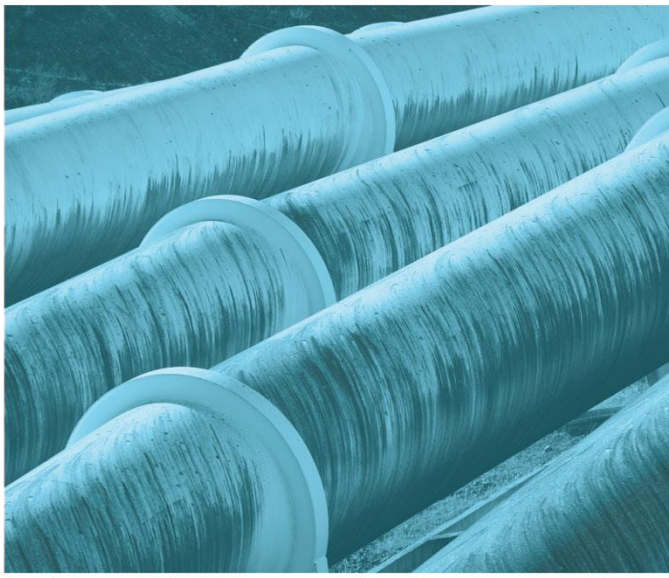



Griffith Base Hospital Redevelopment

Noise and vibration impact assessment

Prepared for Health Infrastructure
January 2021

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Griffith Base Hospital Redevelopment

Noise and vibration impact assessment

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Health Infrastructure

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Prepared by	**Approved by**
	
James Small	**Najah Ishac**
Associate	Director
28 January 2021	28 January 2021

This report has been prepared in accordance with the brief provided by the client and has relied upon the information collected at the time and under the conditions specified in the report. All findings, conclusions or recommendations contained in the report are based on the aforementioned circumstances. The report is for the use of the client and no responsibility will be taken for its use by other parties. The client may, at its discretion, use the report to inform regulators and the public.

Executive Summary

This report has been commissioned by NSW Health Infrastructure to address potential noise impacts associated with the Griffith Base Hospital (GrBH) redevelopment located along Noorebor Avenue, Griffith NSW (the Project) in support of the state significant development application (SSDA). The proposal will include:

- demolition of Buildings 1, 2, 6, 15, 16, 17, 19, 20, 22, 25, 28, 29, 31 and 35;
- demolition of the temporary car park;
- construction of a new clinical services building; and
- construction of a new western car park.

The scope of this assessment is to undertake a review of potential noise and vibration impacts associated with the construction and operation of the Project in accordance with Environmental Protection Authority (EPA) guidelines. This includes noise and vibration impacts associated with:

- demolition and construction works on the site;
- on-site vehicle movements which will predominantly be associated with new carparking on the GrBH campus;
- additional road traffic generated by the Project;
- mechanical plant operation; and
- road traffic noise intrusion into the Project.

The assessment of noise and vibration from the construction and use of the site has been undertaken to address Item 11 of the Secretary's Environmental Assessment Requirements (SEARs). Noise from the construction and operation of the Project has been assessed against the following guidelines and policies referenced in Item 11:

- Noise Policy for Industry (NSW Environment Protection Authority (EPA), 2017);
- Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009);
- Assessing Vibration: A Technical Guideline (Department of Environment and Conservation, 2006); and
- Development Near Rail Corridors and Busy Roads - Interim Guideline (Department of Planning, 2008) (referred to as the 'interim guideline').

An assessment of construction noise and vibration has been undertaken. Noise predictions indicate some exceedance of the project noise management levels. This is not atypical for a project of this size which is being constructed in proximity to sensitive land uses. Vibration generated by heavy construction works are expected to generally comply with cosmetic damage limits excepting select pieces of machinery which may need to be carefully reviewed for implementation on the site. A detailed construction noise and vibration management plan should be prepared as part of the main works contract to ensure that proposed construction methodologies are managed such that noise and vibration impacts from the site are minimised as practicable.

A review of operational noise impacts indicates the following:

- noise from on-site vehicle movements will comply with the noise emission requirements of the NPfI. It is noted that on-site vehicle movements exist as part of the current GrBH arrangement and potential increases due to the proposal would result in a generally imperceptible change in existing noise levels;

- the potential for sleep awakenings will be due to cars starting within the new main and western carparks during the night-time period. Predicted noise levels indicate noise from these events are unlikely to exceed the sleep awakening screening criteria of the NPfI at offsite residences;

- the Project is expected to result in marginal increases to traffic volumes on surrounding roads. The subsequent increase in road traffic noise level will be generally imperceptible and as such comply with the requirements of the RNP;

- a preliminary review of noise impacts associated with mechanical plant operation has been undertaken. It is expected that mechanical plant noise can be suitably treated using relatively standard acoustic treatments such as lined ductwork, acoustic attenuators and the like such that the acoustic requirements of the NPfI are achieved. Noise from mechanical plant is reviewed as part of the detailed design and construction phases and as such is generally conditioned within the project consent. It is expected that a similar condition would be included in this case; and

- the Project is not near rail or aircraft infrastructure and as such noise intrusion from these sources has not been addressed. Roads surrounding the hospital do not carry volumes significant enough to warrant additional assessment in accordance with the Department of Planning *Development Near Rail Corridors and Busy Roads - Interim Guideline* and the State Environmental Planning Policy (Infrastructure).

It is concluded that noise and vibration generated by the construction and operation of the Project may be suitably managed to achieve the requirements of the ICNG, NPfI and RNP. Noise intrusion into the Project has been assessed against the NSW government's interim guideline. In the absence of any significant external noise source, no additional acoustic treatments are warranted in this instance.

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1 Introduction

1.1 Background

Indigeco and EMM Consulting Pty Ltd (EMM) have been engaged by Health Infrastructure to assess potential noise and vibration impacts associated with the proposed Griffith Base Hospital (GrBH) redevelopment ('the Project'). The redevelopment will be constructed on the existing GrBH precinct located at 1 Noorebar Avenue, Griffith NSW.

The Project includes the demolition of existing on-site structures and the construction of a new Clinical Services Building. This report addresses noise and vibration impacts associated with the GrBH redevelopment.

This noise and vibration impact assessment (NVIA) has been prepared to accompany the state significant development application (SSDA) for the Project and addresses the requirements of Item 11 of the Secretary's Environmental Assessment Requirements (SEARs). This includes noise and vibration impacts associated with:

- demolition and construction works on the site;
- on-site vehicle movements which will predominantly be associated with new carparking on the GrBH campus;
- additional road traffic generated by the Project;
- mechanical plant operation; and
- road traffic noise intrusion into the Project.

1.2 SEARs requirements

The report has been prepared to address the requirements of the SEARs issued for the project. Item 11 relates to the assessment of noise impacts from the site and is detailed in Table 1.1.

Table 1.1 SEARs requirements

Item	Requirement	Where addressed in report
11. Noise and vibration	• Provide a noise and vibration impact assessment that:	
	– includes a quantitative assessment of the main noise and vibration generating sources during demolition, site preparation, bulk excavation and construction.	Section 4
	– details the proposed construction hours and provide details of, and justification for, instances where it is expected that works would be carried out outside standard construction hours.	Section 4
	– includes a quantitative assessment of the main sources of operational noise.	Section 6
	– outlines measures to minimise and mitigate the potential noise impacts on nearby sensitive receivers.	Section 8
	– considers sources of external noise intrusion in proximity to the site (including, road rail and aviation operations) and identifies building performance requirements for the proposed development to achieve appropriate internal amenity standards.	Section 7
	– demonstrates that the assessment has been prepared in accordance with polices and guidelines relevant to the context of the site and the nature of the proposed development.	Section 4
	Relevant Policies and Guidelines:	
	• NSW Noise Policy for Industry 2017 (NSW Environment Protection Authority (EPA)	Section 4.3
	• Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009)	Section 4.1
	• Assessing Vibration: A Technical Guideline 2006 (Department of Environment and Conservation, 2006)	Section 4.2.1
	• Development Near Rail Corridors and Busy Roads - Interim Guideline (Department of Planning, 2008)	Section 7

1.3 Glossary of acoustic terms

A number of technical terms are required for the discussion of acoustics. These are explained in Table 1.2.

Table 1.2 Glossary of acoustic terms

Term	Description
dB	Noise is measured in units called decibels (dB).
A-weighting	There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
L_{A1}	The A-weighted noise level exceeded for 1% of a measurement period.
L_{A10}	The A-weighted noise level which is exceeded 10% of the time. It is approximately equivalent to the average of maximum noise levels.
L_{A90}	Commonly referred to as the background noise, this is the A-weighted level exceeded 90% of the time.
L_{Aeq}	The A-weighted energy average noise from a source and is the equivalent continuous sound pressure level over a given period. The $L_{Aeq,15min}$ descriptor refers to an L_{Aeq} noise level measured over a 15-minute period.
L_{Amax}	The maximum root mean squared A-weighted sound pressure level received at the microphone during a measuring interval.
RBL	The Rating Background Level (RBL) is an overall single value background level representing each assessment period over the whole monitoring period.
Sound power level	This is a measure of the total power radiated by a source. The sound power of a source is a fundamental property of the source and is independent of the surrounding environment.

It is useful to have an appreciation of decibel, the unit of noise measurement. Table 1.3 gives an indication as to what an average person perceives about changes in noise levels:

Table 1.3 Perceived change in noise

Change in sound pressure level (dB)	Perceived change in noise
up to 2	typically indiscernible
3	just perceptible
5	noticeable difference
10	twice (or half) as loud
15	large change
20	four times (or quarter) as loud

Examples of common noise levels are provided in Figure 1.1.

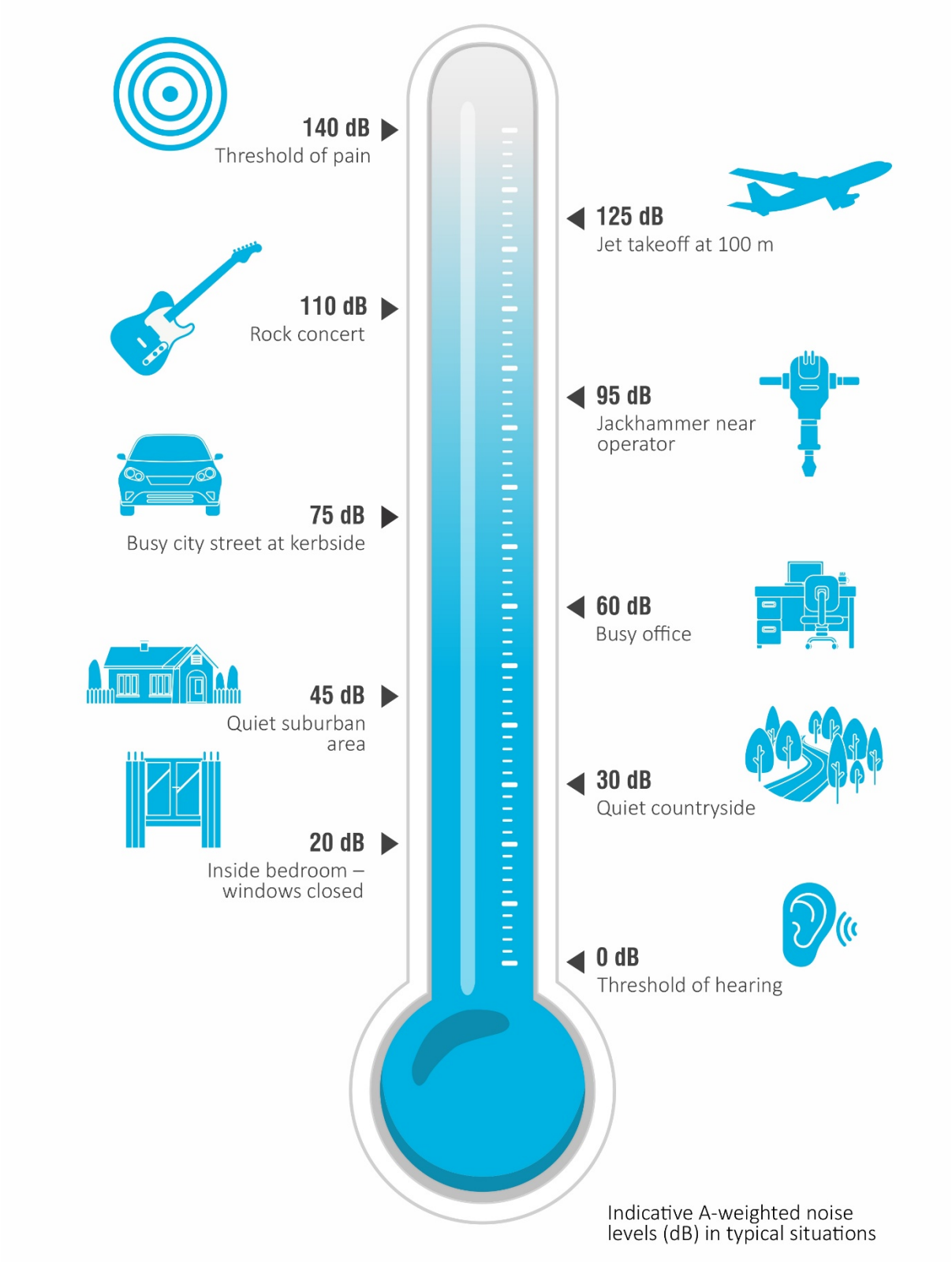

Figure 1.1 **Common noise levels**

2 Site background

2.1 Site description

The GrBH is an existing hospital campus located at 1 Noorebar Avenue, Griffith NSW. The existing hospital incorporates multiple individual buildings, the majority of which will be consolidated into the new Clinical Services Building.

2.2 Development proposal

The overall site development will include the new main building which is a four-storey structure with a roof top plant level and will generally include an emergency department, aged care and rehabilitation beds, operating theatres, medical imaging, a wellness centre (renal, oncology, Hospital in the Home, clinics, outpatient rehab) gym; and a clinical link to the adjoining private hospital. The development will also include additional carparking.

This report presents a review of noise and vibration generated by the construction and operation of the development. The scope of works associated with the SSDA entails:

- demolition of Buildings 1, 2, 6, 15, 16, 17, 19, 20, 22, 25, 28, 29, 31 and 35;
- demolition of the temporary car park;
- construction of a new clinical services building;
- construction of a new western car park; and
- construction of a new main car park.

2.3 Surrounding uses and sensitive receivers

The site is generally surrounded by residential land use, healthcare, places of worship and education. Assessment locations have been grouped into separate noise catchment areas (NCAs), with the worst affected assessment location in each NCA forming the basis of the assessment of potential impact. The land uses within each NCA are summarised in Table 2.1 and illustrated in Figure 3.1.

Table 2.1 Noise catchment areas

NCA	Land uses within NCA	Representative noise monitoring position
NCA1	Residential	NM1
NCA2	Residential	NM1
NCA3	Residential	NM2
NCA4	Education Commercial Healthcare Place of public worship Residential	NM2
NCA5	Residential Education	NM3
NCA6	Residential Place of public worship	NM3
NCA7	Education	Noise monitoring not required for purely educational uses
NCA8 (St Vincent's Private Community Hospital)	Healthcare	Noise monitoring not required for purely healthcare uses
NCA9 (Private practice on the GrBH campus)	Healthcare	Noise monitoring not required for purely healthcare uses

Source: EMM (2020); DFSI (2017); GA (2011); ASGC (2006)

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GDA 1994 MGA Zone 55

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KEY

- Griffith Base Hospital Campus
- Rail line
- Major road
- Local road
- Named watercourse
- Named waterbody

INSET KEY

- NPWS reserve
- State forest

Site locality map

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3 Existing environment

Noise monitoring was conducted to establish the existing prevailing noise environment at the Project development site. Three unattended noise loggers were used at points on the site's western, northern and eastern boundaries.

3.1 Measurement locations

The noise monitoring locations were selected after careful inspection of the Project development site, giving due consideration to other noise sources which may influence the readings (e.g. mechanical plant near the monitor), the proximity of neighbouring sensitive locations to the proposed site, and security issues for the noise monitoring devices.

The noise monitors were located on the GrBH precinct due to access restrictions to surrounding residential assessment locations.

Noise monitoring was carried out using three Rion NL-42 environmental noise loggers. The details of each noise monitoring location are provided in Table 3.1 and illustrated in Figure 2.1.

Table 3.1 Monitoring locations – 17 to 31 March 2020

Monitor ID	Equipment type and serial number	Monitor location		
		Address	Easting (MGA)	Northing (MGA)
NM1	Rion NL-42 SN 810712	GrBH[1] – north	411868	6206241
NM2	Rion NL-42 SN 521657	GrBH - west	411831	6206101
NM3	Rion NL-42 SN 410151	GrBH - southeast	412124	6206088

Loggers were programmed to record statistical noise level indices continuously in 15 minute intervals in accordance with the requirements of the NPfI, including the L_{Amax}, L_{A1}, L_{A10}, L_{A50}, L_{A90}, L_{A99}, L_{Amin} and the L_{Aeq}. Calibration of all instrumentation was checked prior to and following measurements. All equipment carried appropriate and current NATA (or manufacturer) calibration certificates.

3.2 Weather affected noise data

Weather data for the survey period was obtained from the BOM weather station at Griffith Airport (ID 075041). The wind speed and the rainfall data were used to exclude noise data during periods of any rainfall and/or wind speed in excess of 5 m/s (approximately 9 knots) at the microphone height in accordance with NPfI methods.

3.3 Measured noise levels

A summary of the existing background and ambient noise levels is provided in Table 3.2. Daily results and charts from the noise logger are provided in Appendix A.

The rating background noise levels (RBL) presented in Table 3.2 have been determined in accordance with the NPfI.

Table 3.2 Summary of unattended ambient noise monitoring

Noise monitoring location	Time period[1]	Existing noise levels	
		$L_{Aeq(period)}$, dB	Rating background level (RBL), dB
NM1	Day	58	41
	Evening	48	39
	Night	45	36
NM2	Day	56	42
	Evening	50	37
	Night	47	32
NM3	Day	52	40
	Evening	49	38
	Night	43	33

Note 1. The daytime is 7 am to 6 pm; evening 6 pm to 10 pm; night-time 10 pm to 7 am. On Sundays and Public Holidays, the daytime is 8 am to 6 pm; evening 6 pm to 10 pm; night-time 10 pm to 8 am.

KEY

- Assessment location
- Noise monitoring location
- Griffith Base Hospital Campus
- Noise catchment area
- Cadastral boundary

Source: EMM (2020); DFSI (2017)

0 50 100 m

GDA 1994 MGA Zone 55

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Assessment locations and noise monitoring positions

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Figure 3.1

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4 Assessment criteria

4.1 Construction noise

The Interim Construction Noise Guideline (ICNG) (DECC 2009) has been jointly developed by NSW Government agencies including the EPA and Department of Planning, Industry and Environment (DPIE). The objectives of the guideline relevant to the planning process are to promote a clear understanding of ways to identify and minimise noise from construction and to identify 'feasible' and 'reasonable' work practices.

The guideline recommends standard construction hours where noise from construction activities is audible at residential premises (ie assessment locations):

- Monday to Friday 7.00 am to 6.00 pm;
- Saturday 8.00 am to 1.00 pm; and
- no construction work is to take place on Sundays or public holidays.

Construction work is not currently proposed outside of the ICNG recommended construction hours. The ICNG acknowledges that works outside standard hours may be necessary, however, justification should be provided to the relevant authorities.

The ICNG provides two methodologies to assess construction noise emissions. The first is a quantitative approach, which is suited to major construction projects with typical durations of more than three weeks. This method requires noise emission predictions from construction activities at the nearest assessment locations and assessment against ICNG recommended noise levels.

The second is a qualitative approach, which is a simplified assessment process that relies more on noise management strategies. This method is suited to short-term infrastructure and maintenance projects of less than three weeks.

This assessment has adopted a quantitative approach. The assessment includes identification of assessment locations, description of likely works involved including predicted noise levels and proposed management measures that include a complaint's handling procedure which is to be further developed as part of a construction environmental noise and vibration management plan.

4.1.1 Noise management levels

Table 2 of the ICNG provides guidance on establishing noise management levels (NML) for residential assessment locations during standard hours and has been reproduced in Table 4.1.

Table 4.1 ICNG residential NMLs

Time of day	NML $L_{Aeq,15min}$	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 $L_{Aeq,15min}$ 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 residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
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	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 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.

Source: ICNG (DECC 2009).

Table 4.2 summarises noise management levels for non-residential land uses as defined in the ICNG.

Table 4.2 ICNG noise management levels at non-residential land uses

Land use	Management level, $L_{Aeq,15\ minute}$
Classrooms at schools and other educational institutions	Internal noise level 45 dB (when in use)
Hospital wards and operating theatres	Internal noise level 45 dB (when in use)
Places of worship	Internal noise level 45 dB (when in use)

Source: ICNG (DECC, 2009).

4.1.2 Project construction NMLs

The construction NMLs for residential assessment locations were developed based on the RBLs provided in Table 3.2. The NMLs for standard construction hours adopted for this assessment were derived in accordance with the ICNG for all residential assessment locations and are presented in Table 4.3. The highly noise affected management level (HNL) has also been provided.

Table 4.3 Construction NMLs for residential assessment locations during standard hours

Assessment location	Period	RBL, dB(A)[1]	NML, $L_{Aeq,15min}$, dB	HNL[2]
NCA01 NCA02	Day (standard ICNG hours)	41	51	75
NCA03 NCA04		42	52	75
NCA05 NCA06		40	50	75

Notes: 1. Based on the day period RBL established in Table 3.2.
2. HNL – highly noise affected level

The construction NMLs for non-residential assessment locations are based on the recommended internal noise levels provided in Table 4.4 in accordance with the ICNG.

Table 4.4 Noise management levels at non-residential land uses

Land use	Management level, $L_{Aeq,15\ minute}$
Classrooms at schools and other educational institutions	Internal noise level 45 dB (when in use) External noise level 65dB (when in use)[1]
Hospital wards and operating theatres	Internal noise level 45 dB (when in use) External noise level 65 (when in use)[1]
Places of worship	Internal noise level 45 dB (when in use) External noise level 55 (when in use)[2]

Notes: 1. A 20dB reduction has been applied to these uses for a closed façade which is typical for classrooms and hospital wards.
2. A 10dB reduction has been applied for places of worship representing windows open for ventilation purposes.

4.2 Construction vibration

Vibration criteria for the project has been adopted from the following guidelines and standards:

- human comfort limits provided in the NSW *Assessing Vibration: a technical guideline* (DEC, 2006);
- Australian Standard AS 2187.2 - 2006 “Explosives - Storage and Use - Use of Explosives”; and
- BS 7385 Part 2-1993 “Evaluation and measurement for vibration in buildings Part 2” as they are “applicable to Australian conditions”.

4.2.1 Human comfort – Assessing vibration: a technical guideline (DEC)

The human comfort assessment criteria provided in the *Assessing Vibration: a technical guideline* (DEC, 2006) is based on the limits contained in BS 6472 – 2008 'Evaluation of human exposure to vibration in buildings (1-80Hz)'.

The guideline presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. At vibration values below the preferred values, there is a low probability of adverse comment or disturbance to building occupants. Where all feasible and reasonable mitigation measures have been applied and vibration values are still beyond the maximum value, it is recommended the operator negotiate directly with the affected community.

The guideline defines three vibration types and provides direction for assessing and evaluating the applicable criteria. Table 2.1 of the guideline provides examples of the three vibration types and has been reproduced in Table 4.5.

Table 4.5 Examples of types of vibration (from Table 2.1 of the guideline)

Continuous Vibration	Impulsive Vibration	Intermittent Vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading. Blasting is assessed using ANZECC (1990).	Trains, intermittent nearby construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer these would be assessed against impulsive vibration criteria.

Intermittent vibration is representative of activities such as impact hammering, vibratory rolling or general excavation work (such as an excavator tracking) and, as such, is most relevant to this assessment.

Intermittent vibration (as defined in Section 2.1 of the guideline) is assessed using the vibration dose concept which relates to vibration magnitude and exposure time.

Section 2.4 of the Guideline provides acceptable values for intermittent vibration in terms of vibration dose values (VDV) which requires the measurement of the overall weighted RMS (root mean square) acceleration levels over the frequency range 1 Hz to 80 Hz. To calculate VDV the following formula (refer *section 2.4.1* of the guideline) was used:

$$VDV = \left[\int_0^T a^4(t)dt\right]^{0.25}$$

Where VDV is the vibration dose value in $m/s^{1.75}$, *a (t)* is the frequency-weighted rms of acceleration in m/s^2 and *T* is the total period of the day (in seconds) during which vibration may occur.

The Acceptable Vibration Dose Values (VDV) for intermittent vibration are reproduced in Table 4.6.

Table 4.6 Acceptable vibration dose values (VDV) for intermittent vibration (m/s $^{1.75}$)

Location	Daytime		Night-time	
	Preferred value, m/s$^{1.75}$	Maximum value, m/s$^{1.75}$	Preferred value, m/s$^{1.75}$	Maximum value, m/s$^{1.75}$
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

Notes: 1. Daytime is 7 am to 10 pm and night-time is 10 pm to 7 am.

2. These criteria are indicative only, and there may be a need to assess intermittent values against continuous or impulsive criteria for critical areas.

There is a low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values. Adverse comment or complaints may be expected if vibration values approach the maximum values. The Guideline states that activities should be designed to meet the preferred values where an area is not already exposed to vibration.

4.2.2 Cosmetic damage vibration criteria

Most commonly specified "safe" structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks and are set well below the levels that have potential to cause damage to the main structure.

In terms of the most recent relevant vibration damage criteria, Australian Standard AS 2187.2 - 2006 'Explosives - storage and use - Use of explosives' recommends the frequency dependent guideline values and assessment methods given in *BS 7385 Part 2-1993 'Evaluation and measurement for vibration in buildings'* be used as they are "applicable to Australian conditions".

The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (eg compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 4.7 and graphically in Figure 4.1.

Table 4.7 Transient vibration guide values – minimal risk of cosmetic damage

Line	Type of building	Peak component particle velocity in frequency range of predominant pulse, mm/s	
		4 Hz - 15 Hz	15 Hz and Above
1	Reinforced or framed structures industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	N/A
2	Un-reinforced 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

AS2187 states that the guide values in Table 4.7 relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration gives rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 5.4 may need to be reduced by up to 50%.

Sheet piling activities (for example) are considered to have the potential to cause dynamic loading in some structures (eg residences) and it may, therefore, be appropriate to reduce the transient values by 50% for this activity.

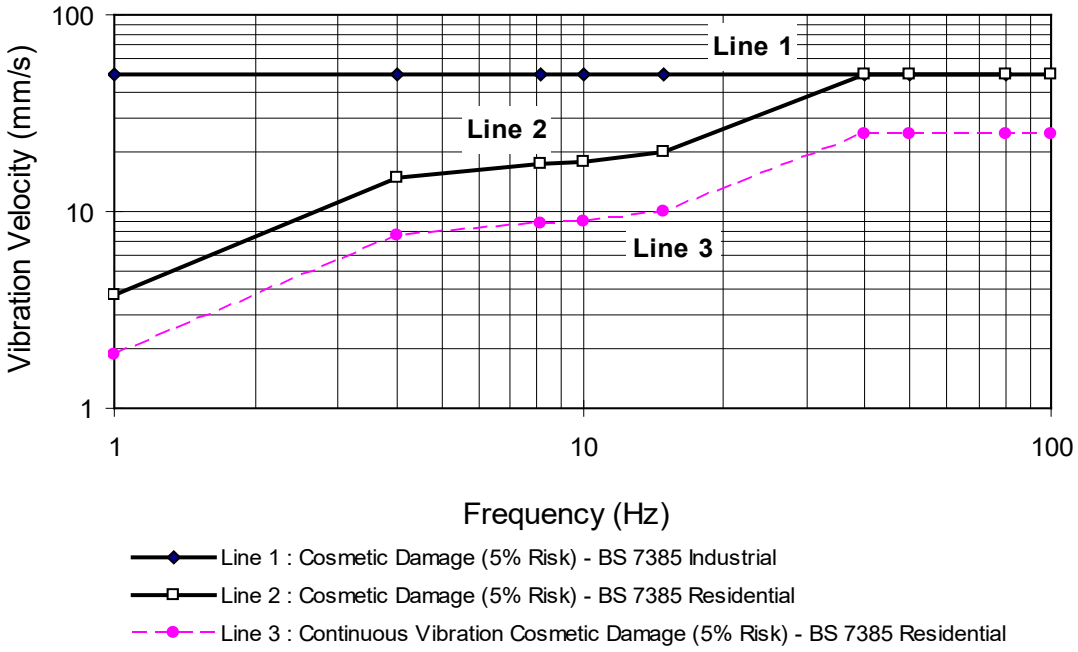


Figure 4.1 Graph of transient vibration guide values for cosmetic damage

In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high

displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 4.7, 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 guide values in Table 4.7 should not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, AS2187 specifies that vibration measurements should be undertaken at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) should be compared with the criteria curves presented in Table 4.7.

It is noteworthy that, additional to the guide values nominated in Table 4.7, the standard states that:

> Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK.

Also that:

> A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive.

4.3 Operational noise

Noise from industrial and commercial sites or processes (eg onsite vehicle movements, mechanical plant etc.) in NSW is regulated by the local council, Department of Planning, Industry and Environment (DPIE) and/or the EPA, and generally have a licence and/or development consent conditions stipulating noise limits. These limits are generally derived from project specific trigger or operational noise levels predicted at assessment locations. They are based on EPA guidelines (ie NPfI) or noise levels that can be achieved by a specific site following the application of all feasible and reasonable noise mitigation.

The objectives of noise trigger levels for industry are to protect the community from excessive intrusive noise and preserve amenity for specific land uses. It should be noted that the audibility of a noise source does not necessarily equate to disturbance at an assessment location.

To ensure these objectives are met, the EPA provides two separate criteria: intrusiveness criteria and amenity criteria. The fundamental difference being intrusiveness criteria apply over 15 minutes in any period (day, evening or night), whereas the amenity criteria apply to the entire assessment period (day, evening or night).

It is noted that whilst the hospital is not an industrial use, the NPfI is included in Item 11 of the SEARs and as such has been adopted for the assessment of noise generated by the Project.

4.3.1 Intrusiveness criteria

The intrusiveness criteria require that $L_{Aeq\ (15\ min)}$ noise levels from the proposed development do not exceed the RBL by more than 5 dB. Measured RBLs have been used to derive intrusiveness criteria at each noise monitoring location. It is noted that intrusiveness noise levels are only applicable at residential assessment locations.

Table 4.8 presents the intrusive noise criteria applicable at residences determined for the GrBH based on the measured RBLs provided in Table 3.2.

Table 4.8 Intrusive noise criteria

Assessment location	Representative NML[1]	Measured background noise level, RBL, dB[2]			Intrusive noise criteria $L_{Aeq,15min}$, dB[3,4]		
		Day	Evening	Night	Day	Evening	Night
NCA1 & NCA 2	NML1	41	39	36	46	44	41
NCA3 & NCA 4	NML2	42	37	32	47	42	37
NCA5 & NCA 6	NML3	40	38	33	45	43	38

Notes. 1. Noise measurement location (NML) shown in Figure 2.1.

2.The daytime is 7.00 am to 6.00 pm; evening 6.00 pm to 10.00 pm; night-time 10.00 pm to 7.00 am. On Sundays and Public Holidays, the daytime is 8.00 am to 6.00 pm; evening 6.00 pm to 10.00 pm; night-time 10.00 pm to 8.00 am.

3. The RBL is a NPfI term and is used represent the background noise level.

4. L_{Aeq} is the energy averaged noise level over the measurement period and representative of general ambient noise.

4.3.2 Amenity criteria

The assessment of amenity is based on noise criteria specific to the land use. The amenity criteria are used to assess the cumulative impacts of industrial noise. Where the measured existing industrial noise approaches recommended amenity criteria, it needs to be demonstrated that noise levels from new industry will not contribute to existing industrial noise such that criteria are exceeded.

The corresponding recommended amenity criteria for the proposed development are given in Table 4.9.

Table 4.9 Amenity criteria

Receiver type	Indicative area	Period[1]	Recommended noise level dB, $L_{Aeq\ (period)}$
Residential	Suburban	Day	55
		Evening	45
		Night	40
School classroom – internal	All	Noisiest 1-hour period when in use	35 (see notes for table)
Hospital ward			
internal	All	Noisiest 1-hour	35
external	All	Noisiest 1-hour	40
Place of worship – internal	All	When in use	40
Commercial premises	All	When in use	65

Notes. 1. The daytime is 7.00 am to 6.00 pm; evening 6.00 pm to 10.00 pm; night-time 10.00 pm to 7.00 am. On Sundays and Public Holidays, the daytime is 8.00 am to 6.00 pm; evening 6.00 pm to 10.00 pm; night-time 10.00 pm to 8.00 am.

The recommended amenity noise levels represent the objective for total industrial noise at a receiver location, whereas the project amenity noise level represents the objective for noise from a single industrial development at a receiver location. 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 equals the recommended amenity noise level (Table 4.9) minus 5 dB(A).

The following exceptions to the above method to derive the project amenity noise level apply:

- in areas with high traffic noise levels;
- in proposed developments in major industrial clusters;
- where the resultant project amenity noise level is 10 dB or more lower than the existing industrial noise level. In this case the project amenity noise levels can be set at 10 dB below existing industrial noise levels if it can be demonstrated that existing industrial noise levels are unlikely to reduce over time; and
- where cumulative industrial noise is not a necessary consideration because no other industries are present in the area, or likely to be introduced into the area in the future. In such cases the relevant amenity noise level is assigned as the project amenity noise level for the development.

There are currently no significant industrial noise sources in the vicinity of the site. As such, no additional correction to the amenity noise level is applied.

4.3.3 Project noise trigger level

The project-specific noise level (PNTL) is the lower of the calculated intrusive or amenity criteria. The PNTL specific to land use would be developed as the scheme progresses as relevant to the end land use that the locations of nearest noise sensitive receivers.

A summary of the PNTL for assessment of operational noise from the GrBH is presented in Table 4.10, showing in all cases that the intrusive noise criteria are the limiting and hence final PNTLs.

Table 4.10 Project noise trigger levels – residential receivers

Assessment location	Assessment period[1]	Intrusiveness noise level, $L_{Aeq,15min}$, dB	Amenity noise level[2], $L_{Aeq,15min}$, dB	PNTL[3], $L_{Aeq,15min}$, dB
NCA1 NCA2	Day	46	58	46
	Evening	44	48	44
	Night	41	43	41
NCA3 NCA4	Day	47	58	47
	Evening	42	48	42
	Night	37	43	37
NCA5 NCA6	Day	45	58	45
	Evening	43	48	43
	Night	38	43	38

Notes: 1. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; Evening: 6 pm to 10 pm; Morning shoulder: 6 am to 7 am Monday to Saturday, 6 am to 8 am Sundays and public holidays; Night: remaining periods.

2. Project amenity $L_{Aeq,15min}$ noise level is the recommended amenity noise level $L_{Aeq,period}$ +3 dB as per the NPfI. In the absence of existing or future industrial noise sources, the amenity level has not been adjusted 5dB.

3. PNTL is the lower of the calculated intrusiveness or amenity noise levels.

The amenity noise levels for uses other than residential are provided Table 4.11.

Table 4.11 Project noise trigger levels – uses other than residential

Receiver type	Amenity noise level[1], $L_{Aeq,15min}$ dB
School classroom – internal	38 (internal) – noisiest 1-hour period
	48[2] (external) – noisiest 1-hour period
Hospital ward	
internal	38 – noisiest 1-hour period
external	43 – noisiest 1-hour period
Place of worship – internal	43 (internal) – when in use
	53[2] (external) – when in use
Commercial premises	68 – when in use

Notes: 1. Project amenity $L_{Aeq,15min}$ noise level is the recommended amenity noise level $L_{Aeq,period}$ +3 dB as per the NPfI. In the absence of existing or future industrial noise sources, the amenity level has not been adjusted 5dB.

2. A 10dB reduction across an open window to establish the external noise limit

4.3.4 Sleep disturbance criteria

The development will operate during the night-time period (10 pm to 7 am) and therefore, in accordance with the NPfI, the potential for sleep disturbance has been assessed.

The NPfI suggests that a detailed maximum noise level event assessment should be undertaken where the development/premises night-time noise levels at a residential location exceed:

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

Some guidance regarding potential for sleep disturbance is also provided in the DECCW's Road Noise Policy (RNP) (2011). The RNP calls upon a number of studies that have been conducted into the effect of maximum noise levels on sleep. The RNP acknowledges that, at the current level of understanding, it is not possible to establish absolute noise level criteria that would correlate to an acceptable level of sleep disturbance. However, the RNP provides the following conclusions from the research on sleep disturbance:

- maximum internal noise levels (L_{Amax}) below 50 to 55 dB are unlikely to awaken people from sleep; and
- one or two noise events per night, with maximum internal noise levels (L_{Amax}) of 65 to 70 dB, are not likely to affect health and wellbeing significantly.

It is commonly accepted by acoustic practitioners and regulatory bodies that a facade including a partially open window will reduce external-to-internal noise levels by 10 dB. Therefore, external noise levels in the order of 60 to 65 dB calculated at the facade of a residence is unlikely to cause awakening affects.

The sleep disturbance criteria for all residential assessment locations are provided in Table 4.12.

Table 4.12 Maximum noise level event screening criteria

Assessment location	Assessment period[1]	Adopted RBL, dB(A)	Maximum noise level event screening criteria, dB	
			RBL +5 dB or standard[1]	RBL +15 dB or standard[1]
			$L_{Aeq,15min}$	L_{Amax}
NCA1 &NCA2	Night	36	41	52
NCA3 & NCA4	Night	32	40	52
NCA5 & NCA6	Night	33	40	52

Notes: 1. Whichever is greater.

4.4 Road traffic noise

Land use developments with the potential to generate additional road traffic noise requires assessment for potential noise impact. The principle guidance to assess the impact of the road traffic noise on assessment locations is in the NSW RNP. Whilst not specifically referenced in the SEARs, the assessment of road traffic noise generation is undertaken as best practice.

The road traffic noise assessment criteria for residential land uses (ie assessment locations) is presented in Table 4.13, reproduced from Table 3 of the RNP for local roads.

Table 4.13 Road traffic noise assessment criteria for residential land uses

Road Category	Type of project/development	Assessment criteria – dBA	
		Day (7:00 am to 10:00 pm)	Night (10:00 pm to 7:00 am)
Local Roads	Existing residences affected by additional traffic on existing local roads generated by land use developments.	$L_{eq,1hr}$ 55 (external)	$L_{eq,1hr}$ 50 (external)

Additionally, the RNP states that where existing road traffic noise criteria are already exceeded, any additional increase in total traffic noise level should be limited to +2 dB.

5 Construction noise and vibration impact assessment

A preliminary assessment of noise and vibration impacts from the proposed construction of the Project has been undertaken. At this stage, a detailed construction methodology has not been developed. As such, noise predictions are based on the likely worst-case plant and activities that may be deployed on site for each stage of construction.

5.1 Construction stages

5.1.1 Demolition, excavation and site preparation phase

The site is occupied by existing GrBH structures which are to be demolished to make way for the new Clinical Services Building. For the most part, these structures are relatively insubstantial and will be demolished using excavators and hydraulic hammers to break-up rubble.

The development will include a sub-level lower ground floor which will require excavation activities. It is anticipated that excavation will likely be undertaken using a suite of excavator mounted appliances including:

- rock saw;
- milling attachment;
- rock hammer; and
- bucket.

The worst-case appliance for noise and vibration will be the rock hammer due to its noise level and intermittent noise characteristics. Excavated fill is expected to be removed from the site using dump trucks and truck and dog type arrangements.

Site preparation works will typically entail the detailed excavation and relocation of fill around the site using excavators and dozers.

5.1.2 General construction phase

The general construction phase of the project will typically include:

- the erection of structure including formwork and concrete works;
- building façade including cladding and glazing installation;
- internal partitioning;
- mechanical, hydraulic and electrical services;
- clinical finishes; and
- external landscaping.

For the most part, general construction works will be significantly quieter than the demolition and excavation works.

5.2 Construction noise modelling

Equipment sound power levels have been taken from the Department of Environment, Food and Rural Affairs (DEFRA) 2005, *Update of Noise Database for Prediction of Noise on Construction and Open Sites*, where relevant to the project. Otherwise data was sourced from an EMM database of similar equipment which is based on measurements at other construction sites as indicated.

Acoustically significant mobile equipment items were considered in the model for each construction area and adopted typical worst-case scenarios and utilisation. A detailed analysis of equipment should be undertaken as part of the main works contractor's construction noise and vibration management plan once detailed information of plant equipment is established. Typical worst-case plant utilised for the assessment are presented in Table 5.1.

Table 5.1 Construction phase and equipment sound power levels

Construction phase	Construction appliance	Sound power level, dB $L_{Aeq\ 15min}$
Demolition	Breaker on excavator (brick foundations)[1]	118
	Excavator dumping rubble[1]	113
	Dump trucks	103
Excavation	Rock hammer[1]	120
	Rock saw[1]	117
	Excavator (clearing site)[1]	106
Site preparation	Excavator (earthworks) [1]	106
	Dozer[1]	108
Construction phase	Concrete pump[1]	106
	Power float	100
	Concrete saw (cutting slabs) [1]	112

Notes: 1. Noise level adopted from DEFRA noise database.

5.3 Predicted noise levels

The proponent will manage construction noise levels where exceedances of NMLs have been identified. The construction noise management methods will be detailed in a construction noise and vibration management plan (CNVMP) as discussed further in Section 5.4.

The ICNG recommends the following where NMLs are predicted to be exceeded:

- application of feasible and reasonable work practices to minimise noise; and
- inform potentially impacted residents of the nature of the works to be carried out, expected noise levels and duration and relevant contact details.

Noise predictions have been presented for the most affected assessment location in each NCA. Where there are several types of land use within the NCA, predictions are presented for the most affected assessment location for that land use.

Predicted noise levels are presented for each individual item of plant. Concurrent operation will result in cumulative noise effect at each assessment location. The cumulative noise level from construction works is to be addressed in detail as part of the construction noise and vibration management plan.

5.3.1 Predicted noise levels during demolition works

The demolition phase will include the removal of existing structures on the site. For the most part, this includes low set brick structures. Predicted noise levels are based on demolition works at each existing building structure, with the worst-case noise level for each location presented.

Noise predictions from the demolition phase are provided in Table 5.2.

Table 5.2 Predicted construction noise levels during demolition

NCA	Land use	Assessment location	Predicted construction noise level, dB $L_{Aeq\ 15min}$			'Noise affected' NML, dB $L_{Aeq\ 15min}$[1]	'Highly noise affected' level, dB $L_{Aeq\ 15min}$[2]
			Breaker on excavator	Excavator dumping rubble	Dump truck		
1	Residential	R7	64	59	49	51	75
2	Residential	R11	66	61	51	51	75
3	Residential	R15	61	56	46	52	75
4	Residential	R22	57	52	42	52	75
	Healthcare	R20	56	51	41	65	n/a
	Place of worship	R21	58	53	43	55	n/a
	Education	R19	58	53	43	65	n/a
5	Residential	R24	55	50	40	50	75
	Education	R29	56	51	41	65	n/a
6	Residential	R30	59	54	44	50	75
7	Education	R42	70	65	55	65	n/a
8	Healthcare	R43	75	70	60	65	n/a
9	Healthcare	R44	68	63	53	65	n/a

Notes: 1. Noise affected level based on RBL + 5dB in accordance with the ICNG.

2. Highly noise affected level based on 75dBA in accordance with the ICNG.

Noise predictions indicate that construction noise levels for works during the excavation phase will exceed 'noise affected' NMLs at all worst affected residential assessment locations for one or more activities. The 'highly noise affected' level is not predicted to be exceeded during the demolition phase.

Exceedances of the background + 10dB NML is not uncommon for this type of development where significant demolition may occur, particularly given the proximity of surrounding assessment locations and proposed works to be undertaken.

Noise predications indicate exceedances of the NML for non-residential assessment locations in NCA4, NCA7, NCA8 and NCA9.

Possible mitigation measures are discussed in Section 5.4. Noise mitigation measures and strategies should be formulated as part of the detailed construction noise and vibration management plan.

5.3.2 Predicted noise levels during excavation works

The removal of rock during the excavation of the lower ground floor will likely require rock hammering and sawing. These activities have been addressed for the excavation phase. Predicted noise levels are based on excavation works within the bounds of the lower ground footprint.

Noise predictions from the excavation phase are provided in Table 5.3.

Table 5.3 Predicted construction noise levels during excavation

NCA	Land use	Assessment location	Predicted construction noise level, dB $L_{Aeq\ 15min}$			'Noise affected' NML, dB $L_{Aeq\ 15min}$[1]	'Highly noise affected' level, dB $L_{Aeq\ 15min}$[2]
			Rock breaker	Rock saw	Excavator (ground excavation)		
1	Residential	R7	64	61	50	51	75
2	Residential	R9	66	63	52	51	75
3	Residential	R15	62	59	48	52	75
4	Residential	R22	58	55	44	52	75
	Healthcare	R20	57	54	43	65	n/a
	Worship	R21	58	55	44	55	n/a
	Education	R19	59	56	45	65	n/a
5	Residential	R24	55	52	41	50	75
	Education	R29	54	51	40	65	n/a
6	Residential	R30	53	50	39	50	75
7	Education	R42	58	55	44	65	n/a
8	Healthcare	R43	67	64	53	65	n/a
9	Healthcare	R44	69	66	55	65	n/a

Notes: 1. Noise affected level based on RBL + 5dB in accordance with the ICNG.
2. Highly noise affected level based on 75dBA in accordance with the ICNG.

Noise predictions indicate that construction noise levels for works during the excavation phase will exceed 'noise affected' NMLs at all worst affected residential assessment locations for one or more activities. The 'highly noise affected' level is not expected to be exceeded during the excavation phase.

Noise predications indicate exceedances of the NML for non-residential assessment locations in NCA4, NCA7, NCA8 and NCA9.

Possible mitigation measures are discussed in Section 5.4. Noise mitigation measures and strategies should be formulated as part of the detailed construction noise and vibration management plan.

5.3.3 Prediction noise levels during site preparation works

Site preparation will typically include detailed excavation of top-soil and clay and is not anticipated to include significant amounts of heavy excavation such as rock hammering or sawing. These detailed works will likely occur across the site, including in the carpark area.

Noise predictions from the site preparation works are provided in Table 5.4.

Table 5.4 Predicted construction noise levels during site preparation works

NCA	Land use	Assessment location	Predicted construction noise level, dB $L_{Aeq\ 15min}$		'Noise affected' NML, dB $L_{Aeq\ 15min}$[1]	'Highly noise affected' level, dB $L_{Aeq\ 15min}$[2]
			Excavator	Dozer		
1	Residential	R6	52	54	51	75
2	Residential	R9	52	54	51	75
3	Residential	R15	48	50	52	75
4	Residential	R22	46	48	52	75
	Healthcare	R20	43	45	65	n/a
	Worship	R21	46	48	55	n/a
	Education	R19	46	48	65	n/a
5	Residential	R24	45	47	50	75
	Education	R29	45	47	65	n/a
6	Residential	R30	46	48	50	75
7	Education	R42	60	62	65	n/a
8	Healthcare	R43	73	75	65	n/a
9	Healthcare	R44	55	57	65	n/a

Notes: 1. Noise affected level based on RBL + 5dB in accordance with the ICNG.

2. Highly noise affected level based on 75dBA in accordance with the ICNG.

Noise predictions indicate that construction noise levels during the site preparation works will generally comply with the 'noise affected' NMLs at the vast majority of representative residential assessment locations, with some marginal exceedances within NCA1 and NCA2. The 'highly noise affected' level is not expected to be exceeded during the site preparation phase.

Construction noise levels at non-residential assessment locations will generally comply with the project NMLs, excepting those in NCA8 which is immediately adjacent the GrBH.

Possible mitigation measures are discussed in Section 5.4. Noise mitigation measures and strategies should be formulated as part of the detailed construction noise and vibration management plan.

5.3.4 Predicted noise levels during general construction works

The loudest typical works during general construction will be the cutting of concrete slabs and activities during concrete pours. The location of concrete pumps has been assumed to be in close proximity to the main building envelope and may occur on the site or off Warrambool Street adjoining NCA7. Predictions are provided for the closest likely representative construction location to the respective NCA.

Noise predictions from the general construction phase are provided in Table 5.5.

Table 5.5 Predicted construction noise levels during construction

NCA	Land use	Assessment location	Predicted construction noise level, dB $L_{Aeq\ 15min}$			'Noise affected' NML, dB $L_{Aeq\ 15min}$[1]	'Highly noise affected' level, dB $L_{Aeq\ 15min}$[2]
			Concrete pump	Concrete saw	Concrete saw		
1	Residential	R6	52	46	58	51	75
2	Residential	R9	52	46	58	51	75
3	Residential	R15	48	42	54	52	75
4	Residential	R22	44	38	50	52	75
	Healthcare	R20	43	37	49	65	n/a
	Worship	R21	44	38	50	55	n/a
	Education	R19	45	39	51	65	n/a
5	Residential	R24	41	35	47	50	75
	Education	R29	40	34	46	65	n/a
6	Residential	R30	40	34	46	50	75
7	Education	R42	60	54	66	65	n/a
8	Healthcare	R43	73	67	79	65	n/a
9	Healthcare	R44	55	49	61	65	n/a

Notes: 1. Noise affected level based on RBL + 5dB in accordance with the ICNG.
2. Highly noise affected level based on 75dBA in accordance with the ICNG.

Noise predictions indicate that construction noise levels during general construction works will generally comply with the 'noise affected' NMLs at the vast majority of residential assessment locations, with some exceedances within NCA1, NCA2 and NCA3. The 'highly noise affected' level is not expected to be exceeded during the general construction phase.

Construction noise levels at non-residential assessment locations will generally comply with the project NMLs, excepting those healthcare buildings immediately adjacent the GrBH and the school to the east during concrete sawing if close to the eastern boundary of the non-clinical support services building.

Possible mitigation measures are discussed in Section 5.4. Noise mitigation measures and strategies should be formulated as part of the detailed construction noise and vibration management plan.

5.4 Construction noise mitigation

Mitigation measures which may be employed to further minimise noise impacts from the construction of the project are discussed in this section. These can include physical measures, such as acoustic screens or shrouds, or noise management measures such as scheduling, community consultation and the like.

5.4.1 Community consultation

Community consultation and complaints handling procedures should be developed such that noise affected receivers may be kept apprised of:

- construction timeline;
- expected noisy works particularly concrete pours which may extend into the evening; and
- readily available avenues to address noise complaint.

5.4.2 Acoustically rated site hoarding

Acoustically rated site hoarding may be employed between the site and surrounding receiver locations. The use of imperforate materials such as plywood (a typically standard hoarding material) can provide realistic noise reductions in the order of 10-15dB assuming that the barrier inhibits line of sight to receptor locations.

5.4.3 Temporary noise barriers

Temporary noise barriers may be incorporated around particularly noisy static equipment to minimise noise being transmitted to surrounding noise sensitive locations.

5.4.4 Scheduling of works

Noisy works may be scheduled to times which are more mutually agreeable to surrounding noise receptors. This can also include scheduling works such that multiple pieces of noisy plant equipment are not being utilised in close proximity to a particular noise receptor.

5.4.5 Plant and equipment

Additional measures for plant and equipment include:

- where possible, choose quieter plant and equipment based on the optimal power and size to most efficiently perform the required tasks;
- operate plant and equipment in the quietest and most efficient manner; and
- regularly inspect and maintain plant and equipment to minimise noise and vibration level increases, to ensure that all noise and vibration reduction devices are operating effectively.

5.4.6 Work practices

Work practice methods include:

- regular reinforcement (such as at toolbox talks) of the need to minimise noise and vibration;

- regular identification of noisy activities and adoption of improvement techniques;
- avoiding the use of portable radios, public address systems or other methods of site communication that may unnecessarily impact upon nearby residents;
- locating vehicles to minimise noise;
- where possible, avoid the use of equipment that generates impulsive noise (i.e. hammering);
- minimise the movement of materials and plant and unnecessary metal-on-metal contact; and
- minimise truck movements.

5.5 Construction vibration

5.5.1 Mobile plant and equipment

Safe working distances for typical items of vibration intensive plant are listed in Table 5.6. The safe working distances are quoted for both "Cosmetic Damage" (refer British Standard BS 7385) and "Human Comfort" (refer British Standard BS 6472-1).

Table 5.6 Recommended safe working distances for vibration intensive plant

Plant Item	Rating/Description	Safe working distance	
		Cosmetic damage (BS 7385)	**Human response (BS 6472)**
Small hydraulic hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium hydraulic hammer	(900 kg - 12 to 18t excavator)	7 m	23 m
Large hydraulic hammer	(1600 kg - 18 to 34t excavator)	22 m	73 m
Vibratory pile driver	Sheet piles	2 m to 20 m	20 m
Pile boring	≤ 800 mm	2 m (nominal)	N/A
Jackhammer	Hand-held	1 m (nominal)	Avoid contact with structure
Vibratory Rollers	<50kN (Typically 1-2 tonnes)	5 m	15 to 20 m
	<100kN (Typically 2-4 tonnes)	6 m	20 m
	<200kN (Typically 4-6 tonnes)	12 m	40 m
	<300kN (Typically 7-13 tonnes)	15 m	100 m
	>300kN (Typically 13-18 tonnes)	20 m	100 m
	>300kN (>18 tonnes)	25 m	100 m

Source: From Transport Infrastructure Development Corporation Construction's Construction Noise Strategy (Rail Projects), November 2007 – based on residential building.

Safe work distances relate to continuous vibration. For most construction activity, vibration emissions are intermittent in nature. The safe working distances are therefore conservative.

The safe working distances presented in Table 5.6 are indicative and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions.

The safe working distances have been used to assess the potential for construction vibration impacts based on proposed construction activities. With regard to cosmetic damage, we note:

- vibratory rollers will typically be utilised for the new carpark and as such are unlikely to exceed vibration limits for receivers external to the site;
- all other equipment will generally satisfy the minimum offset distances excepting the large hydraulic hammer and vibratory pile driver. These pieces of plant should be selected with consideration to proximity to receiver structures.

Human response vibration limits should be considered with the preparation of the detailed construction noise and vibration management plan. Consideration should be given to existing patient wards and consultation rooms particularly where vibration sensitive equipment such as microscopes and the like are utilised.

6 Assessment of operational noise impacts

6.1 Assessment methodology

Noise generated by the development will be generally associated with the following noise sources:

- vehicle movements within the new carparks;
- road traffic noise generation; and
- mechanical plant operation.

6.2 Vehicle movements in the carpark

Vehicles using internal driveways have been assessed using the expected traffic movements provided in the PTC 2021 *Griffith Base Hospital Redevelopment –Traffic & Parking Report* prepared for Health Infrastructure.

Vehicle movements in and out of the development post-main works are provided in Figure 24 of the PTC (2021) report. The peak traffic volumes are summarised in Table 6.1.

Table 6.1 Peak on-site vehicle movements (PTC 2021)

Carpark	Vehicle movements per hour			
	Time of day	Vehicles in	Vehicles out	Total movements
Main carpark	AM	174	87	261
	PM	117	124	241
West	AM	19	9	28
	PM	14	14	28
Clinical	AM	13	15	28
	PM	22	13	35
Nurse Education	AM	8	2	10
	PM	7	8	15

Noise associated with vehicles using the parking lot has been assessed using the sound power levels in Table 6.2.

Table 6.2 Site traffic noise sources and expected volumes

Traffic source	Source SWL, L_{Aeq} dB(A)	Source SWL, L_{max} dB(A)
Cars	83 at 10km/h[1]	94 (car starting)

Notes: 1. Derived from the Federal Highway Administration (FHWA) traffic noise model.

The predicted noise levels from on-site vehicle movements are provided in Table 6.3. Peak hour carpark movements are expected to occur during daytime hours and as such predicted noise levels have been compared against the daytime PNTL.

Table 6.3 Predicted noise levels from on-site vehicle movements

Noise catchment area	Predicted noise level, dB $L_{Aeq\ 15min}$	Daytime PNTL, dB $L_{Aeq\ 15min}$	Exceedance of PNTL
NCA1	31	46	nil
NCA2	34	46	nil
NCA3	34	47	nil
NCA4	37	47	nil
NCA5	42	45	nil
NCA6	34	45	nil

Noise from peak hour carpark movements are expected to comply with the daytime PNTL which is when peak movements are likely to occur. There is sufficient buffer (ie at least 10dB) between the predicted noise level and daytime PNTL to allow for cumulative impacts from other noise sources such as mechanical plant operation.

Carpark movements during the evening and night time period are expected to be sporadic in the absence of visiting hours and specialist consultations.

6.3 Sleep disturbance assessment

Maximum noise levels from the development during the night period with the potential to cause sleep disturbance at nearby residences have been assessed in accordance with the criteria provided in Table 4.12 based on the guidance of the NPfI.

Sleep disturbance due to instantaneous noise events (eg cars starting and doors closing) have been assessed. The predicted noise levels from these events are provided in Table 6.4.

Table 6.4 Predicted maximum noise levels at residential assessment locations

Stage	Noise catchment area	Predicted noise level, dB L_{Amax}	Screen criteria, dB L_{Amax}	Exceedance of screening criteria
	NCA1	37	52	nil
	NCA2	41	52	-
	NCA3	40	52	-
	NCA4	36	52	-
	NCA5	34	52	-
	NCA6	40	52	-

Noise from loud events such as cars starting during the night-time period are expected to comply with the sleep awakening screening criteria. As such, sleep awakenings from the use of the Project during the night time period are unlikely to occur.

6.4 Road traffic noise generation

The potential for road traffic noise generation has been assessed based on the traffic projections provided in the PTC (2021) report adopting the existing and future traffic volumes.

Road noise modelling has been conducted to establish the existing road traffic noise level along Noorebar Avenue southeast of the Korringal Avenue intersection. This location has been selected as it presents the highest likely road traffic noise level due to the exit and entry location of the main carpark.

Given the relatively low volumes of traffic utilising Noorebar Avenue, the US EPA Federal Highways (FHWA) method is more relevant in the assessment of road traffic noise. Movements within the night-time period are expected to be sporadic and as such the potential for road traffic noise generation has been assessed for the daytime peak hour.

The existing level of road traffic noise has been established based on the predevelopment road model provided in the SIDRA movement summaries included in Attachment 1 of the PTC (2021) report.

Table 6.5 Existing road traffic (PTC, 2021)

Time period	Peak hour traffic	Predicted road traffic noise level, dB $L_{Aeq\ 1\ hour}$ at 15m from road
AM peak hour	435 (6% heavy vehicle)	58
PM peak hour	462 (8% heavy vehicle)	59

Predicted noise levels indicate that existing road traffic noise levels exceed the 55dB $L_{Aeq\ 1\ hour}$ noise criteria for local roads. As such, the potential for road traffic noise generation has been assessed with regard to the 2dB relative increase criteria which is established by comparing the pre-development traffic volumes with post-development traffic volumes as provided in Table 6.5. The traffic volumes provided in Table 6.5 have been adopted from the SIDRA movement summaries included in Attachment 1 of the PTC (2021) report and account for traffic growth up to the opening year 2024.

Table 6.6 Increase in road traffic noise level

Time period	Pre-development traffic volumes (year 2024)	Post-development traffic generation (year 2024)	Relative increase in noise level
AM peak hour	463	660	1.5dB
PM peak hour	491	693	1.5dB

The relative increase in noise level on surrounding roads post development will be in the order of 1.5dB which will comply with the 2dB relative increase criteria of the RNP. This 1.5dB increase will be generally imperceptible to receiver locations within the worst cast catchment area along Noorebar Avenue adjacent the main carpark entry and exit.

6.5 Mechanical plant

A detailed review of mechanical plant cannot be undertaken at the SSDA stage given that the mechanical design is only in its infancy. A detailed review is generally conducted during the detailed design and construction phases of the project. However, an in-principle assessment of operational noise impacts has been undertaken to discuss potential mitigation measures which may be employed to reduced mechanical noise emissions from the site.

Rooftop mechanical plant will likely include:

- supply and relief air fans;
- air handling units, typically located within enclosed plant rooms;
- cooling towers;
- water-cooled chillers; and
- pumps.

Supply and relief air fans can be acoustically treated using a combination of lined duct work, fan wrapping and intake/discharge attenuators where required.

Air handling units will be located within plant rooms and as such are unlikely to significantly contribute to noise emissions from the site;

Cooling towers may require a combination of the following acoustic treatments to achieve compliance with noise emission criteria:

- acoustic intake louvres and/or solid cladding to inhibit visual line of sight to air intakes of the cooling towers; and
- discharge silencers on the cooling tower fan.

Water-cooled chillers and pumps will be generally located within roof top plant rooms. Where noise from these chillers could exceed noise requirements, the following would be considered:

- acoustic louvres may be installed for fresh air intake or discharge; and/or
- fresh air louvres may be backed with solid cladding if required with additional intake and/or exhaust fans to draw air into the plant room.

The aforementioned acoustic treatments are typical of this application and would be considered in further detail with the development of the mechanical scheme.

A detailed review of mechanical plant should be undertaken as part of the detailed design and construction phases to ensure that cumulative noise emissions comply with the PNTLs provided in Table 4.10 and Table 4.11.

7 External noise intrusion

The SEARs require that noise intrusion from external noise sources be addressed in accordance with the Department of Planning *Development Near Rail Corridors and Busy Roads - Interim Guideline*.

EMM notes that the GrBH is not in close proximity to rail or major road infrastructure which would trigger assessment under the interim guideline and the Infrastructure State Environmental Planning Policy (SEPP).

This is supported by Clause 102 of the Infrastructure SEPP relating to noise impact from road corridors which nominates the following:

> 102 Impact of road noise or vibration on non-road development
>
> This clause 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 RMS) and that the consent authority considers is likely to be adversely affected by road noise or vibration—
>
> residential accommodation,
>
> a place of public worship,
>
> a hospital,
>
> an educational establishment or centre-based child care facility.

Furthermore, the interim guideline states that:

> In other circumstances (eg. development adjacent to a road with an annual average daily traffic volume of 20,000–40,000 vehicles) these guidelines provide best practice advice.

The roads surrounding the hospital have annual daily traffic far less than 20,000 vehicles and as such would not require further assessment to address the requirements of the SEPP infrastructure or interim guideline.

8 Recommend mitigation measures

The following mitigation measures are recommended based on the assessment of:

- construction noise and vibration;
- operational noise generated by the development; and
- noise intrusion from external noise sources.

8.1 Construction noise and vibration

A detailed construction noise and vibration management plan should be prepared as part of the main works contract to ensure that all feasible and reasonable treatments and management conditions are considered to minimise noise and vibration from the site.

8.2 Operational noise

No additional mitigation measures are required to address noise generated by the use of the new main and western carpark.

Additional traffic noise on surrounding streets due to additional vehicle movements generated by the development are expected to comply with the RNP without additional mitigation measures.

A detailed review of mechanical plant should be undertaken as part of the detailed design and construction phases to ensure that cumulative noise emissions comply with the PNTLs provided in Table 4.10 and Table 4.11.

8.3 Noise intrusion from external noise sources

The GrBH is not located in proximity to any significant external noise source (including, road rail and aviation operations). As such, no additional noise mitigation measures will be required above that typically adopted for hospital developments (ie closed façade).

9 Conclusion

Indigeco and together with EMM have coordinated to prepare a noise and vibration impact assessment for the Griffith Base Hospital redevelopment in Griffith, NSW in support of the Project SSDA. This assessment has addressed the requirements outlined in Item 11 of the SEARs issued for the Project.

Construction noise predictions indicate some exceedance of the project NML at assessment locations surrounding the site. The most affected will be those locations on the same block as the GrBH including the new St Vincent's Private Community Hospital immediately adjoining the northern boundary of the development. It is noted that the 'highly affected' NML is not expected to be exceeded and that works will be limited to standard hours only.

Vibration generated by heavy construction works are expected to comply with cosmetic damage limits, although select pieces of machinery may need to be carefully reviewed for implementation on the site.

A detailed construction noise and vibration management plan will be prepared as part of the main works contract to ensure that all feasible and reasonable treatments and management conditions are considered to minimise noise and vibration from the site. This review would be undertaken once demolition, excavation and construction methodologies and equipment can be detailed appropriately.

Operational noise associated with on-site vehicle movements has been addressed. Predictions indicate that noise from peak hour movements during the daytime period will comply with the NPfI. Carpark movements during the evening and night-time period are expected to be sporadic in the absence of visiting hours and specialist consultations.

The potential for sleep awakenings due to sporadic movements within the new main and western carparks during the night-time period have been assessed. Predictions indicate that noise due to these events are unlikely to cause sleep awakening reactions.

Road traffic noise predictions indicate that existing road traffic noise levels exceed the road planning noise levels of the RNP. As such, the assessment of road traffic noise generation has been assessed with regard to the 2dB relative increase criterion. Additional road traffic generated by the development will result in a predicted 1.5dB increase in existing road traffic noise level on surrounding roadways. This increase would be generally imperceptible and would comply with the 2dB relative increase criteria of the RNP.

External noise intrusion into the development has been addressed. Road traffic volumes on surrounding roadways are not significant enough to warrant assessment under and hence are expected to comply with the Department of Planning *Development Near Rail Corridors and Busy Roads - Interim Guideline*.

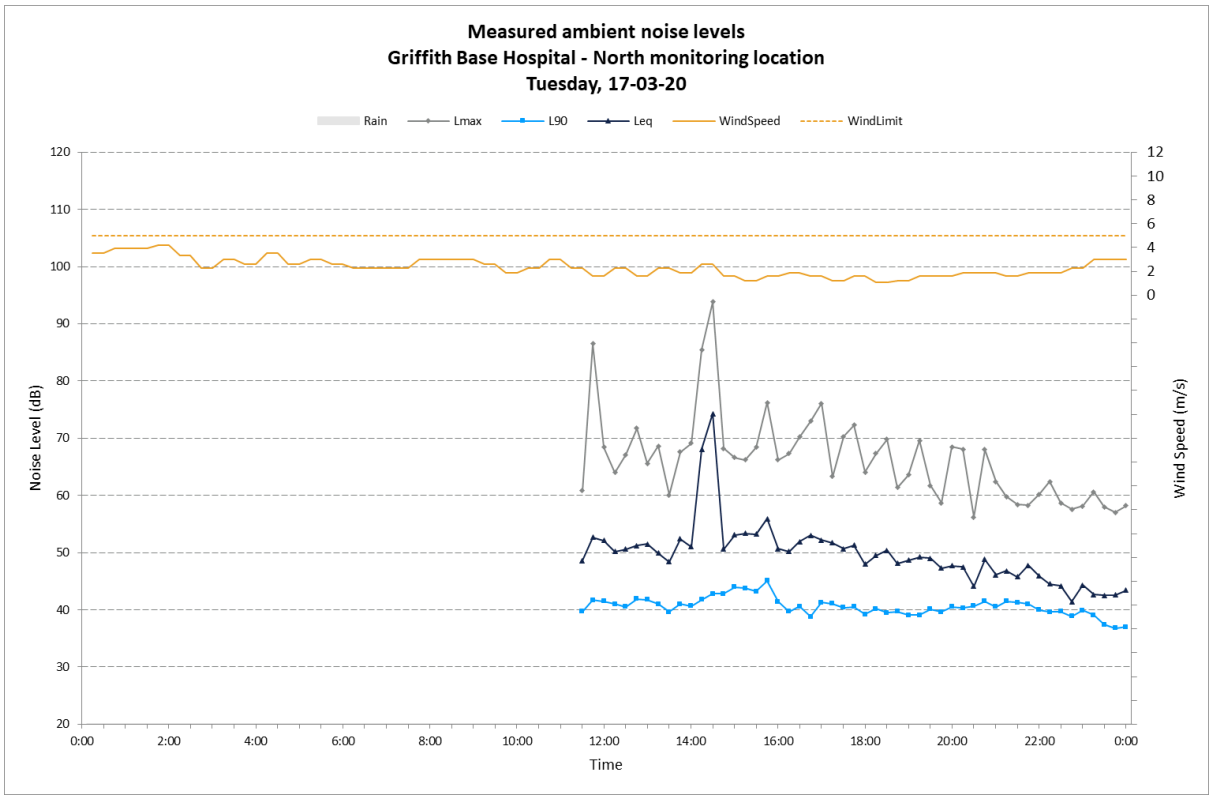
Appendix A

Unattended noise monitoring results

Table A.1 Summary of daily noise logging results – NM1

Date	ABL Day[1]	ABL Evening[1]	ABL Night[1]
Tuesday, 17-03-20	0	39	36
Wednesday, 18-03-20	42	39	36
Thursday, 19-03-20	45	40	37
Friday, 20-03-20	43	40	37
Saturday, 21-03-20	40	41	36
Sunday, 22-03-20	41	39	36
Monday, 23-03-20	40	39	37
Tuesday, 24-03-20	41	37	35
Wednesday, 25-03-20	40	38	35
Thursday, 26-03-20	41	37	36
Friday, 27-03-20	41	39	36
Saturday, 28-03-20	39	39	35
Sunday, 29-03-20	40	37	35
Monday, 30-03-20	42	38	37
Tuesday, 31-03-20	0	0	0
Summary Values	41	39	36

Notes: 1. A "0" indicates insufficient data samples due to adverse weather or other extraneous effects.


Measured ambient noise levels
Griffith Base Hospital - North monitoring location
Tuesday, 17-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
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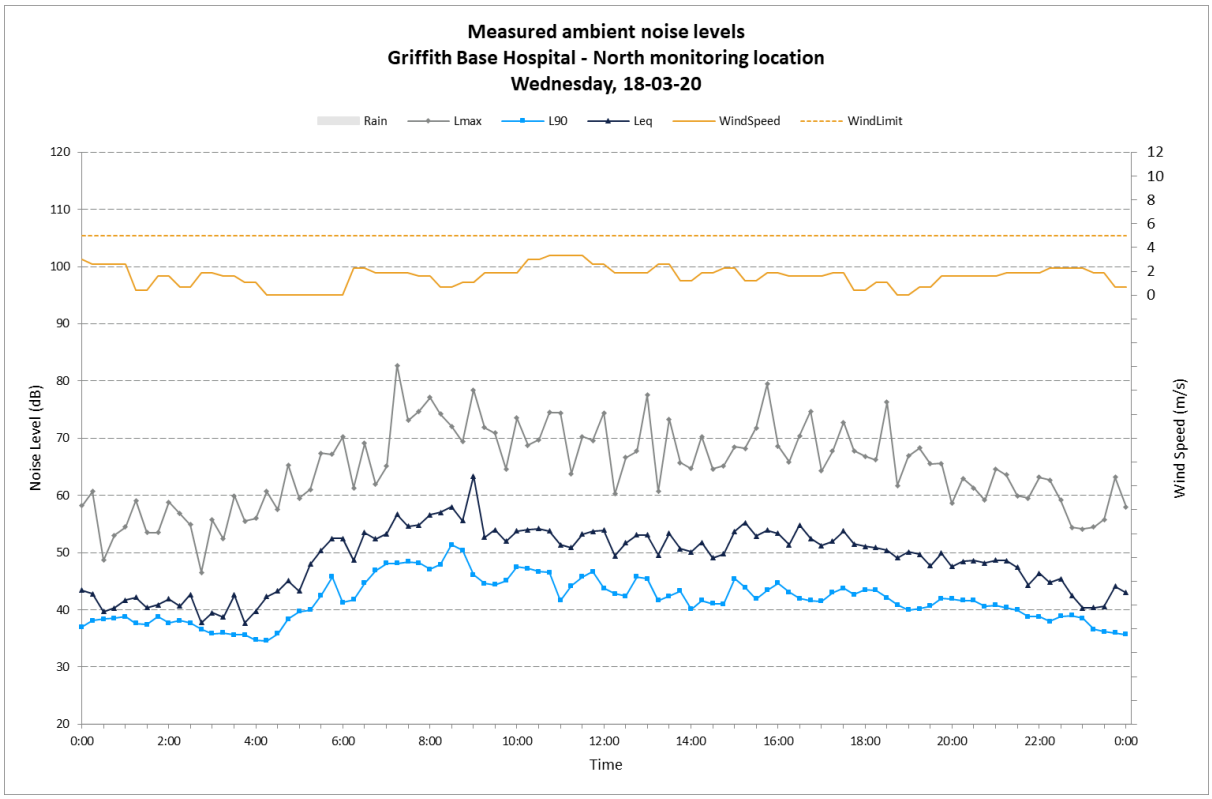
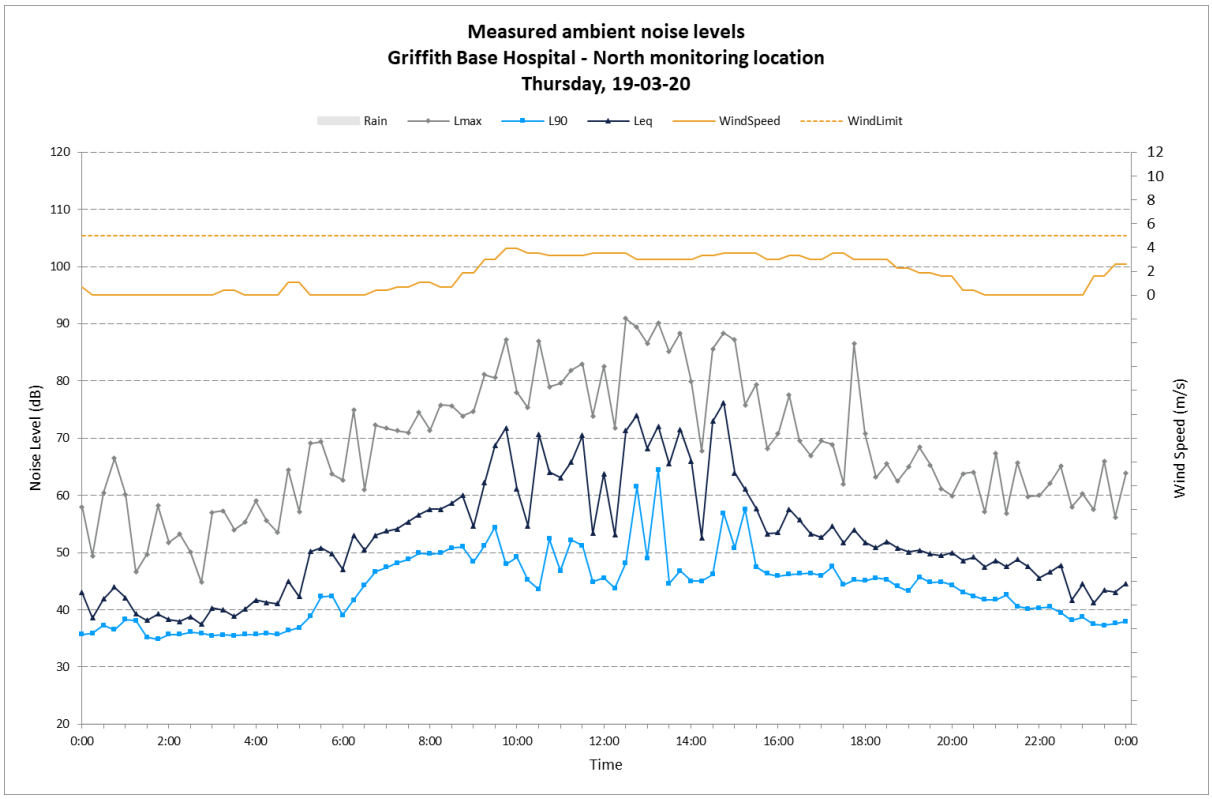
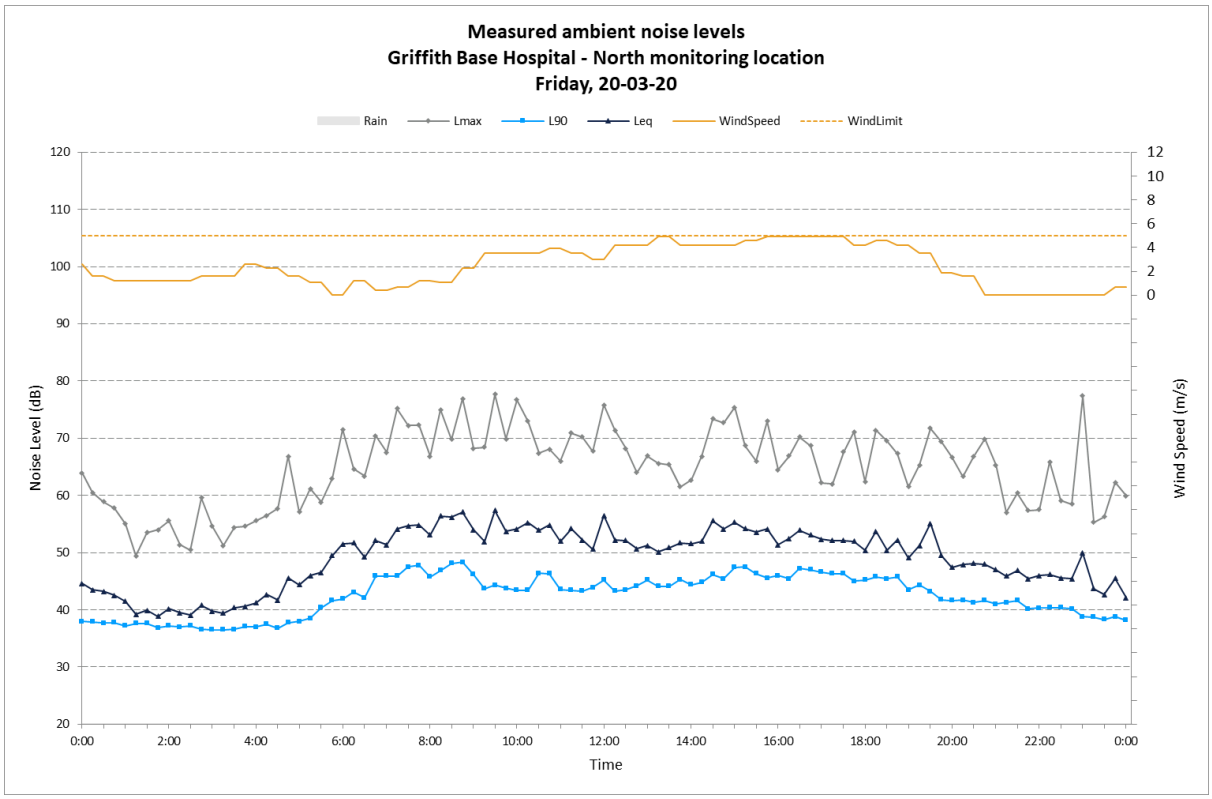

Measured ambient noise levels
Griffith Base Hospital - North monitoring location
Wednesday, 18-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Griffith Base Hospital - North monitoring location
Thursday, 19-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Griffith Base Hospital - North monitoring location
Friday, 20-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
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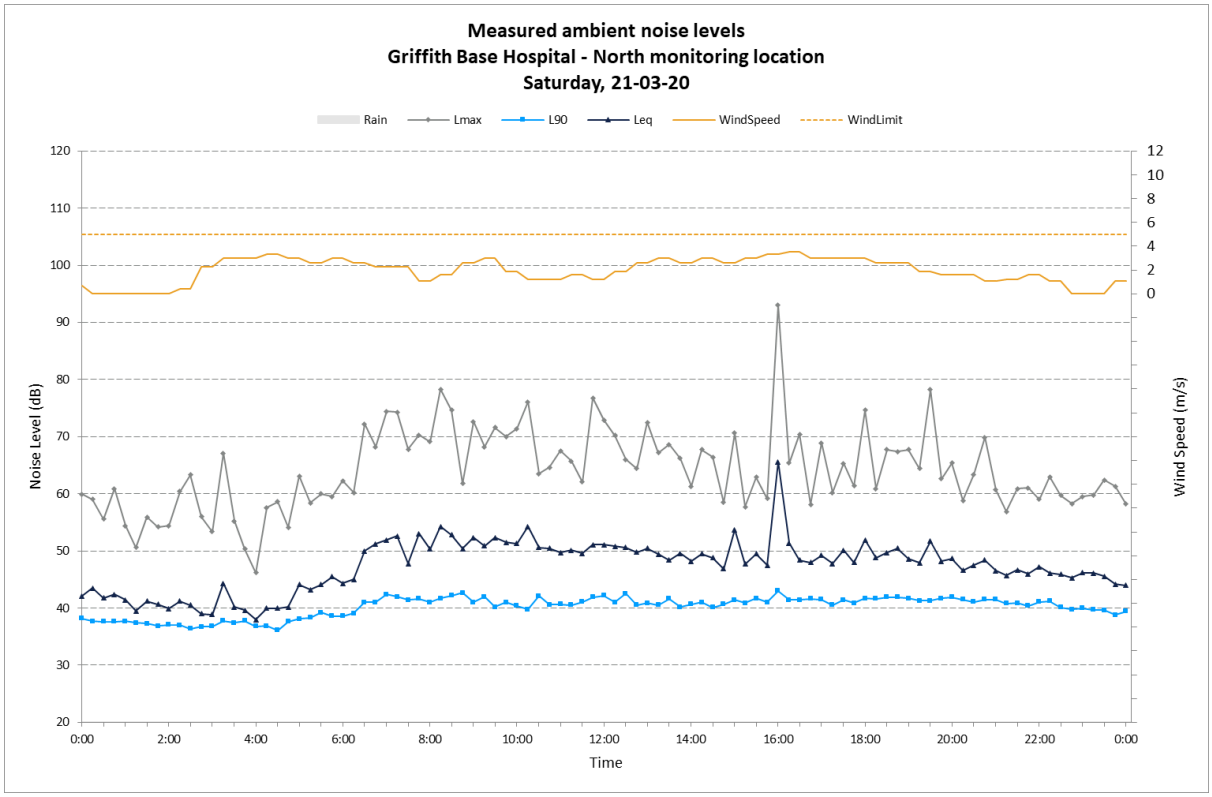
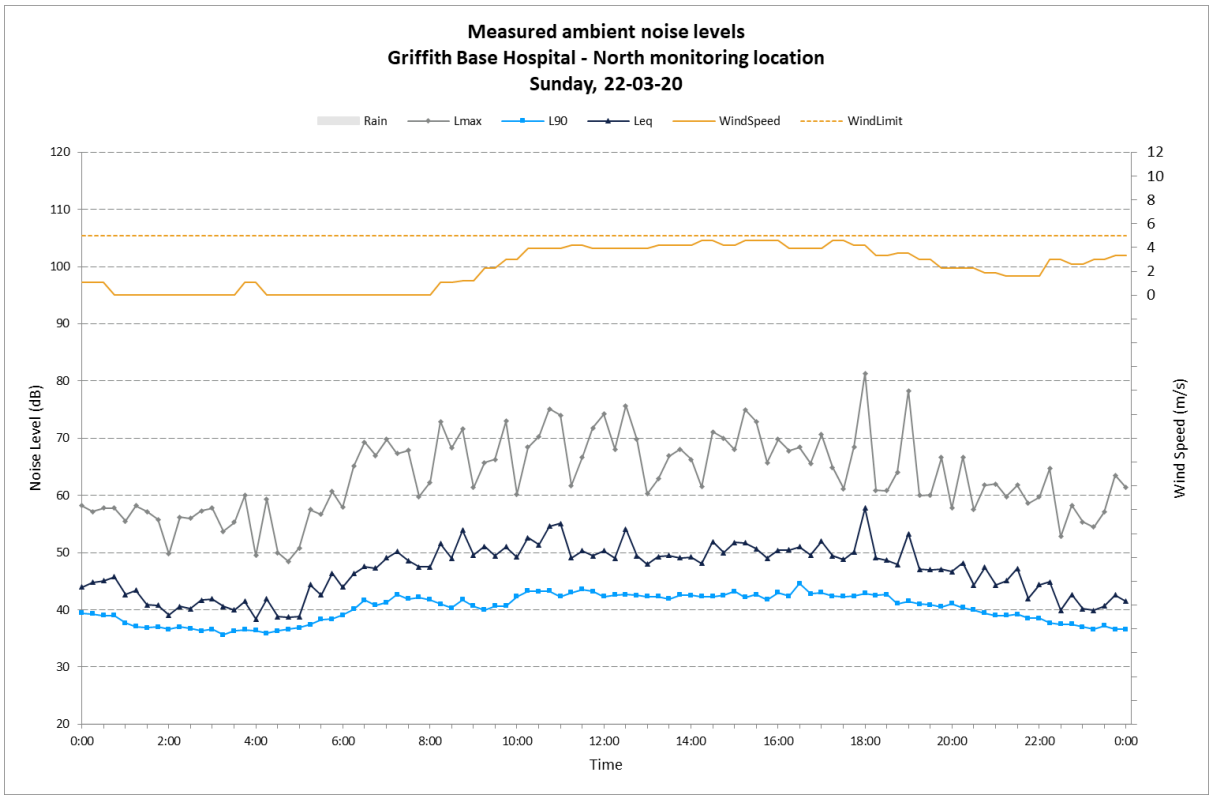
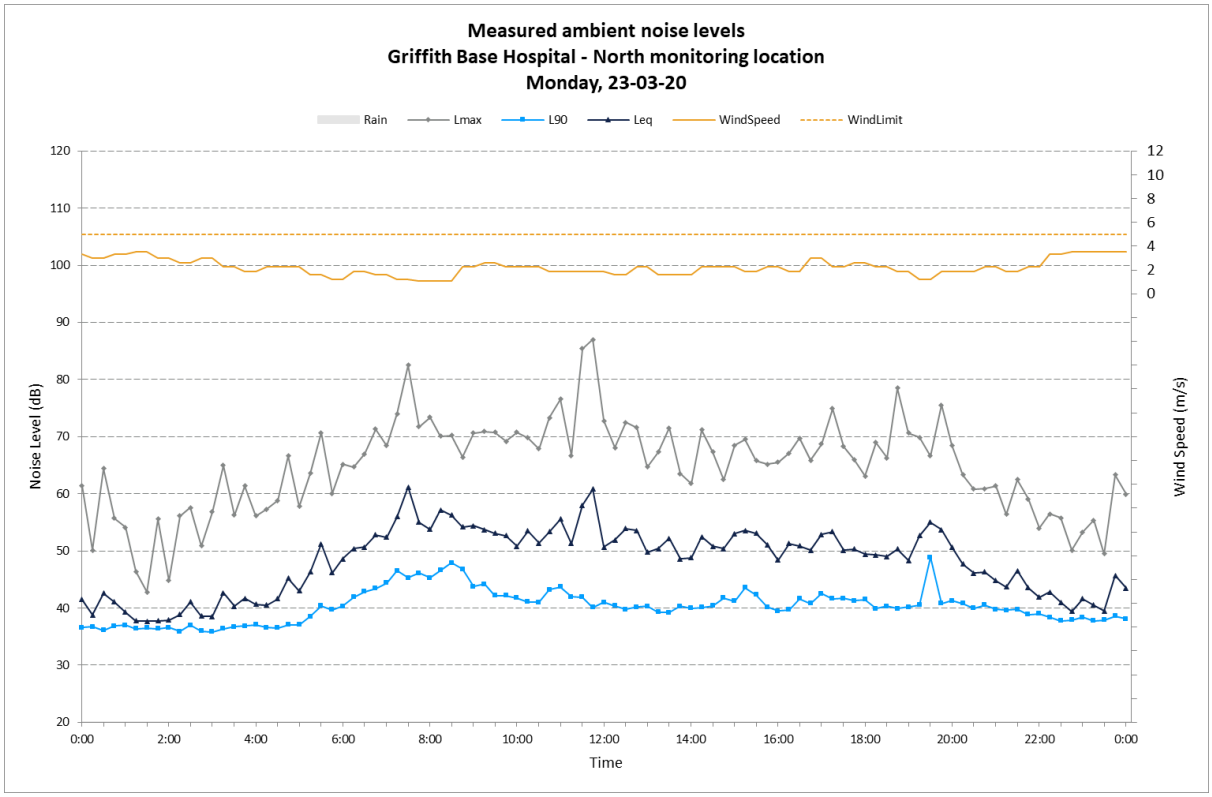

Measured ambient noise levels
Griffith Base Hospital - North monitoring location
Saturday, 21-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Griffith Base Hospital - North monitoring location
Sunday, 22-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Griffith Base Hospital - North monitoring location
Monday, 23-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00

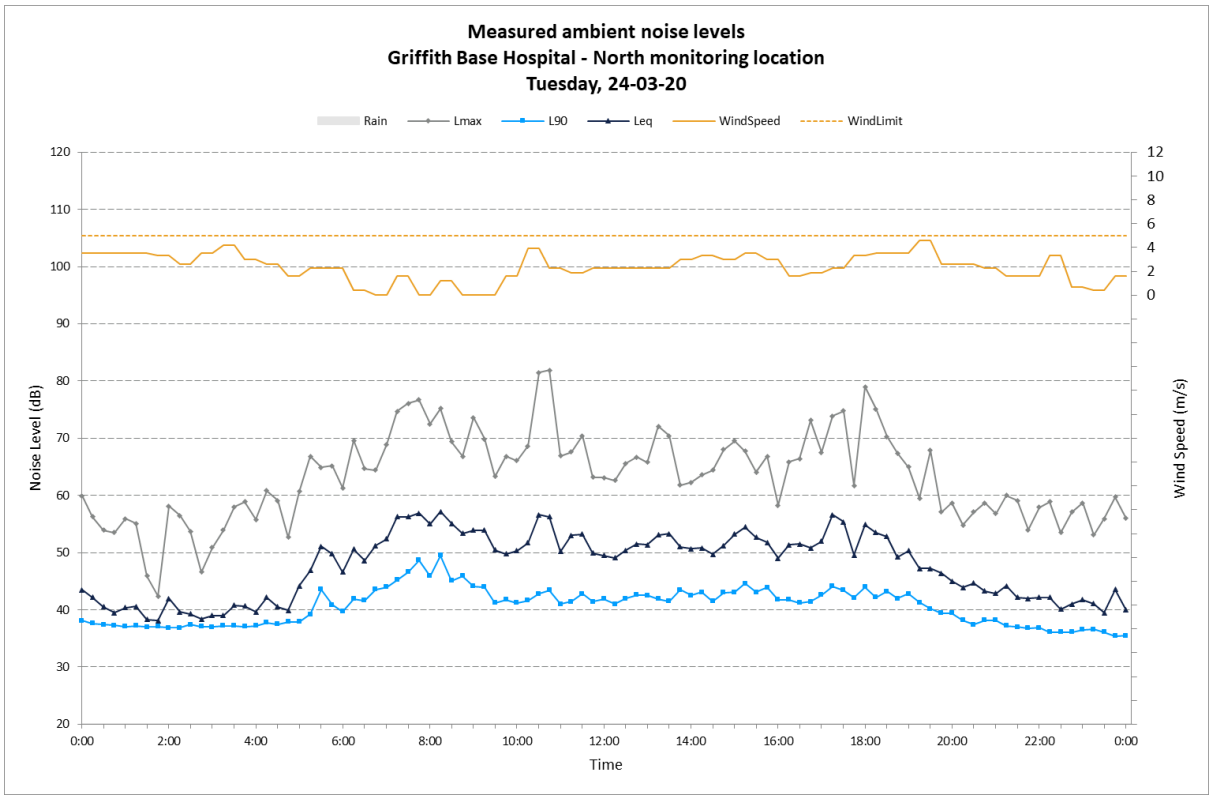
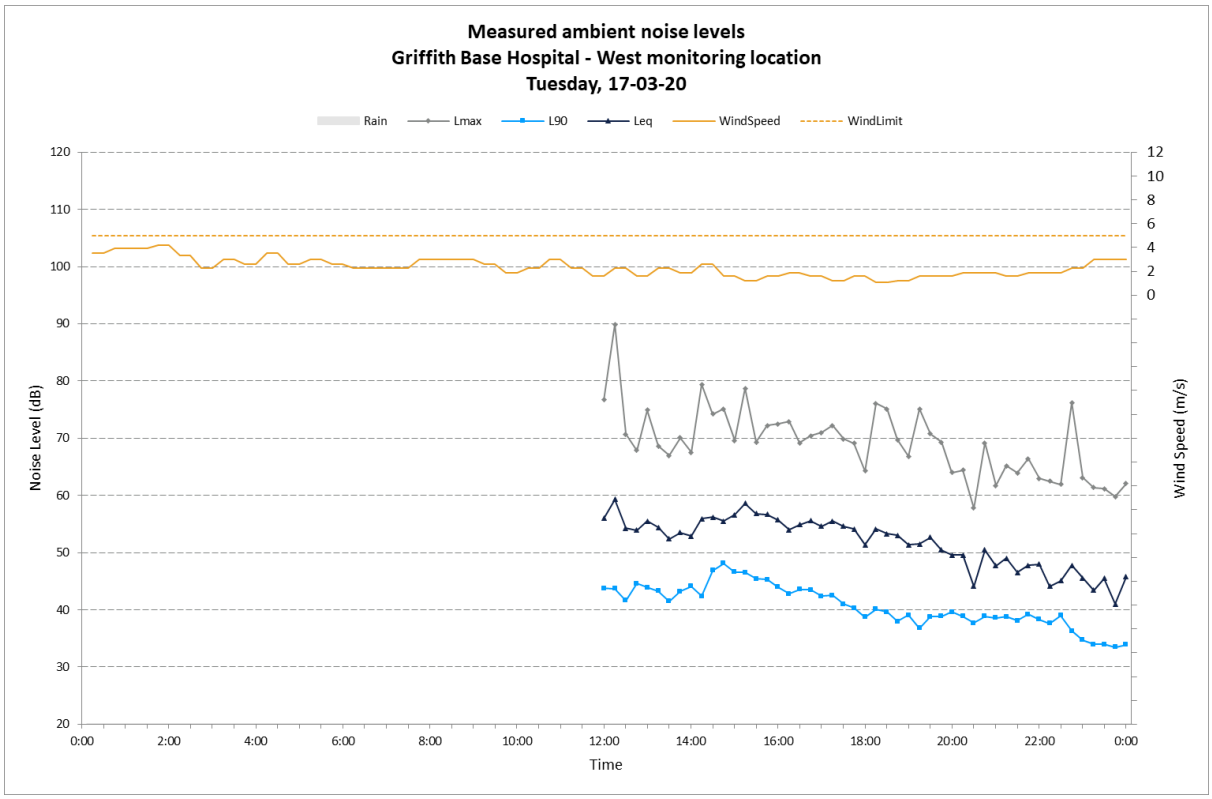
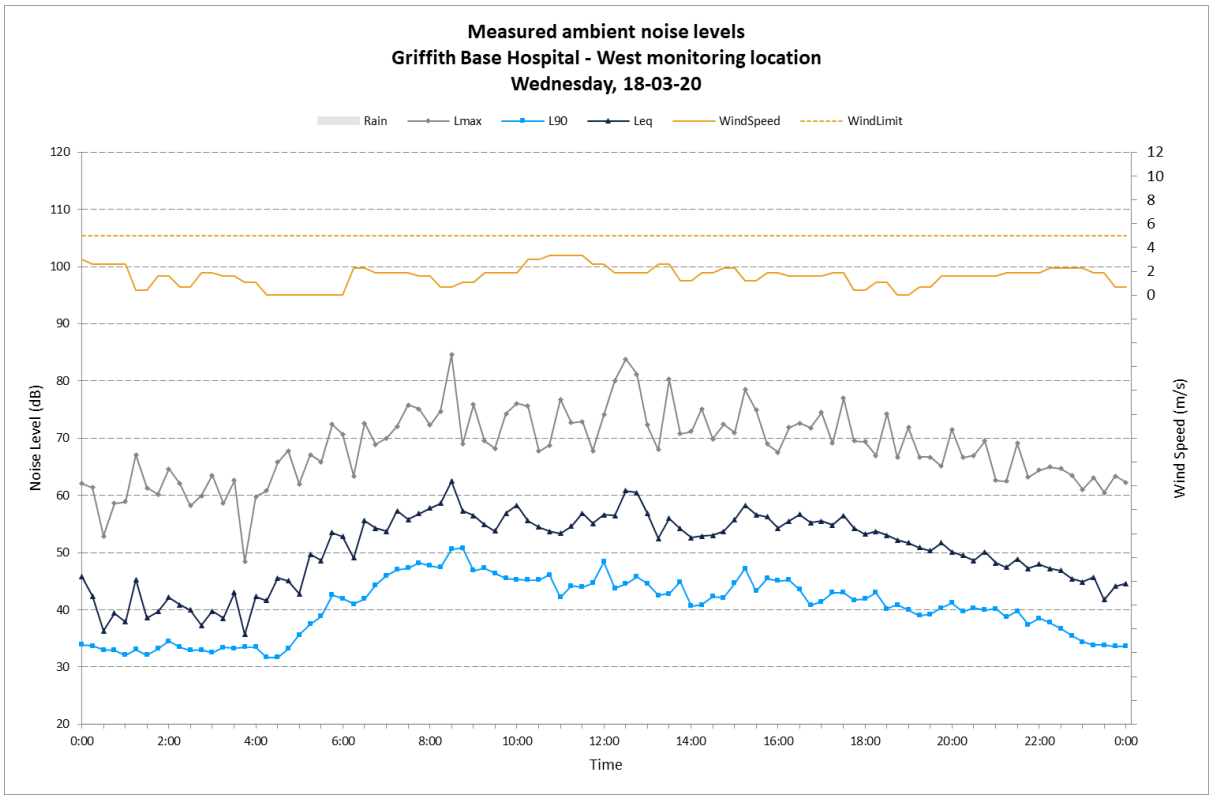

Measured ambient noise levels
Griffith Base Hospital - North monitoring location
Tuesday, 24-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00

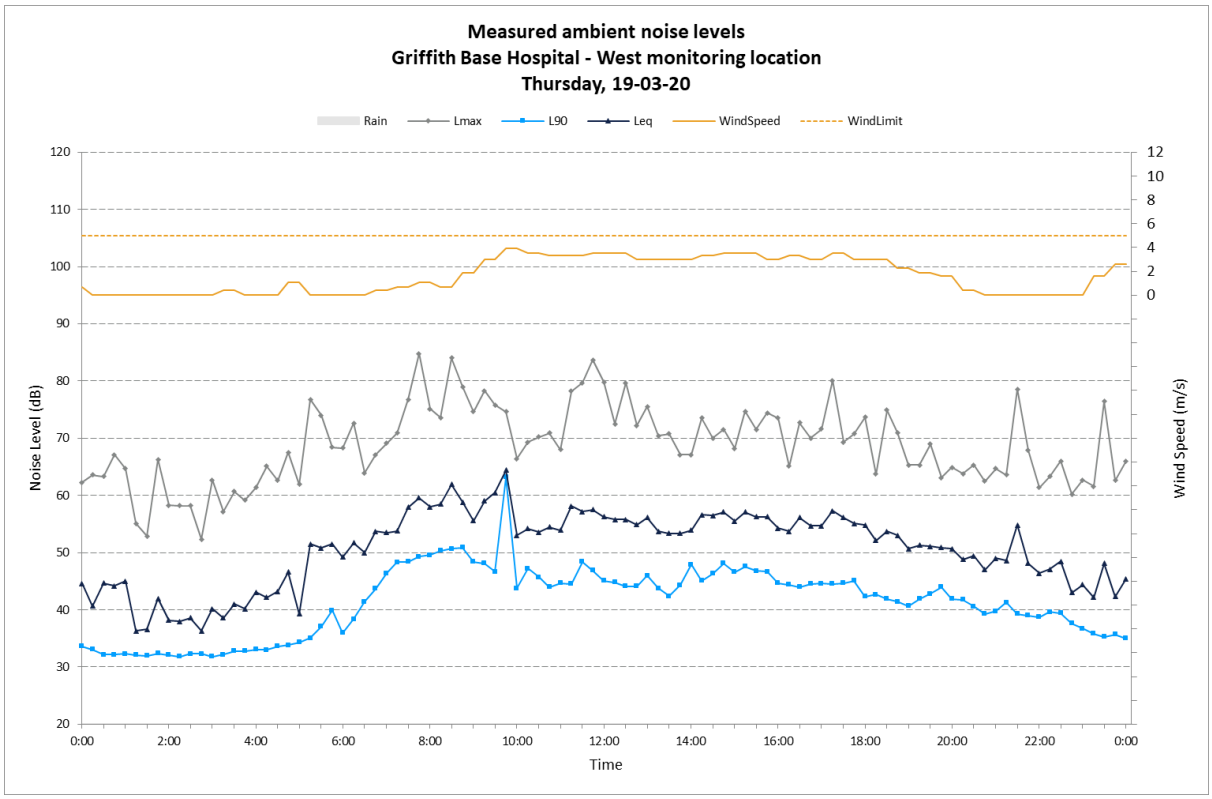
Table A.2 Summary of daily noise logging results – NM2

Date	ABL Day[1]	ABL Evening[1]	ABL Night[1]
Tuesday, 17-03-20	0	38	32
Wednesday, 18-03-20	42	39	32
Thursday, 19-03-20	44	39	34
Friday, 20-03-20	45	39	33
Saturday, 21-03-20	40	40	33
Sunday, 22-03-20	40	37	32
Monday, 23-03-20	42	37	32
Tuesday, 24-03-20	43	34	32
Wednesday, 25-03-20	43	37	31
Thursday, 26-03-20	42	37	34
Friday, 27-03-20	42	37	32
Saturday, 28-03-20	38	38	33
Sunday, 29-03-20	40	36	32
Monday, 30-03-20	42	37	33
Tuesday, 31-03-20	0	0	0
Summary Values	42	37	32

Notes: 1. A "0" indicates insufficient data samples due to adverse weather or other extraneous effects.


Measured ambient noise levels
Griffith Base Hospital - West monitoring location
Tuesday, 17-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time


Measured ambient noise levels
Griffith Base Hospital - West monitoring location
Wednesday, 18-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time


Measured ambient noise levels
Griffith Base Hospital - West monitoring location
Thursday, 19-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
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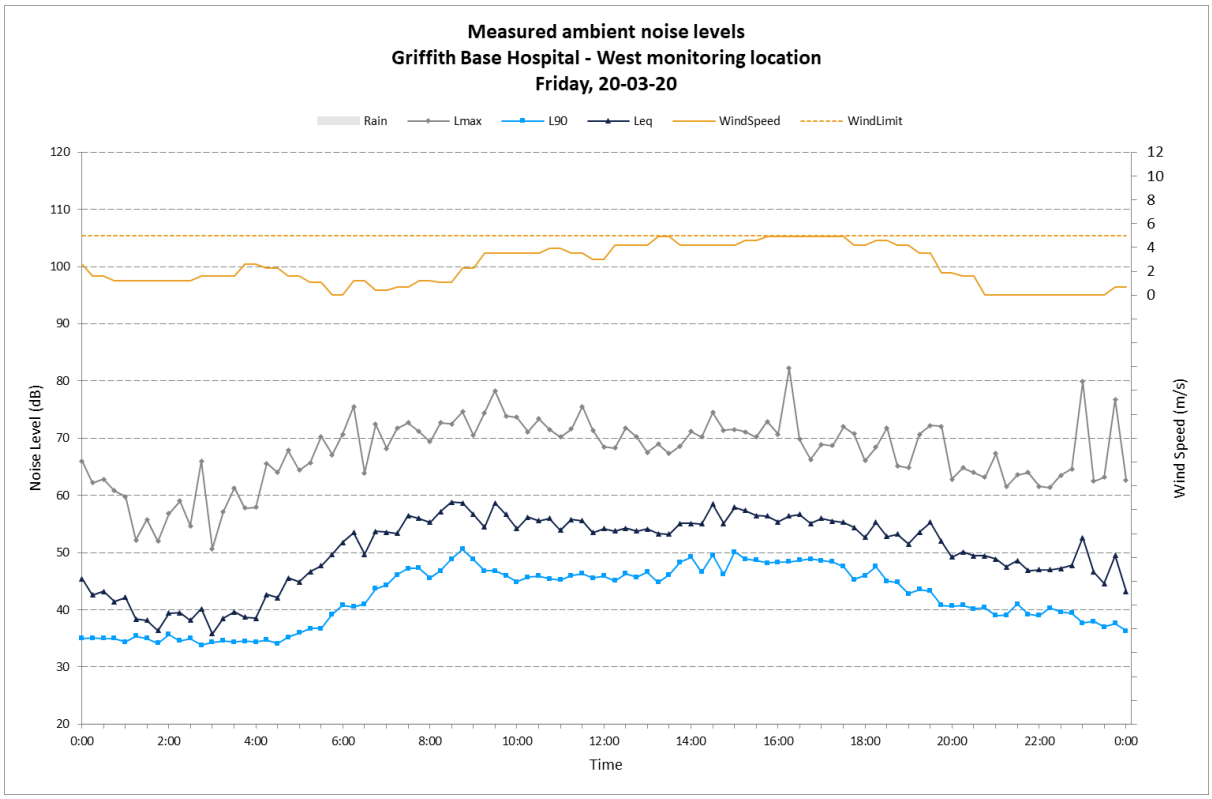
Measured ambient noise levels
Griffith Base Hospital - West monitoring location
Friday, 20-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
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0:00
2:00
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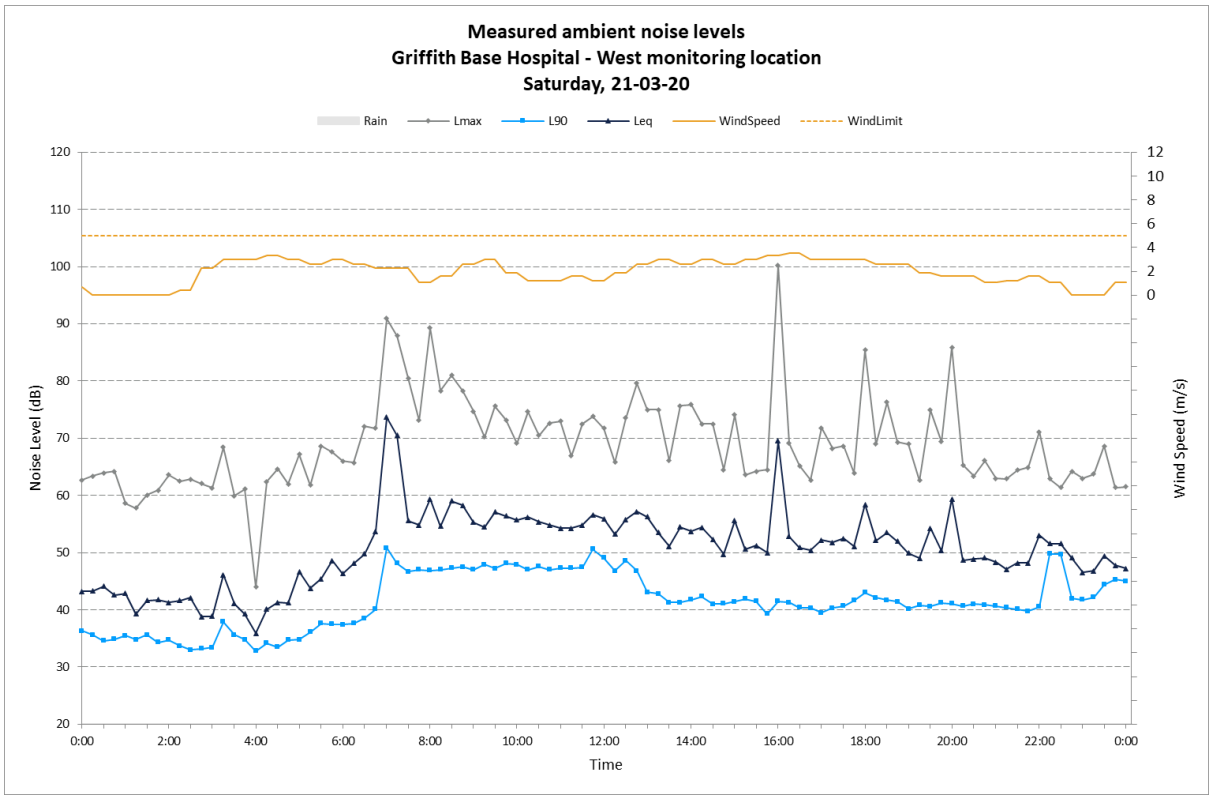
Measured ambient noise levels
Griffith Base Hospital - West monitoring location
Saturday, 21-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
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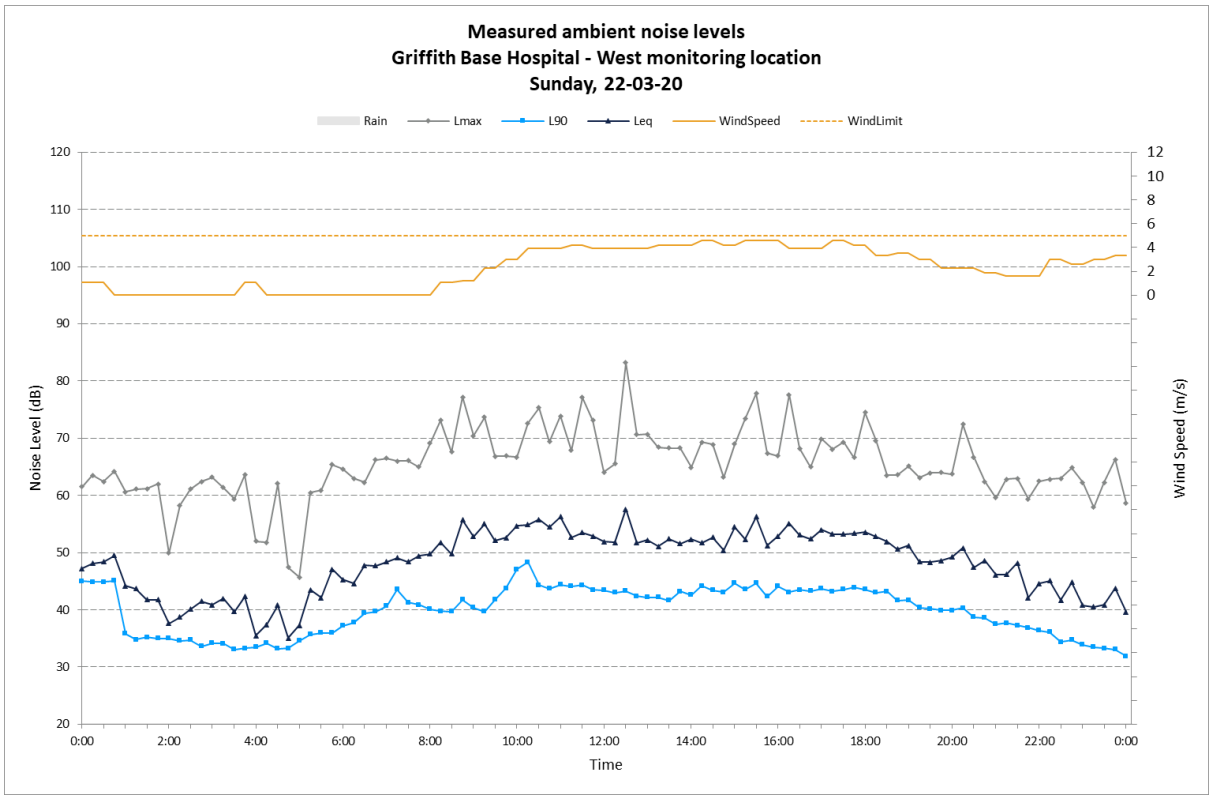
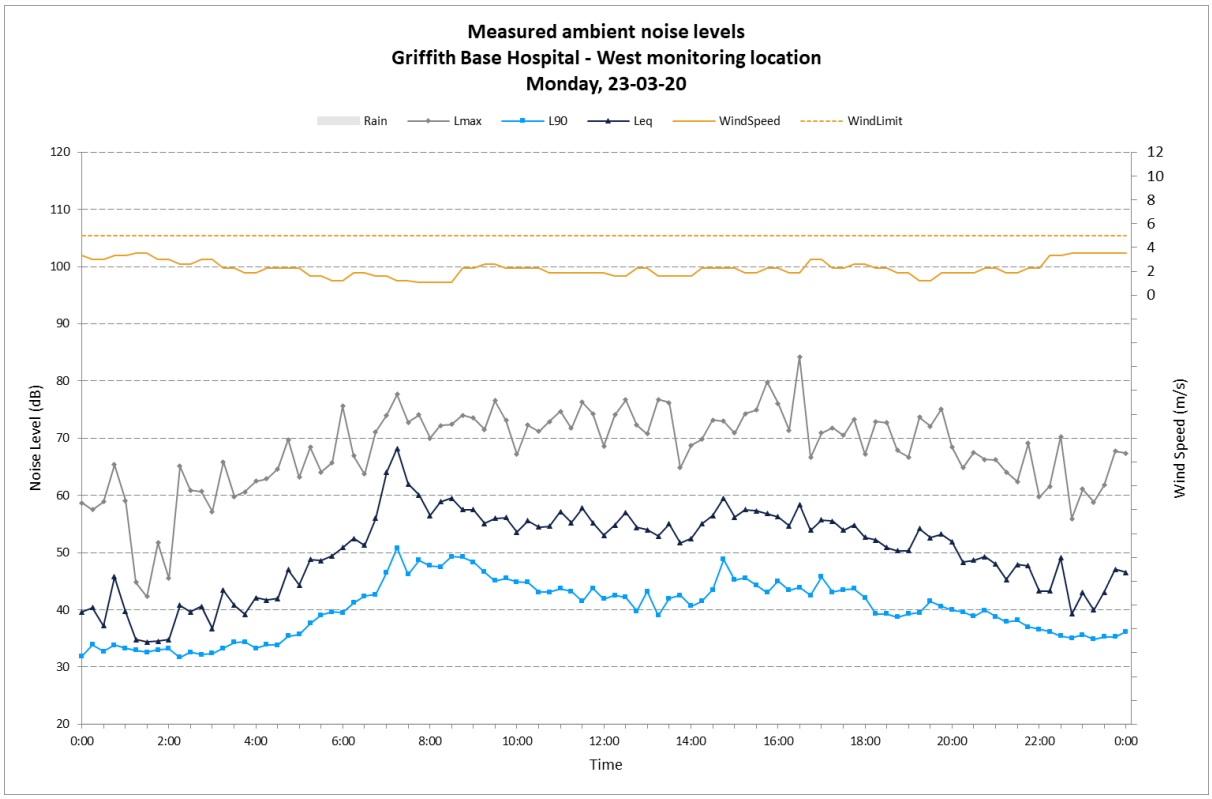

Measured ambient noise levels
Griffith Base Hospital - West monitoring location
Sunday, 22-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Griffith Base Hospital - West monitoring location
Monday, 23-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
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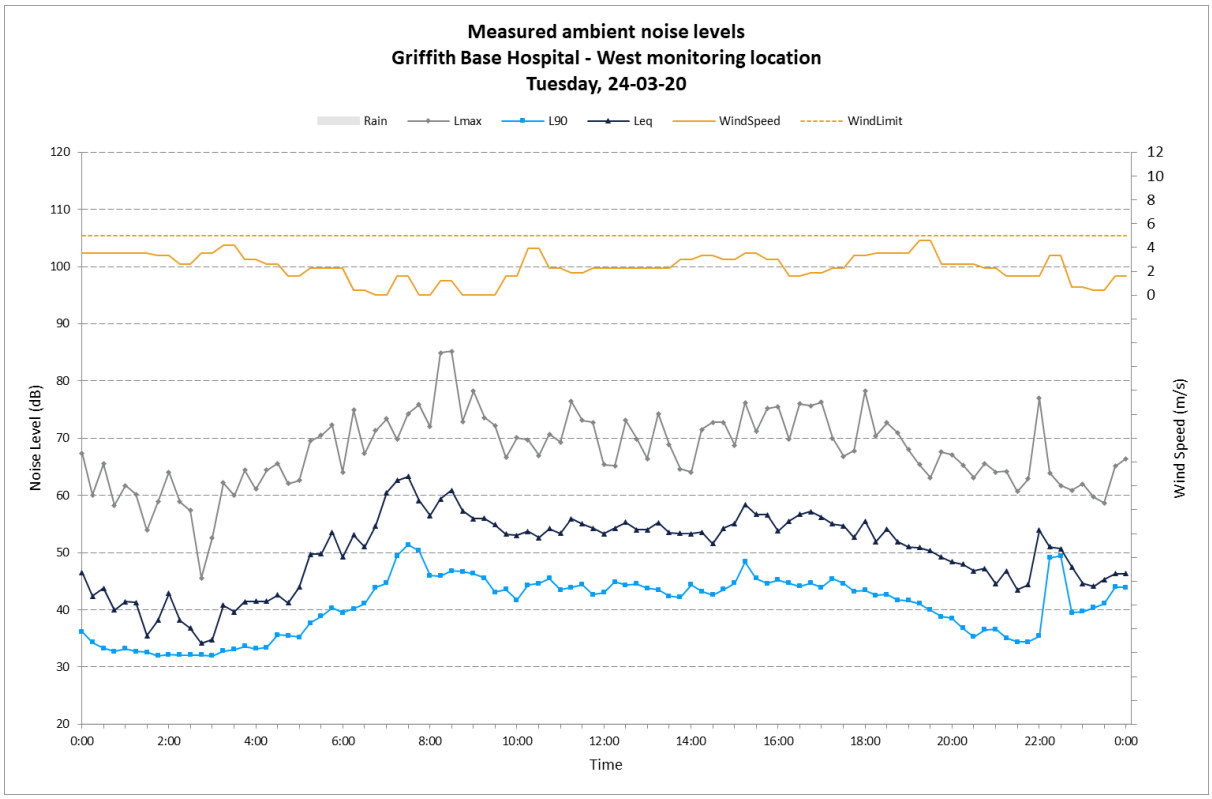
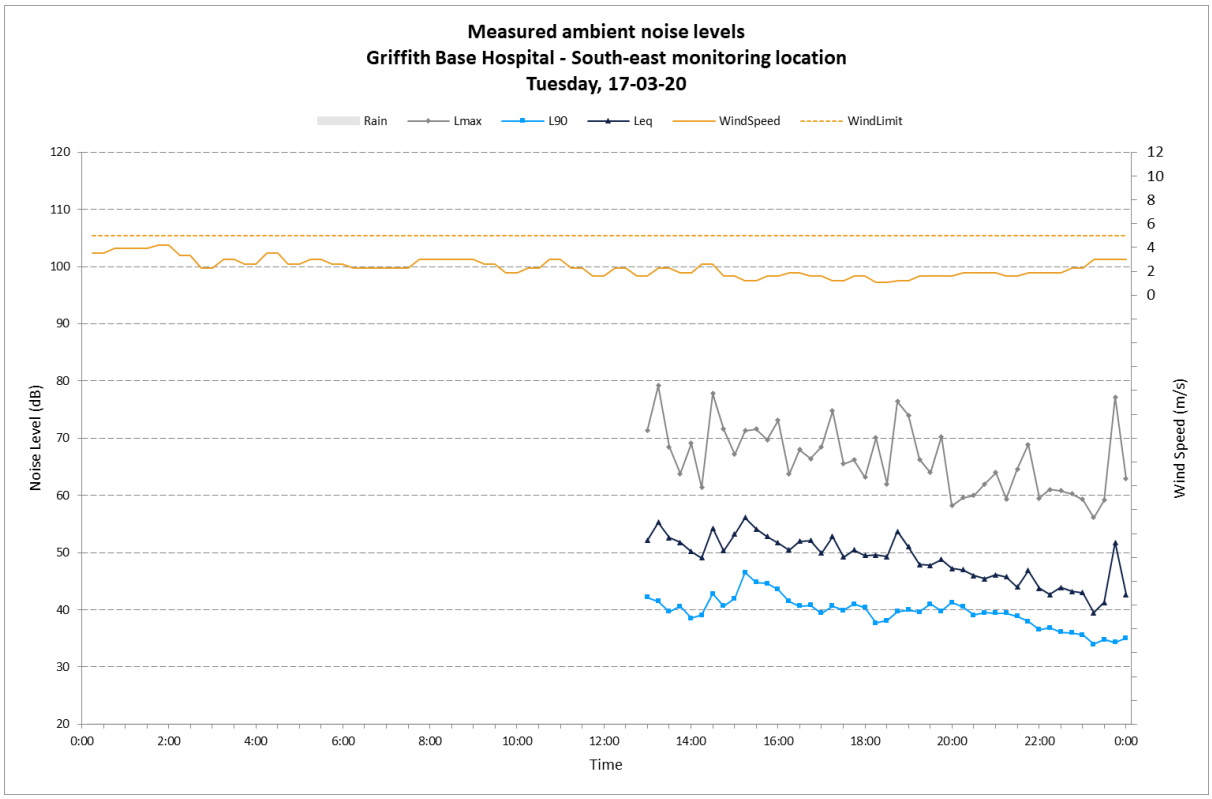
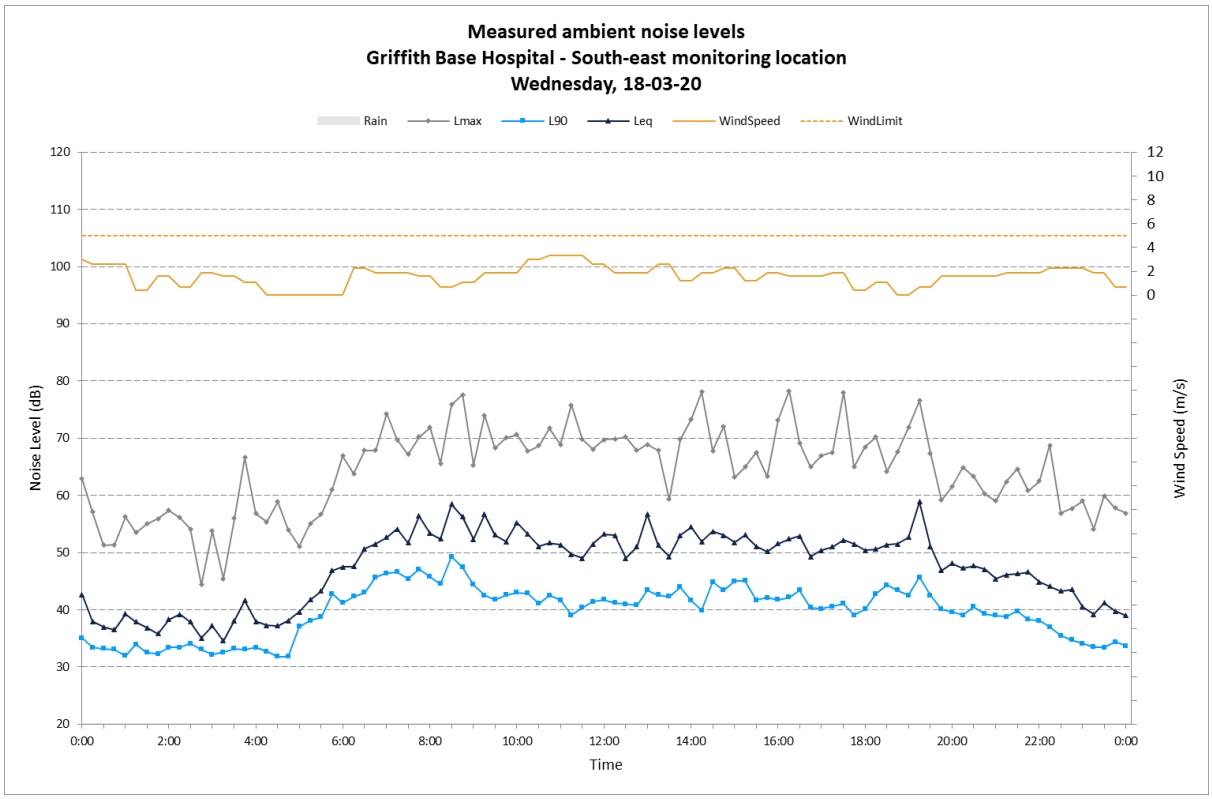

Measured ambient noise levels
Griffith Base Hospital - West monitoring location
Tuesday, 24-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00

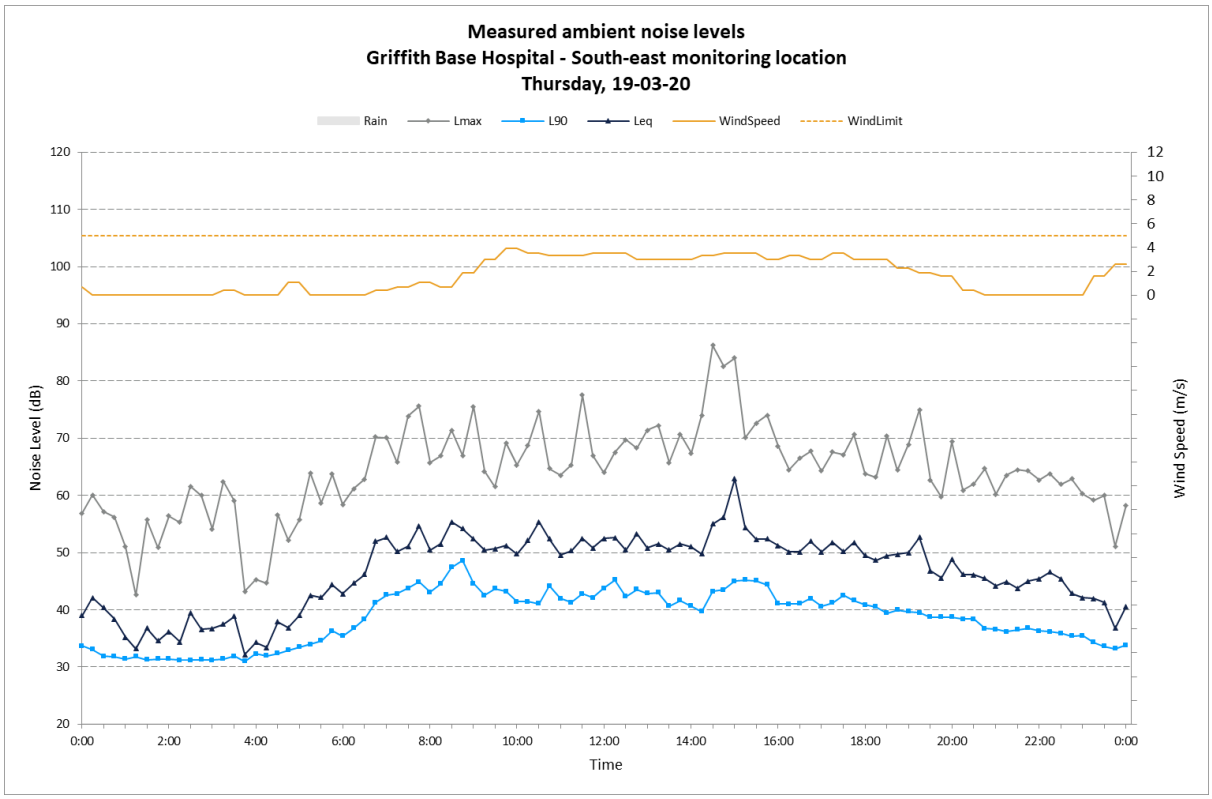
Table A.3 Summary of daily noise logging results – NM3

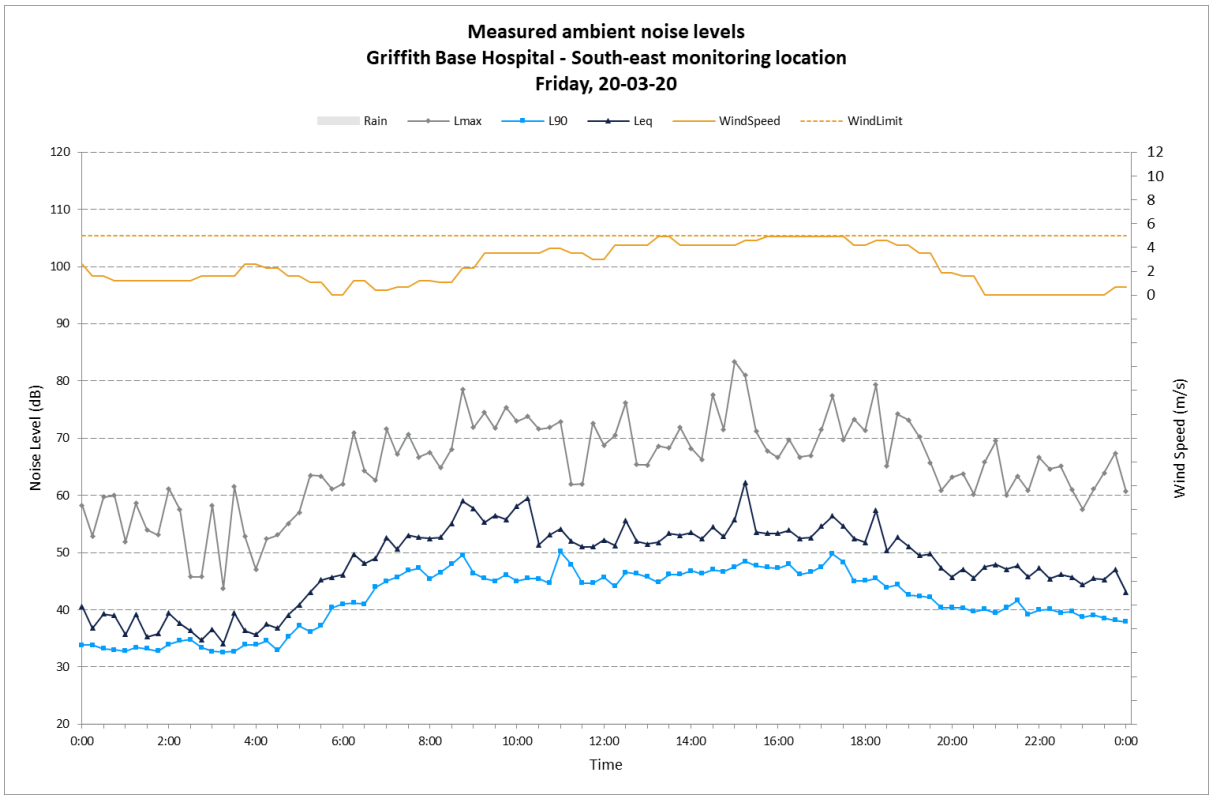
Date	ABL Day[1]	ABL Evening[1]	ABL Night[1]
Tuesday, 17-03-20	0	38	32
Wednesday, 18-03-20	40	38	31
Thursday, 19-03-20	41	36	33
Friday, 20-03-20	45	39	35
Saturday, 21-03-20	40	41	34
Sunday, 22-03-20	41	39	34
Monday, 23-03-20	41	39	34
Tuesday, 24-03-20	40	35	33
Wednesday, 25-03-20	42	38	33
Thursday, 26-03-20	40	36	32
Friday, 27-03-20	40	37	31
Saturday, 28-03-20	36	37	30
Sunday, 29-03-20	37	33	31
Monday, 30-03-20	40	39	36
Tuesday, 31-03-20	0	0	0
Summary Values	40	38	33

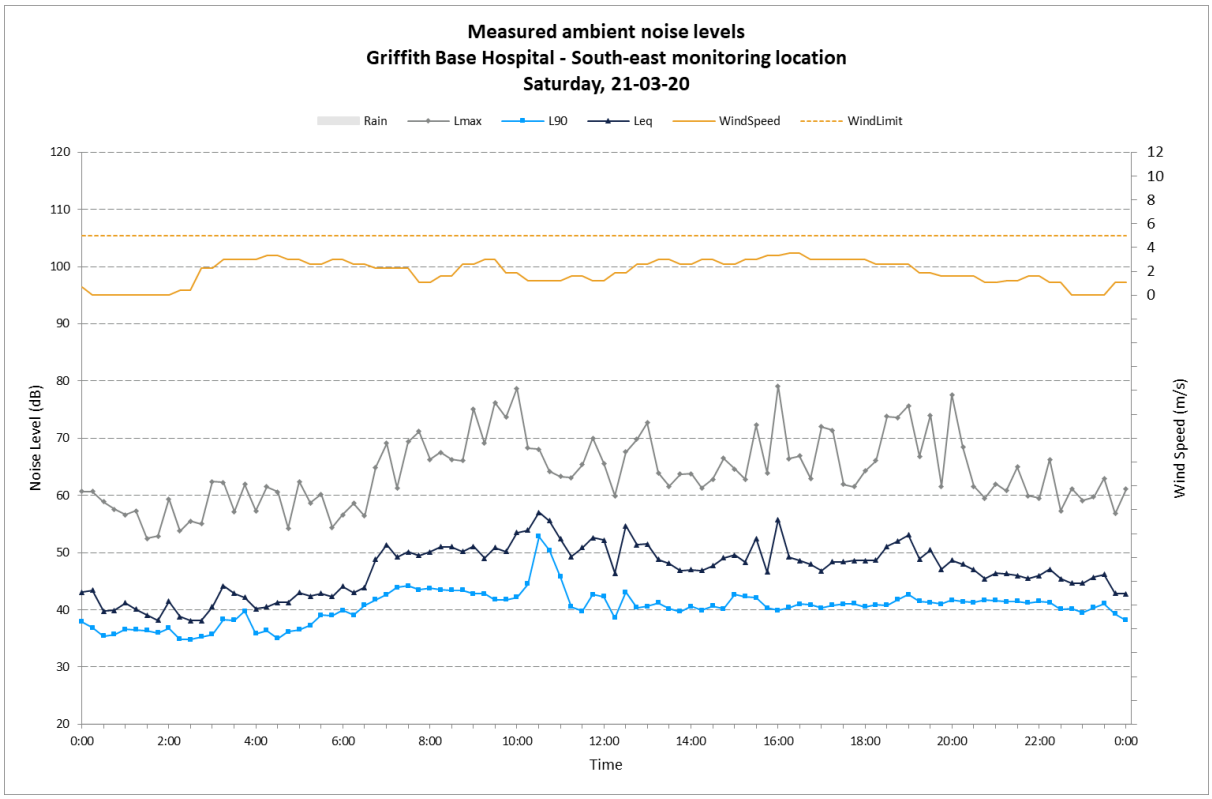
Notes: 1. A "0" indicates insufficient data samples due to adverse weather or other extraneous effects.

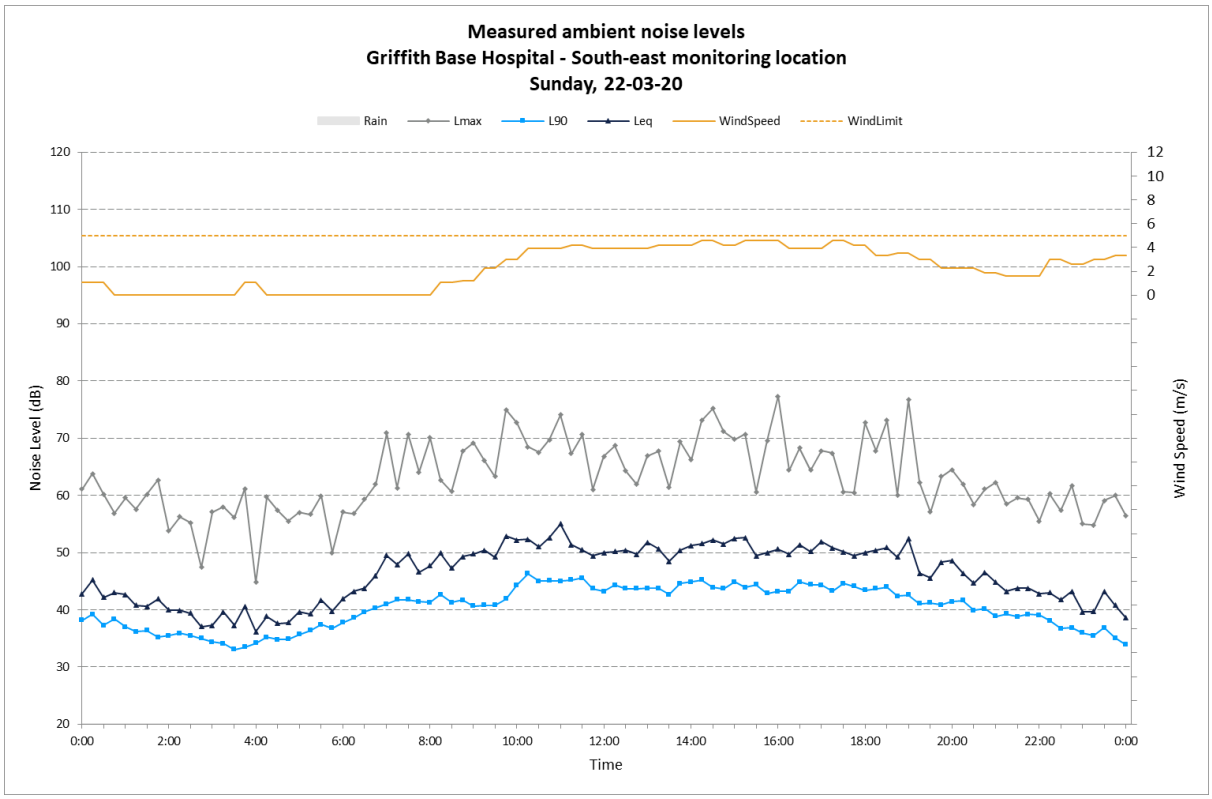

Measured ambient noise levels
Griffith Base Hospital - South-east monitoring location
Tuesday, 17-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00

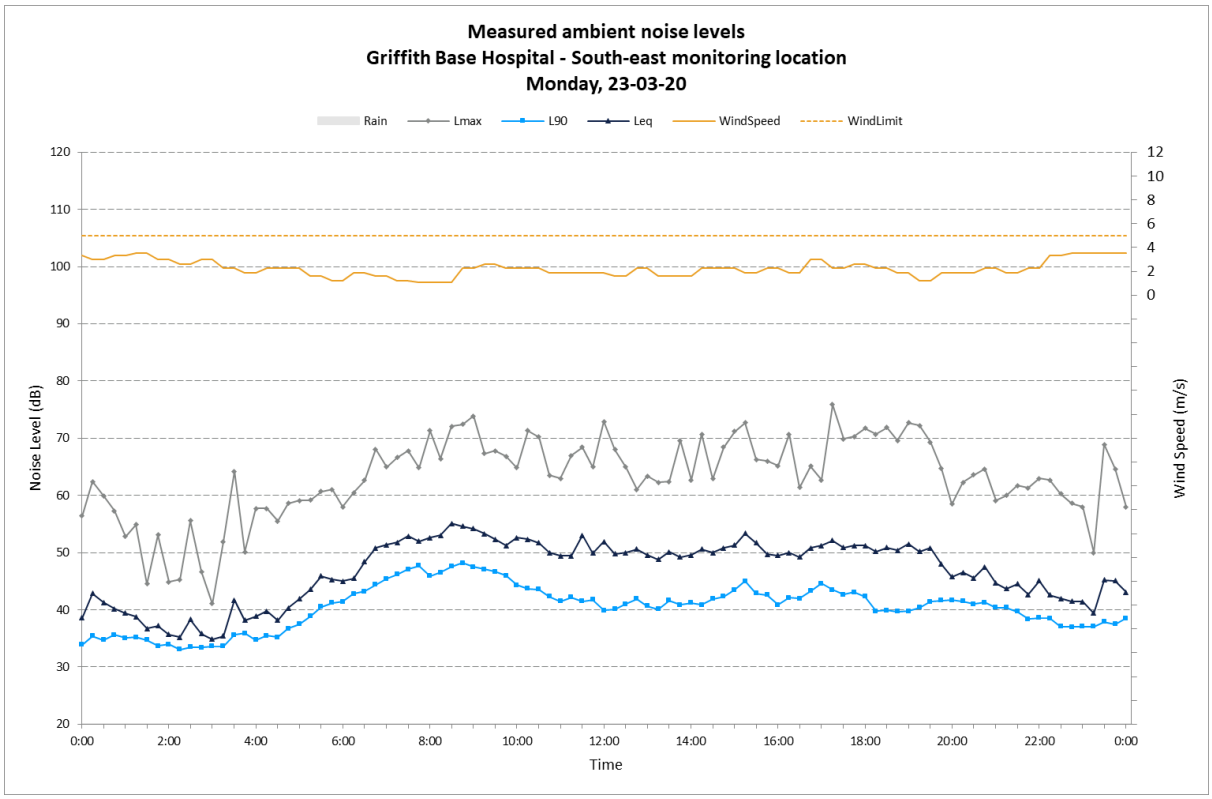

Measured ambient noise levels
Griffith Base Hospital - South-east monitoring location
Wednesday, 18-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00

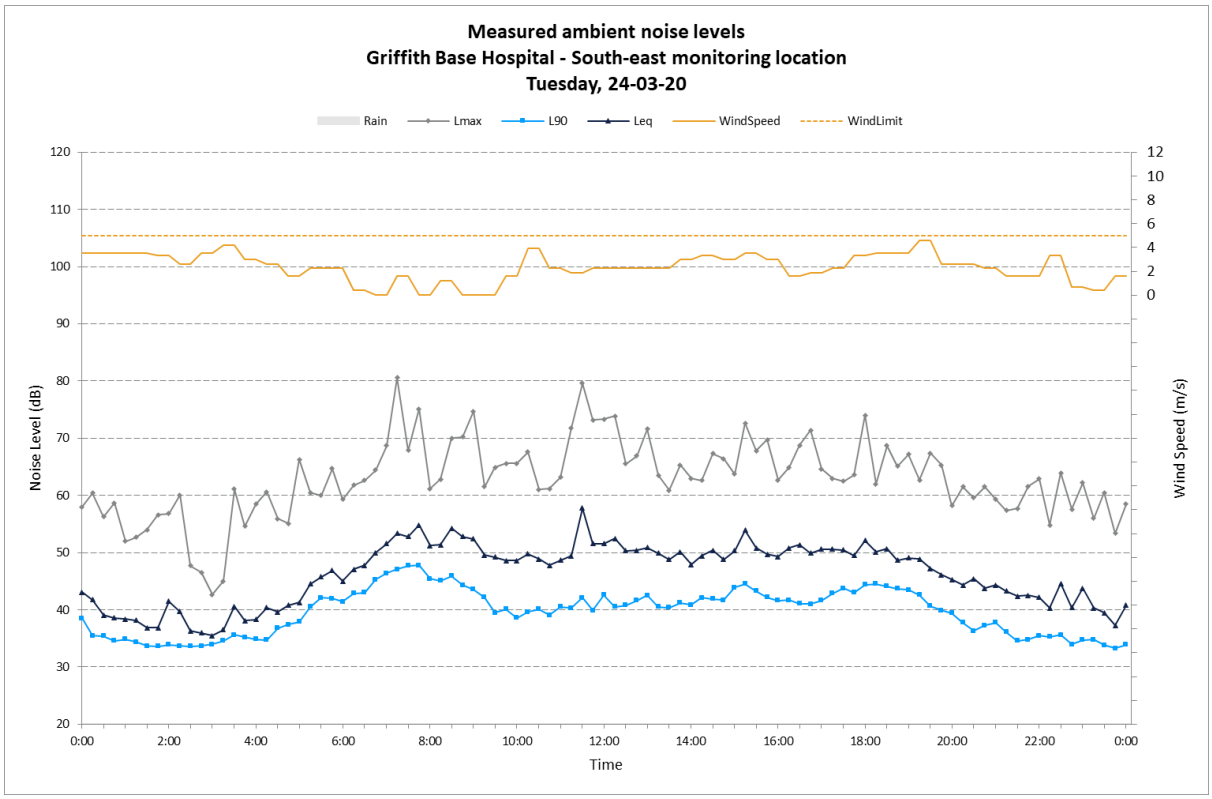

Measured ambient noise levels
Griffith Base Hospital - South-east monitoring location
Thursday, 19-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Griffith Base Hospital - South-east monitoring location
Friday, 20-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Griffith Base Hospital - South-east monitoring location
Saturday, 21-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Griffith Base Hospital - South-east monitoring location
Sunday, 22-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Griffith Base Hospital - South-east monitoring location
Monday, 23-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Measured ambient noise levels
Griffith Base Hospital - South-east monitoring location
Tuesday, 24-03-20
Rain
Lmax
L90
Leq
WindSpeed
WindLimit
Noise Level (dB)
Wind Speed (m/s)
Time
120
110
100
90
80
70
60
50
40
30
20
12
10
8
6
4
2
0
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00