WOOD & GRIEVE ENGINEERS

Herston Quarter
Specialist Rehabilitation & Ambulatory Care Centre

Noise Impact Assessment for Development Application

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Date:
17 January 2018

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Revision

REVISION	DATE	COMMENT	APPROVED BY
1	4/08/2017	Draft	**MLL**
2	17/01/2018	Final	**MLL**

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Contents

1.	INTRODUCTION	1
2.	REFERENCED DOCUMENTS	2
3.	PROJECT OVERVIEW	3
3.1	Site description	3
3.2	Proposed SRACC building	3
3.3	Acoustic issues	6
4.	ACOUSTIC ENVIRONMENT	7
4.1	Noise sensitive receptors	7
4.2	Environmental noise sources	7
4.3	Noise survey	7
5.	ACOUSTIC CRITERIA	9
5.1	Environmental noise and vibration emissions	9
5.2	Environmental Noise intrusion from transportation sources	15
5.3	Demolition, excavation and construction noise and vibration	20
6.	ASSESSMENT OF ENVIRONMENTAL NOISE LEVELS	23
6.1	Transportation noise intrusion assessment	23
6.2	Building service noise emissions assessment	30
6.3	Construction noise and vibration	30
7.	RECOMMENDATIONS FOR CONSTRUCTIONS	31
7.1	Building envelope	31
7.2	Building services treatments	31
8.	CONCLUSION	32
APPENDIX 1 - GLOSSARY OF ACOUSTIC TERMS		33
APPENDIX 2 – NOISE MONITORING RESULTS		35
APPENDIX 3 – NOISE MODEL DETAILS		41
APPENDIX 4 – COMPUTER 3D MODEL VIEWS AND NOISE MAPS		43

1. Introduction

Wood & Grieve Engineers (WGE) has been commissioned by HASSELL, to prepare a noise impact assessment to support the development application for the Specialist Rehabilitation and Ambulatory Care Centre (SRACC), which is to be located in the Herston Quarter redevelopment campus, within the Herston Health Precinct. The SRACC building is being developed for use by government by Australian Unity and Watpac.

SRACC will be a multi-purpose healthcare building that will be administered by Queensland Health and operated by Metro North Hospital and Health Service (MNHHS). The building will consist of the following elements:

- seven operating theatres, three endoscopy rooms and recovery spaces;
- a surgical and endoscopic centre with a 32-bed surgical inpatient room; and
- 100 rehabilitation beds, and special purpose rehabilitation support areas.

This report outlines the acoustic impacts for the SRACC building and provides acoustic advice in terms of noise mitigation for noise emission from the operation of the site and noise intrusion from noise sources external to the site. The items outlined in this report include the following:

- acoustic criteria for the following items:
    - Environmental noise emissions; and
    - Environmental noise intrusion
- acoustic design advice for the following items:
    - Building facades;
    - Mechanical plant environmental noise emissions;

The noise impact assessment for the project has addressed the environmental noise criteria specified in the Herston Quarter Priority Development Area (PDA) *Interim Land Use Plan* (ILUP). Noise measurements were conducted to determine applicable noise limits based on the noise criteria and noise modelling was conducted to predict the likely noise impacts.

The environmental noise issues associated with the SRACC project have been assessed against these criteria and recommendations are made to provide a consistent acoustical outcome for the building. In addition, vibration criteria are proposed for the construction stage of the project.

A glossary of acoustic terms used in this report is presented in **Appendix 1.**

2. Referenced documents

The following documents are referred to within this report:

1. Australian Standard AS/NZS 2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors;
2. AS 2436-2010 Guide to noise and vibration control on construction, demolition and maintenance sites;
3. Brisbane City Council Planning Scheme 2014 - Centre or Mixed Use Code;
4. Queensland Environmental Protection (Noise) Policy 2008, Environmental Protection Act (EPA) 1994 (Qld), Office of the Queensland Parliamentary Counsel;
5. Herston Quarter Priority Development Area (PDA) Interim Land Use Plan (ILUP)[1];
6. Department of Transport and Main Roads (TMR) – Road Traffic Noise Management: Code of Practice;
7. Queensland Government Queensland Development Code (QDC) Mandatory Part 4.4 (MP4.4) 'Buildings in transport noise corridors';
8. Queensland State Development Assessment Provisions (SDAP) - Module 1: Community Amenity V1.10;
9. SRACC Project Deed Schedule 25 – Output Specification Part A – Strategic Functional Design Brief;
10. Helicopter Noise Impacts on Hospital Development Design by Aaron James and Luke Zoontjens - Proceedings of Acoustics 2012 – Fremantle;
11. AS/NZS 2021:2015 Acoustics – Aircraft Noise Intrusion – Building Siting and Construction;
12. British Standard BS 5228-2:2009 - Code of practice for noise and vibration control on construction and open sites – Part 2: Vibration;
13. British Standard BS 7385-2:1993 - Evaluation and measurement for vibration in buildings. Guide to damage levels from groundborne vibration;
14. German Standard DIN 4150-3:1999 - Structural vibration - Effects of vibration on structures;

[1] https://www.dilgp.qld.gov.au/resources/plan/pda/herston-quarter-pda-ilup.pdf

3. Project overview

3.1 Site description

3.1.1 Herston Health Precinct

The Herston Health Precinct is located in the Brisbane suburb of Herston. The precinct contains various buildings including:

- Royal Brisbane Women's Hospital;
- The University of Queensland Faculty of Medicine;
- The University of Queensland Oral Health Centre;
- The University of Queensland Centre for Clinical Research;
- The University of Queensland School of Public Health;
- QIMR Berghofer Medical Research Institute;
- Queensland Health Clinical Skills Development Service; and
- Various other health related buildings.

In the south-western corner of the site is a disused building which was the Queensland Royal Children's Hospital. The building became vacant with the development of the Lady Cilento Children's Hospital in South Brisbane. The Queensland Government declared an area of the Herston Health Precinct as the Herston Quarter Priority Development Area (PDA) in order to facilitate development of the site.

3.1.2 Herston Quarter Priority Development Area

The Herston Quarter Priority Development Area (PDA) was declared on 18 November 2016 and is now being developed by Australian Unity. The development of the PDA is currently controlled by the *Interim Land Use Plan (ILUP)*[2]. The site approximate outline is shown on **Figure 1**.

The PDA is bordered by Herston Road to the south, Bramston Terrace to the west and the Royal Brisbane and Women's Hospital (RBWH) to the east and north. The PDA is in close proximity to various other health buildings utilized by Metro North Hospital and Health Service (MNHHS).

The proposed layout of the SRACC building within the PDA is provided in **Figure 2.** The PDA includes significant state-listed heritage places including the Lady Lamington Nurses Home, Edith Cavell and Lady Norman buildings which will be preserved and adaptively re-used.

3.2 Proposed SRACC building

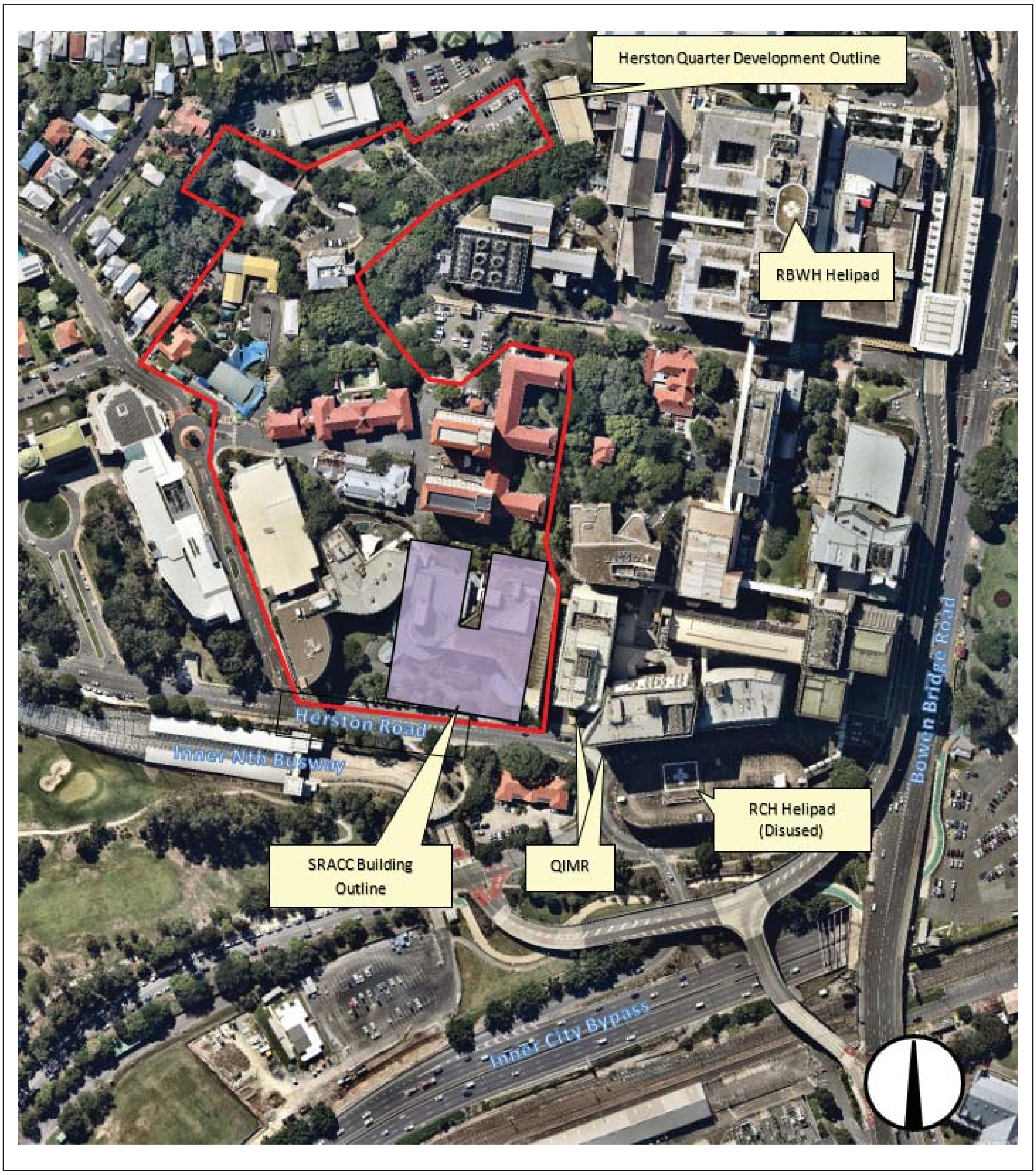
3.2.1 Location

The location of the SRACC Building is shown on **Figure 1.** The building will replace the existing and disused Royal Children's Hospital building, which will be demolished.

[2] https://www.dilgp.qld.gov.au/resources/plan/pda/herston-quarter-pda-ilup.pdf

Project overview

Figure 1: Aerial Photo of the Area Showing an Overview of the Site and Measurement Locations (Source: Nearmap)



Project overview

Figure 2: Herston Quarter PDA Map (Source: client)

1. Lamington Place	8. Lady Lamington Towers
2. Herston Square	9. Lady Lamington Building
3. Spanish Steps	10. Retirement Living
4. Green Heart	11. Car Park
5. Specialist Rehabilitation and Ambulatory Care Centre	12. Edith Cavell Building
6. Aged Care	13. Lady Norman Building
7. Private Hospital	14. Residential Tower

3.2.2 Building overview

SRACC will be used by Queensland Health and is to be operated by Metro North Hospital and Health Service (MNHHS) and will consist of the following elements:

- seven operating theatres, three endoscopy rooms and recovery spaces;
- a surgical and endoscopic centre with a 32-bed surgical inpatient room; and
- 100 rehabilitation beds, and special purpose rehabilitation support areas.

The building will have eight floors, as described **Table 1**.

Table 1: Building uses by floor

Floor	Description
Basement	Non Clinical Support, Kitchen, Engineering, Plant, Carpark
Ground	Main Entry, Combined Clinics, Pharmacy, Rehab Engineering, Carpark &Plant
Level 1	Medical Imaging, Pathology, Education And Research, Clinical Directorate, Facility Admin, Carpark & Plant
Level 2	Endoscopy, Engineering, Travel, Sterilizing Services Unit, Surgery, Stage 1/2 Recovery
Level 3	Retail, Facilities Management, Staff Amenities, Surgical Inpatient Unit, Plant (Chillers and large AHU Plant)
Level 4	General Rehab, In-patient Therapy Unit & Gait Lab
Level 5	Special Rehabilitation, Brain Injury Unit
Level 6	Single bed rooms, Audiology, Gym, Procedure room, Consulting rooms, MDT Room and Offices.
Level 7	Sleep Study Rooms / Research, Offices (private and open plan), Consulting and assessment rooms, shell space.
Roof	Plant – Cooling Towers and Generators

At the time of issue of this report, Level 6 and Level 7 are yet to be briefed by the client and tenants.

3.2.3 General description of construction

The building will be a concrete frame building with seven floors and a single basement level.

The facade of the building will be constructed to meet acoustic, energy efficiency and structural requirements and consist of aluminum window-wall construction with solid backed and vision areas between concrete columns. The roof of the building will be concrete slab construction with an areas of lightweight steel-framed areas over central rooftop plant spaces.

3.3 Acoustic issues

The following environmental noise and vibration matters have been identified for the subject site:

- Environmental noise emissions to noise sensitive receptors;
- Noise intrusion from transportation noise sources (road traffic and emergency helicopters); and
- Noise and vibration emissions from demolition, excavation and construction.

4. Acoustic environment

4.1 Noise sensitive receptors

The proposed SRACC building will have a number of large mechanical plant items which emit noise to the exterior of the building. Demolition, excavation and construction of the new building will also generate noise and vibration. Both the mechanical plant, the demolition and construction activities have the potential to have an adverse environmental impact on nearby noise sensitive receptors.

With reference to **Figure 1** and **Figure 2**, the following noise sensitive receptors are identified in **Table 2**.

Table 2: Noise sensitive receptors

Direction	Description
North	Future residential uses in heritage buildings (Lady Lamington Towers, Lady Lamington Building, Edith Cavell Building), other hospital buildings including Mental Health.
East	QIMR Buildings
South	Sensitive receptors located at a significant distance, where other sources of noise are dominant and the noise impact of SRACC is negligible
West	Future private hospital and residential tower

4.2 Environmental noise sources

There are a number of noise sources around the proposed SRACC building that have a potential to have an acoustic impact on the subject building. Based on observations conducted during noise monitoring (see **Section 4.3** below for details on this), the following potential noise intrusion impacts have been identified:

- Traffic noise from Herston Road (dominant road traffic noise source);
- Traffic noise from Inner Northern Busway (minor to negligible);
- Helicopter overflight to the Ned Hanlon building rooftop helipad; and
- Localized mechanical plant of nearby buildings.

The dominant noise sources on site are helicopter noise (during overflights) and road traffic noise along Herston Road. The highest noise levels (and noise intrusion) impacts will be produced by helicopter overflights, which will determine the acoustic requirements for the building facades. As it is discussed in **Section 6.1.3**, adequate helicopter noise attenuation by the building facade would result in compliance with the applicable internal design sound levels for road traffic noise intrusion and mechanical plant systems installed at other buildings.

4.3 Noise survey

A noise surveys have been conducted. This comprised unattended long-term noise logging (approximately one week) to quantify the existing noise environment on site during normal road traffic flow conditions (i.e. outside school holiday periods and public holidays).

Acoustic environment

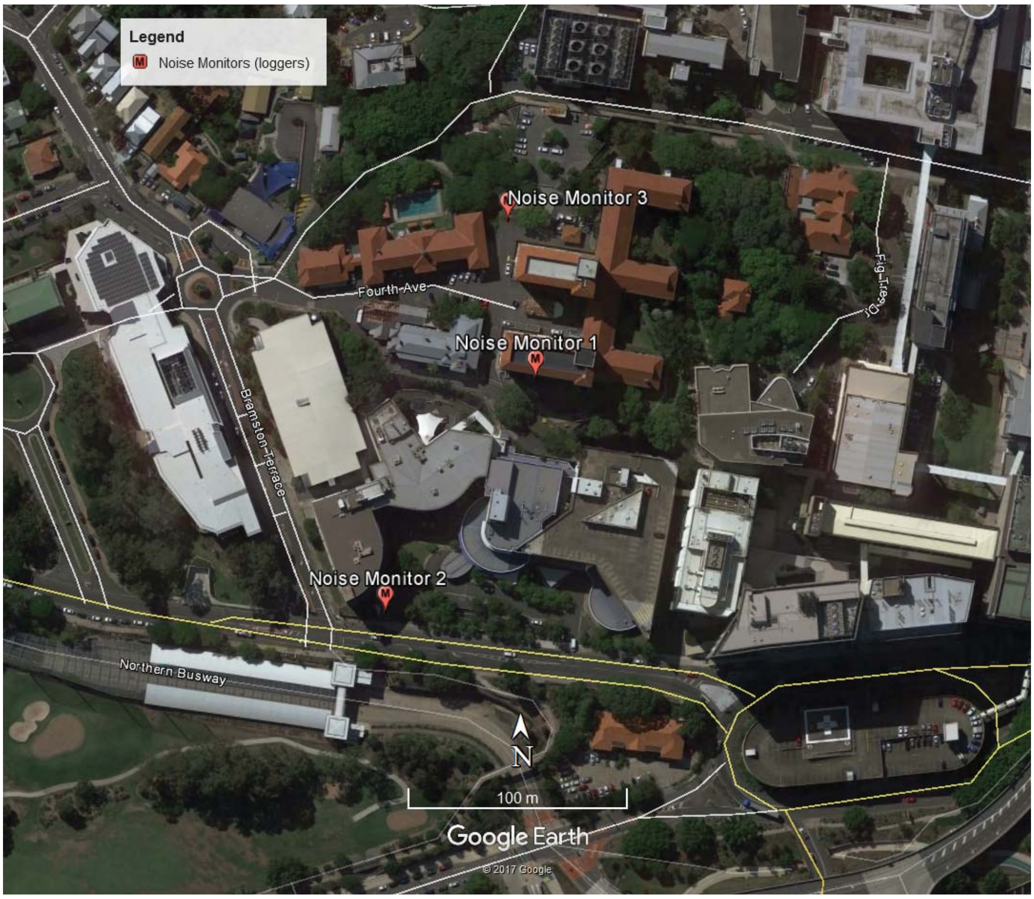
Noise monitoring was conducted at the following locations:

- **Noise Monitor 1, Lady Lamington Building**: Noise monitoring was conducted between 4 July and 11 July 2017. A noise logger was placed at the building verandah facing Herston Road, on Level 3.
- **Noise Monitor 2, Herston Road:** Noise monitoring was conducted between 15 June and 23 June 2017. A noise logger was placed at ground level, approximately 5m from the Herston Road kerb.
- **Noise Monitor 3, back of site:** Noise monitoring was conducted between 15 June and 23 June 2017. A noise logger was installed between the Edith Cavell Building and the Lady Lamington buildings, at ground level.

The location of noise loggers is shown in **Figure 3**. The logging locations are considered representative of the noise environment near and far from major road traffic noise sources, and of the noise levels at elevated areas.

Further details including the equipment used and noise monitoring results is presented in **Appendix 2**. The noise measurements were conducted in accordance to Australian Standard AS 1055.1-1997 – *Acoustics – Description and measurement of environmental noise*.

Figure 3: Noise Monitoring Locations



5. Acoustic criteria

The applicable environmental noise legislation to the project is specified in the *Interim Land Use Plan (ILUP)*, which purpose is to regulate development within the Priority Development Area (PDA) until the development scheme for the area takes effect.

The applicable noise criteria are taken from the ILUP and the Council and state policies to which it refers to.

5.1 Environmental noise and vibration emissions

5.1.1 Herston Quarter PDA Interim Land Use Plan (ILUP)

The Herston Quarter PDA Interim Land Use Plan (ILUP) makes reference to environmental and transportation noise effects associated with the development of the PDA. Section 4.16 or the (ILUP) refers to the following:

> *The siting, design, construction and operation of development supports community safety and gives appropriate consideration to development constraints by:*
>
> *…….*
>
> - *managing and minimising noise emissions on sensitive uses*, including those from transport noise corridors**.*
>
> ** For guidance on acoustic amenity, refer to the BCC Planning Scheme Centre or mixed use code.*
>
> *** Refer to the requirements, standards and guidance identified in the Environmental Protection (Noise) Policy 2008, as well as the Transport and Main Roads Traffic Noise Management: Code of Practice with respect to external road traffic noise levels, and the Queensland Development Code Mandatory Part 4.4 'Buildings in a Transport Noise Corridor', each as amended or replaced from time to time. Transport noise corridors are mapped on the Department of Infrastructure, Local Government and Planning's State Planning Policy Interactive Mapping System.*

5.1.2 BCC Planning Scheme 2014 - Centre or Mixed Use Code

For acoustic amenity and noise emissions from the proposed development, the ILUP refers to noise criteria contained in the Brisbane City Council Planning Scheme 2014 - Centre or Mixed Use Code.

The Centre or Mixed Use Code contains performance outcomes and acceptable outcomes that are the assessment criteria for the development. The acoustically-relevant performance outcomes and acceptable outcomes from the Centre or Mixed Use Code are presented in **Table 3**. The applicable noise limits are presented in **Section 5.1.5**, as applied in combination with other environmental noise criteria presented within this section. These apply to mechanical plant as other noise sources (e.g. deliveries) will operate in the building basement where there are no external sensitive receptors.

Acoustic criteria

Table 3: Acoustic Criteria from Centre or Mixed Use Code

<table>
<tr><th>Performance outcomes</th><th>Acceptable outcomes</th></tr>
<tr><td colspan="2">Section A—If for self-assessable or assessable development</td></tr>
<tr><td rowspan="2"><u>PO1</u>
Development:
(a) has hours of operation which are controlled so thatthe use does not detrimentally impact on the amenity of adjoining residents;
(b) does not result in noise emissions that exceed the noise (planning) criteria in Table 9.3.3.3.F, low frequency noise criteria in Table 9.3.3.3.G and night-time noise criteria in Table 9.3.3.3.H in a sensitive zone or a nearby sensitive use, except music noise where located in a Special entertainments precinct identified in a neighbourhood plan.
Note—A noise impact assessment report prepared inaccordance with the Noise impact assessment planning scheme policy can assist in demonstrating achievement of thisperformance outcome.</td><td><u>AO1.1</u>
Development:
(a) for accommodation activities, dwelling unit or emergency services has unlimited hours ofoperation;
(b) for a club, if licensed, function facility, hotel or nightclub entertainment facility does not generate noise which is clearly audible and detectable, or impacts on the amenity of a resident, in a dwelling or other sensitive use;
Note—Development for a club, if licensed, function facility, hotel or nightclub entertainment facility is not expected to achieve this outcome.
(c) for any other use:
(i) where in the Principal centre zone or Major centrezone has unlimited hours ofoperation;
(ii) where in the District centre zone, Neighbourhood centre zone or Mixed usezone:
(A) has hours of operation, including for deliveries, whichare limited to 6am to 10pm; or
(B) does not generate noise which is clearly audibleand disturbing in a dwelling or othersensitive use;
(iii) where in any other zone:
(A) has hours of operation, including for deliveries, whichare limited to 6am to 8pm; or
(B) does not generate noise which is clearly audibleand disturbing in a dwelling or othersensitive use.</td></tr>
<tr><td><u>AO1.2</u>
Development ensures mechanical plant or equipment is acoustically screened from an adjoining sensitive use.
Note—Mechanical plant includes generators, motors, compressors and pumps e.g. air-conditioning, refrigeration or cold room motors</td></tr>
<tr><td colspan="2">Additional criteria for development if for a food and drink outlet</td></tr>
<tr><td><u>PO6</u>
Development mitigates impacts on residential amenityin or adjoining the building through:
(a) providing an outdoor dining area thatis appropriately located;
(b) ensuring external dining and entertainmentareas are visually and acoustically screened from an adjoining dwelling.</td><td><u>AO6</u>
Development provides for external diningor entertainment areas to be:
(a) located in or directly adjacent to thepublic realm;
(b) visually and acoustically screened from anadjoining dwelling.</td></tr>
</table>

Acoustic criteria

Section C—If for assessable development	
PO18 Development minimises the adverse impact of a use on building occupants and residents in or adjoining the site through appropriate land use mix. Note—Low impact commercial activities are shops, banks, offices and similar.	AO18 Development provides: (a) co-location of low impact commercial activities where air or noise impacts are not detectable and disturbing in a dwelling or other sensitive use; (b) co-location of uses with potential air or noise impacts away from sensitive uses; (c) mitigation of impacts resulting from co-location of food and drink outlet uses such as a restaurant with residential uses in the same building; (d) that nightclub entertainment facilities are not co-located with residential or other sensitive development within the same building; (e) that the location of exhaust or ventilation outlets from food outlets, drycleaners, salons, carparks and bus stations as far from a sensitive use as practicable; (f) adequate separation distances between service stations and any sensitive use; (g) dwelling balconies and windows do not overlook ventilation stacks and bulk waste bin storage areas.
PO60 Development of garages, driveways and parking structures minimise impacts on the amenity of neighbouring dwellings.	AO60.1 Development for a car park: (a) provides a 2m-high acoustic fence and a landscaped area 1.5m wide where located adjacent to a neighbouring dwelling; (b) is acoustically screened where the car park is used at night and where located adjacent to a neighbouring dwelling.
	AO60.2 Development for a driveway or vehicle movement area is screened by a 2m-high acoustic fence along the side or rear boundary if located adjacent to a residential dwelling.
PO61 Development provides refuse and recycling collection and facilities that: (a) are located conveniently in an unobtrusive dedicated storage room or separate screened structure; (b) are located and managed so that adverse impacts on building occupants, neighbouring properties and the public realm are minimised; (c) provide for refuse and recycling including source separation; (d) are of a design which allows low-frequency service collection; (e) minimise ongoing building management cost for occupants	AO61.2 Development is designed and constructed to ensure refuse storage and recycling collection and storage facilities do not have any odour, noise or visual impacts which are detectable and disturbing at the site or adjoining sites.

Acoustic criteria

5.1.3 Environmental Protection Act

According to the *Environmental Protection Act 1994*, an occupier of the premises must not use, or permit the use of, air-conditioning or Refrigeration equipment on any day-

(a) before 7a.m, if it makes a noise of more than 3dBA above the background level; or
(b) from 7.a.m. to 10p.m, if it makes a noise of more than 5dBA above the background level; or
(c) after 10p.m, if it makes a noise of more than 3dBA above the background level.

The project specific noise criteria based on the *Environmental Protection Act 1994* are summarised in **Table 4** below.

Table 4: Noise Criteria for Different Noise Sources Based on the Environmental Protection Act 1994

Type	Period	Criteria
Air Conditioning Equipment	Before 7 am	<3 dBA above RBL
	7 am – 10 pm	<5 dBA above RBL
	After 10 pm	<3 dBA above RBL

5.1.4 Environmental Protection (Noise) Policy 2008

The Environmental Protection (Noise) Policy 2008 (EPP(Noise)) identifies environmental values to be enhanced or protected, states acoustic quality objectives, and provides a framework for making decisions about the acoustic environment.

Acoustic Quality Objectives for Sensitive Receivers

According to the *Environmental Protection (Noise) Policy 2008,* an acoustic quality objectives stated in **Table 5** below, Column 3 for a sensitive receptor stated in column 1 and for a time of day stated in column 2, is prescribed for enhancing or protecting the environmental value stated in column 4 of the schedule for the objective. It is intended that the acoustic quality objectives be progressively achieved as part of achieving the purpose of this policy over the long term.

Table 5: Acoustic Quality Objectives as Defined in Schedule 1 of the (EPP(Noise))

Column 1	Column 2	Column 3			Column 4
Sensitive Receptor	Time of Day	Acoustic Quality Objectives (measured at the receptor) dB(A)			Environmental Value
		LAeq,adj,1hr	LA10,adj,1hr	LA1,adj,1hr	
Dwelling (for outdoors)	Daytime and evening	50	55	65	Health and wellbeing
Dwelling (for indoors)	Daytime and evening	35	40	45	Health and wellbeing
	Night-time	30	35	40	Health and wellbeing in relation to the ability to sleep
hospital, surgery or other medical institution (for indoors)	Visiting hours	35	-	-	health and wellbeing
hospital, surgery or other medical institution (for indoors)	anytime, other than visiting hours	30	-	-	health and wellbeing, in relation to the ability to sleep

Acoustic criteria

Background Creep

Section 10 of the Environmental Protection Policy 2008 states the following regarding the control of "background creep".

10 Controlling background creep

(1) This section states the management intent for an activity involving noise.

(2) To the extent that it is reasonable to do so, noise from an activity must not be—

(a) for noise that is continuous noise measured by LA90,T—more than nil dB(A) greater than the existing acoustic environment measured by LA90,T; or

(b) for noise that varies over time measured by LAeq,adj,T—more than 5dB(A) greater than the existing acoustic environment measured by LA90,T

5.1.5 Environmental noise vibration limits

The operational noise criteria for the project is detailed in **Section 5.1.1** to **Section 5.1.4**. Specifically, these apply to mechanical plant noise emissions. The applicable noise limits at sensitive receptors are obtained when the noise criteria are combined with the measured noise levels detailed in **Section 4.3.** The resulting noise limits are presented in **Table 6.**

It is noted that specific locations of vibration sensitive equipment and vivariums in adjoining buildings have not been identified at this stage. When surrounding buildings are surveyed, noise limits can be derived from the Criteria provided in **Section 5.1**.

Acoustic criteria

Table 6: Operational environmental noise criteria summary

Noise Criteria	Noise Limit at the receptor, dBA								
	Day (7am - 6pm)			Evening (6pm - 10pm)			Night (10pm - 7am)		
	Mon 1	Mon 2	Mon 3	Mon 1	Mon 2	Mon 3	Mon 1	Mon 2	Mon 3
City Plan 2014 – Intrusive Noise Criteria									
Measured RBL	54	58	47	52	54	45	50	48	44
Permitted noise level increase	5			5			5		
Noise limit at sensitive receptor, $L_{Aeq,adj,T}$	**59**	**63**	**52**	**57**	**59**	**50**	**55**	**53**	**49**
Brisbane City Plan 2014 – Acoustic amenity criteria at a sensitive use in the major centre zone									
Noise level at sensitive use	$L_{Aeq,adj,11hr} \leq 60$			$L_{Aeq,adj,4hr} \leq 55$			$L_{Aeq,adj,9hr} \leq 50$		
EPP (Noise) 2008 – Acoustic Quality Objectives									
Dwelling (for outdoors): $L_{Aeq,adj,1hr}$	50			50			-		
$L_{A10,adj,1hr}$	55			55			-		
$L_{A1,adj,1hr}$	65			65			-		
Resulting strictest component limits, $L_{Aeq,adj,1hr}$	**50**			**50**			**-**		
EPP (Noise) 2008 – Controlling Background Creep									
Measured $L_{A90,T}$	55	58	47	53	55	45	52	51	45
Permitted noise increase for continuous source	0			0			0		
Noise limit at sensitive receptor $L_{A90,T}$	**55**	**58**	**47**	**53**	**55**	**45**	**52**	**51**	**45**
Measured $L_{A90,T}$[1]	55	58	47	53	55	45	52	51	45
Permitted noise increase for time-varying source	5			5			5		
Resulting component noise limits $L_{Aeq,adj,T}$	**60**	**63**	**52**	**58**	**60**	**50**	**57**	**56**	**50**
EPA 1994[2]									
Measured $L_{A90,T}$	55	58	47	53	55	45	52	51	45
Permitted noise increase to air conditioning and refrigeration equipment:	5			5			3		
Resulting component noise limit, $L_{Aeq,Adj,T}$	**60**	**63**	**52**	**58**	**60**	**50**	**55**	**54**	**48**
Resulting strictest measured noise limits, $L_{Aeq,Adj,T}$	**50**	**50**	**47**	**50**	**50**	**45**	**50**	**50**	**45**

1. For practical purposes, the $L_{A90,T}$, is taken to be the same as the $L_{Aeq,Adj,T}$ for continuous noise sources.
2. The EPA Act 1994 defines the day period between 7am-7pm, and the evening period between 7pm-10pm. The ending and starting period have been shifted to 6pm to be consistent with the Brisbane City Council definition. The impact of the shift is zero as the acoustic quality objective is the noise limit selected in the day time and evening periods, as it is the most conservative.

5.2 Environmental Noise intrusion from transportation sources

The PDA ILUP makes reference to transportation noise effects, the requirements, standards and guidance identified are:

- Environmental Protection (Noise) Policy 2008,
- Transport and Main Roads Traffic Noise Management: Code of Practice with respect to external road traffic noise levels (TMR Code of Practice); and
- Queensland Development Code Mandatory Part 4.4 'Buildings in a Transport Noise Corridor'.

There are three transportation noise sources which affect the site. These are:

- Road traffic noise from council controlled roads;
- Noise from the Inner Northern Busway; and
- Emergency helicopter overflights

5.2.1 Road traffic noise

Environmental Protection (Noise) Policy 2008

The Environmental Protection (Noise) Policy 2008 is silent on the issue of road traffic noise.

TMR Code of Practice

The TMR Code of Practice is applied within this study as a technical guideline for the prediction of road traffic noise onto the proposed development. The noise limits specified within this document were not applied to the Northern Inner Busway, which specific limits are specified in **Section 5.2.2** below.

Queensland Development Code Part MP 4.4

The Queensland Development Code Part MP 4.4 - *'Buildings in a Transport Noise Corridor'* August 2015 (QDC MP4.4) specifies Noise Categories to ensure that habitable rooms of residential buildings are adequately protected from transport noise. The purpose of the QDC MP4.4 is to ensure any habitable rooms of Class 1, 2, 3 and 4 buildings located in a transport noise corridor are designed and constructed to reduce transport noise. The Code requires that each external facade of a habitable room be assigned a noise category which is dependent upon the future noise exposure at the facade.

The proposed building is not a Class 1, 2, 3 and 4 building by definition; therefore, QDC MP4.4 is not applicable.

Road Traffic Noise Criteria – Overview

As demonstrated in this section, there are no specific regulatory noise criteria applicable to road traffic noise intrusion in the PDA. The is no mandatory requirement to treat the building against road traffic noise. Thus, the SRACC building will address road traffic noise by designing the building facade, such that the indoor design sound levels from AS/NZS 2107:2016 are met to provide the requirement of the client's brief. The applicable noise levels form the standard are reproduced in column 2 of **Table 7**.

Acoustic criteria

Table 7: Recommended Indoor Design Sound Levels and Reverberation Times based on AS/NZS 2107:2016

Type of occupancy/activity	*Proposed Indoor Design Sound Level, L_{Aeq} (dBA) and Reverberation Time Based on AS/NZS2107:2016*	
	Indoor Design Sound Range, L_{eq}, dBA	**Design reverberation time (t) range (seconds)**
Audiological test rooms	See AS/NZS 1269.4 and AS ISO 8253	See Note 3
Control rooms	40 to 50	0.4 to 0.6
Corridors and lobby spaces	< 50	See Note 1
Consulting rooms	40 to 45	0.4 to 0.6
Dining areas	40 to 45	See Note 1
Geriatric rehabilitation	40 to 45	0.6
Kitchens, sterilizing and service areas	< 55	< 0.8 (See Note 8)
Laboratories	40 to 50	0.4 to 0. 7
Maintenance workshops	< 60	See Note 1
MRI/CT Scan/X-Ray areas/Ultrasound	45 to 50	See Note 1
Nurses' stations	40 to 45	0.4 to 0.7
Office areas	35 to 45	0.4 to 0.7
Operating theatres	40 to 50	See Notes 1,8
Patient lounge	40 to 45	0.4 to 0.6
Post-Op, Pre-Op, recovery rooms	40 to 45	0.4 to 0.6 (see Note 8)
Pharmacies	45 to 50	0.4 to 0.6
Staff rooms	40 to 45	0.4 to 0.6
Sterilizing areas in operating theatres	40 to 45	< 0.9 (see Note 8)
Surgeries/treatment/procedure rooms	40 to 45	0.4 to 0. 7
Utility rooms	50 to 60	-
Single bed	35 to 40	0.4 to 0. 7
Multiple beds	35 to 40	0.4 to 0.7 (See Note 8)
Waiting rooms, reception areas	40 to 50	< 0. 7
Audio-visual areas	35 to 45	0.6 to 0.8
Conference rooms	35 to 40	0.6 to 0. 7
Board and conference rooms	30 to 40	0.6 to 0. 8
Executive office	35 to 40	0.4 to 0.6
Open plan office	40 to 45	0.4 (see Note 1)
Undercover carparks	65	-
Small retail stores (general)	50	See Note 1

Note 1: Reverberation time should be minimized for noise control.
Note 3: Specialist advice should be sought for these spaces.
Note 8: Health requirements for hygiene and infection control may preclude achieving these recommended reverberation times.

5.2.2 Inner Northern Busway noise

Acoustic criteria for the project will need to address noise intrusion into the building from the Busway. As of 1st July 2013 the development application is referred to the State Assessment and Referral Agency (SARA) which is the Department of State Development, Infrastructure and Planning. It is understood that this is applicable in this instance.

Relevant noise criteria are included in Module 1 of the State Development Assessment Provisions (SDAP), which also references the following documents:

- Department of Transport and Main Roads (TMR) – Road Traffic Noise Management: Code of Practice.
- Queensland Government Queensland Development Code (QDC) Mandatory Part 4.4 (MP4.4) 'Buildings in transport noise corridors'.
- Department of Transport and Main Roads (TMR) – Policy Position Statement for Development on Land Affected by Environmental Emissions from Transport and Transport Infrastructure Version 2.0 dated 10/05/13.

For a Hospital near a Busway, the relevant Performance Outcome (PO) and Acceptable Outcomes (AO) are presented in **Table 8** below.

Table 8: SDAP Module 1. Community amenity P05

Particular development near a Busway or light rail	
PO5 Development involving a hospital achieves acceptable noise levels for workers and patients by mitigating adverse impacts on the development from noise generated by a Busway or light rail.	**AO5.1** All facades of buildings for a hospital exposed to noise from a Busway or light rail meet the following external noise criteria: (1) ≤55 dB(A) Leq (1 hour) facade corrected (maximum hour during normal opening hours). (2) ≤50 dB(A) Leq (1 hour) facade corrected (maximum hour between 10 pm and 6 am) (3) ≤64 dB(A) Lmax (1 hour) facade corrected (between 10 pm and 6 am). **AO5.2** Every private open space and passive recreation area* in an accommodation activity or residential care facility (other than a residential building) exposed to noise from a busway or light rail meet the following external noise criteria: (1) ≤52 dB(A) Leq (1 hour) free field (maximum hour between 6 am and 10 pm) (2) ≤66 dB(A) Lmax free field. AND **AO9.2** Patient care areas exposed to noise from a Busway or light rail meet the following internal noise criteria#: (1) ≤35 dB(A) Leq (1 hour) (maximum hour during opening hours). Note: Areas exposed to noise from a Busway or light rail are measured in accordance with AS1055.1–1997 Acoustics – Description and measurement of environmental noise.

5.2.3 Emergency helicopter overflights

The SRACC building is affected by overflights from helicopters moving to and from the Ned Halon building rooftop helipad. Noise intrusion from these movements have the potential to be disruptive however helicopters typically operate infrequently during emergencies and each event is of a short duration; as such they are generally tolerated noise events by staff and patients.

Under the ILUP there is no obligation to treat the building against helicopter noise intrusion. Thus, the SRACC building will address helicopter noise intrusion to meet the requirements of the brief.

Queensland Health - Directive Guideline for Helicopter Landing Sites

The Queensland Government has issued Guideline # QH-HSDGDL-039-1:2013 Department of Health – *Helicopter Landing Sites – Planning, Implementation and Management*. The guideline requires that the planning of helicopter landing sites considers noise and vibration impacts associated with operations. The document recommends that criteria are implemented; however, no guidance is provided as to suitable noise goals or limits.

AS/NZS 2021:2015 Acoustics – Aircraft Noise Intrusion – Building Siting and Construction

AS/NZS 2021:2015 provides guidance as to the 'acceptability' of building sites based on the extent of aircraft noise intrusion, as well as the extent and construction of noise reduction treatments required for 'conditionally acceptable' sites to achieve 'acceptable' internal levels. The standard deals specifically with noise from take-off, landing and circuit training operations at civil aerodromes or military airfields. The standard focuses on noise impacts from a busy airfield on to unrelated land uses. As such, it may be overly stringent when assessing noise impacts from an emergency helipad which is used sporadically and possesses significant social worth to the community.

Peer reviewed papers

A paper presented at a conference of the Australian Acoustical Society in 2012 by James and Zoontjens provides an extensive review of literature regarding noise intrusion criteria and modelling procedures in their paper *Helicopter Noise Impacts on Hospital Development Design* (2012)[3]. They recommend:

- A maximum level of Lmax 45 dBA is the limit to avoid any sleep disturbance issues for frequent noise events; however, this target is not practicable to achieve or is reasonable in the context of ambient internal conditions and other design requirements.
- A maximum level of Lmax 65 dBA or appears reasonable for general hospital wards and sensitive spaces, due to ambient levels from typical activities.
- Critically sensitive spaces (intensive care and individual patient wards) could benefit from reduced noise intrusion criteria and should be considered carefully on a case by case basis.

SRACC Project Deed Schedule 25

SRACC Project Deed Schedule 25 – Output Specification Part A – Strategic Functional Design Brief, Attachment 4 Technical Specifications, Section 3 provides the limits in **Table 9** applicable to Helicopter noise intrusion.

[3] https://www.acoustics.asn.au/conference_proceedings/AAS2012/papers/p21.pdf

Acoustic criteria

Table 9: SRACC Project Deed Schedule 25 – Criteria for Helicopter Movements and Intermittent Noise.

Type or occupancy / activity	Helicopter Noise Source LAmax (dBA)	Other Noise Sources LAmax (dBA)
IPU patient areas	55	45
Operating rooms, treatment, procedural and consult / examination rooms	65	52
Laboratories, offices and general areas	70	65

The criteria from the Project Deed Schedule 25 include a criterion of 55 dBA. This is referenced in the paper referenced above. (*Helicopter Noise Impacts on Hospital Development Design by Aaron James and Luke Zoontjens - Proceedings of Acoustics 2012*). This paper states:

> *"A maximum limit of no less than LAmax 65dB for general hospital wards and sensitive spaces appears reasonable against the likely ambient noise levels from typical activities. Selected spaces identified as potentially benefitting from further acoustic controls (e.g. NICU / PICU, individual patient wards) should be carefully considered on a case by case basis."*

The application of criteria lower than 65 dBA adds significant cost and should be only be adopted after careful consideration. Precedence for recent hospital projects on the application of these criteria can assist:

- At Lady Cilento Children's hospital, where the facade acoustic design was undertaken by the author, a blanket criterion of 65 dBA of L_{Amax} was applied and lower limits were not applied.
- For the New Ward Building of Rockhampton Hospital no criteria less than 65 dBA were applied.
- For Gold Coast University Hospital, criteria of 65 dBA and 70 dBA were applied in all but Intensive care sleep facilities where lower criteria were adopted.
- Based on our understanding of PA Hospital and the Ned Halon building, criteria less than 65 dBA were not adopted.

Proposed helicopter noise limits

With consideration to all of the above, the noise limits presented in **Table 10** are considered to be the most appropriate for the assessment of helicopter noise intrusion, based on the successful adoption of limits in recent projects.

Table 10: Noise Criteria for emergency helipads

Room Description	Indoor Design Sound Level LAmax,slow dBA
Sleep Study Rooms*	55
Wards and Patient Accommodation	65
General office areas and smaller meeting rooms, Lab Space	70
Circulation and public areas	75

*subject to briefing.

5.2.4 SRACC External areas

Outdoor Areas

Directly outside the building in walkways, courtyard and the like must be protected to a degree by noise emissions from building services in the SRACC building. The noise criteria applicable here are listed in **Table 11**.

Table 11: External Noise Limits for Campus Areas Building for Noise Generation from New Campus Buildings

Room Type	L_{Aeq}
Courtyards, outdoor dining and heavily trafficked walkways	50 dBA
Other walkways	60 dBA
On and off-site residences and other noise sensitive uses	Refer to applicable statutory requirements

Public Realm Spaces

The Quarter PDA Interim Land Use Plan (ILUP) and BCC Planning Scheme 2014 - Centre or Mixed Use Code are silent on criteria for Public Realm Space. For noise intrusion onto the site from the Busway, noise limits are presented in **Table 8**.

5.3 Demolition, excavation and construction noise and vibration

Regulatory requirements

Noise from building construction activities is addressed in the Queensland Environmental Protection Act 1994, Part 3B division 3 default Noise Standards Clause 440r Building Work.

This clause places specific constraints on the permitted hours for building construction activity, but does not impose noise level limits:

(1) A person must not carry out building work in a way that causes an audible noise –
(a) on a business day or Saturday, before 6.30am or after 6.30pm; or
(b) on any other day, at any time."

Vibration criteria

Vibration can cause both annoyance to building occupiers and damage to structures. Vibration limits for construction have been extracted from British Standard BS 5228-2:2009, BS 7385-2:1993 and German Standard DIN 4150-3:1999.

Table B.1 of BS 5228-2:2009 provides guidance on effects of vibration levels in relation to human perception and disturbance, measured as Peak Particle Velocity (PPV). The guidance values are reproduced in **Table 12.** According to the standard, *"for construction it is considered more appropriate to provide guidance in terms of the PPV, since this parameter is likely to be more routinely measured based upon the more usual concern over potential building damage."*

Table 12: BS 5228-2 2009 Guidance on effects of vibration effects

PPV Vibration level, mm/s	Effect
0.14	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3	Vibration might be just perceptible in residential environments.
1.0	it is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10	Vibration is likely to be intolerable for any more than a very brief exposure to this level.

Table 1 of BS 7385-2:1993 provides guide values for transient vibration relating to cosmetic damage. The guide values are reproduced in **Table 13.** According to the standard, *"minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values."*

Table 13: BS 7385-2:1993 transient vibration guide values for cosmetic damage

Line (see Figure 4)	Type of Building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above
Note 1 Values referred to are at the base of the building on the side facing the source of vibration. Note 2 For line 2, at frequencies below 4 Hz, a maximum displacement of 0.6 mm (zero to peak) should not be exceeded.			

Figure 4: Transient vibration guide values for cosmetic damage

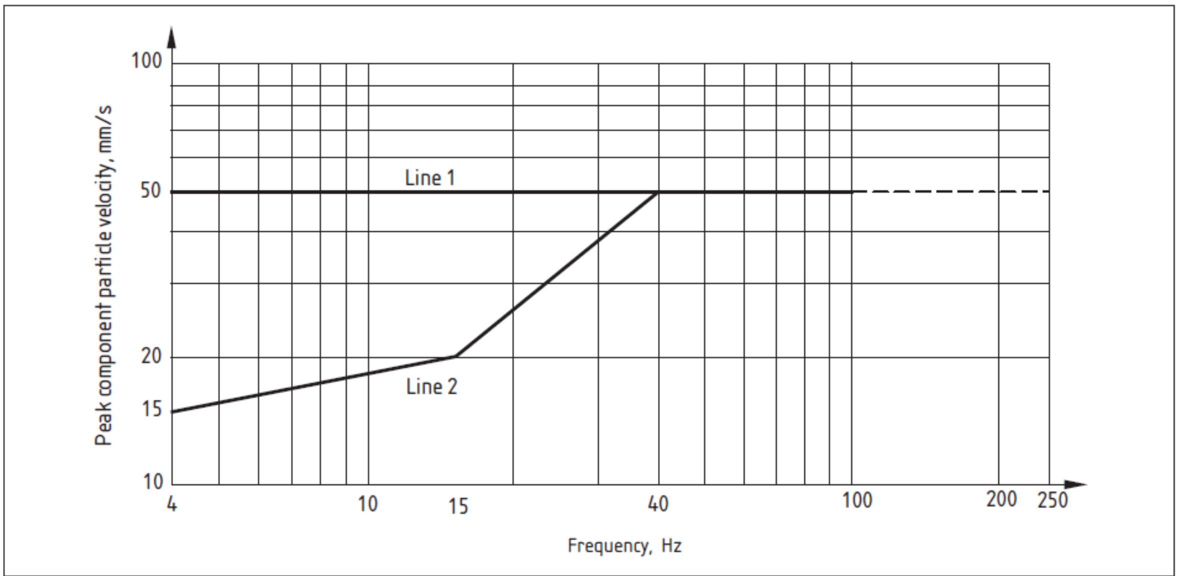


Table 1 of DIN 4150-3:1999 provides guidance values for vibration velocity at the foundation and in the plane of the highest floor of various types of buildings. The values are reproduced in **Table 14.** According to the standard, *"experience has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur"*.

Table 14: DIN 4150-3:1999 vibration limits. Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on structures

Type of Structure	**Guideline values for velocity, in mm/s**			
	Vibration at the foundation at a frequency of			**Vibration at horizontal plane of highest floor**
	1 Hz to 10 Hz	**10 Hz to 50 Hz**	**50 Hz to 100 Hz[1]**	**All frequencies**
Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwellings and buildings of similar design or use	5	5 to 15	5 to 20	15
Structures that because of their particular sensitivity to vibration, do not correspond to those listed in groups 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

[1]At frequencies above 100 Hz, the values given in this column may be used as minimum values

In addition to the values presented in **Table 14,** DIN 4150-3:1999 states that where short-term vibration causes floors to vibrate, if v_z is no greater than 20 mm/s when measured at the point of maximum velocity (which is usually at the centre of the floor), a reduction in the serviceability of the floor is not to be expected. In the case of buildings as in row 3 of **Table 14**, it may be necessary to lower this value to prevent minor damage.

6. Assessment of environmental noise levels

6.1 Transportation noise intrusion assessment

External noise sources have been identified to affect the SRACC Building and will place specific noise reduction performance requirements on the facades of the building. The noise reduction performance requirements of the building envelope will need to be sufficient to meet the internal noise limits detailed in **Section 5.2** for helicopter noise and **Table 7** for road traffic noise.

A three dimensional computer model of the site was built using SoundPLAN 7.4 acoustic software to predict the noise levels from transportation noise onto the building. The model is a representation of the existing and future site which incorporates the following inputs:

- Calculation algorithms – SoundPLAN implementation of the accepted noise prediction standards.
- Terrain elevation – a 3D representation of the existing terrain and at completion of construction.
- Ground surface corrections – areas of soft (absorptive) and hard (reflective) ground.
- Buildings – Detailed implementation of the proposed building from drawings (i.e. layout, height, floors), and the surrounding buildings from other sources (e.g. google earth).
- Roads sources – the placement of each road as a source line and the input of road traffic volumes, speeds and road surface corrections.
- Helicopter sources – Flight paths and sound power level of the source
- Sensitive receptors – Locations where the noise limits are to be assessed

For full details of the inputs applied to the acoustic model, refer to **Appendix 3**. 3D views of the computer model are provided in **Appendix 4.**

6.1.1 Road traffic noise modelling

Road traffic noise calculations were conducted by applying the SoundPLAN implementation of the UK Department of Transport Welsh Office *Calculation of Road Traffic Noise* 1988 (CoRTN) algorithms. CoRTN is widely accepted in Australia for the calculation of road traffic noise and, in addition with *SoundPLAN*, is recommended in the Department of Transport and Main Roads (TMR) document *Transport Noise Management Code of Practice Volume 1 – Road Traffic Noise,* dated November 2013 (CoP 2013).

The SoundPLAN model was verified by comparing the calculated results from existing road traffic noise and the measured noise at Noise Monitor 2, which is the closest noise monitoring location to Herston Road.

The verified noise model was then modified to incorporate the SRACC building and predict road traffic noise levels at the building facades for ultimate traffic volume projections provided by BCC.

Road traffic noise model verification

According to CoP 2013, a road traffic noise model is deemed to be verified when the average difference between the measured and calculated values of the $L_{A10,18hr}$ noise descriptor is no more than ±2 dB(A). CoP 2013 further states that:

- *"If the average difference between existing measured and calculated noise descriptors values is positive (i.e. average measured values exceed the calculated values), then the calculated values shall be adjusted upwards by this average difference before determining the predicted values."*
- *"If the average difference between existing measured and calculated noise descriptors values is negative (i.e. average calculated values exceed the measured values), then no adjustment shall be made to the calculated values before determining the predicted values."*

Assessment of environmental noise levels

To verify the road traffic noise model, the average weekday $L_{A10(18hr)}$ measured in June 2017 at Noise Monitor 2 was compared with the predicted $L_{A10(18hr)}$ for the existing traffic volumes. A comparison between predicted and measured noise levels is presented in **Table 15**. The difference between existing measured and calculated $L_{A10(18hr)}$ was less than 2 dB(A) and the predicted noise level was higher than the measured noise level. As such, the road traffic noise model is considered verified and slightly conservative.

Noise levels at Monitor 1 and Monitor 3 were not used for verification purposes as road traffic is not the dominant noise source at these locations. This is clear when observing the noise time trace plots provided in **Appendix 2**.

Table 15: Road traffic noise model verification

Monitoring location	Monitor location	Average measured weekday $L_{A10,18hr}$, dBA	Predicted $L_{A10,18hr}$, dBA	Predicted minus measured noise level, dBA
Noise Monitor 2	Herston Road	67.4	67.7	0.3

Traffic noise descriptor conversion factors

To design the building to comply with the indoor design sound levels specified in **Table 7**, a noise prediction of the $L_{Aeq,T}$ noise descriptor is required. Since CoRTN was designed for predictions of the $L_{A10,18hr}$ noise descriptor only, a conversion factor was determined as the difference between these noise descriptors. The data measured by Noise Monitor 2 was used to obtain the conversion factor, as it is the most exposed to road traffic noise (i.e. it is the closest monitor to the road).

The noise levels measured between Monday 19 June and Tuesday 20 June were the least affected by extraneous noise, as shown in the time traces. As such, the max $L_{Aeq,1hr}$ between those days were averaged and subtracted from the average measured $L_{A10,18hr}$ for the same days. The resulting value was then added to the ultimate noise predictions of the $L_{A10,18hr}$ at the building facades to obtain ultimate $L_{Aeq,1hr}$ noise levels.

The conversion factor is presented in **Table 16**.

Table 16: Noise conversion factors for ultimate road traffic noise calculations

Monitoring location	Monitor location	Average measured 19-20 June $L_{A10,18hr}$, dBA	Average measured max $L_{Aeq,1hr}$, dBA	Conversion factor as sound level difference, dBA
Noise Monitor 2	Herston Road	66.9	65.9	-1.0

Free-field road traffic noise

To determine the facade attenuation requirements for the Herston building a free field noise level is required. CoRTN is designed to apply a +2.5 dB correction to all noise predictions at 1m from a facade. As such, the correction was reversed by subtracting 2.5 dB from the predicted values.

In summary, the following procedure was applied to arrive to the free field $L_{Aeq,1hr}$:

1. The facade corrected $L_{A10,18hr}$ was predicted at 1m from the building facades at all floor levels.
2. The free field noise levels was obtained by subtracting the 2.5 dB facade correction applied by SoundPLAN by default when modelling noise levels at receptors attached to a building facade, in accordance to CoRTN.

3. A -1.0 dB conversion factor was further applied to obtain the max $L_{Aeq,1hr}$ noise descriptor.
4. The road traffic noise attenuation required is obtained as the difference between the predicted free-field $L_{Amax,1hr}$ and the applicable indoor design sound level from column 5 of **Table 7**.

Inner Northern Busway

Whilst the proposed SRACC building will be located opposite the Inner Northern Busway, the carriageway is located at a lower grade than Herston Road. During a site inspection conducted it was observed that the noise levels from the Busway are negligible compared to the noise produced by Herston Road at ground level. Further, during the assessment of transportation noise (See **Section 6.1.3**) it was found that noise at the lowest level facades will be controlled by road traffic noise from Herston Road (which further confirms the site observations), and that the noise levels at upper floors will be controlled by helicopter overflights. As such, an assessment of the assessment of the Inner Northern Busway noise on its own can only be conducted via noise predictions and validation of measurements are not possible.

Road traffic volumes for the Inner Northern Busway could not be obtained from TMR for noise predictions; therefore, a road traffic noise prediction was conducted at the Spanish Steps outdoor space to determine the likely impact of the Northern Busway, as compared with the noise predictions for Herston Road.

It was found that Herston Road is the dominant road traffic noise source exceeding the SDAP AO5.2 external criteria of noise level noise criteria of 52 dBA up to an approximate 55 m distance from the Herston Road kerb (we note that Herston Road is not assessable under this code). The noise contribution of the Inner Northern Busway is much lower than that of Herston Road and is negligible at close distance from the roads. As such, compliance with the noise limit is expected at most areas of the Spanish Steps.

It is noted that the noise attenuation for helicopter overflights will be greater than that required to attenuate road traffic noise; therefore, compliance with the internal noise limits for helicopter noise intrusion would result in compliance with the internal noise limit for busway noise intrusion.

Based on the above explanation, road traffic noise emissions from the Inner Northern Busway were not assessed further.

Driveway Noise

A ramp will be located on the Southeast corner of the building. The following is noted in relation to its potential noise impacts:

1. The ramp will be used for the displacement of vehicles off Herston Road onto Basement 1, where deliveries will occur; therefore, noise impacts from loading and unloading vehicles will not be perceived at sensitive receptor locations;
2. The SRACC driveway will be located adjacent the QIMR Berghofer Medical Research Institute deliveries driveway. Vehicles using the QIMR driveway are expected to cause noise levels onto itself that would be similar to those which would be produced by the SRACC driveway; therefore, no new noise impacts are expected; and
3. The noise impacts produced by the driveways are likely to be minimized by the noise produced by Herston Road, which is the dominant noise source in the area.

Based on the above explanation, building deliveries noise has not been assessed further.

6.1.2 Helicopter noise modelling

Helicopter noise predictions were conducted using the SoundPLAN implementation of International standard ISO 9613-2:1996 – *Acoustics – Attenuation of sound during propagation outdoors*.

The noise emission of a Bell 412 EP rescue helicopter taking off was estimated from sound level measurements reported by James and Zoontjens[4], using acoustic first principles.

The flight path was modelled on advice from an aeronautical engineer for a previous recent hospital project. Modelling has assumed a 70 m vertical line starting at the top of the Ned Hanlon building rooftop, followed by a straight line with a 3 degree slope, above the SRACC building. Three lines of infinite points were entered in the model to assess the helicopter approach to the building from various angles and thus allow for the prediction of worst-case noise levels.

Helicopter noise model verification

A similar procedure to that applied to verify the road traffic model was applied to the helicopter model by comparing noise predictions with helicopter noise levels measured by Noise Monitor 1 on Level 3 of the Lady Lamington Building.

Three helicopter events were identified by analyzing the audio recordings of a 7-day period:

- 4-7-2017 – 7:30 pm
- 8-7-2017 – 9:00 pm
- 9-7-2017 – 3:30 am

The above values were averaged and compared with the noise predictions at the Noise Monitor 1 location. The results are presented in **Table 17**. On average, the noise model predicts 2.7 dB higher than the average measured noise level.

This level of accuracy is considered adequate for the highly variable helicopter noise. As such, the computer noise model was used to conduct noise predictions at all facades of the SRACC building; however, it is noted that additional noise monitoring will be conducted to obtain a larger sample of emergency helicopter overflights and refine the noise model further. At this stage the model has been used un-adjusted and predictions are conservative.

Table 17: Helicopter noise model verification

Monitoring location	Monitor location	Measured helicopter LAmax, dBA	Predicted helicopter L_{Amax}, dBA	Predicted minus measured noise level, dBA
Noise Monitor 1	Lady Lamington	92.0	88.7	
		84.7	89.7	
		83.0	89.4	
	Average	**86.6**	**89.3**	**2.7**

6.1.3 Transportation noise levels and facade acoustic requirements

Table 18 presents the results of noise predictions of transportation noise. The naming convention used to identify the building facades is presented in **Figure 5** and noise maps depicting the transportation noise levels onto the building facades are provided in **Appendix 4**.

The following is deduced from the table:

1. Generally, helicopter flyovers produce the highest predicted noise levels at the building facades; therefore, they will determine the facade attenuation requirements;
2. Road traffic noise the dominant transportation noise at the South facades of Level 0 and Level 1. The dominant noise source is Herston Road.

[4] https://www.acoustics.asn.au/conference_proceedings/AAS2012/papers/p21.pdf

3. At Level 2 and above, helicopter noise becomes dominant and the noise attenuation required largely exceeds that of road traffic noise, dictating the design of the building facade. As such, any potential additional noise intrusion from the Inner Northern Busway resulting higher levels of the building will be adequately mitigated.

The following fixed glass systems are provided preliminary for the classifications in **Table 18**:

- **Glass Type A:** 6 mm toughened – 12mm air space – 6 mm toughened
- **Glass Type B:** 6 mm toughened – 12mm air space – 10 mm toughened
- **Glass Type C:** 6 mm toughened – 12mm air space – 8.76 mm laminate
- **Glass Type D:** 8 mm toughened – 12mm air space – 4mm - 0.51 Saflex Q- 4 mm laminate

Further helicopter noise measurements using audio - recording noise loggers will be conducted on site as the project progresses to determine whether the above acoustic recommendations can be reduced.

Glazing is to be procured to a performance based specification and glass types provided are indicative.

Figure 5: Building facade naming convention

Level 0

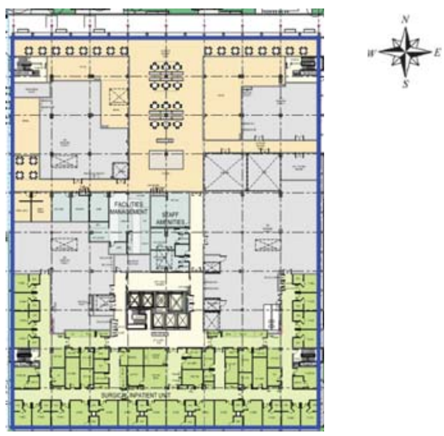
External facade (S, E, W)

Level 1

External facade (N, S, E, W)

Level 2

External facade (N, S, E, W)



Level 3

External facade (N, S, E, W)

Assessment of environmental noise levels

Level 4

Internal facade (N, S, E, W)

External facade (N, S, E, W)

Level 5

Internal facade (S, E, W)

External facade (N, S, E, W)

Level 6

Internal facade 1 (S, E, W)

Internal facade 2 (N, E, W)

External facade (N, S, E, W)

Level 7

Internal facade 1 (S, E, W)

Internal facade 2 (N, E, W)

External facade (N, S, E, W)

Assessment of environmental noise levels

Table 18: Transportation noise predictions and glass type classification

Floor level	Facade direction	Free-field Road traffic Max $L_{Aeq,1hr}$, dBA	Road traffic noise attenuation required, dBA	Helicopter L_{Amax}, dBA	Helicopter noise attenuation required, dBA	Dominant transportation source	Glass type
0	E	60	25	96	31	Helicopter	B
0	S	64	29	88	23	Road traffic	A
0	W	54	19	95	30	Helicopter	B
1	E	53	18	98	33	Helicopter	D
1	S	67	32	95	30	Road traffic	B
1	W	61	26	95	30	Helicopter	B
2	E	58	23	96	31	Helicopter	B
2	N	35	-	96	31	Helicopter	B
2	S	67	31	97	32	Helicopter	C
2	W	62	27	95	30	Helicopter	B
3	E	57	22	96	31	Helicopter	B
3	N	36	1	97	32	Helicopter	C
3	S	66	31	96	31	Helicopter	B
3	W	60	25	96	31	Helicopter	B
4	E	57	22	97	32	Helicopter	C
4	N	39	4	97	32	Helicopter	C
4	S	65	30	96	31	Helicopter	B
4	W	60	25	97	32	Helicopter	C
4	E (Internal)	25	-	97	32	Helicopter	C
4	N (Internal)	20	-	97	32	Helicopter	C
4	W (Internal)	22	-	96	31	Helicopter	B
5	E	55	20	97	32	Helicopter	C
5	N	39	4	92	27	Helicopter	B
5	S	48	13	99	34	Helicopter	D
5	W	59	24	97	32	Helicopter	C
5	E	27	-	97	32	Helicopter	C
5	N	21	-	97	32	Helicopter	C
5	W	23	-	97	32	Helicopter	C
6	E	56	21	97	32	Helicopter	C
6	N	44	9	98	33	Helicopter	D
6	S	64	29	97	32	Helicopter	C
6	W	60	25	97	32	Helicopter	C
6	E	30	-	98	33	Helicopter	D
6	N	31	-	97	32	Helicopter	C
6	W	31	-	98	33	Helicopter	D
6	E	55	20	97	32	Helicopter	C
6	S	51	16	97	32	Helicopter	C
6	W	57	22	97	32	Helicopter	C
7	E	55	20	98	33	Helicopter	D
7	N	43	8	98	33	Helicopter	D
7	S	63	28	97	32	Helicopter	C
7	W	59	24	98	33	Helicopter	D
7	E (Internal)	34	-	98	33	Helicopter	D
7	N (Internal)	34	-	98	33	Helicopter	D
7	W (Internal)	33	-	98	33	Helicopter	D
7	E (Internal)	58	23	97	32	Helicopter	C
7	S (Internal)	54	19	97	32	Helicopter	C
7	W (Internal)	59	24	97	32	Helicopter	C

6.2 Building service noise emissions assessment

The noise emissions from the operation of the Project must comply with the noise limits detailed in **Section 5.1.5**. The nearest noise sensitive receptors on the site are within the hospital campus and will include residential uses to the west, north-west and north. These future receptors will be in the order 60 to 80 metres from plant based on the available information.

Noise emissions from building services located on the building rooftop which are part of SRACC include:

- Cooling towers;
- Standby electrical generator;
- Mechanical plant room: and
- Exhaust fans.

A preliminary calculation has been conducted to estimate the combined noise emission from the above equipment / plant rooms. The closest facade of a surrounding sensitive receptor building will be located at approximately 64 m from the rooftop plant room. The estimated combined sound power expected to result in compliance with the strictest noise limit of $L_{Aeq,T}$ 45 dBA (see **Table 6**) is 89 dBA.

The above combined noise emission is achievable and detailed calculations of mechanical plant noise will be conducted as the project progresses and the plants specifics are defined. It is expected that in order to comply with the environmental noise limits, the following treatments would be required:

1. Acoustic treatment to the proposed cooling towers, including:
    a. Variable speed drives and low-noise fans (proposed);
    b. Solid acoustic screen barriers with absorptive inner face equivalent to the height of the towers (three sides minimum (assuming no treatment is required to the south).
2. Roof top plant room construction incorporates acoustic linings to improve sound insulation and absorption, in the form of plasterboard or Speedpanel™ and fibrous (e.g. glasswool) insulation;
3. All external intakes and discharges to have internal acoustic linings for all ducting close to utilised external areas;
4. Discharge attenuators (louvres) or internal acoustic lining to roof exhaust discharges to meet noise limits from all roof-mounted plant;
5. Acoustic enclosure to generators; and
6. Appropriately selected vibration isolation for all services;

6.3 Construction noise and vibration

For the management of construction noise and vibration for the SRACC building, a Construction Noise and Vibration Management Plan (CNVMP) will be required addressing all aspects of AS 2436:2010 *Guide to noise and vibration control on construction, demolition and maintenance sites*. Consideration will be required for the following items:

- Proximity of heritage buildings and other adjoining buildings;
- buildings containing sensitive equipment and vivariums;
- User consultation for the sensitive equipment and vivariums;
- Details of dilapidation surveys, noise and vibration monitoring proposed;
- Complaint handling procedures; and
- Construction noise and vibration management techniques to be imposed.

7. Recommendations for constructions

This section provides construction recommendations to meet the acoustic criteria in **Section 0**.

7.1 Building envelope

7.1.1 Facade

The noise reduction requirements for the building envelope are specified in **Section 6.1.3** (**Figure 5** and **Table 18**).

The acoustic requirements of the building facades are largely controlled by the noise produced by emergency helicopter overflights to and from the Hanlon building rooftop helipad. The noise produced by the flight paths has the potential to expose all facades of the building.

Based on the results of noise predictions, road traffic noise is the dominant noise source at the Level 0 and Level 1 South facades. For the facades removed from the road, the noise reduction requirements are reduced as the additional distance between the noise sources and the facade results in a lower level of noise directly outside the building.

Acoustic systems comprising Insulated Glazing Units (IGU) will be required. Indicative glazing systems are provided in **Section 6.1.3**. Glazing will be procured to a performance based specification. Secondary glazing may be required in the Sleep study areas depending on user briefing.

The thermal efficiency requirements for the building may dictate a thicker combination of glass and/or laminated glass. Increasing glass thickness, using laminated glass and/or increasing airspace between panes increases the acoustic performance.

For the solid areas of the facades (i.e. non-glazing areas), the noise reduction performance must be better than the acoustic performance than the glass. This is readily achievable with precast concrete, masonry or lightweight construction containing cavity fibrous insulation.

7.1.2 Roof

The roof of the building over occupied areas is to consist of a concrete slab. Insulation will be pinned to the underside of the slab for thermal reasons. It is expected that this will provide sufficient noise reduction for all environmental sources impacting the building.

7.2 Building services treatments

7.2.1 Mechanical services

Noise emissions from external mechanical plant must comply with the acoustic criteria as nominated in **Section 5.1.5**. The nearest noise sensitive receptors on the site are within the hospital campus and will include residential uses to the west, north-west and north. These receptors will be between 60-80 metres from the SRACC plant, based on the available information.

Detailed calculations including computational noise modelling will be conducted when detailed specifications of all mechanical plant to be installed become available at a later stage to determine the combined noise contribution from all roof top mechanical plant to specify the necessary acoustic treatments. As explained in **Section 6.2**, the following noise controls are likely to be required:

- Appropriate selected vibration isolation for all services.
- Chiller plant room - areas of acoustically absorptive room linings and acoustic louvres/attenuators to the exterior. Depending on the usage under, a floating floor may be required in this area or the ceilings under treated.
- All external intakes and discharges – internal acoustic linings for all ducting intakes and outlet close to utilised external areas selected to meet noise criteria.
- Inclusion of discharge attenuators or internal acoustic linings to all roof exhaust discharges to meet noise limits from all roof-mounted plant.
- For the roof-level cooling towers:
  - Variable speed drives and low-noise fans (Howden or similar).
  - Solid acoustic screen barriers with absorptive inner face equivalent to the height of the towers (three sides (assuming no treatment is required to the south)).

7.2.2 Electrical services

It is understood that containerised diesel generators are proposed to serve the SRACC Building. The enclosures and exhaust will be specified to meet specific noise criteria close to each set to ensure the noise limits at nearby existing and future sensitive receptors are met.

The performance of the enclosures may be reduced if they are used in conjunction with noise barriers or strategic placement, or if generators enclosed in standard acoustic enclosures are placed inside the roof top plant room.

8. Conclusion

This report summarises the environmental noise impacts of the proposed acoustical design criteria and construction requirements for the Herston Specialist Rehabilitation and Ambulatory Care Centre. Acoustic monitoring and a review of applicable legislation were conducted to determine the noise limits for the Project. Computational noise modelling was conducted to determine the likely impacts of the project, based on the noise limits.

Results of noise predictions are presented in this report and recommendations are provided to comply with the applicable environmental noise limits for the project.

Based on the results of the noise assessment conducted, the noise impacts associated with the SRACC building can be controlled to acceptable levels compliant with the noise limits. Thus, development is considered acceptable from an acoustics perspective.

Please contact the undersigned with any questions regarding this report on 07 3811 4543.

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Appendix 1 - Glossary of Acoustic Terms

Appendix 1 - Glossary of Acoustic Terms

NOISE	
Acceptable Noise Level:	The acceptable LAeq noise level from industrial sources, recommended by the EPA (Table 2.1, INP). Note that this noise level refers to all industrial sources at the receiver location, and not only noise due to a specific project under consideration.
Adverse Weather:	Weather conditions that affect noise (wind and temperature inversions) that occur at a particular site for a significant period of time. The previous conditions are for wind occurring more than 30% of the time in any assessment period in any season and/or for temperature inversions occurring more than 30% of the nights in winter).
Acoustic Barrier:	Solid walls or partitions, solid fences, earth mounds, earth berms, buildings, etc. used to reduce noise.
Ambient Noise:	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment Period:	The period in a day over which assessments are made.
Assessment Location	The position at which noise measurements are undertaken or estimated.
Background Noise:	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level.
Decibel [dB]:	The units of sound pressure level.
dB(A):	A-weighted decibels. Noise measured using the A filter.
Extraneous Noise:	Noise resulting from activities that are not typical of the area. Atypical activities include construction, and traffic generated by holidays period and by special events such as concert or sporting events. Normal daily traffic is not considered to be extraneous.
Free Field:	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground
Frequency:	Frequency is synonymous to pitch. Frequency or pitch can be measured on a scale in units of Hertz (Hz).
Impulsive Noise:	Noise having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.

Appendix 1 - Glossary of Acoustic Terms

Intermittent Noise:	Level that drops to the background noise level several times during the period of observation.
LAmax	The maximum A-weighted sound pressure level measured over a period.
LAmin	The minimum A-weighted sound pressure level measured over a period.
LA1	The A-weighted sound pressure level that is exceeded for 1% of the time for which the sound is measured.
LA10	The A-weighted sound pressure level that is exceeded for 10% of the time for which the sound is measured.
LA90	The A-weighted level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
LAeq	The A-weighted "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
LAeqT	The constant A-weighted sound which has the same energy as the fluctuating sound of the traffic, averaged over time T.
Reflection:	Sound wave changed in direction of propagation due to a solid object met on its path.
R-w:	The Sound Insulation Rating R-w is a measure of the noise reduction performance of the partition.
SEL:	Sound Exposure Level is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound Absorption:	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound Level Meter:	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound Pressure Level:	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound Power Level:	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise:	Containing a prominent frequency and characterised by a definite pitch.

Appendix 2 – Noise Monitoring Results

Appendix 2 – Noise Monitoring Results

Two noise surveys have been conducted. The surveys comprised unattended long-term noise logging (approximately one week) to quantify the existing noise environment on site. One environmental noise monitor was installed at each of the following locations to measure environmental noise:

- **Noise Monitor 1, Lady Lamington Building:** Noise monitoring was conducted by WGE between 4 July and 11 July 2017. A noise logger was placed at the building verandah, on Level 3.
- **Noise Monitor 2, Herston Road**: Noise monitoring was conducted by SLR between 15 June and 23 June 2017. A noise logger was placed at ground level, approximately 5m from Herston Road kerb.
- **Noise Monitor 3, back of site:** Noise monitoring was conducted by SLR between 15 June and 23 June 2017. A noise logger was installed between the Edith Cavell Building and the Lady Lamington buildings, at ground level.

The following instrumentation was used:

- Noise Monitor 1, ARL Ngara Type 1 data acquisition system, serial 878083.
- Noise Monitor 2, SVAN 957, Type 1 sound level meter, serial 23293
- Noise Monitor 3, SVAN 957, Type 1 sound level meter, serial 23243
- Pulsar Type 1 acoustic calibrator, model 105, serial 72913 (used with Noise Monitor 1 only).

The noise Monitors were placed with the microphone facing upwards at nominal microphone height of 1.5 m, and was setup to measure the A-weighted L_{Amin}, L_{A90}, L_{Aeq}, L_{A10}, L_{A1} and L_{AMax} noise descriptors with a FAST instrument response, at 15 minute intervals.

Results of relevant measured noise descriptors are presented in **Table 19** to **Table 21**. Where data was not measured for a full period (i.e. at the start and end), the cells are shown dashed in the tables. Time traces of relevant noise descriptors are shown graphically in **Figure 6** to **Figure 8**.

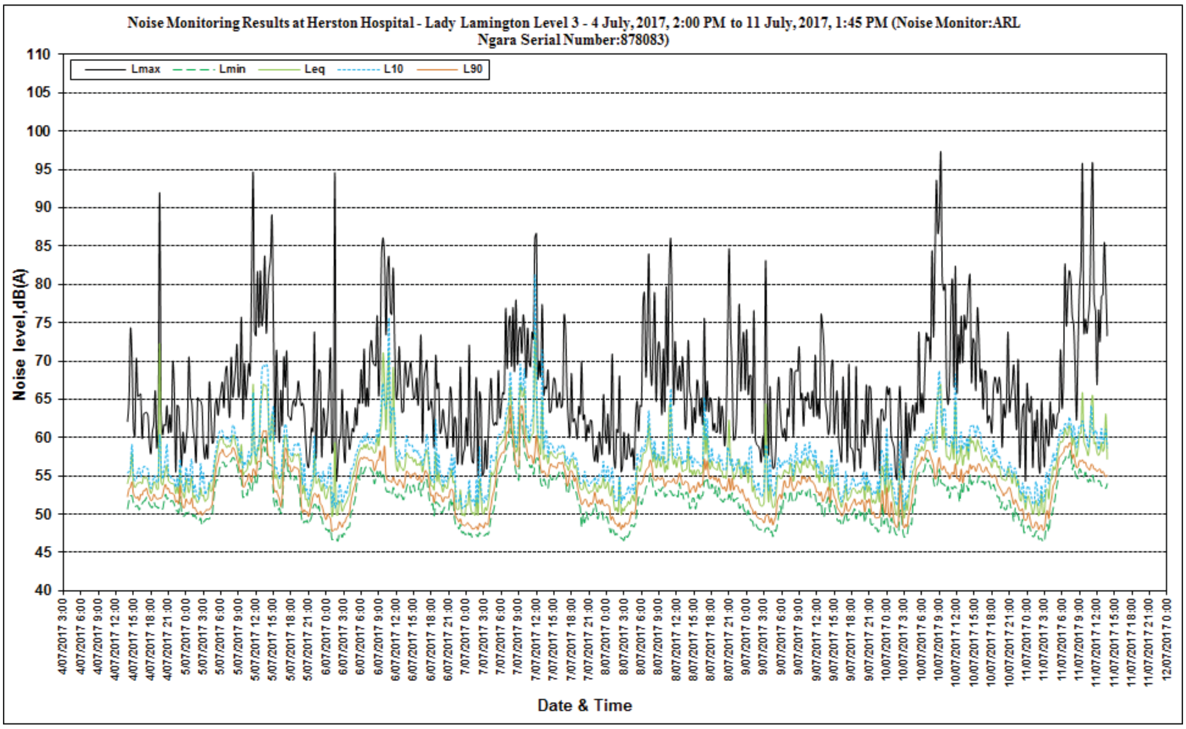
The location of noise monitors is shown in **Figure 3**.

Appendix 2 – Noise Monitoring Results

Table 19: Summary of measured noise levels (rounded) – Noise Monitor 1

Noise descriptor	Average all days	Tue 4 July	Wed 5 July	Thu 6 July	Fri 7 July	Sat 8 July	Sun 9 July	Mon 10 July
$L_{A10(18hr),6am\text{-}12am}$	58	-	59	58	60	58	56	59
$L_{Aeq,7am\text{-}6pm}$	59	-	61	62	63	58	55	60
$L_{Aeq,6pm\text{-}10pm}$	56	61	55	55	55	57	53	56
$L_{Aeq,10pm\text{-}7am}$	55	55	55	55	54	55	55	55
$RBL_{,7am\text{-}6pm}$	54	-	53	54	55	54	51	55
$RBL_{,6pm\text{-}10pm}$	52	52	50	52	51	53	50	52
$RBL_{,10pm\text{-}7am}$	50	50	48	48	49	49	49	48
$L_{AMax,7am\text{-}6pm\ (Average)}$	89	-	95	86	87	86	76	97
$L_{AMax,6pm\text{-}10pm\ (Average)}$	76	92	67	71	70	85	69	74
$L_{AMax,10pm\text{-}7am\ (Average)}$	76	71	95	77	79	83	74	83
$L_{A90,7am\text{-}6pm}$	55	-	56	55	58	55	53	56
$L_{A90,6pm\text{-}10pm}$	53	53	53	52	53	54	51	53
$L_{A90,10pm\text{-}7am}$	52	53	52	51	51	51	52	52

Figure 6: **Time trace of relevant noise descriptors, Noise Monitor 1**

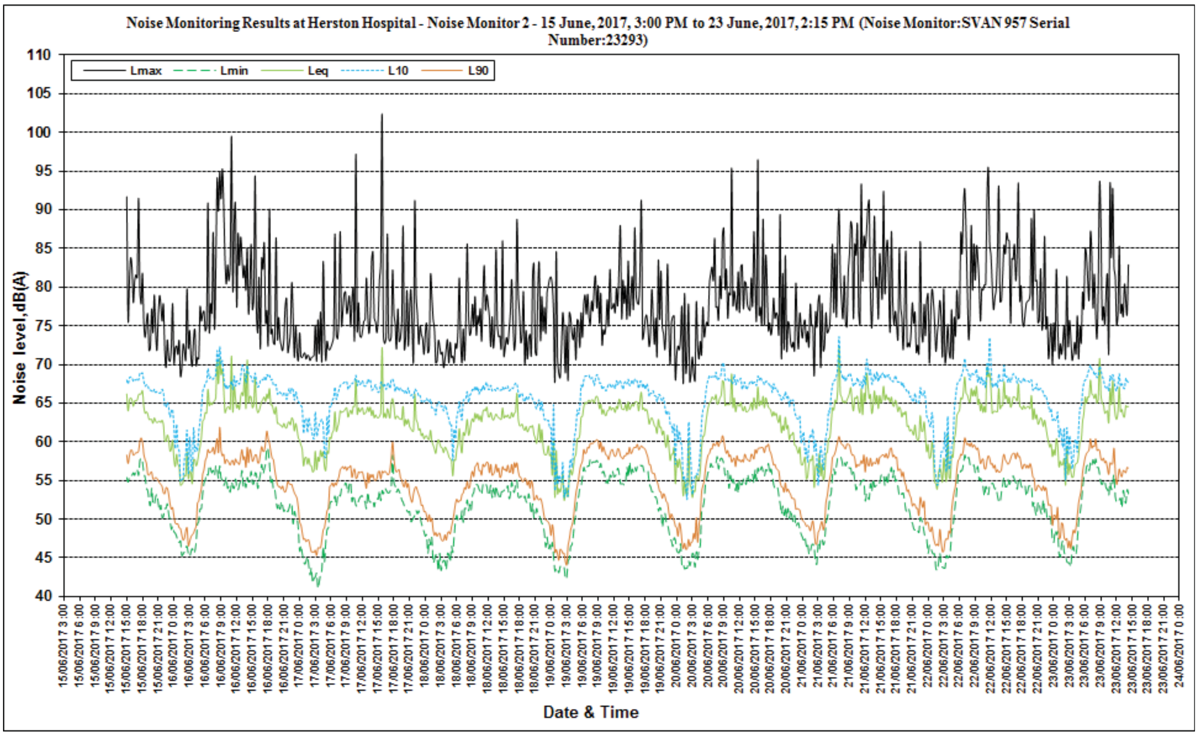


Appendix 2 – Noise Monitoring Results

Table 20: Summary of measured noise levels (rounded) – Noise Monitor 2

Noise descriptor	Average all days	Thu 15 June	Fri 16 June	Sat 17 June	Sun 18 June	Mon 19 June	Tue 20 June	Wed 21 June	Thu 22 June
$L_{A10(18hr),6am-12am}$	67	-	68	67	66	67	67	68	68
$L_{Aeq,7am-6pm}$	65	-	67	65	63	65	65	66	66
$L_{Aeq,6pm-10pm}$	63	63	64	63	62	62	63	63	64
$L_{Aeq,10pm-7am}$	60	60	60	60	59	60	60	61	61
$RBL_{,7am-6pm}$	58	-	57	55	54	58	58	57	56
$RBL_{,6pm-10pm}$	54	55	54	53	53	53	54	52	54
$RBL_{,10pm-7am}$	48	48s	46	48	46	47	49	47	47
$L_{AMax,7am-6pm\ (Average)}$	95	-	100	102	89	91	97	93	95
$L_{AMax,6pm-10pm\ (Average)}$	87	82	90	88	83	84	89	85	90
$L_{AMax,10pm-7am\ (Average)}$	87	91	87	91	85	83	86	90	87
$L_{A90,7am-6pm}$	58	-	58	56	56	59	59	58	58
$L_{A90,6pm-10pm}$	55	56	56	55	54	55	55	54	56
$L_{A90,10pm-7am}$	51	51	50	50	50	51	52	51	51

Figure 7: **Time trace of relevant noise descriptors, Noise Monitor 2**

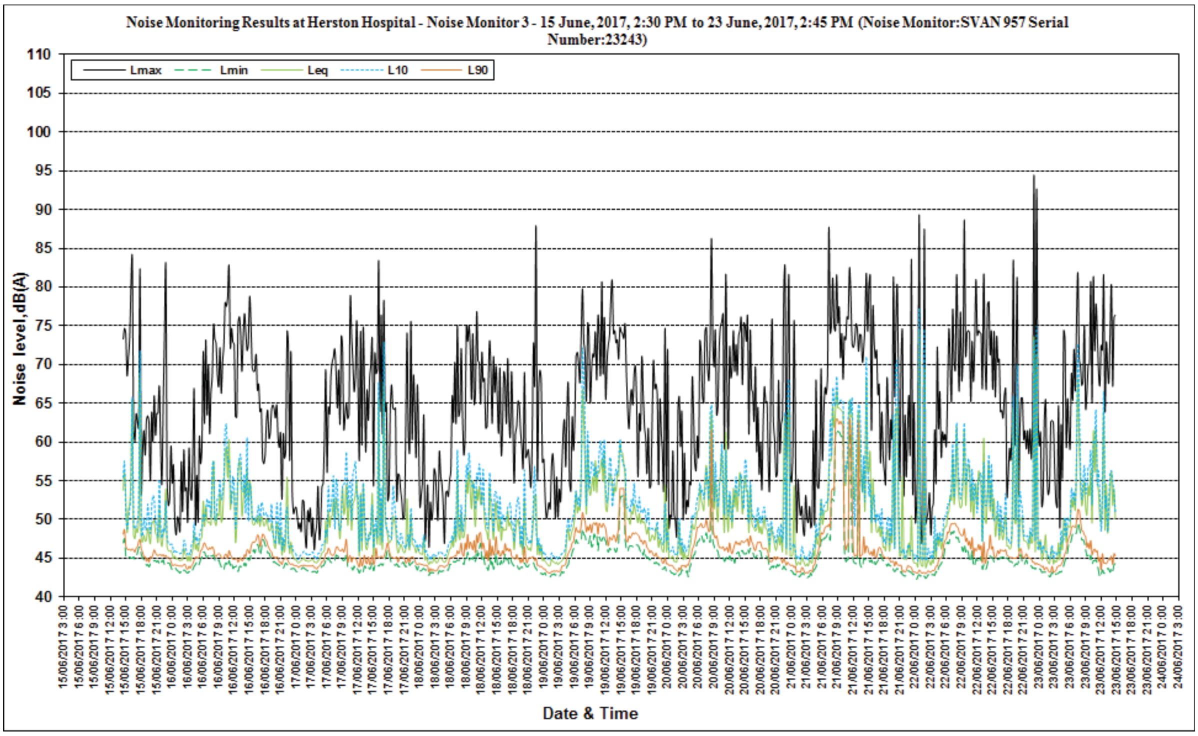


Appendix 2 – Noise Monitoring Results

Table 21: Summary of measured noise levels (rounded) – Noise Monitor 3

Noise descriptor	Average all days	Thu 15 June	Fri 16 June	Sat 17 June	Sun 18 June	Mon 19 June	Tue 20 June	Wed 21 June	Thu 22 June
$L_{A10(18hr),6am\text{-}12am}$	53	-	52	51	51	54	53	55	53
$L_{Aeq,7am\text{-}6pm}$	55	-	54	55	52	57	55	61	55
$L_{Aeq,6pm\text{-}10pm}$	51	48	48	48	48	49	48	57	57
$L_{Aeq,10pm\text{-}7am}$	52	48	47	46	48	49	53	60	60
$RBL_{,7am\text{-}6pm}$	47	-	45	44	45	47	46	45	45
$RBL_{,6pm\text{-}10pm}$	45	45	45	45	44	46	45	44	45
$RBL_{,10pm\text{-}7am}$	44	44	44	43	43	44	43	43	43
$L_{AMax,7am\text{-}6pm}$ (Average)	84	-	83	83	77	81	86	88	89
$L_{AMax,6pm\text{-}10pm}$ (Average)	74	67	65	74	69	71	76	81	84
$L_{AMax,10pm\text{-}7am}$ (Average)	83	83	74	76	88	75	83	89	94
$L_{A90,7am\text{-}6pm}$	47	-	46	45	46	49	47	51	47
$L_{A90,6pm\text{-}10pm}$	45	45	46	45	45	47	45	44	45
$L_{A90,10pm\text{-}7am}$	45	45	44	44	45	45	45	44	45

Figure 8: **Time trace of relevant noise descriptors, Noise Monitor 3**



Appendix 2 – Noise Monitoring Results

Figure 9: BoM weather observations during June noise monitoring period (monitored days highlighted)

Brisbane, Queensland

June 2017 Daily Weather Observations

Most observations from Brisbane City, but some from Brisbane Airport.

Australian Government
Bureau of Meteorology

Date	Day	Temps		Rain	Evap	Sun	Max wind gust			9am						3pm					
		Min	Max				Dirn	Spd	Time	Temp	RH	Cld	Dirn	Spd	MSLP	Temp	RH	Cld	Dirn	Spd	MSLP
		°C	°C	mm	mm	hours		km/h	local	°C	%	eighths		km/h	hPa	°C	%	eighths		km/h	hPa
1	Th	10.4	21.7	0	5.4	9.4	SSE	31	12:18	14.8	54	1	SW	7	1028.3	21.0	43	2	S	7	1025.6
2	Fr	11.2	22.8	0	4.0	9.9	WSW	22	09:58	16.3	53	1	SW	9	1029.1	22.1	39	1	S	7	1025.1
3	Sa	10.7	23.5	0	4.6	9.3	WSW	20	10:54	16.7	58	1	WSW	7	1026.5	22.8	45	1	SW	7	1022.8
4	Su	11.8	23.8	0	4.0	8.6	S	17	11:28	17.2	63	1	SW	7	1025.0	23.2	45	2	SSE	6	1021.1
5	Mo	10.5	23.6	0.2	4.0	9.3	SSW	19	09:57	16.0	72	1	SW	6	1024.5	23.1	38	3	SSW	4	1020.3
6	Tu	10.8	22.6	0	2.4	9.4	W	28	15:16	17.4	64	2	SSW	2	1021.4	22.3	22	2	W	9	1016.5
7	We	9.7	20.2	0	5.6	10.0	SW	24	11:29	14.5	46	1	WSW	9	1018.9	19.9	28	1	W	7	1016.0
8	Th	9.4	21.8	0	4.0	10.0	W	20	14:11	15.0	54	0	SW	7	1020.2	21.1	38	1	WSW	6	1017.7
9	Fr	10.9	23.2	0	3.2	6.7	W	19	11:51	17.4	58	1	SW	6	1021.6	22.0	52	6	SW	7	1019.5
10	Sa	15.2	22.9	0	2.2	8.2	SE	26	13:00	19.6	61	2	S	6	1024.3	21.0	61	4	SE	11	1022.0
11	Su	15.3	21.1	18.8	4.2	2.4	SSW	17	04:06	16.0	94	8	SW	4	1023.7	20.2	87	4	WSW	6	1020.6
12	Mo	13.9	22.4	14.6	0.8	7.4	SW	24	22:42	17.8	83	4	WSW	6	1021.0	22.0	63	5	SSW	6	1017.1
13	Tu	14.3	18.9	6.0	3.8	0.0	SSE	39	16:11	15.9	90	8	SW	6	1019.1	17.0	90	8	S	9	1019.7
14	We	15.8	20.3	10.2	2.2	2.0	SSE	28	14:11	18.9	73	7	SSW	7	1023.2	18.8	92	8	SSE	7	1022.7
15	Th	14.8	22.9	24.8	4.2	3.8	SE	35	12:39	17.6	75	6	SW	6	1025.1	21.7	62	7	SSE	9	1021.5
16	Fr	14.8	24.1	0	3.4	4.4	ESE	20	13:01	19.4	74	6	SW	4	1022.6	22.1	69	7	SE	7	1019.8
17	Sa	17.1	24.6	0	2.4	5.3	WSW	19	11:55	19.3	80	7	SW	4	1020.4	23.9	64	7	SSW	7	1016.8
18	Su	13.9	23.6	0.2	2.6	10.1	WSW	26	13:31	18.8	70	1	SW	7	1020.1	22.6	48	1	S	11	1018.3
19	Mo	15.4	22.7	0	4.0	6.4	SW	28	09:59	19.3	62	1	SSW	9	1021.9	22.3	55	7	SSW	7	1020.3
20	Tu	15.8	21.0	0	4.4	5.1	SSW	24	12:55	17.9	66	7	SSW	7	1022.4	20.0	62	7	S	7	1020.7
21	We	12.2	23.4	0	4.0	9.2	WSW	20	11:21	17.2	61	1	SW	7	1023.4	23.3	44	4	SSW	6	1021.3
22	Th	13.7	22.7	0	3.4	7.2	SE	20	11:53	17.8	62	2	SW	6	1026.0	20.5	55	3	ESE	4	1022.4
23	Fr	10.3	23.7	0	3.2	9.4	W	24	14:49	15.2	71	1	SW	6	1023.3	23.1	37	3	W	9	1018.4
24	Sa	10.4	24.5	0	3.4	8.9	S	17	10:55	14.3	75	7	S	2	1018.6	24.0	33	5	WNW	2	1015.4
25	Su	11.0	24.2	0	2.2	9.8	ENE	20	14:25	15.9	68	6	SSW	2	1020.5	22.6	53	3	NNE	7	1017.3
26	Mo	12.2	25.1	0	2.6	9.5	ENE	19	15:47	16.2	74	2	SW	6	1021.5	24.8	40	2	SW	4	1019.3
27	Tu	12.4	22.1	0	3.0	4.9	E	15	13:01	15.5	74	7	SW	4	1025.4	20.5	71	7	NE	6	1023.3
28	We	13.4	23.9	0.2	2.0	9.2	ENE	19	12:41	17.7	78	7	S	4	1025.3	22.4	61	6	NNE	7	1022.2
29	Th	13.8	24.5	0	3.2	8.6	NE	22	15:20	19.3	73	6	WSW	2	1021.9	23.2	60	4	NE	9	1017.5
30	Fr	15.6	23.0	5.0	5.0	8.3	W	24	09:21	17.1	78	4	W	9	1022.2	21.9	45	2	SSE	9	1019.7
Statistics for June 2017																					
	Mean	12.9	22.8		3.4	7.4				17.1	68	3		5	1022.9	21.8	53	4		7	1020.0
	Lowest	9.4	18.9		0.8	0.0				14.3	46	0	#	2	1018.6	17.0	22	1	WNW	2	1015.4
	Highest	17.1	25.1	24.8	5.6	10.1	SSE	39		19.6	94	8	#	9	1029.1	24.8	92	8	#	11	1025.6
	Total			80.0	103.4	222.7															

Temperature, humidity, wind, pressure and rainfall observations are from Brisbane {station 040913}. Cloud, evaporation and sunshine observations are from Brisbane Aero {station 040842}

Brisbane Airport is located about 12 kilometres north east of the Brisbane City site, and closer to the coast. The evaporation, sunshine and cloud values should be used as a guide only.

IDCJDW4019.201706 Prepared at 13:04 GMT on 21 Jul 2017

Users of this product are deemed to have read the information and accepted the conditions described in the notes at http://www.bom.gov.au/climate/dwo/IDCJDW0000.pdf

Appendix 2 – Noise Monitoring Results

Figure 10: BoM weather observations during July noise monitoring period (monitored days highlighted)

Brisbane, Queensland
July 2017 Daily Weather Observations
Most observations from Brisbane City, but some from Brisbane Airport.

Australian Government
Bureau of Meteorology

Date	Day	Temps		Rain	Evap	Sun	Max wind gust			9am						3pm					
		Min	Max				Dirn	Spd	Time	Temp	RH	Cld	Dirn	Spd	MSLP	Temp	RH	Cld	Dirn	Spd	MSLP
		°C	°C	mm	mm	hours		km/h	local	°C	%	eighths		km/h	hPa	°C	%	eighths		km/h	hPa
1	Sa	10.0	20.4	0.2	2.8	9.9	SE	17	14:04	14.2	56	1	SW	4	1027.9	19.5	33	1	WSW	6	1025.4
2	Su	7.6	21.6	0	3.6	9.1	SW	17	09:53	12.4	69	1	SW	7	1027.7	21.4	44	1	N	4	1023.7
3	Mo		22.3	0	2.8	8.2	ENE	19	13:13			1	S	4	1024.6	20.4	61	7	NE	7	1019.6
4	Tu	13.9		0	1.8	8.7	NE	15	15:20	17.8	78	2	S	2	1020.9			2	ENE	7	1016.1
5	We	9.3	26.4	0.2	2.8	8.4	SSW	17	16:38	17.2	72	0	SSE	2	1019.5	25.3	37	2	ENE	7	1014.2
6	Th	12.2	23.6	6.6	3.2	9.6	W	22	09:09	18.6	57	1	WSW	7	1019.2	23.4	36	1	WNW	6	1015.6
7	Fr	11.9	16.4	4.8	4.2	0.0	WSW	17	07:14	13.5	90	8		Calm	1016.6	15.2	92	8	WSW	4	1013.6
8	Sa	8.7	21.9	7.0	2.4	9.2	WNW	22	14:36	16.2	75	2	E	2	1019.0	21.5	30	2	WNW	11	1016.5
9	Su	6.8	21.5	0.2	1.8	7.8	WSW	13	10:22	14.0	60	2	SSW	2	1022.8	20.8	33	7	ENE	4	1019.7
10	Mo	11.6	21.7	0	3.4	6.0	ESE	17	13:53	15.6	56	7	SW	6	1025.7	20.1	43	7	ESE	2	1024.0
11	Tu	13.5	22.8	0.4	3.2	7.6	E	22	16:19	16.4	61	4	SW	6	1027.6	20.7	50	3	E	7	1024.5
12	We	10.7	21.3	0	3.4	7.3	SSW	22	12:22	15.4	60	6	SW	7	1029.5	19.7	51	3	SSW	6	1025.8
13	Th	10.8	20.8	0	3.6	9.3	ENE	19	14:38	15.1	69	2	SSW	7	1027.5	18.7	59	3	ENE	7	1024.1
14	Fr	9.3	22.7	0	3.2	9.9	ENE	19	13:32	13.9	78	1	SW	4	1024.3	20.3	57	3	NE	7	1020.5
15	Sa	11.4	24.6	0	2.4	9.5	W	28	18:08	17.1	74	1		Calm	1022.2	22.6	58	2	ENE	9	1017.3
16	Su	14.9	23.1	23.4	2.0	8.1	E	17	14:14	17.0	81	6	W	2	1020.7	20.6	62	2	ESE	2	1018.9
17	Mo	11.8	23.2	0	6.8	9.8	NNE	17	16:50	16.0	82	1	WSW	4	1023.0	21.5	64	2	ENE	7	1018.7
18	Tu	14.2	26.3	0	2.4	9.8	WSW	30	23:14	15.3	97	1	WSW	2	1020.6	24.1	60	1	ENE	7	1014.6
19	We	14.3	19.1	4.2	6.0	9.8	W	50	12:25	17.2	41	1	W	17	1013.2	17.9	32	2	WSW	19	1010.0
20	Th	9.4	20.7	0	7.6	10.1	W	37	15:10	15.5	51	0	WSW	9	1017.7	20.1	36	0	W	17	1014.2
21	Fr		21.6	0	6.2	10.0	W	20	13:25	14.0	48	0	SW	6	1019.3	21.4	25	0	WSW	6	1017.0
22	Sa	7.5	21.8	0	3.2	9.9	WSW	15	10:23	13.2	57	0	SW	6	1024.1	20.8	40	1	ENE	6	1020.3
23	Su	8.2	23.2	0	3.2	9.9	W	26	12:37	13.9	75	0	WSW	6	1022.8	22.6	32	1	W	9	1017.4
24	Mo	5.9	25.3	0	3.8	9.8	WSW	19	12:44	13.4	52	0	SW	7	1022.1	24.9	25	0	W	6	1019.0
25	Tu	7.9	23.8	0	2.4	10.1	SSE	22	13:40	13.8	57	1	WSW	6	1024.3	23.2	22	0	WSW	7	1020.6
26	We	7.8	25.7	0	3.8	10.1	W	15	13:24	13.7	58	0	SW	4	1023.3	25.2	22	0	W	6	1019.0
27	Th	9.7	23.3	0	3.2	9.9	E	24	16:02	15.7	53	0	SSW	4	1023.8	21.7	45	1	ESE	11	1021.7
28	Fr	9.8	26.3	0	4.4	9.8	W	17	14:26	15.1	68	3	SW	4	1023.8	25.5	34	3	WNW	9	1018.6
29	Sa	10.2	24.8	0	4.0	10.2	NE	15	15:21	15.9	55	0	WSW	4	1022.1	24.5	15	0	S	4	1019.1
30	Su	7.7	24.2	0	3.2	10.0	NNE	17	16:27	13.3	61	0	SW	4	1022.8	23.5	38	0	NE	7	1018.4
31	Mo	11.0	25.6	0	2.8	9.9	NNE	26	15:48	14.8	84	0	ESE	4	1022.8	22.8	57	1	NE	11	1017.9
Statistics for July 2017																					
	Mean	10.3	22.9		3.5	9.0				15.2	65	1		4	1022.6	21.7	43	2		7	1018.9
	Lowest	5.9	16.4		1.8	0.0				12.4	41	0		Calm	1013.2	15.2	15	0	ESE	2	1010.0
	Highest	14.9	26.4	23.4	7.6	10.2	W	50		18.6	97	8	W	17	1029.5	25.5	92	8	WSW	19	1025.8
	Total			47.0	109.6	277.7															

Temperature, humidity, wind, pressure and rainfall observations are from Brisbane {station 040913}. Cloud, evaporation and sunshine observations are from Brisbane Aero {station 040842}

Brisbane Airport is located about 12 kilometres north east of the Brisbane City site, and closer to the coast. The evaporation, sunshine and cloud values should be used as a guide only.

IDCJDW4019.201707 Prepared at 00:26 GMT on 1 Aug 2017

Appendix 3 – Noise model details

Appendix 3 – Noise model details

A three dimensional computer model of the site was built using SoundPLAN 7.4 acoustic software to predict the noise levels from transportation noise onto the Project building. The model is a representation of the existing and future site which incorporates the following inputs:

- Calculation algorithms – SoundPLAN implementation of the noise prediction standards used.
- Terrain elevation – a 3D representation of the existing terrain and at completion of construction.
- Ground surface corrections – areas of soft (absorptive) and hard (reflective) ground.
- Buildings – Detailed implementation of the proposed building from drawings (i.e. layout, height, floors), and the surrounding buildings from other sources (e.g. google earth).
- Roads sources – the placement of each road as a source line and the input of road traffic volumes, speeds and road surface corrections.
- Helicopter sources – Flight paths and sound power level of the source
- Sensitive receptors – Locations where the noise limits are to be assessed

The model inputs are detailed below.

Calculation algorithms

Road traffic noise was calculated using the SoundPLAN implementation of the UK Department of Transport Welsh Office *Calculation of Road Traffic Noise* 1988 (CoRTN).

Helicopter noise was calculated using the SoundPLAN implementation of ISO 9613-2 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation*.

Terrain

The following 3D file of the study area covering the site and the closest sensitive receptors was provided by Hassell Studio Architects on 22 June 2017:

- Post demo.dwg

The file was imported in SoundPLAN and lines were converted to elevation line elements. Ground contours at 0.25m intervals, as required by CoP 2013 for road traffic noise models, were not available for calculations.

Ground surface corrections

The following ground absorption coefficients were applied to the computer model as absorption areas, determined from aerial views:

- Roads have been modelled as reflective objects. A ground absorption area covering the roads surrounding the project were entered with an absorption coefficient of 0.0.
- Large built up areas have been modelled as reflective objects with an absorption coefficient of 0.0. These areas were digitised based on georeferenced aerial imagery.

Roads

Herston Road and Bramston Terrace were entered in the model as road sources, following the alignment of aerial photography.

Appendix 3 – Noise model details

Road traffic volumes for these roads were provided by BCC as existing and ultimate road traffic volume projections. The traffic volumes, percentage commercial vehicles (%CV) provided by BCC and the traffic speeds used in modelling are presented in **Table 22**.

As per CoP 2013, it was assumed the 18-hour traffic volume between 6am-12am is 94% of total vehicles per day.

It is noted that road traffic volumes for the Inner Northern Busway could not be obtained from TMR.

Table 22: Road traffic volumes used in noise modelling

Road	Existing Traffic				Ultimate traffic			
	Volume, per day	18-hour traffic	% CV	Speed, Km/hr	Volume, per day	18-hour traffic	% CV	Speed, Km/hr
Herston Road	13,000	12,220	3.0	50	17,000	15980	3.0	50
Bramston Terrace	4,000	3,760	3.0	40	7,000	6580	3.0	40

Road Surface corrections

A road surface correction of 0 dB was applied for Dense Graded asphalt roads (DGA) as per CoP 2013.

Further, a -0.7 dB and -1.7 dB correction was applied when conducting road traffic free-field and facade corrected noise predictions, respectively. This is also in accordance with CoP 2013.

Buildings

The 3D model of the site was developed following the actual floor levels and dimensions as specified in the available drawings.

Surrounding buildings were modelled following the layout in aerial photography and the elevations as measured of 3D buildings within GoogleEarth^{TM}. This process is expected to provide sufficient accuracy in predicting the shielding and reflection effects of surrounding buildings within the acoustic model.

Receptor points

Building receptors were entered at single point receivers at 1 m from all the exposed building facades of the SRACC building, at 1.5m above FFL.

Helicopter noise source

The noise emission of a Bell 412 EP was estimated from the sound pressure levels reported in *Helicopter Noise Impacts on Hospital Development Design (by Aaron James and Luke Zoontjens - Proceedings of Acoustics 2012).* The sound power level of the helicopter was calculated using acoustics first principles, assuming a point source at 100m distance. The sound power levels entered in the model are presented in

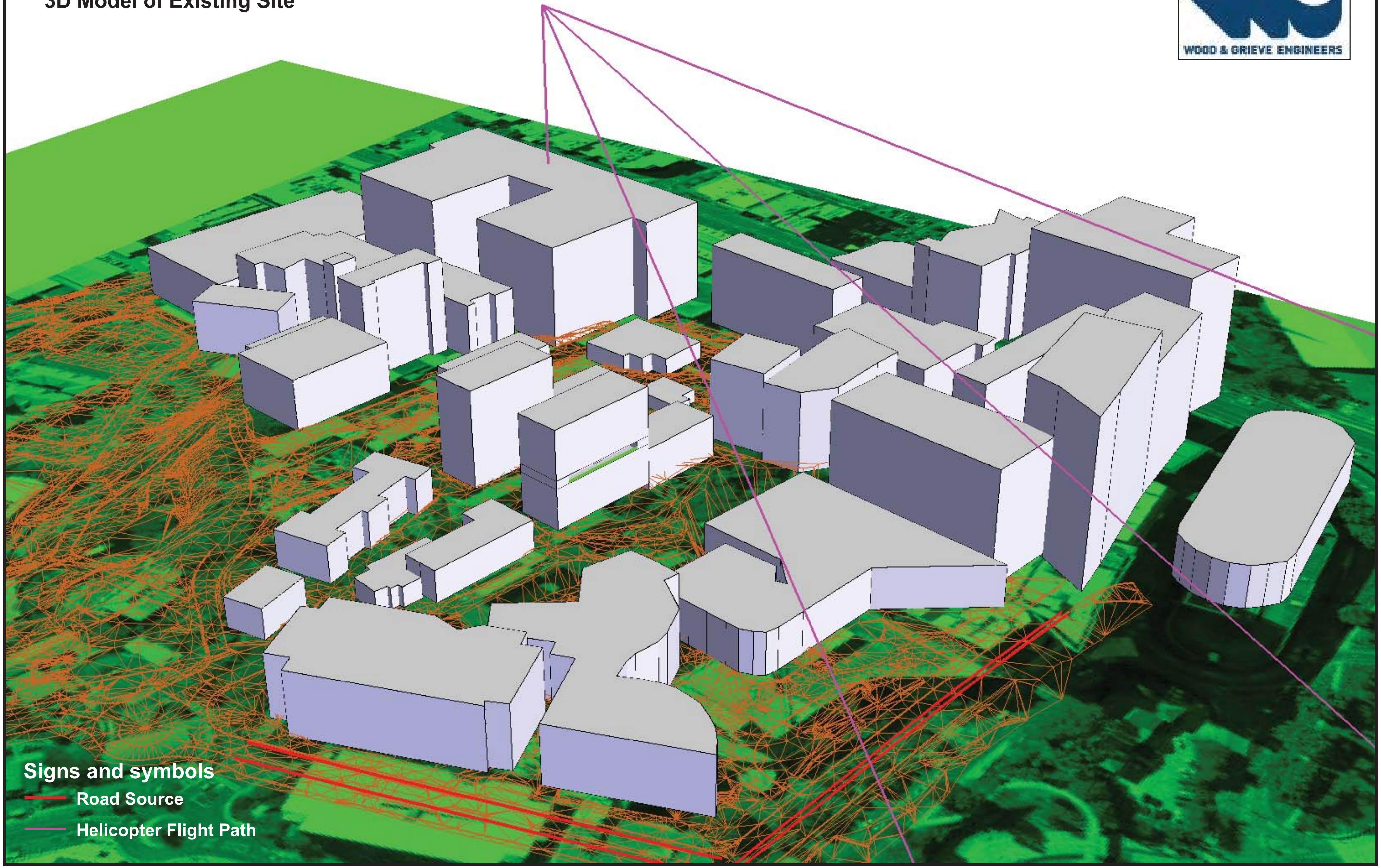
Table 23: Sound power levels, Lw, entered in the computer noise model

Operation	1/1 Octave band sound power level, L_w (linear)							Overall L_w, dBA
	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	
Take-off vertical	146	143	142	138	137	133	127	141
Take-off overhead	140	149	146	143	142	138	132	146
Landing vertical	142	136	138	134	131	133	125	138
Landing overhead	147	149	148	147	140	135	128	147

Appendix 4 – Computer 3D model views and noise maps

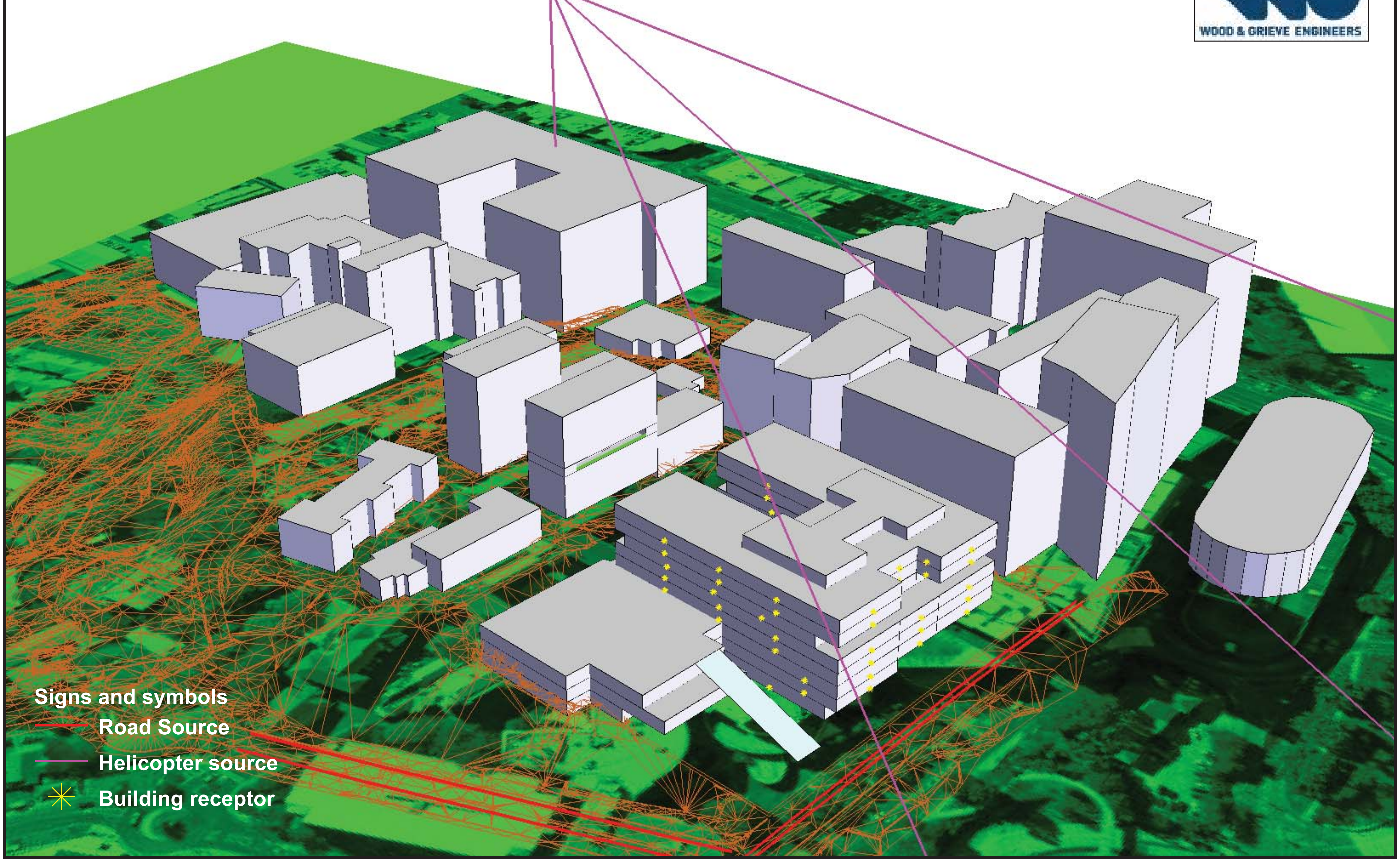
Appendix 4 – Computer 3D model views and noise maps

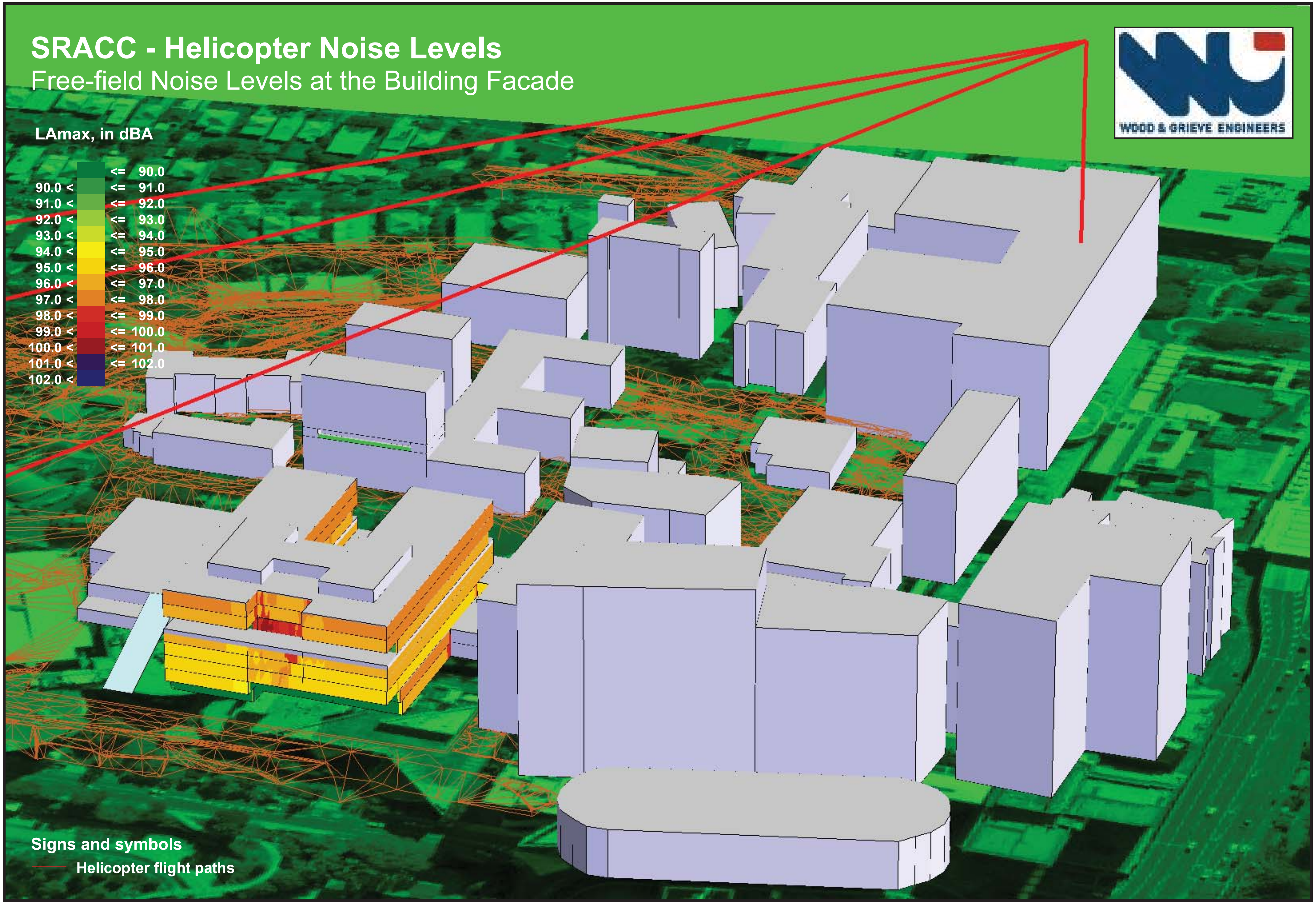
Herston Quarter Specialist Rehabilitation & Ambulatory Care Centre (SRACC)
3D Model of Existing Site

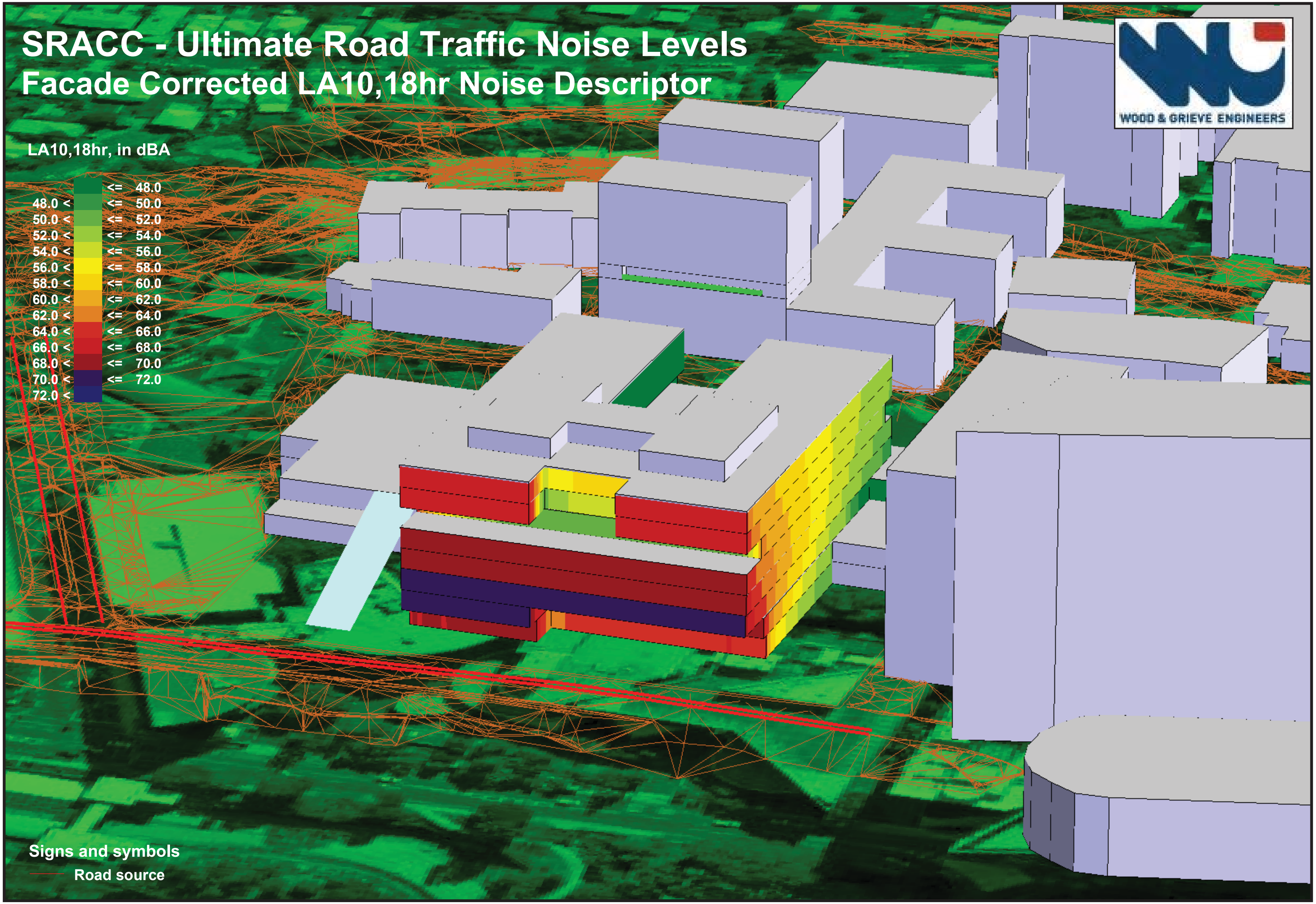


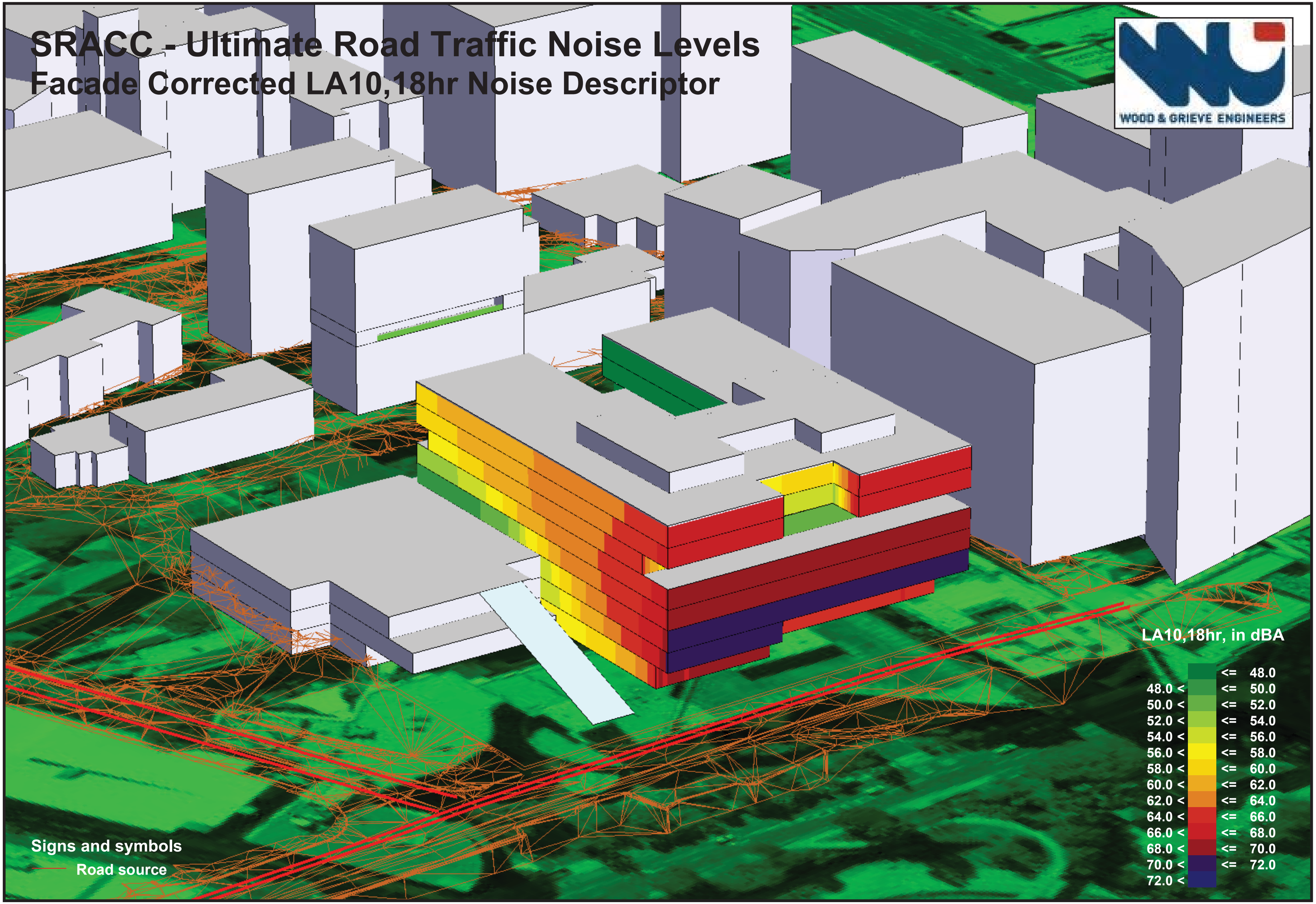
Herston Quarter Specialist Rehabilitation & Ambulatory Care Centre (SRACC)

3D Model of the Site With Proposed Building




SRACC - Helicopter Noise Levels
Free-field Noise Levels at the Building Facade
WOOD & GRIEVE ENGINEERS
LAmax, in dBA
<= 90.0
90.0 < <= 91.0
91.0 < <= 92.0
92.0 < <= 93.0
93.0 < <= 94.0
94.0 < <= 95.0
95.0 < <= 96.0
96.0 < <= 97.0
97.0 < <= 98.0
98.0 < <= 99.0
99.0 < <= 100.0
100.0 < <= 101.0
101.0 < <= 102.0
102.0 <
Signs and symbols
Helicopter flight paths


SRACC - Ultimate Road Traffic Noise Levels
Facade Corrected LA10,18hr Noise Descriptor
WOOD & GRIEVE ENGINEERS
LA10,18hr, in dBA
<= 48.0
48.0 < <= 50.0
50.0 < <= 52.0
52.0 < <= 54.0
54.0 < <= 56.0
56.0 < <= 58.0
58.0 < <= 60.0
60.0 < <= 62.0
62.0 < <= 64.0
64.0 < <= 66.0
66.0 < <= 68.0
68.0 < <= 70.0
70.0 < <= 72.0
72.0 <
Signs and symbols
Road source


SRACC - Ultimate Road Traffic Noise Levels
Facade Corrected LA10,18hr Noise Descriptor
WOOD & GRIEVE ENGINEERS
LA10,18hr, in dBA
<= 48.0
48.0 < <= 50.0
50.0 < <= 52.0
52.0 < <= 54.0
54.0 < <= 56.0
56.0 < <= 58.0
58.0 < <= 60.0
60.0 < <= 62.0
62.0 < <= 64.0
64.0 < <= 66.0
66.0 < <= 68.0
68.0 < <= 70.0
70.0 < <= 72.0
72.0 <
Signs and symbols
Road source