Hospital Road Randwick Services Diversions – Review of Environmental Factors (REF) – Acoustic Review

Health Infrastructure NSW

1 Reserve Road, St Leonards NSW 2065

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20087 Hospital Road Randwick Services Diversion REF – Acoustic Review – R6

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Hospital Road Randwick Services Diversions – Review of Environmental Factors (REF) – Acoustic Review

PREPARED BY:

Pulse Acoustic Consultancy Pty Ltd
ABN 61 614 634 525
Level 4, 73 Walker Street, North Sydney, 2060

Matthew Furlong
Senior Acoustic Engineer M.A.A.S.
Mob: +61 452 414 785
E: matthewfurlong@pulseacoustics.com.au www.pulseacoustics.com.au

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1 INTRODUCTION

Pulse Acoustic Consultancy Pty Ltd (Pulse Acoustics) has been engaged by Health Infrastructure NSW (HI) to undertake an acoustic review and summary that will support the Review of Environmental Factors (REF) for the proposed Hospital Road upgrade works.

The Randwick Health and Education Precinct (RHEP) is one of the most comprehensive health innovation districts in Australia. While health care at RHEP has been evolving for over 160 years, the last five years has seen a strengthening of collaboration amongst a wide range of organisations in the precinct, including with government, universities and community.

Hospital Road is an important campus road that supports the precinct and provides access to existing buildings such as the Sydney Children's Hospital (SCH) and Royal Hospital for Women (RHW). Hospital Road provides access to the campus logistical hub located on Delivery Drive. Additionally, Hospital Road will become a key link for vehicles and pedestrians enabling the integration of the existing campus with the future Integrated Acute Services Building (IASB) and Sydney Children's Hospital Stage 1/ Children's Comprehensive Cancer Centre (CCCC).

The Hospital Road REF scope will involve the diversion of services from the Hospital Road area highlighted in the diagrams on the following page. This scope will require critical service infrastructure to be relocated to be located outside of the project area. The proposed scope of works on Hospital Road will include the following key elements:

- Hospital Road North services diversions.
- Remediation of Hospital Road North.
- Retention piling north-south on Hospital Road.
- Retention piling east-west along the High Street boundary; and
- Excavation of Hospital Road North.

The works detailed above on Hospital Road are pivotal in allowing for the development of an interlinked campus and removing the interface between pedestrians and vehicles to provide for a safe and interconnected campus link. To achieve this, key service infrastructure assets that are currently located in Hospital Road will need to be diverted. Additionally, remediation, piling works, and excavation will need to be undertaken.

This assessment will address potential construction noise and vibration impacts on nearby sensitive receivers due to the proposed works outlined above. In this report Pulse Acoustics will discuss the relevant acoustic criteria which have been adopted as well as the outcomes of the acoustic assessment.

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

1.1 Relevant Guidelines

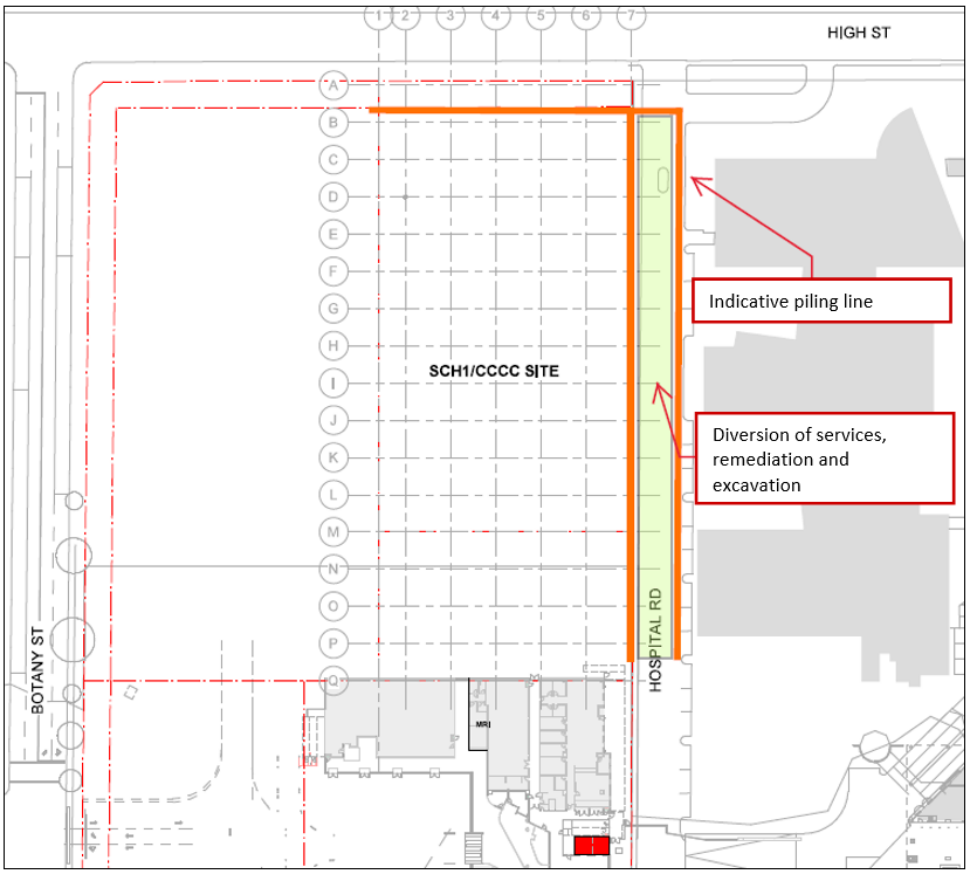
Acoustic criteria which have been adopted in this assessment include requirements from the following guidelines or legislative documents:

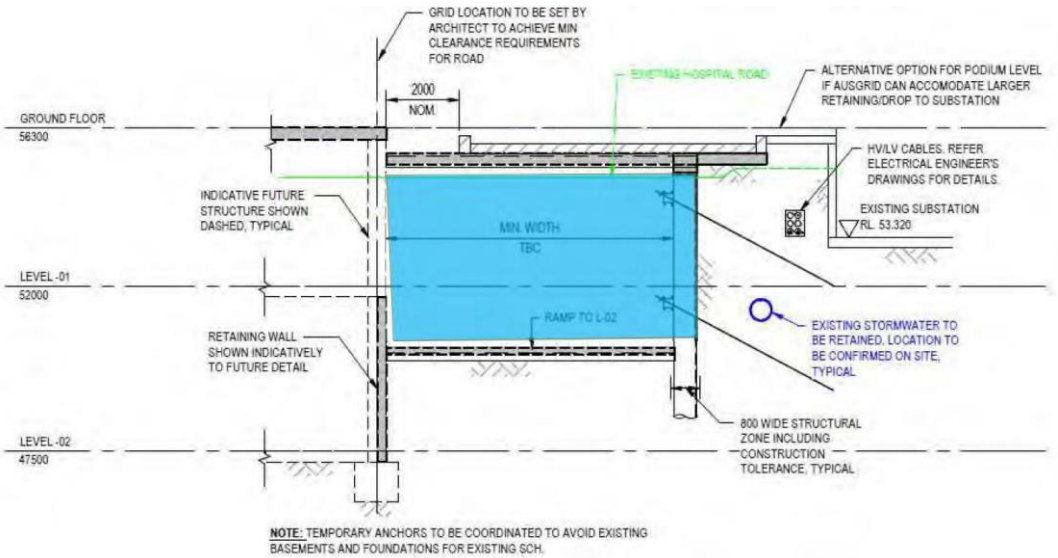
- Randwick City Council *Local Environmental Plan (LEP) 2013*;
- Randwick City Council *Development Control Plan (DCP) 2013, section E2 - Randwick Education and Health E2 Specialised Centre*;
- NSW Health Infrastructure *Engineering Services Guidelines (ESG) August 2006*.
- NSW EPA *Noise Policy for Industry (NPI) 2017*;
- NSW EPA *Road Noise Policy (RNP) 2011*;
- NSW EPA (formerly, Department of Environment and Climate Change) *Assessing Vibration: a technical guideline 2006*;
- Australian Standard AS 2670.2 1990 - *Evaluation of Human Exposure to Whole Body Vibration - Part 2: Continuous and Shock Induced Vibration in Buildings (1 Hz to 80 Hz)*
- British Standard BS 6472 - 2008 - *Evaluation of Human Exposure Vibration in Buildings (1 Hz to 80 Hz)*
- 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);
- German DIN 4150: Part 3 – 1999 *"Effects of Vibration on Structure"* (DIN 1999); and

1.2 Hospital Road

Hospital Road provides access to Delivery Drive and is currently accessed by vehicles and pedestrians from Magill Street to the South and High Street to the North. The figure below shows the area of Hospital Road that this report addresses and illustrates the scope of works.

Figure 1-1 Hospital Road Location





The future works on Hospital Road will involve excavation works to enable the lowering of Hospital Road for vehicle access whilst constructing a new podium level for pedestrians to allow for the interconnectivity across the campus precinct. These works on Hospital Road are pivotal in allowing for the development of an interlinked campus and removing the interface between pedestrians and vehicles. To achieve this, key service infrastructure assets that are currently located in Hospital Road will need to be diverted.

1.3 Surrounding Precincts

The existing Randwick Hospitals Campus includes the four major hospitals: Prince of Wales Hospital, Royal Hospital for Women, Prince of Wales Private, and the Sydney Children's Hospital, Randwick. In addition to these hospitals, speciality clinics, such as the Eastern Suburbs Mental Health Service, NeuRA, the Bright Alliance, Black Dog Institute, Scientia Clinical Research and Ronald McDonald House, are located around the campus.

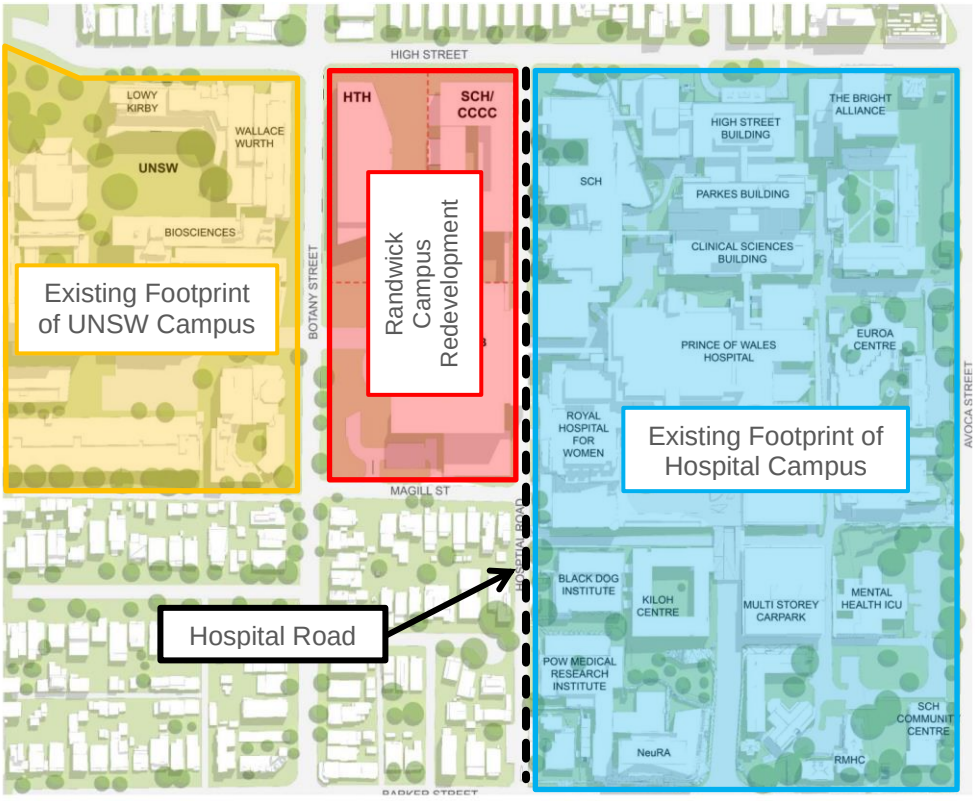
The existing hospital campus is bounded by High Street to the north, Avoca Street to the east, Barker Street to the south and Hospital Road to the west. The site covers an area of approximately 120,000 square metres.

Randwick has been providing healthcare to the local community for over 160 years. Over the last 20 years the volume, complexity and range of healthcare services provided has grown significantly. Currently, 60% of the infrastructure is over 30 years old. To ensure that the future operation of the hospital is capable of meeting the future needs of the community, the hospital will require significant upgrades.

Located to the west of the Randwick Hospital Campus is the UNSW education campus. For the last 60 year UNSW has had Teaching Hospital affiliations with the Prince of Wales (POW) Hospital, Sydney Children's Hospital (SCH) Randwick and the Royal Hospital for Women with the desire for a more integrated connection between the Education and Health Campuses.

As part of the $1.5 billion dollar redevelopment of Randwick Hospital Campus, the NSW Government has acquired an entire block of land to develop the new Integrated Health and Education Precinct. This new precinct will be located adjacent to both Randwick Hospital and UNSW (see Figure 1-2 below).

Figure 1-2 New Randwick Health and Education Precinct (RHEP)



The new precinct is separated into three buildings:

- New Integrated Acute Services Building (IASB) located along the southern portion of the site,
- New Sydney Children's Hospital Stage 1 (SCH1) and Children's Comprehensive Cancer Centre (CCCC) building located along the north-east corner of the site (Corner of High Street and Hospital Road); and
- UNSW Health Translation Hub (HTH) building located in the north-west corner of the site (Corner of High Street and Botany Street).

All three buildings will be connected via above-ground bridges and podiums.

1.4 Surrounding Receivers

The nearest sensitive receivers to the works 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: Hospital buildings are located on the eastern side of Hospital Road within the existing Randwick Hospital Precinct. The closest is the existing Children's Hospital Located on the corner of High Street and Hospital Road.

A map showing the site location as well as nearest receivers is provided in Figure 1-3 below. Additionally, shown in Figure 1-4 below are the onsite measurements which were conducted as part of this assessment.

Figure 1-3 Site Map and Surrounding Receivers

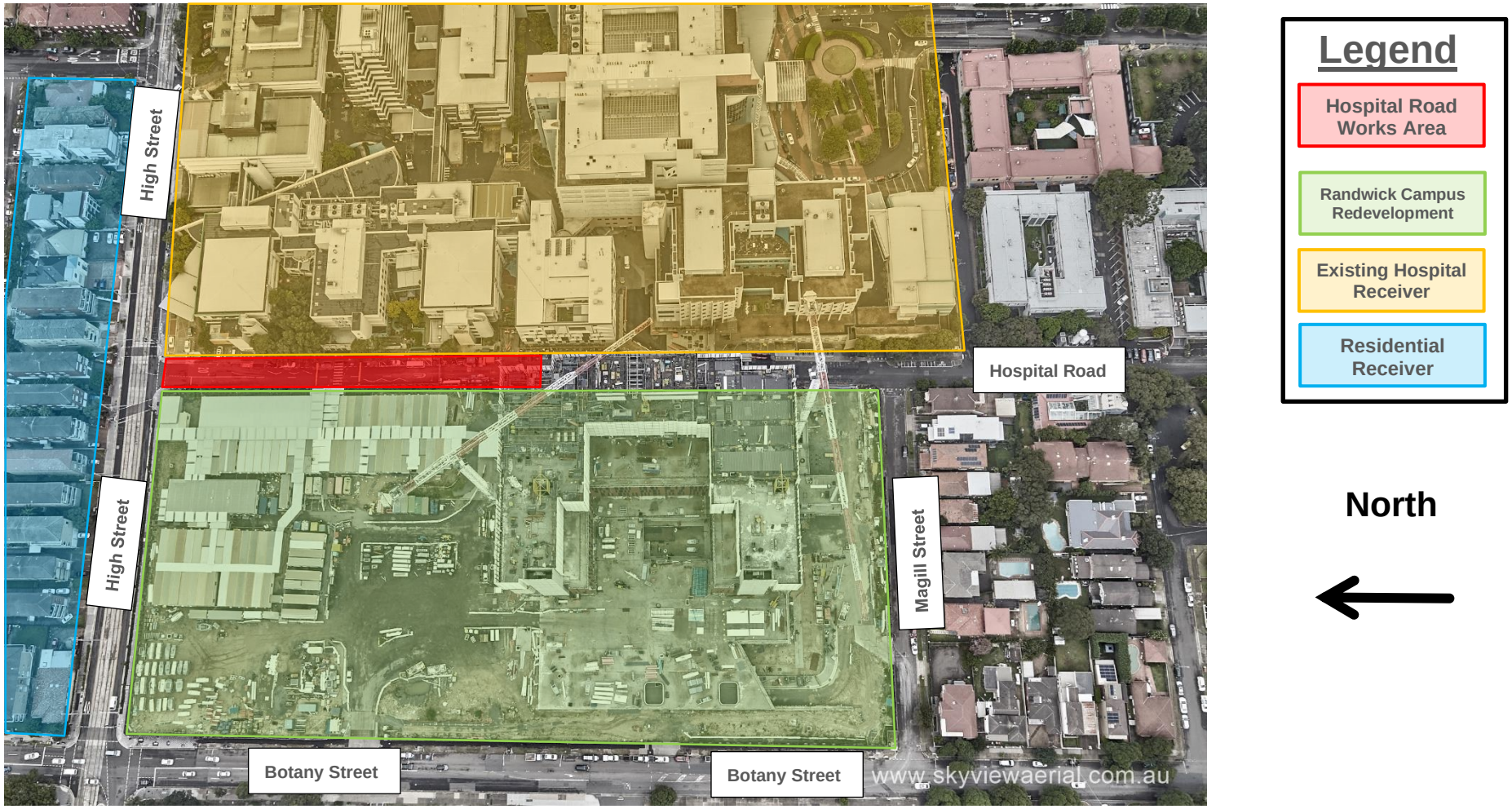
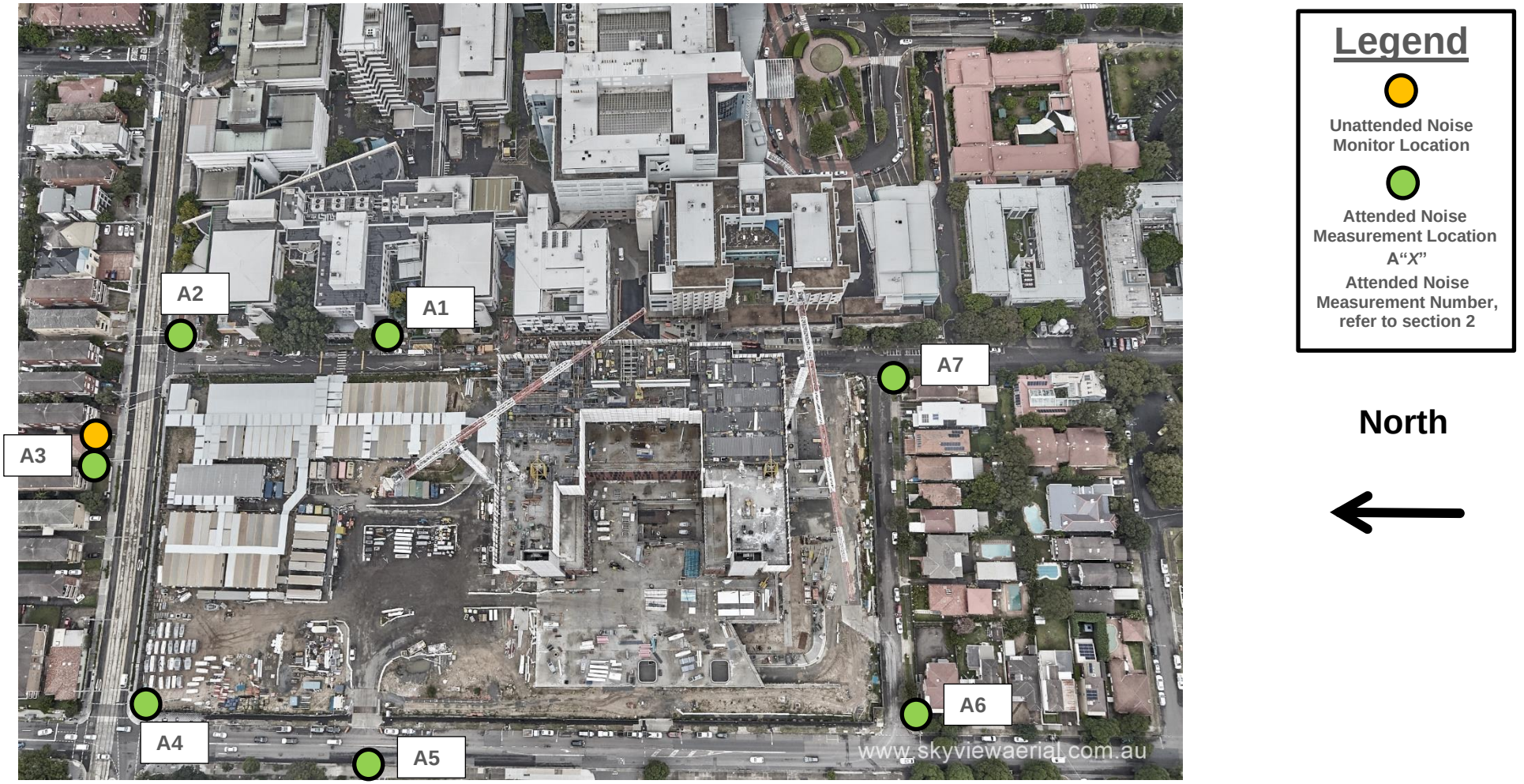


Figure 1-4 Site Map and Measurement Locations



2 ACOUSTIC NOISE AND VIBRATION SURVEY

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

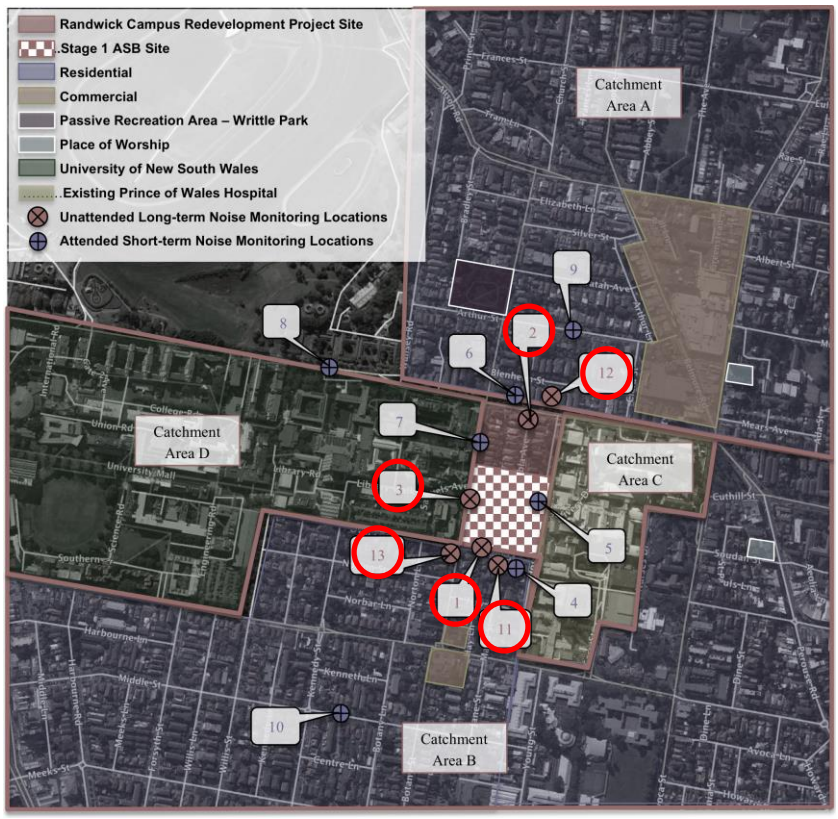
2.1 Unattended Noise Monitoring

Unattended noise monitoring has previously been undertaken around the site by Acoustic Studio (i.e. IASB Acoustic Consultant) during the SSD stage for the Integrated Acute Services Building 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 2-1 Acoustic Studio Measurement Locations – Figure 1 of Acoustic Report



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

Figure 2-2 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 3rd 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 2-3 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 2-4 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 2-5 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[3], 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 2-6 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 2-7 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 Sydney L2 Light Rail network along High Street has been completed and become operational. Existing vehicle movements along the previous roadways have been altered with the operation of the Light Rail. Significant amounts of demolition, 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 decommissioning of Eurimbla Avenue.

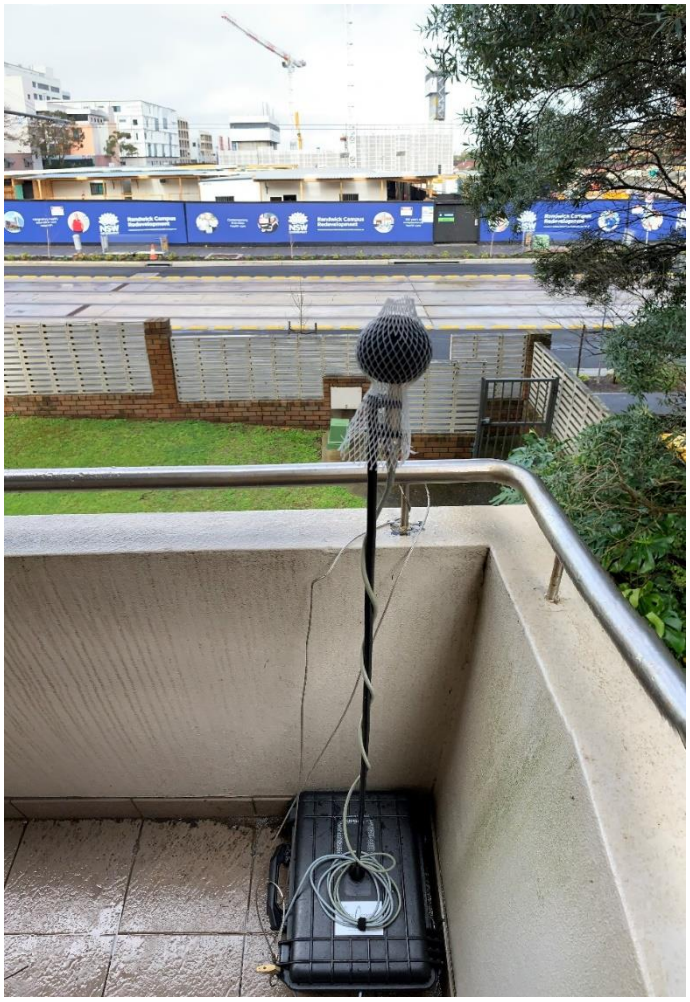
Whilst the monitoring outlined above is still believed to be valid, this must be verified with updated onsite noise surveys.

An unattended noise survey was conducted 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 2-8 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 2-8 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.

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 constructions.
- Due to the nature of the area 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, hospital is still operation and traffic levels along Botany Street are relatively similar.
- An unusual localise 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 localise 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.

2.1.1 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 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 (ID 067105).

Table 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 2-8	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.

2.1.2 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 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 2-8	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.

2.2 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 to 2:30am.

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

Table 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.	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	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	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	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)	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.

Table 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	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	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.

3 NOISE AND VIBRATION CRITERIA

3.1 Construction Noise Criteria

Relevant construction noise criteria applicable to this REF assessment are outlined below.

3.1.1 NSW Health *Engineering Services Guidelines (ESG) August 2016*

NSW Health ESG 2016 does not contain any applicable construction noise criteria. As such the requirements of the NSW EPA (formerly DECC) *Interim Construction Noise Guideline (ICNG) 2009* will be adopted in the absence of any requirements.

3.1.2 Randwick Council *Land Environment Plan (LEP) 2012*

Randwick Council LEP 2012 does not contain any applicable construction noise criteria. As such the requirements of the NSW EPA (formerly DECC) *Interim Construction Noise Guideline (ICNG) 2009* will be adopted in the absence of any requirements.

3.1.3 Randwick Council *Development Control Plan (DCP) 2013*

Randwick Council DCP 2013 does not contain any applicable construction noise criteria. As such the requirements of the NSW EPA (formerly DECC) *Interim Construction Noise Guideline (ICNG) 2009* will be adopted in the absence of any requirements.

3.1.4 NSW EPA (Former DECC) *Interim Construction Noise Guideline (ICNG) 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;
- Encourage 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
- Provide flexibility in selecting 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 Table 4 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	Noise affected 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 $L_{Aeq(15minute)}$ 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 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	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 Industrial Noise Policy (EPA 2000).

Construction noise levels within hospital wards and operating theatres is not to exceed 45dB $L_{Aeq,15minute}$, when measured internally.

Based on the measured background noise levels summarised in Section 2, the NMLs 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 1:00pm**	**Outside Standard Hours** **All hours not listed in the adjacent column.**
Residences (Measured externally)	**61** (RBL (51) + 10dB)	Saturday 7:00am to 8:00am 1:00pm to 6:00pm: **56** (RBL (51) + 5dB) Sunday 8:00am to 6:00pm: **56** (RBL (51) + 5dB) Monday to Sunday 6:00pm to 10:00pm: **53** (RBL (48) + 5dB) Monday to Sunday 10:00pm to 7:00am: **51** (RBL (46) + 5dB)
Hospital wards and operating theatres (Measured internally)	**45**	

3.2 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

Effects of ground borne vibration on buildings may be segregated into the following three categories:

- Human comfort – vibration in which the occupants or users of the building are inconvenienced or possibly disturbed. Refer to further discussion in Section 3.3.1.
- Effects on building contents – where vibration can cause damage to fixtures, fittings and other non-building related objects. Refer to further discussion in Section 3.3.2.
- Effects on building structures – where vibration can compromise the integrity of the building or structure itself. Refer to further discussion in Section 3.3.2.

3.3.1 Vibration Criteria – 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
Critical working areas (e.g. hospital operating theatres, precision laboratories)	Day or night-time	0.0050	0.010	0.10	0.20
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
Critical working areas (e.g. hospital operating theatres, precision laboratories)	Day or night-time	0.0050	0.010	0.10	0.20
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
Critical working areas (e.g. hospital operating theatres, precision laboratories)	0.10	0.20	0.10	0.20
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 Vibration Criteria – 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).

3.3.2.1 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 3-1.

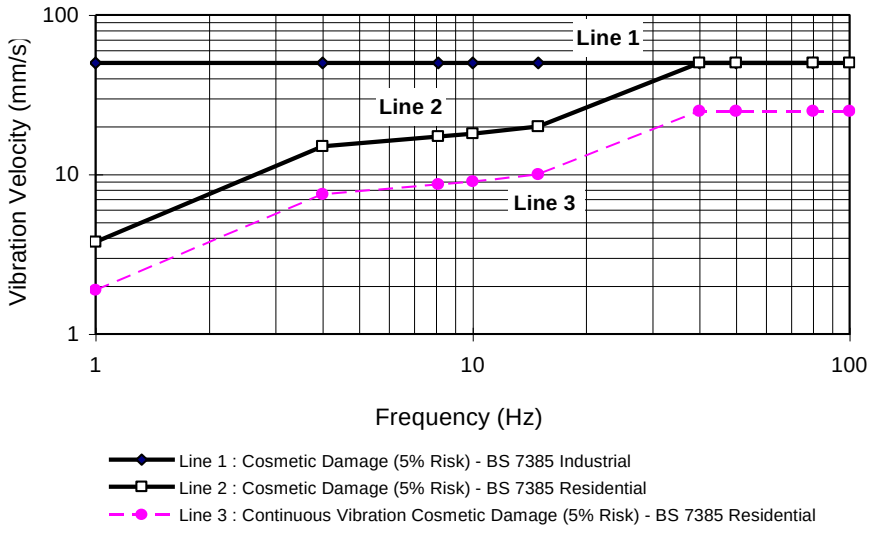
Table 9 Transient vibration criteria as per standard BS 7385 Part 2 - 1993

Line in Figure 3-1	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 that it 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 3-1).

Figure 3-1 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 the calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the values in Table 9 should not be reduced for fatigue considerations.

3.3.2.2 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.

3.4 Ground-Borne Noise Criteria

According to the ICNG, the criterion 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.

It is noted that the ground borne criteria will apply for construction works undertaken outside of standard hours. That is, work conducted during the evening period Monday to Friday between 6:00pm and 7:00am.

4 CONSTRUCTION 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 11 below.

Table 11 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	Power hand tools	94	105
	Semi Rigid Vehicle [1]	105	
Ground Works and Excavation	Excavator bucket	108	117
	Hand held jack hammer [1]	111	
	Dump truck [1]	105	
	Concrete saw [1]	114	
	Power hand tools	94	
	Piling Rig	108	
Services Switching	Power hand tools	94	108
	Semi Rigid Vehicle [1]	105	
	Container Diesel Generator [2] (1250 KVA)	105	

Note 1: An assumed time correction has been applied, this being 5minutes of operation in any 15minute interval.
Note 2: Indicative noise level, subject to size.

4.1.1 Predicted Noise Levels

Predicted noise levels for each receiver are presented below. For the residential receivers two tables are presented. The first table for each receiver presents the assessment during typical construction hours and the other table presents the assessment for periods outside typical construction hours. All are in accordance with the requirements of the DECC Interim Construction Noise Guideline.

As the construction noise requirement for the hospital is an internal requirement, façade attenuation equal to a 6mm float (Rw 29) has been included in the calculations.

Table 12 Receiver 1 - Summary of predicted construction noise levels (DECC Interim Construction Noise Guideline) –TYPICAL HOURS

Phase	Activity	Individual Sound Power Level (dBA re 1pW)	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	Power hand tools	94	105	46 to 57	57 to 68	**Noise Affected Level** Monday to Friday 7:00am to 6:00pm Saturday 8:00am to 1:00pm **61** (RBL + 10dB) **Highly Noise Affected Level** Monday to Friday 7:00am to 6:00pm Saturday 8:00am to 1:00pm **75**	**Noise affected**
	Semi Rigid Vehicle	105		57 to 68			
Ground Works and Demolition	Excavator	108	117	60 to 71	69 to 80		**Noise affected during works undertaken further away from the residents.** **Highly noise affected in close proximity.**
	Handheld jack hammer	111		63 to 74			
	Dump truck	105		57 to 68			
	Concrete saw	114		66 to 77			
	Power hand tools	94		46 to 57			
	Piling Rig	108		60 to 71			
Services Switching	Power hand tools	94	108	46 to 57	57 to 68		**Noise affected**
	Semi Rigid Vehicle	105		57 to 68			
	Container Diesel Generator	105		57 to 68			

Table 13 Receiver 1 - Summary of predicted construction noise levels (DECC Interim Construction Noise Guideline) – OUTSIDE TYPICAL HOURS

Phase	Activity	Individual Sound Power Level (dBA re 1pW)	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	Power hand tools	94	105	46 to 57	57 to 68	Saturday 7:00am to 8:00am 1:00pm to 6:00pm Sunday 8:00am to 6:00pm: **56** (RBL + 5dB) Monday to Sunday 6:00pm to 10:00pm **53** (RBL + 5dB) Monday to Sunday 10:00pm to 7:00am **51** (RBL + 5dB)	**Exceedance.**
	Semi Rigid Vehicle	105		57 to 68			
Ground Works and Demolition	Excavator	108	117	60 to 71	69 to 80		**Exceedance.**
	Handheld jack hammer	111		63 to 74			
	Dump truck	105		57 to 68			
	Concrete saw	114		66 to 77			
	Power hand tools	94		46 to 57			
	Piling Rig	108		60 to 71			
Services Switching	Power hand tools	94	108	46 to 57	57 to 68		**Exceedance.**
	Semi Rigid Vehicle	105		57 to 68			
	Container Diesel Generator	105		57 to 68			

Table 14 Receiver 2 - Summary of predicted construction noise levels (DECC Interim Construction Noise Guideline) –Anytime

Phase	Activity	Individual Sound Power Level (dBA re 1pW)	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	Power hand tools	94	105	27 to 41	38 to 52	Anytime **45** (Internal)	**Generally exceeding when in close proximity.**
	Semi Rigid Vehicle	105		38 to 52			
Ground Works and Demolition	Excavator	108	117	41 to 55	50 to 64		**Generally exceeding when in close proximity.**
	Handheld jack hammer	111		44 to 58			
	Dump truck	105		38 to 52			
	Concrete saw	114		47 to 61			
	Power hand tools	94		27 to 41			
	Piling Rig	108		41 to 55			
Services Switching	Power hand tools	94	108	27 to 41	41 to 55		**Generally exceeding when in close proximity.**
	Semi Rigid Vehicle	105		38 to 52			
	Container Diesel Generator	105		38 to 52			

4.1.2 Summary of Predicted Noise Levels

Exceedances above the NMLs are predicted for both during *"typical construction hours" (7:00am to 6:00pm M-F and 8:00am to 1:00pm Saturday)* as well as works conducted *"outside of typical construction hours"*. Generally, most of the proposed works during the day will comply with the high noise affected level of 75dBA, with exception of works which are undertaken near a receiver.

As mentioned above, if these works are undertaken outside typical construction hours exceedances have been predicted. However, as the proposed works will occur either on a footpath or along the existing roadway, night works are likely to be required with consideration to the High Street and Hospital Road Junction. Due to either road closures, light rail disruptions or safety these works will need to occur during these periods. As such, a wide range of acoustic mitigation techniques have been developed with consideration to the residential receivers along High Street but also the existing hospital campus.

4.2 Construction Traffic Noise Assessment

From the criteria discussed in Section 3.2, 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.

4.3 Vibration Assessment

In order to maintain compliance with the human comfort vibration criteria discussed in Section 3.3.1, it is recommended that the indicative safe distances listed in Table 15 should be maintained.

These indicative safe distances should be validated onsite during the first onsite working days. During any of the listed activities in Table 15, attended vibration measurements should be undertaken at any sensitive receiver to confirm if the onsite works will result in a non-compliance. In the event of compliance, no further actions are required. However, if measured vibration levels outlined in 3.3 are being exceeded work should stop immediately and alternate work methodologies developed.

Since the criteria for scientific or medical equipment can be more stringent than those required for human comfort, vibration validating measurements should be conducted to determine the vibration level and potential impact onto this sensitive equipment.

Additionally, any vibration levels should be assessed in accordance with the criteria discussed in Section 3.3. This information should also be included as part of the CNVMP.

Table 15 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	Handheld	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 16 below summarises the management procedures recommended for airborne noise and vibration impact. These procedures are also further discussed in the report. Hence, where applicable, links to further references are provided in Table 16.

Table 16 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 5.7. For noise impact, also refer to Section 5.2.3. For vibration impact, also refer to Section 5.3.1.
Project Notification	PN	Issue project updates to stakeholders, discussing overview 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 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 5.2.4. For vibration impact, refer to Section 5.3.2.
Complaints Management System	CMS	Implement a management system which includes procedures on receiving and addressing complaints from affected stakeholders.	Refer to Section 5.5.
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. The offer could include movie tickets, meal vouchers, gift cards or equivalent measures.	-
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).	-

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 are 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 Table 5 for list of NMLs used in the acoustic assessment). The allocation of these procedures are summarised in Table 17 below.

Table 17 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 – 1:00 pm	0 - 3	GMM
	4 - 10	GMM, PN, V [1], CMS, AC
	> 10	GMM, PN, V, CMS, SN, AC
Outside Standard Hours All other times.	0 - 10	GMM, AC
	11 - 20	GMM, PN, V [1], CMS, AC
	> 20	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 additional details of the construction program become available.

For hospital ward areas, management measures are provided in Section 5.2.5.

5.1.3 Allocation of Vibration Management Procedures

Table 18 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 (either for residences as well as non-residential receivers).

Table 18 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 – 1:00 pm	Over human comfort criteria (refer to Section 3.3.1)	GMM, PN, V, RO
	Over building damage criteria (refer to Section 3.3.2)	GMM, V, AC
Outside Standard Hours All other hours	Over human comfort criteria (refer to Section 3.3.1)	GMM, SN, V, RO, CMS
	Over building damage criteria (refer to Section 3.3.2)	GMM, V, AC

5.2 Site Specific Noise Mitigation Measures

5.2.1 Respite Periods

Predicted noise levels outlined in section 4.1 indicate exceedances above the Noise Management Levels (NMLs) as indicated in section 3. To militate against any exceedances, the site will need to introduce periods of respite. See below.

Table 19 Recommended Respite Periods – Typical Hours

Monday to Friday	Saturday
7:00am to 7:30am – No works (Respite Period)	7:00am to 7:30am – No works (Respite Period)
7:30am to 10:00am – Works	7:30am to 10:00am – Works
10:00am to 11:30am – No works (Respite Period)	10:00am to 11:00am – No works (Respite Period)
11:30am to 1:00pm – Works	11:00am to 1:00pm – Works
1:00pm to 2:30pm – No works (Respite Period)	1:00pm to 2:00pm – No works (Respite Period)
2:30pm to 5:30pm – Works	2:00pm to 3:30pm – Works

Note: Recommended respite periods outlined above are only for activities that exceed the NMLs (i.e. concrete cutting, jack hammering, etc). Activities which are compliant with the NMLs can continue through these periods.

In the event the activities outlined in section 4.1 are required to be undertaken outside typical hours due to road closures or safety concerns, the activity should be undertaken as quickly as possible and utilise the shoulder periods of the work window rather than the middle.

5.2.2 Diesel Generator

As outlined in section 4.1 of this report, an assessment of the diesel backup generator has been undertaken. It is not currently known whether it will be required; however, in the likelihood it is required we would recommend the following mitigation measures be implemented.

- Locate the generator in a location which provides the highest level of separation between the High Street residents and the generator, whilst also mindful of the Magill Street residences to the south.
- If required, a temporary screen should be constructed if it exceeds the NMLs.
- Ensure the location of the generator does not produce ground borne vibrations into nearby buildings.

- Once the exact size and selection of the generator is known, a review of the anticipated noise levels should be conducted to verify the acoustic mitigation measures.

5.2.3 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.

5.2.4 Attended Noise Monitoring

Attended noise monitoring, if required, will be performed by an acoustical consultant directly engaged by the contractor.

Monitoring should take place for proximity of works adjacent to the High Street residences and works near any ward areas.

- Differentiate between construction noise sources and other extraneous noise events (such as road traffic and aircraft noise).
- Note and identify any excessive noise emitting machinery or operation.

In the event of any complaints, the noise impact at the affected location should be confirmed by conducting attended noise measurements.

The survey methodology and any equipment should comply with the requirements discussed in standard AS 1055.1-1997.

5.2.5 Noise Mitigation Measures for Hospital Receivers

Where exceedances have been identified in section 4.1, the following mitigation measures are recommended:

- Undertake general mitigation measures as discussed in Section 5.7
- Issue project updates to workers in the affected wards. The updates can include overview of current and upcoming works, as well as advanced warning of potential disruptions. These updates can also be issued through an email distribution list or via social media. Refer to Section 5.4 for further details.
- Signage to be posted in order to provide stakeholders information regarding project details, emergency contacts and enquiry contact information.

- Work with the affected parties within the hospital to ensure if a relocation of patients or staff members occurs swiftly and timely. This may also include a cease of works during a sensitive time within the ward (i.e. meetings etc.)

5.2.6 Alternate Equipment or Process

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

In some cases, the investigation may result in no possible other equipment can be used however a different process could be undertaken.

5.2.7 Acoustic Enclosures/Screening

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

For plant items which are static it is recommended in the event exceedances are being measured due to its operation of the plant item, an acoustic enclosure/screen is constructed to reduce impacts. These systems can be constructed from temporary noise barriers 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 which is 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).

5.3 Vibration Mitigation Measures

5.3.1 General Comments

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

- Any vibration generating plant and equipment is to be located 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.
- 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 Attended Vibration Monitoring

Conduct attended measurements of vibration generating plant at commencement of works in order to validate the indicative safe working distances advised in table 25 and consequently, to establish safe working distances suitable to the project. Measurements should be conducted at the nearest affected property boundary. These safe working distances should be defined by considering the vibration criteria discussed in Section 3.3 (i.e. criteria for structural damage, human comfort and impact to scientific or medical equipment).

5.4 Community Consultation

Active community consultation and the maintenance of positive relations with local residents and businesses would assist in alleviating concerns and thereby minimising complaint. It is common for construction projects to provide community consultation if an exceedance of noise goals has been predicted. This communication is commonly conducted in the form of a letter box drop or more active engagement with more highly impacted receivers.

This form of notification should provide specific notification of the duration and timing of the construction activities so that residents are informed about the proposed works ahead of time. The letter should also provide the community with a hotline number for a community liaison officer available to adequately respond to all project related enquiries.

Ideally the hotline number should provide concerned locals an opportunity to raise any concerns with the project proponent and provide an opportunity to determine the best method to satisfy all requirements.

Prior to the works onsite being undertaken, it is recommended that community consultation with the neighbouring affected parties be undertaken.

The communication however should not be limited to the beginning of the onsite works but throughout providing the community with constant updates to the progress and upcoming works. In our experience these could include:

- Site noticeboard.
- Email notifications; and
- Letterbox drops.

5.5 Complaints Management System

Should complaints arise they must be dealt with in a responsible and uniform manner, therefore, a management system to deal with complaints is detailed below:

Local residents and land-owners should be informed by direct mail of a direct 24 hour telephone line where any noise complaints related to the construction will be recorded. The 24 hour telephone line number will be made available on the construction site signage.

All complaints should be investigated by the Contractor in accordance with the procedures outlined in Australia Standard 2436-2010. Consequently, a complaint response procedure should be implemented. Information to be gathered as part of this process should include;

- location of complainant
- time/s of occurrence of alleged noise or vibration impacts

- nature of impact particularly with respect to vibration
- Perceived source
- Prevailing weather conditions and similar details that could be utilised to assist in the investigation of the complaint.

All resident complaints will be responded to in the required timeframe and action taken recorded.

Post receiving a noise and or vibration complaint the process outlined in the *Contingency Plans* below should be undertaken.

5.6 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.

5.7 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.

5.7.1 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.

5.7.2 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.
- Operating plant and equipment in the quietest and most efficient manner.

5.7.3 On Site Noise Mitigation

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

5.7.4 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.

5.7.5 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.

5.7.6 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

It is advised that mobile plant and trucks operating on site for a significant portion of the project are to have reversing alarm noise emissions minimised. This is to be implemented subject to recognising the need to maintain occupational safety standards

No public address system should be used on site, unless used for emergency situations.

APPENDIX A: ACOUSTIC TERMINOLOGY

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
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.
L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	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).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Background Sound Low	The average of the lowest levels of the sound levels measured in an affected area in the absence of noise from occupants and from unwanted, external ambient noise sources. Usually taken to mean the LA90 value

dB (A)	'A' Weighted overall sound pressure level
Sound Power Level, L_W 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

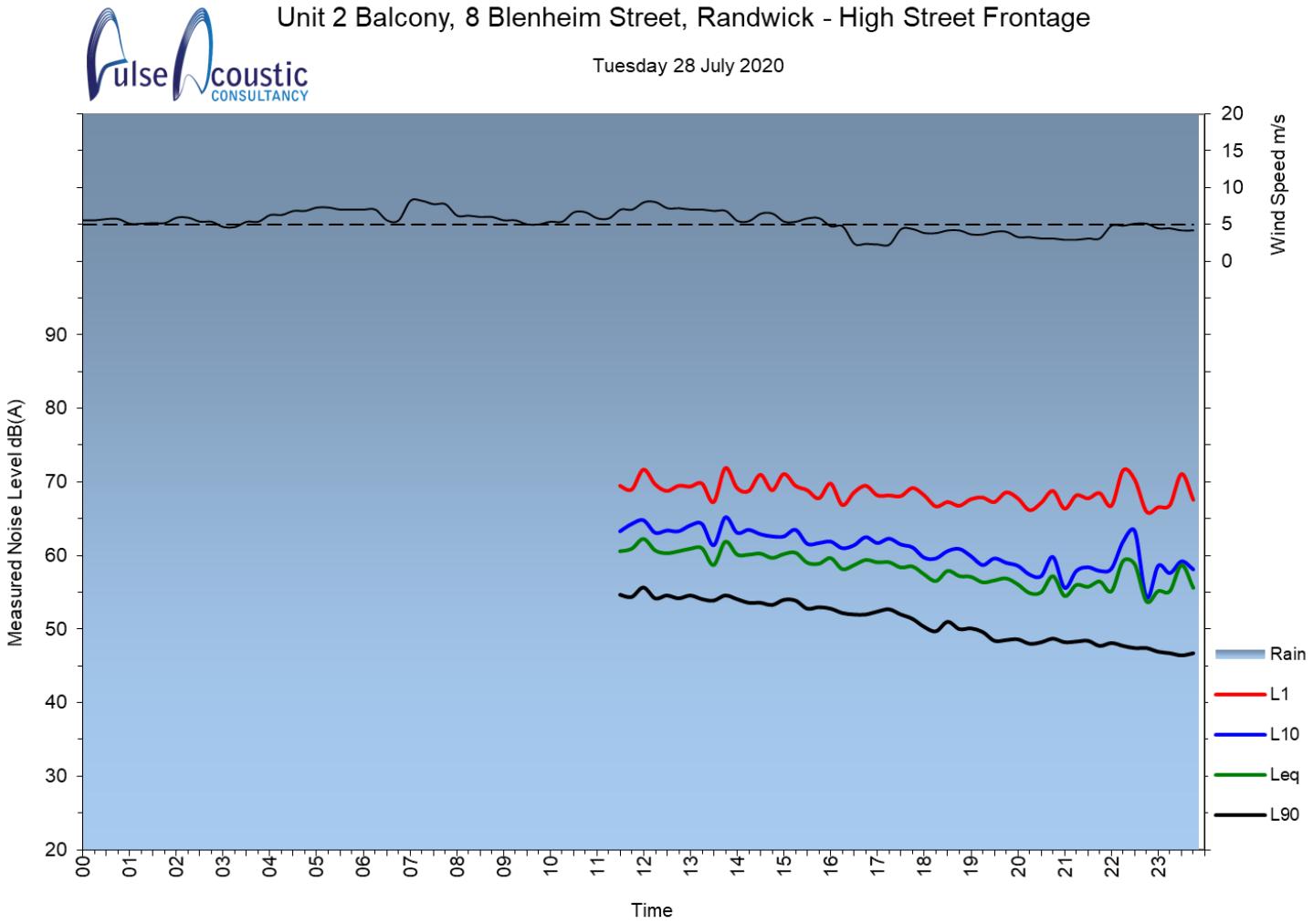
APPENDIX B: UNATTENDED NOISE MONITORING RESULTS

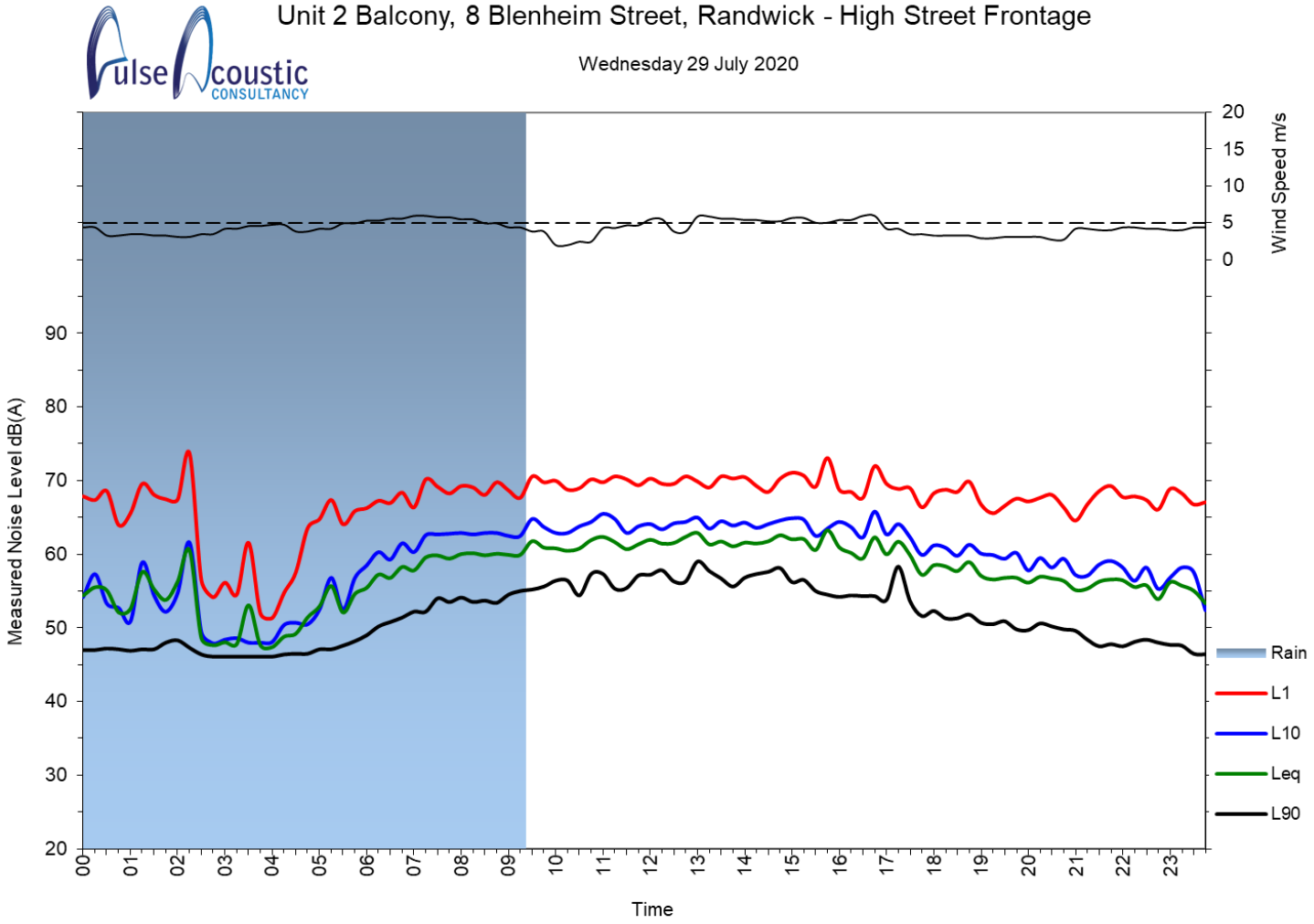
Weather Station: Sydney (Observatory Hill)

Weather Station ID: 066062

Co-ordinates: Lat: -33.86°S, Lon: 151.20°E, Height: 43.37m AMSL

Figure B-0-1 Photo of Unattended Noise Monitor Location – Rear of 8 Blenheim Street, Randwick


Unit 2 Balcony, 8 Blenheim Street, Randwick - High Street Frontage
Tuesday 28 July 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90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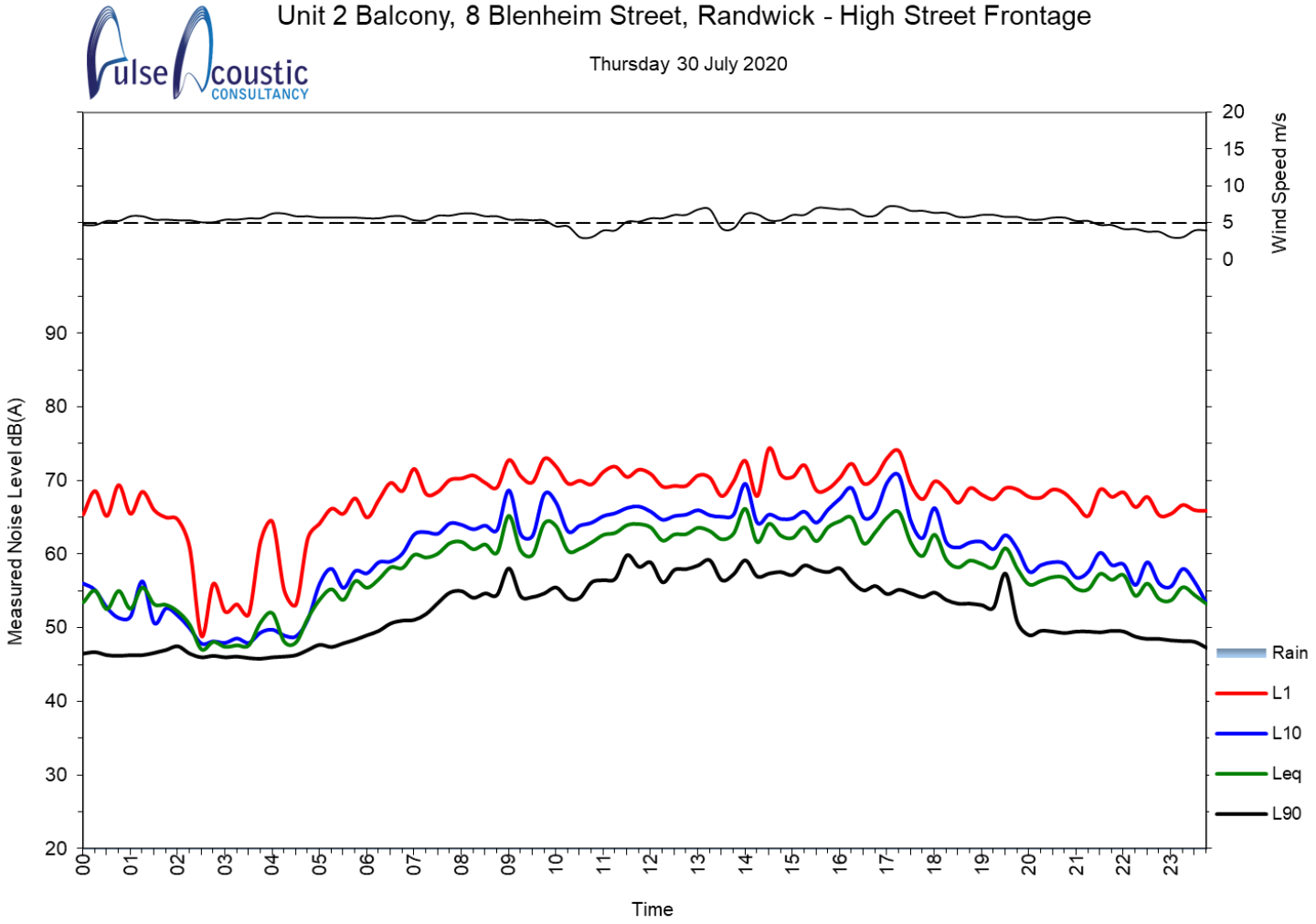
Wednesday 29 July 2020
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90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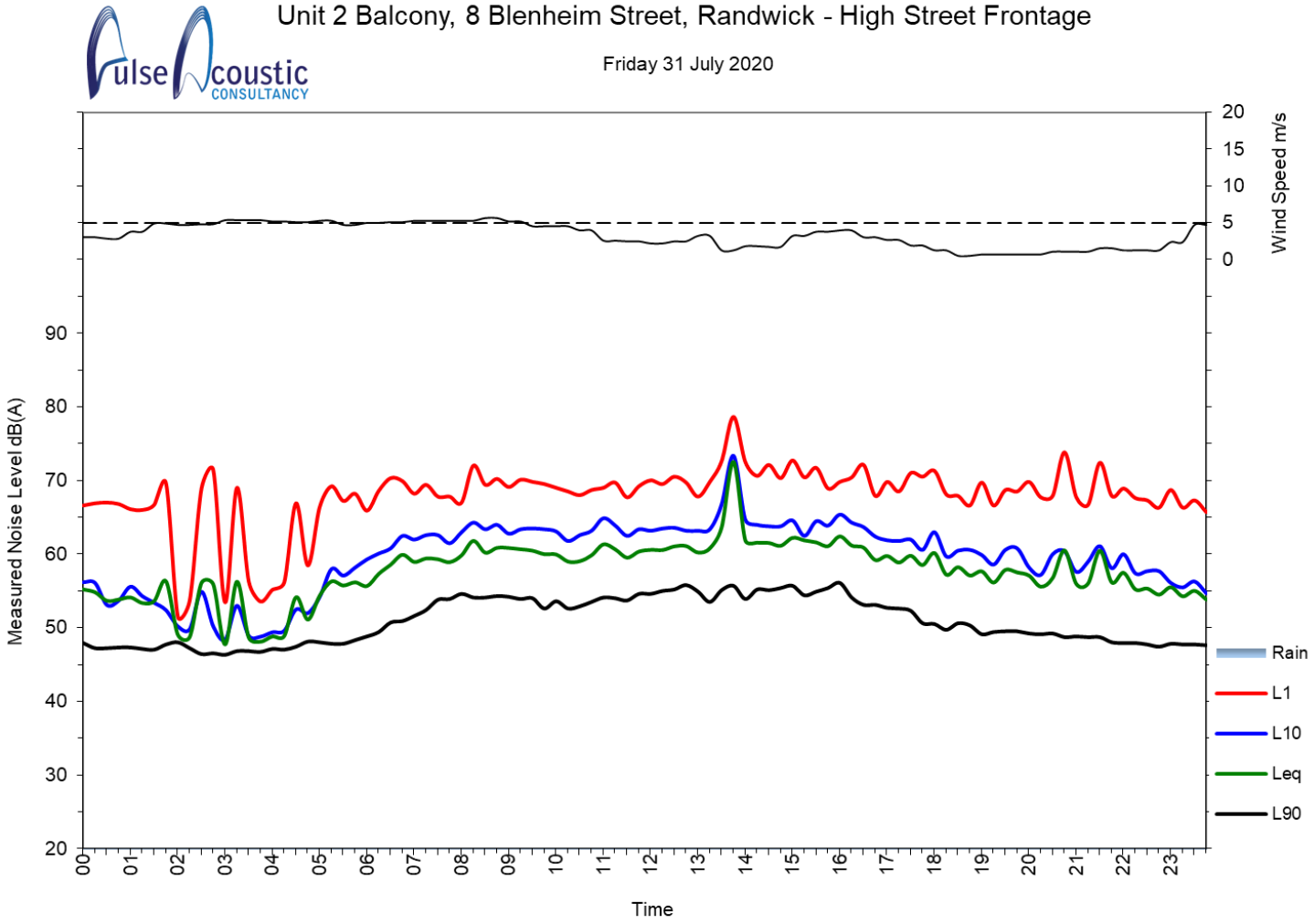
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90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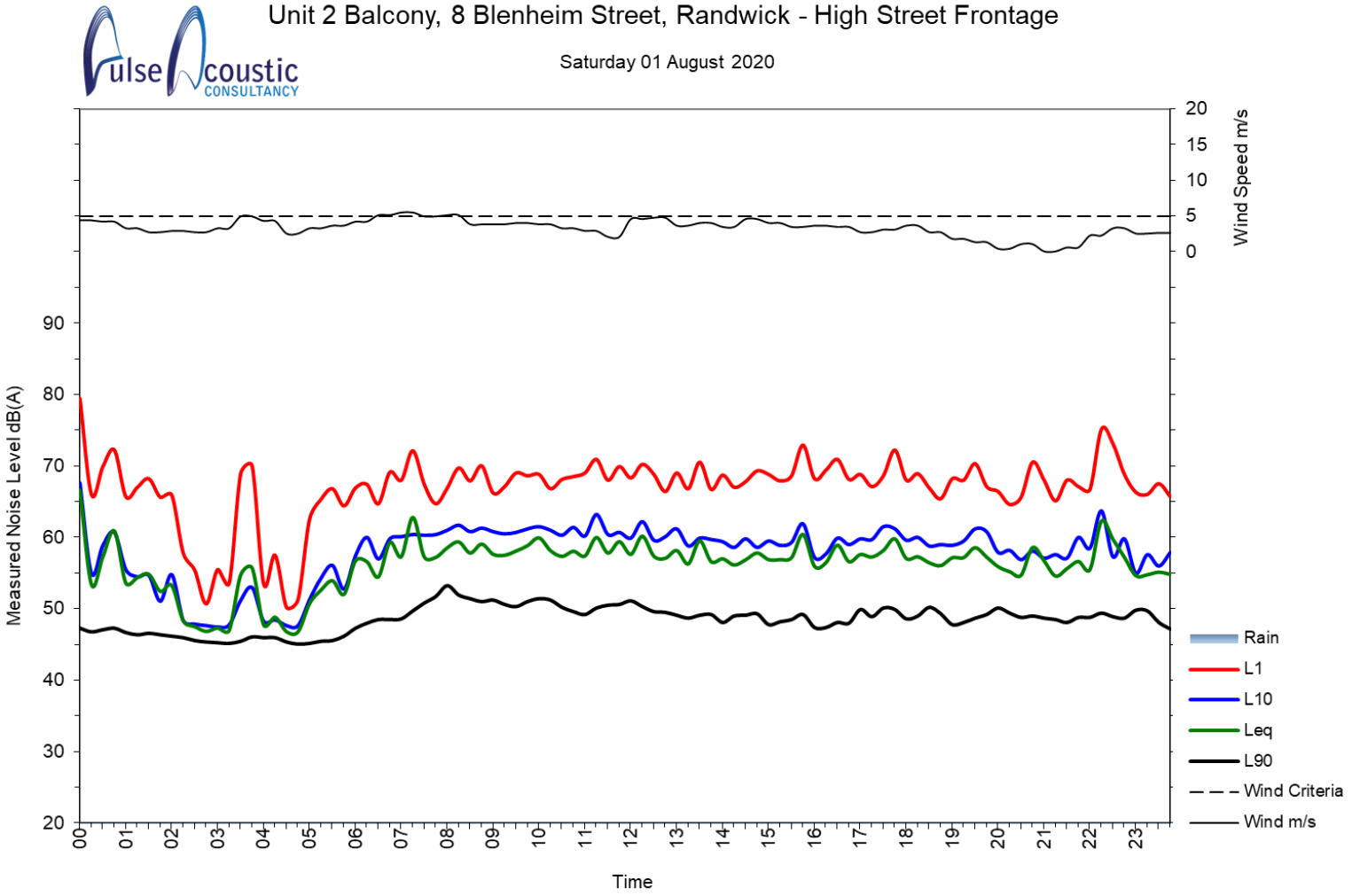
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90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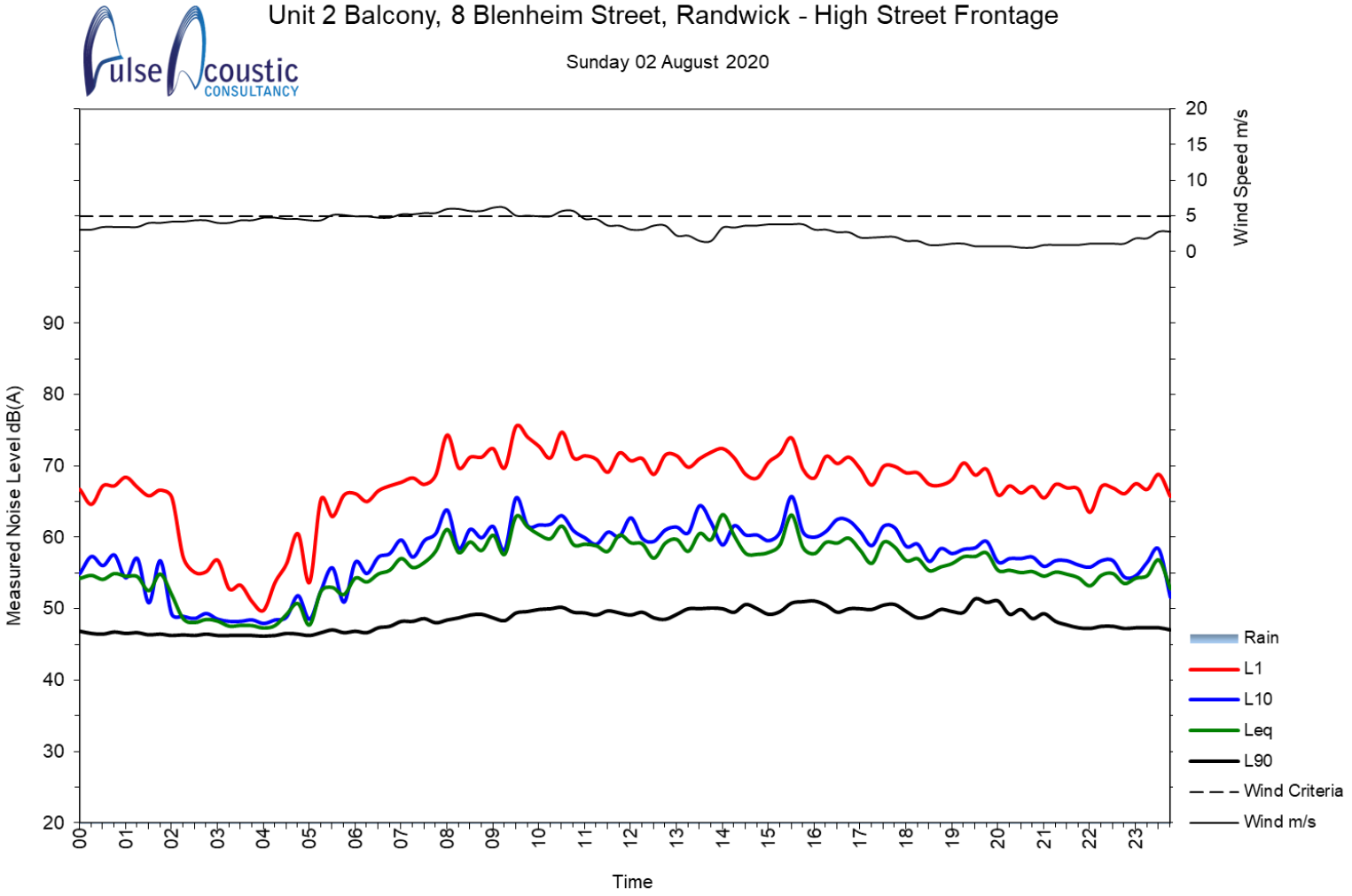
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s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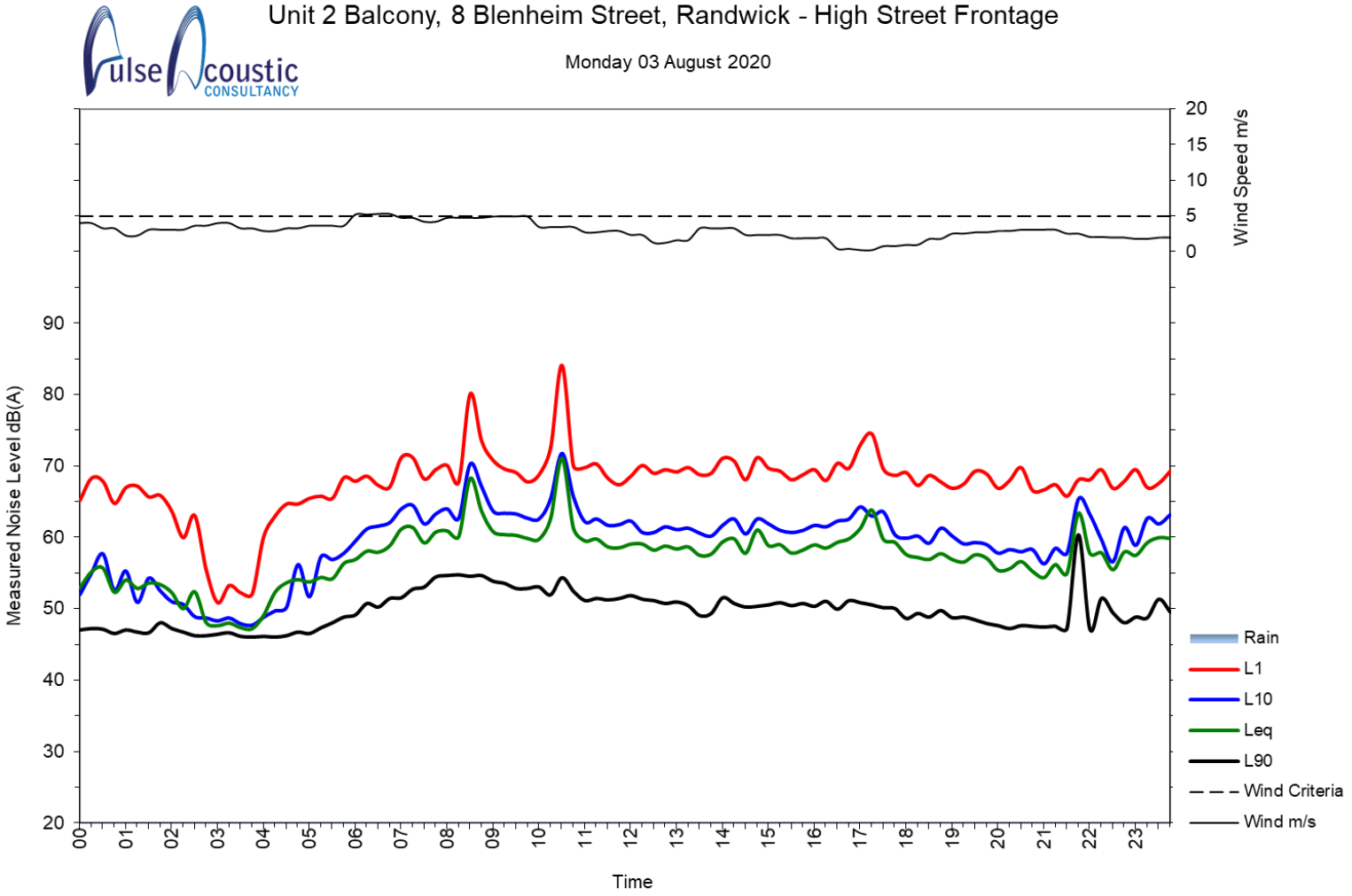
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s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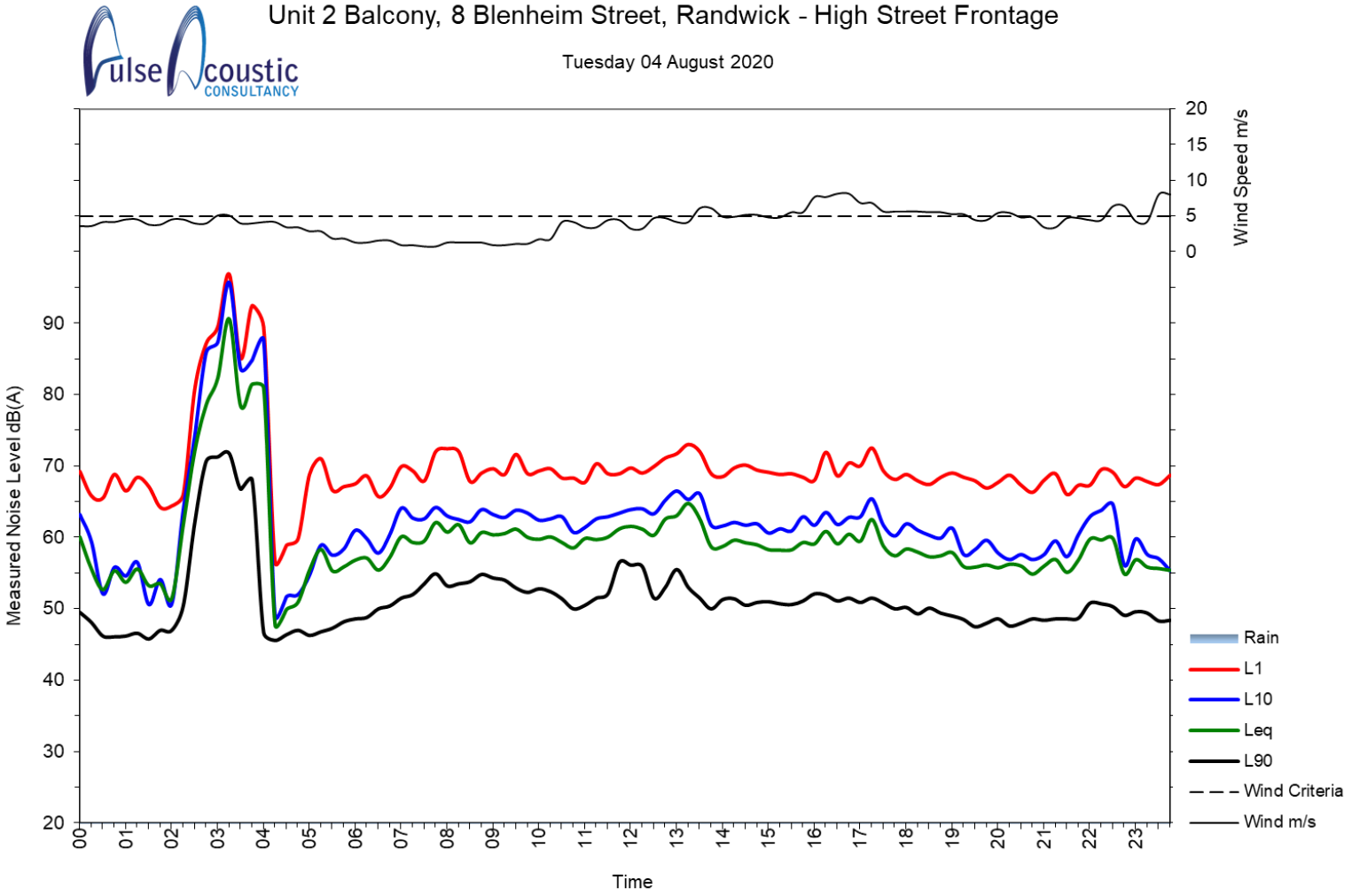
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s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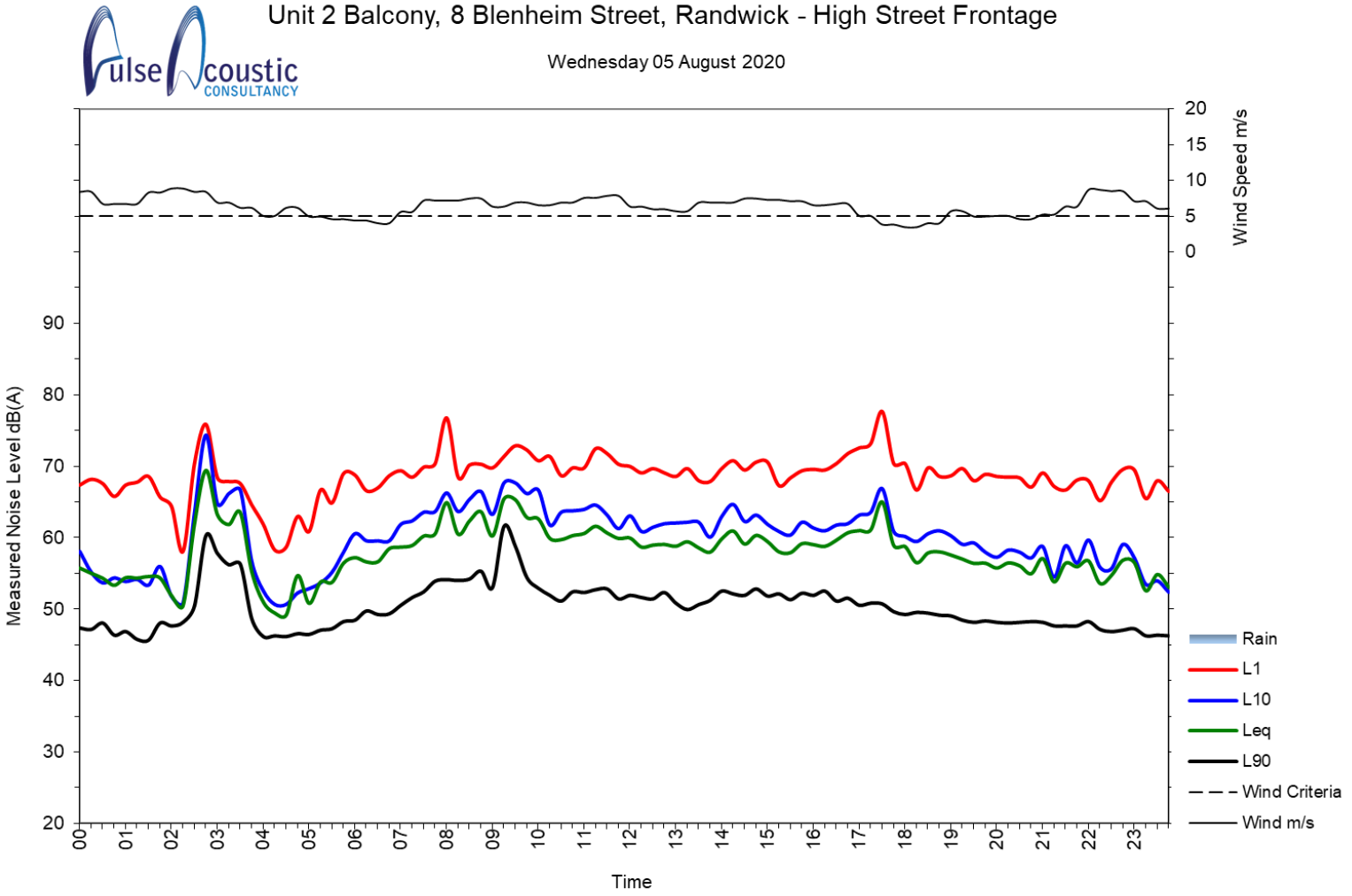
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s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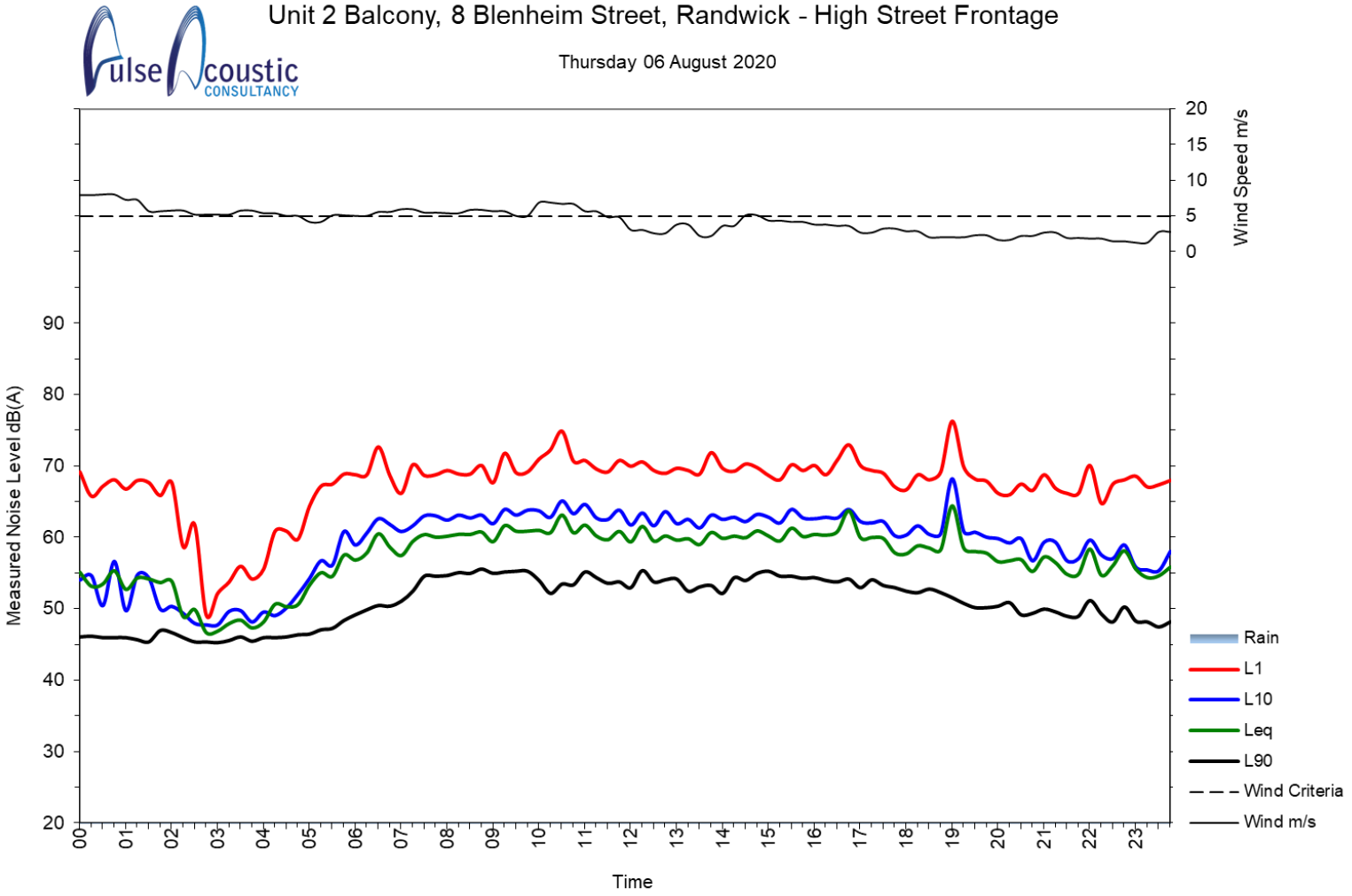
Measured Noise Level dB(A)
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s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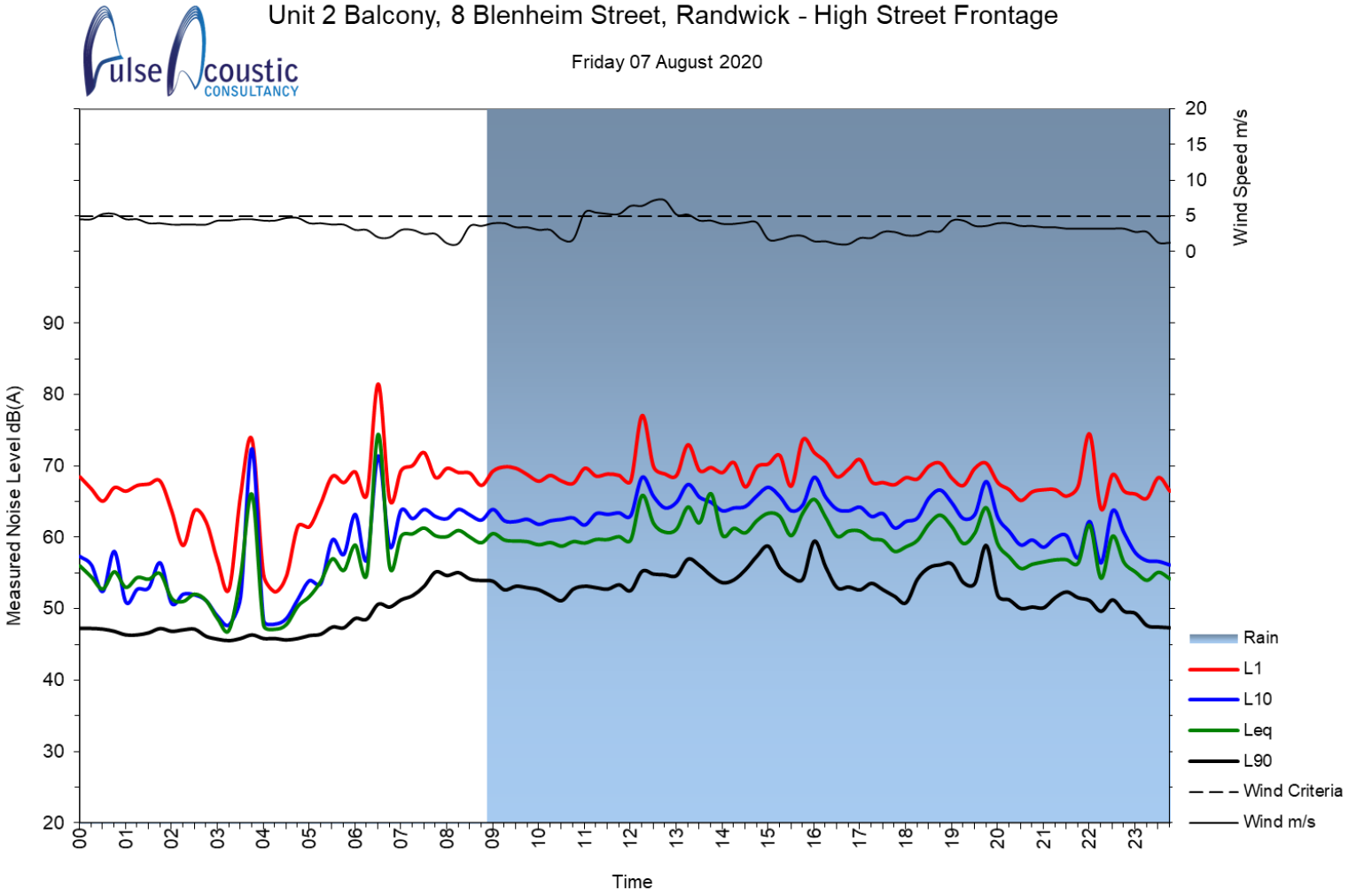
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s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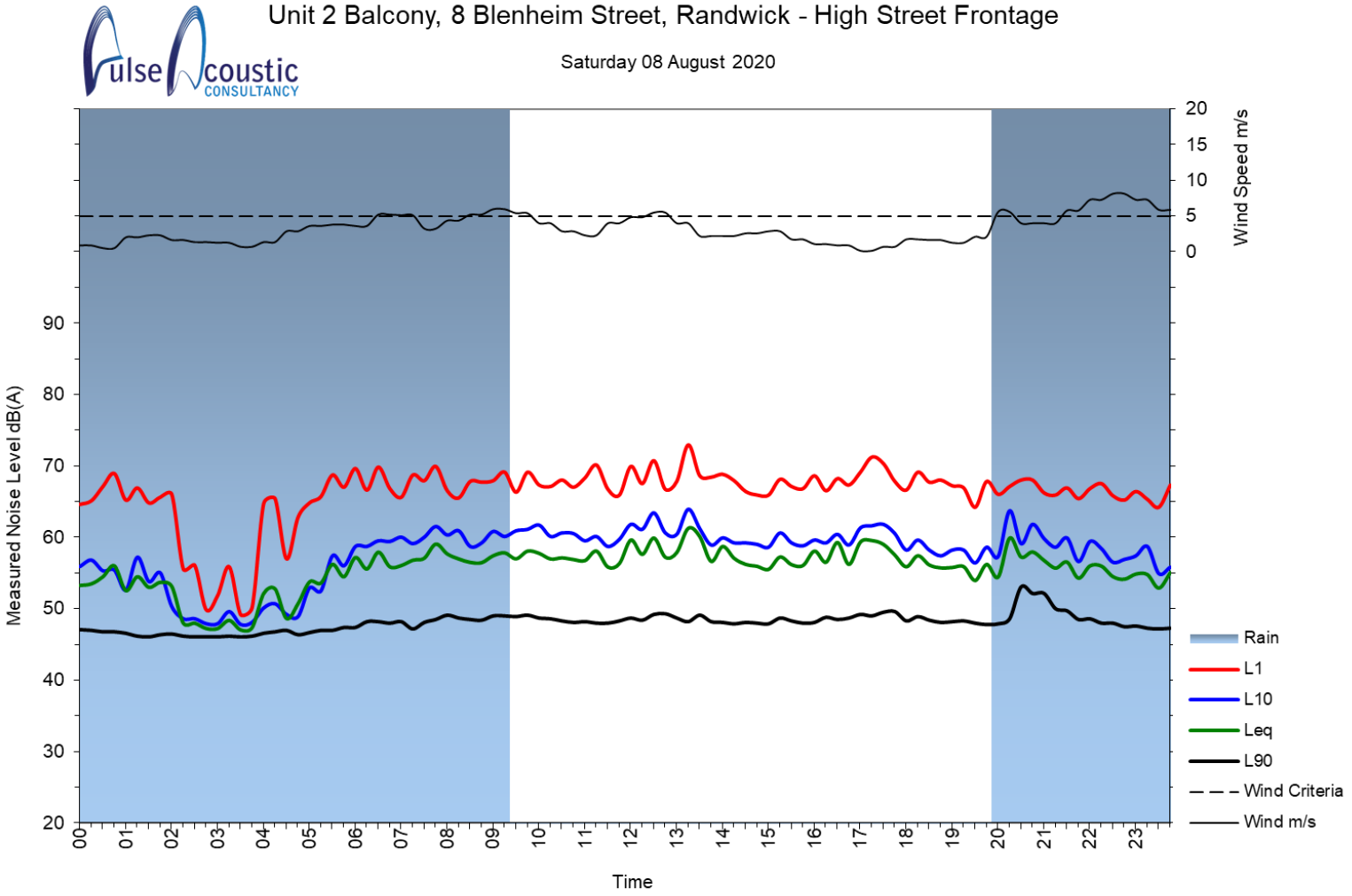
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s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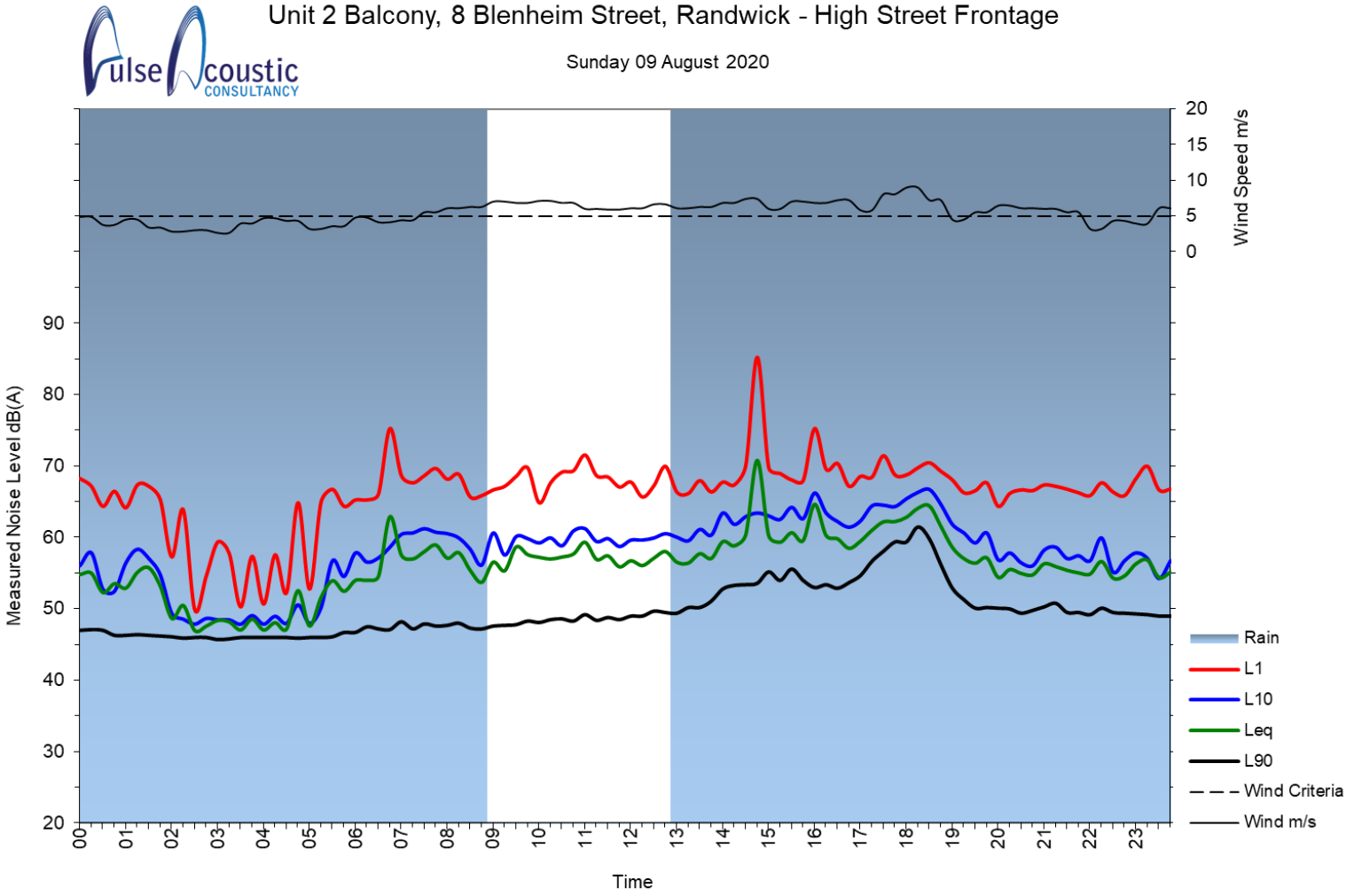
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s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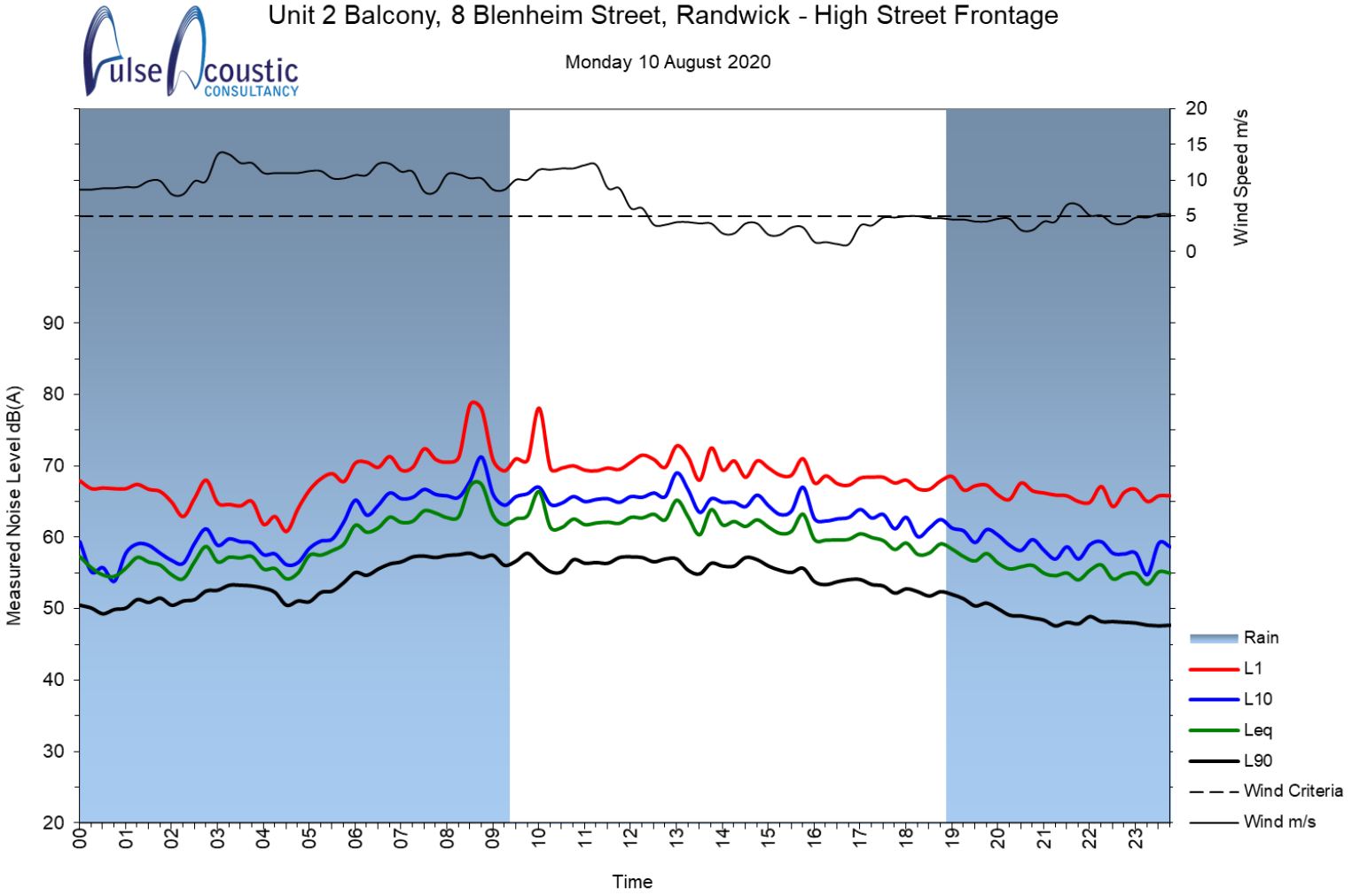
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s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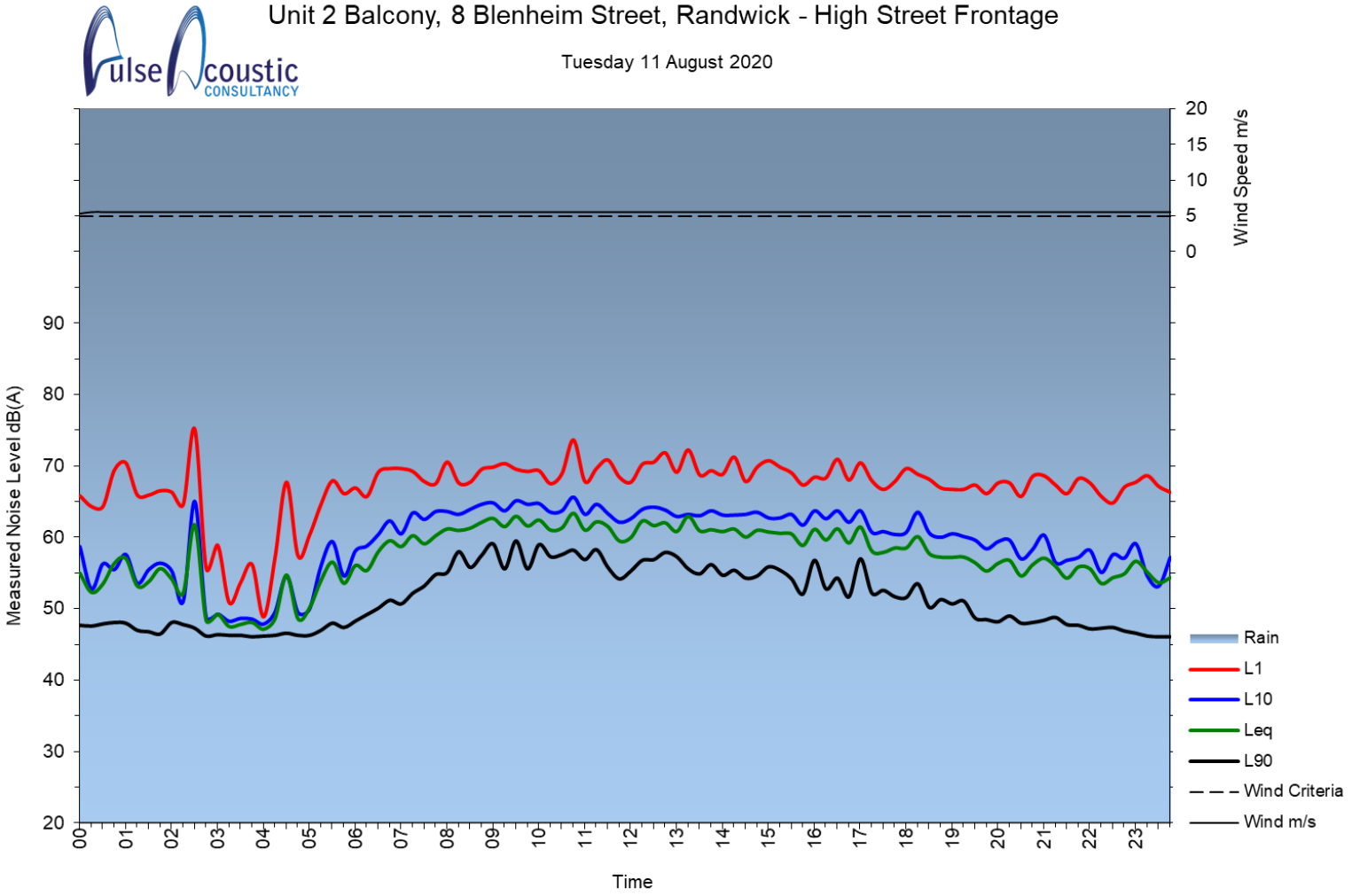
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s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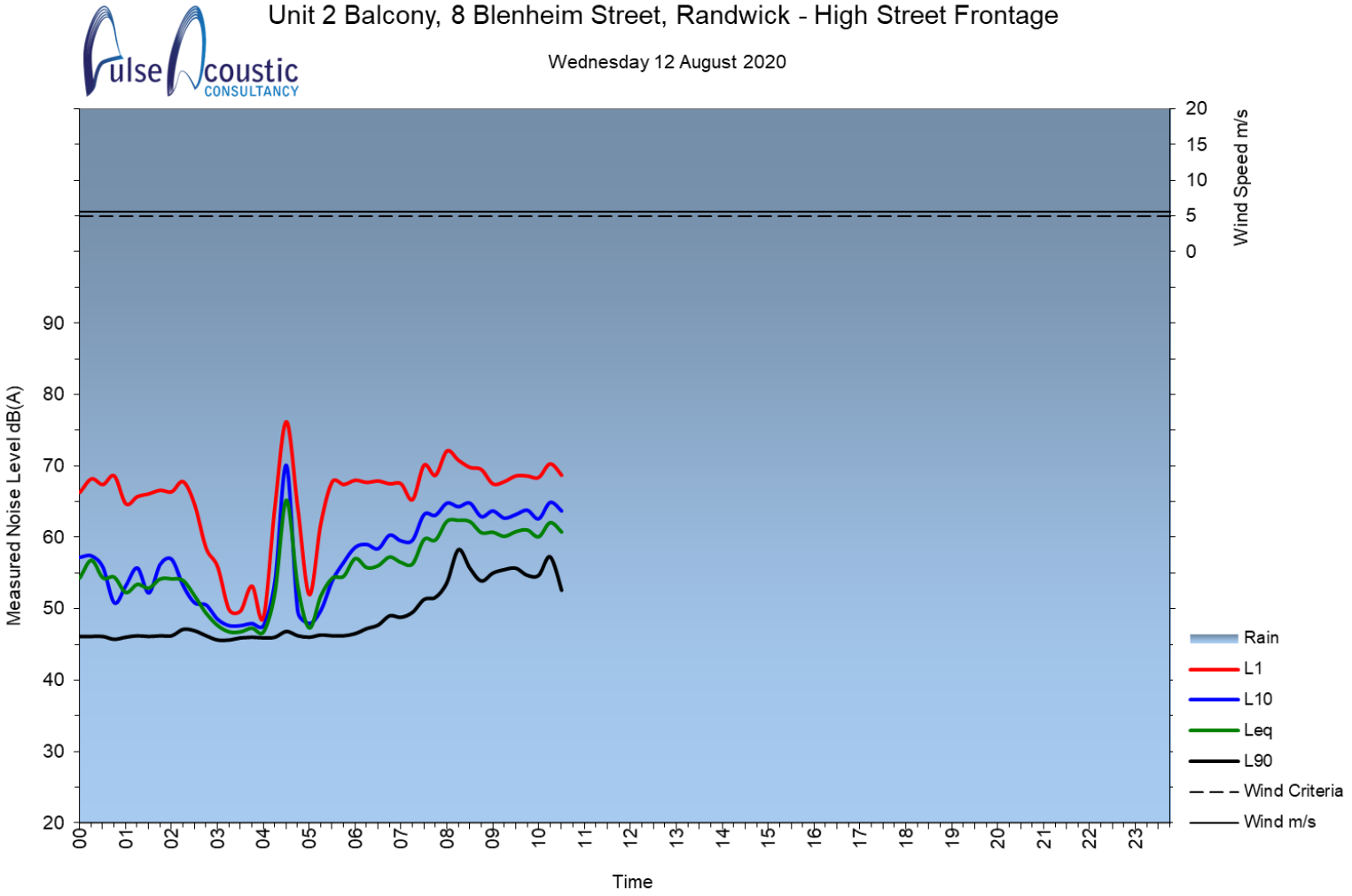
Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s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Wind Speed m/s
Time
Rain
L1
L10
Leq
L90
Wind Criteria
Wind m/s