Sydney Children's Hospital Stage 1 and Minderoo Children's Comprehensive Cancer Centre (SCH1 & MCCCC) – Construction Noise & Vibration Management Sub Plan (CNVMSP)

John Holland Pty Ltd
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DOCUMENT CONTROL

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1 INTRODUCTION

Pulse White Noise Acoustics (PWNA) has been engaged by John Holland Pty Ltd (JH) to prepare a Construction Noise and Vibration Management Sub-Plan (CNVMSP) for the construction of the new Sydney Children's Hospital Stage 1 and Minderoo Children's Comprehensive Caner Centre (SCH1 & MCCCC) as part of the Randwick Campus Redevelopment (RCR).

This CNVMSP has been prepared to satisfy the requirements of Condition B18 and B42 of the Consent given in the Schedule 2 of the Development Consent issued for Application No. SSD 10831778, dated 17th December 2021.

Onsite unattended noise levels have previously been determined for the project by Pulse Acoustic Consultancy Pty Ltd (Pulse) in the site's *SSDA Acoustic Assessment* submitted as part of the SSD Application reference "*20087 SCH1-CCCC – SSDA Acoustic Assessment – R4*", dated 20th April 2021. These levels are adopted for this assessment.

A glossary of acoustic terminology used throughout this report is included in Appendix A.

1.1 Condition Satisfaction

In addressing the requirements of Condition B18 (see section 3.1) and Condition B42, each item is addressed in the following section:

Table 1 Condition Satisfaction Table

CEMP Condition Satisfaction Table		
Condition	**Condition Requirements**	**Document/Sub-Plan Reference**
Condition B18	The Construction Noise and Vibration Management Sub-Plan must address, but not be limited to, the following:	-
	(a) be prepared by a suitably qualified and experienced noise expert;	Refer to Appendix C: Author Curriculum Vitae (CV) – Page 56
	(b) describe procedures for achieving the noise management levels in EPA's Interim Construction Noise Guideline (DECC, 2009);	Refer to section 3.2.1 – Page 24.
	(c) describe the measures to be implemented to manage high noise generating works such as piling, in close proximity to sensitive receivers;	Refer to section 5 – Page 42.
	(d) include strategies that have been developed with the community for managing high noise generating works;	Refer to section 5.4 – Page 48.
	(e) describe the community consultation undertaken to develop the strategies in condition B18(d);	Refer to section 5.4 – Page 48.
	(f) include a complaints management system that would be implemented for the duration of the construction; and	Refer to section 5.4 – Page 48.
	(g) include a program to monitor and report on the impacts and environmental performance of the development and the effectiveness of the implemented management measures in accordance with the requirements of condition B18.	Refer to section 5.2.3 & 5.3.2 – Page 46 & 45.
Condition B42	Prior to the commencement of any construction works or any preparatory, demolition or excavation works, whichever is the earlier, the following documentation must be provided for the review and endorsement of TfNSW:	-
	(a) final geo-technical and structural report / drawings. Geotechnical reports should include any potential impact on the light rail corridor located adjacent to the subject development site, easement and substratum;	N/A
	(b) final construction methodology with construction details pertaining to structural support during excavation or ground penetration;	N/A

CEMP Condition Satisfaction Table		
	(c) details of the vibration and movement monitoring system that will be in place before excavation commences;	Refer to section 5.3.2 – Page 46.
	(d) final cross sectional drawings showing ground surface, rail tracks, sub-soil profile, proposed basement excavation and structural design of sub-ground support adjacent to the Rail Corridor located adjacent to the subject development site. Cross sectional drawings should also include the accurate RL depths and horizontal distances from assets (tracks, overhead lines, structures and cables) to the nearest point of excavation or ground penetration works. All measurements are to be verified by a Registered Surveyor; and	N/A
	(e) detailed survey plan with location of services.	N/A

1.2 Development Overview

The subject site has a legal description of Lot 100 in DP1249692; Lots 1 - 4 in DP13995; Lots A - D in DP304806; Lots A and B in DP303478; Lots A and B in DP102029; Lots A and B in DP167106; Lots 6 and 7 in DP13997; Lots A and B in DP441943; and Lots 12-14 in DP12909.

The Project comprises a site area of 9,870m². The Project will have an indicative building footprint of approximately 5,828m², whilst the remaining 4,042m² will comprise of ground plane access, public domain, and landscaping works. The project includes:

- Construction and operation of a new 9 storey hospital, including 2 levels of basement building, plus upper plant room to provide:
    - A new children's emergency department and emergency short-stay unit, accessible from Botany Street
    - Street with direct links to new and existing services
    - A new children's intensive care unit
    - New inpatient units for medical and surgical specialties
    - A new medical short-stay unit
    - A new pharmacy and pathology collection
    - Australia's first Children's Comprehensive Cancer Centre including:
        - State-of-the-art technologically advanced wet and dry laboratory spaces
        - Education, training and research spaces
        - New oncology inpatient units, and patient and family focused retreat areas
        - A new day oncology unit
    - New front of house and retail facilities; and
    - Building identification signage zones.
- New High Street visitor drop off.
- Integration via pedestrian skybridges with the Integrated Acute Services Building (approved under SSD 10339 and 9113), currently under construction and with the proposed Health Translation Hub (HTH, SSD 10822510).

- Short-stay patient parking connected to existing Botany Street intersection.
- Basement Ambulance access, loading dock, back of house and logistics services via Hospital Road.
- Public domain and associated landscaping, including tree removal; and
- Associated site preparation, civil works, and utilities services.

1.3 Construction Period

The construction period is indicatively provided below.

Table 2 Indicative Construction Period

Phase	Weeks
Site Establishment	Five (5) Weeks
Excavation	Thirty (30) Weeks
Structure	Forty-one (41) Weeks
Façade	Thirty (30) Weeks
Internal Fitout	Seventy-seven (77) Weeks
Landscaping Works	Six (6) Weeks.

Anticipated project completion is Early 2025.

1.4 Site Layout

The SCH1/MCCCC redevelopment is located in the north-east corner of the new RCR precinct.

The future building is surrounded by the following:

- Along the northern façade boundary of the proposed building is High Street. High Street was recently redeveloped as part of the Stage 2 CBD Southeast Light Rail Project. Works associated with this project converted High Street from a typical roadway to a roadway which accommodates both light rail vehicles and passenger vehicles. Located on the opposite side of High Street are existing multi-storey (2-3 levels) residential buildings. These receivers are the nearest receivers to the future building.
- Situated along the eastern boundary of site is Hospital Road which is subject to a separate Planning Approval Pathway and does not form part of this development application.
- To the south of the proposed building is the Price of Wales (POW) *Acute Services Building* (ASB), which is currently under construction. The ASB is a 13-storey building housing a range of critical services for the POW Hospital. Further south of the ASB is Magill Street with more residential receivers.
- Lastly, along the future western boundary of the site is the proposed UNSW HTH building (subject of a separate planning approval SSD-10822510). The proposed 15-storey HTH will accommodate new health related education, research and administrative facilities. It will allow health educators to work alongside clinic with a link bridge connection between the two proposed buildings. Further west of the proposed HTH is Botany Street.

The main vehicle access to the proposed SCH1/MCCCC building will be via a new signalised intersection along Botany Street which serves the precinct. Located on the opposite side of Botany Street is the existing UNSW Kensington Campus.

The nearest sensitive receivers to the site are identified below.

Receiver 1: Single and multi-storey residential buildings/dwellings located to the north of the site across High Street. Receivers which are multi storey are typically four storeys in height. Receivers are located along the southern side of Blenheim Street (No. 2-34) and eastern side of Botany Street on the same block (no. 43-47). Receiver one will be known as *Blenheim Street Receivers* in this report.

Receiver 2: Single and multi-storey residential buildings/dwellings located to the northwest of the site across High Street/Botany Street. Receivers which are multi storey are typically four storeys in height. Receivers are located along the northern side of High Street (No. 30-44) and western side of Botany Street on the same block (no. 26-38). Receiver two will be known as *Botany Street Receivers* in this report.

Receiver 3: Single and multi-storey residential dwellings located to the south of the new precinct (beyond the ASB) across Magill Street. Receivers which are multi storey are typically two storeys in height. Receivers are located along the southern side of Magill Street (No. 1-15), northern side of Hay Street within the same block (no. 2-16) and eastern side of Botany Street (no. 103-111A). Receiver three will be known as *Magill Street Receivers* in this report.

Receiver 4: Single and multi-storey residential dwellings located to the southwest of the new precinct (beyond the ASB) across Botany Street. Receivers which are multi storey are typically two storeys in height. Receivers are located along the northern side of Norton Street (No. 10-34) and western side of Botany Street (no. 40-44). Receiver four will be known as *Norton Street Receivers* in this report.

Receiver 5: Hospital buildings are located on the eastern side of Hospital Road within the existing RHC. The closest is the existing SCH located on the corner of High Street and Hospital Road.

Receiver 6: Educational buildings located on the western side of Botany Street within the existing UNSW Kensington Campus. The closest of these include the Wallace Wurth (C27) building, Biological Sciences North and South buildings (D26 and E26) and Australian Graduate School of Management (AGSM) building (G27).

Receiver 7: Proposed UNSW HTH building to be constructed within the RHC along the western façade of the project building.

Receiver 8: Future POW ASB building currently under construction to the south of the project building.

A map showing the site location as well as nearest receivers is provided below. Additionally, shown below are the onsite measurements which were conducted as part of this assessment.

Figure 1 Site Map and Surrounding Receivers

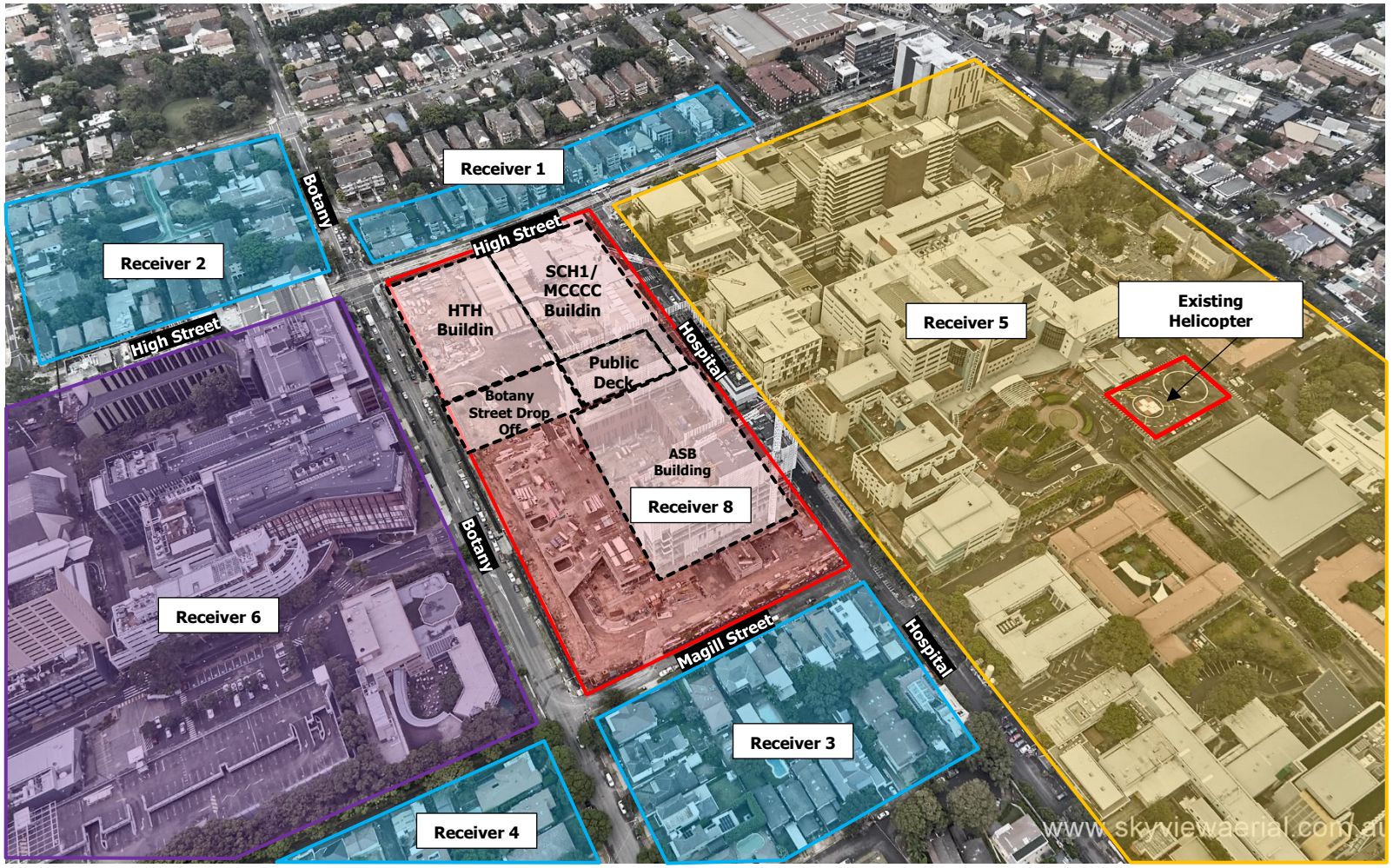


Figure 2 Site Map and Measurement Locations

2 EXISTING ACOUSTIC ENVIRONMENT

Measurements of the existing background noise levels have previously been conducted Pulse Acoustic Consultancy Pty Ltd as part of their SSDA *Acoustic Assessment* ("*20087 SCH1-CCCC – SSDA Acoustic Assessment – R4*", dated 20th April 2021) which was submitted as part of the SSD Application. Information regarding the monitoring conducted by Pulse Acoustic Consultancy Pty Ltd is provided below.

Figure 3 Extract of Pulse *SSD Acoustic Assessment*

Health Infrastructure NSW
1 Reserve Road, St Leonards NSW 2065

3 ACOUSTIC NOISE AND VIBRATION SURVEY

3.1 Onsite Noise Measurements

Measured noise levels from both the unattended and attended noise surveys are outlined below.

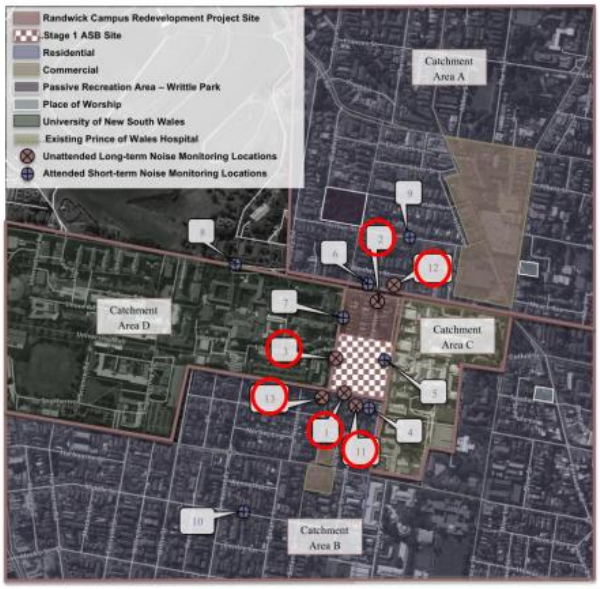
3.1.1 Unattended Noise Monitoring

Unattended noise monitoring has previously been undertaken around the site by Acoustic Studio (i.e., IASB Acoustic Consultant) during the SSDA stage for the IASB to the south. Details of the monitoring survey were presented in the *Noise and Vibration Impact Assessment for State Significant Development (SSD) – Acute Services Building (ASB)*, reference 20180808 AUR.0003.Rep.docx, dated 8th August 2018, prepared by Acoustic Studio.

Results of the Acoustic Studio unattended noise survey are detailed below.

Outlined in Figure 1 of the Acoustic Studio Report is a visual representation of the measurement locations. Figure 1 of the Acoustic Studio report has been reproduced below for information.

Figure 3-1 Acoustic Studio Measurement Locations – Figure 1 of Acoustic Report



Note: Relevant noise measurements have been circled in red below for ease of identification.

Pulse Acoustic Consultancy Pty Ltd Page 16 of 100

Figure 3 Extract of *SSD Acoustic Assessment* (Cont.)

Figure 3-2 Acoustic Studio Measurement Information – Section 4 of Acoustic Report – Page 19

4 Existing Noise Environment

4.1 General Survey Information

A survey of the existing noise environment around the site perimeter bounded by Magill Street, Botany Street, High Street and Hospital Road was conducted with six individual unattended noise monitors used to continuously record the noise levels on the site. Unattended long-term noise monitoring was carried out from Wednesday 18th October to Friday 3rd November 2017 and Wednesday 18th to Wednesday 25th July 2018 to establish the typical range of ambient noise levels of the proposed site and surrounds.

Unattended long-term noise monitoring was carried out with the following noise loggers:

- Logger 1: B&K 3659-B (Serial Number 3010119).
  - This logger was used at Location 1 from 18th to 22nd October 2017 and then from 26th October to 3rd November 2017.
  - This logger was used at Location 13 from 18th to 25th July 2018.
- Logger 2: Ngara (Serial Number 878197).
  - This logger was used at Location 2 from 18th to 25th October 2017.
- Logger 3: RTA 02 (Serial Number 038).
  - This logger was used at Location 3 from 23rd October to 3nd November 2017.
- Logger 4: Ngara (Serial Number 878000).
  - This logger was used at Location 11 from 18th to 25th July 2018.
- Logger 5: Ngara (Serial Number 87809E).
  - This logger was used at Location 12 from 18th to 24th July 2018.

The loggers recorded L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} noise parameters at 15-minute intervals continuously for the 25-day measurement period. The calibrations of the loggers were checked before and after use and no variations were noted.

The unattended long-term noise monitoring locations are shown in Figure 1. The noise loggers at Locations 1, 2 and 3 were located at the street-side boundaries of existing residential and commercial properties at the site. At Locations 11, 12 and 13, the noise loggers were located within the front yards of residential properties in the vicinity of the proposed development. These locations were chosen as they:

- are secure places to leave the noise loggers unattended, and
- are representative of background and ambient noise levels (Location 11, 12 and 13) at the nearest and potentially most-affected noise sensitive residential

Figure 3 Extract of *SSD Acoustic Assessment* (Cont.)

Figure 3-3 Acoustic Studio Measurement Information – Section 4 of Acoustic Report – Page 20

receivers, plus traffic noise levels (Location 1, 2 and 3) along roads surrounding the site.

Operator attended, short-term monitoring was also carried out on Wednesday 18th, Monday 23rd and Wednesday 25th of October and Friday 3rd of November 2017 in order to supplement the long-term outdoor data across the site and at key surrounding receivers, such as UNSW, POW Hospital and residences nearby, and to obtain spectral noise data for traffic noise at the proposed site.

Attended short-term measurements were made with two Brüel & Kjær Hand-held Analysers Type 2250 (Serial Numbers 2832406 and 3010373). The calibrations of the analysers were checked before and after the surveys and no variation in levels occurred.

Windshields were used to protect the microphones of all the loggers and analysers. Weather conditions were calm and dry during the attended noise surveys.

Saiham Siraj of Acoustic Studio Pty Ltd carried out the surveys.

The unattended long-term noise monitoring locations and attended short-term noise monitoring locations are shown in Figure 1.

The High Street residential receivers (Catchment A) are currently affected by construction noise associated with the Sydney CBD and South East Light Rail Project. Acoustic Studio has undertaken attended, short-term noise level measurements along High Street and on surrounding streets to establish:

a) the construction noise levels currently affecting the Catchment A residences on High Street; and
b) the likely Rating Background Level (RBL) for the Catchment A residences in the absence of the Sydney CBD and South East Light Rail Project construction works.

The results from these additional attended, short-term noise level measurements are included in Section 4.3.

4.2 Unattended Long-term Monitoring Results

The loggers were located at the proposed site at the following locations:

- Location 1 – at the backyard of the existing 101 Botany Street residential property (owned by UNSW) located in the southwestern corner of the site, to capture existing **traffic noise** levels along Magill Street.
- Location 2 – at the parking space east of the existing 1-3 Eurimbla Avenue commercial building to capture existing **traffic noise** levels along High Street.
- Location 3 – at the front yard of the existing 79 Botany Street residential building to capture existing **traffic noise** levels along Botany Street.
- Location 11 – at the front yard of 7 Magill Street residential property to capture a combination of **ambient and background noise** levels along Magill Street. This

Figure 3 Extract of *SSD Acoustic Assessment* (Cont.)

Figure 3-4 Acoustic Studio Measurement Information – Section 4 of Acoustic Report – Page 21

logger location is representative of the background and ambient noise levels at the nearest residential receivers on Magill Street.

- Location 12 – at the front yard (High Street frontage) of 12 Blenheim Street residential property to capture existing **ambient and background noise** levels along High Street. This logger location is representative of the background and ambient noise levels at the nearest residential receivers on High Street.
- Location 13 – at the front yard of 40 Botany Street residential building to capture existing **ambient and background noise** levels along Botany Street. This logger location is representative of the background and ambient noise levels at the nearest residential receivers on Botany Street.

The unattended long-term noise monitoring locations are shown in Figure 1.

The detailed results of the unattended long-term noise monitoring at the six (6) logger locations are shown in Appendix B.

Figure 3-5 Acoustic Studio Measurement Information – Section 4 of Acoustic Report – Page 22

4.2.1 Traffic Noise

Traffic noise monitoring results are summarised in Table 1 below.

Location	Traffic Noise Levels[1], dB(A)			
	Period		Noisiest 1 Hour Period	
	Day $L_{eq\ (15\ hr)}$	Night $L_{eq\ (9\ hr)}$	Day $L_{eq\ (1\ hr)}$	Night $L_{eq\ (1\ hr)}$
Location 1[4] Traffic along Magill Street (Catchment B)	45	43	47	45
Location 2 Traffic along High Street (Catchment A)	58	52	59	54
Location 3 Traffic along Botany Street (Catchment D)	59	55	60	60

Table 1: Summary of measured long-term traffic noise levels

4.2.2 Background and Ambient Noise

The logged data shows the background and ambient noise levels representative of the area. The recorded background noise levels have been used to establish limiting criteria for noise emitted from the operation of the new building.

The background sound level is defined as the sound level exceeded 90% of the time, and is designated as the L_{90}. The ambient noise level impacting on the buildings is referred to as the equivalent continuous sound level (L_{eq}). This parameter is commonly used to describe a time varying noise such as traffic noise.

Figure 3 Extract of *SSD Acoustic Assessment* (Cont.)

Figure 3-6 Acoustic Studio Measurement Information – Section 4 of Acoustic Report – Page 22

The background sound levels have been established in general accordance with the methodology described in the NSW NPI, i.e. the 10th percentile background sound level for each period for each day of the ambient noise survey. The median of these levels is then presented as the background sound level for each assessment period. These background noise levels are shown in Table 2 below together with the L_{Aeq} ambient noise levels measured for each period.

In accordance with the NSW NPI, any data likely to be affected by rain, wind or other extraneous noise have been excluded from the calculations.

[3] Levels are adjusted to represent levels at facades, taking into consideration distance attenuation, façade reflection and shielding to the logger location.

[4] Levels are adjusted to exclude ambient noise levels which are not associated with traffic from Magill Street.

Figure 3-7 Acoustic Studio Measurement Information – Section 4 of Acoustic Report – Page 23

Location	Background Noise Levels (RBL), dB(A)			Leq Ambient Noise Levels, dB(A)		
	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am
Logger Location 3 79 Botany Street (Catchment D)	47	41	39	60	58	55
Logger Location 11 7 Magill Street (Catchment B)	46	44	43	55	51	51
Logger Location 12 12 Blenheim Street (Catchment A)	47	45	43	59	53	55
Logger Location 13 40 Botany Street (Catchment B)	49	46	43	65	64	59

Table 2: Long-term background and ambient noise levels

Based on our observations during the site inspections, both ambient and background noise levels around the proposed site are generally dominated by traffic noise around the site at all six locations and also by construction noise at Locations 2, 3 and 12.

Since the period in which Acoustic Studio undertook the detailed unattended noise surveys outlined above, the surrounding area has been subject to significant change. Between the dates of monitoring outlined above, the construction of the CBD and South East Light Rail (CSELR) for the L2 Randwick Line and L3 Kingsford Line has been completed and become operational. Existing vehicle movements along the previous roadways have been altered with the operation of the CSELR. Significant amounts of demolition, bulk excavation, and part construction of the new IASB building has occurred/occurring on the two blocks of land between Hospital Road and Botany Street from High Street to Magill Street, including the closure decommissioning of Eurimbla Avenue.

Figure 3 Extract of *SSD Acoustic Assessment* (Cont.)

Whilst the monitoring outlined above is still believed to be valid, this must be verified with updated onsite noise surveys.

An unattended noise survey was conducted by Pulse Acoustics between Tuesday 28th July 2020 and Wednesday 12th August 2020 on the level 2 balcony of 8 Blenheim Street, Randwick building. Specifically, unit 2 which faces south along High Street directly opposite the project site, as shown in Figure 3-8 below.

Instrumentation for the survey comprised one Svan 971 noise logger (serial number 74365). Calibration of the logger was checked prior to and following the measurements. Drift in calibration did not exceed ±0.5 dB. All equipment carried appropriate and current NATA (or manufacturer) calibration certificates.

Charts presenting summaries of the measured daily noise data are attached in Appendix B. The charts present each 24-hour period and show the L_{A1}, L_{A10}, L_{Aeq} and L_{A90} noise levels for the corresponding 15-minute periods. This data has been filtered to remove periods affected by adverse weather conditions based on weather information.

Figure 3-8 Unattended Noise Monitor Location – High Street – Rear of 8 Blenheim Street Randwick – Level 2

Based on the unattended noise measurements outlined above, the results of each survey are presented below.

Figure 3 Extract of *SSD Acoustic Assessment* (Cont.)

Upon review the monitoring data presented in Appendix B and the site observations made during our attended noise surveys the following has been concluded:

- Daytime noise levels between 7:00am and 5:00pm will be slightly affected by construction activities associated with the IASB building currently under construction.
- Due to the nature of the area in which the project site is located the measured levels during a Sunday when construction activities do not occur will be a good indication of RBL's. As the light rail movements are similar, the hospital is still in operation and traffic levels along Botany Street are relatively similar.
- An unusual localised activity is occurring during the early morning period on most of the monitored days. As can be clearly identified in Tuesday 8th August 2020 and Wednesday 9th August 2020.
- In addition to the localised noise identified above; a noise event for a short to medium duration is occurring during the early morning periods on a few of the monitoring days. As can be clearly identified on Friday 7th August 2020 and Wednesday 12th August 2020.

3.1.2 Results in accordance with the NSW *EPA Noise Policy for Industry (NPI) 2017* (RBL's)

In order to assess the acoustical implications of the development at nearby noise sensitive receivers, the measured background noise data of the logger was processed in accordance with the NSW EPA's *Noise Policy for Industry* (NPI, 2017).

The Rating Background Noise Level (RBL) is the background noise level used for assessment purposes at the nearest potentially affected receiver. It is the 90th percentile of the daily background noise levels during each assessment period, being day, evening and night. RBL $L_{A90\ (15minute)}$ and L_{Aeq} noise levels are presented in Table 3-1.

Data affected by adverse meteorological conditions and by spurious and uncharacteristic events have been excluded from the results, and also excluded from the data used to determine the noise emission criteria. Meteorological information has been obtained from the Observatory Hill Station (ID 067105).

Table 3-1 Measured Ambient Noise Levels corresponding to the NPI's Assessment Time Periods

Measurement Location	Daytime[1] 7:00 am to 6:00 pm		Evening[1] 6:00 pm to 10:00 pm		Night-time[1] 10:00 pm to 7:00 am	
	L_{A90}[2] (dBA)	L_{Aeq}[3] (dBA)	L_{A90}[2] (dBA)	L_{Aeq}[3] (dBA)	L_{A90}[2] (dBA)	L_{Aeq}[3] (dBA)
Location 1, High Street. See Figure 3-8	51	61	48	57	46	60

Note 1: For Monday to Saturday, Daytime 7:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 7:00 am. On Sundays and Public Holidays, Daytime 8:00 am – 6:00 pm; Evening 6:00 pm – 10:00 pm; Night-time 10:00 pm – 8:00 am

Note 2: The L_{A90} noise level is representative of the "average minimum background sound level" (in the absence of the source under consideration), or simply the background level.

Note 3: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

Figure 3 Extract of *SSD Acoustic Assessment* (Cont.)

3.1.3 Results in accordance with the NSW Department of Planning "Development near Rail Corridors and Busy Roads – Interim Guideline"

In determining the required façade construction for the proposed building in accordance with the internal noise level requirements of NSW Department of Planning "Development near Rail Corridors and Busy Roads – Interim Guideline" measured noise levels are shown based on the time periods defined by the SEPP below.

Data affected by adverse meteorological conditions and by spurious and uncharacteristic events have been excluded from the results, and also excluded from the data used to determine the noise emission criteria.

Table 3-2 Measured Ambient Noise Levels corresponding to the "Development near Rail Corridors and Busy Roads – Interim Guideline" Assessment Time Periods

Measurement Location	Daytime [1] 7:00 am to 10:00 pm	Night-time [1] 10:00 pm to 7:00 am
	$L_{Aeq\ (whole\ period)}$ [2] (dBA)	$L_{Aeq\ (whole\ period)}$ [2] (dBA)
Location 1, High Street. Figure 3-8	60	60

Note 1: For Monday to Sunday, Daytime 7:00 am – 10:00 pm; Night-time 10:00 pm – 7:00 am.

Note 2: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

3.1.4 Attended Noise Measurements

In addition to the unattended noise survey previously and currently being undertaken, an attended noise survey was carried out to establish levels at key locations within and surrounding the site. These are summarised below.

The attended noise measurements were conducted using a Brüel & Kjær Type 2250 sound level meter (serial number 3006332). Calibration of the sound level meter was checked prior to and following the measurements using a Brüel & Kjær Type 4231 sound calibrator (serial number 3009148). The calibrator emitted a calibration tone of 94 dB at 1 kHz. The drift in calibration did not exceed ±0.5 dB. All equipment carries appropriate and current NATA (or manufacturer) calibration certificates.

Attended noise measurements were undertaken on Tuesday 16th June 2020 at 3:30pm to 5:30pm and Wednesday 17th June 2020 at 12:30am and 2:30am.

Results of the attended noise measurements are outlined in Table 3-3 below.

Figure 3 Extract of *SSD Acoustic Assessment* (Cont.)

Table 3-3 Measured Results of the Attended Noise Survey

Measurement Location	Date and Time	Measured Noise Level (dBA)		Comments
		$L_{A90\ (15\text{-}min)}$[1]	$L_{Aeq\ (15\text{-}min)}$[2]	
Location 1: Hospital Road, Outside Southern Wing of Existing SCH. (See Figure 2-2)	Tuesday 16th June 2020 at 3:30pm to 5:30pm	55	61	Construction noise affected, IASB works.
	Wednesday 17th June 2020 at 12:30am and 2:30am	51	53	Mechanical noise from existing SCH building, occasional Light Rail Vehicle along High Street.
Location 2: Corner of Hospital Road and High Street, Existing SCH Side (See Figure 2-2)	Tuesday 16th June 2020 at 3:30pm to 5:30pm	53	63	Occasional Light Rail Vehicle, occasional passenger vehicle, pedestrian signal and distant traffic noise.
	Wednesday 17th June 2020 at 12:30am and 2:30am	52	53	Occasional Light Rail Vehicle, distant traffic movements from Botany, distant mechanical noise from existing SCH building and pedestrian signal.
Location 3: High Street, Southern Boundary of 10 Blenheim Street, Randwick (See Figure 2-2)	Tuesday 16th June 2020 at 3:30pm to 5:30pm	52	61	Occasional Light Rail Vehicle, occasional passenger vehicle, pedestrian signal, tyre noise over concrete expansion gaps and distant traffic noise from Botany Street.
	Wednesday 17th June 2020 at 12:30am and 2:30am	46	60	Occasional Light Rail Vehicle, distant traffic noise from Botany Street, distant mechanical noise from UNSW Wallace Wurth and existing SCH buildings.
Location 4: Corner of High Street and Botany Street, new Hospital precinct side (See Figure 2-2)	Wednesday 17th June 2020 at 12:30am and 2:30am	45	57	Occasional vehicle movement along Botany Street, distant mechanical noise from existing SCH building.
Location 5: Botany Street, outside Entrance to Wallace Wurth Building (C27,UNSW) (See Figure 2-2)	Tuesday 16th June 2020 at 3:30pm to 5:30pm	61	68	Frequent traffic movements along Botany Street
	Wednesday 17th June 2020 at 12:30am and 2:30am	48	58	Occasional vehicle movement along Botany Street, distant Light Rail Vehicle, distant mechanical noise from existing SCH building.

Note 1: The L_{A90} noise level is representative of the "average minimum background sound level" (in the absence of the source under consideration), or simply the background level.

Note 2: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

Figure 3 Extract of *SSD Acoustic Assessment* (Cont.)

Table 3-3 Measured Results of the Attended Noise Survey (Cont.)

Measurement Location	Date and Time	Measured Noise Level (dBA)		Comments
		$L_{A90\ (15\text{-}min)}$[1]	$L_{Aeq\ (15\text{-}min)}$[2]	
Location 6: Corner of Magill Street and Botany Street, outside 103 Botany Street, Randwick (See Figure 2-2)	Tuesday 16th June 2020 at 3:30pm to 5:30pm	54	65	Frequent traffic noise, both along Botany Street and Magill Street.
	Wednesday 17th June 2020 at 12:30am and 2:30am	45	46	Distant mechanical noise from both UNSW Wallace Wurth and existing SCH buildings.
Location 7: Magill Street, northern boundary of 5 Magill Street, Randwick (See Figure 2-2)	Tuesday 16th June 2020 at 3:30pm to 5:30pm	47	56	Moderate traffic movements along Magill Street
	Wednesday 17th June 2020 at 12:30am and 2:30am	44	45	Distant mechanical noise from existing SCH buildings.

Note 1: The L_{A90} noise level is representative of the "average minimum background sound level" (in the absence of the source under consideration), or simply the background level.

Note 2: The L_{Aeq} is the energy average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.

In the assessment of construction noise in NSW "Background + 10dBA" (or known as a *Noise Affected Level)* objective is applied. As such, to determine what the noise affected level is for each of the surrounding residential receivers, rating background noise levels presented in the table below have been adopted.

Table 3 Assumed ambient noise levels at residential receivers

Receiver Number	Receiver Location	Adopted Measured Rating Background Level at Receiver Location dBA L_{A90}[2]
		7:00am to 6:00pm (Monday to Friday) 8:00am to 5:00pm (Saturday)
Receiver 1	2-34 Blenheim & 47 Botany Street, Randwick	47 (Acoustic Studio)
Receiver 2	30-44 High Street & 26-38 Botany Street, Randwick	47 (Acoustic Studio)
Receiver 3	1-15 Magill Street, 2-16 Hay Street & 103-111A Botany Street, Randwick	46 (Acoustic Studio)
Receiver 4	10-34 Norton Street & 40-44 Botany Street, Randwick	49 (Acoustic Studio)
Receiver 5	Randwick Hospital Campus	N/A
Receiver 6	UNSW Main Campus (Across Botany Street)	N/A
Receiver 7	UNSW HTH (Future Building)	N/A
Receiver 8	ASB (Future Building)	N/A

Note 1: LA90 noise level is representative of the "average minimum background sound level" (in the absence of the source under consideration), or simply the background level.

3 NOISE AND VIBRATION CRITERIA

Relevant noise and vibration criteria for construction activities are detailed below.

3.1 SSD 10831778 Development Consent – Schedule 2 Conditions

Conditions of the consent which relate to construction noise and or vibration are detailed below.

Condition B9:

B9. Where the offer for a pre-construction survey is accepted (as required by condition B8), the Applicant must ensure a survey by a suitably qualified and experienced expert is undertaken prior to the commencement of vibration generating works that could impact on the identified buildings.

Condition B10:

B10. Prior to the commencement of any vibration generating works that could impact on the buildings surveyed as required by condition B9, the Applicant must:

(a) provide a copy of the relevant survey to the owner of each residential or commercial building surveyed in the form of a Pre-Construction Survey Report;

(b) submit a copy of the Pre-Construction Survey Report to the Certifier; and

(c) provide a copy of the Pre-Construction Survey Report to the Planning Secretary when requested.

Condition B14:

Environmental Management Plan Requirements

B14. Management plans required under this consent must be prepared in accordance with relevant guidelines, including but not limited to the *Environmental Management Plan Guideline: Guideline for Infrastructure Projects* (DPIE April 2020).

Note: The Environmental Management Plan Guideline is available on the Planning Portal at: www.planningportal.nsw.gov.au/majorprojects/assessment/post-approval

Note: The Planning Secretary may waive some of these requirements if they are unnecessary or unwarranted for particular management plans.

Condition B18:

B18. A Construction Noise and Vibration Management Plan (CNVMP) must address, but not be limited to, the following:

(a) be prepared by a suitably qualified and experienced noise expert;

(b) describe procedures for achieving the noise management levels in EPA's *Interim Construction Noise Guideline* (DECC, 2009);

(c) describe the measures to be implemented to manage high noise generating works in close proximity to sensitive receivers;

(d) include strategies that have been developed with the community for managing high noise generating works;

(e) describe the community consultation undertaken to develop the strategies in condition B18(d);

(f) include a complaints management system that would be implemented for the duration of the construction; and

(g) include a program to monitor and report on the impacts and environmental performance of the development and the effectiveness of the management measures.

Note:

- *In addressing **item (a)** above, refer to Appendix C.*
- *In addressing **item (b) & (c)** above, refer to section 5.*

- *In addressing **item (d) & (e)** above, refer to section 5.4 specifically.*
- *In addressing **item (f) above**, refer to section 5.4 & 5.5.*
- *In addressing **item (g) above**, refer to sections 5.2.3 & 5.3.2 specifically.*

Condition B42:

B42. Prior to the commencement of any construction works or any preparatory, demolition or excavation works, whichever is the earlier, the following documentation must be provided for the review and endorsement of TfNSW:

(a) final geo-technical and structural report / drawings. Geotechnical reports should include any potential impact on the light rail corridor located adjacent to the subject development site, easement and substratum;

(b) final construction methodology with construction details pertaining to structural support during excavation or ground penetration;

(c) details of the vibration and movement monitoring system that will be in place before excavation commences;

(d) final cross sectional drawings showing ground surface, rail tracks, sub-soil profile, proposed basement excavation and structural design of sub-ground support adjacent to the Rail Corridor located adjacent to the subject development site. Cross sectional drawings should also include the accurate RL depths and horizontal distances from assets (tracks, overhead lines, structures and cables) to the nearest point of excavation or ground penetration works. All measurements are to be verified by a Registered Surveyor; and

(e) detailed survey plan with location of services.

Condition C3:

Construction Hours

C3. Construction, including the delivery of materials to and from the site, may only be carried out between the following hours:

(a) between 7am and 6pm, Mondays to Fridays inclusive; and

(b) between 8am and 5pm, Saturdays.

No work may be carried out on Sundays or public holidays.

Condition C4:

C4. Construction activities may be undertaken outside of the hours in condition C3 if required:

(a) by the Police or a public authority for the delivery of vehicles, plant or materials; or

(b) in an emergency to avoid the loss of life, damage to property or to prevent environmental harm; or

(c) where the works are inaudible at the nearest sensitive receivers; or

(d) for the delivery, set-up and removal of construction cranes, where notice of the crane-related works is provided to the Planning Secretary and affected residents at least seven days prior to the works; or

(e) where a variation is approved in advance in writing by the Planning Secretary or his nominee if appropriate justification is provided for the works.

Condition C5:

C5. Notification of such construction activities as referenced in condition C4 must be given to affected residents before undertaking the activities or as soon as is practical afterwards.

Condition C6:

C6. Rock breaking, rock hammering, sheet piling, pile driving and similar activities may only be carried out between the following hours:

(a) 9am to 12pm, Monday to Friday;

(b) 2pm to 5pm Monday to Friday; and

(c) 9am to 12pm, Saturday.

Condition C11:

C11. Construction must be undertaken in accordance with the construction noise management levels detailed in the *Interim Construction Noise Guideline* (DECC, 2009). All feasible and reasonable noise mitigation measures must be implemented and any activities that could exceed the construction noise management levels must be identified and managed in accordance with the management and mitigation measures identified in the approved Construction Noise and Vibration Management Plan.

Condition C12:

C12. The Applicant must ensure construction vehicles (including concrete agitator trucks) do not arrive at the site or surrounding area outside of the construction hours of work outlined under condition C3 unless permitted by C4.

Condition C13:

C13. The Applicant must implement, where practicable and without compromising the safety of construction staff or members of the public, the use of 'quackers' to ensure noise impacts on surrounding noise sensitive receivers are minimised.

Condition C14:

C14. Vibration caused by construction at any residence or structure outside the site must be limited to:

(a) for structural damage, the latest version of *DIN 4150-3 (1992-02) Structural vibration - Effects of vibration on structures* (German Institute for Standardisation, 1999); and

(b) for human exposure, the acceptable vibration values set out in the *Environmental Noise Management Assessing Vibration: a technical guideline* (DEC, 2006) (as may be updated or replaced from time to time).

Condition C15:

C15. Vibratory compactors must not be used closer than 30 metres from residential buildings unless vibration monitoring confirms compliance with the vibration criteria specified in condition C14.

Condition C16:

C16. The limits in conditions C14 and C15 apply unless otherwise outlined in a Construction Noise and Vibration Management Plan, approved as part of the CEMP required by condition B18 of this consent.

Condition C49:

C49. The Applicant must mitigate all noise and vibration during construction to the extent possible and provide vibration monitoring equipment and provide the results to the Sydney Light Rail Operator at intervals required by TfNSW and the Sydney Light Rail Operator, and immediately implement corrective actions in the event that the noise or vibration exceeds acceptable limits.

3.2 Construction Noise Criteria

3.2.1 NSW EPA Interim Construction Noise Guideline (ICNG) – DECC 2009

Noise criteria for construction and demolition activities are discussed in the *Interim Construction Noise Guideline* (ICNG). The ICNG also recommends procedures to address potential impacts of construction noise on residences and other sensitive land uses. The main objectives of the ICNG are summarised as follows:

- Promote a clear understanding of ways to identify and minimise noise from construction works;
- Focus on applying all "feasible" and "reasonable" work practices to minimise construction noise impacts;

- Construction to be undertaken only during the recommended standard hours unless approval is given for works that cannot be undertaken during these hours;
- Streamline the assessment and approval stages and reduce time spent dealing with complaints at the project implementation stage; and
- Site-specific feasible and reasonable work practices in order to minimise noise impacts.

The ICNG contains a quantitative assessment method which is applicable to this project. Guidance levels are given for airborne noise at residences and other sensitive land uses.

The quantitative assessment method involves predicting noise levels at sensitive receivers and comparing them with the Noise Management Levels (NMLs). The NML affectation categories for residential receivers have been reproduced from the guideline and are listed in the table below.

Table 4 NMLs for quantitative assessment at residences

Time of Day	Noise Management Level $L_{Aeq(15minute)}$[1,2]	How to Apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays ***(Or approved construction hours as per section 2.2 of the ICNG).***	***"Noise Affected Level"*** RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured LAeq(15minute) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	"Highly Noise Affected Level" 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. 2. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours ***(Non-approved original construction hours)***	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB above the noise affected level, the proponent should negotiate with the community.

Note 1 *Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.*

Note 2 *The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours). The term RBL is described in detail in the NSW Noise Policy for Industry (EPA 2017).*

Note 3 *Requirements listed in the table above are in accordance with the Construction Hours listed in Condition C3 and C4.*

Construction noise levels at other noise receivers are outlined below:

- Construction noise levels within classrooms at schools and other educational institutions is not to exceed 45dB LAeq,15minute, when measured internally.

- Construction noise levels within hospital wards and operating theatres is not to exceed 45dB LAeq,15minute, when measured internally.

- Construction noise levels at offices, retail outlets is not to exceed 70dB LAeq,15minute, when measured externally.

Based on the measured background noise levels summarised in section 3, and the NMLs outlined above the construction noise criteria to be used in this assessment are listed in Table 5.

Table 5 NMLs as basis for the acoustic assessment

Receiver Types		NML, dB $L_{Aeq(15minute)}$
		Standard Hours **Monday to Friday: 7:00am to 6:00pm** **Saturday: 8:00am to 5:00pm**
Residences (Measured externally)	Receiver 1	**57** + *HNAL* (**75**)
	Receiver 2	**57** + *HNAL* (**75**)
	Receiver 3	**56** + *HNAL* (**75**)
	Receiver 4	**59** + *HNAL* (**75**)
Education institutions (Measured internally)		**45**
hospital wards and operating theatres (Measured internally)		**45**
Offices & retail outlets (Measured externally)		**70**

3.2.2 Construction Traffic Noise Criteria

For existing residences and other sensitive land uses affected by additional traffic on existing roads, the NSW *Road Noise Policy (RNP)* states that for noise associated with increased road traffic generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB during both day and night-time periods. An increase of 2 dB represents a minor impact that is considered barely perceptible to the average person.

3.3 Vibration Criteria

3.3.1 Human Comfort

Vibration effects relating specifically to the human comfort aspects of the project are taken from the guideline titled *"Assessing Vibration – A Technical Guideline"*. (AVTG) This type of impact can be further categorised and assessed using the appropriate criterion as follows:

- Continuous vibration – from uninterrupted sources (refer to Table 6).
- Impulsive vibration – up to three instances of sudden impact e.g. dropping heavy items, per monitoring period (refer to Table 7).
- Intermittent vibration – such as from drilling, compacting or activities that would result in continuous vibration if operated continuously (refer to Table 8).

Table 6 Continuous vibration acceleration criteria (m/s^2) 1 Hz-80 Hz

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or night-time	0.020	0.014	0.040	0.028
		0.04	0.029	0.080	0.058
Workshops	Day or night-time	0.04	0.029	0.080	0.058

Table 7 Impulsive vibration acceleration criteria (m/s^2) 1 Hz-80 Hz

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day or night-time	0.64	0.46	1.28	0.92
Workshops	Day or night-time	0.64	0.46	1.28	0.92

Table 8 Intermittent vibration impacts criteria ($m/s^{1.75}$) 1 Hz-80 Hz

Location	Daytime		Night-time	
	Preferred Values	Maximum Values	Preferred Values	Maximum Values
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

3.3.2 Building Contents and Structure

The vibration effects on the building itself are assessed against international standards as follows:

- For transient vibration: British Standard BS 7385: Part 2-1993 *"Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from ground borne vibration"* (BSI 1993); and
- For continuous or repetitive vibration: German DIN 4150: Part 3 – 1999 *"Effects of Vibration on Structure"* (DIN 1999).

Note: British Standard BS 7385 and German Standard DIN 4150 are being referenced in lieu of any relevant Australian Standards for vibration impacts to either building contents or structures.

3.3.2.1 British Standard BS 7385 Part 2 - 1993

For transient vibration, as discussed in standard BS 7385 Part 2-1993, the criteria are based on peak particle velocity (mm/s) which is to be measured at the base of the building. These are summarised in Table 9 and illustrated in Figure 4.

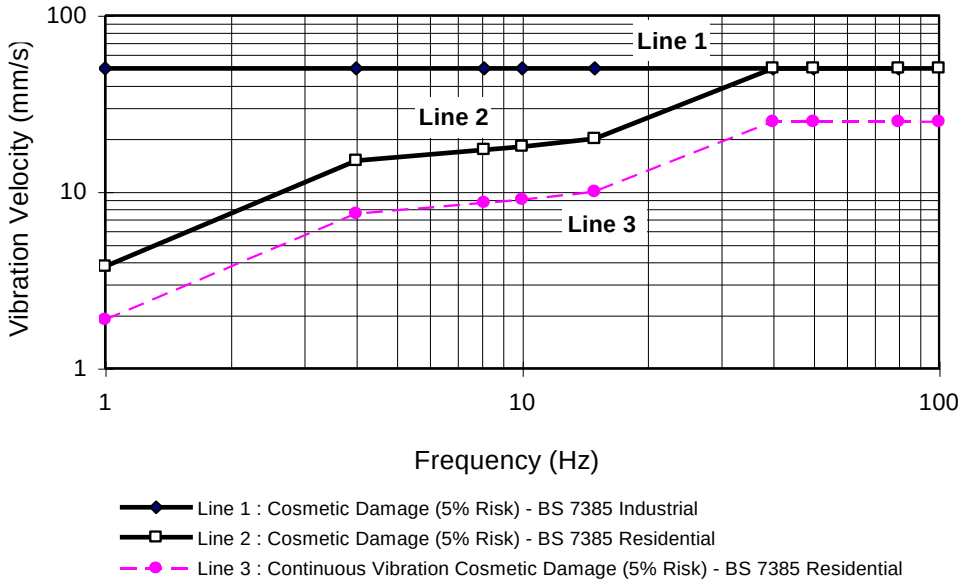
Table 9 Transient vibration criteria as per standard BS 7385 Part 2 - 1993

Line in 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 framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Standard BS 7385 Part 2 – 1993 states that the values in Table 9 relate to transient vibration which does not cause resonant responses in buildings.

Where the dynamic loading caused by continuous vibration events is such as that results in dynamic magnification due to resonance (especially at the lower frequencies where lower guide values apply), then the values in Table 9 may need to be reduced by up to 50% (refer to Line 3 in Figure 4).

Figure 4 BS 7385 Part 2 – 1993, graph of transient vibration values for cosmetic damage



In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the recommended values corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard also states that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 9, and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the values above should not be reduced for fatigue considerations.

3.3.2.2 German Standard DIN 4150 Part 3 - 1999

For continuous or repetitive vibration, standard DIN 4150 Part 3-1999 provides criteria based on values for peak particle velocity (mm/s) measured at the foundation of the building; these are summarised in Table 10. The criteria are frequency dependent and specific to particular categories of structures.

Table 10 Structural damage criteria as per standard DIN 4150 Part 3 - 1999

Type of Structure	Peak Component Particle Velocity, mm/s			
	Vibration at the foundation at a frequency of			Vibration of horizontal plane of highest floor at all frequencies
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]	
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 and/or use	5	5 to 15	15 to 20	15
Structures that, because of their sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

Note 1: For frequencies above 100Hz, at least the values specified in this column shall be applied.

3.3.3 Sensitive Scientific and Medical Equipment

Some scientific equipment (e.g., electron microscopes and microelectronics manufacturing equipment) can require more stringent objectives than those applicable to human comfort.

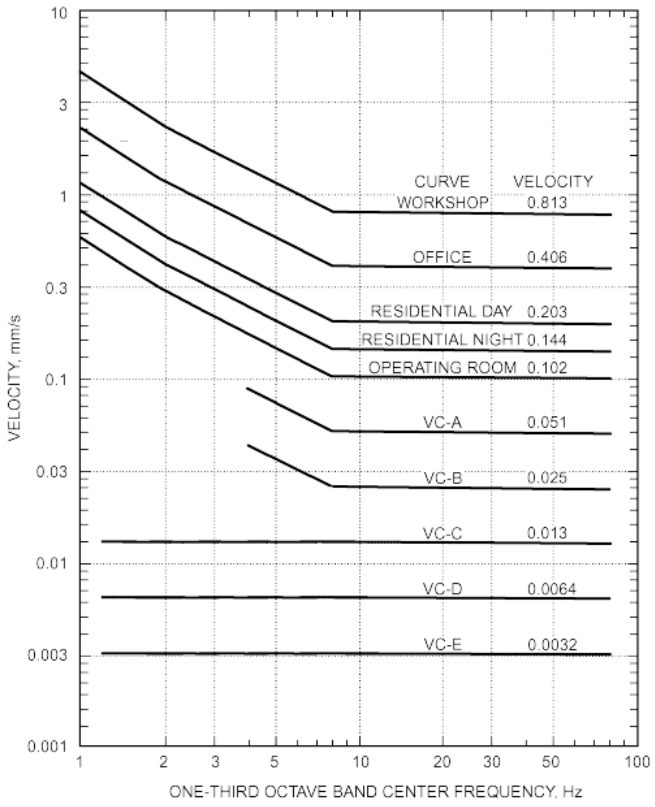
Where it has been identified that vibration sensitive scientific and/or medical instruments are likely to be in use at the nearest existing hospital buildings, objectives for the satisfactory operation of the instrument should be sourced from manufacturer's data.

Where manufacturer's data is not available, generic vibration criterion (VC) curves may be adopted as vibration goals. These generic VC curves are presented below in Table 11 and Figure 5.

Table 11 Criteria for vibration sensitive equipment

Equipment	Curve
Bench microscopes up to 100× magnification; laboratory robots	0.102 mm/s
Bench microscopes up to 400× magnification; optical and other precision balances; coordinate measuring machines; metrology laboratories; optical comparators; microelectronics manufacturing equipment; proximity and projection aligners, etc.	0.051 mm/s VC-A
Microsurgery, eye surgery, neurosurgery; bench microscopes at magnification greater than 400×; optical equipment on isolation tables; microelectronic manufacturing equipment, such as inspection and lithography equipment (including steppers) to 3 mm line widths	0.025 mm/s VC-B
Electron microscopes up to 30 000× magnification; microtomes; magnetic resonance imagers; microelectronics manufacturing equipment, such as lithography and inspection equipment to 1 mm detail size	0.013 mm/s VC-C
Electron microscopes at magnification greater than 30 000×; mass spectrometers; cell implant equipment; microelectronics manufacturing equipment, such as aligners, steppers, and other critical equipment for photolithography with line widths of 1/2 µm; includes electron beam systems	0.0054 mm/s VC-D
Non-isolated laser and optical research systems; microelectronics manufacturing equipment, such as aligners, steppers, and other critical equipment for photolithography with line widths of 1/4 µm; includes electron beam systems	0.0032 mm/s VC-E

Figure 5 Criteria for vibration sensitive equipment (ASHRAE 2007, HVAC Applications, Chapter 47 *"Sound and Vibration Control"*)



3.3.4 Transport for New South Wales (TfNSW) Rail Infrastructure Vibration Criteria

Currently the Conditions of Consent does not nominate any vibration criteria applicable to the light rail infrastructure along High Street. Therefore, the vibration criteria which is provided below has been developed based on other TfNSW vibration requirements we have seen in the past on previous projects.

*Vibration levels from any construction activities associated with the Sydney Children's Hospital Stage 1 and Children's Comprehensive Caner Centre (SCH1/CCCC) should not exceed **12mm/s Peak Particle Velocity (PPV)** when measured at the nearest representative location adjacent to the rail infrastructure.*

3.4 Ground-Borne Noise Criteria

According to the NSW EPA *Interim Construction Noise Guideline (*ICNG) 2009, the criteria for ground-borne noise at residences is defined as follows:

- Maximum internal noise levels of 40 dB $L_{Aeq(15mins)}$ between 6:00pm and 10:00pm.

4 NOISE AND VIBRATION ASSESSMENT

4.1 Construction Noise Assessment

Sound power levels have been predicted for the construction tasks identified in the project program. The equipment anticipated for use in each task is based on previous project experience. The sound power levels for the equipment likely to be used for each of the listed tasks are provided in Table 12 below.

Table 12 Summary of predicted sound power levels

Tasks	Equipment	Sound Power Levels (dBA re 1pW)	Aggregate Sound Power Level per Task (dBA re 1pW)
Site Establishment Works	Mobile crane	110	113
	Power hand tools	109	
	Semi Rigid Vehicle [1]	105	
Ground Works and Demolition	Excavator	112	120
	Hydraulic Hammer	118	
	Piling Rig	110	
	Handheld jack hammer [1]	111	
	Dump truck [1]	104	
	Concrete saw [1]	114	
	Skid steer	110	
	Power hand tools	109	
Structure	Handheld jack hammer [1]	106	117
	Concrete saw [1]	114	
	Power hand tools	109	
	Welder	101	
	Concrete pump truck	110	
	Concrete agitator truck	108	
Internal Works	Power hand tools	109	109
Common and External Works	Concrete agitator truck	108	114
	Saw cutter [1]	104	
	Dump truck [1]	104	
	Concrete saw [1]	114	
	Power hand tools	109	

Note 1: An assumed time correction has been applied, this being 5 minutes of operation in any 15-minute interval.

Table 13 Receiver 1 - Summary of preliminary predicted construction noise levels – Blenheim Street Residences

Phase	Activity	Aggregate Sound Power Level (dBA re 1pW)	Predicted Individual Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Predicted Combined Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Criteria dBA $L_{Aeq\ 15\ minutes}$	Summary of Result
Site Establishment Works	Mobile crane	113	58 to 72	61 to 76	**Monday to Friday** 07.00-18.00 47 + 10 = **57** **Saturday** 08.00-17.00 47 + 10 = **57** **Highly Noise Affected Level** Standard Construction Hours **75**	**Works indicatively predicted to have the potential to exceed the BG+10dBA and could have the potential to be above the Highly Noise Affected Level when working near a receiver**
	Power hand tools		57 to 71			
	Semi Rigid Vehicle		53 to 68			
Ground Works and Demolition	Excavator	119	60 to 74	66 to 81		**Works indicatively predicted to have the potential to exceed the BG+10dBA and could have the potential to be above the Highly Noise Affected Level when working near a receiver**
	Handheld jack hammer		54 to 69			
	Dump truck		52 to 67			
	Concrete saw		62 to 77			
	Skid steer		58 to 72			
	Power hand tools		57 to 71			
Structure	Handheld jack hammer	117	54 to 69	65 to 80		**Works indicatively predicted to have the potential to exceed the BG+10dBA and could have the potential to be above the Highly Noise Affected Level when working near a receiver**
	Concrete saw		62 to 77			
	Power hand tools		57 to 71			
	Welder		49 to 63			
	Concrete pump truck		58 to 72			
	Concrete agitator truck		56 to 70			
Internal Works	Power hand tools	109	57 to 71	57 to 71		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
Common and External Works	Concrete agitator truck	117	56 to 70	65 to 79		**Works indicatively predicted to have the potential to exceed the BG+10dBA and could have the potential to be above the Highly Noise Affected Level when working near a receiver**
	Saw cutter		52 to 67			
	Dump truck		52 to 67			
	Concrete saw		62 to 77			
	Power hand tools		57 to 71			

Table 14 Receiver 2 - Summary of predicted construction noise levels – Botany North Residences

Phase	Activity	Aggregate Sound Power Level (dBA re 1pW)	Predicted Individual Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Predicted Combined Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Criteria dBA $L_{Aeq\ 15\ minutes}$	Summary of Result
Site Establishment Works	Mobile crane	113	56 to 63	59 to 66	**Monday to Friday** 07.00-18.00 47 + 10 = **57** **Saturday** 08.00-17.00 47 + 10 = **57** **Highly Noise Affected Level** Standard Construction Hours **75**	**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Power hand tools		55 to 62			
	Semi Rigid Vehicle		51 to 58			
Ground Works and Demolition	Excavator	119	58 to 65	64 to 71		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Handheld jack hammer		52 to 59			
	Dump truck		50 to 57			
	Concrete saw		60 to 67			
	Skid steer		56 to 63			
	Power hand tools		55 to 62			
Structure	Handheld jack hammer	117	52 to 59	63 to 70		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Concrete saw		60 to 67			
	Power hand tools		55 to 62			
	Welder		47 to 54			
	Concrete pump truck		56 to 63			
	Concrete agitator truck		54 to 61			
Internal Works	Power hand tools	109	55 to 62	55 to 62		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
Common and External Works	Concrete agitator truck	117	54 to 61	63 to 70		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Saw cutter		50 to 57			
	Dump truck		50 to 57			
	Concrete saw		60 to 67			
	Power hand tools		55 to 62			

Table 15 Receiver 3 - Summary of predicted construction noise levels – Magill Street Residences

Phase	Activity	Aggregate Sound Power Level (dBA re 1pW)	Predicted Individual Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Predicted Combined Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Criteria dBA $L_{Aeq\ 15\ minutes}$	Summary of Result
Site Establishment Works	Mobile crane	113	43 to 48	46 to 52	**Monday to Friday** 07.00-18.00 46 + 10 = **56** **Saturday** 08.00-17.00 46 + 10 = **56** **Highly Noise Affected Level** Standard Construction Hours **75**	**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Power hand tools		42 to 47			
	Semi Rigid Vehicle		38 to 44			
Ground Works and Demolition	Excavator	119	45 to 50	51 to 57		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Handheld jack hammer		39 to 45			
	Dump truck		37 to 43			
	Concrete saw		47 to 53			
	Skid steer		43 to 48			
	Power hand tools		42 to 47			
Structure	Handheld jack hammer	117	39 to 45	51 to 56		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Concrete saw		47 to 53			
	Power hand tools		42 to 47			
	Welder		34 to 39			
	Concrete pump truck		43 to 48			
	Concrete agitator truck		41 to 46			
Internal Works	Power hand tools	109	42 to 47	42 to 47		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
Common and External Works	Concrete agitator truck	117	41 to 46	50 to 55		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Saw cutter		37 to 43			
	Dump truck		37 to 43			
	Concrete saw		47 to 53			
	Power hand tools		42 to 47			

Table 16 Receiver 4 - Summary of predicted construction noise levels – Norton Street Residences

Phase	Activity	Aggregate Sound Power Level (dBA re 1pW)	Predicted Individual Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Predicted Combined Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Criteria dBA $L_{Aeq\ 15\ minutes}$	Summary of Result
Site Establishment Works	Mobile crane	113	52 to 58	56 to 62	**Monday to Friday** 07.00-18.00 49 + 10 = **59** **Saturday** 08.00-17.00 49 + 10 = **59** **Highly Noise Affected Level** Standard Construction Hours **75**	**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Power hand tools		51 to 57			
	Semi Rigid Vehicle		48 to 54			
Ground Works and Demolition	Excavator	119	54 to 60	61 to 67		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Handheld jack hammer		49 to 55			
	Dump truck		47 to 53			
	Concrete saw		57 to 63			
	Skid steer		52 to 58			
	Power hand tools		51 to 57			
Structure	Handheld jack hammer	117	49 to 55	60 to 66		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Concrete saw		57 to 63			
	Power hand tools		51 to 57			
	Welder		43 to 49			
	Concrete pump truck		52 to 58			
	Concrete agitator truck		50 to 56			
Internal Works	Power hand tools	109	51 to 57	51 to 57		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
Common and External Works	Concrete agitator truck	117	50 to 56	59 to 65		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Saw cutter		47 to 53			
	Dump truck		47 to 53			
	Concrete saw		57 to 63			
	Power hand tools		51 to 57			

Table 17 Receiver 5 - Summary of predicted construction noise levels – Randwick Hospital Campus

Phase	Activity	Aggregate Sound Power Level (dBA re 1pW)	Predicted Individual Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Predicted Combined Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Criteria dBA $L_{Aeq\ 15\ minutes}$	Summary of Result
Site Establishment Works	Mobile crane	113	43 to 58	46 to 62	**Monday to Friday** 07.00-18.00 **Saturday** 08.00-17.00 **45dBA (applies when properties are being used)**	**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Power hand tools		42 to 57			
	Semi Rigid Vehicle		38 to 54			
Ground Works and Demolition	Excavator	119	45 to 60	51 to 67		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Handheld jack hammer		39 to 55			
	Dump truck		37 to 53			
	Concrete saw		47 to 63			
	Skid steer		43 to 58			
	Power hand tools		42 to 57			
Structure	Handheld jack hammer	117	39 to 55	50 to 66		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Concrete saw		47 to 63			
	Power hand tools		42 to 57			
	Welder		34 to 49			
	Concrete pump truck		43 to 58			
	Concrete agitator truck		41 to 56			
Internal Works	Power hand tools	109	42 to 57	42 to 57		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
Common and External Works	Concrete agitator truck	117	41 to 56	50 to 65		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Saw cutter		37 to 53			
	Dump truck		37 to 53			
	Concrete saw		47 to 63			
	Power hand tools		42 to 57			

Table 18 Receiver 6 - Summary of predicted construction noise levels - UNSW

Phase	Activity	Aggregate Sound Power Level (dBA re 1pW)	Predicted Individual Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Predicted Combined Noise Level at Receiver dBA $L_{Aeq\ 15\ minutes}$	Criteria dBA $L_{Aeq\ 15\ minutes}$	Summary of Result
Site Establishment Works	Mobile crane	113	38 to 43	42 to 47	**Monday to Friday** 07.00-18.00 **Saturday** 08.00-17.00 **45dBA (applies when properties are being used)**	**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Power hand tools		37 to 42			
	Semi Rigid Vehicle		34 to 39			
Ground Works and Demolition	Excavator	119	40 to 45	47 to 52		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Handheld jack hammer		35 to 40			
	Dump truck		33 to 38			
	Concrete saw		43 to 48			
	Skid steer		38 to 43			
	Power hand tools		37 to 42			
Structure	Handheld jack hammer	117	35 to 40	46 to 51		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Concrete saw		43 to 48			
	Power hand tools		37 to 42			
	Welder		29 to 34			
	Concrete pump truck		38 to 43			
	Concrete agitator truck		36 to 41			
Internal Works	Power hand tools	109	37 to 42	37 to 42		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
Common and External Works	Concrete agitator truck	117	36 to 41	45 to 50		**Works indicatively predicted to have the potential to exceed the BG + 10dBAhowever below the Highly Noise Affected Level.**
	Saw cutter		33 to 38			
	Dump truck		33 to 38			
	Concrete saw		43 to 48			
	Power hand tools		37 to 42			

4.2 Construction Traffic Noise Assessment

It is proposed that the construction traffic would access the site via Botany Street as a primary access route. This information has been provided by ARUP who are the construction traffic engineer for the project.

From the criteria discussed in Section 3, it is noted that vehicle numbers on surrounding roads would need to increase by around 60% from existing traffic flows, for a 2 dB increase in road traffic noise to occur. As noted previously, a 2 dB increase in road traffic noise is not considered to be noticeable.

Based on the number of vehicles projected over each of the phases, it is concluded that noise impacts from construction traffic is unlikely to have an impact at the nearest affected properties. As a result, no further assessment is required.

4.3 Vibration Assessment

In order to maintain compliance with the human comfort vibration criteria discussed in Section 3, it is recommended that the indicative safe distances listed in Table 19 should be maintained. These indicative safe distances should be validated at the start of construction works by undertaking measurements of vibration levels generated by construction and demolition equipment to be used on site.

The criteria for scientific or medical equipment can be more stringent than those required for human comfort. Vibration validating measurements should be conducted at each site to determine the vibration level and potential impact to this sensitive equipment.

Additionally, any vibration levels should be assessed in accordance with the criteria discussed in Section 3. This information should also be included as part of the CNVMSP.

Table 19 Recommended indicative safe working distances for vibration intensive plant

Plant	Rating / Description	Safe Working Distances (m)	
		Cosmetic Damage (BS 7385: Part 2 DIN 4150: Part 3)	Human Comfort (AVTG)
Vibratory roller	< 50 kN (Typically 1 – 2 tonnes)	5	15 – 20
	< 100 kN (Typically 2 – 4 tonnes)	6	20
	< 200 kN (Typically 4 – 6 tonnes)	12	40
	< 300 kN (Typically 7 – 13 tonnes)	15	100
	> 300 kN (Typically more than 13 tonnes)	20	100
Small hydraulic hammer	300 kg, typically 5 – 12 tonnes excavator	2	7
Medium hydraulic hammer	900 kg, typically 12 – 18 tonnes excavator	7	23
Large hydraulic hammer	1600 kg, typically 18 – 34 tonnes excavator	22	73
Vibratory pile driver	Sheet piles	2 – 20	20
Jackhammer	Hand held	1	Avoid contact with structure and steel reinforcements

5 NOISE AND VIBRATION MANAGEMENT PLAN

5.1 Acoustic Management Procedures

5.1.1 Summary of Management Procedures

Table 20 below summarises the management procedures recommended for airborne noise and vibration impacts. These procedures are also further discussed in the report. Hence, where applicable, links to further references are provided in Table 20.

Table 20 Summary of mitigation procedures

Procedure	Abbreviation	Description	Further Reference
General Management Measures	GMM	Introduce best-practice general mitigation measures in the workplace which are aimed at reducing the acoustic impact onto the nearest affected receivers.	Refer to Section 5.6 For noise impact, also refer to Section 5.2 For vibration impact, also refer to Section 5.3
Project Notification	PN	Issue project updates to stakeholders, discussing overviews of current and upcoming works. Advanced warning of potential disruptions can be included. Content and length to be determined on a project-by-project basis.	Refer to Section 5.4.
Verification Monitoring	V	Monitoring to comprise attended or unattended acoustic surveys. The purpose of the monitoring is to confirm measured levels are consistent with the predictions in the acoustic assessment, and to verify that the mitigation procedures are appropriate for the affected receivers. If the measured levels are higher than those predicted, then the measures will need to be reviewed and the management plan will need to be amended.	For noise impact, refer to Section 5.2.3 and Section 5.2.4. For vibration impact, refer to Section 5.3.2
Complaints Management System	CMS	Implement a management system which includes procedures for receiving and addressing complaints from affected stakeholders	Refer to Section 5.4.
Specific Notification	SN	Individual letters or phone calls to notify stakeholders that noise levels are likely to exceed noise objectives. Alternatively, contractor could visit stakeholders individually in order to brief them in regards to the noise impact and the mitigation measures that will be implemented.	Refer to Section 5.4.
Respite Offer	RO	Offer provided to stakeholders subjected to an ongoing impact.	Refer to Section 5.2.1
Alternative Construction Methodology	AC	Contractor to consider alternative construction options that achieve compliance with relevant criteria. Alternative option to be determined on a case-by-case basis. It is recommended that the selection of the alternative option should also be determined by considering the assessment of on-site measurements (refer to Verification Monitoring above).	Refer to Section 5.6.1 and 5.6.2

The application of these procedures is in relation to the exceedances over the relevant criteria. For airborne noise, the criteria are based on NMLs. The allocation of these procedures is discussed in Section 5.1.2

For vibration, the criteria either correspond to human comfort, building damage or scientific and medical equipment. The application of these procedures is discussed in Section 5.1.3.

5.1.2 Allocation of Noise Management Procedures

For residences, the management procedures have been allocated based on noise level exceedances at the affected properties, which occur over the designated NMLs (refer to Section 3). The allocation of these procedures is summarised in Table 21 below.

Table 21 Allocation of noise management procedures – residential receivers

Construction Hours	Exceedance over NML (dB)	Management Procedures (see definition above)
Standard Hours Mon – Fri: 7:00 am to 6:00 pm Sat: 8:00 am – 4:00 pm	0 - 10	GMM
	4 - 10	GMM, PN, V [1], CMS, AC
	> 10	GMM, PN, V, CMS, SN, AC
	Above 75dBA	GMM, PN, V, CMS, SN, RO, AC
Outside Standard Hours Any hours not listed above	0 - 5	GMM
	>6	GMM, PN, V, CMS, SN, RO, AC

Notes
1. *Verification monitoring to be undertaken upon complaints received from affected receivers*

Please note the following regarding the allocation of these procedures:

- The exceedances have been estimated as part of the acoustic assessment, and these are summarised in Section 4.1.
- The allocation of procedures is based on the assumptions used for noise level predictions (refer to Section 4.1). Consequently, these allocations can be further refined once onsite works are undertaken and further development of the construction program.

For non-residential receivers (such as education and health), management measures are provided in Section 5.2.4.

5.1.3 Allocation of Vibration Management Procedures

Table 22 below summarises the vibration management procedures to be adopted based on exceedance scenarios (i.e., whether the exceedance occurs over human comfort criteria, building damage criteria, or criteria for scientific and medical equipment). Please note these management procedures apply for any type of affected receiver (i.e., for residences as well as non-residential receivers).

Table 22 Allocation of vibration management procedures

Construction Hours	Exceedance Scenario	Management Procedures
Standard Hours Mon – Fri: 7:00 am to 6:00 pm Sat: 8:00 am – 4:00 pm	Over human comfort criteria (refer to Section 3)	GMM, PN, V, RO
	Over building damage criteria (refer to Section 3)	GMM, V, AC
Outside Standard Hours Mon – Fri: 6:00 pm to 7:00 pm Sat: 1:00 pm to 4:00 pm	Over human comfort criteria (refer to Section 3)	GMM, SN, V, RO, CMS
	Over building damage criteria (refer to Section 3)	GMM, V, AC

5.2 Site Specific Noise Mitigation Measures

5.2.1 Respite Periods

Predicted noise levels outlined in Section 4.1 indicate that in some cases when works are being undertaken within proximity of receiver boundaries, exceedances above the Noise Management Levels (NMLs) may occur. In addition, in accordance with Condition C6 respite periods are recommended for noisy activities. As such the following respite conditions are recommended in accordance with C6 or when works extended periods of noisy works are affecting a surrounding receiver above the HNAL of 75dBA. See below.

Table 23 Recommended Respite Periods

Monday to Friday	Saturday
7:00am to 9:00am – **No** rock breaking, rock hammering, sheet piling, pile driving and similar activities. (Respite Period)	8:00am to 9:00am – **No** rock breaking, rock hammering, sheet piling, pile driving and similar activities. (Respite Period)
9:00am to 12:00pm – Works	9:00am to 12:00pm – Works
12:00pm to 2:00pm – **No** rock breaking, rock hammering, sheet piling, pile driving and similar activities. (Respite Period)	12:00pm to 4:00pm – **No** rock breaking, rock hammering, sheet piling, pile driving and similar activities. (Respite Period)
2:00pm to 5:00pm – Works	
5:00pm to 6:00pm – **No** rock breaking, rock hammering, sheet piling, pile driving and similar activities. (Respite Period)	

Note: Recommended respite periods for noisy works has been formulated in accordance with Condition C6 from the *Notice of Determination – Approval.*

5.2.2 General Comments

The contractor will, where reasonable and feasible, apply best practice noise mitigation measures. These measures shall include the following:

- Maximising the offset distance between plant items and nearby noise sensitive receivers.
- Preventing noisy plant working simultaneously and adjacent to sensitive receivers.
- Minimising consecutive works in the same site area.
- Orienting equipment away from noise sensitive areas.
- Carrying out loading and unloading away from noise sensitive areas.

In order to minimise noise impacts during the works, the contractor will take all reasonable and feasible measures to mitigate noise effects.

The contractor will also take reasonable steps to control noise from all plant and equipment. Examples of appropriate noise control include efficient silencers and low noise mufflers.

The contractor should apply all feasible and reasonable work practices to meet the NMLs and inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels, duration of noise generating construction works, and the contact details for the proposal.

5.2.3 Noise Monitoring

Based on the predicted noise levels outlined 4.1 it is recommended unattended noise monitoring is conducted at Receiver 1 (Blenheim Street Receivers – See Figure 1).

In addition, should ongoing noise complaints be received at other surrounding locations attended noise measurements may be undertaken from time to time to supplement the unattended monitoring.

The unattended noise monitoring system should be accessible by the project team via an online portal and monitored by the project acoustic consultant to provide real-time feedback with notifications and data analysis.

The survey methodology and equipment will comply with the monitoring requirements as discussed in Australian Standard AS 1055.1-1997.

All onsite measurements will be undertaken to investigate compliance against the noise management levels (NML's) which are formulated in section 3 above (i.e., Project Approval and NSW EPA ICNG).

The location of the monitors will be determined by the location and type of works being undertaken on the site, and will be reviewed monthly, or as work location and type progresses (whichever is first). Due to the extent of works area and the complex nature of the project sequencing, several monitors may be required throughout the duration of the project.

Monthly reporting is to be undertaken which should include the following noise descriptors: L_{A90}, L_{A10} and L_{Aeq}.

5.2.4 Noise Mitigation Measures for Non-Residential Receivers

Where exceedances have been identified in Section 4, the following mitigation measures are recommended:

- Undertake general mitigation measures as discussed in Section 5.6
- Issue project updates to tenants in affected premises. The updates can include overview of current and upcoming works, as well as advanced warning of potential disruptions.
- Signage to be posted to provide stakeholders information regarding project details, emergency contacts and enquiry contact information.

5.2.5 Alternate Equipment or Process

Exceedance of the site's NMLs should result in an investigation as to whether alternate equipment could be used, or a difference process could be undertaken.

In some cases, the investigation may conclude that the use of other equipment is not possible, however, a different process could be undertaken.

5.2.6 Acoustic Enclosures/Screening

Typically, on a construction site there are three different types of plant that will be used: mobile plant (i.e., excavators, skid steers, etc.), semi mobile plant (i.e., hand tools generally) or static plant (i.e., diesel generators).

For plant items which are static it is recommended that, in the event exceedances are being measured due to operation of the plant item, an acoustic enclosure/screen is constructed to reduce impacts. These systems can be constructed from Fibre Cement (FC) sheeting or, if airflow is required, acoustic attenuators or louvres.

For semi mobile plant, relocation of plant should be investigated to either be operated in an enclosed space or at locations away from a receiver.

With mobile plant it is generally not possible to treat these sources. However, investigations into the machine itself may result in a reduction of noise (i.e., mufflers/attenuators etc).

5.2.7 Site Cranes

Three (3) permeant site cranes are proposed, all three being electric cranes connected to mains power. As such we understand no diesel power generators are required for the operation of the cranes. Information for each of the three (3) cranes are provided below:

- TC1 (Tower Crane 1): Terex CTT 561A-24 with a 59m jib.
- TC2 (Tower Crane 2: Terex CTT 332-16 with a 60m jib.
- TC3 (Tower Crane 3): Yongmao STL 230-18 with a 50m jib.

Based on the crane selections above the following the following is noted:

- Cranes to be installed are recommended to be electric. Should these cranes require ground-based diesel generators for backup, acoustic enclosures/screens are to be provided. Refer to 5.2.6 above.
- Crane Sound Power Levels (Lw) should not exceed 102dBA (externally).

5.3 Site Specific Vibration Mitigation Measures

5.3.1 General Comments

As part of the CNVMSP, the following vibration mitigation measures should be implemented:

- Any vibration generating plant and equipment is to be in areas within the site in order to lower the vibration impacts.
- Investigate the feasibility of rescheduling the hours of operation of major vibration generating plant and equipment.
- Use lower vibration generating items of construction plant and equipment; that is, smaller capacity plant, where feasible
- Minimise conducting vibration generating works consecutively in the same area (if applicable).
- Schedule a minimum respite period of at least 30 minutes before activities commence which are to be undertaken for a continuous 4-hour period.
- Use only dampened rock breakers and/or "city" rock breakers to minimise the impacts associated with rock breaking works.

5.3.2 Vibration Monitoring

As required in Conditions B42 and C49, vibration monitoring must be provided to the Transport for NSW (TfNSW) Infrastructure, see below.

Condition B42:

B42. Prior to the commencement of any construction works or any preparatory, demolition or excavation works, whichever is the earlier, the following documentation must be provided for the review and endorsement of TfNSW:

(a) final geo-technical and structural report / drawings. Geotechnical reports should include any potential impact on the light rail corridor located adjacent to the subject development site, easement and substratum;

(b) final construction methodology with construction details pertaining to structural support during excavation or ground penetration;

(c) details of the vibration and movement monitoring system that will be in place before excavation commences;

(d) final cross sectional drawings showing ground surface, rail tracks, sub-soil profile, proposed basement excavation and structural design of sub-ground support adjacent to the Rail Corridor located adjacent to the subject development site. Cross sectional drawings should also include the accurate RL depths and horizontal distances from assets (tracks, overhead lines, structures and cables) to the nearest point of excavation or ground penetration works. All measurements are to be verified by a Registered Surveyor; and

(e) detailed survey plan with location of services.

Condition C49:

C49. The Applicant must mitigate all noise and vibration during construction to the extent possible and provide vibration monitoring equipment and provide the results to the Sydney Light Rail Operator at intervals required by TfNSW and the Sydney Light Rail Operator, and immediately implement corrective actions in the event that the noise or vibration exceeds acceptable limits.

Therefore, as a minimum vibration monitoring should be provided along the northern boundary of the site adjacent to the TfNSW Light Rail Infrastructure.

Like the methodology outlined for the noise monitoring above, unattended vibration monitoring system should regular feedback with regards to the management levels. Vibration monitoring will target civil and vibration intensive works. In addition, attended vibration measurements may be undertaken from time to time to supplement the unattended monitoring.

The vibration monitoring results will also be accessible by the project team via an online portal and monitored by the project acoustic consultant.

All vibration measurements are to be undertaken in accordance with the methodologies outlined in British Standard 7385-1:1990 Evaluation and measurement for vibration in buildings, DIN V 4150-1 Vibrations in Building; Influence On Persons In Buildings and DIN 4150-1 Effects On Structures.

The monitoring locations would be on a stiff part of the structure (at the foundation) on the side of the structure adjacent to the subject construction works, or in a suitable location at the site boundary.

Unattended monitoring systems will be configured to record the peak vibration levels and to trigger an alarm when predetermined vibration thresholds are exceeded. The thresholds correspond to an "Operator Warning Level" and an "Operator Halt Level", where the Warning Level is 75% of the Halt Level. The Halt Level should be determined based on the vibration criteria for building contents and structure (refer to Section 3).

Exceedance of the "Operator Warning Level" would not require excavation or demolition work to cease, but rather, alerts the site manager to proceed with caution at a reduced force or load.

An exceedance of the "Operator Halt Level" would require the contractor to implement an alternative excavation technique pending further analysis of the vibration frequency content in order to determine any potential exceedance of the criteria.

The location of the monitors will be determined by the location and type of works being undertaken on each site, and will be reviewed monthly, or as work location and type progresses (whichever is first). Due to the extent of works and the complex nature of the project sequence, several monitors will be required throughout the duration of the project.

If an exceedance above the management criteria is identified, an alert will be issued to the project team, who will assess whether it is at a 'Warning' or a 'Halt' level. If it is a 'Halt' level exceedance, the project team will complete a Noise and Vibration Investigation Checklist (see appendix A) to determine the appropriate course of action. A summary of the available alternate mitigation measures is to be provided as part of the monthly report. However, we do note in some cases alternate methodologies may not be available or cannot be implemented due to other project constraints.

5.4 John Holland Community and Engagement Management Plan

John Holland has prepared a site-specific *Community and Stakeholder Management Plan* which will manage all community engagement, compliant managements, and stakeholder relationships. To ensure consistency, all community and engagement will be managed as per that plan. Refer to the *John Holland Community and Stakeholder Management Plan.*

5.5 Contingency Plans

Contingency plans are required to address noise or vibration problems if excessive levels are measured at surrounding sensitive receivers and/or if justified complaints occur. Such plans include:

- Stop the onsite works.
- Identify the source of the main equipment within specific areas of the site which is producing the most construction noise and vibration at the sensitive receivers; and
- Review the identified equipment and determine if an alternate piece of equipment can be used or the process can be altered.
- In the event an alternate piece of equipment or process can be used, works can re-commence.
- In the event an alternate piece of equipment or process cannot be determined implement a construction assessment to be performed by a suitably qualified acoustic consultant.

The Superintendent shall have access to view the Contractor's noise measurement records on request. The Superintendent may undertake noise monitoring if and when required.

5.6 General Mitigation Measures (Australia Standard 2436-2010)

As well as the above project specific noise mitigation controls, AS 2436-2010 "*Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites*" sets out numerous practical recommendations to assist in mitigating construction noise emissions. Examples of strategies that could be implemented on the subject project are listed below, including the typical noise reduction achieved, where applicable.

5.6.1 Adoption of Universal Work Practices

- Regular reinforcement (such as at toolbox talks) of the need to minimise noise and vibration.
- Regular identification of noisy activities and adoption of improvement techniques.
- Avoiding the use of portable radios, public address systems or other methods of site communication that may unnecessarily impact upon nearby sensitive receivers.
- Where possible, avoiding the use of equipment that generates impulsive noise.

- Minimising the need for vehicle reversing for example (particularly at night), by arranging for one-way site traffic routes.
- Use of broadband audible alarms on vehicles and elevating work platforms used on site.
- Minimising the movement of materials and plant and unnecessary metal-on-metal contact.
- Minimising truck movements.

5.6.2 Plant and Equipment

- Choosing quieter plant and equipment based on the optimal power and size to most efficiently perform the required tasks.
- Selecting plant and equipment with low vibration generation characteristics, where feasible.
- Operating plant and equipment in the quietest and most efficient manner.

5.6.3 On Site Noise Mitigation

- Maximising the distance between noise activities and noise sensitive land uses.
- Installing purpose-built noise barriers, acoustic sheds and enclosures around static plant.

5.6.4 Work Scheduling

- Providing respite periods which could include restricting very noisy activities to time periods that least affect the nearby noise sensitive locations, restricting the number of nights that after-hours work is conducted near residences or by determining any specific requirements.
- Scheduling work to coincide with non-sensitive periods.
- Planning deliveries and access to the site to occur quietly and efficiently and organising parking only within designated areas located away from the sensitive receivers.
- Optimising the number of deliveries to the site by amalgamating loads where possible and scheduling arrivals within designated hours.
- Including contract conditions that include penalties for non-compliance with reasonable instructions by the principal to minimise noise or arrange suitable scheduling.

5.6.5 Source Noise Control Strategies

Some ways of controlling noise at the source are:

- Where reasonably practical, noisy plant or processes should be replaced by less noisy alternatives.
- Modify existing equipment: Engines and exhausts are typically the dominant noise sources on mobile plant such as cranes, graders, excavators, trucks, etc. In order to minimise noise emissions, residential grade mufflers should be fitted on all mobile plant utilised on site.
- Siting of equipment: locating noisy equipment behind structures that act as barriers, or at the greatest distance from the noise-sensitive area; or orienting the equipment so that noise emissions are directed away from any sensitive areas, to achieve the maximum attenuation of noise.
- Regular and effective maintenance.

5.6.6 Miscellaneous Comments

Deliveries should be undertaken, where possible, during standard construction hours.

Maximise hammer penetration (and reduce blows) by using sharp hammer tips. Keep stocks of sharp profiles at site and monitor the profiles in use.

"As per Consent Condition C13, where practicable, the use of "quackers" will be used to ensure noise impacts on surrounding noise sensitive receivers are minimised. This will not be implemented where it is deemed the use of quackers (as opposed to standard vehicle notification devices) would compromise the safety of construction staff or members of the public.

No public address system should be used on site (except for the use by emergency systems).

6 CONCLUSION

Pulse White Noise Acoustics (PWNA) has been engaged by John Holland Group Pty Ltd to prepare a Construction Noise and Vibration Management Sub Plan (CNVMSP) for the construction of the new Sydney Children's Hospital Stage 1 and Minderoo Children's Comprehensive Caner Centre (SCH1 & MCCCC) as part of the Randwick Campus Redevelopment (RCR).

This CNVMSP has been prepared to satisfy the requirements of Condition B18 of the Consent given in the Schedule 2 of the Development Consent issued for Application No. SSD 10831778, dated 17th December 2021.

An assessment of noise and vibration impacts from the required processes to be undertaken during the construction period of the project (including excavation and construction) has been undertaken and suitable treatments, management controls, perioding measurements and community engagement has been detailed in this report.

Providing the recommendations in this report are included in the construction of the site, compliance with the relevant EPA's Interim Construction Noise Guideline Objectives and 22 of the projects *Conditions of Consent* can be achieved.

For any additional information please do not hesitate to contact the person below.

Regards

Matthew Furlong
Senior Acoustic Engineer
Pulse White Noise Acoustics

APPENDIX A: ACOUSTIC GLOSSARY

The following is a brief description of the acoustic terminology used in this report:

Ambient Sound	The totally encompassing sound in a given situation at a given time, usually composed of sound from all sources near and far.
Audible Range	The limits of frequency which are audible or heard as sound. The normal ear in young adults detects sound having frequencies in the region 20 Hz to 20 kHz, although it is possible for some people to detect frequencies outside these limits.
Character, acoustic	The total of the qualities making up the individuality of the noise. The pitch or shape of a sound's frequency content (spectrum) dictate a sound's character.
Decibel [dB]	The level of noise is measured objectively using a Sound Level Meter. The following are examples of the decibel readings of every day sounds; 0dB the faintest sound we can hear 30dB a quiet library or in a quiet location in the country 45dB typical office space. Ambience in the city at night 60dB Martin Place at lunch time 70dB the sound of a car passing on the street 80dB loud music played at home 90dB the sound of a truck passing on the street 100dB the sound of a rock band 115dB limit of sound permitted in industry 120dB deafening
dB(A)	*A-weighted decibels* The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter. The sound pressure level in dB(A) gives a close indication of the subjective loudness of the noise.
Frequency	Frequency is synonymous to *pitch*. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Loudness	A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on
LMax	The maximum sound pressure level measured over a given period.
LMin	The minimum sound pressure level measured over a given period.
L1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L10	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L90	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{90} noise level expressed in units of dB(A).
Leq	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
dB (A)	'A' Weighted overall sound pressure level

Sound Pressure Level, LP dB	A measurement obtained directly using a microphone and sound level meter. Sound pressure level varies with distance from a source and with changes to the measuring environment. Sound pressure level equals 20 times the logarithm to the base 10 of the ratio of the rms sound pressure to the reference sound pressure of 20 micro Pascals.
Sound Power Level, Lw dB	Sound power level is a measure of the sound energy emitted by a source, does not change with distance, and cannot be directly measured. Sound power level of a machine may vary depending on the actual operating load and is calculated from sound pressure level measurements with appropriate corrections for distance and/or environmental conditions. Sound power levels is equal to 10 times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power of 1 picoWatt

APPENDIX B: NOISE & VIBRATION INVESIGATION CHECKLIST

Pulse White Noise Acoustics (PWNA) and John Holland Group Pty Ltd (JHG) have prepared the following noise and vibration investigation checklist to assist the onsite construction team in investigation any received noise and vibration complaint or identifying an exceedance over the management levels. This checklist should be completed in conjunction with the *SCH1/CCCC – Construction Noise Vibration Management Sub-Plan* prepared by PWNA.

Should any noise and vibration complaint be received, JHG must complete the following steps:

Exceedance/Complaint Information

Complaint reference number:..... .....

Date Received: .....

Location of Complaint: .....

Complainant Contact Details:.....

Step	Task	Completed Response
1	Pause onsite works	
2	Identify the main source(s) construction noise and/or vibration within specific areas of the site which is impacting the most at the sensitive receiver.	
3	Review the identified equipment and determine if an alternate piece of equipment can be used or the process can be altered. ***(If no, skip to step 5)***	
4	In the event an alternate piece of equipment or process can be used, works can re-commence incorporating possible and practical mitigation measures.	
5	In the event an alternate piece of equipment or process cannot be determined implement a construction assessment to be performed by a suitably qualified acoustic consultant. This may include additional respite periods.	

APPENDIX C: AUTHOR CURRICULUM VITAE (CV)

MATTHEW FURLONG

Senior Acoustic Engineer

Qualifications

Bachelor of Creative Technology (Audio Engineering and Sound Production)

Matthew Furlong has 8 years' experience in delivering acoustic design on architectural, environmental and infrastructure projects, including conceptual, detailed design, construction and post-construction stages.

He has consulted for mixed use of commercial and residential developments, developing in-principal recommendations for the client and managing contractor providing detailed design advice as well as full construction services.

In addition to the above, Matthew has been part of many consulting teams in many education, health, fitouts and Land and Environmental Court (LEC) proceedings across the state.

Selected Project Experience

Industrial

- Acoustic Design Erskine Park Industrial Area
- Acoustic Design and Construction Services Snackbrands Orchard Hills

Commercial / Educational / Health Facilities

- Formulation of the new Victorian Health Engineering Guidelines (Acoustics)
- Development Application and Acoustic Design 210-220 George Street Sydney
- Acoustic Design and Construction Services 151 Clarence Street, Sydney
- Development Application for 390-396 Pitt Street, Haymarket
- Acoustic Design and Construction Services Chifley Plaza Internal Works
- Development Application 371-375 Pitt Street, Sydney
- Construction Services Fitout of the Department of Premier and Cabinets
- Noise Investigations for Transport NSW (Chatswood and Burwood)
- SSDA and Acoustic Design Meadowbank Education Precinct
- CNVMP and Construction Services Anzac Park Public School
- CNVMP and Construction Services Alexandria Park Public School
- Construction Services for Wagga Wagga Base Hospital Stage 2
- SSDA and Acoustic Design for Concord Repatriation General Hospital
- SSDA and Acoustic Design Nepean Public Hospital
- Master Planning, Feasibility, Schematic, SSDA and Acoustic Design Sydney Children's Hospital Stage 1 & Children's Comprehensive Cancer Centre (SCH1/CCCC), Randwick
- Schematic Design for Western Sydney Airport – Nancy Warb(WSA)

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P 1800 4 PULSE (1800 478 573) **E** info@pwna.com.au **pwna.com.au** ABN 95 642 886 306

Residential

- Acoustic Design for Crown Casino Sydney
- Acoustic Design and Construction Services 130 Elizabeth Street, Sydney (One30Hyde)
- Acoustic Design and Construction Services Trinity Terraces Rosebery
- Construction Services 1a Coulson Street, Erskinville
- Construction Services for the Erko Apartments Erskinville
- Construction Services for the Eve Apartments Erskinville
- Acoustic Design 54-56 Riley Street and 1 Crown Lane, Darlinghurst
- Development Application, Acoustic Design and Construction Services New Life Darling Harbour, 495 Harris Street, Ultimo
- Development Application, Acoustic Design and Construction Services Meriton Developments (Mascot, Rosebery, Epping, Parramatta, Pagewood, Bondi, Dee Why, Zetland, Waterloo, North Sydney, Sydney, Macquarie Park)
- Development Application, Acoustic Design and Construction Services Summer Hill Flourmill Stages 1, 2, 3 and 4.
- Acoustic Design and Construction Services Macquarie Park Village
- Acoustic Design and Construction Services Ryde Gardens
- Acoustic Design and Construction Services Tempo Apartments Victoria Road Drummoyne
- Development Application, Acoustic Design and Construction Services Winston Hills Mall Residential
- Construction Services Presbyterian Aged Care Paddington
- Acoustic Design and Construction Services Wahroonga Nursing Home
- Acoustic Design and Construction Anglicare Castle Hill (ARV)
- Acoustic Design and Construction Cardinal Freeman Village, Ashfield

- Licensed Premises

- Development Application for The Cauliflower Hotel, Waterloo
- Development Application for Christopher Hanna Salon and Bar, 13-15a Bridge Street, Sydney

Memberships

- Member of Australian Acoustical Society (M.A.A.S)