Wyong Hospital Stage 3 Redevelopment

Review of Environmental Factors - Acoustics

NSW Health Infrastructure
PO Box 1060
North Sydney NSW 2059

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PULSE WHITE NOISE ACOUSTICS Suite 601, L6, 32 Walker St, North Sydney NSW 2060
P 1800 4 PULSE (1800 478 573) **E** info@pwna.com.au **pwna.com.au** ABN 95 642 886 306

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PREPARED BY:

Pulse White Noise Acoustics Pty Ltd
ABN 95 642 886 306
Suite 601, Level 6, 32 Walker Street, North Sydney, 2060
1800 4 PULSE

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1 INTRODUCTION

Pulse White Noise Acoustics (PWNA) has been engaged to undertake an acoustic assessment of the Stage 3 refurbishment works at Wyong Hospital. This assessment is required as part of the Review of Environmental Factors (REF) for the development. These refurbishment works are proposed for the existing Blocks B and C buildings.

This report summarised the results of an acoustic assessment provided for the proposed redevelopment. The assessment addresses the impacts from operational scenarios, as well as from typical construction activities that are anticipated as part of the refurbishment works.

A list of acoustic terminology used in this report is included in Appendix A of this report.

1.1 Project Description

The Wyong Hospital Redevelopment Stage 3 works comprises adaptive reuse of the existing decanted spaces within Blocks B and C.

Block B will be refurbished to accommodate the following departments:

- Nunyara Aboriginal Health Unit. This consists of consultation rooms, meeting rooms, enclosed office spaces (2P), workstation areas, waiting areas, amenities, reception area, lounge area.
- Wyong Women's Centre Clinic. This department includes consultation rooms, procedure rooms, amenities, waiting areas, workstations, staff room, parent room.
- Medical Staff Workspace. This includes enclosed office spaces (2P, 3P, 4P), workstation areas (open office), collaborative space, staff rooms, amenities, store rooms.
- New South Wales Health Pathology. This comprises enclosed office spaces (2P, 4P), meeting rooms, laboratory facilities, staff room, amenities, cool room, storage.

Block C will be refurbished to accommodate the following departments:

- Expanded Cancer Day Unit.
- Carer Support Unit.

The refurbished spaces in Block C will include the following facilities:

- Enclosed office spaces (1P, 2P), Meeting rooms, quiet room, lounge areas.
- 4 chair pods & rapid assessment areas (open office areas).
- Isolation rooms, consultation rooms,
- Workstation areas,
- Staff room, waiting areas, amenities.

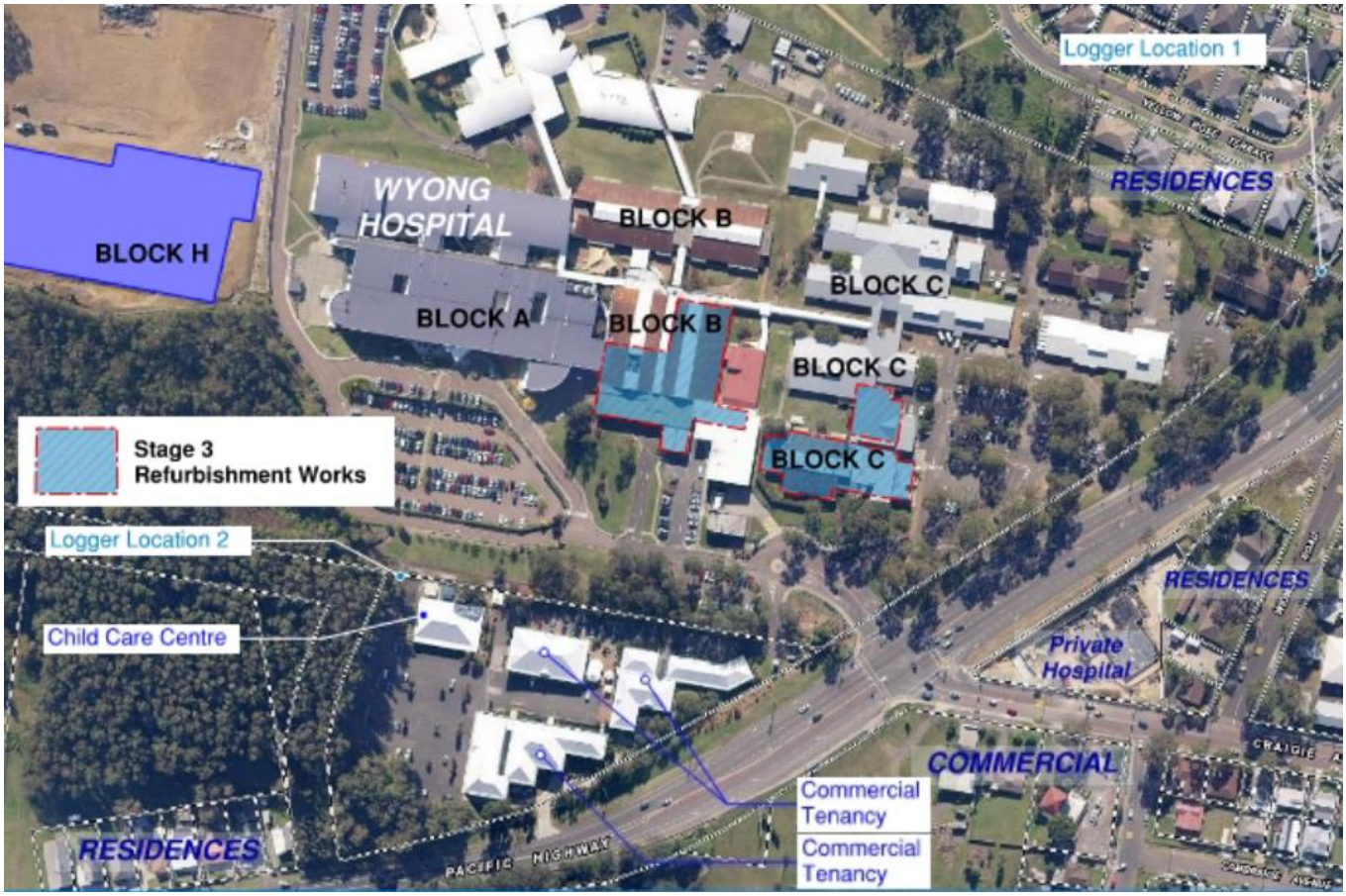
1.2 Site Layout

The proposed refurbishment works will be conducted within Blocks B and C buildings. These buildings are situated at a central location within the Wyong Hospital campus.

The hospital campus is surrounded by various residential and commercial premises, of which the following are considered to be potentially impacted by the operational and construction activities related to the Stage 3 redevelopment works (refer to Figure 1):

- Residences located at following locations:
    - Along Yellow Rose Terrace, approximately 135m north from the project site.
    - Along Pacific Highway, approximately 240m south-west from the project site.
    - Along Wiowera Road, approximately 140m east from the project site.
- Private hospital (i.e. Tuggerah Lakes Private Hospital), located in the junction between Craigie Avenue and Pacific Highway, approximately 80m east from the project site.
- Kanwal Medical Complex, which comprises commercial tenancies and a childcare centre. This is located 80m south from the project site.
- Commercial premises located along Craigie Avenue, between Pacific Highway and Pearce Road. These are located 130m south-east from the project site.

Figure 1 Site layout



1.3 Conditions From Review of Environmental Factors (REF)

Standard acoustic conditions which are relevant to the REF, are summarised below:

21. Noise Management Measures

21.1 During preparation of the construction program, consult with the hospital to determine what areas (if any) of the hospital is particularly noise sensitive, and at what time (ward rooms, operating theatres, etc.).

21.2 Identify feasible acoustic controls or management techniques (use of screens, scheduling of noisy works, notification of adjoining land users, respite periods) when excessive levels may occur.

21.3 For activities where acoustic controls and management techniques still cannot guarantee compliant noise levels, implement a notification process whereby nearby development is made aware of the time and duration of noise intensive construction processes.

31. Noise and Vibration Management

31.1 All works will be in accordance with AS 2436-2010 Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites.

31.2 Building contractors are to implement the requirements of the Office of Environment Interim Construction Noise Guideline (July 2009) as far as practicable.

31.3 Construction is to be carried out in accordance with the Building Code of Australia deemed-to-satisfy provisions with respect to noise transmission.

31.4 All reasonable, practicable steps are to be undertaken to reduce noise and vibration from the site.

31.5 Plant and equipment is to be maintained, checked and calibrated in accordance with the appropriate design requirements and to ensure that maximum sound power levels are not exceeded.

31.6 Plant and equipment (where possible) is to be strategically positioned on site to reduce the emission of noise from the site to the surrounding area, users of the site and on site personnel.

31.7 Unnecessary noise is to be avoided when carrying out manual operations and operating plant equipment.

31.8 Any equipment not used for extended periods is to be switched off.

31.9 Construction vehicles (including concrete agitator trucks) are to not arrive at the site or any surrounding residential precincts outside of the construction hours of work.

These conditions are addressed in this report as follows:

- Operational acoustic assessment is addressed in Section 5.
- Noise mitigation measures listed in Condition 21; are included in Section 6.4.1. These measures are recommended to be included in a Construction Noise and Vibration Management Plan (CNVMP).
- In Condition 31, all clauses except for clause 31.3; are included in the noise and vibration management measures discussed in Section 6.4.
- Clause 31.3, in Condition 31, is found to be irrelevant since sound insulation requirements in accordance with the Building Code of Australia; are not applicable to the project scope. These sound insulation requirements are only applicable to residential and accommodation buildings categorised as Class 2, 3 or 9c. None of these categories are relevant to the hospital refurbishment project.

2 EXISTING ACOUSTIC ENVIRONMENT

2.1 Unattended Noise Monitoring

To determine the existing ambient noise levels on site, an unattended noise survey was undertaken between Wednesday 26 July and Thursday 3 August 2023. Noise loggers were deployed as follows (refer to Figure 1 for logger locations):

- Logger location 1: Along north-eastern property boundary, adjacent to residences along Yellow Rose Terrace. Logger was positioned 25m from the northbound kerb of the Pacific Highway with direct line of sight to road traffic along this road corridor. Instrumentation used: Svan 977A noise logger, serial number 81344.

- Logger location 2: Along south-western property boundary, facing the Kanwal Medical Complex. Instrumentation used: Svan 958A noise logger, serial number 69812.

Calibration of the loggers was checked prior to and following measurements. Drift in calibration did not exceed ±0.5 dB. All equipment carried appropriate and current NATA (or manufacturer) calibration certificates.

Charts presenting summaries of the measured daily noise data are attached in Appendix B. The charts present each 24-hour period and show the L_{A1}, L_{A10}, L_{Aeq} and L_{A90} noise levels for the corresponding 15-minute periods. This data has been filtered to remove periods affected by adverse weather conditions based on weather information obtained from Lake Macquarie - Cooranbong weather station (ID 061412).

2.2 Noise Descriptors & Terminology

Environmental noise constantly varies in level with time. Therefore, it is necessary to measure environmental noise in terms of quantifiable time periods and statistical descriptors. Typically, environmental noise is measured over 15-minute periods and relevant statistical descriptors of the fluctuating noise are determined to quantify the measured level.

Noise (or sound) consists of minute fluctuations in atmospheric pressure capable of detection by human hearing. Noise levels are expressed in terms of decibels, abbreviated as dB or dBA, the "A" indicating that the noise levels have been frequency weighted to approximate the characteristics of normal human hearing. Because noise is measured using a logarithmic scale, 'normal' arithmetic does not apply, e.g. adding two sound sources of equal values result in an increase of 3dB (i.e. 60 dBA plus 60 dBA results in 63 dBA). A change of 1 dB or 2 dB in the sound level is difficult for most people to detect, whilst a 3 dB – 5 dB change corresponds to a small but noticeable change in loudness. A 10 dB change roughly corresponds to a doubling or halving in loudness.

The most relevant environmental noise descriptors are the L_{Aeq}, L_{A1}, L_{A10} and L_{A90} noise levels. The L_{Aeq} noise level represents the "equivalent energy average noise level". This parameter is derived by integrating the noise level measured over the measurement period. It represents the level that the fluctuating noise with the same acoustic energy would be if it were constant over the measured time period.

The L_{A1}, L_{A10} and L_{A90} levels are the levels exceeded for 1%, 10% and 90% of the sample period. These levels can be considered as the maximum noise level, the average repeatable maximum and average repeatable minimum noise levels, respectively.

Specific acoustic terminology is used in this assessment report. An explanation of common acoustic terms is included as Appendix A.

2.3 Noise Monitoring Results

The noise levels measured at the nominated logger locations have been used to assess the noise impact of the development into the nearest noise affected receivers identified in Section 0. The time periods used are in accordance with those recommended in the NSW Noise Policy for Industry (NSW NPI). The measurement results are presented in Table 1 below.

Table 1 Measured ambient noise levels in accordance with the NSW NPI

Measurement Location	Daytime 7:00 am to 6:00 pm		Evening 6:00 pm to 10:00 pm		Night Time 10:00 pm to 7:00 am	
	L_{A90}	L_{Aeq}	L_{A90}	L_{Aeq}	L_{A90}	L_{Aeq}
Logger Location 1 North-eastern property boundary	44	57	44	51	39	47
Logger Location 2 South-western property boundary	41	50	41	46	36	44

Notes:

1. *For Monday to Saturday, Daytime 7:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 7:00 am. On Sundays and Public Holidays, Daytime 8:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 8:00 am*
2. *The L_{A90} noise level is representative of the "average minimum background sound level" (in the absence of the source under consideration), or simply the background level*
3. *The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.*

3 OPERATIONAL ACOUSTIC CRITERIA

3.1 NSW Noise Policy for Industry

In NSW, the control of noise emissions is the responsibility of Local Governments and the NSW Environment Protection Authority (NSW EPA).

The NSW EPA has prepared a document titled Noise Policy for Industry (NSW NPI) which provides a framework and process for determining external noise criteria and subsequent assessments. The NSW NPI criteria for industrial noise sources have two components:

- Controlling the intrusive noise impacts for residents and other noise sensitive receivers in the short term; and
- Maintaining noise level amenity of particular land uses for residents and sensitive receivers in other land uses.

3.1.1 Intrusive Noise Impacts (Residential Receivers)

The NSW NPI states that the noise from any single source should not intrude greatly above the prevailing background noise level. Industrial noises are generally considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (L_{Aeq}), measured over a 15 minutes period, does not exceed the background noise level measured in the absence of the source by more than 5 dBA. This is often termed the Intrusiveness Criterion.

The 'Rating Background Level' (RBL) is the background noise level to be used for assessment purposes and is determined by the methods given in the NSW NPI. Using the rating background noise level approach results in the intrusiveness criterion being met for 90% of the time. Adjustments are to be applied to the level of noise produced by the source that is received at the assessment point where the noise source contains annoying characteristics such as tonality or impulsiveness.

3.1.2 Protecting Noise Amenity (All Receivers)

To limit continuing increase in noise levels, the maximum ambient noise level within an area from industrial noise sources should not normally exceed the acceptable noise levels specified in Table 2.2 of the NSW NPI. That is, the ambient L_{Aeq} noise level should not exceed the level appropriate for the particular locality and land use. This is often termed the 'Background Creep' or Amenity Criterion.

The amenity assessment is based on noise criteria specified for a particular land use and corresponding sensitivity to noise. The cumulative effect of noise from industrial sources needs to be considered in assessing the impact. These criteria relate only to other continuous industrial-type noise and do not include road, rail or community noise. If the existing (measured) industrial-type noise level approaches the criterion value, then the NSW NPI sets maximum noise emission levels from new sources with the objective of ensuring that the cumulative levels do not significantly exceed the criterion.

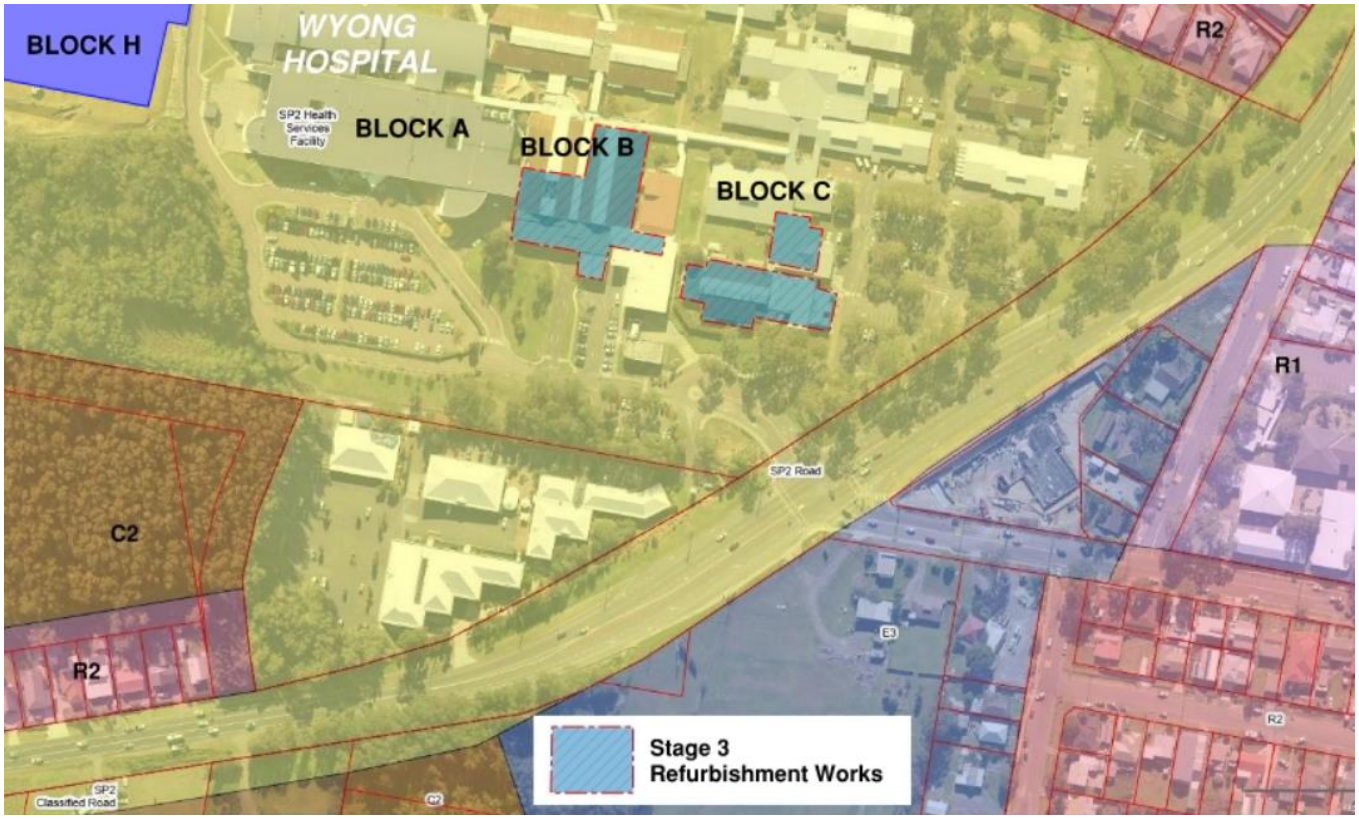
3.1.3 Area Classification

The NSW NPI characterises the "suburban residential" noise environment as an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry. This area often has the following characteristic: evening ambient noise levels defined by the natural environment and human activity.

Based on typical RBLs listed on Table 2.3 of the NSW NPI, the L_{A90} noise levels measured at Logger Location 2 (as listed in Table 1) are found to be in close correlation to those corresponding to a suburban residential environment. However, the L_{A90} noise levels measured at Logger Location 1 correlate closer to an urban residential environment. Nevertheless, Figure 2 shows that the residential properties along the north-eastern property boundary are zoned as R2. This classification in Table 2.3 of the NSW NPI is categorised as suburban residential. Furthermore, the residences along Wiowera Road, adjacent to the private hospital, can also be classified as suburban residential. These residences are located within Zone E3, which is also included as suburban residential in Table 2.3 of the NSW NPI.

Therefore, all nearest impacted residences are considered as suburban residential receivers.

Figure 2 Zoning around project site



For childcare centres, the amenity criteria are obtained from the *"Guideline for Child Care Centre Acoustic Assessment"* (GCCCAA), issued by the Association of Australian Acoustical Consultants (AAAC). Based on the GCCCAA, the following is recommended to mitigate the external noise impact on children:

- In outdoor play or activity areas, the $L_{Aeq,\ 1\ hour}$ noise level from road, rail or industry should not exceed 55 dBA during the hours the childcare operates.
- In indoor play or sleeping areas, the $L_{Aeq,\ 1\ hour}$ noise level from road, rail or industry should not exceed 40 dBA during the hours the childcare operates.

Table 2 NSW NPI – Recommended L_{Aeq} amenity noise levels from industrial noise sources

Type of Receiver	Indicative Noise Amenity Area	Time of Day[1]	Recommended Amenity Noise Level ($L_{Aeq, period}$)[2]
Residences	Suburban	Day	55
		Evening	45
		Night	40
Hospital wards, external Existing Wyong Hospital buildings Private hospital (Tuggerah Lakes Private Hospital)	All	Noisiest 1 hour	50
Commercial premises Kanwal Medical Complex Commercial premises along Craigie Avenue	All	When in use	65
Child care centre at Kanwal Medical Complex	Outdoor play area	When in use	55 dB $L_{Aeq, 1\ hour}$ [4]
	Indoor play area Sleeping areas	When in use	40 dB $L_{Aeq, 1\ hour}$ [4]

Note 1: For Monday to Saturday, Daytime 7:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 7:00 am. On Sundays and Public Holidays, Daytime 8:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 8:00 am

Note 2: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

Note 3: To convert external noise levels from internal noise levels, a noise reduction of 25 dB has been assumed for non-openable windows.

Note 4: Amenity criteria obtained from the ""Guideline for Child Care Centre Acoustic Assessment", issued by the AAAC

3.1.4 Project Trigger Noise Levels

The intrusive and amenity criteria for industrial noise emissions derived from the measured data are presented in Table 3. These criteria are nominated for the purpose of determining the operational noise limits for mechanical plant associated with the development to potentially affected noise sensitive receivers.

For each assessment period, the lower (i.e. the more stringent) of the amenity or intrusive criteria are adopted. These are shown in bold text in Table 3.

Table 3 External noise level criteria in accordance with the NSW NPI

Location	Time of Day	Project Amenity Noise Level, $L_{Aeq,\ period}$ [1] (dBA)	Measured $L_{A90,\ 15\ min}$ (RBL) [2] (dBA)	Measured $L_{Aeq,\ period}$ Noise Level (dBA)	Intrusive $L_{Aeq,\ 15\ min}$ Criterion for New Sources (dBA)	Amenity $L_{Aeq,\ 15\ min}$ Criterion for New Sources (dBA) [4,8]
Residences (north and east from project site) Along Yellow Rose Terrace Along Wiowera Road	Day	50	44	57	**49**	53
	Evening	40	44	51	49	**44**
	Night	35	39	47	44	**40**
Residences (south from project site) Along Pacific Hwy, adjacent to the Kanwal Medical Complex	Day	50	41	50	**46**	53
	Evening	40	41	46	46	**43**
	Night	35	36	44	41	**38**
Hospital wards, external Existing Wyong Hospital buildings Private hospital (Tuggerah Lakes Private Hospital)	Noisiest 1 hour	45	N/A	50	N/A	**48**
Commercial premises Kanwal Medical Complex Commercial premises along Craigie Avenue	When in use	60	N/A	50	N/A	**63**
Child care centre at Kanwal Medical Complex	When in use	50	N/A	50	N/A	**53**

Note 1: Project Amenity Noise Levels corresponding to "suburban" areas, equivalent to the Recommended Amenity Noise Levels minus 5 dBA

Note 2: L_{A90} Background Noise or Rating Background Level (RBL)

Note 3: Project Noise Trigger Levels are shown in bold

Note 4: This is based on the assumption that the existing noise levels are unlikely to decrease in the future

Note 5: As per Section 2.3 of the NSW Noise Policy for Industry, the evening RBL is set to no greater than the daytime RBL

Note 6: Intrusive criterion is equal to the RBL + 5 dB

Note 7: Amenity Criterion corresponding to "suburban" areas, equivalent to the Recommended Amenity Noise Levels (Section 3.1.2) minus 5 dBA + 3 dB to convert from the measurement "period" to a 15 minute criteria

Note 8: Where the measured L_{Aeq} noise levels are more than 10 dB higher than the Project Amenity Criterion, then the 15 minute Amenity Noise Criteria is equal to the measured $L_{Aeq,period}$ noise levels minus 10 dBA + 3 dB to convert from the measurement "period" to a 15 minute criteria

Note 9: The lower of the amenity and the intrusiveness level is typically used as the applicable overall noise criterion for the day, evening and night periods. The overall noise criteria is shown in bold above

3.1.5 Sleep Disturbance

In accordance with the NSW NPI, sleep disturbance is to be assesses in two stages addressing the likelihood of sleep disturbance and sleep awakening.

For the criterion addressing the likelihood of sleep disturbance, the NSW NPI recommends that the maximum noise level event should not exceed the following:

- 40 dB $L_{Aeq,\ 15\ minutes}$ or the prevailing RBL plus 5 dB, whichever is the greater; and / or
- 52 dB L_{AFmax} or the prevailing RBL plus 15 dB, whichever is the greater

As a result, the following criteria are adopted as the criterion for the likelihood of sleep disturbance at all residences:

- For residences located north and east from the project site (i.e. along Yellow Rose Terrace and along Wiowera Road): 54 dB L_{Amax}.
- For residences located south from the project site (i.e. along Pacific Highway, adjacent to the Kanwal Medical Complex): 52 dB L_{Amax}

Regarding sleep awakening, ongoing research is still being undertaken to quantify an appropriate criterion. The NSW Road Noise Policy (NSW RNP) provides guidelines and a summary of current research being undertaken on this topic. According to the NSW RNP, an accurate representation of sleep disturbance impacts on a community from a noise source is particularly difficult to quantify mainly due to differing responses of individuals to sleep disturbance – this is found even within a single subject monitored at different stages of a single night's sleep or during different periods of sleep.

In addition, the differing grades of sleep state make a definitive definition difficult, and even where sleep disturbance is not noted by the subject, factors such as heart rate, mood and performance can still be negatively affected.

An assessment of sleep disturbance should consider the maximum noise level or $L_{A1(1\ minute)}$, and the extent to which the maximum noise level exceeds the background level and the number of times this may happen during the night-time period. Factors that may be important in assessing the extent of impacts on sleep include:

- How often high noise events will occur;
- Time of day (normally between 10.00pm and 7.00am); and
- Whether there are times of day when there is a clear change in the existing noise environment (such as during early morning shoulder periods).

Currently the information relating to sleep disturbance impacts indicates that:

- Maximum internal noise levels below 50–55 dBA are unlikely to cause an awakening from a sleep state.
- One or two noise events per night with maximum internal noise levels of 65–70 dBA are not likely to affect health and wellbeing significantly.

As a result, the adopted sleep awakening criterion for the project is an internal noise level of 50 - 55 dB L_{AFmax}. This criterion is applicable for noise emissions generated by short term events occurring during the night time period. Therefore, allowing for a 10 dB noise reduction for open windows, it is proposed that the noise screening criterion for sleep awakening should be 60 - 65 dB L_{AFmax} external noise level at residential properties.

3.1.6 Emergency Plant / Infrequent Operations

For emergency plant, such as stand-by generators, which only operate occasionally (such as emergencies and maintenance operations), the NSW NPI allows for modifying factors that can be subtracted from the predicted noise levels. These modifying factors should be applied prior to assessing against the external noise level criteria. These duration modifying factors are summarised in Table 4 below.

Table 4 Modifying factors for duration

Allowable Duration of Noise (one event in any 24 hour period)	Allowable Exceedance at Receiver for the Period of Noise Event	
	Daytime and Evening (7am – 10pm)	Night time (10pm – 7am)
1 to 2.5 hours	2	Nil
15 minutes to 1 hour	5	Nil
6 minutes to 15 minutes	7	2
1.5 minutes to 6 minutes	15	5
Less than 1.5 minutes	20	10

Note: Where the duration of the noise event is smaller than the duration of the project trigger noise level (PNTL), that is, less than 15 minutes, the allowable adjusted project noise trigger level (APNTL) is derived as follows:

$$APNTL = 10\log((10^{\frac{PNTL}{10}}\ x\ (\frac{900 - duration}{900})) + (10^{\frac{PNTL+allowable\ exceedance\ in\ table\ above}{10}}\ x\ duration))$$

3.2 Internal Noise Level Criteria

3.2.1 State Environmental Planning Policy (Transport & Infrastructure) 2021

The State Environmental Planning Policy (Transport & Infrastructure) 2021 (Transport & Infrastructure SEPP) was introduced to assist the delivery of necessary infrastructure by improving regulatory certainty and efficiency. The Infrastructure SEPP has specific planning provisions and development controls for various types of infrastructure, and also for development located adjacent to infrastructure. To provide guidelines for this type of assessment (noise intrusion from road and rail traffic noise), the Department of Planning of the NSW Government has prepared a document titled *"Developments Near Rail Corridors and Busy Roads – Interim Guideline"* (DNRC & BR-IG).

The DNRC & BR-IG applies to development adjacent to rail corridors and busy roads. It can also provide a useful guide for all development that may be impacted by, or may impact on, rail corridors or busy roads.

In accordance with clause 2.120 of the Transport & Infrastructure SEPP, the following is stated:

> *(1) This section applies to development for any of the following purposes that is on land in or adjacent to the road corridor for a freeway, a tollway or a transitway or any other road with an annual average daily traffic volume of more than 20,000 vehicles (based on the traffic volume data published on the website of TfNSW) and that the consent authority considers is likely to be adversely affected by road noise or vibration:*
>
> *(a) residential accommodation,*
>
> *(b) a place of public worship,*
>
> *(c) a hospital,*
>
> *(d) an educational establishment or centre-based childcare facility*

(3) If the development is for the purposes of residential accommodation, the consent authority must not grant consent to the development unless it is satisfied that appropriate measures will be taken to ensure that the following L_{Aeq} levels are not exceeded:

(a) In any bedroom in the residential accommodation—35 dBA at any time between 10 pm and 7 am,

(b) Anywhere else in the residential accommodation (other than a garage, kitchen, bathroom or hallway)—40 dBA at any time.

Based on traffic volume information available on the Transport for NSW (TfNSW) website, it is noted that the Pacific Highway is a road corridor with an annual average daily traffic (AADT) volume of more than 20,000 vehicles.

However, it is noted that the proposed refurbishment works do not include bedrooms for residential use. Therefore, the conditions stated in the Transport & Infrastructure SEPP are not applicable to this assessment. Nevertheless, Section 3.2.2 summarises recommended internal noise levels which will be defined as part of the project specific requirements. These project specific requirements are not mandatory to the assessment, but it confirms that internal noise levels will be addressed as part of the quality requirements for the project.

3.2.2 Standard AS/NZS 2107:2016

The project specific requirements for internal noise levels are defined from the recommended design noise levels listed in standard AS/NZS 2107:2016. Standard AS/NZS 2107:2016 recommends a range with lower and upper levels for building interiors based on room designation and location of the development relative to external noise sources.

The levels for areas relevant to this development are given in Table 5 below. In this report we will confine our recommendations to dBA levels, however, where the background noise appears to be unbalanced, AS/NZS 2107:2016 provides direction in terms of suitable diagnostic tools that can be used to assess the spectrum distribution of the background noise.

Section 6.18 of standard AS/NZ 2107:2016 notes that the presence of discrete frequencies or narrow band signals may cause the sound level to vary spatially within a particular area and be a source of distraction for occupants. Where this occurs, the sound level shall be determined as the highest level measured in the occupied location(s).

If tonal components are significant characteristics of the sound within a measurement time interval, an adjustment shall be applied for that time interval to the measured A-weighted sound pressure level to allow for the additional annoyance. If the background sounds include spectral imbalance, then the RC (Mark II) levels indicated in Table 5 should be referenced (see also Appendix D of standard AS/NZ 2107:2016 for additional guidance).

Generally, where the final noise levels are within +/- 2 dB of the specified level given above, the design criteria will be considered met. Both the upper and lower limits will need to be satisfied especially where privacy is important or where noise intrusion to be avoided.

Table 5 Recommended design internal noise levels as per standard AS/NZS 2107:2016

Type of Occupancy/Activity	Design Sound Level Range ($L_{Aeq,t}$)	Project Design Noise Level	
		Approx. RC Mark II	dBA
Corridors and lobby spaces	< 50	45	50
Board & conference room Meeting rooms Shared meeting room	30 – 40	35	40
Meeting rooms (small) Offices 1P-4P Quiet rooms Isolation rooms	40 – 45	40	45
Consulting rooms Consultation rooms Procedure rooms	40 – 45	40	45
Sterilising, service areas	< 55	50	55
Laboratories Laboratory – Core (Pathology) Transfusion Morphology	40 – 50	40	45
Office areas: Workstations 4 chair pods Rapid assessment areas Collab. space	35 - 45	40	45
Staff rooms	40 - 45	40	45
Waiting rooms, reception areas	40 – 50	40	45
Toilets, amenities	< 55	50	55

3.3 Vibration Criteria – Human Comfort

Vibration effects relating specifically to the human comfort aspects of the project are taken from the guideline titled *"Assessing Vibration – A Technical Guideline"*. (AVTG) This type of impact can be further categorised and assessed using the appropriate criterion as follows:

- Continuous vibration - from uninterrupted sources (refer to Table 6).
- Impulsive vibration - up to three instances of sudden impact e.g. dropping heavy items, per monitoring period (refer to Table 7).
- Intermittent vibration - such as from drilling, compacting or activities that would result in continuous vibration if operated continuously (refer to Table 8).

Table 6 Continuous vibration acceleration criteria (m/s^2) 1 Hz-80 Hz

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions, and places of worship	Day or night-time	0.020	0.014	0.040	0.028
		0.04	0.029	0.080	0.058
Workshops	Day or night-time	0.04	0.029	0.080	0.058

Table 7 Impulsive vibration acceleration criteria (m/s^2) 1 Hz-80 Hz

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions, and places of worship	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

Table 8 Intermittent vibration impacts criteria (m/s$^{1.75}$) 1 Hz-80 Hz

Location	Daytime		Night-time	
	Preferred Values	Maximum Values	Preferred Values	Maximum Values
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

4 CONSTRUCTION NOISE & VIBRATION CRITERIA

4.1 Construction Noise Criteria

4.1.1 Interim Construction Noise Guideline

Noise criteria for construction and demolition activities are discussed in the *Interim Construction Noise Guideline* (ICNG). The ICNG also recommends procedures to address potential impacts of construction noise on residences and other sensitive land uses. The main objectives of the ICNG are summarised as follows:

- Promote a clear understanding of ways to identify and minimise noise from construction works.
- Focus on applying all "feasible" and "reasonable" work practices to minimise construction noise impacts.
- Encourage construction to be undertaken only during the recommended standard hours unless approval is given for works that cannot be undertaken during these hours.
- Streamline the assessment and approval stages and reduce time spent dealing with complaints at the project implementation stage.
- Provide flexibility in selecting site-specific feasible and reasonable work practices to minimise noise impacts

The ICNG contains a quantitative assessment method which is applicable to this project. Guidance levels are given for airborne noise at residences and other sensitive land uses.

The quantitative assessment method involves predicting noise levels at sensitive receivers and comparing them with the Noise Management Levels (NMLs). The NML affectation categories for residential receivers have been reproduced from the guideline and are listed in Table 9 below.

Specific non-residential receivers in the vicinity of the proposed construction site, and their recommended 'management levels', are presented in Table 10.

Based on the measured background noise levels summarised in Section 2, the NMLs to be used in this assessment are listed in Table 11.

It is our understanding that construction works will be conducted under typical standard construction hours.

Table 9 NMLs for quantitative assessment at residences (from ICNG)

Time of Day	Noise Management Level $L_{Aeq(15minute)}$[1,2]	How to Apply
Recommended standard hours: Monday to Friday 7:00 am to 6:00 pm Saturday 8:00 am to 1:00 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. 2. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB above the noise affected level, the proponent should negotiate with the community.

Note 1 *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 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.*

Note 2 *The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours). The term RBL is described in detail in the NSW Industrial Noise Policy (EPA 2000).*

Table 10 NMLs for quantitative assessment at non-residential receivers

Land Use	$L_{Aeq(15minute)}$ Construction NML
Hospital wards, external: [1] Existing Wyong Hospital buildings Private hospital (Tuggerah Lakes Private Hospital)	70 (external)
Offices, retail outlets: Kanwal Medical Complex Commercial premises along Craigie Avenue	70 (external)
Child care centre at Kanwal Medical Complex [1]	65 (external)

Note 1: External noise level criterion estimated from internal noise level criterion assuming a 25 dB noise level difference for non-openable facade windows

Table 11 NMLs as basis for the acoustic assessment

Receiver Types	NML, dB $L_{Aeq(15minute)}$	
	Standard Hours **Monday to Friday: 7 am to 6 pm** **Saturday: 8 am to 1 pm**	**Outside Standard Hours**
Residences (north and east from project site) Along Yellow Rose Terrace Along Wiowera Road	54	N/A
Residences (south from project site) Along Pacific Hwy, adjacent to the Kanwal Medical Complex	51	N/A
Hospital wards, external Existing Wyong Hospital buildings Private hospital (Tuggerah Lakes Private Hospital)	50	N/A
Commercial premises Kanwal Medical Complex Commercial premises along Craigie Avenue	65	N/A
Child care centre at Kanwal Medical Complex	65	N/A

Note 1: External noise level criterion estimated from internal noise level criterion assuming a 25 dB noise level difference for non-openable facade windows

Note 2: External noise level criterion estimated from internal noise management level of 45 dB $L_{Aeq,\ 15\ minutes}$ for construction activities within private enclosed offices

4.1.2 Sleep Disturbance

It is noted that construction works will be undertaken during standard construction hours. These standard hours are only part of the daytime period. Therefore, a sleep disturbance assessment is not required.

4.2 Construction Traffic Noise Criteria

For existing residences and other sensitive land uses affected by additional traffic on existing roads, the NSW Road Noise Policy (NSW RNP) states that for noise associated with increased road traffic generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB during both day and night-time periods. An increase of 2 dB represents a minor impact that is considered barely perceptible to the average person.

4.3 Vibration Criteria

Effects of ground borne vibration on buildings may be segregated into the following three categories:

- Human comfort – vibration in which the occupants or users of the building are inconvenienced or possibly disturbed. Refer to further discussion in Section 3.3.
- Effects on building contents – where vibration can cause damage to fixtures, fittings and other non-building related objects. Refer to further discussion in Section 4.3.1.
- Effects on building structures – where vibration can compromise the integrity of the building or structure itself. Refer to further discussion in Section 4.3.1.
- Effects on scientific and medical equipment – where vibration can have an impact on the functionality of scientific and medical equipment. Refer to discussion in Section 4.3.2.

4.3.1 Vibration Criteria – Building Contents & Structure

The vibration effects on the building itself are assessed against international standards as follows:

- For transient vibration: British Standard BS 7385: Part 2-1993 *"Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from ground borne vibration"* (BSI 1993); and
- For continuous or repetitive vibration: German DIN 4150: Part 3 – 1999 *"Effects of Vibration on Structure"* (DIN 1999).

4.3.1.1 Standard BS 7385 Part 2 – 1993

For transient vibration, as discussed in standard BS 7385 Part 2-1993, the criteria are based on peak particle velocity (mm/s) which is to be measured at the base of the building. These are summarised in Table 12 and illustrated in Figure 3.

Table 12 Transient vibration criteria as per standard BS 7385 Part 2 - 1993

Line in Figure 3	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and Above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Standard BS 7385 Part 2 – 1993 states that the values in Table 12 relate to transient vibration which does not cause resonant responses in buildings.

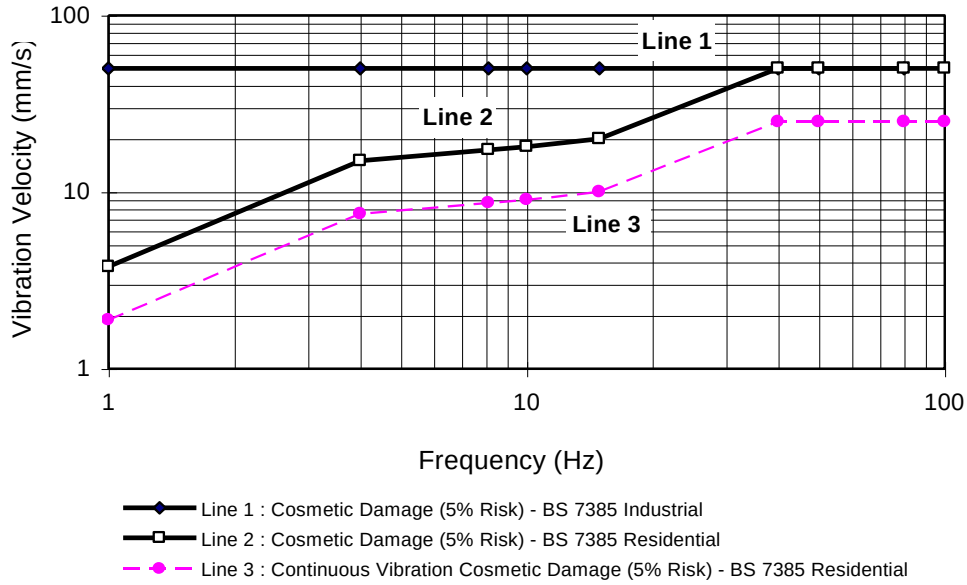
Where the dynamic loading caused by continuous vibration events is such as that results in dynamic magnification due to resonance (especially at the lower frequencies where lower guide values apply), then the values in Table 12 may need to be reduced by up to 50% (refer to Line 3 in Figure 3).

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

The standard also states that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 12, and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the values in Table 12 should not be reduced for fatigue considerations.

Figure 3 BS 7385 Part 2 – 1993, graph of transient vibration values for cosmetic damage



4.3.1.2 Standard DIN 4150 Part 3 – 1999

For continuous or repetitive vibration, standard DIN 4150 Part 3-1999 provides criteria based on values for peak particle velocity (mm/s) measured at the foundation of the building; these are summarised in Table 13. The criteria are frequency dependent and specific to particular categories of structures.

Table 13 Structural damage criteria as per standard DIN 4150 Part 3 - 1999

Type of Structure	Peak Component Particle Velocity, mm/s			
	Vibration at the foundation at a frequency of			Vibration of horizontal plane of highest floor at all frequencies
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]	
Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their 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 to 8	8 to 10	8

Note 1: For frequencies above 100Hz, at least the values specified in this column shall be applied.

4.3.2 Scientific & Medical Equipment

Some scientific equipment (e.g. electron microscopes and microelectronics manufacturing equipment) can require more stringent objectives than those applicable to human comfort.

Where it has been identified that vibration sensitive scientific and/or medical instruments are likely to be in use at the nearest existing hospital buildings, objectives for the satisfactory operation of the instrument should be sourced from manufacturer's data.

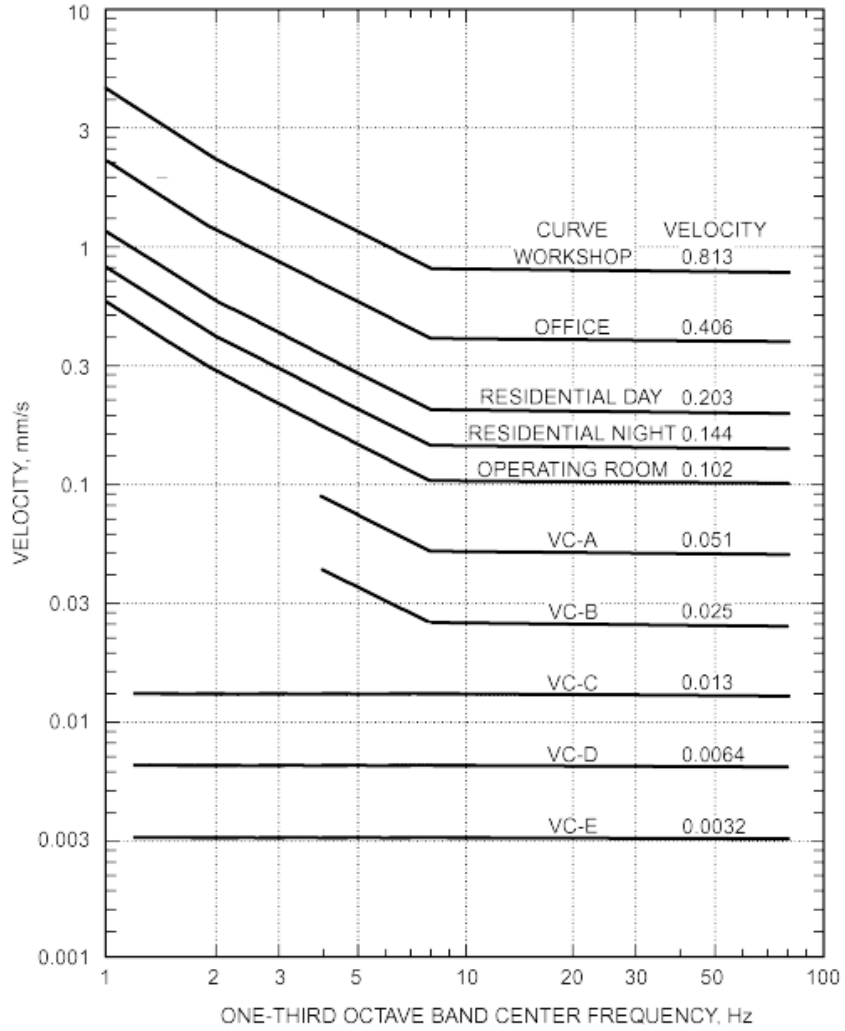
Where manufacturer's data is not available, generic vibration criterion (VC) curves may be adopted as vibration goals. These generic VC curves are presented below in Table 14 and

Figure 4.

Table 14 Criteria for vibration sensitive equipment

Equipment	Curve
Bench microscopes up to 100× magnification; laboratory robots	0.102 mm/s
Bench microscopes up to 400× magnification; optical and other precision balances; coordinate measuring machines; metrology laboratories; optical comparators; microelectronics manufacturing equipment; proximity and projection aligners, etc.	0.051 mm/s VC-A
Microsurgery, eye surgery, neurosurgery; bench microscopes at magnification greater than 400×; optical equipment on isolation tables; microelectronic manufacturing equipment, such as inspection and lithography equipment (including steppers) to 3 mm line widths	0.025 mm/s VC-B
Electron microscopes up to 30 000× magnification; microtomes; magnetic resonance imagers; microelectronics manufacturing equipment, such as lithography and inspection equipment to 1 mm detail size	0.013 mm/s VC-C
Electron microscopes at magnification greater than 30 000×; mass spectrometers; cell implant equipment; microelectronics manufacturing equipment, such as aligners, steppers, and other critical equipment for photolithography with line widths of 1/2 µm; includes electron beam systems	0.0054 mm/s VC-D
Non-isolated laser and optical research systems; microelectronics manufacturing equipment, such as aligners, steppers, and other critical equipment for photolithography with line widths of 1/4 µm; includes electron beam systems	0.0032 mm/s VC-E

Figure 4 Criteria for vibration sensitive equipment (ASHRAE 2007, HVAC Applications, Chapter 47 "Sound and Vibration Control")



4.4 Ground-Borne / Structure-Borne Noise Criteria

Ground-borne noise is noise generated by vibration transmitted through the ground into a structure. There is no specific ground-borne noise criteria in the ICNG or other statutory regulations. However, based on previous project experience, we recommend a noise limit of 40 dB $L_{Aeq\ (15\ minutes)}$ for ward and bedroom areas in residential properties and hospital premises.

It is advised that the recommended ground-borne limits should only be applicable when ground-borne noise levels are higher than airborne noise levels.

5 OPERATIONAL ACOUSTIC ASSESSMENT

5.1 External Noise Emissions – Building Services

At this stage, no detailed design has been developed for mechanical services. Therefore, no detailed acoustic assessment has been conducted.

Nevertheless, we recommend the mechanical plant design and equipment selection should be made so that the aggregate noise level from all external emissions, comply with the external noise level criteria discussed in Section 3.1.

This should be conducted as part of the detailed assessment of mechanical noise emissions which is required to be undertaken during the later design stages.

The following design measures could be considered as part of the detailed design stage in order to achieve compliance:

- Mechanical plant installation locations and the positioning of external air duct paths (such as inlets and outlets) near the property boundary should be limited, as far as practicable.
- Plant room walls should achieve a minimum airborne sound insulation performance of Rw 45 -50. Whenever possible, the plant rooms should only be accessible from inside the building.
- If airflow paths are required to/from outside (such as outside air, exhaust air, relief air, etc) these paths should be fully ducted and include minimum 50 mm thick internal insulation; and / or include acoustic louvres. When the extent of ductwork is not sufficient for treatment, then rectangular silencers may be required (this especially applies to fans and AHUs).
- Ornamental louvres should generally only be considered if they are blanked off with FC sheeting or plant room external walls (subject to a further detailed acoustic assessment).
- All plant room walls and roof / ceiling to be internally lined with insulation, which in combination with insulation facing, should achieve a minimum noise reduction coefficient (NRC) rating of 0.8.
- AHUs and FCUs should include return air / outside air plenums which are in internally lined with minimum 50 mm thick insulation.
- Variable speed drives should be implemented whenever possible.
- Reduce the number of operational plant items between 6:00 pm and 7:00 am (and during the night-time period generally).
- Outdoor units and other plant items to be screened from direct line of sight to the affected residences (depending on their locations).
- Stand-by generators should be acoustically treated to achieve the external noise level criteria discussed in Section 3.1, by accounting the modifying factors listed in Section 3.1.6 for maintenance operations. The treatment is likely to comprise an acoustic enclosure, rectangular silencers / louvres for air intakes and air discharge paths; and mufflers on the exhaust.

The above recommendations should be considered as in-principle, best practice acoustic treatment that will need to be confirmed during detailed design stages.

Finally, it is recommended that mechanical services should be designed to achieve compliance with external noise level criteria discussed in Section 3.1. All conceptual measures listed above should be confirmed and developed further during detailed design stages of the project.

5.2 Internal Noise Emissions – Building Services

The mechanical ventilation design is still ongoing at the time of issuing this report. Nevertheless, it is advised that this should be designed to achieve the internal noise level criteria discussed in Section 3.2. That is, the internal design noise levels designated for the project as part of the quality requirements. Subject to confirmation, these requirements might include the recommended noise levels identified in the Engineering Services Guidelines developed by NSW Health (not included in this report).

Mechanical plant should be resiliently mounted. Vibration isolation mounts and supports should be designed to achieve compliance with vibration criteria discussed in Section 3.3.

6 CONSTRUCTION NOISE & VIBRATION ASSESSMENT

6.1 Construction Noise Assessment

At this stage, no construction program is available for the project. Therefore, it is assumed that construction works will extend for 6 - 12 months. Based on this timeline, typical construction activities have been assumed, these are summarised in Table 15. This table also lists the construction equipment used for each activity.

Table 15 Summary of predicted sound power levels

Tasks	Equipment	Sound Power Levels dB $L_{Aeq\ 15\ minutes}$ (dBA re 1pW)	Aggregate Sound Power Level per Task dB $L_{Aeq\ 15\ minutes}$ (dBA re 1pW)
Site establishment	Scissor lift	93	110
	Mobile crane	107	
	Power hand tools	105	
	Forklift	103	
Demolition	Concrete saw [1]	119	121
	Pneumatic hammering [1]	116	
	Dump truck	106	
Structural & façade	Concrete mixer truck	105	113
	Concrete pump	103	
	Power hand tools	109	
	Welding	100	
	Hand held grinder [1]	106	
	Elevated platform	100	
Fitout works	Elevated platforms	100	117
	Hand held grinder [1]	106	
	Power hand tools	103	
	Floor grinders [1]	116	
	Nail gun	95	

Note 1: A 5 dB penalty is included in the corresponding sound power levels, as discussed in Section 4.5 of the ICNG

For this assessment, the nearest affected receivers on which our assessment is conducted, are listed in Table 16 below.

Based on the equipment sound power levels given in Table 15, noise levels have been predicted at these nearest affected properties for each construction scenario (where each construction scenario comprises two or more construction tasks). These predicted noise levels are summarised in Table 17. Please note that the noise predictions consider a worst-case scenario where noise sources have been located as close as possible to nearest affected receivers.

These predicted noise levels have been assessed against the construction noise criteria discussed in Section 4.1. The outcomes of this assessment are summarised in Table 18.

Table 16 Receiver IDs for assessment purposes

Receiver ID	Noise Sensitive Locations	Type
RE01	Residences along Pacific Hwy, adjacent to Kanwal Medical Complex	Residential
RE02	Residences along Wiowera Road	Residential
RE03	Residences along Yellow Rose Terrace	Residential
CC01	Childcare centre at Kanwal Medical Complex	Child Care Centre
CM01	Kanwal Medical Complex	Commercial
PH01	Private Hospital (i.e. Tuggerah Lakes Private Hospital)	Hospital
BA	Wyong Hospital: Existing Block A Building	Hospital
BB	Wyong Hospital: Existing Block B Building (north of refurbishment works site)	Hospital
BC	Wyong Hospital: Existing Block C Building (north of refurbishment works site)	Hospital

From the assessment outcomes summarised in Table 18, the following is noted:

- Existing buildings within Wyong Hospital will be the most impacted receivers. Furthermore, these are likely to be highly noise affected by construction activities.
- External residences and commercial receivers are likely to be noise affected by construction activities.

Therefore, based on these findings, the conceptual management procedures discussed in Section 6.4 are recommended.

It is also recommended that a construction noise and vibration management plan (CNVMP) should be developed to account for these recommended operational procedures and to manage the acoustic impact onto the nearest affected receivers.

Table 17 Predicted external $L_{Aeq\ (15\ minutes)}$ noise levels at nearest impacted receivers

Scenario	Tasks	Aggregate Sound Power Level per Scenario (dBA re 1pW)	Predicted $L_{Aeq,\ 15min}$ Noise Levels, dBA								
			RE01	RE02	RE03	CC01	CM01	PH01	BA	BB	BC
1	Site establishment	110	50-55	55-60	55-60	55-65	60-65	55-65	60-80	60-75	65-80
2	Demolition	121	65-70	65-70	65-70	65-75	70-75	65-75	70-90	70-85	75-85
3	Structural steel, façade and roof	113	55-60	55-65	55-65	60-65	60-70	60-65	60-80	60-80	65-80
4	Fitout works	117	60-65	60-65	60-65	60-70	65-70	60-70	65-85	65-85	70-85

Table 18 Summary of assessment outcomes and exceedances based on the ICNG criteria

Scenario	Parameter	Assessment Outcomes								
		RE01	RE02	RE03	CC01	CM01	PH01	BA	BB	BC
1	*Predicted Noise Levels, dBA*	*50-55*	*55-60*	*55-60*	*55-65*	*60-65*	*55-65*	*60-80*	*60-75*	*65-80*
	Within standard construction hours									
	Exceedance over NML, dB	0-4	1-6	1-6	0	0	5-15	10-30	10-25	15-30
2	*Predicted Noise Levels, dBA*	*65-70*	*65-70*	*65-70*	*65-75*	*70-75*	*65-75*	*70-90*	*70-85*	*75-85*
	Within standard construction hours									
	Exceedance over NML, dB	14-19	11-16	11-16	0-10	5-10	15-25	20-40	20-35	25-35
3	*Predicted Noise Levels, dBA*	*55-60*	*55-65*	*55-65*	*60-65*	*60-70*	*60-65*	*60-80*	*60-80*	*65-80*
	Within standard construction hours									
	Exceedance over NML, dB	4-9	1-11	1-11	0	0-5	10-15	10-30	10-20	15-30
4	*Predicted Noise Levels, dBA*	*60-65*	*60-65*	*60-65*	*60-70*	*65-70*	*60-70*	*65-85*	*65-85*	*70-85*
	Within standard construction hours									
	Exceedance over NML, dB	9-14	6-11	6-11	0-5	0-5	10-20	15-35	15-35	20-35

*Note 1: Nil exceedances (i.e. 0 dB shown with **green** font) indicate compliance. Exceedances shown with **orange** font indicate noise affected receivers. Exceedances shown with **red** font indicate highly noise affected receivers*

6.2 Construction Traffic Noise Assessment

No information regarding vehicular traffic movements related to construction activities; is available at this stage. Nevertheless, it is noted that vehicle numbers on surrounding roads would need to increase by around 60% from existing traffic flows, for a 2 dB increase in road traffic noise to occur.

6.3 Vibration Assessment

To maintain compliance with the human comfort vibration criteria discussed in Section 4.3, it is recommended that the indicative safe distances listed in Table 19 should be maintained. These indicative safe distances should be validated prior to the start of construction works by undertaking measurements of vibration levels generated by construction and demolition equipment to be used on site. These measurements should especially be undertaken within nearest impacted hospital buildings, such as Blocks A, B and C. Validation acoustic survey should also include measurements of ground-borne / structure-borne noise levels.

Since the criteria for scientific or medical equipment (should any of these exist close to the site) can be more stringent than those required for human comfort, vibration validating measurements should be conducted at each site to determine the vibration level and potential impact onto this sensitive equipment. It is recommended that these validating measurements should be conducted prior to undertaking vibration intensive activities (such as demolition of existing floor slab components and façade constructions, etc.)

Additionally, any vibration levels should be assessed in accordance with the criteria discussed in Section 4.3. This information should also be included as part of the CNVMP.

Finally, we recommend that construction and demolition activities within hospital premises should be conducted in coordination with NSW Health Infrastructure (Central Coast Local Health District) to minimise disruption to the hospital . Refer to further discussion in Section 6.4.3.

Table 19 Recommended indicative safe working distances for vibration intensive plant

Plant	Rating / Description	Safe Working Distances (m)	
		Cosmetic Damage (BS 7385: Part 2 DIN 4150: Part 3)	Human Comfort (AVTG)
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
Jackhammer	Hand held	1	Avoid contact with structure and steel reinforcements

6.4 Noise & Vibration Management Procedures

The contractor is recommended to develop a construction noise and vibration management plan (CNVMP) that recommend appropriate mitigation measures to manage the noise and vibration impacts to potentially affected receivers.

The following sub-sections discuss the issues and measures that can be considered as part of this CNVMP.

6.4.1 Noise Mitigation Measures

A detailed construction program should be provided which should include the following:

- Schedule of construction activities (classified into scenarios if applicable).
- List of construction equipment per activity.
- Location of construction equipment.
- Duration of construction activities, as well as proposed construction hours.

The construction program should be prepared in consultation with hospital management to determine what areas (if any) of the hospital is particularly noise sensitive, and at what time (ward rooms, operating theatres, etc.).

This construction program should be issued to assist with the prediction of the noise impacts and to develop mitigation measures to ameliorate these impacts. A 3D computer noise model can be produced to conduct the noise level predictions and undertake the relevant assessment. The outcomes of this assessment should be discussed in the CNVMP.

The contractor should, where reasonable and feasible, apply best practice noise mitigation measures. These measures include the following:

- Maximising the offset distance between plant items and nearby noise sensitive receivers.
- Identify feasible acoustic controls or management techniques (use of screens, scheduling of noisy works, notification of adjoining land users, respite periods) when excessive levels may occur.
- Preventing noisy plant from working simultaneously and / or being located adjacent to sensitive receivers.
- Minimising consecutive works in the same site area.
- Orienting equipment away from noise sensitive areas.
- Carrying out loading and unloading away from noise sensitive areas.

To minimise noise impacts during the works, the contractor should take all reasonable and feasible measures to attenuate the noise impact. On-site noise and vibration measurements should be conducted to validate the predicted impacts and propose mitigation measures as construction activities develop.

The contractor should also take reasonable steps to control noise from all plant and equipment. Examples of appropriate noise control include efficient silencers and low noise mufflers.

The contractor should apply all feasible and reasonable work practices to meet the NMLs and inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels, duration of noise generating construction works, and the contact details for the Construction Manager.

A potential approach would be to schedule a respite period after continuous construction activity or undertaking high noise generating works at less sensitive times.

For activities where acoustic controls and management techniques still cannot guarantee compliant noise levels, implement a notification process whereby nearby development is made aware of the time and duration of noise intensive construction processes.

Finally, undertake an assessment of road traffic noise generated by light and heavy vehicle movements which are associated with the development's construction. For this purpose, a traffic study report should be commissioned to determine the relevant traffic flows and assess the predicted road traffic noise levels in accordance with the criteria discussed in Section 4.2.

6.4.2 Vibration Mitigation Measures

The following vibration mitigation measures are recommended to be considered as part of a CNVMP:

- Vibration generating plant and equipment should be located in areas within the site where lower vibration impacts are predicted.
- Investigate the feasibility of rescheduling the hours of operation of major vibration generating plant and equipment to less sensitive time periods.
- Identify other vibration sensitive structures such as tunnels, gas pipelines, fibre optic cables, Sydney Water retention basins, etc. Specific vibration goals should be determined on a case-by-case basis by an acoustic consultant which is to be engaged by the construction contractor.
- Identify heritage structures as well as vibration sensitive premises (such as those containing scientific and vibration sensitive medical equipment). Safe working distances from vibration generating equipment should be established to achieve compliance with the criteria discussed in Section 4.3.

  We recommend that attended measurements of vibration generating plant be conducted at the commencement of works to confirm compliance with the vibration criteria discussed in Section 4.3. Measurements should be conducted at the nearest affected property boundary. If possible, measurements will also be used to validate the safe working distances advised in Table 19 and to establish safe working distances suitable to the project.
- Use lower vibration generating items of construction plant and equipment, that is, smaller capacity plant.
- Minimise conducting vibration generating works consecutively in the same area (if applicable).
- Schedule a minimum respite period prior to long continuous activities.
- Use only dampened rock breakers and/or "city" rock breakers to minimise the impacts associated with rock breaking works.

6.4.3 Impact Onto Existing Hospital Premises

Noise and vibration levels from the proposed works will mostly affect the existing Wyong Hospital buildings. As such, internal management of the potential impacts should be managed between the managing contractor and NSW Health Infrastructure (Central Coast Local Health District).

Due to the difficulty in predicting the operational parameters of the hospital during the construction works (i.e. number of staff, number of patients, location of patients, operational times, etc.), the noise and vibration mitigation measures will need to be adopted on a case by case basis. Some of these mitigation measures are outlined below:

- Ongoing communication between the managing contractor and NSW Health Infrastructure during the works.
- Consultation with the end users of the affected spaces.
- Temporary relocation of patients and or staff during high levels of noise and vibration.
- Noise and vibration monitoring to be undertaken at the nearest most affected areas within the building, with real-time feedback capabilities to ensure for a quick response to any exceedances or complaints.

- Alternate selection of equipment and/or methodologies.

6.4.4 Miscellaneous Measures

Deliveries should be undertaken, where possible, during standard construction hours.

Maximise hammer penetration (and reduce blows) by using sharp hammer tips. Keep stocks of sharp profiles at the site and monitor the profiles in use.

It is advised that mobile plant and trucks operating on site for a significant portion of the project are to have reversing alarm noise emissions minimised (i.e. "smart" reversing alarms that set the alarm level relative to the current ambient noise environment) and incorporate broadband noise rather than a tonal signal. This is to be implemented subject to recognising the need to maintain occupational safety standards.

No public address system should be used on site.

Nearest affected receivers should be notified in advanced for construction activities likely to cause an adverse impact. Consequently, a complaint response procedure should be implemented. Information to be gathered as part of this process should include location of complainant, time/s of occurrence of alleged noise or vibration impacts (including nature of impact particularly with respect to vibration), perceived source, prevailing weather conditions and similar details that could be utilised to assist in the investigation of the complaint. All complaints will be responded to in the required timeframe, and action taken should be recorded.

Construction vehicles (including concrete agitator trucks) are to not arrive at the site or any surrounding residential precincts outside of the construction hours of work. For this assessment, it is considered that construction hours are as per the standard hours listed in the ICNG (i.e. refer to Section 4.1, Table 9).

Any equipment not used for extended periods is to be switched off.

7 CONCLUSIONS

Pulse White Noise Acoustics has undertaken an acoustic impact assessment for the Stage 3 refurbishment works at Wyong Hospital. These refurbishment works are to be conducted within existing the Blocks B and C buildings.

From the operational assessment, it is found that mechanical plant design and equipment selection should be made so that the aggregate noise level from all external emissions, comply with the external noise level criteria discussed in Section 3.1 and internal noise level criteria discussed in Section 3.2. Mechanical plant should be resiliently mounted. Vibration isolation mounts and supports should be designed to achieve compliance with vibration criteria discussed in Section 3.3.

Additionally, we recommend that a construction noise and vibration management plan (CNVMP) be developed for the construction works related to the development. This CNVMP should consider the operational procedures and mitigation measures summarised in Section 6.4.

Based on the findings from the acoustic assessment, it is our opinion that the proposed development can achieve compliance with the operational and construction acoustic criteria required by local authorities, provided the conceptual recommendations discussed herein are implemented. These noise mitigation recommendations can be further developed at the later detailed design stages; when the CNVMP is submitted to local authorities.

APPENDIX A: ACOUSTIC TERMINOLOGY

The following is a brief description of the acoustic terminology used in this report.

Sound power level	The total sound emitted by a source
Sound pressure level	The amount of sound at a specified point
Decibel [dB]	The measurement unit of sound
A Weighted decibels [dB(A])	The A weighting is a frequency filter applied to measured noise levels to represent how humans hear sounds. The A-weighting filter emphasises frequencies in the speech range (between 1kHz and 4 kHz) which the human ear is most sensitive to, and places less emphasis on low frequencies at which the human ear is not so sensitive. When an overall sound level is A-weighted it is expressed in units of dB(A).
Decibel scale	The decibel scale is logarithmic in order to produce a better representation of the response of the human ear. A 3 dB increase in the sound pressure level corresponds to a doubling in the sound energy. A 10 dB increase in the sound pressure level corresponds to a perceived doubling in volume. Examples of decibel levels of common sounds are as follows:

0dB(A)	Threshold of human hearing
30dB(A)	A quiet country park
40dB(A)	Whisper in a library
50dB(A)	Open office space
70dB(A)	Inside a car on a freeway
80dB(A)	Outboard motor
90dB(A)	Heavy truck pass-by
100dB(A)	Jackhammer/Subway train
110 dB(A)	Rock Concert
115dB(A)	Limit of sound permitted in industry
120dB(A)	747 take off at 250 metres

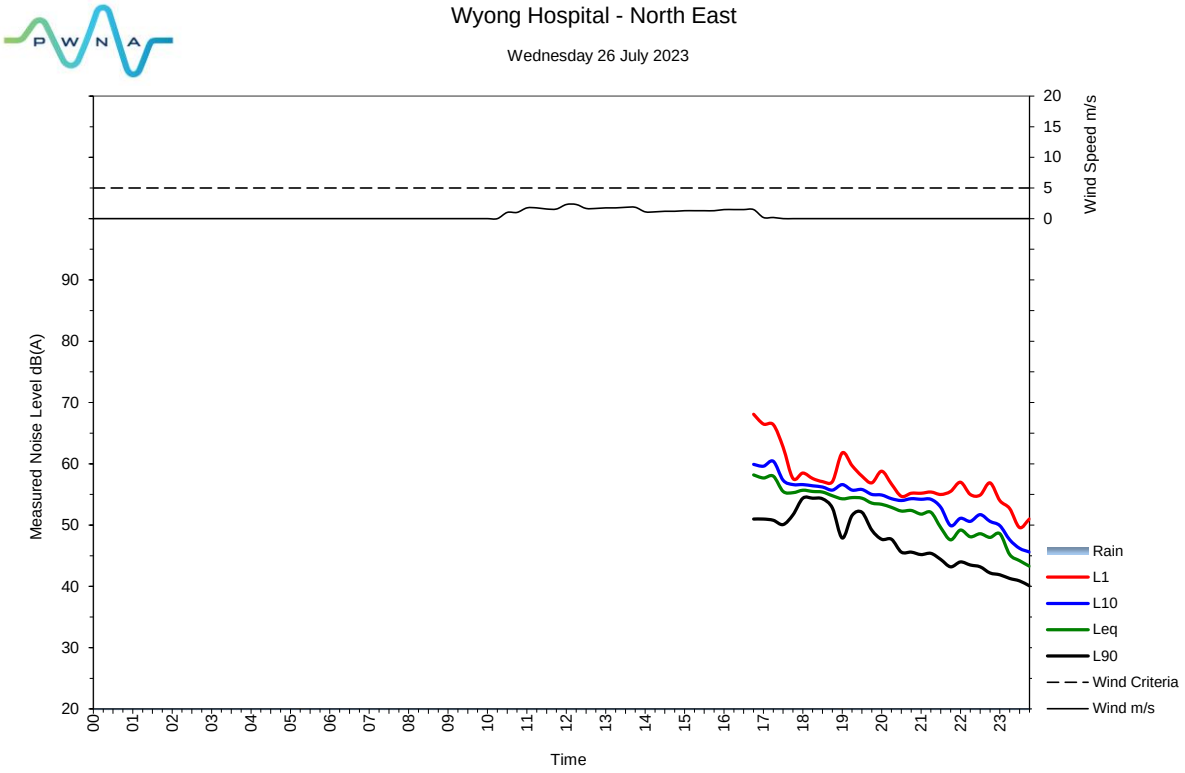
Frequency [f]	The repetition rate of the cycle measured in Hertz (Hz). The frequency corresponds to the pitch of the sound. A high frequency corresponds to a high pitched sound and a low frequency to a low pitched sound.
Ambient sound	The all-encompassing sound at a point composed of sound from all sources near and far.
Equivalent continuous sound level [L_{eq}]	The constant sound level which, when occurring over the same period of time, would result in the receiver experiencing the same amount of sound energy.
Reverberation	The persistence of sound in a space after the source of that sound has been stopped (the reverberation time is the time taken for a reverberant sound field to decrease by 60 dB)
Air-borne sound	The sound emitted directly from a source into the surrounding air, such as speech, television or music
Impact sound	The sound emitted from force of one object hitting another such as footfalls and slamming cupboards.
Air-borne sound isolation	The reduction of airborne sound between two rooms.
Sound Reduction Index [R] (Sound Transmission Loss)	The ratio the sound incident on a partition to the sound transmitted by the partition.
Weighted sound reduction index [R_w]	A single figure representation of the air-borne sound insulation of a partition based upon the R values for each frequency measured in a laboratory environment.
Level difference [D]	The difference in sound pressure level between two rooms.

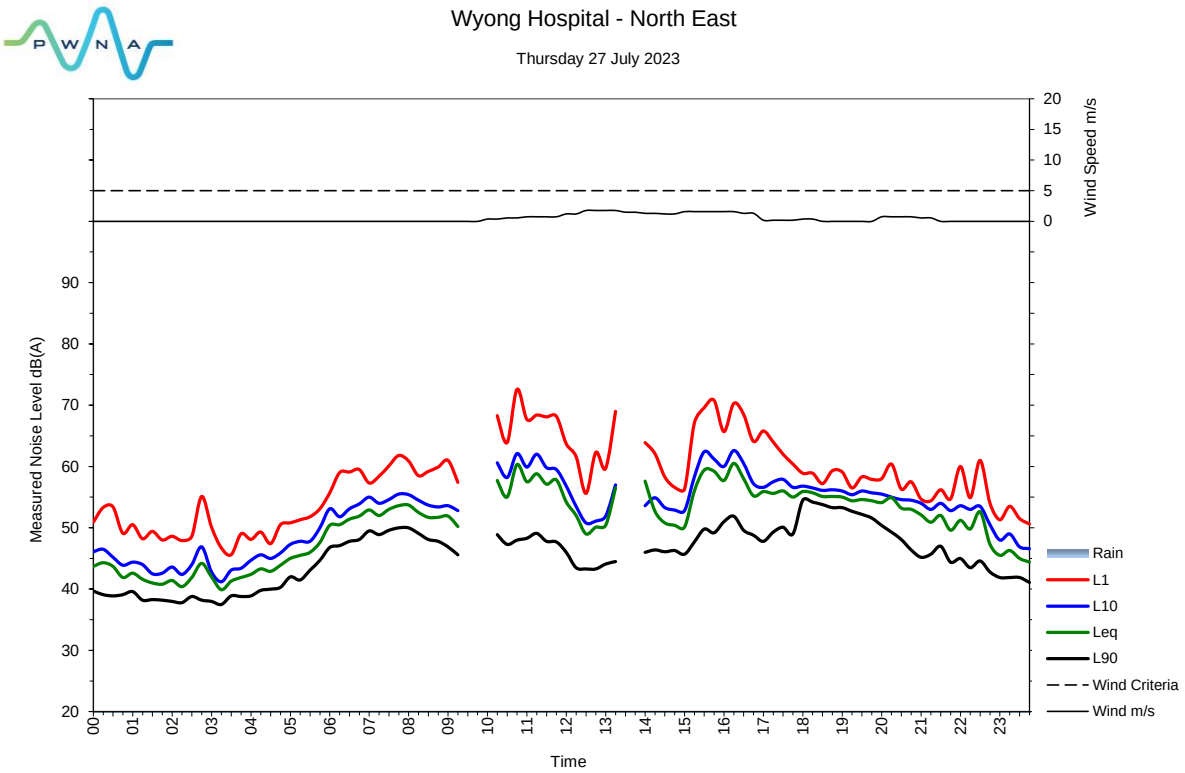
Normalised level difference [D_n]	The difference in sound pressure level between two rooms normalised for the absorption area of the receiving room.
Standardised level difference [D_{nT}]	The difference in sound pressure level between two rooms normalised for the reverberation time of the receiving room.
Weighted standardised level difference [$D_{nT,w}$]	A single figure representation of the air-borne sound insulation of a partition based upon the level difference. Generally used to present the performance of a partition when measured in situ on site.
C_{tr}	A value added to an R_w or $D_{nT,w}$ value to account for variations in the spectrum.
Impact sound isolation	The resistance of a floor or wall to transmit impact sound.
Impact sound pressure level [L_i]	The sound pressure level in the receiving room produced by impacts subjected to the adjacent floor or wall by a tapping machine.
Normalised impact sound pressure level [L_n]	The impact sound pressure level normalised for the absorption area of the receiving room.
Weighted normalised impact sound pressure level [$L_{n,w}$]	A single figure representation of the impact sound insulation of a floor or wall based upon the impact sound pressure level measured in a laboratory.
Weighted standardised impact sound pressure level [$L'_{nT,w}$]	A single figure representation of the impact sound insulation of a floor or wall based upon the impact sound pressure level measured in situ on site.
C_I	A value added to an L_{nW} or $L'_{nT,w}$ value to account for variations in the spectrum.
Energy Equivalent Sound Pressure Level [$L_{A,eq,T}$]	'A' weighted, energy averaged sound pressure level over the measurement period T.
Percentile Sound Pressure Level [$L_{Ax,T}$]	'A' weighted, sound pressure that is exceeded for percentile x of the measurement period T.

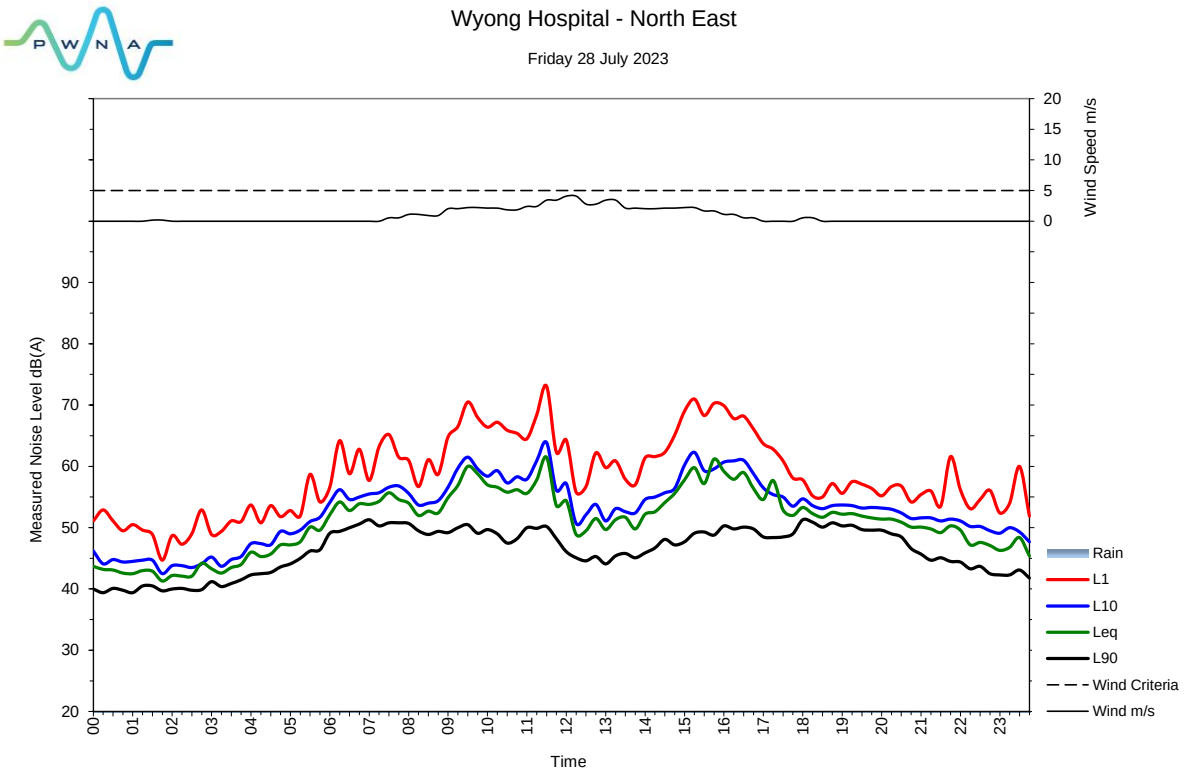
*Definitions of a number of terms have been adapted from Australian Standard AS1633:1985 *"Acoustics – Glossary of terms and related symbols"*

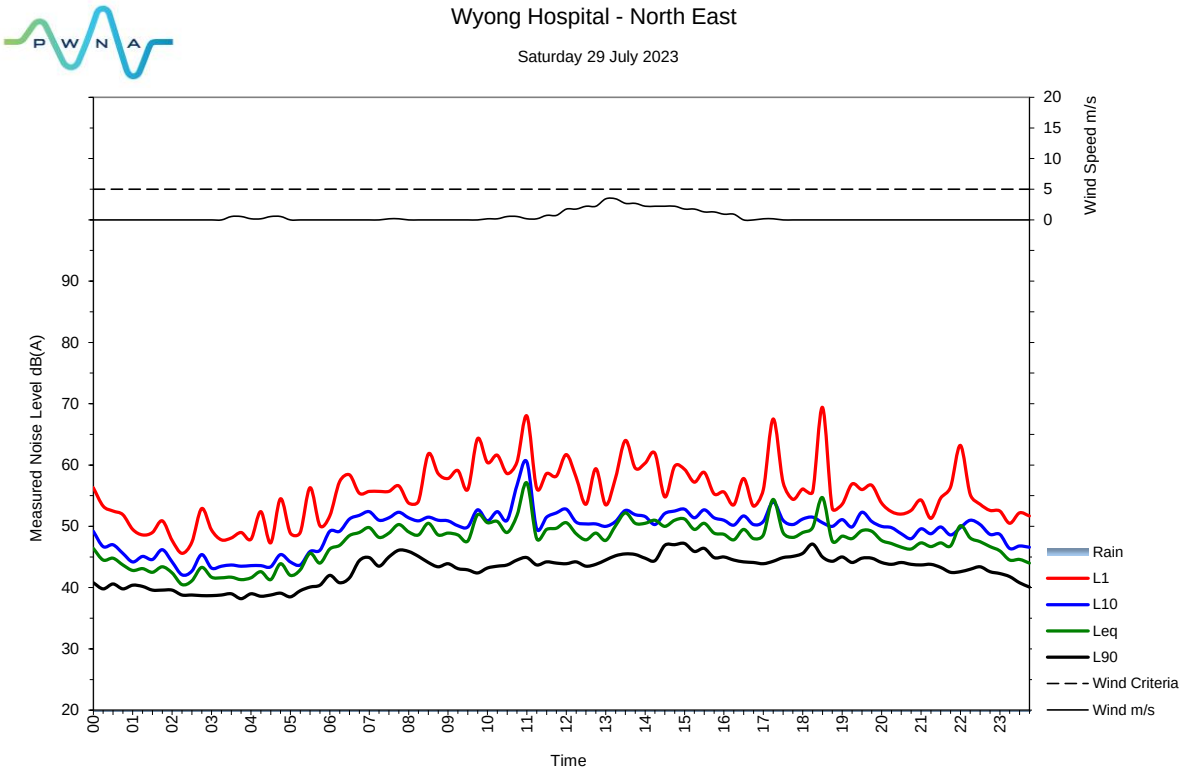
APPENDIX B: NOISE LOGGER CHARTS

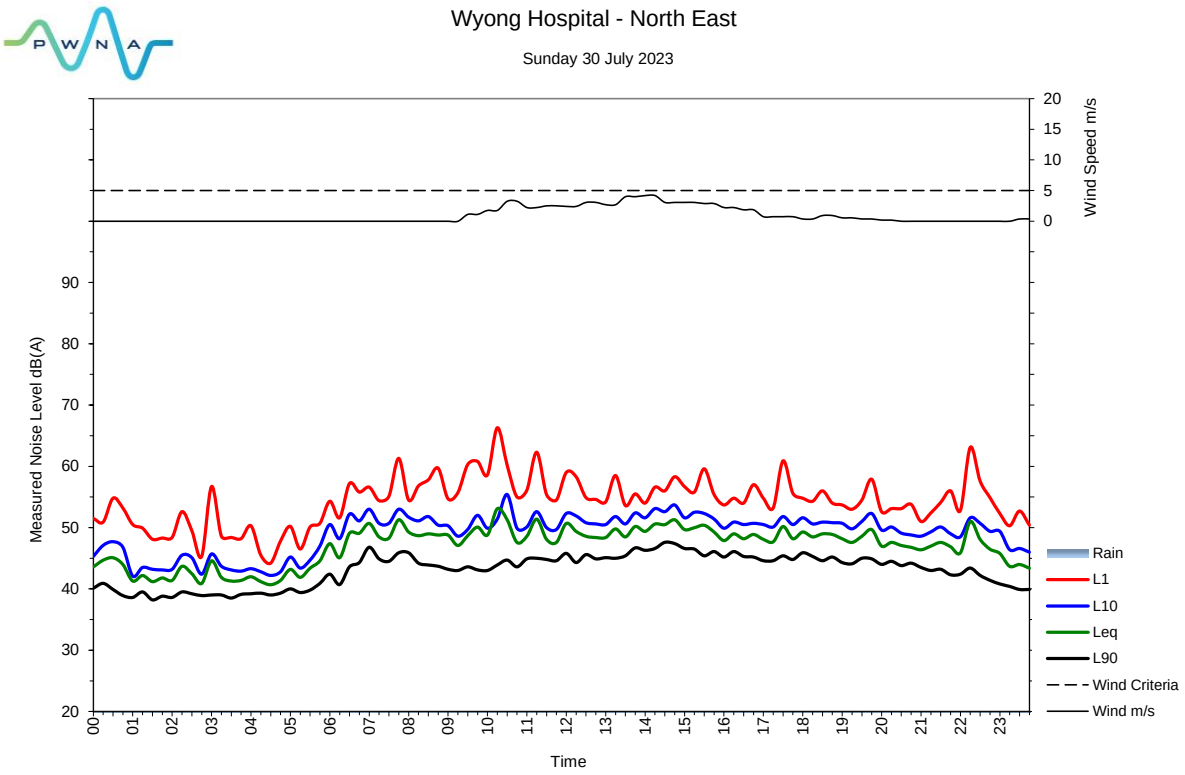
Logger Location 1: North-Eastern Property Boundary

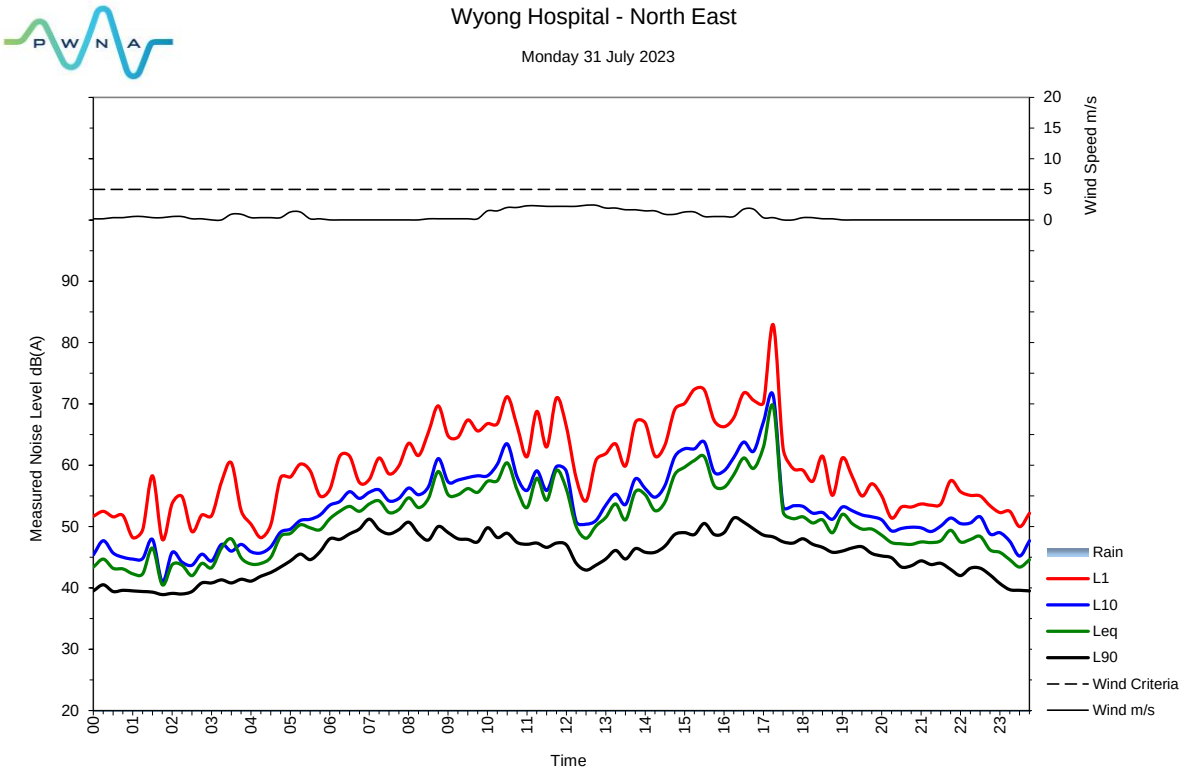


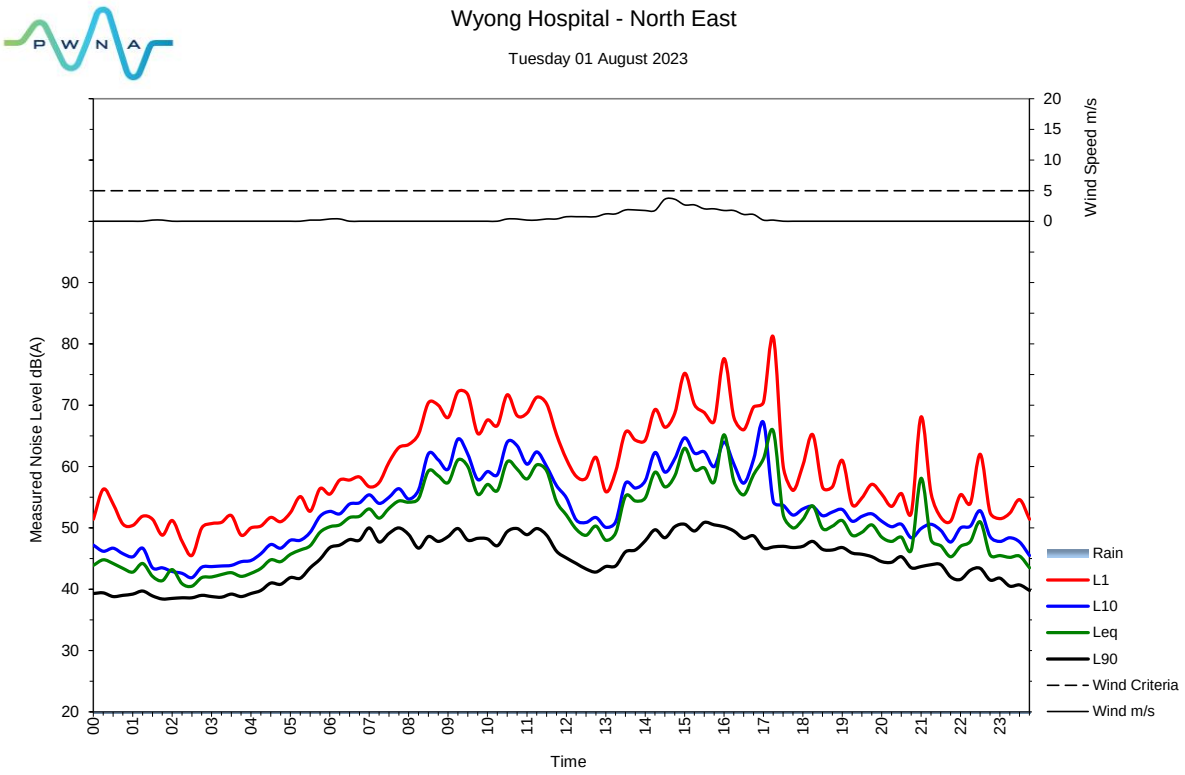


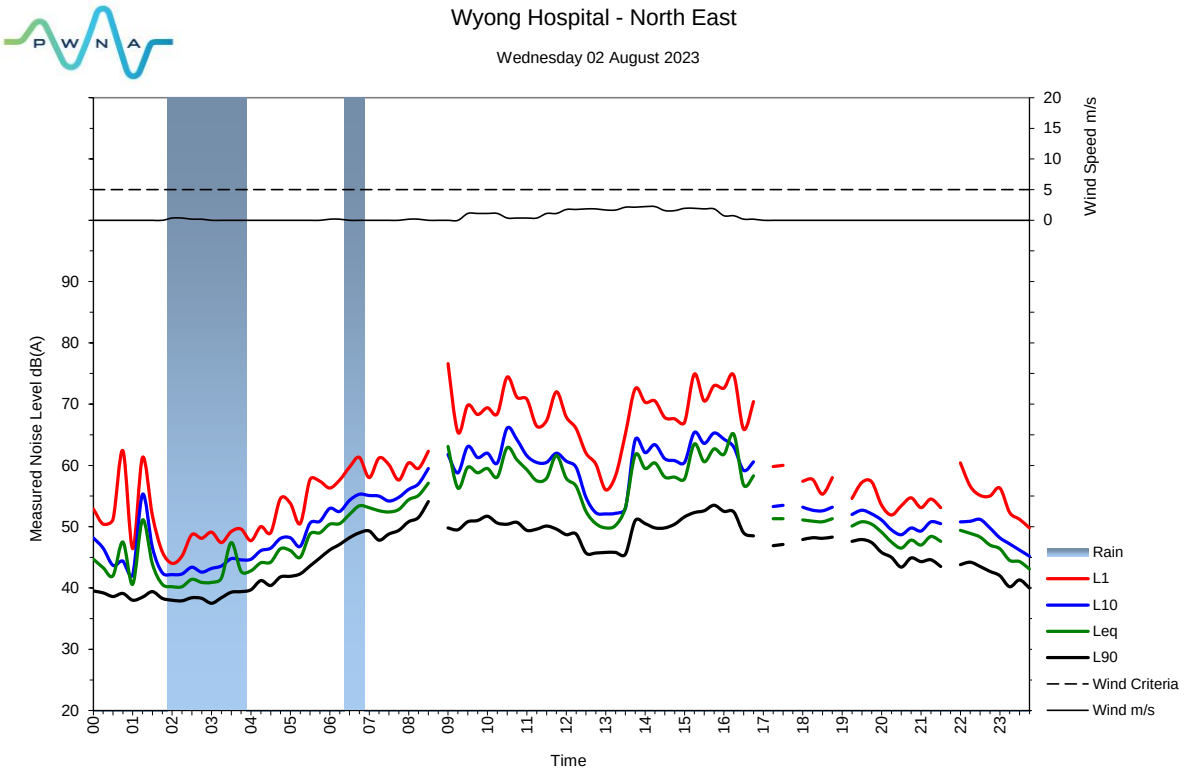

Wyong Hospital - North East
Friday 28 July 2023
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


Wyong Hospital - North East
Saturday 29 July 2023
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

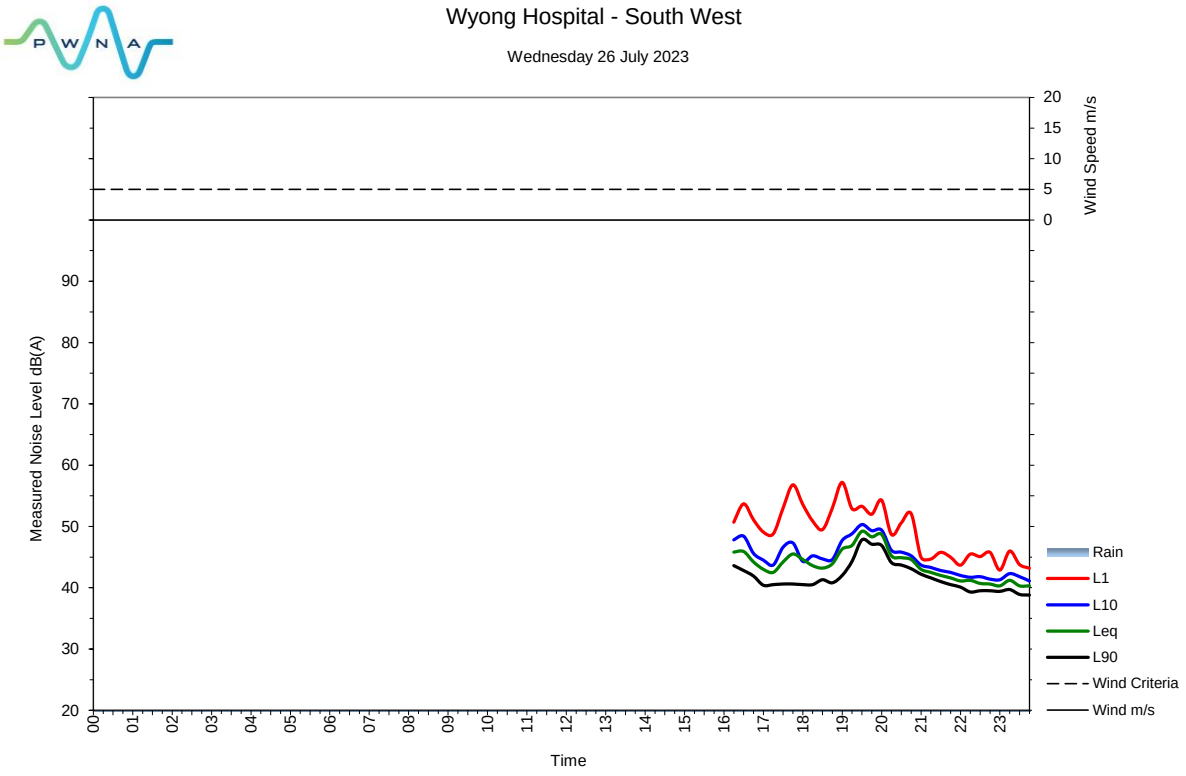

Wyong Hospital - North East
Sunday 30 July 2023
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

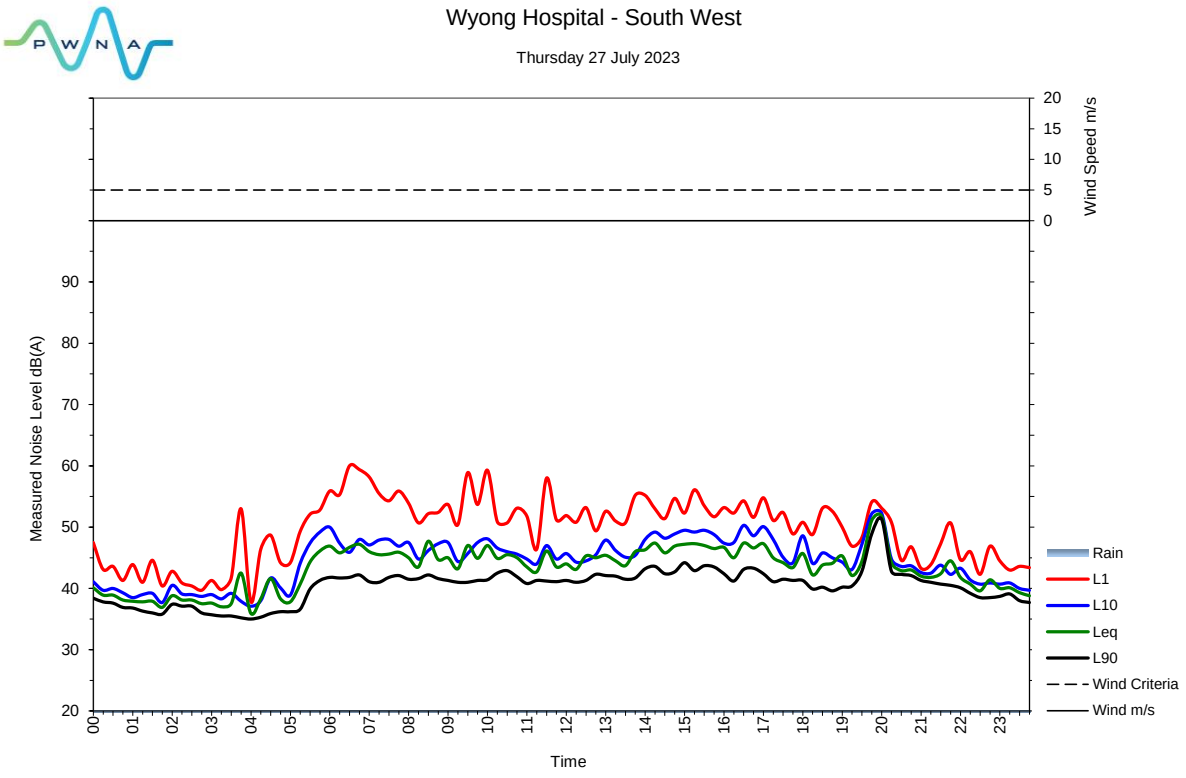

Wyong Hospital - North East
Monday 31 July 2023
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

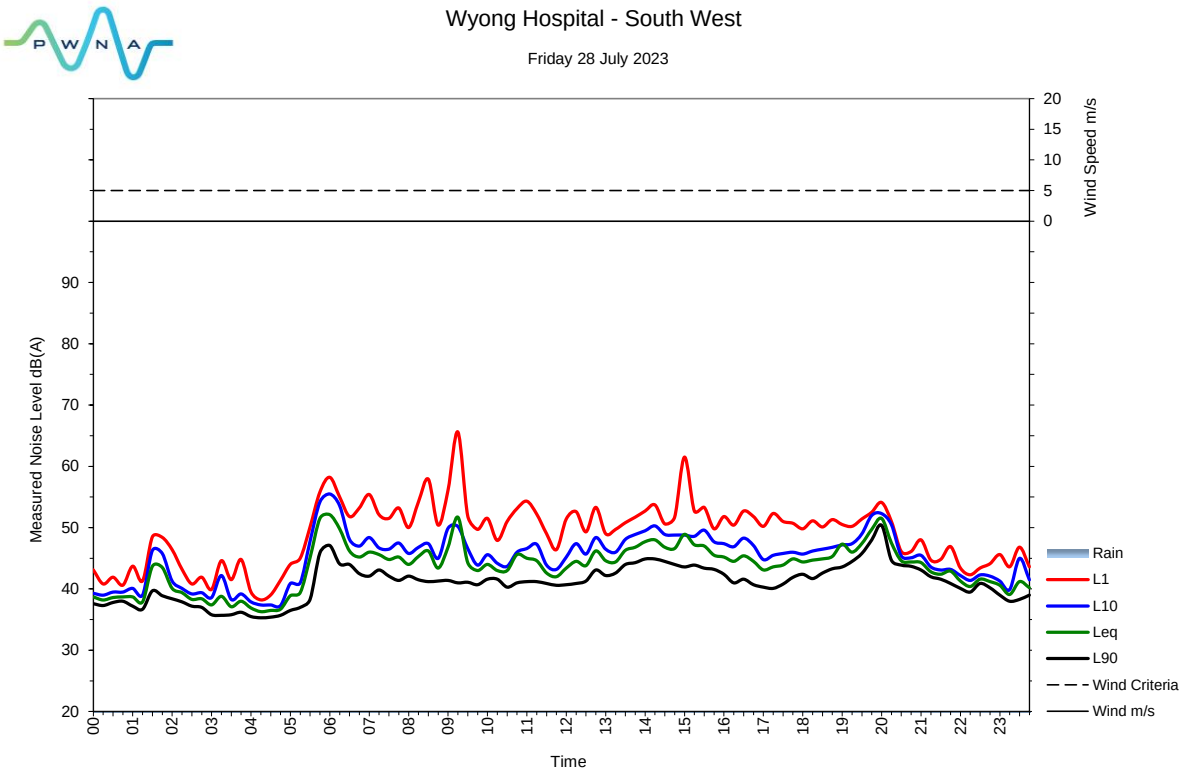

Wyong Hospital - North East
Tuesday 01 August 2023
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


Wyong Hospital - North East
Wednesday 02 August 2023
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s

Logger Location 2: South-Western Property Boundary






Wyong Hospital - South West
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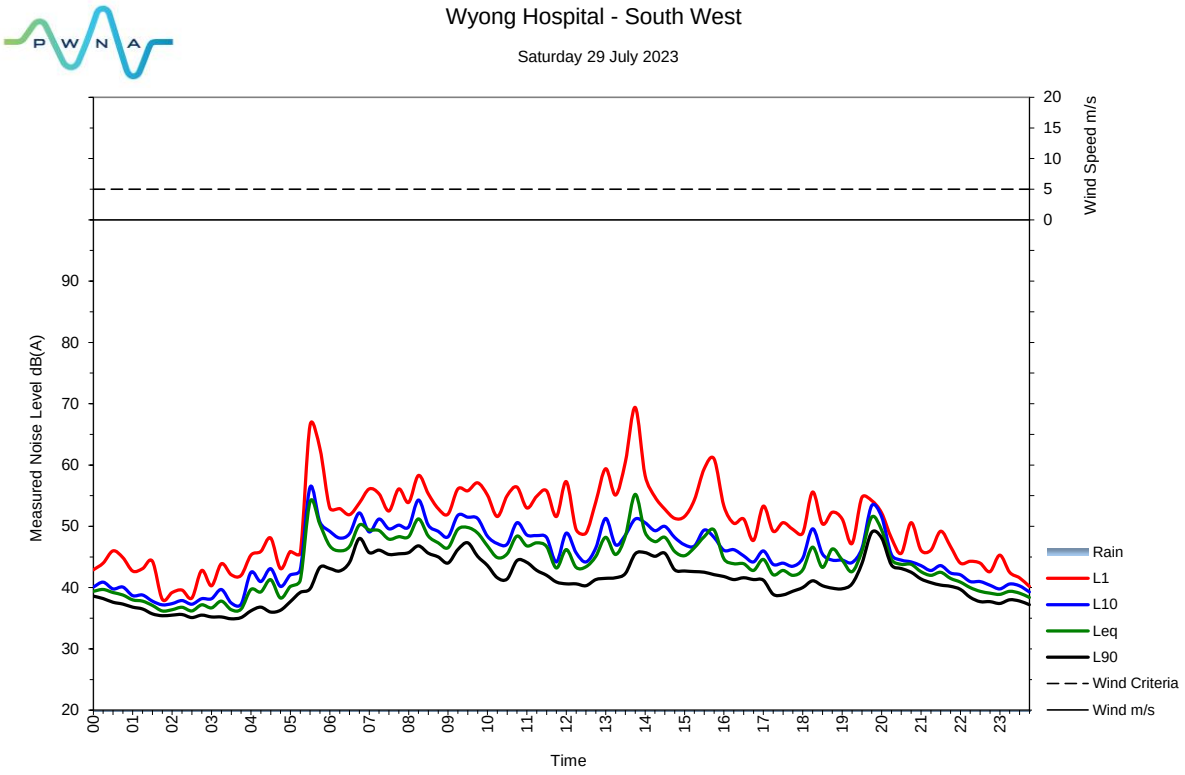
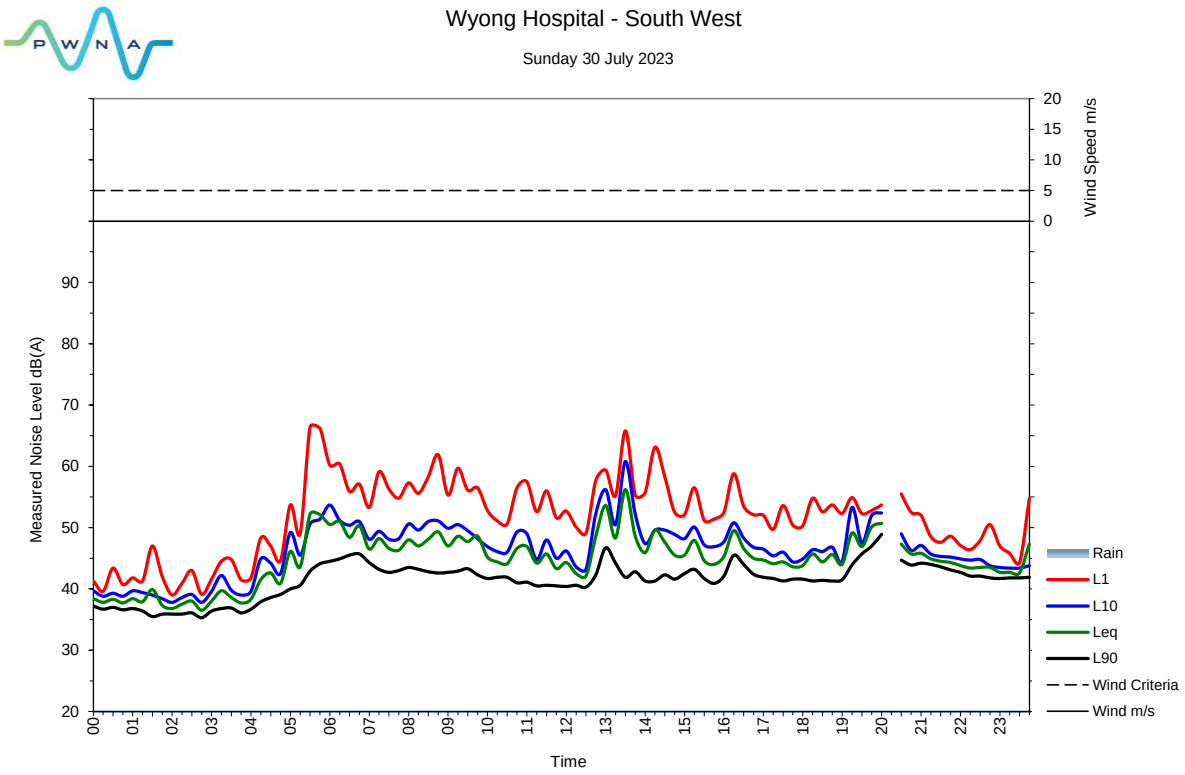
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


Wyong Hospital - South West
Saturday 29 July 2023
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


Wyong Hospital - South West
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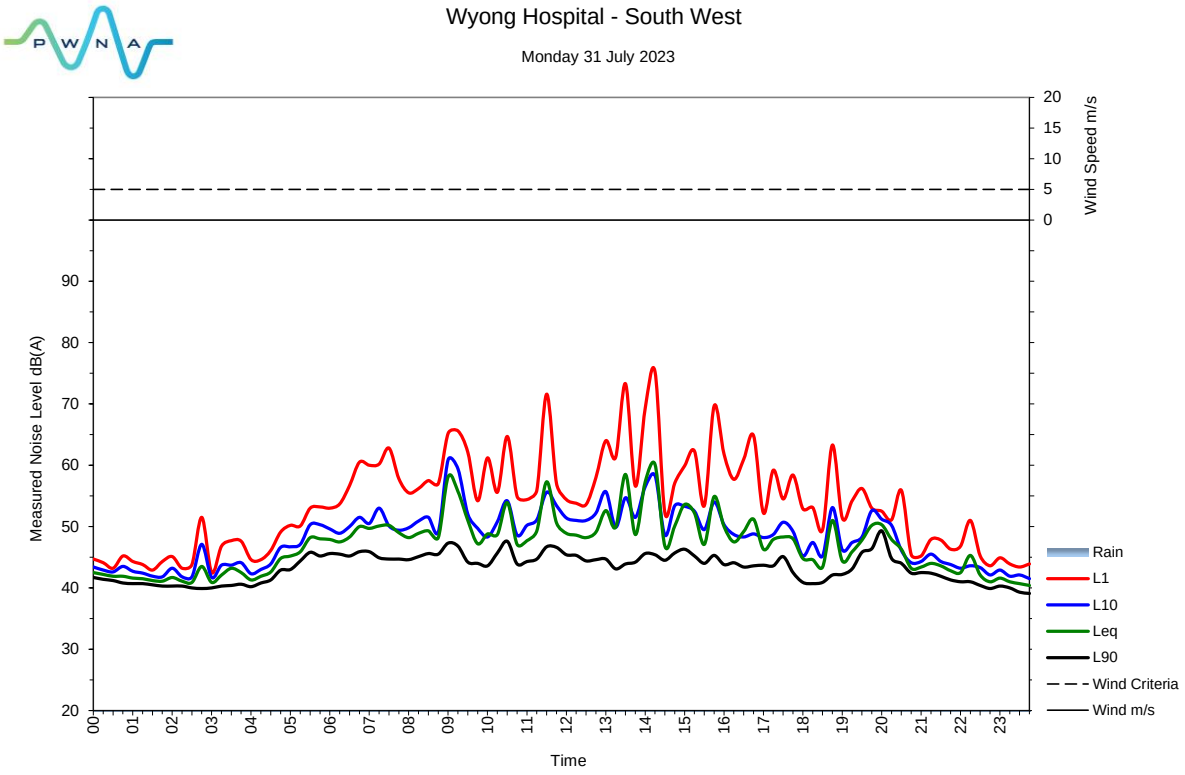
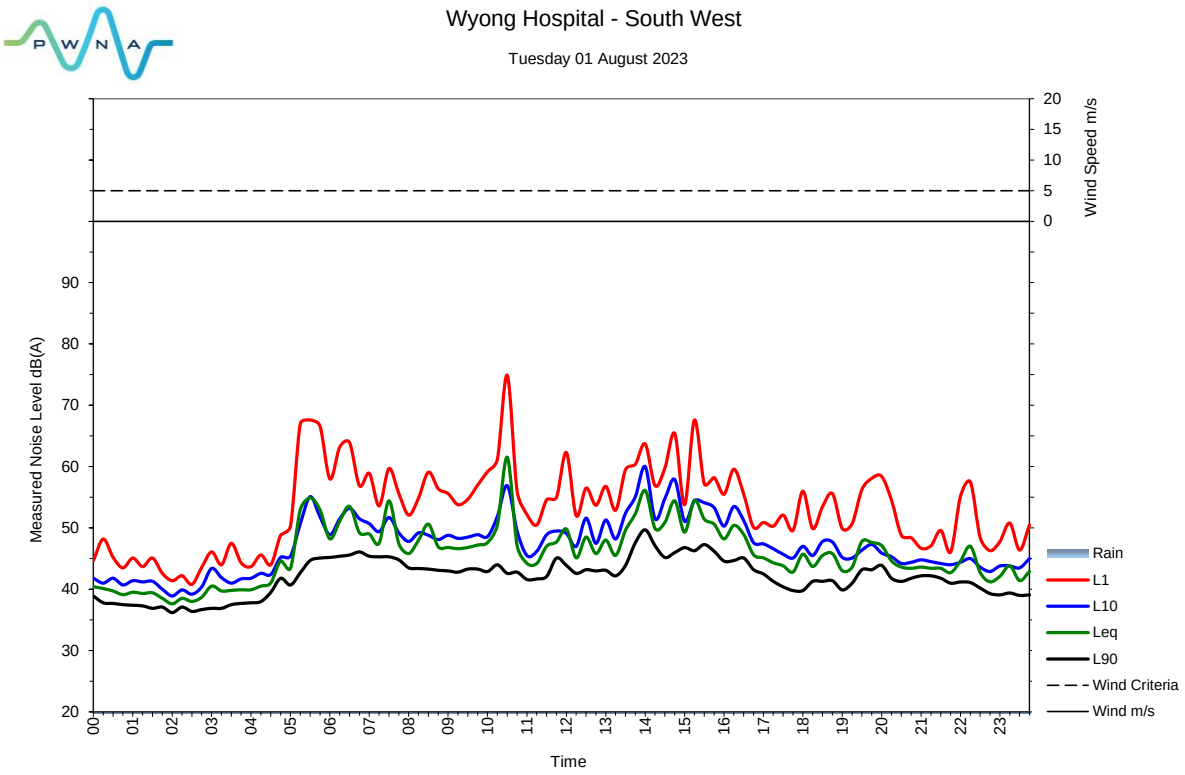
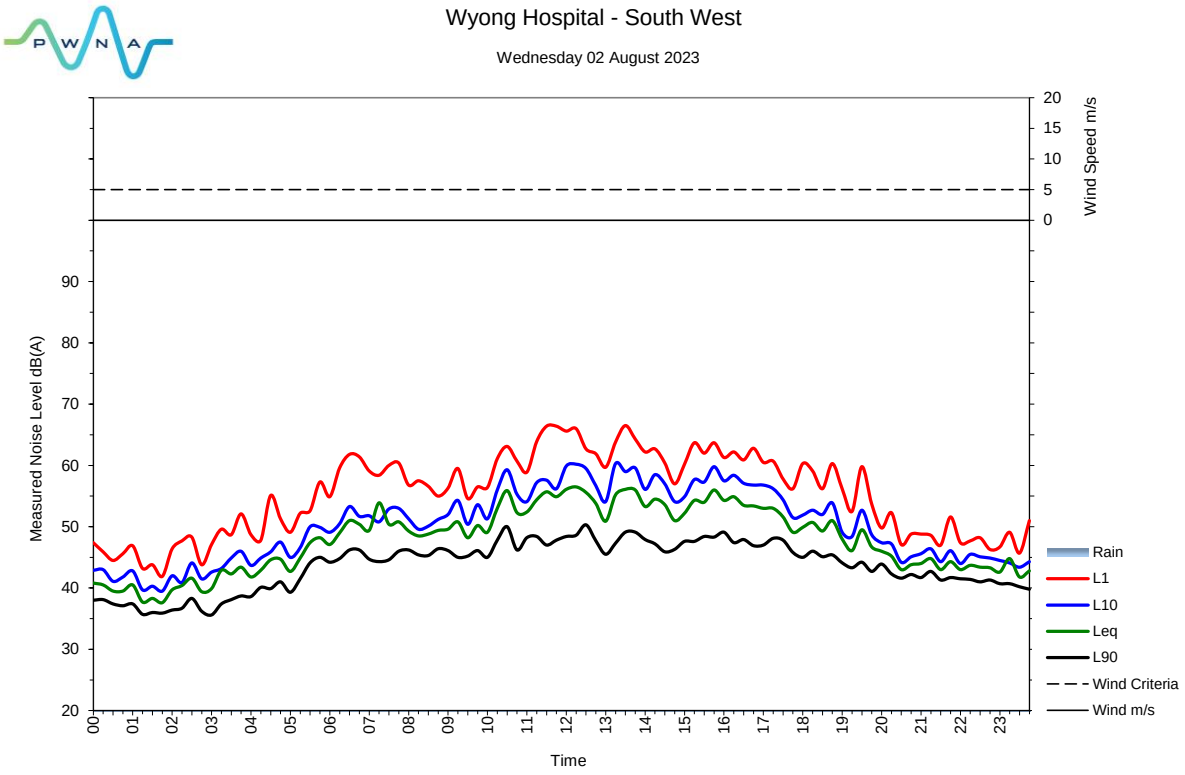
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


Wyong Hospital - South West
Monday 31 July 2023
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


Wyong Hospital - South West
Tuesday 01 August 2023
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s


Wyong Hospital - South West
Wednesday 02 August 2023
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
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Leq
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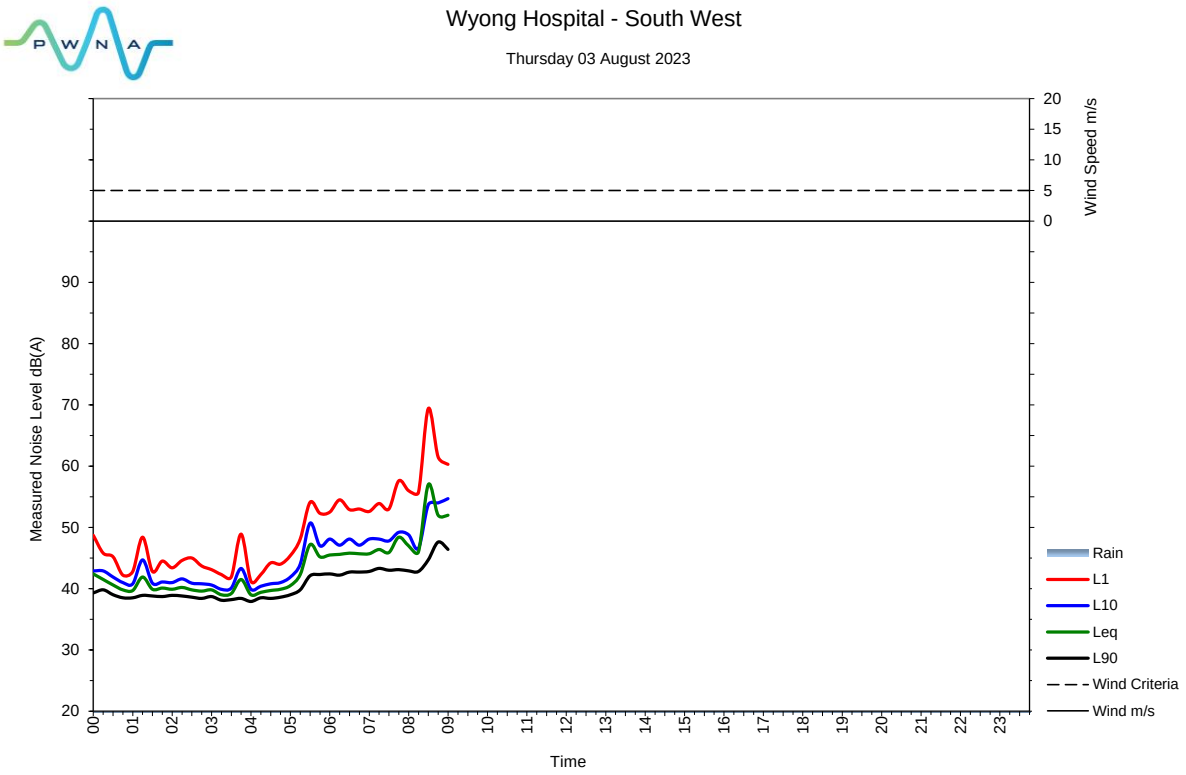
Wind Criteria
Wind m/s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Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s