Report

ACOUSTIC ASSESSMENT

Dubbo Base Hospital Redevelopment – Stage 1 & 2 Review of Environmental Factors (REF)
Health Infrastructure NSW

CONFIDENTIAL

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NORMAN DISNEY & YOUNG

CONSULTING ENGINEERS

NDY Management Pty Limited trading as Norman Disney & Young
ABN 29 003 234 571
60 Miller Street
North Sydney NSW 2060

Telephone: +61 2 9928-6800
Facsimile: +61 2 9955-6900

www.ndy.com

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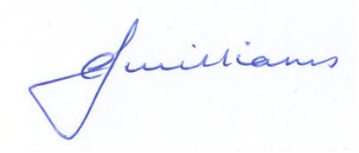

Client Name:	Health Infrastructure NSW
Client Contact:	Bruno Zinghini
Project Co-ordinator:	Tom Cockings
Editor:	Renzo Arango

Verification By: Tom Cockings

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1. EXECUTIVE SUMMARY

The purpose of this report is to provide a review of environmental factors (REF) with respect to noise and vibration for the demolition, excavation construction and operation of the proposed new buildings and refurbishments at the Dubbo Base Hospital site.

This report:

- Identifies relevant input information including management levels, Standards and engineering inputs (noise data, construction staging, geographic survey information);
- Documents NDY Sound's calculation methodology including identification of noise sources, nearest potentially affected receivers and calculation procedures;
- Presents predicted operational noise impacts arising from the new buildings and changes to car parks on the site;
- Discusses measures to control operational noise emission to the environment;
- Presents predicted construction noise and vibration impacts arising from the proposed works; and
- Presents reasonable and feasible mitigation / management options to be considered by the building contractor and sub-contractors as part of the overall Construction Management Plan (CMP).

If all of the measures discussed and considered in Section 6 (Operational Noise), Section 9 (Construction Noise) and Section 10 (Construction Vibration) are implemented, then all of the environmental noise and vibration requirements for the development will be satisfied. It is, therefore, our opinion that approval with respect to noise and vibration should be granted.

2. BACKGROUND INFORMATION

2.1. Authorization

Authorization to conduct this acoustic assessment has been provided by Catherine Lee from TSA Management.

2.2. Revision History

Date	Revision	Reason for Revision
12th June 2012	1.0	Draft
22nd June 2012	2.0	Issue
11th July 2012	3.0	Final Issue

2.3. Information Sources

- Department of Environment, Climate Change and Water (DECCW) *Interim Construction Noise Guidelines* (ICNG) dated July 2009
- Australian Standard AS 2436-2010 *Guide to noise and vibration control on construction, demolition and maintenance sites*
- Australian Standard AS 2187.2:2006 *'Explosives - Storage and Use - Part 2: Use of Explosives'*
- British Standard BS 7385 Part 2-1993 'Evaluation and measurement for vibration in buildings Part 2'
- Department for Environment Food and Rural Affairs (DEFRA, (UK)) *Update of noise database for prediction of noise on construction and open sites* dated 2005
- Transport Infrastructure Development Corporation (TIDC) *Construction Noise Strategy, November 2007.*
- Department of Environment. Climate Change and Water (DECCW) *Industrial Noise Policy* (INP, 2000).
- Department of Planning of the NSW Government. *Developments Near Rail Corridors and Busy Roads – Interim Guideline* (DNRCBR-IG).
- Geotechnical Report – Douglas Partners: Report on Geotechnical Investigation Dubbo Base Hospital Redevelopment Myall Street (72811)

3. INTRODUCTION

3.1. Scope

NDY Sound has been engaged to conduct an acoustic assessment for the works related to the redevelopment of the Dubbo Base Hospital. This assessment is addressed in two reports:

- The Stage 1 & 2 Review of Environmental Factors (REF) report – this report.
- The Stage 1 & 2 State Significant Development DA (SSD DA) report.

For the REF acoustic report, the following issues are addressed based on instructions provided by TSA Management (as per email issued 20th June 2012):

- Demolition of various structures including the existing Nurses Accommodation and Boiler House buildings.
- Construction of a new electrical substation building (including switchboard and generators) and relocation of existing pad mount substations.
- Upgrades and expansion of the existing car park.
- Termination and relocation of existing hydraulic, water, sewer, stormwater, gas and electrical infrastructure services across the site.
- Relocation of sheds to accommodate a new link road and construction access road in the northern part of the site.
- Construction of a new building for ICT infrastructure.
- Minor reconfiguration of the Hospital's main entry and front of house areas.
- Provision of new landscaping.

This REF acoustic assessment considers the external noise and vibration impact at the nearest affected receivers, which relates to the works listed above. The noise assessment will be separated into the following:

- Operational Noise Assessment
- Construction Noise and Vibration Assessment

3.2. Site Layout

The extent of the existing hospital premises is shown in Figure 3-1. The location of the nearest noise sensitive receivers is also shown in this figure. These include:

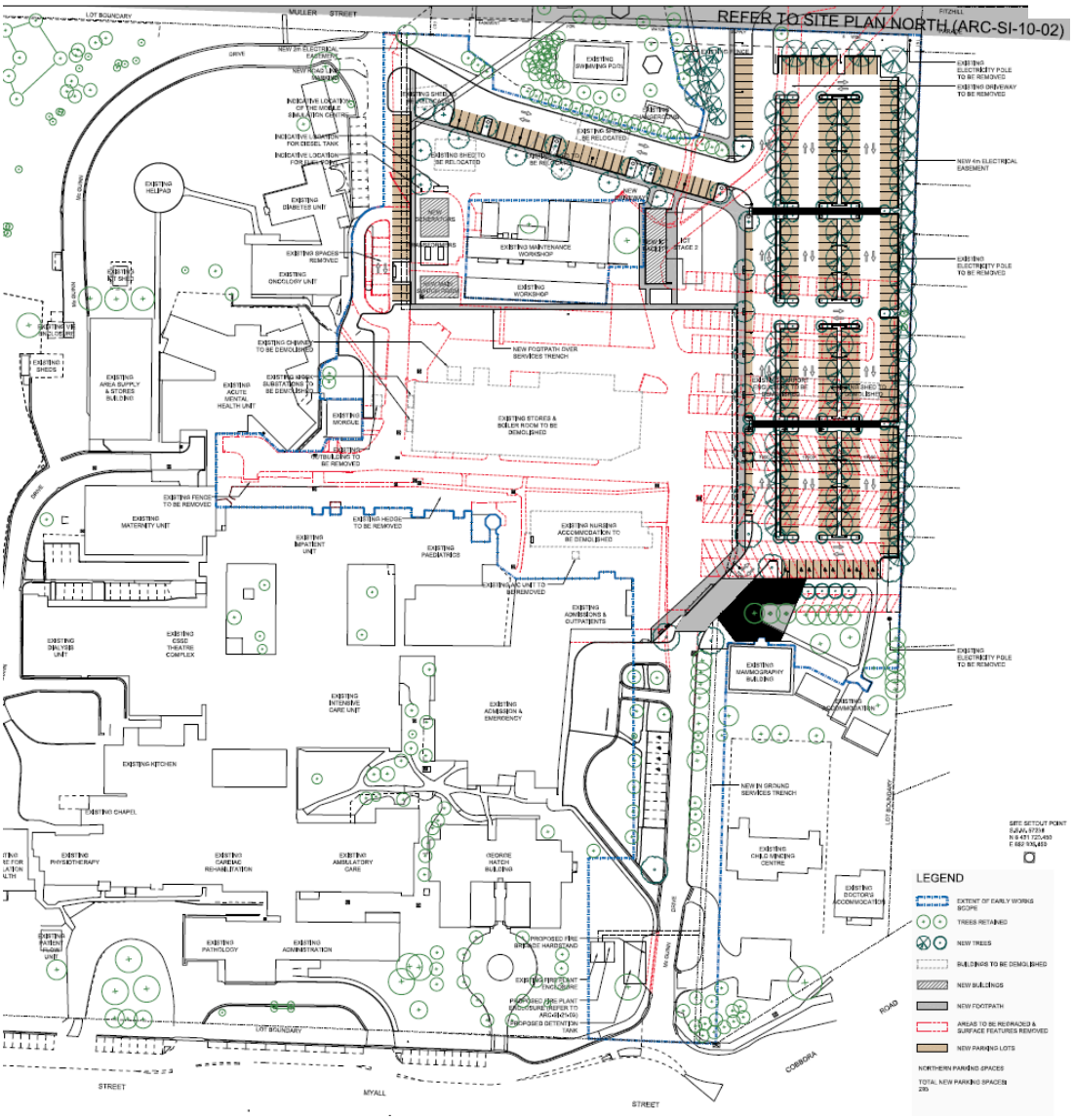
- Residences along Leonard Street (east of site).
- Residences along Morgan Street (west of site) and light industrial premises along the railway line
- Dubbo Nursing Home
- Dubbo Private Hospital
- Existing Dubbo Base Hospital buildings

Figure 3-1: Site layout (extract from NSW Government Health Infrastructure report)

Figure 3-2 shows the extents of the works proposed under the REF process for this project. These include:

- Demolition of various structures including the existing Nurses Accommodation and Boiler House buildings.
- Construction of a new electrical substation building (including switchboard and generators) and relocation of existing pad mount substations
- Upgrades and expansion of the existing car park
- Relocation of sheds to accommodate a new link road and construction access road in the northern part of the site
- Construction of a new building for ICT infrastructure
- New landscaping.

Figure 3-2: Extent of works under the REF



4. ACOUSTIC SURVEY

4.1. Methodology

Unattended noise measurements were conducted to determine the existing ambient noise levels for the area. The location where these unattended measurements were conducted is shown as *Logger Location* in Figure 3-1.

The equipment used to conduct these unattended measurements was an Acoustic Research Laboratories Environmental Logger Rion Type NL-42EX (Serial Number 00410152).

The equipment calibration was checked prior to, and after the noise survey. No significant drift was noted during the calibration procedure. The noise monitor was configured to record all relevant noise indices including background noise (L_{A90}) and equivalent continuous noise levels L_{Aeq}. Samples were recorded at 15 minute continuous intervals. The noise monitor responses were set to *fast*.

4.2. Weather Data

In order to verify that the noise data was obtained during suitable meteorological conditions, weather data was obtained from the Bureau of Meteorology (BOM). Rain and wind speed data was used from Dubbo Airport (Station Number 065070) as a representative site.

Noise data has been excluded from the results if:

- Rain was observed during the fifteen minute noise measurement period and/or
- Wind speed exceeded 5 m/s at the measurement height of 1.5 m above ground. Wind data obtained from the BOM is presented as the value at 10 m above ground, and from this velocities were estimated to represent wind speed at 1.5 m above ground.

4.3. Unattended Noise Measurements

For the purpose of the assessment, the measured data was processed into time periods as follows:

- Daytime: 0700 to 1800
- Evening: 1800 to 2200
- Night-time: 2200 to 0700

The measured background (L_{A90}) and equivalent continuous (L_{Aeq}) noise levels during these defined time periods are presented in Table 4-1.

The L_{A90} noise levels presented are *Rating Background Levels* (RBLs), being the median of the lowest 10^{th} percentile of the background L_{A90} samples in each daytime, evening and night-time measurement period, for each 24 hour period during the noise survey.

The L_{Aeq} noise levels presented are the logarithmic average of all the L_{Aeq} samples taken in each of the daytime, evening and night-time periods.

Table 4-1 Unattended measured noise levels – Logger Location

Noise Index	Noise Level dB re 20 µ Pa		
	Daytime 0700 to 1800	**Evening 1800 to 2200**	**Night-time 2200 to 0700**
L_{A90} (RBL)	41	42	37
L_{Aeq}	51	48	46

5. OPERATIONAL ACOUSTIC CRITERIA

5.1. External Noise Level Criteria – NSW Industrial Noise Policy

Based on the unattended noise survey discussed in Section 4 of this report, the external noise level criteria for nearest residences have been derived in accordance with the NSW Industrial Noise Policy (NSW INP). This was issued by NSW Environmental Protection Authority which is now part of the NSW Office of Environment and Heritage.

The NSW INP provides assessment methodologies, criteria and detailed information on the assessment of stationary mechanical plant items in NSW. The NSW INP criteria for industrial noise sources consider two (2) components:

- Controlling **intrusive** noise impacts for residential receivers. Assessing intrusiveness generally requires noise measurements to quantify background (L_{A90}) noise levels at a location considered representative of the most potentially affected residential receiver(s). The intrusiveness criterion essentially means that the equivalent continuous noise level (L_{Aeq}) of the source(s) under consideration should be controlled to within 5 dB of the background noise level.
- Maintaining noise **amenity** for various categories of land use (including residential receivers and other sensitive receivers). The amenity criterion is based on the sensitivity of a particular land use to industrial-type noise. The cumulative effect of noise from industrial sources needs to be considered. The existing noise level from industrial sources is measured. If it approaches the amenity value for the land use, noise levels from new industrial-type noise sources need to be controlled so that the cumulative effect does not result in aggregate noise levels that would significantly exceed the criterion.

Nearby noise sensitive receivers are considered to be *suburban* according to the definitions in the NSW INP for the purposes of assessing the amenity criteria. Refer to Appendix A for weekly graph distribution of measured noise levels.

Therefore, the project external noise level criteria for residences have been derived from the unattended measured noise levels discussed in Section 0. The criteria are shown in Table 5-1.

Table 5-1: External noise level criteria - Residential properties

Type of Receiver	Noise Level dB re 20 µ Pa		
	Daytime 0700 to 1800	**Evening 1800 to 2200**	**Night-time 2200 to 0700**
Intrusiveness Assessment $L_{Aeq,15min}$			
Residential Premises	**46**	47	42
Amenity Assessment $L_{Aeq,period}$			
Residential Premises	53	**38**	**36**

Note: Bold numbers indicate the lowest of the two assessment criteria for that time period and are the most stringent criteria to be used in this assessment

For receivers other than residences, we recommend to use the amenity criteria discussed in the NSW INP as recommended in the Application Notes for this policy. These criteria are listed in the table below.

Table 5-2: External noise level criteria – Non-Residential receivers

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level dB	
			Acceptable	Recommended Maximum
Hospital (external)	All	Noisiest 1hr period	50	55
Commercial premises	All	When in use	65	70
Industrial premises	All	When in use	70	75
Active recreation area	All	When in use	55	60
Passive recreation area	All	When in use	50	55

5.2. Modifying Factors for Duration

For noise events which occur for a period of less than two and a half hours in any 24 hour period, (such as maintenance operations for the stand-by generators), the predicted noise levels related to these short term events can be decreased by the modifying factors listed in Table 5-3.

Table 5-3: Modifying factors for duration

Duration of Noise Event	Modifying Factors	
	Day time and evening (0700 to 2200)	Night-time (2200 to 0700)
1 to 2.5 hours	2	Nil
15 minutes to 1 hour	5	Nil
6 minutes to 15 minutes	7	2
1.5 minutes to 6 minutes	15	5
Less than 1.5 minutes	20	10

These factors are to be applied to the predicted noise levels from these short term events before comparison with the NSW INP criteria in Table 5-1.

5.3. Traffic Noise Criteria for External Receivers (Residential)

Traffic noise impacts on the nearby residential dwellings should satisfy the conditions discussed in the *NSW Road Noise Policy* (NSW RNP) issued by the NSW Office of Environment and Heritage.

Section 3.4 of the NSW RNP states the following:

*"For existing residences and other sensitive land uses affected by **additional traffic on existing roads generated by land use developments**, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'no build option'.*

Consequently, for this development, an increase in traffic noise levels related to the new development should be limited to a maximum of 2 dB.

5.4. Car Park Noise

Traffic movements within the development and the proposed new car park will be assessed against the NSW INP. As such, the noise level criteria as discussed in Section 5.1 will be used in our assessment of this noise source. This will apply to all traffic routes through the hospital premises to the car park, the existing car park and the new extension of the existing car park. This criteria is applied in this way because the parking conditions will change and a holistic view of the entire site in this manner is appropriate and provides a conservative assessment.

5.5. The State Environmental Planning Policy (Infrastructure) 2007 (SEPP 2007)

5.5.1. Noise and Vibration from Rail Corridors

Clause 87 of the SEPP 2007 requires that the potential impact of rail noise and vibration should be considered for several development types which includes hospitals.

Hence, in order to provide guidelines for this type of assessment the Department of Planning of the NSW Government has prepared a document called *Developments Near Rail Corridors and Busy Roads – Interim Guideline* (DNRCBR-IG).

Section 3.5.1. of the DNRCBR-IG discusses the level of assessment that is required based on distance from the rail corridor. These are summarised in Figure 5-1 and Figure 5-2. The rail corridor located west from the hospital premises is used for passenger and freight services.

Figure 5-1: Summary on the application of rail noise assessment (extract from DNRCBR-IG, Section 3.5.1)

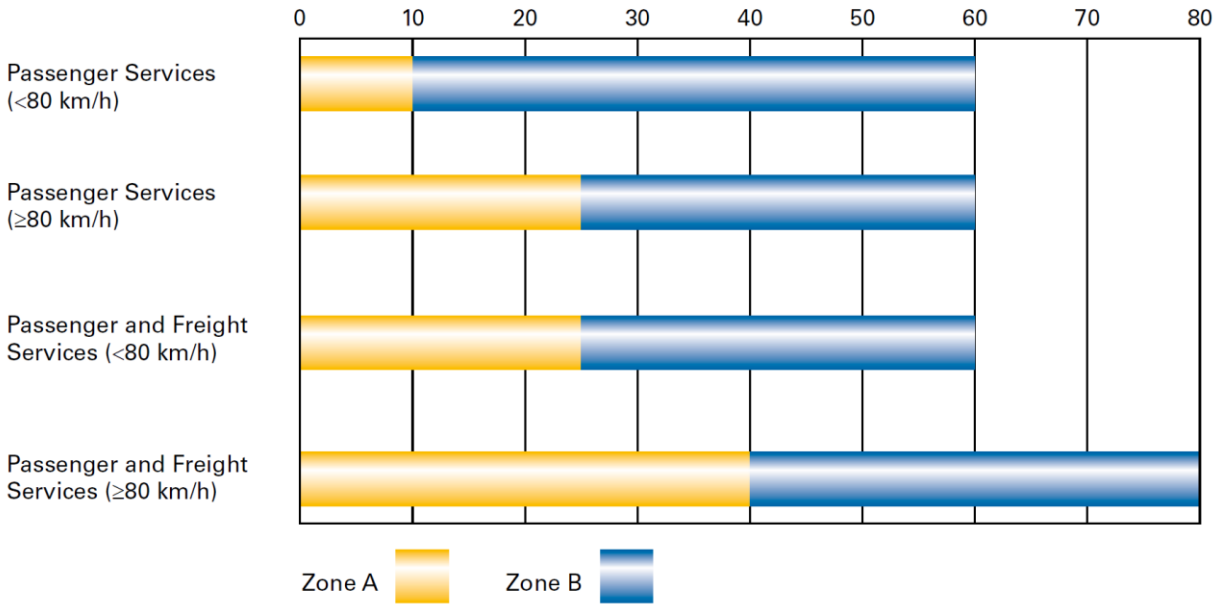


Figure 3.1: Acoustic Assessment Zones based on distance (m) of noise-sensitive development from operational track (not corridor)

Figure 5-2: Summary on the application of rail vibration assessment (extract from DNRCBR-IG, Section 3.5.1)

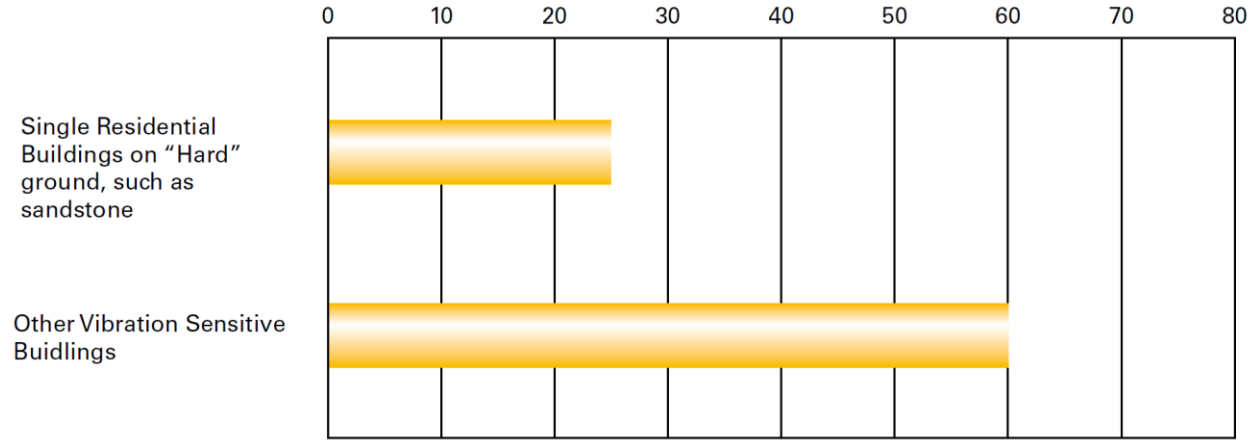


Figure 3.2: Distance from the nearest operational track (m)

For developments located within Zone A, a full impact assessment is required. For single dwelling residences located within Zone B, standard mitigation measures apply.

It is estimated that the distance from the rail corridor to the existing renal unit (where refurbishment works will take place) is approximately 95 m. Also, the distance from the rail corridor to the new hospital building is approximately 195 m.

Therefore, based on these distances, it is concluded that the development areas included in the REF DA scope do not require a rail noise and vibration assessment.

5.5.2. Noise and Vibration from Road Corridor

Clause 102 of the SEPP 2007 requires that the potential impact of road noise and vibration should be considered for several development types which includes hospitals. A development should be assessed if the nearby road is a freeway, tollway or a transit way or has an annual average daily traffic volume (AADT) of more than 40,000 vehicles (based on the traffic volume data available on the website of the RTA).

The latest traffic volume information available (which corresponds to 2002), for the Golden Highway (which is nearest major road corridor), indicates that the AADT is 19,156. This is below the benchmark that determines whether a road noise and vibration impact assessment is required.

Therefore such assessment is not applicable for the development addressed in the REF scope.

6. ACOUSTIC ASSESSMENT - OPERATIONAL NOISE SOURCES

A 3D noise model of the site was created using the industry standard software package SoundPLAN. The model included local topographical information, buildings, shielding from fences and ground absorption. This model was used as the basis for noise predictions at the nearest receivers due to noise emission from mechanical services, car parking and road traffic.

6.1. Mechanical Services Noise

Mechanical plant information is not available for the development at the time of writing this report. Therefore, NDY Sound has used noise data for small to medium sized air conditioning plant, which would be typical of the equipment required for the proposed new buildings of the development. For the generators we have assumed up to two (2) typical diesel generators of approximately 1500 kVA. This information has been used to predict the environmental noise emission from the site to the nearest noise sensitive receivers (as identified in Section 3.2). Assessing the worst case acoustic scenario the shortest offset distance between the mechanical plant and the receivers is:

- **55 m**: East between the residence on Leonard Street and the proposed ICT facility.
- **5 m**: South east between the existing maintenance workshops and the proposed generators.
- **24 m**: West between the existing Diabetes unit and the proposed generators.
- **48 m**: North east between the existing swimming pool and the proposed generators.
- **135 m**: East between the residence on Leonard Street and the proposed generators.
- **235 m**: West between the residences on Morgan Street and the proposed generators.

In order to achieve the environmental noise emission criteria (see Table 5-1) at this offset distance the mechanical plant must achieve an aggregate sound power level of:

- **79 dBA Lw**: For the proposed ICT facility mechanical / air conditioning plant.
- **87 dBA Lw**: For the proposed generators (assuming the generators are run for 1 hour or less during maintenance procedures and that the nearby maintenance sheds are assumed to be 'Industrial' receivers).

The limiting aggregate sound power levels for the plant, is the summation of the emitted sound power level contributions from all mechanical plant items in each plant room or plant area.

To achieve the sound power level emission given above we estimate that typical medium-sized air conditioning plant will need to be attenuated by 0 - 10 dB. This can be readily achieved with standard noise control measures such as:

- Re-location of equipment.
- Attenuators (silencers).
- Shielding from the buildings or using localised roof top barriers.
- Selection of the quieter equipment.

To achieve the sound power level emission given above we estimate that the generator plant will need to be attenuated by 20 - 30 dB. This can be readily achieved with standard noise control measures for this type of equipment such as:

- Large attenuators (silencers).

- Shielding from the buildings or using localised roof top barriers.
- Primary and if necessary secondary in-series exhaust mufflers.
- Acoustic access doors and or airlock systems.
- Heavy duty acoustic enclosures.

The mechanical plant noise emission should be assessed during the detailed design stages and appropriate noise control measures implemented to satisfy the noise criteria discussed in Section 5.1.

6.2. Traffic Noise on Local Roads

NDY Sound has reviewed the traffic information contained in the Dubbo Base Hospital Concept Design Report - Stage 1/2 Redevelopment. The largest increase of vehicles trips generated by the proposed development will be 85 trips in the weekday AM period, which approximates to 14 additional vehicle trips per hour.

Existing hourly vehicle movements on the surrounding supply roads are not available for direct assessment. However, to generate a noise increase of 2 dB (the criteria limit) due to road traffic, the existing hourly traffic volumes would need to be 24 vehicles or less. None of the surrounding roads will have hourly traffic volumes that are this low – they will be significantly higher. Therefore, the noise impact due to additional vehicles is negligible and is not required to be considered further. The requirements of the NSW RNP are satisfied.

6.3. Car Park Noise

Details of the proposed car park extension to the East of the site are shown in Figure 3-2 above. There will be approximately 70 new car park spaces in the future under the current proposal. Many of the new parking spaces will be constructed to the north of the existing car park, adjacent to the residential boundary on the east of the site.

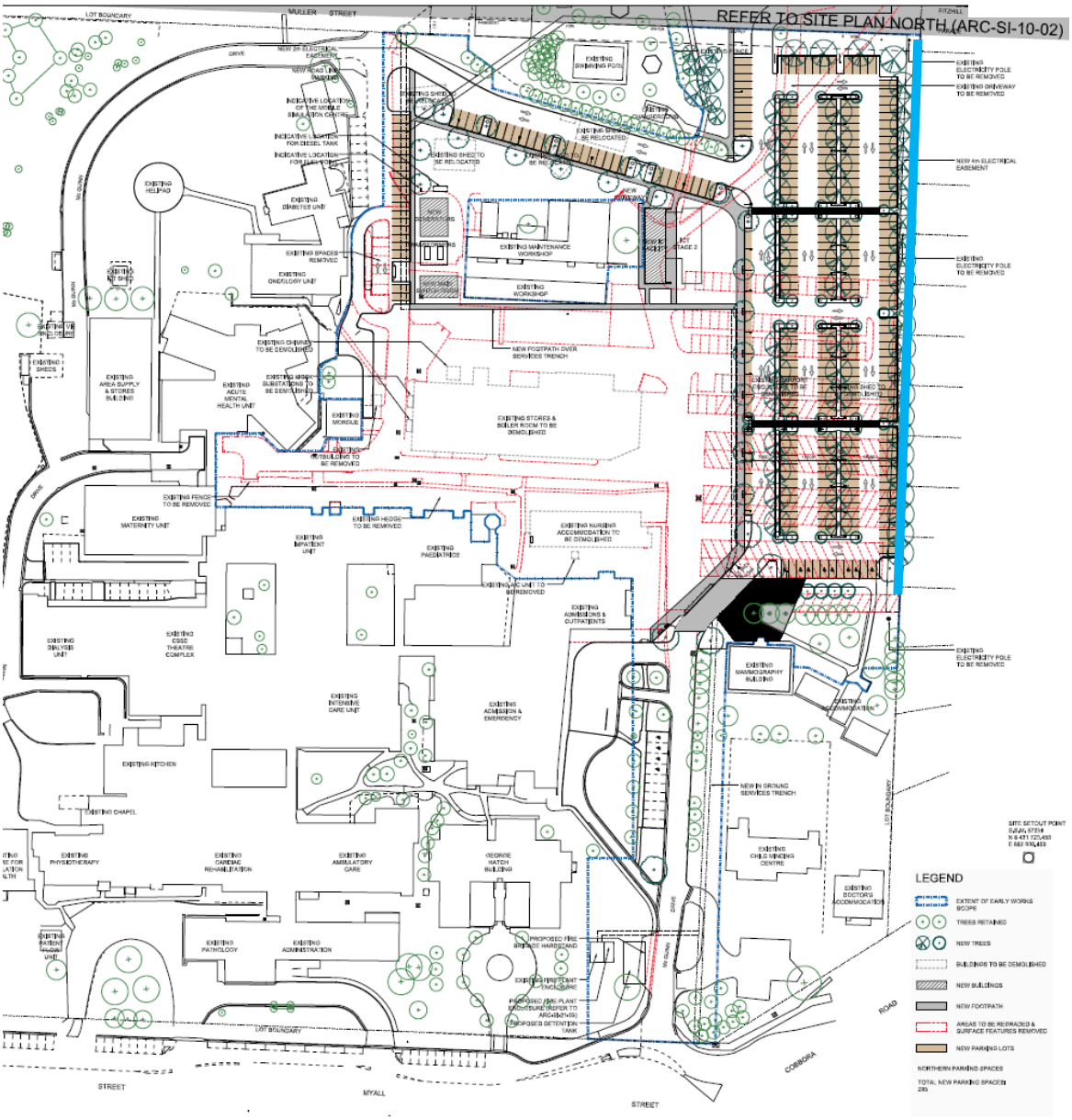
Noise emission to the residences along Leonard Street (worst case) will not change for the residential receivers currently adjacent to the existing carpark – as the density of car parking will remain unchanged. However, to the north of the existing car park where the additional spaces will be located there will be some noise impact due to the additional spaces. This noise impact was assessed by calculating the noise emission of cars moving into parking spaces with the following modelling parameters:

- Car moving: 89 dBA L_W.
- Average vehicle speed: 5 km/h.
- Average time spent manoeuvring into space: 106 seconds.
- Worst case scenario 14[1] vehicles park enter / leave the car park in a 1 hour period.

This scenario is considered the worst case during AM periods. The noise emission from vehicles parking will exceed the applicable criteria if no noise control is applied to the site. The only feasible and reasonable method to control noise emission from car parks is with noise barriers / walls. Noise walls, of varying heights, along the eastern boundary adjacent to the car park were investigated within the noise model. A noise wall with a height of 1.8 m (as illustrated in Figure 2 below) was determined to satisfy the noise criteria in relation to car park noise emission.

[1] Based on the Concept Design Report AM traffic peak of 85 cars and assuming AM period extends for approximately 6 hours between 0600 and 1200

Figure 6-1: Extents of the recommended noise wall to control car park noise



Blue = 1.8 m high fence

All fences must be continuous, free from gaps, sealed to the ground and comprise a material with a minimum surface density of 8 kg/m^2. Standard ColourBond or lapped and capped timber paling fences are suitable noise barriers.

Note: the noise wall location is indicative and should be reviewed to maintain compliance during the detailed design.

7. CONSTRUCTION NOISE CRITERIA

7.1. The Interim Construction Noise Guideline (ICNG)

The Interim Construction Noise Guideline (ICNG) is aimed at managing noise from construction works regulated by the NSW Office of Environment and Heritage. It is also the de facto guideline for acoustic practitioners and other interested parties, used to assist in the assessment of noise emission from construction activities.

On this basis, the ICNG is used in this document to assess potential noise emission from proposed construction activities at the hospital site.

With reference to Section 1.3 of the ICNG, the main objectives of the Guideline are to:

- Use Noise Management Levels (NML's) to identify demolition, excavation and construction noise sources or scenarios that require engineering controls or administrative management (The term criteria is specifically not used in the ICNG).
- Promote a clear understanding of ways to identify and minimise noise from construction works.
- Focus on applying all feasible and reasonable work practices to minimise construction noise impacts.
- Encourage construction to be undertaken only during the recommended standard hours unless approval is given for works that cannot be undertaken during these hours.
- Streamline the assessment and approval stages and reduce time spent dealing with complaints at the project implementation stage.
- Provide flexibility in selecting site-specific and reasonable work practices in order to minimise noise impacts.

The sections below present important concepts and procedures to be followed in the application of the ICNG.

7.2. Feasible and Reasonable

Two salient concepts in the ICNG are those of what are 'Feasible' and 'Reasonable' measures to minimise noise impacts. The guideline defines these concepts as follows:

Feasible

"A work practice or abatement measure is feasible if it is capable of being put into practice or of being engineered and is practical to build given project constraints such as safety and maintenance requirements".

Reasonable

"Selecting reasonable measures from those that are feasible involves making a judgment to determine whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the measure.

The regulatory authority may review the information on feasible and reasonable work practices provided by the proponent, and compare the practices against those applied on similar projects. The regulatory authority may negotiate additional work practices that it considers may also be feasible and reasonable".

7.3. Qualitative and Quantitative Assessment

The ICNG provides for both a quantitative and a qualitative method of assessing the impact of construction noise.

The guideline states that a qualitative assessment method may be used for short-term maintenance work, and the definition of short-term is that the "*works are not likely to affect an individual or sensitive land use for more than three weeks in total*".

It is our understanding that the upgrades works for the facility will take longer than three weeks, hence, we consider that a quantitative assessment is the most appropriate for this project.

7.4. Noise Management Levels for Residences

In accordance with the quantitative assessment discussed in the ICNG, the noise management levels (NMLs) for residences are summarised in Table 7-1.

The term RBL applies to the Rating Background Level and is defined in the NSW Industrial Noise Policy (NSW INP). The RBL is often interchangeable with the term 'background noise level'. These are listed in Table 4-1, as obtained from previous noise surveys by others. Consequently, the recommended NMLs based on RBL values have been estimated and included in Table 7-2.

Table 7-1. Summary of quantitative assessment

Time of Day	Management Level $L_{Aeq\ (15\ min)}$	How to Apply
Recommended standard hours: Monday to Friday 0700 to 1800 Saturday 0800 to 1300 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 affected noise level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dBA	The highly affected level represents the point above which there may be strong community reaction to the 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 occur, taking into account: 1. Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid morning or mid afternoon for works near residences 2. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5	Strong justification would typically be required for work outside the recommended standard hours. The proponent should apply for 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 dBA above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see Section 7.2.2 of ICNG.

Table 7-2. NMLs for residences

Noise Sensitive Receivers	Daytime		Where Assessed
	Measured RBL $L_{A90(15min)}$ (dB)	Noise Management Level $L_{Aeq(15min)}$ (dB)	
Residences along Leonard Street	41	**51**	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.
Residences along railway corridor – Morgan Street	41	**51**	

The NMLs apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. This is in accordance with the ICNG requirements and based on an assumption that, if occupants of a residential premise are at home during the day, they would mainly occupy the ground floor living areas. Noise levels would be higher at upper floors of exposed residences given typical shielding provided by fences, outbuildings, adjacent buildings and the like.

If the construction noise levels exceed 75 dBA at residential premises, additional measures must be implemented. Principally, this involves further time restrictions or less noise-intensive work practices, in exchange for an extension of the construction duration.

7.5. Noise Management Levels for Other Noise Sensitive Receivers

It is also necessary to establish construction noise management levels for noise-sensitive receivers within the hospital campus. These are based on the ICNG and identified in Table 7-3

Table 7-3. NMLs for other noise sensitive receivers

Land Use	Management Level $L_{Aeq\ (15\ min)}$ (applies when properties are being used)
Hospital Wards and Operating Theatres	Internal Noise Level 45 dB
Active Recreation Area	External Noise Level 65 dB
Passive Recreation Area	External Noise Level 60 dB
Offices	External Noise Level 75 dB

For the purpose of this assessment:

- The criteria corresponding to hospitals should apply at those buildings identified in Figure 3-1.
- On the assumption that the existing building facades offer an external to internal noise reduction of 20 dB (with the weakest facade component assumed to be commercial quality glazing, no operable panes, with 6 mm glass), the corresponding external management level at the facade of buildings is the internal noise level listed in Table 7-3, plus 20 dB. Should compliance testing be undertaken, measurements should be undertaken within the affected building(s) and measured results assessed against the recommended internal noise level.
- The *active recreation area* criterion applies to the open swimming pool area situated to the east of the Dubbo Nursing Home.

8. CONSTRUCTION VIBRATION CRITERIA

This section presents the benchmarks used to assess vibration impacts due to the construction works. The criteria discussed below are non-mandatory. Instead they are goals that should be sought to be achieved through the application of all feasible and reasonable mitigation measures. Where all feasible and reasonable measures have been applied and vibration values are still beyond the maximum value, the operator would need to negotiate directly with the affected stakeholders in the hospital and residential community[2].

Ground vibration impacts for buildings near construction sites may be defined by five (5) categories for this development, in increasing order of subjective intensity:

- **Medical Equipment / Operating Theatres** – vibration levels that may affect sensitive operations particularly those using optical magnification.
- **Ground Borne Noise** – vibration which travels through the ground and into building structures. The vibrating building structures generate airborne noise inside the rooms.
- **Human Comfort** (*Nuisance*) – perceptible vibration in which building occupants are inconvenienced or disturbed.
- **Cosmetic Damage** – vibration where the building surfaces begin to show cosmetic cracks.
- **Building Damage** – long or short term vibration in which the integrity of a building or structure itself is placed at risk.

In occupied buildings, achieving criteria for minimising nuisance / ground borne noise infers compliance with building damage criteria.

The following subsections provide a brief review of applicable Standards and vibration criteria for the minimisation of nuisance and building risk. The criteria are applicable in the z-axis (vertical direction) and vibration levels shall be appropriately weighted for this axis[2].

8.1. Medical Equipment / Operating Theatres

Operating theatres especially those with delicate surgery that relies on optical magnification can be susceptible to vibration. To augment the assessment of vibration the Peak Particle Velocity (PPV) in mm/s shall be used to define reasonable limits where optical magnification is used. These PPV limits are given in Table 8-1 below.

Table 8-1. PPV vibration velocity values for spaces that use optical magnification, mm/s

Location	Time period	Preferred values	Maximum values
Operating theatres with optical magnification ≤ 40×	All hours	0.14	0.28
Operating theatres with optical magnification > 40×	All hours	0.05	0.10

[2] As per NSW DECCWs *Assessing Vibration - A Technical Guideline*.

8.2. Ground Borne Noise

Ground-borne noise occurs when energy associated with vibration intensive activity causes surfaces within a room to vibrate. The energy is then imparted into the air within the room and can result in audible noise (dependent upon ambient background noise levels and the level of airborne noise intrusion associated with nearby construction activities).

Based on the guidance given in the NSW DECCW Interim Construction Noise Guidelines (ICNG), we propose the following noise management levels for ground borne noise.

Table 8-2. Ground Borne Noise Targets, L_{Aeq} dB

Location	Ground Borne Noise Management Level L_{Aeq} (dB re 20 µPa)
Residential dwellings	45
Wards and Recovery Areas	45
Operating Theatres	45
Offices	55

Notes:
1. Management levels applicable during the construction hours discussed NSW ICNG.
2. Time weighting for ground borne noise should be set to *Slow* (1s)

8.3. Human Comfort

With regard to human perception and annoyance, ground vibration from construction activities is assessed as three (3) separate components; intermittent[3] vibration, impulsive and continuous vibration.

Applying a Peak Particle Velocity (PPV) limit of 0.2 mm/s (referred to in DIN 4150) is intended to correspond to the human threshold of vibration perception. However, it poorly accounts for the likely human response to intermittent vibration over extended time periods.

On this basis criteria founded on ISO and Australian Standards are therefore presented as an improved benchmark for physical monitoring of compliance. The applicable human comfort vibration goals for continuous, intermittent and impulsive vibration sources are provided in the tables below. In all cases, the vibration goals are expressed in terms of the RMS vibration velocity level in mm/s, measured in the most sensitive direction (z-axis).

[3] The term 'intermittent' is used to collectively refer to impulsive or short term events, including vehicle pass-bys, pile driving or hammering.

Table 8-3. RMS vibration velocity values for continuous vibration, mm/s

Location	Time period	Preferred values	Maximum values
Theatres, Precision Labs	All hours	0.1	0.2
Residences / Wards	0700-2200	0.2	0.4
	2200-0700	0.14	0.28
Offices / Consultation / Staff Areas	All hours	0.4	0.8
Workshops / Labs / Utility	All hours	0.8	1.6

Table 8-4. RMS vibration velocity values for impulsive vibration, mm/s

Location	Time period	Preferred values	Maximum values
Theatres, Precision Labs	All hours	0.1	0.2
Residences / Wards	0700-2200	6.0	12.0
	2200-0700	2.0	4.0
Offices / Consultation / Staff Areas	All hours	13.0	26.0
Workshops / Labs / Utility	All hours	13.0	26.0

For intermittent vibration (typical of construction activities such as rock breakers, piling, excavators and the like) the fourth-power Vibration Dose Value (VDV) is submitted as an improved metric. The VDV is measured over each diurnal period as a cumulative dose value. The VDV is more sensitive to peaks in vibration, and also includes weightings to account for the variation in human sensitivity to vibration with frequency. Table 8-5 provides the applicable goals for intermittent vibration.

Table 8-5. Acceptable vibration dose values for intermittent vibration, $m/s^{1.75}$

Location	Time period	Preferred values	Maximum values
Theatres, Precision Labs	All hours	0.1	0.2
Residences / Wards	0700-2200	0.2	0.4
	2200-0700	0.13	0.26
Offices / Consultation / Staff Areas	All hours	0.4	0.8
Workshops / Labs / Utility	All hours	0.8	1.6

The DECCW vibration guideline notes the following in relation to the preferred and maximum vibration levels:

> *There is a low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values. Activities should be designed to meet*

the preferred values where an area is not already exposed to vibration. Where all feasible and reasonable measures have been applied, values up to the maximum value may be used if they can be justified. For values beyond the maximum value, the operator should negotiate directly with the affected community. Situations exist where vibration above the preferred values can be acceptable, particularly for temporary disturbances and infrequent events of short term duration.

In circumstances where work is short term, feasible and reasonable mitigation measures have been applied, and the project has a demonstrated high level of social worth and broad community benefits, then higher vibration values (above the maximum) may apply. In such cases, best management practices should be used to reduce values as far as practicable, and a comprehensive community consultation program should be instituted.

8.4. Cosmetic Damage

Australian Standard AS 2187.2:2006 *'Explosives - Storage and Use - Part 2: Use of Explosives'* recommends frequency dependent values and assessment methods as given in BS 7385.2:1993 and is considered the most recent and relevant standard for vibration damage goals.

The standard sets values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are considered to give a minimum risk of vibration-induced damage, where a 95% probability of *no* effect is regarded as the lowest risk scenario.

The standard typically considers transient vibration events such as demolition, blasting and piling etc. Activities such as rock breaking / hammering and sheet piling are considered to have the potential to cause dynamic loading (from continuous / intermittent sources of vibration), so the transient vibration level criteria are reduced by 50%.

For most construction activities involving continuous or intermittent vibration sources such as rock breakers, piling rigs, vibratory rollers, excavators and the like, the predominant vibration energy occurs at frequencies greater than 4 Hz (and usually in the 10 Hz to 30 Hz range). On this basis, a conservative vibration damage screening level of **7.5 mm/s** will be adopted for assessment purposes.

In order to assess the likelihood of cosmetic damage due to vibration, evaluation should be undertaken at the base of the building and the highest of the vibration components (transverse, longitudinal and vertical directions) should be compared with the guidance curves in AS 2187.2:2006

If vibration levels are predicted to exceed 7.5 mm/s, then more detailed analysis of the building structure, vibration source, dominant frequencies and dynamic characteristics of the building structure will be required.

8.5. Structural Damage

DIN 4150 Part 3 provides guidance on vibration velocity levels for both intermittent and continuous long-term events to prevent structural damage to buildings. These criteria are summarised in Table 8-6. We recommend adherence to (and have applied criteria from) the 1999 version of this Standard.

Table 8-6. DIN Part 3 4150:1999 structural damage safe limits for building vibration, mm/s

Group	Type of Structure	Intermittent vibration limit by frequency range [4]			Continuous vibration [5], all frequencies
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz	
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	10
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	5
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	2.5

With regard to Table 8-6, application of overall (broad frequency spectrum) vibration velocity limits of the following are considered suitable in lieu of more detailed analysis of spectral content:

- 5mm/s for both continuous and intermittent vibration at residential locations,
- 5-20mm/s for intermittent vibration at commercial locations, and
- 2.5mm/s for continuous and 3mm/s for intermittent vibration at sensitive locations

[4] When evaluated at the foundation
[5] When evaluated in the horizontal plane of floor of uppermost storey.

9. ACOUSTIC ASSESSMENT – CONSTRUCTION NOISE SOURCES

9.1. Methodology

A computer noise model has been produced to predict airborne noise at the nearest affected receivers due to construction activities. The model includes ground topography, existing buildings, receivers and construction / demolition plant. These plant items are simulated in the model during the construction stages as discussed in Section 3.1 of this report. This has enabled the acoustic simulation of the various construction scenarios at each stage of the works.

9.2. Construction Equipment

The following list construction and demolition equipment is proposed, as summarised in Table 9-1 to illustrate the typical nosiest activities.

Table 9-1. List of construction / demolition equipment

Activity	Equipment
Existing Nurses Accommodation and Boiler House	
Demolition	Handsaws Handheld Jackhammer 1 × 13 tonne excavator with hydraulic claw 1 × 22 tonne excavator with hydraulic claw
New Electrical Substation & ICT Facility	
Construction	Delivery trucks Concrete pumps Concrete vibrators Electric hand tools Hand tools Handheld Jackhammers Impact drills Diamond brick saws Electrical Crane and Lifts
Refurbishment Main Entry / Mortuary / Mental Health Entrances	
Construction	Electric hand tools Hand tools Handheld Jackhammers Impact drills Diamond brick saws
Landscaping / Car park expansion / Relocation of Services	
Earth Works	1 × D10 bulldozer 3 × bogey tipper trucks 1 × grader 1 × 815 compactor 1 × 13 tonne excavator with rock breaker 2 × 22 tonne excavators with buckets 1 × Bobcat

From this equipment, the items more likely to produce an external noise impact have been identified. For these items, sound power levels have been derived from pressure level data tabulated in Department for Environment Food and Rural Affairs (DEFRA, (UK)) *Update of noise database for prediction of noise on construction and open sites*.

Table 9-2. Sound power levels for construction / demolition equipment (dB re 1 pW)

Item	Octave Band Centre Frequency (Hz)							
	63	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Hand Held Jackhammer	118	107	103	106	106	111	119	120
13 tonne excavator	120	116	114	113	110	108	104	96
22 tonne excavator	118	121	114	111	110	108	107	106
D10 bulldozer	108	112	104	105	107	109	97	87
Bogey tipper truck	120	109	113	108	108	109	102	98
Grader	115	114	110	106	111	105	101	92
Bobcat (70 KW)	122	116	115	114	108	108	104	95
Electric hammer head crane	110	105	108	104	94	94	84	78
50 tonnes hydraulic crane	106	97	95	92	93	85	77	68
Manitou forklift	122	116	108	108	108	107	104	101
Concrete pump	112	110	100	99	101	101	94	86
Concrete vibrator	110	108	108	101	97	100	98	93

9.3. Predicted Noise Levels

Noise levels have been predicted by considering all items of non-stationary and stationary plant; as well as the combinations of equipment which would operate in any given 15 minute period according to construction / demolition tasks.

Based on the inputs presented above, the construction noise levels shown in Table 9-3 to Table 9-5 illustrate the expected range of construction noise levels for the works at different stages in the project programme. The noise levels produced during these construction stages are considered the highest levels which will be produced during the construction programme (i.e. worst case scenarios).

In these tables, the construction noise levels are also compared against the relevant NMLs.

Table 9-3. Predicted Demolition Noise Levels

Noise Sensitive Receiver	Noise Management Level $L_{Aeq(15min)}$ (dB)	Predicted Demolition Noise Level $L_{Aeq(15min)}$ (dB)	Comment
External Residences			
Leonard Street	51	47-53	*Noise affected*: Some community reaction expected. Employ feasible and reasonable measures
Morgan Street	51	45-50	Does not exceed the NML. No further action required
Hospital Premises			
Diabetes / Oncology	65	70-75	*Noise affected: Some community reaction expected. Employ feasible and reasonable measures*
Acute Mental Health	65	65-70	
Mammography	65	65-70	
Paediatrics / Admissions	65	68-73	

Table 9-4. Predicted Earthworks Noise Levels

Noise Sensitive Receiver	Noise Management Level $L_{Aeq(15min)}$ (dB)	Predicted Earthworks Noise Level $L_{Aeq(15min)}$ (dB)	Comment
External Residences			
Leonard Street	51	82-87	*Highly noise affected.* Strong community reaction. Direct consultation required. Employ reasonable and feasible measures.
Morgan Street	51	50-55	*Noise affected*: Some community reaction expected. Employ feasible and reasonable measures
Hospital Premises			
Diabetes / Oncology	65	75-80	*Highly noise affected.* Strong community reaction. Direct consultation required. Employ reasonable and feasible measures.
Acute Mental Health	65	75-80	
Mammography	65	73-78	
Paediatrics / Admissions	65	75-80	

Table 9-5. Predicted Construction Noise Levels

Noise Sensitive Receiver	Noise Management Level $L_{Aeq(15min)}$ (dB)	Predicted Construction Noise Level $L_{Aeq(15min)}$ (dB)	Comment
External Residences			
Leonard Street	51	47-53	*Noise affected*: Some community reaction expected. Employ feasible and reasonable measures
Morgan Street	51	< 50	Does not exceed the NML. No further action required
Hospital Premises			
Diabetes / Oncology	65	65-70	*Noise affected: Some community reaction expected. Employ feasible and reasonable measures*
Acute Mental Health	65	65-70	
Mammography	65	< 60	Does not exceed the NML. No further action required
Paediatrics / Admissions	65	< 60	

9.4. Noise Summary

From the information shown in the tables above, the eastern residential receivers are identified as being *highly noise affected* during the earthworks stage.

These receivers will have a strong reaction to the construction noise as per the classifications in the NSW ICNG. Therefore, specific noise control measures are required for the residential receivers, such as noise barriers. We recommend that a temporary construction hoarding at least 1.8 m high along the eastern boundary adjacent to the new car park area is installed. Figure 6.1 illustrates the required extents of the noise wall that should be installed. The wall should be continuous, free from gaps, sealed to the ground and comprise a material with a minimum surface density of 8 kg/m^2 (standard colourbond or 10 mm plywood make suitable construction noise barriers).

Nearby receivers within the hospital premises are largely identified as *highly noise affected receivers*, especially during the earthworks stage. These receivers are likely to have a *strong* reaction to the construction noise as per the classifications in the ICNG.

To address the *noise affected* and *highly noise affected* receivers we recommend that reasonable and feasible noise control measures are investigated and documented in a Construction Management Plan (CMP). The measures considered should include (but not be limited to) the noise control measures below:

Noise Control Measures – Noise Affected

- Notify in writing all *noise affected* residential receivers of the construction operations. The notification should include the nature, expected noise levels and duration of the construction works as well as contact details for complainants. This should be provided between 5 and 14 days before commencement on site.
- Non-tonal reversing alarms or alarms that adjust their volume depending on the ambient noise environment should be considered, if community complaints are received in relation to tonal reversing alarms.
- Locate site entrances away from residential receivers (where practical).
- Reduce throttle settings and turn off equipment when not in use. This is especially important for all construction related traffic movements.
- Optimise the number of vehicle trips to and from the site – movements can be organised in to amalgamated loads rather than using a number of vehicles with smaller loads.
- For machines with enclosures around engine bays etc, check that doors and door seals are in good working order.
- Selection of the quietest equipment and plant with quieter mufflers and enclosures, where feasible and reasonable.
- Regularly inspect and maintain equipment to ensure it is in good working order. Also check the condition of mufflers.
- Equipment must not be operated until it is maintained or repaired, where maintenance or repair would address the annoying character of noise identified.
- Avoid use of radios or stereos outdoors.
- Avoid shouting, talking loudly and slamming vehicle doors.

Noise Control Measures – Highly Noise Affected

Further reasonable and feasible measures (to those already required for *noise affected receivers*) that should considered in the construction management plan for the hospital receivers are:

- Clearly visible signage specifying any security measures and key contact details will be erected at key locations in the nearest hospital buildings.
- Selecting low noise equipment for site levelling works.
- Regularly train workers and contractors (such as toolbox talks) on ways to minimise noise.
- Ensure site managers periodically check the site for noise problems so that solutions can be quickly applied.
- Vacate internal spaces at certain periods of the day when construction noise is the loudest (especially those facing the construction and demolition / excavation works) e.g. schedule nosiest activities during typical hospital staff break and lunch times.

10. VIBRATION ASSESSMENT – CONSTRUCTION

The following buildings outside and inside the hospital site are within 50 m of the proposed construction site(s) and are considered for vibration assessment:

- Residential dwellings to the east on Leonard Street
- Existing Mammography
- Existing Diabetes
- Existing Acute Mental Health
- Existing Inpatient
- Existing Admissions and Outpatients
- Existing Paediatrics
- Existing Work shops

10.1. Site Geotechnical Conditions

The geotechnical report notes the following with respect to excavation and general ground conditions:

> *Excavation will be required to level the development areas on the site and is expected to be limited to maximum depths of about 2 m. Excavation will therefore be required in filling, soil and extremely weathered rock which should be readily achievable using conventional earthmoving equipment such as a hydraulic excavator with bucket attachment. Based on the information available to date, excavation in strong rock is unlikely to be required.*

Therefore, the following vibration assessment considers earthworks activities only with a typical excavator and bucket attachment. No *heavy* rock breaking is considered in this assessment. Earthworks activities will define the limiting, worst case scenarios for vibration.

10.2. Vibration Levels – Safe Working Distances

Table 10-1 illustrates the safe working distances for potential earthworks equipment against the various spaces within the existing hospital building and nearest residential dwellings. The safe working distances presented have been calculated by considering the most applicable vibration criteria and or ground borne noise criteria (whichever is more stringent)

Note: vibration is calculated at the building footings for residential dwellings not the residential boundary as is the case for noise assessments.

Table 10-1. Indicative safe working distances to satisfy the most stringent vibration criteria

Equipment Type	Safe Working Distance (m)						
	Residential	Mammography / Diabetes	Mental Health	Inpatient	Admissions	Pediatric	Workshops
22 T Excavator[1] (bucket /tyne) or Dozer	15	15	15	15	15	15	5
Rock Breaker (Small 13T)	15	15	15	15	15	15	5
Dump truck	10	10	10	10	10	10	5
Handheld breaker	5	5	5	5	5	5	<5

Note:
1.Assuming use in rock / material < 10 MPa strength only. No rock breaking

10.3. Vibration Summary

The safe working distances for the residential and hospital buildings are not overly restrictive. Construction activities such as excavation and *light* rock breaking may have to take place within the safe working distances indicated above. If this is the case, consultation with the affected community members (residential or hospital) should be undertaken to establish periods of respite or periods where the impacts will be reduced (i.e. when the residents are not at home). To address the potential exceedances of the human comfort the following measures should be considered in the Construction Management Plan:

- Clearly visible signage specifying any security measures and key site contact details will be erected at key locations inside the nearest hospital buildings and at hospital entrances.
- Direct consultation with the relevant users, residents and stakeholders occupying the nearest hospital buildings / residential dwellings to understand periods when the users may be less sensitive to vibration.
- Schedule the most vibration intensive construction activities to accommodate those periods.
- Provide respite periods and duration restrictions as part of the consultation.
- Vibration monitoring:
  - At the nearest hospital receiver and within (or directly adjacent) the most sensitive space. This also applies for vibration sensitive equipment within the hospital.
  - Vibration monitoring results to be assessed against the nominated vibration goals and compiled into a report to be forwarded to the construction contractor and project manager.

- Reporting to be submitted within one week of being undertaken or at bimonthly intervals for continuous monitoring.

Cosmetic damage and structural damage vibration levels are not expected for any of the proposed construction activities. The safe working distances above are calculated based on the human comfort criteria. As such, exceeding these levels does not pose a risk to the infrastructure or buildings, but may cause disturbance and nuisance to the residents, staff and patients. The Construction Management Plan should be mindful of this and aim to strike a balance between minimising disturbance levels from vibration and the duration of the construction process.

11. APPENDIX A: MEASURED NOISE LEVELS