Acoustic Design Report
Kempsey District Hospital
S13069RP1

Image: SKM-S2F

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01	20 August 2013	Updated to include mechanical services advice and Refurbished Drug and Alcohol.
02	17 September 2013	Updated to incorporate peer review input For D&C Tender

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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.

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Executive summary

Resonate Acoustics presents a Tender issue acoustic design report for the proposed New Clinical Services Building (NCSB) and refurbishments at Kempsey District Hospital (KDH) at Kempsey, NSW.

This report is a revision of our Acoustic Design Report S13069RP1 Issue 1 and is based upon design decisions, value management decisions and peer review input subsequent to that report.

This Tender issue addresses a Peer Review of the previous (100% Design Development) issue. The Peer Review was undertaken by Acoustic Logic Consultancy (report 20130823.1/0826A/R1/TT, dated 3 September 2013).

Resonate Acoustics has been instructed by Health Infrastructure NSW to implement all Peer Review recommendations in full, (with the exception of a floating concrete slab in the chiller plant room). The adoption of the Peer Review represents the revised acoustic brief for the Kempsey Hospital Redevelopment project.

Acoustic aspects of this report that adopt the Peer Review Advice are:

- Plant noise – external
- Duct cross talk
- Partition acoustic ratings
- Partition construction
- Hydraulic services including lagging of pipework
- Vibration isolation
- Helicopter noise intrusion through the facade

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Table of Contents

1 Introduction

Resonate Acoustics has been engaged by Health infrastructure to prepare a Tender issue acoustic design report for the proposed New Clinical Services Building (NCSB) at Kempsey District Hospital (KDH) at Kempsey, NSW.

The purpose of this acoustic report is to:

- Reconfirm or update design criteria set out in our Acoustics Design Report S13069RP1 Issue 1 dated 20 August 2013.
- Document acoustic design advice that takes into account all design decisions, value management decisions and peer review input at the time of tender issue.

Specifically, this report documents a summary of advice relating to:

- Mechanical services noise emission to the environment during:
  - Normal operation mechanical services
  - Emergency equipment testing (containerised set generator)
- Mechanical services noise levels in internal spaces
- Hydraulic services noise control
- Facade glazing
- Internal partitions
- Internal doors
- Ceilings and acoustic baffles therein
- Reverberation time and specialist acoustic finishes
- New Clinical Services Building

Inputs to this report include:

- Our Acoustic Design Report S13069RP1 Issue 1
- Meetings and correspondence with the SKM-S2F architectural design team during June, July and September 2013
- NSW DEC Industrial Noise Policy (INP, 2000)
- NSW OEH Road Noise Policy (RNP, 2011)
- Australian/New Zealand Standard AS/NZS 2107:2000 – Acoustics – Recommended Internal Design Sound Levels and Reverberation Times for Building Interiors
- Green Building Council of Australia Green Star Healthcare v1
- Acoustic Logic Consultancy Peer Review (report 20130823.1/0826A/R1/TT, dated 3 September 2013).
- Instruction to adopt the Peer Review (Aconex, 3 September 2013)

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 lower ground floor and rooftop plant areas. 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, and River Street to the north west, 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 site plan and identifies key locations including the unattended noise logging site used to establish noise emission criteria.

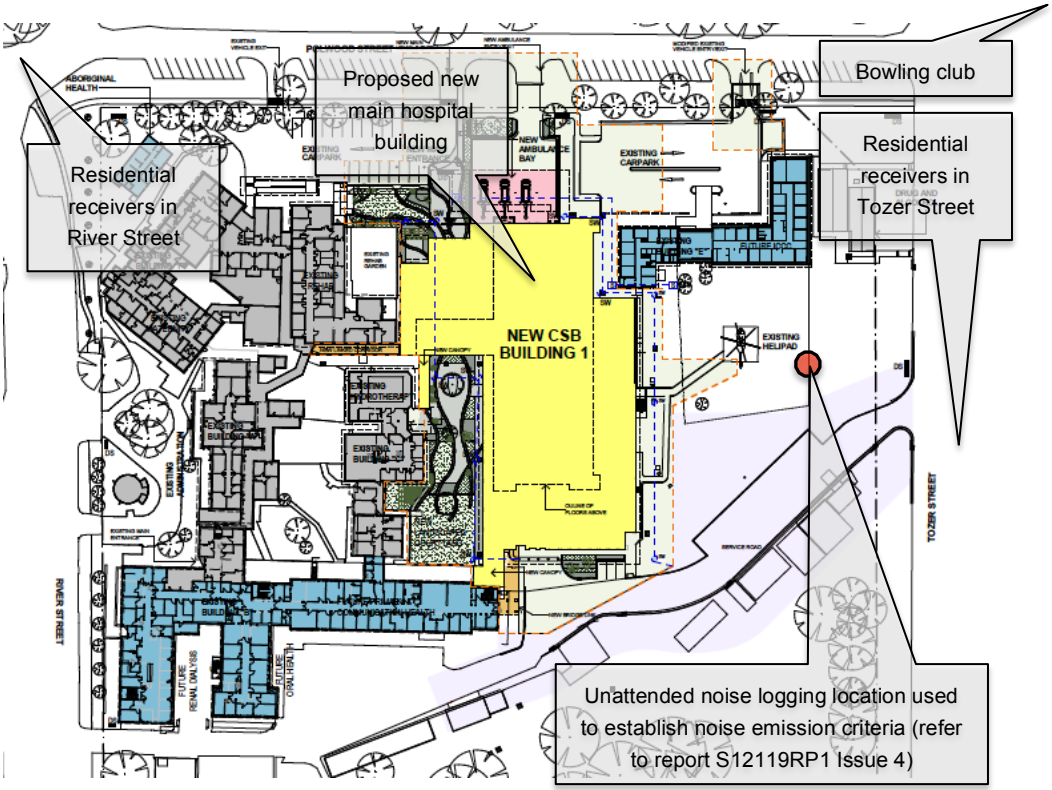


Image: SKM-S2F 5027-SKM-AR-DWG-N1-B101 Issue 5

Figure 1 - Site plan

3 Design criteria

Section 3 reproduces all relevant acoustic design criteria for the project. Section 3 is for information only.

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…acoustic 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)

These requirements relate to operational nose emission (DGR 3 and 5) and construction stage noise and vibration emission (DGR 5).

Operational noise emission from stationary noise sources (mechanical services plant) is considered in this report to address DGR 3 and 5. Acoustic controls are recommended to satisfy project specific noise levels established in accordance with the Industrial Noise Policy (INP) at the schematic design stage.

Construction noise and vibration was fully assessed at the schematic design stage. Our construction noise and vibration assessment is provided as a stand-alone report, reference S13069RP2.

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.

The resultant environmental noise goals (Project Specific Noise Levels) for normal operation at the KDH Redevelopment project are:

- Daytime: 44 dB L_{Aeq}
- Evening: 40 dB L_{Aeq}
- Night-time: 35 dB L_{Aeq}

These criteria do not allow any margin for future additional mechanical plant or equipment.

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 as part of the early works package.

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

- 49 dB L_{Aeq} during the day time period at the nearby residences
- 45 dB L_{Aeq} during the evening period at the nearby residences
- 55 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 do not take into account any future additional generator(s). These criteria were lowered by 3 dB for the project early works package to account for an additional future generator that would operate concurrently with the generator being provided for the redevelopment project.

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

Helicopter noise intrusion criteria (noise intrusion to inside the New Clinical Service Building) are based upon criteria recommended in the Peer Review in accordance with the instruction from Health Infrastructure NSW. These criteria are presented in Table 2:

Table 2 –L_{AFmax} noise criteria for hospitals

Room	Time period	Criterion, L_{AFmax}
Operating theatres	Unspecified	65
Wards. Offices, consulting rooms		70
Laboratories		75
Service areas		85

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]. 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
Wards – multi-bed	40 – 45	0.4 – 0.7
Waiting rooms, reception areas	40 – 50	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)]
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		
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

Notes on internal noise levels:
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 tasks undertaken at the schematic design stage, external noise intrusion is not an influence upon steady state internal noise levels as external noise levels in the vicinity of the hospital site are low.

Notes on reverberation time:
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.

3.7 Rainfall noise

At the conclusion of the schematic design stage, no metal deck or other lightweight roof areas were proposed at the KDH Redevelopment.

No such roof structures have been re-introduced into the design, and as such rainfall noise intrusion into occupied spaces is not considered further in this report.

3.8 Internal acoustic separation

Internal acoustic separation requirements for the KDH redevelopment project are based upon the recommendations of the Peer Review and subsequent correspondence with the project architect.

A summary of the adopted partition ratings for major spaces from the Peer Review (presented in terms of Weighted Sound Reduction Index (R_w)) are presented in Table 4:

Table 4 – Partition ratings (R_w)

Space type	Proposed R_w rating (between rooms)	Proposed R_w rating (to corridor with door[1])
Private office - General	40	35
Private office – Head of department	45	40
Ward – IPU, CCU	40-45[2]	35
Ward - Emergency	45	35
Interview, Consult/exam, meeting	45	40

Note: 1: Whilst not explicitly stated in the Peer Review, it is assumed that the 'wall to corridor rating' therein applies to corridor walls that contain a door.
2: 40 has been taken to apply to a two-person ward, 45 for a one-person ward.

The partition ratings for other spaces have been applied based on acoustic similarity or consistency to those listed.

Partition ratings are presented as a coloured markup in Appendix 3.

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 5:

Table 5 - 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

Section 4 provides a summary of acoustic design advice provided since the schematic design stage.

4.1 Normal operation mechanical services

Schematic design stage advice
During the schematic design stage Resonate Acoustics 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 was recommended. The structural design response is a structural slab that varies from 220 mm thick to 290 mm thick below plant areas.
- In addition to the above, a suspended set plasterboard ceiling was recommended in a localized area below the cooling towers. The architectural design response for the whole of Level 2 is a suspended acoustic ceiling tile with a minimum acoustic rating of CAC 40 (38 for toilets/wet areas) or a suspended 13 mm thick standard mass plasterboard ceiling. In both cases the ceiling void is approximately 1.2 m deep (minimum) and contains various types of thermal insulation affixed to the underside of the plant room roof slab.

Detailed design stage advice
Our initial review of environmental noise levels due to the operation of mechanical services was based on the following:

- Metal deck roof to all plant room spaces with 60 mm thick glasswool thermal insulation on the underside of the roof sheet (taken to provide a Noise Reduction Coefficient of NRC 0.65 minimum).
- Chillers in separate area within the north plant room
- 30 mm thick Kingspan walls
- 17.5 m^2 of architectural louvres on the northern wall of the north plant room
- 15.7 m^2 of architectural louvres on the western wall of the north plant room
- 5 m^2 of architectural louvres on the northern wall of the suction plant room
- 17.5 m^2 of architectural louvres on the southern wall of the chiller plant room
- 3 m^2 of architectural louvres on the northern wall of the boiler room.
- 13.5 m^2 of architectural louvres on the southern wall of the south plant room.
- 24.0 m^2 of architectural louvres on the western wall of the south plant room.
- Chillers at 50% capacity based on McQuay WMC290D data
- Cooling Towers at 100% capacity – see discussion below

The louvre areas have been based on advice provided by the project architect on 16 September 2013.

With no acoustic treatment, predicted noise levels at the nearest residential receptors with all plant operating are predicted to be:

- Up to 40 dB(A) L_{eq} at Tozer Street receivers to the east.
- Up to 38 dB(A) at River Street receivers to the north west.

The above levels exceed the night time noise criteria by up to 5 dB(A), and therefore acoustic treatment is required.

To reduce noise levels to achieve compliance with the criteria, the treatments in Table 6 have been established in consultation with the project architect and mechanical engineer:

Table 6 Treatments for control of environmental noise

Item	Recommended treatments / comments
Cooling towers	Provide an enclosure around the cooling towers to a minimum height of 0.5 m above the top of the cooling towers. The enclosure should be constructed of: • Solid airtight barrier of material with surface mass greater than 10 kg/m^2 to the southern side. • Absorptive material to the inside face of the solid southern barrier and to the outside face of the northern plant room (i.e.: the northern wall of the cooling tower enclosure). The lining shall be acoustically equivalent to 50 mm thick Pyrotek Reapor (NRC 0.9). • Acoustic louvres to the eastern and western sides, acoustically equivalent to IAC Slimshield SL-300 louvres.
North plant room louvres	Install louvres acoustically equivalent to Fantech SBL1. Maximum areas are as follows: • 17.5 m^2 northern wall of the north plant room • 28.3 m^2 western wall of the north plant room • 24.3 m^2 eastern wall of the north plant room The minimum acoustic louvre area required by the project mechanical engineer for the north plant room is 52 m^2. Portions of the eastern louvered area can be blanked off to achieve this minimum.
Chiller plant room louvres	Install louvres acoustically equivalent to Fantech SBL1. Maximum areas are as follows: 24.5 m^2 southern wall of the chiller plant room

Item	Recommended treatments / comments
Chiller plant room absorption	Install 50 m^2 of absorption (in addition to thermal insulation on soffit) with a Noise Reduction Coefficient of NRC 1.0 such as Megasorber P100. This can be distributed on any available wall area.
Suction plant louvres	Install louvres acoustically equivalent to Fantech SBL1. Maximum areas are as follows: • 5 m^2 northern wall of the suction plant room Note that no acoustic data has been provided for the suction plant. The reverberant noise level in this room has been taken to be no higher than the AHU plant room.
South plant room louvres	Install louvres acoustically equivalent to Fantech SBL1. Maximum areas are as follows: • 27.3 m^2 southern wall of the south plant room • 43.2 m^2 western wall of the south plant room The minimum acoustic louvre area required by the project mechanical engineer for the south plant room is 66 m^2. Portions of the either louvered area can be blanked off to achieve this minimum.
Boiler room louvres	Architectural louvres acceptable up to 3m^2 (combined between high and low level).
Plant room roof (All rooms)	Absorption to be provided on the underside of the entire roof in all plant spaces, with a minimum Noise Reduction Coefficient (NRC) of 0.65 such as 50 mm glasswool blanket. This can be the insulation blanket provided for thermal control.
All GEF, TEF, IEF	All General Exhaust Fans, Toilet Exhaust Fans and Isolation Exhaust Fans are to be installed within the plant rooms and treated with 3 m of internally lined duct and one internally lined bend between the fan and the environment.

With the recommendations above incorporated into the design, the predicted noise level at nearby residences is up to 36 dB(A) L_{eq}. We are advised that the cooling tower operation would be reduced at night (approximately 50% operation or -8 dB).

Consequently the highest predicted noise level is 35 dB(A) L_{eq} at receivers at the northern end of Tozer Street which satisfies the project night-time noise criterion and consequently is taken to satisfy the Director General's Requirements.

4.2 Emergency equipment maintenance and testing

Information regarding control of noise emission from the backup power generator was provided as part of the project Early Works package (within the project electrical specification by others). Consequently it does not form part of this report or Tender.

4.3 Road traffic

No further or updated assessment of road traffic noise has been undertaken during the detailed design stage.

Consequently the assessment and recommendations contained within our schematic stage report S12119RP1 Issue 4 still apply.

5 Internal noise

5.1 Mechanical services

Internal noise levels from the operation of the mechanical services have been reviewed. Our review is based on:

- Coloured PDF's showing ductwork layout provided by Umow Lai on 29 July 2013.
- Revised GJ Walker FCU and AHU data dated 13 August 2013.
- Compressor selections provided by Umow Lai on 14 August 2013.
- Two Shinwa SDC-U 300 cooling towers as advised by Umow Lai on 1 August 2013.
- Return air fan selections provided by Umow Lai on 23 July 2013.
- B.K.B. Building Solutions pump selections provided on 29 July 2013.
- Dakin budget proposal for two McQuay WMC290D chillers provided on 31 July 2013.

Recommendations

Our review is based on the understanding that there is a minimum of 25 mm thick acoustic lining in all supply and return air ductwork AHU/RAF systems. Our review comments are summarised in Table 7.

Table 7 – Internal mechanical services noise tratements

Unit	Recommended treatments / comments
Air Handling Units	
AHU 2.4, 2.5 and 2.6	Provide a Fantech RT07G QS attenuator or acoustical equivalent in the supply paths of these units. Attenuator to be located either immediately before the supply duct leaves the plant room, or as the duct enters the ceiling space on level 2.
Return Air Fans	
RAF 1.2, 1.3, 1.6, 2.4, 2.5, 2.7	Provide a minimum of 2.5 metres of acoustically lined ductwork with 50 mm thick lining located adjacent to where the duct leaves the plant room.
RAF G.5, 1.1, 2.3	Provide a minimum of 3.5 metres of acoustically lined ductwork with 50 mm thick lining located adjacent to where the duct leaves the plant room.
RAF G.1, G.3, 1.4, 2.1, 2.2, 2.6, 2.8	Provide a minimum of 4 metres of acoustically lined ductwork with 50 mm thick lining located adjacent to where the duct leaves the plant room.
RAF G.4, G.7	Provide a minimum of 6 metres of acoustically lined ductwork with 50 mm thick lining located adjacent to where the duct leaves the plant room.

Unit	Recommended treatments / comments
GEF, TEF, IEF	
All General Exhaust Fans (GEF), Toilet Exhaust Fans (TEF) and Isolation Exhaust Fans (IEF)	3 m internally lined duct and one internally lined bend between the fan and the first room served.
Fan Coil Units	
Isolation Rooms and Acute Bays	Limit linear sound power level of FCU to: • 63 Hz: 75 dB • 125 Hz: 70 dB • 250 Hz: 70 dB • 500 Hz: 70 dB • 1000 Hz: 70 dB • 2000 Hz: 70 dB • 4000 Hz: 65 dB Fan coil units located above corridor outside of room served 3 m of internally lined rigid ductwork minimum One internally lined rigid bend Spigot to flexible duct connection after lined duct and bend 2 m of acoustic flex minimum. Wrap fan coil unit in loaded vinyl (e.g. Wavebar 4 kg/m^2)
Other areas	Sound power level of FCU limited to the octave band and overall values shown in mechanical services schedule 3 m of internally lined rigid ductwork One internally lined rigid bend First spigot to flexible duct connection after lined duct and bend 2 m of acoustic flex minimum. Wrap fan coil unit in loaded vinyl sheet (e.g. Wavebar 4 kg/m^2) Return air ceiling plenum arrangements are to have return air no closer than 3m to the FCU and the intervening ceiling space is to be treated with 10 m^2 50 mm insulation material on top of the ceiling tiles.

We note that our review has not considered noise from the outside air fans, as sound power data was not available for those units. Based on the sizes of these fans it is anticipated that

internal noise levels will be controlled with lined ductwork/bends and wrapping of fans located over occupied space.

Duct velocities - guidance

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

In order to control duct cross talk between adjacent spaces, all common ductwork shall be internally lined with minimum 25 mm insulation and ducts shall be provided with a minimum 1.5 m acoustic flexible duct.

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.

Control of hydraulic noise for this project takes into account the Peer Review input.

Fixing of hydraulic supply services

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

- Where a staggered stud or twin stud arrangement is specified, pipework should be supported from the wet side (toilet, bathroom, dirty utility 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

Water flow rates - guidance

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:

- 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**
Single en suites located over other wards	• CAC 38 (minimum) acoustic ceiling tiles as specified, plasterboard or equivalent, and • Acoustically lag pipe bends and traps and within 400 mm either side of bends and traps only. (Not the entirety of the pipe run).	• 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, consultation, interview, meeting rooms	• CAC 40 (minimum) acoustic ceiling tiles, plasterboard or equivalent, and • Acoustically lag full extent of 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 studds

OR

- Enclose the bare down pipes with:
  - 2 x 16 mm thick fire-rated plasterboard
  - 50 mm thick, 11kg/m3 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

The control of helicopter noise intrusion is based upon Peer Review input.

Helicopter maximum noise levels
Reference helicopter sound pressure levels, based on a helicopter at 30 m from the facade, are:

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	105	102	101	97	96	92	86	101
Landing	101	95	97	93	90	92	84	97
Helicopter path directly overhead								
Take off	99	108	105	102	101	97	91	105
Landing	106	108	107	106	99	94	87	106

All Wards and Bays on eastern facade and south facade between grids 6 and 8:

- Upgrade insulated glazing units (IGUs) to incorporate one sheet of 10.38 mm laminated glass OR where required for clinical purposes, provide a jockey sash of 6 mm float glass spaced 50 mm from the inside of the IGU.
- Bulk insulation to be provided behind the Kingspan facade equal to 50 mm thick glasswool 11 kg/m^3.

Staff Lounge and Emergency Department Workshop on eastern façade:

- Upgrade insulated glazing units (IGUs) to incorporate one sheet of 10.38 mm laminated glass.
- Bulk insulation equal to 50 mm thick glasswool 11 kg/m^3 to be provided behind the Kingspan facade.

Operating Theatre on eastern façade:

- Provide a deep void glazing system. Install a jockey sash spaced the maximum possible offset from the IGU within the window reveal for all glazed areas.
- Bulk insulation equal to 50 mm thick glasswool 11 kg/m^3 to be provided behind the Kingspan facade.
- The inner layer of the eastern facade shall be comprised of two layers of dense plasterboard 10.5 kg/m^2 minimum (e.g. fire-rated plasterboard, impact-rated plasterboard) within the operating theatre.

6 Architectural acoustics

6.1 New building

Partition types for the KDH project are presented in Table 11 and in Appendix 4. The partitions that have been developed for this project are based upon the Peer Review recommendations in accordance with the instruction from Health Infrastructure NSW.

A marked-up set of main building and refurbished area plans (updated and based upon the general arrangement architectural drawings issued for Tender) is presented in Appendix 3.

Note that the partition types are based upon a minimum ceiling performance of CAC 40 (38 for toilets/wet areas) as per the architectural specification.

Table 11 - Summary of KDH project specific partition types – new building

Rank	Nominal Acoustic Rating, dB Rw	Height	Construction	Depth mm	CSR[1] Type	Comment
1 Blue	35	Breaks ceiling line	13 mm standard plasterboard No insulation 92 mm steel studs 13 mm standard plasterboard	118	010	Typical occupied space to corridor with door
2 Green	40	Breaks ceiling line	13 mm standard plasterboard 50 mm insulation 92 mm steel studs 13 mm standard plasterboard	118	010	Typical occupied space to occupied space e.g. offices
3 Yellow	45	Breaks ceiling line 1,200 mm band of acoustic insulation in the ceiling either side of partition.	13 mm Impact-rated pb for entire area 92 mm steel studs 50 mm insulation 13 mm Impact-rated pb for entire area	118	050	One bed ward to one bed ward, procedure rooms, consult rooms

Rank	Nominal Acoustic Rating, dB Rw	Height	Construction	Depth mm	CSR[1] Type	Comment
4 Orange	50	One inner layer of pb full height	13 mm Impact-rated pb 13 mm Fire-rated[4] pb 92mm steel studs 50 mm insulation 13 mm Fire-rated pb 13 mm Impact-rated pb	144	075	Operating Theatre, Comms Rooms to Wards or meeting room
5 Red	55	Inner 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	Not used, for information only.

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

Staggered studs

Staggered studs are specified where wet area services such as a cistern are present in a partition between a wet area and an occupied space such as a meeting room. The services are top be affixed to the studs on the wet area side. This mitigates structure-borne noise due to hydraulic noise, particularly through tap bodies and cisterns. 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.

Wet areas

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.

Communications Rooms (Comms Rooms)

For Comms rooms, where:

- A wall is not full height for fire rating OR
- A wall is not full height for acoustic control (i.e.: is specified as less than Rank 4/R_w 50),

A baffle is to be provided in the ceiling space to control noise breakout from the comms room. The baffle is to be comprised of 13 mm thick dense plasterboard with a minimum surface density of 10.5 kg/m^2.

All penetrations through the baffle are to be acoustically treated with mastic, bulk insulation or fire pillows dependent on the nature of the penetration.

Acoustic detail at facade

Where acoustically-rated partitions abut the facade (at a plasterboard wall or window mullion) the junction is to be acoustically detailed such that the specified partition is not de-rated by flanking noise at the junction. Such junctions are to be detailed at the Construction Documentation (CD) phase of the project. Common treatments at window mullions are:

- Infill panel to be 1 x 18 mm medium density fibreboard (MDF) for R_W 40 partitions
- 2 x 18 mm MDF for R_W 45 partitions

The joins between the mullion and partition edge are to be sealed airtight with a flexible caulking compound.

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 project schematic design briefing, the maximum door thickness 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 or lower partitions 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 6.38 mm laminated glass with an acoustic rating of no less than 33 dB Rw.

Acoustically-improved door sets complete with seals to all closing faces and at the threshold may be required for plant rooms.

Doors and associated seals are to be acoustically reviewed at the Construction Documentation (CD) phase of the project.

Door seals

From our earlier briefings 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 the glazing shall be a minimum of 6.38 mm laminated glass with an acoustic rating of no less than 33 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.

Lift core cladding

In addition to the lift core concrete structure, a separate lift core cladding/lining is required to control lift noise to occupied spaces. The cladding/lining shall comprise the following as a minimum:

- 1 x 13 mm thick standard 8.5 kg/m^2 plasterboard on separate studs with at least 20 mm clearance from the lift concrete structure, ensuring that there is no contact between the lift core and the separate studs
- 50 mm thick glasswool insulation between the core and the lining with a minimum density of 11 kg/m^3.

Ceilings

The partition advice presented herein is based on:

- A set plasterboard ceiling on both sides of a partition between two person wards.
- All supply and return air grilles are treated with lined cushion boxes.
- Acoustic ceiling tiles with a minimum Ceiling Attenuation Class (CAC) or Weighted Ceiling sound Reduction Index (D_{nCw}) of no less than 40 (for all areas except toilets) such as Armstrong fine-fissured 1714M High CAC and a minimum CAC or 38 for toilets such as Armstrong fine-fissured Ceramaguard.

Ceilings in all areas except toilets/wet areas are to have a Noise Reduction Coefficient of not less than NRC 0.70. Ceilings in toilets/wet areas are to have a Noise Reduction Coefficient of not less than NRC 0.55.

Acoustic absorption

No allowance is made for acoustic absorption in any occupied space beyond the specified floor, wall and ceiling finishes.

Minimum acoustic absorption requirements apply to the cooling tower enclosure and Level 3 plant rooms. Refer to Table 6.

Partition penetrations

Penetrations through acoustically-rated partitions can de-rate acoustic separation between adjacent spaces.

It will be necessary for the contractor to allow for acoustically-detailed penetrations including:

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

Penetrations are to be acoustically reviewed at the Construction Documentation phase of the project.

Electrical outlets

General Power Outlets and other outlets in acoustically rated walls should not be installed back to back unless acoustically treated using in-wall baffles or proprietary acoustically-rated back boxes.

7 Green Star

Green Star criteria are presented in Section 3.9. This advice is reproduced from the schematic design stage.

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 5. 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 2:

Figure 2 – Existing noisy fan at north of existing ward building

8 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.

Pipework connected to pumps and chillers shall be isolated using 25 mm spring hangers within 15 m of the pump or chiller, 100 pipe diameters of the pump or chiller, or as otherwise specified by the mechanical or hydraulic services specification, whichever is the greater.

Typical plant and equipment vibration isolation requirements are presented in Table 12:

Table 12 - Typical vibration isolation requirements

Equipment	Mount	Isolation (incorporating rubber isolation pads)	Minimum static deflection (mm)
Air handling unit	Direct mount	Open spring	40[1]
Boiler	Steel rails	Restrained spring	40
Chiller	Direct mount	Restrained spring	15 times the long-term point load static deflection of the structural slab, taken to be 5 mm, i.e.: 75 mm to provide 98 % vibration isolation efficiency.
Cooling Tower >500 rpm	Direct mount	Restrained spring	20
Pump	Inertia base	Open spring	40

Note: 1: Unless otherwise provided in the AHU by default

It is the responsibility of services contractors, particularly the mechanical service contractor to design and select appropriate springs and isolation for each plant item in their services package. Note that it may be necessary for the contractor(s) to engage the services of an appropriately qualified vibration consultant or vibration isolation manufacturer to assist in this process.

Resonate acoustics

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 3:

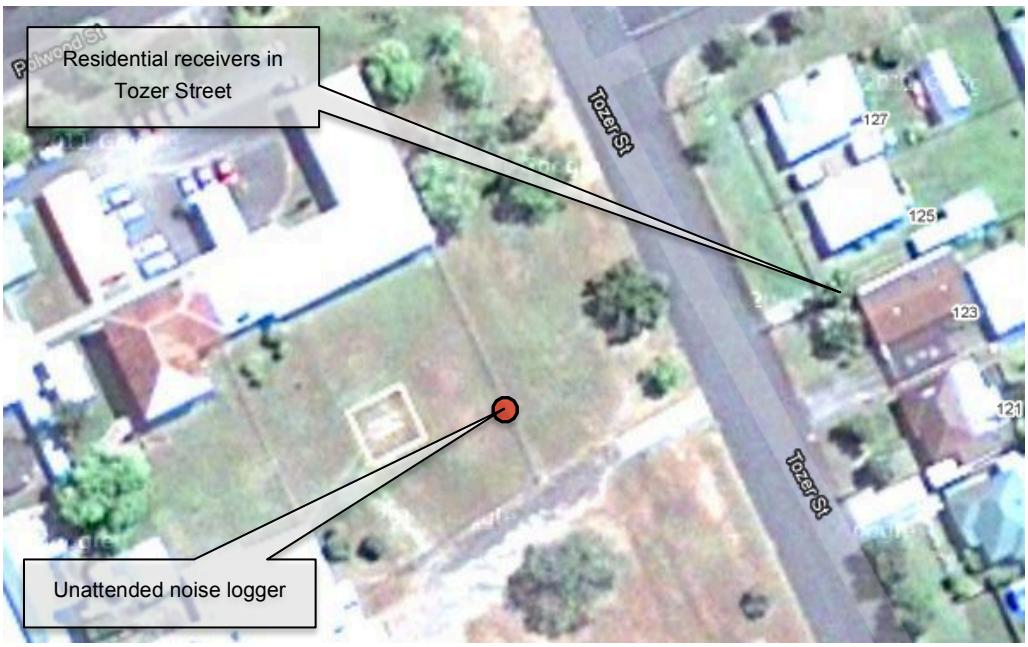


Figure 3 - Unattended noise logging location

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 4. The background noise level is the lowest green line entitled L_{A90}:

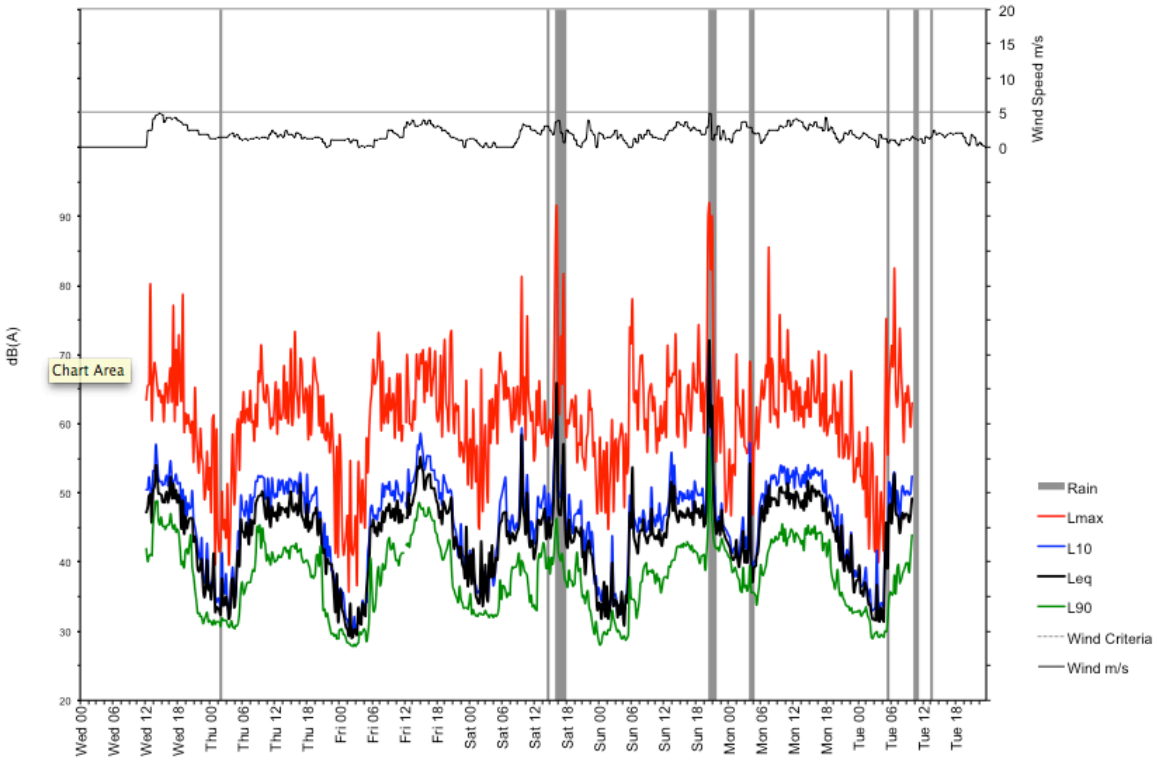


Figure 4 - Noise logging chart Wednesday 9 January to Tuesday 15 January 2013

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 13.

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 13 - 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 13 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.

Appendix 2 – Partition design

(Deleted following Peer Review)

Appendix 3 – Partition mark-ups

Resonate acoustics

KDH Lower Ground Floor

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

Partitions:

Rank 1

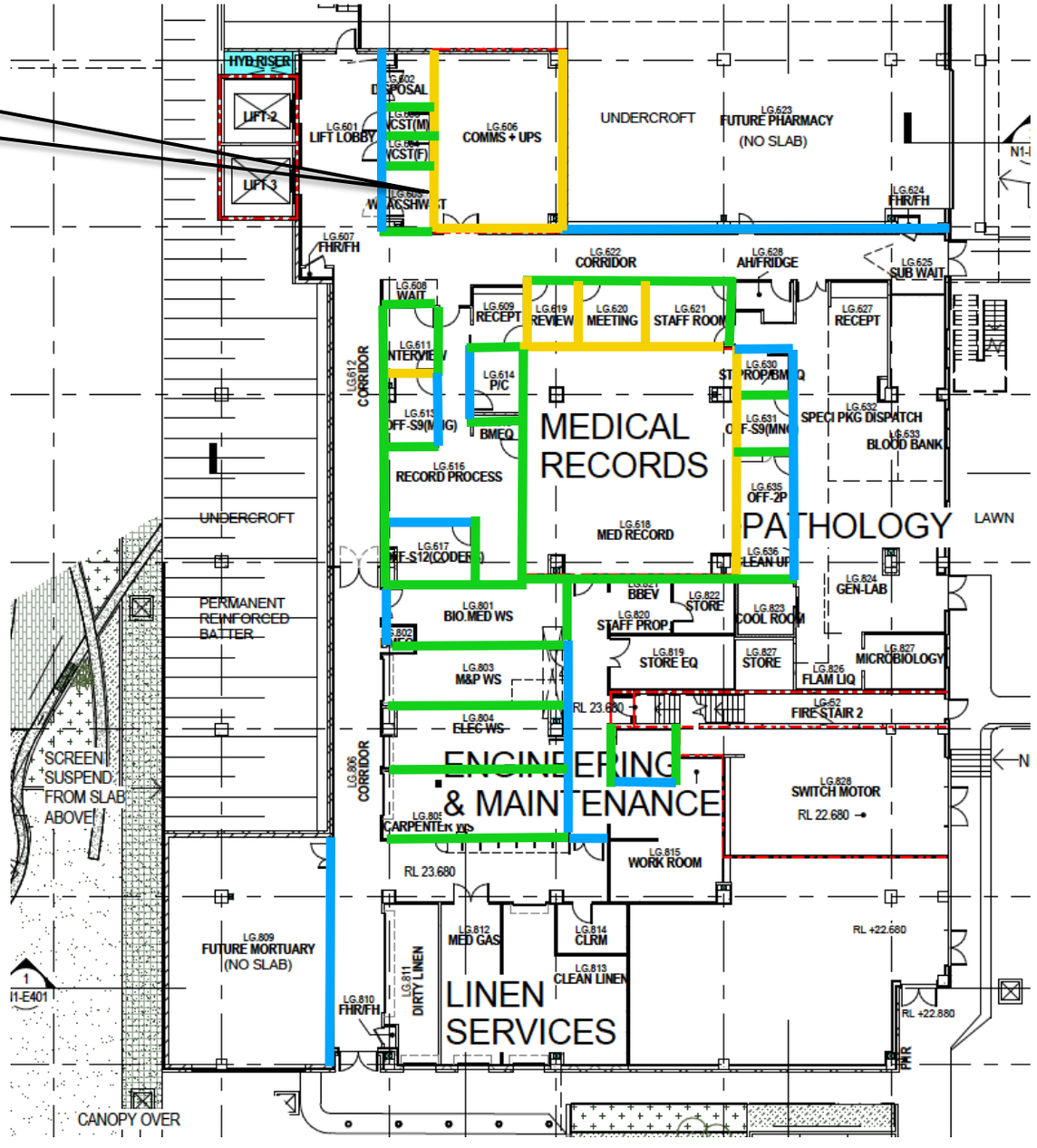
Rank 2

Rank 3

Rank 4

Rank 5

Comms rooms with no ceiling (all) required to have baffle above ceiling line where not full height for fire rating



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

Partitions:

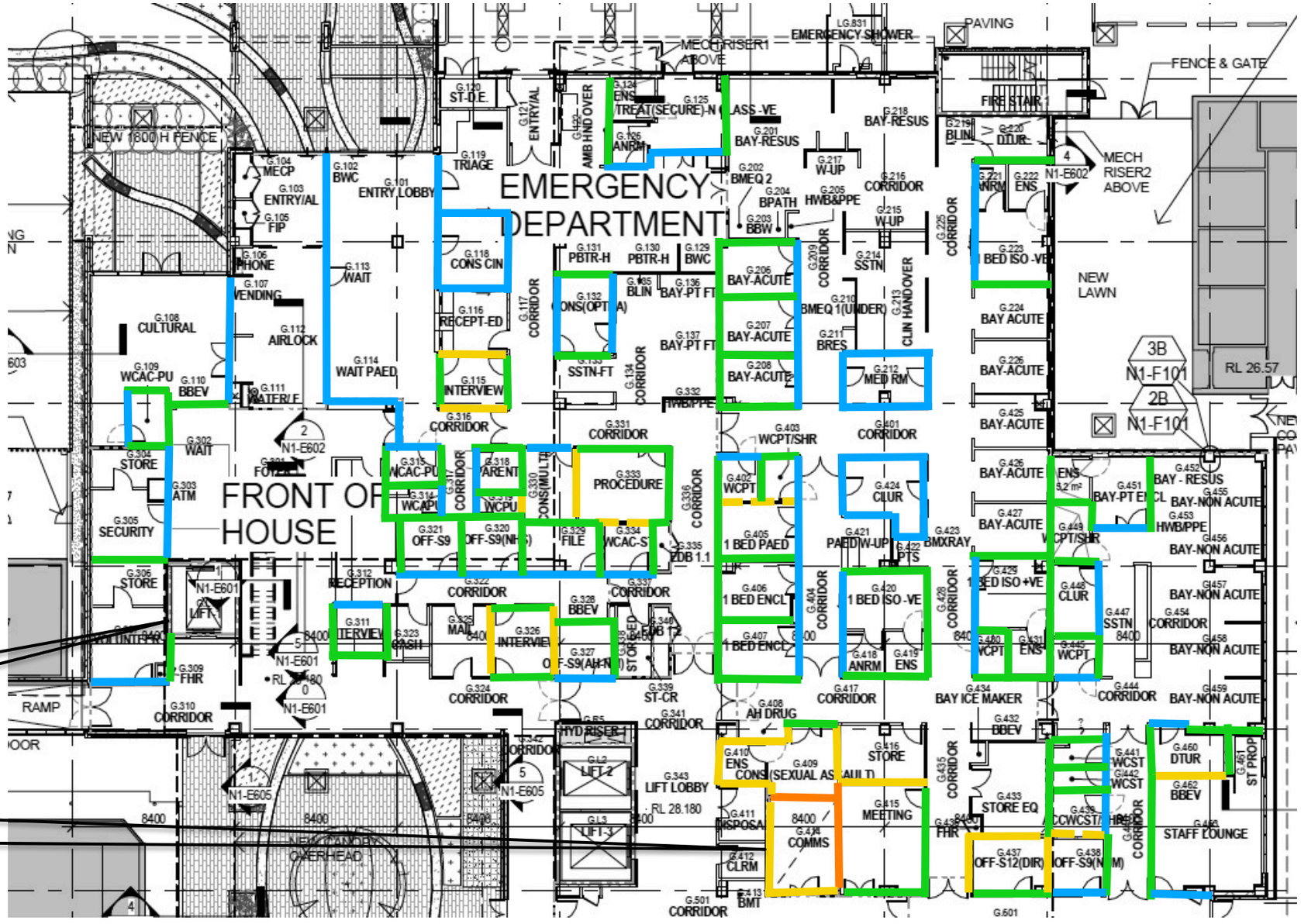
Rank 1

Rank 2

Rank 3

Rank 4

Rank 5



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

Partitions:

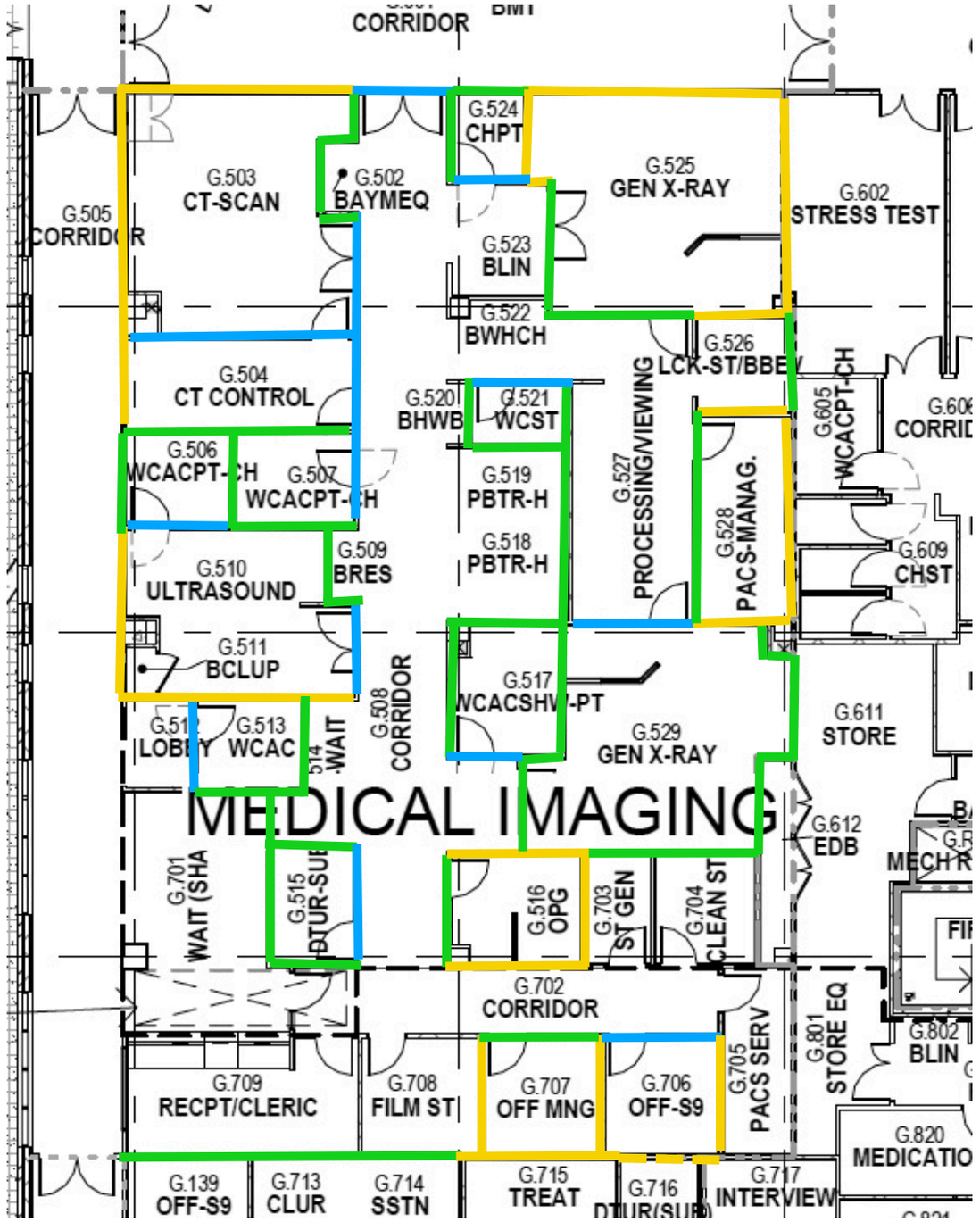
Rank 1

Rank 2

Rank 3

Rank 4

Rank 5



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

Partitions:

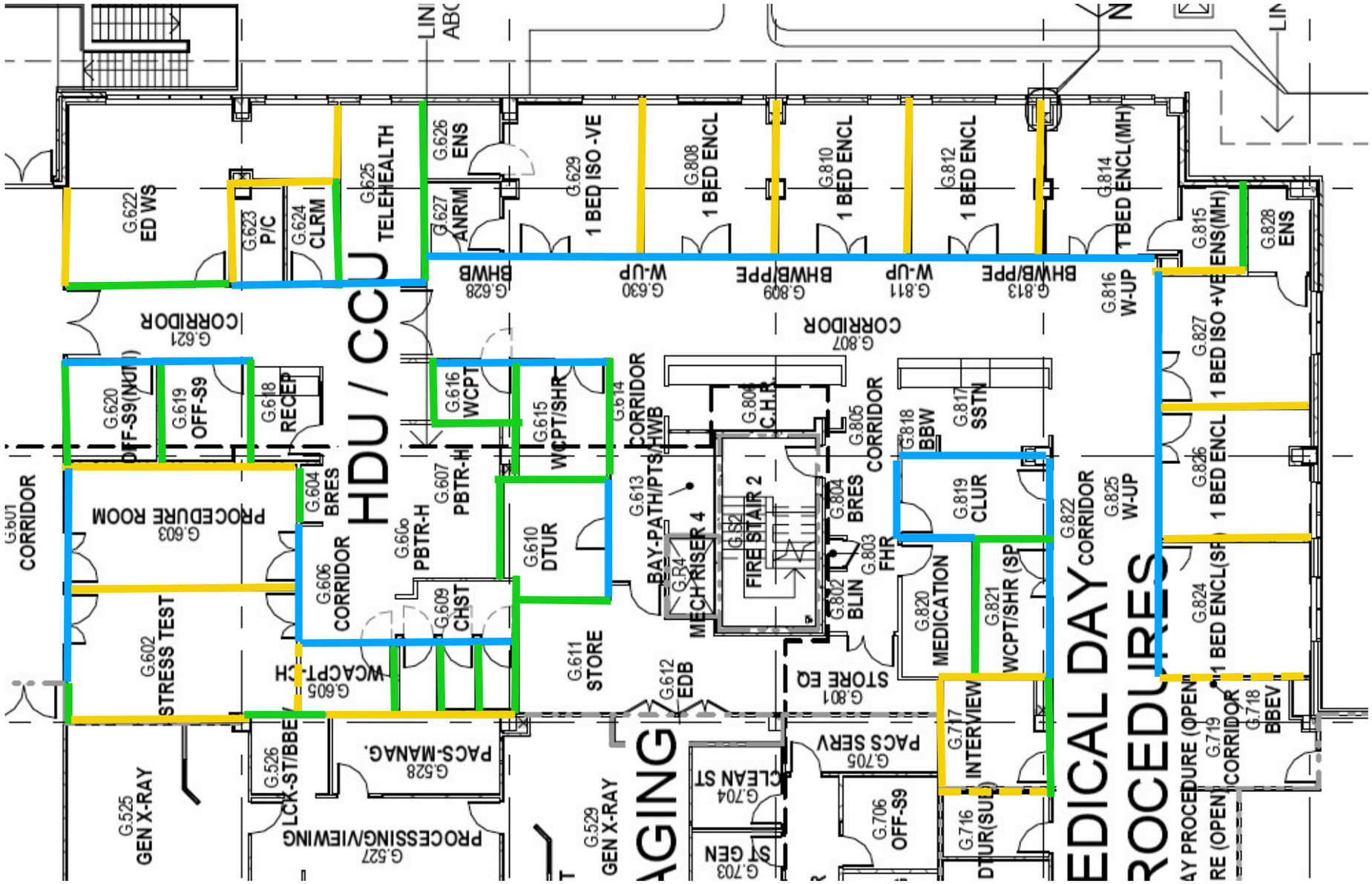
Rank 1

Rank 2

Rank 3

Rank 4

Rank 5



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

Partitions:

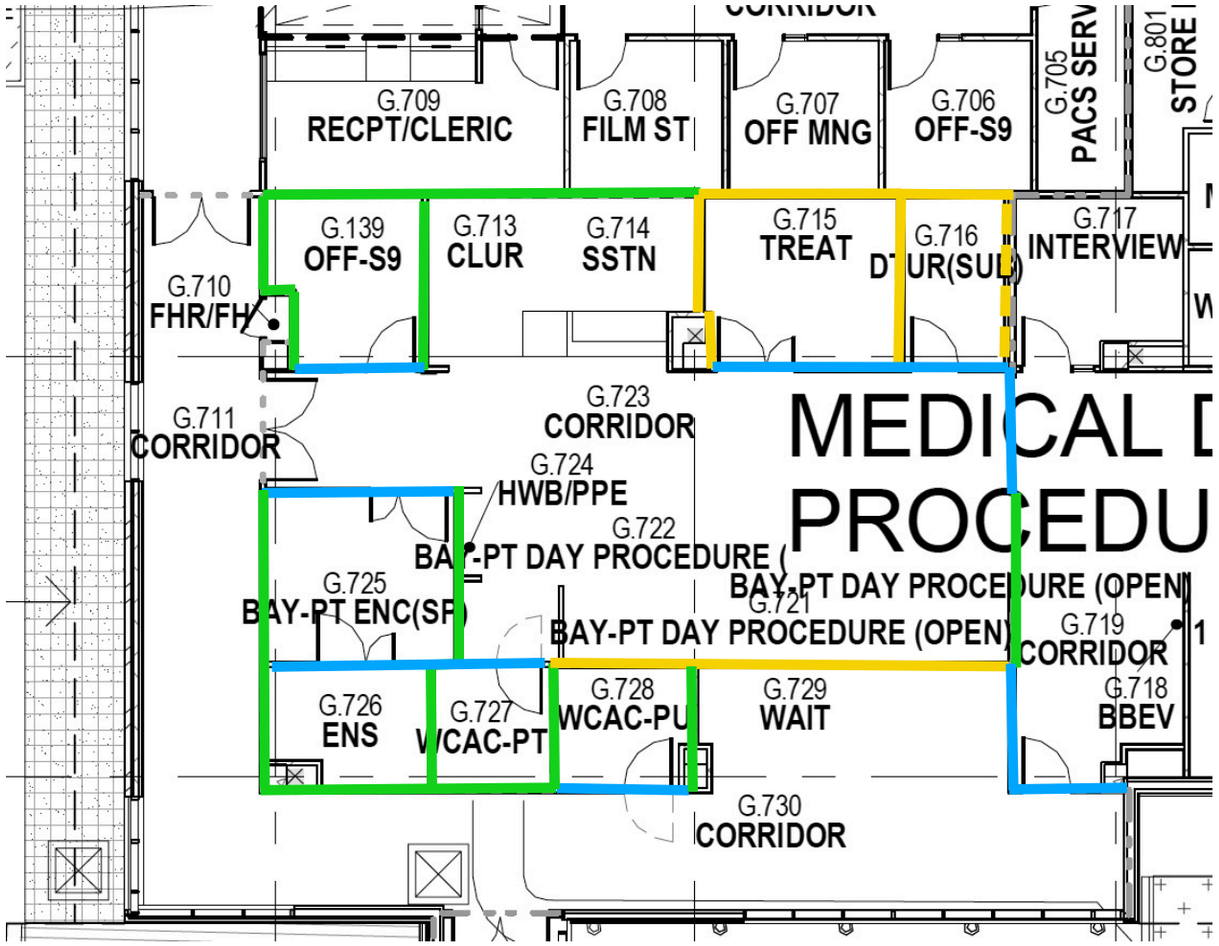
Rank 1

Rank 2

Rank 3

Rank 4

Rank 5



Resonate acoustics

IPU Department | Level 01

Key

Partitions:

Rank 1

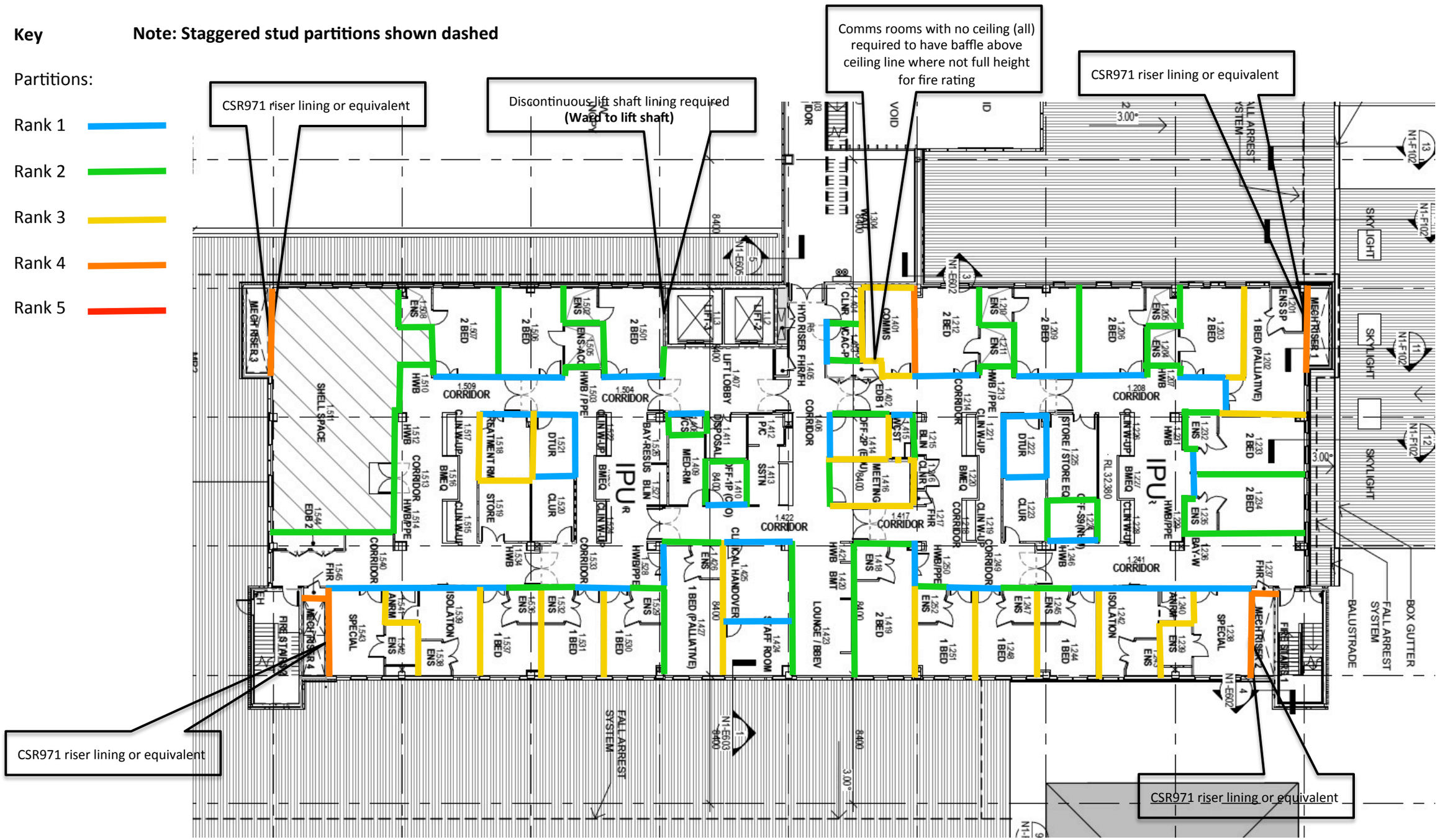
Rank 2

Rank 3

Rank 4

Rank 5

Note: Staggered stud partitions shown dashed



Resonate acoustics

Peri-Op Department | Level 02

Key

Note: Staggered stud partitions shown dashed

Partitions:

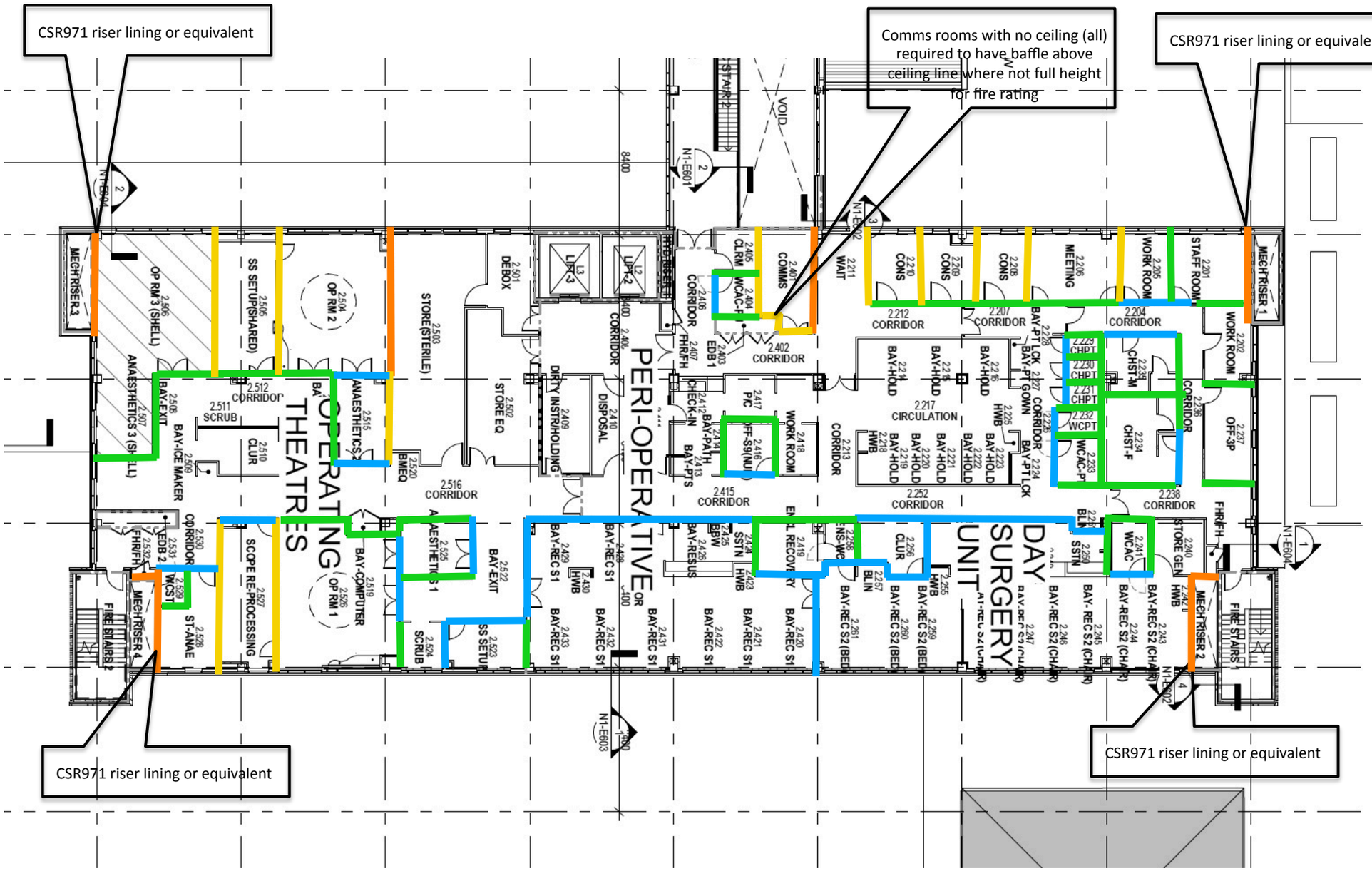
Rank 1

Rank 2

Rank 3

Rank 4

Rank 5



Resonate Acoustics | KDH | Partition Markup | 17 September 2013 | NTS | Based on 5027-SKM-DWG-N1-D104 Issue 8 and Peer Review Comments

Resonate acoustics

Rooftop Plant| Level 03

Key

Note: Staggered stud partitions shown dashed

Partitions:

Rank 1

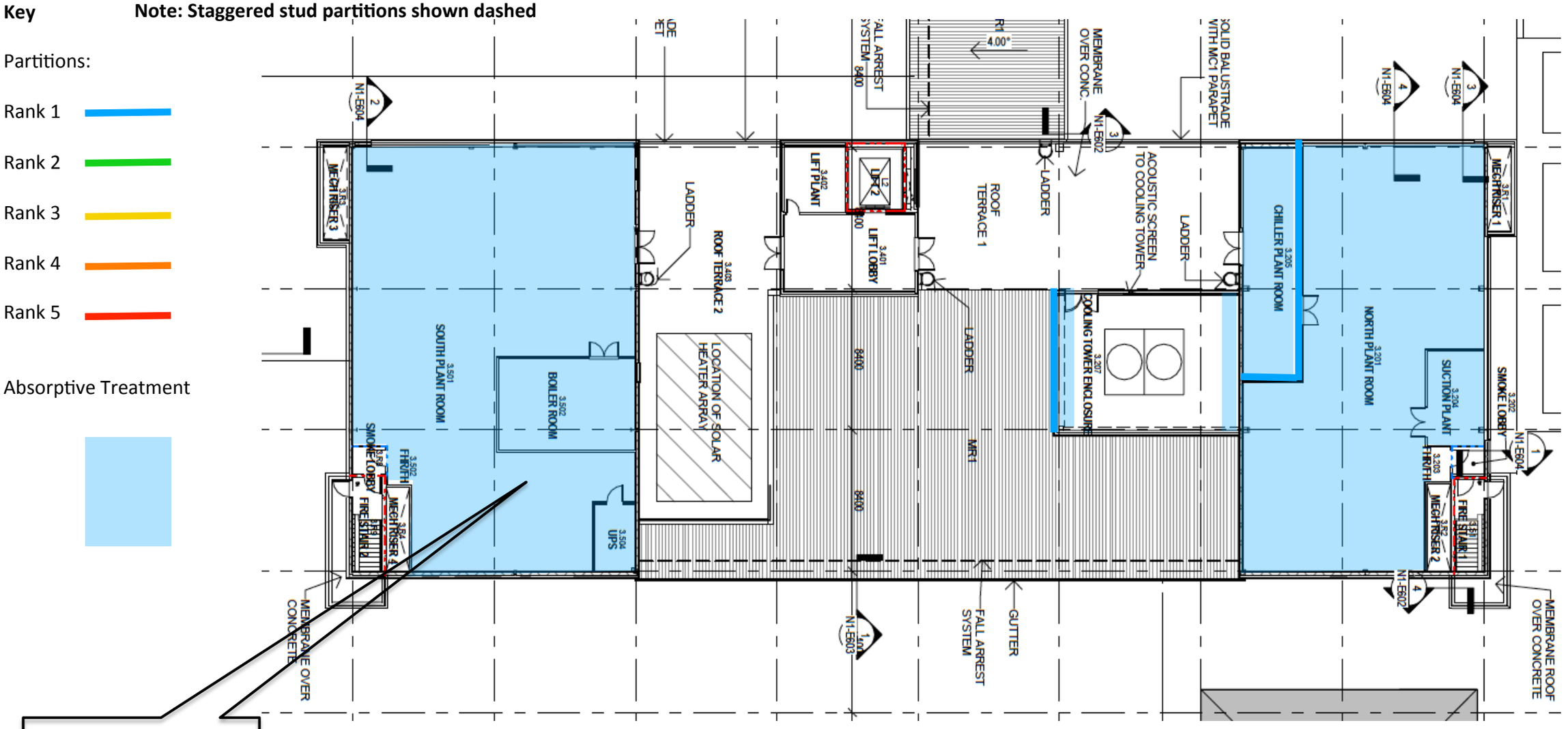
Rank 2

Rank 3

Rank 4

Rank 5

Absorptive Treatment



Appendix 4 – Partition data sheets

Project Specific Construction - Refer to KDH Acoustic Design Report

Resonate acoustics

35 dB Rw | Rank 1 | Partition

Summary

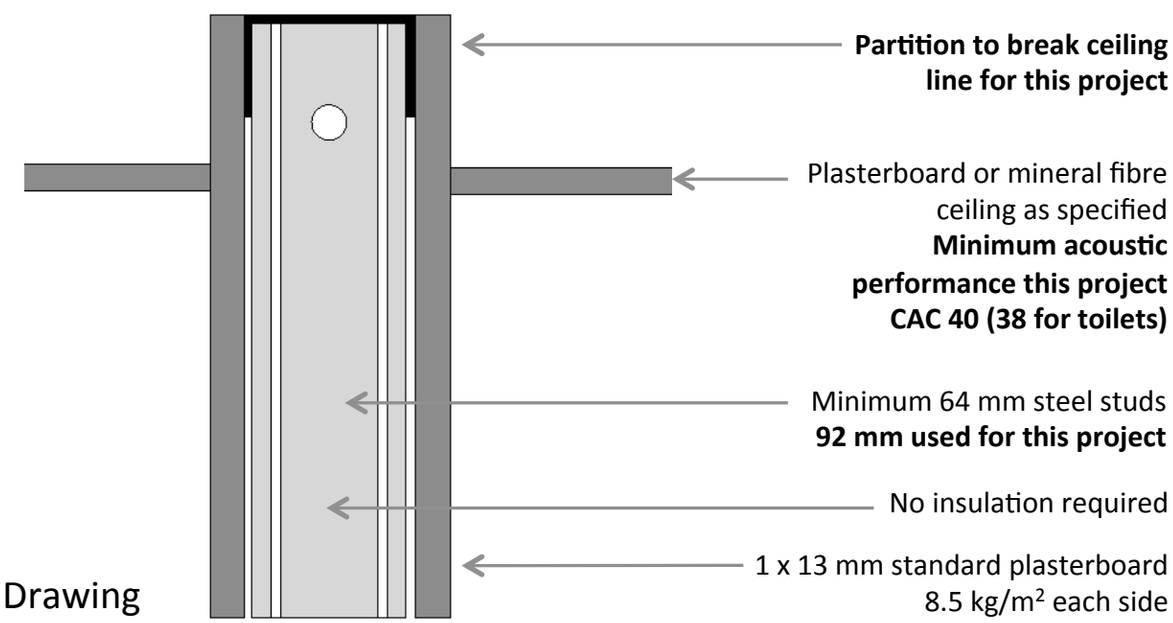
- The 35 dB Rw partition is an absolute bare minimum acoustic design to ensure that a minimum level of separation is provided between two spaces.
- It is classified as 'poor' according to the AAAC *Guidelines for Commercial Building Acoustics*
- This construction can be built to the ceiling line of a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

Ceiling Baffle	Thickness (mm)	Lining Mass (kg/m²)	Cost (re 40 dB Rw)
Not required	90	17	- 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 (64 mm studs) 36 (92 mm studs)	Boral Selector S1313 Page B2	35

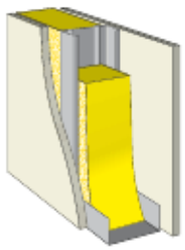
Standard plasterboard >= 8.5 kg/m², Dense plasterboard >= 10.5 kg/m², Sound rated plasterboard >= 12.5 kg/m²

Drawing



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	-

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/m^2)	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/m^2)	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 .

Project Specific Construction - Refer to KDH Acoustic Design Report

40 dB Rw | Rank 2 | Partition

Summary

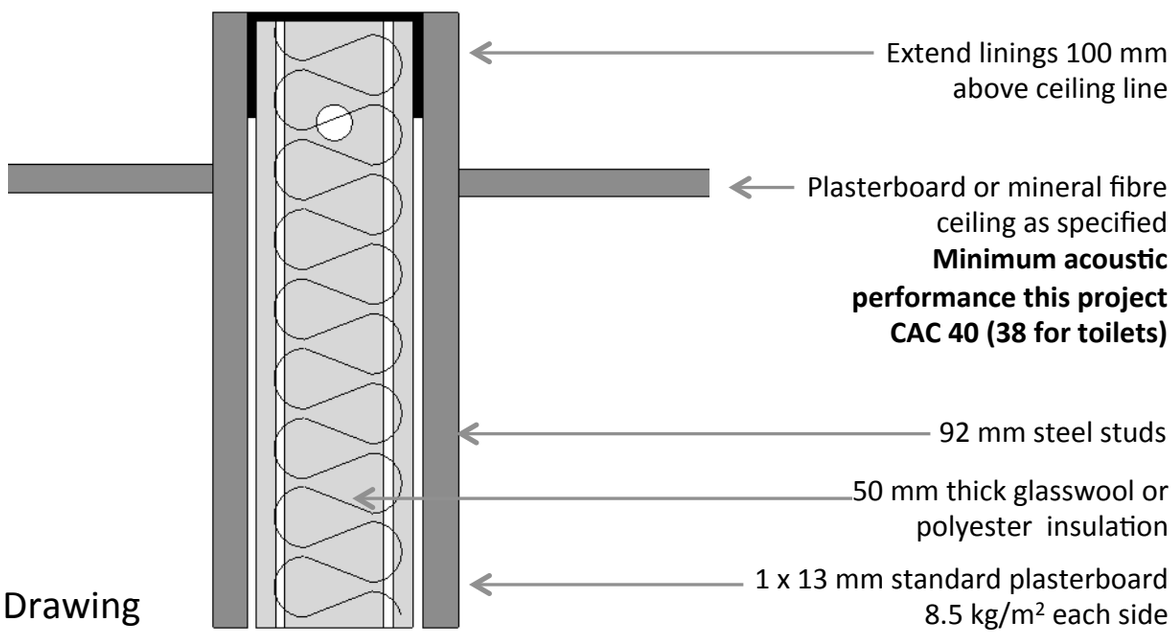
- Improvement over Rank 1 partition is insulation material in the partition void

Baffle	Thickness (mm)	Lining Mass (kg/m^2)	Cost (re 40 dB Rw)
Not proposed for KDH project	118	17	+ 0%

Rw Rating	Rank 2 System	Resonate Library Data	Comparable System 1	Comparable Rating 1	Comparable System 2	Comparable Rating 2
40	• **13 mm standard plasterboard** • **92 mm steel studs** • **13 mm standard plasterboard** • **50 mm glasswool or polyester insulation**		CSR Redbook 2011 CSR 010 Page B9	40 (64 mm studs) 41 (92 mm studs)		

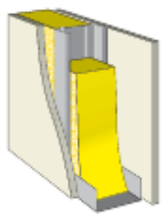
Standard plasterboard >= 8.5 kg/m^2, Dense plasterboard >= 10.5 kg/m^2, Sound rated plasterboard >= 12.5 kg/m^2

Drawing



Industry Data

CSR 010



Both Sides

- 1 x 13mm GYPROCK Plasterboard CD.

(a) Nil	34/26	35/28	[illegible]	37/30
(b) 50 GW Partition 11kg	39/29	40/31	41/32	42/33
(c) 75 GW Partition 11kg	–	42/33	42/33	43/34
(d) TSB3/ASB3 Polyester	39/31	39/32	40/33	41/34
(e) 60 Soundscreen™ 1.6	–	41/31	42/32	43/33
WALL THICKNESS mm	77	90	102	118

Transmission Loss Values (dB)

63 Hz	125 Hz	250 Hz	500 Hz	1kHz	2kHz	4kHz	8kHz
-	14	30	41	48	47	52	-

S12119 KDH Redevelopment| Rank 2 | Partition | September 2013

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/m^2)	Perimeter Seals	Threshold Seal
30	32 mm thick solid core door Raven or Kilargo Seals all round	32	15	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/m^2)	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 .

Project Specific Construction - Refer to KDH Acoustic Design Report

Resonate acoustics

45 dB Rw | Rank 3 | Partition

Summary

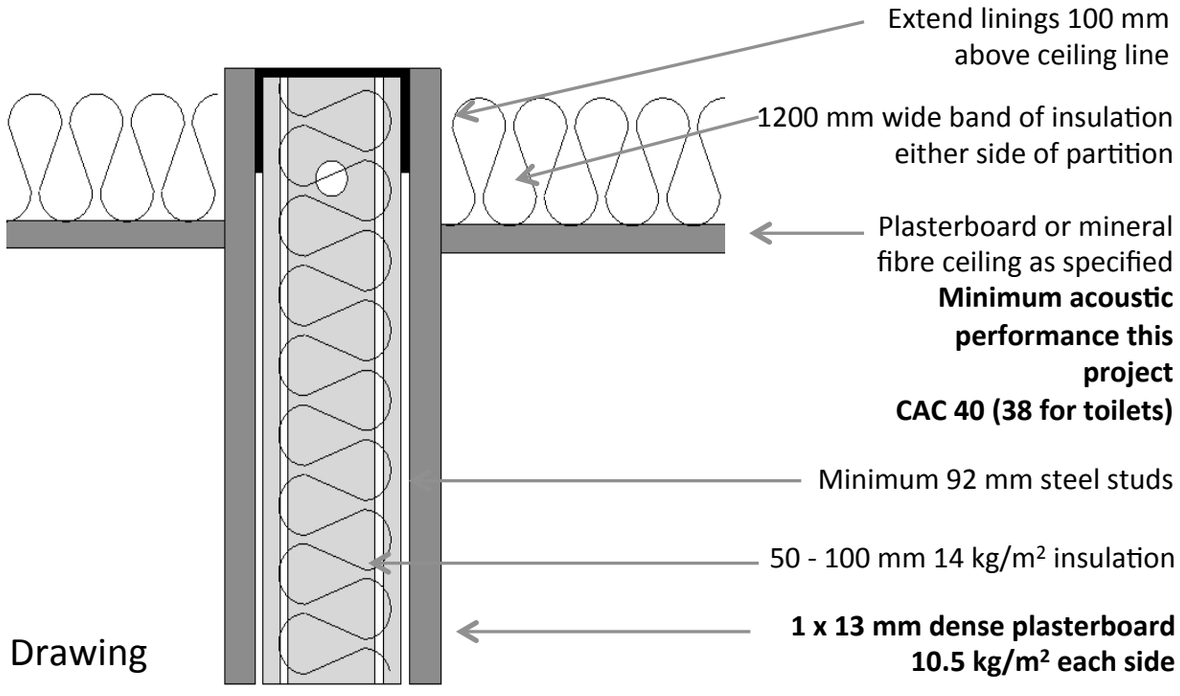
- Project specific construction
- Upgrade over Rank 2 is the insulation material in the cavity and a 1200 mm wide of insulation (50 mm 14 kg/m^3) either side of the partition
- All mechanical services ceiling penetrations on either side of partition are to be treated with lined cushion box.
- Based on Peer Review Input

Ceiling Baffle	Thickness (mm)	Lining Mass (kg/m^2)	Cost (re 40 dB Rw)
Insulation as noted	118	21	+ 30 %

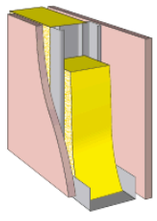
Rw Rating	Rank 3 System	Resonate Library Data	Comparable System 1	Comparable Rating 1	Comparable System 2	Comparable Rating 2
45	• **13 mm dense plasterboard** • **92 mm steel studs** • **1 x 13 mm dense plasterboard** • **50 mm 14 kg/m^3 insulation in cavity, and in 1200mm wide band either side of partition in ceiling cavity**	*16mm plasterboard/92mm steel studs/16mm plasterboard with 100 mm 0.8kg/m^2 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



CSR 050



Both Sides

- 1 x 13mm GYPROCK FYRCHEK plasterboard.

Industry Data

(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	-

S12119 KDH Redevelopment | Rank 3 | Partition | September 2013

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

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/m^2)	Perimeter Seals	Threshold Seal
35	45mm thick solid core door Raven or Kilargo Seals all round	45	27	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/m^2)	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 .

Project Specific Construction - Refer to KDH Acoustic Design Report

50 dB Rw | Rank 4 | Partition

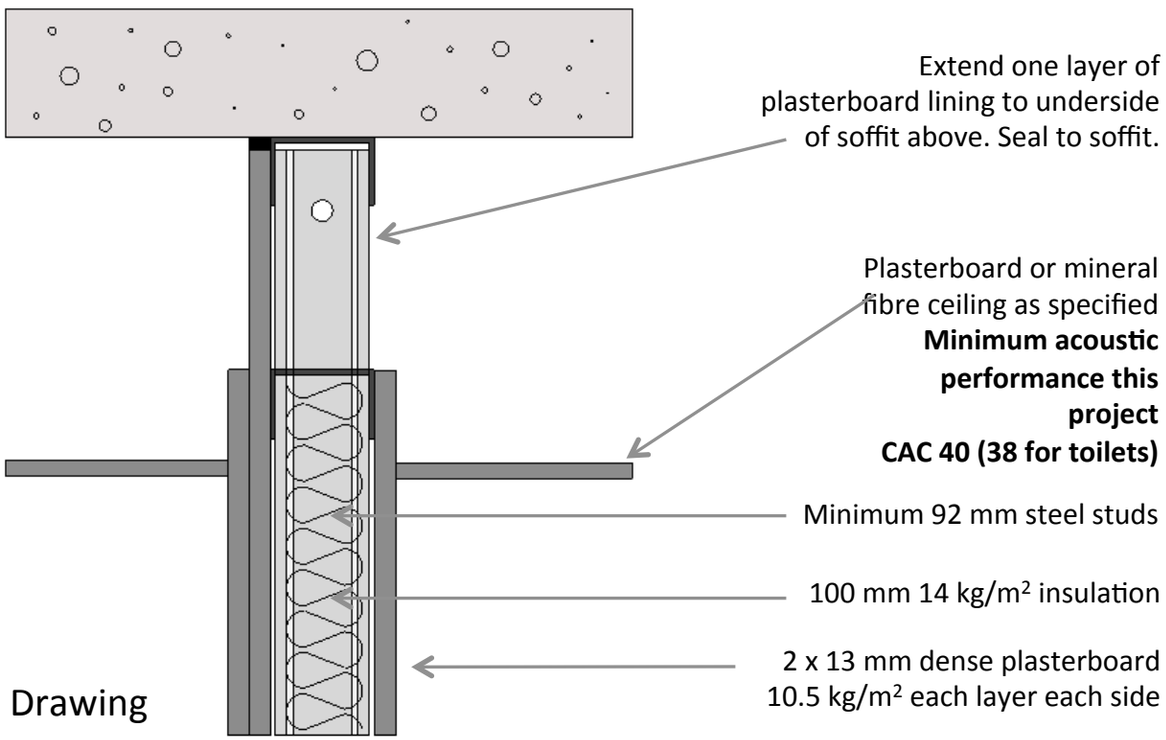
Summary

- 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

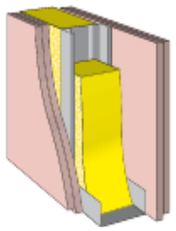
Standard plasterboard >= 8.5 kg/m², Dense plasterboard >= 10.5 kg/m², Sound rated plasterboard >= 12.5 kg/m²



Drawing

Industry Data

CSR 075



Both Sides

- 2 x 13mm GYPROCK FYRCHEK plasterboard.

(a) Nil	44/37	45/38	46/40	47/41
(b) 50 GW Partition 11kg	49/40	50/41	51/43	52/44
(c) 75 GW Partition 11kg	–	52/43	52/44	53/45
(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	-

S12119 KDH Redevelopment | Rank 4 | Partition | September 2013

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

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/m^2)	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/m^2)	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 .

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

55 dB Rw | Rank 5 | Partition

Summary

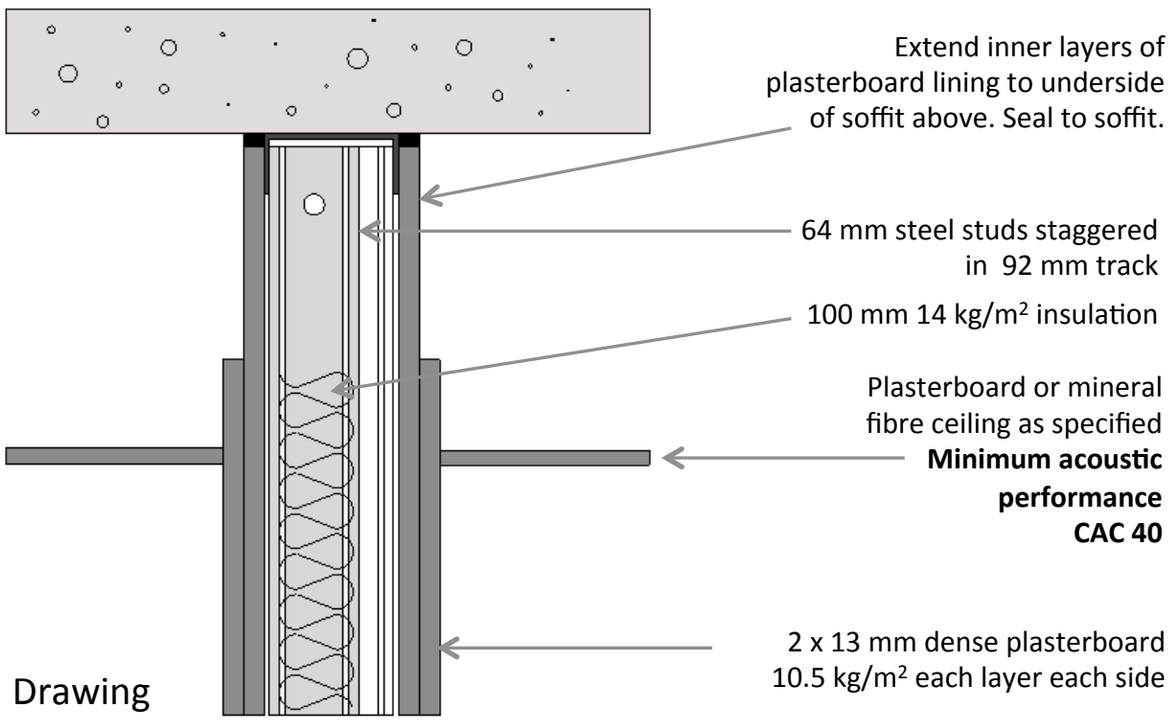
- Project specific construction
- Upgrades over Rank 4 are staggered stud construction and extending all layers of plasterboard (on each side of the studs) to the underside of the soffit above
- Alternative construction using 150 mm steel studs (not staggered) is provided in the Acoustic Design Report

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

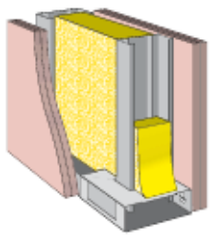
Standard plasterboard >= 8.5 kg/m², Dense plasterboard >= 10.5 kg/m², Sound rated plasterboard >= 12.5 kg/m²

Drawing



Industry Data

CSR 175



Both Sides

- 2 x 13mm GYPROCK FYRCHEK plasterboard.

(a) Nil	~~48/42~~
(b) 50 GW Partition 11kg	56/48
(c) 75 GW Partition 14kg	~~58/50~~
(d) TSB4/ASB4 Polyester	56/**50**
(e) 60 Soundscreen™ 1.6	58/**50**①
WALL THICKNESS mm	144

Transmission Loss Values (dB)

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

S12119 KDH Redevelopment | Rank 5 | Partition | September 2013

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

Resonate acoustics

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/m^2)	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/m^2)	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 .

Appendix 5 – Acoustically absorptive finishes

Acoustic Ceiling tiles are presented in Table 14.

Table 14 - 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 15.

Table 15 - 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 16.

Table 16 - 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 17.

Table 17 - 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
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

(Deleted following Peer Review)