Susan Wakil AO Health Building

SEARS Noise and Vibration Assessment

M17183RP2 Revision C

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Document Information

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Revision Table

Report revision	Date	Comments
0	22 June 2017	Draft Issue
A	11 August 2017	For Issue
B	19 January 2017	Updated Issue to respond to DPE comments
C	31 January 2018	Minor Amendments

Glossary

A-weighting	A spectrum adaption that is applied to measured noise levels to represent human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
Daytime	Between 7 am and 6 pm as defined in the INP.
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of that sound level.
dB(A)	'A' Weighted sound level in dB.
Evening	Between 6 pm and 10 pm as defined in the INP.
Frequency (Hz)	The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone), but slow movements mean the frequency (pitch/tone) is low. 1 Hz is equal to 1 cycle per second. The human ear responds to sound in the frequency range of 20 to 20,000 Hz.
INP	New South Wales *Industrial Noise Policy*, 2000.
Intrusive Noise	Noise emission that when assessed at a noise-sensitive receiver (principally a residential premises boundary) is greater than 5 dB(A) above the background noise level.
L_{10}	Noise level exceeded for 10% of the measurement time. The L_{10} level is commonly referred to as the average maximum noise level.
L_{90}	Noise level exceeded for 90% of the measurement time. The L90 level is commonly referred to as the background noise level.
L_{eq}	Equivalent Noise Level—Energy averaged noise level over the measurement time.
L_{max}	Maximum measured sound pressure level in the time period.
mm/s	Millimetres per second—units of vibration velocity.
Night-time	Between 10 pm on one day and 7 am on the following day as defined in the INP.
Rating Background Level (RBL)	Overall single-figure A-weighted background level representing an assessment period (Day/Evening/Night). For the short-term method, the RBL is simply the measured $L_{90,15min}$ noise level. For the long-term method, it is the median value of all measured background levels during the relevant assessment period.

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Executive summary

The University of Sydney are proposing to develop a Health Precinct on the Camperdown campus. Stage 1 of the Susan Wakil AO Health Precinct involves the construction of an eight-level building that will provide a range of teaching and support spaces for the co-location of the Faculty of Nursing and Midwifery, the Faculty of Health Sciences and the Central Clinical School. The Stage 1 building will be constructed adjacent to the Royal Prince Alfred Hospital.

The Department of Planning & Environment (DPE) has issued Stage 1 of the Health Precinct with Secretary's Environmental Assessment Requirements (SEARs) for the preparation of an Environmental Impact Statement (EIS). SEAR 7 defines the requirement for a Noise and Vibration Assessment as part of the EIS, to consider construction and operational noise and vibration from the development. This report has been prepared to address SEAR 7.

Construction phase

A preliminary construction noise and vibration assessment has been conducted against noise and vibration criteria determined from:

- existing noise monitoring data for the site
- the *Interim Construction Noise Guideline* (ICNG)
- *Assessing Vibration – a technical guideline* (the Vibration Guideline).

Based on the preliminary assessment, it is anticipated that some noise and vibration impacts may occur during construction at the Royal Prince Alfred Hospital and Wesley College on the University of Sydney Campus. Limited noise impacts may also occur at the University of Sydney Oval to the north of the site.

The construction noise and vibration impacts are considered to be manageable through:

- the development and implementation of a Construction Noise and Vibration Management Plan
- carrying out works during the nominated working hours, and avoiding particularly noisy activities during the nominated extended work hours on Saturdays (7:30 – 8 am, 1 – 3:30 pm)
- appropriate stakeholder consultation and complaint handling procedures for noise and vibration
- the implementation of all feasible and reasonable work practices to minimise noise and vibration from the site in accordance with the ICNG and Vibration Guideline.

Operational phase

Operational noise emission criteria for the development have been established in accordance with the NSW *Industrial Noise Policy* (INP). The noise emission criteria for the nearest noise-sensitive land uses are shown in Table 1.

Table 1 INP noise emission criteria for residential land uses and Colleges

Location	INP noise emission criteria, dB(A) $L_{eq,15min}$		
	Day 7 am–6 pm	Evening 6 pm–10 pm	Night 10 pm–7 am
Wesley College	47	46	41
St Andrew's College, Women's College, Sydney University Village and southern residential land uses	48	44	42
Royal Prince Alfred Hospital	47 (external)	47 (external)	47 (external)

Noise emissions from the development will predominantly be a result of rooftop mechanical plant including a rooftop plant room, water-cooled chiller and cooling towers.

An assessment of operational noise from the rooftop mechanical plant has been undertaken, and it is expected that compliance with the operational noise criteria can be achieved at the nearest noise-sensitive land uses, namely the Hospital and Wesley College, as long as the design includes:

- appropriate siting of the outdoor cooling towers on the eastern side of the rooftop
- appropriate roof and wall constructions for the rooftop plant enclosures
- appropriate selection of acoustically-rated louvres for the rooftop plant areas.

As the design and construction of the project progresses, the following recommendations apply to operational noise from the site:

- Construction and selection of the rooftop plant and enclosures should be in general accordance with the recommendations of Section 6.1 of this report. A detailed acoustic review of all proposed rooftop plant should be undertaken prior to construction to confirm that the proposed noise control measures are sufficient.
- Post-construction noise monitoring should be conducted to confirm the operational noise predictions for rooftop plant. Given the difficulty associated with monitoring externally at the Hospital facade, this may need to consist of monitoring on the rooftop to confirm the assumed source levels and predictions.
- The following activities should be undertaken only between the hours of 7:30 am to 6 pm Monday to Friday:
  - goods deliveries
  - waste collection
  - grounds maintenance around the building.

1 Introduction

The University of Sydney are proposing to develop a Health Precinct on the Camperdown campus, to support the business needs of the health disciplines and to co-locate the faculties of Nursing and Midwifery and Health Sciences with components of Medicine, Pharmacy, and Dentistry.

Stage 1 of the Susan Wakil AO Health Precinct involves the construction of an eight-level building that will provide a range of teaching and support spaces for the co-location of the Faculty of Nursing and Midwifery, the Faculty of Health Sciences and the Central Clinical School. The Stage 1 building will be constructed adjacent to the Royal Prince Alfred Hospital.

The Department of Planning & Environment (DPE) has issued Stage 1 of the Health Precinct with Secretary's Environmental Assessment Requirements (SEARs) for the preparation of an Environmental Impact Statement (EIS). SEAR 7 defines the requirement for a Noise and Vibration Assessment as part of the EIS:

> Identify and provide a quantitative assessment of the main noise and vibration generating sources during construction and operation. Outline measures to minimise and mitigate the potential noise impacts on surrounding sensitive receivers.
>
> *Relevant Policies and Guidelines:*
>
> - *NSW Industrial Noise Policy (EPA)*
> - *Interim Construction Noise Guideline (DECC)*
> - *Assessing Vibration: A Technical Guideline 2006*

This report has been prepared to address SEAR 7 and:

- Details the results of background noise monitoring conducted around the site.
- Defines noise and vibration assessment criteria for the construction and operation of the Stage 1 building.
- Identifies likely construction phase noise and vibration impacts and recommends management procedures to be implemented during construction.
- Provides an assessment of operational noise from the development.

2 Project description

2.1 Location

Stage 1 of the Health Precinct will be constructed on the Camperdown campus, located on Lambie Dew Drive and immediately east of the Royal Prince Alfred Hospital. Figure 1 shows the proposed site location.

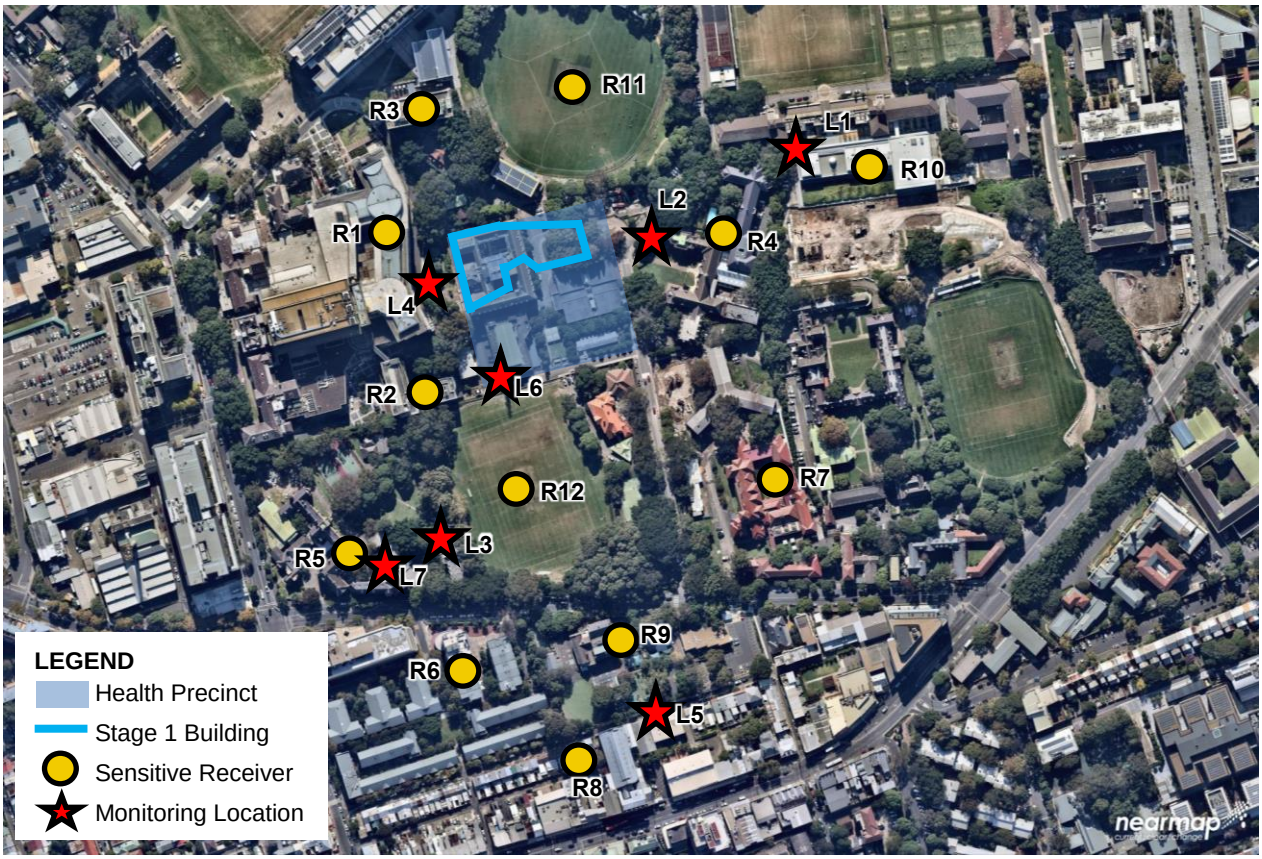

Figure 1 Stage 1 site location

A number of noise and vibration-sensitive land uses are located in the immediate vicinity of the Stage 1 site as shown on Figure 1, with the most significant being the Hospital to the west and Wesley College to the east. The nearest non-University residences are located a significant distance away from the site.

The sensitive land uses are summarised in Table 2 alongside a description of the land use.

Table 2 Noise and vibration sensitive land uses

Reference (see Figure 1) and name	Description
Health buildings	
R1 – Royal Prince Alfred Hospital	Main hospital building. Approximately 30 m west of site.
R2 – Gloucester House	Royal Prince Alfred Hospital building housing Sydney Cancer Centre. Approximately 50 m southwest of site.
R3 – Centenary Institute	Medical research institute. Approximately 80 m north of site.

Reference (see Figure 1) and name	Description
Residential buildings and colleges	
R4 – Wesley College	Colleges and/or residential villages located on or around University of Sydney Camperdown campus. Wesley College is the closest, approximately 60 m east of the site.
R5 – St Andrew's College	
R6 – Sydney University Village	
R7 – Women's College	
R8 – Campbell Street	Nearest non-University residential uses to the south of the site. Over 300 m south of site.
Educational buildings	
R9 – Newtown North Public School	Public school, also includes Carillon Avenue Childcare Centre. Approximately 230 m south of site.
R10 – Sydney Nanoscience Hub	Educational and research building housing highly vibration-sensitive equipment. Approximately 150 m east of site.
Recreational land uses	
R11 – University Oval No. 1	Active recreation land uses. University Oval No. 1 is approximately 50 m north of the site.
R12 – St Andrew's College Oval	

2.2 Stage 1 development

Stage 1 of the Health Precinct will involve the construction of an eight-level building (Level 0 up to Level 7) on the footprint shown in Figure 1. Landscaping will also occur around the Health Precinct area.

2.2.1 Construction

Construction of the Stage 1 development is scheduled to commence in December 2017 and be completed by mid-2019. The construction staging has been broadly summarised in Table 3.

Table 3 Anticipated construction schedule

Stage	Description
Site establishment	Bulk excavation and services diversions. December 2017 – January 2018
Substructure	Piling works, followed by creation of Level 0 substructure. January – May 2018
Superstructure and facade	Creation of building superstructure up to Level 7 roof and installation of building facade progressively. May – December 2018
Internal works and fitout	Internal works and fitout of all levels. Will commence progressively as Level superstructures completed. July 2018 – June 2019
External landscaping	Landscaping works around the Stage 1 building and Health Precinct. December 2018 – June 2019

It is planned that works would be undertaken during the hours of:

- Monday to Friday 7 am to 6 pm
- Saturday 7:30 am to 3:30 pm
- No work on Sundays or public holidays.

Generally, these working hours align with the standard working hours documented within the NSW *Interim Construction Noise Guideline*, with the exception of:

- work is proposed from 7:30 am to 8 am on Saturday mornings
- work is proposed from 1 pm to 3:30 pm on Saturday afternoons

These extended hours are proposed for the works for the Stage 1 development as:

- the hours are not considered significantly more noise-sensitive than the standard working hours on Saturday given that works are not proposed prior to 7 am and the noise sensitivity of the Royal Prince Alfred Hospital would not be expected to change between a weekday and a Saturday
- it would assist in expediting completion of the project, reducing the overall disruption to users of the Hospital
- the hours are consistent with recent approvals for projects at the University of Sydney such as the F23 Administration Building and F07 LEES 1 Building.

The demolition of the existing buildings at the site is to be undertaken as part of a separate project, which has been subject to a separate Review of Environmental Factors and approval. It is noted that these demolition works will also be undertaken from 7:30 am to 3:30 pm on Saturdays as part of this process.

2.2.2 Operation

The Stage 1 building will house teaching, research, office and support spaces that are not expected to have a noise and vibration impact outside of the building footprint. A small carpark, with space for no more than 25 vehicles, and a loading dock will be located on Level 0 and accessed via a road to the east of the building on the University of Sydney campus.

The predominant operational noise consideration for the development will be the rooftop plant, which will include a water-cooled chiller and cooling towers. This will generally operate during daytime hours, although operation may commence at 6 am and may extend into the evening at times.

3 Existing environment

The existing environment in the area immediately around the site is typical of an urban University campus, with a relatively low level of steady background noise from distant traffic and mechanical plant, with short-term noise from pedestrians and occasional vehicles on and around the campus.

3.1 Unattended noise monitoring

Unattended noise monitoring conducted in accordance with the NSW INP has been used to establish existing conditions at sites representative of the following key receptor locations:

- Wesley College, which represents the nearest residential-type land use to the east of the site. This is based on monitoring previously conducted by AECOM at Wesley College in 2012 prior to the development of the Sydney Nanoscience Hub.
- Royal Prince Alfred Hospital
- St Andrew's College, which represents the nearest residential-type land not within the University campus.

The unattended measured noise levels are presented in Table 4. Details on the monitoring conducted by Resonate at each site are included within Appendix A.

Table 4 Unattended monitoring results

Location[1]	Rating Background Level, dB(A) L_{90}[2]			Ambient noise level, dB(A) L_{eq}		
	Day 7 am–6 pm	Evening 6 pm–10 pm	Night 10 pm–7 am	Day 7 am–6 pm	Evening 6 pm–10 pm	Night 10 pm–7 am
Wesley College L1[3]	46	46	46	55	56	51
Royal Prince Alfred Hospital L6	48	47	45	57	51	51
St Andrew's College L7	50	50	47	58	54	52

(1) Refer to Figure 1 for the location of the monitoring.

(2) The Rating Background Level is a measure of the typical minimum steady background noise level for each time of day.

(3) Monitoring conducted AECOM across the period from 9 to 16 March 2012 in accordance with the NSW INP. Monitoring was conducted at two locations with the measurement requirements for the quietest location shown here.

The adoption of the 2012 results for this assessment at Wesley College is considered conservative as noise levels typically increase over time and it does not include any mechanical plant noise from the Sydney Nanoscience Hub. It is noted that current construction works underway near the Sydney Nanoscience Hub mean that any additional unattended noise logging conducted at present near Wesley College may have been influenced by construction noise.

3.2 Attended noise monitoring

To supplement the unattended monitoring results, attended monitoring was conducted at locations around the site on Friday, 16 June 2017 between 10:00 am and 11:30 am. The monitoring was conducted during University exam period and therefore there were fewer pedestrians on campus at the time of the measurements than would be during teaching times.

The monitoring was conducted using a Class 2 Rion NL-42 sound level meter (serial number 946977) carrying a current calibration certificate from a NATA-accredited laboratory. Field calibration was conducted at the commencement and conclusion of the logging period and no significant calibration drift was observed.

The measured noise levels over 15-minute periods at each location are shown in Table 5, with the measurement locations shown on Figure 1. The measurements indicate that there is a moderate level of existing noise in the environment during the daytime period, including relatively steady noise levels of 61 dB(A) L_{eq} at the Royal Prince Alfred Hospital eastern facade.

Table 5 Attended monitoring results on Friday, 16 June 2017

Location	Measured noise level, dB(A)				Description
	L_{max}	L_{10}	L_{eq}	L_{90}	
Wesley College L2	79	62	60	51	Measurement at 10:00 am. Influenced by construction noise, aircraft flyover and distant traffic noise.
St Andrew's College L3	70	59	56	52	Measurement at 10:30 am. Influenced by aircraft noise, mechanical plant at Hospital and distant construction noise.
Royal Prince Alfred Hospital L4	82	63	61	57	Measurement at 10:50 am. Influenced by traffic and activity around Hospital loading dock, mechanical plant and distant traffic.
97 Campbell Street L5	79	66	53	57	Measurement at 11:20 am. Influenced by road traffic noise and aircraft flyover.

4 Assessment criteria

4.1 Construction noise

Construction noise in New South Wales is assessed using the Department of Environment & Climate Change (now Environment Protection Authority) *Interim Construction Noise Guideline* (ICNG). The ICNG is also defined as the relevant guideline for construction noise by the SEARs issued by DPE.

The ICNG aims to manage noise from construction works regulated by the EPA. It is also intended to provide guidance to other interested parties in the management of construction noise, and has therefore been adopted for this construction noise assessment. The ICNG prescribes $L_{eq,15min}$ Noise Management Levels (NML) for sensitive receivers as part of a quantitative construction noise assessment. Where the predicted or measured construction noise level exceeds these management levels, then all feasible and reasonable work practices should be implemented to reduce construction noise, and community consultation regarding construction noise is required to be undertaken.

4.1.1 Residential land uses

The NMLs prescribed for residential land uses by the ICNG are presented in Table 6. The levels apply at the most exposed property boundary of the noise sensitive receiver at a height of 1.5 metres above ground level. The NMLs have also been adopted for the University colleges on and around the Camperdown campus including:

- Wesley College
- St Andrew's College
- Sydney University Village
- Women's College.

Table 6 Noise management levels for residential land uses

Time of day	NML, $L_{eq,15min}$	Application notes
Recommended Standard Working Hours	Noise affected: RBL + 10 dB(A)	May be some community reaction to noise. • Where the predicted or measured construction noise level exceeds the noise affected level, all feasible and reasonable work practices should be applied to meet the noise affected level. • All residents potentially impacted by the works should be informed of the nature of the works, the expected noise levels and duration, and provided with site contact details.
	Highly noise affected: 75 dB(A)	May be strong community reaction to noise. • Where construction noise is predicted or measured to be above this level, the relevant authority may require respite periods that restrict the hours that the very noisy activities can occur. • Respite activities would be determined taking into account times identified by the community when they are less sensitive to noise, and if the community is prepared to accept a longer period of construction to accommodate respite periods.
Outside recommended Standard Working Hours	Noise affected: RBL + 5 dB(A)	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the affected noise level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the affected noise level, the proponent should negotiate with the affected community.

4.1.2 Other sensitive land uses

The ICNG also prescribes NMLs for other sensitive land uses, including educational buildings and hospitals. The NMLs for relevant land uses are summarised in Table 7 and apply only when those land uses are in use.

Table 7 ICNG noise management levels for other sensitive land uses

Land use	NML $L_{eq,15min}$ (applies when property in use)
Classrooms at schools and other educational institutions	Internal noise level of 45 dB(A)
Hospital wards and operating theatres	Internal noise level of 45 dB(A)
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion).	External noise level of 65 dB(A)

For those receivers where an internal NML applies, it is common to assume an outdoor-to-indoor noise reduction of 25 dB(A). This is based on a standard commercial building facade with windows kept closed, such as that at the Royal Prince Alfred Hospital. Therefore, for this assessment, an external NML of 70 dB(A) $L_{eq,15min}$ will be used for the health and educational sensitive land uses surrounding the development site.

4.1.3 Noise Management Levels

Table 8 summarises the NMLs applicable to sensitive land uses around the Health Precinct Stage 1 site during the construction phase. The NMLs are based on the background levels measured at St Andrew's College in 2018 and Wesley College in 2012, with those levels applied to other sensitive land uses, where relevant. Works are only proposed during Standard Working Hours and during extended periods on Saturdays, but NMLs are also presented for other time periods for information.

Table 8 Noise Management Levels applicable to Health Precinct Stage 1

Land use	NML for time period, dB(A)		
	Standard Working Hours	Extended periods on Saturdays 7:30 – 8 am, 1 – 3:30 pm	Other times (if required)
Wesley College	56 (NML) 75 (Highly noise affected)	51	51
St Andrew's College, Women's College, Sydney University Village and southern residential land uses	60 (NML) 75 (Highly noise affected)	55	52
Royal Prince Alfred Hospital and associated buildings	70	70	70
Newtown North Public School and Childcare Centre	60[1]	60	60
Other educational buildings	70	60	70
Sporting ovals	65	65	65

(1) A lower NML has been established for the Newtown North Public School and Childcare Centre on the basis that windows may be left open for ventilation in which case a 15 dB(A) outdoor-to-indoor difference would be expected. The NML is also consistent with that established for St Andrew's College which is exposed to a similar level of noise from Carillon Avenue.

4.2 Construction vibration

Ground vibration generated by construction can have a range of effects on buildings and building occupants. The main effects are generally classified as:

- human disturbance – disturbance to building occupants: vibration which inconveniences or interferes with the activities of the occupants or users of the building
- effects on building structures – vibration which may compromise the condition of the building structure itself.

In general, vibration criteria for human disturbance are more stringent than vibration criteria for effects on buildings. Building occupants will normally feel vibration readily at levels well below those which may cause a risk of cosmetic or structural damage to a structure. However, it may not always be practical to achieve the human comfort criteria. Furthermore, unnecessary restriction of construction activities can prolong construction works longer than necessary, potentially resulting in other undesirable effects for the local community.

Construction vibration criteria have been adopted from the following sources:

- Cosmetic and structural damage to buildings: German Standard DIN 4150-3[1]
- Human comfort: *Assessing Vibration – A Technical Guideline* (the Vibration Guideline)

4.2.1 Cosmetic and structural damage

DIN 4150-3 summarises structural and cosmetic damage assessment criteria for different types of buildings, which are presented in Table 3, which are widely used for the assessment of construction vibration effects on buildings in Australia. The criteria are specified as Peak Particle Velocity (PPV) levels measured in any direction at or adjacent to the building foundation.

Table 3 DIN 4150-3 vibration cosmetic and structural damage criteria

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

With respect to the project site, the only neighbouring State heritage sites on the NSW Office & Environment Heritage Register are:

- Royal Prince Alfred Hospital Admissions Block and Victoria & Albert Pavilions which are both located on the western side of the Hospital away from the works.

[1] German Standard DIN 4150-3, 1999, *Structural Vibration – Part 3: Effects of vibration on structures*.

- The University Women's College which is over 100 m from the site.

DIN 4150-3 states that exposing buildings to vibration levels higher than that recommended would not necessarily result in damage. Rather, it recommends these values as maximum levels of short-term construction vibration at which experience has shown damage reducing the serviceability of structures will not occur due to vibration effects.

DIN 4150-3 is considered to be suitable for the assessment of both structural and cosmetic damage as it considers a reduction in serviceability of the structure is deemed to have occurred if:

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

4.2.2 Human comfort

The ICNG recommends that vibration from construction works be assessed under *Assessing Vibration – a technical guideline* (the Vibration Guideline), consistent with the SEARs issued by DPE.

The vibration assessment criteria defined in the Vibration Guideline are for human comfort and represent goals that, where predicted or measured to be exceeded, require the application of all feasible and reasonable mitigation measures. Where the maximum value cannot be feasibly and reasonably achieved, the operator would need to negotiate directly with the affected community.

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

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

The majority of construction activities as part of the proposed works would be expected to be continuous or intermittent in nature.

Table 9 presents the management levels for continuous and impulsive vibration at different land uses. The management levels specified are as overall unweighted RMS vibration velocity levels. The Vibration Guideline specifies the management levels as suitable for vibration sources predominantly in the frequency range 8-80 Hz as would be expected for construction vibration.

For intermittent vibration, the Vibration Dose Value (VDV) is used as the metric for assessment as it accounts for the duration of the source, which will occur intermittently over the assessment period. The VDV management levels at different land uses for intermittent vibration sources are presented in Table 10.

Table 9 RMS velocity management levels for continuous and impulsive vibration

Land use	Continuous vibration – RMS vibration velocity, mm/s		Impulsive vibration – RMS vibration velocity, mm/s	
	Preferred	Maximum	Preferred	Maximum
Critical areas[1]	0.1	0.2	0.1	0.2
Residences and hospital wards – daytime[2]	0.2	0.4	6.0	12.0
Residences and hospital wards – night time[3]	0.14	0.28	2.0	4.0
Offices, schools	0.4	0.8	13.0	26.0
Workshops	0.8	1.6	13.0	26.0

(1) Critical operating areas include hospital operating theatres and precision laboratories where sensitive operations are occurring.

(2) Daytime is defined by the Vibration Guideline to be 7 am to 10 pm.

(3) Night time is defined by the Vibration Guideline to be 10 pm to 7 am.

Table 10 VDV management levels for intermittent vibration

Land use	VDV – intermittent vibration, $m/s^{1.75}$	
	Preferred	Maximum
Critical areas[1]	0.1	0.2
Residences and hospital wards – daytime[2]	0.2	0.4
Residences and hospital wards – night time[3]	0.13	0.26
Offices, schools	0.4	0.8
Workshops	0.8	1.6

(1) Critical operating areas include hospital operating theatres and precision laboratories where sensitive operations are occurring.

(2) Daytime is defined by the Vibration Guideline to be 7 am to 10 pm.

(3) Night time is defined by the Vibration Guideline to be 10 pm to 7 am.

4.2.3 Sensitive equipment

Certain land uses around the site have vibration-sensitive equipment that could be affected by vibration levels well below the level at which discomfort may arise for occupants of buildings. This would include the Sydney Nanoscience Hub and may also include sensitive equipment at the Royal Prince Alfred Hospital.

Specific vibration criteria for sensitive equipment will depend on equipment specifications. However, a number of 'generic' vibration criteria have been developed over the years for sensitive electron microscope equipment. The VC criteria developed by Colin Gordon and Associates is internationally accepted and is one of the most commonly used vibration criteria for sensitive equipment. The VC criteria are reproduced in Table 11, with the highest value for operating theatres corresponding to the lowest 'Preferred' level from the Guideline for continuous vibration shown in Table 9.

Consultation will need to be undertaken with the Hospital, in particular, to determine the location and sensitivity of equipment near to the site. It is noted that the vibration criteria for sensitive equipment can be difficult to achieve during construction works and, therefore, it may be necessary to coordinate vibration-intensive works with neighbouring land uses such that they are not occurring at times when use of the equipment is required.

Table 11 Generic VC criteria for sensitive equipment (from Colin Gordon and Associates)

Criterion curve	Amplitude, mm/s[1]	Detail size, µm[2]	Description of use
Operating theatre	0.1	25	Vibration not perceptible. Suitable in most instances for surgical suites, microscopes to 100x and for other equipment of low sensitivity.
VC-A	0.05	8	Adequate in most instances for optical microscopes to 400x, microbalances, optical balances, proximity and projection aligners etc.
VC-B	0.025	3	Appropriate for inspection and lithography equipment (including steppers) to 3 µm line widths.
VC-C	0.0125	1 – 3	Appropriate standard for optical microscopes to 1000x, lithography and inspection equipment (including moderately sensitive electron microscopes) to 1 µm detail size, TFT-LCD stepper/scanner processes.
VC-D	0.00625	0.1 – 0.3	Suitable in most instances for demanding equipment, including many electron microscopes (SEMs and TEMs) and E-Beam systems.
VC-E	0.00312	< 0.1	A challenging criterion to achieve. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems. E-Beam lithography systems working at nanometer scales, and other systems requiring extraordinary dynamic stability.
VC-F	0.00156	n/a	Appropriate for extremely quiet research spaces; generally difficult to achieve in most instances, especially cleanrooms. Not recommended for use as a design criterion, only for evaluation.
VC-G	0.00078	n/a	Appropriate for extremely quiet research spaces; generally difficult to achieve in most instances, especially cleanrooms. Not recommended for use as a design criterion, only for evaluation.

(1) As measured in one-third octave bands over the frequency range 8 to 80 Hz (for operating theatres, VC-A and VC-B) or 1 to 80 Hz (for VC-C through VC-G).

(2) The detail size refers to line width in the case of microelectronics fabrication, the particle (cell) size in the case of medical and pharmaceutical research, etc. It is not relevant to imaging associated with probe technologies, AFMs, and nanotechnology.

4.3 Operational noise criteria

Noise emissions from the Stage 1 Building when operational should comply with the requirements of the NSW *Industrial Noise Policy* (INP). The INP applies to noise emissions from rooftop plant and the like at the development.

The INP sets two separate noise criteria to meet desirable environmental outcomes:

- Intrusiveness – steady-state noise from the site should be controlled to no more than 5 dB(A) above the background noise level in the area. In this case, the steady-state L_{eq} noise level should not exceed the RBL measured for different time periods in the environment.
- Amenity – amenity criteria are set based on the land use of an area. It requires noise levels from new industrial noise sources to consider the existing industrial noise level such that the cumulative effect of multiple sources does not produce noise levels that would significant exceed the amenity criteria.

Internal noise criteria are also set by the INP for non-residential land uses such as hospital wards, educational facilities and active recreation areas.

Table 12 presents the INP noise emission criteria for residential land uses, including St Andrew's College the Colleges on the University campus, for the Day, Evening and Night periods.

Table 12 INP noise emission criteria for residential land uses and Colleges

Level	**INP noise emission criteria, dB(A) $L_{eq,15min}$ (dB re 20 µPa)**					
	St Andrew's College, Women's College, Sydney University Village and southern residential land uses			**Wesley College**		
	Day 7 am–6 pm	**Evening 6 pm–10 pm**	**Night 10 pm–7 am**	**Day 7 am–6 pm**	**Evening 6 pm–10 pm**	**Night 10 pm–7 am**
Rating Background Level (RBL)	*50*	*50*	*47*	*46*	*46*	*46*
Intrusive criterion (RBL + 5 dB)	55	55	52	51	51	51
Amenity criterion for all sources (Suburban[1])	55 – 60	45 – 50	40 – 45	55 – 60	45 – 50	40 – 45
Amenity criterion for new sources[2]	48	44	42	47	46	41
Project specific criterion[3]	**48**	**44**	**42**	**47**	**46**	**41**

(1) A suburban classification has been adopted for the site, described as an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry.

(2) The Amenity criterion for new sources have been determined on the conservative basis that ambient noise levels measured at each site were controlled by existing industrial noise.

(3) The project-specific criteria are the minimum of the Intrusive criterion and the Amenity criterion for new sources for each time period.

Table 13 presents the applicable INP criteria for other (non-residential) sensitive land uses. The most relevant of these to the consideration of noise emissions from the rooftop plant is the Royal Prince Alfred Hospital.

Table 13 INP noise emission criteria for other sensitive land uses

Land use	Time of day	Noise emission criteria, dB(A)	
		Acceptable	Recommended maximum
Hospital wards, such as Royal Prince Alfred Hospital	Noisiest one-hour period	Internal 35 External 50	Internal 40 External 55
Classrooms	Noisiest one-hour period when in use	Internal 35	Internal 40
Active recreation area	When in use	External 55	External 60
Commercial premises	When in use	External 65	External 70

Based on the existing noise measurements conducted at the Hospital, the existing ambient noise level exceeds the recommended maximum noise level, particularly during the daytime period when there is more activity around the Hospital site and more noise from mechanical plant, including from Hospital buildings. At night, noise levels from activity and mechanical plant are lower, with industrial noise at night time in the order of 47 dB(A) based on the measurement data collected at Location 6.

Given the existing noise environment, and a desire not to increase it in accordance with the NSW INP, a project-specific noise criterion of 47 dB(A) $L_{eq,1h}$ has been applied at the western facade of the Hospital for all time periods. This is less than 5 dB above the minimum RBL measured at the site during the night time period.

It is noted that the adoption of this criterion is considered conservative. The western facade of the Hospital that faces the Health Building does not include operable windows and it is assumed that ventilation to these spaces is provided by other means. No balconies or outdoor areas exist on the western facade. Therefore, as windows on the western facade will remain closed, an external noise level of 50 dB(A) would be expected to result in an internal noise level in the order of 25 dB(A) in this scenario, significantly lower than the acceptable internal noise level recommended by the INP.

5 Construction assessment

5.1 Construction noise

5.1.1 Construction noise sources

Table 14 summarises the assumed sound power levels (L_W) for the major construction noise sources which we expect would be on site during each phase. The sound power levels have been based on data obtained from previous measurements conducted by Resonate and those within the UK Department for Environment, Food and Rural Affairs (DEFRA) *Update of noise database for prediction of noise on construction and open sites*. An overall sound power level for each phase has also been assumed based on the loudest typical source(s) operating for each works phase.

Table 14 Construction noise source sound power levels

Stage	Typical plant items	Assumed sound power level, dB(A)
Site establishment	Large excavator	111
	Vibratory roller	107
	Concrete truck	109
	Concrete pump	107
	Large truck	108
	Typical overall sound power level	**112**
Substructure	Bored piling rig	111
	Crane	106
	Large excavator	111
	Pneumatic jackhammer	109
	Concrete truck	109
	Concrete pump	107
	Large truck	108
	Typical overall sound power level	**114**
Superstructure and facade	Concrete truck	109
	Concrete pump	107
	Crane	106
	General hand tools	98
	Large truck	108
	Typical overall sound power level	**111**
Internal works and fitout	General hand tools	98
	Compressor	94
	Portable generator	95
	Typical overall sound power level	**84**[1]

Stage	Typical plant items	Assumed sound power level, dB(A)
External landscaping	Large excavator	111
	Grader	112
	Large truck	108
	Typical overall sound power level	**113**

(1) Includes a 15 dB(A) indoor-to-outdoor reduction in noise levels for internal works.

5.1.2 Typical construction noise levels

Typical worst-case construction noise levels have been predicted using a three-dimensional environmental noise model of the site and surrounds, developed in SoundPlan version 7.4 environmental noise modelling software, including:

- topography
- building structures
- ground absorption (ground assumed to be 50% absorptive and 50% reflective)
- air absorption
- attenuation with distance.

Predictions have been carried out based on the environmental noise prediction algorithms documented in ISO 9613-2:1996 *Acoustics - Attenuation of sound during propagation outdoors -- Part 2: General method of calculation*. This provides predictions typical of conditions where the receiver is downwind of the source or where there is a moderate ground-based temperature inversion.

It is important to note that these predictions are typical worst-case predictions as they assume that:

- The construction works are occurring at the nearest point to each receiver and that the receiver is located at the most exposed position (e.g. the nearest windows of Wesley College and the Hospital).
- The noisiest construction sources are operating continuously for the entire 15-minute period. This will not occur at all times as equipment will regularly be stood down or idled while other activities are undertaken.

Standard working hours

Typical worst-case predicted noise levels are shown in Table 15 for each sensitive-receiver location and each phase of works. Predicted noise levels that exceed the relevant Standard Work Hours NML are highlighted in **bold** type.

Based on the predictions, it can be seen that construction noise from the site is predicted to exceed the relevant NMLs at:

- The Royal Prince Alfred Hospital and associated Gloucester House for major external works. The predicted exceedance is a maximum of 5 – 6 dB(A).
- Wesley College during major external works.
- University Oval No. 1 during major external works.

At other locations, no significant noise impacts are expected during the construction phase, particularly if work is only undertaken during standard working hours. Recommendations for construction noise management are provided in Section 5.3.

Table 15 Typical worst-case external construction noise levels for each phase during standard working hours

Receiver	Typical worst-case external construction noise level for phase, dB(A) L_{eq}				
	Site establishment	Substructure	Superstructure and facade	Internal works and fitout	External landscaping
R1 – Royal Prince Alfred Hospital	**74**	**76**	**73**	46	**75**
R2 – Gloucester House	70	**72**	69	42	**71**
R3 – Centenary Institute	63	65	62	35	64
R4 – Wesley College	**65**	**67**	**64**	37	**66**
R5 – St Andrew's College	52	54	51	24	53
R6 – Sydney University Village	49	51	48	21	50
R7 – Women's College	48	50	47	20	49
R8 – Campbell Street	44	46	43	16	45
R9 – Newtown North Public School	49	51	48	21	50
R10 – Sydney Nanoscience Hub	50	52	49	22	51
R11 – University Oval No. 1	**70**	**72**	**69**	42	**71**
R12 – St Andrew's College Oval	57	59	56	29	58

Extended Saturday hours

Typical worst-case predicted noise levels are shown in Table 16 for each sensitive-receiver location and each phase of works. These predicted noise levels are compared to the relevant NMLs for the extended Saturday hours (from 7:30 – 8 am and 1 – 3:30 pm) with any exceedances highlighted in **bold** type.

Based on the predictions, it can be seen that construction noise from the site is predicted to exceed the relevant NMLs at:

- The Royal Prince Alfred Hospital and associated Gloucester House for major external works. The predicted exceedance is a maximum of 5 – 6 dB(A) at the Hospital. For extended works on Saturday adjacent to the Hospital, it is expected that management measures will be able to be implemented such that construction noise levels do not exceed the Extended Hours NML by more than 5 dB.
- Wesley College during major external works. Consultation will need to be undertaken with Wesley College to identify any particular sensitivity during extended hours work on Saturdays and to manage that appropriately.
- University Oval No. 1 during major external works.

Table 16 Typical worst-case external construction noise levels for each phase during extended Saturday hours

Receiver	Typical worst-case external construction noise level for phase, dB(A) L_{eq}				
	Site establishment	Substructure	Superstructure and facade	Internal works and fitout	External landscaping
R1 – Royal Prince Alfred Hospital	**74**	**76**	**73**	46	**75**
R2 – Gloucester House	70	**72**	69	42	**71**
R3 – Centenary Institute	63	65	62	35	64
R4 – Wesley College	**65**	**67**	**64**	37	**66**
R5 – St Andrew's College	52	54	51	24	53
R6 – Sydney University Village	49	51	48	21	50
R7 – Women's College	48	50	47	20	49
R8 – Campbell Street	44	46	43	16	45
R9 – Newtown North Public School	49	51	48	21	50
R10 – Sydney Nanoscience Hub	50	52	49	22	51
R11 – University Oval No. 1	**70**	**72**	**69**	42	**71**
R12 – St Andrew's College Oval	57	59	56	29	58

5.2 Construction vibration

Table 17 summarises recommended safe working distances for key vibration-generating activities that would be expected during the construction phase, based on prior measurements conducted by Resonate Acoustics. We understand that preliminary geotechnical studies have indicated that bored piling will be able to be undertaken and that no rock-breaking will need to occur at the site.

Table 17 Recommended safe working distances for key vibration generating activities

Plant	Rating	Typical safe working distance for occupant comfort, m		Typical safe working distance for building damage, m	
		Preferred vibration target	Maximum vibration target	Heritage structure	Commercial building
Vibratory roller	< 7t	≥ 35	≥ 20	≥ 10	≥ 2
	7t – 12t	≥ 50	≥ 30	≥ 15	≥ 5
	≥ 13t	≥ 75	≥ 40	≥ 20	≥ 10
Excavator	Large excavator digging	≥ 25	≥ 15	≥ 5	≥ 1
Bored piling	≤ 800mm	≥ 20	≥ 10	≥ 2	≥ 1
Jackhammer	Handheld	–(1)	–(1)	≥ 3	≥ 1

Based on the safe working distances above, vibration impacts on buildings are not expected and impacts on occupant comfort are likely to be limited to any vibratory compaction works occurring near to the Royal Prince Alfred Hospital. Recommendations are provided in Section 5.3 for the management of construction vibration from the works.

The safe working distances in Table 17 do not address highly vibration-sensitive equipment, such as that at the Sydney Nanoscience Hub and that may be housed at the Hospital. Given the significant distance to the Sydney Nanoscience Hub and the relatively low vibration intensity of the proposed works, impacts on equipment at this location are not expected. Consultation should be undertaken with the Hospital, as per the recommendations in Section 5.3, to determine whether specific vibration sensitive equipment needs to be taken into account during the works.

5.3 Recommendations

To manage the potential impact of noise and vibration during construction, reasonable and feasible management measures and work practices should be implemented as detailed below.

5.3.1 Construction Noise and Vibration Management Plan

Prior to the commencement of major construction works for the Stage 1 building being considered as part of this EIS, the contractor should develop a Construction Noise and Vibration Management Plan (CNVMP). The CNVMP should:

- identify relevant construction noise and vibration criteria as detailed in this report
- identify neighbouring sensitive land uses for noise and vibration
- summarise key noise- and vibration-generating construction activities and the associated predicted levels at neighbouring land uses
- provide justification for works during extended working hours on Saturday (7:30 – 8 am and 1 – 3:30 pm)
- identify reasonable and feasible work practices to be implemented during the works
- summarise stakeholder consultation and complaints handling procedures for noise and vibration.

5.3.2 Stakeholder consultation

Nearby stakeholders should be consulted prior to the works and kept regularly informed of potential noise and vibration impacts from the works. Specifically, this would involve:

- Consultation with the Royal Prince Alfred Hospital to determine the location of noise and vibration sensitive uses on the eastern building facade, and to discuss noise and vibration mitigation options with them such as appropriate programming of noisy works.
- Consultation with residential Colleges at the University of Sydney, in particular Wesley College, to inform them of the works.

A noise and vibration complaints handling procedure and register should be developed and implemented during construction.

5.3.3 Work programming

Work should be programmed such that works occur during the following hours, namely:

- Monday to Friday 7 am to 6 pm
- Saturday 7:30 am to 3:30 pm
- No work on Sundays or public holidays.

The extended hours on Saturday (7:30 – 8 am, 1 – 3:30 pm) are proposed as:

- the hours are not considered significantly more noise-sensitive than the standard working hours on Saturday given that works are not proposed prior to 7 am and the noise sensitivity of the Royal Prince Alfred Hospital would not be expected to change between a weekday and a Saturday

- it would assist in expediting completion of the project, reducing the overall disruption to users of the Hospital
- the hours are consistent with recent approvals for projects at the University of Sydney such as the F23 Administration Building and F07 LEES 1 Building, and are consistent with the working hours for the separately assessed and approved demolition works at the subject site.

Given that these extended hours on Saturday do occur outside of the standard working hours defined by the ICNG, separate management measures are proposed for these hours as detailed in Section 5.3.7

While it is not expected to occur, if any works are to occur outside of the working hours nominated above, then justification would need to be provided and appropriate mitigation measures applied. The CNVMP should define an approval process for work undertaken outside of approved hours and for identifying reasonable and feasible mitigation measures to be implemented in accordance with the ICNG.

5.3.4 Truck movements and site access

Truck movements during long term construction projects have the potential to cause annoyance for sensitive receivers, even where trucks may be travelling on sealed roads. The design and selection of site access routes shall consider the potential disturbance to residents. In particular:

- site access and delivery points shall be located as far away from the Royal Prince Alfred Hospital as possible
- truck movements shall use arterial roads and be diverted away from residential streets and the Hospital where feasible
- loading and unloading operations should be undertaken as far away as is practicable from the Hospital
- deliveries to/from site shall not occur during the night time period where possible.

5.3.5 Site management

Site management procedures should include the following:

- processes that generate lower noise levels should be selected where feasible
- the simultaneous operation of noisy plant or equipment close together and near the Hospital should be avoided
- noisy plant should be located as far away from sensitive land uses, in particular the Hospital, as is practical to allow efficient and safe completion of the task
- the potential shielding provided by site topography and intervening buildings should be taken into account in locating equipment, particularly with respect to reducing noise levels at the Hospital
- site compounds should be located as far away as possible from the Hospital and other sensitive land uses
- equipment that is used intermittently should be shut down or throttled down to a minimum during periods where it is not in use
- works should be planned to reduce the need for, and noise from, reversing signals
- warning horns should not be used as signalling devices
- two way radios should be set to the minimum effective volume
- noise associated with packing up plant and equipment at the end of works should be minimised.

5.3.6 Equipment management

Equipment management should include the following:

- selection of low-noise plant and equipment where possible
- equipment should be well maintained
- equipment should have quality mufflers and silencers installed where relevant
- equipment not in use on site should be shut down
- tasks should be completed using the minimum feasible power and equipment.

5.3.7 Extended Saturday hours

For works occurring during extended hours on Saturday (7:30 – 8 am, 1 – 3:30 pm) it is recommended that:

- High noise activities are avoided during these hours where feasible, specifically:
  - piling works
  - jackhammering.
- Consultation should be undertaken with Wesley College to determine any specific sensitivity and respite needs during these extended hours. This consultation should be documented within the CNVMP, with resulting management measures identified.

6 Operational assessment

6.1 Mechanical plant

Based on a rooftop plant design supplied by Laing O'Rourke on 22 December 2017 and plant noise data supplied by Laing O'Rourke on 9 and 10 January 2018, we understand that the rooftop plant will consist of:

- 2 x BAC CPSC-0716-07N cooling towers with a sound power level of 100 dB(A). The cooling towers are located towards the eastern end of the roof and shielding is provided on the western side by the chiller enclosure.
- An eastern plant enclosure with louvres on the northern face containing:
  - 2 x large Carrier chillers (30XWV-338) with sound power level of 104 dB(A)
  - 1 x small Carrier chiller (30XWV-180) with sound power level of 98 dB(A)
  - 6 x Carrier AHUs with ducted supply and return air, and radiated sound power levels of 76 to 81 dB(A)
- A western plant enclosure with louvres on the western and southern face containing:
  - 6 x Carrier AHUs with ducted supply and return air, and radiated sound power levels of 76 to 82 dB(A).

The sound power level data for the currently selected plant is included in Appendix B.

It is understood that some fans may also be installed within the rooftop enclosures however information is not available for these yet. It has been assumed that the reverberant sound pressure level within each enclosure would increase by approximately 3 dB with the inclusion of the radiated noise from the fans.

As the equipment will be located on the rooftop, with a parapet at low level around areas of the rooftop, there will be little or no direct line-of-sight between the rooftop plant and the neighbouring noise-sensitive land uses, although the shielding effect will be lower to the upper levels of the Royal Prince Alfred Hospital as the building will be constructed to similar height to the Hospital.

Based on the mechanical plant information above, noise levels have been predicted at the various noise sensitive locations around the site using a three-dimensional environmental noise model developed in SoundPlan version 7.4 environmental noise modelling software implementing the ISO 9613-2:1996 prediction algorithms. The model also takes into account:

- distance attenuation
- ground absorption (ground assumed to be 50% absorptive and 50% reflective)
- air absorption
- the topography and relative height of the noise sources and receivers
- shielding provided by buildings and intervening structures where relevant.

Operation of the plant may commence at 6 am and therefore compliance would be required with the most stringent night time noise criteria. Compliance with the night time criteria would result in compliance being achieved with the less stringent day and evening INP criteria.

Based on the selected mechanical plant and the environmental noise predictions, the following treatments are recommended for incorporation in the design and construction of the rooftop plant to achieve compliance with the INP:

- As per the current design information, the cooling towers should be located on the eastern side of the rooftop, with shielding provided to the northern and eastern side by the western plant enclosure.
- The western plant enclosure should be constructed as follows:
  - The roof and walls of the plant enclosure should be minimum 0.42 mm thick metal deck or acoustic equivalent.
  - Doors to the plant room should be located on the eastern side as is currently documented.

  - The western louvres on the enclosure should be acoustically-rated louvres with equivalent acoustic performance to Fantech SBL2. No specific acoustic requirements apply to the small louvre proposed on the southern side of this enclosure.
- The eastern plant enclosure should be constructed as follows:
  - The roof and walls of the plant enclosure should be minimum 0.42 mm thick metal deck or acoustic equivalent.
  - Doors to the plant room should be located on the northern and southern side as is currently documented.
  - The northern louvres on the enclosure should be acoustically-rated louvres with equivalent acoustic performance to Fantech SBL2.
- Any fans within either enclosure that exhaust, or intake, via the louvres should consider the use of an acoustic attenuator prior to the outlet. The requirement for an acoustic attenuator should be confirmed by the acoustic consultant as the selection and design of the fans progresses.

6.2 Transient noise sources

Other operational noise from the site will typically be limited to noise from cars accessing the car park and occasional loading dock deliveries. Access to the car park and loading dock is located on the eastern side of the western wing of the building, such that it is over 100 m from Wesley College and the Hospital is well shielded from these sources. Noise levels from car movements into and out of the building, and loading dock access from a typical delivery truck is predicted to be below 47 dB(A) L_{eq} at the Hospital facade and well below the INP daytime criterion of 51 dB(A) L_{eq} at Wesley College.

To minimise any potential noise impact on neighbouring land uses, it is recommended that the following activities are undertaken only between the hours of 7:30 am to 6 pm Monday to Friday:

- goods deliveries
- waste collection
- grounds maintenance around the building.

6.3 Recommendations

The following recommendations apply to operational noise from the site:

- Construction and selection of the rooftop plant and enclosures should be in general accordance with the recommendations of Section 6.1. A detailed acoustic review of all proposed rooftop plant should be undertaken prior to construction to confirm that the proposed noise control measures are sufficient.
- Post-construction noise monitoring should be conducted to confirm the operational noise predictions for rooftop plant. Given the difficulty associated with monitoring externally at the Hospital facade, this may need to consist of monitoring on the rooftop to confirm the assumed source levels and predictions.
- The following activities should be undertaken only between the hours of 7:30 am to 6 pm Monday to Friday:
  - goods deliveries
  - waste collection
  - grounds maintenance around the building.

7 Conclusion

This report presents a construction and operational noise and vibration assessment for the proposed Stage 1 of the University of Sydney Health Precinct. Stage 1 involves the construction of an eight-level building that will provide a range of teaching and support spaces for the co-location of the Faculty of Nursing and Midwifery, the Faculty of Health Sciences and the Central Clinical School. The Stage 1 building will be constructed adjacent to the Royal Prince Alfred Hospital.

Construction noise and vibration criteria have been determined in accordance with relevant guidance such as the ICNG and Vibration Guideline. It is likely that construction works may have some noise and vibration impact on the Royal Prince Alfred Hospital and some construction noise impact on Wesley College at the University of Sydney. It is anticipated that these impacts will be able to be managed through works being carried out during the nominated working hours and with the implementation of reasonable and feasible management measures and work practices.

Operational noise emission criteria have been set in accordance with the NSW INP and apply predominantly to mechanical plant noise emissions from the site. An assessment of operational noise from the site has been undertaken, with recommendations provided for the control of noise from the rooftop plant based on current plant selections and design information. These recommendations should be reviewed as the design progresses, with post-construction noise monitoring undertaken to confirm the acoustic performance once the building is operational.

Appendix A—Unattended noise monitoring information

Unattended noise logging

An unattended environmental noise survey was conducted during the period Wednesday, 10 January 2018 to Wednesday, 17 January 2018. The noise logging was conducted at two locations, with position shown on Figure 1:

- Location 6: southern side of Bosch buildings, location selected to provide a secure location for noise monitoring that was representative of eastern facade of Royal Prince Alfred Hospital.
- Location 7: St Andrew's College, location shielded from Traffic on Carillon Avenue.

The monitoring was conducted during University holiday period and therefore noise levels from activities from the University would be expected to be lower than during semester.

Equipment

The equipment used was:

- Location 6: Rion NL-42 sound level meter, serial number 946976.
- Location 7: Rion NL-42 sound level meter, serial number 245575.

Both noise monitors carry current calibration certificates from a NATA-accredited laboratory. Field calibration was conducted at the commencement and conclusion of the logging period and no significant calibration drift was observed.

The noise logger was configured to record all relevant noise indices, including A-weighted background noise level (L_{90}) and equivalent continuous noise levels (L_{eq}). Samples were accumulated at 15-minute intervals. The time response of the logger was set to 'fast'.

Weather conditions

In order to provide an indication that noise data was obtained during suitable meteorological conditions, half-hourly weather data was obtained from the Bureau of Meteorology (BOM) Automatic Weather Station (AWS) 066062 at Observatory Hill, Sydney.

Noise data has been excluded from the processed results if:

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

Measured noise levels

For reference, a weekly chart showing the graphed noise logging results is shown in Figure A1 for Location 6 (Hospital) and Figure A2 for Location 7 (St Andrew's College).

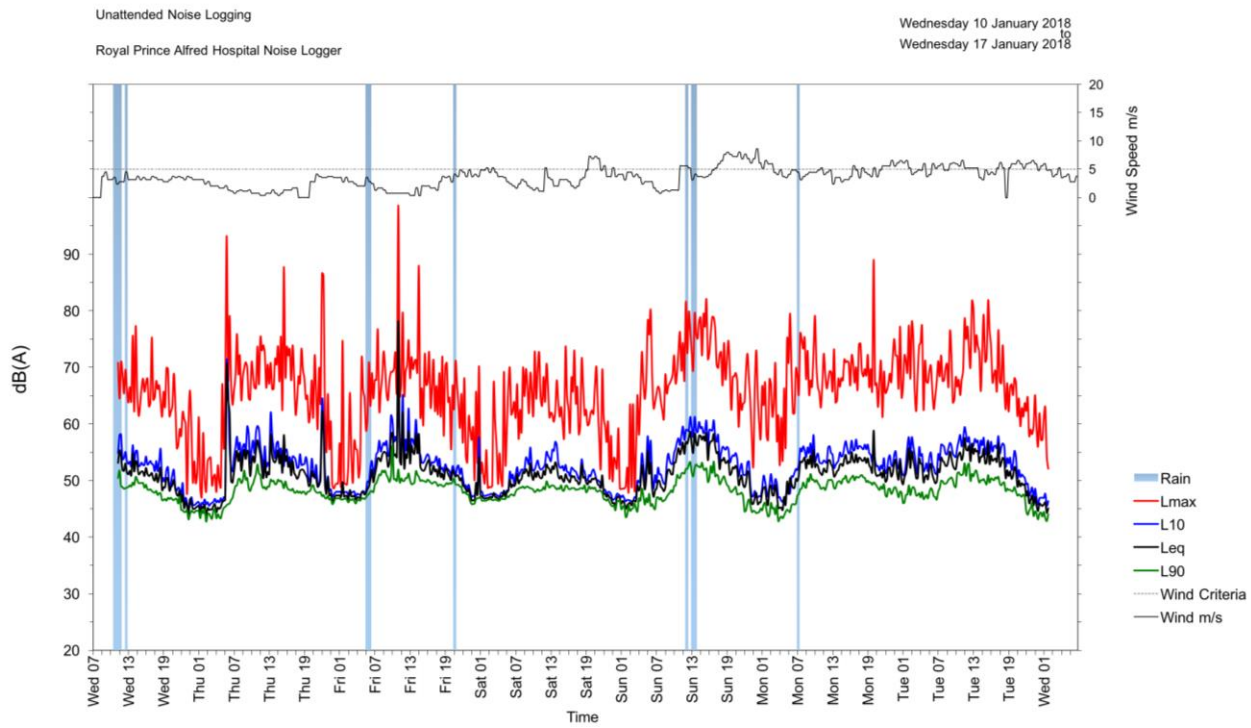

Figure A1 Noise monitoring results for Location 6 (Hospital)

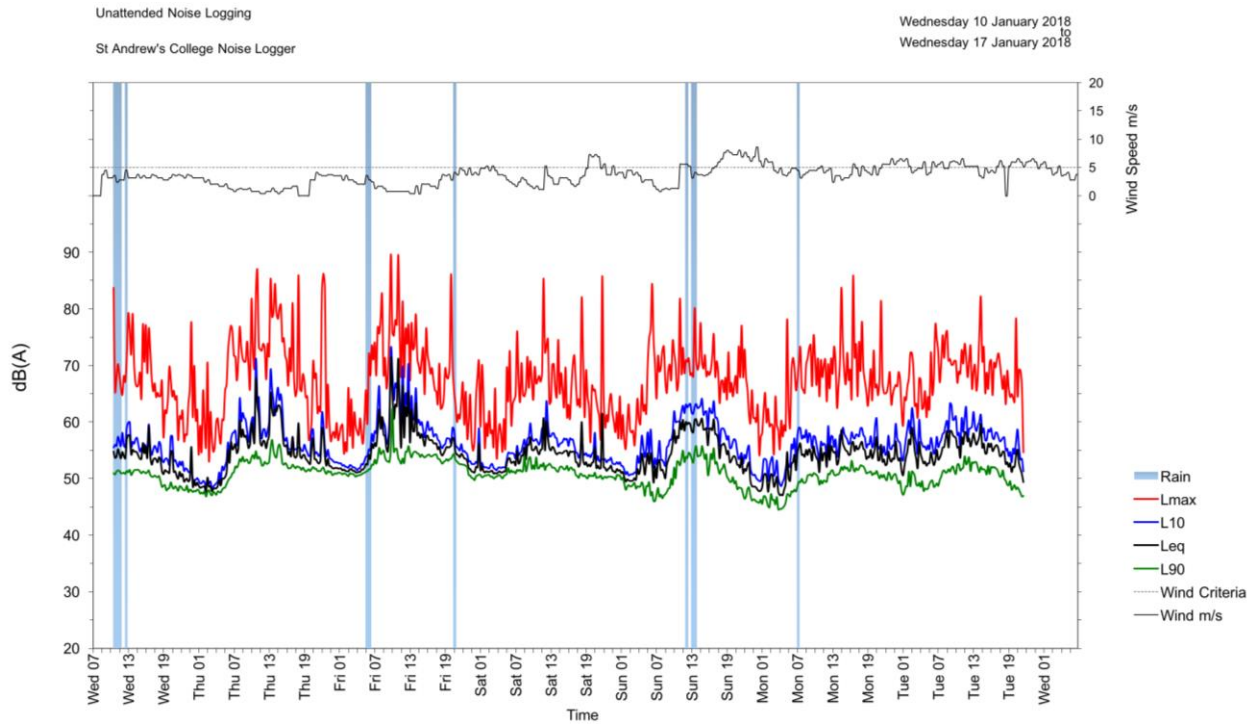

Figure A2 Noise monitoring results for Location 7 (St Andrew's College)

Appendix B—Rooftop plant sound power levels

Plant item	Location	Sound power level in dB at octave band centre frequency in Hz							Overall L_w
		63	125	250	500	1k	2k	4k	dB(A)
Cooling tower (x2)	Outdoor	107	105	104	98	91	91	86	100
Large chiller (x2)	Eastern enclosure	–	86	108	98	100	88	81	104
Small chiller		–	84	97	93	95	88	78	100
AHU-3-E		89	85	83	79	74	66	45	80
AHU-5-E		92	91	79	76	72	65	44	80
AHU-6-E		89	85	83	79	74	66	45	81
AHU-9-E		90	86	83	79	74	66	45	80
AHU-15-E		84	79	77	72	71	64	42	76
AHU-E-OA		85	81	79	75	73	66	44	78
AHU-1-W	Western enclosure	82	77	77	72	70	65	42	76
AHU-2-W		89	86	83	79	74	66	45	80
AHU-4-W		91	90	82	79	73	67	45	81
AHU-7-W		90	88	76	77	78	74	53	82
AHU-8-W		85	81	80	78	75	70	46	80
AHU-W-OA		91	93	80	78	74	67	45	81