Warrawong Community Health Centre

Acoustics Report

Review of Environmental Factors

14 December 2023

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Revision Schedule

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001	14/11/2023	REF-Draft	James Ashpole	Meisha Stevens
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Contents

1 Introduction

The Review of Environmental Factors (REF) relates to the construction works proposed for the Warrawong Community Health Centre located at 91 Cowper Street, Warrawong. This report presents the acoustic performance requirements and criteria in compliance with relevant governing organisations and offers recommended noise mitigation strategies to minimise the impact of the construction works to the local environment.

The proposed construction works is comprised of the following stages:

- Stage 1 – Tree Removal
- Stage 2 - Demolition of existing structures
- Stage 3 – Excavation
- Stage 4 – Structure

This report has been prepared to detail the Assessment of the REF scope of works associated with the development of the Warrawong Community Health Centre.

Consequently, this report discusses the following issues:

- Project overview which summarises extent of the development works and site layout
- External noise level criteria based on existing environmental noise data in the vicinity of the site
- Acoustic assessment of construction activities
- Acoustic assessment of operational noise from the proposed development
- Conclusions discussing the outcomes from the acoustic assessments; as well as the feasibility of the project
- Impact of the construction noise and vibration generated by the construction equipment on the nearest most-affected receivers

This report is based on our understanding of the proposed project, application of the relevant state guidelines and professional experience within the acoustic field. Therefore, this report shall not be relied upon as providing any warranties or guarantees.

1. Background Information

1.1 Reference Documents

The following reference documents have been used as the basis of the acoustic criteria and assessment methods:

- Engineering Services Guideline (NSW HI ESG), NSW Health Infrastructure, 2021.
- Wollongong Development Control Plan (DCP) 2009
- Noise Policy for Industry (NPI), NSW EPA, 2017
- Road Noise Policy (RNP), NSW EPA, 2011
- Interim Construction Noise Guideline (ICNG), NSW DECC, 2009
- Construction Noise Strategy, Transport for NSW, 2013
- Assessing Vibration: A Technical Guideline, NSW DEC , 2006
- Department of Planning (DoP) – Development near Rail Corridors and Busy Roads – Interim Guideline
- AS 2436:2010 *Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites*
- British Standard BS 5228: Part 1:1997 *Noise and Vibration Control on Construction and Open Sites*
- British Standard BS 7358:1993 *Evaluation and Measurement for Vibration in Buildings – Part 2: Guide to Damage Levels from Ground-borne Vibration*
- German Standard DIN 4150-Part 3 *Structural vibration in buildings – Effects on structures*
- *ASHRAE Handbook - HVAC Applications*, American Society of Heating and Refrigeration Engineers (ASHRAE), 2016
- AS/NZS 1668.1:2015 The use of ventilation and air conditioning in buildings Part 1: Fire and smoke control in buildings
- AS/NZS 2107:2016 Acoustics – Recommended Design Sound Levels and Reverberation Times for Building Interiors
- AS 2822:1985 Acoustics – Methods of Assessing and Predicting Speech Privacy and Speech Intelligibility

1.2 Information Sources

The acoustic assessments are based on the following project documentation:

- REF Architectural drawings prepared by Cox Architecture, dated 20th October 2023.
- Noise data collected on site through the use of a noise monitors and a hand held spectrum analyser.
- Aconex Correspondence with Savills regarding the construction stages and expected equipment

2 Project Description

2.1 Site Description – Noise & Vibration Sensitive Receivers

The proposed Warrawong Community Health Centre (WCHC) Development is located at 91 Cowper Street, Warrawong. The site is bounded by the existing Port Kembla Hospital to the south and West, Cowper Street to the North, and Fairfax Road to the East. Beyond Cowper Street and Fairfax Road, are residential properties which will be considered the most affected noise sensitive receivers when considering noise emissions from the proposed development.

The proposed area of the site location is shown in Figure 1, together with the boundaries of the adjacent land and use and the locations of the short-term and long-term noise monitoring.

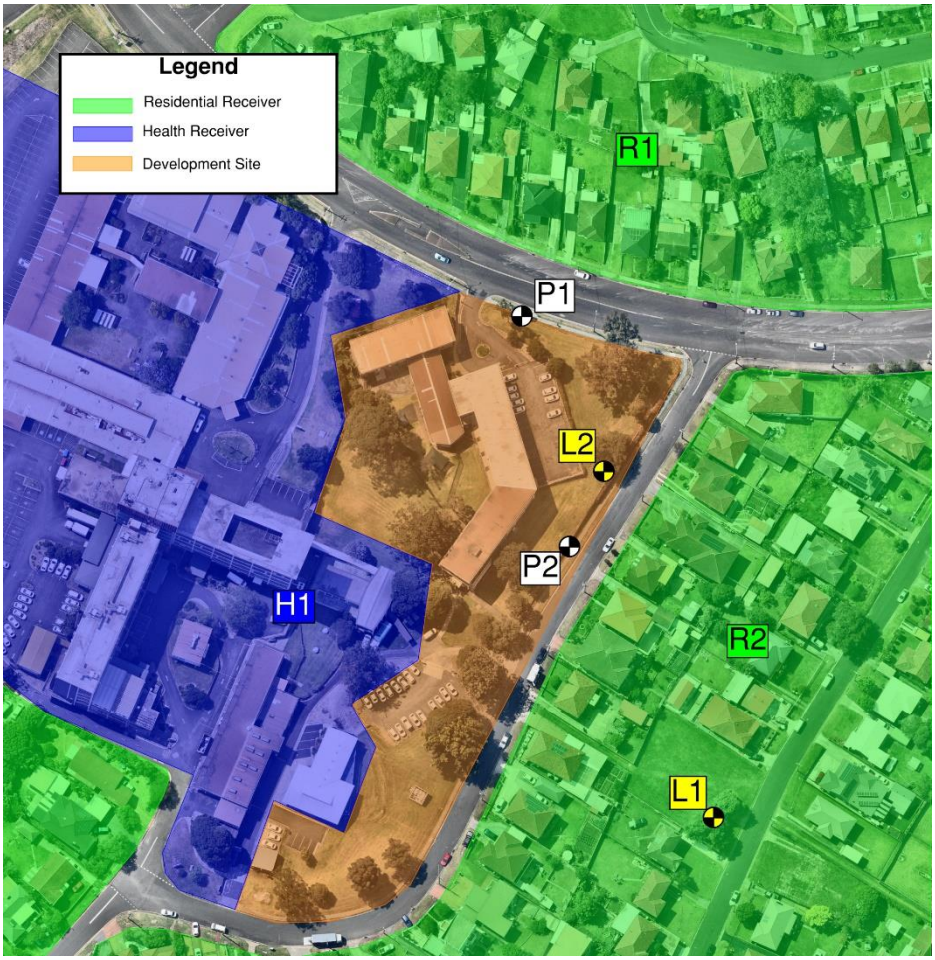

Figure 1: Aerial Photo of the Area Showing an Overview of the Site and Measurement Locations

Source: nearmap.com

2.2 Instrumentation

The equipment used for the noise survey was the following:

- Hand-held sound spectrum analyser Brüel & Kjær Type 2250, S/N 3027679
- Brüel & Kjær Sound Calibrator, S/N: 2709826
- Environmental Noise Logger Brüel & Kjær Type 2250 , S/N: 3011850
- Environmental Noise Logger Cube 01dB, S/N: 11881

All equipment was calibrated before and after the measurements and no significant drift was found. All equipment carries current traceable calibration certificates that can be provided upon request.

2.3 Unattended Survey Results

2.3.1 Background and Ambient Noise Monitoring

A Noise and Vibration monitor was placed at position L1 as shown in Figure 1 to measure the background and ambient noise that is representative of the surrounding noise-sensitive residential receivers. Noise monitor L1 was installed from the 12th to the 19th October 2023. The results of the unattended background and ambient noise surveys is shown in Table 1 below (for the day, evening and night time periods).

During the monitoring period an unexpected error occurred, with the latter half of the week exhibiting uncharacteristic noise levels. In order to determine the viability of the data, it was compared with the logger installed at L2 to determine reasonable targets for establishing the project specific noise criteria. The design of mechanical plant and other sources related to external noise emissions will be dictated but the more-stringent night-time criteria. The NSW NPI outlines minimum RBL's for the night time to be 30 dB(A) which will be adopted for the project.

The noise monitoring results of logger location L1 and L2 is representative of the residential ambient noise level and will be used to establish the noise emission targets for the project, as well as the construction noise criteria.

Table 1: Summary of unattended ambient noise measurements

Location	Equivalent Continuous Noise Level $L_{Aeq,period}$ - dB(A)			Background Noise Level RBL - dB(A)		
	Day	Evening	Night	Day	Evening	Night
L1 (first half of week)	49	51	43	37	36	28
L2	57	60	54	44	41	30

The local ambient noise environment is dominated by ambient traffic noise from traffic movements along Cowper Street and Fairfax Road throughout the majority of the day, evening and night time periods. Note that any rain affected data during the period of logging has been excluded from the calculations. Refer to Figure 2 below for the noise data.

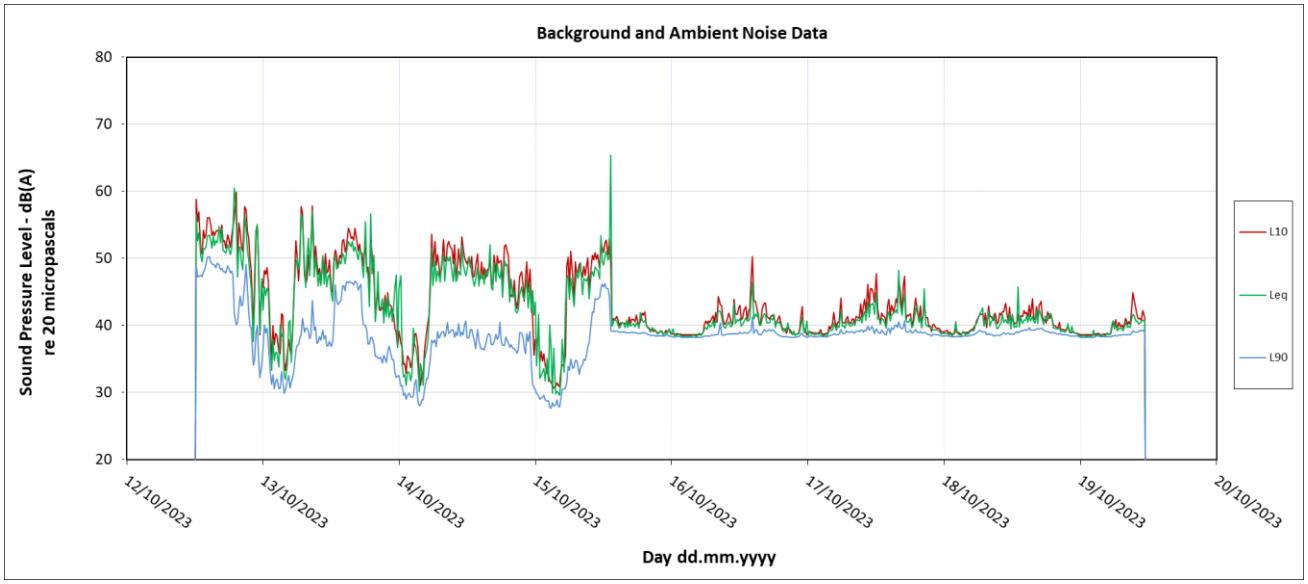

Figure 2: Unattended background and ambient noise monitoring data - L1

2.3.2 Traffic Noise Monitoring

A noise monitor was placed at position L2 as shown in Figure 1 to measure the noise generated by traffic movements along Cowper Street during the 15 hour and 9 hour periods established in the Department of Planning's Development near Rail Corridors and Busy Roads- Interim Guideline. Noise monitor L2 was installed from the 12th to the 19th October 2023. The results of the unattended background and ambient noise surveys is shown in Table 2 below (for the day, evening and night time periods).

The noise monitoring results of logger location L2 is representative of traffic movements and will be used to determine the impacts on the building façade as well as determining potential increase in environmental noise due to increases in traffic movements.

Table 2: Summary of unattended traffic noise measurements

Location	Equivalent Continuous Noise Level $L_{Aeq, period}$ – dB(A)		Noisiest 1 Hour $L_{Aeq,1hour}$ – dB(A)	
	Day (15hr)	Night (9hr)	Day	Night
L2	57	52	59	57

Note that any rain affected data during the period of logging has been excluded from the calculations.

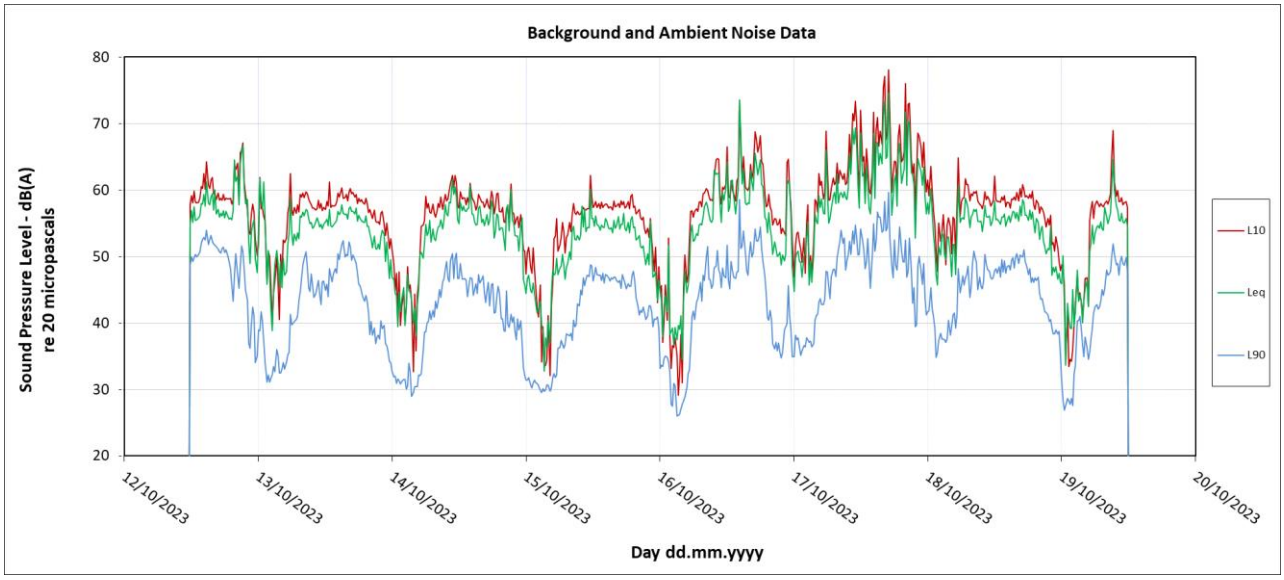

Figure 3: Unattended background and ambient noise monitoring data – L2

2.4 Attended Noise Measurements

Attended noise measurements of 15-minute duration were conducted on site to characterize the noise intruding into the development and to validate the results of the unattended monitoring. A summary of the attended noise measurements taken in the vicinity of the proposed development site are shown in Table 3.Refer to Figure 1 for measurement locations.

Table 3: Summary of attended noise measurements

Measurement Location	Measurement Time	L_{Aeq} dB(A)	L_{A90} dB(A)	L_{Amax} dB(A)	Comments
P1	11:08am 19/10/2023	69	53	88	Ambient Noise is dominated by wildlife (birds). Medium Traffic along Cowper Street
P2	11:26am 19/10/2023	57	46	77	Ambient Noise is dominated by wildlife noise. Intermittent traffic along Fairfax Road.

3 Acoustic Criteria

3.1 External Noise Emissions

3.1.1 Wollongong Council Development Control Plan (DCP) 2009

Wollongong City Council DCP doesn't provide a specific criterion regarding external emissions

In the absence of any specific external noise requirements in the Wollongong Council Development Control Plan, the NSW Noise Policy for Industry (NPI) has been applied to the address the noise emissions from proposed development. The NPI sets out noise criteria to control the noise emission from industrial noise sources from activities listed in Schedule 1 of the POEO Act and regulated by the EPA. The external noise due to mechanical services from the proposed development is also addressed following the guideline in the NSW EPA's NPI.

The criteria outlined in the NSW EPA Noise Policy for Industry 2017 presented in Section 3.1.2 addresses any requirement of the DCP.

3.1.2 NSW EPA Noise Policy for Industry (NPI)

The calculation is based on the results of the ambient and background noise unattended monitoring, addressing two components:

- Controlling intrusive noise into nearby residences (Intrusiveness Criteria)
- Maintaining noise level amenity for particular land uses (Amenity Criteria)

Once both criteria are established, the most stringent for each considered assessment period (day, evening, night) is adopted as the project noise trigger level (PSNL).

3.1.2.1 Intrusiveness Criteria

The NSW NPI states the following:

> *"The intrusiveness of an industrial noise source may generally be considered acceptable if the level of noise from the source (represented by the LAeq descriptor), measured over a 15minute period, does not exceed the background noise level by more than 5 dB when beyond a minimum threshold."*

The intrusiveness criterion can be summarised as L_{Aeq}, 15 minute ≤ RBL background noise level plus 5 dB(A).

Table 4 - NSW NPI Rating background noise levels (RBLs)

Period	Noise Descriptor – dB(A)	Noise Criteria – dB(A)
Residential		
Daytime 7am – 6pm	$L_{Aeq,15min}$ ≤ RBL + 5	42
Evening 6pm – 10pm	$L_{Aeq,15min}$ ≤ RBL + 5	41
Night 10pm – 7am	$L_{Aeq,15min}$ ≤ RBL + 5	35[1]

Note: 1. Based on the minimum assumed RBLs and project intrusiveness noise levels as outline in the NSW NPI.

3.1.2.2 Amenity Criteria

The NSW NPI states the following:

> *"To limit continuing increases in noise levels from application of the intrusiveness level alone, the ambient noise level within an area from all industrial noise sources combined should remain below the recommended amenity noise levels specified in Table 2.2 where feasible and reasonable. The recommended amenity noise levels will protect against noise impacts such as speech interference, community annoyance and some sleep disturbance. The recommended amenity noise levels have been selected on the basis of studies that relate industrial noise to annoyance in communities (Miedema and Voss, 2004).*

To ensure that industrial noise levels (existing plus new) remain within the recommended amenity noise levels for an area, a project amenity noise level applies for each new source of industrial noise as follows "Project amenity noise level for industrial developments = recommended amenity noise level (Table 2.2) minus 5, +3 dB(A) to convert from a period level to a 15 minute level".

The applicable parts of Table 2.2: Amenity noise levels from Industrial Noise Sources – L_{Aeq}, dB(A) which are relevant to the project are reproduced below:

Table 5- NSW NPI amenity criteria for external noise levels

Type of Receiver	Noise amenity area	Time of Day	L_{Aeq}, dB(A)	Project amenity noise level $L_{Aeq, 15min}$
			Recommended amenity noise level	
Residential	Suburban	Day	55	53
		Evening	45	43
		Night	40	38
Hospital Ward Internal	All	Noisiest 1-hour	35	32
Hospital Ward External	All	Noisiest 1-hour	50	48

*Suburban area as defined in EPA NPI Table 2.2.

Note that where the resultant project amenity noise level is 10dB or more lower than the existing industrial noise level the project amenity noise levels can be set at 10dB below existing industrial noise levels if it can be demonstrated that existing industrial noise levels are unlikely to reduce over time.

3.1.2.3 'Modifying Factor' Adjustments

The NSW NPI also states:

> *"Where a noise source contains certain characteristics, such as tonality, intermittency, irregularity or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same noise level."*

In order to take into account the potential annoying character of the noise an adjustment of 5 dB(A) for each annoying character aspect and cumulative of up to a total of 10 dB(A), is to be added to the measured value to penalise the noise for its potentially greater annoyance aspect.

Table C1 of Fact Sheet C of the NSW NPI (see Table 6 below) provides procedures for determining whether an adjustment should be applied for greater annoyance aspect.

Table 6 - Table C1 from the NSW NPI – Modifying factor corrections

Factor	Assessment / Measurement	When to Apply	Correction[1]	Comments
Tonal Noise	One-third octave band analysis using the objective method for assessing the audibility of tones in noise – simplified method *(ISO1996.2-2007 – Annex D)*.	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: • 5 dB or more if the centre frequency of the band containing the tone is in the range 500–10,000 Hz • 8 dB or more if the centre frequency of the band containing the tone is in the range 160–400 Hz • 15 dB or more if the centre frequency of the band containing the tone is in the range 25–125 Hz.	5 dB[2,3]	Third octave measurements should be undertaken using unweighted or Z-weighted measurements. **Note**: Narrow-band analysis using the reference method in *ISO1996-2:2007, Annex C* may be required by the consent/regulatory authority where it appears that a tone is not being adequately identified, e.g. where it appears that the tonal energy is at or close to the third octave band limits of contiguous bands.
Low Frequency Noise	Measurement of source contribution C-weighted and A-weighted level and one-third octave measurements in the range 10–160 Hz	Measure/assess source contribution C- and A-weighted $L_{eq,T}$ levels over same time period. Correction to be applied where the C minus A level is 15dB or more and: • where any of the one-third octave noise levels in Table C2 are exceeded by up to and including 5 dB and cannot be mitigated, a 2dB(A) positive adjustment to measured/predicted A-weighted levels applies for the evening/night period • where any of the one-third octave noise levels in Table C2 are exceeded by more than 5 dB and cannot be mitigated, a 5-dB(A) positive adjustment to measured/predicted A-weighted levels applies for the evening/night period and a 2dB(A) positive adjustment applies for the daytime period.	2 or 5 dB[2]	A difference of 15 dB or more between C- and A-weighted measurements identifies the potential for an unbalance spectrum and potential increased annoyance. The values in Table C2 are derived from Moorhouse (2011) for DEFRA fluctuating low-frequency noise criteria with corrections to reflect external assessment locations.

Factor	Assessment / Measurement	When to Apply	Correction[1]	Comments
Intermittent Noise	Subjectively assessed but should be assisted with measurement to gauge the extent of change in noise level.	The source noise heard at the receiver varies by more than 5 dB(A) and the intermittent nature of the noise is clearly audible.	5 dB	Adjustment to be applied for **night-time only.**
Duration	Single-event noise duration may range from 1.5 min to 2.5 h	One event in any assessment period.	0 to 20 dB(A)	The project noise trigger level may be increased by an adjustment depending on duration of noise (see Table C3).
Maximum Adjustment	Refer to individual modifying factors	Where two or more modifying factors are indicated	Maximum correction of 10dB(A)[2] (excluding duration correction)	

Notes: 1. Corrections to be added to the measured or predicted levels, except in the case of duration where the adjustment is to be made to the criterion.

2. Where a source emits tonal and low-frequency noise, only one 5-dB correction should be applied if the tone is in the low-frequency range, that is, at or below 160 Hz.

3. Where narrow-band analysis using the reference method is required, as outlined in column 5, the correction will be determined by the ISO1996-2:2007 standard.

3.1.2.4 For the purpose of the proposed development the above modifying factor are not anticipated to be applicable, these factors have been provided for information.

3.1.2.5 Sleep Disturbance

The NPI establishes sleep disturbance criteria for residential receivers in close proximity to industrial noise sources during the night-time period, such as vehicle movements and car door slams on private roads. The criteria for protecting the amenity of surrounding residential receivers in regards to sleep disturbance is:

- $L_{Aeq,15min}$ 40 dB(A) or prevailing RBL plus 5dB, whichever is greater, and/or
- L_{AFmax} 52 dB(A) or prevailing RBL plus 15dB, whichever is greater

Table 7 summarises the sleep disturbance criteria for the proposed development.

Table 7 - Sleep Disturbance Criteria

Period	Sleep Disturbance Criteria	
	L_{AFmax} – dB(A)	**$L_{Aeq,15min}$ – dB(A)**
Residential		
Night (10:00pm to 7:00am)	52	40

3.1.3 Project Noise Trigger Level

Project Noise Trigger Levels for the project are adopted as the more stringent of the intrusiveness and amenity, in this case, the intrusiveness criteria have been used for the residential receivers adjacent to the development. Refer to Table 8 for the NSW NPI project specific criteria applicable to the noise emissions associated with the mechanical plant including external plant and plant rooms. The criteria presented in Table 8 are the project specific noise target which the operation of the site must comply and shall be assessed at the boundary of the nearest affected the residential receivers.

Table 8 – Project Noise Trigger Levels

Receiver	Period	Descriptor	PNTL dB(A)
Residential	Day	$L_{Aeq, 15min}$	42
	Evening	$L_{Aeq, 15min}$	41
	Night	$L_{Aeq, 15min}$	35
		L_{AFmax}	52
Hospital Ward Internal	All	Noisiest 1-hour	32
Hospital Ward External	All	Noisiest 1-hour	48

3.2 Vibration

3.2.1 Human Comfort – Continuous and Impulsive Vibration Criteria

Structural vibration in buildings can be detected by occupants and can affect them in many ways including reducing their quality of life and also their working efficiency. Complaint levels from occupants of buildings subject to vibration depend upon their use of the building and the time of the day. The vibration emitted from construction works should be such that it does not exceed the maximum limits set out in the criteria presented Table 9 to Table 10. The guide on preferred values for human comfort have been extracted from the NSW DEC *Assessing Vibration: A Technical Guideline* (2006). The criteria for continuous and impulsive vibration are summarized in Table 9.

Table 9: Criteria for Exposure to Continuous and Impulsive Vibration

Place	Time	Vibration Acceleration (mm/s^2)			
		Preferred		Maximum	
Continuous Vibration		**z axis**	**x and y axis**	**z axis**	**x and y axis**
Critical working areas (e.g. hospital operating theatres precision laboratories)	Day or night time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night time	0.007	0.005	0.014	0.010
Offices	Day or night time	0.020	0.014	0.040	0.028
Workshops	Day or night time	0.040	0.029	0.080	0.058
Impulsive Vibration		**z axis**	**x and y axis**	**z axis**	**x and y axis**
Critical working areas (e.g. hospital operating theatres precision laboratories)	Day or night time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night time	0.10	0.071	0.20	0.14
Offices	Day or night time	0.64	0.46	1.28	0.92
Workshops	Day or night time	0.64	0.46	1.28	0.92

Disturbance caused by vibration will depend on its duration and its magnitude. This methodology of assessing intermittent vibration levels involves the calculation of a parameter called the Vibration Dose Value (VDV) which is used to evaluate the cumulative effects of intermittent vibration. The criteria applicable when considering periods of intermittent vibration are presented in Table 10.

Table 10: Acceptable Vibration Dose Values for Intermittent Vibration (1.75 m/s)

Location	Daytime		Night time	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Critical areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

3.2.2 Structural Damage

Ground vibration criteria are defined in terms of levels of vibration emission from construction activities that will not damage surrounding buildings or structures. It should be noted that human comfort criteria are normally expressed in terms of acceleration whereas structural damage criteria are normally expressed in terms of velocity. The human comfort criteria are also often exceeded before a risk of structural damage.

Structural damage criteria are presented in German Standard DIN 4150-Part 3 *Structural vibration in buildings – Effects on structures* and British Standard BS 7385-2:1993 *Evaluation and Measurement for Vibration in Buildings*. The British Standard BS 7385-2:1993 establishes vibration values for buildings based on the lowest vibration levels above which damage has been credibly demonstrated. These values are evaluated to give a minimum risk of vibration-induced damage, where minimal risk for a named effect is usually taken as 95% probability of no effect. The aforementioned values are summarised in Table 10.

4 Construction Noise and Vibration Criteria

4.1 Construction Noise Criteria

Noise criteria for construction sites are established in accordance with the NSW ICNG. It is important to note that the recommended criteria are for planning purposes only. Numerous other factors need to be considered when assessing potential noise impacts from construction works.

The *Interim Construction Noise Guideline* (ICNG) by NSW DECC recommends the following standard hours of construction, which will be assumed as the constructions hours for the project:

- Monday to Friday: 7am to 6pm
- Saturday: 8am to 1pm
- Sunday and public holidays: no work

However, in undertaking the assessment of potential noise intrusion associated with the proposed construction activities, the assessment procedures and criteria in Chapter 4 of the NSW ICNG have been considered.

Consequently, the Noise Management Levels (NMLs) for the construction and demolition activities are presented in Table 11.

Table 11: NSW OEH ICNG Construction Noise Criteria

Time of Day	Management Level $L_{Aeq,15min}$ *	How to Apply
Recommended Standard Hours: Mon – Fri (7am – 6pm) Sat (8am – 1pm) No work on Sunday & 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 $L_{Aeq,15min}$ 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 residences 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 in, taking into account: • Times identified by the community when they are less sensitive to noise (such as before and after school, for works near schools, or mid-morning or mid-afternoon for works near residences) • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside 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 5 dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see Section 7.2.2. of the NSW ICNG

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

Regarding the NMLs:

- The NMLs are based on the quantitative assessment method as discussed in the NSW ICNG. This has been assumed in this manner since we consider the hospital development works not as short-term activities (i.e. duration of more than three weeks).
- It is recommended that the working hours to undertake the development works should be as per the normal construction hours discussed in the NSW ICNG; these are:
  - Monday to Friday: 7 am to 6 pm
  - Saturday: 8 am to 1 pm
  - No work on Sundays or public holidays
- Feasible measures, as discussed in the NSW ICNG, is defined as follows: *"A work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements".*
- Reasonable measures, as discussed in the NSW ICNG, is defined as follows: *"Selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure. The regulatory authority may review the information on feasible and reasonable work practices provided by the proponent, and compare the practices against those applied on similar projects. The regulatory authority may negotiate additional work practices that it considers may also be feasible and reasonable".*
- For non-residential premises, the NSW ICNG recommends the following NMLs:
  - For commercial premises: 70 dB(A) $L_{Aeq\ (15\ minutes)}$ external noise level
  - For places of worship, hospital wards and operating theatres: 45 dB(A) $L_{Aeq\ (15\ minutes)}$ internal noise level. Based on the assumption that the existing hospital façade provides a 15 dB(A) noise reduction (which corresponds to typical 10.38 mm thick laminated commercial glazing), then the external NML is estimated as 60 dB(A) $L_{Aeq\ (15\ minutes)}$.

4.2 Construction Vibration Criteria

For human comfort, the NSW ICNG recommends the use of the vibration criteria as discussed in the NSW AV-TG. Hence refer to Section 3.2 for further discussion regarding these criteria.

In addition to these human comfort criteria, we also recommend considering the following vibration criteria which address structural damage.

4.2.1 Structural Damage – Vibration Criteria

Generally structural vibration criteria are defined to minimize the risk of cosmetic superficial damage (such as surface cracks). These criteria are set below the levels that have the potential to cause damage to the main structure.

Structural damage criteria are presented in German Standard DIN4150-Part 3 "Structural vibration in buildings – Effects on structures" and British Standard BS7385-Part 2: 1993 "Evaluation and Measurement for Vibration in Buildings".

Table 12 indicates the vibration limits presented in DIN4150-Part 3 to ensure structural damage does not occur.

Table 13 presents guide values for building vibration, based on the lowest vibration levels above which cosmetic damage has been demonstrated as per BS 7385-Part 2:1993.

Table 12: Guideline value of vibration velocity (vi) for evaluating the effects of short-term vibration

Line	Type of Structure	Vibration velocity, vi, in mm/s			
		Foundation At a frequency of			Plane of floor of uppermost full storey
		< 10Hz	10 - 50Hz	50 -100*Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20-40	40-50	40
2	Dwellings and buildings of similar design and/or use	5	5-15	15-20	15
3	Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3-8	8-10	8
*For frequencies above 100Hz, at least the values specified in this column shall be applied					

Table 13: Transient vibration guide values for cosmetic damage

Type of Building	Peak Particle Velocity in frequency range of predominant pulse (PPV)	
	4 Hz to 15 Hz	15 Hz and above
Residential or light commercial type buildings	15mm/s at 4Hz increasing to 20mm/s at 15Hz	20mm/s at 15Hz increasing to 50mm/s at 40Hz and above

4.2.2 Criteria for Vibration Sensitive Equipment

Existing surrounding receivers have not been identified as housing any vibration sensitive equipment. As such, no specific vibration criteria outside of those outlined above have been established for the proposed development.

5 Operational Noise Impact

The following section discusses the operational noise impact of the proposed development to the surrounding noise sensitive receivers.

5.1 Mechanical Noise Emissions

The following noise sources are associated with the site operation, and details about expected noise levels from these sources are given in the ensuing sub-sections. Noise sources from general operations at the site typically include mechanical services noise from air-conditioning equipment and exhaust fans. These noise sources have been used to predict the worst-case scenario to nearby sensitive receivers.

The proposed development has the following mechanical noise sources:

- Heat Recovery Units located on ground floor.
- Exhaust Fans ducted to the façade of the proposed development on both Ground floor and Level 1
- Outside Air Fans ducted to the façade of the proposed development on both Ground floor and Level 1.

In order to assess the worst case scenario, it was assumed that the air conditioning units associated with the proposed development are running at any time throughout a 24hr period, noting that a reduced capacity is expected during the nighttime hours. With all, night time is the most stringent period for the noise generated by the operation of the mechanical plant, therefore this criterion was used as the noise target at the boundary of the nearest sensitive receivers for the project.

At the time of the assessment, data for the Outside Air Fans for the proposed development was not available. This assessment should be updated upon finalization of the selections of the outside air fans, as well as any changes of specific equipment.

5.1.1 Proposed Maximum Noise Levels

Table 14 presents the proposed maximum sound power levels for individual mechanical units to achieve the noise criteria shown at the nearest sensitive receiver of the site. Typical mechanical plant spectra have been implemented in the calculations, and will need to be amended once specific units have been selected later in the design stage.

Table 14: Proposed Maximum acoustic power for individual mechanical units

Item	SWL re 10^{-12} W, dB(A)								
	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	Overall dB(A)
Heat Recovery Unit REYQ30BYM	85	81	78	74	69	62	57	51	76
Heat Receovery Unit REYQ10BYM	84	68	66	64	60	51	48	46	66
JETLINE-125	66	53	59	61	52	53	50	42	61
JETLINE-150 ECO	58	54	60	61	58	56	54	48	64
JETLINE-200	56	56	65	69	68	63	61	58	72
JETLINE-250	61	53	63	64	64	59	54	55	61

RIL-200SW	45	50	54	55	56	58	53	46	62
AP0312AP5/10	77	76	78	76	81	79	73	62	85
AP0402AP5/10	78	80	86	85	84	82	77	69	89
AP0312AP10/17	81	77	86	84	86	81	76	65	89
AP0402AP10/12	81	81	91	90	88	84	79	71	92

Table 15 presents the predicted noise emissions at the nearby noise sensitive receivers without any additional mitigation measures.

Table 15: Predicted Noise Levels at worst-case most affected receiver (without additional Mitigation Measures)

Receiver Location	Period	Predicted Noise Level $L_{Aeq,15min}$ - dB(A)	Criteria dB(A)	Compliance (Yes/No)
H1	Night Period (10:00pm – 7:00am)	39	50	Yes
R1	Night Period (10:00pm – 7:00am)	35	35	Yes
R2	Night Period (10:00pm – 7:00am)	35	35	Yes

Note: 1. Exceedance of 1dB(A) is not deemed as a perceptible change, refer to discussion below

At this stage, selections and specific locations for mechanical equipment have potential to change; therefore this assessment and mitigation measures should be considered as preliminary. A full detailed analysis of all plant items should be carried out as the design progresses. Given the proximity of the site to the nearby noise-sensitive receivers, it is not expected that the mechanical plant items will cause any adverse impact to the surrounding receivers provided the minimum mitigation measures outlined above have been met.

Additional mitigation measures for the mechanical plant should be considered during the design development phase so as to comply with the outlined criteria at the nearest sensitive receivers. These amelioration measures could include but not limited to the following:

- Positioning mechanical plant away from nearby receivers
- Select low noise mechanical equipment
- Acoustic attenuators fitted to duct work
- Acoustic louvres or solid barriers may be required, surrounding plant items on the rooftop. This mitigation may also be influenced by internal noise criteria within the hospital development itself.
- Where possible, locate noisy plant within an enclosed space.

Internally located equipment which exhausts at roof level should include sufficient ductwork to allow for acoustic internal lining or an attenuator for supply and exhaust to meet environmental noise criteria.

5.2 External Car Park Noise Assessment

The noise relating to the operation of the on grade carpark has been assessed to the most affected noise-sensitive receivers surrounding the site. The most affected noise sensitive residential receiver is expected to be the adjacent residential receivers at R1 and R2 (across Cowper Street and Fairfax Road Respectively). The assessment has been conducted based on the worst-case assumption of 5 total vehicle events in any given 15-minute period.

This assessment is considered to be conservative and compliance is expected to be achieved at noise sensitive receivers.

The noise activities that have been used in the assessment are as follows:

- Car doors closing
- Movement of cars entering and exiting the carpark

Table 16 presents a summary of the sound power levels of the noise sources, and presents the predicted noise at the most affected noise sensitive receivers.

Table 16: Typical sound power levels of carpark noise sources

Noise Source	Typical SWL dB(A)
Car door closing	98
Car movement	82

Table 17: Predicted vehicle noise at receiver.

Receiver Location	Descriptor	Predicted Noise Level $L_{Aeq,15min}$ - dB(A)	Criteria dB(A)	Compliance (Yes/No)
R1 & R2	$L_{Aeq,\ 15min}$	33	38 (Night time)	Yes

Based on this assessment, and provided the acoustic mitigation measures as detailed above are implemented, the noise emissions from the operation of the car park are expected to meet the noise limits established for the proposed development.

6 Construction Noise Assessment

6.1 Proposed Construction Activities

In this assessment, the noise impact from the Warrawong Community Health Centre works are considered. The proposed construction works will consist of the following stages:

- **Warrawong Community Health Centre scope of works**
  - Tree Removal
  - Demolition
  - Excavation
  - Structure

The hours of work are expected to occur during the daytime hours, as follows:

- Monday to Friday: 7am to 6pm
- Saturday: 8am to 1pm
- Sunday and public holidays: no work

The worst-case scenarios for both hospital and residential receivers are covered.

6.2 Expected Construction Equipment

The noise sources likely to be associated with the works listed in the previous section of this report are presented in Table 18. The equipment noise levels have been extracted from AS 2436:2010 *Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites* and *Construction Noise Strategy, Transport for NSW.*

Table 18: Predicted Sound Power Levels for Construction and Demolition Equipment

Stages	Duration of Stage	Equipment	Sound Power Level – dB(A)	Average-case[1]		Worst-case[1]	
				Quantity	Usage in 15-minute (% Time)	Quantity	Usage in 15-minute (% Time)
Tree Removal	Less than 1 month	Chainsaw[2]	119[1]	1	40	1	60
		Mulcher[2]	118	1	40	1	60
Remediation Works / Demolition	2 months	20t Excavator with bucket attachment	107	1	40	1	60
		Tip truck	108	2	40	2	60
		Water Cart	108	1	40	1	60
Excavation	2 months	20t Excavator with bucket attachment	107	1	60	1	50
		12t Pad Foot Roller	112	1	60	1	50
		12t Smooth Drum Roller	112	1	40	1	40
		Tip truck	108	2	40	4	60
		Piling Rig Bored	116	1	40	1	50
		Water Cart	108	1	50	2	50
Construction	4 months	Concrete Pump	110	1	25	1	25
		Electric Crane	105	1	25	1	40
		Hand Tools	102	2	50	4	75
		Tip truck	108	1	40	2	60

Note: 1. A +5 dB correction factor has been included in accordance with recommendations given in Section 4.5 of the ICNG
2. Only one is expected to be operating at any given time.

The NSW INCG outlines criteria for construction noise and the level at which it is considered to affect residential receivers and are outlined in Table 19. Table 20 show the criteria for other land uses other than residential in accordance with the NSW INCG.

Table 19: Interim Construction Noise Guideline criteria for residential receivers

Time of Day	Management Level $L_{Aeq(15min)}$	Affection of noise on receiver
Standard Hours Monday – Friday 7am - 6pm Saturday 8am – 1pm	RBL + 10dB	Noise Affected
	$\geq$ 75 dB(A)	Highly Noise Affected
Outside of Standard Hours	RBL + 5 dB	Noise Affected

Table 20: Interim Construction Noise Guideline criteria other noise sensitive receivers

Land Use	Management Level $L_{Aeq(15min)}$ during use
Hospital wards and operating theatres	45 dB(A) internal noise level

For the purposes of the assessment, it is largely unknown what the build-up of the façade for the adjacent hospital buildings is. As a worst-case scenario a 10dB loss has been assumed (accounting for any open windows and the like). Therefore the Noise Management levels for the prediction to these receivers will assume 45 + 10dB(A) to determine the external noise criteria for hospital receivers.

6.3 Noise Modelling & Assumptions

In order to assess the noise impact from the site during the various stages, acoustic predictions of the propagation of noise from construction noise sources were taken into account to estimate the resulting noise effects on the surrounding noise sensitive receivers. The noise model represents the 'reasonable' worst case periods of construction activities, meaning that all the equipment of each stage are operating simultaneously during a 15-minute observation period.

The assumptions that were made within the assessment include the following:

- The predicted noise levels represent the worst case scenario for each receiver
- The predicted noise levels at the nearby sensitive receivers have been assessed with the acoustic recommendations as shown in 9.1 implemented.
- The effect of other additional mitigation measures (respite periods, flexshield barriers to the scaffolding) has **not** been included within the model, however respite periods and such should be implemented as part of the management plan. This modelling only reflects those worst-case periods.
- The height of the receivers has been assumed as 1.5m from ground level
- The noise levels have been assessed using neutral weather conditions. i.e. no rain or strong wind.
- As detailed construction plan is still to be developed with equipment, vehicles etc. to be selected, Stantec has made typical assumptions on equipment to be used on site for each stage of the works.

The noise levels at the surrounding sensitive receivers have been based on the assumptions and aforementioned sound power levels of the equipment. The results of the predicted noise levels are presented in the following section.

6.4 Construction Noise Level Prediction Results

The predicted construction noise levels at the closest receivers with each identified zone have been presented in Table 21 to Table 24. For assessment purposes, the Evaluation Scenarios, 'Worst-case' and 'Average-case' are also presented.

Table 21: Predicted Noise Levels – Stage 1: Tree Removal

ID	Receiver	Predicted Noise Level Range		Noise Management Level	Noise Management Level Exceedance (dB)		Highly Noise Affected Criteria L_{eq}	Compliance with highly noise affected*	
		Average-Case	Worst-case		Average-Case	Worst-case		Average-Case	Worst-case
R1 306 Cowper Street	Residential	66	75	47	19	28	75	Yes	Yes
R2 7 Fairfax Rd	Residential	65	75	47	18	28	75	Yes	No
R2 11 Fairfax Rd	Residential	66	80	47	19	33	75	Yes	No
H1 Building C	Health	72	82	55	17	27	75	Yes	No
H2 Building F	Health	75	82	55	20	27	75	Yes	No
H2 Building G	Health	68	72	55	13	17	75	Yes	Yes

Table 22: Predicted Noise Levels – Stage 2: Demolition

ID	Receiver	Predicted Noise Level Range		Noise Management Level	Noise Management Level Exceedance (dB)		Highly Noise Affected Criteria L_{eq}	Compliance with highly noise affected*	
		Average-Case	Worst-case		Average-Case	Worst-case		Average-Case	Worst-case
R1 306 Cowper Street	Residential	68	73	47	21	26	75	Yes	Yes
R2 7 Fairfax Rd	Residential	68	74	47	21	27	75	Yes	Yes
R2 11 Fairfax Rd	Residential	68	73	47	21	26	75	Yes	Yes
H1 Building C	Health	66	71	55	11	16	75	Yes	Yes
H2 Building F	Health	68	78	55	13	23	75	Yes	No
H2 Building G	Health	63	75	55	8	20	75	Yes	Yes

Table 23: Predicted Noise Levels – Stage 3: Excavation

ID	Receiver	Predicted Noise Level Range		Noise Management Level	Noise Management Level Exceedance (dB)		Highly Noise Affected Criteria L_{eq}	Compliance with highly noise affected*	
		Average-Case	Worst-case		Average-Case	Worst-case		Average-Case	Worst-case
R1 306 Cowper Street	Residential	72	76	47	25	29	75	Yes	No
R2 7 Fairfax Rd	Residential	71	78	47	24	31	75	Yes	No
R2 11 Fairfax Rd	Residential	72	77	47	25	30	75	Yes	No
H1 Building C	Health	74	79	55	19	24	75	Yes	No
H2 Building F	Health	72	82	55	17	27	75	Yes	No
H2 Building G	Health	69	80	55	14	25	75	Yes	No

Table 24: Predicted Noise Levels – Stage 4: Construction

ID	Receiver	Predicted Noise Level Range		Noise Management Level	Noise Management Level Exceedance (dB)		Highly Noise Affected Criteria L_{eq}	Compliance with highly noise affected*	
		Average-Case	Worst-case		Average-Case	Worst-case		Average-Case	Worst-case
R1 306 Cowper Street	Residential	69	72	47	22	25	75	Yes	Yes
R2 7 Fairfax Rd	Residential	69	72	47	22	25	75	Yes	Yes
R2 11 Fairfax Rd	Residential	71	74	47	24	27	75	Yes	Yes
H1 Building C	Health	71	74	55	16	19	75	Yes	Yes
H2 Building F	Health	73	76	55	18	21	75	Yes	No
H2 Building G	Health	65	68	55	10	13	75	Yes	Yes

6.5 Discussion and Assessment

Based on the results of this assessment, the following conclusions are made:

- Noise levels are not predicted to exceed the Highly Noise Affected criteria (75 dBA) during all stages of work at the identified receivers for the average-case scenario.
    - The Highly Noise Affected Criteria is expected to be exceeded during the worst-case scenario for residential receivers located at R2 due to dump truck movements associated with the removal and delivery of materials on site. This is expected to be a relatively short-term exposure with truck movements along the eastern boundary. Compliance with the highly noise affected criteria is expected during the average case.
    - At all other times the noise level would be under the highly noise affected criteria.
- Compliance is expected to be achieved with the Highly Noise Affected Criteria (75dBA) during all stages at the identified receivers when considering the Average-Case scenario works.
- ICNG does not set out the Highly Noise Affected Criteria for non-residential receivers. Nevertheless, it should be noted that noise levels are predicted to comply with the Highly Noise Affected criteria (75 dBA) during all of the proposed stages of works at the nearest identified non-residential (i.e. hospital) receivers for both average- and worst-case scenarios.
- Primarily the cause of the exceedances at the identified receivers (worst-case scenario) is due to bored piling works, and equipment operating in close proximity to the surrounding boundary. There is minimal distance between the proposed works and receivers in many instances and is difficult to provide a high level of mitigation. The noise associated with the worst-case scenario is expected to be transient and intermittent in nature and is not expected to cause any long-term exposure at the receivers.
- Noise levels are predicted to exceed the NML during all the assumed stages of work at the nearest identified receivers for various works during both average- and worst-case scenarios.
- Noise levels during all the assumed stages of work are expected to exceed the Noise Management Level by up to 25dB during the average noise emissions; and up to 33dB during the Worst-Case (during tree removal) assessment scenario for the identified receivers.
- Noise levels do demonstrate higher noise levels of up to 82dB (Worst-case – at the identified close proximity health receivers) during the excavation period and tree removal. However, these works are representative of a worst-case scenario and is expected to be short-term and not have any prolonged impact. Compliance with the Highly Noise Effected Criteria (75dBA) is demonstrated during the Average-case scenario.

Based on the above, the proposed construction works have the potential to give rise to adverse noise impacts at identified noise sensitive receivers. Therefore, all reasonable and feasible measures should be applied on site to assist in reducing the overall noise emissions on site, as per the recommendations in Section 9. It is noted, however, the Average-case scenario is expected to represent the average noise expected from the entire site at a receiver and expected to representative of the longer-term average noise emissions. Therefore, this situation represents typical average construction noise emissions which are predicted to be below the Highly Noise Affected criterion at the nearest identified noise sensitive receivers in all instances.

7 Construction Traffic Noise Generation

Construction traffic movement prediction data is not available and the ICNG does not specify construction traffic noise criteria. However, based on the existing noise levels during the Day period, a typical heavy vehicle movement of four trucks per hour is assumed. On this basis, the construction traffic noise is unlikely to increase the existing traffic noise levels on surrounding roads by 2dB, as per the 'Relative Increase' limit imposed by the NSW Road Noise Policy. As an indication a 3dB increase would represent a doubling of traffic in the area.

8 Construction Vibration Assessment

The vibration associated with construction is dependent on several variables including the types of machinery, the proximity to the nearby receivers as well as the ground type.

Generally speaking, vibration can be more difficult to control than noise, and there are few generalizations that can be made about its control. It should be kept in mind that vibration may cause disturbance by causing structures to vibrate and radiate noise in addition to perceptible movement. Impulsive vibration can, in some cases, provide a trigger mechanism that could result in the failure of building components that had previously been in a stable state. Regarding equipment expected to have a greater vibrational impact (i.e. rock breaking), multiple respite periods should be offered per day. Additionally, regular communication with the affected residents should be maintained to schedule any highly vibration inducing activities for suitable time periods.

Further to the above, generic safe working distances for vibration impacts associated with various types of machinery at given distances are presented within the *"Construction Noise Strategy "*document (issued by the Transport Infrastructure Development Corporation, dated November 2007). This document presents the safe construction working limits for Cosmetic Damage to adjacent structures and Human Comfort. It is recommended that the indicative safe working distances should be maintained from vibrating equipment which could be used during demolition and construction tasks.

The following vibration intensive plant that are assumed for this project are assessed in this Section:

- 20t Excavator - with hammer
- 20t Excavator - with bucket
- Pile Boring
- Vibratory Roller

Indicative recommended 'Safe working' distances for the above vibration intensive plant boundaries are provided in Table 25. At distances beyond the Safe working distances, the recommended targets are unlikely to be exceeded.

Table 25: Recommended Safe Working distances for vibration intensive plant

Plant Item	Rating / Description	Safe Working Distance (m)	
		Structural Cosmetic Damage	Human Comfort
Vibratory Roller	< 300 kN (Typically 7 – 13 tonnes)	15	100
	> 300 kN (Typically more than 13 tonnes)	20	100
Small hydraulic hammer	300 kg, typically 5 – 12 tonnes excavator	2	7
Medium hydraulic hammer	900 kg, typically 12 – 18 tonnes excavator	7	23
Large hydraulic hammer	1600 kg, typically 18 – 34 tonnes excavator	22	73
Pile Boring	< 800 mm	2	N/A
Jackhammer	Hand held	1	Avoid contact with structure (including slab reinforcements)

At receivers within the recommended ‘Safe Working’ a more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the structure is needed to determine the applicable safe vibration level. Additionally, site measurements and alternative equipment or methodologies, should be considered. This exercise would be undertaken by the contactor as part of an updated CNVMP.

No receiver is identified within the Structural Cosmetic Damage zone for any in the vicinity of the proposed project. Therefore, any structural damage due to the vibration emission associated with the construction of the proposed development is unlikely. However, there is potential when using the larger excavators and vibratory rollers on the boundary of the site that some exceedance of the Human Comfort Criteria may occur. However, the distances in Table 25 relate to continuous vibration and construction works are often more intermittent than continuous, the actual perceived vibration impact can be smaller.

Based on the assumptions made in this report, no structure is identified within the recommended ‘Safe Working’ distances. However, vibration monitoring is recommended as per Section 9.5 at the commencement of work in order to verify the safe working distances for cosmetic damage and human comfort, and to determine suitable distances for sensitive receivers. If the levels are compliant with the vibration limits, then work may proceed based on the implementation of the measures as detailed in this report. If there are exceedances, reasonable and feasible mitigation measures and additional vibration monitoring should be conducted.

PART 2 – MANAGEMENT PLAN

9 Noise & Vibration Management Strategies

9.1 Project Specific Recommendations

Project specific recommendations and required mitigation methods have been listed below. Further general noise mitigation and management measures are provided in Section 9.2.

9.1.1 Noise

- *Site Hoarding* - The use of both A-class or B-class hoardings are required to be installed to mitigate the impact of the highest predicted noise levels. The extent of the hoardings is indicated by the markup presented in Figure 4.

  The construction of the barrier should be impervious of gaps and cracks, which would compromise its performance, and it will be comprised of acoustically suitable materials such as, 17 mm plywood. The barrier is able to reduce the noise levels experienced at the ground-level receivers directly around the site by 3-7 dB.

- *Temporary barriers* - Barriers should be mobile and extend to a height 1 m above noise source. These barriers should envelop the work location to ensure no direct line of sight to nearby receivers (ground level). Practical and feasible measures should be taken to allow the noise barrier to be located within 4 m of the noise source. Note that these localised noise barriers are proposed in addition to the site bounding hoarding outlined above.

  Where high noise impacts are expected, the ICNG requires that all feasible and reasonable work practices be employed. It is noted that the performance of noise barriers are compromised where there is a direct line of sight to a noise source. However, to protect the receiver closer to the ground level, localised noise barriers should be utilised when the following equipment is in use:

- In addition to the sound attenuating barrier, at least one respite period such as, 12:00pm – 1:00pm or otherwise agreed with the community, should be offered per day during the most intensive periods of hammering and rock breaking. Frequent and proactive communication with the sensitive receivers is also encouraged, thus enabling tuning the works schedule to accommodate possible important religious events and allowing the tenants to prepare their expectations on the changing noise environment. More details regarding communication with the community can be found in Section 9.3.

Figure 4: Extent of acoustic barrier (A-Class or B-Class Hoarding)

No exceedances of the criteria are expected at residential receivers located to the south (in closer proximity to the carpark works), as such acoustic barriers are not expected to be required in association with the demolition of the existing carparks.

9.1.2 Vibration

No receiver is identified within the Structural Cosmetic Damage zones in the vicinity of the proposed project. However, vibration monitoring for the proposed works has been outlined in Section 8.5.3 to ensure no adverse impacts occur on nearby sensitive receivers.

Should different construction equipment to those proposed in Table 18 are to be used, additional long-term and attended vibration monitoring may be required. This is to ensure that the acceptable levels of vibration are satisfied during the use of the vibration intensive equipment as per vibration limits set out in Section 4.2.

Upon any exceedances in vibration levels, reasonable and feasible measures should be considered to lessen the impact, such as alternative means of works or reducing the capacity of equipment to achieve a safe working distance. Using the smooth drum rollers over vibratory rollers as much as possible should reduce the vibration impact of compacting works.

To further dimmish the vibration impact, the respite period from 12:00pm – 1:00pm recommended for noise impact reasons should also apply for vibration. If the criteria are still exceeded at any sensitive receivers, suitable working times should be discussed between the receiver and the contractor.

9.2 General Acoustic Recommendations for Construction

Australian Standard AS 2436 – 2010 *Guide to noise and vibration control on construction, demolition, and maintenance sites* recommends the following techniques that could be applied to minimise the spread of noise and vibration to potential receivers.

9.2.1 Noise

Figure 5 demonstrates the preferred order of actions taken to mitigate excessive construction noise emissions. If a process that generates significant noise levels cannot be avoided, the amount of noise reaching the receiver should be minimised. Two ways of achieving this are to either increase the distance between the noise source and the receiver or to introduce noise reduction measures, such as screens. Practices that will reduce noise from the site include:

- Increasing the distance between noise sources and sensitive receivers.
- Reducing the line-of-sight noise transmission to residences or other sensitive land uses using temporary barriers (stockpiles, shipping containers and site office transportable can be effective barriers).
- Constructing barriers that are part of the project design early in the project to introduce the mitigation of site noise.
- Installing purpose-built noise barriers, acoustic sheds, and enclosures.

Physical methods to reduce the transmission of noise between the site works and residences, or other sensitive land uses, are generally suited to works where there is longer-term exposure to the noise. A few of these methods have been introduced in Figure 5 below.

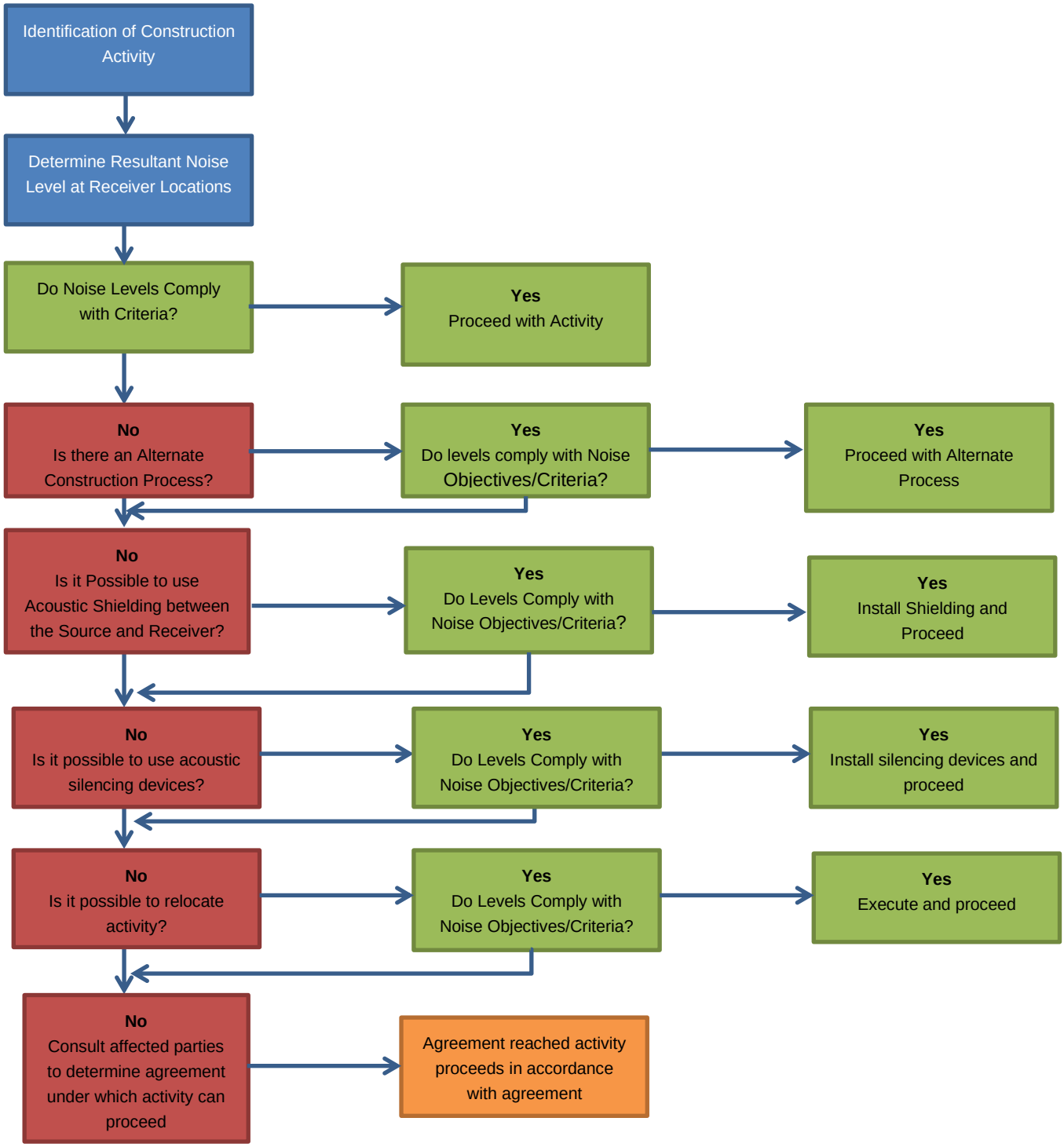

Figure 5: Noise Mitigation Management Flow Chart

Screening

On sites where distance is limited, screening of noise may be beneficial or even the only way to reduce construction noise impacts on the nearby receivers. Below, screening options for various situations have been introduced. Constructing and utilising these screening methods should be considered already during the planning stages.

Temporary buildings: One option to introduce screening is to position structures such as stores, storage piles, site offices and other temporary buildings between the noisiest part of the site and the nearest dwellings. Due to shielding provided by these buildings, some of the noise emission from the site can be reduced. If the buildings are occupied, however, sound insulation measures may be necessary to protect site workers inside the buildings.

Hoarding: Another way of implementing screening is to build hoarding that includes a site office on an elevated structure. This option offers superior noise reduction when compared with a standard, simple hoarding. The acoustic performance is further enhanced when the hoarding is a continuous barrier.

Partial building structures: On some sites, partially completed or demolished buildings can be used as noise shields for certain equipment. A noisy, stationary plant can be placed in a basement, the shell of which has been completed, provided reverberant noise can be controlled. Where compressors or generators are used in closed areas, it is also necessary to ensure that the exhaust gases are discharged directly to the outside air and that there is good cross-ventilation to prevent the build-up of poisonous carbon monoxide fumes and to allow an adequate air supply to maintain efficiency when operating the equipment.

Earth mounds and embankments: Where constructing noise barriers and using partial building shells is not practical, a worthwhile reduction in noise can be obtained by siting the plant behind and as close as possible to mounds of earth, which may effectively screen any noise sensitive areas from the plant. These mounds can often be designed into the construction schedule or site arrangement for future landscaping.

Long, temporary earth embankments can provide quite an effective noise screen for mobile equipment moving, for example, on a haulage road. When the earthworks are complete, the earth mounds should be removed, if possible, with smaller quieter excavators. A noise barrier like this may be a more reliable method of noise control than the imposition of restrictions on throttle settings.

Where earth noise barriers are not practical due to lack of space, consideration should be given to the possibility of constructing temporary screens from wood or any equivalent material in surface density.

Equipment operating 24h: When it comes to water pumps, fans and other plant equipment that operate on a 24-hour basis, they may not be an irritating source of noise during the day but can be problematic at night. They should therefore be effectively screened by either situating them behind a noise barrier or by being positioned in a trench or a hollow in the ground. Again, generated reverberant noise must be minimised and adequate ventilation should be ensured.

General remarks:

In many cases, it is not practical to screen earthmoving operations effectively, but it may be possible to partially shield a construction plant at the early stages of the project with protective features required to screen traffic noise.

The usefulness of a noise barrier will depend upon its length, its height, its position relative to the source and the receiver, and the material of which it is made. A barrier designed to reduce noise from a moving source should extend beyond the last property to be protected by at least ten times the shortest distance from the said property to the barrier. A barrier designed to reduce noise from a stationary source should, where possible, extend beyond the direct line of sight between the noise source and the receiver by a distance equal to ten times the effective barrier height, which is the height above the direct line between source and receiver.

If the works are already predominantly located within nominally closed structures, careful consideration should be given to reducing noise breakout at any openings.

Crane (diesel operated)

An appropriate silencer on the muffler and acoustic screen around the engine bay are recommended to attenuate the noise from the machine.

Reversing and warning alarms

Community complaints often involve the intrusive noise of alarms commonly used to provide a safe system of work for vehicles operating on a site. Beeper reversing alarm noise is generally tonal and may cause annoyance at significant distances from the work site.

There are alternative warning alarms capable of providing a safe system of work that are equal to or better than the traditional "beeper", while also reducing environmental noise impacts. The following alternatives should be considered for use on construction sites as appropriate:

- Broadband audible alarms incorporating a wide range of sound frequencies (as opposed to the tonal frequency 'beep') are less intrusive when heard in the neighbourhood.
- Variable-level alarms reduce the emitted noise levels by detecting the background noise level and adjusting the alarm level accordingly.
- Non-audible warning systems (e.g. flashing lights, reversing cameras) may also be employed, provided that safety considerations are not compromised.
- Proximity alarms that use sensors to determine the distance from objects, such as people or structures, and generate an audible alarm in cabin for the driver.
- Spotters or observers.

The above methods should be combined, where appropriate.

9.2.2 Vibration

Vibration can be more difficult to control than noise, and there are few generalisations that can be made about its control. It should be kept in mind that vibration may cause disturbance by causing structures to vibrate and radiate noise in addition to perceptible movement. Impulsive vibration can, in some cases, provide a trigger mechanism that could result in the failure of building components that had previously been in a stable state.

It should be remembered that failures, sometimes catastrophic, can occur as a result of conditions not directly connected with the transmission of vibrations, e.g. the removal of supports from retaining structures to facilitate site access. BS 7385-2 provides more information on managing ground-borne vibration and its potential effects on buildings. Where site activities may affect existing structures, a thorough engineering appraisal should be made at the planning stage.

General principles of seeking minimal vibration at receiving structures should be followed in the first instance. Predictions of vibration levels likely to occur at sensitive receivers are recommended when they are relatively close, depending on the magnitude of the source of the vibration or the distance associated. Relatively simple prediction methods are available in textbooks, codes of practice and standards, however, it is preferable to assess site transmission and propagation characteristics between source and receiver locations through measurements.

Guidance for measures available for the mitigation of vibration transmitted can be sought in more detailed standards, such as BS 5228-2 or policy documents, such as the NSW DEC *Assessing Vibration: A technical guideline*. Identifying the strategy best suited to the control of vibration follows a similar approach to that of noise: avoidance, control at the source, control along the propagation path, control at the receiver, or a combination of these. It is noted that vibration sources can include stationary plant (pumps and compressors), portable plants (jackhammers and pavement vibrators), mobile plants, pile-drivers, tunnelling machines and activities, and blasting, amongst others. Unusual ground conditions, such as a high water-table, can also cause a difference to the expected or predicted results.

The following general vibration management measures are provided to minimise vibration impact from construction activities to the nearest affected receivers relevant to both human comfort and structural damage limits identified in Section 3.2.

- Building condition surveys:
    - Prior to work, carry out building dilapidation studies on all structures within the Safe Working Distances defined in Table 25 for cosmetic damage.

- Community consultation:
    - notify the community of construction work and its impacts;
    - notify the community that the amount of vibration experienced, or at which loose objects may rattle, is significantly lower than the level at which minor cosmetic damage is expected to occur.
    - Management measures may include alternative construction methods.
- Equipment selection/ construction method:
    - Utilise less vibration emitting construction methods where feasible & reasonable.

9.3 Complaint Handling Procedures and Community Liaison

It is recommended that the builder directly contact adjacent noise sensitive receivers and provide them with the following information:

- The contact details for a nominated representative in order to make noise / vibration complaints.
- Explain the timeframe for the construction works and the proposed activities, i.e. the proposed start / stop dates of work and a description of the noise producing equipment that will be used.
- Notify the noise sensitive receivers and Wollongong Council in a timely manner should there be any need for an extension to the proposed arrangements.
- Wollongong Council should be notified of the nature and details of complaints received (time, complainant etc.) and what remedial action has taken place, if any.
- Where noise is demonstrated as being compliant with criteria, this should not limit the proponent in undertaking further additional reasonable and feasible steps to reduce noise emissions.

To assist in the management of noise and vibration complaints various procedures are to be followed. These include:

- Clearly visible signage identifying any key personnel along with their contact details to be erected along the perimeter of the building site including;
    - A 24 hour contact name, phone number and email address provided for the resident to address any complaint. The signage will declare; “For any enquiry, complaint or emergency relating to this site at any time please contact…”
- Give complaints a fair hearing.
- Have a documented complaints process, including an escalation procedure so that if a complaint is not satisfied there is a clear path to follow.
- Call back as soon as possible to keep people informed of action to be taken to address noise problems. Call back at night time only if requested by the complainant to avoid further disturbance.
- Implement all feasible and reasonable measures to address the source of the complaint.
- A register is to be kept by the contractor to keep a record of complaints and detail any information associated with them. The contents of the register will include:
    - The name and the address of the complainant
    - Time and date of the complaint
    - The nature of the complaint (Noise/Vibration)
    - Subsequent details
    - Remedial action undertaken

The contents of the register will be maintained and updated with any new complaint without delay. The complaints will be reported to both Wollongong Council and the Contractor. The investigation of the complaint and any remedial actions will be performed by the builder and/or client representative.

9.4 Site Inductions

To ensure that effective and consistent communication with the construction team and community, minimise the impact to the surrounding noise sensitive receivers, and mitigation measures are correctly implemented, a site induction is required. to all site personnel. Site inductions are required to ensure that all contractors, subcontractors and other personnel working on and visiting the site are aware of their obligations conveyed by this noise and vibration management plan

The intent of the site induction is to raise awareness and educate site personnel by identifying the impacts of noise and vibration, and the implementation of project specific mitigation and control measures. Site inductions will include the following items to make site workers aware of the project's obligations as detailed in the Acoustic Noise and Vibration Management Plan:

- Site personnel should be made aware of the project specific and standard noise and vibration measures (i.e. site hoardings, localised barriers around high noise generating equipment)
- During periods of work which generate potential of high noise impact (I.e. work exceeding the highly noise affect criteria of L_{Aeq} 75dB) as measured at the nearby noise sensitive receivers. Works must only be undertaken in a continuous block of no more than 3 hours, with at least a 1-hour respite period between each block of work generating high noise impact, where the location of the work is likely to impact the same receivers.
- Standard Construction hours of works
- Construction vehicles must not arrive and depart the site or surrounding residential precincts outside the established construction hours.
- Access pathways to site on the boundary (hoarding / gates) should remain closed at all times when not in use.
- Identification of the nearby noise sensitive receivers
- Complaint handling and communication procedures
- Relevant licence and approval conditions
- Location of loading and unloading areas
- Selection of low-noise tools where possible. All equipment should be well maintained (e.g. serviced, lubricated) to reduce noise.
- Site safety (i.e. Hearing Protection, limiting amount of time an individual is exposed to loud noise sources).

9.5 Noise & Vibration Monitoring Strategy

9.5.1 General Methodology

Noise and vibration levels should be monitored from time to time to ensure that noise generated as a result of remediation and construction activities does not disturb local businesses and residents.

Monitoring may be in the form of regular checks by the builder or indirectly by an acoustic consultant engaged by the builder and in response to any noise or vibration complaints. Where noise and vibration criteria are being exceeded or in response to valid complaints, noise and / or vibration monitoring should be undertaken. This would be performed at the affected property and on site adjacent to the affected receivers.

The results of any noise or vibration monitoring are to be provided to the relevant party or person in a timely manner allowing the builder to address the issue and respond to the complaints.

Noise and vibration monitoring can take two forms:

Short-term monitoring - Short-term monitoring consists of attended monitoring when critical stages of the construction are occurring. This normally provides real-time assistance and guidance to the subcontractor on site, telling them when the noise and vibration criteria are exceeded. Thus, the selection of alternative method on construction or equipment selection is allowed in order to minimise noise and vibration impacts.

Long-term monitoring - Similarly to short-term monitoring, long-term monitoring provides real-time alerts to the builder / site manager when the noise and vibration criteria are exceeded. Instead of someone being on site measuring, noise and vibration loggers are used. Typically, the noise and vibration loggers stay on site for a period of several months for the critical construction stages of the project. Sometimes the period of construction noise and vibration monitoring is dictated by the local authorities.

Both methodologies are complementary and normally used simultaneously providing a significant amount of data via the long-term monitoring, but also providing information on the sources of noise and vibration generating exceedances via the short-term or attended monitoring.

9.5.2 Noise Monitoring Program

The most noise and vibration sensitive receivers have been identified as the health receivers found within the hospital precinct (H1) to the West and South of the site. As such, monitors have been proposed to be located as close as possible to these receivers. No sensitive equipment has been identified within these buildings, so no sensitive equipment criteria have been established for the project. Monitoring would consist of structural and cosmetic damage.

Additionally, it is important for personnel on site to be aware of noise and vibration triggers that occur within the construction periods, so that they can adjust activities and mitigate impact on the surrounding receivers in a prompt manner. To ensure the noise and vibration generated by the construction activities adhere to the criteria presented in this report, the monitors must be configured to send a text message via SMS to the project team with every breach of the criteria for each monitor. By doing so, personnel on site gets notified and can act in a prompt manner to mitigate noisy activities as far as practical and as quickly as possible.

The following monitoring program is proposed for this project. Refer to Figure 6 for the approximate monitoring locations.

Table 26 - Proposed noise and vibration monitoring locations details

Sensitive Receiver Details	Proposed Monitoring Type and Phase
H1	Noise – Excavation and Demolition
	Vibration – Excavation and Demolition

The monitoring programme as shown above is to be carried out during the likely noisiest stages as agreed with the Acoustic engineer and Contractor.

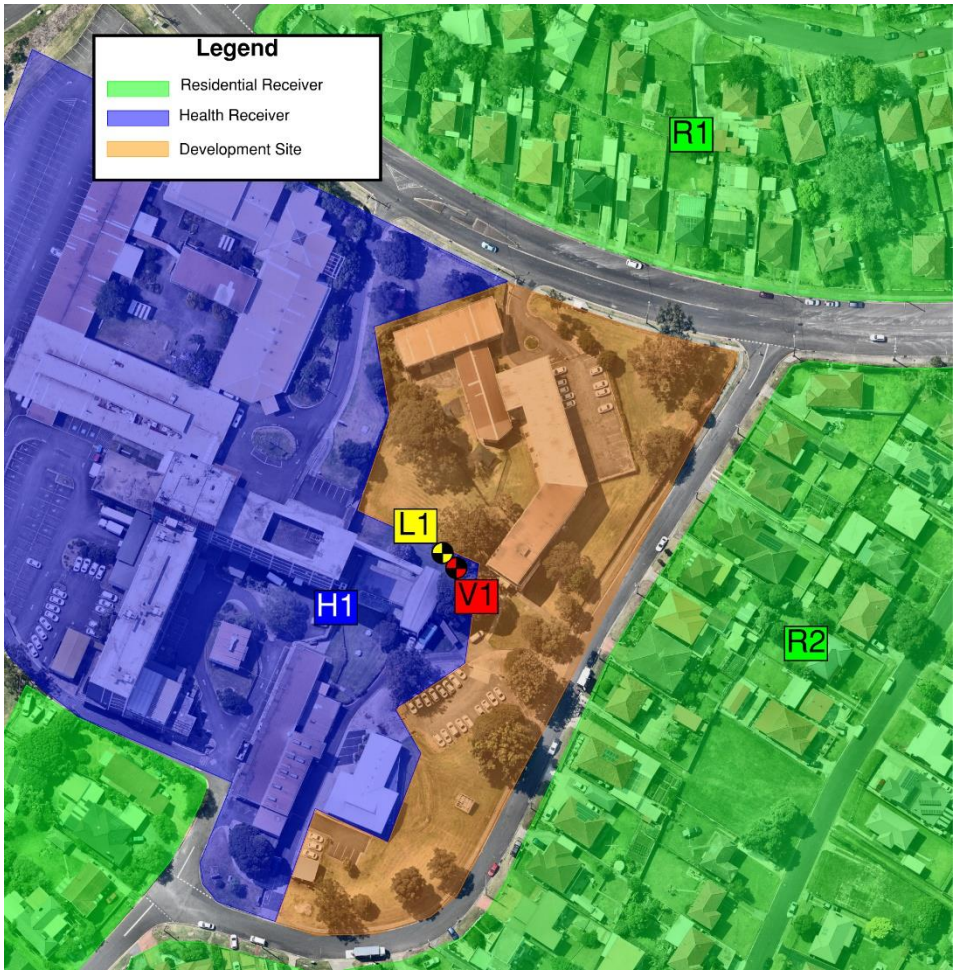

Figure 6: Unattended Noise and Vibration Monitoring Location

10 Conclusion

A Construction Noise and Vibration Impact Assessment has been provided for the assumed typical construction works for the construction works associated with the Warrawong Community Health Centre development.

The details of the noise and vibration assessments undertaken to predict the impacts on sensitive receivers have been presented in Sections 5, to 8. the following conclusions are made:

- Noise levels are not predicted to exceed the Highly Noise Affected criteria (75 dBA) during all stages of work at the identified receivers for the average-case scenario.
    - The Highly Noise Affected Criteria is expected to be exceeded during the worst-case scenario for residential receivers located at R2 due to dump truck movements associated with the removal and delivery of materials on site. This is expected to be a relatively short-term exposure with truck movements along the eastern boundary. Compliance with the highly noise affected criteria is expected during the average case.
    - At all other times the noise level would be under the highly noise affected criteria.
- Compliance is expected to be achieved with the Highly Noise Affected Criteria (75dBA) during all stages at the identified receivers when considering the Average-Case scenario works.
- ICNG does not set out the Highly Noise Affected Criteria for non-residential receivers. Nevertheless, it should be noted that noise levels are predicted to comply with the Highly Noise Affected criteria (75 dBA) during all of the proposed stages of works at the nearest identified non-residential (i.e. hospital) receivers for both average- and worst-case scenarios.
- Primarily the cause of the exceedances at the identified receivers (worst-case scenario) is due to bored piling works, and equipment operating in close proximity to the surrounding boundary. There is minimal distance between the proposed works and receivers in many instances and is difficult to provide a high level of mitigation. The noise associated with the worst-case scenario is expected to be transient and intermittent in nature and is not expected to cause any long-term exposure at the receivers.
- Noise levels are predicted to exceed the NML during all the assumed stages of work at the nearest identified receivers for various works during both average- and worst-case scenarios.
- Noise levels during all the assumed stages of work are expected to exceed the Noise Management Level by up to 25dB during the average noise emissions; and up to 33dB during the Worst-Case (during tree removal) assessment scenario for the identified receivers.
- Noise levels do demonstrate higher noise levels of up to 82dB (Worst-case – at the identified close proximity health receivers) during the excavation period and tree removal. However, these works are representative of a worst-case scenario and is expected to be short-term and not have any prolonged impact. Compliance with the Highly Noise Effected Criteria (75dBA) is demonstrated during the Average-case scenario.

Based on the above, the proposed construction works have the potential to give rise to adverse noise impacts at identified sensitive noise receivers. Therefore, all reasonable and feasible measures should be applied on site to assist in reducing the overall noise emissions on site, as per the recommendations in Section 9. It is noted, however, the Average-case scenario is expected to represent the average noise expected from the entire site at a receiver and expected to representative of the longer-term average noise emissions. Therefore, this situation represents typical average construction noise emissions which are predicted to be below the Highly Noise Affected criterion at the nearest identified noise sensitive receivers in all instances.

A construction traffic noise impact on the surrounding roads has been qualitatively assessed. The traffic noise generated in association with the construction of the proposed development is unlikely to impact nearby residents.

No receiver is identified within the vibration Structural Cosmetic Damage zone in the vicinity of the proposed project. Therefore, exceedance in the vibration criteria for structural damage is unlikely.

Vibration monitoring for the proposed works has been outlined in Section 8.5.3 to ensure no adverse impacts occur on nearby sensitive receivers, specifically in relation to the human comfort criteria which is more stringent than the structural cosmetic damage limits. Should different construction equipment to those proposed in Table 18 be used, long-term and attended vibration monitoring may be required. This is to ensure that the acceptable levels of vibration are maintained during the use of the vibration intensive equipment, as per vibration limits set out in Section 3.2.

To reduce the noise and vibration impacts on the sensitive receivers, noise and vibration management strategies have been proposed in Section 9. Erecting a sound attenuating barrier around the site and localised barriers around stationary equipment are recommended.

The information presented in this report shall be reviewed if any modifications to the features of the development specified in this report occur, including and not restricted to selection of equipment/machinery and modifications to the proposed construction program.

Appendices

Appendix A Glossary of Acoustic Terms

NOISE	
Acceptable Noise Level:	The acceptable LAeq noise level from industrial sources, recommended by the EPA (Table 2.1, INP). Note that this noise level refers to all industrial sources at the receiver location, and not only noise due to a specific project under consideration.
Adverse Weather:	Weather conditions that affect noise (wind and temperature inversions) that occur at a particular site for a significant period of time. The previous conditions are for wind occurring more than 30% of the time in any assessment period in any season and/or for temperature inversions occurring more than 30% of the nights in winter).
Acoustic Barrier:	Solid walls or partitions, solid fences, earth mounds, earth berms, buildings, etc. used to reduce noise.
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 Location	The position at which noise measurements are undertaken 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.
Decibel [dB]:	The units of sound pressure level.
dB(A):	A-weighted decibels. Noise measured using the A filter.
Extraneous Noise:	Noise resulting from activities that are not typical of the area. Atypical activities include construction, and traffic generated by holidays period and by special events such as concert or sporting events. Normal daily traffic is not considered to be extraneous.
Free Field:	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground
Frequency:	Frequency is synonymous to pitch. Frequency or pitch can be measured on a scale in units of Hertz (Hz).
Impulsive Noise:	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:	Level that drops to the background noise level several times during the period of observation.
LAmax	The maximum A-weighted sound pressure level measured over a period.
LAmin	The minimum A-weighted sound pressure level measured over a period.
LA1	The A-weighted sound pressure level that is exceeded for 1% of the time for which the sound is measured.
LA10	The A-weighted sound pressure level that is exceeded for 10% of the time for which the sound is measured.
LA90	The A-weighted 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).
LAeq	The A-weighted “equivalent noise level” is the summation of noise events and integrated over a selected period of time.

LAeqT	The constant A-weighted sound which has the same energy as the fluctuating sound of the traffic, averaged over time T.
Reflection:	Sound wave changed in direction of propagation due to a solid object met on its path.
R-w:	The Sound Insulation Rating R-w is a measure of the noise reduction performance of the partition.
SEL:	Sound Exposure Level 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 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.

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