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NOISE & VIBRATION ASSESSMENT

For DA Submission of Proposed Development

Lot No. 4
No.158-164 Hawkesbury Rd and 2A Darcy Rd, Westmead

Part 1: Environmental Noise Assessment
Part 2: Traffic Noise Assessment
Part 3: Mechanical Plant & Equipment Noise Assessment
Part 4: Intertenancy Acoustic Privacy
Part 5: Noise Control Recommendations
Part 6: Construction Noise Management Plan
Part 7: Construction Vibration Impact Assessment & Management Plan

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Date	***Revision History***	***Prepared By***	***Reviewed and Authorised by***
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1.0 INTRODUCTION

Acoustic Noise & Vibration Solutions Pty Ltd (ANAVS) has been commissioned to prepare an acoustic assessment for the proposed development at Lot 4, No. 158-164 Hawkesbury Rd & 2A Darcy Rd, Westmead (Figures 1 & 2 – Site Location).

As per architectural plans by Turner Architects dated the 16th December, 2016, the proposed residential development consists of three (3) towers and four (4) levels of basement parking as follows (Figure 3 – Proposed Site Plan):

- Building D – Twenty-One (21) Storeys
- Building E – Nine (9) Storeys
- Building F – Seven (7) Storeys

The proposed development will be located on Lot 4 of the site (Figure 2) with Darcy Rd located approximately 70 metres north of the site. Parramatta Marist High School is located adjacent to the western boundary of the site, while Westmead Hospital is located approximately 100 metres north of the site (Figure 4 – Surrounding Environment).

The proposed site at Lot 4, No.158-164 Hawkesbury Rd and 2A Darcy Rd, Westmead will potentially be affected by the following noise sources:

1. Traffic noise from Darcy Rd
2. Marist High School's Operation & Playground Activities
3. Westmead Hospital Operation including noise emitted by associated Mechanical Plant & Equipment and Ambulance Siren Noise

There are no residential receiver's currently located adjacent to the proposed development. Therefore for the purpose of this report, the nearest potential receiver for any potential impact from the proposed development will be considered as Marist High School located west of the site (Figure 3).

The above mentioned noise sources will be quantified and assessed in this report and we will propose practical and effective acoustic treatment measures to ensure that the acoustic amenity of the surrounding residences as well as the future residents of the development is maintained.

In this report we will also address the impact of Construction Noise & Vibration by conducting an impact assessment and recommendations for mitigation and management measures to be implemented, to minimise the potential for adverse impact at the nearest potentially affected receivers, resulting from excavation and construction works.

This report has been prepared to form part of the development application to be submitted to Parramatta City Council and provides supporting design and assessment information relating to the noise issues associated with the development.

2.0 ACOUSTIC DESCRIPTORS

Maximum Noise Level (L_{Amax}) – The maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.

L_{A1} – The L_{A1} level is the noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the L_{A1} level for 99% of the time.

L_{A10} – The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The L_{A10} is a common noise descriptor for environmental noise and road traffic noise.

L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.

L_{A50} – The L_{A50} level is the noise level which is exceeded for 50% of the sample period. During the sample period, the noise level is below the L_{A50} level for 50% of the time.

L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

ABL – The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10th percentile (lowest 10th percent) background level (L_{A90}) for each period.

RBL – The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period – daytime, evening and night time.

3.0 SCOPE OF WORKS

The aim of this report is to calculate, assess the projected noise levels and determine the building materials to be used and the construction methods to be adopted such that the proposed development at Lot 4, No. 158-164 Hawkesbury Rd & 2A Darcy Rd, Westmead is built to achieve acceptable internal noise levels.

This report will also identify the noise emissions generated by the proposal and will recommend acoustic and management controls in order to reduce noise impacts on the current and future neighbouring residential/commercial receivers, including the proposed development at Lot 4, No. 158-164 Hawkesbury Rd &2A Darcy Rd, Westmead in order to comply with the relevant acoustic criteria.

The acoustic noise and vibration assessment for the proposed development will be broken down into the following sections:

Part 1: Environmental Noise Assessment

This component of the report has been written to address the environmental noise impacts on all aspects of the proposed development. As previously mentioned, Parramatta Marist High is located adjacent to the western boundary of the site, while Westmead Hospital is located 100metres north of the site (Figure 4).

The main potential noise source affecting the proposed development will be from the operation and playground activities from adjacent Marist High School and mechanical plant/equipment of Westmead Hospital (including Ambulances) (Figure 3). We have provided recommendations to ensure the development's compliance with the noise criteria outlined in AS 2107 Acoustics – Recommended Design Sound Levels and Reverberations times for Building Interiors (2000);

Part 2: Traffic Noise Assessment

The proposed development is located approximately 70 metres south of Darcy Rd and therefore may be affected by traffic noise. The internal noise levels of the proposed residential development must comply with Clause 102 of the State Environmental Planning Policy (SEPP) Infrastructure 2007, AS 3671 'Road Traffic Noise Intrusion – Building Siting and Construction', AS 2107 'Acoustics – Recommended Design Sound Levels and Reverberation Times' and Council requirements.

Proposed Lot 3, which will comprise of a commercial development, will be located between Darcy Rd and the proposed development at Lot No. 4.

Part 3: Mechanical Plant & Equipment Noise Assessment

Here we addressed the potential noise impacts of the proposed mechanical plant and equipment of the development on both the acoustic environment of the proposed residential units and the existing neighbouring dwellings. The mechanical plant and equipment noise assessment was carried out in accordance with the EPA's Industrial Noise Policy.

Part 4: Intertenancy Acoustic Privacy

The aim of this section of the report is to determine the building materials to be used and the construction methods to be adopted such that the floors and walls of the proposed sole occupancy units comply with Section F5 of the BCA.

Part 5: Noise Control Recommendations

Here we provide noise control recommendations to ensure the development complies with the criteria set out in Parts 1-4.

Part 6: Construction Noise Management Plan

The construction noise management plan presents the relevant noise emission criteria, noise prediction calculations, an impact assessment and recommendations for mitigation and management measures to be implemented, to minimise the potential for adverse impact at the nearest potentially affected receivers, resulting from excavation and construction works.

This part of the report complies with the following the relevant industry and professional standards and guidelines:

- Section 80A of the Environmental Planning & Assessment Act, 1979
- Protection of the Environment Operations Act 1997 (NSW)
- Protection of the Environment Operations (Noise Control) Regulation 2008 (NSW).
- Interim Construction Noise Guideline, Department of Environment & Climate Change July 2009;
- Australian Standard 2436 – 1981 Guide to Noise control on Construction, maintenance and demolition sites;
- NSW Industrial Noise Policy, January 2000;
- Assessing Vibration: A Technical Guideline, Department of Environment & Climate Change 2006;
- Australian Standard AS2436-1981 *Guide to Noise Control on Construction, Maintenance and Demolition Sites*.

Part 7: Construction Vibration Impact Assessment & Management Plan

This section develops a vibration management plan to address construction vibration control and mitigation measures to be implemented during site activities to manage vibration issues associated with the bore drilling and excavation in the close vicinity of Marist High School.

The plan has been prepared with consideration of the following standards, guidelines and legislation:

- NSW Industrial Noise Policy (DEC 2000);
- Assessing Vibration: A Technical Guideline (DEC 2006);
- Protection of the Environment Operations Act 1997 (NSW);
- Protection of the Environment Operations (Noise Control) Regulation 2008 (NSW);
- Australian Standard AS2436-1981 *Guide to Noise Control on Construction, Maintenance and Demolition Sites*; and
- German Standard *DIN 4150 Part 3 – 1999 Structural Vibration In Buildings – Effects on Structures.*

4.0 NOISE SURVEY AND INSTRUMENTATION

Noise measurements for the assessment of the proposed development were carried out at various locations of the site (Figure 5 – Noise Reading Locations) as follows:

1) Location A was at the proposed site's northern boundary where we conducted unattended long term noise monitoring in order to determine the existing acoustic environment, including traffic noise Darcy Rd, and noise from Westmead Hospital operations (incluyding mechanical plant & ambulances)

2) Unattended noise measurements were carried out at Location B at the sites western boundary in order to determine the existing acoustic noise from Marist High School

The unattended noise loggers were deployed at the site (at Locations A & B) for a total of seven (7) days between Monday 21st November and Monday the 28th November, 2016 to determine a conservative reading of the existing day and evening noise levels [15hrs-7:00 -22:00] $L_{(A90,\ 15\ minutes\ [1hr])}$ and $L_{(Aeq,\ 15\ minutes\ [1\ hr])}$ and to determine a conservative reading of existing night and early morning noise levels [9hrs-22:00-7:00] $L_{(A90,\ 15\ minutes\ [1hr])}$ and $L_{(Aeq,\ 15\ minutes\ [1\ hr])}$.

The measurement procedure and the equipment used for the noise survey are described below. All sound pressure levels are rounded to the nearest whole decibel. All measurements were taken in accordance with the Australian Standards AS1055

"*Acoustics- Description and Measurements of Environmental Noise*". The noise readings presented ere carried out using the SVAN 957

-
- Type 1 sound level measurements meeting IEC 61672:2002
- General vibration measurements (acceleration, velocity and displacement) and HVM meeting ISO 8041:2005 standard
- Three parallel independent profiles
- 1/1 and 1/3 octave real time analysis
- Acoustic dose meter function
- FFT real time analysis (1920 lines in up to 22.4 kHz band)
- Reverberation Time measurements (RT 60)
- Advanced Data Logger including spectra logging
- USB Memory Stick providing almost unlimited logging capacity
- Time domain signal recording
- Advanced trigger and alarm functions
- USB 1.1 Host & Client interfaces (real time PC "front end" application supported)
- RS 232 and IrDA interfaces
- Modbus protocol

The sound level meter was calibrated before the survey. Any noise results affected by strong wind or rain have been disregard. The Full Average Statistical Noise Parameters $L_{(Aeq,\ 15\ minutes)}$, $L_{(A90,\ 15\ minutes)}$, $L_{(A10,\ 15\ minutes)}$, $L_{(A1,\ 15\ minutes)}$ are presented in Figures 6 & 7. Results were found to be as follows:

Table 1 - Summary of Noise Readings 21st November, 2016 – 28th November, 2016

Point A	**LA_{eq}**	**L_{90}**
Day & Evening Time 7:00am-10:00pm	58 dB(A)	53 dB(A)
Night & Early Morning Time 10:00pm-7:00am	53 dB(A)	46 dB(A)

Table 2 - Summary of Noise Readings 21st November, 2016 – 28th November, 2016

Point B	**LA_{eq}**	**L_{90}**
Day & Evening Time 7:00am-10:00pm	57 dB(A)	50 dB(A)
Night & Early Morning Time 10:00pm-7:00am	52 dB(A)	41 dB(A)

5.0 ACOUSTIC STUDY

Since environmental noise levels vary with time, it is not possible to use a specific number to define the acoustic environment of the site. Hence the preferred method of recording and presenting noise measurements is based upon a statistical approach. To accurately determine the environmental noise a 15-20 minute measurement interval is utilised. The three principle parameters are the L_{10}, L_{90} and the L_{eq}.

Conversely the L_{90} level, commonly referred to as the background noise level, is the level that is exceeded for 90% of the time and is considered to be the approximate average minimum noise level. The L_{eq} parameter represents the average noise level during a measurement period. It is derived by integrating the noise levels measured over the 15 minute period.

5.1 PART 1: ENVIRONMENTAL NOISE ASSESSMENT

This component of the report has been written to address the environmental noise impact of the adjacent Marist High School & Westmead Hospital on all aspects of the proposed development. The main potential noise source affecting the proposed development will be from the following:

- operation and playground activities from adjacent Marist High School
- operation & activities of Westmead Hospital (including Ambulance Sirens)
- Mechanical Plant & Equipment from Westmead Hospital

5.1.1 AS 2107 ACOUSTICS – RECOMMENDED DESIGN SOUND LEVELS AND REVERBERATIONS TIMES FOR BUILDING INTERIORS (2000)

AS 2107 "Acoustics – Recommended Design Sound Levels and Reverberations times for Building Interiors" (2000) has formulated the criteria for developments situated in urban areas. The levels have been derived from relevant Australian Standards, the measurements and analysis of noise conditions in other similar developments and standards established in completed projects.

As traffic noise levels are not constant, a LA_{eq} noise level descriptor is used when assessing this type of noise source. The LA_{eq} is the mean energy level of noise being measured and has been found to accurately describe the level of annoyance caused by traffic noise.

It is usual practice, when we find it necessary to recommend internal sound levels in buildings to refer to Australian/New Zealand Standard AS 2107. This standard provides

recommended noise levels for steady state such as noise from building services and quasi-steady state sounds, such as traffic and industrial noise. The noise levels recommended in AS 2107 take into account the function of the area and apply to the sound level measured within the space unoccupied although ready for occupancy. The standard recommends the following noise levels for residential buildings.

Table 3 - AS/NZS 2107:2000 Criteria for Houses & Apartments

AUSTRALIAN STANDARD AS/NZS 2107:2000 RECOMMENDED DESIGN NOISE LEVELS, LAeq		
Type of occupancy	Recommended Design Sound Level	
Activity	Satisfactory	Maximum
Houses in areas with negligible transportation		
Sleeping Areas	25	35
Houses and Apartments near minor roads		
Living Areas	30	40
Sleeping Areas	30	35
Work Areas	35	40
Apartment common areas (e.g. foyer, lift lobby)	45	55
Houses and Apartments near major roads		
Living Areas	35	45
Sleeping Areas	30	40
Work Areas	35	45
Apartment common areas (e.g. foyer, lift lobby)	45	55

5.2 PART 2: TRAFFIC NOISE ASSESSMENT

The proposed development at Lot 4, No. 158-164 Hawkesbury Rd & 2A Darcy Rd, Westmead is located within 70 metres of Darcy Rd and therefore noise from the major road needs to be addressed as per the criteria below.

5.2.1 ACOUSTICAL STUDY (AS/NZS 2107:2000)

The above standard has formulated the criteria for developments situated in urban areas. The levels have been derived from relevant Australian Standards, the measurements and analysis of noise conditions in other similar developments and standards established in completed projects.

As traffic noise levels are not constant, a Leq noise level descriptor is used when assessing this type of noise source. The Leq is the mean energy level of noise being measured and has been found to accurately describe the level of annoyance caused by traffic noise.

It is usual practice, when we find it necessary to recommend internal sound levels in buildings to refer to Australian/New Zealand Standard AS/NZS 2107:2000 "Acoustics – Recommended Design Sound Levels and Reverberations times for Building Interiors".

This standard provides recommended noise levels for steady state such as noise from building services and quasi-steady state sounds, such as traffic and industrial noise. The noise levels recommended in AS/NZS 2107:2000 take into account the function of the area and apply to the sound level measured within the space unoccupied although ready for occupancy. The standard recommends the following noise levels for residential buildings.

AUSTRALIAN STANDARD AS/NZS 2107:2000 RECOMMENDED DESIGN NOISE LEVELS, LAeq

Type of occupancy	Recommended Design Sound Level	
Activity	Satisfactory	Maximum
Houses in areas with negligible transportation		
Sleeping Areas	25	35
Houses and Apartments near minor roads		
Living Areas	30	40
Sleeping Areas	30	35
Work Areas	35	40
Apartment common areas (e.g. foyer, lift lobby)	45	55
Houses and Apartments near major roads		
Living Areas	35	45
Sleeping Areas	30	40
Work Areas	35	45
Apartment common areas (e.g. foyer, lift lobby)	45	55

5.2.2 ACOUSTICAL STUDY (AS 3671-1989) & CLAUSE 102 OF THE STATE ENVIRONMENTAL PLANNING POLICY – (INFRASTRUCTURE) 2007

Australian Standard 3671 "Traffic noise intrusion building siting and construction" is used to determine the type of building materials required to satisfactorily attenuate traffic noise so that internal traffic noise levels recommended in Australian Standard 2107-2000 "Recommended design sound levels and reverberations for building interiors" and Clause 102 of the State Environmental Planning Policy – (Infrastructure) 2007, can be achieved.

By taking in to consideration that the proposed development is considered to be "sensitive to traffic noise or vehicle emissions", it must be "appropriately located and designed, or include measures, to ameliorate potential traffic noise or vehicle emissions within the site of the development" arising from Darcy Rd.

Under Clause 102, where the development is for residential use and is located in or adjacent to a relevant road corridor, a consent authority must not grant consent unless it is satisfied that appropriate measures will be taken to ensure that the following LAeq levels are not exceeded:

- in any bedroom in the building – 35dB(A) at any time between 10.00p.m. and 7.00a.m.
- anywhere else in the building (other than a garage, kitchen, bathroom or hallway) – 40dB(A) at any time.

Maximum design sound level is defined as the level of noise that has been found to be acceptable by most people for the environment in question and also to be not intrusive. In this assessment, satisfactory design sound levels were used where practically possible.

In accordance with Section 3.4.2.6 of AS 3671 the traffic noise attenuation (TNAc) required for each building component (walls, windows, ceiling, etc) is determined from the following equation:

$$TNAc = TNR + 10 \log 10 [(Sc / Sf) \times (3/h) \times 2T60 \times C] \quad \text{.....4.1}$$

Where *TNAc* = the traffic noise attenuation required of the component, in decibels.
TNR = the traffic noise reduction, determined in Clause 3.3;
Sc/Sf = area ratio of the component
h = ceiling height of room, in metres
T60 = reverberation time of room, in seconds
C = number of components.

The tables provided in the relative Australian standards for selecting building materials (walls, windows, ceiling etc) are expressed in terms of their Rw (weighted sound reduction index) or STC. Section 3.4.3.1 defines the relation between Rw and TNAc calculated in [4.1] as follows:

$$Rw \text{ (or } STC) \approx TNAc + 6 \quad \text{.....4.2}$$

This formula approximate all allowances made for the spectral composition of the noise.

The proposed development is to comply with the Department of Planning's document titled "Development Near Rail Corridors and Busy Roads – Interim Guidelines". The noise criteria for residential buildings in Table 2.1 for both road and rail are specified in the Infrastructure SEPP. Other values in Table 3.1 are based on the Environmental Criteria for Road and Traffic Noise (EPA1999).

Table 4 - Noise Criteria

Residential Buildings		
Type of occupancy	**Noise Level dBA**	**Applicable time period**
Sleeping areas (bedroom)	35	Night 10 pm to 7 am
Other habitable rooms (excl. garages, kitchens, bathrooms & hallways)	40	At any time

The proposed development is to comply with the Department of Planning's document titled "Development near Rail Corridors and Busy Roads – Interim Guidelines".

5.2.3 SLEEP AROUSAL

Section 5.4 of the NSW Road Noise Policy mentions the Environment Protection Authority NSW 1999 guideline which aims at limiting the level of sleep disturbance due to environmental noise. It states that the $L_{A1,\ 1\ minute}$ level of any noise should not exceed the ambient L_{AF90} noise level by more than 15dB. This guideline takes into account the emergence of noise events, but does not directly limit the number of such events or their highest level, which are also found to affect sleep disturbance.

Applying the above thus the sleep disturbance criteria for the above project is $L_{A1,\ 1\ minute}$ and should not be exceeded by [L_{A90} =46 dB(A) plus 15]= 61 dB(A).

There are other studies on sleep disturbance like the one carried the enHealth Council (2004) and the guidelines published by the World Health Organisation (1999) were reviewed and analysed in terms of the guidance on noise exposure and sleep disturbance. The enHealth report states that:

' as a rule for planning for short-term or transient noise events, for good sleep over 8 hours the indoor sound pressure level measured as a maximum instantaneous value not exceed approximately 45 dB(A) $L_{A,(Max)}$ more than 10 or 15 times per night'.

5.3 PART 3: MECHANICAL PLANT & EQUIPMENT NOISE ASSESSMENT

The proposed four (4) levels of basement parking at Lot 4, No. 158-164 Hawkesbury Rd and 2A Darcy Rd, Westmead are located below ground level and therefore natural ventilation becomes an issue. Natural ventilation will not be possible in the lower basement levels and a mechanical extract system should be used. The mechanical ventilation system needs to achieve six air changes per hour for exhaust fume extract and ten air changes per hour for smoke clearance.

The noise from the mechanical ventilation system at the above address is governed under Section 2.1 of the NSW Industrial Noise policy. Noise intrusion from the mechanical ventilation plan is generally considered acceptable if the weighted level of noise from the source measured over a 15 minutes interval does not exceed the background noise level by more than 5dB.

$$L_{Aeq,15\ minutes} < \text{background levels} + 5$$

Therefore the noise emission criterion is **50 + 5 = 55 dB(A) during the Day**
41 + 5 = 46 dB(A) during the Night

Section 3.1 of the above policy defines the background level as $L_{A90,15\ minutes}$ which is the Noise exceeded 90% percent of a time period over which annoyance reactions may occur (taken to be in 15 minute periods).

After applying the distance attenuation formula the maximum outdoor sound level from all the mechanical plant and equipment collectively at any residential boundary should not exceed the background noise level plus 5dB(A).

To achieve compliance with the nominated noise criteria, the following noise mitigation measures are required:

MECHANICAL PLANT	RECOMMENDATIONS
Car Park Supply air	• Install a silencer Min 2D (E29/90)[1] or Equivalent.
Car Park Exhaust Fan	• Provide silencer before and after Fan. • Silencer Min 2D (E29/90)[1] or Equivalent. • Lagged duct with min 38mm 32 kg/m^3 acoustic insulation.

Note:

1. All silencers should be placed 1 to 2 duct diameter distance away from the fans. Specifications of silencers/acoustic louvers are provided in Table below

Insertion Loss of Recommended Silencers [dB]								
FREQUENCY [Hz]	63	125	250	500	1000	2000	4000	8000
Attenuator/Silencer	6	11	18	31	36	27	24	17

Alternative attenuator/silencer or acoustic louvers can be considered provided that the insertion loss values are equal or greater than the values specified in the Table above. It is the requirement that any supplier of any mechanical plant located outdoors meet the sound power reduction requirements.

We recommend that further acoustic assessment is carried out once the development has been approved and mechanical services plans have been prepared.

5.4 PART 4: INTERTENNANCY ACOUSTIC PRIVACY

The aim of this section of the report is to determine the building materials to be used and the construction methods to be adopted such that the floors and walls of the proposed sole occupancy units comply with Section F5 of the BCA.

5.4.1 ACOUSTICAL PRIVACY BETWEEN UNITS (WALLS & FLOOR) SECTION F5 OF THE BCA

Sound isolation between units is mainly determined in accordance with section F5 of the BCA (Building Code of Australia). Section F5 of the BCA nominates laboratory acoustic performances of various types of walls and floor construction elements adopted by the building industry.

A Building Solution is proposed to comply with the Deemed to Satisfy Provisions if Performance Requirements FP5.1 to FP 5.6 is satisfied by complying with section F5.1 to F5.7 of the BCA.

An alternative solution to the Deemed To Satisfy Provisions of F5.1 to F5.7 must be determined in accordance with section A0.10 of the BCA (Relative Performance Requirements).

Section F5 of the BCA acts as a protection from any noise annoyance being transmitted between adjoining sole-occupancy units or from a common spaces to sole occupancy unit.

5.4.2 WALLS BETWEEN ADJACENT OCCUPANCY UNITS

Airborne sound insulation rating of walls is determined using the weighted sound reduction index R_w or weighted sound reduction index with spectrum adaptation terms ($R_w + C_{tr}$) as determined in accordance with AS/NZS 1276.1 or ISO 171.

Proposed Walls separating one sole occupancy unit from another or one sole occupancy unit from a public corridor, staircase, or a plant room will comply with the Deemed to Satisfy Provision in the section F5 of the BCA provided the following table is satisfied.

Table 5 - Building Component between Units –Walls

Building Component between Units-Walls	**Attenuation Required.**
Living/Bedroom - Living/Bedroom	$R_w + C_{tr} \geq 50$ dB
Kitchen/Laundry/Toilet-Living/Bedroom Kitchen/Laundry/Toilet- Kitchen/Laundry/Toilet	$R_w + C_{tr} \geq 50$ dB- Discontinuous.
Living/Bedroom - Corridor/Staircase	$R_w \geq 50$ dB
Plant Room/ Lift Shaft -Living/Bedroom	$R_w \geq$ 50dB – Discontinuous.

5.4.3 FLOORS BETWEEN OCCUPANCY UNITS

The Floors separating sole occupancy units at Lot 4, No. 158-164 Hawkesbury Rd and 2A Darcy Rd, Westmead must have both an Impact Sound insulation rating $L_{n,w}+C_l$ no more than 62 and must have an $R_w + C_{tr}$ not less than 50.

5.4.4 SOUND INSULATION FOR PIPNG & SERVICES

If a duct, soil, waste or water supply pipe that is embedded or passes through one or more than one sole occupancy unit then it must be separated from the other rooms by construction of $R_w + C_{tr}$ (airborne) not less than:

- 25 if the adjacent room is a kitchen or non-habitable.
- 40 if adjacent room is habitable.

5.4.5 DOORS OF SOLE OCCUPANCY UNITS

Section F5 of the BCA states that any door "that separates a sole-occupancy unit from a stairway, public corridor, public lobby or the like" must have an $Rw \leq 30$.

5.5 PART 5: NOISE CONTROL RECOMMENDATIONS

5.5.1 BUILDING COMPONENTS - EXTERNAL

To limit the level of within the mixed use development we recommend that the proposed external building components are as follows:

Table 6 – Window's Schedule

Window Schedule	Rw Rating Achieved
Windows & Sliding Doors in Living/Dining/Kitchen & Bedrooms Areas of all Units are to be 6mm laminated with full perimeter acoustic seals.	30-32
Windows in all other areas of the development (Bathrooms/Laundries, Stair wells, Hallways etc) are unrestricted and to be in accordance with AS 2047 (Windows in Buildings).	-
External Walls are to be equivalent to double skin cavity brick walls, with a minimum 270/250mm double brick, brick veneer construction or any other form of construction that achieves an Rw of 44.	44
Roof is to be minimum 150mm Concrete Roof and/or Galvanised Steel Trough Roofing, on 13mm plaster board ceiling & 75mm thick, 11kg/m³ mineral wool batts between ceiling joists or any other combination having an STC of minimum 44)	40-44

5.5.2 BUILDING COMPONENTS - INTERNAL

5.5.2.1 INTERNAL WALLS SEPARATING ADJACENT OCCUPANCIES

The common walls between the units vary between a living/bedroom to a living/bedroom, living/bedroom to kitchen/bathroom, living/bedroom to a common corridor/staircase & bathroom/kitchen to a lift-shaft.

Party walls separating sole occupancy units from adjacent sole occupancy units, common areas/staircase and lift shafts are to be constructed as per the following wall system or any other form of construction that achieves an Rw+Ctr ≥ 50/ Rw ≥ 50.

Dry-Dry, Wet-Dry, Wet-Wet, Dry-Wet to Corridor/Staircase (*Refer to Figure 8)*

- 13mm Plasterboard*
- 75mm Hebel Power Panel in conjunction with 200mm Concrete Column
- 20mm gap from Concrete Column
- 64mm Steel Stud with minimum 50mm Bradford Insulation Batts
- 13mm Plasterboard*

Habitable to Lift Shaft (*Refer to Figure 9)*

- 200mm Concrete Wall 13mm Plasterboard
- 20mm Cavity
- 64mm Stud with 75mm Glasswool Insulation
- 13mm Fyrchek Plasterboard*

Note* 6mm FC + Waterproofing Membrane + Tiles, to be used in Wet Areas

5.5.2.2 FLOORS SEPARATING OCCUPANCIES

The sound insulation required for the floor system is $R_w + C_{tr} \geq 50$ dB & $L_{n,w} + C_{tr} \leq 62$ satisfying Section F5 of the BCA & $D_{nT,w} + C_{tr} \geq 50$. In Order to satisfy the above,

For carpet areas - ***Please see Figure 10 (Slab Detail – Carpet)***:

- An 80mm False Ceiling and 13mm Plasterboard followed by
- a 200mm thick Concrete Slab covered with
- a Layer of Carpet underlay followed by
- Carpet

For tiled areas - ***Please see Figure 11 (Slab Detail – Direct Stick On)***:

- An 80mm False Ceiling and 13mm Plasterboard followed by
- A minimum 200mm Concrete Slab covered with
- Adhesive followed by
- 5mm Acoustic Matting followed by
- Adhesive followed by
- Minimum 10mm Tiles

OR ***Please see Figure 12 (Slab Detail – Screed Bed)***

- An 80mm False Ceiling and 13mm Plasterboard followed by
- A minimum 200mm Concrete Slab covered with
- Adhesive followed by
- 5mm Acoustic Matting followed by
- Screed Bed
- Adhesive, followed by
- Minimum 10mm Tiles

Note* *If a minimum 80mm false ceiling with minimum 50mm thick insulation is used in ceiling cavity beneath the 200mm concrete slab, then no acoustic matting is required beneath the tiles. Additionally, water proofing membrane is to be used in wet areas. For Floor Systems above non-habitable areas, no false ceiling is required. Please refer to Figure 13.*

5.5.2.3 SOUND INSULATION FOR PIPNG & SERVICES

To achieve an Rw + Ctr not less than 25 (i.e. if the adjacent room is a kitchen or non habitable) for any riser in the kitchen or any non-habitable room:

- Minimum of
- One layer of 13 mm plasterboard are required to partition the services/ waste pipes from any kitchen or non-habitable room or
- One layer of 10mm plaster board plus a cupboard or
- Two layers of 10mm plasterboards plus tiles.
  In all situations riser should be filled with insulation bats.

To achieve an Rw + Ctr not less than 40 (i.e. if adjacent room is habitable):

- Minimum of one layer of 13 mm plasterboard are required as a partition for the services/waste pipes from a habitable room, and in addition the pipes are to be lagged with an acoustic lagging material such as Pyrotech's Soundlag 4525C (Ph:9534 5366) or equivalent is always considered provided certification of performance.

For pipes and risers constructed in the wardrobes and kitchen cabinets, refer to ***Figure 14 & 15 - Pipes & Services Insulation Details Vertical Shaft***

Services running horizontally can be insulated using Bradford insulation batts. ***Refer to Figure 16 – Pipes & Services Insulation Details (Horizontal Run).***
However no lagging is required in floors separating habitable areas from the basement car park and between horizontal wet areas.

Access doors and panels must be firmly fixed so as to overlap the frame or rebate the frame by not less than 10 mm, and be fitted with a proper sealing gasket along all edges and constructed of:

- wood, particle board or block board not less than 38 mm thick; or
- compressed fibre reinforced cement sheeting not less than 9 mm thick; or
- other suitable material with a mass per unit area not less than 24 kg/m2
-

5.5.2.4 INTERNAL UNIT ENTRY DOORS

In order to achieve compliance with Section F5 of the BCA, as per Section 2.4 of this report, we recommend that doors separating sole-occupancy units from common areas be Solid Core minimum 40mm thick with acoustic seals fitted around the door. A drop seal is required at the base of the external door.

5.6 PART 6: CONSTRUCTION NOISE MANAGEMENT PLAN

This section of the report presents the relevant noise emission criteria, noise prediction calculations, an impact assessment and recommendations for mitigation and management measures to be implemented, to minimise the potential for adverse impact at the nearest potentially affected receivers, resulting from excavation and construction works.

5.6.1 DESCRIPTION OF OPERATIONS AND ENVIRONS

The excavation and construction works will be undertaken on site at Lot 4, No. 158-164 Hawkesbury Rd and 2A Darcy Rd, Westmead (Figure 1 – Site Location). The background noise in the local area is currently dominated chiefly by Marist High School's playground, west of the site, Darcy Rd and Westmead Hospital north of the site (Figure 4- Surrounding Environment).

ANAVS understands that the excavation and construction works are proposed over a few months, during the daytime hours only. ANAVS is advised that normal construction works will be undertaken between the hours as stated in the DECC Interim Construction Noise Guideline which are as follows:

- Monday to Friday 7:00am to 6:00pm
- Saturday 8:00am to 1:00pm
- No work on Sundays or public holidays unless otherwise approved.

Blasting can be carried out between Monday to Friday 9:00am to 5:00pm Saturday 9:00am to 1:00pm. No blasting is to be undertaken on Sundays or public holidays.

Working hours may change subject to approval. The relevant authority (consent, determining or regulatory) may impose more or less stringent construction hours. A site location map and aerial photo are included within the Appendix of this report showing the location of the site and nearest potentially affected receivers.

5.6.2 PROJECT SPECIFIC NOISE CRITERIA

The following sections outline the relevant construction noise & vibration emission criteria and conditions applicable to the works.

5.6.2.1 DECCW CONSTRUCTION NOISE CRITERIA

In this section, the relevant construction noise emission criteria and conditions applicable to the works are outlined, based on the NSW Department of Environment, Climate

Change's and Water's (DECCW) Interim Construction Noise Guideline (ICNG). The ICNG is the appropriate guideline for use in construction noise assessments and is to be used when establishing specific construction noise management levels for a particular project.

The NSW DECCW's ICNG is developed to manage noise from construction works. The ICNG advises that a qualitative methodology of for assessment of construction noise emission may be undertaken for short-term works (less than 3 weeks). However, for larger construction projects, a quantitative assessment of construction noise should be undertaken.

Section 4 of the ICNG classifies noise criteria into the following categories:
- Airborne noise;
- Ground-borne noise;
- Sleep disturbance at residences;
- Blasting and vibration; and
- Predicting noise levels – quantitative assessment.

The ICNG also goes on to state that when developing noise mitigation strategies for reducing construction noise emission focus should be given to *"applying all 'feasible' and 'reasonable' work practices to minimise construction noise impacts"*. The ICNG provides management levels (criteria) for construction noise emission at residential receivers, and other various sensitive receivers. The management noise levels at residential receivers are dependent upon the relevant Rated Background Level (RBL) at the residential receiver, and the time of day that the construction noise is to be generated.

ANAVS has determined the daytime ambient background noise environment at a nearby location representative of the nearest residential receiver at Marist High School (Figure 4 – Noise Reading Locations).

5.6.2.2 AIRBORNE NOISE

Criteria for Residential Receivers and other Sensitive Land Uses are set using the information in the table below.

Table 7 - Ambient Noise Environment Criteria

Time of day	**Management Level $L_{Aeq, (15min)}$**	**How to apply**
Residential Receivers		
Recommended standard hours: Monday to Friday 7:00am to 6:00pm Saturday 8:00am to 1:00pm No work on Sundays or public holidays unless otherwise approved.	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}, (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 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. -Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: - Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences - If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	- A strong justification would typically be required for works outside the recommended standard hours. - The proponent should apply all feasible and reasonable work practices to meet the noise affected level. - Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 (ICNG)

Other Sensitive Land Uses (eg Classrooms at Schools & other Educational Institutions)		
Time of Day	**Management Level $L_{Aeq, (15min)}$**	**Comments**
Applies when School is in use ie Monday to Friday 7:00am to 6:00pm	Internal Noise Level 45 dB(A)	Complies with Criteria of above report provided below recommendations are adhered to ✓

5.6.3 METHODOLOGY FOR EMISSION PREDICTION AND ASSESSMENT

ANAVS understands that the following items of noise emitting equipment and machinery are likely to be used during the excavation and construction works on site:

Excavation (Around 6 months duration)
- Excavator; and
- Trucks (for removal of materials).

Construction (Around 1.5 years duration)
- Concrete Trucks;
- Trades (Brick Layers, Concreters, Renderers, Roofers, Carpenters, Plumbers etc.);
- Concrete Pumps; and
- Trucks (for removal of materials).

Accordingly, assessment of the operation of above items requires calculation of their noise emission levels to nearby potentially affected receiver locations.
ANAVS has conducted operator-attended noise monitoring of similar equipment/activities at many other sites on numerous occasions. Based on previous operator-attended surveys of similar activities and equipment, prediction calculations have been undertaken to predict the noise impact at adjacent receiver locations, resulting from the proposed works.

In our noise prediction calculations and modelling, the noise emission contribution from the above items of equipment has been incorporated into the prediction calculations and modelling along with various loss factors, including:

- Losses due to distance and ground topography;
- Airborne noise losses;
- Losses due to direction;
- Weather conditions; and
- Acoustic shielding.

5.6.4 NOISE EMISSION PREDICTION AND ASSESSMENT

ANAVS advises that the project is likely to be undertaken in two main stages:

- Excavation; and
- Construction.

It is likely that earthworks and excavation works would be undertaken over a period of 6 months. Construction works would then be undertaken and may last for a period between 1.5-2 years. The excavation stage typically produces the highest levels of noise emission during a project such as this.

5.6.5 NOISE EMISSION PREDICTION CALCULATIONS

ANAVS has performed prediction calculations and determined maximum LAeq noise emission levels at adjacent receiver locations, resulting from proposed excavation activities, including use of the tools and equipment listed in this report.

For the purpose of noise assessment, the likely maximum *"at source"* noise levels (sound pressure levels at 1 metre) have been used as detailed below.

Excavation

- Excavator (30 tonne) — 90 dB (A); and
- Trucks (for removal of materials) — 85 dB (A).

Construction

- Concrete Mixers — 90 dB (A);
- Concrete Pumps — 100 dB (A);
- Bricklayers, Roofers, Carpenters 55 -65 dB (A); and
- Trucks (for removal of materials) — 85 dB (A).

Table 8- Maximum Excavation, and Construction Noise Emission at Boundaries

Location of Residential Receivers Boundary	Time of the Day	Maximum Predicted LA_{eq} Level dB(A) from Building Works	Site specific construction noise emission criteria ($L_{Aeq(15\ min)}$)	Criteria Exceeded by
Marist High School No. 2 Darcy Rd, Westmead	Mon-Fri 7am-6pm	49	60	Nil
	Sat 8am-1pm	49	60	Nil

Note should be made that the predicted noise levels above, are the maximum predicted LAeq noise levels from an activity at the nearest boundaries of the listed properties, resulting from proposed excavation and building works at the centre of the subject site. Typically, received LA_{eq} noise emission levels would be expected to be lower than these during the majority of the excavation and construction works. Significantly lower noise levels than those presented would also be expected within (inside) the nearest potential residential receivers residences.

Due to the fact that highest noise emitting items are unlikely to be used for a long duration then it is unlikely to lead to complaints.

5.6.6 CONSTRUCTION NOISE ASSESSMENT

Noise emission resulting from excavation has been considered and is likely to cause higher noise emission levels than during the majority of the construction phase of the project, when much of the noise emission can be significantly contained within the new building envelope.

The predicted noise emission levels presented above indicate LAeq noise emission associated with the proposed excavation and building works will exceed the relevant construction noise criterion at certain times.
ANAVS advises that lower noise levels, which are likely to be acceptable, would be received inside these nearby/adjacent dwellings, when the external windows are closed.

To ensure that construction noise emission levels from the proposed works are kept to a minimum, ANAVS provides recommendations for feasible and reasonable noise mitigation and management, which should be incorporated into the noise management plan for the proposed excavation.

5.6.7 DISCUSSION AND RECOMMENDATIONS

Further to the predicted noise emission levels presented above, ANAVS advises that measures are required to minimise and manage noise emission and impact from the proposed excavation works at the site.

ANAVS understands that proposed works at Lot 4, No. 158-164 Hawkesbury Rd & 2A Darcy Rd, Westmead will only be carried out during daytime hours only:

- Monday to Friday 7.00am to 6.00pm
- Saturday 8.00am to 1.00pm

ANAVS recommends the following measures be implemented to minimise and manage noise emission from the subject excavation:

5.6.7.1 NOISE INDUCTION OF ALL SITE STAFF

ANAVS recommends all site staff be inducted, ensuring each person is aware of the noise management and mitigation procedures applicable to the site and site works.

All site managers should be made aware of noise and vibration limits, applicable control measures and methods. They should ensure that all agreed noise and vibration measures are carried out by employees and sub-contractors.
When a builder/contractor has made noise reduction commitments all staff need to be made aware of them. Workers and sub-contractors need to be trained to follow noise management practices (a toolbox meeting may be an effective way to do this).

Embedding requirements to manage noise in tenders, employment contracts or sub-contractor agreements can be an effective tool for pro-active noise management. This ensures that responsibility for noise rests with all people involved.

5.6.7.2 IMPLEMENTATION OF AN APPROPRIATE COMMUNITY LIAISON PROCEDURE

ANAVS recommends implementation of an appropriate community liaison procedure, including a noise management and compliant procedure, and continual liaison with the nearby potentially affected receivers.

Community Liaison

Community consultation is an essential part of managing noise from a construction project. Builders/contractors should aim to:

- establish good working relationships with community stakeholders;
- give and receive feedback on construction activity and performance during a project; and
- discuss the community's concerns and be proactive in complaint resolution.

As part of a community consultation strategy, neighbouring premises should be given written notification of the project. The information should outline the type and duration of works, likely noise impacts, and provide contact details for feedback and/or complaints.

The minimum notification period is 48 hours before noisy work is scheduled.

Methods of notification for noisy works and ongoing communication about a project's progress can include:

- letterbox drops;
- meetings;
- individual contact;
- a website (for larger projects); or
- a regular newsletter with site news, project planning etc.

In some areas, provision of multi-lingual notification may be required.

Complaint Resolution

A person may have experienced noise disturbance for some time before they approach the builder/contractor or the Council, and may have become tense and angry. This is particularly important to acknowledge when the complaint refers to disturbed sleep and/or noise that is tonal (beeping, metal-on- metal), impulsive (hammering, pile driving) or low frequency (truck engine, heavy machinery).

The builder/contractor should respond respectfully to a complaint and implement all feasible and reasonable measures to address the issue. High impact projects should have a readily accessible contact point such as a 24-hour toll-free information and complaints line. The builder/contractor should call back as soon as possible, and then maintain communication about how the issue is to be resolved.

The complaint management process should be well documented, with details about the following:

- the noise/s in question;
- the time of the complaint and the person making it;
- the person dealing with the complaint and how they plan to do so;
- how resolution of the complaint is to be communicated to the person who made the complaint, the community and the Council;
- who should be contacted if the complaint cannot be resolved; and
- the time taken for responses.

5.6.7.3 IMPLEMENTATION OF A NOISE MONITORING AND REPORTING PROGRAM

ANAVS recommends noise measurements and monitoring to be carried out during the project. The frequencies of noise monitoring and summary reports are to be determined during the course of the works, in response to complaints, should they arise.

In response to requests, ANAVS will attend site and carry out operator-attended noise measurements and monitoring of site equipment and operations.

5.6.7.4 USE OF QUIETEST AVAILABLE EQUIPMENT AND LOWEST VIBRATION GENERATING EQUIPMENT FOR WORKS (WHERE FEASIBLE AND REASONABLE)

As indicated within the previous section, ANAVS will carry out operator-attended noise measurements of site equipment and operations (as required/requested), to ensure quietest techniques and equipment are being used for the subject works.

All builders/contractors should endeavour to use low-noise, well-maintained equipment where feasible and reasonable. Deciding to use low-noise equipment in the early stages of a project can be of considerable benefit in reducing noise, especially for medium and high impact projects.

Selecting Equipment

Consideration of equipment noise levels should be part of each stage of project planning and contract specification. The builder/contractor should look at different types of equipment that do the same job and compare the noise level data. Noise emission labels are often provided on equipment and can be used to assist in this process. Investigate high-quality mufflers, enclosures, low- noise tool bits/blades and inquire from suppliers about lower-noise equipment.
Alternative Equipment

Compressors for pneumatic equipment can often cause problem noise levels and should be silenced, enclosed and located appropriately. Hydraulic or electrical equipment may be a viable alternative. Electrical equipment may also be used in place of diesel or petrol engines, but care must be taken with the location of the generator and supply line.
Impacts from noisy excavation works can be reduced by alternative work methods. Alternatives to rock-breaking include hydraulic splitters for rock and concrete, hydraulic jaw crushers, rock and concrete sawing. Smaller rock breakers/excavators are generally preferable to larger machines, but increased time on the job should be considered.

5.6.7.5 USE ACOUSTIC BARRIERS

Barriers or screens can be an effective means of reducing noise. Barriers can be located either at the source or receiver. The placement of barriers at the source is generally only effective for static plant (tower cranes). Placing barriers at the source cannot effectively attenuate equipment which is on the move or working in rough or undulating terrain.

Barriers can also be placed between the source and the receiver. The degree of noise reduction provided by barriers is dependent on the amount by which line of sight can be blocked by the barrier. If the receiver is totally shielded from the noise source reductions of up to 15 dB (A) can be effected. Where only partial obstruction of line of sight occurs, noise reductions of 5 to 8 dB (A) may be achieved. Where the barrier does not obstruct line of sight, generally no noise reduction will occur.

As barriers are used to provide shielding and do not act as an enclosure, the material they are constructed from should have a noise reduction performance which is approximately 10 dB(A) greater than the maximum reduction provided by the barrier. In this case the use of a material such as 10 or 15mm plywood would be acceptable for the barriers.

5.6.7.6 SILENCING DEVICES

Where construction process or appliances are noisy, the use of silencing devices may be possible. These may take the form of engine shrouding, or special industrial silencers fitted to exhausts.

5.6.7.7 MATERIAL HANDLING

The installation of rubber matting over material handling areas can reduce the sound of impacts due to material being dropped by up to 20dB(A).

5.6.7.8 TREATMENT OF SPECIFIC EQUIPMENT

In certain cases it may be possible to specially treat a piece of equipment to reduce the sound levels emitted. These may take the form of engine shrouding, or special industrial silencers fitted to exhausts.

5.6.7.9 ESTABLISHMENT OF SITE PRACTICES

This involves the formulation of work practices to reduce noise generation. This includes locating fixed plant items as far as possible from residents as well as rotating plant and equipment to provide respite to receivers.

Construction vehicles accessing the site should not queue in residential streets and should only use the designated construction vehicle routes. Loading of these vehicles should occur as far as possible from any sensitive receiver.

5.6.7.10 STRATEGIC POSITIONING OF PROCESSES ON-SITE

Where practicable, particular processes of activities can be located in particular positions on site to minimise noise to surrounding sensitive receivers. For example, stationary plant may be positioned where direct line of sight shielding can be achieved using natural barriers, or may maximise the distance to the nearest sensitive receiver.

5.6.7.11 ESTABLISHMENT OF DIRECT COMMUNICATION WITH AFFECTED PARTIES

In order for any construction noise management programme to work effectively, continual communication is required between all parties that may be potentially impacted upon, the builder and the regulatory authority. This establishes a dynamic response process that allows for the adjustment of control methods and criteria for the benefit of all parties.

The objectives of the consultation process are to:

- Inform and educate the groups about the project and the noise controls being implemented.
- Increase understanding of all acoustic issues related to the project and the options available.
- Identify group concerns generated by the project, so that they can be addressed.

The owners of the site are to contact the owners/residents of the neighbouring potentially affected sites that are including but not limited to Marist High School at No. 2 Darcy Rd, Westmead. A letter shall be dropped off in the mailbox of the affected parties prior to the construction of the proposed development and it should include the following information:

- Briefly inform them of the works and the estimated duration of the works.
- Explain to the affected parties the projects acoustic issues and how it may affect them and inform them of the measures implemented to decrease the affects.
- Ask the potentially affected receivers to contact the builder, attach his/her details, or to mail a letter to a designated mail box should they have any queries or issues.

5.7 PART 7: CONSTRUCTION VIBRATION IMPACT ASSESSMENT & MANAGEMENT PLAN

The following plan contains details on the management procedures to be used to control vibration levels during site works. The proposed activities will be reviewed to assess the potential impacts and detail relevant mitigation measures to ensure that appropriate mitigation measures and works scheduling are adopted for all works, with the aim of:
• achieving appropriate noise and vibrations goals for the project;
• limiting noise and vibration impacts to standard construction hours; and
• minimising potential impacts to the adjacent Marist High School

It is important to note that predicting vibration levels are not accurate as specific details of the geology in the vicinity of the site varies and is unknown.

5.7.1 CONSTRUCTION ACTIVITIES ONSITE

Vibration causing construction activities include but are not limited to earthworks, pavement removal, demolition and construction activities. Specific vibration generating activities that will occur during construction works include:
• Movement of construction equipment, plant, trucks, site vehicles;
• Materials and equipment loading and unloading;
• Excavator/piling rig hammering/ sandstone cutting activities potentially associated with bulk excavation works and/or construction of foundations;
• Use of concrete cutter, circular saws, nail guns;
• Use of excavation equipment, jackhammer, hand tools, welding equipment;
• Crane operations;
• Operation of generators and air compressors;
•Operation of mobile concrete/grout, plant/mixer, concrete pump, asphalt paving equipment; and
• Smooth/vibratory drum roller for pavement construction.

Vibration generating equipment is not often used constantly, making accurate predictions of dose values for intermittent vibration is difficult in practice. Determining vibration dose values and compliance with the criteria relies on field measurements during the activity.

To give an indication of potential situations where the criteria for intermittent vibration might be exceeded, the information presented in Table 9 has been used to determine the time it would take before the vibration dose values are exceeded for various items of plant. In these calculations it is assumed that the equipment would be in continuous use for the full duration of the specified time. The times outlined are therefore considered to be conservative.

Table 9 - Intermittent Vibration

Equipment	Approximate Time to Reach a VDV of 0.4 (hours) at given distance					
	5m	10m	20m	30m	40m	50m
Vibratory Roller	<1	<1	<1	1.3	8	15
Heavy rock hammer	<1	0.6	46	>1000	>1000	>1000
Rock saw	<1	<1	0.7	3	8	14
Rock drill (estimate)	1.3	30	>1000	>1000	>1000	>1000
Bored piling	<1	3	46	193	741	>1000
Light rock hammer	113	>1000	>1000	>1000	>1000	>1000

The vibration criteria in relation to structures are adopted from the German Standard *DIN 4150 Part 3-1999 Structural Vibration in Buildings – Effects on Structures.* These are shown below.

Table 10 - Vibration velocity guide values – short term vibration on structures (mm/s)

Building Type	Vibration at the foundation at a frequency of			Vibration at horizontal plane of highest floor at all 1Hz to frequencies
	1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz	
Buildings used for commercial purposes, industrial buildings and buildings of a similar design	20	20 to 40	40 to 50	40
Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15
Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value	3	3 to 8	8 to 10	8

Prior to the commencement of construction of each part of the project that may impact on the existing Marist High the following shall occur:

• identify the risk from impact / damage based on the criteria in the table above;

• a risk assessment will be undertaken by appropriately qualified and experienced geotechnical and construction engineering experts.

The major sources of vibration caused by the project will include the use of excavators with rock breakers (or grinding heads attached), bulldozers and vibratory rollers. Typical ground vibration from bulldozers range from 1 mm/s to 2 mm/s at a distance of approximately 5m. At distances of 20m or greater, vibration levels are generally below 0.2 mm/s. Table below details the typical ground vibration from a range of plant and equipment.

Table 11 - Typical Vibration Levels

Operation	Frequency of vibration (Hz)	Peak Vibration Level (mm/s) at Given Distance					
		5m	10m	20m	30m	40m	50m
Light rock hammer	30-60	0.2	0.06	0.02	0.01	0.01	0.01
Heavy rock hammer	30-60	5	1.5	0.5	0.2	0.15	0.1
Vibratory Roller	~30 Hz	7	3	1.05	0.55	0.35	0.3
Rock saw	45-90	0.75	0.5	0.3	0.2	0.16	0.14
Bored piling	30-60	0.4	0.2	0.1	0.07	0.05	0.04
Rock drill (estimate)	18-60	1.1	0.5	0.2	0.1	0.05	0.04

Ground vibration caused by vibratory rollers can be up to 1.05mm/s at 20m. Table below shows the safe working distances for the use of vibratory rollers close to buildings.

Table 12 - Safe Working Distances from Vibratory Rollers

Roller Class	Weight Range (tonnes)	Centrifugal Force (kN)	Distance from Building (m)	
			A	B
I – Very Light	Less than 1.25	10-20	3	No effect
II – Light	1 to 2	20-50	5	No effect
III – Medium	2 to 4	50-100	6	12
IV – Medium Heavy	4 to 6	100-200	12	24
V – Heavy	7 to 11	200-300	25	50
VI – Very Heavy	12 and over	Over 300	25	50

Note: Source of data: ARRB Special Report No.11, *"Ground Vibrations: Damaging Effects to Buildings"*.

A: Values suggested to prevent damage to buildings and structures

B: Values suggested to minimise strongly adverse comment from residents

Generally, vibration caused by the project is predicted to be less than structural damage criteria. Where vibration causing works are being undertaken in close proximity to the Marist High School boundary, careful selection of plant will be necessary as outlined above from rock hammers and vibratory rollers. Plant and machinery selection will be undertaken by the relevant builders/engineers in consultation with ANAVS P/L during construction planning and during the development of Construction Method Statements. Further review of equipment selection will occur if ANAVS P/L predict significant exceedance of intermittent vibration dose value criteria and/or structural damage limits.

5.7.2 IMPACTS OF EXCESSIVE NOISE AND VIBRATION DOSES

Vibration caused by the project works can be classified as intermittent vibration under the DECCW's *"Assessing Vibration: a technical guideline"*. The human comfort goals for intermittent vibration from this guideline applicable for the project are shown in the table below.

Table 13 - Preferred and maximum vibration dose values for human comfort

Building Type	Intermittent Vibration ($m/s^{1.75}$)	
	Preferred	Maximum
Critical working areas (e.g. hospital operating theatres, laboratories)	0.10	0.20
Residential daytime (7:00am to 10:00pm)	0.20	0.40
Residential night time (10:00pm to 7:00am)	0.13	0.26
Offices, educational institutions. Places of worship	0.40	0.80
Workshops	0.80	1.60

The 'human annoyance' criteria for intermittent vibration are cumulative dose values, rather that instantaneous particle velocities or acceleration. Determining dose values depends not only on vibration levels but the length of time over which they affect a receiver. Vibration generating equipment is not often used constantly, making accurate predictions of dose values for intermittent vibration difficult in practice. Determining vibration dose values and compliance with the criteria relies on field measurements during the activity.

5.7.3 VIBRATION MANAGEMENT OBJECTIVES

The construction noise and vibration management objectives include, but are not limited to, the following:

- To avoid and/or minimise adverse noise/vibration impacts associated with the operation of any plant, machinery or other equipment on site at all times through implementation of construction methodology and appropriate management measures.
- To comply with relevant EPA (NSW DECCW) Construction Noise Level Objectives (LA10) targets.
- To minimise the potential impact of construction works on the adjacent Marist High School boundary main within the works site.

Our main goal is to ensure there is no damage to the existing Marist High boundary associated with site works involving vibration generations activities undertaken at the site.

Vibration assessment criteria is established based on the geotechnical assessment of proposed construction works. These assessment criteria will be agreed with project managers in regard to the activities required to be completed, giving consideration to the location of the works, the levels produced and the proximity of existing buildings, infrastructure and flora and fauna.

Where site monitoring identifies potential exceedances of acceptable noise/vibration levels, site practices shall be reviewed as per the contingency plan outlined below and may include implementation of additional mitigation measures as noted below.

5.7.4 PROJECT SPECIFIC VIBRATION CRITERIA

The builder is to adopt methods and/or equipment as follows:

Table 14 - Maximum Peak Particle Velocity of Various Rock Breaking Equipment

Distance from adjoining structure (m)	Maximum Peak Particle Velocity 5 mm/sec		Maximum Peak Particle Velocity 10 mm/sec	
	Equipment	Operating Limit (% of Max. Capacity)	Equipment	Operating Limit (% of Max. Capacity)
1.5 to 2.5	Hand operated jackhammer only	100	300 kg rock hammer	50
2.5 to 5.0	300 kg rock hammer	50	300 kg rock hammer or	100
			600 kg rock hammer	50
5.0 to 10.0	300 kg rock hammer or	100	600 kg rock hammer or	100
	600 kg rock hammer	50	900 kg rock hammer	50

5.7.5 STANDARD MITIGATION & MANAGEMENT MEASURES

The following vibration mitigation measures will be adopted during site project activities:
• Staging of site works to maximise use of the existing site features/facilities as barriers where possible.
• All site personnel must adhere to the site OH&S requirements in relation to use of appropriate personal protective equipment (PPE) when operating, or in the vicinity of noise/vibration generating plant/equipment.
• Noise and vibration awareness training for all site staff including subcontractors as part of general site induction and tool-box talk activities.
• Strict adherence to approved works times. In the event that out of hours delivery activities are required, the approval process will be completed via consultation with the Project Managers office. Any specific additional mitigation measures requested by ANAVS P/L will also be adhered to.
• Works will be scheduled, where practical, to avoid simultaneous vibration causing activities occurring on site.
• Vehicles, plant and machines/equipment used intermittently during construction activities (i.e. cranes, excavators, bobcats, lifting equipment, etc) will be shut down, as practicably achievable, in the period between works activities rather than allowed to idle.
• The duration of noise/vibration intensive works will be minimised through a regular review of the program and construction methodologies during project team meetings.
• In addition the site layout (including plant, equipment, waste, materials etc loading/unloading areas, location of fixed noise generating equipment including generators, etc) design process is to consider the potential for minimisation of movement of plant and equipment within the construction site where possible.
• Piling/piering works will be undertaken using non-percussive piling methods where achievable given the subsurface conditions. Reference will be made to the existing geotechnical site assessment report for advice on suitable protection distances from heritage structures for the use of moderate to heavy impact machinery.
• Regular and effective plant/equipment maintenance will be completed and documented throughout the project period and documentation will be maintained on site demonstrating completion of maintenance logs and associated checklists in order to ensure all machinery is in good working order and use does not generate excess noise/vibration.
• Plant, equipment and vehicles will not be operated in the event that excessive noise/vibration is produced at start up as a result of maintenance being required.
• All plant, machinery and works vehicles will have an efficient muffler design in accordance with the manufacturer's specifications. The mufflers will be well maintained and regularly tested with the results documented in the maintenance logs.
• Care will be taken by site personnel to ensure materials will not be dropped from a height either onto or from vehicles or from the roof, overhead bridge or other raised

location. Power drills, saws, planers, nail guns etc will be used inside where possible to achieve acoustic muffling or where possible, to the south of buildings to provide shielding between the user and sensitive receptors.
• Radio/music audible in areas external to the building/vehicles will not be permitted on site as they have the potential to interfere with out measurements.
• Where monitoring of site conditions and activities indicates the potential or actual occurrence of noise/vibration exceedances at nearby sensitive receptors, the effectiveness of installation of temporary shielding options, including portable noise walls in the form of timber hoarding, compressed fibre board panels, steel sheeting etc (with no gaps between panels) will be evaluated prior to ongoing noise generation activities, etc.
• The quietest and least vibration causing suitable plant reasonably available will be selected for each works activity. This will include review of documentation provided by manufacturers, suppliers, hire companies in relation to equipment prior to delivery to site.

Where vibration levels at the sensitive receiver/receptor location exceed the nominated goals at two successive monitoring events or where significant community complaints are recorded with respect to site noise, the relevant source will be identified and any additional feasible and reasonable measures available will be implemented to either reduce noise emissions or reduce the impact on receptors. This may include evaluation of the works activity and subsequent use of alternative methodologies and/or equipment.

5.7.6 MONITORING CONSTRUCTION VIBRATION

Vibration monitoring may be carried out where predicted vibration levels approach or exceed structural damage criteria, in response to complaints or for the purpose of refining construction methods or techniques to minimise vibrations. Monitoring will be carried out in accordance with:
• for structural damage vibration – *German Standard DIN 4150 and BS 7385: Part 2 – 1993*;
• for human exposure to vibration – the evaluation criteria presented in the *Environmental Noise Management Assessing Vibration: A Technical Guideline* (DECC 2006).

Prior to the site activities a dilapidation inspection and report of the existing Marist High boundary is to be carried out. This report will include the identification of potential damage associated with vibration and/or earthworks impacts including cracks and other indicators of settlement.

During site activities that may pose a risk to the Marist High boundary main and associated structures at the site (demolition, excavation and boring within 25m radius of the buildings, internal refurbishment works on the buildings, etc), a visual inspection of

Marist High Boundary condition will be taken at least twice daily. In the event that impacts are observed (structural cracking, paint flaking/damage, dust fall etc) as an indicator of structure movement, all current site works in the vicinity of the building(s) will be ceased. Broad site project staff will assess and document the potential requirements of remedial/corrective works to the building, attenuative measures or alternative site activity methodology for the completion of ceased works to the approval of the project manager prior to works continuing in this area of the site.

5.7.7 TESTING & REPORTING

The daily site diary will be used to record any auditory observations during site works. Notes relating to community complaints will also be recorded in the daily site diary in addition to resulting actions. The vibration monitoring will be carried out by ANAVS P/L using a SVANTEK957 noise and vibration level meter or similar.

Vibration monitoring will be carried out during the excavation phase and whilst the bore of piers is occurring then monitoring will cease. Monitoring will be carried out at regular intervals along the Marist High boundary and monitoring points will be re-established to be perpendicular to the vibration causing works. As the works move out of the 10 meter section along the Marist High boundary so will the vibration monitoring. Monitoring results will be checked on a regular basis by the ANAVS P/L as required and recorded on the daily environmental check list in addition to periodic reporting to project managers. Where required, vibration monitoring results will be reviewed by the project manager and kept on file on site.

In addition, photo monitoring points will be established at the vibration monitoring location to provide pre-commencement photographs looking toward the works site to provide a pre-works visual record of the site presence when viewed from beyond the site boundary.
Photos will be obtained in digital format at 50-55m aperture (to approximate the naked view). This vibration monitoring location was chosen as it is the most sensitive location.

All investigations and/or corrective actions will be documented and compiled within the Environmental Complaints, Non-conformances and Corrective Actions Register to be maintained.

5.7.8 NON-COMPLIANCE MANAGEMENT

Where actual vibration levels are found to exceed the predicted allowable worst case levels, the cause/source of excessive noise generation will be identified, ANAVS will immediately initiate an investigation of the circumstances of the exceedance and explore further opportunities to reduce noise through reasonable and feasible mitigation

measures. If deficiencies are identified and non-compliances with the environmental requirements and the objectives of this plan are observed, an Environmental Incident Report will be completed as described in the CEMP and relevant actions/mitigations will be enforced. Details of all non-compliances and corrective actions taken will be included in the six monthly compliance reports.

ANAVS P/L will be notified immediately of any exceedances of the vibration levels outlined in this CVMP and will:

- advise the builder to stop/slow down works,
- investigate the circumstances of the exceedance;
- consult with the builder as required;
- work in conjunction with site personnel to investigate and implement mitigation measures; and
- report the outcome of these measures through the environmental reporting process.

5.7.9 AUDITING REQUIREMENTS

Internal audits aimed at evaluating the conformance of the system, process or product, as appropriate, shall be carried out by the Health Safety and Environmental (HSE) Manager who is independent of the project staff. An internal audit will be completed at least once during the project. An audit report will be issued within one week of completion of audit. Any deficiencies identified will be identified in the audit report. The management personnel responsible for the area shall take timely corrective action on the deficiencies found.

5.7.10 CORRECTIVE ACTION

A non-conformance resulting from the receipt of a complaint and/or the recording of 2 successive exceedances of noise criteria may result in the following corrective actions being implemented by the project site staff:

- An evaluation of the non-conformance to improve management strategies to prevent recurrence;
- Address complaint and respond to complainant with proposed mitigation measures;
- Undertake additional training of the site staff in respect to implementation of mitigation measures for the management of noise and vibration; and
- Notification of relevant government authorities, if required.

Specifically, additional mitigation measures, outlined above will be considered in the event of a non-conformance. Subsequently additional monitoring activities will be

completed as appropriate to demonstrate attenuation of noise levels following recommencement of noise generating activities.

In addition broad site staff will investigate and organise/order the repair/removal excessively/unusually noisy plant, machinery, equipment including that operated by sub-contractors;

Where vibrations result in damage to heritage structures at the site, temporary protection/rectification works will be completed prior to recommencement of site works as appropriate. In addition work practices will be reviewed and modified as appropriate to ensure ongoing damage is minimised. Longer term management/repairs will be discussed as applicable with the project managers.

6.0 NOISE IMPACT STATEMENT AND CONCLUSION

ANAVS have taken background noise level measurements at the most noise sensitive locations near the proposed development located at Lot 4, No. 158-164 Hawkesbury Rd & 2A Darcy Rd, Westmead. The levels of noise emission from the adjoining development have been calculated and quantified using reliable test data.

The construction of the proposed development at Lot 4, No. 158-164 Hawkesbury Rd & 2A Darcy Rd, Westmead, if carried out as recommended in plans and specifications and including the acoustic recommendations in this report then it will meet the required noise measures.

The construction methods for the proposed mixed use development are to be carried out as recommended in this report to ensure the Parramatta Marist High School is not affected by vibration. In summary the specifications of this report are to be implemented in order for the development to meet the required site specific vibration levels and to meet the requirements of the relevant codes and standards as outlined in this report.

We hope this report meets your requirements. Should you require further explanations, please do not hesitate to contact us.

Yours sincerely,

M. Zaioor
Australian Acoustical Society (Member).
M.S. Eng'g Sci. (UNSW).
M.I.E.(Aust), CPEng

7.0 APPENDIX

Figure 1 - Site Location

Figure 2 - Site Location (b)

Figure 3 - Proposed Site Plan

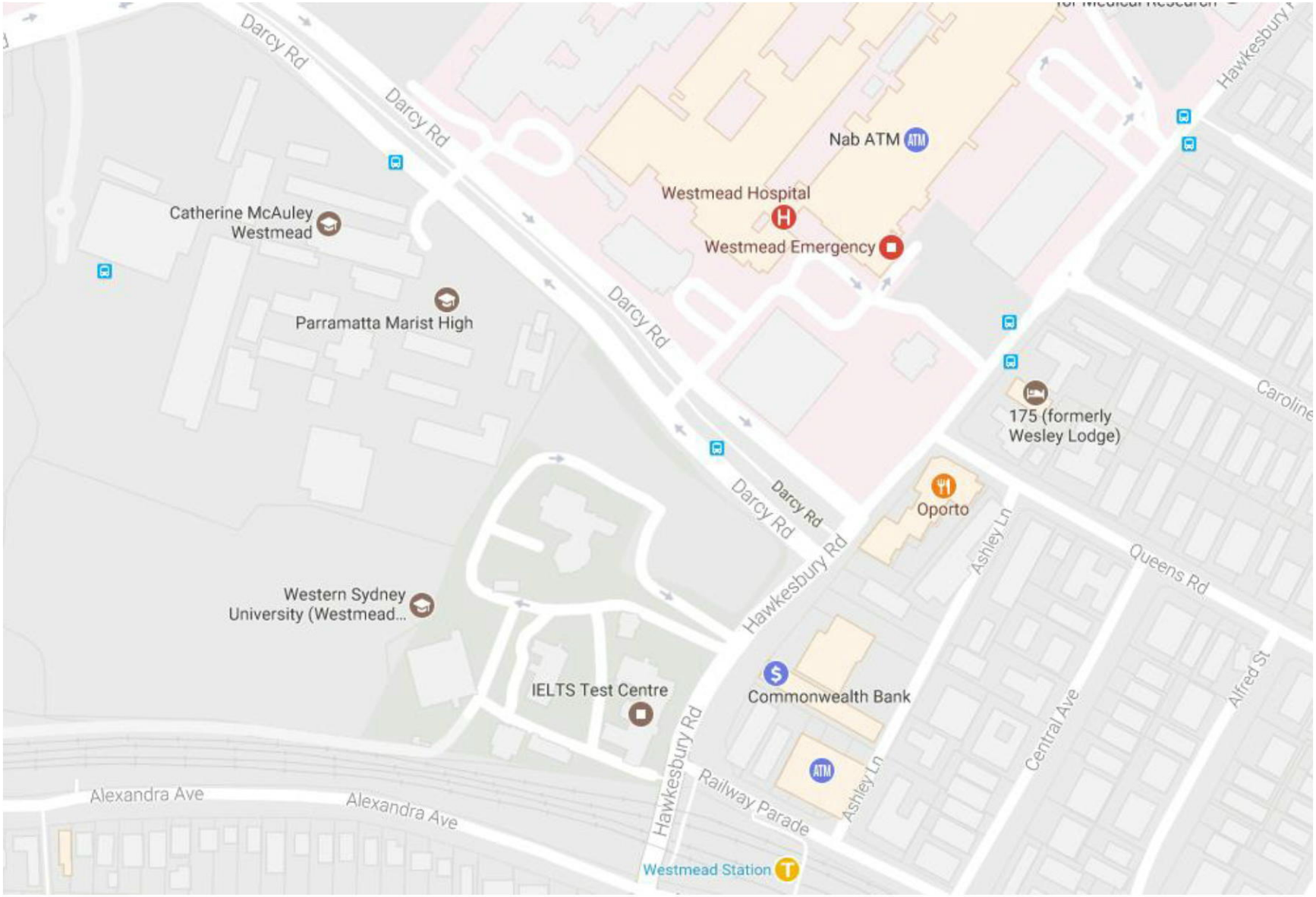


Figure 4 – Surrounding Environment

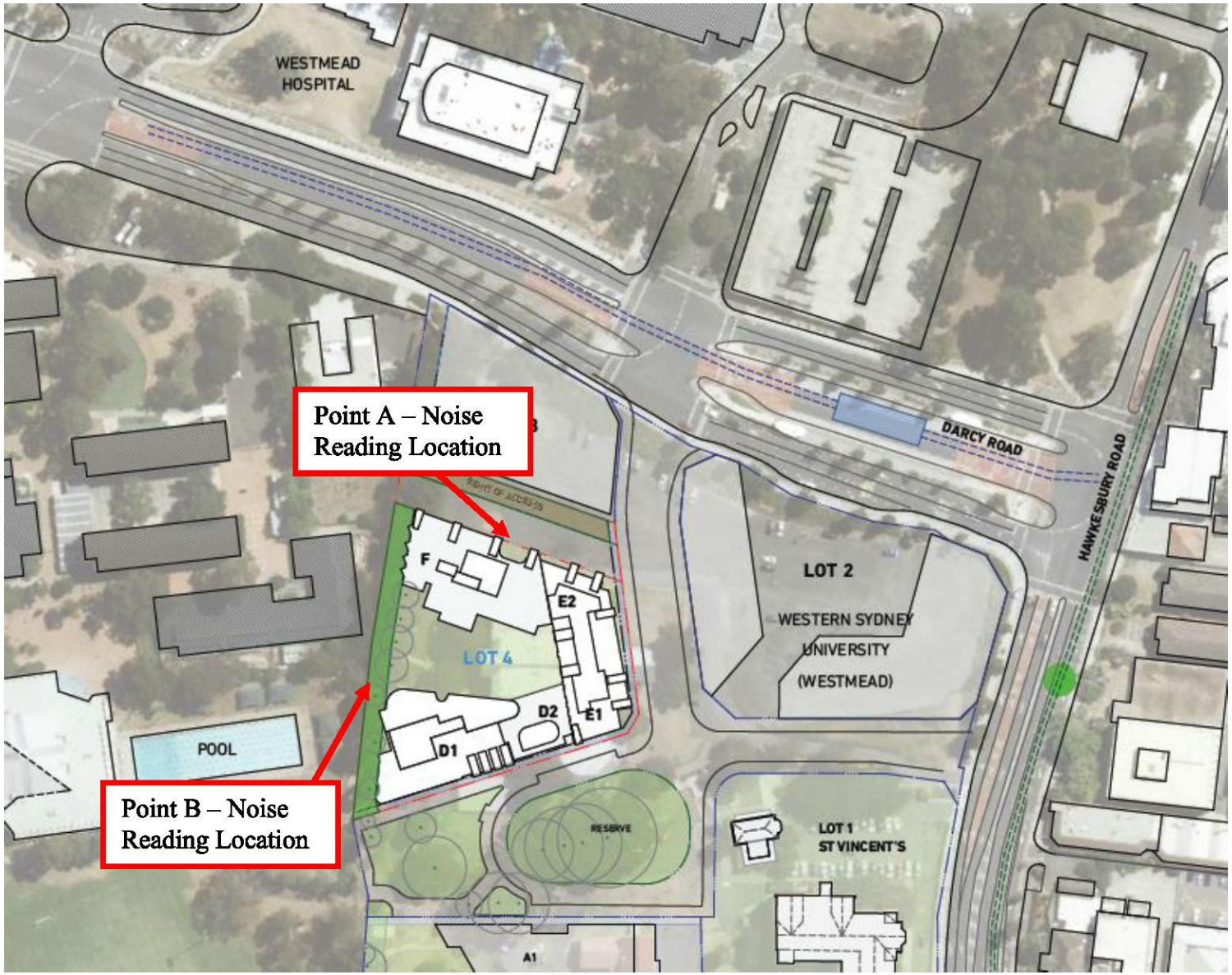


Figure 5 - Noise Reading Location

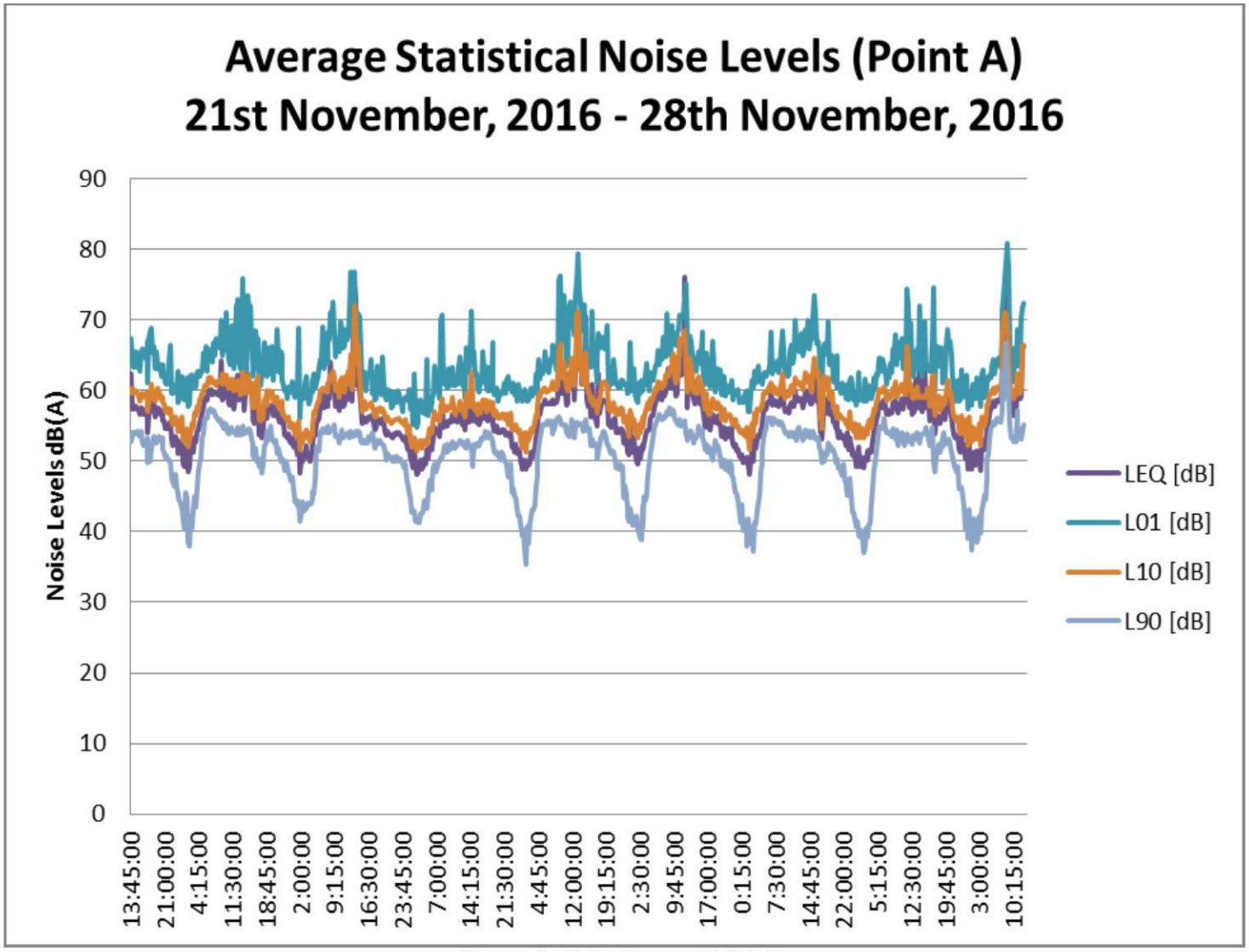


Figure 6 - Noise Survey (Point A)

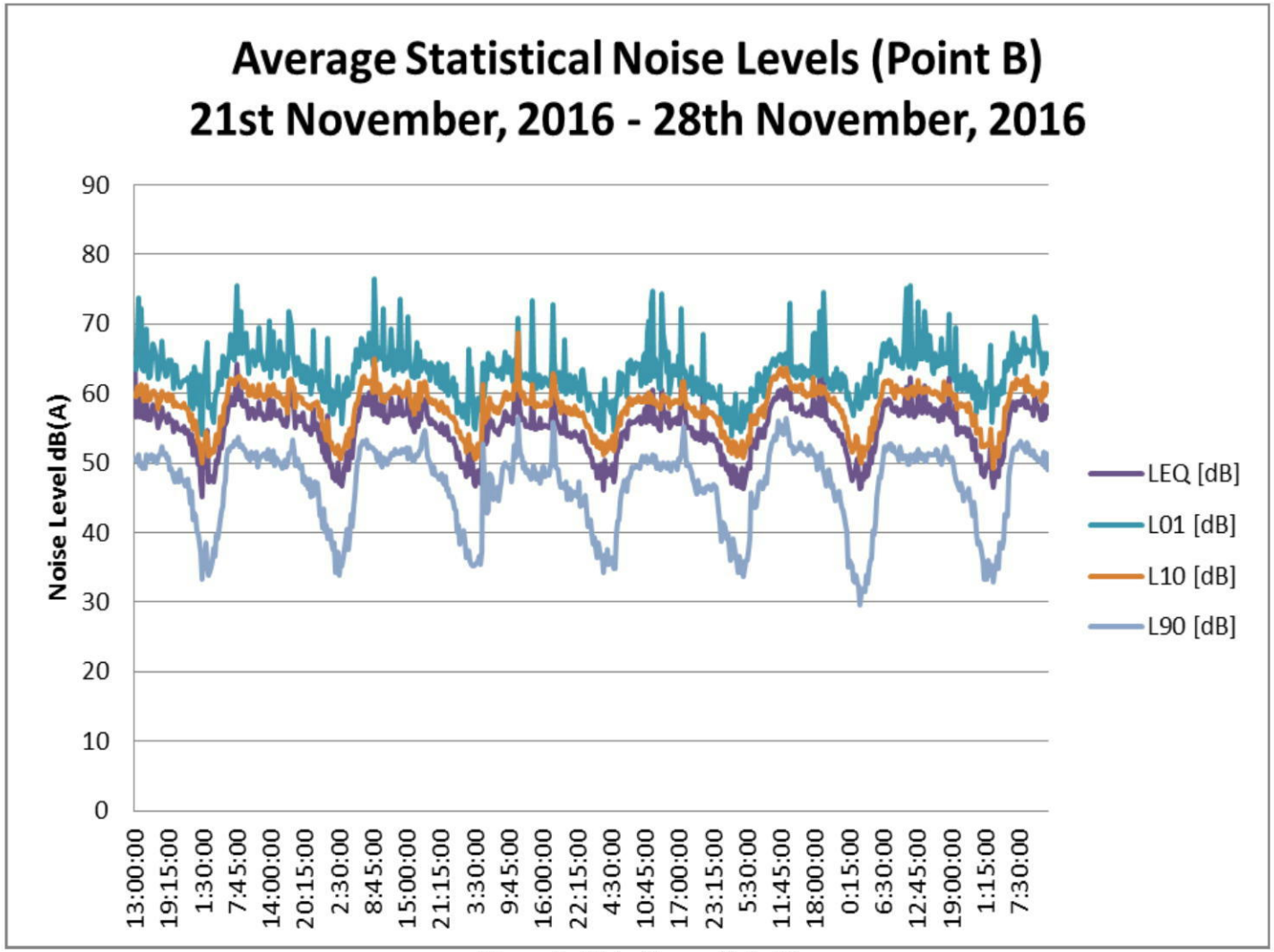
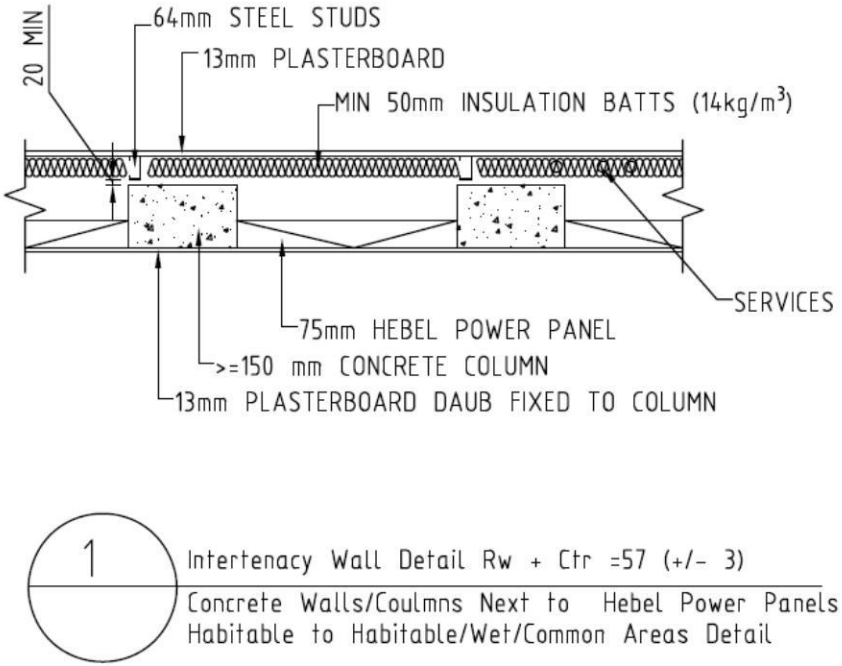


Figure 7 - Noise Survey Point B



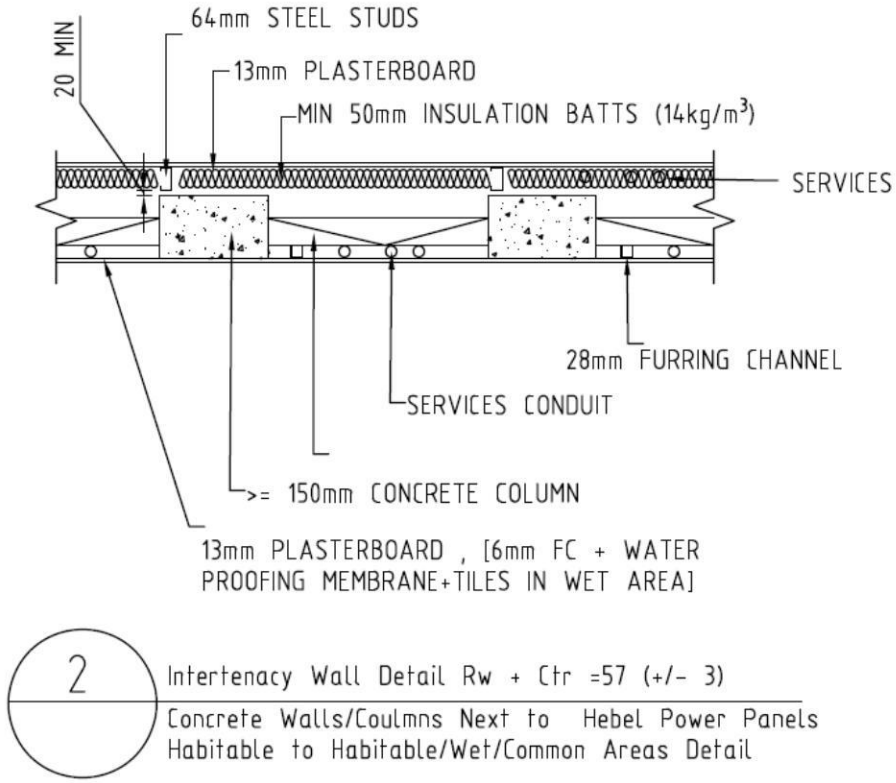


Figure 8 - Inter-tenancy Wall Specification (Dry-Dry, Wet-Dry, Wet-Wet, Habitable-Corridor/Staircase)

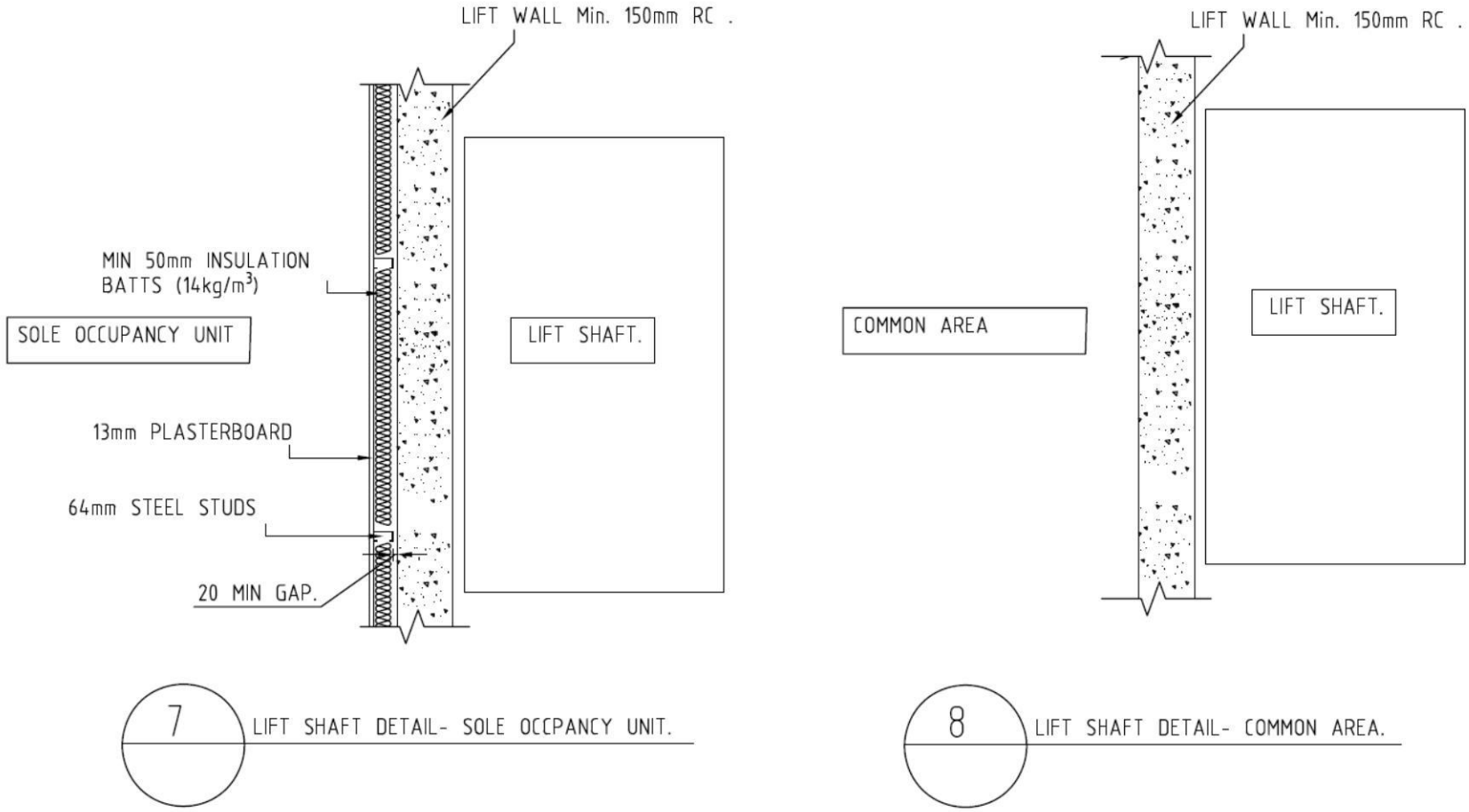


Figure 9 - Lift Shaft Wall Specification

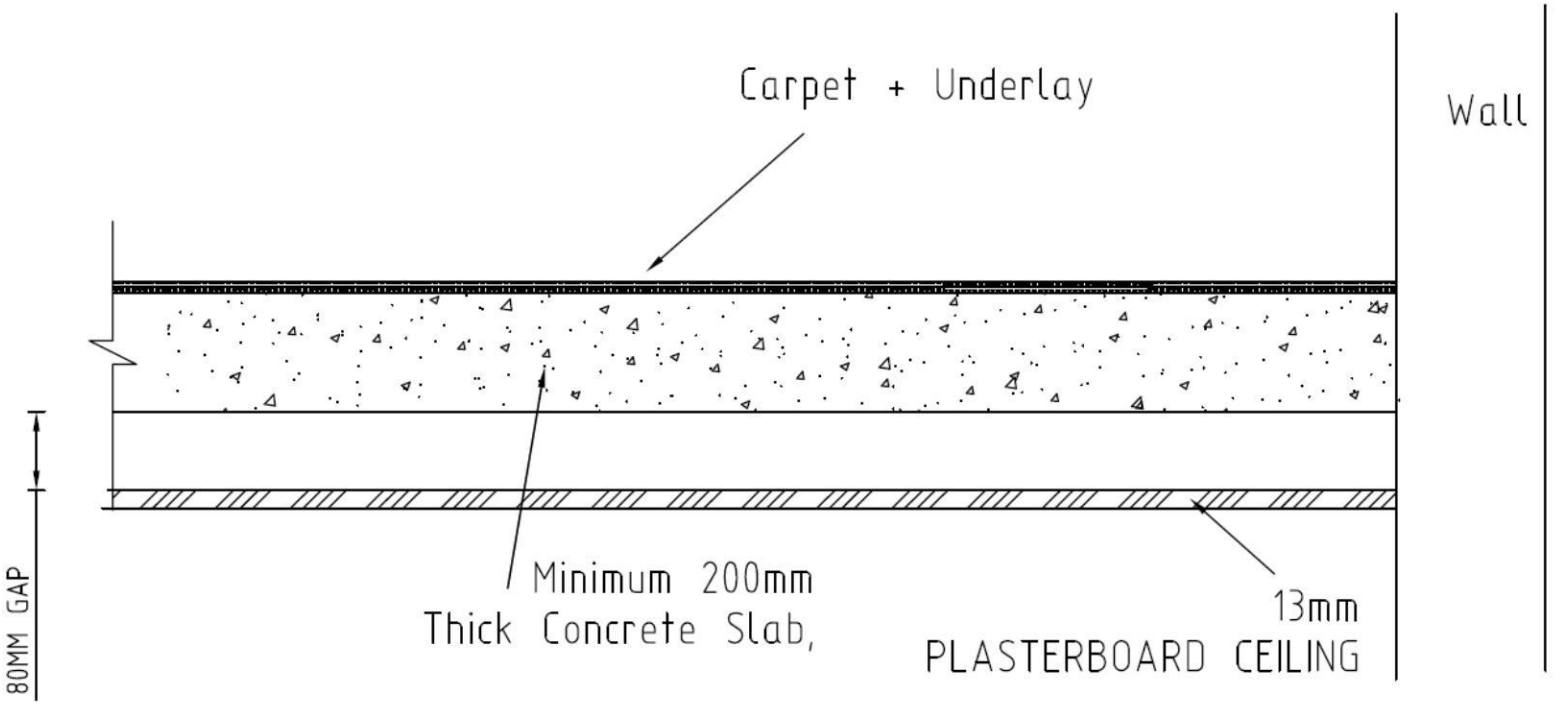


Figure 10 - Slab Detail (Carpet)

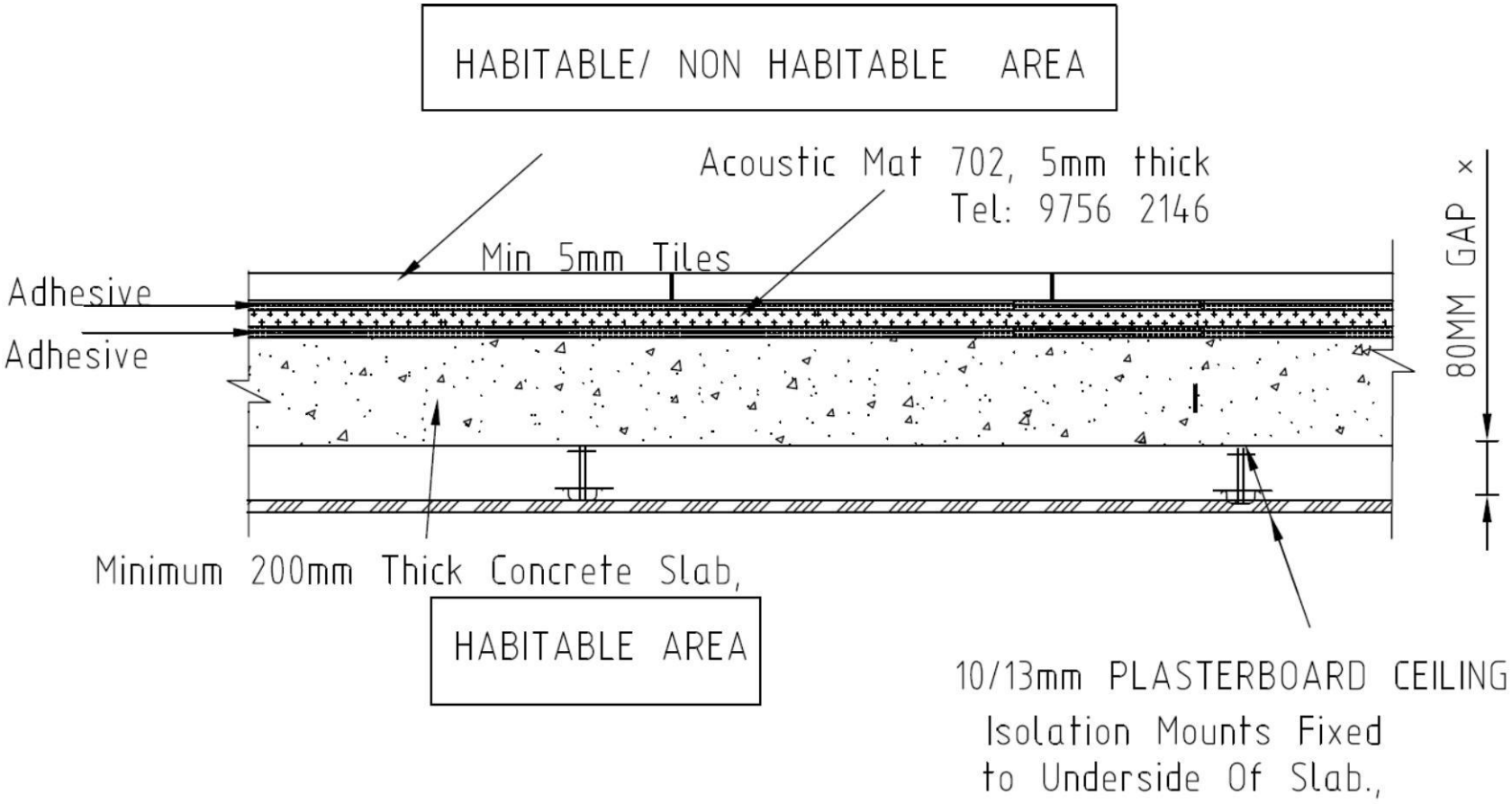


Figure 11 - Slab Detail (Tile)

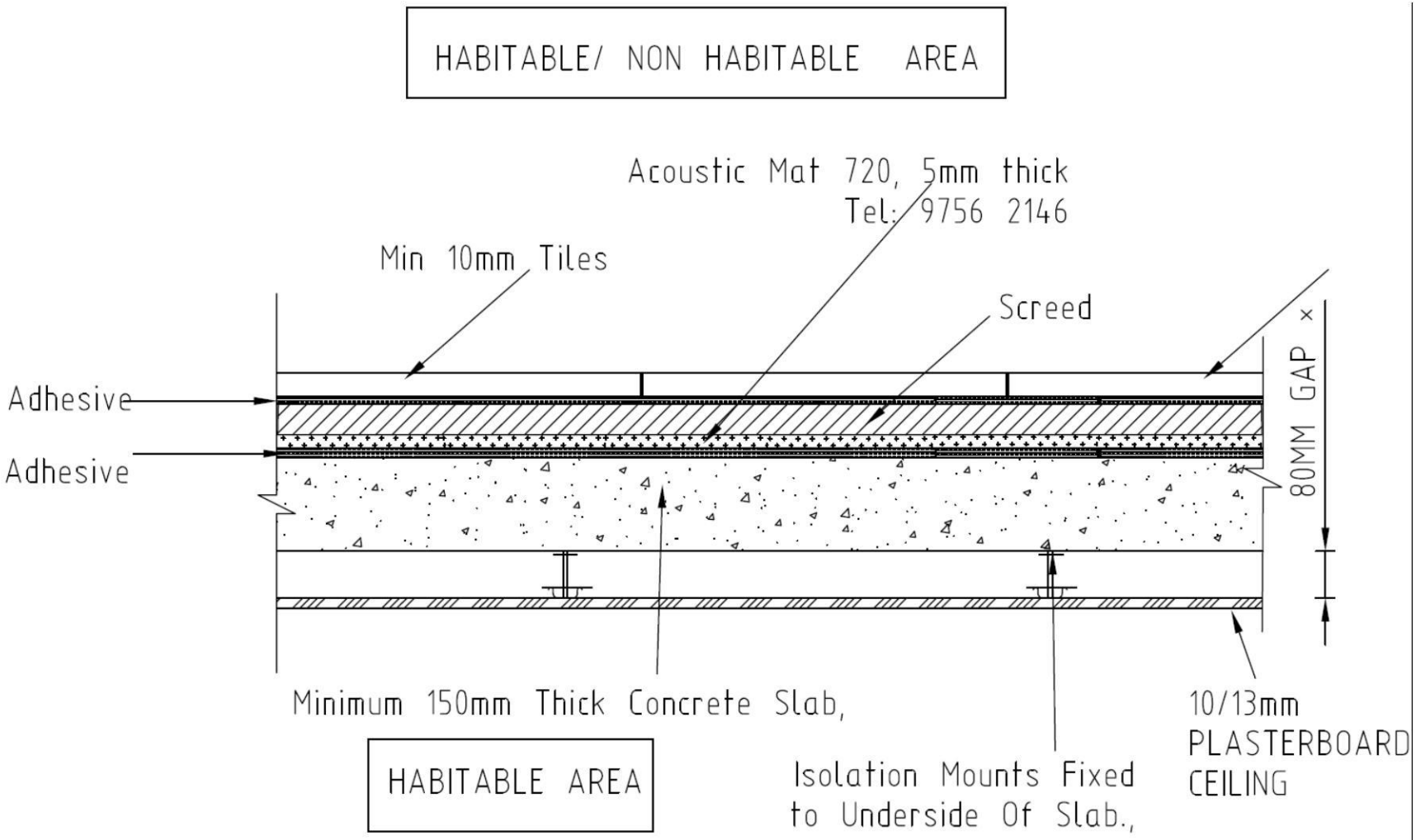


Figure 12 – Slab Detail (Tile + Screed)

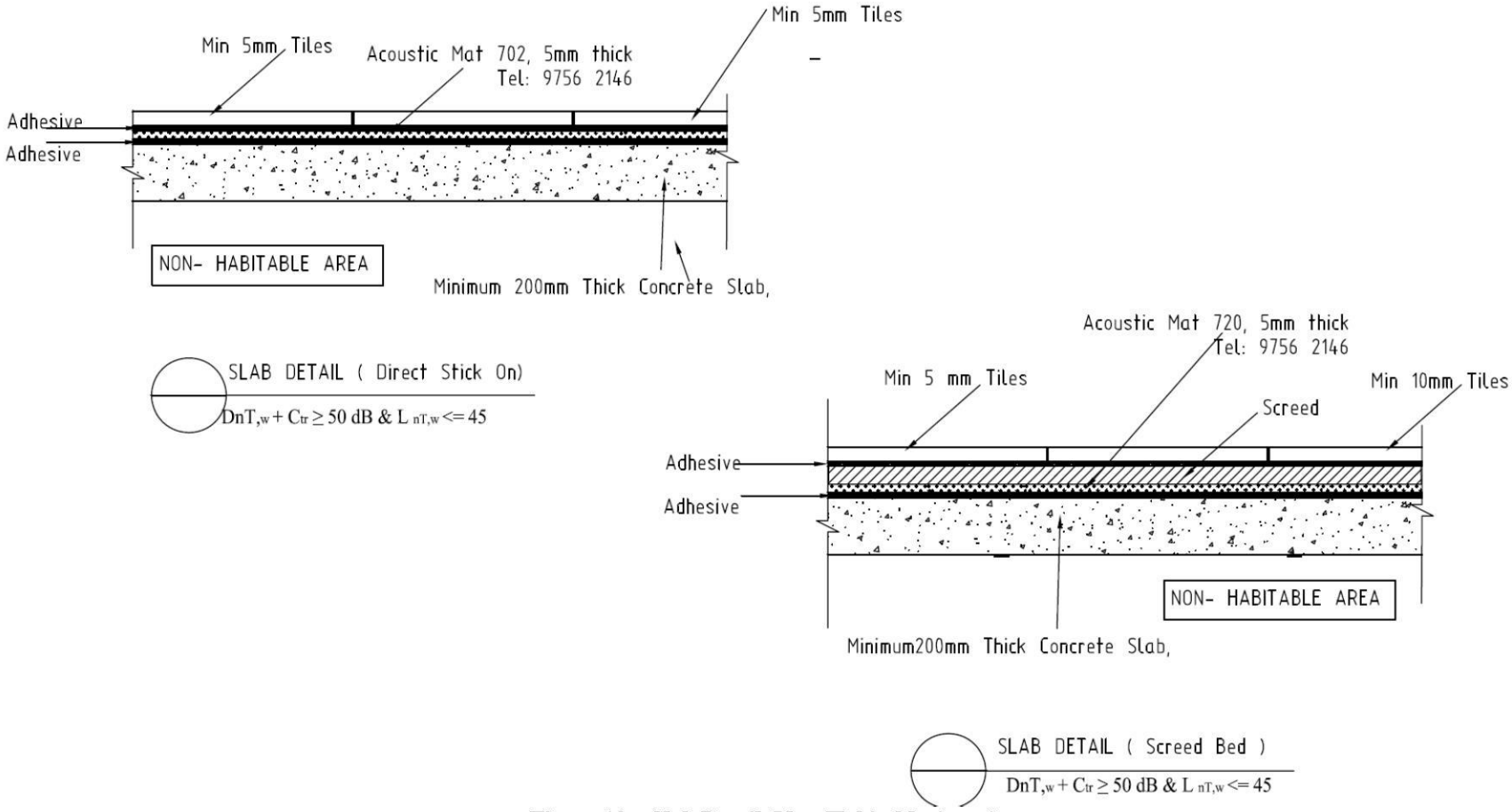


Figure 13 – Slab Detail (Non-Habitable Areas)

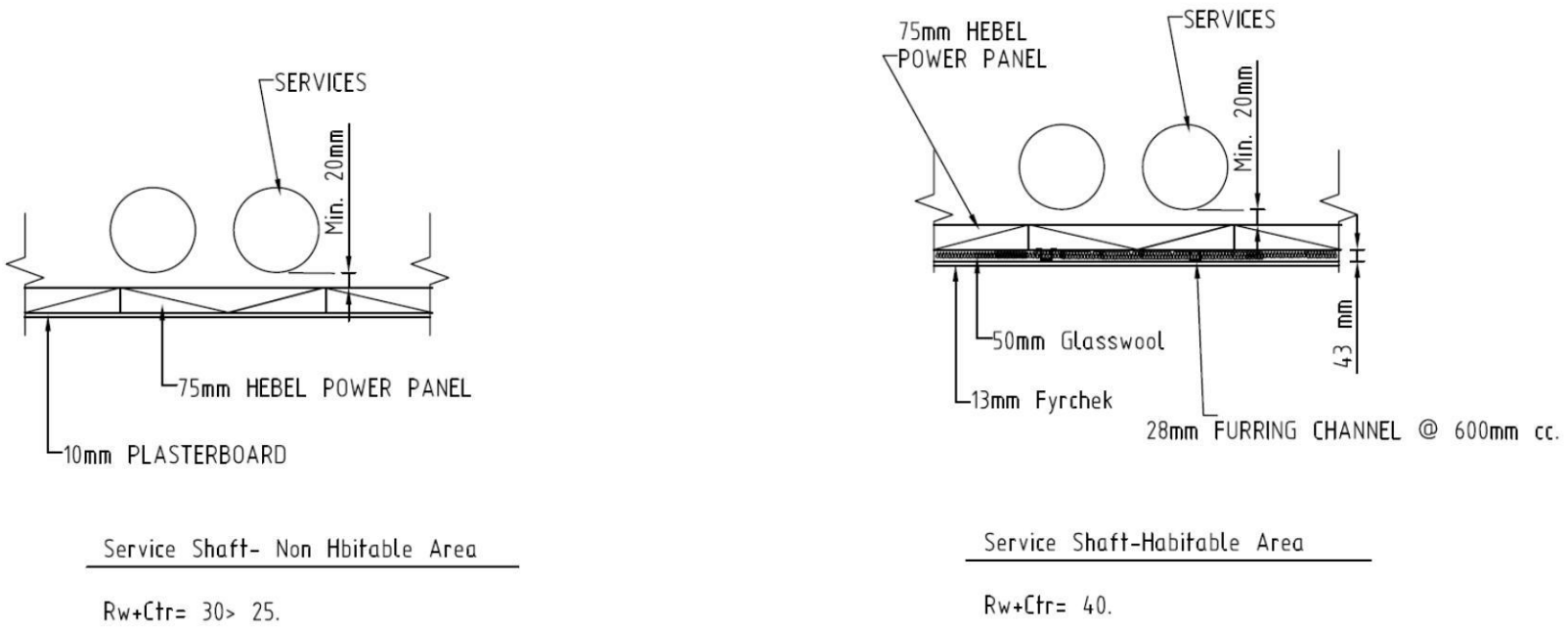


Figure 14 - Pipes & Services Insulation Details Vertical Shaft

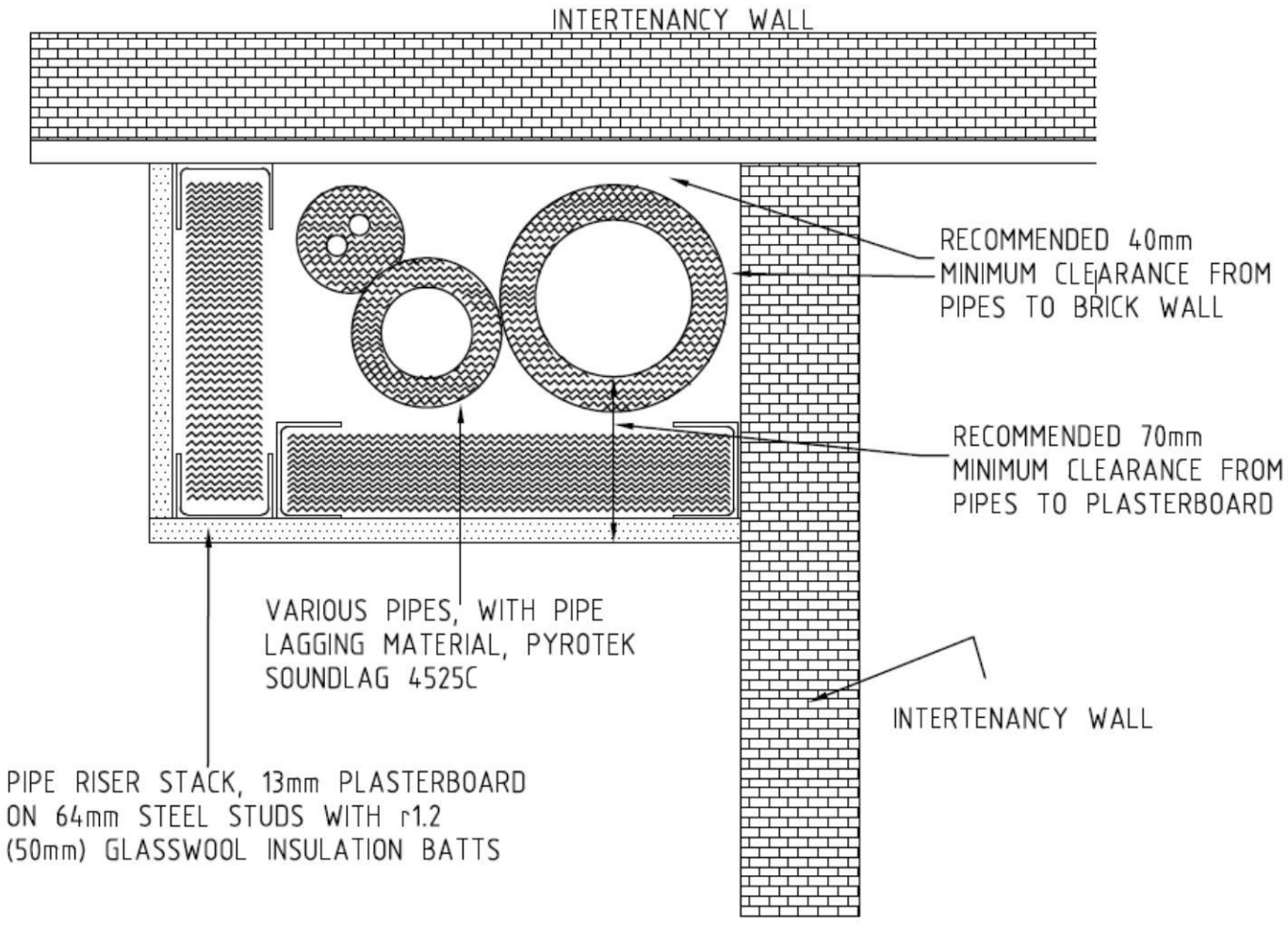


Figure 15 - Pipes & Services Insulation Details Vertical Shaft Wardrobe

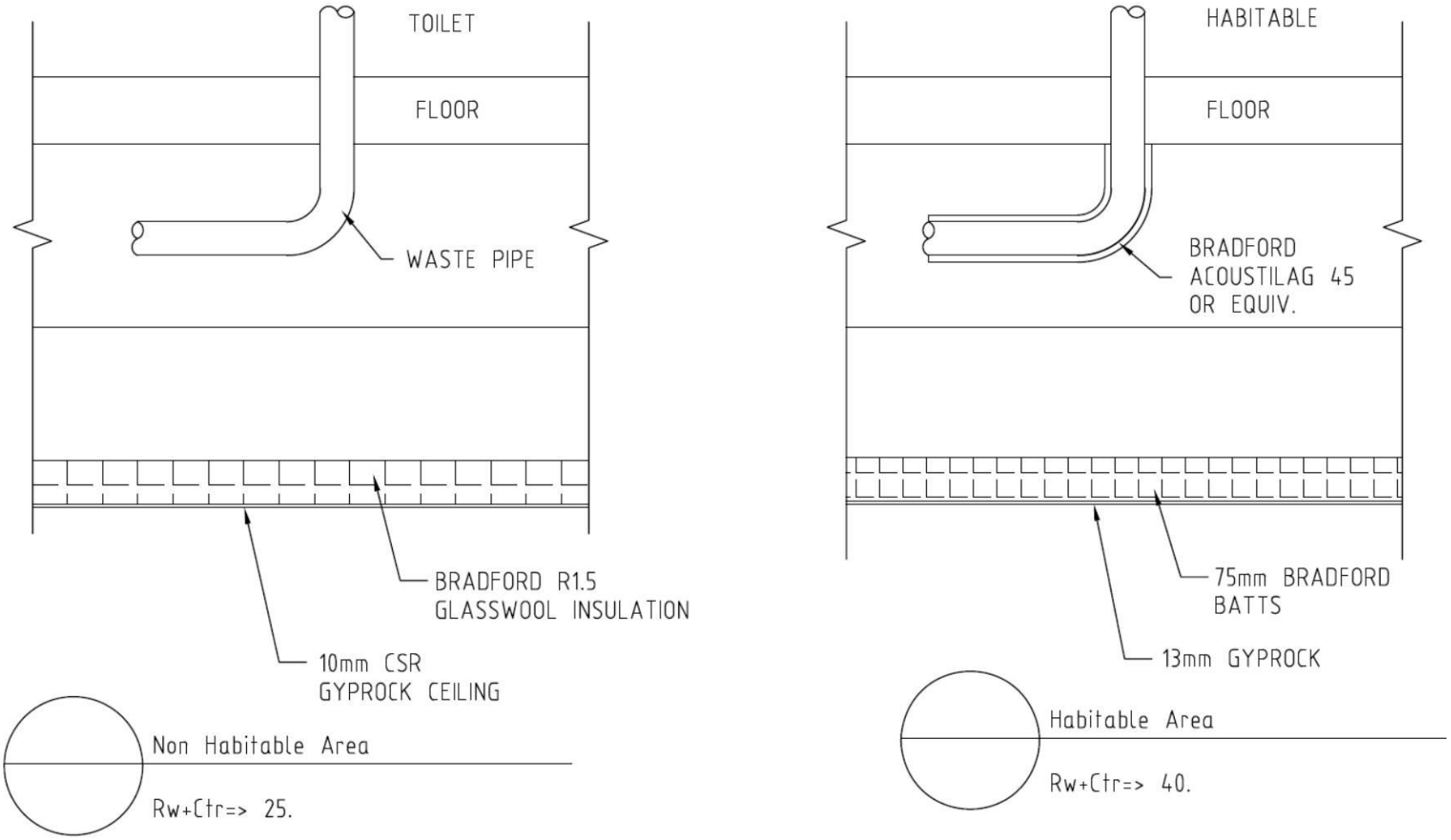


Figure 16 - Pipes & Services Insulation Details Horizontal Run