried out with respite periods, such that: • high noise impact activities will only be carried out between: - 8:00 am and 6:00 pm Monday to Friday; and - 8:00 am and 1:00 pm Saturday (noting that most works would occur during weekend possession periods, this time period should be the preference). • high noise impact activities will be carried out in continuous blocks of up to 3 hours. Respite from high noise impact activities will be provided between each block for at least 1 hour. No high noise impact activities will be carried out during this 1-hour respite period. Where high noise generating plant and equipment are required to be used during the night period (OOHW Period 2), respite periods would be implemented and/or duration reduction considered in consultation with the affected community to reduce the overall duration of impacts in accordance with the TfNSW CNVS.	Minimises noise impact.
Site inductions	Airborne noise Vibration	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • All relevant project specific and standard noise and vibration mitigation measures • Permissible hours of work • Any limitations on noise generating activities with special audible characteristics • Location of nearest sensitive receivers • Construction employee parking areas • Designated loading/unloading areas and procedures • Site opening/closing times (including deliveries) • Environmental incident procedures.	Keeps construction workforce informed of actions required to minimise noise and vibration impact.
Behavioural practices	Airborne noise	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors. No excessive revving of plant and vehicle engines. Controlled release of compressed air.	0-20 dB reduction Reduce annoyance + sleep disturbance.
Heavy Vehicle Code of Conduct	Airborne noise	Develop a Heavy Vehicle Code of Conduct (HVCC) for all drivers to adhere to. The HVCC would require appropriate training of project contractors. It would include noise management methods such as limiting idling and compression braking, and traffic management practises to minimise noise emissions from vehicles entering and leaving the site.	Minimises noise impacts
Verification monitoring	Airborne noise	A noise monitoring program should be carried out for the duration of works in accordance with the Construction Noise and Vibration Management Plan or Construction Environmental Management Plan and any approval conditions.	Minimises noise and vibration impact.

Action required	Applies to	Details	Estimated noise benefit
Attended vibration measurements	Vibration	Site-specific minimum working distances must be determined by the construction contractor prior to the use of plant close to or within the minimum working distances listed in Section 4.5. Where specified in the site assessment, or structures have been identified within the cosmetic damage minimum working distance, attended vibration measurements should be undertaken at the commencement of vibration generating activities to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage. If the monitoring above identifies that vibration is likely to exceed the structural damage objectives, a different construction method with lower source vibration levels should be considered.	Reduces vibration impact + risk of building damage.

4.6.3 Cumulative noise impacts

Currently the other known construction projects in the nearby vicinity are the construction of the new dwellings on the subdivided lots by Mirvac, directly west and south from the works area.

Where concurrent construction works are to occur, these noise impacts could result in overall greater construction noise impacts, either in terms of level or overall duration of exposure.

Where required, the following measures are to be used to mitigate and manage cumulative noise impacts along with potential construction fatigue:

- Coordinating work between construction sites to minimise cumulative noise impacts, where feasible and reasonable (ie. to ensure that the same sensitive receivers are not impacted on multiple consecutive nights from different projects without consideration of appropriate respite for these receivers). This is unlikely to occur as majority of the residential builts will be during daytime only.

- Additional feasible and reasonable at-source mitigation when there is the potential for cumulative construction impacts, where programming is not practical to avoid cumulative impact

- Community consultation to gauge key noise impacts and issues and identify any unknown impacts from concurrent or consecutive sets of constructions works

- Consideration of cumulative construction noise impacts during the development of noise mitigation and management measures for the worksites, including coordination between construction projects, where reasonable and feasible.

These mitigation measures would be included in each construction support site's detailed design and site-specific CNVIS. The project CNVMP would include how the above measures would be incorporated during the works.

4.6.4 Vibration impacts management

During detailed design a review of the potentially impacted items that fall within the minimum working distances for cosmetic damage as identified in Section 4.5 (heritage and otherwise) would be undertaken. Following this, condition surveys of all the potentially impacted buildings/structures would be completed prior to the commencement of construction work. The building/structure condition reports will also confirm the appropriate vibration criteria (ie. reinforced or unreinforced structures, structurally sound or unsound heritage buildings).

Site specific minimum working distances for vibration significant plant items will be measured on site where plant and equipment is likely to operate close to or within the recommended minimum working distances for cosmetic damage (see Section 4.5). Where plant is required to operate within the established site specific minimum working distances, vibration monitoring is recommended during the construction activity to verify that vibration levels achieve compliance with the structural damage objectives and alternative construction methodologies should be investigated.

Where monitoring above identifies that vibration is likely to exceed the structural damage objectives, a different construction method with lower source vibration levels should be considered.

Notification by letterbox drop would be carried out for all buildings in the vicinity of the construction site. As a minimum this should be all buildings within the worst case vibration intensive plant minimum working distance. These measures are to address potential community concerns that perceived vibration may cause damage to property. Notification is to be provided to all occupants prior to any works that may cause vibration.

A management procedure should be implemented to deal with vibration complaints. Each complaint should be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures should be put in place to mitigate future occurrences.

Where vibration is found to be excessive, management measures should be implemented to ensure vibration compliance is achieved. Management measures may include modification of construction methods such as using smaller equipment, establishment of minimum working distances as mentioned above, and if necessary, time restrictions for the most excessive vibration activities. Time restrictions are to be negotiated with affected receivers.

4.6.5 Additional mitigation measures

In accordance with the ICNG and the CNVS, all feasible and reasonable mitigation measures outlined in Sections 4.6.1 to Section 4.6.4 to minimise noise and vibration levels at the nearest receivers will be implemented, where practicable. The implementation of these measures should significantly reduce the noise and vibration impacts on nearby sensitive receivers.

Nevertheless, due to the highly variable nature of construction activities and the likelihood of work needing to be undertaken outside the standard construction hours, exceedances of construction noise objectives are likely to occur. Where construction noise and vibration levels are still predicted to exceed the noise objectives after implementing the standard mitigation measures, the Additional Mitigation Measures Matrices (AMMM) shall be used to determine the additional measures and implementation where reasonable and feasible in accordance with the CNVS, and in consultation with TfNSW communications representatives.

Table 4-9: Additional airborne noise management measures matrix

Construction hours	Predicted airborne $L_{Aeq(15min)}$ noise level at receiver			Additional mitigation measures
	Receiver perception	dB(A) above RBL	dB(A) above NML	
Standard Hours	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
	75 dBA or greater	**N/A**	**N/A**	**PN, V, SN**
OOHW Period 1	Noticeable	5 to 10	≤ 5	-
	Clearly Audible	> 10 to 20	> 5 to 15	PN, RP#, DR#
	Moderately intrusive	> 20 to 30	> 15 to 25	PN, V, SN, RO, RP#, DR#
	Highly intrusive	> 30	> 25	PN, V, SN, RO, RP#, DR#
OOHW Period 2	Noticeable	0 to 10	≤ 5	PN
	Clearly Audible	10 to 20	> 5 to 15	PN, V, SN, RO^, RP#, DR#
	Moderately intrusive	20 to 30	> 15 to 25	PN, V, SN, RO^, RP#, DR#
	Highly intrusive	> 30	> 25	PN, V, SN, RO^, RP#, DR#, AA

Notes: PN = Project notification RO = Project specific respite offer RP = Project specific respite offer
V = Verification monitoring AA = Alternative accommodation DR = Duration reduction
SN = Specific notifications, individual briefing or phone call

Respite periods and duration reduction are not applicable when works are carried out during OOHW Period 1 Day only (ie. Saturday 6am-7am & 1pm-6pm, Sundays / Public Holidays 8am-6pm)

^Respite offers during OOHW Period 2 are only applicable for evening periods (ie. Sundays / Public Holidays 6pm-10pm), and may not be required if a respite offer has already been made for the immediately preceding OOHW Period 1.

Table 4-10: Additional vibration noise management measures matrix

Construction hours	Receiver perception	above VML	Additional mitigation measures
Standard Hours	Human disturbance	> HVML	PN, V, RO
	Building damage	> DVML	V, AC
OOHW Period 1	Human disturbance	> HVML	PN, V, SN, RO, RP, DR
	Building damage	> DVML	V, AC
OOHW Period 2	Human disturbance	> HVML	PN, V, SN, RO, RP, DR, AA
	Building damage	> DVML	V, AC

Notes: PN = Project notification; V = Verification monitoring; SN = Specific notifications, individual briefing or phone call; AC = Alternative construction methodology; RO = Project specific respite offer; AA = Alternative accommodation; RP = Project specific respite offer; DR = Duration reduction

Reasonable measures to ameliorate noise and/or vibration impact will need to be considered based on the level of impact and duration of the works, including:

- short term residual impacts from specific construction activities that generate noise or vibration above the management levels, where these works are not in the highly sensitive night period and occur over a shorter timeframe (eg. 1 to 2 weeks). Consideration should be given to offering respite in the form of movie tickets, coffee/meal vouchers or similar.

- short term residual impacts where a specific phase of the construction work generates noise or vibration that exceeds the management levels within the highly sensitive night period. Consideration should be given to offering alternative accommodation for the duration of the noise or vibration impact.

5 Conclusion

This noise and vibration impact assessment has been prepared to describe and assess the noise and vibration impacts associated with the Pedestrian Bridge Crossing project proposal.

The noise and vibration assessment has investigated potential impacts from:

- Construction noise and vibration impacts from the Proposal's construction works.

5.1 Construction noise and vibration assessment

An assessment of construction noise impact from the Proposal construction works has been undertaken. Noise emissions from the proposed construction works have been predicted and assessed against the relevant noise management levels set by the ICNG and the Transport for NSW *Construction Noise and Vibration Strategy* (2019) (CNVS) during the recommended standard hours for construction. Potential impacts from out of hours construction works during rail possession periods has also been assessed.

The construction works associated with Proposal are likely to take place about 15 weeks with up to 3 track possession periods (currently programmed for July to October 2023). Piling rig will be needed for bored piers and crane for bridge install.

As some of the proposed works are to be undertaken within the rail corridor, the existing rail traffic would impose major risks to rail users and construction workers due to the extremely close proximity between all parties involved, the majority of the works will have to be undertaken during possession periods which will require works during both standard and outside of standard hours including night works.

Construction noise levels were predicted by modelling the likely construction noise sources to nearby noise sensitive receiver locations across six construction activity scenarios that are likely to occur.

Airborne construction noise

During standard construction hours, the assessment found that residential receivers located near to the construction work area have the potential to be noise affected (ie. > NML) by the works during all construction stages. The highest impacts are during piling works, loud site investigation works and civil related services works when they occur close to a residence.

The residences with direct line of site to works areas are likely to be the most noise affected.

During standard construction hours, for the main construction area, the predictions indicate that during typical loud works, construction noise levels may be up to 20 dB of the NML which can be considered moderately intrusive. No residence is predicted to be highly noise affected [ie. > 75 dB(A)] at any stage during the construction works.

Arrangements to the site layout of the temporary compound to provide acoustic shielding (ie temporary site sheds, site storage containers, etc.) should be considered further.

As the works are to be carried out within an active rail corridor, some of the activities will need to be completed outside standard construction hours during rail possession periods or during the midnight to dawn shutdown period. Works outside standard construction hours are likely to be moderately intrusive at nearby residential receivers during construction works, depending upon the noise intensiveness of the construction activities and mitigation and management measures that are implemented. Activities with the potential to disturb sleep such as metal-on-metal clangs/bangs (ie. excavator buckets), air-releases from equipment require management to minimise the potential for sleep disturbance, for both the main works area and the site compounds and laydown area. Where construction noise and vibration levels are still predicted to exceed the noise objectives after implementing all feasible and reasonable mitigation measures determined through a further review at detailed design, the TfNSW CNVS Additional Mitigation Measures Matrices (AMMM) should be used to determine the additional measures that should be implemented where reasonable and feasible.

No non-residential receiver has been predicted to be noise impacted.

Construction vibration

The potential vibration impacts to receivers have been reviewed against the relevant guidelines for structural damage from vibration and for human disturbance. The risk of structural damage to property is assessed as low for most nearby receivers. Further assessment of vibration impact may be required at the detailed design phase to ensure vibration impact is managed and mitigated where feasible.

Construction traffic

Construction traffic noise has been reviewed in accordance with the RNP and considering that the proposed construction packages do not include a large number of associated heavy vehicles movements the noise increase from construction-related traffic is expected to be minor and inconsequential, if managed appropriately.

Due to the predicted impacts determined in this assessment, recommendations to manage and/or minimise noise and vibration impacts where they occur for the construction works associated with the Proposal have been provided in Section 4.6 and are to be reviewed and incorporated during detailed design where feasible and reasonable.

5.2 Operational noise and vibration assessment

In regard to the operation of the Proposal, Renzo Tonin and Associates does not envisage any ongoing noise and vibration emissions once the pedestrian bridge is operational. The decking will be constructed out of in-situ concrete so any noise and vibration associated with footfall will be minimal. Accordingly, operational noise is not addressed further in the report.

References

1. ASHRAE Applications Handbook (SI) (2003), Chapter 47 Sound and Vibration Control, pp47.39-47.40

2. British Standard (2008), *BS 6472-2008: Evaluation of human exposure to vibration in buildings (1-80Hz)*

3. British Standard (2009), *Code of practice for noise and vibration control on construction and open sites- Part 2: Vibration*, BS 5228-1:2009

4. NSW Department of Climate Change and Water (2011), *Road Noise Policy* (RNP)

5. NSW Department of Environment and Climate Change (2009), *Interim Construction Noise Guideline* (ICNG)

6. NSW Department of Environment Conservation (2006), *Assessing Vibration; a technical guideline* (AVTG)

7. NSW Environment Protection Authority (1999), *Environmental Criteria for Road Traffic Noise* (ECRTN)

8. NSW Environment Protection Authority (2013), *Rail Infrastructure Noise Guideline* (RING)

9. NSW Environment Protection Authority (2016), *Noise Policy for Industry* (NPfI)

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

11. Standards Australia (2016), *Guide to Noise Control on Construction, Demolition and Maintenance Sites*, AS 2436:2010 (R2016)

12. Transport for NSW (2019), *Construction Noise and Vibration Standard* (2019) (DMS-ST-157, Revision 4.2 with revised Table 8 and 9) (CNVS)

13. International Organization for Standardization (1996), *Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation*, ISO 9613-2:1996

14. International Organization for Standardization (2015), *Acoustics - Software for the calculation of sound outdoors - Part 3: Recommendations for quality assured implementation of ISO 9613-2 in software according to ISO 17534-1*, ISO/TR 17534-3:2015

15. British Standard (1993), BS 7385: Part 2-1993 Evaluation and Measurement for Vibration in Buildings

16. German Standard (2016), *DIN 4150-3: 2016-02, Structural vibration - Effects of vibration on structures*

APPENDIX A Glossary of terminology

A.1 Glossary of terminology

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment period	The period in a day over which assessments are made.
Assessment Point	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level (see below).
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of common sounds in our daytime environment:

threshold of hearing	0 dB	The faintest sound we can hear
	10 dB	Human breathing
almost silent	20 dB	
	30 dB	Quiet bedroom or in a quiet national park location
generally quiet	40 dB	Library
	50 dB	Typical office space or ambience in the city at night
moderately loud	60 dB	CBD mall at lunch time
	70 dB	The sound of a car passing on the street
loud	80 dB	Loud music played at home
	90 dB	The sound of a truck passing on the street
very loud	100 dB	Indoor rock band concert
	110 dB	Operating a chainsaw or jackhammer
extremely loud	120 dB	Jet plane take-off at 100m away
threshold of pain	130 dB	
	140 dB	Military jet take-off at 25m away

dB(A)	A-weighted decibels. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.

Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.
L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.
tph	Trains per hour

A.2 Acoustic concepts

A.2.1 Sound and noise

The terms 'sound' and 'noise' are almost interchangeable, except that in common usage 'noise' is often used to refer to unwanted sound. Sound is a vibration that travels as an audible wave of pressure through the air from a source to a receiver location such as the human ear. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) is a unit of measurement used to express the ratio of a quantity to another on a logarithmic scale to make the wide range of sound pressure more manageable.

Sound power is the rate at which a source emits acoustic energy and is unaffected by the environment. It is a property of the source that is emitting acoustic energy.

In contrast, **sound pressure** is the effect, and it is affected by factors associated with the built and natural environment such as distance, direction, obstacles etc. The sound pressure is the acoustic energy or 'noise level' at a distance away from the noise source. The relationship between sound power and sound pressure can be explained by considering the analogy of an electric heater, which radiates heat into a room and temperature is the effect. Like sound pressure, temperature also reduces with distance from the source following the inverse square law.

In this technical working paper, **sound power level** is identified by the symbols **SWL** or $\mathbf{L_w}$, while **sound pressure level** is represented by **SPL** or $\mathbf{L_p}$, and both have the same scientific unit in dB.

A.2.2 Individual's perception of sound

The loudness of sound depends on its sound pressure level. The A-weighted decibel [dB(A)] is generally used for the purposes of environmental noise impact assessment as it has been adjusted to account for the varying sensitivity of the human ear to different frequencies of sound. People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dB(A) is a good measure of the loudness of environmental noise to the human ear as it considers this frequency dependant sensitivity.

Different noise sources having the same dB(A) level generally sound equally loud. However, the frequency of a sound is what gives it a distinctive pitch or tone – for example, the rumble of distant thunder is an example of a low frequency sound and a whistle is an example of a high frequency sound. Most sounds we hear in our daily lives have sound pressure levels in the range of 30 to 90 dB(A). The following table provide some points of reference, measured in dB(A), of familiar sounds and those from construction activities.

Table A-1: Perception of sound - familiar sounds and construction noise

Common sounds	Construction noise	Sound pressure level
Leaf blower at operator's ear	Concrete saw or jack hammer 7 metres away	90 dB(A)
Airplane cabin during cruise (Airbus 321)	Excavator (with bucket) 7 metres away	80 dB(A)
General traffic noise kerbside next to Military Road	Towable compressor 7 metres away	75 dB(A)
Normal conversation at 1 metre		60 dB(A)
Outdoor air conditioning unit 1 metre away	Towable compressor 50 metres away	55 dB(A)
General office		50 dB(A)
Inside private office	Ground-borne noise from road header tunnel excavation between depths of 20 metres to 50 metres	40 dB(A)
Inside bedroom		30 dB(A)

In terms of sound perception, a change of 1 dB(A) or 2 dB(A) in the sound pressure level is difficult for most people to detect, while a 3 dB(A) to 5 dB(A) change corresponds to a small but noticeable change in loudness. An increase in sound level of 10 dB(A) is perceived as a doubling of loudness. However, individuals may perceive the same sound differently since many factors can influence an individual's response, including:

- The specific characteristics of the noise (eg. frequency, intensity, duration of the noise event)
- Time of day noise events occur
- Individual sensitivities and lifestyle
- Reaction to an unfamiliar sound
- Understanding of whether the noise is avoidable and the notions of fairness.

A.2.3 Environmental noise assessment indicators

Environmental noise is an accumulation of noise pollution that occurs outside and is most commonly attributed to various modes of transport as well as industrial and construction activities. Environmental noise has been shown to have an adverse effect on the quality of life, especially following long-term exposure. The focus of the present technical assessment is on annoyance and sleep disturbance as they constitute most of the burden related to the impact of environmental noise on health outcomes. Noise annoyance is defined by the World Health Organization as a feeling of displeasure, nuisance, disturbance or irritation caused by a specific sound. Sleep disturbance relates to difficulty with sleep initiation, consolidation as well as awakening and reduced quality of sleep.

In New South Wales, contemporary environmental noise assessment criteria for addressing noise annoyance and sleep disturbance are specified by the Environment Protection Authority (EPA). Potential road traffic noise impact is assessed in accordance with the NSW Road Noise Policy. For motorway and ventilation facilities that are permanently fixed, and associated noise emissions are long-term in nature, noise criteria have been adopted in accordance with the Noise Policy for Industry. For enabling construction activities which are temporary in nature and highly variable, EPA's Interim Construction Noise Guideline provides the underlying assessment principles for the determination of potential construction noise impact.

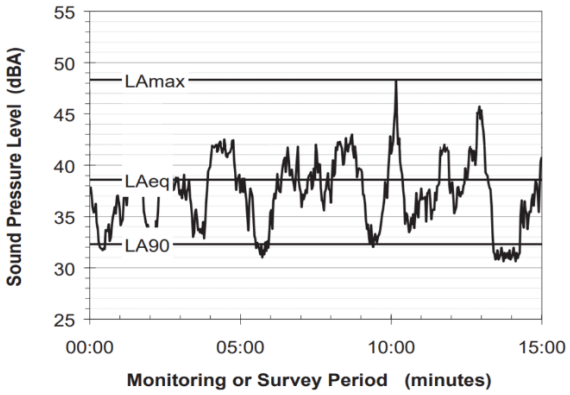
L_{Aeq} - To protect against long-term repeated noise exposure, the indicator for assessing the cumulative noise exposure level over a specific time interval is the equivalent sound pressure level, denoted as LAeq. The LAeq indicator accounts for the total energy content from all sources of sound under consideration. The fact that the L_{Aeq} is a cumulative measure means that louder activities have greater influence of the LAeq level than do quieter ones, and activities that last longer in time have greater LAeq than do shorter ones. An increase in the number of events also increases the LAeq. Further, people react to the duration of noise events, judging longer events to be more annoying than shorter ones, assuming equal maximum noise levels.

L_{Amax} - It is important to note that even though L_{Aeq} levels are numerically lower than maximum noise levels (denoted as LAmax). None of the noise is ignored, just as all the rain that falls in the rain gauge in one hour counts toward the total. In the case of noisy but short-lived maximum noise events, which can sometime result in immediate short-term awakening reaction, potential impact is assessed using the LAmax indicator in which its emergence above the background noise environment is evaluated.

L_{A90} - The L_{A90} is the level of noise that is present almost constantly, or for 90 percent of the time and is commonly referred to as the background noise. Typical examples of what types of noise may contribute to the background noise levels are continuously flowing traffic or air conditioner noise.

These three noise indicators of L_{Amax}, L_{Aeq} and L_{A90} are presented in Figures A-1 for example noise monitoring survey period showing the sound pressure level of a varying noise environment such as environmental noise.

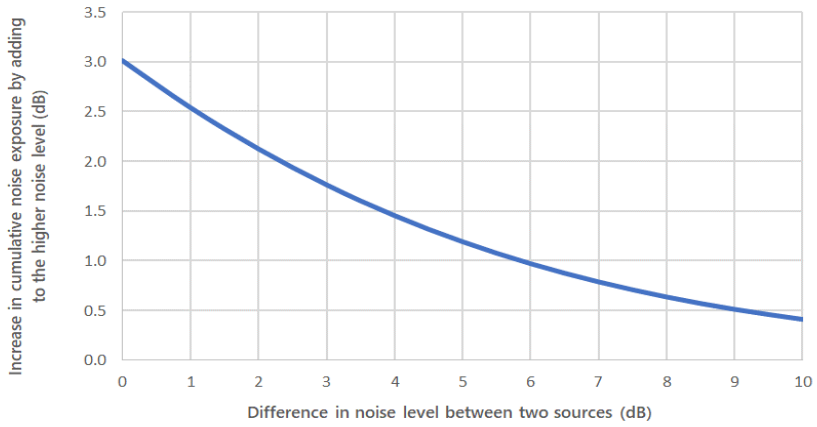
Figure A-1: Environmental noise assessment indicators



A.2.4 Cumulative sound exposure

As illustrated in Figure A-2, for two activities that result in the same amount of acoustical energy or noise level at a receiver location, the cumulative sound exposure level would be 3 dB higher than the level of just one single activity. This is because the decibel (dB) scale is logarithmic. Conversely, if the activity closer to your home results in noise exposure level that is 10 dB higher than the activity occurring further away, the quieter works would contribute very little to the cumulative noise exposure level.

Figure A-2: Difference in noise level between two sources



APPENDIX B Noise monitoring methodology

B.1 Noise monitoring equipment

A noise monitor consists of a sound level meter housed inside a weather resistant enclosure. Noise levels are monitored continuously with statistical data stored in memory for every 15-minute period.

Long term noise monitoring was conducted using the following instrumentation:

Description	Type	Octave Band Data
RTA06 (NTi Audio XL2, with low noise microphone)	Type 1	1/1 octaves

Notes: All meters comply with AS IEC 61672.1 2004 "Electroacoustics - Sound Level Meters" and designated either Type 1 or Type 2 as per table, and are suitable for field use.

The equipment was calibrated prior and subsequent to the measurement period using a Brüel & Kjær Type 4231 calibrator. No significant drift in calibration was observed.

B.2 Meteorology during monitoring

Measurements affected by extraneous noise, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the NPfI. The Bureau of Meteorology (BOM) provided meteorological data, which is considered representative of the site, for the duration of the noise monitoring period. The data was modified to allow for the height difference between the BOM weather station, where wind speed and direction is recorded at a height of 10 metres above ground level, and the microphone location, which is typically 1.5 metres above ground level (and less than 3 metres). The correction factor applied to the data was taken from Australian Standard AS1170.2 Section 4.2.5.1.

B.3 Noise vs time graphs

Noise almost always varies with time. Noise environments can be described using various descriptors to show how a noise ranges about a level. In this report, noise values measured or referred to include the L_{10}, L_{90}, and L_{eq} levels. The statistical descriptors L_{10} and L_{90} measure the noise level exceeded for 10% and 90% of the sample measurement time. The L_{eq} level is the equivalent continuous noise level or the level averaged on an equal energy basis. The measurement sample periods are 15 minutes. The Noise - vs- Time graphs representing measured noise levels, as presented in this report following this section, illustrate these concepts for the broadband results.

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Stevens Road - Rail

Background & Ambient Noise Monitoring Results - NSW 'Industrial Noise Policy', 2000

	L_{A90} Background Noise Levels[4]			L_{Aeq} Ambient Noise Levels		
Date	**Day[1]**	**Evening[2]**	**Night[3]**	**Day[1]**	**Evening[2]**	**Night[3]**
Wednesday-01-August-2018	-	46.8	42.0	-	57.2	57.0
Thursday-02-August-2018	40.0	44.2	47.0	56.7	59.8	58.6
Friday-03-August-2018	41.3	40.8	34.8	56.2	53.8	52.4
Saturday-04-August-2018	42.6	42.7	36.7	57.6	58.1	53.6
Sunday-05-August-2018	38.0	45.6	44.0	53.3	56.6	58.3
Monday-06-August-2018	44.1	39.0	32.9	57.9	54.0	53.9
Tuesday-07-August-2018	46.1	37.8	35.0	60.9	54.0	55.0
Wednesday-08-August-2018	40.1	39.7	39.7	57.5	54.6	58.3
Thursday-09-August-2018	40.7	49.8	44.3	57.7	58.4	58.1
Friday-10-August-2018	-	-	-	-	-	-
Representative Weekday[5]	**41.0**	**40.8**	**39.7**	**58.1**	**56.6**	**56.7**
Representative Weekend[5]	**40.3**	**44.2**	**40.4**	**56.0**	**57.4**	**56.6**
Representative Week[5]	**41.0**	**42.7**	**39.7**	**57.7**	**56.8**	**56.7**

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
2. Evening is 6:00pm to 10:00pm
3. Night is the remaining periods
4. Assessment Background Level (ABL) for individual days
5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq}
6. Leq is calculated in the free field. 2.5dB is subtracted from results if logger is placed at facade

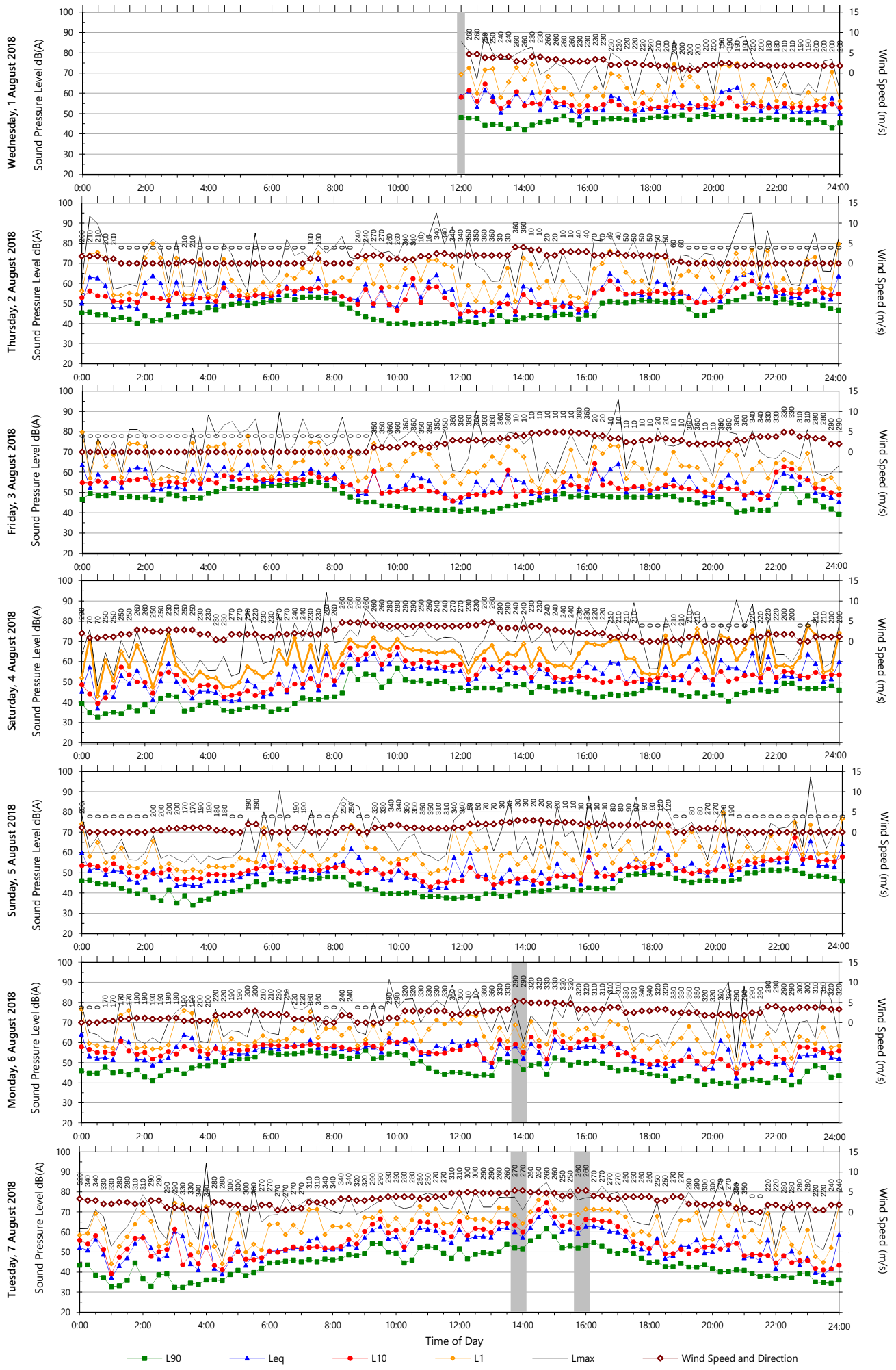
Stevens Road - Rail

Road / Rail Noise Monitoring Results (at one metre from façade)

	L_{Aeq} Noise Levels		$L_{Aeq\ 1hr}$ Noise Levels			
Date	**Day[1]**	**Night[2]**	**Day - Up[4]**	**Day - Low[5]**	**Night - Up[4]**	**Night - Low[5]**
Wednesday-01-August-2018	59.1	59.5	63.5	54.4	63.2	54.3
Thursday-02-August-2018	60.3	61.1	64.3	50.0	63.0	54.7
Friday-03-August-2018	58.2	54.9	63.3	51.3	60.0	44.8
Saturday-04-August-2018	60.3	56.2	63.8	55.3	61.0	46.9
Sunday-05-August-2018	56.8	60.8	60.8	49.7	64.6	54.9
Monday-06-August-2018	59.6	56.4	61.6	52.3	61.4	50.5
Tuesday-07-August-2018	62.3	57.5	67.9	54.5	61.3	47.5
Wednesday-08-August-2018	59.4	60.8	63.2	53.5	63.3	51.1
Thursday-09-August-2018	60.4	60.6	63.4	55.0	63.1	56.5
Friday-10-August-2018	59.8	-	61.0	51.6	-	-
Representative Weekday[3]	**60.0**	**59.2**	**64.0**	**53.1**	**62.4**	**52.8**
Representative Weekend[3]	**58.9**	**59.1**	**62.6**	**53.3**	**63.2**	**52.5**
Representative Week[3]	**60**	**59**	**64**	**53**	**63**	**53**

Notes:

1. Day is 7:00am to 10:00pm
2. Night is 10:00pm to 7:00am
3. Logarithmic average of daily L_{Aeq}
4. Upper 10th percentile $L_{Aeq\ 1hr}$
5. Lower 10th percentile $L_{Aeq\ 1hr}$
6. Values are calculated at the facade. 2.dB is added to results if logger is placed in the free field


Wednesday, 1 August 2018
Thursday, 2 August 2018
Friday, 3 August 2018
Saturday, 4 August 2018
Sunday, 5 August 2018
Monday, 6 August 2018
Tuesday, 7 August 2018
Sound Pressure Level dB(A)
Wind Speed (m/s)
Time of Day
L90
Leq
L10
L1
Lmax
Wind Speed and Direction

Unattended Monitoring Results

Location: Stevens Road - Rail