APPENDIX D

Noise and Vibration Assessment

KEMPSEY DISTRICT HOSPITAL
DEVELOPMENT APPLICATION AND ENVIRONMENTAL IMPACT STATEMENT - SSD5363

Acoustic Schematic Design Report
Kempsey District Hospital
S12119RP1

Image: BVN Donovan Hill

Report Date: April 4th, 2013
Reference: S12119, Issue 4

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Document Information

Project	Kempsey District Hospital
Client	Umow Lai
Report title	Schematic Acoustic Design Report
Project Number	S12119
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Checked by	DRJ

Revision Table

Report revision	**Date**	**Comments**
Draft 1	January 24th, 2013	Draft – Umow Lai Issue
Draft 2	January 30th, 2013	Draft – General Issue
Issue 1	February 28th, 2013	SD Issue
Issue 2	March 6th, 2013	SD Issue
Issue 3	March 13th, 2013	SD Issue
Issue 4	April 4th, 2013	Town Planner Comments

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Glossary

'A' Weighted	A spectrum adaption that is applied to noise levels to represent human hearing as human hearing does not respond equally at all frequencies. See also Frequency.
Daytime	Defined assessment period, NSW Industrial Noise Policy Between 7.00 a.m. and 6.00 p.m
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of loudness.
dB(A)	'A' Weighted sound level in dB.
D_W	Weighted Level Difference—noise level difference or reduction between two enclosed spaces. It quantifies the acoustic separation between two spaces. It relates to the R_W rating of the separating building elements (such as walls and doors) and also includes all noise flanking paths (such as ceiling voids, joins and seals) and the acoustic absorption in the receiving space. The higher the D_W rating the better the acoustic separation.
$D_{nC,W}$ / CAC	Weighted Ceiling Noise Reduction Index / Ceiling Attenuation Class—these values represent the ability of a ceiling to prevent the transmission of sound. The $D_{nC,W}$ / CAC is a measure of sound reduction between rooms with a common ceiling plenum (or space). A higher value equates to better acoustic separation provided by the ceiling.
Evening	Defined assessment period, NSW Industrial Noise policy Between 6.00 p.m. and 10.00 pm
Frequency (Hz)	The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone); slow movements mean the frequency (pitch/tone) is low. 1 Hz is equal to 1 cycle per second. The human ear responds to sound in the frequency range of 20 Hz to 20,000 Hz.
L_{10}	Noise level exceeded for 10 % of the measurement time. The L_{10} level represents the 'average maximum' noise level and is often used to represent traffic or music noise.
L_{90}	Noise level exceeded for 90 % of the measurement time. The L_{90} level is commonly referred to as the background noise level. See also 'RBL'.

L_{eq}	Equivalent Noise Level—Energy averaged noise level over the measurement time. The L_{eq} has the same energy as the time varying sound pressure level over a give assessment period. This is not an arithmetic average.
L_{max}	The maximum noise level measured.
Masking	The provision of noise, usually continuous, broadband and 'neutral' to decrease the perception of other sounds, usually those that are transient (variable) and have the potential to distract.
Night-time	Defined assessment period, NSW Industrial Noise policy Between 10.00 p.m. and 7.00 a.m.
Noise source	Premises or a place at which an activity is undertaken, or a machine or device is operated, resulting in the emission of noise
NR	Noise Rating—a single number evaluation of noise level based on a standard set of curves. The NR level is normally around 5 dB below the 'A' weighted noise level.
NRC	Noise Reduction Coefficient—A single number that represents the acoustic absorption of a material. It is the average of the sound absorption coefficients at 250, 500, 1000 & 2000 Hz for that material. Values are between 0.0 and 1.0, with NRC 1.0 representing the highest level of absorption.
RBL	Rating Background Level—the overall single figure background level representing each assessment period (day/evening/night) over the whole monitoring period.
R_W	Weighted Sound Reduction Index—A laboratory-measured value of the acoustic separation provided by a single building element (such as a partition). The higher the R_W the better the noise isolation provided by a building element.
$R_w + C_{tr}$	A measure of the sound insulation performance of a building element with a C_{tr} spectrum adaptation term placing greater emphasis on the low frequency performance.
Reverberation Time (RT_{60})	Of a room, for a sound of a given frequency or frequency band, the time that would be required for the decaying sound pressure level in the room to decrease by 60 decibels.

Executive summary

Resonate Acoustics has undertaken acoustic schematic design tasks for the proposed upgrades to Kempsey District Hospital (KDH) at Kempsey, NSW.

The purpose of this acoustic input is to:

- Address key issues three ('Amenity') and five ('Noise and Vibration') in the Director General's Requirements, re-issued 5 December 2012
- Propose acoustic design criteria
- Provide an appropriate starting point for subsequent detailed design tasks
- Provide the project architect with standard acoustic constructions and constructions developed specifically for this project
- Demonstrate that schematic design alternatives have been evaluated

Director General's Requirements (DGRs)

This report provides criteria, methodologies and schematic designs to address DGR key issues:

- Three ('Amenity') and
- Five ('Noise and Vibration').

In doing so, the acoustic amenity of nearby land uses and the existing and upgraded hospital has been considered.

Specifically, for DGR 5, noise emission criteria have been provided for:

- Stationary mechanical noise sources using the NSW *Industrial Noise Policy* (INP) and
- Road traffic noise sources using the *Road Noise Policy* (RNP).

The use of the emergency backup power generator has been considered separately and it is proposed that an additional margin be permitted for noise emission from this noise source to account for its infrequent operation.

In most cases, control of noise and vibration sources to provide appropriate amenity for the upgraded hospital will ensure appropriate amenity for the nearby noise-sensitive land uses. Common acoustic controls have been provided which will need to be evaluated and applied for individual noise sources during the detailed design stage.

Construction Noise and Vibration

This report presents a quantitative construction noise and vibration assessment for the project. The interim Construction Noise Guideline (ICNG) has been used as the basis of criteria. Typical of large construction projects, exceedances of the established noise (and to a lesser extent vibration) criteria are predicted at some nearby receivers including the existing hospital buildings. It will be necessary for all reasonable and feasible measures to be considered and implemented by the contractor to minimise the construction noise and vibration impacts upon noise and vibration affected receivers. Consultation with the community and the hospital is recommended.

Schematic Acoustic Design Advice

More broadly, generic and project-specific acoustic strategies and constructions have been documented to provide an appropriate starting point for subsequent detailed design tasks.

Acoustic strategies are schematic and not all fully resolved; however the information and designs herein form the basis for an appropriate acoustic outcome for hospital staff, patients and the nearby general community.

Planning Approval Processes

Four components of work are proposed as part of the Kempsey District Hospital Redevelopment Project. These components of work are:

- Phase 1 enabling works
- Phase 2 enabling works
- Phase 3 enabling works and
- Main Works

Phases 1 and 2 are subject to a Review of Environmental Factors (REF) approval process.

Phase 3 and the Main Works are subject to a State Significant Development Application Approval (SSDA) process.

The construction noise and vibration assessment in this report applies to all components of work (i.e. Phase 1 to Main works inclusive). Section 10 refers and is submitted for incorporation into the REF and in support of the SSDA.

All other sections of this report relate to operational noise (and vibration) and acoustic design. These apply only to the Main Works component of the project and are therefore provided in support of the SSDA.

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1 Introduction

Resonate Acoustics has been engaged by Health infrastructure NSW to undertake acoustic schematic design tasks for the proposed upgrades to Kempsey District Hospital (KDH) at Kempsey, NSW.

The purpose of this acoustic input is to:
- Address key issues three ('Amenity') and five ('Noise and Vibration') in the Director General's Requirements, re-issued 5 December 2013
- Propose design criteria
- Provide an appropriate starting point for subsequent detailed design tasks,
- Provide the project architect with standard acoustic constructions and constructions developed specifically for this project
- Demonstrate that schematic design alternatives have been evaluated

Specifically, this report provides schematic design input for:

- Mechanical services noise emission to the environment during:
  - Normal operation
  - Emergency equipment testing (generator)
- Mechanical (and hydraulic) services noise levels in internal spaces
- Facade glazing
- Internal partitions
- Internal doors
- Ceilings and acoustic baffles therein
- Reverberation time and specialist acoustic finishes
- Construction noise and vibration

Inputs to this report include:
- Briefing meeting at Johnstaff Projects, 20 December 2012 attended by Johnstaff Projects, BVN Donovan Hill and Resonate Acoustics
- NSW DEC Industrial Noise Policy (INP, 2000)
- NSW DECC Interim Construction Noise Guideline (ICNG, 2009)
- NSW OEH Road Noise Policy (RNP, 2011)
- Association of Australian Acoustical Consultants (AAAC) Guideline for Commercial Building Acoustics
- Australian/New Zealand Standard AS/NZS 2107:2000 – Acoustics – Recommended Internal Design Sound Levels and Reverberation Times for Building Interiors
- UK Department of Health Estates and Facilities Division Acoustics: Health technical memorandum 08-01
- Green Building Council of Australia Green Star Healthcare v1

2 Proposal and site

It is proposed to construct a new main hospital building and upgrade several existing buildings at Kempsey District Hospital (KDH), Kempsey, NSW.

The proposed new main building is comprised of a three-storey building, plus undercroft and rooftop plant area. It is located in the approximate centre of the hospital site bounded by River Street to the west, Polwood Street to the north, Tozer Street to the east and West Kempsey cemetery to the south.

The nearest residential receivers are located in Tozer Street approximately 80 m to the east, whilst Kempsey Heights Bowling Club is located approximately 90 m to the north east. Undeveloped land is located to the north of Polwood Street.

Figure 1 shows a schematic site plan and identifies key locations including the unattended noise logging site referenced in Appendix 1. The numbered locations refer to the backup power generator site options considered in Section 4.2.

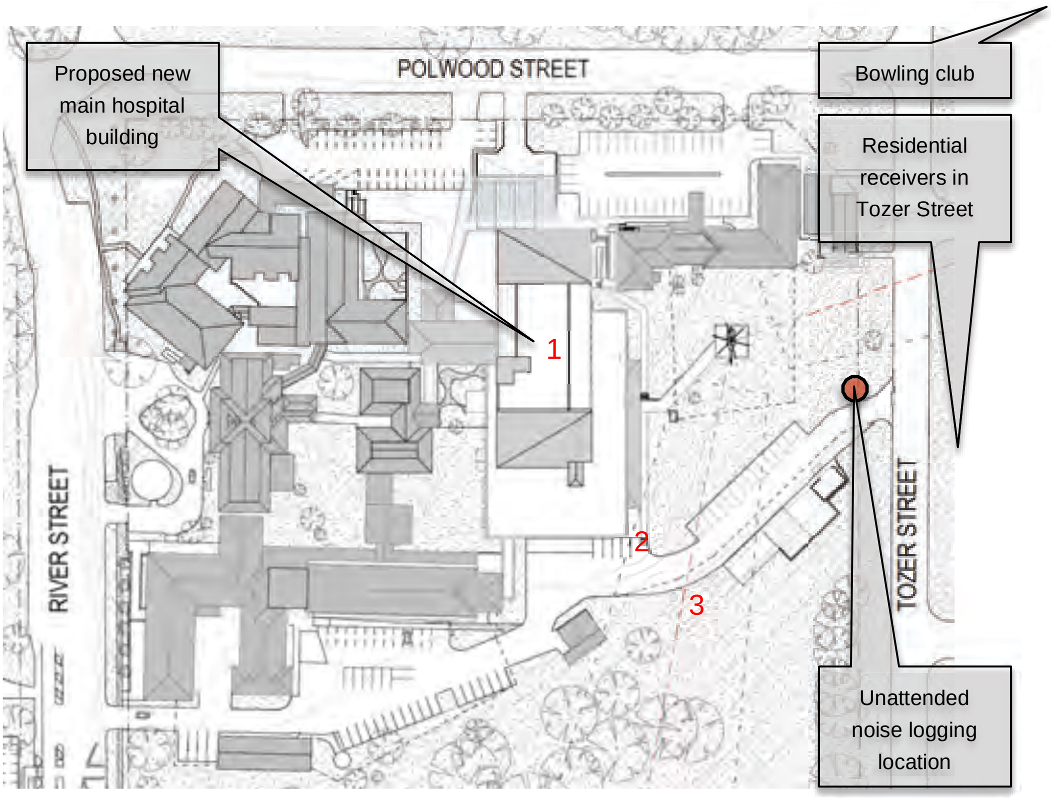

Image: BVN Donovan Hill

Figure 1 - Schematic site plan

3 Design criteria

3.1 Director General's Requirements

Director General's Requirements (DGRs) have been issued for the KDH project (Re-issued 5 December 2012).

The criteria and assessments presented in this report address the following key issues within the DGRs:

3. *Amenity*
   Detail amenity impacts including solar access, acoustic impacts, visual privacy, servicing requirements (including but not limited to waste management, loading zones, mechanical plant), overshadowing and wind impacts. A high level of environmental amenity for land uses adjacent must be demonstrated.
5. *Noise and Vibration*
   Identify and provide a quantitative assessment of the main noise and vibration generating sources and activities at all stages of construction and any noise sources during operation. Outline measures to minimise and mitigate the potential noise and vibration impacts on existing hospital operations and surrounding occupiers of land. Relevant policies and guidelines: NSW Industrial Noise Policy (EPA), Interim Construction Noise Guideline (DECC)

It is necessary to consider and design for the acoustic amenity of adjacent land uses during the construction and operation of the upgraded hospital.

During the construction stage, and in accordance with Section 10, all reasonable and feasible measures shall be considered and implemented to minimise the construction noise and vibration impacts upon nearby residential premises and other sensitive land uses including the hospital itself.

During the operational stage, in most cases, control of noise and vibration sources to provide appropriate amenity for the upgraded hospital will ensure appropriate amenity for the nearby noise-sensitive land uses.

During the detailed design stage, noise and vibration from specific sources shall be assessed at existing hospital receivers, the new hospital buildings and at nearby noise-sensitive land uses to fully address the DGRs.

As part of the acoustic schematic design process, an unattended noise logging exercise has been undertaken in order to derive quantitative noise emission criteria. This is described in Appendix 1.

Sections within this report that address the DGRs are 3.2, 3.3, 3.4 4.1, 4.2, 4.3 and 10.

3.2 Noise emission - Normal operation

In order to address key issues three and five of the DGRs, noise emissions from stationary noise sources associated with the project shall be controlled to meet the NSW Industrial Noise Policy (INP).

The INP provides criteria and methodologies for the assessment of stationary noise sources in NSW. There are two criteria considered, being the control of intrusive noise impacts (for residential land uses only) and maintaining noise amenity for all noise-sensitive land uses.

Intrusive noise impacts are based on a margin over the existing noise environment (the ‘Background plus 5 dB(A)’ method) and the amenity criteria are set values for different periods of the day depending upon the noise sensitivity of nearby land uses. The set values are subject to adjustment for a range of reasons, including accounting for existing industrial-type noise contribution in the area. In this case it is considered that the existing industrial noise contribution at nearby residential premises is nil.

In order to determine the amenity criteria for nearby residences (principally those in Tozer Street, refer to Figure 1), it is necessary to determine the residential receiver type.

Resonate Acoustics considers that residential receivers in the vicinity of the project site are located within a ‘suburban’ noise environment according to the receiver types set out in Sections 2.2.1 and 2.2.2 of the INP.

A suburban noise environment is characterised within the INP as:

- An area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry. This area often has the following characteristics:
  - Decreasing noise levels in the evening period (1800–2200); and/or
  - Evening ambient noise levels defined by the natural environment and infrequent human activity.

The other nearby land uses for which amenity criteria must be assigned include the existing hospital buildings, the bowling club to the north east (considered an active recreation area) and the cemetery to the south (considered a passive recreation area). The amenity criteria for all of these locations and the intrusive criteria for residential receivers are identified in Table 1.

Table 1 - Industrial Noise Policy criteria – all land uses

Criteria	Intrusive and Amenity Noise Levels (dB re 20 μPa), $L_{Aeq,period}$		
	Daytime 07:00 – 18:00	Evening 18:00 – 22:00	Night-time 22:00 – 07:00
Residential Intrusive	44	40	35
Suburban Residential Amenity	55	45	40
Active Recreation Amenity	55 (When in use)		
Passive Recreation Amenity	50 (When in use)		
Hospital Ward - External	50 (During the noisiest one hour period)		

For equipment that operates continuously during any or all of the defined time periods, it is the lowest of the intrusive and amenity criteria that govern noise emission from the site.

It is prudent to allow a future noise contribution from future development of the site. It is therefore recommended to control the contribution of the KDH Redevelopment to below the criteria above. It is proposed to design to 5 dB below the residential intrusive criteria in Table 1. For further explanation, refer to Section 11.1.

The resultant environmental noise criteria for normal operation at the KDH Redevelopment project would therefore be:

- Daytime: 39 dB L_{Aeq}
- Evening: 35 dB L_{Aeq}
- Night-time: 30 dB L_{Aeq}

These are low (stringent) noise criteria that reflect the low existing background and ambient noise levels in the vicinity. Comprehensive noise controls will be required for major plant items that are externally located; or intake from, or exhaust to, the external environment.

Refer to Section 11.1 for a discussion on future development of the site and why it may be permissible to increase these criteria by up to 5 dB(A).

3.3 Noise emission - Emergency equipment maintenance and testing

For emergency equipment sources (for example backup power generators) that operate up to a maximum of one hour in either the daytime or evening period, a noise increase of 5 dB above the intrusive criteria is permitted, as presented in Table 4.2 in the INP.

For the KDH Redevelopment project, it is proposed that one generator will be installed.

It is considered prudent to allow for the noise contribution of an additional generator at this location should future development of the site require additional capacity. The daytime and evening permissible noise contribution for maintenance and testing are therefore the intrusive noise criteria (Table 1) plus 5 dB (no more than one hour operation), minus 3 dB (to account for a second future generator).

This equates to permissible emergency equipment maintenance and testing noise levels of:

- 46 dB L_{Aeq} during the day time period at the nearby residences
- 42 dB L_{Aeq} during the evening period at the nearby residences
- 52 dB L_{Aeq} at nearby hospital facades.

Note that these criteria relate only to periodical testing and maintenance of emergency-use equipment such as the backup power generator.

These criteria assume that any additional future generator is co-located in the service compound and is of equal or lesser sound power. (Refer to Section 11.1)

3.4 Road traffic noise

Criteria for road traffic noise impacts associated with the project are derived from the NSW Office of Environment and Heritage *Road Noise Policy* (RNP, 2011) and the RNP Application Notes (2012).

Table 3 of the RNP provides road traffic noise assessment criteria for residential land uses. The relevant criteria are for the Local Road category (when considering the residences in Tozer Street) and the type of project is 'Existing residences affected by additional traffic on existing local roads generated by land use developments'. The assessment criteria are:

- 55 dB $L_{Aeq,\ (1\ hour)}$ Daytime (7 am to 10 pm)
- 50 dB $L_{Aeq,\ (1\ hour)}$ Night-time (10 pm to 7 am)

The RNP also provides a relative increase criterion, being that the increase over existing road traffic noise levels shall be controlled to within 2 dB of the 'no build option'.

3.5 Helicopter noise

Resonate Acoustics is not aware of any formal Health Infrastructure NSW criteria in relation to maximum internal noise levels due to helicopter activity. There are however a range of suggested criteria from other authorities and peers within the acoustic consulting industry. With reference to the peer-reviewed paper *Helicopter Noise Impacts on Hospital Development Design* - Zoontjens, James, 2012, the range of permissible maximum noise levels from a range of sources (some excluding helicopters) is presented in Table 2:

Table 2 –L_{AFmax} noise criteria for hospitals

Source	Room	Time period	Criterion, L_{AFmax}
UK Healthcare Facilities Document, 'Acoustics: Technical Design Manual 4032:0.6 for Healthcare Facilities, 2012[1]	Single bed ward, single bed recovery areas and on call rooms, relatives' overnight stay, multi-bed wards	Night	45
	Operating Theatres	24 hours	50
Zoontjens, James, 2012	NICU/PICU/Critical in-patient wards	Unspecified	55
	Wards and sensitive spaces	Unspecified	65
New Zealand Ministry of Health	NICU facilities	Unspecified	70

Note 1: Specifically excludes helicopter noise

Discussions with BVN Donovan Hill architects (and with reference to their experience of criteria adopted at similar facilities) suggests that a maximum noise level higher than the values above may be appropriate given the anticipated infrequency of helicopter noise events. Refer to Section 5.3.

3.6 Internal noise levels and reverberation times

Steady-state internal noise levels and reverberation time criteria are based on the recommendations of Australian/New Zealand Standard (AS/NZS) 2107:2000[1] and our experience of similar developments.

The relevant internal noise level range and mid-frequency reverberation criteria are presented in Table 3.

Table 3 – Recommended internal noise levels and reverberation times—Health Buildings

Type of occupancy/activity	Recommended Design Sound Level L_{eq} dB(A)	Recommended Reverberation Time (T), s[(1)]
Clinical		
Casualty areas	40 – 45	0.4 – 0.6
Corridors and lobby spaces	40 – 50	0.4 – 0.6
Consulting rooms	40 – 45	0.4 – 0.6
Delivery suites	45 – 50	0.4 – 0.6
Dental clinics	40 – 45	0.4 – 0.6
Geriatric rehabilitation	40 – 45	0.4 – 0.6
Intensive care wards	40 – 45	0.4 – 0.6
Kitchens, sterilising and service areas	50 – 55	0.6 – 0.8
Laboratories	45 – 50	0.4 – 0.7
Nurses' stations	40 – 45	0.4 – 0.7
Operating theatres	40 – 45	—[(2)]
Pharmacies	45 – 50	0.4 – 0.6
Sterilising areas in operating theatres	40 – 45	—[(2)]
Surgeries	40 – 45	0.4 – 0.7
Wards – single bed	35 – 40	0.4 – 0.7

[1] Australian/New Zealand Standard 2107:2000 *Acoustics—Recommended design sound levels and reverberation times for building interiors.*

Type of occupancy/activity	Recommended Design Sound Level L_{eq} dB(A)	Recommended Reverberation Time (T), s[(1)]
Wards – multi-bed	40 – 45	0.4 – 0.7
Waiting rooms, reception areas	40 – 50	0.4 – 0.7
Staff		
Meeting room	35 – 40	0.4 – 0.6
Office areas	40 – 45	0.4 – 0.7
Private Offices	35 – 40	0.6 – 0.8
Staff room	40 – 45	0.4 – 0.6
Engineering		
Generator room (generator operational)	<105 [4]	Note 3
Plant Room (plant operational)	<85	Note 3

Note: (1) Mid-frequency reverberation refers to the reverberation time at the medium frequencies, being 500 Hz or 1000 Hz or an average of both.
(2) Specialist advice should be sought for these spaces – principally to ensure that any acoustically absorptive treatments can satisfy applicable hygiene requirements.
(3) Reverberation time should be minimised as far as practicable for noise control
(4) Refer to Section 8 for information regarding Occupational Health and Safety

For this project, steady state internal noise levels will primarily be a function of the operation of the mechanical services system and the acoustic control thereof. Based on schematic design tasks including the noise survey presented in Appendix 1, external noise intrusion is not considered to be an influence upon steady state internal noise levels as external noise levels in the vicinity of the hospital site are low.

Reverberation time within spaces will be a function of materials within a room or corridor. It is noted that the presence of acoustically absorptive finishes within hospitals is strongly influenced by hygiene requirements.

Hygiene requirements take precedence over acoustic requirements and in some cases acoustic finishes cannot be provided. Consequently it may not be possible to target the reverberation times presented in Table 3 for all spaces during the detailed design stage.

3.7 Rainfall noise

It is prudent to apply a rainfall noise criterion where a lightweight roof structure, i.e.: material other than concrete is present over occupied clinical, administrative or public spaces.

At this stage of the design and based on our briefing, it is understood that no such roof areas are subject to further consideration at the KDH Redevelopment. Should such roof structures be re-introduced into the design, rainfall noise shall need to be considered.

The criteria would likely be based on the following rainfall intensities:

- 10 mm/hour as a general design level, and
- 15 mm/hour for sensitive areas.

3.8 Internal acoustic separation

There are no defined criteria or Australian Standards that specify acoustic separation requirements for healthcare facilities.

Consequently, the recommended levels of acoustic separation are based on:

- Room noise source and tolerance levels—for noise isolation from adjacent spaces
- Subjective performance requirements—for speech privacy

For the KDH project, these parameters are based upon:

- Briefing meeting at Johnstaff Projects, 20 December 2012 attended by Johnstaff Projects, BVN Donovan Hill and Resonate Acoustics
- Association of Australian Acoustical Consultants (AAAC) *Guideline for Commercial Building Acoustics*
- UK Department of Health Estates and Facilities Division *Acoustics: Health technical memorandum 08-01*
- Our experience of similar projects.

Background information regarding Resonate Acoustics partition design process for the KDH project is presented in Appendix 2.

A mark-up of floor plans showing recommended levels of acoustic separation is shown in Appendix 3.

The recommended levels of separation (and the noise source and tolerance levels on which they are based) should be confirmed and agreed upon by the client to ensure that they have an understanding of the proposed design.

3.9 Green Star

Based on our briefing, it is understood that whilst achieving a specific Green Star outcome is not mandatory, a 4 Star outcome is to be targeted. In the event that the acoustics points are to be targeted, the Green Star criteria from *Healthcare V1* are provided below:

IEQ 7: Internal noise levels
One point is awarded where it is demonstrated that:

- The internal noise levels from building services meet the recommended design sound levels provided in Table 1 of AS/NZS 2107:2000 for 95% of the project's nominated area.

For the purposes of this credit, nominated area is OFA (Operating Floor Area).

IEQ 19: Places of respite
One point is awarded where it is demonstrated that at least two designated places of respite with direct physical connection to the natural environment are provided in accordance with all of the following:

- Where the place of respite is outdoors, it must be shown that, in addition, the space is classified as having a noise exposure category of 'A' or 'B' as defined in the Draft Interim Sound and Vibration Design Guidelines for Hospital and Healthcare Facilities[2] Table 1.3-1

An excerpt from Table 1.3-1 is presented below in Table 4:

Table 4 - Excerpt from Table 1.3-1

Exterior site noise exposure category	A	B
General description	Minimal	Moderate
Day-night average sound level (L_{dn}) (dB)	<65	65 – 70
Average hourly nominal maximum sound level (dB(A))	<75	75 – 80
Distance from nearest highway (m) [1]	305	75 – 305
Slant distance from nearest aircraft flight track (m) [1]	>1220	610 – 1220
Distance from nearest rail line (m) [1]	455	150 – 455
Exterior shell composite STC rating	35	40
Exterior patient sitting areas	Some shielding of principal noise sources may be required	Requires shielding of principal noise sources

Note 1: Converted from feet in original document and rounded to the nearest 5 metres

[2] Drafted by members of the Joint Subcommittee on Speech Privacy of the Acoustical Society of America (ASA) (Technical Committees for Architectural Acoustics and Noise), the institute of Noise control Engineering (INCE) and the National Council of Acoustical Consultants (NCAC) (USA, 2006)

4 External noise

4.1 Normal Operation

At this schematic design stage, it is envisaged that the dominant source of external noise emission will be the rooftop (level 3) plant.

Particular items of mechanical plant that will contribute to external noise emission will include the two cooling towers located centrally on the rooftop. Based upon preliminary discussions with the mechanical services consultant, the sound power of each cooling tower is in the order of 96 dB(A), with the total sound power of two running simultaneously being 99 dB(A).

At the north and south of the rooftop plant floor, there are enclosed plant rooms containing Air Handling Units (AHUs), chillers, pumps and other, less acoustically significant plant items.

Based upon the noise criteria presented in Section 3.2, the limiting sound power for normal operation plant and equipment for the daytime, evening and night-time periods have been calculated as follows:

Table 5 – Limiting aggregate sound power for the KDH Redevelopment project

	Period		
	Daytime	Evening	Night-time
Criterion, dB(A) (Section 3.2)	39	35	30
Distance to Tozer Street receivers, m	80	80	80
Hemispherical propagation loss, dB(A)	46	46	46
Limiting Sound Power, dB(A)	85	81	76

Should the nearest existing hospital building with direct line of sight to the major rooftop plant items be no closer than 40 m to the noise existing plant, the limiting power to meet the 'Hospital Ward – External' criterion is 90 dB(A), and is therefore no more limiting than the requirement for residential receivers.

It is evident from the limiting sound power levels in Table 5 and the statement above regarding cooling tower sound power that acoustic controls will be necessary for the external noise criteria to be satisfied. Treatment options that should be subject to consideration are:

Rooftop plant rooms

- Selecting the quietest equipment for a given task and duty
- Lining the maximum possible extent of internal wall and soffit surfaces with industrial grade acoustically absorptive material

- Locating air intake and discharge locations away from residential receivers
- Providing silencers and/or acoustic louvers for air intake and discharge locations

Cooling Towers

- Selecting the quietest cooling towers for the required duty
- Reducing operation speed when thermal load is reduced
- Investigating manufacturers noise control options such as intake and exhaust attenuation kits, (noting that exhaust silencers increase the effective source height of the cooling tower)
- Provide a barrier/acoustic louvre arrangement at the eastern edge of the roof between the cooling towers and the Tozer Street residences. It is noted that screens shown on the architectural drawings will provide acoustic benefit (for the intake noise at low level) and should be taken into account in acoustic design calculations at the design the.

Mechanical plant generally

- Selection of the quietest equipment to serve the required function/duty
- Judicious location with respect to noise-sensitive receivers
- Enclosure in purpose-designed, acoustically-lined plant rooms
- Barriers – purposed designed and incidental such as intervening buildings, locating plant centrally on roof rather than edge to minimize direct line of sight to receivers.
- Silencers (attenuators)
- Internal duct lining
- External duct cladding
- Time controls to limit equipment operation to a minimum

During the schematic design stage Resonate Acoustics has advised that:

- In order to control noise levels in the Level 2 occupied spaces as a result of the operation of the cooling towers, a 250 mm thick minimum concrete floor slab shall be provided.
- In addition to the above, a suspended set plasterboard ceiling will be required in a localized area below the cooling towers.

We understand that the preferred structural option at the time of this report is a flat concrete slab that varies in thickness, with a minimum thickness of 220 mm. This is moderately less than the minimum recommended slab thickness and as such the suspended plasterboard ceiling may need to be upgraded to control noise levels to within the level 2 occupied spaces. This advice is subject to the sound power of the selected cooling towers to be determined during the detailed design stage. A screed topping of 50 mm is proposed in many areas and this should be included in acoustic design at later stages.

Acoustic design tasks for the chillers, pumps and Air Handling Units in the rooftop plant rooms will also be based upon a slab thickness of 220 mm as per the preferred structural design. No topping (screed) is proposed for slab that separates Level 2 and the rooftop (Level 3) plant.

4.2 Emergency equipment maintenance and testing

Through consultation with the project electrical services consultant, it has been established that:

- One backup power generator will be provided as part of the KDH Revelopment project
- The generator will be rated at approximately 750 kVA
- There are three location options for the generator:
    1) Rooftop of the new main building, approximately centre on plan. There is a preference for the generator in this location to be a 'containerised set'.
    2) Undercroft of the new main building, at the south east corner. This would be an 'open set' located in a generator room.
    3) In the grounds of the hospital, near to the services compound/east of the site near Tozer Street
- A future generator of the same duty and noise emission may be co-located with the KDH Redevelopment generator for option (2) and (3).

A schematic stage assessment of the three location options is provided in Table 6. The assessment is based upon an open generator set with an overall sound power of 117.6 dB(A). A lay description of the relative levels of required treatment is provided for each option, ranging from 'Minimal' to 'Very High'.

Table 6 – Schematic stage generator noise assessment

Location Option (Refer to Figure 1)	Assessment		
	Airborne noise control		Vibration controls
	To Hospital	To residences	To hospital
1) Rooftop	High A separate isolated floor slab may need to be considered and/or a significantly acoustically improved suspended ceiling.	High A containerised set that achieves 70 dB(A) at 7 m will be required. If a second generator is to be provided in future, the requirement for both will be 67 dB(A) at 7 m.	Very High A minimum of 95% isolation efficiency required to control structure-borne noise.

Location Option (Refer to Figure 1)	Assessment		
	Airborne noise control		Vibration controls
	To Hospital	To residences	To hospital
2) Undercroft	Very High A thick concrete floor slab and separate acoustic ceiling to control noise to ground floor occupied spaces. Fully lined generator room. Acoustically designed riser construction for exhaust stack.	Moderate Measures to control noise emission to hospital will serve to control noise at residences.	Moderate Generator will be supported on grade (ground) and so more routine vibration isolation measures will be appropriate.
3) Service compound. Approximately 60 m from Tozer Street residences, 20 m from hospital facades	Very High A containerised set that achieves 64 dB(A) at 7 m will be required. If a second generator is to be provided in future the requirement for both will be 61 dB(A) at 7 m.	High A containerised set that achieves 67 dB(A) at 7 m will be required. If a second generator is to be provided in future the requirement for both will be 64 dB(A) at 7 m.	Minimal

Preferred generator option
On the basis of input from other disciplines and consultants, Option 3 has been identified as the preferred option for the KDH Redevelopment project. An additional generator may be co-located with the KDH Redevelopment generator to meet future demand.

The sound pressure level specification provided in Table 6 (64 dB(A) at 7 metres, each generator) is provided on the basis of meeting the emergency equipment maintenance and testing criterion of 49 dB(A) for residential premises in Tozer Street during the daytime period as stated in Section 3.3.

Consistent with the acoustic design of similar hospital projects, moderate exceedances of the hospital facade criterion of 55 dB(A) may be experienced (with two generators operational) at nearby hospital building facades, given their proximity of approximately 20 m from the generator site.
With proposed and an additional future generator operational, a sound pressure level of up to 60 dB(A) is predicted at the facades. This is not considered to be of significant consequence

due to the noise control provided by the proposed jockey sash glazing systems. However, the acoustic upgrade to the containerised sets required to achieve absolute compliance outside the hospital facades would result in a larger container size and increased cost.

Containerised set – sound pressure level at 7 metres
It is a generator industry standard specification to rate the noise emission of generators in terms of free-field sound pressure level at 7 metres from the generator.

Advice in this report regarding compliance with noise criteria is provided on the basis that the quoted sound pressure levels are omni-directional from the containerised sets. That is, the quoted sound pressure level would be the same at any position 7 metres from the acoustic centre of the containerised set.

Containerised set – Acoustic responsibility
The container acoustic design, silencer and muffler design and installed acoustic performance of the containerised set (in terms of satisfying the acoustic criteria provided in this report) shall be the responsibility of the generator supplier/contractor.

4.3 Road traffic

The project traffic consultant has provided existing daily traffic numbers and predicted additional traffic that will be generated by the project. The traffic numbers and resultant noise level increases on surrounding roads are presented in Table 7:

Table 7 – Traffic flows and noise level increases

Location	Existing daily two-way traffic flows	Additional daily traffic generated by project	Noise level increase (dB)
Polwood Street	800 - 1000	300	1.1 - 1.4
River Street	7,000	500	0.3
Tozer Street	1,200 – 1,500	100	0.3

A review of Table 7 shows that the relative traffic noise level increases on surrounding roads are within a margin of 2 dB and as such satisfy the relative noise level increase requirements of the NSW Road Noise Policy (RNP).

The impact of service vehicles using the new service road entry on Tozer Street has also been considered with respect to the daytime 55 dB $L_{Aeq(1\ hour)}$ criterion in the RNP. It is understood that delivery vehicles would enter the service road at Tozer Street and exit onto River Road.

A worst case scenario of a heavy vehicle, being a slowly manoeuvring semi-trailer with a sound power of 102 dB(A), has been considered.

Schematic calculations show that one vehicle per hour during the daytime period (7 am to 10 pm) could arrive at the Tozer Street service road entry whilst achieving compliance. (It is assumed that the vehicle does not stop at the Tozer Street entry point). An increased number of smaller delivery vehicles (such as 10 m rigid trucks) could be accommodated whilst maintaining compliance.

Vehicle numbers should be confirmed during the detailed design stage to ensure that compliance is achieved. Reasonable and feasible measures should be developed to mitigate road traffic noise impacts.

It is unlikely that heavy vehicle movements during the night-time period would achieve compliance with the night-time 50 dB $L_{Aeq(1\ hour)}$ criterion at the Tozer Street residences. It is also understood that deliveries during the night-time period would be an unlikely scenario.

5 Internal noise

5.1 Mechanical services

Down-duct noise

Noise levels within the hospital due to the operation of the ducted rooftop plant and on-floor plant items will be determined by:

- The location of the noisy equipment
- The supply, return (and sometimes the case radiated) sound power of the equipment
- Duct route and configuration including the number of (internally lined) bends
- The location return air grilles (relative to noisy items)
- Air velocity within the mechanical services system
- Whether or not it is permissible to provide silencers and internally-lined bends and ductwork (based on hygiene considerations). Note that in our experience internal acoustic lining is permissible in clinical areas (in ducts and packing within silencers) subject to the correct inclusion and placement of filters and lining material such as Mylar or Melinex facing. Should no lining be permissible, or if only packless-type silencers are acceptable, the options to control down-duct noise will be severely limited.

An acoustically-appropriate starting point for design stage acoustic tasks will minimise the extent (and therefore the cost) of acoustic treatment required.

At this schematic stage no detailed information regarding internal mechanical services is available for review; consequently no acoustic review has taken place.

Where a choice exists and in order to minimise acoustic intervention, it is recommended that:

- Mechanical equipment is selected on the basis of the quietest model that serves the function
- Equipment rooms are located remotely from noise-sensitive rooms
- Main duct runs (risers and horizontal main ducts in ceiling spaces) are located adjacent to the least noise-sensitive spaces (e.g. service areas and corridors)
- Internally-line duct bends are present prior to the first noise-sensitive space by default
- Internal duct lining (nominally 50 mm thick) is implemented by default prior to the first noise-sensitive space
- Physical space, static pressure capacity and a budgetary allowance is retained for silencers (attenuators) and/or lined ductwork to be provided prior to the first noise-sensitive space and after FCUs and VAVs.
- Air velocities do not exceed the values stated in Table 8
- In-ceiling mechanical equipment, (Fan Coil Units, Variable Air Volume devices) are located above corridors and service areas, not occupied spaces

Duct velocities

As noted above, the air velocity within ducts will influence noise levels within internal spaces. Table 8 provides guidance on maximum air velocities to enable acoustic design sound levels to be achieved. Where a range of acceptable noise levels is given for a space (Refer Table 3), the air velocity corresponding to the lower end of the range shall be targeted.

Table 8 – Maximum air velocities for acoustic design

Design Sound Level, dB L_{Aeq}	Riser	Main Duct	Branch Duct	Run out Duct
	Maximum air velocity, m/s			
35	9	7	5	3
40	11	8	6	4
45	13	9	7	5
50	15	10	8	6
55	17	12	9	7

Duct cross-talk

Duct cross-talk refers to the concept of acoustically joining adjacent spaces (that are intended to be acoustically separated) through the mechanical services system. This can occur when adjacent spaces share common supply and/or return air duct systems.

The preferred acoustic approach to duct configuration is to locate common ducts over a corridor and provide a separate rigid run-out ducts to each space (in doing so a number of bends are introduced). The duct and bends would be internally lined, depending upon the degree of acoustic separation required.

Mechanical services strategies to address cross talk are presented in Appendix 6.

Duct cross talk would also occur through transfer ducts between occupied spaces and corridors where the return air is located within the corridor. Allowance should be made for the transfer duct to be lined and to incorporate an appropriate number of lined bends depending on the room privacy/disturbance requirements.

5.2 Hydraulic services

The control of hydraulic services noise within hospitals and healthcare facilities is not governed by specific acoustic criteria. Hydraulic noise is often intermittent, the source levels and characteristics are variable and as such it is considered inappropriate to apply an absolute noise criterion.

A common approach to hydraulic noise control is a prescriptive one; specifying constructions (between hydraulic services and occupied spaces) that have proven to give an appropriate outcome in typical circumstances.

Hydraulic services noise is principally a structure-borne issue where the coupling of pipework to building structure results noise transfer through structural elements. This is then re-radiated as airborne noise.

Partition construction

For pipework or hydraulic services within a partition adjacent to an occupied space, an isolated (separate stud) partition is the acoustic ideal to reduce structure borne noise. In this case the pipework is affixed to the wet area side of the partition.

The next best acoustic strategy is to use a staggered stud partition. Again, the pipework shall be affixed to the wet area side of the partition. This strategy has been proposed for the KDH project between, for example, en suite bathrooms and adjacent wards.

Fixing of hydraulic supply services

With respect to hydraulic services in walls, the following should be noted:

- Pipework should be supported from the wet side (toilet, bathroom, kitchen side) of the isolated partition studwork
- Pipework must be kept clear of plasterboard wall linings
- Pipes must not be supported by wall lining sheets
- All penetrations should be sealed with a flexible caulking compound to ensure no gaps
- Pipework should be acoustically isolated at mounting points and penetrations—pipe insulation (Bradflex, Armaflex or similar), 6 mm thick neoprene, closed cell foam or ‘unicushion’ is required between all pipes and pipe clamps; alternatively provide neoprene element vibration isolation hangers to pipe supports or mounting points.

Water flow rates

Water flow velocities should be limited to 2.5 m/s by increasing the pipe size where necessary.

Soil and waste water pipe isolation

Soil and waste water pipes are to be fixed in accordance with the following:

- Waste pipes should be acoustically isolated at mounting points and penetrations—pipe insulation (Bradflex, Armaflex or similar), 6 mm thick neoprene, closed cell foam or 'unicushion' is required between all pipes and pipe clamps; alternatively provide neoprene element vibration isolation hangers to pipe supports or mounting points
- Ensure there is no direct contact between waste pipes and surrounding elements. A 20 mm clearance is an appropriate allowance.

The ceiling and riser construction requirements to separate soil and waste pipes from normally occupied areas are presented in Table 9.

Table 9 Ceiling and riser construction requirements for soil and waste pipes

Area	Construction	
	Ceilings	Risers
General occupied spaces	• CAC 35 mineral fibre ceiling tiles or equivalent, and • Acoustically lag pipe OR lay 75 mm thick glasswool insulation with minimum 14 kg/m^3 over ceiling for a minimum of 1200 mm each side of the pipe.	• 1 x 13 mm plasterboard on metal studs with 75 mm thick glasswool insulation with a minimum density of 14 kg/m^3
Noise sensitive areas including wards, operating theatres	• CAC 35 mineral fibre ceiling tiles with or equivalent, and • Acoustically lag pipe, and • Lay 75 mm thick glasswool insulation with minimum 14 kg/m^3 over ceiling for a minimum of 1200 mm each side of the pipe.	• 1 x 13 mm plasterboard on metal studs with 75 mm thick glasswool insulation with a minimum density of 14 kg/m^3, and • Acoustically lag pipe.

Down pipe isolation

To isolate noise from down pipes to occupied spaces, one of the following treatments is required:

- Acoustically lag down pipes and enclose with 1 x 13 mm plasterboard on metal studs

OR

- Enclose the bare down pipes with:
  - 2 x 16 mm thick fire-rated plasterboard
  - 50 mm thick, 11kg/m^3 glasswool insulation between the studs

Syphonic type systems shall be fully lagged in all cases.

Lagging products

Suitable acoustic lagging products include

- Pyrotek *Soundlag 4525C*
- Bradford *Acoustilag 45*
- Acoustica *Acoustiflex PL5/15*

Other lagging systems with 25 mm insulation with a 4.5 kg/m^2 loaded vinyl backing are also acoustically acceptable. All acoustic lagging should be installed in strict accordance with the manufacturer's recommendations.

5.3 Helicopter noise intrusion

Background information

Resonate Acoustics has undertaken a schematic design review of helicopter noise intrusion to internal spaces of the proposed new main hospital building.

We have sourced helicopter noise data from a peer-reviewed paper (*Helicopter Noise Impacts on Hospital Development Design* - Zoontjens, James, 2012) recently presented at the Australian Acoustical Society conference.

The noise data is for a Bell 412 under several operating conditions at 100 m distance and is presented as L_{AFmax}, which represents the maximum noise level during a pass by. Data is presented in Table 10:

Table 10 - Helicopter noise data

Aspect	Sound pressure level, dB L_{ZFmax} at Octave band centre frequency (Hz)							Overall dB(A)
	63	125	250	500	1k	2k	4k	
Helicopter path perpendicular to observer to helipad								
Take off	95	92	91	87	86	82	76	91
Landing	91	85	87	83	80	82	74	87
Helicopter path directly overhead								
Take off	89	98	95	92	91	87	81	95
Landing	96	98	97	96	89	84	77	96

We have consulted with Rehbein aviation consultants who have advised that the typical minimum offset distance of the helicopter from the hospital east facade will be 30 m (approach and/or departure from the south east).

The Helicopter Landing Site (HLS) is approximately 35 m from the façade meaning that even if the helicopter approached and/or departed from another direction, the helicopter would always end up no further than 35 m from the facade.

There is a negligible 1 dB difference between 30 m and 35 m so we have assessed 30 m on a conservative basis. Accordingly, the values shown above have been increased by 10 dB (being the difference in sound level from a point source at 100 m and 30 m).

The location of the HLS in relation to the nearest hospital façade is shown in Figure 2. The dashed red line indicates the flight path that would result in the 30 m offset distance.

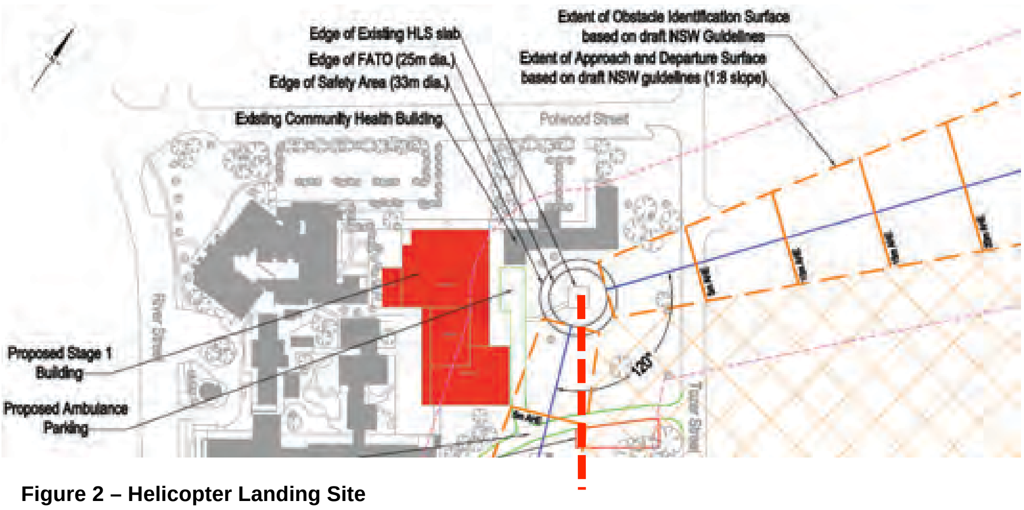

Figure 2 – Helicopter Landing Site

Schematic Design Advice

For schematic design purposes, a room at the most affected façade with the following characteristics has been considered:

- 10.8 m^2 facade area of which 8 m^2 is glazed and 2.8 m^2 is lightweight/drywall/spandrel panel construction. The glazed area is the limitation of acoustic performance.
- 0.8 seconds mid-frequency reverberation time within the room.

Based upon the helicopter noise events presented in Table 10, a range of typical constructions has been considered to determine a range of noise outcomes. Table 11 presents the findings:

Table 11 – Construction types, composite Rw and noise outcomes

Acoustic Rating, dB Rw			Results in internal noise level L_{AFmax}	Typical Construction	
Wall	Glazing	Composite		Wall	Glazing (Glass/airspace/ glass, mm)
45	32	33	79	One layer of dense plasterboard, 150 mm airspace, insulation, Kingspan or similar panel.	6/12/6 IGU
	38	39	77		6/16/6.8 *Optiphon*[1] IGU
	41	42	75		6/16/8.8 *Optiphon* IGU
	42	43	75		6/16/10.8 *Optiphon* IGU

Acoustic Rating, dB Rw			Results in internal noise level L_{AFmax}	Typical Construction	
Wall	**Glazing**	**Composite**		**Wall**	**Glazing (Glass/airspace/ glass, mm)**
	38	39	73		6/50/6 Jockey
	47	46	71		8.8 *Optiphon*/16/12.8 *Optiphon* IGU
	48	47	70		16.8 *Optiphon*/16/16.8 *Optiphon* IGU
	45	45	70		10/100/6 Jockey

Note 1: *Optiphon* is a registered trademark of Pilkington Glass

It is apparent from Table 11 that it is impractical to target maximum noise levels lower than 70 dB(A) as the required glazing types required far exceed construction norms. This is due to the fact that helicopter noise events contain much low frequency energy and whilst improved glazing types may contribute to a higher composite Rw, the incremental improvement in low frequency performance is small, resulting in small overall dB(A) reductions.

Note for example the table entry for the 6/50/6 Jockey system which whilst providing a lower composite Rw rating than some of the *Optiphon* IGU systems (i.e. could be perceived as a lower performance system), results in a lower overall dB(A) noise level in the room (i.e. performs better). This is because the jockey sash system has improved low frequency performance, which aligns with the significant low frequency energy of the helicopter event.

The options available to allow lower noise levels to be targeted are to:

- Minimise glazing (noting that halving the glazed area and ensuring a suitable wall construction below would result in a 3 dB reduction and quartering the glazed area would result in a 6 dB reduction)
- Not use glazing for sensitive spaces
- Relocate rooms for which a lower noise criterion would be beneficial (to the west facade or centre of plan for example)

Providing significantly improved glazing to control helicopter activity would result in over-performance with respect to other external noise sources. Anecdotally, for patients, this may result in increased disconnection from the outside world.

The 6 mm float/50 mm airspace/6 mm float glazing could be substituted with a commercially available insulated glass unit (IGU) and a jockey sash spaced approximately 50 mm from the IGU. This is understood to be the current proposal for clinical areas on the most affected eastern facade and for clinical areas generally.

We note that substituting an IGU in place of a single glazed element on one side of a large air gap (such as a jockey sash arrangement) could be expected to result in a very small increase in performance, typically giving a noise reduction of no more than 1 dB(A).

The minimum glazing currently proposed is IGUs in a 6/12/6 configuration for non-clinical areas.

The advice presented herein is schematic and applies to a typical room on the eastern facade. It may be prudent to consider user group/client comments on the appropriateness of the criteria range in Table 2, the proposed adoption of the 75 dB L_{Amax} criterion and whether lower maximum noise levels should be considered for critical spaces, such as operating theatres.

It is understood that helicopter movements at the hospital are infrequent. This may give merit to the adoption of a higher internal noise criterion than that which would be preferred for more frequent helicopter activity.

6 Architectural acoustics

6.1 New building

Resonate Acoustics has developed project specific acoustically-rated partition types for the KDH project. These are presented in Table 12 and in Appendix 4.

A marked-up set of main building sketch plans is presented in Appendix 3 with recommended partition types depending on the use of each room.

Mark-ups for areas to be refurbished will follow.

The partitions that have been developed for this project are based upon:

- Briefing meeting at Johnstaff Projects, 20 December 2012 attended by Johnstaff Projects, BVN Donovan Hill and Resonate Acoustics
- Association of Australian Acoustical Consultants (AAAC) *Guideline for Commercial Building Acoustics*
- UK Department of Health Estates and Facilities Division *Acoustics: Health technical memorandum 08-01*
- Our experience of similar projects.

During the briefing meeting, it was established that internal partitions shall be based upon 92 mm steel studs, plasterboard shall be impact-rated such as CSR ‘Impactchek’, all partitions shall break the ceiling line and partitions between occupied spaces shall include at least one layer of plasterboard that extends full height and sealed to the soffit above.

Partition Design

A description of our partition design process is detailed in Appendix 2. Partition data sheets are presented in Appendix 4.

Briefly however, a range of partitions is provided to account for a room’s sensitivity to noise disturbance from adjacent spaces and/or to address the acoustic privacy requirements of a room. The range steps in 5 dB increments from partitions rated at 35 dB Rw (Rank 1, the lowest end of the range) to 60 dB Rw (Rank 6).

The project specific partitions for KDH differ from our default constructions presented at the briefing meeting, primarily due to the partitions being based on a 92 mm stud (our default constructions are based on a 64 mm stud). One of the consequences of this is that the Rank 1 partition is not used in the KDH project.

A summary of the partition types developed for KDH is presented in Table 12:

Table 12 - Summary of KDH project specific partition types – new building

Rank	Nominal Acoustic Rating, dB Rw	Height	Construction	Depth mm	CSR[1] Type	Comment
2 Green	40	Breaks ceiling line	13 mm Impact-rated[2] pb[3] 92mm steel studs 13 mm Impact-rated pb	118	050	Typical occupied space to corridor with door - see text **'Corridor Walls'**
3 Yellow	45	One layer of plasterboard full height	13 mm Impact-rated pb 92mm steel studs 100 mm insulation 13 mm Impact-rated pb	118	050	Typical occupied space to occupied space – see text **'Wet Areas'**
4 Orange	50	Inner layers full height	13 mm Impact-rated pb 13 mm Fire-rated[4] pb 92mm steel studs 75 mm insulation 13 mm Fire-rated pb 13 mm Impact-rated pb	144	075	Typical specialist clinical space partition
5 Red	55	All layers full height	13 mm Impact-rated pb 13 mm Fire-rated pb 64/76 mm steel studs (staggered in 92mm track) 100 mm insulation 13 mm Fire-rated pb 13 mm Impact-rated pb	144 or 202	175	Typical operating theatre partition – see text **'Alternative Rank 5 Partition'**
6 Purple	60	All layers full height	13 mm Impact-rated pb 13 mm Fire-rated pb Twin 92 mm steel studs (spaced 20 mm apart) 100 mm insulation 13 mm Fire-rated pb 13 mm Impact-rated pb	256	275	Provisionally used for generator room

Notes
1) Other manufacturers provide comparable systems including Boral and Lafarge. Consult with us should you require these product references. Note the CSR systems shown are based on fire-rated plasterboard. It is acceptable to use impact rated plasterboard.
2) 13 mm Impact-rated plasterboard has a minimum mass of 10.5 kg/m^2
3) pb = plasterboard
4) 13 mm Fire-rated plasterboard has a minimum mass of 10.5 kg/m^2

Corridor Walls

Where a door is present in a partition, the door and gaps around the door control (limit) the acoustic performance of the partition as a whole. For this reason, unless the door and seals are substantially upgraded, it is ineffective and inefficient to specify highly-rated partitions.

We have specified a Rank 2 partition for the majority of occupied space to corridor partitions where a door is present. The Rank 2 project specific construction is nominally a 40 dB Rw partition. Realistically, with no insulation it would routinely achieve 38 dB Rw. This 2 dB deficit is of no consequence in such cases, as the composite (overall) result is acoustically comparable.

Table 13 presents scenarios that demonstrate this:

Table 13 Corridor partitions with doors – composite outcomes

Scenario	Partition Area	Door Area	Partition Rating dB Rw	Door Rating dB Rw	Composite Rating dB Rw
A	75%	25%	40	30	35
B	75%	25%	38	30	34
C	75%	25%	40	25	31
D	75%	25%	38	25	30

A review of Table 13 shows that the composite effect of the reduced partition performance is a negligible 1 dB. This includes scenarios C and D with a Rank 1 (25 dB Rw) door and scenarios A and B with a Rank 2 (30 dB Rw) door.

Where doors form a smaller proportion of a total partition area, it can be worthwhile to improve the partition rating and adding insulation may be appropriate in such cases. The Rank 2 partition would then differ from Rank 3 only in that no layers of plasterboard would extend to the underside of the slab above.

Wet Areas

It is recommended that where wet area services are present in a partition between a wet area and an occupied space that a staggered stud partition system is used, and the services affixed to the studs on the wet area side. This mitigates structure-borne noise due to hydraulic noise, particularly through tap bodies. The partition system in this case may be a 64 or 76 mm stud in a 92 mm track, spaced at 300 mm staggered centres.

For wet areas, an acoustically equivalent lining material is 7.5 mm fibrous cement sheet/'blue board'. One layer of the specified plasterboard can be substituted with one layer of 7.5 mm fibrous cement sheet/blue board.

Alternative Rank 5 Partition

Should 64 or 76mm staggered studs be structurally unsuitable, an Alternative Rank 5 partition is:

- 13 mm Impact-rated plasterboard
- 13 mm Fire-rated plasterboard
- 150 mm studs at 600 mm centres with 100 mm insulation
- 13 mm Fire-rated plasterboard
- 13 mm Impact-rated plasterboard

Doors

It is common for there to be a disconnect between an acoustic ideal (constructions derived from acoustic criteria) and construction industry expectations of normal practice. This is particularly the case for doors.

Based on the briefing meeting, it is understood that the maximum door thickness that should be considered is 45 mm solid core doors, with a typical case being a 32-35 mm solid core door. Such doors meet the acoustic ratings for Rank 2 and Rank 1 respectively. As such their use will de-rate the performance of higher-rated partitions. This effect has been mitigated by specifying Rank 2 partitions in most cases where a door is present.

Where a viewing panel is present in a door or adjacent to a door, the glazing shall be a minimum of 10.38 mm laminated glass with an acoustic rating of no less than 35 dB Rw.

Acoustically-improved door sets complete with seals to all closing faces and at the threshold will be required for plant rooms and the generator room in particular. The performance of such doors can be specified during the detailed design stage once internal noise levels due to the operation of the mechanical services and generator are known.

Door Seals

From our briefing it is understood that the use of door seals for doors in occupied spaces, (particularly for threshold seals) is to be minimised (due to accessibility requirements) This will acoustically de-rate Rank 2 and above partitions.

Where possible it is recommended that as a minimum, some form of light-duty perimeter acoustic seals are considered, such as:

- Kilargo is1212 or 1515 ‘Batwing’
- Raven RP120 Delta

Seals rated for hospital hygiene requirements are available, such as the Antimicrobial Silicone Seal range by Kilargo.

It will be imperative to ensure gap sizes around doors are kept to an absolute minimum if no seals are to be provided at the threshold, to minimise the acoustic impact of this design decision.

Glazed Areas

Where glazing is present in a partition (typically a Rank 2 partition from an occupied space to a corridor), the glazing shall be a minimum of 10.38 mm laminated glass with an acoustic rating of no less than 35 dB Rw.

Should glazed areas be introduced into Rank 3 partitions or higher, then higher performance glazing will be required if the overall partition performance is to be maintained.

Ceilings

The partition advice presented herein is based on a set plasterboard ceiling or ceiling tiles with a minimum Ceiling Attenuation Class (CAC) or Weighted Ceiling sound Reduction Index (D_{ncw}) of no less than 35 such as *Armstrong Bioguard Acoustic*. Should a lesser ceiling be present on one or more sides of a partition (such as lightweight fibreglass or perforated plasterboard), then the partition advice will need to be reviewed and may need to be upgraded. Refer to Appendix 5 for a schedule of ceiling tiles and other acoustically absorptive products and materials.

Acoustic Absorption

The shaded areas in Appendix 3 show recommended areas for which for acoustically absorptive material should be specifically considered. The treatment is recommended for noise control within waiting areas, heavily used public corridors and areas where staff, carers and/or patients may seek respite from the noise of hospital activities. Treatments might take the form of:

- Upgraded acoustic ceiling tiles (with a higher Noise Reduction Coefficient (NRC))
- Carpeted areas in waiting/sitting areas
- Acoustic wall panels

The selection of such elements will be strongly influenced by the architectural intent for each space. The selection of such elements will therefore need to be made during the detailed design stage. Refer to Appendix 5 for a schedule of acoustically absorptive products and materials.

Partition penetrations

Penetrations through acoustically-rated partitions can de-rate acoustic separation between adjacent spaces by an unacceptable margin.

It will be necessary to provide acoustic details for penetrations including:

- Rigid ducts
- Hydraulic pipework
- Electrical cables, conduits and cable trays

These details should be provided as part of the detailed design stage acoustic input.

Electrical outlets

General Power Outlets and other electrical outlets in acoustically rated walls should not be installed back to back unless acoustically treated.

6.2 Refurbished areas

Several departments are to be refurbished, and new partitions will be provided to some areas. Within those areas, some rooms will feature all new partitions, whilst in others, not all partitions will be new.

From our briefing, it is understood that providing new full height partitions is unlikely to be permissible due to the intention to retain the existing ceilings. It is therefore not possible to apply the acoustic brief and partitions from the new building to comparable spaces in the refurbished areas.

A ‘standard refurbishment partition’ type, built to the ceiling line, has been provided. Refer to Table 14. This partition provides a minimum level of acoustic performance between occupied spaces and corresponds to an ‘average’ subjective rating for conversational voice according to the AAAC Guideline (Refer to Appendix 2). This partition is sensitive to the detailing at the partition/ceiling junction and a suitable, robust detail would need to be developed at the detailed design stage.

It is understood that many existing partitions are 110 mm thick single brick infill panels. With good workmanship and if the existing ceiling achieves a CAC of 35 or greater, this partition (detailed in Table 14) could provide comparable acoustic separation to the existing masonry construction (Rank 3, yellow). With some leakage at the partition head, the result may be up to 5 dB Rw lower (Rank 2, green).

Specific details for internal partition/window mullion junctions will need to be developed at the detailed design stage. Untreated junctions at mullions may compromise the acoustic separation between rooms.

Table 14 - Summary of KDH partition types – refurbished areas

Rank	Nominal Acoustic Rating, dB Rw	Height	Construction	Depth mm	CSR[1] Type	Comment
2 Green	40	Built to ceiling line with two strips of closed cell foam, caulking or other approved detail	13 mm Impact-rated[2] pb[3] 92 mm steel studs 50 mm insulation 13 mm Impact-rated pb	118	010	'Standard refurbishment partition'
3 Yellow	45	Full height	110 mm brickwork	110	n/a	Optional to match existing infill walls

Notes 1) Other manufacturers provide comparable systems including Boral and Lafarge. Consult with us should you require these product references. Note the CSR systems shown are based on fire-rated plasterboard. It is acceptable to use impact rated plasterboard.
2) 13 mm Impact-rated plasterboard has a minimum mass of 10.5 kg/m^2
3) pb = plasterboard

6.3 Audiology room - refurbished area

It is noted that an audiology room is proposed on the ground floor of the existing ward building.

No specific acoustic brief has been provided for this space and no new walls are proposed; consequently no partition or other acoustic recommendations have been provided as part of the schematic stage acoustic tasks.

7 Green Star

Green Star criteria are presented in Section 3.9.

It is a design intention to achieve the internal design sound levels in AS/NZS 2107:2000 (Refer to Table 3). It is therefore feasible achieve this Green Star credit point (IEQ 7). A detailed study of what constitutes 95% of the 'Operating Floor Area' would need to be undertaken.

In order to determine the feasibility of achieving IEQ 19, it will be necessary to assess the development according to the 'noise exposure category' parameters detailed in Table 4. At the schematic design stage, such an assessment has not been conducted. However it is considered likely that the site will fulfil the minimum 'noise exposure category' requirements.

We consider that the outdoor area to the west of the new building could be acoustically suitable as one of the 'places of respite'. If this area was selected, it would be necessary to consider treatment or relocation of the legacy kitchen fan at the north of the existing ward building. This is due to the high noise levels (approximately 65 dB(A) at the nearest accessible locations) that result from the operation of this fan. For clarity this fan is identified in Figure 3:

Figure 3 – Existing noisy fan at north of existing ward building

8 Generator room OH&S

Three options for the generator location have been evaluated in Section 4.2. Options 1 and 3 involve a containerised set. Option 2 involves an open set located in purposed designed room at lower ground floor level.

For option 2, schematic design tasks have been based upon a sound pressure level of 105 dB(A) within the generator room. This is a high sound pressure level with the potential to damage hearing within a very short time frame. Persons entering the generator room whilst the generator is operating should use appropriate personal protective equipment (PPE) to safeguard hearing in the form of:

- In-ear expanding ear plugs or
- Over-ear defenders ('ear muffs')

The individual or combined performance of the above methods should have a minimum SNR (single number rating) of 35.

In addition, signage that meets the requirements of Australian Standard AS 1319:1994[3] shall be provided at all entry points to the generator room. Figure 4 presents an example of appropriate signage.

Figure 4 – Example of signage for generator room entry points

[3] *Australian Standard AS 1319:1994 Safety signs for the occupational environment*

9 Vibration isolation

As a general rule, all mechanical services plant, lift equipment and hydraulic services require consideration of vibration isolation. This is to mitigate the transfer of vibration energy into the building structure, which can result in structure-borne noise transfer. In many cases, ductwork and pipework connected to the mechanical and hydraulic equipment must also be vibration isolated within a specified distance of the equipment.

In some cases, the vibration isolation of equipment is routine and is within the expertise and scope of equipment suppliers and contractors (e.g.: lifts, air handling units).

In other cases, an assessment of the equipment mass, operational speed, start-up characteristics and location within the building must be determined in order for vibration isolation measures and extent to be specified.

Typical vibration isolation requirements are presented in Table 15:

Table 15 - Typical vibration isolation requirements

Equipment	Mount	Isolation	Minimum static deflection (mm)
Air handling unit	Direct mount	Open spring	40
Boiler	Steel rails	Restrained spring	40
Chiller	Direct mount	Restrained spring	40
Cooling Tower >500 rpm	Direct mount	Restrained spring	20
Pump	Inertia base	Open spring	40

Generators would typically be located on steel skids (rails) to distribute load and be isolated using 50 to 100 mm deflection springs. This schematic advice would vary greatly depending on the location of the generator; with the rooftop option requiring greater controls than the undercroft or service compound options.

Note that should the generator be located within the undercroft, all exhaust pipework and mufflers, ductwork, pipework and cabling connected to the generator will require vibration isolation to control structure born noise to the ground floor occupied areas. As a preference, supporting these items from the floor rather than concrete slab above should be considered.

Should the generator be a containerised set located at roof level, the vibration isolation would form part of the generator supplier/contractor’s works. They would need to consult with the structural engineer to determine the point load static deflection of the slab under the dead load of the generator and the isolation would need to achieve a minimum isolation efficiency of 95%.

10 Construction noise and vibration

A quantitative construction noise and vibration assessment has been carried out for the redevelopment of the Kempsey District Hospital in accordance with the DGRs and the *Interim Construction Noise Guideline* (ICNG).

The ICNG aims to manage noise from construction works regulated by the Office of Environment and Heritage. It is also intended to provide guidance to other interested parties in the management of construction noise, and has therefore been adopted for this construction noise assessment.

Table 16 presents that standard hours for construction work recommended by the ICNG.

Table 16 – ICNG recommended standard hours for construction work

Day	Recommended standard hours of work
Monday to Friday	7 am to 6 pm
Saturday	8 am to 1 pm
Sunday and Public Holidays	No work

Work may be undertaken outside of the recommended standard hours where the proponent demonstrates and justifies a need for this to occur. An increased level of noise assessment is required for construction work outside of the standard hours, and stricter noise management levels are applied.

10.1 Noise-sensitive receivers

The site, including the nearest residential locations, are presented in Figure 5

The nearest sensitive receptors to the construction works are hospital wards located in the existing areas of the Kempsey District Hospital. A passive recreation area for acute care patients is also located approximately 25 metres from the new building.

The nearest residential receptors are:

- Tozer Street residences: nearest residences located approximately 100 m from the centre of the new building and 30 m from the services compound and site access road to Tozer Street
- River Street residences: nearest residence located approximately 150 m from the new building.

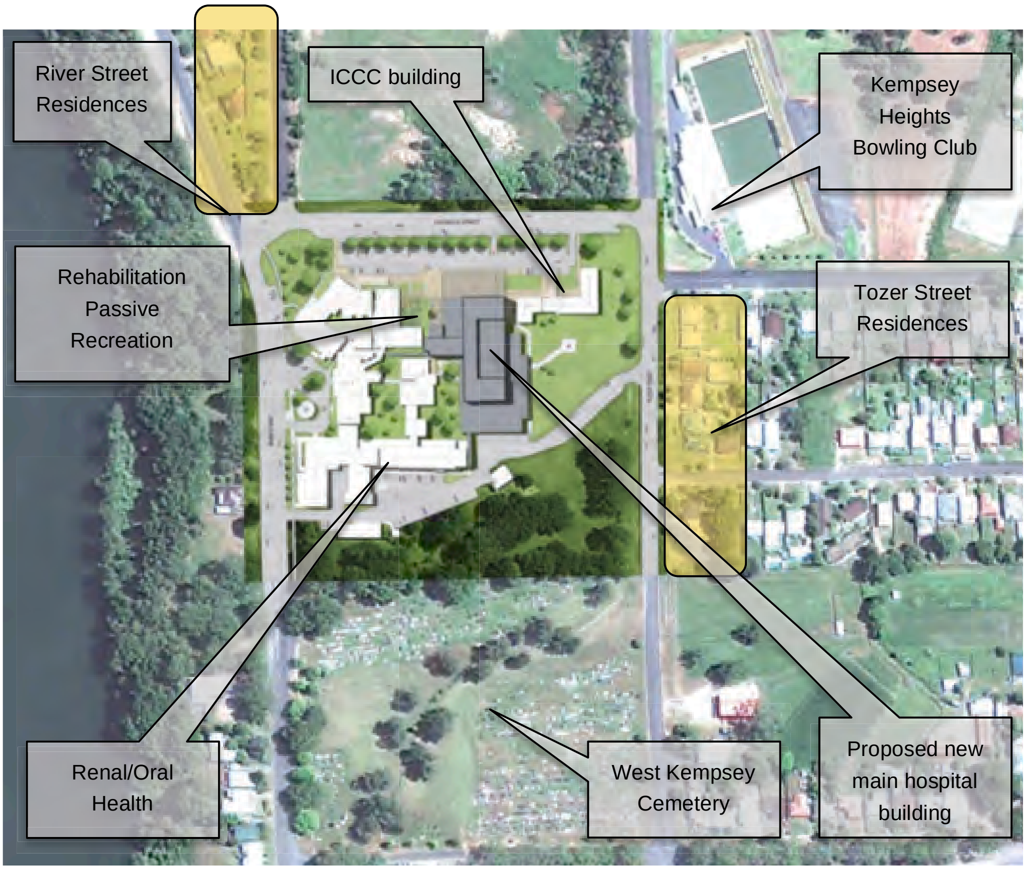

Figure 5 – Kempsey District Hospital and nearest sensitive receivers

The Kempsey Heights Bowling Club is located on the northeast side of the intersection of Tozer Street and Polwood Street, approximately 120 metres from the centre of the new building.

10.2 Schedule and hours of work

Schedule

The redevelopment of the Kempsey District Hospital is expected to commence in mid-2013 and be completed by March 2016.

Table 17 presents the expected construction schedule based on advice provided by Johnstaff Projects and BVN Donovan Hill.

Table 17 – Expected construction schedule

Phase	Description	Expected duration
Enabling works	Relocation of demountable buildings north of site near Polwood Street	< 3 months Jun 2013 – July 2013
	Construction of service road and establishment of service compound	3 months Aug 2013 – Oct 2013
Demolition & site preparation	Demolition of existing buildings to be removed, site preparation and establishment of site sheds	4 months Nov 2013 – Feb 2014
Construction of new building	Construction of new four-storey building. 2 month commissioning phase at end.	17 months Mar 2014 – Jul 2015
Refurbishment of existing Emergency Department	Refurbishment of existing Emergency Department and wards	7 months (some concurrent with construction phase)
Renovation of ICCC building	Renovation of ICCC building at corner of Polwood Street and Tozer Street	7 months Aug 2015 – Feb 2016
Refurbishment of Ante Natal	Refurbishment of Ante Natal building	Until March 2016

The phases with the potential for the most significant construction noise and vibration impacts are expected to be the demolition phase and the construction of the new four-storey building.

Hours of work

We have been advised that construction work on the Kempsey District Hospital redevelopment is only envisaged to be undertaken during the recommended standard hours of work listed in Table 16.

10.3 Noise management levels

The ICNG prescribes $L_{eq,15min}$ noise management levels for sensitive receivers as part of a quantitative construction noise assessment. Where the predicted or measured construction noise level exceeds these management levels, then all feasible and reasonable work practices should be implemented to reduce construction noise, and community consultation regarding construction noise is required to be undertaken.

Residential land uses

The noise management levels prescribed for residential land uses by the ICNG are presented in Table 18. The noise management levels apply at the most exposed property boundary of the residence at a height of 1.5 metres above ground level.

Table 18 - Noise management levels for residential land uses during standard work hours

Management level, $L_{eq,15min}$	Application notes
Noise affected: RBL + 10 dB(A)	May be some community reaction to noise. • Where the predicted or measured construction noise level exceeds the noise affected level, all feasible and reasonable work practices should be applied to meet the noise affected level. • All residents potentially impacted by the works should be informed of the nature of the works, the expected noise levels and duration, and provided with site contact details.
Highly noise affected: 75 dB(A)	May be strong community reaction to noise. • Where construction noise is predicted or measured to be above this level, the relevant authority may require respite periods that restrict the hours that the very noisy activities can occur. • Respite activities would be determined taking into account times identified by the community when they are less sensitive to noise, and if the community is prepared to accept a longer period of construction to accommodate respite periods.

The noise management levels are based on background noise measurements undertaken at a representative site to determine the Rating Background Level (RBL). With reference to Appendix 1, the measured daytime RBL is 39 dB(A). Therefore the noise affected level is 39 dB(A) + 10 dB(A) = 49 dB(A). It is noted that this is a relatively low noise level for construction noise management.

Other noise-sensitive land uses

In addition to residential land uses, noise management levels also need to be determined for existing noise-sensitive areas of the Kempsey District Hospital.

The noise management levels prescribed by the ICNG for relevant non-residential sensitive land uses are presented in Table 19.

Table 19 – Noise management levels for other sensitive land uses

Land use	Noise management level, $L_{eq,15min}$
Hospital wards and operating theatres	Internal noise level: 45 dB(A)
Passive recreation areas (Acute Care area)	External noise level: 55 dB(A)
Active recreation areas (Bowling Club)	External noise level: 65 dB(A)
Offices	External noise level: 75 dB(A)

For the purposes of this assessment, it has been assumed that the existing building facades at the Kempsey District Hospital will reduce internal noise levels by 20 dB(A) relative to external noise levels, based on 6 mm fixed glazing. This allows the application of an external noise management level of 65 dB(A) $L_{eq,15min}$ to hospital wards and operating theatres.

Note that any construction noise monitoring for hospital wards and operating theatres should be undertaken indoors (for comparison with the internal noise management levels).

Summary

Table 20 presents a summary of the external daytime noise management levels at the nearest sensitive receivers to the Kempsey District Hospital redevelopment.

Table 20 – Summary of external daytime noise management levels

Receiver	External noise management level, $L_{eq,15min}$	
	Noise affected	Highly noise affected
Residences – River Road and Tozer Street	49 dB(A)	75 dB(A)
Acute care passive recreation area	55 dB(A)	n/a
Hospital wards and operating theatres	65 dB(A)	n/a
Kempsey Heights Bowling Club	65 dB(A)	n/a
Hospital offices	75 dB(A)	n/a

10.4 Vibration management levels

The effects of ground vibration on buildings resulting from construction activities may be segregated into the following three categories:

- Human comfort – disturbance to building occupants: vibration which inconveniences or possibly disturbs the occupants or users of the building
- Effects on building contents – vibration which may affect the building contents
- Effects on building structures – vibration which may compromise the integrity of the building structure itself.

Human comfort

Vibration criteria for human comfort are more stringent than vibration criteria for effects on building contents and building structural damage. Therefore, achieving compliance with the more stringent limits dictated by human comfort will ensure that compliance is also achieved for the other two categories.

The ICNG recommends that vibration from construction works be assessed under *Assessing Vibration – a technical guideline* (the Guideline). The vibration assessment criteria defined in the Guideline are for human comfort and represent goals that, where predicted or measured to be exceeded, require the application of all feasible and reasonable mitigation measures. Where the maximum value cannot be feasibly and reasonably achieved, the operator would need to negotiate directly with the affected community.

The Guideline defines vibration assessment criteria for continuous, impulsive and intermittent vibration. Vibration can be classed according to the following definitions:

- Continuous vibration: continues uninterrupted for a defined period. Applies to continuous construction activity such as tunnel boring machinery.
- Impulsive vibration: rapid build up to a vibration peak followed by a damped decay or the sudden application of several cycles of vibration at approximately the same magnitude providing that the duration is short. Applies to very occasional construction activities that create distinct events such as the occasional dropping of heavy equipment.
- Intermittent vibration: interrupted periods of continuous vibration (such as a drill) or repeated periods of impulsive vibration (such as a pile driver).

The majority of construction works as part of the Kempsey District Hospital redevelopment would be expected to be continuous or intermittent in nature.

Table 21 presents the management levels for continuous and impulsive vibration. The management levels specified here are as overall unweighted RMS vibration velocity levels. The Guideline specifies these management levels as suitable for vibration sources predominantly in the frequency range 8 to 80 Hz as would be expected for construction vibration. Note that only daytime management levels have been presented due to the specified hours of work.

Table 21 – Daytime RMS velocity management levels for continuous and impulsive vibration

Receiver	Continuous vibration – RMS vibration velocity, mm/s		Impulsive vibration – RMS vibration velocity, mm/s	
	Preferred	Maximum	Preferred	Maximum
Operating theatres / Precision labs	0.1	0.2	0.1	0.2
Residences / Hospital wards	0.2	0.4	6	12
Offices / Consultation rooms	0.4	0.8	13	26
Workshops / Utility areas	0.8	1.6	13	26

For intermittent vibration, the Vibration Dose Value (VDV) is used as the metric for assessment as it accounts for the duration of the source, which will occur intermittently over the assessment period. The daytime VDV management levels for intermittent vibration sources are presented in Table 22.

Table 22 – Daytime VDV management levels for intermittent vibration

Receiver	VDV – intermittent vibration, $m/s^{1.75}$	
	Preferred	Maximum
Operating theatres / Precision labs	0.1	0.2
Residences / Hospital wards	0.2	0.4
Offices / Consultation rooms	0.4	0.8
Workshops / Utility areas	0.8	1.6

Structural damage

For ground vibration to be considered a risk to adjacent building structures, vibration levels may reach considerably higher values than the management levels presented for human comfort.

As there are no directly applicable Australian Standards or guidelines for assessing the levels at which construction vibration may present a risk to building structures, reference is made to German Standard DIN 4150-3.[4] The structural damage ‘safe limits’ specified by DIN 4150-3 are summarised in Table 23. The values are specified as maximum levels measured in any direction at the foundation.

Table 23 – DIN 4150-3 vibration limits

Structure type	Maximum Peak Particle Velocity (PPV), mm/s			
	Foundation of structure			Vibration at horizontal plane of highest floor at all frequencies
	<10 Hz	10-50 Hz	50-100 Hz	
Buildings used for commercial, industrial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwelling and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in rows 1 and 2, and are of great intrinsic value (e.g. heritage-listed buildings)	3	3 to 8	8 to 10	8

DIN 4150-3 recommends these values as maximum levels of short-term construction vibration, at which experience has shown that damage that reduces the serviceability of structures will not occur due to vibration effects. A reduction in serviceability of the structure is deemed to have occurred if:

- cracks form in plastered surfaces of walls
- existing cracks in the building are enlarged
- partitions become detached from loadbearing walls or floors.

If construction vibration levels are predicted to exceed the DIN 4150-3 limits, then alternative, less vibration intensive processes should be investigated.

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4 German Standard DIN 4150-3, 1999, *Structural vibration – Part 3: Effects of vibration on structures*.

10.5 Construction noise assessment

Construction activities

Exact details of the construction activities as part of the KDH redevelopment are not known at this stage. Therefore, a typical plant and equipment list for the key noise generating activities at different stages of the development has been developed based on previous project experience.

Table 24 presents the typical plant list, along with sound pressure levels at a distance of 10 metres sourced from the UK DEFRA database[5] and Appendix A of AS 2436.[6] The sound pressure levels at the higher end of the range presented in the database have been assumed for this assessment, in order to provide a more conservative assessment of construction noise.

Table 24 – Typical construction activities and plant sound levels

Stage	Equipment	Sound pressure level, 10 m from source L_{eq}, dB(A)
Enabling works – relocation of demountable buildings, construction of service road, establishment of service compound	Excavator	79
	Bulldozer	80
	Grader	85
	Truck	78
	Vibratory roller	77
	Diesel generator	65
Demolition	Handsaw	79
	Jackhammer	88
	Excavator	79
	Truck	78
	Diesel generator	65
Site preparation	Excavator	79
	Bulldozer	80
	Grader	85

[5] Department for Environment, Food and Rural Affairs (DEFRA), 2005, *Update of noise database for prediction of noise on construction and open sites*.

[6] Australian Standard AS 2436, 2010, *Guide to noise and vibration control on construction, demolition and maintenance sites*.

Stage	Equipment	Sound pressure level, 10 m from source L_{eq}, dB(A)
	Vibratory roller	77
	Truck	78
	Diesel generator	65
Construction of new building	Crane	76
	Truck	78
	Concrete pump	78
	Concrete vibrator	85
	Electric hand tools	74
	Jackhammer	88
	Diesel generator	65

Note that noise levels from refurbishment works have not been considered as part of this assessment as the works will generally take place within an existing building shell. However, where any external works are required during refurbishment phases (e.g. truck deliveries), then the predicted noise levels from previous phases may be used to provide an assessment of construction noise levels at noise-sensitive receivers.

Predicted noise levels

Construction noise levels have been predicted based on general acoustic principles, taking into account calculated sound power levels of the construction equipment and relevant acoustic factors such as distance attenuation and ground effects. Shielding has been considered at locations where this is relevant, namely the River Road residences and the Kempsey Heights Bowling Club.

Table 25 presents the predicted range of construction external noise levels at the nearest distances to the relevant sensitive receivers, and compares the predicted levels to the noise management levels. The predictions have been carried out for the different combinations of plant that would be expected to operate concurrently during each construction stage.

The predictions can be assumed to be conservative as they consider that the activities are occurring continuously for a 15-minute period and at the nearest location to the considered sensitive receivers (i.e. worst case scenarios).

For reference, the expected reductions in noise level that would occur due to less sustained period of construction activity from any given source are:

- Operation for 10 minutes of the 15 minute assessment period: 2 dB
- Operation for 7.5 minutes of the 15 minute assessment period: 3 dB
- Operation for 5 minutes of the 15 minute assessment period: 5 dB

Table 25 – Predicted construction external noise levels and comparison to noise management levels

Receiver	Noise management level (NML) $L_{eq,15min}$, dB(A)	Predicted noise levels $L_{eq,15min}$, dB(A)	Comment
Enabling works			
Residences – Tozer Street	45	57 – 74	Exceeds NML
Residences – River Road	45	44 – 52	Marginal
Rehabilitation passive recreation area	55	69 – 78	Exceeds NML
Hospital wards and operating theatres	65	68 – 76	Exceeds NML
Bowling club	65	51 – 59	Complies with NML
Hospital offices	75	68 – 76	Marginal
Demolition			
Residences – Tozer Street	45	59 – 69	Exceeds NML
Residences – River Road	45	46 – 55	Exceeds NML
Rehabilitation care passive recreation area	55	71 – 81	Exceeds NML
Hospital wards and operating theatres	65	70 – 79	Exceeds NML
Bowling club	65	55 – 62	Complies with NML
Hospital offices	75	70 – 79	Marginal
Site preparation			
Residences – Tozer Street	45	57 – 66	Exceeds NML
Residences – River Road	45	44 – 52	Marginal

Receiver	Noise management level (NML) $L_{eq,15min}$, dB(A)	Predicted noise levels $L_{eq,15min}$, dB(A)	Comment
Rehabilitation care passive recreation area	55	69 – 78	Exceeds NML
Hospital wards and operating theatres	65	68 – 76	Exceeds NML
Bowling club	65	51 – 59	Complies with noise management level.
Hospital offices	75	68 – 76	
Construction of new building			
Residences – Tozer Street	45	60 – 68	Exceeds NML
Residences – River Road	45	47 – 55	Exceeds NML
Rehabilitation care passive recreation area	55	72 – 80	Exceeds NML
Hospital wards and operating theatres	65	71 – 79	Exceeds NML
Bowling club	65	54 – 62	Complies with noise management level.
Hospital offices	75	71 – 79	Marginal

10.6 Construction vibration assessment

The level of ground vibration generated from construction activities as part of the Kempsey District Hospital redevelopment will depend on the source of the vibration, the distance to the nearest sensitive receivers and site-specific ground factors.

Table 26 presents typical vibration levels for relevant construction plant sourced from the NSW Road Traffic Authority *Environmental Noise Management Manual* (ENMM). Note that the levels are presented as peak particle velocity vibration levels rather than RMS velocity vibration levels but can be approximately compared to the vibration management levels in Table 21 by dividing the plant vibration levels by √2.

Table 26 – Typical vibration levels for construction plant at 10 m

Construction plant	Typical range of peak particle velocity from ENMM at 10 m, mm/s	Approximate RMS vibration levels at 10 m, mm/s
15 tonne roller	7 – 8	5 – 6
Roller	5 – 7	4 – 5
Bulldozer	2.5 – 4	2 – 3
Jackhammer	0.5	0.4

Table 27 presents predicted distances at which it is expected that the vibration management levels from key items of construction plant are expected to be achieved. The distances are based on vibration levels sourced from the ENMM and from measurements previously undertaken by Resonate Acoustics, as well as typical conservative ground propagation factors for vibration.

Table 27 – Predicted distances at which vibration management levels expected to be achieved

Plant item	Distance to achieve human comfort vibration management levels, m			
	Operating theatres / Precision labs	Residences / Hospital wards	Offices / Consultation rooms	Workshops / Utility areas
Vibratory roller	75	50	30	15
Excavator	35	20	10	5
Bulldozer	50	30	15	10
Jackhammer	10	5	5	5

Given the distances from construction activities to sensitive areas of the existing hospital (operating theatres, precision labs and wards), it is likely that the vibration management levels will be exceeded at times during construction. This will require the implementation of all feasible and reasonable management procedures (refer to Section 10.7).

Vibration levels at residential locations are generally expected to comply with the vibration management levels, with the exception of any vibratory roller activity within 50 metres. This may occur during establishment of the site access road and services compound. If vibratory rollers are to be used within these distances, then all feasible and reasonable management procedures should be implemented.

The structural damage limits for residential buildings are predicted to be achieved at distances greater than 15 metres from vibratory rollers and less than 10 metres from the other equipment listed in Table 27. The structural damage limits for commercial buildings at the hospital are not expected to be exceeded at distances greater than 5 metres from construction activities.

Therefore, given the typical distances from construction activities to the nearest structures, vibration from construction activities is not expected to exceed structural damage limits.

10.7 Management measures

As the noise management levels and vibration management levels are predicted to be exceeded at the nearest sensitive receivers at times during the construction phase, construction noise and vibration management measures will need to be implemented in accordance with the ICNG.

Where sensitive receivers are predicted or measured to be noise or vibration affected during construction works, all feasible and reasonable work practices should be implemented to reduce construction noise and/or vibration. An assessment of reasonable and feasible mitigation measures should be conducted by the site supervisor on a daily basis during noisy works.

In relation to the implementation of management measures, feasibility addresses engineering consideration regarding what is practical to build. Reasonableness relates to the application of judgment in arriving at a decision, taking into account the following factors:

- noise or vibration reduction achieved
- number of people benefited
- cost of the mitigation measure
- delay to schedule and whether the measure will prolong exposure to noise/vibration
- community views
- pre-construction noise and vibration levels at receivers.

Construction hours

Construction activities will be undertaken in accordance with the recommended standard construction hours from the ICNG – 7 am to 6 pm Monday to Friday and 8 am to 1 pm Saturday.

Worksite training

'Toolbox talks' should be held at regular intervals with construction workers, including discussion of noise and vibration issues and appropriate noise-related on-site behaviour.

References to noise, vibration and appropriate on-site behaviour should also be included as part of the induction process for site staff.

Temporary barriers and acoustic screening of construction activities

Where works are to be ongoing near sensitive receivers for long periods of time, such as adjacent to noise sensitive areas of the existing hospital, hoarding up to the maximum height that can be reasonable and feasibly achieved.

We understand hoarding of 2.4 metres height will be considered for construction works.

Hoarding should be placed as close as feasible to the construction works, and should be constructed of solid material (e.g. plywood) with no gaps.

Site management

Site management should include the following:

- location of noisy plant as far away from noise sensitive receptors as possible whilst still allowing efficient and safe completion of the work
- care should be taken not to drop materials to cause peak noise events, including from a height into a truck
- if materials are to be dropped into an empty truck tray or disposal bin, the tray/bin should be lined with soil or an equivalent material readily available on site to reduce impact 'drumming' noise where practicable
- plant known to emit noise strongly in one direction should be orientated so that the noise is directed away from noise sensitive areas
- machines that are used intermittently should be shut down in the intervening periods between works or throttled down to a minimum
- noisy activities should be concentrated at one location and moved to another as quickly as possible
- the reversing of vehicles should be minimised to reduce the noise from reversing signals
- the use of vehicles fitted with broadband reversing alarms should be promoted

- truck operators should ensure that tailgates are cleared and locked at the point of unloading
- vehicle warning devices such as horns should not be used as signaling devices
- two way radios should be used at the minimum effective volume
- equipment should be located to take advantage of the barriers provided by existing site features and structures
- when work is complete, the noise of packing up plant and equipment and departing from the site should be minimised.

Equipment management

Equipment management should include the following:

- selection of low-noise plant and equipment
- low vibration alternatives for plant and process should be implemented where feasible
- equipment which has a ‘Low’ and a ‘High’ vibration setting should be operated on the ‘Low’ setting where feasible
- equipment should have quality mufflers installed
- equipment should be well maintained and fitted with adequately maintained silencers which meet the design specifications
- silencers and enclosures should be kept intact, rotating plants will be balanced, loose bolts tightened, frictional noise reduced through lubrication and cutting noise reduced by keeping equipment sharp
- equipment not in use should be shut down
- only necessary power should be used to complete the task
- traffic practice controllers should be used to prevent vehicles and equipment queuing, idling or reversing near noise sensitive receivers
- truck movements along uneven surfaces should be restricted to low speed
- all plant will be properly maintained
- low vibration alternatives for plant and processes will be implemented where possible
- plant that has high and low vibration operating settings will be run on the lowest possible vibration setting where feasible
- truck movements along uneven surfaces will be restricted to low speed.

Community consultation

All noise and vibration affected residential receivers (i.e. Tozer Street residences) should be notified in writing of relevant construction activities, 5 to 14 days prior to the commencement of the activities. The notification should, at a minimum, include the nature and duration of the works, a statement regarding expected noise and/or vibration levels, as well as contact details for complaints.

Noise affected areas of the Kempsey District Hospital should also be kept informed of relevant construction activities within the same timeframes.

A consultation plan for should be developed to ensure that the relevant staff members within each area of the hospital are kept informed.

Complaint management

Clearly visible signage should be erected on the perimeter of the site identifying key site contact details for complainants.

A complaints phone number and email address should be established which is available during work hours. A complaint management procedure should be implemented, including the following processes as a minimum:

1) Assess whether the issue can be resolved easily and take immediate action if possible.
2) If not, assess the construction site and activities and determine whether there is any reason to believe the exposure of receivers is higher than anticipated.
3) Undertake monitoring of noise or vibration (where this is an appropriate response, such as for severe or persistent complaints).
4) Ensure that the appropriate consultation has been undertaken for the activity based on predicted and/or measured noise and vibration levels.
5) If step 3 demonstrates compliance, no further site actions are required (proceed to step 7).
6) If step 3 demonstrates non-compliance, implement all feasible and reasonable mitigation measures.
7) Advise complainant of actions undertaken.

A complaint register should be maintained, including name and address of complainant, nature of complaint, time and date of complaint, outcomes of investigations and any remedial actions undertaken.

11 Assumptions, risks and legacy items

11.1 Assumptions

- It is proposed to design noise emission from the KDH Redevelopment project to 5 dB below the criteria that have been derived in accordance with the NSW Industrial Noise Policy. This is to allow a noise contribution from future development that may occur. If, during the design stage, it is considered future development would account for a lesser proportion of overall site noise emission, then the permissible contribution from the KDH Redevelopment could be made higher, to a maximum of 5 dB above the criteria stated in dot points in Section 3.2. The strategy should be defined and documented during design stage works.
- It is proposed to design noise emission from the emergency backup power generator to 3 dB below the maintenance and testing criterion (derived in Section 3.3). This is to account for the equal noise contribution of a future generator, should additional capacity be required.
- The emergency backup power generator will be tested for up to one hour during the daytime period only (7 am to 6 pm Monday to Friday) which permits a 5 dB margin above the daytime normal operation criteria (Section 3.3)
- A helicopter noise intrusion criteria of 75 dB L_{Amax}, is permissible (Section 3.5)
- It is permissible to exceed normal operation noise levels within nearby hospital buildings and within the hospital grounds whilst the emergency backup power generator(s) are operational during periodic testing and during grid failure. (Section 4.2)
- It is assumed that that the quoted sound pressure levels for containerised generator sets are omni-directional. That is, the industry-quoted sound pressure level would be the same at any position 7 metres from the acoustic centre of the containerised set. (Section 4.2)
- It is permissible to build new partitions in the refurbished area to the ceiling line only. This is on the basis that the existing ceilings will be retained. This will limit the theoretical laboratory acoustic performance of these partitions to between 40 dB Rw (with typical noise leakage at the partition/ceiling junction and/or a ceiling system of below CAC 35) to 45 dB Rw (with no noise leakage at the partition/ceiling junction and a ceiling system of greater than CAC 35) (Section 6.2).

11.2 Risks

- If it is not permissible to exceed normal operation noise levels whilst the emergency backup power generator(s) are operational, additional acoustic controls will be required for the containerised generator(s). The containers would increase in size and cost.
- If the helicopter noise intrusion criterion is not permissible (and a lower criterion is required by the client or users), the glazing system on the east and south facades would require significant additional upgrades and the window systems would be likely to exceed commercially available systems.
- There is no acoustic brief or proposed acoustic treatment for the audiology room on the ground floor of the existing ward building. This room may therefore not achieve acoustic performance requirements commensurate with its intended use.

11.3 Legacy items

- The existing fan located in the undercroft walkway to the north of the existing ward building is noisy, resulting in a sound pressure level of approximately 65 dB L_{Aeq} immediately below the fan intake. Noise from this fan will impact amenity in the outdoor courtyard area to the west of the new main building. It will also impact the ability to obtain Green Star points for this space if it is to be used as a 'Place of Respite' under Green Star Healthcare v1. (Refer Sections 3.9 and 7).
- Legacy noise sources that are to be retained in the refurbished areas may not meet the internal noise criteria established as part of the new build works, either in isolation or combined with the contribution of new sources designed to meet their respective criteria.
- Legacy glazing in refurbished areas is unlikely to control noise intrusion from helicopter pass-bys to the suggested internal noise criterion.
- Legacy partitions in refurbished areas may not provide equivalent acoustic performance to partitions provided for comparable use spaces in the new building.
- Unless specifically stated otherwise, no survey work has been performed to establish the acoustic performance of legacy constructions or the noise emission of legacy noise sources.

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Appendix 1 – Noise logging

Noise logging procedure and location

Unattended noise measurements have been conducted at the eastern boundary of the hospital helicopter landing site during the period Wednesday 9th January to Tuesday 15th January 2013. The equipment used was a Rion NL-18 environmental noise logger, serial number 00460076. The logger calibration was checked prior to, and after noise measurements, and calibration drift did not exceed 0.5 dB.

The noise logger was configured to record all relevant noise indices including background noise (L_{A90}) and equivalent continuous noise levels (L_{Aeq}). Samples were recorded at 15 minute intervals. The noise logger response was set to fast.

The noise logging location is considered representative of the background noise environment at the nearby residential receivers in Tozer Street. The logging location is not subject to any continuous stationary mechanical services noise sources associated with the hospital. During daytime visits to deploy and collect the logger, the noise environment was characterised by infrequent road traffic noise, typical suburban people noise activity and natural sounds such as cicadas.

The equipment location is identified in Figure 6:

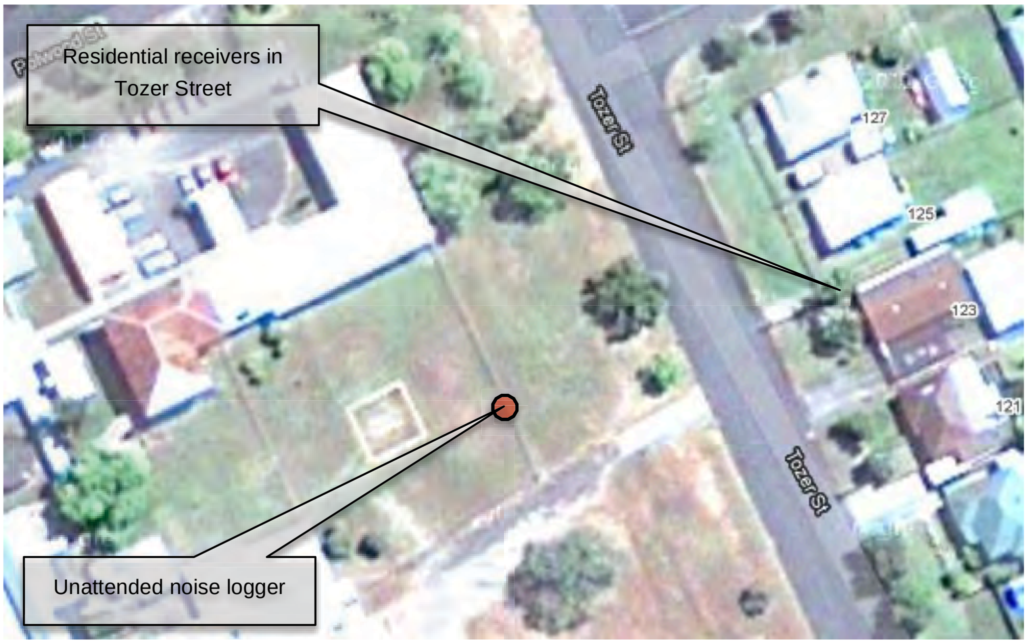


Figure 6 - Unattended noise logging location

Noise logging weather conditions

In order to verify that noise data was obtained during suitable meteorological conditions, half-hourly weather data was obtained from the Bureau of Meteorology (BOM) Automatic Weather Station (AWS) 059007 at Kempsey Airport, approximately 5 km to the west.

Noise data has been excluded from the processed results if:

- Rain was observed during the fifteen minute measurement period and/or
- Wind speed exceeded 5 m/s (18 km/h) at the measurement height of 1.5 m above ground. Wind data obtained from the BOM is presented as the value at 10 m above ground, and these values are halved for the purpose of assessing wind speed at 1.5 m above ground.

Data has also been excluded if is considered spurious upon visual inspection of the charts.

Noise logging graphed results

For reference, a weekly chart showing the graphed noise levels is shown in Figure 7. The background noise level is the lowest green line entitled L_{A90}:

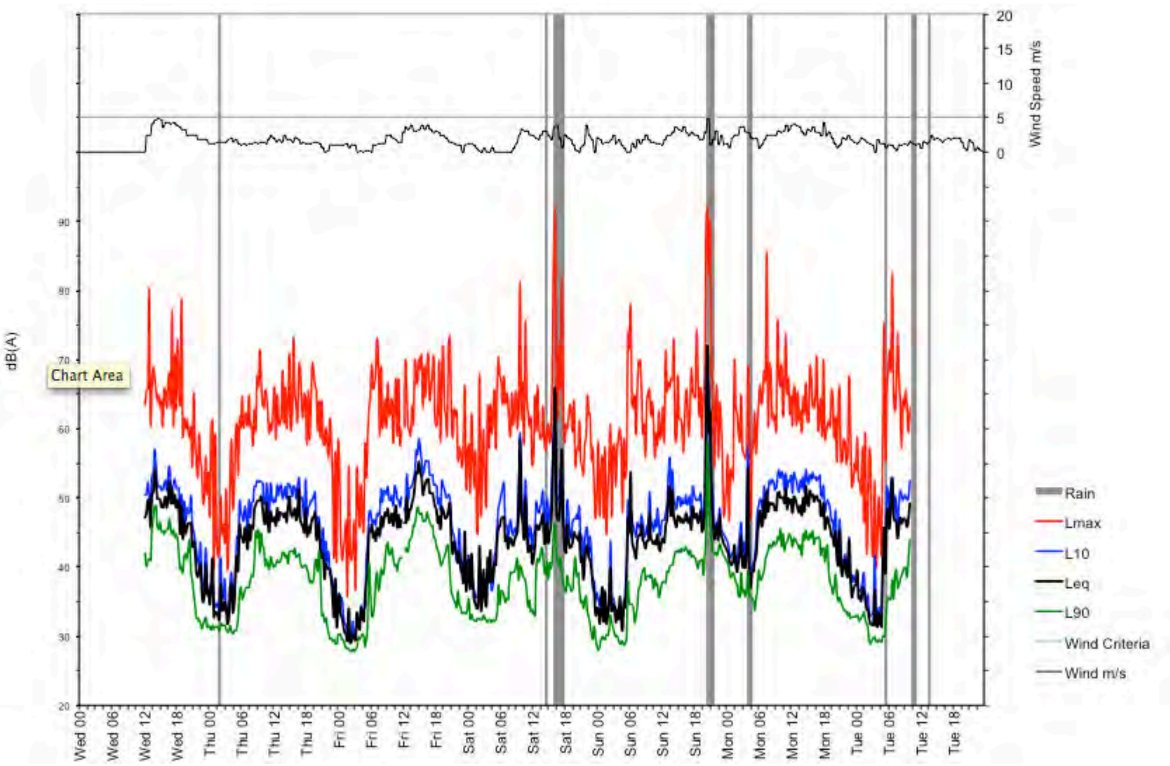


Figure 7 - Noise logging chart Wednesday 9 January to Tuesday 15 January 2013

Measured noise Levels – INP time periods

For the purpose of assessment against Industrial Noise Policy requirements, the measured data has been processed into time periods as follows:

- Daytime: 07:00 to 18:00
- Evening: 18:00 to 22:00
- Night-time: 22:00 to 07:00

The measured background (L_{A90}) and equivalent continuous (L_{Aeq}) noise levels during these defined time periods are presented in Table 28.

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

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

Table 28 - Measured noise levels – INP time periods

Noise metric	Measured Noise Level (dB re 20 µPa)		
	Daytime 07:00 – 18:00	Evening 18:00 – 22:00	Night-time 22:00 – 07:00
RBL	39	35	30
L_{Aeq}	49	46	42

Based on observations on site, it is considered that the noise environment near to the proposed development site is free of existing industrial noise contribution and therefore the values shown in Table 28 shall be used unadjusted.

These values have been used to derive the industrial noise (intrusive) criteria for the site, as discussed in Section 3.2.

It is acknowledged that the noise logging was undertaken during a school holiday period. The criteria derived from the logging may be conservative by an insignificant margin.

Appendix 2 – Partition design

Resonate Acoustics has derived partition design acoustic recommendations from UK Department of Health Estates and Facilities Division *Acoustics: Health technical memorandum 08-01* and Association of Australian Acoustical Consultants (AAAC), *Guideline for Commercial Building Acoustics.*

The 'source room activity noise' and 'receiving space noise tolerance' concepts from the AAAC document (which addresses commercial buildings) have been cross referenced with the involved numerical procedures of the UK document (covering hospitals) to derive the source and tolerance levels shown in Table 29. In turn these are used to select appropriate partition ratings shown in the Appendix 3 partition mark-ups.

Table 29 - Source and Tolerance Levels for Health Care facilities

Type of occupancy / activity	Source room activity noise	Receiving Space noise tolerance
Ward (1 bed)	Average	Low
Ward (>1 bed)	Average	Medium
Birthing room / Nurseries	Very High	Low
Wet area for ward	Average	Medium
Public toilet	Average	Medium
Corridor (no door)	Average	High
Dirty utility room	Average	High
Clean utility / Store room	Low	High
Main kitchen	Very High	High
Ward kitchen / Pantries	Average	High
Operating theatre	Average	Very Low
Consulting room	Average	Low
Treatment room	Average	Low
Interview room	Average	Low
Seminar / Education room	High	Low
Private office	Average	Low

Type of occupancy / activity	Source room activity noise	Receiving Space noise tolerance
Open office	Average	Medium
Waiting / Reception areas	Average	Medium
Meeting room	Average	Low
Boardroom	High	Low

Note that where a room identified in the plans does not meet the exact description in Table 29, judgement has been applied based on experience of similar developments. In some cases it is also appropriate to maintain a higher rating on short sections of partition that would otherwise have a lower rating, in order that the ratings do not continuously change along the length of a partition.

Based on a room's source activity level and the adjacent room's noise tolerance levels, an appropriate R_W for the separating wall may be determined in accordance with Table 30. This table is based on the sound ratings recommended in the *Guideline for Commercial Building Acoustics*[7].

Table 30 - R_W ratings for dividing partitions

Noise tolerance in receiving room	Source room activity noise			
	Low	Average	High	Very High
High	R_W 35	R_W 40	R_W 45	R_W 50
Medium	R_W 40	R_W 45	R_W 50	R_W 55
Low	R_W 45	R_W 50	R_W 55	R_W 60
Very Low	R_W 50	R_W 55	R_W 60	R_W 65

The ratings in Table 30 are based on a typical background noise level of 40 dB(A) L_{eq}.

For lower internal noise levels, the R_W rating needs to be increased to achieve a similar subjective performance. For every 5 dB(A) reduction in the background noise level, the R_W rating should be increased by 5 dB to achieve the same subjective performance.

Table 31 below indicates the typical subjective performance of internal partitions and some general information on acoustic separation between internal spaces.

[7] Association of Australian Acoustical Consultants (AAAC), *Guideline for Commercial Building Acoustics*

Table 31 - Acoustic separation, subjective performance and typical recommended use

R_W	Subjective performance of the separation of different sources	
	Conversational voice	**Raised voice**
40	Average	Poor
45	Average to Good	Poor to Average
50	Good	Average
55	Very Good	Good
60	Excellent	Very Good

The subjective descriptors in Table 31, are explained below:

- Poor—most words are intelligible in the adjacent space.
- Average—some words may be intelligible but conversation not understandable.
- Good—words are generally not intelligible.
- Very Good—suitable for confidential conversations.

Appendix 3 – Partition mark-ups

Resonate acoustics

KDH Lower Ground Floor

Key **Note: Staggered stud partitions shown dashed**

Partitons:

Rank 1

Rank 2

Rank 3

Rank 4

Rank 5

Rank 6

Absorptive Treatment

Resonate acoustics

KDH Emergency Department | Level 00

Key **Note: Staggered stud partitions shown dashed**

Partitons:

Rank 1

Rank 2

Rank 3

Rank 4

Rank 5

Rank 6

Absorptive Treatment

Key **Note: Staggered stud partitions shown dashed**

Partitons:

Rank 1

Rank 2

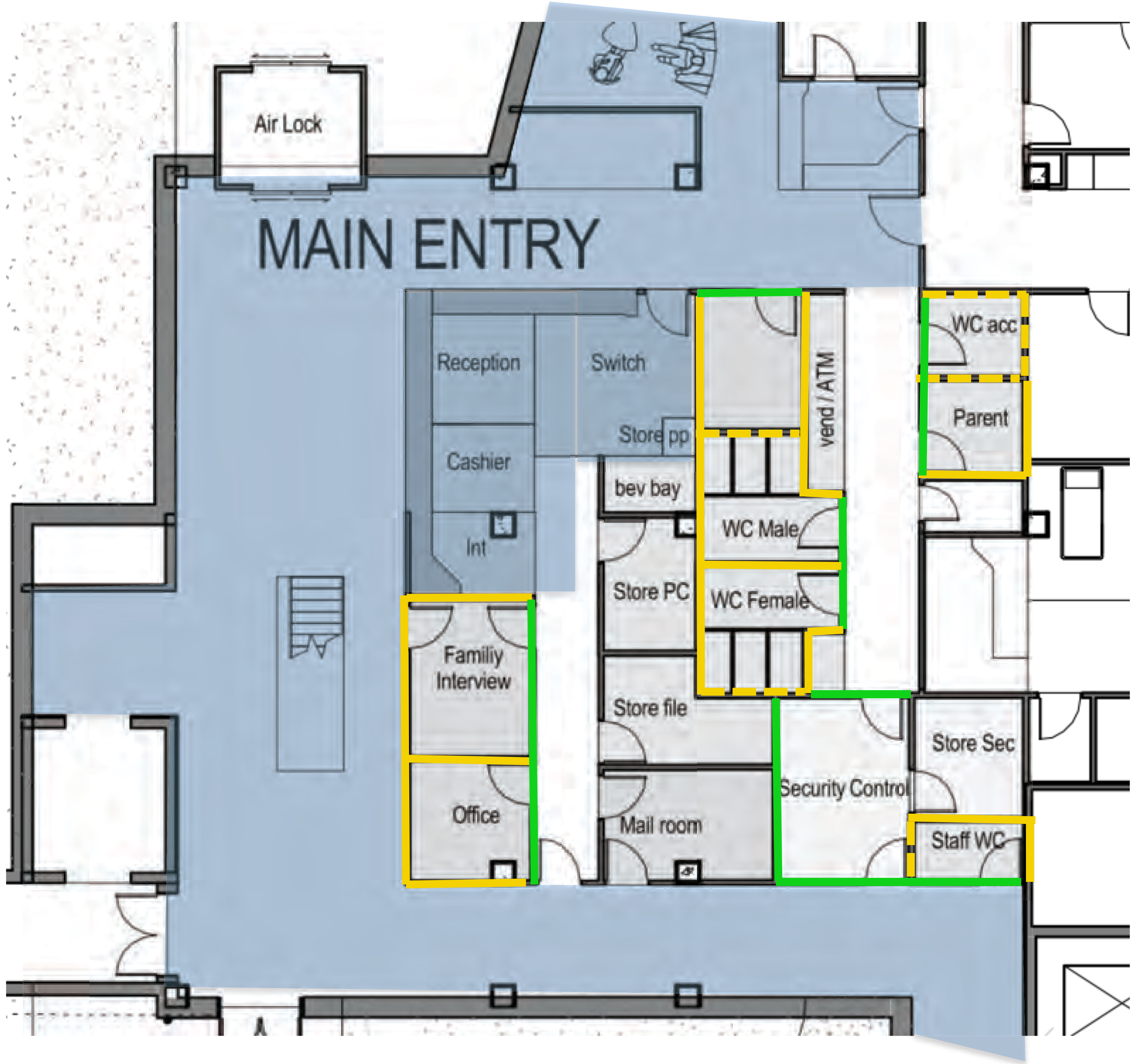
Rank 3

Rank 4

Rank 5

Rank 6

Absorptive Treatment



KDH Imaging Department | Level 00

Key **Note: Staggered stud partitions shown dashed**

Partitons:

Rank 1

Rank 2

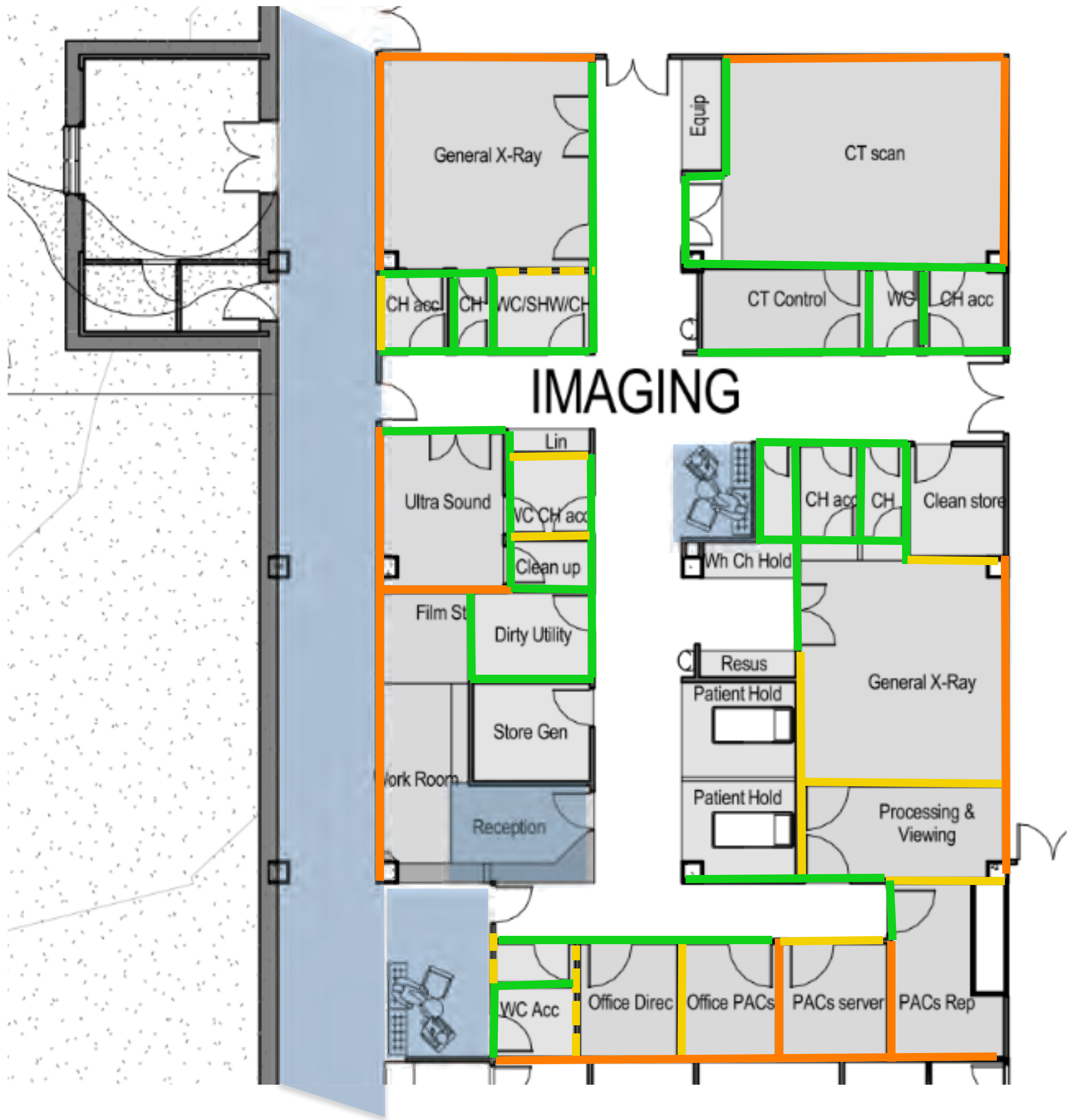
Rank 3

Rank 4

Rank 5

Rank 6

Absorptive Treatment



Key **Note: Staggered stud partitions shown dashed**

Partitons:

Rank 1

Rank 2

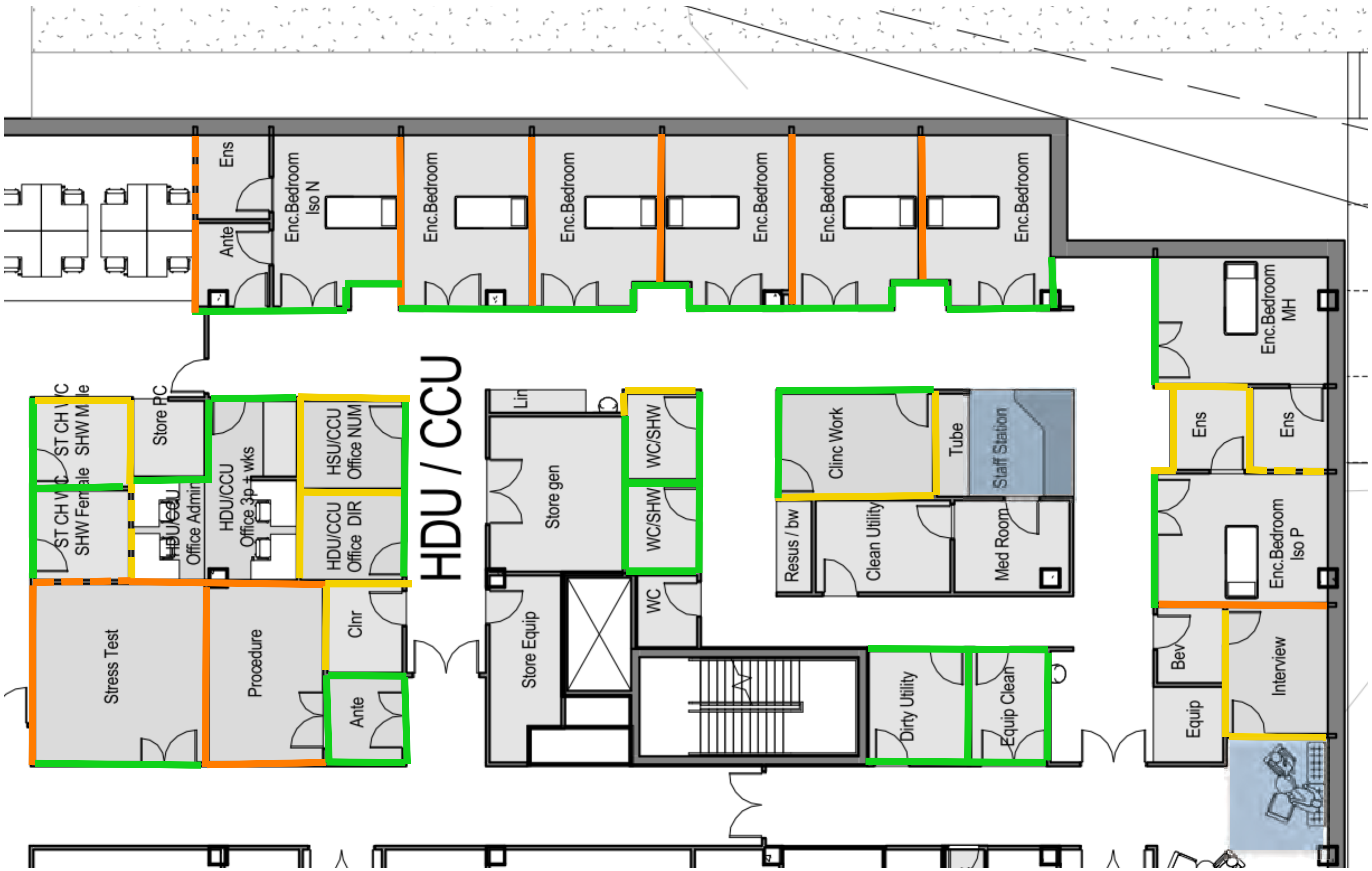
Rank 3

Rank 4

Rank 5

Rank 6

Absorptive Treatment



Key **Note: Staggered stud partitions shown dashed**

Partitons:

Rank 1

Rank 2

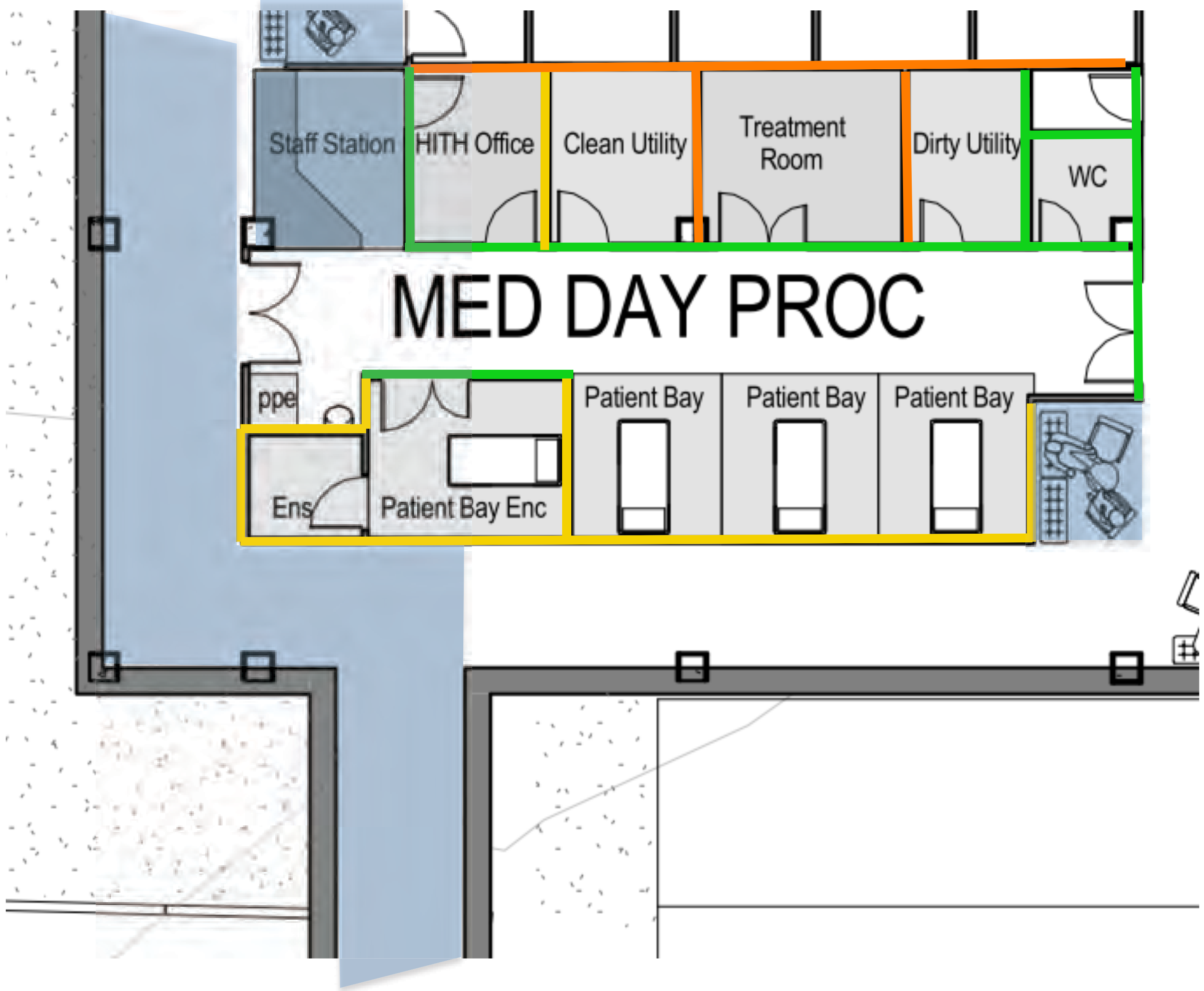
Rank 3

Rank 4

Rank 5

Rank 6

Absorptive Treatment



Key

Partitons:

Rank 1

Rank 2

Rank 3

Rank 4

Rank 5

Rank 6

Absorptive Treatment

Note: Partition Rankings for mechanical service risers subject to quantitative mechanical services assessment at detailed design stage.

Resonate acoustics

Key **Note: Staggered stud partitions shown dashed**

Partitons:

Rank 1

Rank 2

Rank 3

Rank 4

Rank 5

Rank 6

Absorptive Treatment

Discontinuous partition construction to separate riser from occupied space (typical all risers adjacent occupied space)

Discontinuous partition construction to separate wet areas from occupied space (shown dashed) (typical)

Note: Partition Rankings for mechanical service risers subject to quantitative mechanical services assessment at detailed design stage.

Key **Note: Staggered stud partitions shown dashed**

Partitons:

Rank 1

Rank 2

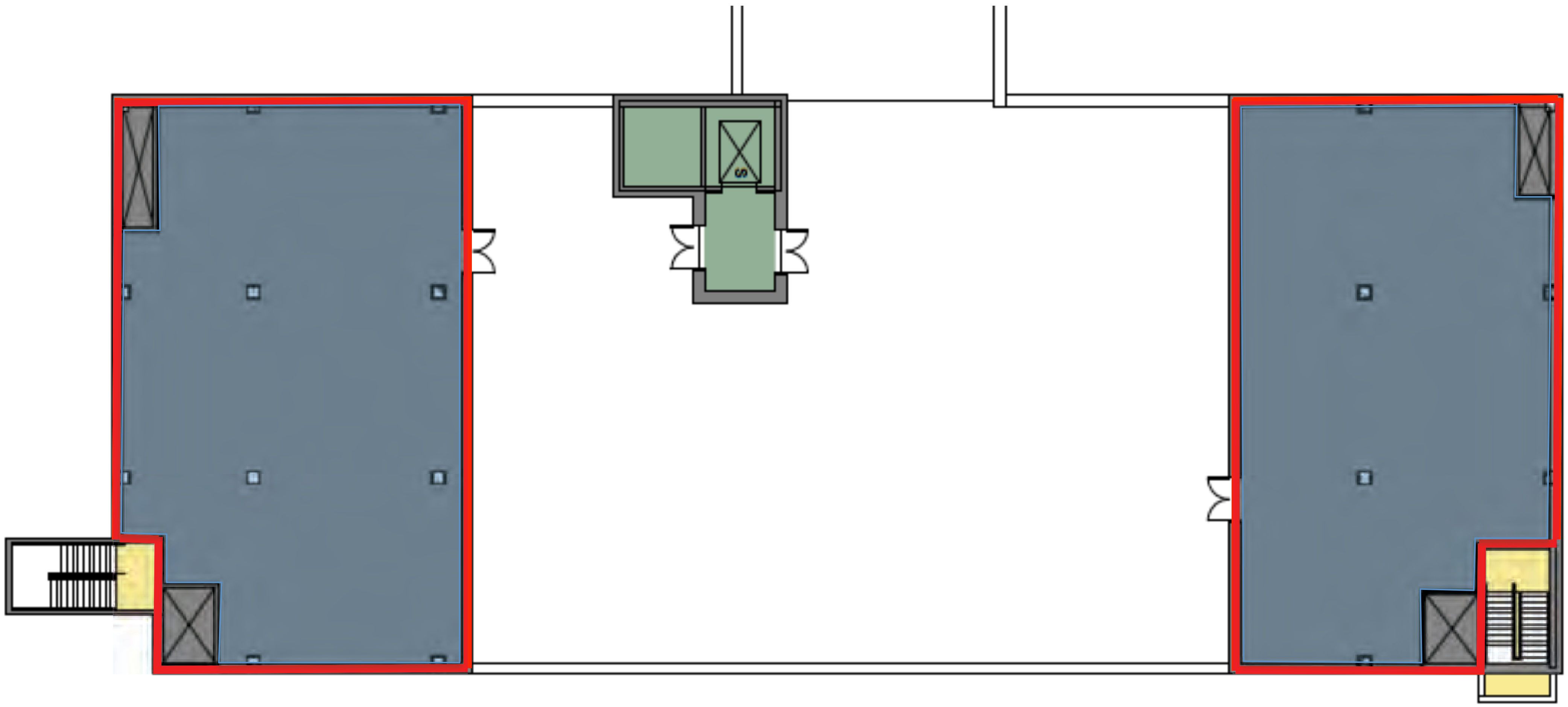
Rank 3

Rank 4

Rank 5

Rank 6

Absorptive Treatment



Note: Partition Rankings for plant rooms subject to quantitative mechanical services assessment at detailed design stage.

Appendix 4 – Partition data sheets

Resonate acoustics

35 dB Rw | Rank 1 | Partition

Summary

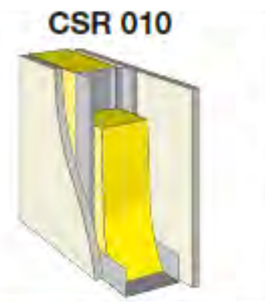
- The 35 dB Rw partition is an absolute bare minimum acoustic design to ensure that a minimum level of separation is provided between two spaces.
- It is classified as 'poor' according to the AAAC *Guidelines for Commercial Building Acoustics*
- This construction can be built to the ceiling line of a CAC 35 ceiling.

Ceiling Baffle	Thickness (mm)	Lining Mass (kg/m^2)	Cost (re 40 dB Rw)
Not required	90	13	- 10 %

Rw Rating	Rank 1 System	Resonate Library Data	Comparable System 1	Comparable Rating 1	Comparable System 2	Comparable Rating 2
35	• **13 mm standard plasterboard** • **64 mm steel studs** • **13 mm standard plasterboard** • **No insulation in the cavity**	*64mm steel studs at 600mm centres, one layer 13mm standard plasterboard on each side with no insulation in cavity*	CSR Redbook 2011 CSR 010 Page B9	35	Boral Selector S1313 Page B2	35

Standard plasterboard >= 8.5 kg/m^2, Dense plasterboard >= 10.5 kg/m^2, Sound rated plasterboard >= 12.5 kg/m^2

Industry Data



CSR 010

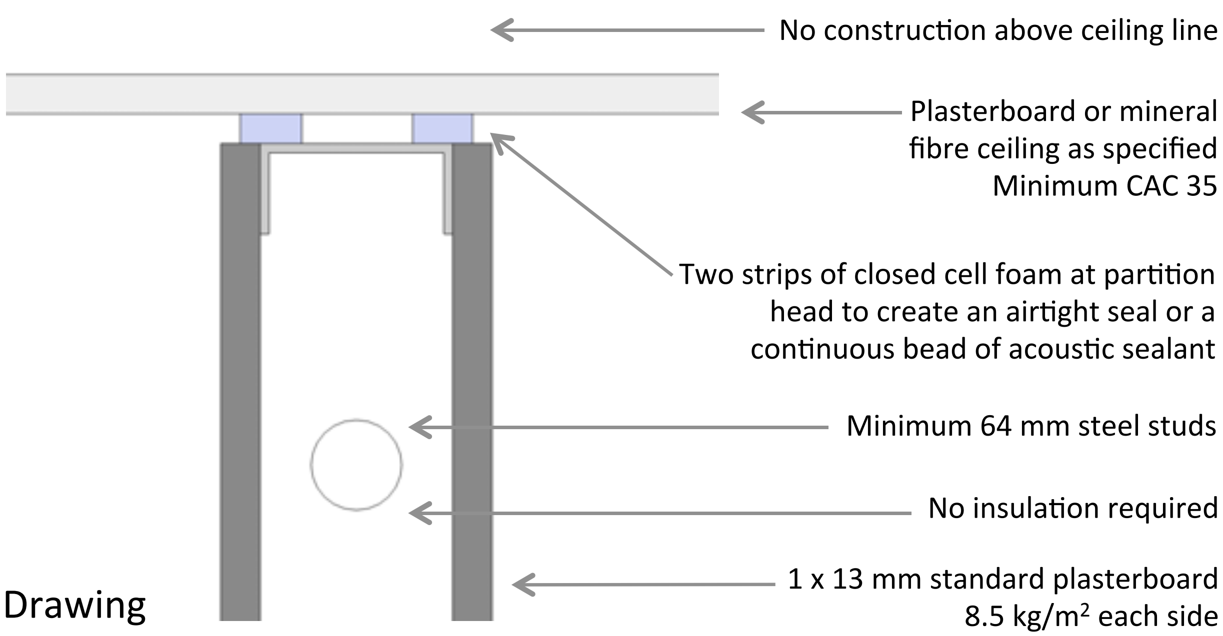
BOTH SIDES

- 1 x 13mm GYPROCK Plasterboard CD.

(a) Nil	34/26	35/28
(b) 50 GW Partition 11kg	39/29	40/31
(c) 75 GW Partition 11kg	–	42/33
(d) TSB3/ASB3 Polyester	39/31	39/32
(e) 60 Soundscreen™ 1.6	–	41/31
WALL THICKNESS mm	77	90

Transmission Loss Values (dB)

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	10	26	37	45	44	37	-



Drawing

35 dB Rw | Rank 1 | Doors and Glazing

Summary - Doors

- On the basis of a door area being **25%** of the total partition, it is preferred that the door rating is within 10 R_W points of the partition giving a net reduction of 5 R_W points.
- The above reductions in performance must include the performance of the door seals; otherwise significant additional reductions in performance will occur.
- Felt seals are acceptable for Rank 1 Doors and glazing, however it is recommend that a felt seal with a plastic centre septum such a *Raven 'Glidefin'* or Schlegel 'Finseal T-slot' be used.

Rw Rating	Rank 1 Door System	Typical Door Thickness (mm)	Typical Door Mass (kg/m²)	Perimeter Seals	Threshold Seal
25	32 mm thick solid core door	32	18	Felt seals with centre septum optional but not required	Not necessary (minimise gaps)

Glazing Transmission Loss Values

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	17	24	27	32	28	34	-

Door Transmission Loss Values

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	17	21	26	29	31	34	-

Rw Rating	Rank 1 Glazing System	Typ. Glazing Thickness (mm)	Typical Glazing Mass (kg/m²)	Frame	Edge mounting
30	Any choice subject to safety requirements	Any choice subject to safety requirements	15	No special requirements	No special requirements

Summary - Glazing

- A lower acoustic rating can normally be tolerated where glazing is used in place of a solid partition. It would also be onerous to require glazing with the same rating. Therefore for each partition Rank, the default glazing is 5 dB Rw lower than the plasterboard partition.
- On the basis of a glazed area being **50%** of the total partition, it is preferred that the glazing rating is within 5 R_W points of the partition resulting in a net reduction of 3 R_W points .

40 dB Rw | Rank 2 | Partition

Summary

- This project specific construction achieves closer to 38 dB Rw with no insulation and would exceed 40 dB Rw with insulation in the void

Baffle	Thickness (mm)	Lining Mass (kg/m²)	Cost (re 40 dB Rw)
Not proposed for KDH project	118	21	+ 0%

Rw Rating	Rank 2 System	Resonate Library Data	Comparable System 1	Comparable Rating 1	Comparable System 2	Comparable Rating 2
40	• **13 mm dense plasterboard** • **92 mm steel studs** • **13 mm dense plasterboard** • **No insulation**	*16 mm standard plasterboard/ 92 mm steel studs/16 mm standard plasterboard/no insulation*	CSR Redbook 2011 CSR 050 Page B11	40	Boral Selector S1313F Page B2.6	37

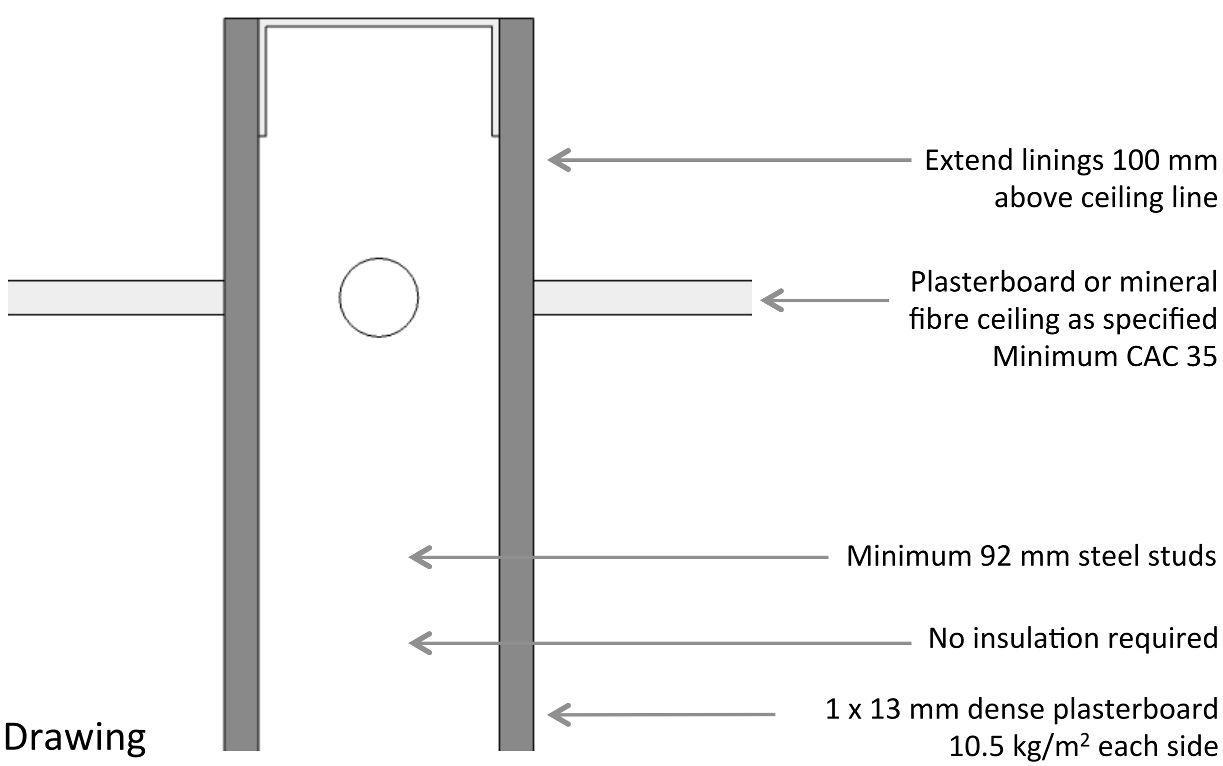
Standard plasterboard >= 8.5 kg/m², Dense plasterboard >= 10.5 kg/m², Sound rated plasterboard >= 12.5 kg/m²

Industry Data

(a) Nil	36/29	38/31	38/3[illegible]	40/3[illegible]
(b) 50 GW Partition 14kg	42/33	44/35	44/3[illegible]	46/[illegible]7
(c) 75 GW Partition 11kg	–	45/36	44/35	46/37
(d) TSB3/ASB3 Polyester	41/34	42/35	42/35	44/37
(e) 60 Soundscreen™ 1.6	–	44/34	44/34	46/36
WALL THICKNESS mm	77	90	102	118

Transmission Loss Values (dB)

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	13	29	40	47	46	51	-



Drawing

40 dB Rw | Rank 2 | Doors and Glazing

Summary - Doors

- On the basis of a door area being **25%** of the total partition, it is preferred that the door rating is within 10 R_W points of the partition giving a net reduction of 5 R_W points.
- The above reductions in performance must include the performance of the door seals; otherwise significant additional reductions in performance will occur.
- Light duty acoustic seals (perimeter and threshold) are required for Rank 2 doors.

Rw Rating	Rank 2 Door System	Typical Door Thickness (mm)	Typical Door Mass (kg/m²)	Perimeter Seals	Threshold Seal
30	45 mm thick solid core door Raven or Kilargo Seals all round	45	21	Raven RP 120 'Delta' OR Kilargo IS1212 OR 1515	Raven RP 8 closing onto RP96 threshold OR Kilargo 8000 series closing onto 4000 series threshold

Glazing Transmission Loss Values

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	26	30	34	33	34	44	-

Door Transmission Loss Values

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	20	22	24	30	33	36	-

Rw Rating	Rank 2 Glazing System	Typ. Glazing Thickness (mm)	Typical Glazing Mass (kg/m²)	Frame	Edge mounting
35	10.38 mm laminated glass	10.38	26	No special requirements	No special requirements

Summary - Glazing

- A lower acoustic rating can normally be tolerated where glazing is used in place of a solid partition. It would also be onerous to require glazing with the same rating. Therefore for each partition Rank, the default glazing is 5 dB Rw lower than the plasterboard partition.
- On the basis of a glazed area being **50%** of the total partition, it is preferred that the glazing rating is within 5 R_W points of the partition resulting in a net reduction of 3 R_W points .

45 dB Rw | Rank 3 | Partition

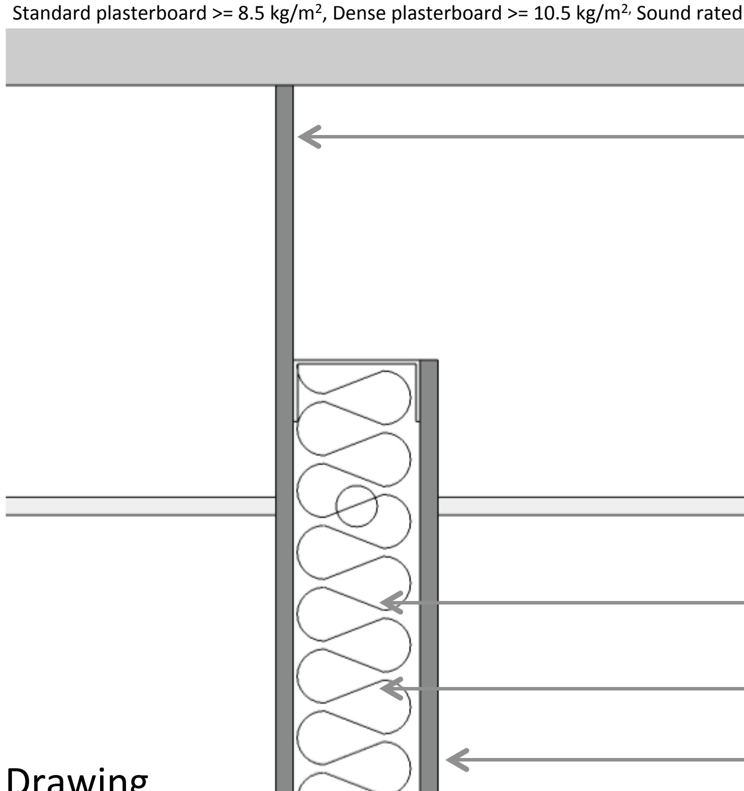
Summary

- Project specific construction
- Upgrade over Rank 2 is the insulation material in the void and extending one layer of plasterboard lining to the underside of the soffit above

Ceiling Baffle	Thickness (mm)	Lining Mass (kg/m^2)	Cost (re 40 dB Rw)
One layer of plasterboard	118	21	+ 30 %

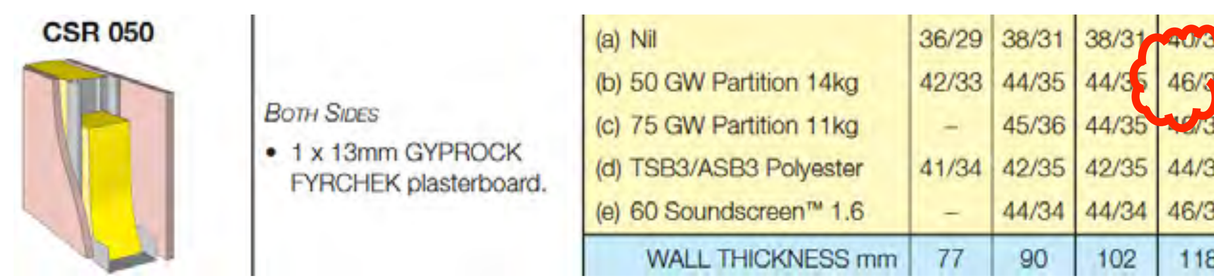
Rw Rating	Rank 3 System	Resonate Library Data	Comparable System 1	Comparable Rating 1	Comparable System 2	Comparable Rating 2
45	• **13 mm dense plasterboard** • **92 mm steel studs** • **1 x 13 mm dense plasterboard** • **50-100 mm 14 kg/m³ insulation**	*16mm plasterboard/92mm steel studs/16mm plasterboard with 100 mm 0.8kg/m² fibreglass in cavity*	CSR Redbook 2011 CSR 040 Page B11	46	Boral Selector S1313F Page B2.6	46

Standard plasterboard >= 8.5 kg/m^2, Dense plasterboard >= 10.5 kg/m^2, Sound rated plasterboard >= 12.5 kg/m^2



Drawing

Industry Data


CSR 050

BOTH SIDES
- 1 x 13mm GYPROCK FYRCHEK plasterboard.

(a) Nil	36/29	38/31	38/31	40/33
(b) 50 GW Partition 14kg	42/33	44/35	44/35	46/37
(c) 75 GW Partition 11kg	–	45/36	44/35	46/37
(d) TSB3/ASB3 Polyester	41/34	42/35	42/35	44/37
(e) 60 Soundscreen™ 1.6	–	44/34	44/34	46/36
WALL THICKNESS mm	77	90	102	118

Transmission Loss Values (dB)

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	18	33	44	49	53	59	-

Resonate acoustics

45 dB Rw | Rank 3 | Doors and Glazing

Summary - Doors

- On the basis of a door area being **25%** of the total partition, it is preferred that the door rating is within 10 R_W points of the partition giving a net reduction of 5 R_W points.
- The above reductions in performance must include the performance of the door seals; otherwise significant additional reductions in performance will occur.
- Light duty acoustic seals are required for Rank 1 doors.

Rw Rating	Rank 3 Door System	Typical Door Thickness (mm)	Typical Door Mass (kg/m²)	Perimeter Seals	Threshold Seal
35	50 mm thick solid core door Raven or Kilargo Seals all round	50	29	Yes – onto positive rebate	Yes– onto positive rebate

Glazing Transmission Loss Values

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-							-

Door Transmission Loss Values

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	24	29	32	34	36	45	-

Rw Rating	Rank 3 Glazing System	Typ. Glazing Thickness (mm)	Typical Glazing Mass (kg/m²)	Frame	Edge mounting
40	12.5 mm Viridian V-lam Hush or Double Glazed: 6.38 mm lam/50 mm air gap/10.38 mm lam	12.5 or 58	31 or 42	One frame acceptable for double glazing	Soft edge mounting

Summary - Glazing

- A lower acoustic rating can normally be tolerated where glazing is used in place of a solid partition. It would also be onerous to require glazing with the same rating. Therefore for each partition Rank, the default glazing is 5 dB Rw lower than the plasterboard partition.
- On the basis of a glazed area being **50%** of the total partition, it is preferred that the glazing rating is within 5 R_W points of the partition resulting in a net reduction of 3 R_W points .

50 dB Rw | Rank 4 | Partition

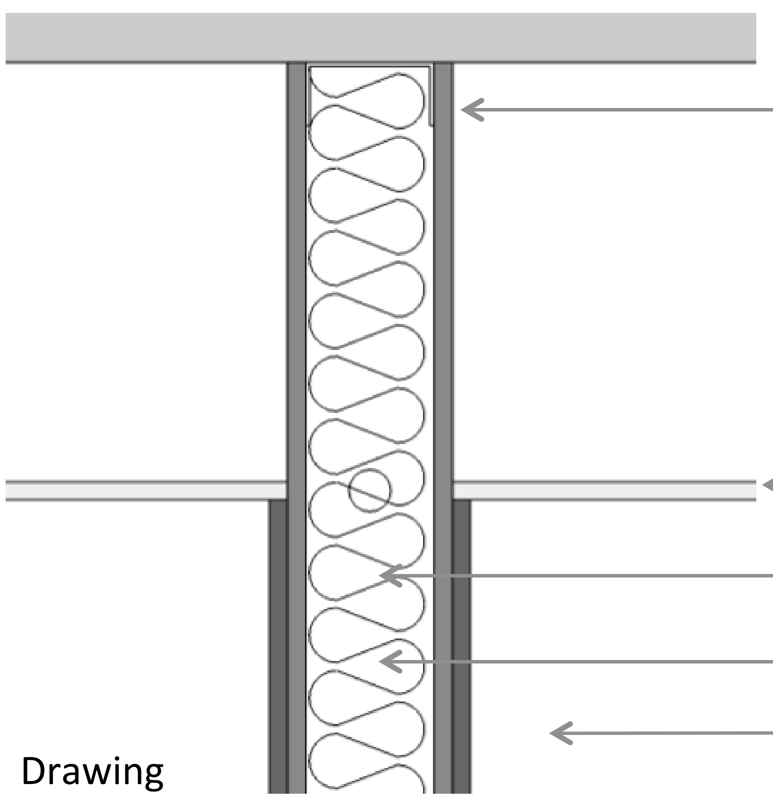
Summary

- Project specific construction
- Upgrades over Rank 3 are the additional plasterboard linings and extending two layers of plasterboard (one on each side of the studs) to the underside of the soffit above

Ceiling Baffle	Thickness (mm)	Lining Mass (kg/m²)	Cost (re 40 dB Rw)
Two layers of plasterboard	144	42	+ 70 %

Rw Rating	Rank 4 System	Resonate Library Data	Comparable System 1	Comparable Rating 1	Comparable System 2	Comparable Rating 2
50	• **2 x 13 mm dense plasterboard** • **92 mm steel studs** • **2 x 13 mm dense plasterboard** • **100 mm 14 kg/m³ insulation**	*Two layers 16 mm gypsum board on both sides of 92 mm steel studs at 600 mm centres with blanket in cavity*	CSR Redbook 2011 CSR 075 Page B11	52	Boral Selector S2626F Page B2.7	53

Standard plasterboard >= 8.5 kg/m², Dense plasterboard >= 10.5 kg/m², Sound rated plasterboard >= 12.5 kg/m²



Extend two layers of plasterboard lining to underside of soffit above. Seal to soffit.

Plasterboard or mineral fibre ceiling as specified Minimum CAC 35

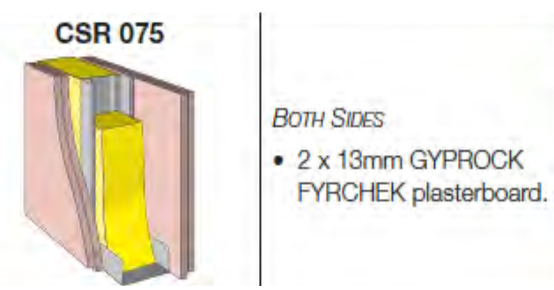
Minimum 92 mm steel studs

100 mm 14 kg/m² insulation

2 x 13 mm dense plasterboard 10.5 kg/m² each layer each side

Drawing

Industry Data



(a) Nil	44/37	45/38	46/40	47/41
(b) 50 GW Partition 11kg	49/40	50/41	51/43	52/4[illegible]
(c) 75 GW Partition 11kg	–	52/43	52/44	52/45
(d) TSB3/ASB3 Polyester	49/42	49/42	50/44	51/45
(e) 60 Soundscreen™ 1.6	–	51/41	52/43	53/44
WALL THICKNESS mm	103	116	128	144

Transmission Loss Values (dB)

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	28	40	50	56	52	60	-

Resonate acoustics

50 dB Rw | Rank 4 | Doors and Glazing

Summary - Doors

- On the basis of a door area being **25%** of the total partition, it is preferred that the door rating is within 10 R_W points of the partition giving a net reduction of 5 R_W points.
- The above reductions in performance must include the performance of the door seals; otherwise significant additional reductions in performance will occur.

Rw Rating	Rank 4 Door System	Typical Door Thickness (mm)	Typical Door Mass (kg/m²)	Perimeter Seals	Threshold Seal
40	60 mm thick solid core door with full suite of seals. Door and frame designed and manufactured as one item	60	32	Yes – onto positive rebate	Yes– onto positive rebate

Glazing Transmission Loss Values

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	28	36	42	46	50	55	-

Door Transmission Loss Values

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	25	28	40	44	40	43	-

Rw Rating	Rank 4 Glazing System	Typ. Glazing Thickness (mm)	Typical Glazing Mass (kg/m²)	Frame	Edge mounting
45	10.38 mm laminated glass/ 100 mm airspace/ 6.38 mm laminated glass	117	42	One frame acceptable for double glazing	Soft edge mounting

Summary - Glazing

- A lower acoustic rating can normally be tolerated where glazing is used in place of a solid partition. It would also be onerous to require glazing with the same rating. Therefore for each partition Rank, the default glazing is 5 dB Rw lower than the plasterboard partition.
- On the basis of a glazed area being **50%** of the total partition, it is preferred that the glazing rating is within 5 R_W points of the partition resulting in a net reduction of 3 R_W points .

55 dB Rw | Rank 5 | Partition

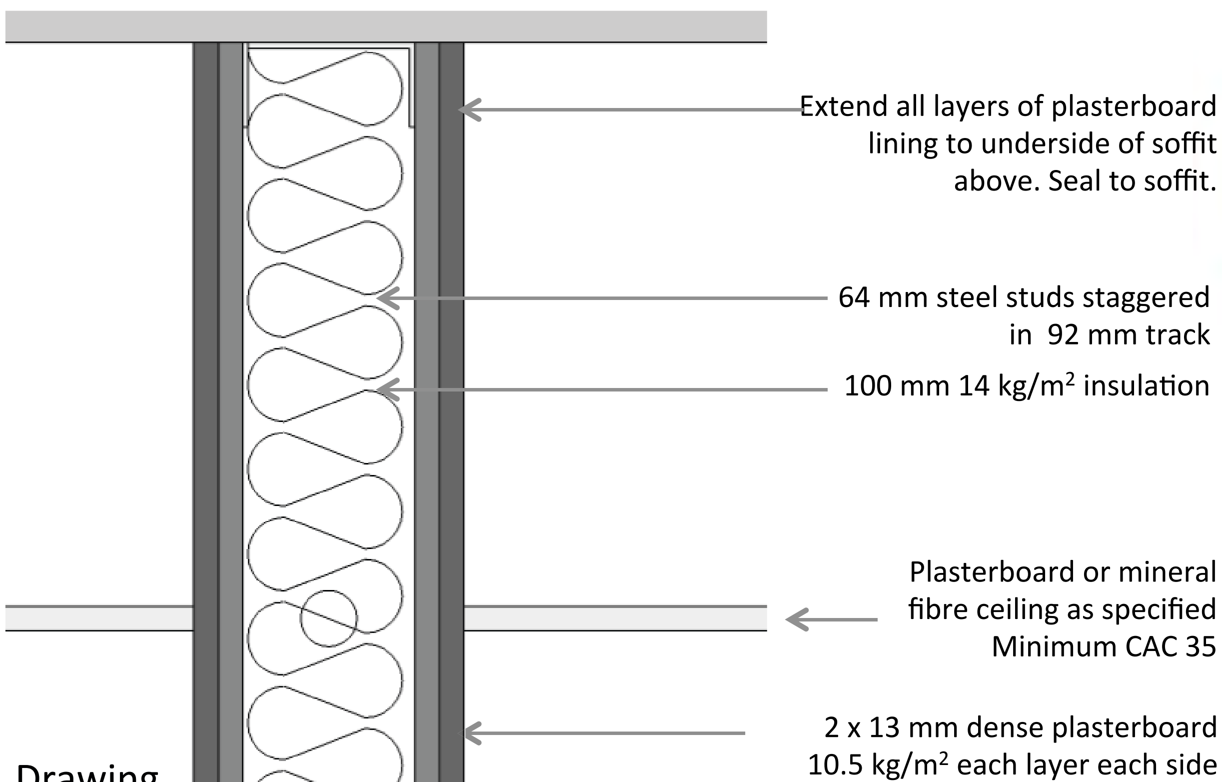
Summary

- Project specific construction
- Upgrades over Rank 4 are staggered stud construction and extending all layers of plasterboard (on each side of the studs) to the underside of the soffit above
- Alternative construction using 150 mm steel studs (not staggered) is provided in the Acoustic Design Report

Ceiling Baffle	Thickness (mm)	Lining Mass (kg/m²)	Cost (re 40 dB Rw)
All plasterboard layers to slab	144	42	+ 100 %

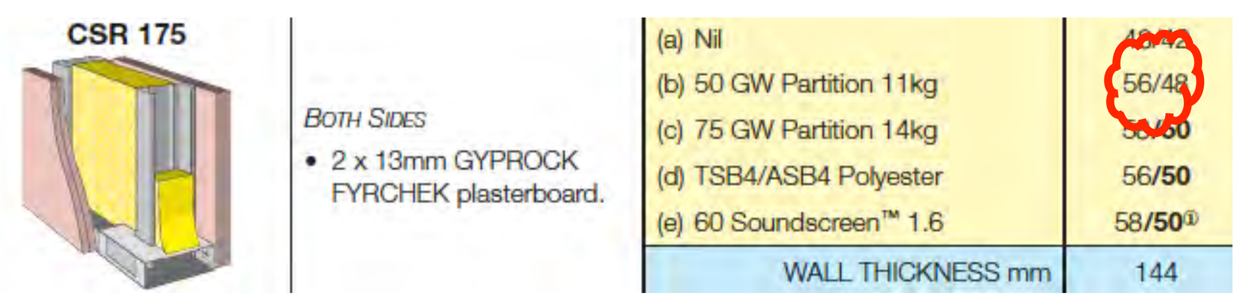
Rw Rating	Rank 5 System	Resonate Library Data	Comparable System 1	Comparable Rating 1	Comparable System 2	Comparable Rating 2
55	• **2 x 13 mm dense plasterboard** • **64 mm or 76 mm steel studs** • **Staggered in 92 mm track** • **2 x 13 mm dense plasterboard** • **100 mm 14 kg/m³ insulation**	2 x 16mm fire rated plasterboard both sides. Staggered 64 mm steel studs in 92 mm track @ 300 centers and impact clips. S3 Dacron fill in cavity.	CSR Redbook 2011 CSR 175 Page B16	56	Boral Selector SS2626F Page B2.11	58

Standard plasterboard >= 8.5 kg/m², Dense plasterboard >= 10.5 kg/m², Sound rated plasterboard >= 12.5 kg/m²



Drawing

Industry Data



Transmission Loss Values (dB)

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	38	40	54	58	57	61	-

Currently not proposed for use at KDH - Refer to KDH Acoustic Design Report – For Information Only

55 dB Rw | Rank 5 | Doors and Glazing

Summary - Doors

- On the basis of a door area being **25%** of the total partition, it is preferred that the door rating is within 10 R_W points of the partition giving a net reduction of 5 R_W points.
- The above reductions in performance must include the performance of the door seals; otherwise significant additional reductions in performance will occur.

Rw Rating	Rank 5 Door System	Typical Door Thickness (mm)	Typical Door Mass (kg/m²)	Perimeter Seals	Threshold Seal
45	80 mm thick solid core door with full suite of seals. Door and frame designed and manufactured as one item	80	26	Seals designed as part of complete door and frame system	Seals designed as part of complete door and frame system

Glazing Transmission Loss Values

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	36	42	46	50	51	55	-

Door Transmission Loss Values

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	23	38	42	48	49	52	-

Rw Rating	Rank 5 Glazing System	Typ. Glazing Thickness (mm)	Typical Glazing Mass (kg/m²)	Frame	Edge mounting
50	10.38 mm laminated glass/ 200 mm airspace/ 6.38 mm laminated glass	217	42	Twin frames	Soft edge mounting

Summary - Glazing

- A lower acoustic rating can normally be tolerated where glazing is used in place of a solid partition. It would also be onerous to require glazing with the same rating. Therefore for each partition Rank, the default glazing is 5 dB Rw lower than the plasterboard partition.
- On the basis of a glazed area being **50%** of the total partition, it is preferred that the glazing rating is within 5 R_W points of the partition resulting in a net reduction of 3 R_W points .

60 dB Rw | Rank 6 | Partition

Summary

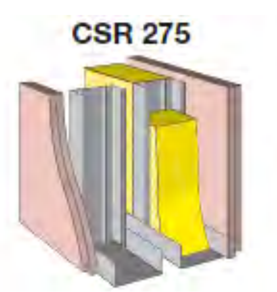
- Project specific construction
- Upgrades over Rank 5 are the sound rated plasterboard and twin stud construction (completely discontinuous construction)
- Provisionally used for generator room. May need to be higher again - blockwork/separate stud may be appropriate

Ceiling Baffle	Thickness (mm)	Lining Mass (kg/m²)	Cost (re 40 dB Rw)
Slab to Slab construction	256	42	+ 120 %

Rw Rating	Rank 6 System	Resonate Library Data	Comparable System 1	Comparable Rating 1	Comparable System 2	Comparable Rating 2
60	• **2 x 13 mm sound rated plasterboard** • **92 mm steel studs** • **20 mm offset (for ≈200 mm cavity)** • **92 mm steel studs** • **2 x 13 mm sound rated plasterboard** • **100 mm 14 kg/m³ insulation**	*Double leaf gypsum board, 2 layers 16mm + 2 layers 16mm on independent 100 x 50mm studs with 38 mm fibreglass insulation in cavity*	CSR Redbook 2011 CSR 275 Page B19	60	Boral Selector ST2626F Page B2.19	63

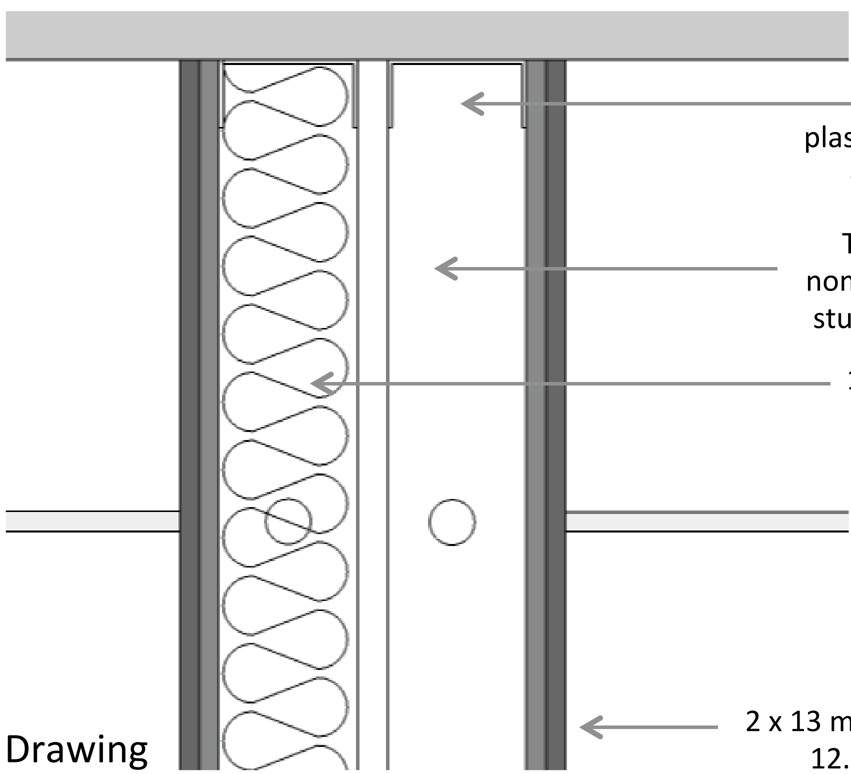
Standard plasterboard >= 8.5 kg/m², Dense plasterboard >= 10.5 kg/m², Sound rated plasterboard >= 12.5 kg/m²

Industry Data


CSR 275

BOTH SIDES
- 2 x 13mm GYPROCK FYRCHEK plasterboard

(a) Nil	50/44	51/45
(b) 50 GW Partition 11kg	59/50	59/51
(c) 75 GW Partition 11kg	60/52	60/52
(d) TSB3/ASB3 Polyester	57/51	58/52
(e) 60 Soundscreen™ 1.6	59/50	60/51
WALL THICKNESS mm	200	252



Extend two layers of plasterboard lining to underside of soffit above. Seal to soffit.

Twin 92 mm steel studs with nominal 20 mm offset between studs to achieve 200mm cavity

100 mm 14 kg/m² insulation

Plasterboard or mineral fibre ceiling as specified Minimum CAC 35

2 x 13 mm sound-rated plasterboard 12.5 kg/m² each layer each side

Drawing

Transmission Loss Values (dB)

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	37	52	61	64	62	64	-

Resonate acoustics

60 dB Rw | Rank 6 | Doors and Glazing

Summary - Doors

- On the basis of a door area being **25%** of the total partition, it is preferred that the door rating is within 10 R_W points of the partition giving a net reduction of 5 R_W points.
- The above reductions in performance must include the performance of the door seals; otherwise significant additional reductions in performance will occur.

Rw Rating	Rank 6 Door System	Typical Door Thickness (mm)	Typical Door Mass (kg/m²)	Perimeter Seals	Threshold Seal
50	Specialist acoustic door such as IAC Colpro. Consider airlock arrangement with lower rank doors in lieu of single door	100	45	Seals designed as part of complete door and frame system	Seals designed as part of complete door and frame system

Glazing Transmission Loss Values

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	-	-	-	-	-	-	-

Unlikely to be achievable

Door Transmission Loss Values

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	-	-	-	-	-	-	-

Highly specialised system – consult with acoustic engineer regarding feasibility

Rw Rating	Rank 6 Glazing System	Typ. Glazing Thickness (mm)	Typical Glazing Mass (kg/m²)	Frame	Edge mounting
55	Glazed areas should not be considered	-	-	-	-

Summary - Glazing

- A lower acoustic rating can normally be tolerated where glazing is used in place of a solid partition. It would also be onerous to require glazing with the same rating. Therefore for each partition Rank, the default glazing is 5 dB Rw lower than the plasterboard partition.
- On the basis of a glazed area being **50%** of the total partition, it is preferred that the glazing rating is within 5 R_W points of the partition resulting in a net reduction of 3 R_W points .

Appendix 5 – Acoustically absorptive finishes

Acoustic Ceiling tiles are presented in Table 32.

Table 32 - Acoustic Ceiling Tiles

Noise Reduction Coefficient (NRC)	Ceiling Attenuation Class (CAC)	Ceiling
0.5	35	USG Radar ClimaPlus Illusion
0.5	33	Armstrong Dune
0.55	33 – 35	USG Radar ClimaPlus
0.55	44	Ecophon Combison
0.55	35 – 40	Armstrong Fine Fissured
0.55	40	Armstrong Fine Fissured Ceramaguard
0.55	35	Armstrong Textura
0.55	$D_{n,cw}$ 34	Mikor Fine Stratos Micro Perforated
0.55	$D_{n,cw}$ 34	Mikor Mecure
0.5 – 0.6	35	USG Olympia Micro ClimaPlus (perforated)
0.6	$D_{n,cw}$ 34	Mikor Star
0.6	$D_{n,cw}$ 34	Mikor Pinhole
0.6	$D_{n,cw}$ 34	Mikor Laguna Micro Perforated
0.65	$D_{n,cw}$ 34	Mikor Saturn
0.65	$D_{n,cw}$ 34	Mikor Fine Fresko
0.65	$D_{n,cw}$ 34	Mikor Fresko
0.6 – 0.7	35	USG Eclispe ClimaPlus
0.7	35 – 40	Armstrong Ultima
0.7	30	Armstrong Dune Max
0.7	39	Armstrong Bioguard Acoustic
0.7	35 – 40	Armstrong Fine Fissured High NRC/High CAC

Noise Reduction Coefficient (NRC)	Ceiling Attenuation Class (CAC)	Ceiling
0.7 – 0.8	35 – 39	USG Mars ClimaPlus
0.8	35	USG Mars ClimaPlus High NRC
0.85	21	Ecophon Focus A
0.85	19	Ecophon Gedina A
0.8 – 0.9	–	Ecophon Sombra A/D (Black tile)
0.9	44	Ecophon Combison DuoA
1.0	30	Ecophon Master A

Direct fix acoustic ceiling treatments are presented in Table 33.

Table 33 - Direct Fix Acoustic Ceiling Treatments

Noise Reduction Coefficient (NRC)	Type	Ceiling
0.8	Glue fixed to underside of soffit	Ecophon Focus B
0.8	Glue fixed to underside of soffit	Ecophon Focus SQ
0.75	Screw fixed to underside of plaster, boarding, battens or concrete	Ecophon Focus F
0.95	Glue fixed to underside of soffit	Ecophon Master B
0.95	Glue fixed to underside of soffit	Ecophon Master SQ
0.95	Screw fixed to underside of plaster, boarding, battens or concrete	Ecophon Master F

Perforated plasterboard ceilings are presented in Table 34.

Table 34 - Perforated Plasterboard Ceilings

Noise Reduction Coefficient (NRC)	Ceiling
0.5	Gyprock perforated plasterboard (10% open area)

Noise Reduction Coefficient (NRC)	Ceiling
0.85	Knauf AcoustiShield Square Pattern (16% open area)
0.85	Knauf AcoustiShield Rectangular Pattern (11% open area)
0.7	Knauf AcoustiShield Circular Pattern (11% open area)
0.7 – 0.8	Boral Echostop 12 mm Square Hole (16% open area)
0.65	Boral Echostop 3 mm Square Hole (8% open area)
0.65	Boral Echostop 6 mm Round Hole (8.5% open area)
0.6 – 0.8	Atkar AudiBoard with minimum 15% open area

Note: All perforated plasterboard ceilings are to be used in conjunction with 50 mm, 32 kg/m^3 polyester insulation such as Tontine 'Acoustisorb 2'.

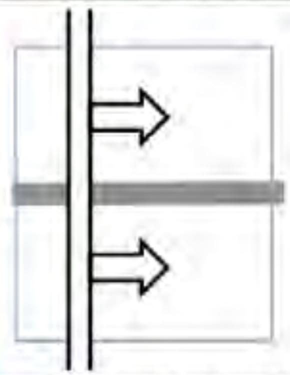
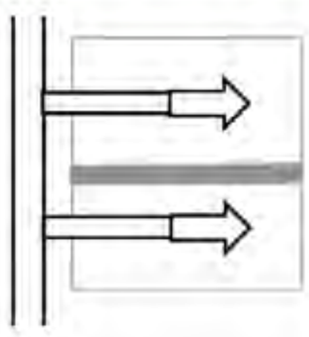
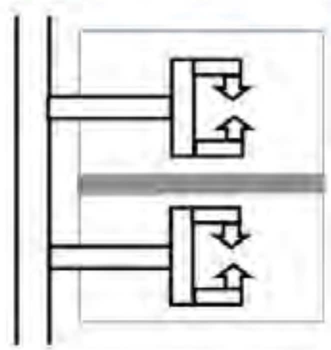
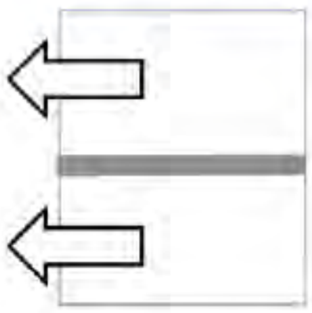
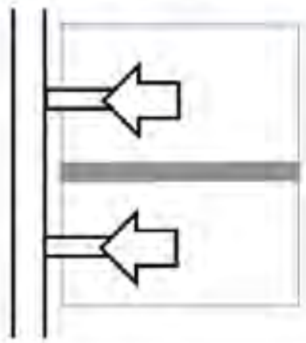
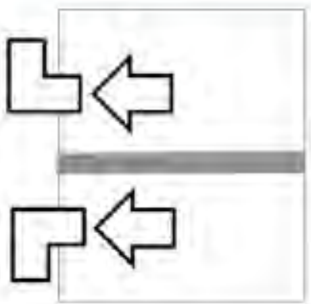
A list of proprietary wall panels or panelling systems is presented in Table 35.

Table 35 - Proprietary Wall Panels

Noise Reduction Coefficient (NRC)	Panel
0.5	Woven Image 'Echo Panel': • installed with 20 mm air gap; to maintain durability, the panel can be installed over a perforated metal sheet, with a minimum open area of 20 percent, which has been installed on 20 mm timber battens • this can be used as a pin board.
0.7 – 0.8	Snap-Tex, FabriTRAK or self fabricated frame system[(1)], constructed with: • 25 mm mineral fibre board for pinnable surface or 50 mm thick fibreglass insulation with a minimum density of 32 kg/m^3 with at least NRC 0.9; a suitable product is 50 mm thick Pink 'SonoBatt 32' • faced with a breathable fabric; any type of fabric may be used except for sheer or extremely thick textiles, as long as light and air can easily pass through the material.
0.7 – 0.8	Atkar 'Audislot AS26–20/47' with an Integrated Acoustic Backing (IAB) with 50 mm thick fibreglass insulation with a minimum density of 14 kg/m^3; a suitable insulation product would be Pink Batts 'Silencer'.
0.8	Sorbalight 30 mm Exel Panels

Noise Reduction Coefficient (NRC)	Panel
	Sontext 25 mm 'Serenity Decorative Acoustic Panels'
	Autex 25mm Quietspace Acoustic panel
	Chessor Industries 'AcoustiPro H' acoustic panels
	Chessor Industries 'AcoustiPro E' acoustic panels
	Chessor Industries 'AcoustiBoard 25' acoustic panels
0.9	Ecophon 'Wall Panel A' and 'Wall Panel C'
	Sorbalight 50 mm Exel Panels
0.95	Megasorber P50 (industrial type facing – for plant rooms and computer rooms)
1.0	Sontext 50 – 75 mm 'Serenity Decorative Acoustic Panels'
	Megasorber P100 (industrial type facing – for plant rooms and computer rooms)

Appendix 6 – Cross-talk control

Rank	Supply Air Configuration			Return Air Configuration		
	Common Main Duct, No Branch	Common Branch Separate Run Out	Separate Branch and Run Out Ducts	Un-ducted	Fully Ducted	Transfer Duct
						
1	4 m between duct take-off 25 mm internal lining	Not required	Not required	Lined elbows at return air grilles	Not required	Not required
2	8 m between duct take-off 25 mm internal lining	1 m between duct take-off 25 mm internal lining Nearest supply air terminals in adjacent rooms should be separated by minimum 4 m of 25 mm internally lined duct	Not required	Lined elbow with 1 m lined duct extension from return air grilles	1 m between branch ducts 25 mm internal lining Nearest return air terminals in adjacent rooms should be separated by a minimum of 4 m of 25 mm internally lined duct	4 m separation 25 mm internal lining 1 lined bend 0.9 m lined duct *Fantech CTL1 or equivalent*
3	Inadequate, consider common branch and separate run out	4 m between duct take-off 25 mm internal lining Nearest supply air terminals in adjacent rooms should be separated by minimum 6 m of 25 mm internally lined duct	Not required	Marginal, consider transfer duct	4 m between branch ducts 25 mm internal lining Nearest return air terminals in adjacent rooms should be separated by a minimum of 5 m of 25 mm internally lined duct	4 m separation 25 mm internal lining 2 lined bends 1.8 m lined duct *Fantech CTU2 or equivalent*
4	Inadequate, consider common branch and separate run out	8 m between duct take-off 25 mm internal lining Nearest supply air terminals in adjacent rooms should be separated by minimum 8 m of 25 mm internally lined duct	Not required	Inadequate, consider transfer duct or fully ducted return air	8 m between branch ducts 25 mm internal lining Nearest supply air terminals in adjacent rooms should be separated by minimum 8 m of 25 mm internally lined duct	4 m separation 50 mm internal lining 2 lined bends 3 m lined duct *Custom ductwork*
5	Inadequate, consider separate branch and run out ducts		Main duct, separate branch ducts and run-out ducts. At least 8 m of 50 mm internally lined duct between supply air terminals in adjacent rooms	Inadequate, consider transfer duct or fully ducted return air with silencers (attenuators)	Consider silencers (attenuators)	4 m separation 50 mm internal lining 2 lined bends 4 m lined duct *Custom ductwork*
6	Case-by-case acoustic analysis required, likely to require a stand-alone air supply and air return system for each space					