New Shellharbour Hospital

Acoustics Report

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Revision

Revision	Date	Comment	Prepared By	Approved By
001	13/05/22	Draft Issue	James Ashpole	Meisha Stevens
002	01/06/22	Early and Enabling Works – Updated	James Ashpole	Meisha Stevens
003	17/06/22	Updates as per comments	James Ashpole	Meisha Stevens
004	09/09/22	DA Updates – additional rock breaking	James Ashpole	Meisha Stevens
005	20/09/22	REF Drawings Updates	James Ashpole	Meisha Stevens
006	18/10/22	Updated REF Scope	James Ashpole	Meisha Stevens
007	21/10/22	Minor Updates	James Ashpole	Meisha Stevens

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Contents

Contents

1. Introduction

The purpose of this report is to provide an acoustic assessment of proposed early and enabling works associated with New Shellharbour Hospital Development located at 86 Dunmore Rd, Dunmore. The proposed early and enabling works comprise two scopes, to be assessed under separate planning approval pathways (Review of Environmental Factors (REF) and Bulk Excavation Development Application (DA)) as listed below. This acoustic assessment assesses both scopes of works accordingly.

The scope of the proposed works includes:

- **REF Scope**

  involve Installation of a new underground high-voltage (HV) feeder from the Shellharbour Zone Substation(Lot 1 DP439066) to the site frontage, as well as electrical infrastructure works within the site of the proposed New Shellharbour Hospital, including new substation and associated works.

  - Trenching between New Shellharbour Hospital Site and the Shellharbour Zone Substation
  - Excavation
  - Substation Installation

- **Development Application for Bulk Excavation**

  - Establishment and use of a construction access road and internal construction road

  Bulk site earthworks (including cut, fill, benching, temporary stockpiling etc) and associated works, in preparation for the construction of the New Shellharbour Hospital (note the hospital construction will be subject to a separate future State Significant Development Application)

  - Demolition
  - Tree Removal

This report has been prepared to detail the Assessment of the two separate early/enabling works scopes associated with the development of the new Shellharbour hospital and has been differentiated accordingly in this report

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
- 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.
- Shellharbour City Council Development Control Plan 2013
- 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:

- Concept Plan Architectural drawings prepared by Cox Architecture, dated 17th March 2022
- Noise data has been based on the measured environmental noise levels documented in the Acoustic Master Planning Report prepared by Stantec, dated 21st December 2021.
- HV Enabling Works For REF prepared by JHA, dated 9th September 2022.
- Electrical Services drawings provided by JHA, dated 29th April 2022.
- Applicable Bulk Excavation documentation and Aconex correspondence

2. Project Description

2.1 Project Background

The New Shellharbour Hospital and Integrated Services Project

The NSW Government has committed to a $100 billion infrastructure pipeline over the next four years, $10.7 billion of which will be spent on new and upgraded health facilities. Underpinning this capital spend is the Government's economic reform and recovery strategy. It is within this context that on 8 September 2020 the NSW Premier announced a $700 million plus commitment to the New Shellharbour Hospital and Integrated Services (NSH&IS) Project (The Project).

2.2 Site Description and Noise & Vibration Sensitive Receivers

The proposed New Shellharbour Hospital development is located at 86 Dunmore Road, Dunmore. The site is bounded by the South Coast Rail Line and Princes Highway to the west, Dunmore Rd to the east, Shellharbour Anglican College to the north, and Agricultural Land to the south. Beyond Dunmore Rd to the east are residential properties and the Links Golf Course.

The nearest noise and vibration sensitive receivers are residential properties found along Dunmore Rd (R1 & R2) to the East of the site and the Shellharbour Anglican College located to the north (E1). The proposed area of the site location is shown in Figure 1, together with the boundaries of the adjacent land and use.

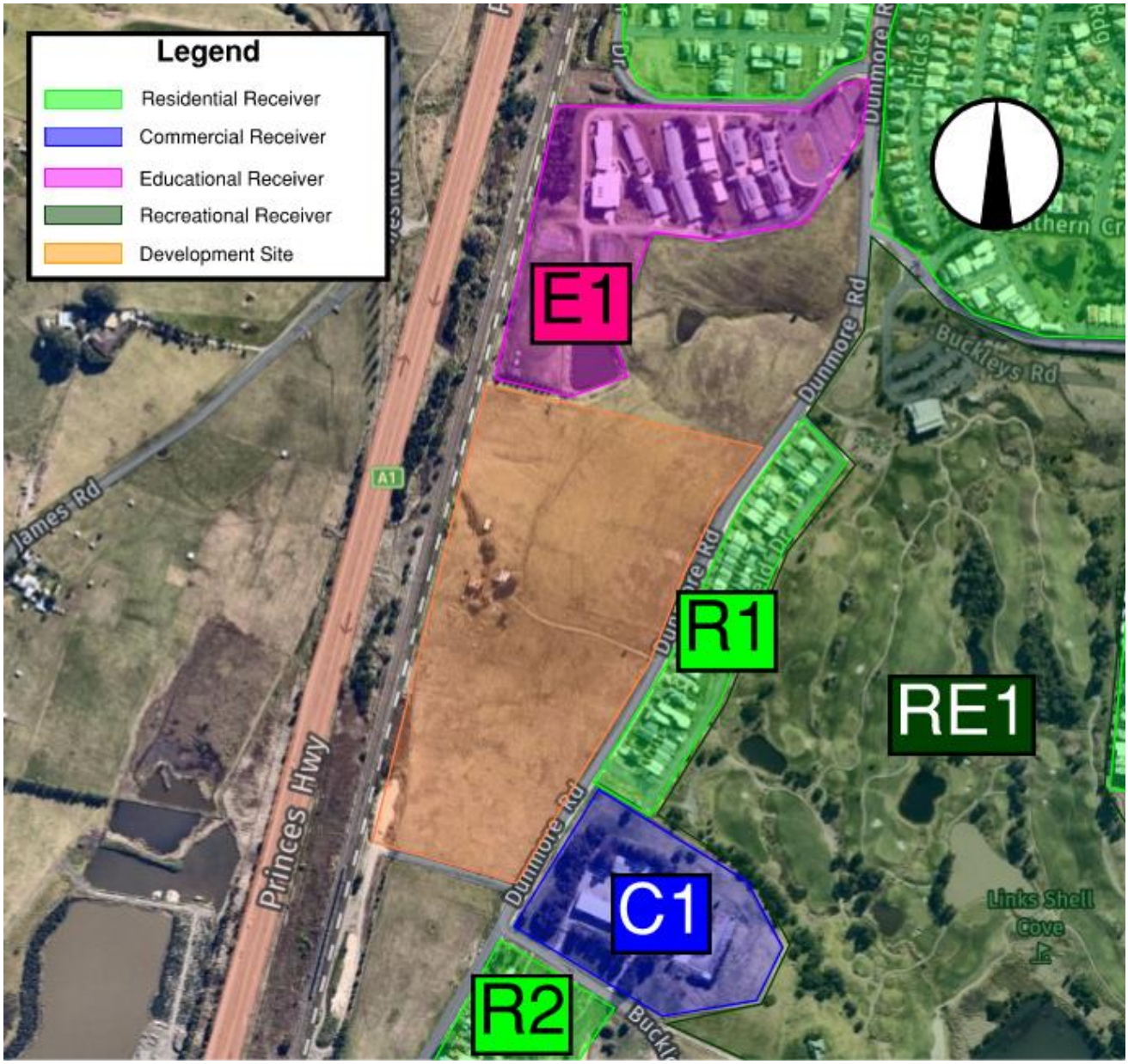

Figure 1: Aerial Photo of the Area Showing an Overview of the Site and Measurement Locations

Source: nearmap.com

2.2.1 REF Scope of Works

The REF scope of works entails trenching for the proposed HV feeder cable route from the northern substation to the hospital site. It is expected that the REF works are expected to be completed in a 6 month period. The extent of the trenching is detailed in Figure 2 below. Health Infrastructure's requirement for a noise impact assessment is that if sensitive receivers will be impacted for more than 3 weeks a quantitative assessment is required. The Acoustic Impact assessment will consider the sensitive receivers along all proposed trenched sections of the proposed HV feeder cable route.

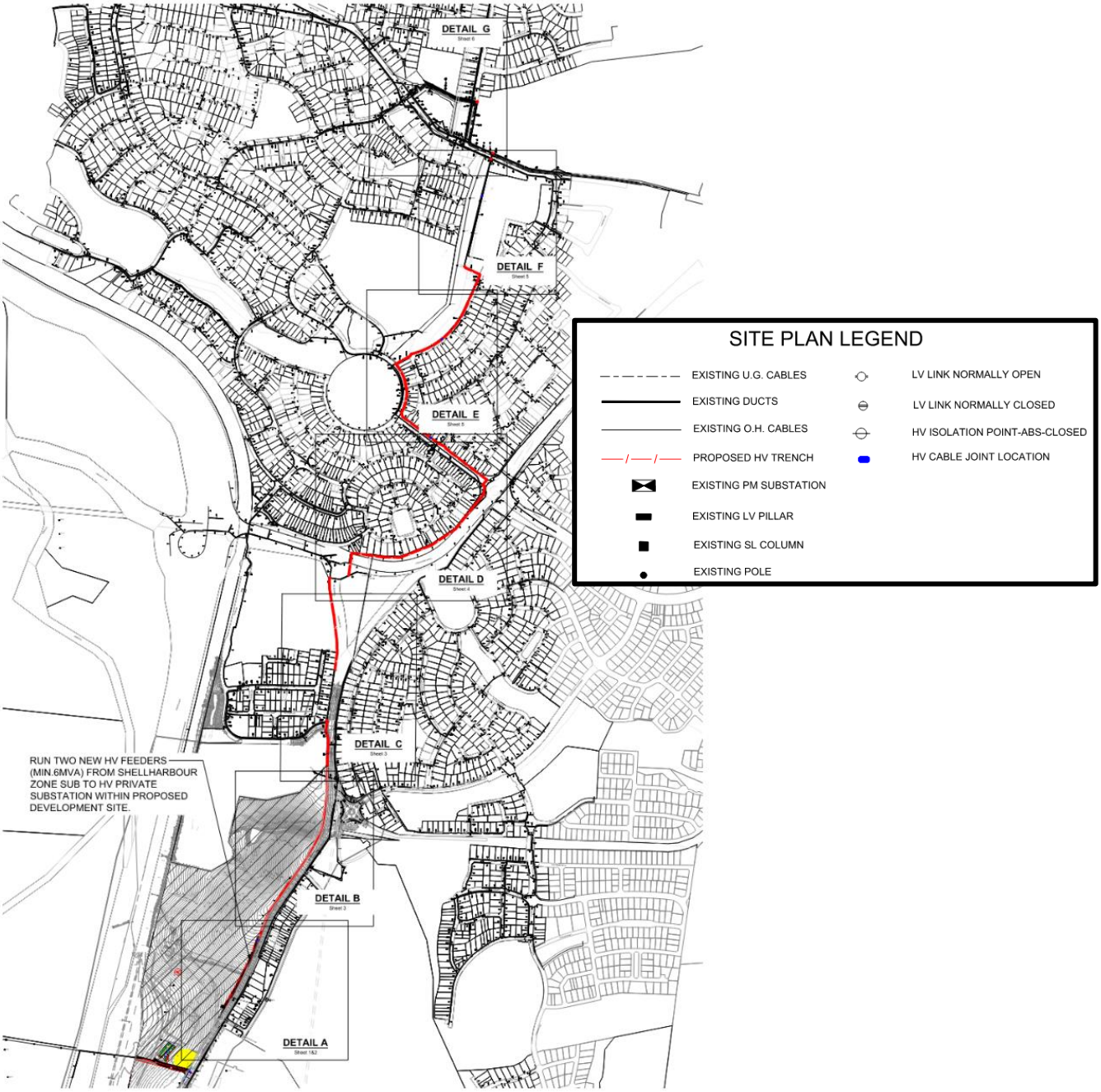

Figure 2: Concept HV Feeder – Trenching Extent

2.2.2 Bulk Excavation DA Scope of works

The Bulk Excavation DA scope of works entails establishment of the site. This includes the establishment and use of construction access roads and internal construction works. Bulk earthworks are proposed to prepare the site for the construction of the New Shellharbour Hospital. The extent of the Bulk Earthworks is detailed in Figure 3 and Figure 4 below. The Acoustic Impact assessment will consider the sensitive receivers along Dunmore Road.

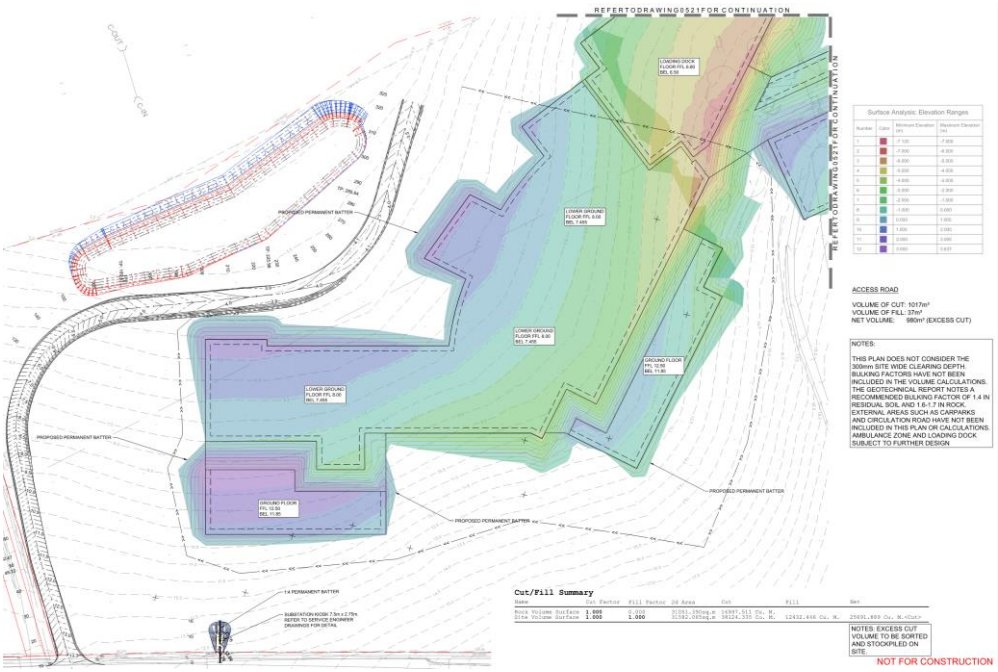

Figure 3: Bulk Earthworks plan – 1

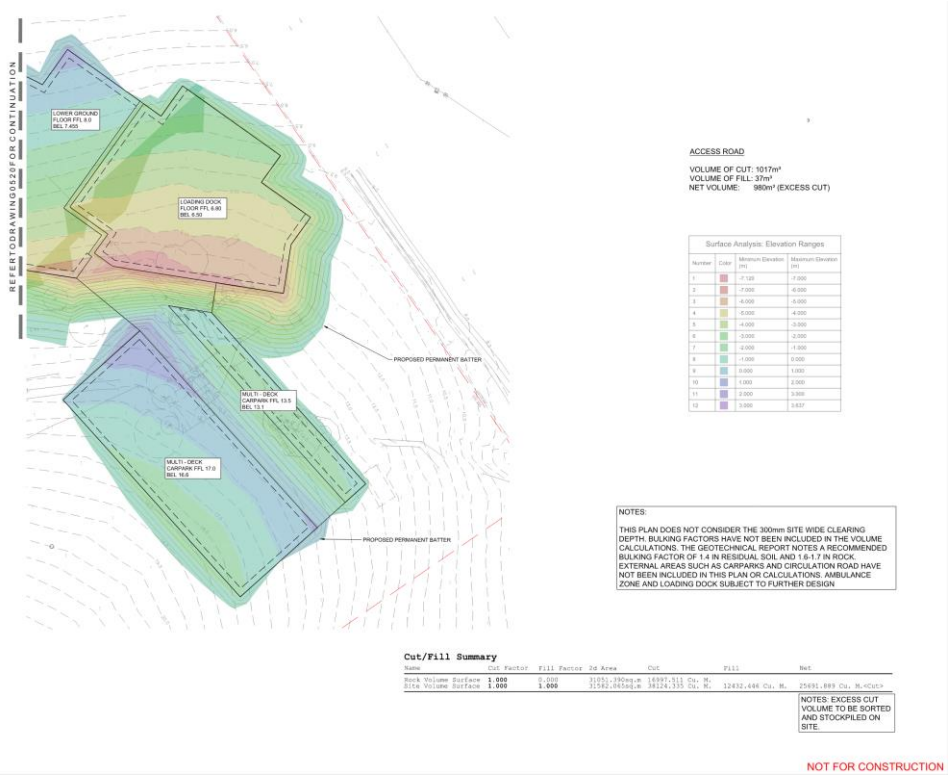

Figure 4: Bulk Earthworks Plan – 2

3. Acoustic Survey

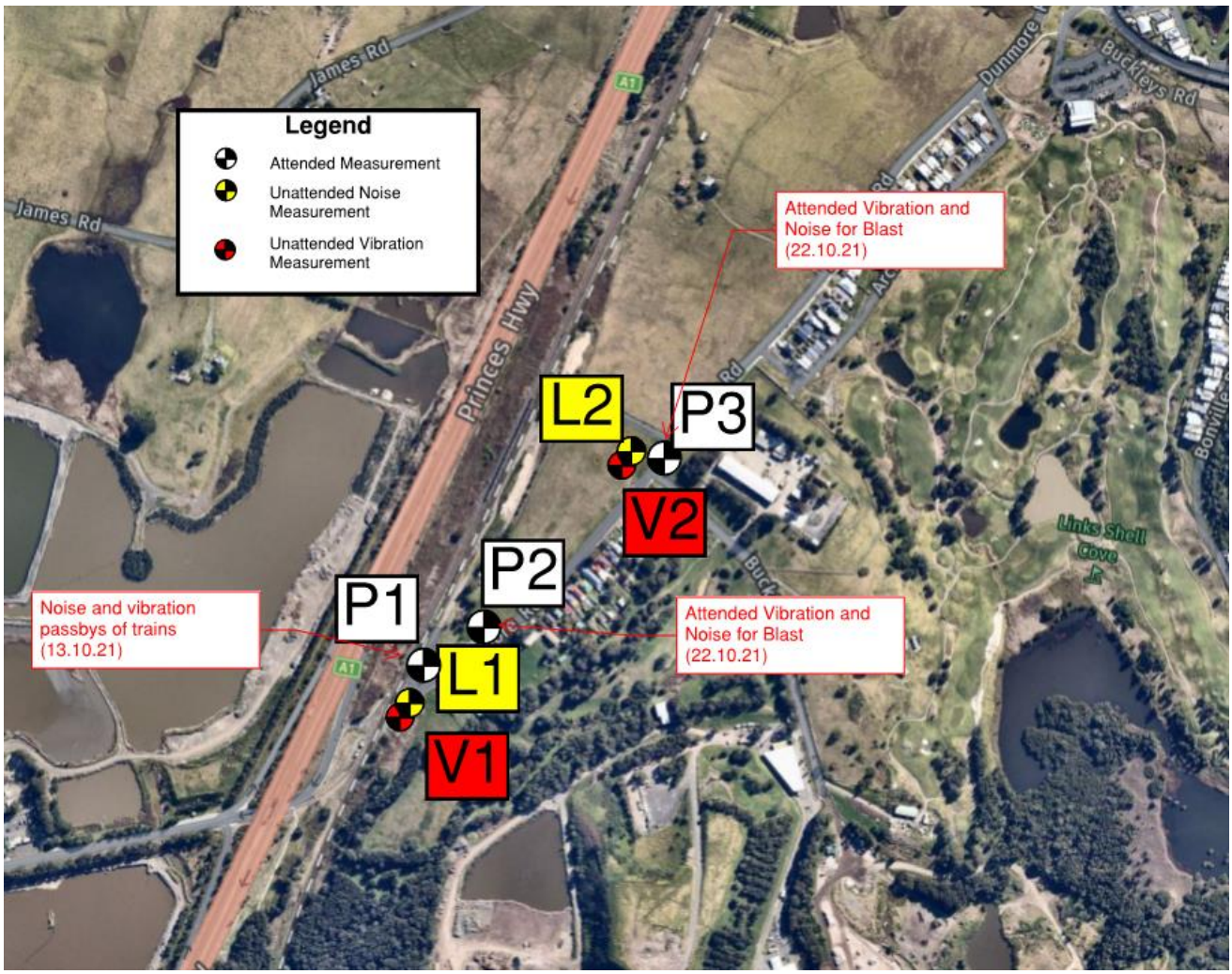

Figure 5: Attended and Unattended monitoring locations

3.1 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
- SVAN 958 Vibration Analyser S/N 15153
- Svan SV30A Sound Calibrator, S/N 17556
- ARL Environmental Noise Logger, NL42EX, S/N 00810713
- ARL Environmental Noise Logger, NL42EX, S/N 00873125
- ARL Environmental vibration Logger, Vibra, S/N Vib00814
- ARL Environmental vibration Logger, Vibra, S/N Vib01711

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.

3.2 Unattended Survey Results

Noise and Vibration monitors were placed at positions L1, L2, V1 & V2 as shown in Figure 5 to measure the background and ambient noise that is representative of the surrounding noise-sensitive residential receivers. All noise and vibration monitors were installed from the 13th to the 22nd of October 2021. The results of the unattended background and ambient noise surveys is shown in Table 1 below (for the day, evening and night time periods).

The noise monitoring results of logger location L2 & V2 is representative of the residential ambient noise level and will be used for noise emission assessments at later stages through the project development, as specific site locations and building massing is firmed. The monitors placed at L1 & V1 have been used to characterise the noise generated by train pass-bys in addition to noise generated by vehicle movements along Princes Highway during the 15 hour and 9 hour periods established in the Department of Planning's Development near Rail Corridors and Busy Roads- Interim Guideline.

Table 1: Summary of unattended 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	62	60	61	51	46	34
L2	58	54	55	48	46	34

The local ambient noise environment is dominated by traffic noise from Princess Highway and occasional train noise from the adjacent rail corridor 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 6 and below for the noise data.

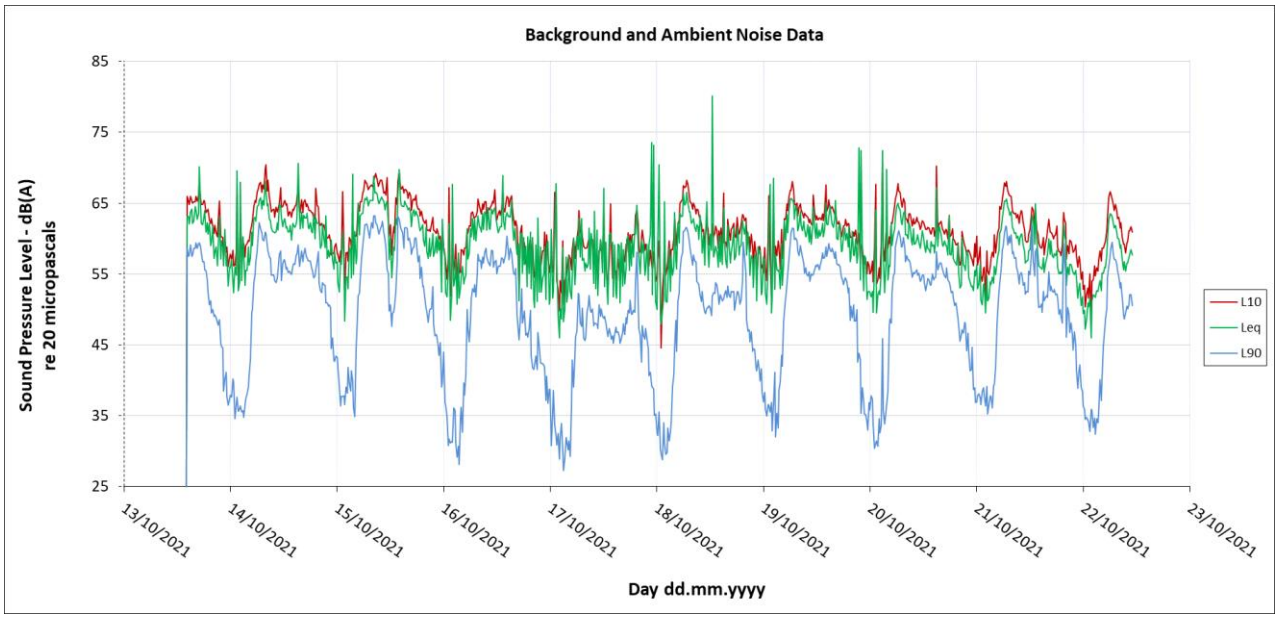

Figure 6: Unattended background and ambient noise monitoring data – L1

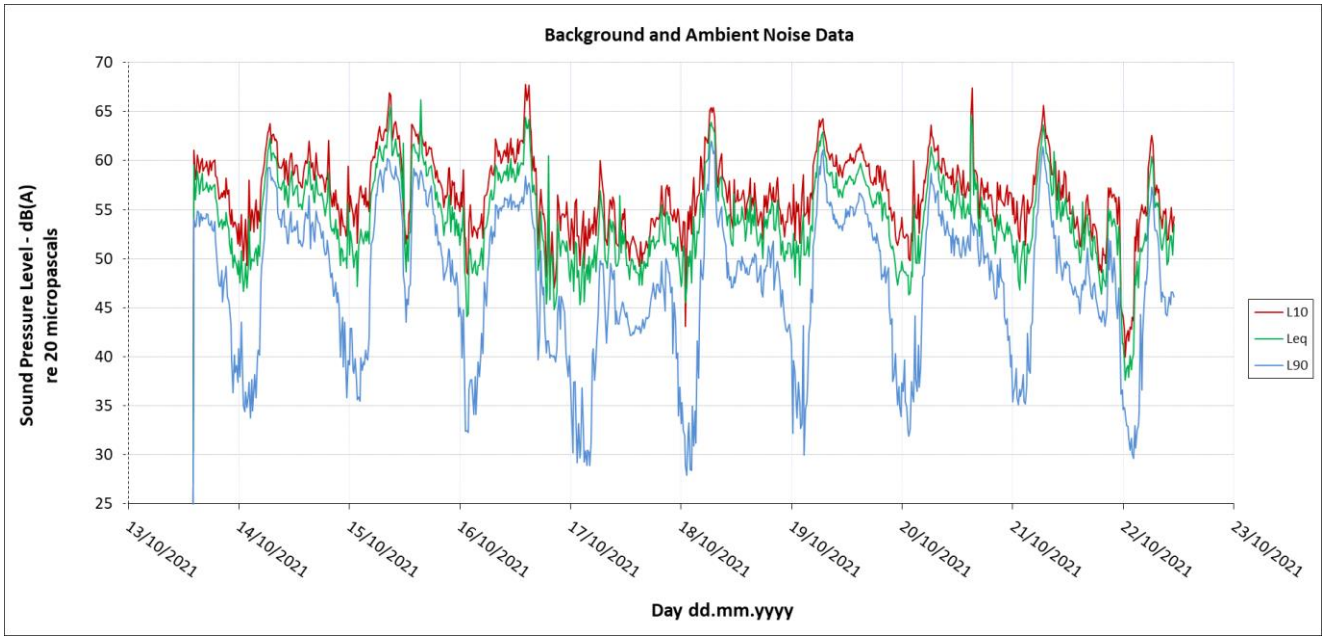

Figure 7: Unattended background and ambient noise monitoring data – L2

Unattended vibration monitors were installed to measure the vibration impact and propagation for train pass bys in the adjacent rail corridor. Weekly summary graphs for the Peak Velocity are presented in Figure 8 and Figure 9 below. The vibration monitor placed at V1 shows a considerable level of correlation with noise events. These peaks have been cross-referenced the South Coast Line Timetable to validate noise and vibration events to be used for the noise and vibration impact assessment.

It should be noted that the vibration monitor placed at V2 shows a smaller measure of correlation with the noise measurements, and is thought to be relatively unaffected by the impact of any vibration from the road and rail sources. There are a couple of notable peaks in the vibration measurements which do not correlate with noise measurements and is thought to be the result of animal interference or similar in the field.

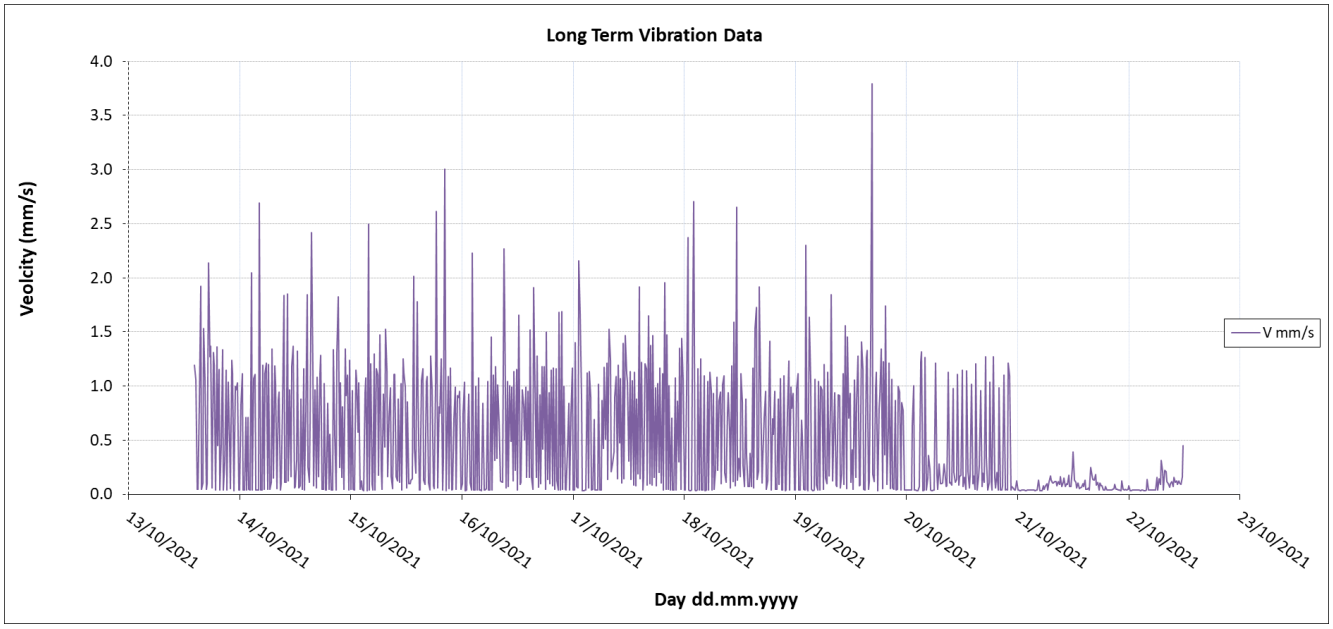

Figure 8: Unattended vibration monitoring data – V1

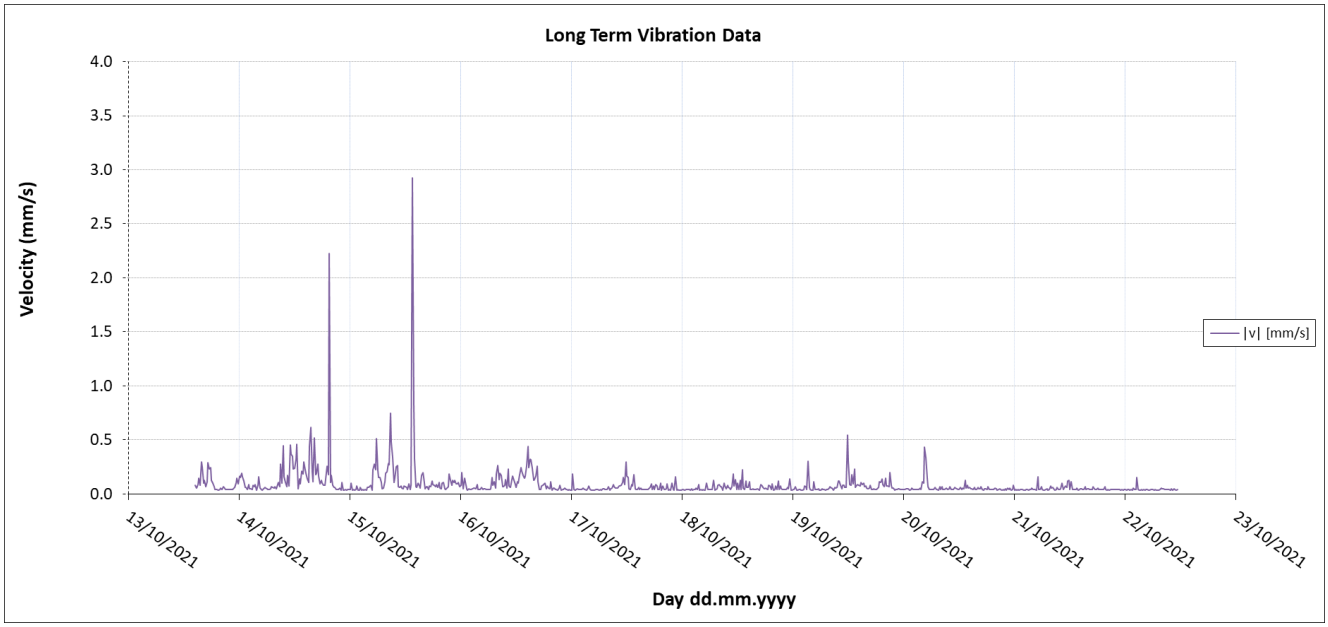

Figure 9: Unattended vibration monitoring data – V2

3.3 Attended Noise Survey Results

Attended noise measurements of 15-minute duration were conducted on site to characterize the local noise environment and to validate the results of the unattended noise monitoring. A summary of the attended noise measurements taken in the vicinity of the proposed development site are shown in Table 2 below.

Table 2 - Attended Noise Survey Results

Measurement Location	Measurement Time	L_{Aeq} dB(A)	L_{A90} dB(A)	L_{Amax} dB(A)	Comments
L1	13/10/2021 11:33am	59	53	75	Noise dominated by vehicle movements along Princes Highway. Occasional movements within the external carpark near the train tracks. Occasional foot traffic / push bikes. No train pass-bys occurred during the 15-minute period.
L2	13/10/2021 12:54	58	52	75	Noise dominated by vehicle movements along Princes Highway. Minimal obstructions to the main noise source (i.e. Direct line of sight to Princess Highway). Intermittent movements along Dunmore Rd, notably large percentage of construction / other heavy vehicles movements associated with works in the north portion of land.

4. Acoustic Criteria

4.1 External Noise Emissions

4.1.1 Shellharbour City Council Development Control Plan (DCP) 2013

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

In the absence of any specific external noise requirements in the Shellharbour City 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 4.1.2 addresses any requirement of the DCP.

4.1.2 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).

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 3 - 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	53
Evening 6pm – 10pm	$L_{Aeq,15min}$ ≤ RBL + 5	51
Night 10pm – 7am	$L_{Aeq,15min}$ ≤ RBL + 5	39

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 4- NSW NPI amenity criteria for external noise levels

Type of Receiver	Noise amenity area	Time of Day	L_{Aeq}, dB(A) Recommended amenity noise level	Project amenity noise level $L_{Aeq, 15min}$
Residential	Rural	Day	50	48
		Evening	45	43
		Night	40	38
School classroom – internal	All	Noisiest 1-hour period when in use	35	33
Commercial premises	All	When in use	65	63
Active Recreation	Al	When in use	55	53

*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.

'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 5 below) provides procedures for determining whether an adjustment should be applied for greater annoyance aspect.

Table 5 - 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.

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

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 6 summarises the sleep disturbance criteria for the proposed development.

Table 6 - 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

4.1.3 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 amenity criteria has been used. Refer to Table 7 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 7 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 7 – Project Noise Trigger Levels

Receiver	Period	Descriptor	PNTL dB(A)
Residential	Day	$L_{Aeq, 15min}$	48
	Evening	$L_{Aeq, 15min}$	43
	Night	$L_{Aeq, 15min}$	38
		L_{AFmax}	52
School classroom – internal	All	Noisiest 1-hour period when in use	33
Commercial premises	All	When in use	63
Active Recreation	All	When in use	53

5. Environmental Noise and Vibration Assessment

5.1 Vibration

5.1.1 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 8 to Table 9. 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 8.

Table 8: 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 9.

Table 9: 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

5.1.2 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 9.

6. Construction Noise and Vibration Criteria

6.1 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 10.

Table 10: 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) $L_{Aeq\ (15\ minutes)}$.

6.2 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 5.1 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.

6.2.1 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 11 indicates the vibration limits presented in DIN4150-Part 3 to ensure structural damage does not occur.

Table 12 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 11: 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 12: 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

6.2.2 Criteria for Vibration Sensitive Equipment

Existing surrounding receivers have not been identified as housing any vibration sensitive equipment. An assessment for vibration sensitive equipment will be undertaken for the design of the hospital, however, would not be applicable for the existing environment.

7. Construction Noise Assessment

7.1 Proposed Construction Activates

In this assessment, the noise impact from the New Shellharbour Hospital Early and Enabling works are considered. The proposed early construction works will consist of the following stages:

- **REF Scope**
  - Trenching between New Shellharbour Hospital Site and the Shellharbour Zone Substation
  - Excavation
  - Substation Installation
- **Bulk Excavation DA**
  - Establishment and use of a construction access road and internal construction road
  - Bulk site earthworks (including cut, fill, benching, temporary stockpiling etc) and associated works, in preparation for the construction of the New Shellharbour Hospital (note the hospital construction will be subject to a separate future State Significant Development Application)
  - Demolition
  - Tree Removal

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 commercial and residential receivers are covered. This means trenching works concentrated along the proposed HV feeder cable route from the northern Shellharbour zone substation to the hospital site.

7.2 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 13. 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 13: Predicted Sound Power Levels for Construction and Demolition Equipment

Scenario	Equipment	Indicative Sound Power Levels dB(A) re 1 pW
REF Works (HV Feeder Route)	Excavator (30 – 40t)	110
	Jackhammer mounted on excavator	115
	Tip Truck	108
Bulk Excavation DA	Excavator (30 – 40t)	110
	Tip truck	108
	Thrust Boring	110
	Machine mounted Hydraulic Drill	110
	Rock Breaker	118

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 14. Table 15 show the criteria for other land uses other than residential in accordance with the NSW INCG.

Table 14: 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 15: Interim Construction Noise Guideline criteria other noise sensitive receivers

Land Use	Management Level $L_{Aeq(15min)}$ during use
Educational Institute	45 dB(A) internal noise level
Active Recreation areas (sporting activities)	65 dB(A) external noise level
Commercial (Offices, retail outlets)	70 dB(A) external noise level

7.3 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
- Multiple worst case receivers were assessed for the proposed HV feeder cable route between the north substation and the hospital site.
- The predicted noise levels at the nearby sensitive receivers have been assessed with no additional mitigation measures (i.e. barriers or hoarding).
- 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.

7.4 Construction Noise Results

7.4.1 REF Works - Results

The predicted construction noise levels for the REF scope of works have been presented in Table 16 in each receiver. For the purpose of the assessment, worst case location of equipment and a receiver height of 1.5 metres was assumed for each receiver.

Noise Management Levels have not been provided for receivers outside of the immediate surrounding area of the proposed New Shellharbour hospital as long term noise monitoring has not been conducted at the multiple locations along the proposed HV feeder cable route. As an alternative, comparison to the Highly Noise Affected Level will dictate the criteria.

Table 16: Predicted Noise Levels – REF Works

Address	Receiver	Predicted Noise Level $L_{Aeq,15min}$	Noise Management Level $L_{eq,15min}$ dB(A)	Highly Noise Affected Criteria $L_{eq,\ 15min}$ dB(A)	Compliance with Highly Noise Affected Level?
73 Dunmore Rd	Residential	68 – 77	58 53 (Outside Standard Hours)	75	No
The Links Shell Cove (Golf Club)	Active Recreation areas	54 - 63	65	75	Yes
38 Hicks Tce	Residential	68 – 77	58 53 (Outside Standard Hours)	75	No
49 Byron Cct	Residential	77 – 85	- -	75	No
22 Lakewood Bvd	Residential	85 – 94	- -	75	No
11 Munmorah Cct	Residential	81 – 89	- -	75	No
27 Burrinjuck Ave	Residential	76 – 85	- -	75	No
95 Parklands Dr	Residential	70 – 79	- -	75	No

Exceedance of the Highly Noise Effected Level for majority of the residential receivers is expected directly adjacent to the works. The trenching works are proposed in some instances very close to noise sensitive receivers, and as such will be difficult to manage noise by introducing physical mitigation measures (i.e. noise barriers). The construction works will be dominated by the use of excavators in all instances. During these times, the predicted noise level will be greater than 75dB(A) at residential receivers.

Some options for managing the impacts include negotiating breaks or respite periods during these works. Temporary flexible noise barriers should be erected around works and moved as work progresses down the proposed cable route. Additionally, it is not expected that each receiver will have long-term exposure to these worst-case construction noise as the trenching progresses along the proposed route.

7.4.2 Bulk Excavation - Results

The predicted construction noise levels for the bulk excavation works have been presented in Table 17 for each noise effected receiver. For the purpose of the assessment, worst case location of equipment and a receiver height of 1.5 metres was assumed for each receiver.

Table 17: Predicted Noise Levels – Bulk Excavation DA Works

Address	Receiver	Predicted Noise Level $L_{Aeq,15min}$	Noise Management Level $L_{eq,15min}$ dB(A)	Noise Management Level Exceedance (dB)	Highly Noise Affected Criteria $L_{eq,15min}$ dB(A)	Compliance with Highly Noise Affected Level?
51 Dunmore Rd	Residential	61 – 79	58	3 - 20	75	No
			53 (Outside Standard Hours)	8 - 25	75	No
Corner of Dunmore Rd and Buckleys Rd	Commercial	56 - 68	70	-	75	Yes
61 Dunmore Rd	Residential	55 – 67	58	9	75	Yes*
			53 (Outside Standard Hours)	2 - 14	75	Yes*

Note: * Compliance demonstrated below Highly Noise Affected criteria, however, exceeding noise management level due to existing low background noise levels in local environment.

Exceedance of the Highly Noise Effected Level for majority of the residential receivers located at 51 Dunmore Road is expected directly adjacent to the works. For the more stationary works which are proposed as part of the Bulk Excavation DA scope the works are localised around the proposed site. A sound attenuating barrier should be erected along the northern and eastern boundaries of the site (facing noise sensitive receivers) during all stages of the bulk excavation works. The construction of the barrier should be impervious to gaps and cracks, which would compromise the performance, and it should be comprised of acoustically suitable materials such as 17mm plywood. Acoustic blanket such as Sonic Quilt by Flex Shield should be installed to the internal face of the barrier (i.e. facing the construction works) to reduce the reverberant build-up of noise and subsequently the noise emissions. Locating site amenities on top of the barrier further increases its effective height and shielding capability.

In addition to the sound attenuating barrier, respite periods should be offered per day during the most intensive periods. Frequent and proactive communication with the residents/tenants of noise sensitive receivers is also encouraged, thus enabling tuning the works schedule to accommodate any noise sensitive activities to prepare their expectation on the changing noise environment.

Bulk Earthworks – Rock Breaking

During the Bulk Excavation phases of construction, it has been proposed that rock breakers will be used regularly. As rock is broken up and removed from the ground during excavation, it will then be broken down further above ground on site to be repurposed. It is expected that due to this process, additional works involving the rock breakers may be required on site. For the purpose of the acoustic modelling it has been assumed that rock-breaking activities of this nature will occur consistently throughout any full 15-minute period (worst case scenario)

Stantec proposes that the rock breaking should be situated to the western side of the site to maximise distance between the rock crushing and any noise-sensitive receivers. Assuming a minimum distance of 150m can be maintained from the boundary of the adjacent residents, the predicted impact contribution of rock breaking activities can be reduced to approximately 65dB(A). Refer to Figure 10 for indicative location of rock crusher. It is also recommended that any site sheds are situated between the rock breaking area and the residential receivers to Dunmore Rd.

Figure 10: Unattended background and ambient noise monitoring data – L2

Similar to the above, this approach should be adopted for any Wet Sawing works to be conducted as part of bulk excavation phase.

Ultimately it is the responsibility of the contractor to prepare a detailed Construction Noise and Vibration Management Plan (CNVMP) to address the impact of these proposed works and provide mitigation measures to minimize the impact to the surrounding sensitive receivers.

7.5 Acoustic Recommendations for Construction and Demolition Activities

According to AS 2436 – 2010 *Guide to noise and vibration control on construction, demolition, and maintenance sites* the following techniques could be applied to minimize the spread of noise and vibrations to the potential receivers.

7.5.1 Noise

Figure 11 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 minimized. 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 transportables 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 below.

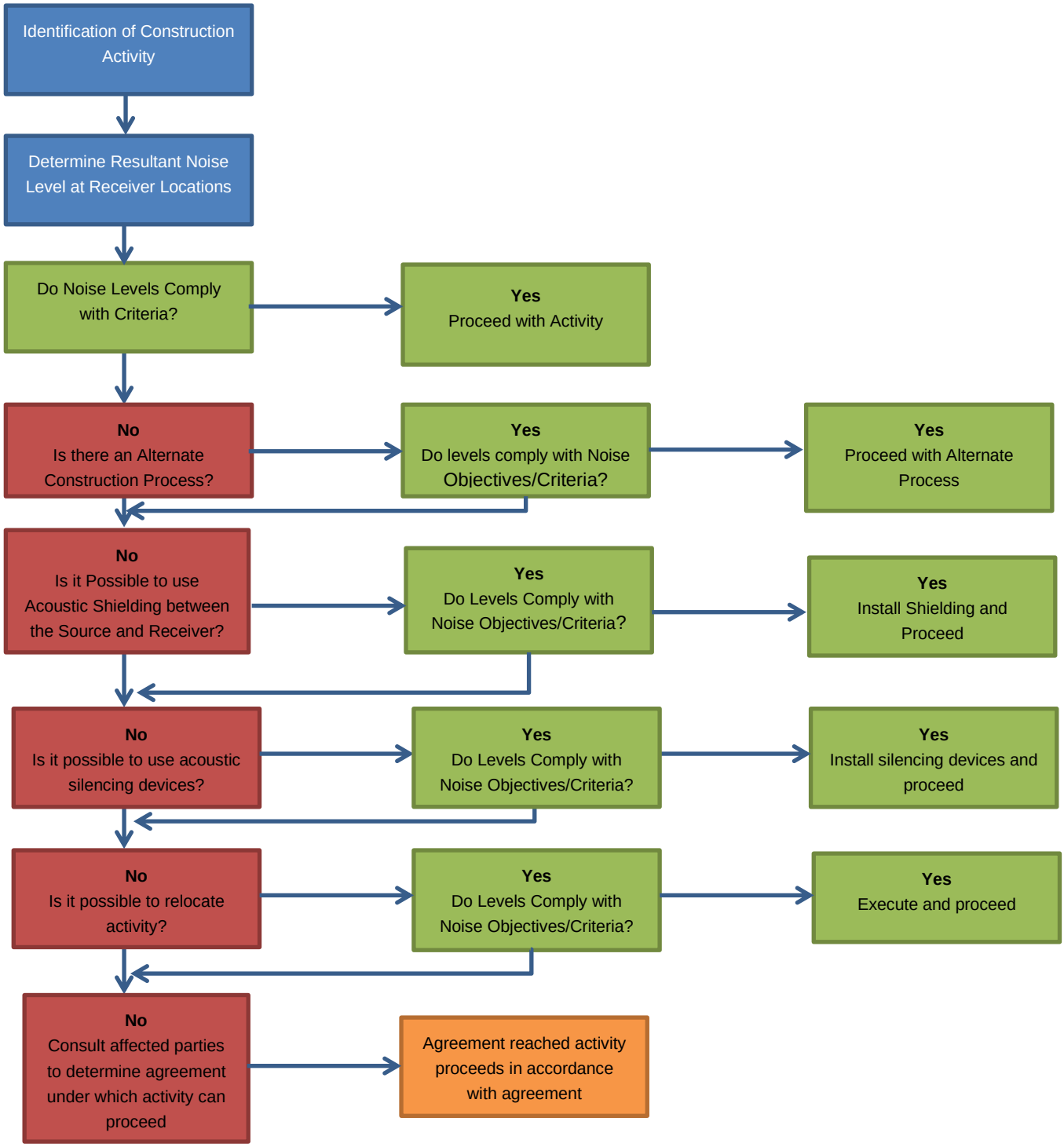

Figure 11: Noise Mitigation Management Flow Chart

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 taken into account 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.

7.6 Vibration Recommendations for Construction and Demolition Activities

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. Due to the lack of information regarding this at the early stages of the development, an accurate calculation of the vibration impacts cannot be predicted.

It is required that a Construction Noise and Vibration Management Plan (CNVMP) is conducted prior to construction to manage construction noise/ vibration as well as to perform high level predictions to avoid non-compliances with the vibration criteria. In addition, the use of noise and vibration monitoring during construction will be essential to ascertain the extent of vibration and noise generated in and around the site.

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.

Table 18: Recommended indicative safe working distances

Plant Item	Rating / Description	Safe Working Distance (m)	
		Structural Cosmetic Damage	Human Comfort
Vibratory Roller	< 50 kN (Typically 1 – 2 tonnes)	5	15 - 20
	< 100 kN (Typically 2 – 4 tonnes)	6	20
	< 200 kN (Typically 4 – 6 tonnes)	12	40
	< 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
Vibratory pile driver	Sheet piles	2 – 20	20
Pile boring	≤ 800 mm	2	N/A
Jackhammer	Hand held	1	Avoid contact with structure (including slab reinforcements)

It is important to note that these safe distances should be confirmed and updated in a CNVMP based on the following information:

- Details of the demolition and construction tasks (including scope and duration).
- List of equipment to be used in each demolition and construction task.

Further to the above, the vibration criteria for vibration sensitive instrumentation (as discussed in Section 6.2.2) are more stringent than the criteria for human comfort. Therefore, the safe working distances could be increased for particular equipment (this is currently not considered in Table 18 above).

Therefore, the following is recommended:

- As part of the CNVMP, a trial test should be conducted where vibration levels are measured near each vibration sensitive equipment when using construction and demolition equipment. These measured vibration levels should be assessed against the equipment criteria, and operational procedures should be investigated. Hence it is advised that the construction and demolition program should be provided to identify and coordinate the tasks from which trial measurements should be undertaken.

Finally, the CNVMP should consider the following amelioration measures which are to be considered to minimise the transmitted vibration around the site:

- Monitor vibration levels using attended/un-attended methods during construction to manage potential excessive vibration.
- Manage construction program to minimise heavy machinery operating concurrently.
- Prepare dilapidation reports on adjacent structures and monitor the effects.
- As far as practical, locate heavy machinery away from nearby sensitive receivers
- A one hour respite period, for example between 12:00pm – 1:00pm (or other period to coincide with construction workers lunch time(s)) may be recommended during high impact vibration generating activities such as demolition, rock breaking, jackhammering and rock sawing.

8. Noise & Vibration Monitoring Strategy

8.1 General Methodology

Noise and vibration levels should be monitored at critical times throughout the construction program to ensure that noise generated as a result of any 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 inside the premises of the affected property or at the site boundary of the affected receivers.

Monitoring is to be undertaken by an experienced noise and vibration monitoring professional or an acoustic consultant. 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
- Long-term monitoring

Both approaches are elaborated below.

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 through the DA conditions.

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.

8.1.1 Noise & Vibration Monitoring Program

The most noise and vibration sensitive receivers have been identified as the residential properties found along Dunmore Road (R1) to the eastern side of the site, and the Educational Development located to the north (E1). As such, monitors have been proposed to be located as close as possible to these receivers.

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 12 for the approximate monitoring locations.

Table 19 - Proposed noise and vibration monitoring locations details

Sensitive Receiver Details	Proposed Monitoring Type and Phase
R1	Noise – All Phases (N1)
	Vibration – All Phases (V1)
E1	Noise – All Phases (N2)
	Vibration – All Phases (V2)

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

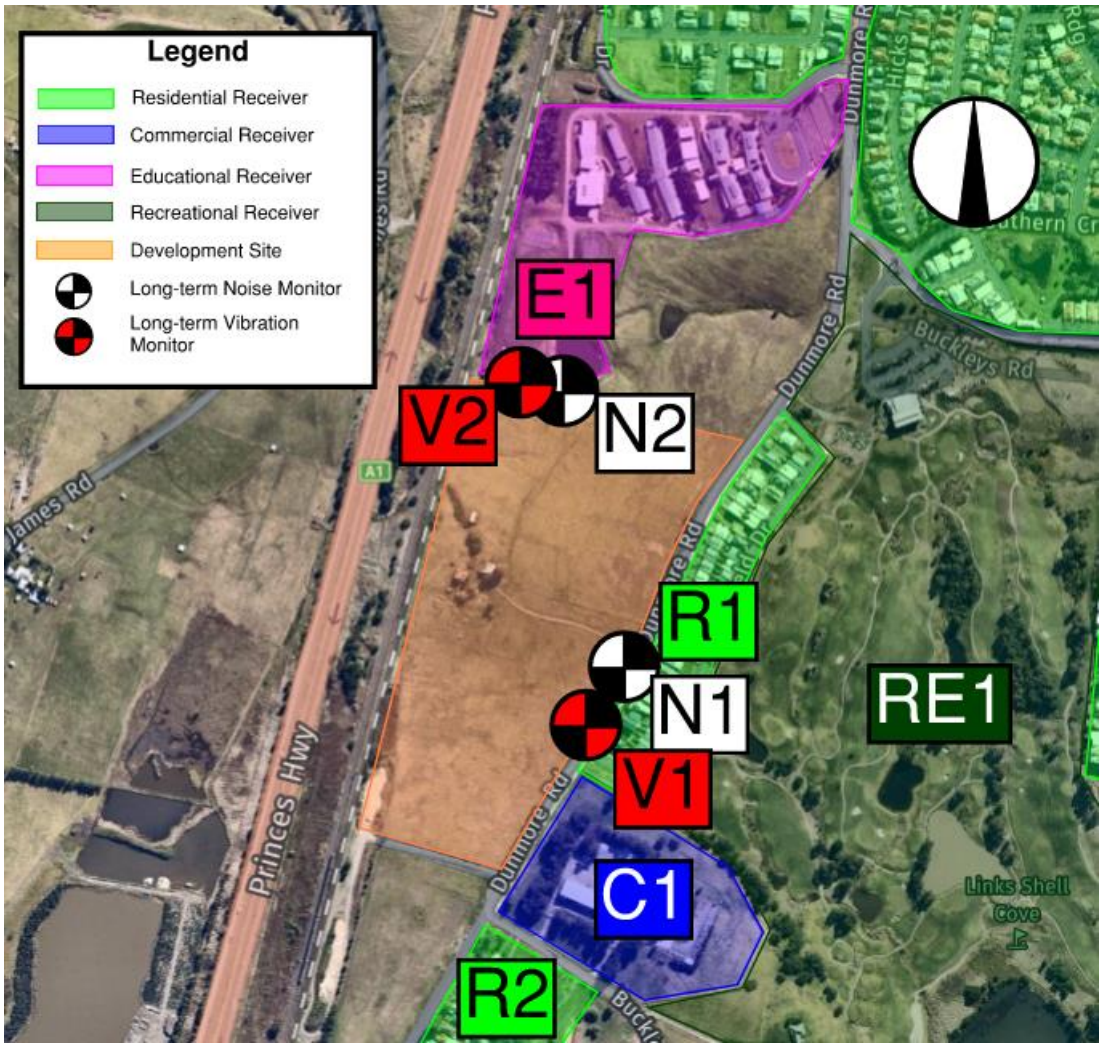

Figure 12: Unattended Noise and Vibration Monitoring Location

9. Conclusion

This report presents the results of a noise and vibration assessment to support the early and enabling works for the New Shellharbour Hospital. This report forms a part of the documentation package to be submitted to the public authority (Health Infrastructure) as part of the Review of Environmental Factors for the proposed development. A separate development application (DA) will be submitted to Shellharbour City Council as the determining authority for the early works DA scope.

The environmental noise and vibration intrusion criteria for the operation and construction of the proposed development have been established based on state policy guidelines and standards.

Road traffic noise criteria intrusion was established based on the requirements of state policy guidelines.

Following our investigation, except where explicitly noted, it was found that no significant noise impacts will occur as a result of the proposed bulk excavation and construction works, should the following mitigation measures be implemented:

- Preparation of a Construction Noise and Vibration Management Plan. This is to be completed by the contractor and is required prior to the commencement of demolition and construction activities on site.
- Placement of noise sources to maximise 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).
- Installing purpose-built noise barriers, acoustic sheds, and enclosures.
- Undertaking short- and long-term noise and vibration monitoring for all stages of construction at locations depicted in Section 8.1.1.

Even though no assessment can be considered as being thorough enough to preclude all potential environmental impacts, having given regard to the above listed conclusions, it is the finding of this assessment that the proposed development should not be refused on the grounds of excessive noise generation.

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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