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Our Reference: NA230258

Your Reference: NA230258 Orange Hospital Consent Memo Rev1

Monday, 6 May 2024

NSW Health infrastructure

Re: NA230258 Orange Hospital Consent Memo – Construction Noise and Vibration

1. Introduction

ACOR Consultants Pty Ltd (ACOR) have been engaged by NSW Health Infrastructure to provide acoustic and vibration consulting services for the proposed refurbishment of the Orange Hospital to accommodate new critical services building. ACOR have been engaged to undertake an acoustic and vibration assessment of the proposed refurbishment and provide design recommendations to achieve relevant acoustic and vibration requirements.

2. Project Description

It is understood that the existing Orange Hospital will be refurbished to cater a three Bed World-Class End of Life Facility (see Figure 1). The single storey development will broadly comprise of the scope elements set out below:

- 3 Bed Rooms
- Lounge
- Courtyard

Figure 1 Site Plan – BVN Architects

3. Regulations, Standards, and Guidelines

The following regulations, standards, and guidelines have been referred to in relation to the noise and vibration impact assessment performed:

- NSW EPA Noise Policy for Industry 2017 (NPI).
- NSW Health – Engineering Services Guidelines 2022
- NSW EPA Noise Guide for Local Government (NGLG).
- NSW EPA Approved Methods for the Measurement and Analysis of Environmental Noise in NSW.
- NSW DEC Assessing Vibration: A Technical Guideline (2006)
- NSW RMS Construction Noise and Vibration Guideline – August 2016
- EPA NSW Interim Construction Noise Guidelines (ICNG) 2009.
- BS ISO 2631-1:1997 Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration Part 1: General Requirements.
- ISO 2631-2:2003(E) Mechanical vibration and shock – Evaluation of human exposure to whole-body vibration – Part 2: Vibration in buildings (1 Hz to 80 Hz).
- NSW Health – Engineering Services Guidelines 2022

4. Reference Documents

Table 1 below shows the documents referred to during the assessment.

Table 1 Reference documents

Document Name	Prepared By	Project No.	Date
World Class End of Life Program – Orange Hospital – Engineering Services	BVN	-	17/04/2024

Document Name	Prepared By	Project No.	Date
WCEoLP Orange Palliative Care_3 bed expansion Option 6.1	BVN	-	27/10/2023
WCEoLP Orange Palliative Care_3 bed expansion Option 6.2	BVN	-	27/10/2023

5. Acoustic Criteria

5.1 NSW EPA Noise Policy for Industry 2017

Industrial noise can have a significant effect on noise-sensitive receivers (see below). Both the increase in noise level above background levels, as well as the absolute level of noise are important factors in how a community will respond to noise from industrial sources. The project "noise trigger level" established in the NPI addresses each of these components of noise impact. The following subsections show the process of determining the project noise trigger level in accordance with the NPI.

5.1.1 Noise Sensitive Receivers

The project site is located at Orange Hospital, Orange, 1502 Forest Rd, NSW 2800. The nearest noise sensitive receivers are residential dwellings to the south and east, with the existing development encircling the project site. Figure 2 below shows the project site and the noise sensitive receivers.

Figure 2 Satellite image showing project site and noise sensitive receivers (Metromap © 2023)

Noise sensitive receivers are listed below in Table 2.

Table 2 Noise sensitive receivers

Noise Sensitive Receiver	Direction from Project Site
Residents along the Crescent	South

Noise Sensitive Receiver	Direction from Project Site
Residents adjacent to Bloomfield Oval	East

5.1.2 Project Intrusiveness Noise Level

The intrusiveness of an industrial noise source may generally be considered acceptable if the level of noise from the source ($L_{Aeq,15min}$) does not exceed the RBL by more than 5 dB, when beyond a minimum threshold (35 dB(A) for the day, 30 dB(A) for the evening and night). This intrusiveness noise level seeks to limit the degree of change a new noise source introduces to an existing environment. The outcome of this approach aims to ensure that the intrusiveness noise level is being met for at least 90% of the time-periods over which annoyance reactions can occur (taken to be periods of 15 minutes). Project intrusiveness noise level is defined as follows:

Project intrusiveness noise level ($L_{Aeq,15min}$) = RBL + 5 dB

Based on the measured RBL presented in *NA230258 AC Orange Hospital Schematic Design Report* and the NPI, the project intrusiveness noise levels are established in Table 3.

Table 3 Project intrusiveness noise levels

	Rating Background Level RBL, dB(A)			Project Intrusiveness Noise Levels, $L_{Aeq,15min}$ dB(A)		
	Day	Evening	Night	Day	Evening	Night
At Residential Location	48	30	30	53	35	35
At Hospital Buildings (Commercial Buildings)	50			-		
The residential receivers are located in a rural environment and thus was considered that unattended noise logging would not be appropriate due to weather and animal activities. It was determined that attended measurements were a suitable alternative. However, to be conservative during evening and night period, NPI recommended assumed noise level was adopted for the project. Based on measurements during the daytime, RBL for daytime is taken from measurement L6 while evening and night periods are based on minimum noise criteria per the Policy.						

5.1.3 Project Amenity Noise Level

To limit continuing increases in noise levels from application of the intrusiveness level alone, the ambient noise level within an area from all industrial noise sources combined should remain below the recommended amenity noise levels specified in Table 2.2 of the NPI, where feasible and reasonable. The recommended amenity noise levels will protect against noise impacts such as speech interference, community annoyance and some sleep disturbance.

The recommended amenity noise levels (Table 2.2 of the NPI) represent the objective for total industrial noise at a receiver location, whereas the project amenity noise level represents the objective for noise from a single industrial development at a receiver location. To ensure that industrial noise levels (existing plus new) remain within the recommended amenity noise levels for an area, a project amenity noise level applies for each new source of industrial noise as follows:

Project amenity noise level $L_{Aeq,15min}$ = Recommended amenity noise level – 5 dB(A) + 3 dB(A)

The recommended amenity noise level should be established from Table 2.2 of the NPI based on the noise sensitive receivers' category, determined based on Table 2.3 of the NPI.

As the NPI states, the approach of deriving the project amenity noise level from the recommended amenity noise level minus 5 dB is based on a receiver not being impacted by more than three to four individual industrial noise sources. To standardise the time periods for the intrusiveness and amenity noise levels, NPI assumes that the Amenity $L_{Aeq,15min}$ will be taken to be equal to the $L_{Aeq,period}$ + 3 decibels (dB).

Considering that the residential noise sensitive receivers are located in an RU2, Rural Residential (rural landscape), the NPI recommended Amenity Noise Level and Project Amenity Noise Level for this project are presented in Table 4 below.

Table 4 Project amenity noise levels

Noise Sensitive Receiver	**Recommended Amenity Noise Level, LAeq dB(A)**			**Project Amenity Noise Levels, LAeq,15min dB(A)**		
	Day	**Evening**	**Night**	**Day**	**Evening**	**Night**
Residential Receivers (Rural)	55	45	40	53	43	38
At Hospital (Commercial Buildings)	50			48		

5.1.4 Project Noise Trigger Level

The project noise trigger level is the lower (that is, the more stringent) value of the project intrusiveness noise level and the project amenity noise level determined in accordance with the NPI. The project intrusiveness noise level aims to protect against significant changes in noise levels, whilst the project amenity noise level seeks to protect against cumulative noise impacts from industry and maintain amenity for particular land uses. Applying the most stringent requirement as the project noise trigger level ensures that both intrusive noise is limited, and amenity is protected and that no single industry can unacceptably change the noise level of an area. It is noted that Intrusive noise levels are only applied to residential receivers (residences). For other receiver types identified in Table 2.2 of the NPI, only the amenity levels apply. The project noise trigger levels for this project are established in accordance with the NPI and are shown below in Table 5.

Table 5 Project noise trigger levels

Noise Sensitive Receiver	**Project Intrusiveness Noise Level, $L_{Aeq,15min}$ dB(A)**			**Project Amenity Noise Level, $L_{Aeq,15min}$ dB(A)**			**Project Noise Trigger Level, $L_{Aeq,15min}$ dB(A)**		
	Day	**Evening**	**Night**	**Day**	**Evening**	**Night**	**Day**	**Evening**	**Night**
Residential Receivers	53	35	35	53	43	38	53	35	35
At Hospital (Commercial Buildings)	-			48			48		

5.1.5 Correction for Modifying Factors

Where a noise source contains certain characteristics, such as tonality, intermittency, irregularity or dominant low-frequency content, a correction should be applied as per the NPI, to the measured or predicted noise levels at the receiver before comparison with the project noise trigger levels. The maximum correction of 10 dB(A) to be applied to the predicted or the measured level where two or more modifying factors are present. NPI recommended correction factors (Table C1 of the NPI) are shown in Table 6.

Table 6 Modifying factor corrections for noise characteristics

Factors	**Corrections[1]**	**Notes**
Tonal Noise	5 dB[2,3]	[1.] Corrections to be added to the measured or predicted levels, except in the case of duration where the adjustment is to be made to the criterion. [2.] Where a source emits tonal and low-frequency noise, only one 5-dB correction should be applied if the tone is in the low-frequency range, that is, at or below 160 Hz. [3.] Where narrow-band analysis using the reference method is required, as outlined in column 5, the correction will be determined by the ISO1996-2:2007 standard
Low-Frequency Noise	2 or 5 dB[2]	
Intermittent Noise	5 dB	
Duration	0 to 20 dB(A)	
Maximum Adjustment	Maximum correction of 10 dB(A)[2] (excluding duration correction).	

As per the NPI, correction for duration is applied where a single-event noise is continuous for a period of less than two and a half hours in any assessment period. The allowable exceedance of the $L_{Aeq,15min}$ equivalent noise criterion is provided in Table C3 of the NPI for the duration of the event. This adjustment is designed to account for unusual and one-off events and does not apply to regular and/or routine high-noise level events. The adjustments for duration are to be applied to the criterion.

5.1.6 Sleep Disturbance Criteria

The potential for sleep disturbance from maximum noise level events from premises during the night-time period needs to be considered. NPI recommends, where the subject development/premises night-time noise levels at a residential location exceed:

- LAeq,15min 40 dB(A) or the prevailing RBL plus 5 dB, whichever is the greater, and/or
- LAFmax 52 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater,

that a detailed maximum noise level event assessment should be undertaken. The detailed assessment should cover the maximum noise level, the extent to which the maximum noise level exceeds the rating background noise level, and the number of times this happens during the night-time period. Based on the NPI, the sleep disturbance criteria for the proposed development are determined as shown in Table 7.

Table 7 Sleep disturbance criteria

Noise Sensitive Receiver	**Rating Background Level (RBL) at Night, L_{A90} dB(A)**	**NPI Recommended Sleep Disturbance Criteria, dB(A)**	
		$L_{Aeq,15min}$ **(**40 dB(A) or the prevailing RBL plus 5 dB, whichever is the greater**)**	**L_{AFmax}** **(**52 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater**)**
Residents along Yellow Rose Terrace	30	40	52
Orange Hospital (commercial)	50	55	65

In addition to the above, NSW Road Noise Policy (RNP) noted that the research on sleep disturbance to date concluded that:

- Maximum internal noise levels below 50–55 dB(A) are unlikely to awaken people from sleep
- One or two noise events per night, with maximum internal noise levels of 65–70 dB(A), are not likely to affect health and wellbeing significantly.

5.2 Helicopter Noise Intrusion Criteria

NSW Health – Engineering Services Guidelines 2022 stipulates that Helicopter operations can exhibit similar noise characteristics to fixed wing aircraft pass-bys and generate high levels of short period steady noise levels hovering or idling. However, emergency medical helicopter operations differ from fixed wing aircraft as:

- They can occur at any time of day or night
- They are generally much less frequent than fixed wing aircraft operations near a typical airport
- They are directly associated with the hospital facility

Please refer to the information below relating to the number of historical helicopter movements per year. note Wyong is a retrieval only hospital and do not drop offs.

Table 8 presents the number of historical helicopter movements per year for Orange Hospital.

Table 8 Helicopter Movements for Orange Hospital during 2023

Month	Movements	Month	Movements
January 2023	19	June 2023	6
February 2023	14	July 2023	19
March 2023	11	August 2023	10
April 2023	13	September 2023	11
May 2023	13		

In 2023, there were approximately 3.22 helicopter movements per week. This frequency of helicopter movements is assumed to continue throughout the lifecycle of the development

Table 9 below outlines the internal noise level criteria that should be considered with respect to the new redevelopment.

Table 9 Helicopter noise intrusion criteria

Room	NSW Health Recommended Internal Noise Levels, L_{Amax} dB(A)
Staff Room	75
Corridors and Lobbies, Reception and Waiting areas	80
ICU Wards, Patient rooms, Bed Wards or sensitive spaces	68

5.3 Internal Noise and Reverberation

NSW Health – Engineering Services Guidelines 2022 recommends design sound level and reverberation criteria for conditions affecting the acoustic environment within building interiors to ensure a healthy, comfortable and productive environment for the occupant and the users. The recommended background sound levels (L_{Aeq}) consider the function of the space and apply to the sound level measured within the space unoccupied but ready for occupancy. The standard is applicable to steady-state or quasi-steady-state sounds. The reverberation times recommended are for the occupied state of the space.

It should be noted that the recommended sound level range provides a recommended minimum sound level to provide acoustic masking that will help to improve speech privacy. When designing building services systems, it is highly unlikely to be possible to design to such a tight tolerance. This is primarily because of the variable nature of modern air handling systems. Therefore, it is likely that there will be some areas within the building that will have internal noise levels below the minimum values recommended in Table 10 especially when building services are running at low speed and/or are in night mode and/or when supplementary systems are not operating.

Table 10 AS/NZS 2107:2106 Recommended internal sound levels and reverberation times

Room Type	NSW Health Criteria	
	Internal Noise Level, L_{eq} dB(A)	Reverberation Time (Sec)
Patient Room / Single Bed Ward	35 to 40	0.4 to 0.7
Patient Corridor	40 to 50	0.4 to 0.6
Rest room – break-out spaces	40 to 45	0.4 – 0.6
Toilets / Ensuite	50 to 55	N/A

It is understood that the proposed building contains a Helipad. Therefore, the ambient noise level at the proposed development site is considered to be much higher than a building located adjacent to a local road. Per the *NSW Health – Engineering Services Guidelines 2022*, infrequent and short duration noise sources such as aircraft; trains and emergency vehicles will have varying impacts on the amenity of internal spaces relative to steady state / continuous noise and therefore should not be assessed using the same criteria.

However, *NSW Health – Engineering Services Guidelines 2022* criteria would be used for mechanical noise assessment of the indoor spaces and reverberation control and design of the indoor key acoustic spaces.

5.3.1 Sound Insulation Ratings of Internal Partitions

Sound insulation criteria for walls & wall/door assemblies for this project are based on *NSW Health – Engineering Services Guidelines 2022*. This guideline states that the acoustic design of walls and floors will be specified to provide a level of acoustic separation appropriate to the intended use of adjacent spaces.

The adjacency of different room types will influence the sound isolation rating required for a construction. The final sound isolation rating should take into account the adjacency of the different room types with consideration of the following:

- The speech privacy requirements of a noise source room
- The noise sensitivity of the receiving room and
- The background noise level in the receiving room.
- The airborne sound isolation of separating constructions, will achieve whichever the greater requirement is of:
- The speech privacy requirements for each room in Table 11, and
- Control of noise from any adjacent noise generating room (such as a plant room) so that the resulting noise level in an adjacent receiving room achieves the nominated levels in Table 11.

The speech privacy levels are defined as shown in Table 11.

Table 11 Speech Privacy Levels

Level of Speech Privacy	**Description**	**Requirement outcome (sound insulation, Dw plus background noise, dBA)**
Confidential	Raised speech would be audible but not intelligible, and normal speech would be audible	80 to 85
Private	Raised speech would be audible and intelligible but not intrusive	75 to 80
Moderate	Normal speech would be audible and intelligible but not intrusive	70 to 75
Not Private	Normal speech would be clearly audible and intelligible	Less than 70

When assessing the sound isolation rating of a construction to achieve internal noise levels (from adjacent noisy areas) and to achieve the speech privacy requirements, the greatest rating of the two assessments takes precedence and should be used as the final sound isolation rating. Note that background noise levels are based on assumed design levels.

5.3.2 Speech Privacy

The Figure 3 below illustrates the important dependence of speech privacy on both sound insulation and background noise levels.

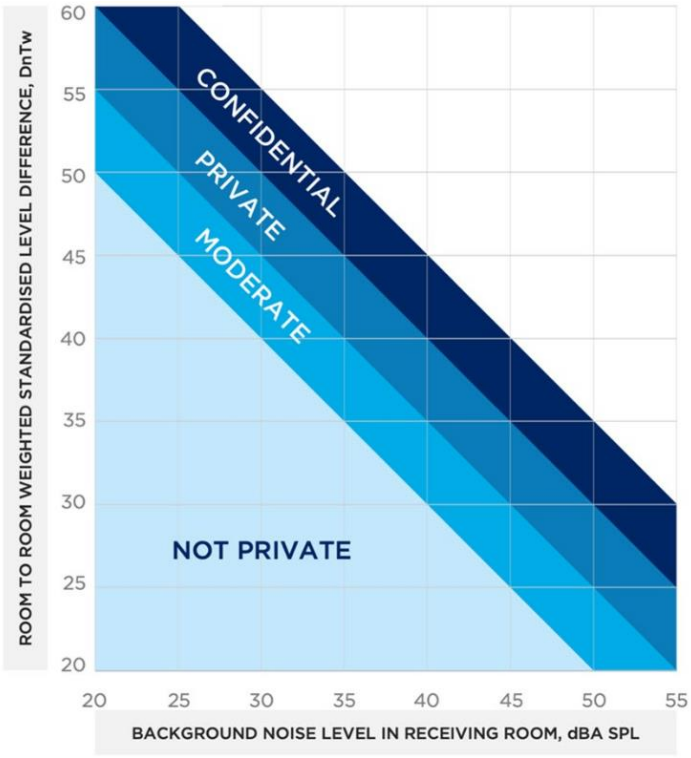

Figure 3 Speech Privacy Curve

Table 12 below presents sound insulation ratings of walls.

Table 12 Sound Insulation Ratings of Walls

Room Type	Speech Privacy Requirement	Door Type / Adjacency		
		Room to room	Room to Reception/Waiting	Room to corridor
Patient Room / Single Bed Ward	Minimum Rw 42 partition	-	-	-
Toilet / Ensuite	Moderate	-	Type 1	-
Patient Corridor	-	-	-	-
Cafeteria / Dining	-	-	-	-
Plant Rooms	-	-	-	-

Notes: *1. Type 1 – Solid core door with perimeter and threshold acoustic seals*

2. Type 2 – Specialist acoustic door set (the use of Type 2 doors should be minimised by appropriate planning)

3. Where no specific acoustic rating has been provided, a moderate level of sound insulation has been targeted

5.4 Construction Noise

The Interim Construction Noise Guideline (ICNG) (DECC, 2009) guideline recommends standard hours for construction activities as Monday to Friday: 7am to 6pm, Saturday: 8am to 1pm and no work on Sundays or public holidays. These hours are not mandatory and the ICNG acknowledges that the following activities have justification

to be undertaken outside the recommended standard construction hours assuming that all reasonable and feasible mitigation measures are implemented to minimise the impacts to the surrounding sensitive land uses:

- the delivery of oversized plant or structures that police or other authorities determine to require special arrangements to transport along public roads
- emergency work to avoid the loss of life or damage to property, or to prevent environmental harm
- works where a proponent demonstrates and justifies a need to operate outside the recommended standard construction hours
- works which maintain noise levels at sensitive receivers to below the noise management levels outside of the recommended standard construction hours.

Construction noise management levels at sensitive residential receivers are provided in

- Table 13. The construction noise management levels during recommended standard hours represent a noise level that, if exceeded, would require management measures including:
- reasonable and feasible work practices
- contact with the residences to inform them of the nature or works to be carried out, the expected noise levels and durations and contact details.

The management measures are aimed at reducing noise impacts at the residential receivers. However, it may not be reasonable and feasible to reduce noise levels to below the noise affected management level. The noise affected construction noise management levels during recommended standard hours is not intended as a noise limit but rather a level where noise management is required and as such should not be included as a noise limit in the environmental protection license.

Table 13 Residential construction noise management levels, dBA

Time of day	**Noise Management level, $L_{Aeq\ (15\ min)}$**	**Application Notes**
Recommended standard hours	Noise affected: RBL + 10 dBA	The noise affected level represents the point above which there may be some community reaction to noise. where the predicted or measured LAeq(15 min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level the proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected: 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: times identified by the community when they are less sensitive to noise (such as before and after school, or mid-morning or mid-afternoon for works near residences) if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected: RBL + 5 dBA	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable measures have been applied and noise is more

Time of day	Noise Management level, $L_{Aeq\ (15\ min)}$	Application Notes
		than 5 dBA above the noise affected level, the proponent should negotiate with the community.

Noise management levels for other sensitive land uses are provided in Table 14 and only apply when the properties are in use.

Table 14: Noise management levels for other sensitive land uses

Land Use	Noise management, $L_{Aeq\ (15\ minutes)}$
Commercial premises	70 dBA (external)

A summary of the construction noise management levels is provided in Table 15

Table 15: Proposal construction noise management levels, dBA

Receiver type	Construction noise management levels, $L_{Aeq(15\ min)}$				
	Standard construction hours		Outside standard construction hours		
	Noise affected	Highly noise affected	Day	Evening	Night
Residential Receivers	60	75	55	35	35
Commercial	70	-	-	-	-

5.5 Protection of the Environment Operations (POEO) Act 1997

The POEO Act 1997 aims to protect, restore and enhance the quality of the noise environment in New South Wales. 'Offensive noise' in the Act is defined as noise:

(a) that, by reason of its level, nature, character or quality, or the time at which it is made, or any other circumstances—

(i) is harmful to (or is likely to be harmful to) a person who is outside the premises from which it is emitted, or

(ii) interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted, or

(b) that is of a level, nature, character or quality prescribed by the regulations or that is made at a time, or in other circumstances, prescribed by the regulations.

For control of noise from Air Conditioners, Pumps and Heat Pump Water Heaters, the Act defines the following in regards to its use on residential premises:

A person is guilty of an offence if -

(a) the person causes or permits an air conditioner / pump to be used on residential premises in such a manner that it emits noise that can be heard within any room in any other residential premises (that is not a garage, storage area, bathroom, laundry, toilet or pantry) whether or not any door or window to that room is open -

(i) before 8 am or after 10 pm on any Saturday, Sunday or public holiday, or

(ii) before 7 am or after 10 pm on any other day,

5.6 Building Vibration Criteria

Human response to floor motion is a complex phenomenon. There are wide variations in vibration tolerance of humans and accordingly the acceptance criteria for human comfort are difficult to define and quantify.

Acceptable values of human exposure to vibration are primarily dependent on the activity taking place in the occupied space (e.g., office, meeting rooms, residential etc.) and the character of vibration (e.g., continuous or intermittent). In addition, specific values are dependent upon social and cultural factors, psychological attitudes, expected interference with privacy, and ultimately the individual's perceptibility.

Vibration transfer within a building has the potential to adversely affect the occupants. The building structure must be designed to achieve appropriate levels of vibration to minimise such adverse effects.

The concept of using base curves to assess human comfort has been adopted from Australian Standard 2670.2:1990. NB - Please note that this standard was superseded by AS ISO 2631.2:2014, however, it is accepted practice within the Australian market to adopt the multiplying factors as presented in Table 2 Appendix A (2670.2:1990) for building vibration from human comfort.

A base curve marks the threshold of human perception and is defined in one-third octave bands from 1 Hz to 80 Hz. Vibration levels below the base curves typically do not result in adverse comments or complaints from occupants. The vibration criteria for different occupancy types are obtained by multiplying the base curve by a factor. Multiplying factors for different occupation types on the recommendations in AS 2670.2:1990 are listed in Table 16.

Table 16 Multiplying factors for satisfactory magnitudes of building vibration

Room Type	**Multiplying Factor**	
	Continuous or Intermittent Vibration	**Transient Vibration excitation with several occurrences per day**
Critical working areas (for example some hospital operating-theatres, some precision laboratories)	1.0	1.0
Boardroom/conference, open plan and private offices	4.0	60 to 128
Engineering, Workshop, co-working and collaborative spaces, Plant rooms	8.0	90 to 128

The ASHRAE curves include workshop, office, residential, operating room and VC curves for sensitive equipment.. Velocity vibration criteria curves (RMS) defined in one-third octave frequency bands (CPB) range 1 to 80 Hz are shown in Table 17.

Table 17 Human Comfort and Equipment Vibration Criteria from Continuous Vibration

Location	**Assessment Period**	**1 to 80Hz Curve mm/s**
Office Areas, Consulting, examination, treatment, procedures, interview, counselling	Day – or Night time	0.406
Hospital operating theatres rooms and critical work areas	Day – or Night time	0.102
Single bed ward (including Mental Health, Parent Accommodation), Multiple bed ward, General intensive care wards, Neonatal or paediatric ICUs, and the like	Day – or Night time	0.140

Guidelines for human comfort with respect to vibration within a building are also provided by NSW Environmental Noise Management – Assessing Vibration: a technical guide (February 2006). This technical guideline provides acceptable RMS acceleration and velocity for continuous, impulsive and intermittent vibration. Velocity and acceleration limits are presented in Table 18.

Table 18 Velocity and acceleration criteria for exposure to continuous and impulsive vibration

Location	**Assessment Period**	**RMS velocity (mm/s)**		**RMS acceleration (m/s^2)**		**Peak velocity (mm/s)**	
Continuous Vibration							
	Preferred		Maximum	Preferred	Maximum	Preferred	Maximum
Offices	Day – or Night time	0.40	0.80	0.020	0.040	0.56	1.1

Location	Assessment Period	RMS velocity (mm/s)		RMS acceleration (m/s^2)		Peak velocity (mm/s)	
Critical Areas, include hospital operating theatres and precision laboratories where sensitive operations are occurring	Day – or Night time	0.10	0.20	0.0050	0.010	0.14	0.28
Impulsive Vibration							
Offices	Day – or Night time	13	26	0.64	1.28	18.0	36.0
Critical Areas, include hospital operating theatres and precision laboratories where sensitive operations are occurring	Day – or Night time	0.10	0.2	0.0050	0.010	0.14	0.28

5.7 Vibration Dose Values (VDV)

The vibration dose value (VDV) is fully described in British Standard BS 6472:2008 Guide to Evaluation of human exposure to vibration in buildings – Part 1: Vibration sources other than blasting.

Table 19 below presents the vibration criteria for human comfort, in terms of preferred and maximum vibration dose values as described in BS 6472 and also provided by NSW Environmental Noise Management – Assessing Vibration: a technical guide (February 2006). The VDV level can be directly related to vibration discomfort experienced by a person. VDV accumulates the vibration energy received over the daytime and night-time periods.

Table 19 Maximum vibration dose values for intermittent vibration

Place	Vibration Dose Values (m/s$^{1.75}$)			
	Daytime (7am – 10pm)		Night-time (10pm – 7am)	
	Preferred	Maximum	Preferred	Maximum
Critical Areas, hospital operating theatres and precision laboratories where operations are occurring	0.10	0.20	0.10	0.20
Offices	0.40	0.80	0.40	0.80
AAAC Guideline for Healthcare Facilities: Single bed ward (including Mental Health, Parent Accommodation), Multiple bed ward, General intensive care wards, Neonatal or paediatric ICUs, and the like	-	0.20	-	0.10
AAAC Guideline for Healthcare Facilities: Consulting, examination, treatment, procedures, interview, counselling etc.	-	0.40	-	0.40
AAAC Guideline for Healthcare Facilities: Boardroom/conference, open plan and private offices, etc.	-	0.80	-	0.80

6. Onsite Acoustic Performance Specification (Dw) and Design Specification

R_w ratings refer to the sound insulation performance of partitions or partition elements measured in a laboratory under controlled conditions, which represents a best-case rating without the influence of other sound paths.

D_w values are used for the measured on-site performance of existing conditions and during construction or post-construction stages. A field test of a partition is typically expected to achieve a lower single-number rating than the equivalent test of the construction in the laboratory due to flanking sounds and other site constraints that can degrade the laboratory performance.

Typically, D_w ratings relate approximately to the R_w laboratory rating of an element, minus 5 dB. For example:

D_w rating = R_w rating – 5

Therefore, to achieve the targeted D_w ratings, it is necessary to provide laboratory R_w ratings around 5 dB over the required D_w rating. It is equally crucial to adequately prevent or treat sound flanking paths such as through the ceiling void, via the façade and services penetrations.

For consistency, the subsequent recommendations regarding partition elements in this within is report will be presented with regards to D_w ratings only. Any on-site compliance testing is to be assessed against the D_w performance expected to be approximately 5 dB less than the nominated R_w rating of the lowest performing partition element.

7. Acoustic Design Advice

7.1 Sound Insulation of Building Façade

Noise intrusion to the building from the external environment has the potential to affect the acoustic amenity within the working environment. The main external noise sources that have been identified in the vicinity of the building are listed below:

- Mechanical Plant/Equipment serving adjacent buildings.
- Road traffic from surrounding roads, predominately along Forest Road.
- Helicopter take-off and landing.

Helicopter noise readings have been taken in previous assessments and corrections for distance have been applied for this project.

Table 20 below presents a summary of the noise measurements that were performed at the site, including a description of the events that took place at the locations of the measurements.

Table 20 External Noise Measurement Results

Location	Measured Noise Level	Description of Noise Events
Helicopter noise level at the external façade (calculated from measured level)	87 dB(A) L_{Aeq} 93 dB(A) L_{Amax}	Helicopter Take-off
North east facing facade	50 dB(A) L_{Aeq} 63 dB(A) L_{Amax}	Noise Impacts from road traffic + nearby mechanical services.

7.2 External Glazing

The building façade will be designed to control external noise intrusion to meet internal noise levels in accordance with Australian Standards and guidelines. This section documents the external glazing recommendations to achieve the nominated internal noise criteria. Table 21 presents the specification of the minimum glass for the external façade.

Table 21 Façade Glazing

Room	Glazing Construction	Rw
Bedroom	Double Glazed Unit comprising of: ▪ 6mm glass ▪ 16mm air space ▪ 8.5mm glass	41
All other areas	Double Glazed Unit comprising of: ▪ 6mm glass ▪ 12mm air space ▪ 6mm glass	33
	Single Glazed Unit comprising of: ▪ 8.38mm laminated glass	34

7.3 External Walls

This section documents the external wall recommendations to achieve the nominated internal noise criteria, if required. The following Table 22 below outlines recommended external wall types.

Table 22 Façade Wall Types

Room	Rw Rating	Preliminary Recommended Façade Construction
Bedroom, lounge	Rw 45	▪ 1x13mm Fire Rated Plasterboard (minimum 10.5 kg/m^2) ▪ 90mm steel studs at maximum 600mm centres ▪ 75mm 14 kg/m^3 glasswool insulation ▪ 1x13mm Fire Rated Plasterboard (minimum 10.5 kg/m^2)
Plant Room	Rw 50	▪ Cemitel Sheet or Weatherboard Cladding ▪ 1x16mm Fire/Moisture Rated Plasterboard (minimum 13 kg/m^2) ▪ 90mm steel studs at maximum 600mm centres ▪ 75mm Gold Batts R1.5 Insulation within cavity ▪ 1x16mm Fire Rated Plasterboard (minimum 13 kg/m^2)
		▪ Masonry/Blockwork Wall ▪ Minimum 40mm cavity ▪ Minimum 70mm steel studs at maximum 600mm centres ▪ 75mm Gold Batts R1.5 Insulation within cavity ▪ 1x10mm GYPROCK Plus plasterboard (or equivalent)

7.4 Roof

A 200mm concrete slab is expected to provide satisfactory acoustic separation to spaces below with regards to performance requirements presented above.

An example lightweight roof construction predicted to achieve noise requirements is provided in Table 23.

Table 23 Example roof constructions

Room	Roof system	Additional considerations
All	▪ 0.6 bmt profiled steel ▪ 100mm insulation roof blanket with density of 32kg/m^3 (e.g. CSR Anticon) ▪ Z Purlin with resilient rail (e.g Rondo 581 with minimum 150mm cavity. ▪ 2 x 16mm fire rated plasterboard (12.5 kg/m^2) ▪ Suspended ceiling system (acoustic absorptive ceiling on suspended light weight grid))	Insulation can be rated to provide thermal and acoustic performance. Additional acoustic treatment to underside of ceiling required for reverberation control within relevant spaces.

Alternative constructions can be selected but must be approved by the Acoustic Engineer or supplier.

Wall to ceiling/roof junctions must be appropriately detailed based on manufacturers specification to not reduce the sound insulation performance due to noise flanking. Junction detailing will be coordinated and reviewed during the documentation phase, including detailing for acoustically rated walls to underside of the roof system.

The building will need to provide appropriate acoustic isolation between adjoining spaces to maintain acoustic privacy and minimise intrusiveness. This section of the report details acoustic specifications for internal walls and floors.

7.5 General Detailing

In order to maintain the required sound insulation performance, the following advice is provided with regards to the installation of partitions:

- All horizontal and vertical joints between boards shall be filled and taped. All acoustically rated walls shall be well sealed and airtight including at all perimeter junctions.
- Where door or window frames are built into the wall, a non-hardening resilient acoustic sealant shall be used to seal all joints between the wall and frame.
- For doors and glazed screens with a sound insulation rating above Rw 40, the vertical and horizontal sections of the frame shall be fully packed with acoustic insulation with a density of at least 32 kg/m^3.
- Head details shall be designed to take up relative movements, live load variations and drying shrinkage.
- All acoustic partitions, floors and ceilings will require acoustic penetration details. Wall partitions rated Rw 55 or higher should not be penetrated by ventilation, electrical or piped services (including cable trays).
- Penetrations in the stud partitions and plasterboard dry lining walls shall be smooth and even, and finished 20mm to 30 mm from the service penetration to allow the penetration to be sealed effectively. The penetrations shall not be oversized.
- Acoustic compressible (neoprene) seal: Material must provide a density of at least 75 kg/m^3 and when installed the density must not alter by more than ±8kg/m^3.
- Standard partition junctions shall be constructed as per the appropriate manufacturer's detailing (e.g. Knauf Technical Manual, CSR Gyprock Red Book, USG Boral Systems+ Manual, etc) unless superseded by details within the architectural plans approved by Acor.
- Acoustic/fire sealant is to be adopted to ensure the sealing of any air gaps and possible discontinuities within the construction. This must be non-hardening resilient acoustic sealant.

7.6 Doors

All doors that are incorporated into partitions that have been assigned a sound insulation rating will need to be fitted with acoustic seals to all sides of the frame and the bottom of the door, to ensure that the door provides a suitable level of sound insulation.

- Timber doors should be specified as solid-core doors.
- Double leaf doors must have seals installed to the meeting stile of the doors.
- Bottom seals should always be specified as drop down seals to ensure that the seal is not subjected to fatigue by rubbing against the floor when opening/closing.
- Doors must not be undercut nor have air relief door grilles in them, as this will severely compromise the acoustic integrity of the door assembly.
- Sliding doors should be avoided where a high level of sound isolation is required.
- Sliding doors will need to incorporate seals on the leading edge, trailing edge and top and bottom of the door. Table 24 below provides examples of hinged door constructions that will achieve the sound insulation requirements for doors to each of the spaces within the building. Options have been provided for both solid timber and glazed doors.

Table 24 Examples of door assemblies

Rw Rating	Door Type	Door Seals
R_w 30	45mm solid core timber door	Frame: RP 24, Bottom: RP 70, Threshold plate: RP 96/ RP66
	12.38mm laminated glass	Frame: RP 24, Bottom: RP 70, Threshold plate: RP 96/ RP66
	10.38mm laminated glass	Frame: RP 10, Bottom: RP 70, Threshold plate: RP 96/ RP66
	Double Glazed unit comprising of 8mm Standard Glass, 10mm gap, 10.5mm laminated hush glass	As per manufacturer's (e.g. Darley) specification.

Alternative door constructions can be adopted but will need to be reviewed in relation to their acoustic performance.

7.7 Internal Glazing

For situations where fixed windows are incorporated into internal plasterboard partitions, the acoustic performance of the window must ensure that the overall sound isolation performance of the wall is not overly degraded. The acoustic performance requirements of the window are dependent on the acoustic rating of the wall in which it is incorporated, as well as whether the window are located in the wall adjoining the corridor, or the wall separating adjoining rooms. Table 25 below presents a summary of the internal window requirements in the project that comprise full-height glazing.

Table 25 Rw / Dw Window Glazing Constructions

Rating	Single glazed construction	Double glazed construction
Rw 40 / Dw 35	12.5mm VLam Hush laminated glass (by Viridian)	10mm laminated glass, 12mm air space, 6.38mm laminated glass
Rw 35 / Dw 30	10.38mm laminated glass	N/A

Rating	Single glazed construction	Double glazed construction
Rw 30/ Dw 25	6.38mm laminated glass	N/A

For situations where fixed windows are incorporated into internal plasterboard partitions such as viewing panels or small portion of glazing (200/400mm wide), the acoustic performance of the window must ensure that the overall sound isolation performance of the wall is not overly degraded. The acoustic performance requirements of the window are dependent on the acoustic rating of the wall in which it is incorporated, as well as whether the window is located in the wall adjoining the corridor.

7.8 Internal Finishes

Ceilings for hospital spaces often have specific requirements for cleanability and moisture resistance.

The acoustic ceiling systems shown in Table 26 below have been identified as having potential for use in hospitals. Suitability of use and the performance of these systems should be confirmed with the respective product suppliers prior to selection.

Table 26 Acoustic Ceilings suitable for Healthcare Facilities

System Name	Product Name	NRC
Armstrong	Bioguard Acoustic (CAC 40)	0.70

7.9 Recommended Finishes

Ceiling tiles with a higher Noise Reduction Coefficient (NRC) perform better in terms of controlling reverberant noise within a space. Therefore, in general, a product with a high NRC rating should be selected for optimum acoustic performance in terms of reverberant noise control. Generally, it is recommended that a ceiling tile with an NRC of 0.7 or greater be used.

Table 27 outlines recommendations for sound absorptive treatment of interior finishes to control reverberant noise and achieve the reverberation time criteria including airborne/impact noise requirements

Table 27 Proposed finishes

Room Type	Preliminary Recommended Finishes	Comments
Bedrooms	▪ Acoustic absorptive ceiling as per recommendations in the right column. ▪ Plasterboard and glazed walls ▪ Vinyl flooring	Clean Mineral fibre tiles are recommended due to hygienic requirements & infection control. Minimum NRC 0.7 recommended.
Lounge	▪ Acoustic ceiling tiles 100% coverage, or alternatively ▪ Perforate plasterboard, 100% coverage ▪ Plasterboard and glazed walls ▪ Vinyl flooring	– Acoustic ceiling tiles – NRC 0.70, CAC 35 – Suitable ceiling tiles that are of the 'clean' type. – Perforate Plasterboard – Perforation area of at least 19.6%, 50mm thick, 14kg/m^3 acoustic insulation batts laid over the ceiling

8. Operational Noise Assessment

8.1 Control of Building Services Noise (Indoor Noise)

ACOR Acoustics will review and provide comprehensive recommendations for the building services to achieve the requirements through the design phases when Mechanical documentation will be provided. The following sections provide our general design considerations to be included in the building services design.

Mechanical services are expected to be finalised in further stages of the design and are not available at the time of writing.

8.2 General Architectural Guidelines

Small gaps and cracks, or incorrect corner detailing and setting of walls can significantly compromise the acoustic rating of the partitions. It is vital to understand that workmanship must be excellent. All gaps and cracks must be sealed with a resilient, non-hardening mastic that can withstand any movement likely throughout the life of the rooms. Generally, a polyurethane mastic or fire mastic that allows for minimum 15% joint movement will be acceptable. The top, bottom and sides of all plasterboard walls, as well as all services penetrations must be fully mastic sealed and inspected, prior to any finishing detailing (skirting, architraves and the like) being provided.

P50 shadow line edging and the like can compromise the acoustic rating of the partitions and it is recommended that such edging not be used unless a suitable detail is provided to minimise leakage.

Door seals are to be installed and adjusted correctly to minimise noise leakage. The manufacturer's instructions for best acoustic practice installation should be followed.

Wall penetration details assume the duct is above an acoustic ceiling or below a data floor. If the duct is exposed within the space, additional treatment may be required and will be determined on an individual basis.

Architectural documentation should show mastic sealing at the base and the head of the of Dw 40 (>Rw45) walls, so this is not missed by the contractor. For the acoustic integrity of building elements to be maintained, all gaps and interfaces along the junctions and joints of linings must be sealed with an appropriate acoustic grade sealant. Penetrations for mechanical or electrical services must be properly blocked and sealed around the ductwork/cabling to ensure the intended acoustic rating of the partition is retained.

Appropriate acoustic caulking products include:

- Bostik Firemastic
- Bostik Seal-n-flex 1
- Pyropanel Multiflex
- Boral Fyreflex
- Sika Sikaflex-11 FC

8.3 Mechanical Services

The transfer of noise from plant and equipment to the building structure should be minimised. To this end, all reciprocating plant and equipment should be provided with suitable vibration isolation mounts that provide at least 95% vibration isolation. In addition, the following should be observed:

Large equipment such as chillers should only be mounted on concrete slabs and should be provided with concrete plinths at least 100 mm high. Mounts should consist of a spring mount and an isolation pad. Typical static deflections of 25-50 mm will be required, depending upon the equipment. The equipment manufacturers should be consulted as to suitable mounting options.

The following acoustic treatment is recommended in accordance with design specifications for internal noise levels:

SS1006CA9/23 Fan (SSF-FF-09)

- Intake: 1.5m 50mm internally lined perforated facng duct liner between fan and intake grille
- Exhaust: 1.5m 50mm internally lined ductwork between fan and exhaust outlet

PUEEC28 Fan (EAF-PCU-1)

- Intake: 1m 50mm internally lined ductwork between fan and intake grille
- Exhaust: 1m 50mm internally lined ductwork between fan and exhaust outlet

Jetline-150ECO Fan (GEF-PCU-1)

- Intake: 1m 50mm internally lined ductwork between fan and intake grille, lined elbow
- Exhaust: 1m 50mm internally lined ductwork between fan and intake grille, lined elbow

Jetline-150ECO Fan (EAF-PCU-2)

- Intake: 1m 50mm internally lined ductwork between fan and intake grille, lined elbow
- Exhaust: 1m 50mm internally lined ductwork between fan and intake grille, lined elbow

Recommend all acoustic internal insulation to be moisture/fibre shedding resistant i.e Melinex or equivalent. Recommend Acoustic flexible ductwork on all supply and return ducts. Recommend Acosutic flexible ductwork does not penetrate acoustic full height walls. Recommend minimum 1.5m long solid acoustically lined ductwork (50mm) as the penetration through the full height wall, which can then be connected to acoustically flexible ductwork.

1. Pumps should be provided with a spring mounted concrete inertia base.
2. All connections of pipework ductwork and the like to any reciprocating equipment must be of the resilient type to prevent any bridging of the vibration isolation.
3. Allowance should be made for attenuators to loud fans and the like, especially where short duct runs are expected. As an indication, 1.5 metres is typically sufficient space for attenuation.

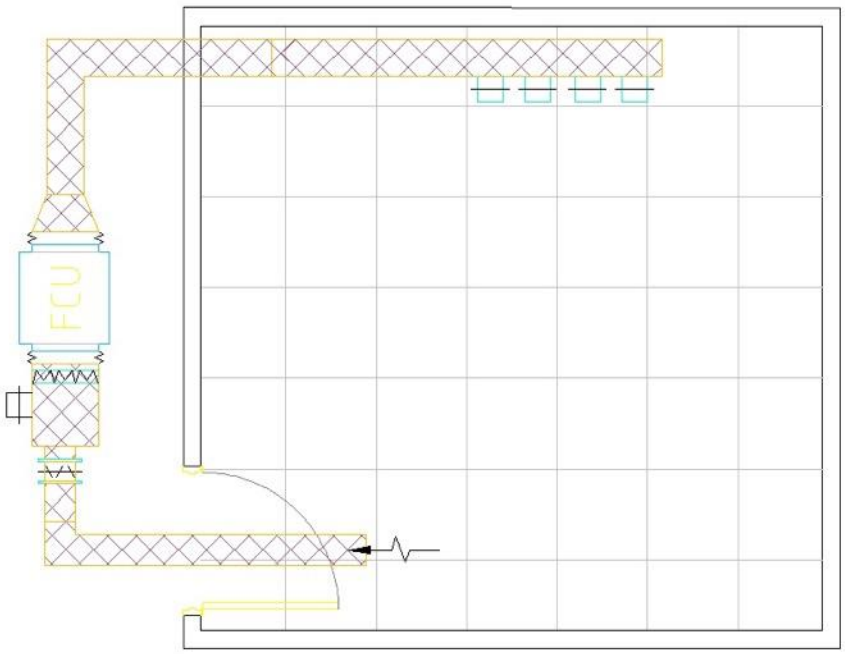

Figure 4 Conceptual Mechanical Design

8.4 Waste Pipes, Vent Pipes for Hydraulic Services and Stormwater Pipes

Following recommendations should be adopted where services and/or waste pipes pass through adjacent to any occupied space:

- Service/waste pipe should be lagged with minimum 5kg/m^2 flexible acoustic barrier bonded with minimum 25mm thick de-coupling convoluted open cell foam. Example of recommended acoustic lagging would be Pyrotek Soundlag 4525C or Thermotic NuWrap 5.
- Suspended ceiling should comprise of a minimum one layer of 13mm thick standard plasterboard (8.5 kg/m^2) or one layer of 9mm fibre cement board. However, Ceiling requirement would be derived from the floor-ceiling assembly design.
- Minimum 75mm, 14kg/m^3 acoustic insulation should be laid over the suspended ceiling.
- Services must not be chased into concrete, masonry, plasterboard elements.
- Vent pipes for hydraulics services (i.e., air moves through these pipes) – acoustic lagging (Pyrotek Soundlag 4525C) is required only for acoustic walls adjacent to teaching rooms, meeting rooms, private office or similar. Partition should be discontinuous or, alternatively, the pipes must be decoupled from the steel structure and plasterboard.

8.5 Service Riser

It is recommended that all service/waste pipe in the service riser should be lagged with minimum 5kg/m^2 flexible acoustic barrier bonded with minimum 25mm thick de-coupling convoluted open cell foam. An example of recommended acoustic lagging would be Pyrotek Soundlag 4525C or Thermotic NuWrap 5. Recommended acoustic treatments for the service risers are provided in Table 28.

Table 28 Recommendations for services

Location	Acoustic Rating	Recommended Construction
Services adjacent to Habitable area	R_w+C_{tr} 40	A lightweight shaft wall system comprising of the following: Side 1: No lining. This is the riser/shaft side. Frame: 102mm (BMT 0.5mm) C-H Stud at 600mm centre. Between Studs: 1 x 25mm Shaft Liner Panel installed in C-H stud. Cavity Insulation: Install 75mm, 14kg/m^3 acoustic insulation in the cavity between Shaft liner and Side 2. Side 2: 1 x 16mm fire-rated plasterboard (surface mass 12.5kg/m^2).

8.6 Electrical Services

All holes for electrical services must be cut or drilled, not punched. Once a cable is passed through an acoustically rated wall, seal the gap around the cable with a resilient, non-hardening mastic. Power points, data outlets and the like must not be installed back-to-back. The minimum offset shall be 300 mm, as shown in Figure 5.

Skirting ducts may only pass into the room through the sound lock. If there are any other skirting ducts present, they must be removed so that they do not compromise the acoustic rating of the as-built partition.

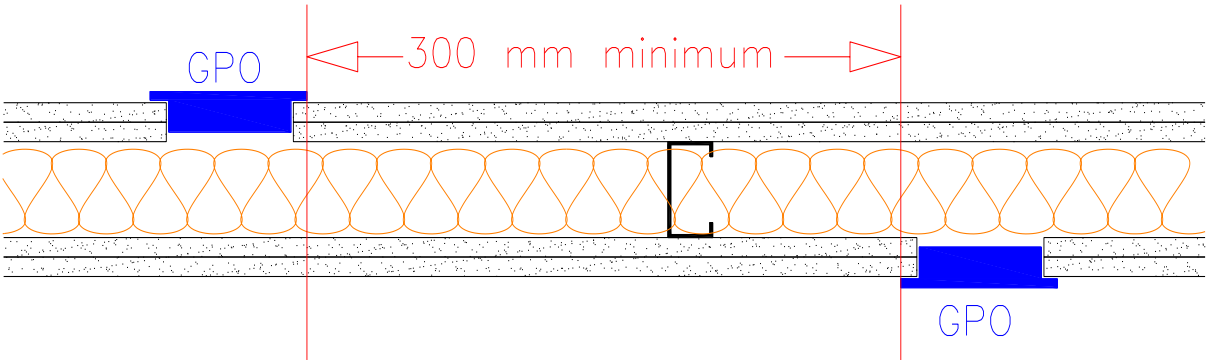

Figure 5 Power Point Offset

It is recommended to use Acoustic GPO (R_w 50) in the acoustic rated wall.

8.7 Hydraulic Services and Mechanical Ductwork Penetrations

All holes for sprinkler pipework must be cut or drilled, not punched. Seal around pipes with a resilient, non-hardening mastic. If the gap is greater than 5 mm, a plasterboard patch is likely to be necessary to reduce this gap. The patch must be screwed and glued using the resilient mastic as shown in Figure 6, pending a review by the security consultant as to their requirements.

These details assume the duct is above an acoustic ceiling or below a data floor. If the duct is exposed within the space, additional treatment may be required and will be determined on an individual basis.

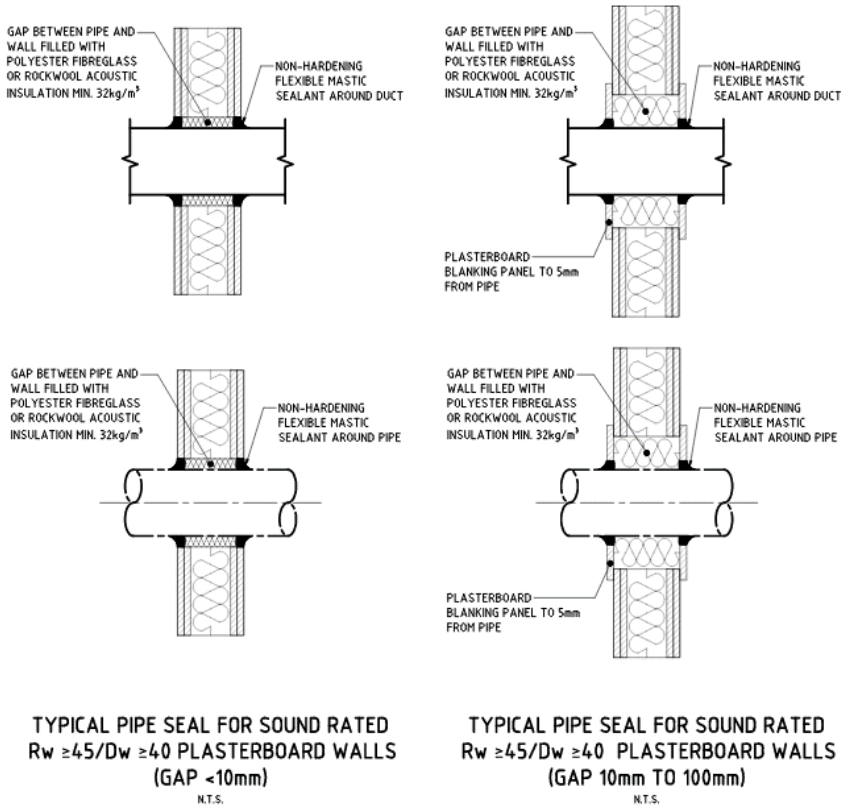

Figure 6 Sprinkler Pipe and Duct Penetration of Acoustic Walls

The same method can be used for sealing around mechanical ducts where they pass through acoustically rated walls. Additional metal angles, etc. are not considered necessary unless required for other reasons.

8.8 Cable Tray Detailing

Ideally, cable trays should run down the hallway, entering each room above the ceiling. At the doorway. If the cable tray runs down the building above the offices and meeting rooms, the detail shown in Figure 7 can be used.

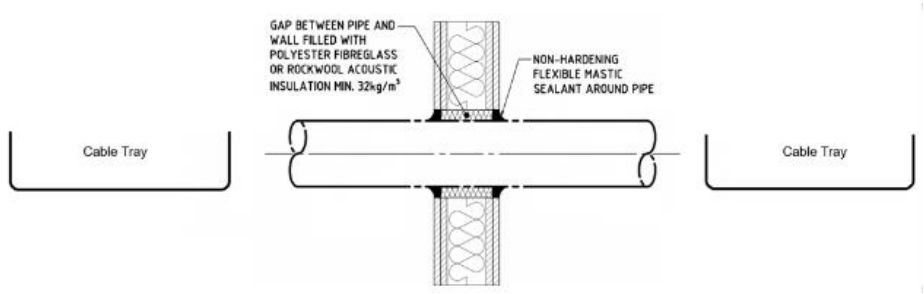

Figure 7 Cable Penetration Detailing – Pipe Penetrations

8.9 Vibration Isolation

All mechanical services plant, equipment and associated ancillaries, and hydraulic services, should be mounted or supported using vibration isolating elements to minimise the transmission of structure-borne noise throughout the building. This includes all building services, such as ductwork and pipework.

It is recommended that all plant, including but not limited to, outdoor condenser units, outdoor fans and pumps be mounted on vibration mounts that achieve an isolation efficiency of at least 95%. Similarly, all in-ceiling fans and fan coil units will need to be supported using isolated hangers.

There should be a flexible coupling or connection installed between each item of plant, such as a fan, air handling unit or pump, and the associated ductwork and pipework.

Rigid contact between ductwork or pipework and the building structure should be avoided by mounting the duct or pipe such that contact does not occur, or by installing a 6mm thick neoprene strip between the duct or pipe and the building structure for cases where space constraints are an issue.

All pipework should be isolated at support points. Main riser and dropper pipes should be supported from the floor slabs only, and mounting points on lightweight walls between the slabs should not be used. All branch and main riser pipes must be supported by rubber lined clips or vibration-isolated hangers.

Pipework should only be located in dividing walls if the dividing walls are of a discontinuous construction. Pipes in dividing walls should be supported by resilient clamps and only be mounted to the wall leaf adjacent to the room served by the pipe, or the wall leaf adjacent to the least noise sensitive space in the case of common pipework. If a pipe is required to be installed in single framed stud wall, the pipe should be connected to the stud frame using vibration isolating elements, for e.g., rubber lined clips or resilient mounts.

8.10 Control of Building Services Noise (Noise Emission to Outdoor)

Compliance with NSW EPA Noise Policy for Industry 2017 is a legislative requirement in the State of New South Wales. The Policy prescribes procedures for determining the statutory environmental noise limits that apply at noise sensitive locations (such as residential areas) due to noise due to commercial, industrial and trade operations. As the proposed development may include centralised plant located on the roof or in common areas, noise emissions from the proposed development are required to comply with these requirements.

At this preliminary design stage, information regarding mechanical services design is no available. However, this will be reviewed in further stages of the project.

9. Operational Vibration Assessment

9.1 Vibration Sensor Locations

Attended structural and ground vibration measurements were performed for the purpose of assessing the existing vibration environment at the proposed site, and to develop an understanding of the external vibration sources to the development. This information is fundamental to understanding the potential impacts that these external vibration sources will have on the design and operation of the building. Images illustrating environmental noise and vibration measurement locations are presented in Figure 8 and Figure 9.

External vibration levels were measured by ACOR at several locations around the site to assess potential external vibration impacts on the Development. The following Table 29 outlines relevant vibration measurement locations.

Table 29 Description of vibration measurement locations

Location	Description
V1	Concrete near fire exit
V2	Ground surface
V3	Ground surface – near plant room
V4	Concrete next to fire exit
V5	Suspended slab. North façade. Level 2 within the building adjacent to the project site and plant rooms

Figure 8 Distance between project site and railway track (>200m)

Figure 9 Background attended noise and vibration measurement locations

9.2 Vibration Instrumentation

Table 30 lists the equipment details used during the monitoring. All instrumentation has been laboratory calibrated and was checked for calibration during the on-site measurements.

Table 30 Equipment details

Instrument	Make	Model	Serial no.
Vibration Noise Assessment			
Geophone	Svantek	SV 803	141569

9.3 Vibration Measurements

A vibration survey was undertaken in order to determine the characteristics and levels of vibration at ground level at existing structures. The assessment of vibration requires the use of an overall frequency-weighted value for each axis (x, y and z directions). This overall value is assessed against the preferred value for the relevant axis. An alternative to using frequency-weighted values is presented as a simplified screening technique in NSW Environmental Noise Management – Assessing Vibration: a technical guide (February 2006).

Table 31 below summarises the vibration levels in three axes measured during day-time period for a range of typical sources.

Table 31 Vibration Compliance

Location	VDV ($m/s^{1.75}$)		RMS velocity (mm/s)		Compliance (VDV/RMS)
	Measured data (X,Y,Z)	Criteria	Measured data (X,Y,Z) (x1000)	Criteria	
1	(0.0002;0.0004; 0.002)	0.1	(0.000002, 0.000003, 0.000003)	0.1	Yes/Yes
2	(0.0005;0.0002; 0.002)	0.1	(0.000002, 0.000002, 0.000002)	0.1	Yes/Yes
3	(0.0005;0.0007; 0.006)	0.1	(0.00004;0.000005;0.000008)	0.1	Yes/Yes
4	(0.0006;0.0002;0.002)	0.1	(0.000003;0.000002;0.000002)(0.0034, 0.0010, 0.0008)	0.1	Yes / Yes
5	(0.0001;0.0002;0.011)	0.1	(0.00001;0.000002;0.00002)(0.0023, 0.0012, 0.0041)	0.1	Yes / Yes

Measured data taken on site confirms all locations comply with prescribed vibration criteria.

The assessment indicates that external vibration complies with established vibration criteria, and the risk of vibration impact to the proposed facility from external sources is minimal. Therefore, no additional structural isolation or vibration attenuation measures are considered necessary to mitigate external vibration ingress.

9.4 Construction Noise and Vibration Assessment and Recommended Mitigation Measures

It is understood that the project is currently at the concept/feasibility design stage and there is no contractor engaged or any construction plan developed, therefore assessment of construction noise and vibration would be preliminary at this stage. The noise emissions from construction have been assessed at the surrounding potentially affected receivers during the standard construction hours. A quantitative assessment has been undertaken with consideration to the ICNG.

Construction activities would generally be carried out during the recommended standard construction working hours. Early morning oversized deliveries may be required on occasion for some of the construction works and may occur outside the recommended construction hours. No work would be intended on Sundays or public holidays.

Construction traffic movements would primarily be associated with the transportation of construction machinery and equipment to the proposal site and the transportation of material. Plant and equipment needed for the proposal would be determined during the construction planning phase. Other equipment may be used however it is anticipated that they would produce similar noise emissions.

It is understood that the majority of works will be enclosed by the project site and thus impacts to external receivers will be minimum. However, the construction activity might risk causing elevated internal noise levels within adjacent functional areas of the building.

The magnitude of off-site noise impact associated with construction will be dependent upon a number of factors:

- The intensity and location of construction activities.
- The type of equipment used.
- Existing background noise levels.
- Intervening terrain and structures.

9.5 Airborne Construction Noise Impacts

- Expected noise impacts will be generated from activities such as:
- Hammering
- Circular Saws
- Cutting & joinery works
- Drilling
- Site radio
- Elevated voices

Noise from the above activity is likely to exceed internal noise criteria. Therefore, it is important that a noise management plan is in place to reduce the noise impact at the adjacent premises.

It is recommended that the following mitigation measures should be adopted.

- Construction should be undertaken within an enclosed area.
- Construction should be adopted during daytime period in consultation with the client.
- Recommend use of flexible noise barriers with internal absorptive finishes (i.e Echo Barrier H10, Flexshield)
- Minimise voices and reduce the radio/music noise.

The following standard actions and mitigation measures presented in the following Table 32 should be implemented, where applicable.

Table 32 Standard Mitigation Measures (Source NSW RMS Construction Noise and Vibration Guideline)

Action Required	Applies to	Details
Management Control		
Site inductions	▪ Airborne noise. ▪ Ground-borne noise & vibration.	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: ▪ all project specific and relevant standard noise and vibration mitigation measures ▪ relevant licence and approval conditions

Action Required	Applies to	Details
		▪ permissible hours of work ▪ any limitations on high noise generating activities. ▪ location of nearest sensitive receivers ▪ construction employee parking areas ▪ designated loading/unloading areas and procedures. ▪ site opening/closing times (including deliveries) ▪ environmental incident procedures.
Behavioural practices	Airborne noise	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors.
Attended vibration measurements	Ground-borne vibration	Where required attended vibration measurements should be undertaken at the commencement of vibration generating activities to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage.
Source Control		
Construction hours and scheduling.	Airborne noise. Ground-borne noise & vibration.	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels should be scheduled during less sensitive time periods.
Construction respite period during normal hours and out-of-hours work	Ground-borne noise & vibration. Airborne noise.	Respite Offers should be considered made where there are high noise and vibration generating activities near receivers. As a guide, work should be carried out in continuous blocks that do not exceed 3 hours each with a minimum respite period of one hour between each block. The actual duration of each block of work and respite should be flexible to accommodate the usage of and amenity at nearby receivers. The purpose of such an offer is to provide residents with respite from an ongoing impact. This measure is evaluated on a project-by-project basis and may not be applicable to all projects.
Equipment selection.	Airborne noise. Ground-borne noise & vibration	Use quieter and less vibration emitting construction methods where feasible and reasonable.
Plan worksites and activities to minimise noise and vibration.	Airborne noise. Ground-borne vibration.	Locate compounds away from sensitive receivers and discourage access from local roads. Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site. Where additional activities or plant may only result in a marginal noise increase and speed up works, consider limiting duration of impact by concentrating noisy activities at one location and move to another as quickly as possible. Very noise activities should be scheduled for normal working hours.
Reduced equipment power	Airborne noise. Ground-borne vibration.	Use only the necessary size and power
Non-tonal and ambient sensitive reversing alarms	Airborne noise.	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work. Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level.
Minimise disturbance arising from delivery of	Airborne noise.	Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers.

Action Required	Applies to	Details
goods to construction sites.		Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible. Avoid or minimise these out of hours movements where possible.
Path Control		
Shield sensitive receivers from noisy activities.	Airborne noise.	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.

Table 33: Highest allowable noise levels for construction equipment

Activity	Description of Activity	Plant/Equipment	L_{Aeq} SWL	L_{Aeq} at 7m
Mobilisation & Site Establishment	Installing construction boundary hoardings/ fences and traffic barriers	Truck (medium rigid)	103	78
		Road truck	108	83
		Scissor Lift	98	73
		Franna crane	98	73
Bulk earthworks	Formation of road alignment. Excavation of soil and rock, hammering/rock breaking, drilling, loading, haulage, compaction of fill areas, grading	Bulldozer D9	116	91
		Scraper 651	110	85
		Excavator (tracked) 35t	110	85
		As above + hydraulic hammer	122	97
		Grader	113	88
		Dump truck	110	85
		Compactor	106	81
		Roller (large pad foot)	109	84
		Water cart	107	82
Activity	Description of Activity	Plant/Equipment	L_{Aeq} SWL	L_{Aeq} at 7m
Mobilisation & Site Establishment	Installing construction boundary hoardings/ fences and traffic barriers	Truck (medium rigid)	103	78
		Road truck	108	83
		Scissor Lift	98	73
		Franna crane	98	73
Bulk earthworks	Formation of road alignment. Excavation of soil and rock, hammering/rock breaking, drilling, loading, haulage, compaction of fill areas, grading	Bulldozer D9	116	91
		Scraper 651	110	85
		Excavator (tracked) 35t	110	85
		As above + hydraulic hammer	122	97
		Grader	113	88
		Dump truck	110	85

Activity	Description of Activity	Plant/Equipment	L_{Aeq} SWL	L_{Aeq} at 7m
		Compactor	106	81
		Roller (large pad foot)	109	84
		Water cart	107	82

9.6 Sleep Disturbance

All construction activity is expected to occur during recommended standard hours therefore sleep disturbance impacts at the neighbouring residential receivers are not expected.

9.7 Construction Traffic Impacts

The application notes for the Road Noise Policy state that "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 as a result, the development should be limited to
2 dB above that of the noise level without the development. This limit applies wherever the noise level without the development is within 2 dB of, or exceeds, the relevant day or night noise assessment criterion." This is also considered to be applicable for construction noise therefore if road traffic noise increases from construction is within 2 dB(A) of current levels then the objectives on the Road Noise Policy are achieved.

A significant increase in traffic volumes would be needed in order to increase road traffic noise by 2 dB(A) (a doubling in traffic corresponds to an approximate 3 dB(A) increase). Construction work would generate light and heavy vehicle movements associated with employees, deliveries, transportation of machinery, materials and equipment to work sites.

The increase in vehicle movements would be limited to the period of construction. Noise level increases due to construction traffic would not be significant when compared with the existing vehicle numbers in the study area.

9.8 Construction Vibration Impacts and Mitigation Measures

- During construction activities, the recommended vibration levels should be complied at all times with DIN 4150 and NSW DEC Assessing Vibration: A Technical Guideline (2006).
- If there is any risk of vibration exceedance, a vibration monitoring system should be installed, to warn the Head contractor and the Operators (via flashing light, audible alarm, SMS, etc) when vibration levels are approaching to the criteria.

10. Conclusion

ACOR Consultants Pty Ltd (ACOR) has undertaken an acoustic review of the proposed World Class End of Life Program, to be located at Orange. Acoustic design review and recommendations are provided to achieve the relevant acoustic criteria for this project, as per below:

- NSW Noise Policy for Industry (NPI) 2017 and NSW Health – Engineering Services Guidelines 2022.
- NSW EPA Noise Policy for Industry 2017 (NPI).
- The external vibration complies with established vibration criteria, and the risk of vibration impact to the proposed facility from external sources is very low. Therefore, no additional structural isolation or vibration attenuation measures are considered necessary to mitigate external vibration ingress.

It is predicted that the proposed development would achieve the relevant noise criteria, provided the design recommendations are implemented.

We trust this information provided in this report meets your requirements. If you have any questions, please do not hesitate to contact ACOR.

Yours sincerely

ACOR Consultants Pty Ltd

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Acoustics Engineer

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Glossary of Acoustic Terms

A-weighting	Frequency weighting applied to the level in each stated octave band by a specified amount, in order to better represent the response of the human ear. The letter 'A' will follow a descriptor, indicating the value has been 'A' weighted. An 'A' weighted noise level may also be written as dB(A).
Ctr	The spectrum adaptation term Ctr adjustment factor takes account of low frequency noise.
CAC	Ceiling Attenuation Class. The CAC determines how much cross-talk will occur between one room and another through the ceiling cavity where both rooms have the tested ceiling tile. This is an ideal situation, with no wall head leaks and no services penetrations in the ceiling. Therefore, it defines the ideal, best possible result as tested in a laboratory
dB	Decibel. This is the unit measurement of sound.
dBA	A weighted decibel is the most commonly used descriptor. The A weighting is an adjustment to the raw sound level to approximate what the average human ear can hear, which is less sensitive at very low and very high frequencies.
Dw	The Weighted Level Difference as defined in AS/NZS ISO 717.1:2004. This is the single number rating describing the ability of a partition to reduce noise as measured in the field with no standardisation or normalisation.
DnTw	The Weighted standardised level difference as defined in AS/NZS ISO 717.1:2004. This is the single number rating describing the ability of a partition to reduce noise as measured in the field. The higher the DnTw rating, the better is the acoustic performance of the wall or floor.
DnTw + Ctr	DnTw + Ctr is DnTw with the addition of a low frequency sound correction factor Ctr (always a negative number remember). Rw + Ctr is used because of the increase in low frequency sound sources such as surround sound systems, drums or bass guitars, and of course traffic or aircraft noise. Two walls can have the same DnTw rating, but have different resistance to low frequency sound, thus a different DnTw + Ctr.
Lw or SWL	Sound power level. This is the total radiated sound energy.
Lp or SPL	Sound pressure level. This is the measurable sound level at a given distance from an item.
Lmax	The RMS maximum noise level of a measurement
L10	90th percentile sound level of a measurement. Often called the average maximum noise level
Leq	The energy average noise level of a measurement.
L90	10th percentile sound level of a measurement. Often called the average background noise level
Leq(T)	The time (T) equivalent energy noise level. The time interval is often in blocks of 10 or 15 minutes for short term measurements, or hours for long-term measurements. Common increments for long term measurements are 1 hour, day, night, 18 hours and 24 hours.
Leq(8h)	The 8 hour equivalent energy noise level. Primarily used for occupational noise assessments
LCpeak	The C weighted peak noise level. Primarily used for occupational noise assessments
Ln,w	The Weighted Normalized Impact Sound Pressure Level. This is a single number rating describing the impact sound performance of a floor ceiling assembly as measured in a laboratory. Assessed in accordance with AS/NZS ISO 717.2. The lower the Ln,w rating, the better is the impact sound isolation performance of a floor-ceiling assembly
L'n'Tw	The weighted standardized impact sound pressure level. This is a single number rating describing the impact sound performance of a floor ceiling assembly as measured in a filed. Assessed in accordance with AS/NZS ISO 717.2. The lower the L'nT,w rating, the better is the impact sound isolation performance of a floor-ceiling assembly

Rw	The Weighted Sound Reduction Index. This is the single number rating describing the ability of a building element to reduce noise as measured in a laboratory. Assessed in accordance with AS/NZS ISO 717.1. The higher the Rw rating, the better is the acoustic performance of the wall or floor.
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