Dubbo Hospital Redevelopment – Noise Impact Assessment

Acoustic Environmental Noise Impact
Construction Noise and Vibration Assessment

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Contents

1. Introduction

Wood & Grieve Engineers have been engaged by Hansen Yuncken (HY) to prepare a Noise Impact Assessment for the Construction Noise and Vibration associated with the construction works to be conducted as part of the Dubbo Health Services Redevelopment Stage 4.

This report has been prepared as part of an Environmental Impact Statement to address the potential impacts upon and measures to protect noise amenity as requested from the NSW Environmental Protection Authority (EPA).

Consequently, this report discusses the following:

- Project overview which summarises extent of the redevelopment works and site layout.
- Unattended acoustic noise survey conducted in order to obtain existing ambient noise levels at the boundary of the nearest noise sensitive receivers
- Construction Noise and Vibration acoustic criteria which are based on regulatory requirements and guidelines typically used for acoustic assessments. These include:
    - NSW Industrial Noise Policy (INP)
    - NSW Interim Construction Noise Guideline (ICNG)
    - Assessing vibration: A technical Guideline.
- Construction Noise Impact Assessment which includes, when required, conceptual treatment.
- Establishment of noise and vibration criteria for typical each phase of the stage 4 construction, demolition and refurbishment.
- Present results of the predicted external noise levels at the facades of the residential, aged care and TAFE receivers using acoustic modelling software during typical operation of Stage 4 Construction.
- Strategies to mitigate the noise and vibration generated during the construction phase.
- Conclusions discussing the outcomes from the acoustic assessment.

The construction for stage 4 of the project includes 4 phases of demolition, construction and refurbishment works:

- Stage 4 Early Works – Demolition and Construction
- Stage 4 A – Demolition and Construction
- Stage 4 B – Demolition, Construction and Fitout
- Stage 4 C – Demolition, Construction and Refurbishment

There is intention to extend the hours of operation from Saturdays 8am – 1pm as outlined in the INCG to 8am – 4pm for construction works on Saturdays. Approval for extended work hours will be granted from the department of planning upon strong justification from the builders. The contractor will need to provide details of works to be done during 1pm – 4pm Saturdays and prove it can meet the more stringent noise affected receiver criteria outlined in this report.

2. Background Information

2.1 Information Sources

- Architectural drawings contained on Aconex transmittal received from: HDR RD TRANSMIT-000028
- 161116_D34_Project Scope_SSD
- SD_Transport Impact Assessment_Draft.pdf 03/05/16
- GTA Consultants "State Significant Development Transport Assessment" Draft Issue 18/11/2016
- WGE acoustic report – "State Significant Development – SSD" dated December 9 2016. "N_RE_008_S4_v3.pdf"
- NSW Environmental Protection Agency (EPA) letter of request for additional information for Environmental Assessment (EA) reference DOC17/278968 dated May 17 2017

2.2 Reference Documents

The acoustic assessment is also based on the following reference documents:

- NSW Industrial Noise Policy (NSW INP), issued on January 2000 by the NSW Environment Protection Authority (NSW EPA)
- Interim Construction Noise Guideline (NSW Department of Environment and Climate Change)
- NSW Road Noise Policy (NSW RNP), issued March 2011 and published by the Department of Environment, Climate Change and Water NSW, now part of the NSW EPA.
- NSW Environmental Noise Control Manual (NSW ENCM) dated 1994.
- Australian Standard, AS 2436-2010, "Guide to Noise Control on Construction, Maintenance and Demolition Sites".
- Assessing Vibration – A Technical Guideline (NSW AV-TG), issued February 2006 by the Department of Environment and Conservation NSW, now part of the NSW EPA.

The predicted noise levels presented in the quantitative assessment are based on the proposed construction program and equipment lists provided in this report.

3. Project Overview

3.1 Proposed Development

The DHS Redevelopment Stage 4 project scope is described as follows:

- Stage 4 – Site preparation works
    - Demolition of George Hatch and Existing Nurses Administration
    - Demolition of Existing Surgical Ward ('S' Block)
    - New Construction – Temporary Corridor Bypass Link
    - New Construction – 1 x permanent corridor bypass link south

- A new 3-storey clinical building comprising:
    - Ground Level
        - Medical Imaging
        - Emergency Department, including Short Stay Unit
        - A refurbished and expanded Main Entry
    - Level 1
        - Renal Dialysis Unit
        - Ambulatory Care Services
    - Level 2
        - 20 bed CCU/ Cardiovascular/ Stroke Unit
        - 12 bed ICU
        - Cardiovascular Suite
    - Level 3
        - Plant Area

- Other associated works
    - Expansion of on grade car parking facilities and improved access and wayfinding.
    - Dedicated ambulance access off Myall Street
    - Amendments to the Cobbora Road roundabout to facilitate entry to the Hospital
    - Demolition of Playmates/Doctors Accommodation
    - Demolition of external component of existing Ambulatory Care Unit
    - Landscaping including tree removal and other public domain works
    - Upgrades of related engineering services infrastructure supporting Stages 4.
    - Refurbishment of the two ICU ensuites within the medical inpatient ward (G-ward).

3.2 Site Description

The Dubbo Hospital is located along Myall Street in Dubbo, NSW. McGuinn Drive runs off Myall Street through the complex. Myall Street is situated off of the major road Cobbora Road and east of the train line as shown in Figure 1. Neighbouring receivers include:

- East – Residential Receivers on Leonard Street separated by the hospital car park.
- North – "Opal Dubbo", a specialist aged care facility and rural health school to the north east of the facility.
- West – Commercial premises (Opioid treatment centre), Train line and Residential Receivers.
- South – TAFE educational institution.

Redevelopment of the hospital complex in stage 4 includes demolition of 3 buildings in the southern section to make way for additional car parking spaces and ambulance access, as well as the demolishment of existing buildings to make way for the new development 4A and 4B.

Project Overview

Detailed staging plans for construction phases of stage 4 are shown in Figure 2, Figure 3 and Figure 4.

Figure 1: Site layout

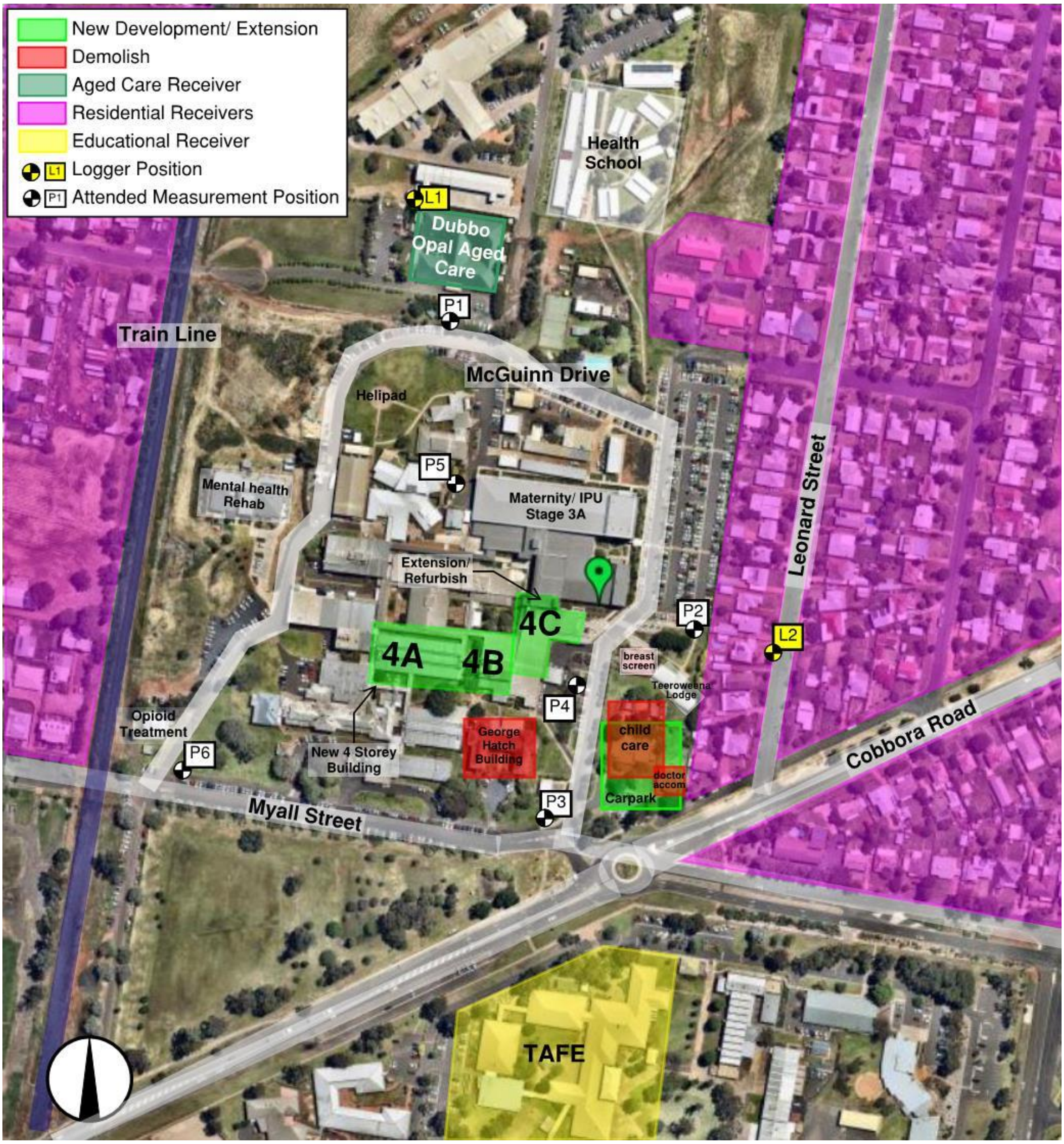


Figure 2: Construction Stage 4: Early Construction Works

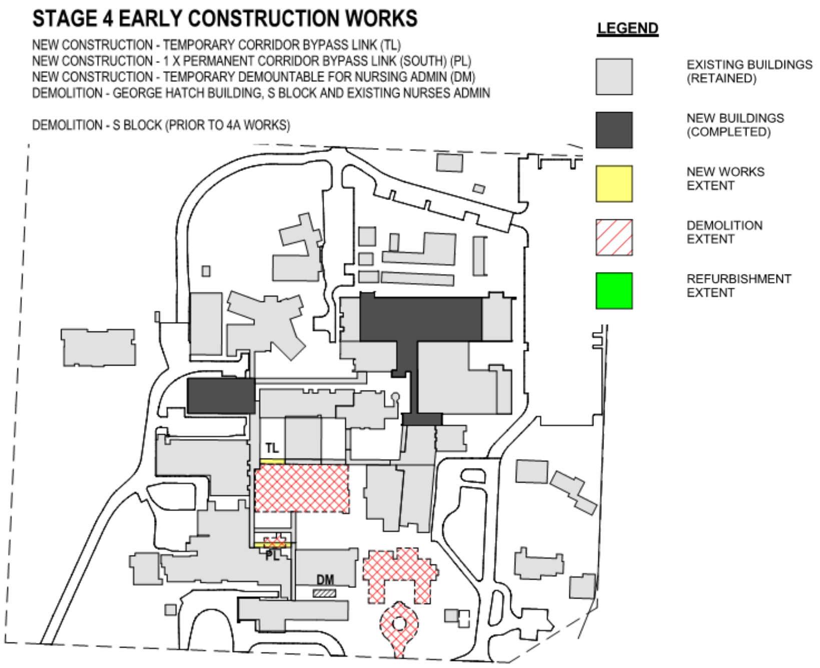
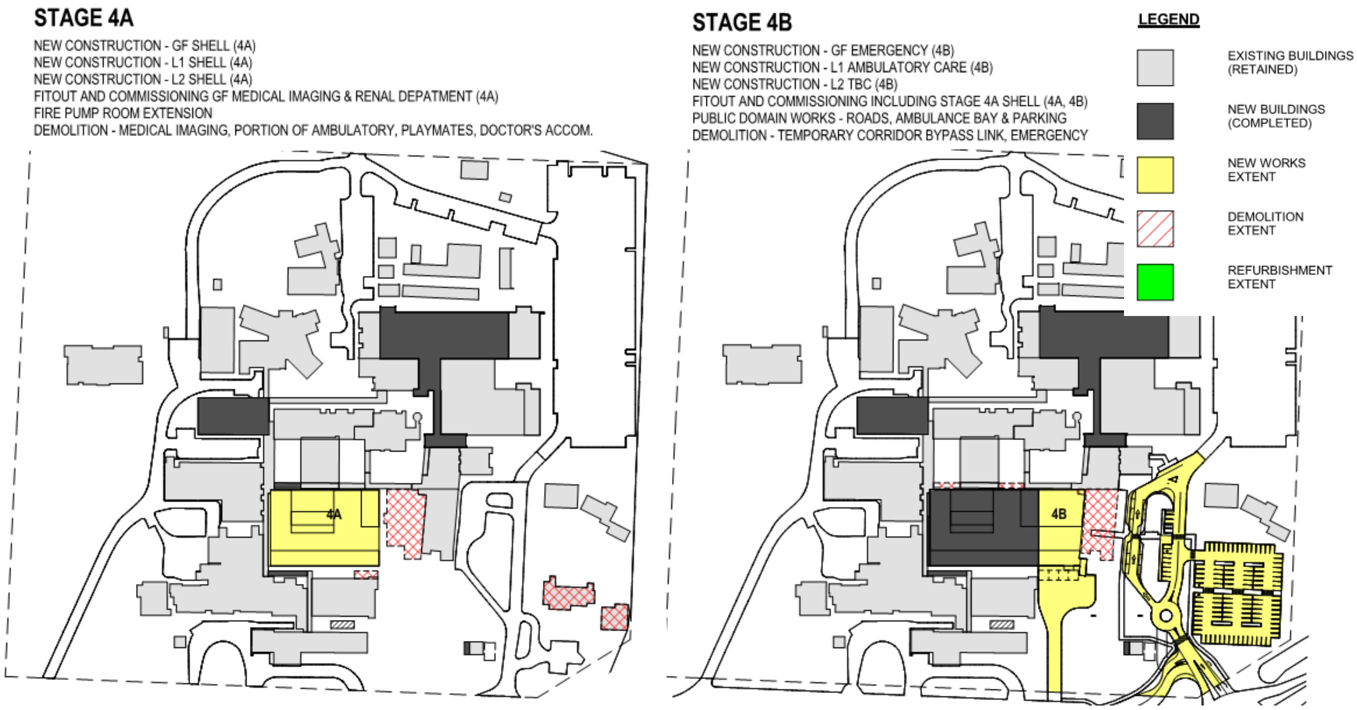
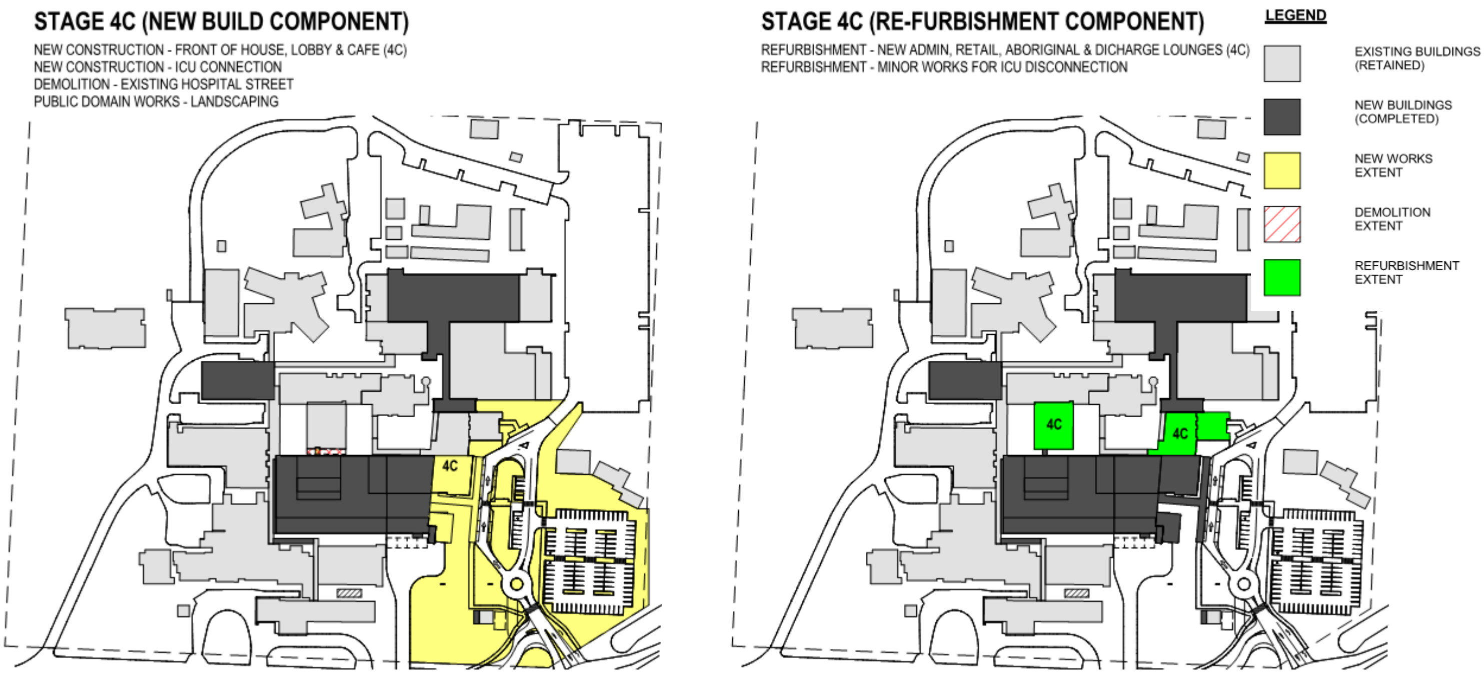


Figure 3: Construction Stages 4A and 4B



Project Overview

Figure 4: Construction Stage 4C



4. Noise Survey

4.1 Attended Traffic Noise Survey

Attended noise measurements were done on site over 2 days to capture typical noise environments in and around the hospital site. A Casella CEL-63X (serial number 3756128) was used in sound level meter mode to capture equivalent background noise in 15 minute intervals, as well as LA90 and LA10 values (see appendix 2 for definitions).

Attended traffic noise measurements of 15-minute duration were conducted on site (P3, P4, P5 and P6) to characterise the traffic noise local to the site. Additional attended noise measurements were conducted at the nearest residential receiver (P1 and P2) to attain a background noise spectrum at the façade of the residential receiver. The attended traffic noise measurements were conducted during AM peak hour as this is considered to be the noisiest period during the week. The attended noise measurement at the façade of the residential receiver was conducted at 9:30pm as this is the quietest period prior to midnight. A summary of the attended noise measurements is shown below in Table 1.

Table 1: Attended noise measurements

Measurement Location (Refer to Figure 1)	Measurement Time	$L_{Aeq,\ 15mins}$ dB(A)	L_{A90} dB(A)	L_{A10} dB(A)	Comments
P1	9:17pm – 9:32pm	54.7	44.5	55	- Bins wheeling past from caged services utility area - Freight trains in distance - revving cars in distance from main road
P2	9:44pm – 9:59pm	46.7	44	52.5	- small group of people outside doctor’s accom - faint rattling of train passing - very little foot or vehicle traffic
P3	9:56am – 10:02am	60.9	55.5	63.5	- little pedestrian traffic, birds chirping - Continuous vehicle traffic in round about - lots of van, trucks and 4WDs
P4	10:06m – 10:13am	54.3	48.5	56	- minimal cars, driving slowly - traffic heard from main road (P3) - relatively little pedestrian movement
P5	10:20pm – 12:27am	51	49	51	- no pedestrians, some birds, little road traffic noise - mostly plant noise from surrounding buildings
P6	10:30pm – 12:37am	52.6	46.5	55	- Traffic from main road - Light traffic entering and existing facilities - small amount of pedestrian movement

4.2 Unattended Measured Noise Levels

Unattended noise measurements of existing ambient noise levels were conducted between 23rd June 2017 and 3rd July 2017. The measurements were undertaken using Environmental Noise Logger Types NL-42EX (serial numbers 521656 and 521657). The location where the loggers were deployed on site is identified as *L1* and *L2* in Figure 1.

This was the second instance of noise monitoring at the boundary of nearby receivers. In accordance with a letter from the EPA to conduct noise monitoring “at the nearest affected residential receivers to determine project specific noise levels in the ***absence of noise from the hospital site***.” To monitor receivers that were both nearby AND without noise contribution from the hospital, locations were chosen further back from the hospital than the initial measurements (at P1 and P2 locations). This included the front yard of the 49 Leonard St to the east, and the rear boundary of the nursing home to the north.

Noise Survey

The loggers were set to measure continuous measurements at 15 minute intervals. The instrument was calibrated prior to and after the survey using a noise calibrator which emitted a calibration tone of 94 dB(A) at 1 KHz. No significant drift was noted during the calibration procedure.

Additionally, in order to confirm that the measurement data was obtained during favourable weather conditions, weather data such as rainfall and wind speed was obtained from the nearest meteorological station which is located at Dubbo Airport AWS (station ID 065070). Consequently, measured noise information was excluded if:

- Rain was observed during a 15 minute measurement period; and / or;
- Wind speed at 1.5m above ground exceeded 5 m/s, (18 km/h)

Weather data was obtained from the Bureau of Meteorology and is shown below in Figure 7 for the dates during noise monitoring.

Table 2 summarises the measured noise levels from the unattended noise survey. The data was processed into the time periods as defined in the NSW INP. These time periods are the following:

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

Table 2: Summary of unattended noise measurements

Location	Rating Background Noise (RBL) Level - LA90			Equivalent Continuous Noise Level - LAeq		
	Day	Evening	Night	Day	Evening	Night
L1	40	41	36	57	47	58
L2	41	42	33	56	54	49

Refer to Appendix 2 and 3 for a visual representation of daily noise levels and corresponding weather data measured during the unattended noise survey.

Figure 5 and Figure 6 show a weekly snapshot of unattended measurements at L1 and L2 accordingly.

Figure 5: L1 Weekly Noise Data

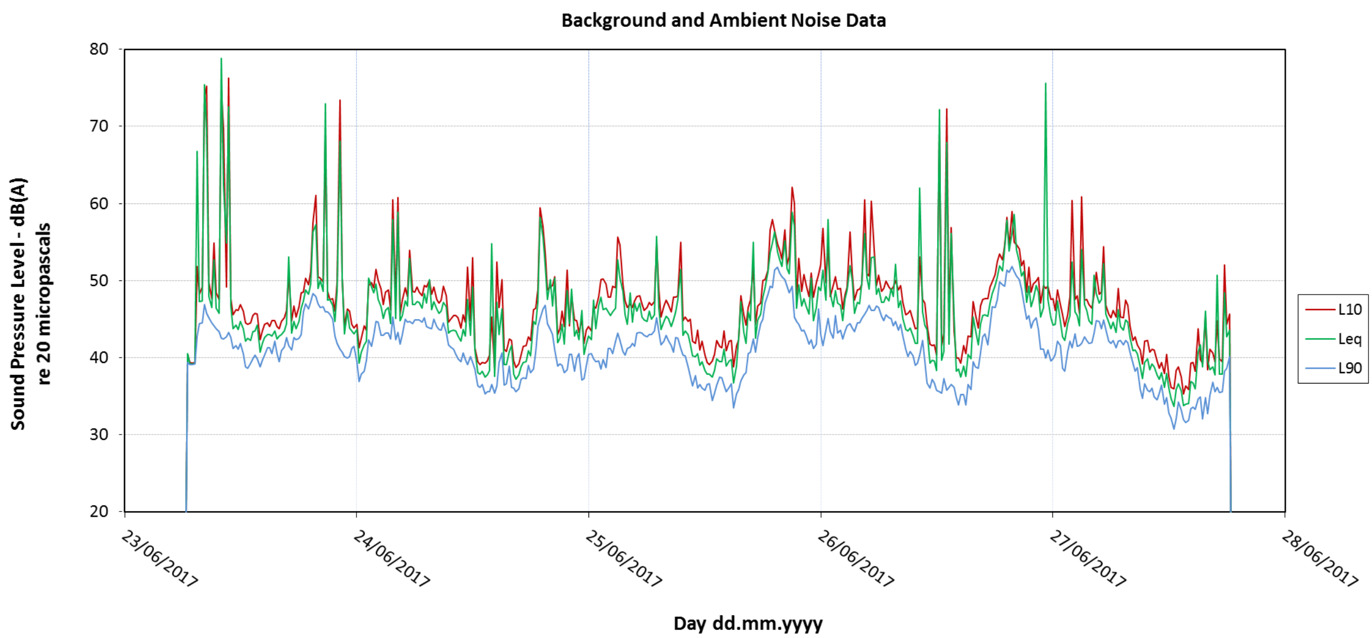


Figure 6: L2 Weekly Noise Data

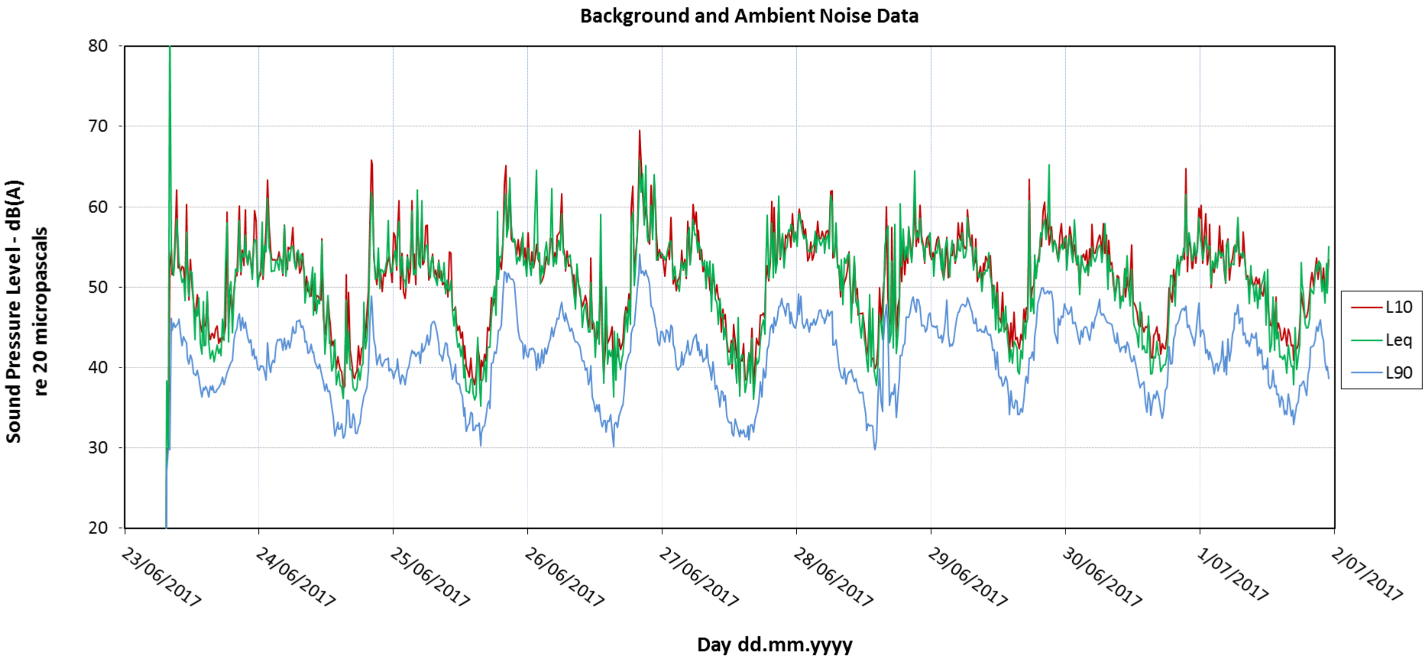
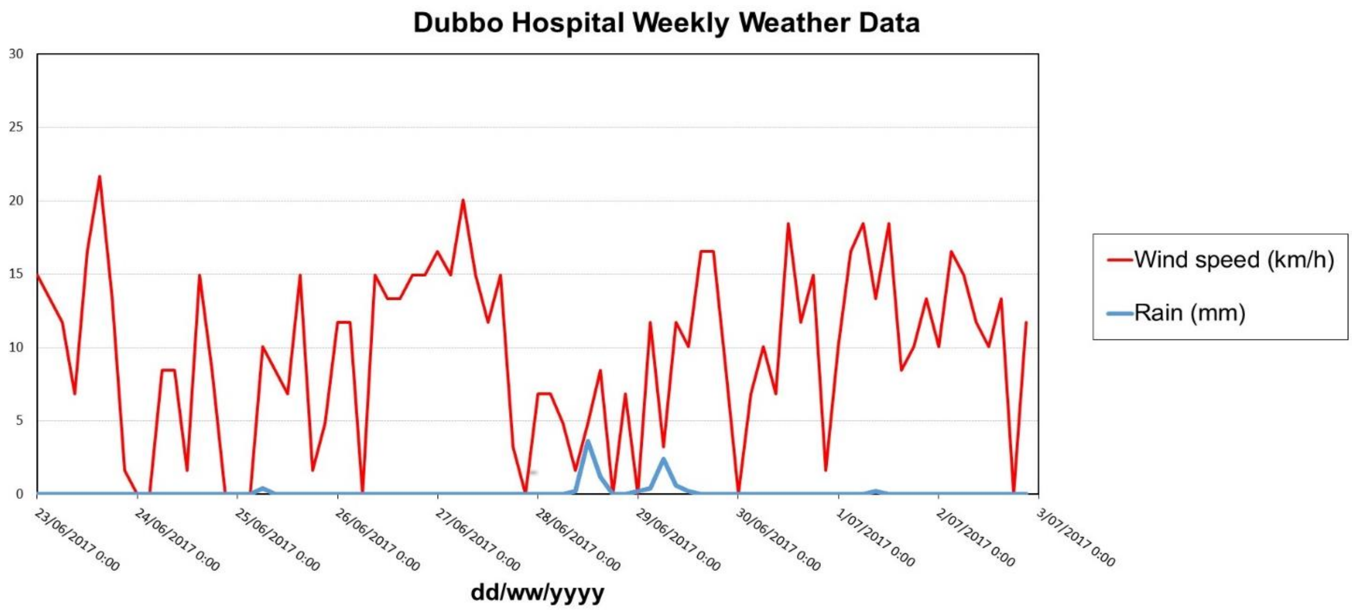


Figure 7: Weekly Weather Data



5. Acoustic Criteria

5.1 Construction Noise Criteria

The noise criteria for construction sites are established in accordance with the Interim Construction Noise Guideline (ICNG July 2009) by the Office of Environment and Heritage (OEH). This document is referred to as OEH's standard policy for assessing construction noise on new projects.

The key components of the ICNG 2009 incorporated into this assessment include:

1. **Use of LAeq as the noise metric for measuring and assessing construction noise**
   In recent years, NSW noise policies including OEH INP and the NSW Environmental Criteria for Road Traffic Noise (ECRTN) have selected the LAeq to be the primary noise metric when measuring and assessing construction noise. Consistent with ICNG 2009, the use of the LAeq as a key descriptor for measuring and assessing construction noise may follow a 'best practice' approach.

2. **Application of feasible and reasonable noise mitigation measures**
   As stated in the ICNG 2009, a noise mitigation measure is feasible if it is capable of being put into practice, and is practical to build given the project constraints. Selecting reasonable mitigation measures from those that are feasible requires one to determine whether the overall noise benefit of applying the measure outweighs the overall social, economic and environmental effects, including the cost of the measure.

3. **Quantitative and qualitative assessment**
   The ICNG 2009 provides two methods for assessment of construction noise, being either a quantitative or a qualitative assessment.

   A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement and prediction of noise levels, and assessment against set criteria.

   A qualitative assessment is recommended for small projects with a short-term duration where works are not likely to affect an individual or sensitive land use for more than three weeks in total. It focuses on minimising noise disturbance through the implementation of feasible and reasonable work practice, and community notification.

   Given the significant scale of the construction works proposed for this Project, a quantitative assessment is carried out herein, consistent with the ICNG 2009 requirements.

4. **Management levels**

   Table 3 below (based on the ICNG criteria and the Conditions of Consent construction hours) sets out the noise management levels and how they should be applied. The guidelines intend to provide respite for residents exposed to excessive construction noise outside the recommended standard hours whilst allowing construction during the recommended standard hours without undue constraints.

   The rating background level (RBL) is used when determining the management level. The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours).

Acoustic Criteria

Table 3: OEH ICNG Construction Noise Criteria at Residences

Time of Day	Management Level $L_{Aeq,15min}$ *	How to Apply
Recommended Standard Construction Hours Mon – Fri (7am – 6pm) Sat (8am – 1pm)	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 residences of the nature of works to be carried out, the expected noise levels and duration as well as contact details.
	Highly Noise Affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur in, taking into account: 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 + 5dB	• The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

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

Table 4 (reproduced from Table 2 Sec 4.1.1 (Chapter 4) of the ICNG 2009) sets out the noise management levels for various sensitive land use developments. Other businesses that may be sensitive to noise including the opioid treatment facility at 170 Myall St, the recommended 'maximum' internal noise levels should comply with in AS/NZS 2107:2000. These are also presented in Table 4.

Table 4: OEH ICNG Construction Noise Criteria at Other Sensitive Land Uses

Land Use	Management Level, $L_{Aeq,15min}$ – applies when land use is being utilized
Classrooms at schools and other educational institutions	Internal noise level 45 dB(A)
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Active recreation areas	External noise level 65 dB(A)
Passive recreation areas	External noise level 60 dB(A)
Opioid Treatment – Waiting room	Internal Noise level 50 dB (A)
Opioid Treatment – Consult room	Internal Noise level 45 dB (A)

5.1.1 Project Specific Noise Levels

Given the criteria set out in Section 5, and the Unattended Measurement results, the Project Specific Construction Noise Levels are adopted as per Table 5.

Table 5: Project Specific Noise Levels

Time of Day	Management Level $L_{Aeq(15min)}$	Affection of noise on receiver
Standard Hours Monday – Friday 7am - 6pm Saturday 8am – 1pm	51 dB (A)	Noise Affected
	$\geq$ 75 dB(A)	Highly Noise Affected
Outside of Standard Hours	46 dB (A)	Noise Affected

5.2 Construction Vibration Criteria

The NSW EPA has issued a document titled *"Assessing vibration: A technical Guideline"* (NSW AV TG) which is dated February 2006. This document has been produced in order to assist on the assessment of vibration levels. The guideline does not however address vibration induced damage to structures or structure-borne noise effects.

For human comfort, vibration and its associated effects are usually classified as continuous, impulsive or intermittent

5.2.1 Human Comfort – Continuous and Impulsive Vibration Criteria

Structural vibration in buildings can be detected by occupants and can potentially have an impact on human comfort. This impact is influenced by the activity conducted by those affected (i.e. use of the building) and the time when the vibration levels occur.

Maximum allowable magnitudes of vibration levels with respect to human response are shown in Table 6. Please note that the assessment period is defined as follows:

- Daytime extends from 7 am to 10 pm.
- Night-time is from 10 pm to 7 am.

Table 6: Preferred and maximum weighted RMS values for continuous and impulsive vibration acceleration (m/s2) 1-80Hz

Location	Assessment period	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration					
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 place of worship	Day or night time	0.020	0.014	0.040	0.028
Critical areas	Day or night time	0.0050	0.0036	0.010	0.0072
Impulsive vibration					
Residences	Daytime	0.30	0.21	0.60	0.42
	Night time	0.10	0.071	0.20	0.014
Offices, schools, educational institutions and place of worship	Day or night time	0.64	0.46	1.28	0.92
Critical areas	Day or night time	0.0050	0.0036	0.010	0.0072

5.2.2 Human Comfort – Intermittent Vibration Criteria

For intermittent events, the vibration assessment is based on Vibration Dose Values (VDVs). VDVs are used in order to evaluate the cumulative effects of intermittent vibration. Various studies support the fact that VDV assessment methods are far more accurate in assessing the level of disturbance than methods which is only based on the vibration magnitude.

Table 7: Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime (7:00am to 10:00pm)		Night-time (10:00pm to 7:00am)	
	Preferred value	Maximum value	Preferred value	Maximum value
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and place of worship	0.40	0.80	0.40	0.80
Critical areas	0.10	0.20	0.10	0.20

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

5.2.3 Structural Damage – Vibration Criteria

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

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

Table 8 indicates the vibration limits presented in DIN4150-Part 3 to ensure structural damage does not occur.

Table 8: Guideline value of vibration velocity (vi) for evaluating the effects of short term vibration

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

Table 9 presents guide values for building vibration, based on the lowest vibration levels above which cosmetic damage has been demonstrated as per BS 7385-Part 2:1993.

Table 9: Transient vibration guide values for cosmetic damage

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

5.2.4 Criteria for Vibration Sensitive Equipment

Vibration criteria for vibration sensitive equipment has been compiled by the American Society of Heating and Refrigeration Engineers (ASHRAE) and published in the *ASHRAE Handbook - HVAC Applications* Figure 8 below summarises these criteria.

Certain hospital equipment has been identified as such vibration sensitive equipment. Hence, in general terms, the applicable criteria for this equipment correspond to the following curves:

- Operating room, for equipment in operating theatres.
- Curves VC-A, VC-B and VC-C for vibration sensitive equipment such as MRIs, CT scanners, etc.

Also please refer to vibration criteria discussed in Section 6 which are classified under *Critical Areas.*

Please note that specific criteria for this equipment are likely to be within the margins of the general criteria provided above. Hence it is recommended that hospital staff or the equipment manufacturer should provide specific vibration criteria for each vibration sensitive instrument.

Figure 8: Building vibration criteria for vibration measured on building structure

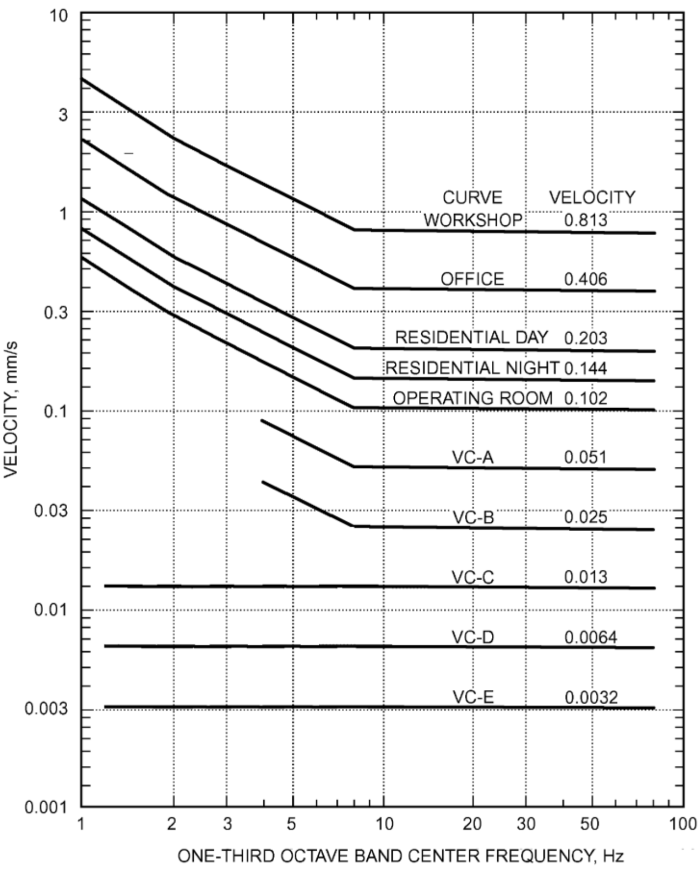


Table 46 Human Comfort and Equipment Vibration Criteria

Human Comfort	Time of Day	8 to 80 Hz Curve,[a] mm/s
Workshops	All	0.813
Office areas	All[b]	0.406
Residential (good environmental standards)	0700-2200[b]	0.203
	2200-0700[b]	0.144
Hospital operating rooms and critical work areas	All	0.102
Equipment Requirements		**Curve[a]**
Adequate for computer equipment, probe test equipment, and microscopes less than 40×		0.203
Bench microscopes up to 100× magnification; laboratory robots		0.102
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
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[c]		0.025
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[c]		0.013
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[c]		0.0054
Unisolated 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[c]		0.0032

[a]See Figure 37 for corresponding curves.
[b]In areas where individuals are sensitive to vibration, use Residential Day curve.
[c]Classes of microelectronics manufacturing equipment:

5.3 Vibration Levels from Construction and Demolition Activities

The vibration associated with construction is dependent on a number of variables including the types of machinery, the proximity to the nearby receivers as well as the ground type.
Safe working distances for vibration impacts associated with various types of machinery at given distances are presented within the *"Construction Noise Strategy "*document (issued by the Transport Infrastructure Development Corporation, dated November 2007). This document presents the safe construction working limits for Cosmetic Damage to adjacent structures and Human Comfort. It is recommended that the indicative safe working distances shown in Table 10 distance should be maintained from vibrating equipment to be used during demolition and construction tasks.

Table 10: Recommended indicative safe working distances

Plant Item	Rating / Description	Safe Working Distance (m)	
		Structural Cosmetic Damage	Human Comfort
Vibratory Roller	< 50 kN (Typically 1 – 2 tonnes)	5	15 - 20
	< 100 kN (Typically 2 – 4 tonnes)	6	20
	< 200 kN (Typically 4 – 6 tonnes)	12	40
	< 300 kN (Typically 7 – 13 tonnes)	15	100
	> 300 kN (Typically more than 13 tonnes)	20	100
Small hydraulic hammer	300 kg, typically 5 – 12 tonnes excavator	2	7
Medium hydraulic hammer	900 kg, typically 12 – 18 tonnes excavator	7	23
Large hydraulic hammer	1600 kg, typically 18 – 34 tonnes excavator	22	73
Vibratory pile driver	Sheet piles	2 – 20	20
Pile boring	≤ 800 mm	2	N/A
Jackhammer	Hand held	1	Avoid contact with structure (including slab reinforcements)

Further to the above the vibration criteria for vibration sensitive instrumentation (as discussed in Section 5.2.4) are more stringent than the criteria for human comfort. Therefore, the safe working distances could be increased for particular equipment. Therefore, the following is recommended:

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

Finally, the CNVMP should consider the following amelioration measures which are to be taken into account in order to minimise the transmitted vibration around the site:
- Monitor vibration levels using attended/un-attended methods during construction to manage excessive vibration.
- Manage construction program so as to minimise heavy machinery operating concurrently.
- Prepare dilapidation reports on adjacent structures and monitor the effects.
- As far as practical, locate heavy machinery away from nearby sensitive receiver

6. Construction Noise Assessment

6.1 Methodology and Assumptions

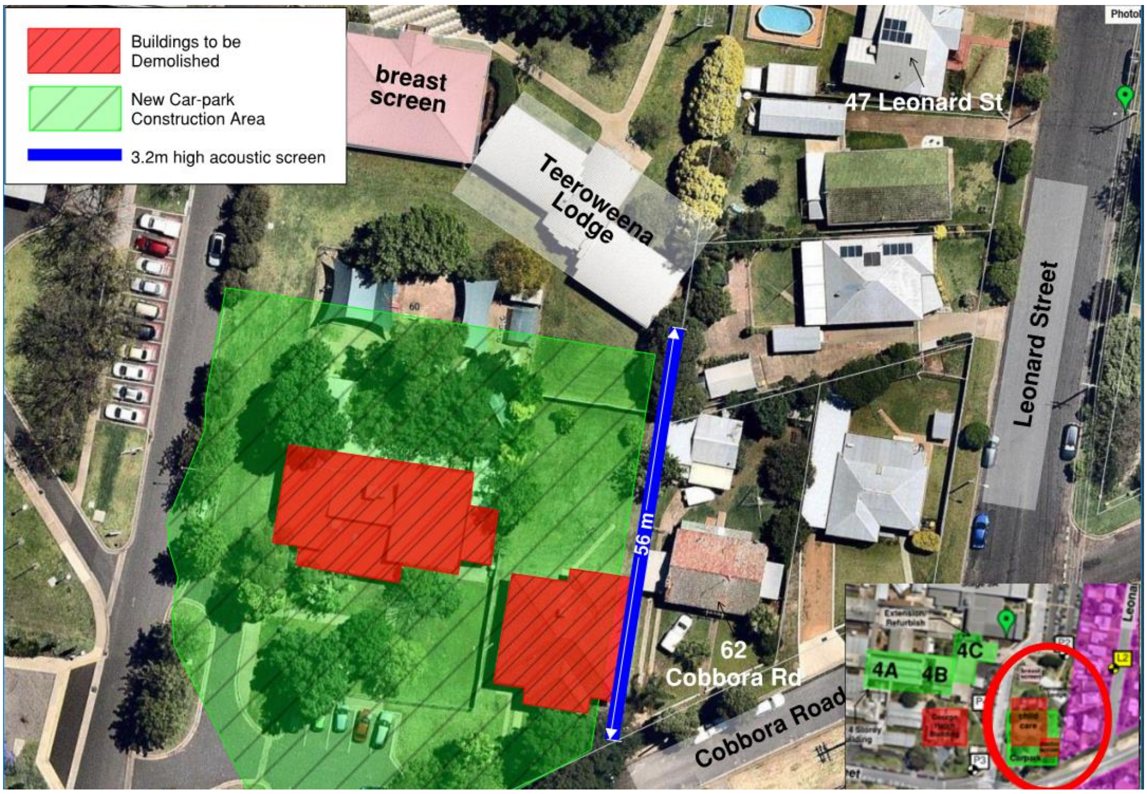
The noise emissions from construction associated with stage 4 of the Dubbo Health Services Redevelopment has been modelled in SoundPLAN 7.4. The modelling has been conducted using an implementation of the ISO 9613-2 Acoustics – Attenuation of the sound during propagation outdoors. The following features were included in the noise model:

- Ground topography
- Ground absorption
- Atmospheric absorption was based on an average temperature of 20°C and an average humidity of 60%
- Atmospheric propagation conditions were modelled with worst wind conditions (source to receiver)

The following assumptions for the premises noise model were made by WGE in order to estimate a suitable noise level corresponding to the type of activities and spaces:

- The equipment noise levels used have been based on AS2436:2010 and the NSW ICNG
- Equipment is used at varying frequency and duration, conservative use for each is shown in tables below
- An acoustic barrier shall be erected with a miniumum height 3.2m along the property boarder line between 60 and 62 Cobbora Road, from Cobbora Rd, back to the Teeroweena Lodge as shown in Figure 9.
    - This is a necessary mitigation measure for both noise and visual privacy for the demolition at 60 Coborra Rd to the neighbouring property at 62 Cobbora Rd.

Figure 9: Acoustic Screen for Construction to Cobbora Rd/ Leonard St Residences



In order to assess the magnitude of potential noise and vibration impacts during construction, a number of typical scenarios using various type of equipment have been used. These scenarios are summarized in Table 11 to Table 14. The equipment noise levels are extracted from AS2436:2010 "Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites" and Department of Environmental and Climate Change NSW – Interim Construction Noise Guideline (July 2009).

Table 11: Equipment Noise Schedule Stage 4 Early Works

Stage 4 Early Works	Equipment	SWL dB (A)	Operation per hour (mins)
Demolition	Excavator	107	40
	Jack hammer	121	40
	Bobcat	105	40
	Truck (6 tonnes)	107	32
	Crane (tower)	105	32
	Generator (diesel)	99	60
	AC unit (site office)	56	60
	Concrete saw	117	40
	Excavator with rock breaker	118	48
Construction	Excavator	107	40
	Generator (diesel)	99	60
	Crane (tower)	105	40
	Hand tools ie. hammers, hand held hydraulic breakers, impact drivers, rattle drills, hammer drills (electric)	102	48
	Forklift	106	40
	Concrete agitator truck	109	48
	Concrete saw	117	32
	Concrete pump truck	108	40
	Concrete vibrator screed	115	40
	AC unit (site office)	56	60

Table 12: Equipment Noise Schedule Stage 4A

Stage 4 A	Equipment	SWL dB (A)	Operation per hour (mins)
Construction	Excavator	107	40
	Crane (tower)	105	40
	Hand tools ie. hammers, hand held hydraulic breakers, impact drivers, rattle drills, hammer drills (electric)	102	48
	Forklift	106	40
	Concrete agitator truck	109	48
	Concrete saw	117	32
	Concrete pump truck	108	40
	Concrete vibrator screed	115	40
	AC unit (site office)	56	60
	Generator (diesel)	99	60
Demolition	Excavator	107	40
	Jack hammer	121	40
	Bobcat	105	40
	Truck (6 tonnes)	107	32
	Crane (tower)	105	32
	Generator (diesel)	99	60
	AC unit (site office)	56	60
	Concrete saw	117	40

Table 13: Equipment Noise Schedule Stage 4B

Stage 4 B	Equipment	SWL dB (A)	Operation per hour (mins)
Construction	Bobcat	105	40
	Truck (6 tonnes)	107	40
	Asphalt paver	108	48
	Concrete agitator truck	109	48
	Concrete saw	117	32
	Concrete pump truck	108	48
	Concrete vibrator screed	115	48
	AC unit (site office)	56	60
	Roller (vibratory)	108	40
	Generator (diesel)	99	60
	Crane (tower)	105	40
	Excavator	107	40
Fitout	Hand held jackhammers, hammer drills (pneumatic)	116	40
	Truck (6 tonnes)	107	40
	Crane (mobile)	104	40
	Crane (tower)	105	40
	AC unit (site office)	56	60
	Hand tools ie. hammers, hand held hydraulic breakers, impact drivers, rattle drills, hammer drills (electric)	102	40
Demolition	Excavator	107	40
	Jack hammer	121	40
	Bobcat	105	40
	Truck (6 tonnes)	107	32
	Crane (tower)	105	32
	Generator (diesel)	99	60
	AC unit (site office)	56	60
	Concrete saw	117	40
	Truck (dump)	117	48
	Excavator with rock breaker	118	48

Table 14: Equipment Noise Schedule Stage 4C

Stage 4 C	Equipment	SWL dB (A)	Operation per hour (mins)
Construction	Excavator	107	40
	Crane (tower)	105	40
	Hand tools ie. hammers, hand held hydraulic breakers, impact drivers, rattle drills, hammer drills (electric)	102	48
	Forklift	106	40
	Concrete agitator truck	109	48
	Concrete saw	117	32
	Concrete pump truck	108	40
	Concrete vibrator screed	115	40
	Generator (diesel)	99	60
	AC unit (site office)	56	60
Demolition	Excavator	107	40
	Jack hammer	121	40
	Bobcat	105	40
	Truck (6 tonnes)	107	48
	Crane (tower)	105	40
	Generator (diesel)	99	40
	AC unit (site office)	56	60
	Truck (dump)	117	40
	Excavator with rock breaker	118	40
	Concrete saw	117	40
Refurbishment	Hand held jackhammers, hammer drills (pneumatic)	116	40
	Truck (6 tonnes)	107	40
	Crane (mobile)	104	40
	Crane (tower)	105	40
	AC unit (site office)	56	60
	Hand tools ie. hammers, hand held hydraulic breakers, impact drivers, rattle drills, hammer drills (electric)	102	40

6.2 Noise Assessment Results

Acoustic modelling of the development and surrounding receivers have been completed and resulting noise impact shown for each phase of the construction. Figure 10 to Figure 11 show the noise contours for each phase of the construction and the impact it is predicted to have on each receiver.

Figure 10: Stage 4 Early Works: Demolitions Noise Contour

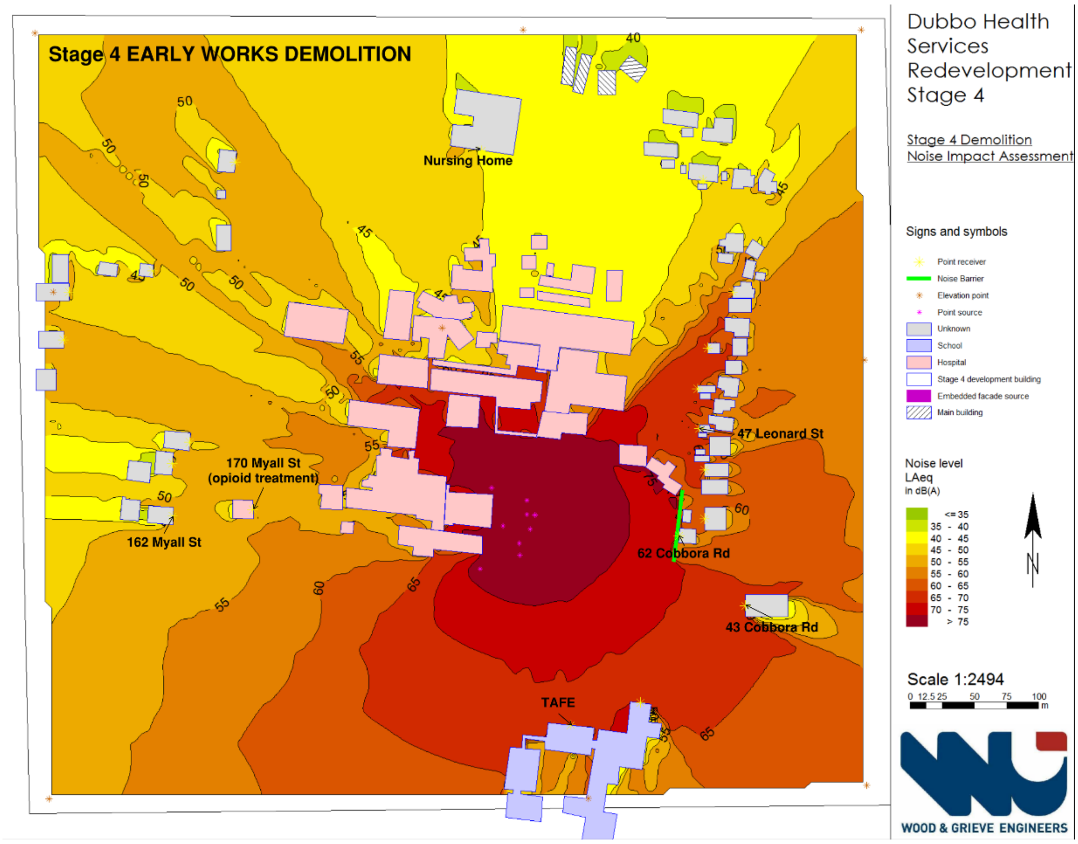


Figure 11: Stage 4 Early Works: Construction Noise Contour

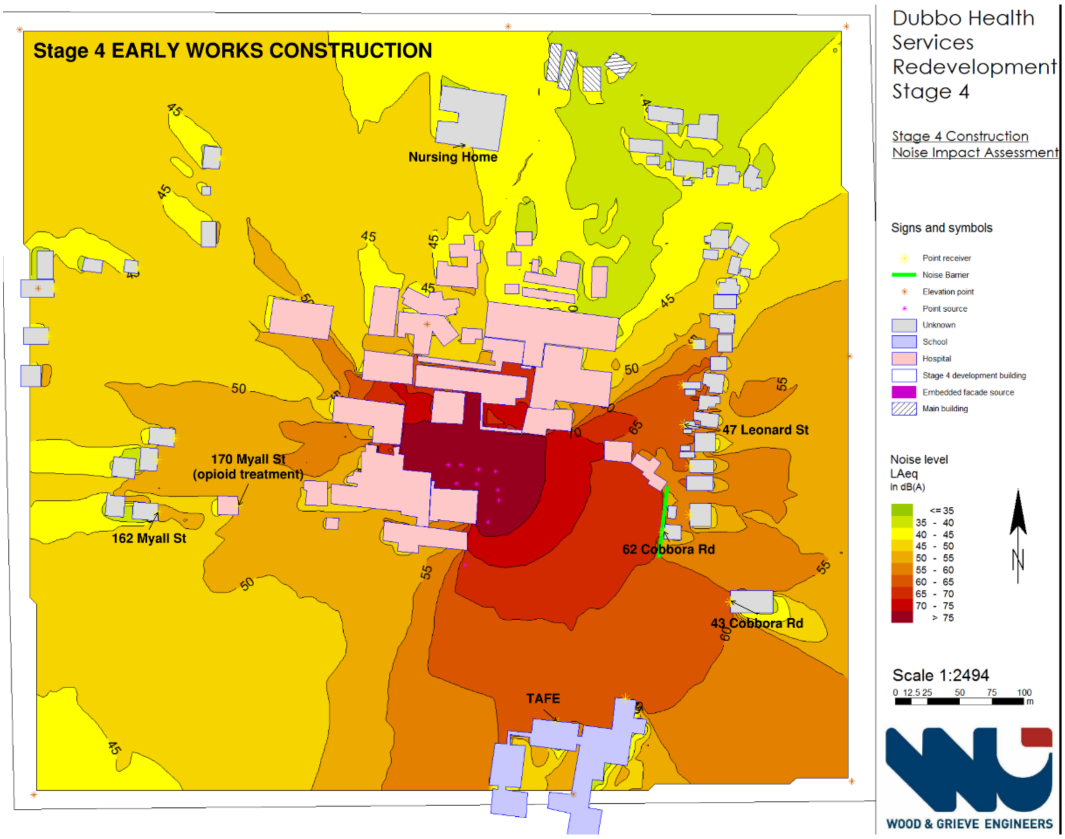


Figure 12: Noise Affected Receivers During Stage 4 Early Works Construction Phase

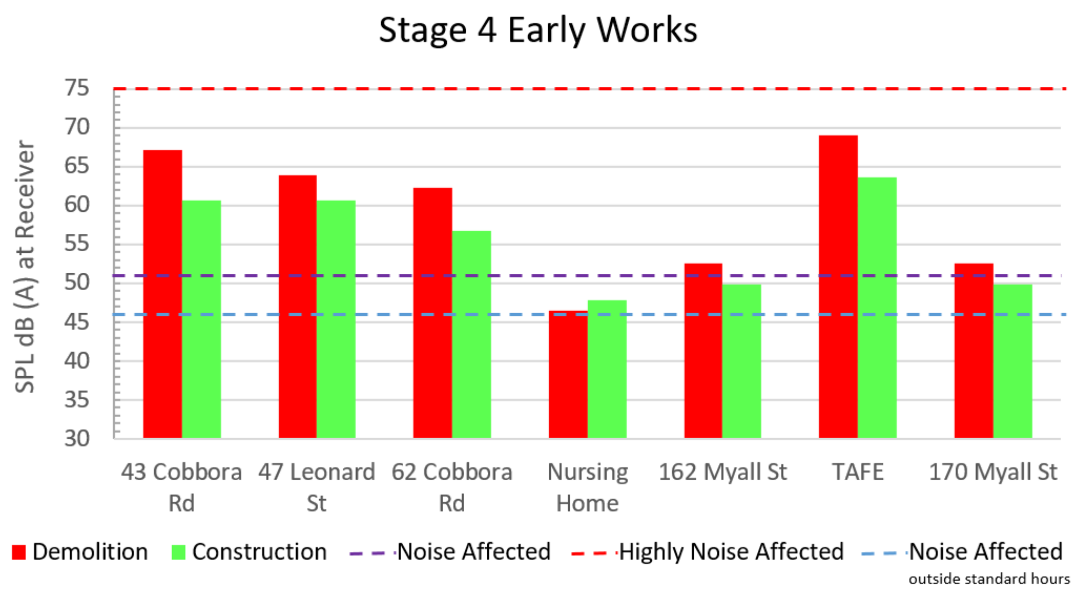


Figure 13: Stage 4A Demolition Noise Contour

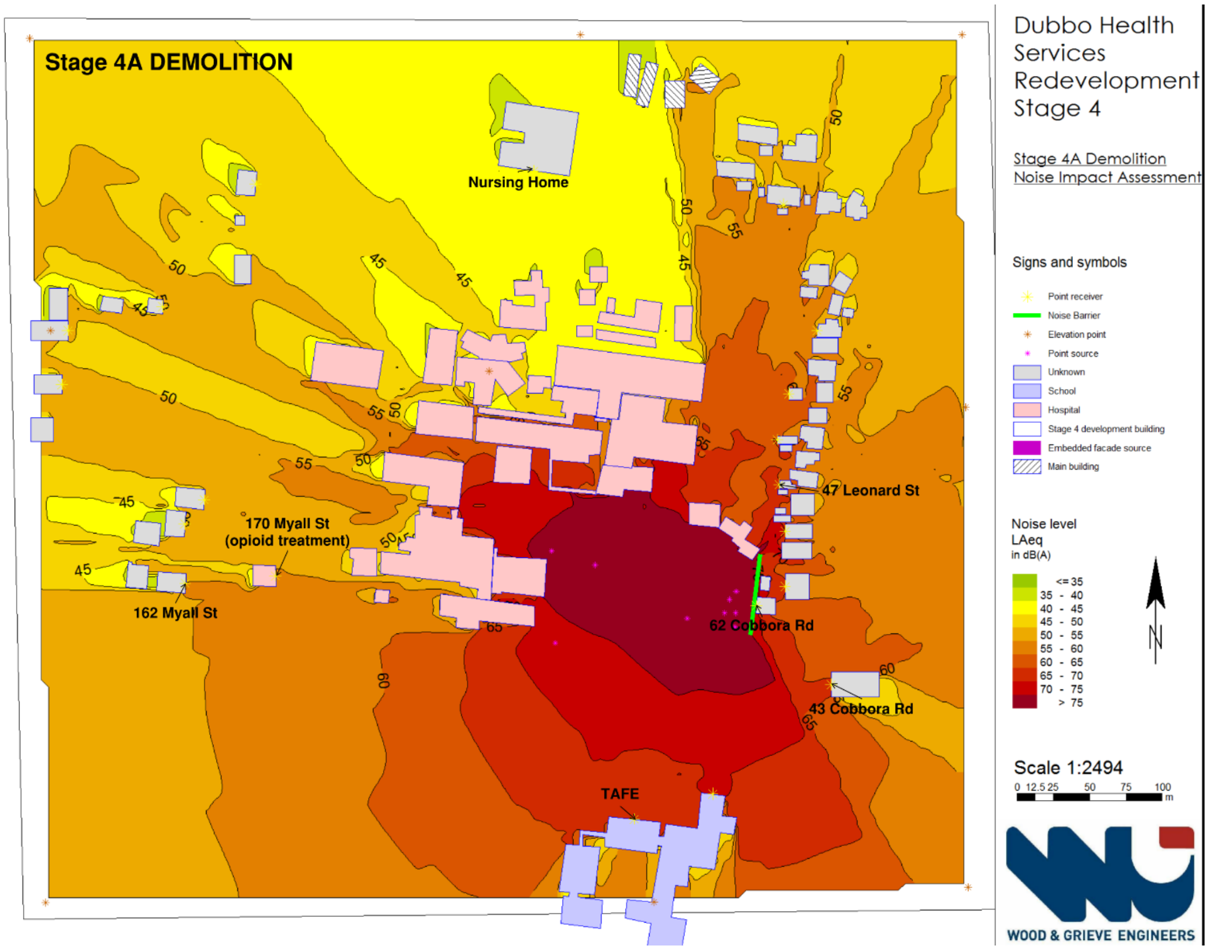


Figure 14: Stage 4A Construction Noise Contour

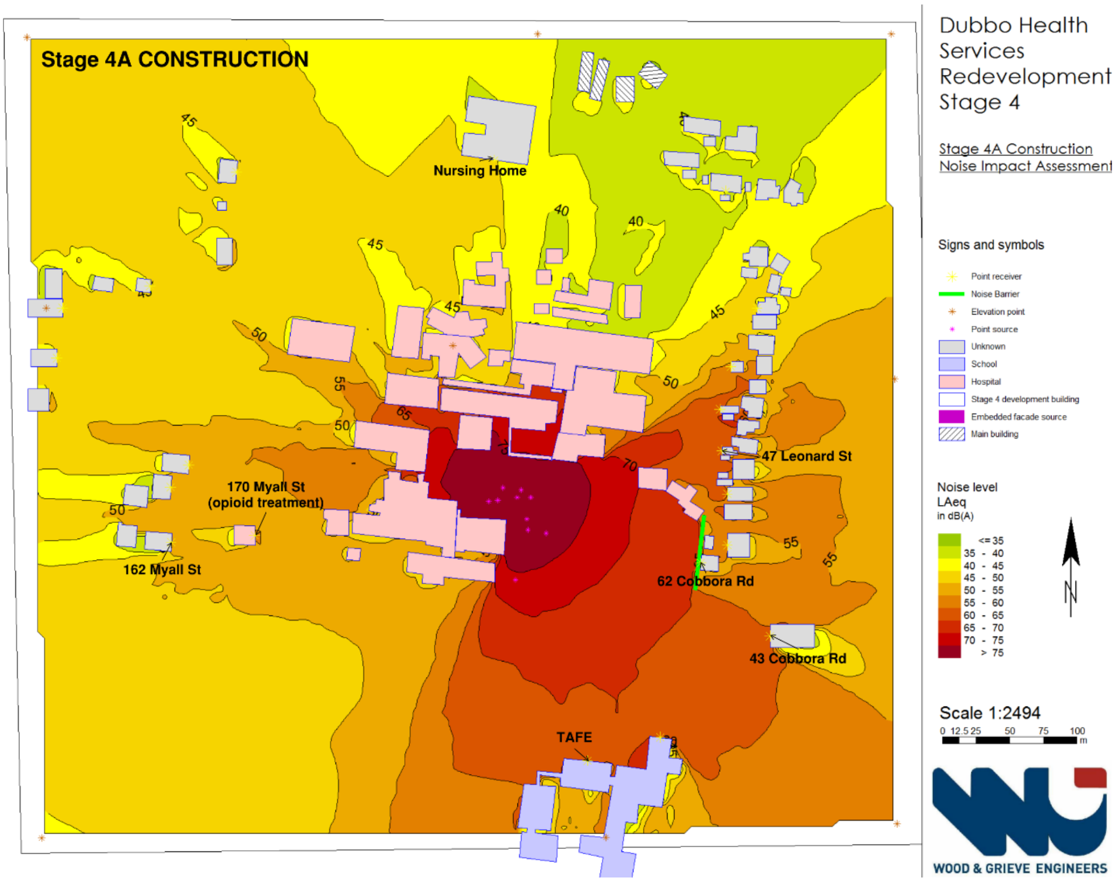


Figure 15: Noise Affected Receivers During Stage 4A

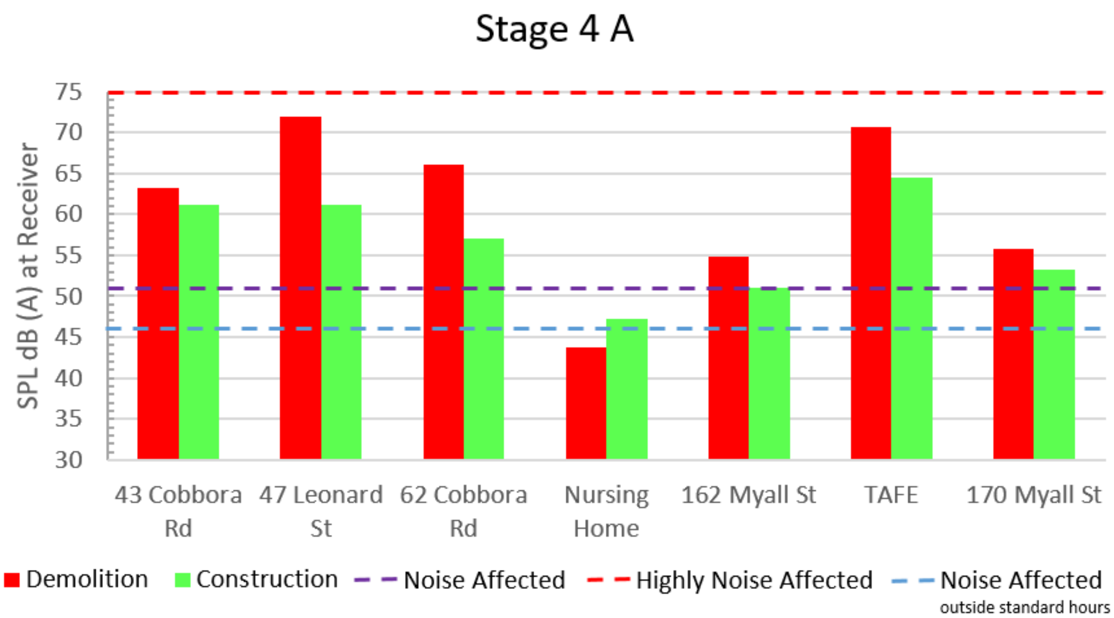


Figure 16: Stage 4B Demolition Noise Contour

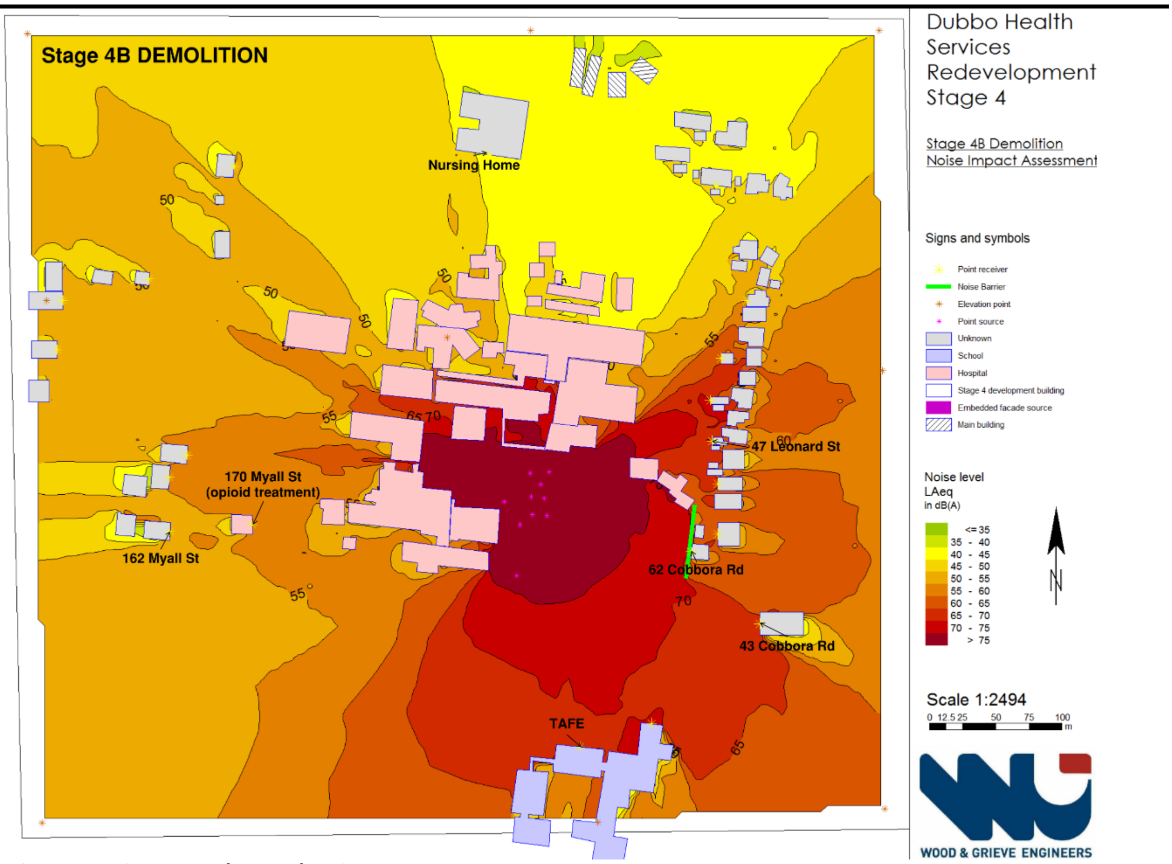


Figure 17: Stage 4B Construction Noise Contour

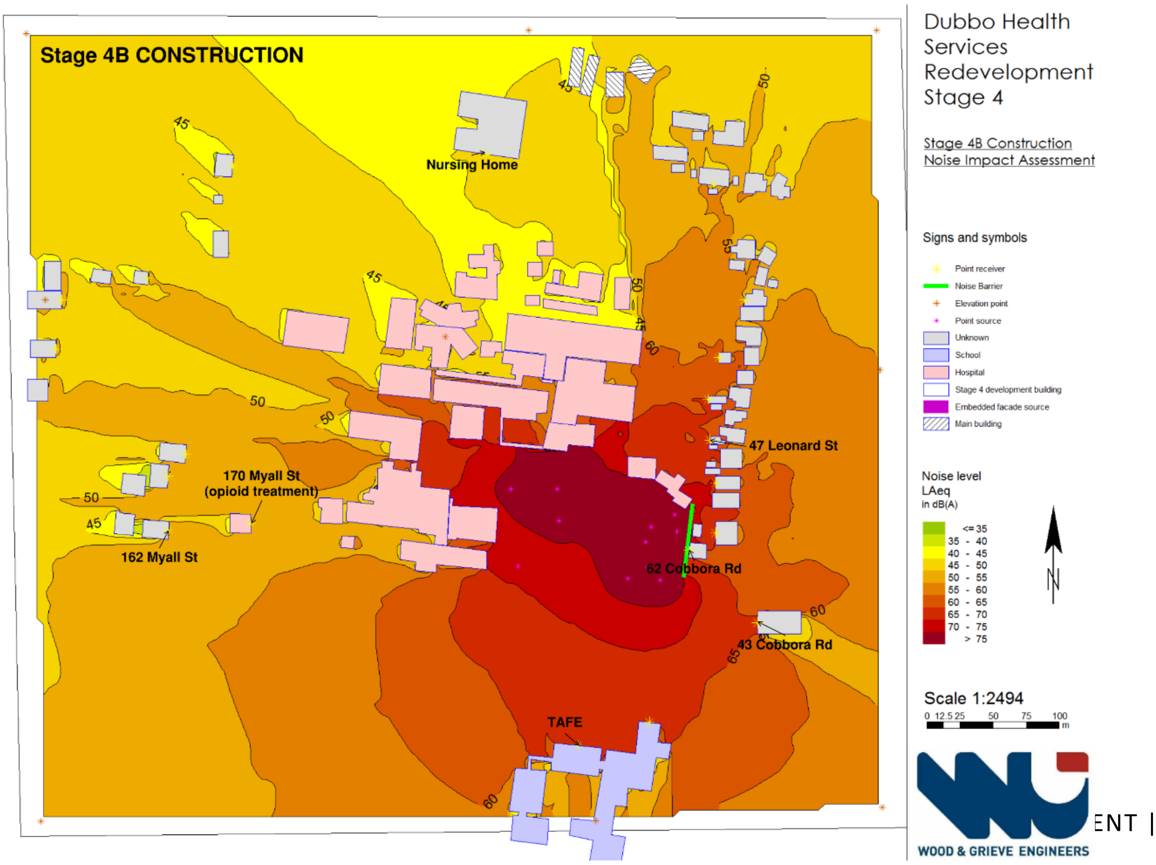


Figure 18: Stage 4B Fit-Out Works Noise Contour

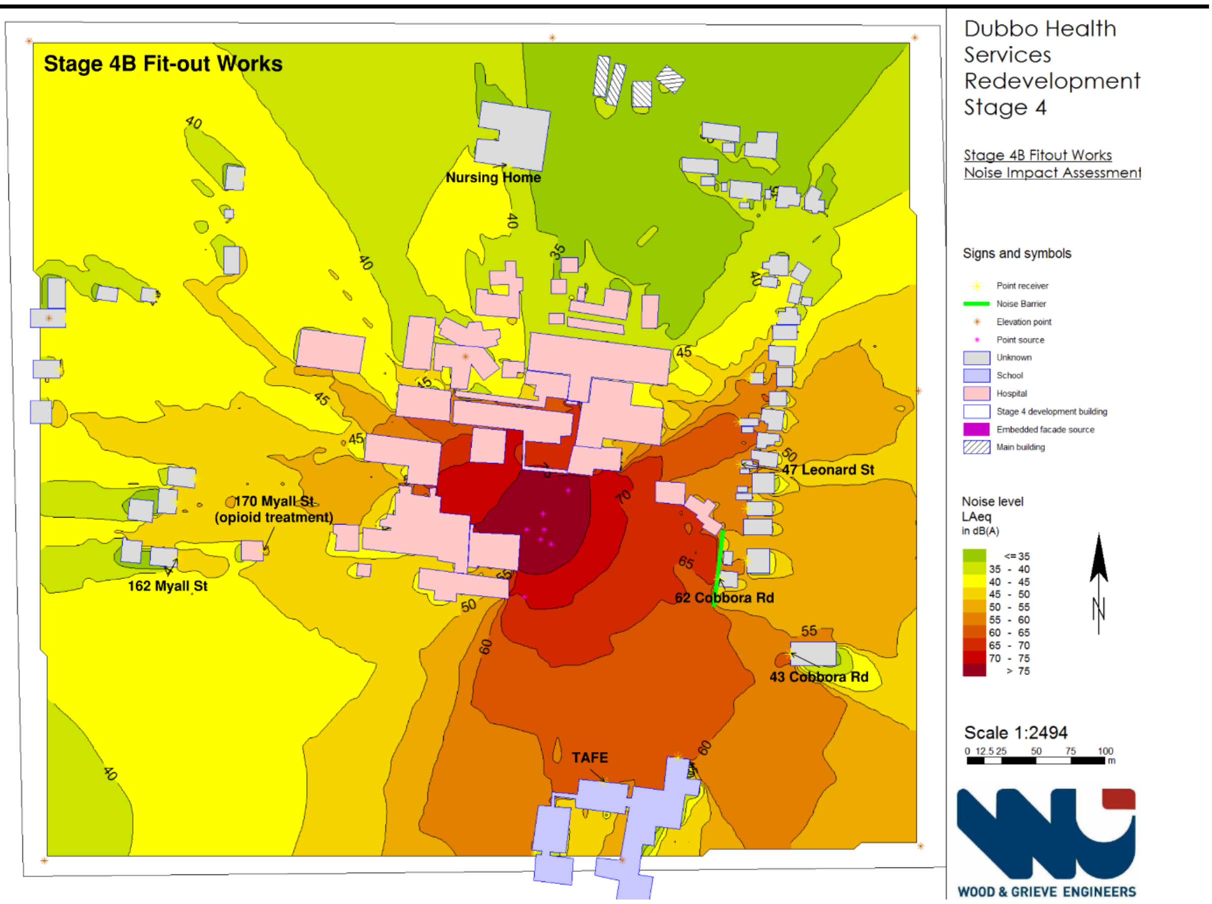


Figure 19: Noise Affected Receivers During Stage 4B

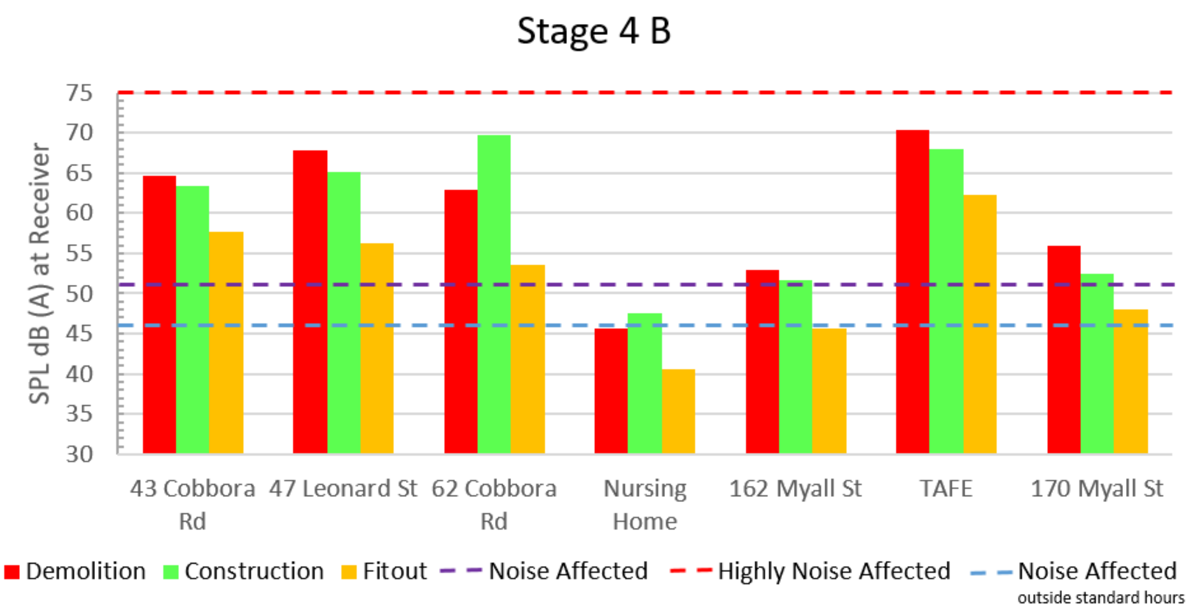


Figure 20: Stage 4C Demolition Noise Contour

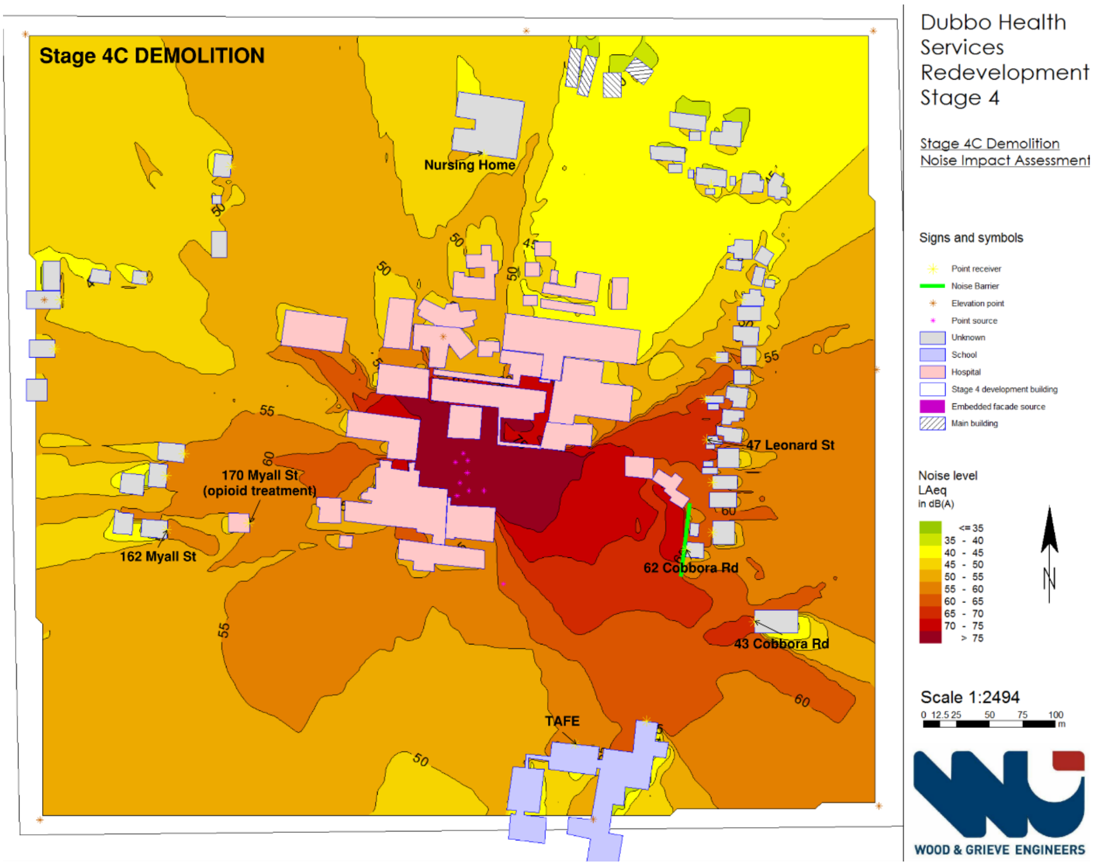


Figure 21: Stage 4C Construction Noise Contour

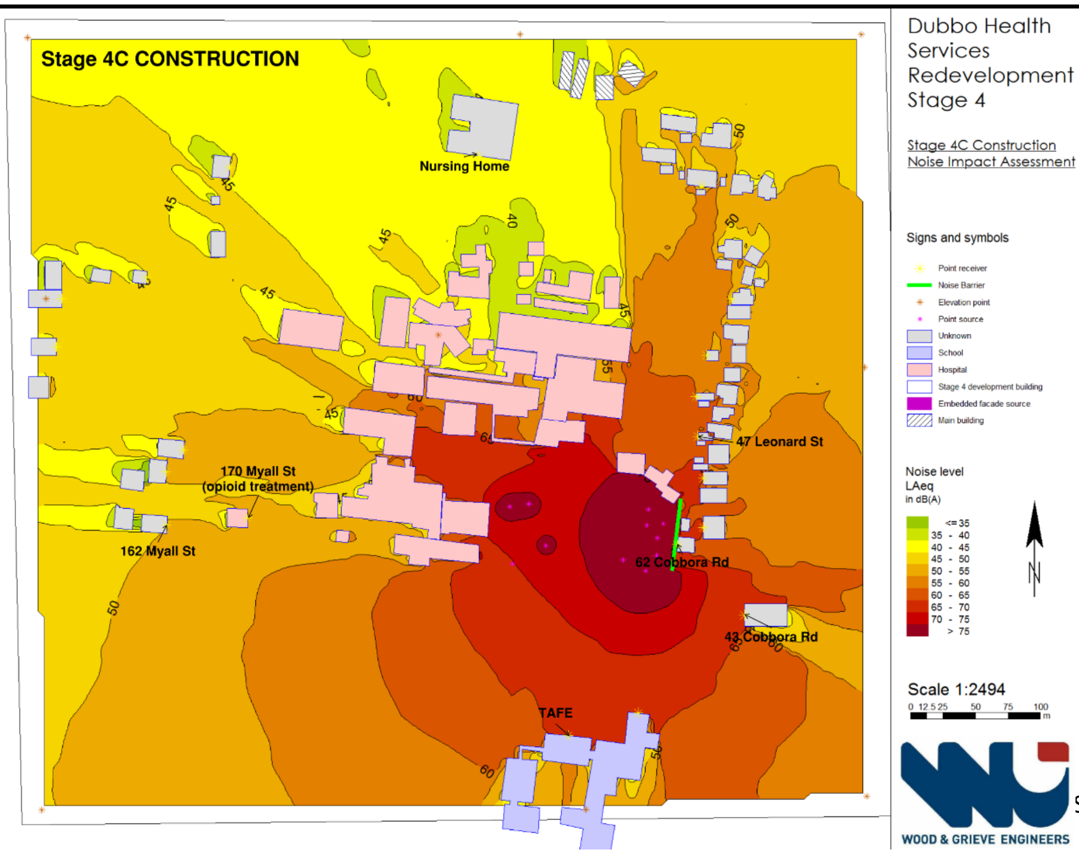


Figure 22: Stage 4C Refurbishment Works Noise Contour

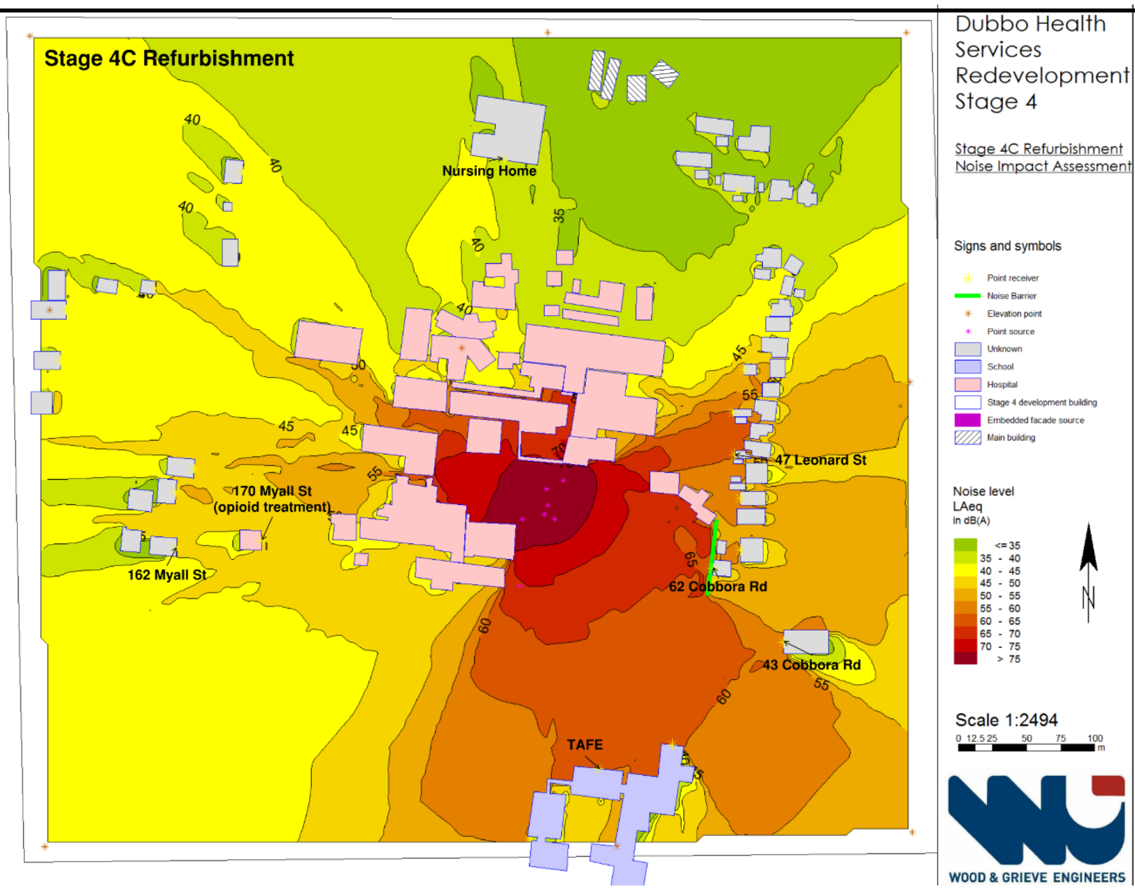
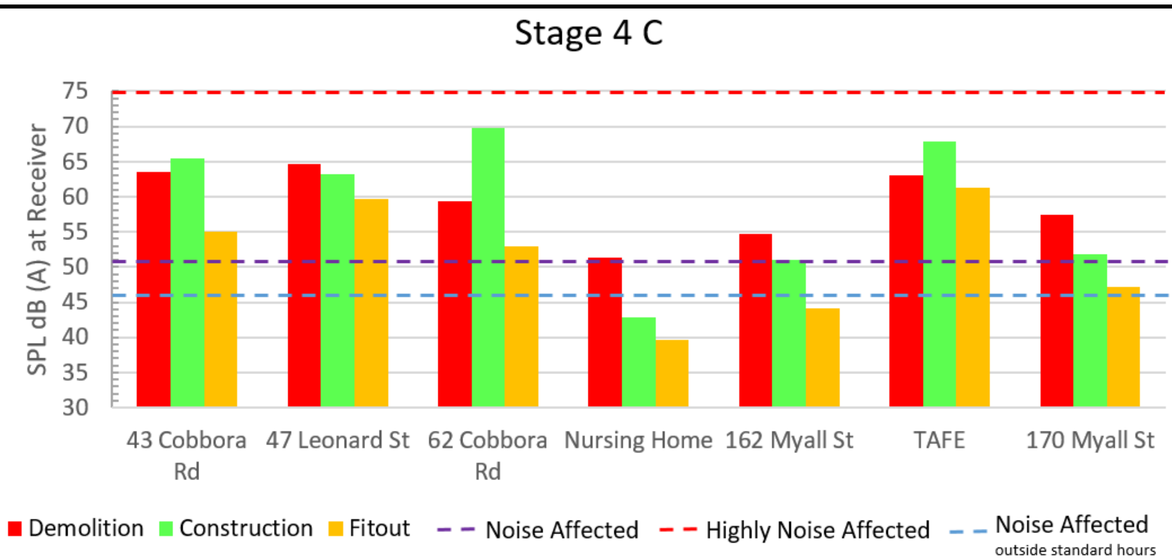


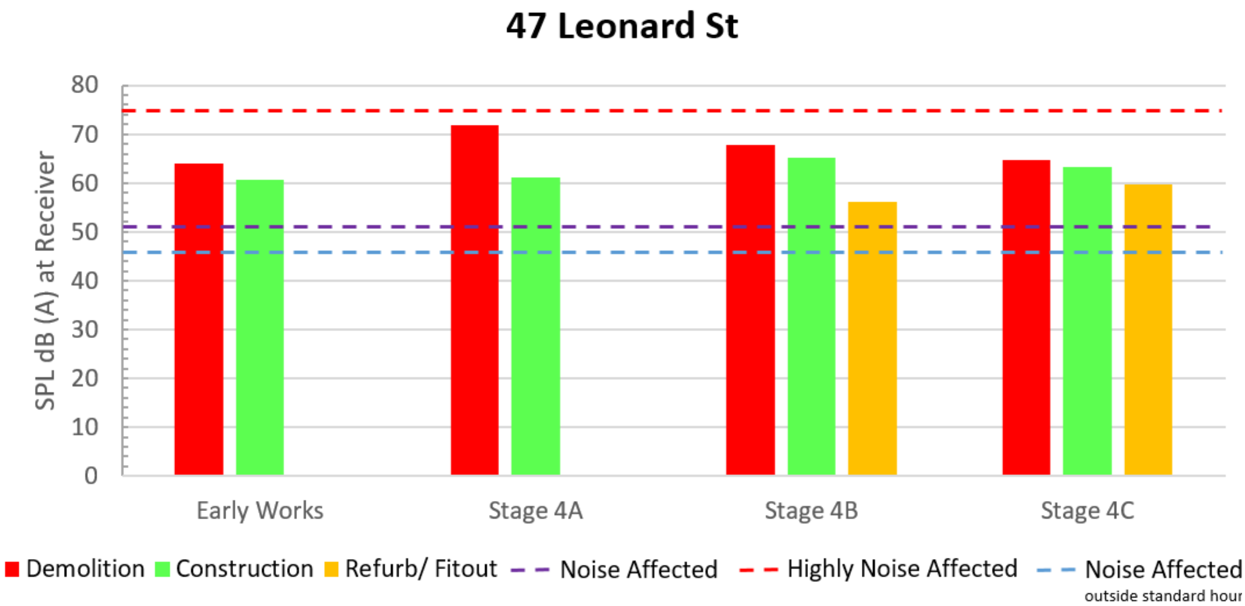
Figure 23: Noise Affected Receivers During Stage 4C

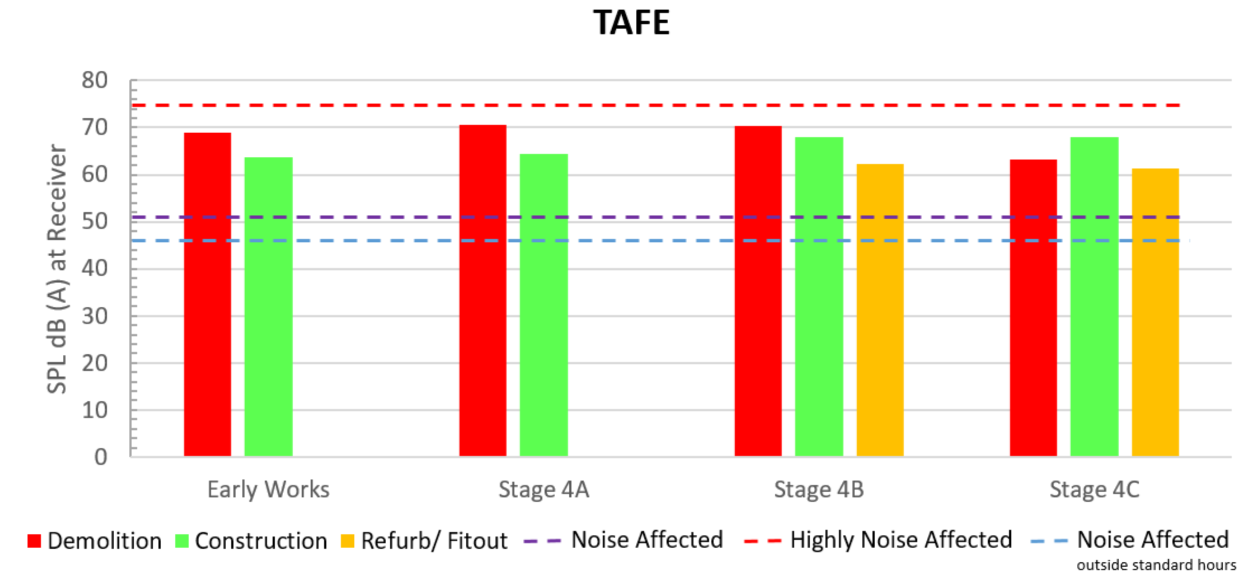


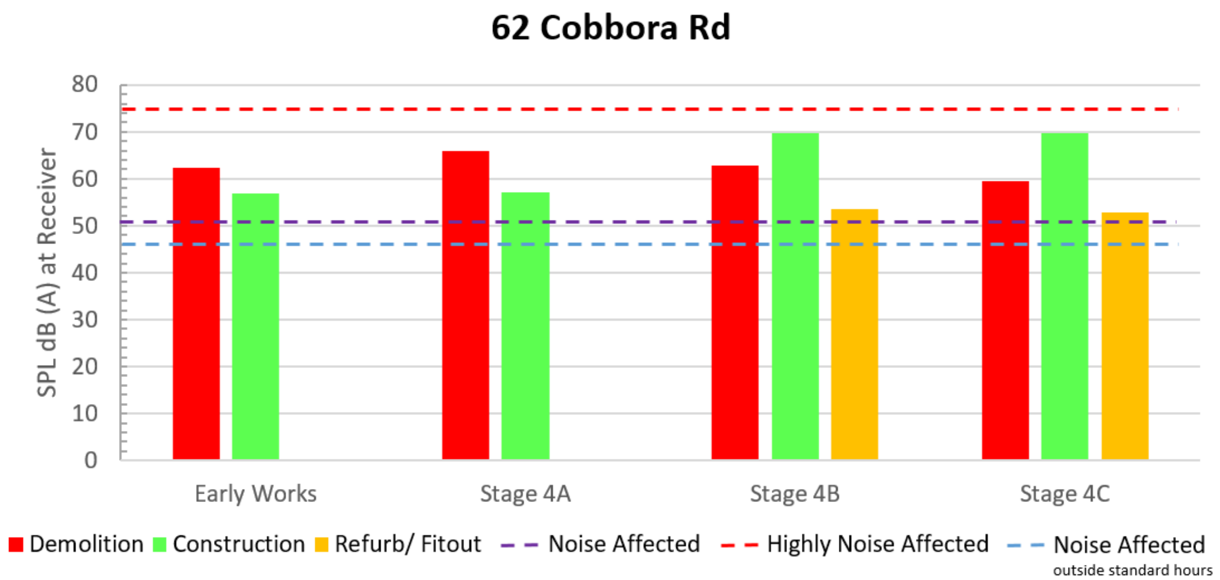
6.2.1 Source contributions

The demolition phase of each stage is typically the biggest noise contributor to nearby receivers, Figure 24 demonstrates the 3 most affected receivers at each phase of the construction program. These results include the 5.4 x 3.2m acoustic barrier at 62 Cobbora Rd, however the results would suggest there would be scope to extend the barrier to shield Leonard Street also residences. As shown, 47 Leonard st is receiving >70 dB (A) at the façade during Stage 4A.

Figure 24: Development Stage Noise Contribution to nearby residential receivers







7. Construction Vibration Assessment

The vibration associated with construction is dependent on a number of variables including the types of machinery selected, the proximity to the nearby receivers as well as the ground type. It is required that a CNVMP is conducted prior to construction in order to manage construction noise/vibration as well as to perform high level predictions to avoid non-compliances with the vibration criteria. In addition, the use of noise and vibration monitoring during construction will be essential in order to ascertain the extent of vibration and noise generated in and around the site.

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

Table 15: Recommended indicative safe working distances

Plant Item	Rating / Description	Safe Working Distance (m)	
		Structural Cosmetic Damage	Human Comfort
Vibratory Roller	< 50 kN (Typically 1 – 2 tonnes)	5	15 - 20
	< 100 kN (Typically 2 – 4 tonnes)	6	20
	< 200 kN (Typically 4 – 6 tonnes)	12	40
	< 300 kN (Typically 7 – 13 tonnes)	15	100
	> 300 kN (Typically more than 13 tonnes)	20	100
Small hydraulic hammer	300 kg, typically 5 – 12 tonnes excavator	2	7
Medium hydraulic hammer	900 kg, typically 12 – 18 tonnes excavator	7	23
Large hydraulic hammer	1600 kg, typically 18 – 34 tonnes excavator	22	73
Vibratory pile driver	Sheet piles	2 – 20	20
Pile boring	≤ 800 mm	2	N/A
Jackhammer	Hand held	1	Avoid contact with structure (including slab reinforcements)

Please note these safe distances should be confirmed and updated in a CNVMP based on the following information:

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

Construction Vibration Assessment

Further to the above the vibration criteria for vibration sensitive instrumentation (as discussed in Section 5.2.4) are more stringent than the criteria for human comfort. Therefore the safe working distances could be increased for particular equipment (this is currently not considered in Table 15).

Therefore, the following is recommended:

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

Finally, the CNVMP should consider the following amelioration measures which are to be taken into account in order to minimise the transmitted vibration around the site:

- Monitor vibration levels using attended/un-attended methods during construction in order to manage potential excessive vibration.
- Manage construction program so as to minimise heavy machinery operating concurrently.
- Prepare dilapidation reports on adjacent structures and monitor the effects.
- As far as practical, locate heavy machinery away from nearby sensitive receivers

The worst affected residence to vibration dosages is 62 Cobbora Rd, whose façade is less than 5m from the doctors accommodation to be demolished during stage 4A as shown in Figure 3 and Figure 9. It is recommended, particularly for the sections of the demolition and carpark construction closest to the neighbouring building, only use small excavators (2m safe working distance), with potential to use a medium size (12t) at a greater distance >7m.

Despite all feasible and reasonable mitigation methods, it is anticipated the residents at 62 Coborra Rd will be very affected by the works, particularly for Stage 4A demolition and 4B carpark construction. All vibration management strategies shall be followed and ongoing vibration monitoring with a flashlight/ alert system in place for when vibration dosages are exceeded.

8. Construction Noise and Vibration Management

8.1 Management Plan

8.1.1 Demolition and Structure works

These two construction stages are predicted to produce the highest noise levels of all of the construction phases. Sporadic attended and unattended monitoring should be conducted during these stages of construction which represent the highest risk in terms of noise and vibration exposure for the surrounding community. This monitoring would include 15 minute measurements using a type 1 sound level meter, vibration analyzer and noise and vibration loggers. Any noise and vibration level exceedances will be reported to builder, which will be logged in their construction register and will be monitored until compliant noise and vibration levels are achieved through various noise and vibration mitigation measures and site management procedures.

It has also been recommended to have ongoing vibration measurements during demolition stages of 4A and carpark construction of 4B at 62 Cobbora Rd to ensure the property is not a t risk of any structural damage.

8.1.2 Other construction works

The remaining phases of construction are predicted to have a lower overall noise and vibration impact on the surrounding residents. Some of the internal works also will be completed after the façade will be installed minimizing even more the predicted noise levels.

Sporadic attended monitoring could also be conducted during this construction stage. This monitoring would include 15 minute measurements using a type 1 sound level meter and vibration analysis. Any noise and vibration level exceedances will be reported to builder, which will be logged in their construction register and will be monitored until compliant noise and vibration levels are achieved through various noise and vibration mitigation measures and site management procedures.

The following flow chart (See Figure 25) can be used to assist with noise mitigation and management measures in order to comply with the standards as aforementioned.

8.2 Generic Noise and Vibration Mitigation Strategies

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

8.2.1 Noise

If noisy processes cannot be avoided, then the amount of noise reaching the receiver should be minimized. There are two ways of achieving this, either in increasing the distance between the noise source and the receiver or in introducing noise reduction measures such as screens.

Physical methods to reduce the transmission of noise between the site works and residences, or other sensitive land uses, are generally suited to works where there is longer-term exposure to the noise. Practices that will reduce noise from the site include:

(a) Increasing the distance between noise sources and sensitive receivers.
(b) Reducing the line-of-sight noise transmission to residences or other sensitive land uses using temporary barriers (stockpiles, shipping containers and site office transportables can be effective barriers).
(c) Constructing barriers that are part of the project design early in the project to provide mitigation against site noise.
(d) Installing purpose built noise barriers, acoustic sheds and enclosures. This is critical between 60 and 62 Cobbora Rd for the duration of construction and demolition. A minimum height of 3.2m has been nominated. Material od the barrier should be selected based on transmission loss from construction to the façade of the residence to meet the criteria outlined in this report.

Screening

On site where distance between source and receiver is limited, the screening of noise may be of benefit and this should be taken into account at the planning stage.

If structures such as stores, site offices and other temporary buildings are situated between the noisiest part of the site and the nearest dwellings, some of the noise emission from the site can be reduced. If these buildings are occupied, then sound insulation measures may be necessary to protect workers occupying them. The existing site offices and buildings have provided shielding to the nursing home receiver to the north as shown in section 6.

A hoarding that includes a site office on an elevated structure offers a superior noise reduction when compared with a standard (simple) hoarding. This performance is further enhanced when the hoarding is a continuous barrier.

Storage of building materials or the placement of shipping containers between the noise source and any noise-sensitive area may also provide useful screening and the same is true of partially completed or demolished buildings. Noisy stationary plant can be put in a basement, the shell of which has been completed, provided reverberant noise can be controlled. Where compressors or generators are used in closed areas, it is necessary to ensure that the exhaust gases are discharged directly to the outside air and that there is good cross-ventilation to prevent the build-up of poisonous carbon monoxide fumes and to allow an adequate air supply to maintain efficient running.

Where such noise barriers are not practicable, a worthwhile reduction in noise can be obtained by siting the plant behind and as close as possible to mounds of earth, which may effectively screen the plant from any noise-sensitive areas. These can often be designed into the construction schedule or site arrangement for future landscaping.

Water pumps, fans and other plant and equipment that operate on a 24-hour basis may not be a source of noise nuisance by day but can create problems at night. They should therefore be effectively screened either by being sited behind a noise barrier or by being positioned in a trench or a hollow in the ground provided this does not generate reverberant noise. In such cases, however, adequate ventilation should also be ensured. Long, temporary earth embankments can provide quite effective noise screen for mobile equipment moving, for example, on a haulage road. When the earthworks are complete, the earth mounds should be removed if possible with smaller, quieter excavators. A noise barrier may be a more reliable method of noise control than the imposition of restrictions on throttle settings.

Construction Noise and Vibration Management

In many cases it will not be practicable to screen earthmoving operations effectively, but it may be possible to partially shield construction plant or to build-in at the early stages protective features ultimately required to screen traffic noise. Where earth noise barriers are not a practical proposition because of lack of space, consideration should be given to the possibility of constructing temporary screens from wood or any of the materials suggested in Appendix D of AS2436:2010 "Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites".

The usefulness of a noise barrier will depend upon its length, its height, its position relative to the source and to the listener, and the material from which it is made. A barrier designed to reduce noise from a moving source should extend beyond the last property to be protected to a distance of not less than ten times the shortest measurement from the property to the barrier. A barrier designed to reduce noise from a stationary source should, where possible, extend to a distance beyond the direct line between the noise source and the receiver to a distance equal to ten times the effective barrier height, which is the height above the direct line between source and receiver.

If the works are predominately within nominally closed structures, careful consideration should be given to reducing noise breakout at any openings.
If complaints from residents along Leonard Street arise, extension of the 5.6m barrier at 62 Cobbora Rd should be extended along the hospital boundary.

Crane (in case it is a diesel operated)

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

Reversing and warning alarms

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

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

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

The above methods should be combined, where appropriate.

8.2.2 Vibration

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

During the demolition works some vibrations (transmitted through the structure from the demolition sites) are expected, being more of a concern for the surrounding sensitive receivers.

It can also trigger annoyance being elevated into action by occupants of exposed buildings, and should therefore be included in planning of communication with impacted communities. It should be remembered that failures, sometimes catastrophic, can occur as a result of conditions not directly connected with the transmission of vibrations, e.g. the removal of supports from retaining structures to facilitate site access. BS 7385-2 provides information on managing ground borne vibration and its potential effects on buildings.

Where site activities may affect existing structures, a thorough engineering appraisal should be made at the planning stage.

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

Comparison of predicted levels of vibration with preferred or regulatory levels will indicate when either more detailed predictions are required or mitigation of transmitted vibration is advisable or necessary. Guidance in measures available for mitigation of vibration transmitted can be sought in more detailed standards, such as BS 5228-2 or policy documents, such as the NSW DEC Assessing Vibration: A technical guideline.

Identifying the strategy best suited to controlling vibration follows a similar approach to that of noise—of avoidance, control at the source, control along the propagation path, control at the receiver, or a combination of these. It is noted that vibration sources can include stationary plant (pumps and compressors), portable plant (jackhammers and pavement vibrators), mobile plant, pile-drivers, tunneling machines and activities, and blasting, amongst others. Unusual ground conditions, such as a high water-table, can also cause a difference to expected or predicted results, especially with piling.

Figure 25: Noise Mitigation Management Flow Chart

8.3 Complaint Handling Procedures and Community Liaison

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

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

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

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

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

In the event of noisy works scheduled, the builder will notify residents 5 business days in advance.

8.4 Noise & Vibration Monitoring Strategy

8.4.1 General Methodology

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

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

Monitoring is to be undertaken by an experienced noise and vibration monitoring professional or an acoustic consultant. The results of any noise or vibration monitoring are to be provided to the relevant party or person in a timely manner allowing the builder to address the issue and respond to the complaints.

Noise and vibration monitoring can take two forms:

1. Short term monitoring
2. Long-term monitoring

Short-term monitoring

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

Long-term monitoring

Similarly, long-term monitoring uses noise and vibration loggers providing real-time alerts to the builder / site manager when the noise and vibration criteria are exceeded.

Typically, the noise and vibration loggers stay on site for a period of several months for the critical construction stages of the project. Sometimes the period of construction noise and vibration monitoring is dictated by the local authorities through the DA conditions.

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

9. Conclusion

A Noise Impact Assessment has been undertaken for the construction works to be conducted at Dubbo Base Hospital, Myall St, Dubbo, NSW. This study was undertaken to meet the information requested from the NSW Environmental Protection Agency as a part of the Environmental assessment of the Dubbo Health Services Stage 4 Development.

An assessment based on all phases of stage 4 construction was conducted in order to assess the nearest most effected receiver and risks associated with the noise and vibration produced by these construction phases. The noise and vibration assessments in Section 6 and 7 are based off the assumption that all equipment will be running simultaneously through each phase at varying frequencies, however this may not be the case and noise levels may vary by between 3-6 dB(A).

As shown in Section 6.2 the noise levels are not expected to reach the highly noise affected criteria at the nearby residential receiver during any construction activities. Noise levels during all phases of construction are typically between noise affected and very noise affected. These receivers will have some reaction to the construction noise as per the classifications in the NSW ICNG. Therefore, feasible and reasonable measures should be assessed and implemented to control noise emission from the site to these residential receivers as documented within the report (section 8.2).

No residential receivers are classified as highly noise affected. Therefore, no further measures are required.

The Commercial receivers are predicted to have a minimum 15 dB transmission loss from façade and given the predicted noise levels at the façade, it is anticipated the internal noise levels will be met at these receivers. Mitigation may have to occur whereby receivers require closed windows to maintain the internal noise levels during periods of peak noise levels during construction.

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

This report looks at the standard hours of construction. Without further information on the works undertaken during the requested extended hours (Saturday 1pm – 4pm) construction noise has been predicted for the full scope of works only. The contractor will need to demonstrate that RBL + 0 dB is met during these extended hours, or seek approval to depart from the standard hours and noise criteria. WGE would suggest works outside of the standard hours could include delivering materials to the site, or refurbishment works that are inside of a closed façade building.

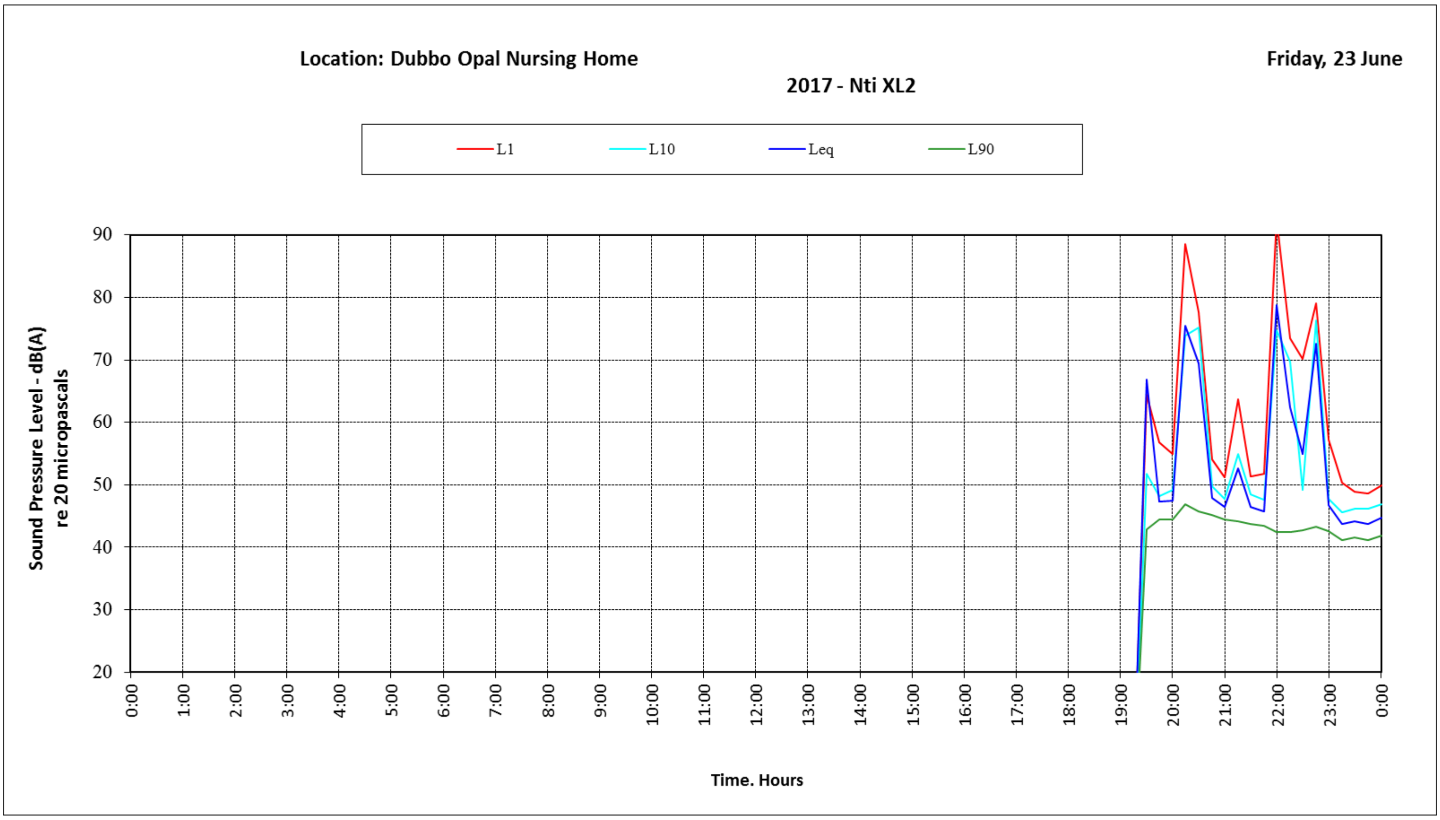
Appendix 1 - Glossary of Acoustic Terms

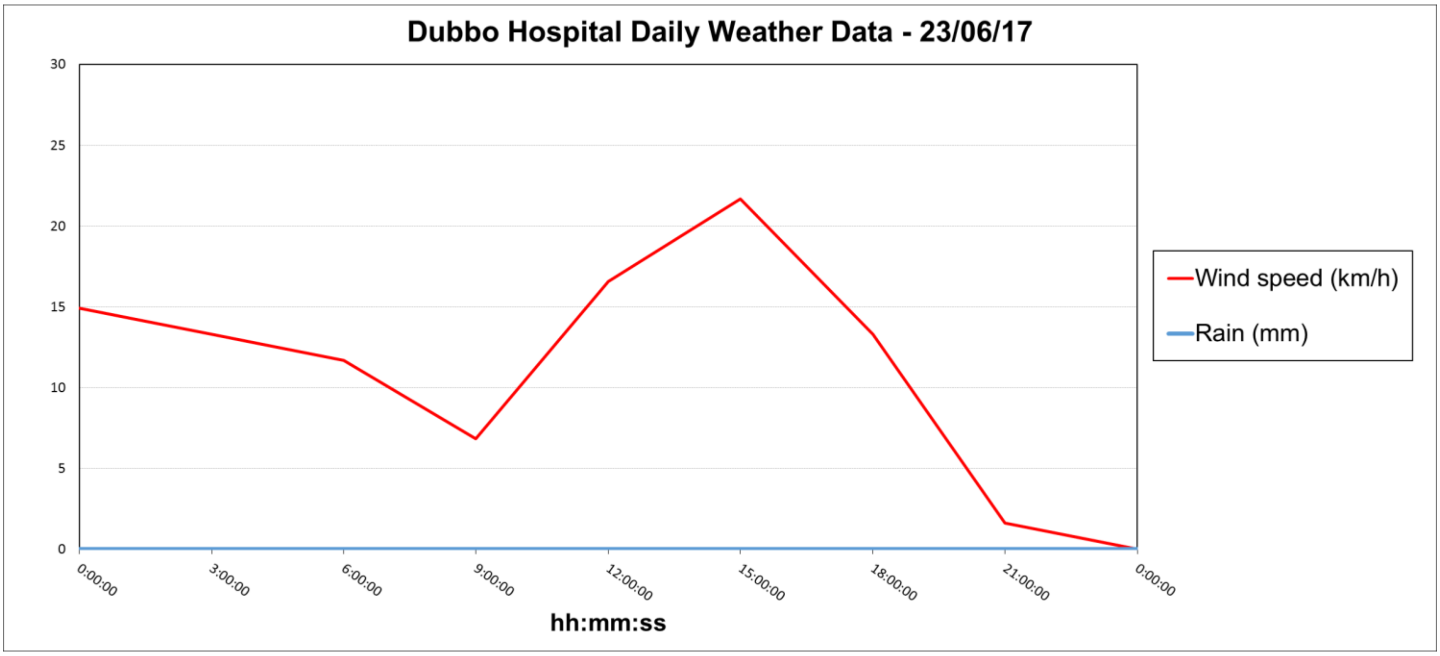
NOISE	
Acceptable Noise Level:	The acceptable LAeq noise level from industrial sources, recommended by the EPA (Table 2.1, INP). Note that this noise level refers to all industrial sources at the receiver location, and not only noise due to a specific project under consideration.
Adverse Weather:	Weather conditions that affect noise (wind and temperature inversions) that occur at a particular site for a significant period of time. The previous conditions are for wind occurring more than 30% of the time in any assessment period in any season and/or for temperature inversions occurring more than 30% of the nights in winter).
Acoustic Barrier:	Solid walls or partitions, solid fences, earth mounds, earth berms, buildings, etc. used to reduce noise.
Ambient Noise:	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment Period:	The period in a day over which assessments are made.
Assessment Location	The position at which noise measurements are undertaken or estimated.
Background Noise:	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level.
Decibel [dB]:	The units of sound pressure level.
dB(A):	A-weighted decibels. Noise measured using the A filter.
Extraneous Noise:	Noise resulting from activities that are not typical of the area. Atypical activities include construction, and traffic generated by holidays period and by special events such as concert or sporting events. Normal daily traffic is not considered to be extraneous.
Free Field:	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground
Frequency:	Frequency is synonymous to pitch. Frequency or pitch can be measured on a scale in units of Hertz (Hz).
Impulsive Noise:	Noise having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.

Appendix 1 - Glossary of Acoustic Terms

Intermittent Noise:	Level that drops to the background noise level several times during the period of observation.
LAmax	The maximum A-weighted sound pressure level measured over a period.
LAmin	The minimum A-weighted sound pressure level measured over a period.
LA1	The A-weighted sound pressure level that is exceeded for 1% of the time for which the sound is measured.
LA10	The A-weighted sound pressure level that is exceeded for 10% of the time for which the sound is measured.
LA90	The A-weighted level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
LAeq	The A-weighted "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
LAeqT	The constant A-weighted sound which has the same energy as the fluctuating sound of the traffic, averaged over time T.
Reflection:	Sound wave changed in direction of propagation due to a solid object met on its path.
R-w:	The Sound Insulation Rating R-w is a measure of the noise reduction performance of the partition.
SEL:	Sound Exposure Level is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound Absorption:	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound Level Meter:	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound Pressure Level:	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound Power Level:	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise:	Containing a prominent frequency and characterised by a definite pitch.

Appendix 2 – Unattended Measurement L1





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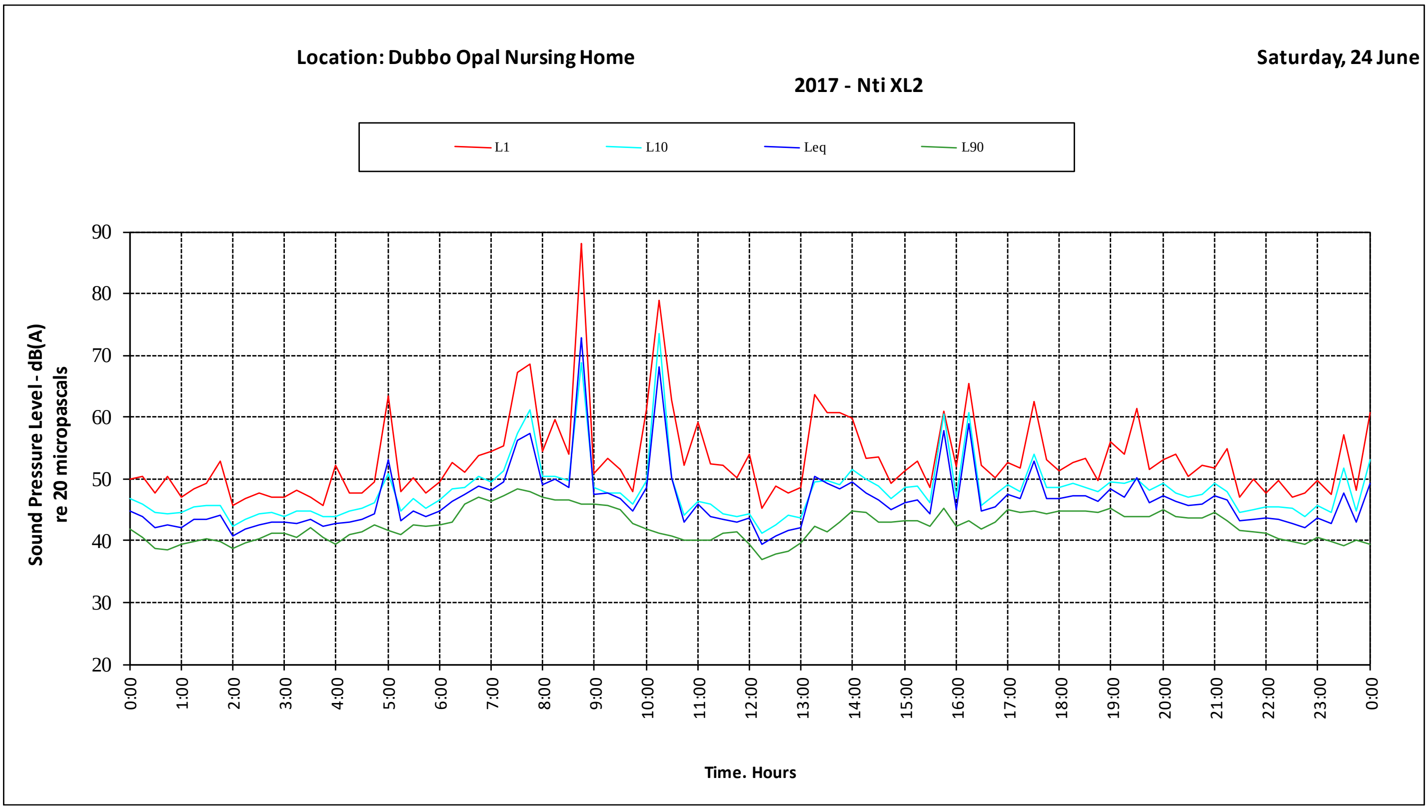

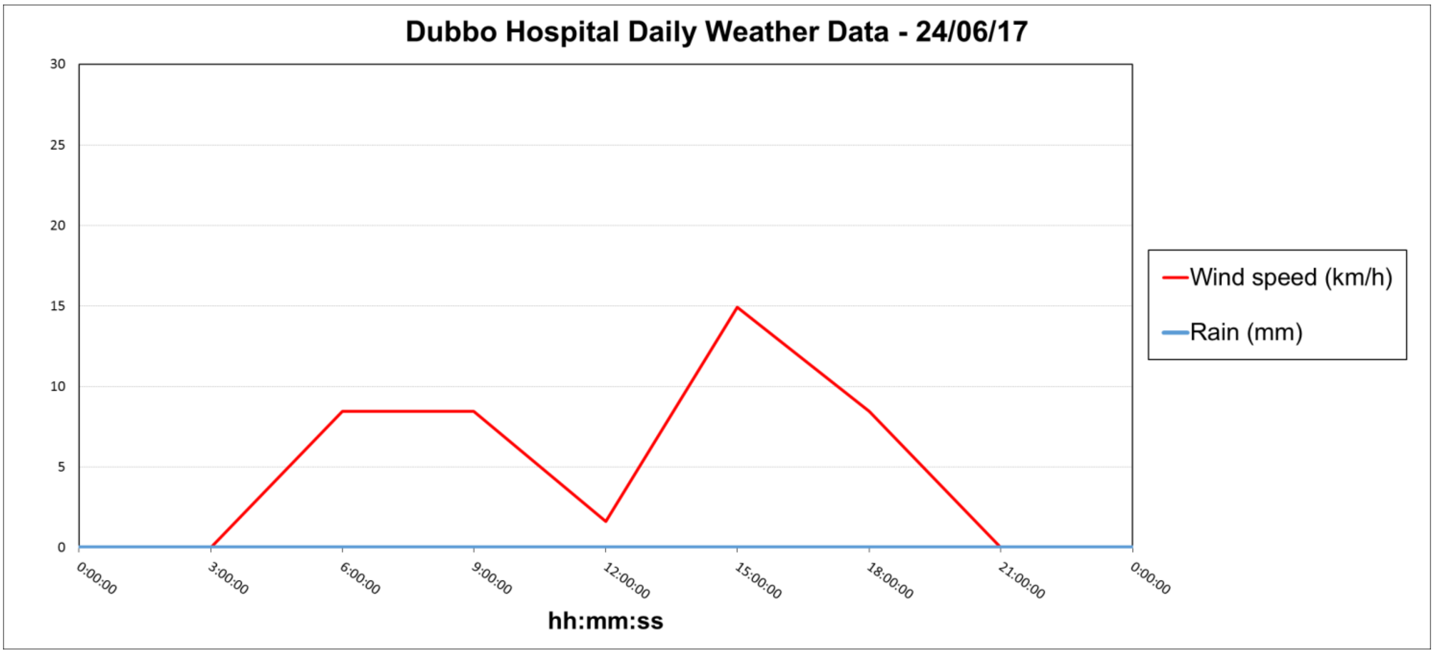

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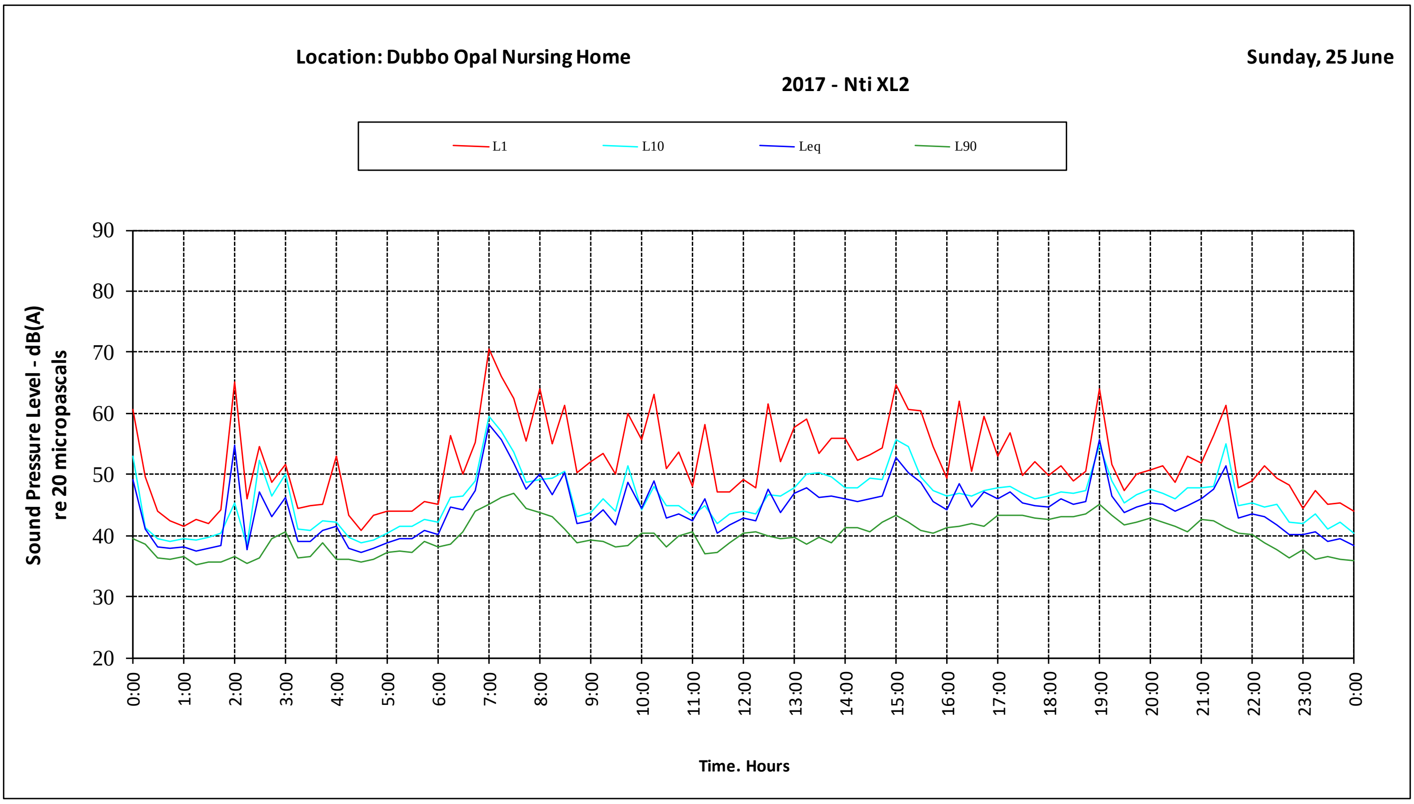

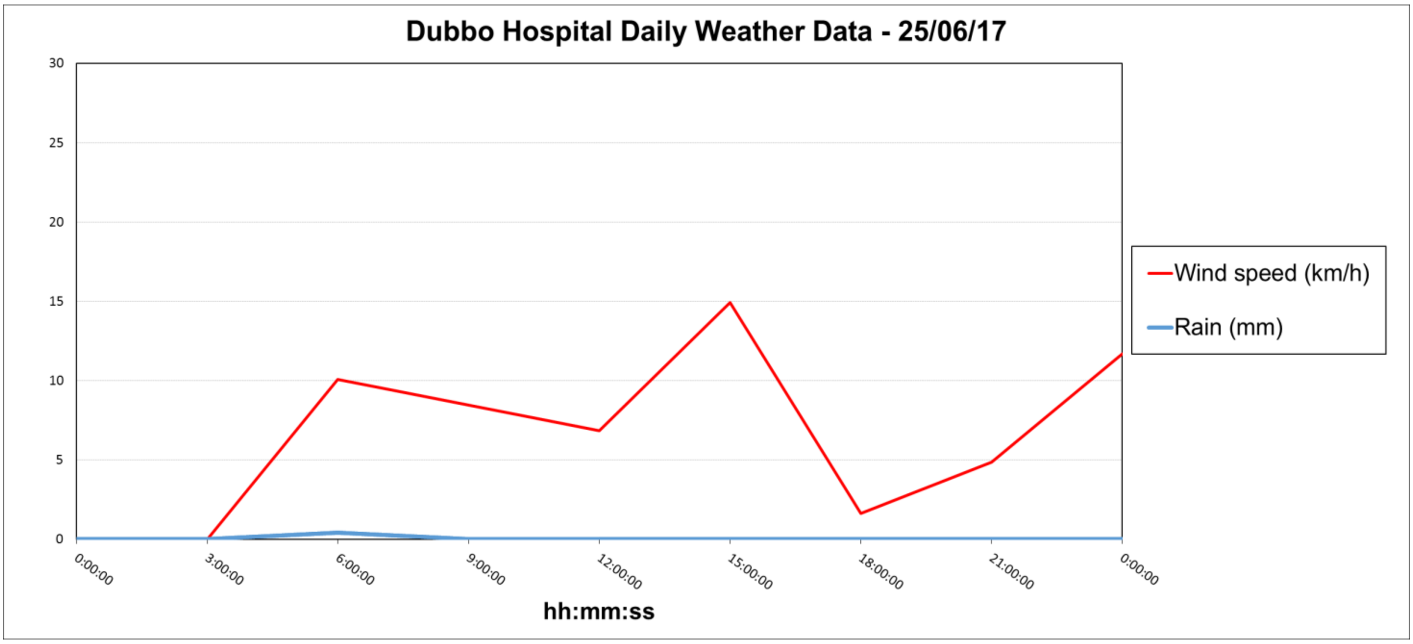

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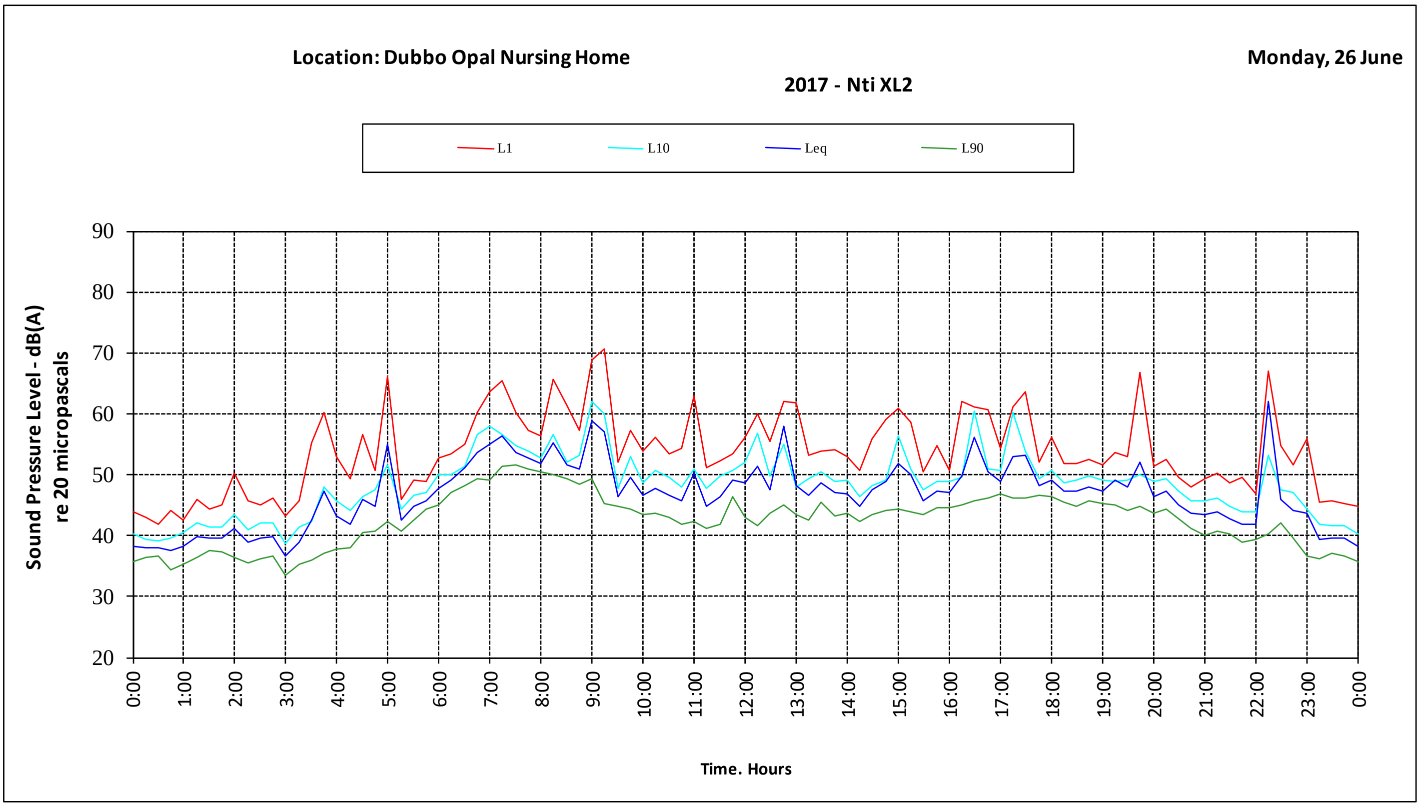

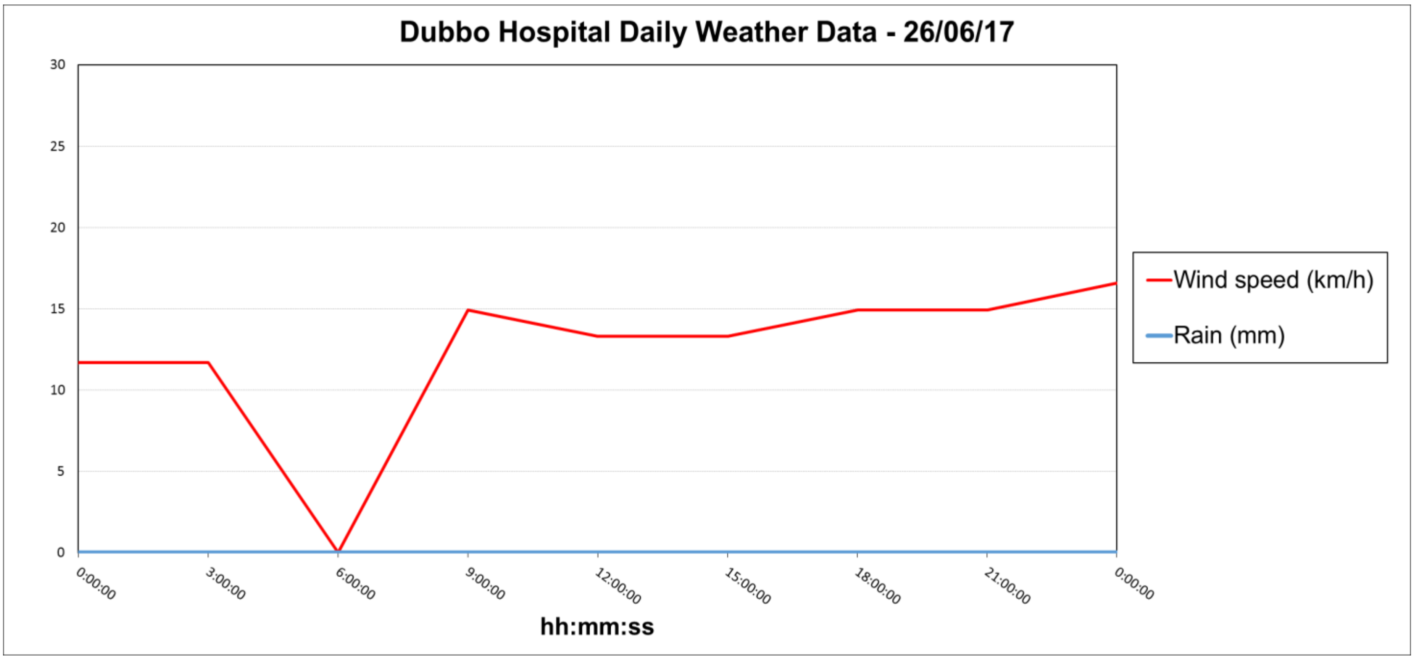

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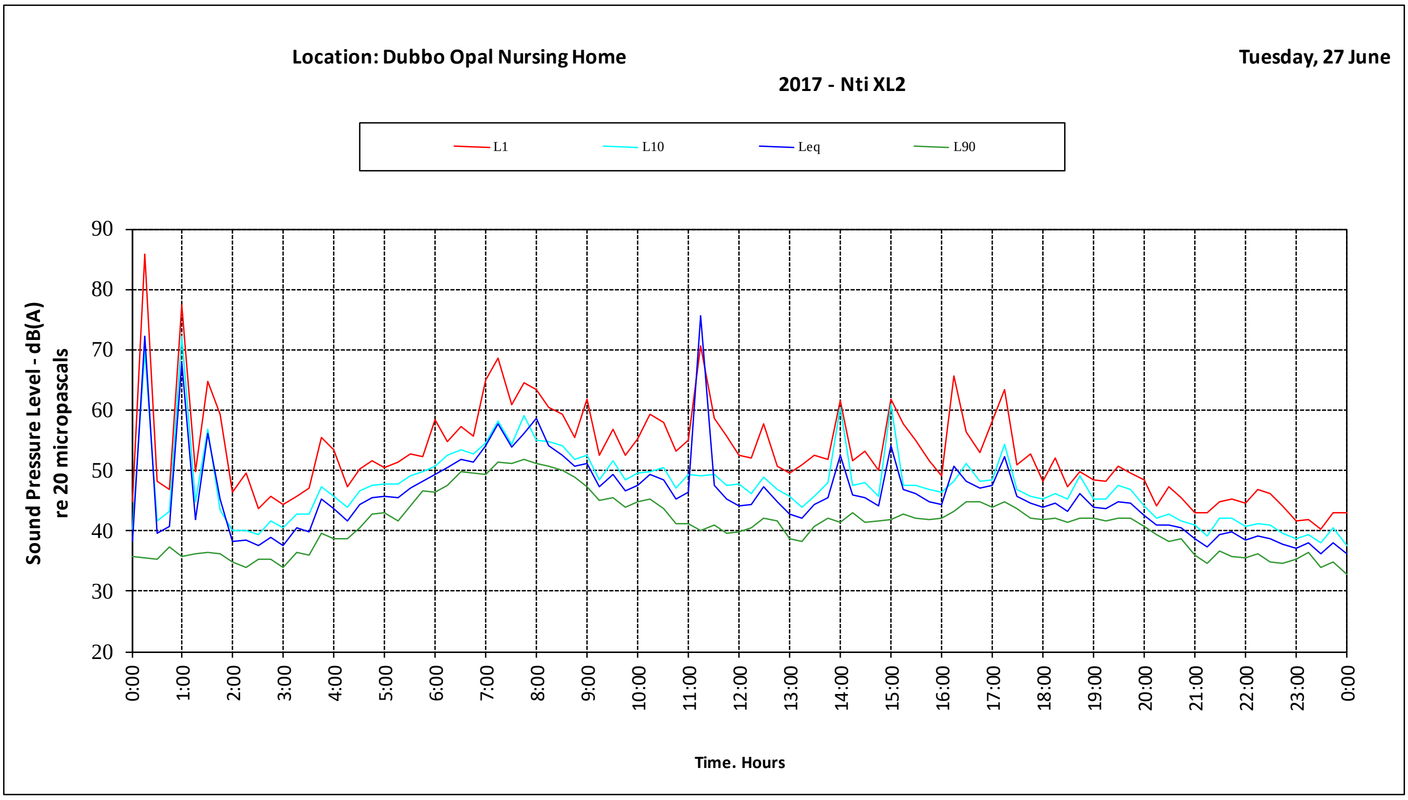

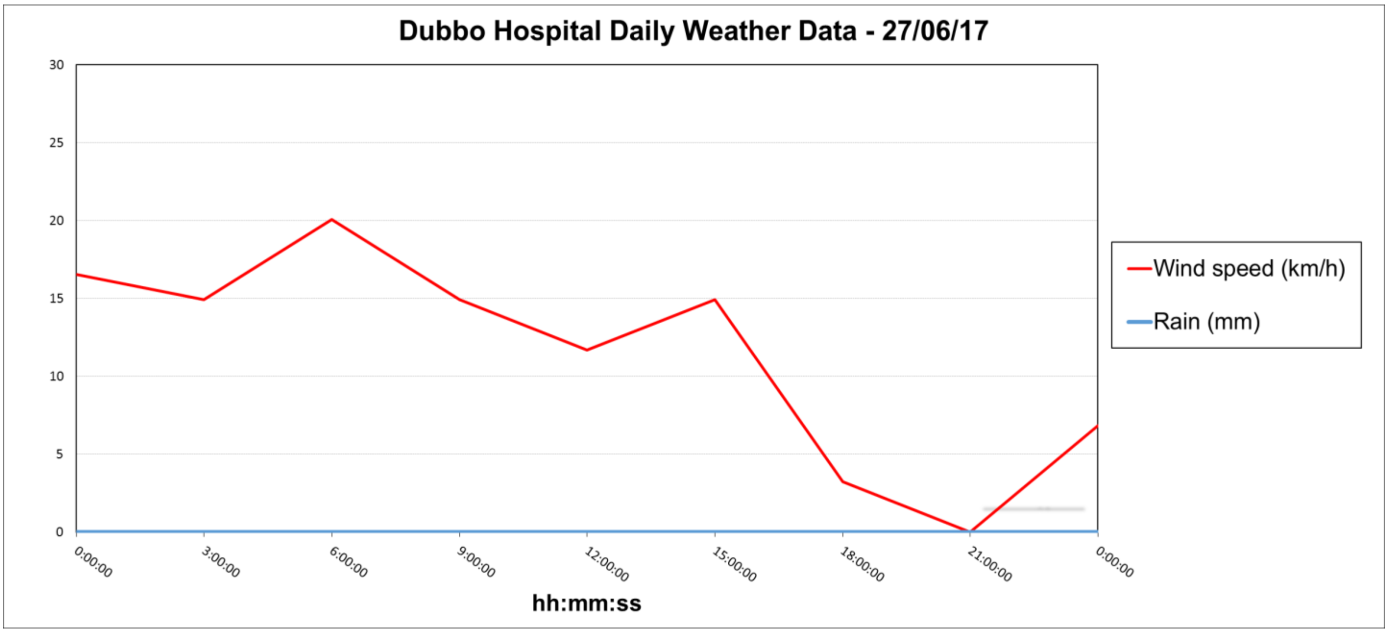

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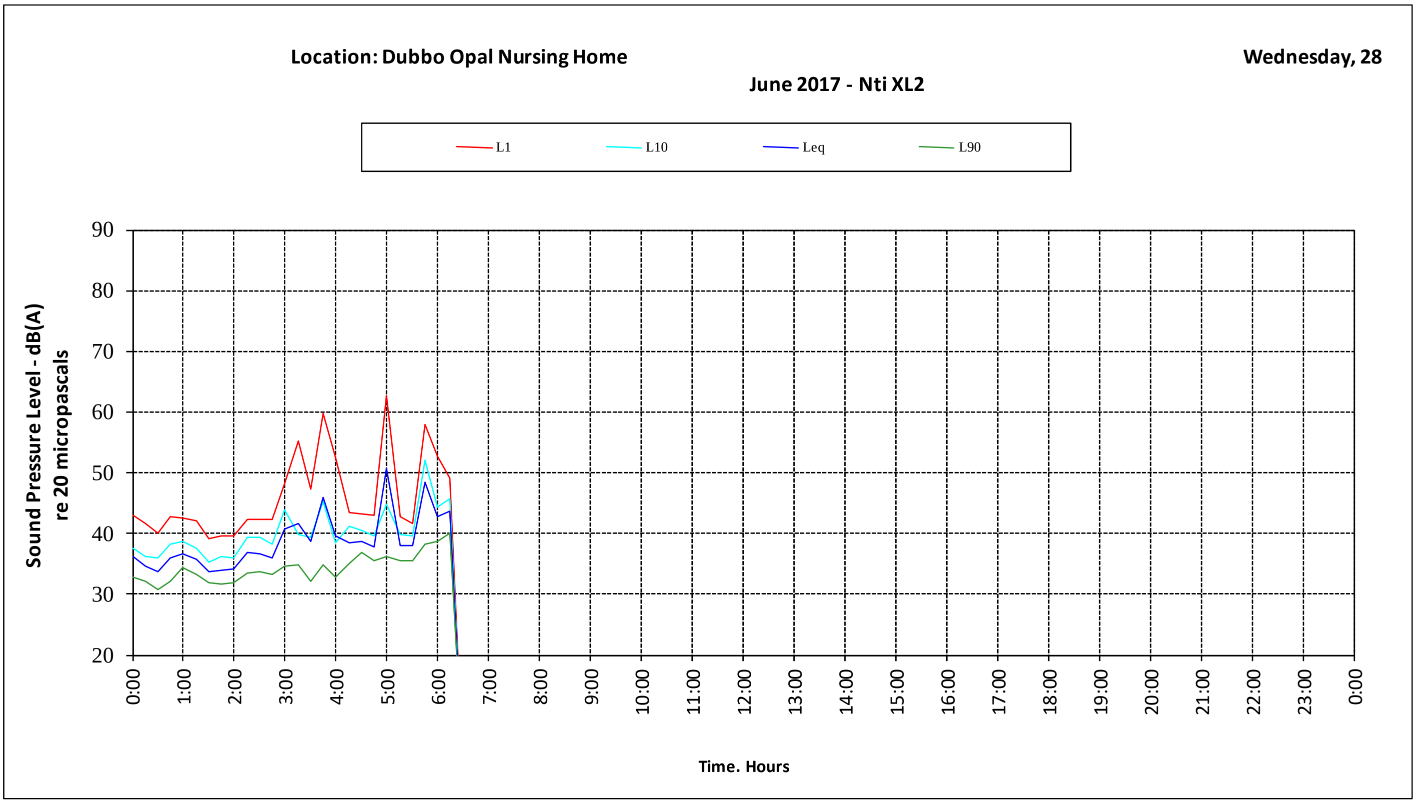

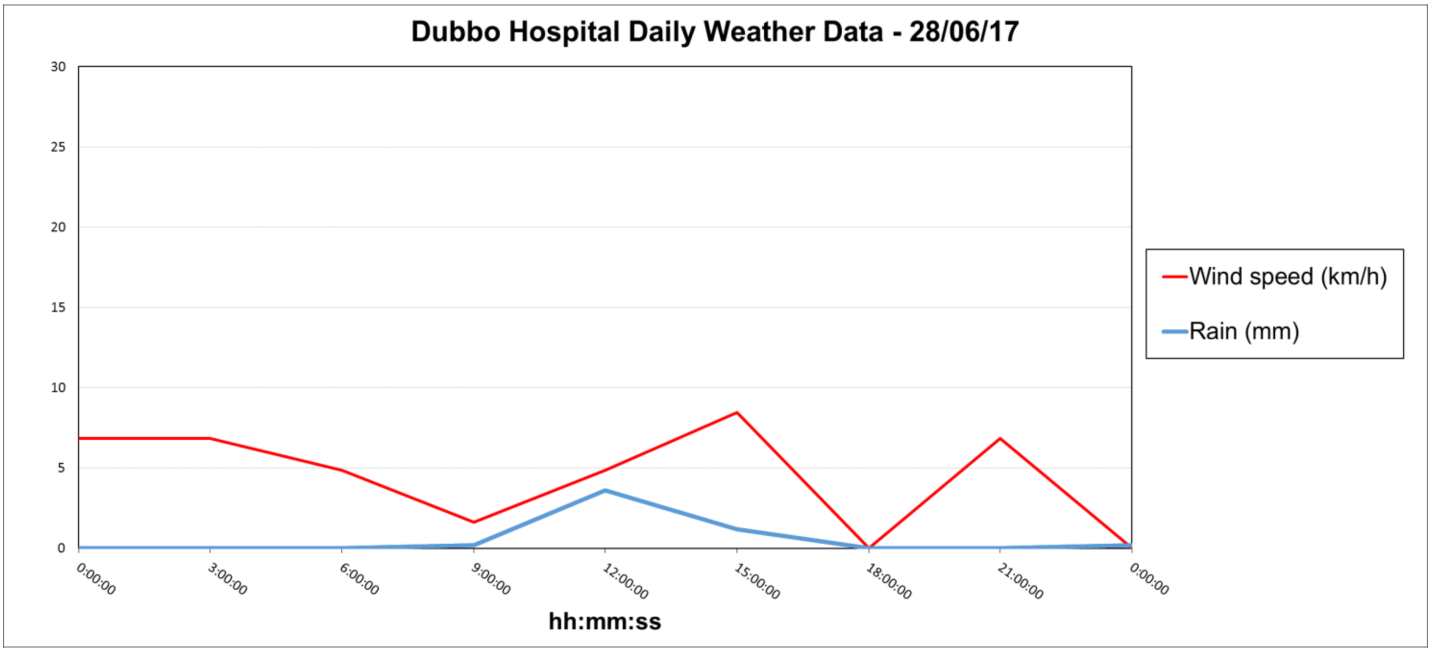

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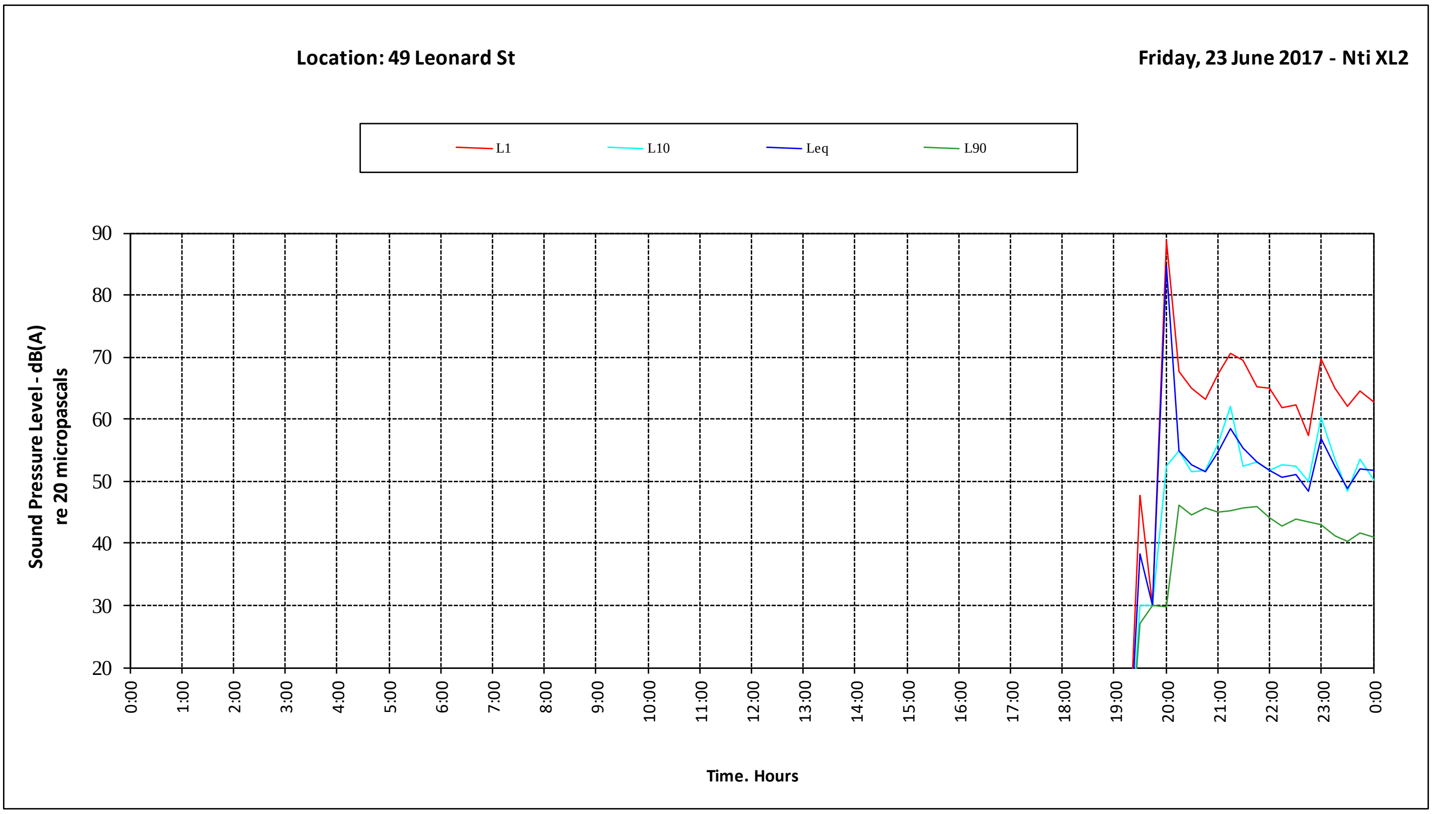

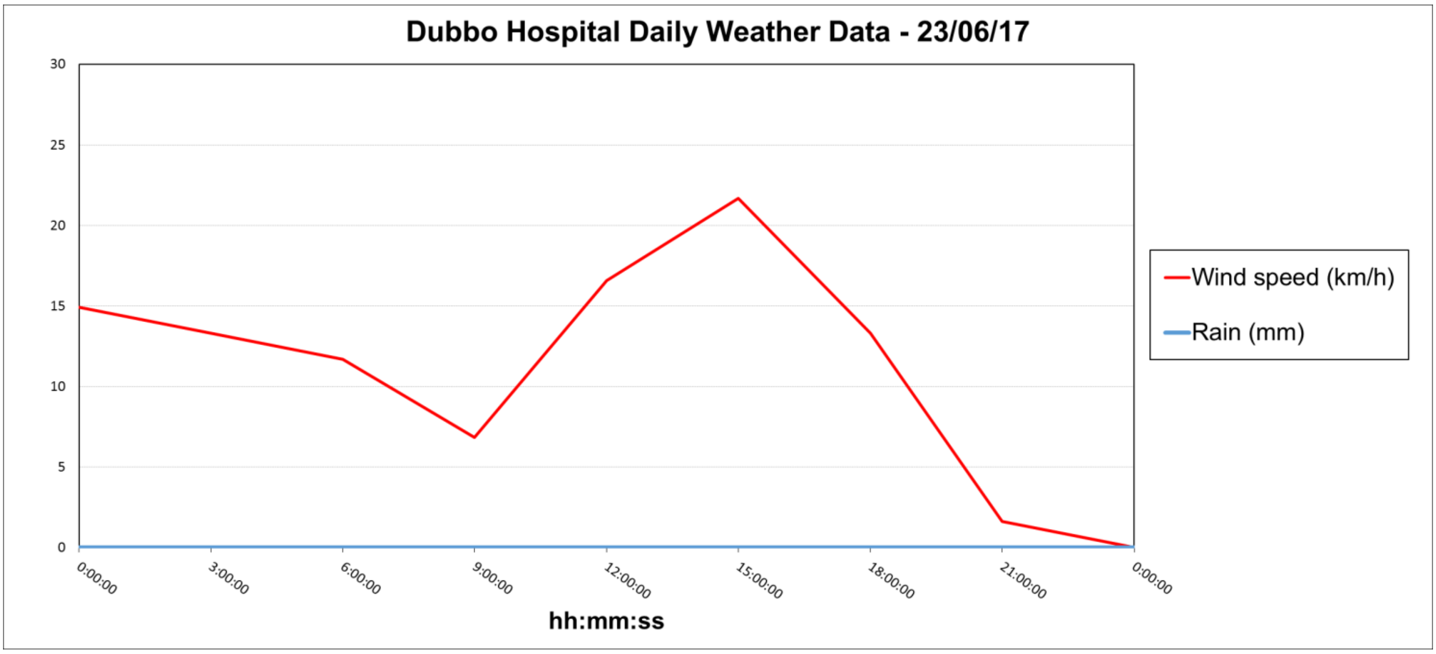

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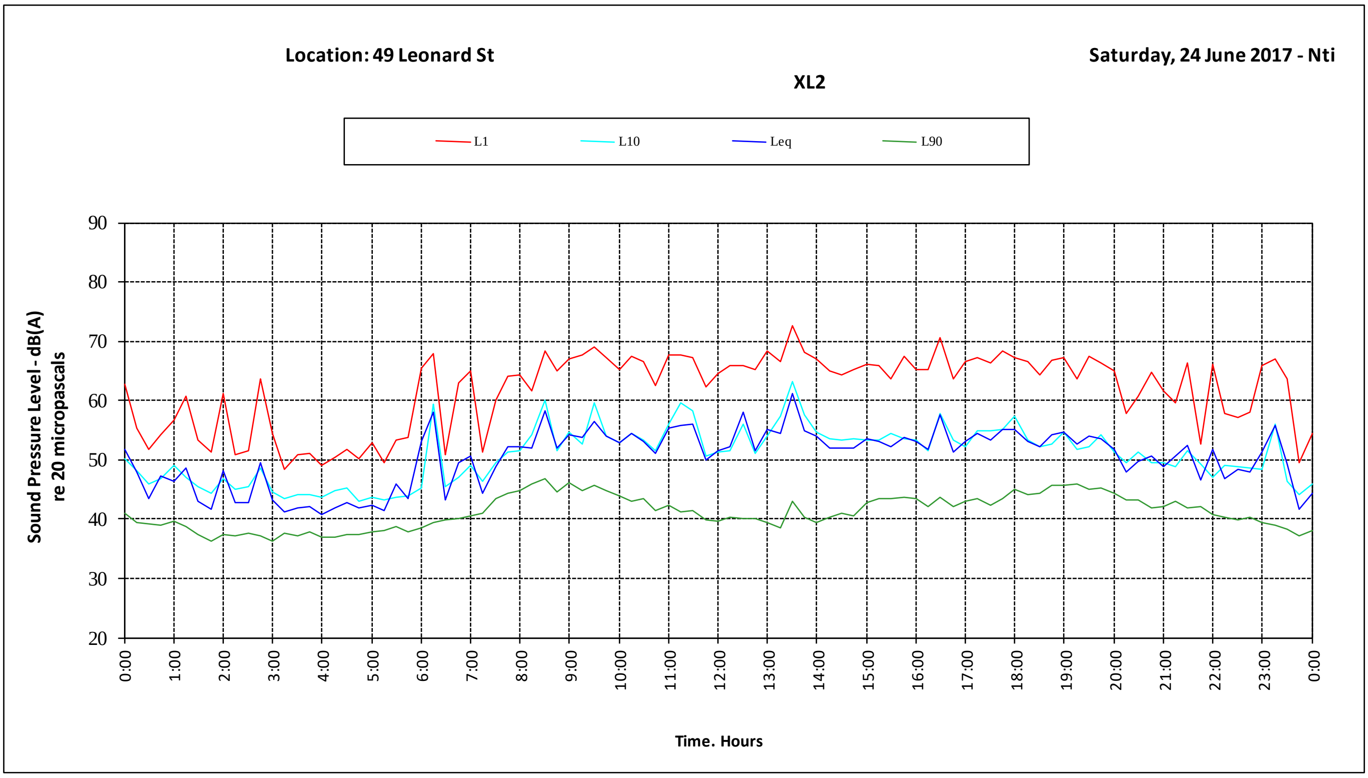

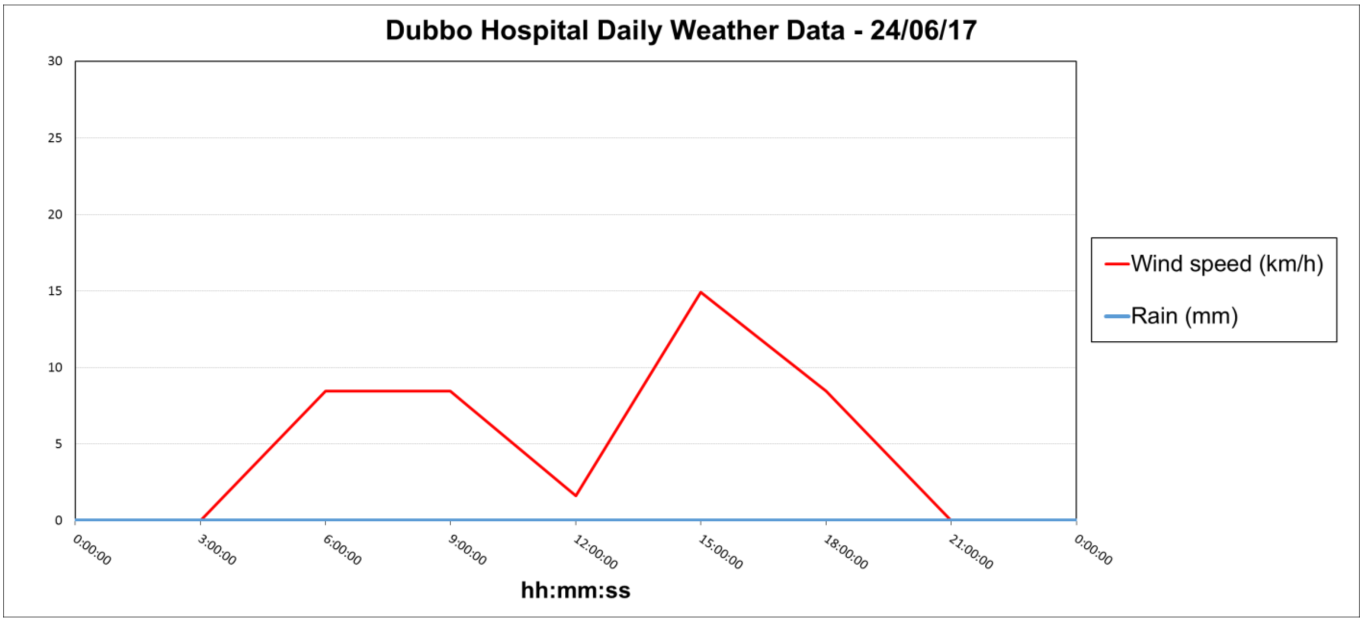

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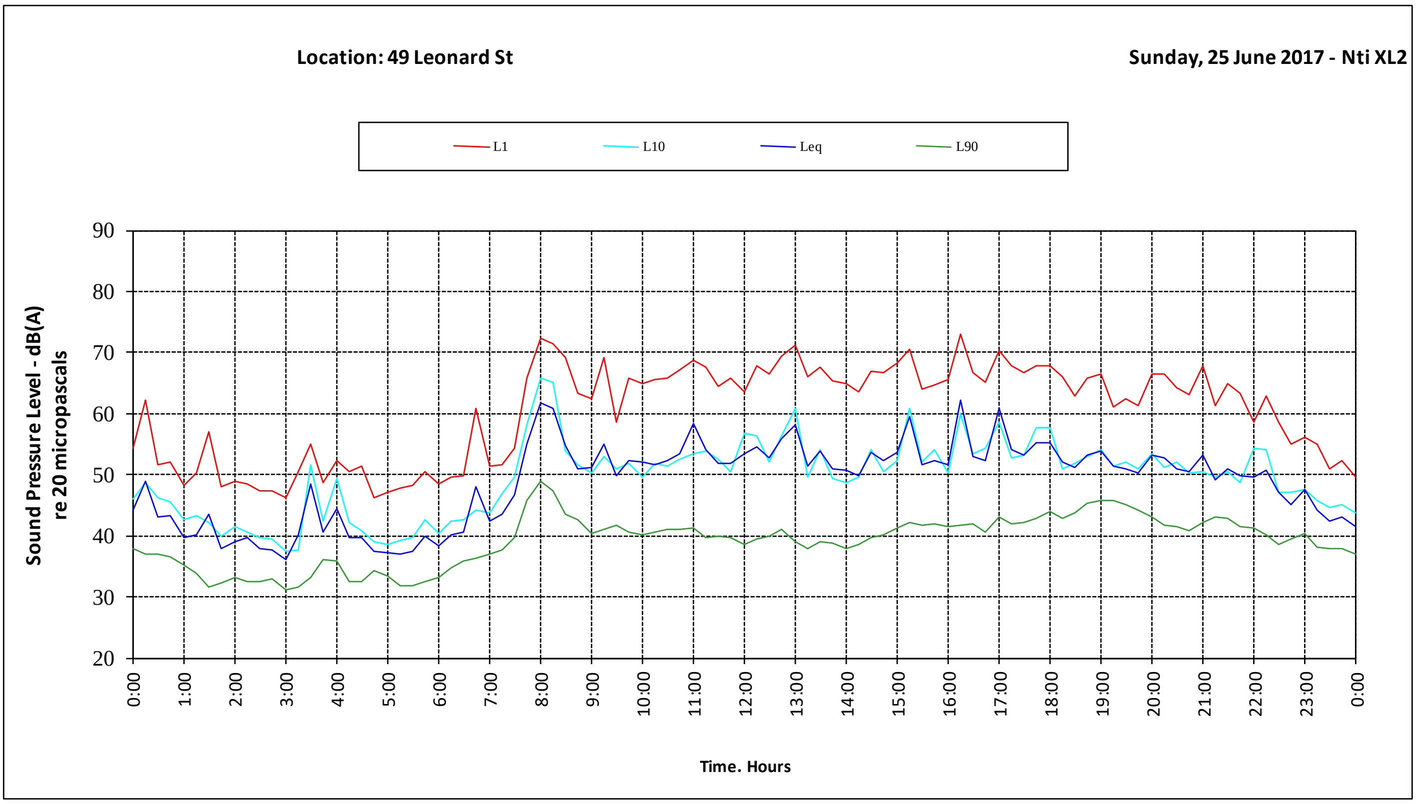

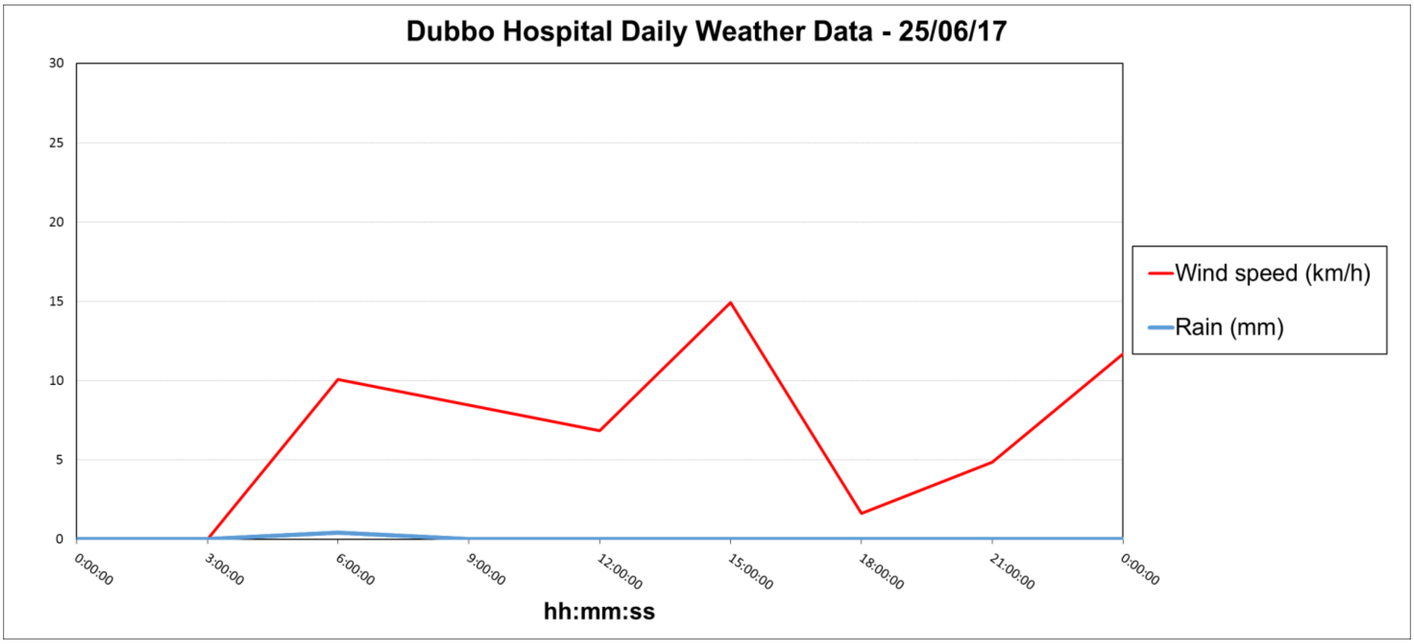

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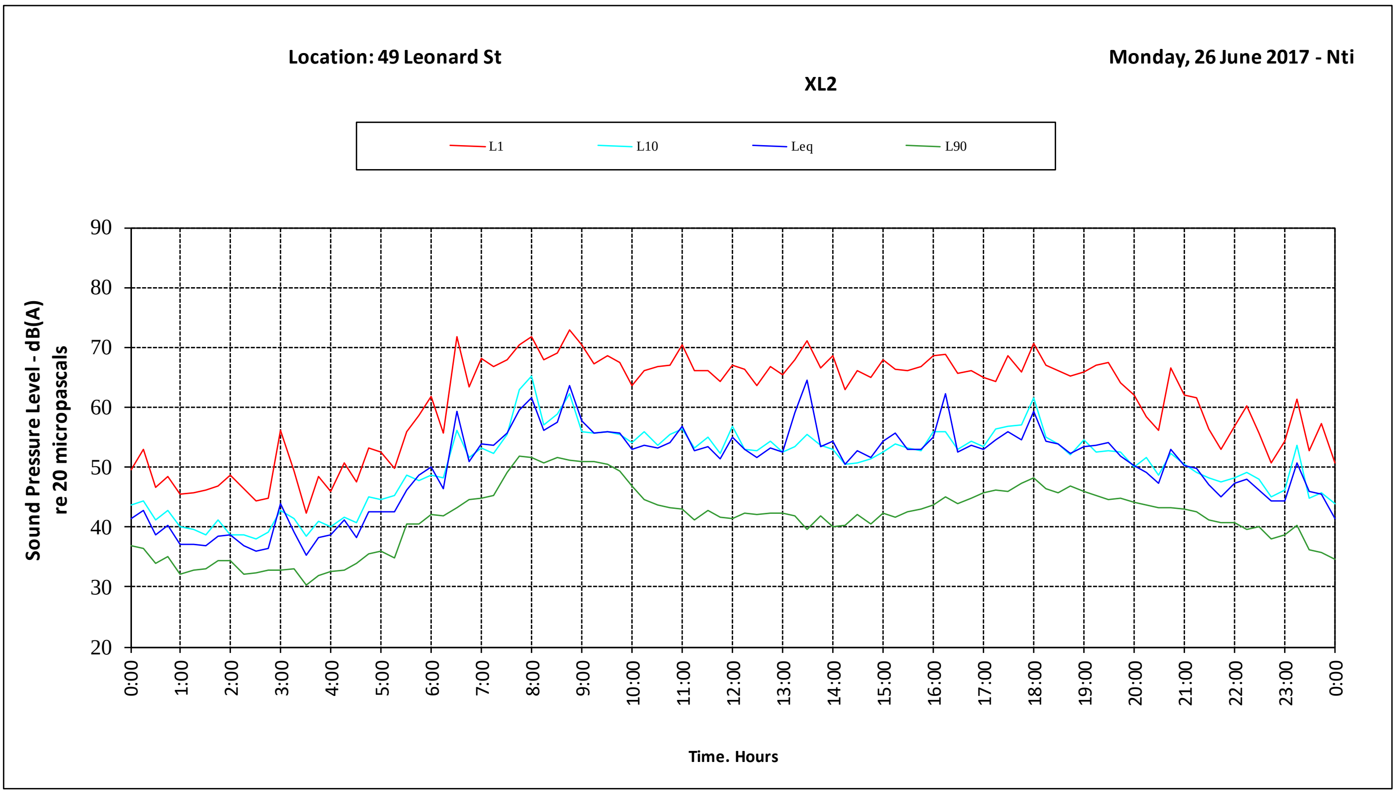

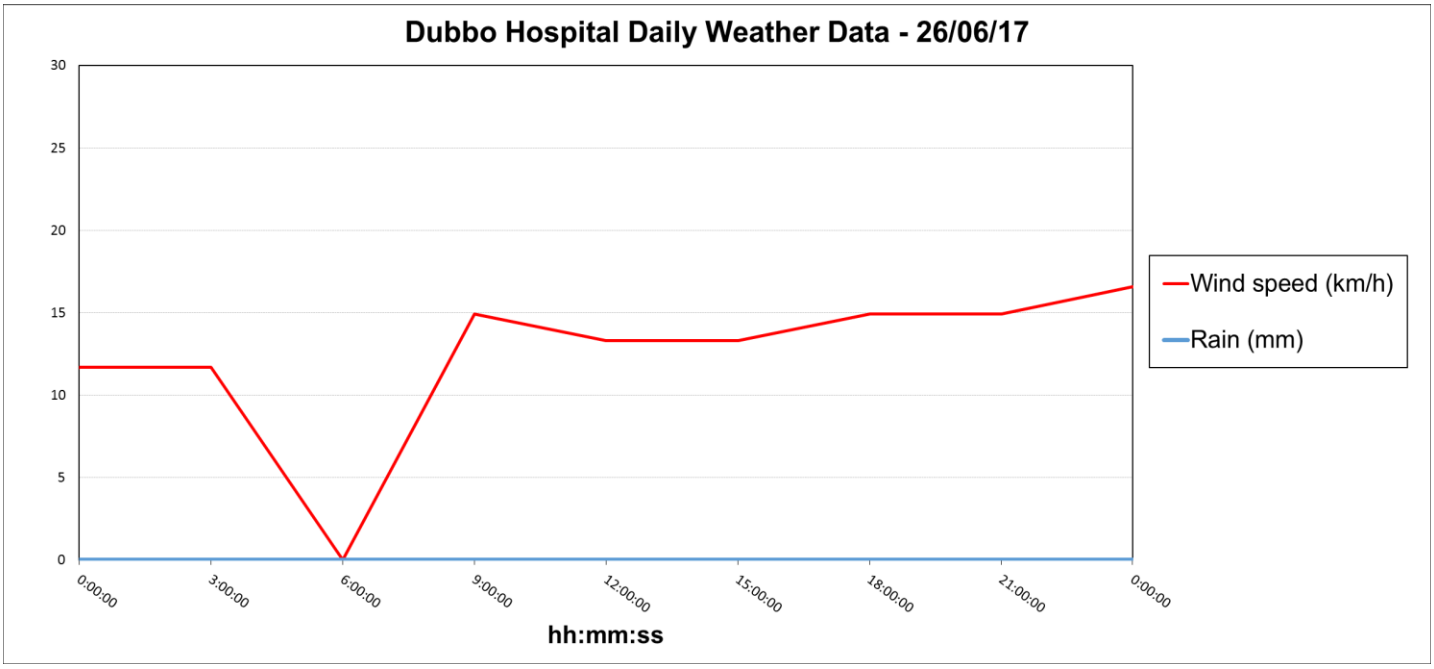

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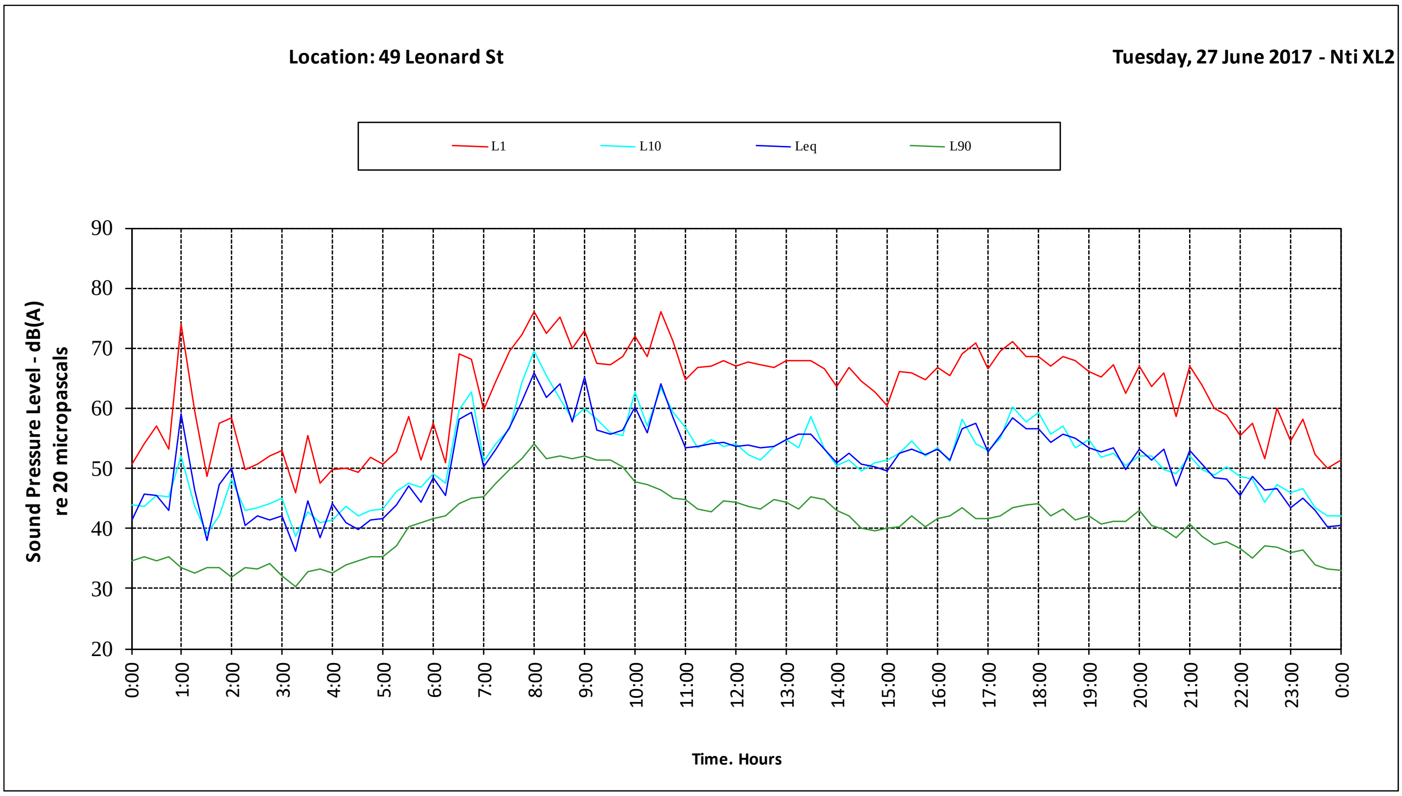

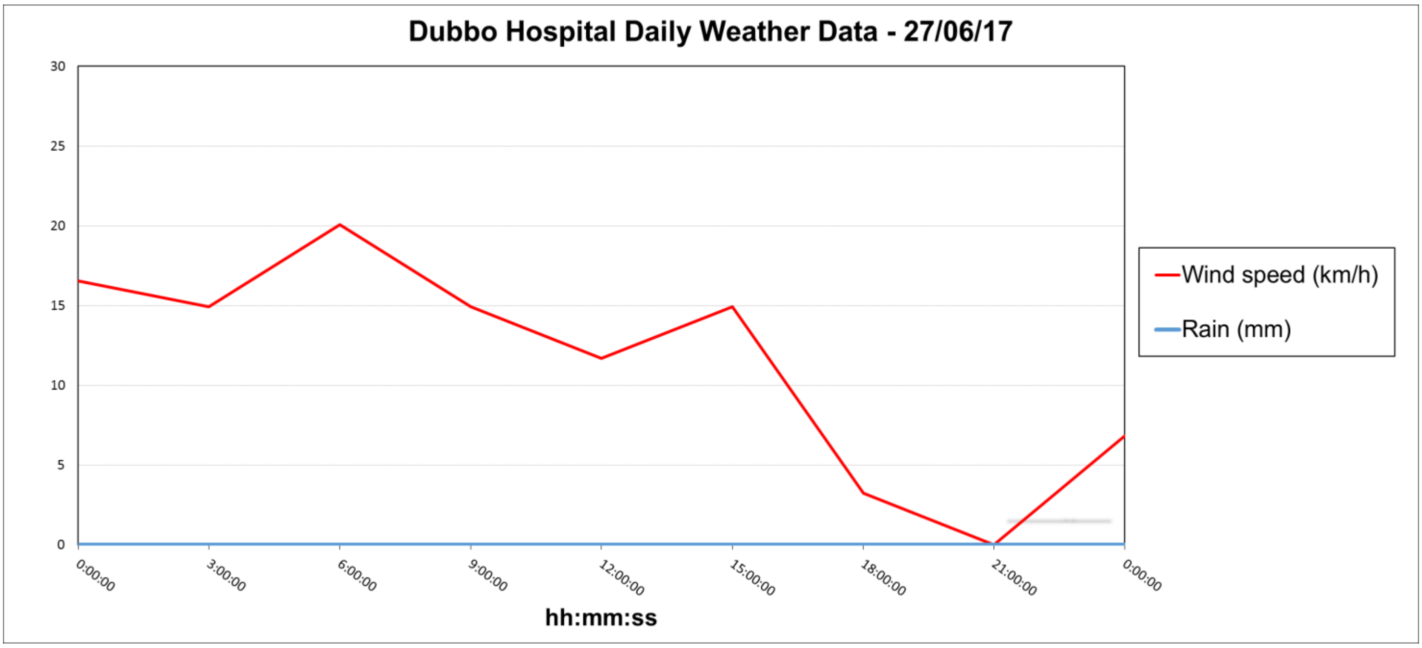

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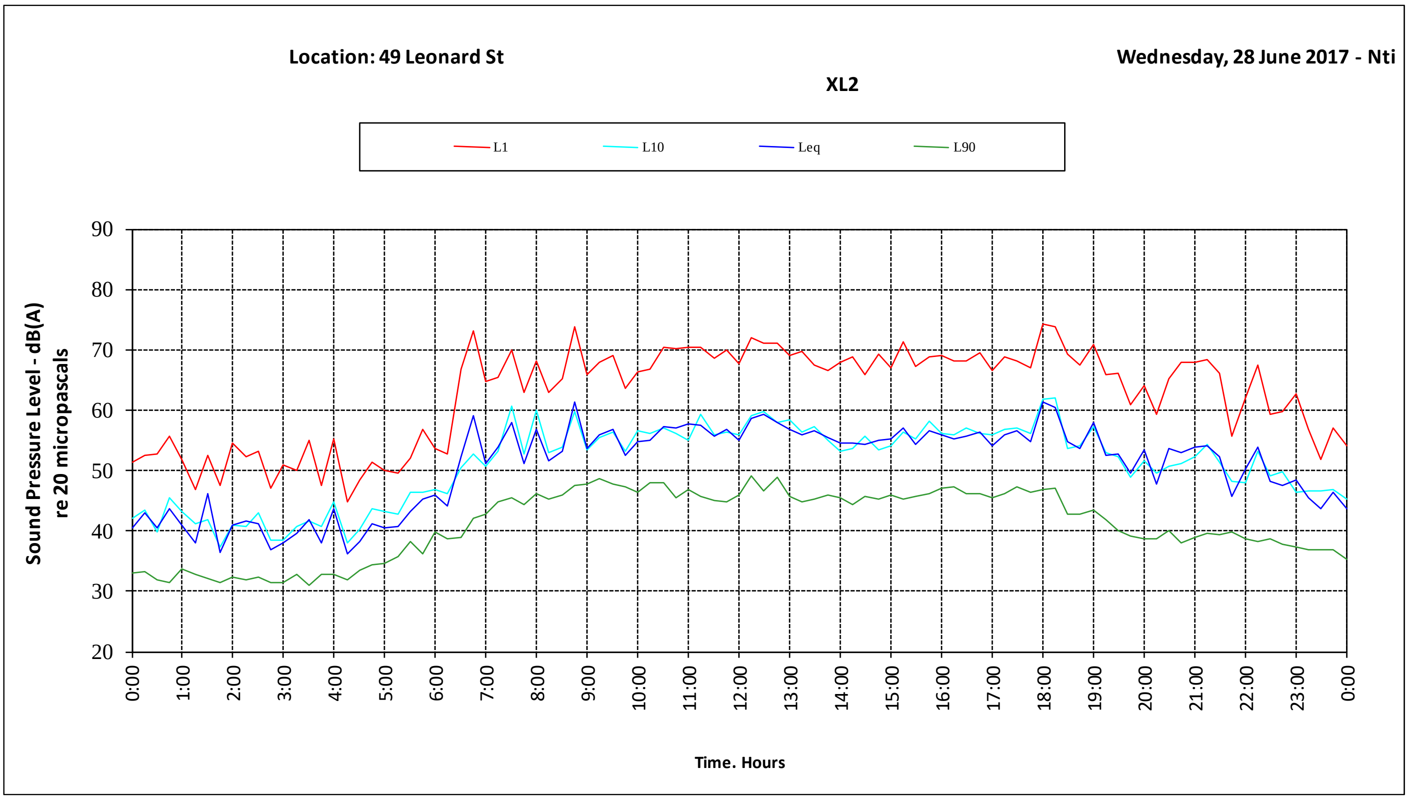

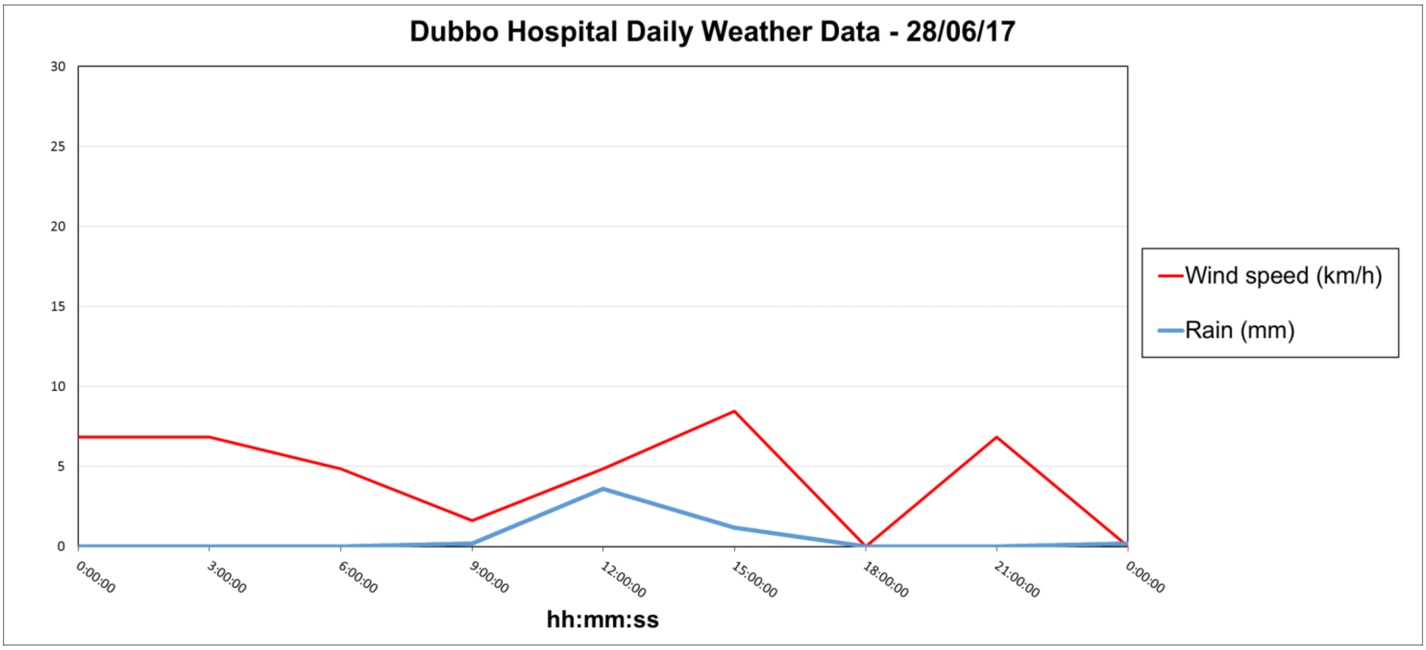

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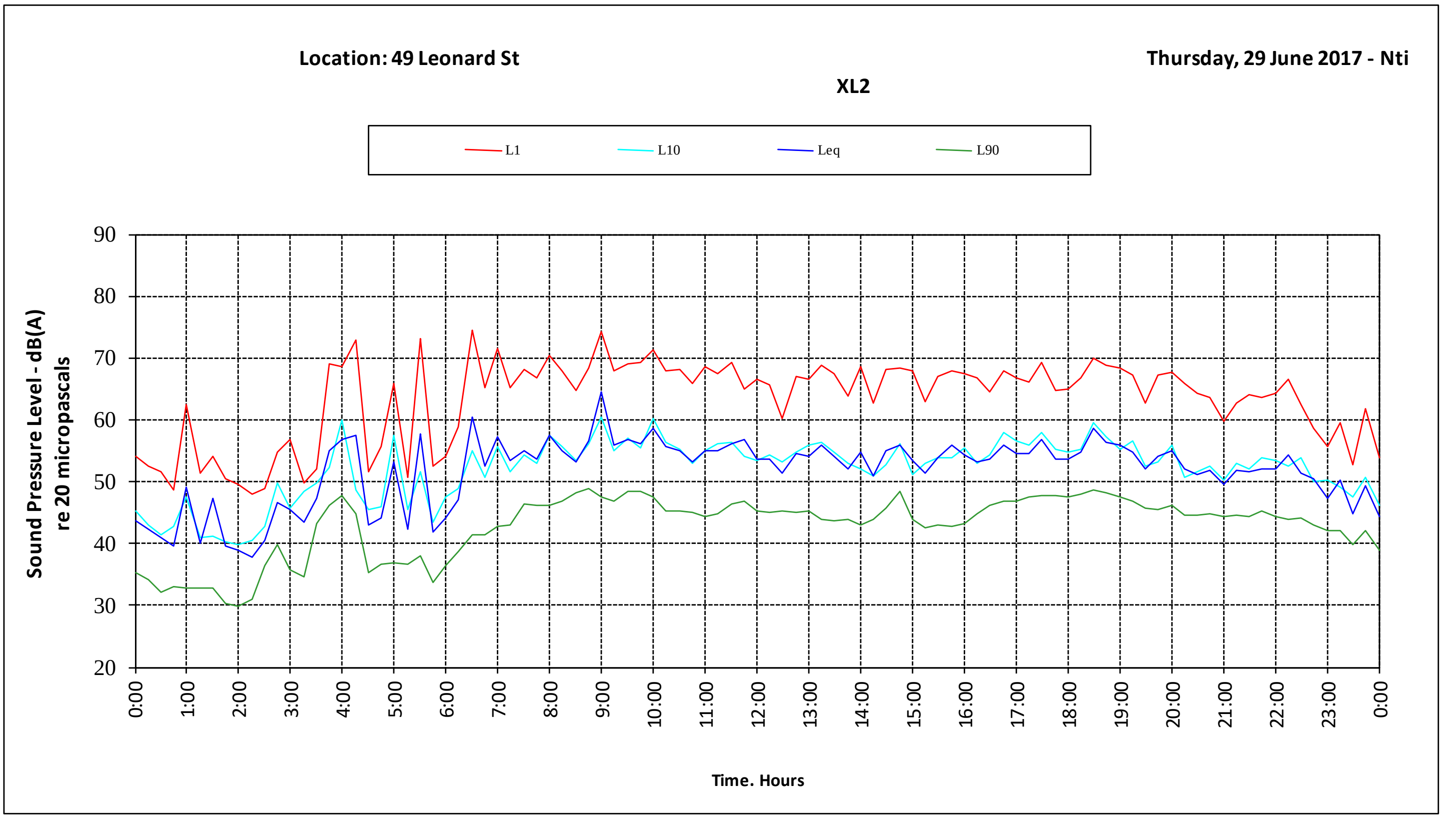

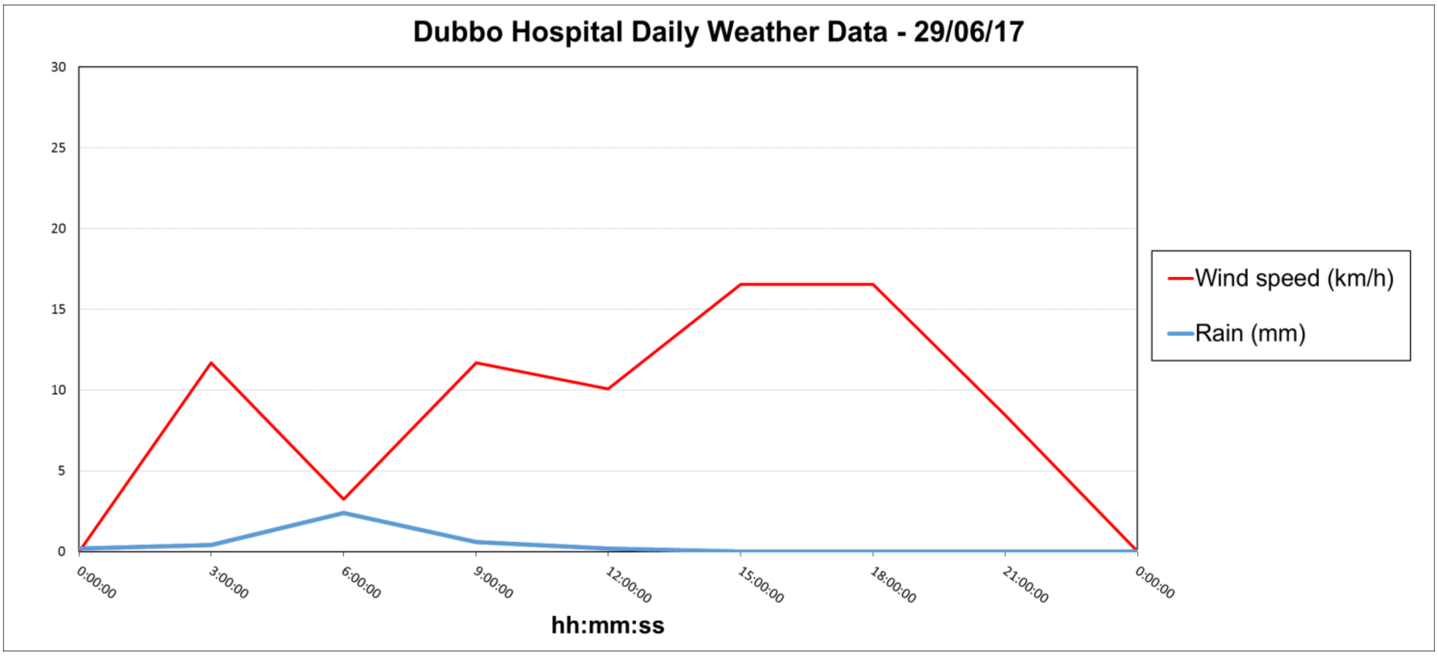

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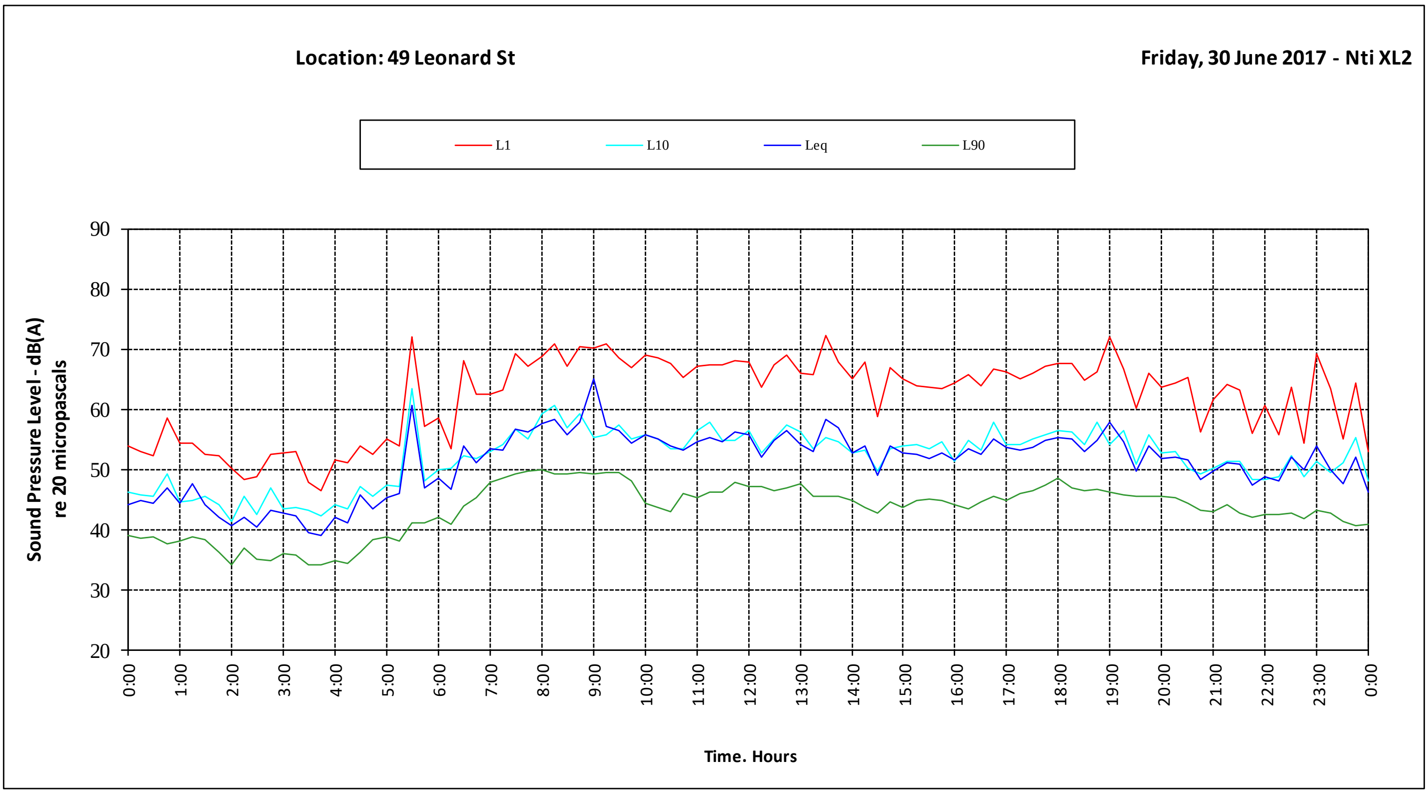

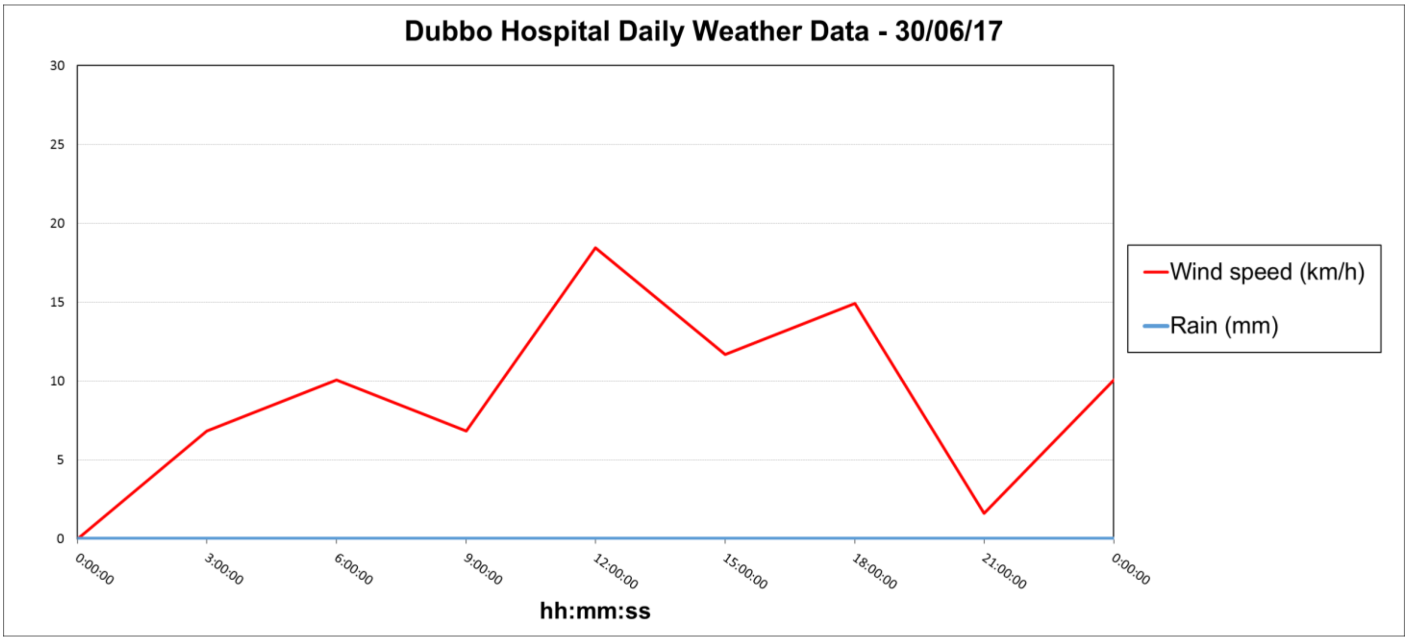

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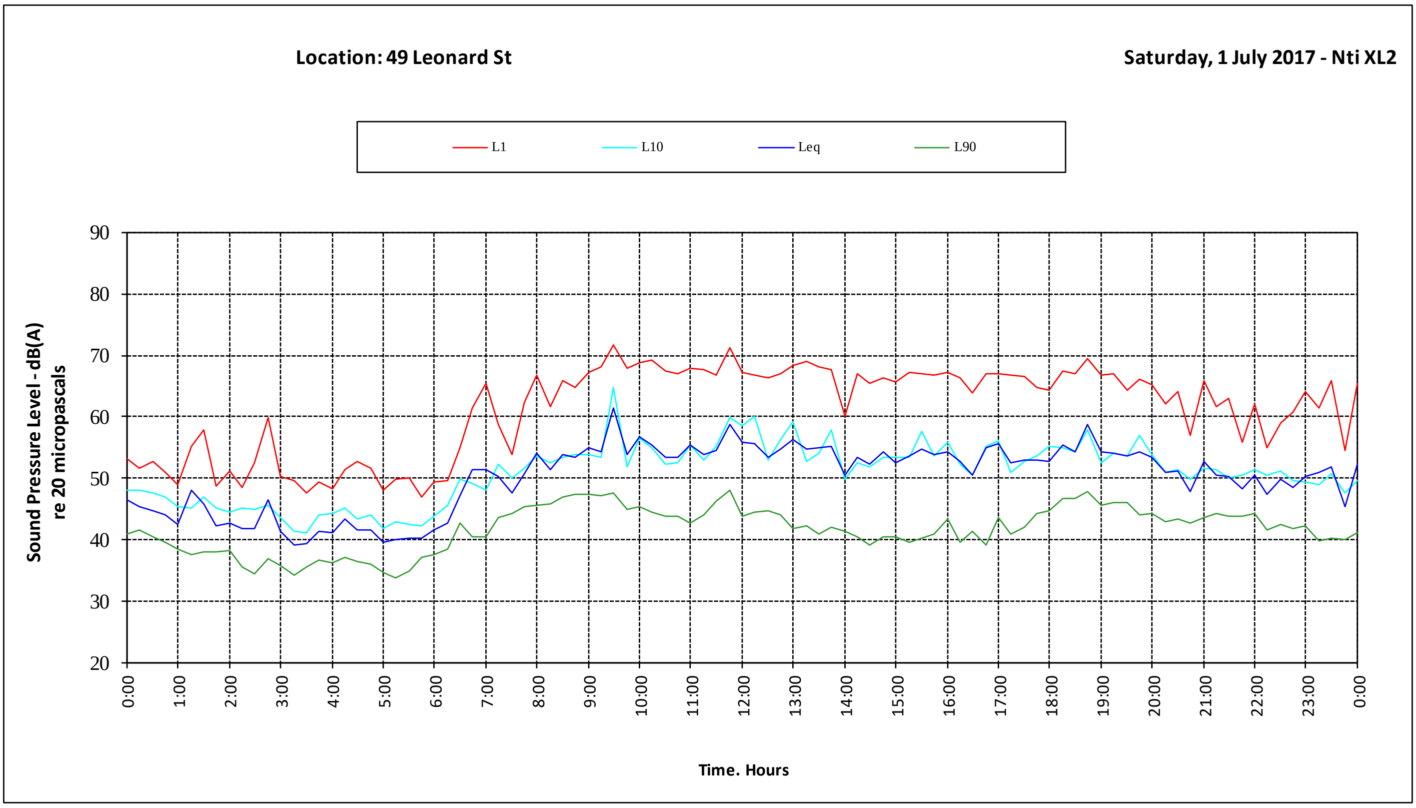

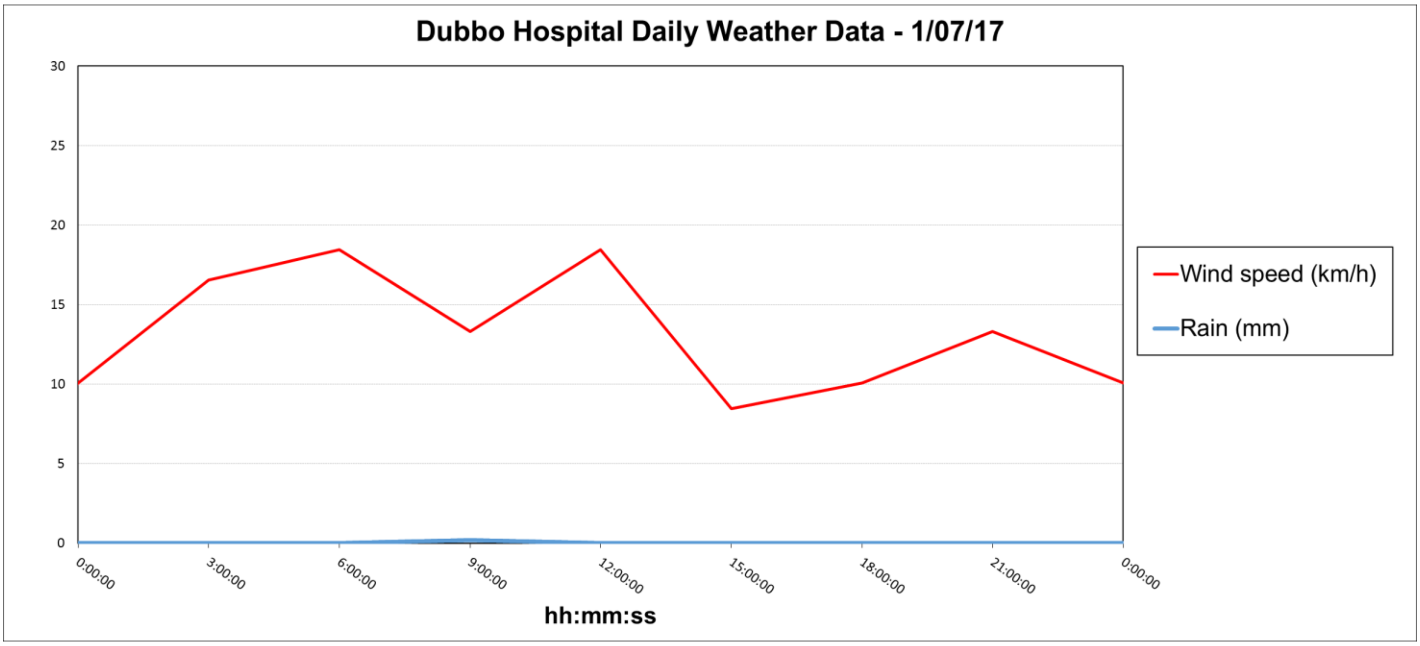

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