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50 ANDERSON STREET, CHATSWOOD

Noise and Vibration Impact Assessment for SSDA

16 April 2025

Bridgestone Projects

TN935-01F02 Acoustic Assessment for SSDA (r5)

35 1982-2017 ACOUSTIC ENGINEERING EXCELLENCE

Sydney Melbourne Brisbane Gold Coast Kuwait Singapore
Renzo Tonin & Associates ABN 29 117 462 861
Level 1/418A Elizabeth St SURRY HILLS NSW 2010 | PO Box 877 STRAWBERRY HILLS NSW 2012
P (02) 8218 0500 F (02) 8218 0501 sydney@renzotonin.com.au www.renzotonin.com.au

aaac Association of Australian Acoustical Consultants

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Contents

1 Introduction

Renzo Tonin & Associates was engaged to undertake a Noise Impact Assessment for a proposed mixed-use shop top housing development at 44-52 Anderson Street, Chatswood.

The proposed development (SSD-75408008) seeks approval to construct 33-storey mixed use shop top housing, including in-fill affordable housing.

Specifically, this SSDA seeks approval for:

- Site preparation works including demolition of existing structures on the site, tree and vegetation clearing, and bulk earthworks;
- Construction of a 33-storey mixed use shop top housing development comprising:
  - A two-storey non-residential podium, with commercial/retail floor space, and
  - Two residential towers, with 123 apartments,
- Construction of an eight-level shared basement car parking for 296 carparking spaces including:
  - 256 residential spaces (including 25 accessible spaces);
  - 22 commercial and retail spaces (including 1 accessible space);
  - 18 visitor spaces;
- Vehicular access from Day Street,
- Communal open space on Level 2 including shared outdoor spaces, swimming pool and associated amenities, sauna and BBQ area and a green spine running between the two towers;
- Associated landscaping and public domain works, and
- Services and infrastructure improvements, as required.

This noise and vibration impact assessment investigates the effects of external noise and vibration intrusion onto the development site from road traffic (Anderson Street) and rail movements (T1- North Shore line and T9 - northern rail line). The advice is based on a detailed study of noise and vibration measurements on the site using both long term logging and attended measurements.

In addition:

- This report will identify operational noise goals and provide in-principle examination of noise emission from the site.
- This report will provide an assessment of noise and vibration created during the construction phase of the development.

This report has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs), in particular presents an assessment of noise intrusion into, and operational noise from the proposed mixed use development at 44-42 Anderson Street, Chatswood.

SEAR 12, relates to acoustics, and states:

Table 1: SEARs Requirements

Item	Description Requirement	Section Reference
Sear 12	Provide a noise and vibration assessment prepared in accordance with the relevant NSW Environment Protection Authority (EPA) Guidelines. The assessment must detail construction and operational noise and vibration impacts on nearby sensitive receivers and structures and outline the proposed management and mitigation measures that would be implemented.	SEPP Transport and Infrastructure and Development Near Rail Corridors and Busy Roads – Sections 4 and 5 EPA Noise Policy for Industry (operational noise emissions) – Section 6. EPA Interim Construction Noise Guidelines (construciton noise vibration) – Section 7.

The report is based on architectural plans from Turner Studio issued for Development Application September 2024.

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001.

Appendix A contains a glossary of acoustic terms used in this report.

2 Site description

The site is located at 44-52 Anderson Street Chatswood, within the City of Willoughby local government area (LGA).

The site is located in Chatswood, between the Pacific Highway and Anderson Street. The immediate urban context surrounding the site is characterised by predominantly residential land uses.

The existing development includes one four-storey and two three-storey residential dwellings. Vehicle access to the buildings is via Day Street and O'Brien Street.

It is proposed to demolish all buildings within the site and construct a new mixed use shop top housing development.

The proposed development will include 12 levels of basement car parking, a mixture of residential and commercial development on podium levels and a residential tower above, up to level 32. Commercial spaces will include cafes, retail/commercial tenancies, loading dock with turntable and building amenities.

The site is located to the east of the north shore rail line (T1) and Chatswood to Epping Metro, near the entry point of the Chatswood rail cover.

Development in the vicinity of the site is as follows:

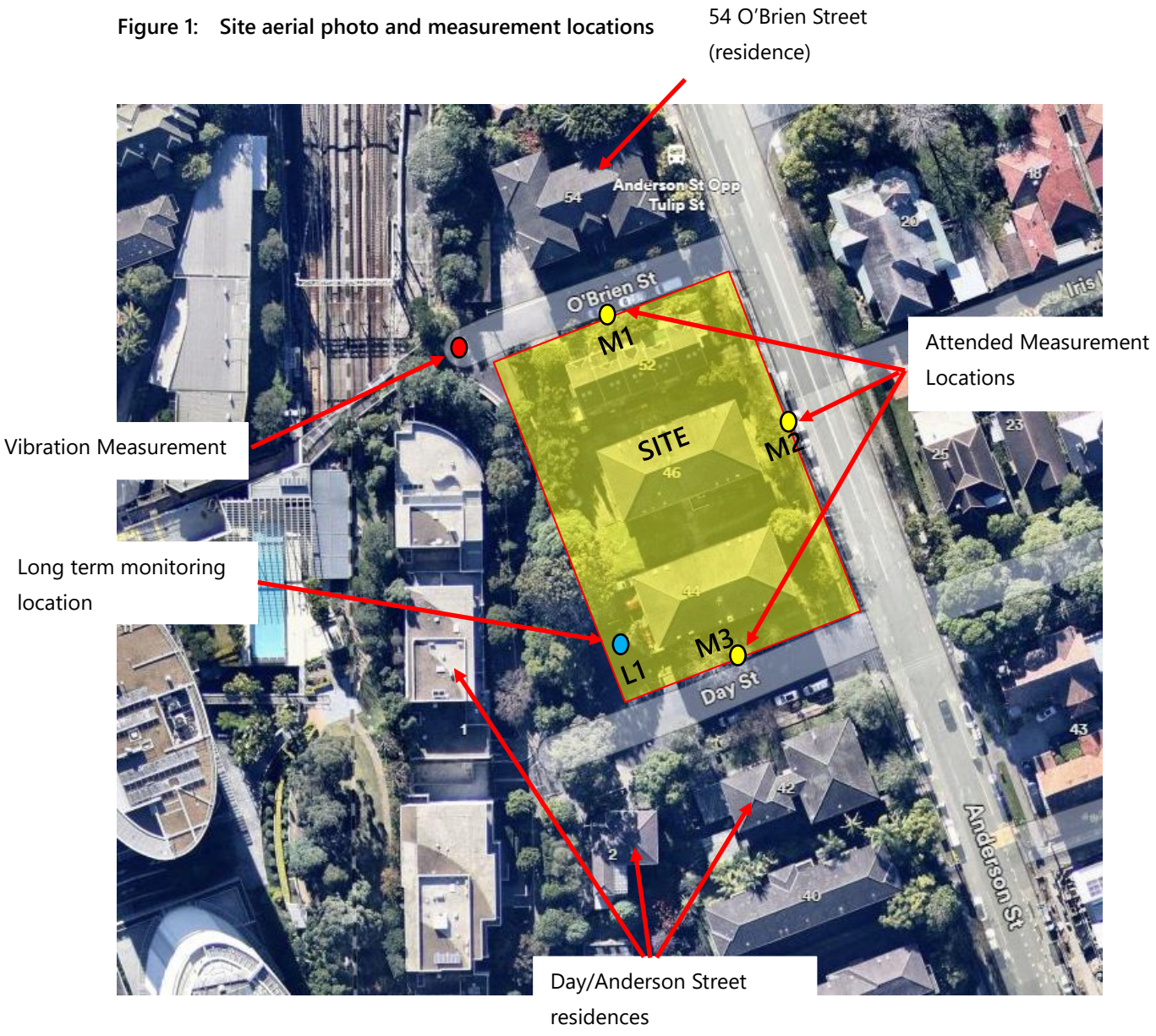
- The eastern edge of the site is bounded by Anderson Street, which carries moderate level of road traffic.
- The western edge is bounded by Day Street Residential Apartments. Further to the west lies the Northern and North Shore Rail Lines, which carry high volume of passenger rail and freight rail.
- The northern edge of the site is bunded by O'Brien Street, further north is residential development (54 Anderson Street).
- On the southern edge of the site is Day Street, further south is residential development (42 Anderson Street)

The nearest noise sensitive development to the site is a follows:

- Residential apartments on Day Street (to the west of the site).
- Residence at 54 Anderson Street (to the north of the site).
- Residence at 42 Anderson Street (to the south of the site).

An aerial photograph showing the site and surrounds is presented below.

Figure 1: Site aerial photo and measurement locations



3 External noise intrusion criteria

3.1 Road Traffic Noise Criteria

The Standards, Government Policies, Guidelines and Council Development Control Plans (DCP) relevant to this development are as follows:

1. Willoughby City Council Development Control Plan 2023
2. State Environment Planning Policy (Transport & Infrastructure) or SEPP T&I 2021
3. Department of Planning publication "Development Near Rail Corridors & Busy Roads – Interim Guideline" 2008
4. Australian Standard AS/NZS 2107:2016 "Acoustics – Recommended design sound pressure levels and reverberation times for building interior"

Anderson Street is not identified as a road requiring a mandatory assessment on the Service NSW Traffic Volume Maps for SEPP in accordance with the State Environment Planning Policy (Transport & Infrastructure) and the Department of Planning's Guideline, however, given the proximity of the site to the rail and Metro lines, and Willoughby City Council's DCP 2023 reference to the State Environmental Planning Policy (Transport & Infrastructure) 2021, the acoustic criteria is Clause 2.120 and the Department of Planning's Interim guideline are considered the most appropriate for this site. The relevant criteria is outlined in Table 2 below.

Table 2: Recommended Maximum Internal Traffic Noise Level

Type of Occupancy	Windows Condition	Maximum Design Noise Level	
		Day[2], L_{Aeq} (15hour)	Night[2], L_{Aeq} (9hour)
Bedrooms	Closed	-	35dB(A)
Open-plan Living/Dining/Kitchen including studies	Closed	40dB(A)	40dB(A)
Lobby[1]	Closed	50dB(A)	-
Retail tenancies[1]	Closed	50dB(A)	-
Commercial (general office areas)	Closed	45dB(A)	

Notes:

1. Occupancies not covered under SEPP (T&I) are based on Australia Standard AS2107 "Acoustics – Recommended design sound pressure levels and reverberation times for building interior"

2. Day is defined as 7am to 10pm. Night is defined as 10pm to 7am next day.

Relevant sections of the SEPP (T&I), Department of Planning Documentation and Council DCP are presented in Appendix B of this report. Results of the background and ambient noise monitoring conducted on site are presented in Appendix C and D.

3.2 Rail Noise and Vibration

3.2.1 Airborne Rail Noise

The existing rail lines impacting on the proposed development is the North Shore Line and the Chatswood to Epping Metro Line. This is a dedicated line passenger train with no freight rail. The site is located north of Chatswood interchange as the rolling stock exit the rail cover.

The airborne rail noise criteria for this development are based on the following documents:

- State Environment Planning Policy (Transport & Infrastructure) 2021 "SEPP (T&I)"
- Department of Planning publication "Development Near Rail Corridors & Busy Roads – Interim Guideline" 2008
- Willoughby Council's Development Control Plan (DCP) 2023

Willoughby City Council's DCP 2023 refers to the State Environmental Planning Policy (Transport & Infrastructure) 2021.

As the proposed site lies approximately 29m from the T1 North Shore, Northern & Western Line and the T2 Inner West & South Line. This lies within the 60m requirement presented in the Development Near Rail Corridors and Busy Roads – Interim Guideline (Department of Planning, 2008) must be considered.

Figure 3.1 of the guideline provides a guide as to the assessment required when noise sensitive developments are located in the vicinity of existing rail lines.

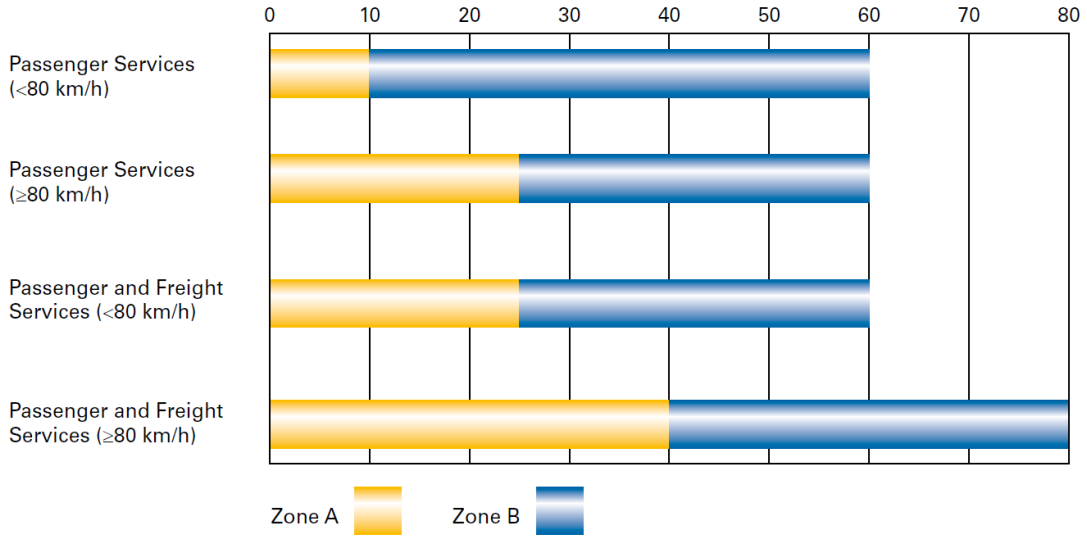


Figure 3.1: Acoustic Assessment Zones based on distance (m) of noise-sensitive development from operational track (not corridor)

The proposed site falls into the 'Passenger (<80km/h)' category, and is 29m from the rail line. This is on in assessment Zone B, which means that a full noise assessment is recommended and will be undertaken in accordance with the SEPP (T&I) Clause 2.100 and The Department of Planning's Interim

Guideline. Table 3 below summaries the airborne rail noise criteria determined suitable for this development.

Table 3: Recommended Internal Noise Criteria for Rail Noise

Occupancy	Windows & Doors Condition	Design Noise Level	
		Day, LAeq (15hour)	Night, LAeq (9hour)
Bedrooms	Closed	-	35
	Open	-	45
All Other Habitable Areas	Closed	40	40
	Open	50	50

Notes:

Day and Night assessment periods are defined as follows.

1. Day is defined as 7:00am to 10:00pm
2. Night is defined as 10pm to 7am

3.2.2 Rail Vibration

The guideline shows that other vibration sensitive buildings up to 60m from the rail line should be assessed. In order to ensure that rail vibration does not adversely impact on the proposed development, a vibration assessment will be undertaken.

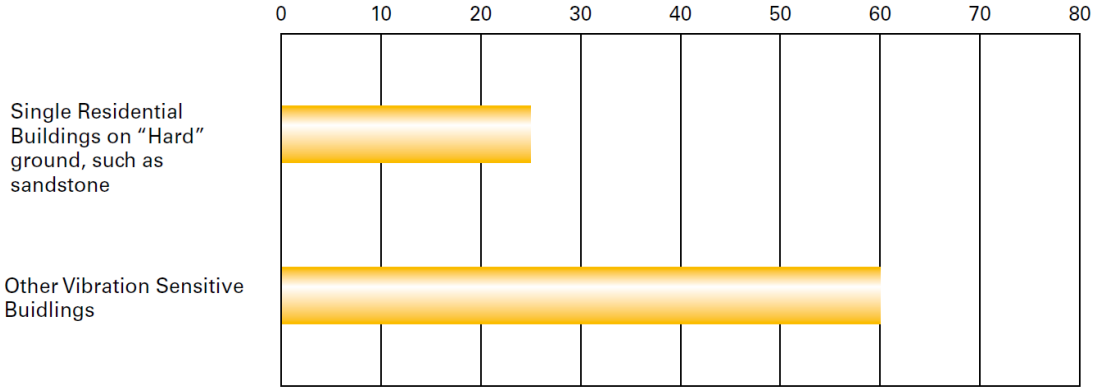


Figure 3.2: Distance from the nearest operational track (m)

The mulit storey mixed use development is therefore recommended for a rail vibration assessment

The Department of Planning Guideline, Section 3.6.3 outlines the following documents which recommend train vibration criteria for residential buildings.

- Assessing Vibration: A technical guideline (EPA 2006)
- German Standard DIN 4150, Part 3 1999
- British Standard BS 7385 Part 2 1993
- Australian Standard AS2670.2 1990

The above documents have been reviewed and the criterion for assessment of vibration from train pass-bys affecting the proposed development is quantified using the following Standards:

- Assessing Vibration: A technical guideline (EPA 2006); and
- British Standard BS 6472-1:2008 Evaluation of Human Exposure to Vibration in Buildings (1 to 8 Hertz)).

Table 2.4 of the Department of Environment Climate Change and Water's document "Assessing Vibration: A technical guideline (EPA 2006)" presents acceptable vibration dose values for intermittent vibration.

Intermittent vibration is to be assessed using vibration dose values (VDVs). The VDV method is a fourth power approach which is more sensitive to peaks in the acceleration waveform and makes corrections to the criteria based on the duration of the source's operation. The VDV can be calculated using the overall weighted rms acceleration of the vibrating source in each orthogonal axis and the total period during which the vibration may occur. Weighting curves are provided in each orthogonal axis in the guideline. Preferred and maximum VDV values are defined in Table 4 below.

Table 4 – Acceptable vibration dose values for intermittent vibration (m/s1.75)

Location	Daytime		Night-time	
	Preferred values	Maximum values	Preferred values	Maximum values
Critical areas	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

Notes: Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am.

Examples of critical areas include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas. Source: BS 6472-1992

Criteria for vibration from the British Standard BS6472:1992 for residential spaces, offices and commercial workshop environments are shown in Figure 1 below.

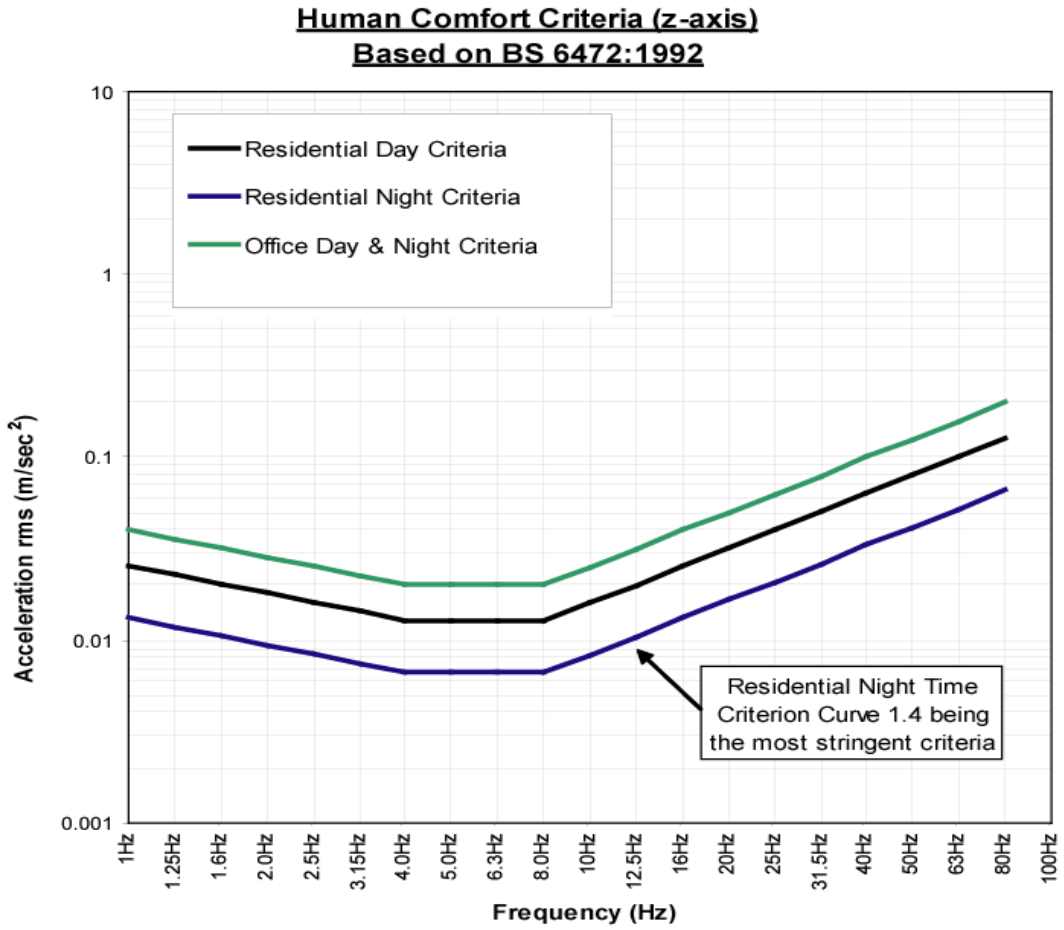


Figure 1 - Tactile Vibration Criteria for Residential Buildings

3.2.3 Ground-borne Noise

Ground-borne noise propagates through the ground as vibration and is then radiated as noise by vibrating wall and floor surfaces. The ISO Standard 14837 Mechanical vibration – Ground-borne noise and vibration arising from rail systems defines ground borne noise as noise generated inside a building by ground-borne vibration generated from the pass-by of rolling stock on rail.

It is normally noticeable only in areas that are well protected from airborne noise.

Ground-borne noise has been measured and calculated in accordance with the Department of Planning Document "Development Near Rail Corridors & Busy Roads – Interim Guideline" 2008.

Ground-borne noise is calculated as an LAMax (slow) for 95% of train pass-bys in accordance with the Guideline. Ground-borne noise has the potential to impact on the apartments facing to the south away from the rail line where the airborne rail noise impacts are lessened.

Passenger trains operate during both the day time and night time periods of the day. As a result, ground-borne noise occurs both during the day time and the night time periods. As a result, the measured ground-borne levels have been assessed against the most stringent of the ground-borne criteria presented in Table 3, which is applied to bedrooms during the night time period.

Ground-borne noise within the proposed development has been calculated using the vibration (acceleration m/s) from train pass-bys measured. Appendix C, Section C.2.1 shows quantity and train types measured during the survey periods.

4 Measured and predicted noise levels

4.1 Noise and Vibration Surveys

4.1.1 Train Noise and Vibration Measurements

The north-western boundary of the site is located approximately 29m from the north-shore rail line and the Sydney Metro corridor. At that location, the trains enter a railway cover. this may increase the likelihood of ground borne noise being noticeable at the site. Train noise and vibration levels were recorded at the end of O'Brien Street, approximately 17m from the rail line and 12m from the site location from 2pm-3pm. Operator-attended noise and vibration measurements were conducted on site on 29th May 2024. A total of 24 rail movements were measured consisting of both Metro and Sydney Trains.

Airborne rail noise measurements were undertaken with full line of sight to the rail line so that rail noise at higher levels of the building could be easily predicted.

Weather conditions were fine during the operator-attended surveys with negligible wind speeds at the monitoring locations. All instruments were calibrated before and after measurement. No significant drift in calibration was observed.

4.1.2 Long-term Noise Survey

Northrop Engineers have previously undertaken long term noise monitoring at the site as part of a previous acoustic assessment of the site [Northrop DA Assessment (SY223151-00-AU-RP01-4) dated 01/06/2023].

One monitor was placed near the south west corner of the site for the ambient noise survey from 6th February to 15th February 2023. The logger was set up in a location that is well shielded from rail and traffic noise.

These levels have been used to establish exiting ambient noise levels at the site. Details of location and survey periods are included in Appendix D.

Long-term noise monitoring locations are shown in the Figure 1 above and detailed in Table 5 below.

Table 5: Noise monitoring locations

Location ID	Description
Long-term noise monitoring	
Location 1	Noise monitor installed on the south- western side of the site of the existing building

Long term noise monitoring has also previously been undertaken on the corner of Wilson Street and the Pacific Highway. These levels, along with short term measurements undertaken along The Pacific Highway, have been used to predict noise levels to facades of the development potentially exposed to

traffic noise from the Pacific Highway, particularly at higher levels where there are fewer intervening structures.

The noise monitors record noise levels on a continuous basis and stores data every fifteen minutes. The noise loggers were calibrated before and after measurements and no significant deviation in calibration was noted. The noise monitoring equipment used here complies with Australian Standard 1259.2-1990 "Acoustics - Sound Level Meters" and is designated as Type 2 instruments suitable for field use.

4.1.3 Short term traffic noise survey

Short term measurements were also undertaken at the midpoints of the Anderson Street, O'Brien Street and Day Street boundaries of the proposed development at ground level in order to determine traffic noise impacts on the site on Wednesday 17th July 2024, and again on Wednesday 9th April 2025. In addition, short term measurements were taken along The Pacific Highway (approx. 116m west of the proposed boundary). The locations are shown in Figure 1, with the results of the survey tabulated below.

Table 6: Measured traffic noise levels

Location	Date and Time	Measured Traffic Noise Level $L_{Aeq,\ 15min}$ [1] at the Boundary
Anderson Street facade	Wednesday 17th July 2024 (3.00pm – 3.15pm)	58 dB(A)
	Wednesday 9th April 2025 (3.00pm – 3.15pm	60dB(A)
Day Street facade	Wednesday 17th July 2024 (3.15pm – 3.30pm)	57 dB(A)
	Wednesday 9th April 2025 (3.15pm – 3.30pm	58 dB(A)
O'Brien Street facade	Wednesday 17th July 2024 (3.30pm – 3.45pm)	56 dB(A)
	Wednesday 9th April 2025 (3.30pm – 3.45pm	57 dB(A)
The Pacific Highway (curb at corner of Wilson Street)	Wednesday 9th April 2025 (4.00pm – 4.15pm	75 dB(A)

Notes:

Noise levels presented are façade corrected values.

4.1.4 Short term rail noise survey

Airborne rail noise measurements were undertaken at the end of O'Brien Street at the junction with the rail corridor with direct line of sight to the rail line in order to obtain data used to predict rail noise levels at higher apartment levels where there would be line of site to the rail and Metro lines. In addition peak rail noise events were measured, with 24 Rail and Metro movements measured across the monitoring period.

4.1.5 Rail Vibration Survey

Train vibration levels were measured using the Sinus SoundBook multi-channel analyser and Endevco accelerometers. An accelerometer was fixed into the ground at the end of O'Brien Street using a steel

spike. For each measurement, three accelerometers (in x, y & z directions) were screw fixed to a steel bracket that has been fixed to a metal plate using powerful magnets.

The recorded ground vibration levels of train pass-bys are shown in Appendix C together with the vibration criteria derived from British Standard BS6472-1992 "Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80 Hz). Vibration levels are well below the recommended vibration dose criteria.

Details of the survey are included in Appendix C.

The table below shows the calculated Vibration Dose Value (VDV) measured at the proposed development site due to existing operations.

Table 7: Calculated Vibration Dose Value (VDV)

Location	Assessment Period	Calculated VDV m/s1.75	Criteria (Preferred values) m/s1.75	Complies?
On the lawn at the edge of O'Brien Street cul-de-sac, approximately 12m from the proposed building facade	Day time (7am - 10pm)	0.03	0.2	Yes
	Night time (10pm - 7am)	0.026	0.13	Yes

The calculated VDV at the measurement location (which is closer to the rail line than the building façade) is below both the daytime and night time criteria determined in accordance with the EPA's document 'Assessing Vibration: A technical guideline'.

The recorded ground vibration levels of train pass-bys are shown in Appendix C together with the vibration criteria derived from British Standard BS6472-1992 "Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80 Hz). Vibration levels are well below the recommended vibration dose criteria.

4.2 Results of noise monitoring

4.2.1 Rail traffic noise

The combined Rail and Metro noise levels have been taken from the representative $L_{Aeq(15/9hr)}$ for the week for both daytime (7am to 10pm) and night-time (10pm to 7am) periods. The design noise levels are presented in Table 2 below.

Table 8: Representative Day and Night Rail Noise Levels

Location	Period	Predicted Rail Noise Level $L_{Aeq, T}$ [1,2] at the Worst Affected Facade
North-western corner of the site facing the rail and Metro lines	Day time (7am to 10pm)	65 dB(A)
	Night time (10pm to 7am)	62 dB(A)

Notes:

Noise levels presented are façade corrected values.

Representative external noise levels, LAeq over 15 hour and 9 hour day and night period respectively,

4.2.2 Road traffic noise

The traffic noise levels have been taken from the representative $L_{Aeq(15/9hr)}$ for the week for both daytime (7am to 10pm) and night-time (10pm to 7am) periods. The design noise levels are presented in Table 2 below.

Table 9: Representative day and night traffic noise levels

Location	Period	Predicted Traffic Noise Level $L_{Aeq,\ T}$ [1,2] at the Worst Affected Facade
Anderson Street facade	Day time (7am to 10pm)	60 dB(A)
	Night time (10pm to 7am)	55 dB(A)
North and Western façade facing the Pacific Highway (above level 7- traffic only)	Day time (7am to 10pm)	62 dB(A)
	Night time (10pm to 7am)	59 dB(A)

Notes:

Noise levels presented are façade corrected values.

Representative external noise levels, LAeq over 15 hour and 9 hour day and night period respectively,

4.2.3 Combined traffic and rail noise levels

The following table presents the combined predicted road traffic and rail noise levels impacting the proposed development

Table 10: Representative day and night traffic noise levels

Location	Period	Predicted Combined Traffic and Rail Noise Level $L_{Aeq,\ T}$ [1,2] at the facade
Anderson Street facade	Day time (7am to 10pm)	60 dB(A)
	Night time (10pm to 7am)	55 dB(A)
Southern (Day Street) facade	Day time (7am to 10pm)	58 dB(A)
	Night time (10pm to 7am)	53 dB(A)
North and Western façade facing the Pacific Highway and rail/metro lines	Day time (7am to 10pm)	67 dB(A)
	Night time (10pm to 7am)	64 dB(A)

Notes:

Noise levels presented are façade corrected values.

Representative external noise levels, LAeq over 15 hour and 9 hour day and night period respectively,

Noise measurement data was then used to create a 3D noise model for the site to determine noise levels across all facades and levels within the proposed development.

4.2.4 Background noise

Table 11 below presents the results of the long-term unattended noise monitoring for background noise.

Table 11: Background noise levels from long-term noise monitoring

Noise Monitoring		Representative Background Noise Levels in dB(A)	Day[1]	Evening[2]	Night[3]
Location	Duration				
L1 - Noise monitor installed on the south- western side of the site of the existing building	6-15 February 2023	L_{A90}	47	47	42
		L_{Aeq}	52	51	46

Notes:

Day, Evening & Night assessment periods are defined in accordance NSW EPA's Noise Policy for Industry as follows.

1. Day is defined as 7:00am to 6:00pm, Monday to Saturday; 8:00am to 6:00pm Sundays & Public Holidays.
2. Evening is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays
3. Night is defined as 10:00pm to 7:00am, Monday to Saturday; 10:00pm to 8:00am Sundays & Public Holidays

4.2.5 Ground-Borne Noise

Given the proximity of the site to the rail tunnel at Chatswood, a ground borne noise assessment is required, particularly for future apartments not impacted by air borne rail noise. The northern and western façades of the building will likely be exposed to airborne noise from rail operations which will dominate the acoustic environment. The southern and eastern façade of the northern building and southern building of the development is somewhat shielded from airborne noise due to the trains being located within the tunnel at that location. As ground-borne noise is normally only noticeable in areas that are well protected from airborne noise, an assessment has been undertaken on the southern and eastern facing units of the northern building, and all apartments within the southern building of the development.

Train vibration levels measured on site were used to predict the regenerated rail noise inside the proposed building from train pass-byes. These calculated noise levels inside the habitable spaces are summarised below and compared to ground-borne noise criteria.

Measurements were made at the location shown in Section 2. This location was selected as it will be representative of apartments that do not face the rail line (while apartments that face the rail line are slightly closer to the vibration source, that will also be impacted by airborne noise from the train, such that any structure borne noise from a train passby will be masked by the airborne noise. It is the apartments that are shielded from the airborne noise (ie – facing away from the train line) that require closest examination of ground borne rail noise.

The internal ground-borne noise level from train pass-bys within units located on the southern facade of Level 2 of the north building and apartments on Level 5 of the South building are presented in the table below.

Table 12 – Calculated Ground-Borne Noise Levels (Night Time)

Location	Calculated Internal Ground-Borne Noise Level dB(A) LAMax (slow)	Internal Ground-Borne Noise Level Criteria dB(A) LAMax (slow) (Bedrooms – Night Time)	Exceedance	Complies?
Level 2 Northern Building - southern/eastern apartments	28 dB(A)	35 dB(A)	-	Yes
Level 5 Southern Building	26 dB(A)	35 dB(A)	-	Yes

5 External Noise Control Recommendations

5.1 Glazing

To achieve the criteria outlined in Table 1 with windows closed, the following table presents the recommended glazing acoustic performances for the proposed development.

Table 13: Recommended acoustic performance of glazing assembly

Facade	Level(s)	Occupancy	Required Acoustic Rating of Glazing Assembly, Rw
North Building			
Northern Façade (O'Brien Street)	Ground Level to Level 1	Retail and commercial	Rw 30
	Level 2-30	Apartment Bedrooms	Rw 32
		Apartment Living Areas	Rw 32
Western Façade (facing Laneway)	Ground Level to Level 1	Retail and commercial	Rw 30
	Level 2-30	Apartment Bedrooms	Rw 34
		Apartment Living Areas	Rw 32
South Façade	Ground Level to Level 1	Retail and commercial	Rw 30
	Level 2-30	Apartment Bedrooms	Rw 28
		Apartment Living Areas	Rw 28
Eastern Facade Façade (facing Anderson Street)	Ground Level to Level 1	Retail and commercial	Rw 30
	Level 2-30	Apartment Bedrooms	Rw 28
		Apartment Living Areas	Rw 28
South Building			
Northern Façade	Ground Level to Level 4	Retail and commercial	Rw 30
	Level 5-32	Apartment Bedrooms	Rw 32
		Apartment Living Areas	Rw 32
Western Façade (facing Laneway)	Ground Level to Level 4	Retail and commercial	Rw 30
	Level 5-32	Apartment Bedrooms	Rw 32
		Apartment Living Areas	Rw 32
South Façade	Ground Level to Level 4	Retail and commercial	Rw 30
	Level 5-32	Apartment Bedrooms	Rw 28
		Apartment Living Areas	Rw 28
Eastern Facade Façade (facing Anderson Street)	Ground Level to Level 1	Retail and commercial	Rw 30
	Level 5-32	Apartment Bedrooms	Rw 28
		Apartment Living Areas	Rw 28

Facade	Level(s)	Occupancy	Required Acoustic Rating of Glazing Assembly, Rw

Notes:

The client is advised not to commence detailing or otherwise commit to partition construction systems which have not been tested in an approved laboratory or for which an opinion only is available. Testing of partition construction systems is a component of the quality control of the design process and should be viewed as a priority because there is no guarantee the forecast results will be achieved thereby necessitating the use of an alternative which may affect the cost and timing of the project. No responsibility is taken for use of or reliance upon untested partition construction systems, estimates or opinions. The advice provided here is in respect of acoustics only.

The information in this table is provided for the purpose of Council approvals process and cost planning and shall not be used for construction unless otherwise approved in writing by the acoustic consultant.

The design in this table is preliminary and a comprehensive assessment shall be conducted prior to Construction Certification.

Before committing to any form of construction or committing to any builder, advice should be sought from an acoustic consultant to ensure that adequate provisions are made for any variations which may occur as a result of changes to the form of construction where only an "estimate" is available for the sound insulation properties of recommended materials.

The glazing supplier shall ensure that installation techniques will not diminish the Rw performance of the glazing when installed on site.

All openable glass windows and doors shall incorporate full perimeter acoustic seals equivalent to Q-Lon, which enable the Rw rating performance of the glazing to not be reduced.

The above glazing thicknesses should be considered the minimum thicknesses to achieve acoustical ratings. Greater glazing thicknesses may be required for structural loading, wind loading etc.

With respect to the above:

- All operable window/door elements are to have acoustic seals (equal to q-lon).
- Indicative R_w values for façade elements as follows:
    - 6mm glass or 6mm/12mm airgap/6mm insulated glazed unit – R_w 29.
    - 6.38mm laminated glass or 6mm/12mm airgap/6mm insulated glazed unit.– R_w 31
    - 10.38mm laminated glass or 6mm/12mm airgap/10.38mm laminated – R_w 35
    - 12.38mm laminated glass or 10mm/12mm airgap/10.5mm laminated – R_w 37
    - 12.5mm V-lam Hush glass or 12mm/12mm airgap/10.5mm laminated – R_w 40.
- For all glazing systems, it is necessary to ensure that the acoustic performance of the window/sliding door frame does not downrate the acoustic performance of the glass. This can be particularly difficult for 12.5mm V-lam hush. Any window frame supplier should provide test reports to demonstrate that their frame will not downrate the acoustic performance of the nominated glass.

5.1.1 External Walls and Roof

External walls and roof are assumed to be masonry. If light weight external wall elements are used, these need to be reviewed in detail and may also impact the glazing requirements for that room (as the cumulative result of noise through window and external wall element needs to be considered).

5.1.2 Supplementary Ventilation

In accordance with the Department of Planning publication "Development Near Rail Corridors & Busy Roads – Interim Guideline" 2008:

If internal noise levels with windows or doors open exceed the criteria by more than 10dBA, the design of the ventilation for these rooms should be such that occupants can leave windows closed, if they so desire, and also to meet the ventilation requirements of the Building Code of Australia

However, the Department of Planning's Apartment Design Guide, July 2015 Objective 4B-1 requires that all habitable rooms are naturally ventilated, within an apartment complex.

Section 4J, *Noise and Pollution*, of the Apartment Design Guide nominates design solutions that may assist with delivering both the natural ventilation requirements and the internal noise levels (windows open) through careful design solutions. These may include wintergardens with operable facades, partially shielded and insulated balconies, building design and orientation, apartment setbacks and selection of acoustic materials for the building construction. An outside air intake for the air conditioning system may also be a solution to providing natural ventilation.

It has long been industry standard to assume a 10dB loss of noise from external to internal through an opened window in a building facade. It is based on the average results of a number of test cases, experimental data and published papers. This assumption has been well documented in The Roads and Traffic Authority (RTA) publications, including the RTA's Environmental Noise Management Manual (ENMM), Table 4.2.

Recent studies on noise reduction through facades with open windows[1] have shown that noise transmission through an open window can vary greatly based on the construction of the facades and noise flanking paths, including exposed floors and roof constructions.

The study indicates that noise loss through an open window of a development consisting of masonry construction with no exposed flooring and a concrete roof will be in the range of 11-15dB.

If an 11-15dB(A) loss is assumed, design solutions in accordance with Section 4J of the Apartment Design Guide are to be considered to meet the ventilation requirements of the Building Code of Australia **for north facing bedrooms on the northern building only**.

It is noted that all north facing apartments located on the northern building of the development are dual aspect, meaning there are ventilation openings to the east and western sides of the building, which may satisfy the ventilation requirements for these apartments. Supplementary advice should be sought to determine if ventilation requirements of the north facing bedrooms on the northern building will be satisfied. Alternatively, an acoustically treated ventilation system, such as acoustic louvres or and acoustically treated ceiling plenum may be used.

[1] Ryan, Lanchester and Pugh, 2011

Further design details are to be investigated during the detailed design phase of the development.

Internal noise levels with windows opened can be met in all other apartments and rooms within the development without additional treatment.

5.1.3 Vibration and Ground-Borne Noise

Airborne noise from rail operations dominates the northern facade of the development. The southern facade of the development is somewhat shielded from airborne noise due to the orientation of the proposed building. The southern building is well shielded from airborne rail operations by the rail tunnel, existing buildings and the proposed northern building. As ground-borne noise is normally only noticeable in areas that are well protected from airborne noise, an assessment has been undertaken of southern and eastern facing apartments of the northern building (Level 2) and apartments located within the southern building deemed shielded from airborne rail noise (Level 5) of the development.

The internal ground-borne noise level from train pass-bys within units located are presented in Table 12 and are found to be compliant. No further vibration isolation treatment is required.

6 Noise Emission Assessment

There are no specific noise emission goals for the site set out in the Willoughby Council's DCP. In the absence of this, the EPA Noise Policy for Industry is the most commonly adopted noise emission guideline for plant and equipment.

For commercial/retail/cafe tenancies, if proposed:

- In the event there was a retail tenant proposing a licenced premises, patron/music noise would be subject to Office of Liquor and Gaming acoustic criteria.

6.1 Criteria - EPA Noise Policy for Industry

The NSW Environment Protection Authority (EPA) sets out noise criteria in its Noise Policy for Industry (NPfI) to control the noise emission from industrial sources.

The NPfI sets noise emission goals based on two sets of acoustic criteria:

- Intrusive criteria and
- Amenity Criteria

6.1.1 Intrusiveness Criteria

These criteria require that industrial noise does not exceed the background noise level by an excessive margin, preventing significant changes in the noise characteristic pertinent to the development site and surrounds. This is commonly referred to as the 'background plus 5' criterion. That is, the noise level from new industrial development, assessed in periods of 15 minutes, should not exceed the existing background noise level (measured in the absence of that development) by more than 5dB(A).

Based on the background noise levels presented in section 3, the intrusiveness criteria are as follows:

Table 14 - Noise Policy for Industry - Intrusiveness Noise Criteria

Receiver	Time of day	Rating Background Noise Level (dB(A)L_{90})	Intrusiveness Noise Criteria (dB(A)$L_{eq(15min)}$)
Residences	Day	47	52
	Evening	47	52
	Night	42	48

6.1.2 Amenity and Project Amenity Criteria

Amenity criteria serve primarily to avoid "noise creep" – for example, if a number of industrial noise sources are permitted to increase the background noise level by 5dB(A) (as permitted by the Intrusiveness Criteria) there would be a point where the cumulative noise level is unacceptable.

A limit on the ultimate acceptable noise level is therefore included in the NPfI as a way of ensuring that cumulative noise impact from industrial growth is curtailed. This limit is set using the Amenity and Project Amenity Criteria. These criteria are determined with reference to ambient noise conditions and the land use of nearby development (residential, commercial, industrial etc).

The Amenity Noise Level is found in table 2.2 of the Noise Policy for Industry.

It is the *Project* Amenity Criteria that sets a site-specific noise emission goal for a development. The Project Amenity Noise Level is typically 2dB(A) below the Amenity Noise level unless there is an exception (discussed in more detail after the following table).

Table 15 - Noise Policy for Industry - Amenity and Project Amenity Noise Levels

Receiver	Noise amenity area	Time of day	Amenity Noise Level dB(A)$L_{eq(Period)}$	Project (Site Specific) Amenity Noise Level dB(A)$L_{eq(15min)}$
Residential	Urban	Day	55	53
		Evening	45	43
		Night	40	38
Place of Worship				

Notes:

- Daytime 7.00 am to 6.00 pm; Evening 6.00 pm to 10.00 pm; Night-time 10.00 pm to 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.
- The LAeq index corresponds to the level of noise equivalent to the energy average of noise levels occurring over a measurement period.
- The Project Amenity Noise Level is typically 2dB(A) below Recommended Amenity Noise Level, unless there is an exception, as detailed below.
- * Project Amenity noise goal adjusted given high traffic noise levels (Traffic Noise Level – 15dB(A))

6.1.3 Maximum noise level event assessment

The potential for sleep disturbance from maximum noise level events, from the proposed development, needs to be considered. Section 2.5 of the NPfI provides sleep disturbance trigger levels, summarised as shown in the table below.

Table 16: Sleep disturbance criteria

Receiver	Sleep Disturbance Trigger Levels, 10:00pm to 7:00am	
	$L_{Aeq,\ 15\ minute}$	L_{AFmax}
All residential	Greater than 40dB(A) or RBL plus 5dB, whichever is the greater	52dB(A) or RBL plus 15dB, whichever is the greater

On applying the on-site measured background noise levels, the triggers are as follows:

Table 17: Sleep disturbance noise trigger levels

Receiver	Sleep Disturbance Trigger Levels, 10:00pm to 7:00am	
	$L_{Aeq,\ 15\ minute}$	L_{AFmax}
Residential premises surrounding site	47dB(A)	58dB(A)

Where noise from the proposed development is predicted to exceed the sleep disturbance trigger levels above, a more detailed noise level assessment is required. The detailed assessment is required to cover the maximum noise level, the extent to which the maximum noise level exceeds the RBL, and the frequency of events occurring during the nighttime.

6.1.4 Summary of Noise Emission Requirements

Taking the more stringent of the intrusiveness and amenity criteria, and also incorporating the sleep disturbance criteria, noise emission goals become as set out below.

Table 17: Summary of Noise Emission Requirements

Location	Noise Trigger Levels – dB(A)$L_{eq(15min)}$		
	Day (7am-6pm)	**Evening (6pm-10pm)**	**Night (10pm-7am)**
Residential	53dB(A)$L_{eq(15min)}$	43dB(A)$L_{eq(15min}$	38dB(A)$L_{eq(15min)}$ and 58dB(A)L_{Max}

6.2 Recommended noise control measures

As details of mechanical plant will be finalised at Detailed Design phase (post DA) phase, the following in-principal recommendations are provided:

6.2.1 Cafés/Restaurants

The primary noise generation associated with a café will be from use of outdoor dining areas. We assume that cafes will lodge their own DA for use of their tenancy. This would typically include an acoustic report that examines proposed patron numbers and times of use of outdoor areas and assesses the noise against the Nosie Policy for Industry or the Office of Liquor and Gaming noise goals (if licenced).

The DA for use acoustic report should propose limits on times or use/patron numbers and acoustic treatments (awnings in outdoor areas, acoustic linings in indoor areas) to ensure that noise to apartment above and outside of the site comply with the legislation identified above.

6.2.2 Loading Dock

Loading docks create a risk of structure borne noise transmission to apartments above, in particular use of pallet jacks and stock trolleys that have nylon wheels or similar. This is particularly a risk at sites where a supermarket is proposed, given their will be a high volume of pallet jack use, and often late at night.

There is no supermarket retail proposed at the above site. As such, loading dock usage would be relatively low and unlikely to be necessary between 10pm and 7am.

The loading dock is located well within the building at Basement 01 Level and does not incorporate a turntable. The loading dock can accommodate 1 small rigid truck and 1 medium rigid truck. It is also the garbage collection point.

Given the location of the loading dock and provided that loading dock use does not occur between 10pm and 7am, there should be no further acoustic treatment required to the loading dock.

6.2.3 Plant and Equipment

Noise from plant and equipment is assessed with reference to the EPA Noise Policy for Industry (criteria as outlined in Section 6.1.4.

The details of the mechanical plant and equipment servicing this development are yet to be finalised at this stage of the development. Therefore, the noise impacts from mechanical plant and equipment should be undertaken during the Detailed Design stage of the project.

However, we note:

- It is likely that primary plant and equipment items consist of car park/basement ventilation plant, stair pressure fans, lobby supply utilities spaces fans and air-conditioner condensers.

- Major fans located either in the basement or roof level such as car park ventilation (typically 75dB(A) at 3m), and utilities fans (typically 65dB(A) at 3m distance) are likely to require induct acoustic treatment between fan and external intake/discharge. This will consist of lined ducting or acoustic attenuators. The extent of treatment will depend on fan selection and position relative to the nearest apartment.

- Openings on the L31 rooftop plantrooms are to be avoided on the façade facing the south building of the site.

- Condenser units are proposed to be a combination of spine mounted units that will serve multiple apartments along with some roof top units. The proposed locations of the spine mounted units on each floor are well shielded from apartments, however, may still require some acoustic treatment to each condenser space given the reverberant nature of the space between the two buildings. There are no significant noise issues anticipated with the roof mounted units. Acoustic screening would easily provide the required attenuation for the units.

6.2.4 Noise from Pool area and terraces (Level 2 -4)

The primary impact of the communal open space on Level 2 to 4 will be to future residents within the development itself. Noise also has the potential to impact existing and future residential receivers surrounding the site.

A 1.8m balustrade is proposed around the pool area. The balustrade is to be glazed or a combination of masonry and glazing. The balustrade is to be installed without gaps between the panelling to also act as a noise barrier.

Typically, use of communal open space will be regulated by building management and strata by-laws to protect residents of that development. Strata by-laws and building management guidelines are to set the following restrictions on the pool area:

- Set limits on times of use of the communal spaces and amenities to day light hours (typically 7am-sunset).

- Prohibit parties and use of amplified music.

- Prohibit anti-social behaviour (shouting etc).

In addition, a management plan is to be developed for the common outdoor areas in consultation with an acoustic consultant that considers potential noise impacts on apartments and neighbouring receivers and set appropriate responses in dealing with potential noise issues arising from the use of the common outdoor areas.

7 Internal sound insulation

As a minimum requirement, walls and floors and separation of services shall comply with the National Construction Code - Building Code of Australia 2022 (BCA).

The development is mixed use, with the residences being Class 2, residential.

7.1 NCC BCA 2022 - Class 2

The National Construction Code Series (NCC) 2022 - Volume 1, Building Code of Australia sets out the following acoustic provisions for Class 2 buildings:

F7D3 Determination of airborne sound insulation ratings

A form of construction required to have an airborne sound insulation rating must –

a. have the required value for weighted sound reduction index (Rw) or weighted sound reduction index with spectrum adaptation term (Rw + Ctr) determined in accordance with AS/NZS 1276.1 or ISO 717.1 using results from laboratory measurements; or

b. comply with Specification 28.

F7D4 Determination of impact sound insulation ratings

1) A floor in a building required to have an impact sound insulation rating must –

a) have the required value for weighted normalised impact sound pressure level (Ln,w) determined in accordance with AS/ISO 717.2 using results from laboratory measurements; or

b) comply with Specification 28

2) A wall in a building required to have an impact sound insulation rating must –

a) for a Class 2 or 3 building be of discontinuous construction;

3) For the purposes of this part, discontinuous construction means a wall having a minimum 20 mm cavity between 2 separate leaves, and

a) for masonry, where wall ties are required to connect leaves, the ties are of the resilient type; and

b) for other than masonry, there is no mechanical linkage between leaves except at the periphery.

F7D5 Sound insulation rating of floors

1) A floor in a Class 2 or 3 building must have an Rw + Ctr (airborne) not less than 50 and an Ln,w (impact) not more than 62 if it separates –

a) sole-occupancy units; or

b) a sole-occupancy unit from a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification.

F7D6 Sound insulation rating of walls

1) A wall in a Class 2 or 3 building must –

a) have an Rw + Ctr (airborne) not less than 50, if it separates sole-occupancy units; and

b) have an Rw (airborne) not less than 50, if it separates a sole-occupancy unit from a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification; and

c) comply with F7D4(2) if it separates:

(i) a bathroom, sanitary compartment, laundry or kitchen in one sole-occupancy unit from a habitable room (other than a kitchen) in an adjoining unit; or

(ii) a sole-occupancy unit from a plant room or lift shaft.

2) A door may be incorporated in a wall in a Class 2 or 3 building that separates a sole-occupancy unit from a stairway, public corridor, public lobby or the like, provided the door assembly has an Rw not less than 30.

5) Where a wall required to have sound insulation has a floor above, the wall must continue to –

a) the underside of the floor above; or

b) a ceiling that provides the sound insulation required for the wall.

F7D7 Sound insulation rating of internal services

1) If a duct or soil, waste or water supply pipe, including a duct or pipe that is located in a wall or floor cavity, serves or passes through more than one sole-occupancy unit, the duct or pipe must be separated from the rooms of any sole-occupancy unit by construction with an Rw+Ctr (airborne) not less than –

a) 40 if the adjacent room is a habitable room (other than a kitchen); or

b) 25 if the adjacent room is a kitchen or non-habitable room.

2)If a storm water pipe passes through a sole-occupancy unit it must be separated in accordance with (1)(a) and (b).

F7D8 Sound isolation of pumps

A flexible coupling must be used at the point of connection between the service pipes in a building and any circulating or other pump.

8 Construction Noise and Vibration Assessment

A detailed Demolition, Excavation and Construction Management Plan is to be prepared for the site prior to the issue of Construction Certificate detailing the site-specific plant and equipment to be used, expected periods of construction, and noise and vibration management treatments and procedures to be implemented.

8.1 Environmental Protection Authority's Construction Noise Guidelines

The Environmental Protection Authority (EPA) released its Interim Construction Noise Guideline (ICNG) in 2009. This document is being referred to as EPA's standard policy for assessing construction noise on new projects.

The key components of the ICNG that can be incorporated into this assessment include:

1. Use of LAeq as the descriptor for measuring and assessing construction noise.

In recent years NSW noise policies including EPA's NSW Industrial Noise Policy (INP) and the NSW Environmental Criteria for Road Traffic Noise (ECRTN) have moved to the primary use of L_{Aeq} over any other descriptor. As an energy average, L_{Aeq} provides ease of use when measuring or calculating noise levels since a full statistical analysis is not required as when using, for example, the L_{A10} descriptor.

Consistent with the latest guideline (ICNG) the use of L_{Aeq} as the key descriptor for measuring and assessing construction noise may follow a 'best practice' approach.

2. Application of feasible and reasonable noise mitigation measures

As stated in the ICNG, a noise mitigation measure is feasible if it is capable of being put into practice and is practical to build given the project constraints.

Selecting reasonable mitigation measures from those that are feasible involves making a judgement to determine whether the overall noise benefit outweighs the overall social, economic and environmental effects, including the cost of the measure.

3. Quantitative and qualitative assessment

The ICNG provides two methods for assessment of construction noise, being either a quantitative or a qualitative assessment.

A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement and prediction of noise levels, and assessment against set criteria.

A qualitative assessment is recommended for small projects with a short-term duration where works are not likely to affect an individual or sensitive land use for more than three weeks in total. It focuses on

minimising noise disturbance through the implementation of feasible and reasonable work practices, and community notification.

Given the significant scale of the construction works proposed for this Project, a quantitative assessment is carried out herein, consistent with the ICNG's requirements.

4. Management Levels

Residences

Table 18 below (reproduced from Table 2 of the ICNG) sets out the noise management levels and how they are to be applied. The guideline intends to provide respite for residents exposed to excessive construction noise outside the recommended standard hours whilst allowing construction during the recommended standard hours without undue constraints.

The rating background level (RBL) is used when determining the management level. The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours).

Table 18: Noise at residences using quantitative assessment

Time of Day	Management Level $L_{Aeq\ (15\ min)}$*	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 + 10dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured $L_{Aeq\ (15\ min)}$ 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 75dB(A)	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: 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 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 + 5dB(A)	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2.

* Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5m 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.

Sensitive Land Use

Table 19 below (reproduced from Table 2 of the ICNG) sets out the noise management levels for various sensitive land use developments.

Table 19: Noise at other sensitive land uses using quantitative assessment

Land use	Management level, $L_{Aeq\ (15\ min)}$ – applies when land use is being utilised
Classrooms at schools and other educational institutions	Internal noise level 45 dB(A)
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Places of worship	Internal noise level 45 dB(A)
Active recreation areas	External noise level 65 dB(A)
Passive recreation areas	External noise level 60 dB(A)
Community centres	Depends on the intended use of the centre. Refer to the 'maximum' internal levels in AS2107 for specific uses.

8.2 Criteria at established receivers

Table 20 presents the construction noise management levels established for the nearest noise sensitive residential receivers based on the noise monitoring undertaken in the vicinity of the site. Based on distances to receivers, the likely most impacted receivers will be the existing residents immediately surrounding the proposed development site. The table below is not an exhaustive assessment of residents in the area but establishes the likely noise impacts and requirements for amelioration treatment during construction. A full assessment will be undertaken at the Construction Certificate stage of the project.

Table 20: Construction noise management levels at residential receivers, dB(A)

Address	Day L_{A90} rating background level (RBL)	Day noise management level $L_{Aeq(15min)}$
B2E Cambridge Apartments (west of site)	47	57
54 Anderson Street, Chatswood (north of site)	47	57
25 Daisy Street, Chatswood (east of site)	47	57
44 Anderson Street, Chatswood (south or site)	47	57

8.2.1 Construction hours

The proposed construction works are expected to be undertaken during standard construction hours, as follows:

Mondays to Fridays:	7:00am to 6:00pm
Saturdays:	8:00am to 1:00pm
Sundays & Public Holidays:	No work performed

8.3 Construction noise assessment

A preliminary construction noise assessment has been undertaken with the highest expected sound power levels for plant and equipment typically used for excavation and construction.

Noise levels at any receiver locations resulting from construction works would depend on the location of the receiver with respect to the area of construction, shielding from intervening topography and structures, and the type and duration of construction being undertaken. Furthermore, noise levels at receivers would vary significantly over the total construction program due to the transient nature and large range of plant and equipment that could be used.

Table 21 presents noise levels likely to be experienced at the nearby affected receivers based on the construction activities, and plant and equipment associated with the proposed development, where the range represents the noise levels from the plant item being at a location furthest away and at a location closest to each receiver location. Noise levels were calculated taking into consideration attenuation due to distance between the construction works and the receiver locations and any intervening structures.

Table 21: Predicted $L_{Aeq(15min)}$ noise levels for typical construction plant, dB(A) – no treatment

Plant item	Plant description	Predicted $L_{eq(15min)}$ construction noise levels at receiver location (external)				
		B2E Cambridge Apartments (west of site)	**54 Anderson Street, Chatswood (north of site)**	**25 Daisy Street, Chatswood (east of site)**	**44 Anderson Street, Chatswood (south or site)**	**Place of worship – 20 Tulip Street, Chatswood**
Noise Management Level		*57*	*57*	*57*	*57*	*65 external -(derived from 45dB(A) internal)*
Demolition						
1.	Concrete saw	71-93	69-84	70-80	69-80	70-80 (50-60 internal)
2.	Excavator mounted hydraulic breaker	71-93	69-84	70-80	69-80	70-80 (50-60 internal)

Plant item	Plant description	Predicted $L_{eq(15min)}$ construction noise levels at receiver location (external)				
		B2E Cambridge Apartments (west of site)	54 Anderson Street, Chatswood (north of site)	25 Daisy Street, Chatswood (east of site)	44 Anderson Street, Chatswood (south or site)	Place of worship – 20 Tulip Street, Chatswood
Excavation						
3.	Rock breaker	71-93	69-84	70-80	69-80	70-80 (50-60 internal)
4.	Rock saw	71-93	69-84	70-80	69-80	70-80 (50-60 internal)
5.	40 tonne excavator with saw and hammer	71-93	69-84	70-80	69-80	70-80 (50-60 internal)
Construction						
6.	Mobile crane	66-88	64-79	65-75	64-75	65-75 (45-55 internal)
7.	Powered hand tools	66-88	64-79	65-75	64-75	65-75 (45-55 internal)
8.	Grinder	65-87	63-78	64-74	63-74	64-74 (44-54 internal)
9.	Truck – cement mixer	64-86	62-77	63-73	62-73	63-73 (43-53 internal)

Based on the predicted construction noise levels presented in the table above, the construction management levels will generally be exceeded when works are conducted at the closest proximity to the nominated receiver locations.

Furthermore, construction noise levels at all receivers are predicted to be greater than the highly noise affected level of 75dB(A) for the operation of the noisiest individual construction plant and equipment in close proximity.

In light of the predicted noise levels above, it is recommended that a feasible and reasonable approach towards noise management measures be applied to reduce noise levels as much as possible to manage the impact from construction noise.

Further details on construction noise mitigation and management measures are provided below.

8.4 General Construction Noise Control Methods

Implementation of noise control measures, such as those suggested in the Interim Construction Noise Guideline (ICNG) and Australian Standard 2436-1981 "Guide to Noise Control on Construction, Maintenance and Demolition Sites", are expected to reduce predicted construction noise levels. Reference to Australian Standard 2436-1981, Appendix E, Table E1 suggests possible remedies and alternatives to reduce noise emission levels from typical construction equipment. Table E2 in Appendix E presents typical examples of noise reductions achievable after treatment of various noise sources. Table E3 in Appendix E presents the relative effectiveness of various forms of noise control treatment.

Table 22: Relative Effectiveness of Various Forms of Noise Control, dB(A) below presents noise control methods, practical examples and expected noise reductions according to AS2436 and according to Renzo Tonin & Associates' opinion based on experience with past projects.

Table 22: Relative Effectiveness of Various Forms of Noise Control, dB(A)

Noise Control Method	Practical Examples	Typical noise reduction possible in practice		Maximum noise reduction possible in practice	
		AS 2436	Renzo Tonin & Assoc.	AS 2436	Renzo Tonin & Assoc.
Screening	Acoustic barriers such as earth mounds, temporary or permanent noise barriers	7 to 10	5 to 10	15	15
Acoustic Enclosures	Engine casing lagged with acoustic insulation and plywood	15 to 30	10 to 20	50	30
Engine Silencing	Residential class mufflers	5 to 10	5 to 10	20	20
Substitution by alternative process	Use electric motors in preference to diesel or petrol	15 to 25	15 to 25	60	40

The Renzo Tonin & Associates' listed noise reductions are conservatively low and should be referred to in preference to those of AS2436, for this assessment.

Table 23: Noise Control Measures for Expected Construction Plant below identifies possible noise control measures which are applicable on the construction plant likely to be used on site.

Table 23: Noise Control Measures for Expected Construction Plant

Plant Description	Screening	Acoustic Enclosures	Silencing	Alternative Process
Concrete Saw	✔	✔	x	x
Jack hammers	✔	x	✔	x
Mobile Crane	✔	✔	✔	x
Front End Loader	✔	x	✔	x
Pneumatic Hand Tools (general)	✔	✔	✔	✔
Bulldozer	✔	x	✔	x
Tracked Excavator	✔	x	✔	x
Concrete Trucks	✔	x	✔	x
Delivery Trucks	✔	x	✔	x
Dump Trucks	✔	x	✔	x
Truck (> 20 tonne)	✔	x	✔	x
Welders	✔	✔	x	x
Cherry Picker	✔	x	✔	x
Concrete Pump	✔	✔	✔	✔
Power Generator	✔	✔	✔	x
Light commercial vehicles	✔	x	✔	x
Silenced Air Compressor	✔	✔	✔	✔

To ensure efficient noise attenuation performance is achieved using any of the methods listed above, it is recommended acoustic engineers work closely with the construction contractors and carry out preliminary testing prior to commencement of works.

In addition to physical noise controls, the following general noise management measures should be followed:

- Plant and equipment should be properly maintained
- Provide special attention to the use and maintenance of 'noise control' or 'silencing' kits fitted to machines to ensure they perform as intended
- Strategically position plant on site to reduce the emission of noise to the surrounding neighbourhood and to site personnel
- As much as possible, non-percussive demolition equipment (dozer with bucket,/saw of rock ripper) should be used in place of percussive equipment (dozer with hydraulic hammer).
- Use of electric cranes (as opposed to diesel) and bored piling (as opposed to vibrated) whenever feasible.
- Avoid any unnecessary noise when carrying out manual operations and when operating plant
- Any equipment not in use for extended periods during construction work should be switched off
- Plant used intermittently to be throttled down or shut down when not in use where practicable
- Notification to immediate surrounding residents (both single dwellings and apartment buildings) should be provided detailed estimated duration of demolition, excavation and construction.
- Noise compliance monitoring for all major equipment and activities on site should be undertaken prior to their commencement of work on site.
- In addition to the noise mitigation measures outlined above, a management procedure would need to be put in place to deal with noise complaints that may arise from construction activities. Each complaint would need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits. The person selected to liaise with the community must be adequately trained and experienced in such matters. **Complaints** - Owners and occupants of nearby affected properties are to be informed by direct mail of a direct telephone line and contact person where any noise and/or vibration complaints are to be reported.
- Good relations with people living and working in the vicinity of a construction site should be established at the beginning of a project and be maintained throughout the project, as this is of paramount importance. Keeping people informed of progress and taking complaints

seriously and dealing with them expeditiously is critical. The person selected to liaise with the community should be adequately trained and experienced in such matters.

8.5 Vibration criteria

Construction vibration is associated with three main types of impact:

- disturbance to building occupants;
- potential damage to buildings; and
- potential damage to sensitive equipment in a building.

Generally, if disturbance to building occupants is controlled, there is limited potential for structural damage to buildings.

Vibration amplitude may be measured as displacement, velocity, or acceleration.

- Displacement (x) measurement is the distance or amplitude displaced from a resting position. The SI unit for distance is the meter (m), although common industrial standards include mm.
- Velocity ($v=\Delta x/\Delta t$) is the rate of change of displacement with respect to change in time. The SI unit for velocity is meters per second (m/s), although common industrial standards include mm/s. The Peak Particle Velocity (PPV) is the greatest instantaneous particle velocity during a given time interval. If measurements are made in 3-axis (x, y, and z) then the resultant PPV is the vector sum (i.e. the square root of the summed squares of the maximum velocities) regardless of when in the time history those occur.
- Acceleration ($a=\Delta v/\Delta t$) is the rate of change of velocity with respect to change in time. The SI unit for acceleration is meters per second squared (m/s2). Construction vibration goals are summarised below.

Construction vibration goals are summarised below.

8.5.1 Disturbance to buildings occupants

Assessment of potential disturbance from vibration on human occupants of buildings is made in accordance with the DECC '*Assessing Vibration; a technical guideline*' (DECC, 2006). The guideline provides criteria which are based on the British Standard BS 6472-1992 '*Evaluation of human exposure to vibration in buildings (1-80Hz)*'. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent'. Table 24 provides definitions and examples of each type of vibration.

Table 24: Types of vibration

Type of vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time)	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
Impulsive vibration	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent vibration	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria.

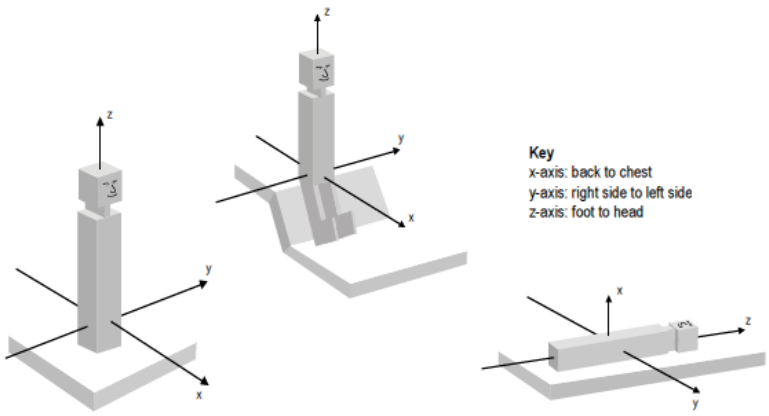
Source: Assessing Vibration; a technical guideline, Department of Environment & Climate Change, 2006

The vibration criteria are defined as a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

> *'Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472).'*

When applying the criteria, it is important to note that the three directional axes are referenced to the human body, i.e. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). Vibration may enter the body along different orthogonal axes and affect it in different ways. Therefore, application of the criteria requires consideration of the position of the people being assessed, as illustrated in Figure 2. For example, vibration measured in the horizontal plane is compared with x- and y-axis criteria if the concern is for people in an upright position, or with the y- and z- axis criteria if the concern is for people in the lateral position.

Figure 2 – Orthogonal axes for human exposure to vibration



The preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and the relevant values are reproduced in Table 25.

Table 25: Preferred and maximum levels for human comfort

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
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
Impulsive vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
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

Notes: 4. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

The acceptable vibration dose values (VDV) for intermittent vibration are defined in Table 2.4 of the guideline and are reproduced in Table 26

Table 26: Acceptable vibration dose values for intermittent vibration ($m/s^{1.75}$)

Location	Daytime[1]		Night-time[1]	
	Preferred value	Maximum value	Preferred value	Maximum value
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

Notes: 5. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am

8.5.2 Building damage

Potential structural damage of buildings as a result of vibration is typically managed by ensuring vibration induced into the structure does not exceed certain limits and standards, such as British Standard 7385 Part 2 and German Standard DIN4150-3. Currently there is no existing Australian Standard for assessment of structural building damage caused by vibration energy.

Within British Standard 7385 Part 1: 1990, different levels of structural damage are defined:

- *Cosmetic - The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition the formation of hairline cracks in mortar joints of brick/concrete block construction.*
- *Minor - The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*

- *Major - Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

The vibration limits in Table 1 of British Standard 7385 Part 2 (1993) are for the protection against cosmetic damage, however guidance on limits for minor and major damage is provided in Section 7.4.2 of the Standard:

> *"7.4.2 Guide values for transient vibration relating to cosmetic damage*
>
> *Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1. In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.*
>
> *Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values."*

Within DIN4150-3, damage is defined as "*any permanent effect of vibration that reduces the serviceability of a structure or one of its components*" (p.2). The Standard also outlines:

> *"that for structures as in lines 2 and 3 of Table 1, the serviceability is considered to have been reduced if*
>
> *cracks form in plastered surfaces of walls;*
>
> *existing cracks in the building are enlarged;*
>
> *partitions become detached from loadbearing walls or floors.*
>
> *These effects are deemed 'minor damage. " (DIN4150.3, 1990, p.3)"*

While the DIN Standard defines the above damage as 'minor', based on the definitions provided in BS7385, the DIN standard is considered to deal with cosmetic issues rather than major structural failures.

British Standard

British Standard 7385: Part 2 '*Evaluation and measurement of vibration in buildings*', can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur.

The cosmetic damage levels set by BS 7385 are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular building types. Damage comprises minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement

render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls. 'Minor' damage is considered possible at vibration magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

BS7385 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4Hz to 250Hz, being the range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The values set in the Standard relate to transient vibrations and to low-rise buildings. Continuous vibration can give rise to dynamic magnifications due to resonances and may need to be reduced by up to 50%.Table 27 sets out the BS7385 criteria for cosmetic, minor and major damage.

Table 27: BS 7385 structural damage criteria

Group	Type of structure	Damage level	Peak component particle velocity1, mm/s		
			4Hz to 15Hz	15Hz to 40Hz	40Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic	50		
		Minor2	100		
		Major2	200		
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50
		Minor2	30 to 40	40 to 100	100
		Major*2	60 to 80	80 to 200	200

Notes: 6. Peak Component Particle Velocity is the maximum Peak particle velocity in any one direction (x, y, z) as measured by a tri-axial vibration transducer.

7. Minor and major damage criteria established based on British Standard 7385 Part 2 (1993) Section 7.4.2

German Standard

German Standard DIN 4150 - Part 3 '*Structural vibration in buildings - Effects on Structure*' (DIN 4150-3), also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are generally recognised to be conservative.

DIN 4150-3 presents the recommended maximum limits over a range of frequencies (Hz), measured in any direction, and at the foundation or in the plane of the uppermost floor of a building or structure. The vibration limits increase as the frequency content of the vibration increases. The criteria applicable to the nearest receivers are presented in Table 28.

Table 28: DIN 4150-3 structural damage criteria

Group	Type of structure	Vibration velocity, mm/s			
		At foundation at frequency of			Plane of floor uppermost storey
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40

Group	Type of structure	Vibration velocity, mm/s			
		At foundation at frequency of			Plane of floor uppermost storey
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz	All frequencies
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15

8.6 Recommended minimum buffer distances

The pattern of vibration radiation is very different to the pattern of airborne noise radiation, and is very site specific as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver. Accordingly, based on a database containing vibration measurements from past projects and library information, Table 29 below presents the recommended minimum working distances for high vibration generating plant.

Table 29: Recommended minimum working distances for vibration intensive plant, m

Plant item	Rating / description	Minimum working distance	
		Cosmetic damage	Human response
Excavator[1]	<=30 Tonne (travelling/ digging)	10	15
Small hydraulic hammer[2]	300kg (5-12 tonne excavator)	2	7
Medium hydraulic hammer[2]	900kg (12-18 tonne excavator)	7	23
Large hydraulic hammer[2]	1600kg (18-34 tonne excavator)	22	73
Pile boring[2]	≤ 800 mm	2 (nominal)	N/A
Pneumatic jack hammer	Hand held	1	Avoid contact with structure
Truck movements[2]	Dump trucks, watercarts, tippers	-	10 m

Notes: 8. TCA Construction Noise Strategy (Rail Projects) November 2011
9. Renzo Tonin & Associates project files, databases & library

Site specific buffer distances should be determined once vibration emission levels are measured from each plant item prior to the commencement of their regular use on site. Where construction activity occurs in close proximity to sensitive receivers, minimum buffer distances for building damage should be determined by site measurements and maintained.

8.6.1 Damage to buried services

Section 5.3 of DIN 4150-3:2016 also sets out guideline values for vibration velocity to be used when evaluating the effects of vibration on buried pipework. These values, which apply at the wall of the pipe, are reproduced, and presented in Table 5 7 below.

Table 24: DIN 4150-3:1999 Guideline values for vibration velocity to be used when evaluating the effects of short-term vibration on buried pipework

Line	Pipe Material	Guideline values for vibration velocity measured on the pipe, mm/s
1	Steel (including welded pipes)	100
2	Vitrified clay, concrete, reinforced concrete, prestressed concrete, metal (with or without flange)	80
3	Masonry, plastics	50

For long-term vibration the guideline levels presented in Table should be halved.

Recommended vibration goals for electrical cables and telecommunication services such as fibre optic cables range from between 50 mm/s and 100 mm/s. It is noted however that although the cables may sustain these vibration levels, the services they are connected to, such as transformers and switch blocks, may not. It is recommended that should such equipment be encountered during the construction process an individual vibration assessment should be carried out. This may include a specific vibration impact statement addressing impact on the utility and consultation with the utility provider to confirm specific vibration requirements.

- *Noise impacts on residential development* – all activities are predicted to comply with the "Background + 10dB(A)" Noise Management Level. The only exception to this is a small exceedance is anticipated during use of an excavator mounted saw or hammer during the demolition/excavation phase.

- *Noise impact on places of worship.* There are potential exceedances of the Noise Management Level to the church adjacent to the site when working near the eastern boundary of the site.

    - The degree of exceedance is generally small for the majority of works.

    - The degree of exceedance is more pronounced during use of heavy excavation equipment.

It is likely that reasonable and feasible noise mitigation will be required. This would typically be addressed in a Construction Noise and Vibration Management Plan, prepared at CC stage. Indicative management measures are detailed below.

8.6.2 Vibration assessment

8.6.2.1 Minimum working distances

The recommended minimum working distances for vibration intensive plant are presented below

Table 27: Recommended minimum working distances for vibration intensive equipment

Plant item	Minimum working distance, m					
	Cosmetic damage			Human disturbance		
	Commercial and industrial buildings1	Dwellings and similar structures1	Sensitive structures (e.g., heritage)1	Residences Day2	Offices	Workshops
Excavator w/Hydraulic Breaker, Vibratory Compactor	5	5	10	20	15	10

Notes: 1. Vibration limits referenced from DIN 4150 Structural Damage - Safe Limits for Short-term Building Vibration.
2. Daytime is 7 am to 10 pm;

Site specific buffer distances for vibration significant plant items must be measured on site where plant and equipment is likely to operate close to or within the minimum working distances for cosmetic damage.

The predicted noise levels presented above indicate:

Based on the location of neighbouring premises surrounding the site along with the excavation required for the construction of the proposed development, vibration monitoring may be required during the excavation and construction period. Human disturbance is also likely to impact the closest residential receivers.

With respect to vibration impact on the rail corridor - acceptable vibration impact on rail infrastructure would typically be indicated by Sydney Trains as approval stage. This is commonly approximately 15mm/s PPV, however must be confirmed. This is necessary to determine whether safe working distances or vibration monitoring would be required.

8.6.2.2 Vibration mitigation measures

The following vibration management measures are provided to minimise vibration impact from construction activities to the nearest affected receivers and to meet the relevant human comfort and building damage vibration limits:

- Dilapidation surveys should be conducted at residents to the north, south and west of the site along with a survey at the adjacent church. This will inform if any of the adjacent industrial development should be subject to vibration criteria different to those identified in section 8.2.2.2

- Where excavation in rock activity occurs within 15m of residential receivers, vibration monitoring is recommended during initial rock excavation to determine if vibration levels are such that they may cause building damage or excessive annoyance to occupants of the building.

- Where vibration is found to be excessive, management measures should be implemented to ensure vibration compliance is achieved. Management measures may include modification of

construction methods such as using smaller equipment, establishment of safe buffer zones as mentioned above, and if necessary, time restrictions for the most excessive vibration activities.

- Notification by letterbox drop would be carried out for all occupied buildings within 50m of the construction site. These measures are to address potential community concerns that perceived vibration may cause damage to property.

- A management procedure should be implemented to deal with vibration complaints. Each complaint should be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures should be put in place to mitigate future occurrences.

9 Conclusion

Renzo Tonin & Associates has completed a Noise and Vibration Impact Assessment of the proposed mixed-use shop top housing development at 44-52 Anderson Street, Chatswood.

The assessment includes investigation of noise impacts onto the site from nearby roads and rail/metro corridor and potential noise impacts from future mechanical plant servicing the development. The assessment has found that reasonable controls can be incorporated into the building design to comply with relevant standards (SEPP Transport and Infrastructure) for internal noise levels (to protect residents from road and rail noise). The site does not require vibration isolation to protect future residents from tactile vibration or excessive ground borne noise.

Noise emission goals for the operation of mechanical plant and equipment have been set in accordance with the Noise Policy for Industry. A preliminary assessment has been undertaken and conclude it is feasible that noise emissions from the subject site can comply with these criteria, subject to detailed design for Construction Certificate.

An examination of noise and vibration from the construction phase of the development is presented in Section 7.

In conclusion, the proposed site is capable of complying with all relevant acoustic criteria through means of standard acoustic treatment and management. All recommended mitigations in this report will be implemented as necessary through ongoing design development to ensure the applicable acoustic design requirements as satisfied.

APPENDIX A Glossary of terminology

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment period	The period in a day over which assessments are made.
Assessment point	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level (see below).
Decibel [dB]	The units that sound is measured in. 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 CBD mall 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 A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in 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.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.
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.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
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 L90 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.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B Criteria and design methodology

B.1 Noise intrusion criteria

B.1.1 State Environmental Planning Policy (Transport and Infrastructure) 2021

The NSW State Environmental Planning Policy (Transport and Infrastructure) 2021 commenced on 1 March 2022 and consolidated a number of former state environmental planning policies. The former State Environmental Planning Policy (Infrastructure) 2007 (known as 'ISEPP') has been integrated into "Chapter 2 Infrastructure" of the Transport and Infrastructure SEPP.

Chapter 2 of the Transport and Infrastructure SEPP aims to facilitate the effective delivery of infrastructure across NSW. The aim of the Chapter includes identifying the environmental assessment category into which different types of infrastructure and services development fall and identifying matters to be considered in the assessment of development adjacent to particular types of infrastructure.

Pertinent to noise assessment, the Transport and Infrastructure SEPP includes the following sections:

2.100 Impact of rail noise or vibration on non-rail development

5. This section applies to development for any of the following purposes that is on land in or adjacent to a rail corridor and that the consent authority considers is likely to be adversely affected by rail noise or vibration-

c. a building for residential use,

d. a place of public worship,

e. a hospital,

f. an educational establishment or centre-based child care facility.

6. Before determining a development application for development to which this section applies, the consent authority must take into consideration any guidelines that are issued by the Planning Secretary for the purposes of this clause and published in the Gazette.

7. If the development is for the purposes of residential accommodation, the consent authority must not grant consent to the development unless it is satisfied that appropriate measures will be taken to ensure that the following LAeq levels are not exceeded-

a. in any bedroom in the residential accommodation - 35 dB(A) at any time between 10 pm and 7am,

b. anywhere else in the residential accommodation (other than a garage, kitchen, bathroom or hallway) - 40 dB(A) at any time.

2.120 Impact of road noise or vibration on non-road development

1. *This section applies to development for any of the following purposes that is on land in or adjacent to the road corridor for a freeway, a tollway or a transitway or any other road with an annual average daily traffic volume of more than 20,000 vehicles (based on the traffic volume data published on the website of TfNSW) and that the consent authority considers is likely to be adversely affected by road noise or vibration:*
    a. *Residential accommodation,*
    b. *a place of public worship,*
    c. *a hospital,*
    d. *an educational establishment or centre-based child care facility.*
2. *Before determining a development application for development to which this section applies, the consent authority must take into consideration any guidelines that are issued by the Planning Secretary for the purposes of this clause and published in the Gazette.*
3. *If the development is for the purposes of residential accommodation, the consent authority must not grant consent to the development unless it is satisfied that appropriate measures will be taken to ensure that the following LAeq levels are not exceeded:*
    a. *in any bedroom in the residential accommodation - 35 dB(A) at any time between 10 pm and 7am,*
    b. *anywhere else in the residential accommodation (other than a garage, kitchen, bathroom or hallway) - 40 dB(A) at any time.*
    c. *(3A) Subsection (3) does not apply to a building to which State Environmental Planning Policy (Housing) 2021, Chapter 3, Part 7 applies.*
4. *In this section, "freeway", "tollway" and "transitway" have the same meanings as they have in the Roads Act 1993.*

B.1.2 Department of Planning publication 'Development near rail corridors and busy roads – Interim guideline'

To support the ISEPP (which is now consolidated into the Transport and Infrastructure SEPP), the NSW Department of Planning released the *Development near Rail Corridors and Busy Roads – Interim Guideline* (December 2008). The Guideline assists in the planning, design and assessment of developments in, or adjacent to, major transport corridors in terms of noise, vibration and air quality. While the Transport and Infrastructure SEPP applies only to roads with an AADT greater than 20,000 vehicles, the guideline is also recommended for other road traffic noise affected sites.

B.1.3 Clarification of Transport and Infrastructure SEPP noise limits

The Guideline clarifies the time period of measurement and assessment. Section 3.4 '*What Noise and Vibration Concepts are Relevant*' and Table 3.1 of Section 3.6.1 confirms that noise assessment is based over the following time periods:

- Daytime 7:00am - 10:00pm $L_{Aeq(15hr)}$
- Night-time 10:00pm - 7:00am $L_{Aeq(9hr)}$

The noise criteria nominated in the Transport and Infrastructure SEPP apply to internal noise levels with windows and doors closed. However as the preliminary noise assessment is based on measurements/predictions at external locations, equivalent external noise criteria has been established. The equivalent external noise criterion is used to determine which areas of the development may require acoustic treatment in order to meet the internal noise requirements of the Transport and Infrastructure SEPP. The equivalent external goals have been determined on the following basis:

- The Guideline states: "*If internal noise levels with windows or doors open exceed the criteria by more than 10dBA, the design of the ventilation for these rooms should be such that occupants can leave windows closed, if they so desire, and also to meet the ventilation requirements of the Building Code of Australia*." The internal criteria with windows open is therefore 10dB(A) above the criteria explicitly outlined in the Transport and Infrastructure SEPP.
- The generally accepted noise reduction through an open window from a free-field external position is 10dB(A). Windows/doors are assumed to be open no more than 5% of room floor area, in accordance with the Building Code of Australia (BCA) ventilation requirements.

Table 30 presents the Transport and Infrastructure SEPP internal noise criteria along with the equivalent external noise criteria for residential premises.

Table 30: Transport and Infrastructure SEPP noise criteria for new residential development

Room	Location	$L_{Aeq,\ 15hr}$ Day 7am – 10pm	$L_{Aeq\ 9hr}$ Night 10pm – 7am
Living rooms*	Internal, windows closed	40	40
	Internal, windows open	50	50
	External free-field (allowing windows to remain open)^	60	60
Bedrooms*	Internal, windows closed	40	35
	Internal, windows open	50	45
	External free-field (allowing windows to remain open)^	60	55

Notes: * Requisite for 20,000AADT Roads only under Transport and Infrastructure SEPP 2021.

^ Guideline states that where internal noise criteria are exceeded by more than 10dB(A) with windows open mechanical ventilation is required. External goals have been calculated on the basis of nominal 10dB(A) reduction through an open window to a free-field position. Windows open to 5% of floor area in accordance with the BCA 2011 requirements.

APPENDIX C Human Comfort Vibration Measurements

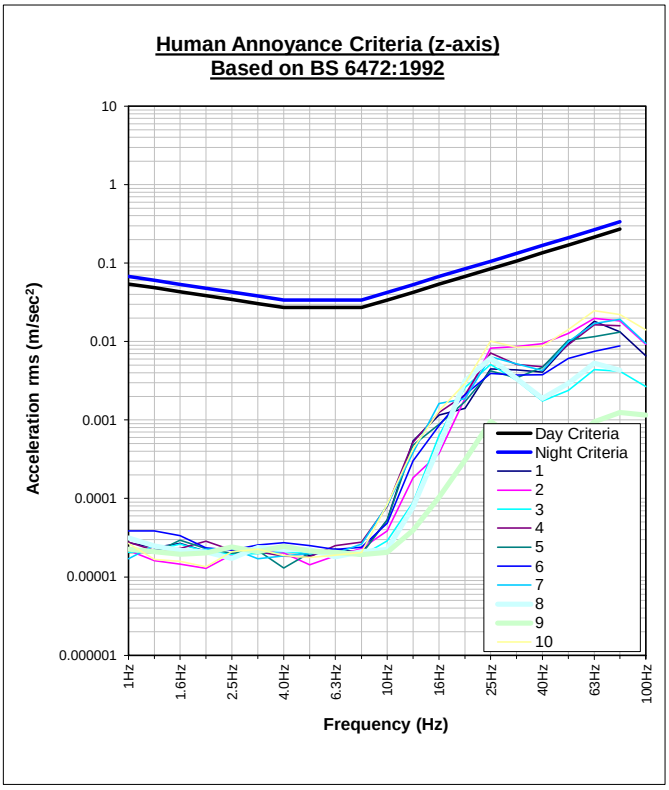
Renzo Tonin & Associates

Vibration Survey Results

Vibration Assessment for Human Annoyance BS6472-1992 & DECCW

Project No.:	TN935-01
Location:	44 Anderson Street, Chatswood
Source:	Trains and Metro

Assessment Location:	**Residential**	**Axis**	**Z**	**Total secs of Vib per Day (t):**	27,000
Type of Vibration:	**Intermittent**			**Total secs of Vib per Night (t):**	16,200



Legend													
Measurement		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Preferred DECCW Criterion**	**Maximum DECCW Criterion**
Acceleration rms (m/sec²)	**1Hz**	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
	1.25Hz	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
	1.6Hz	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
	2.0Hz	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
	2.5Hz	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
	3.15Hz	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
	4.0Hz	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
	5.0Hz	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
	6.3Hz	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
	8.0Hz	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000		
	10Hz	0.0001	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000	0.0001		
	12.5Hz	0.0005	0.0002	0.0001	0.0005	0.0005	0.0003	0.0004	0.0001	0.0000	0.0004		
	16Hz	0.0012	0.0004	0.0006	0.0013	0.0009	0.0008	0.0016	0.0005	0.0001	0.0013		
	20Hz	0.0014	0.0019	0.0026	0.0021	0.0017	0.0021	0.0019	0.0032	0.0003	0.0029		
	25Hz	0.0045	0.0082	0.0051	0.0071	0.0042	0.0039	0.0064	0.0062	0.0010	0.0101		
	31.5Hz	0.0044	0.0086	0.0032	0.0051	0.0034	0.0037	0.0052	0.0034	0.0006	0.0084		
	40Hz	0.0041	0.0094	0.0018	0.0048	0.0047	0.0038	0.0043	0.0019	0.0004	0.0087		
	50Hz	0.0094	0.0127	0.0024	0.0091	0.0105	0.0061	0.0099	0.0029	0.0005	0.0142		
	63Hz	0.0181	0.0197	0.0044	0.0163	0.0116	0.0075	0.0170	0.0053	0.0009	0.0247		
	80Hz	0.0134	0.0184	0.0042	0.0158	0.0132	0.0088	0.0193	0.0043	0.0012	0.0221		
	100Hz	0.0066	0.0092	0.0027	0.0105	0.0093	0.0055	0.0095	0.0032	0.0012	0.0140		
Weighted rms	**Day**												
	Night												
eVDV	**Day**	**0.03**	**0.04**	**0.02**	**0.03**	**0.03**	**0.02**	**0.03**	**0.02**	**0.00**	**0.05**	**0.20**	**0.40**
	Night	**0.01**	**0.02**	**0.01**	**0.02**	**0.01**	**0.01**	**0.02**	**0.01**	**0.00**	**0.02**	**0.13**	**0.26**

NOTE: Red indicates exceedence of Preferred DECCW Criterion

QTS-01 (rev 11) Human Annoyance Vibration Assessment BS6472-DEC - z axis

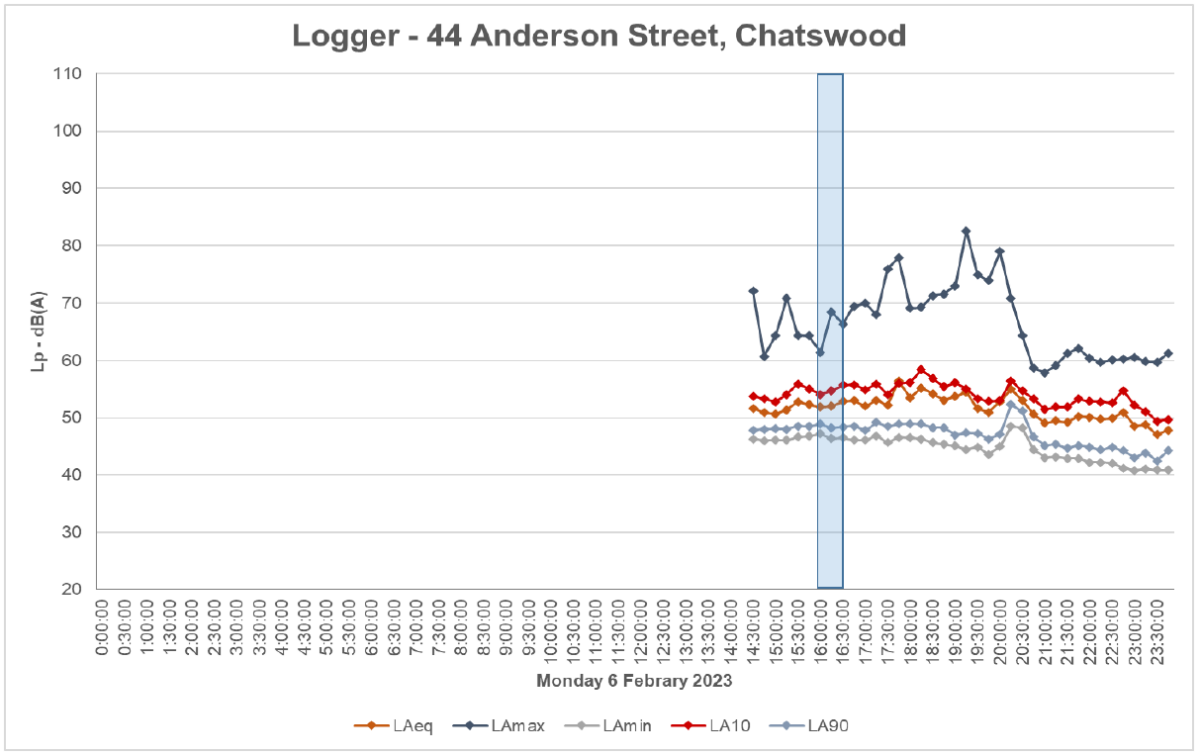
APPENDIX D Long Term Monitoring Locations and Results

Location 1: South Western corner of the site - Day Street (by Northrop Consulting Engineers)

Period: 6th February 2023 - 15th February 2023

Location 2: 2 Wilson Street, Chatswood - Pacific Highway boundary

Period: 9 October 2020 - 16 October 2020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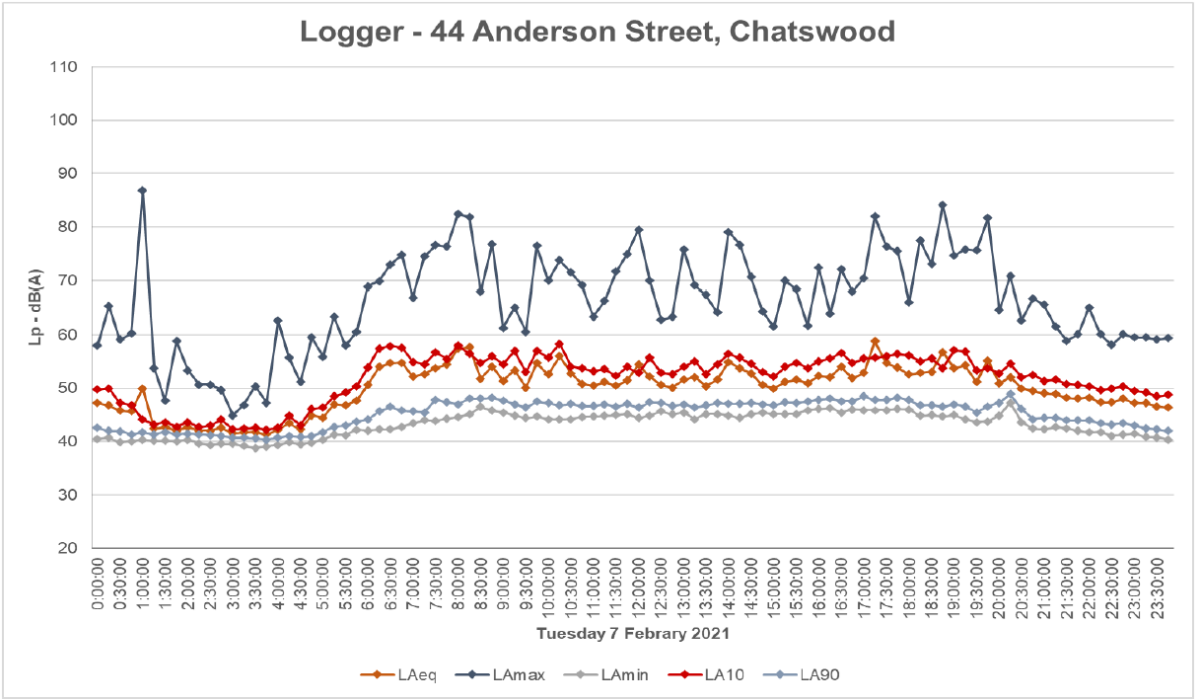
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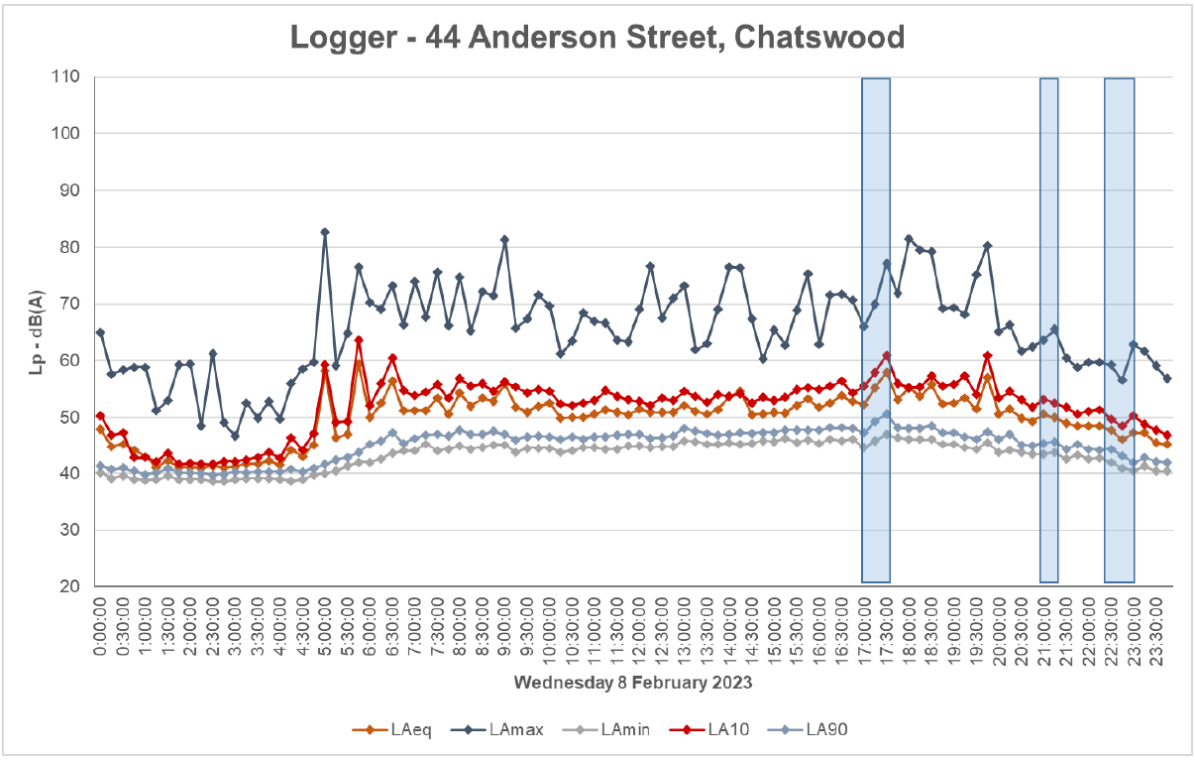
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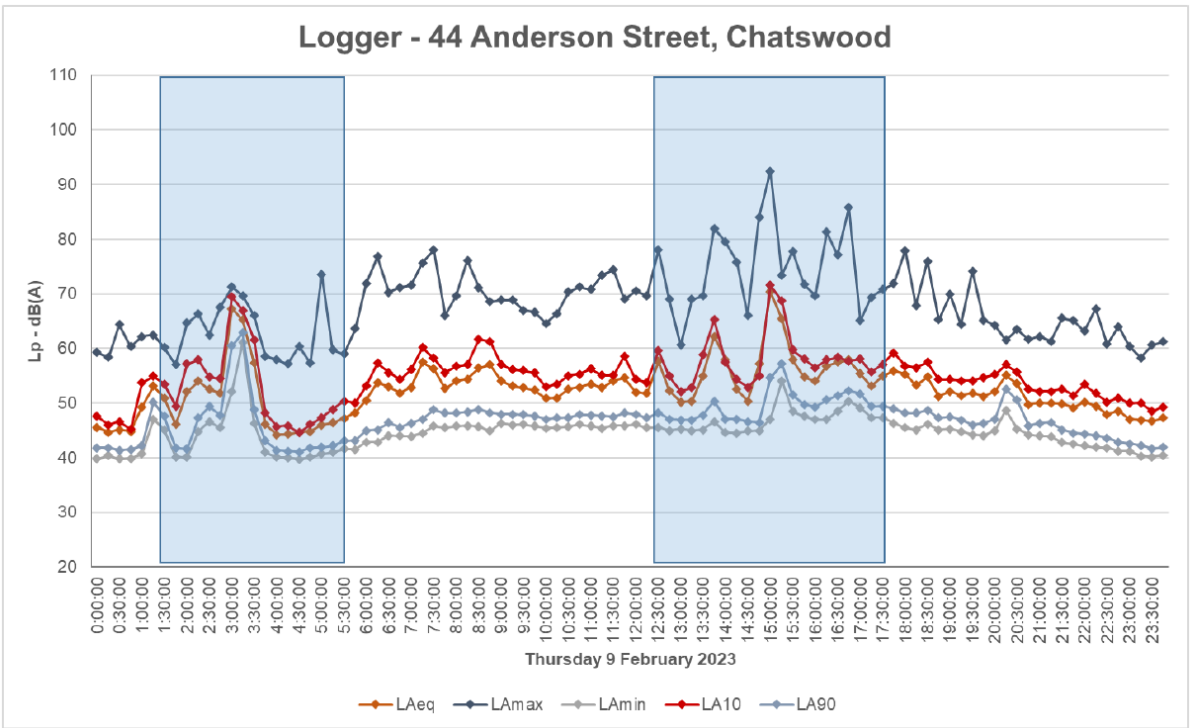
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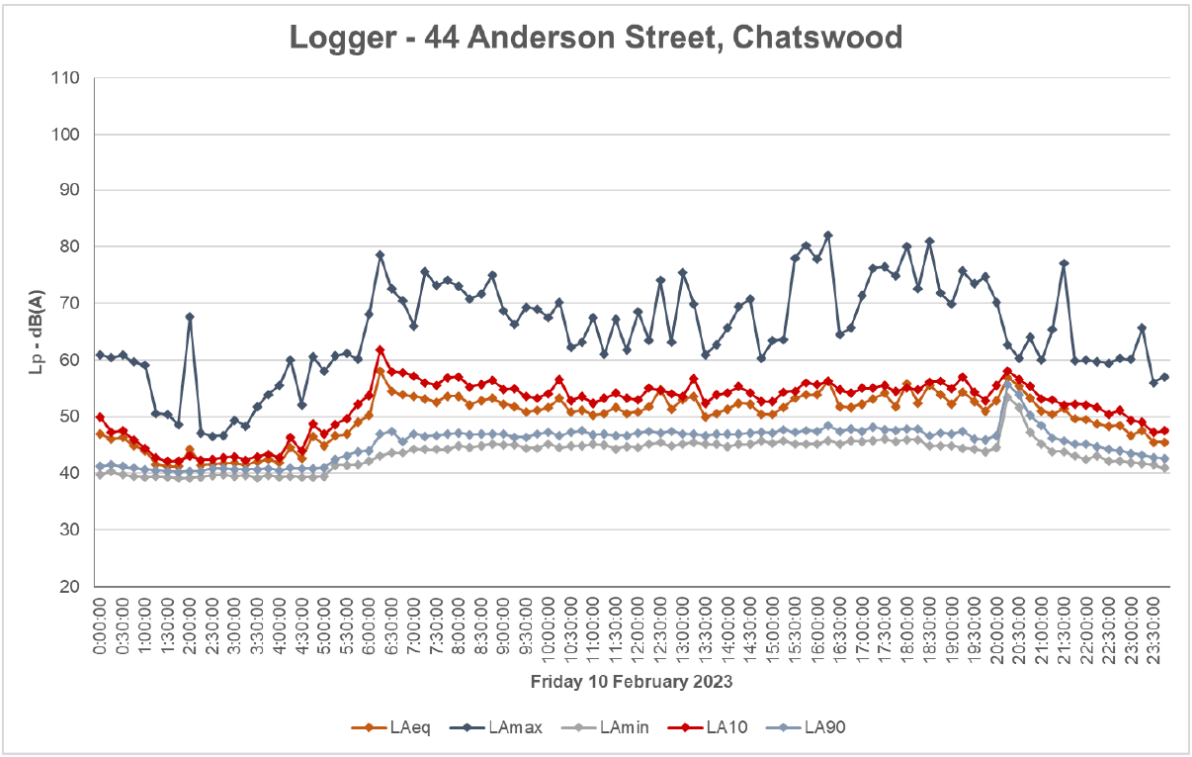
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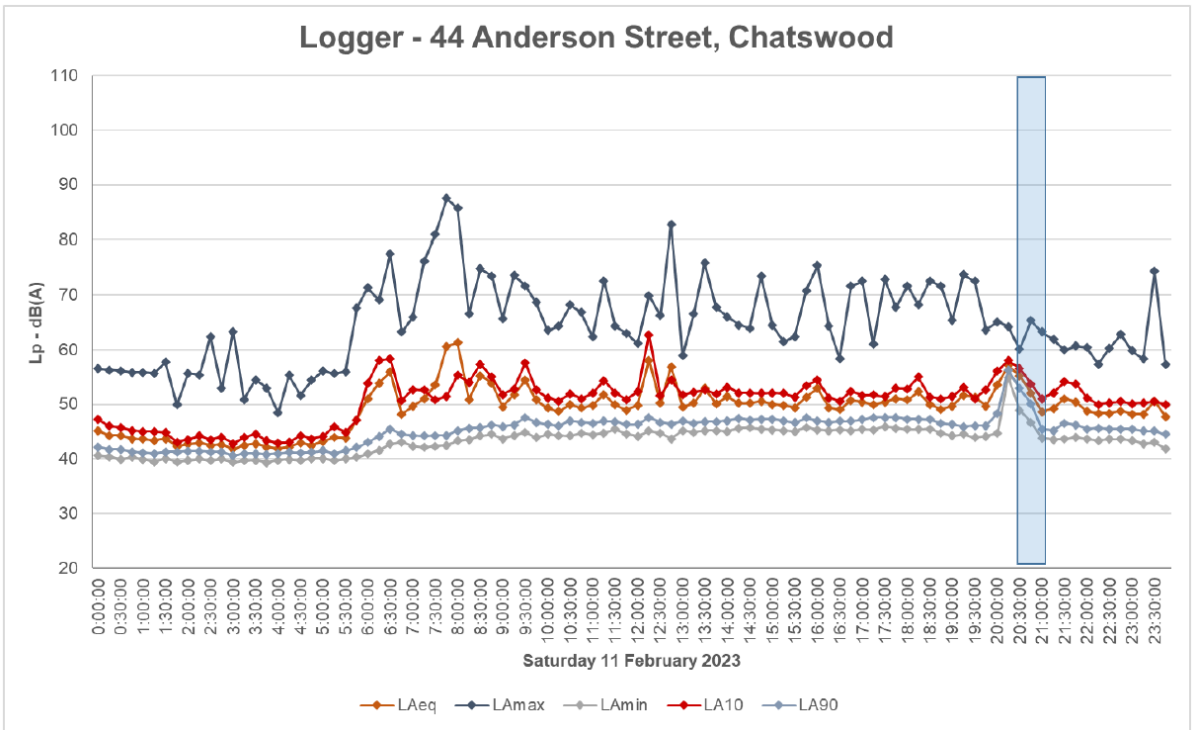
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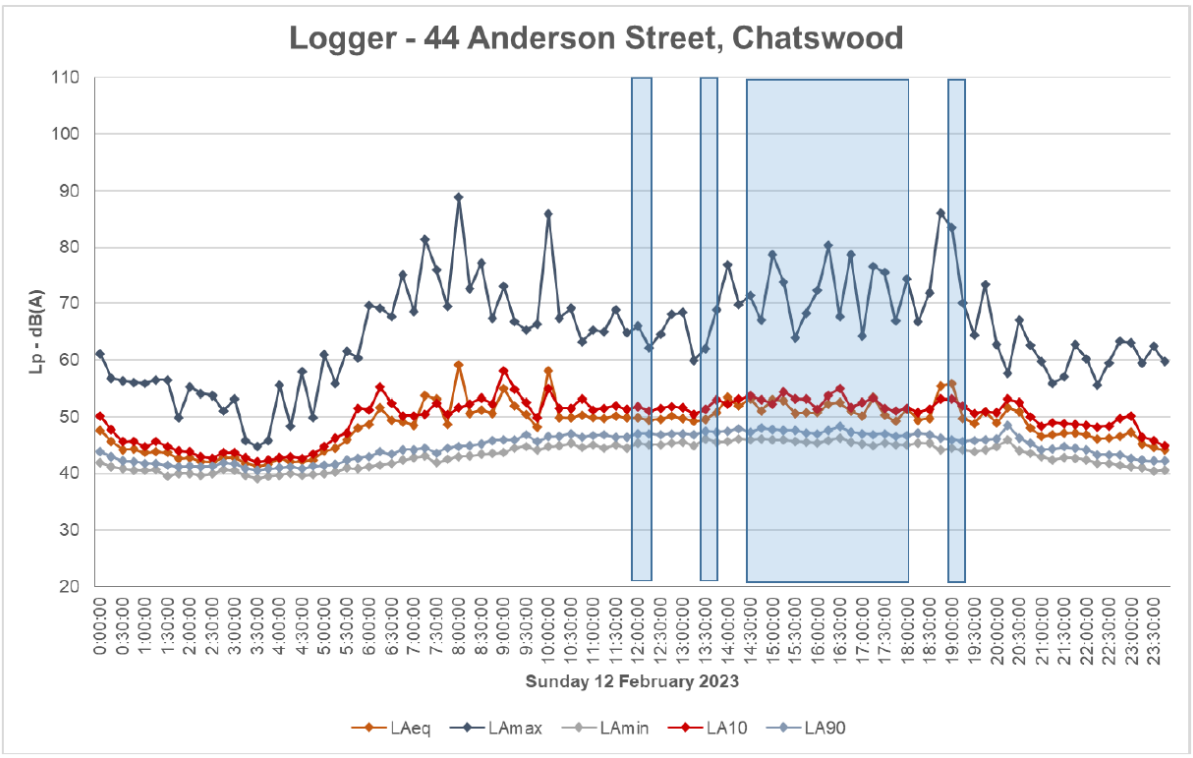
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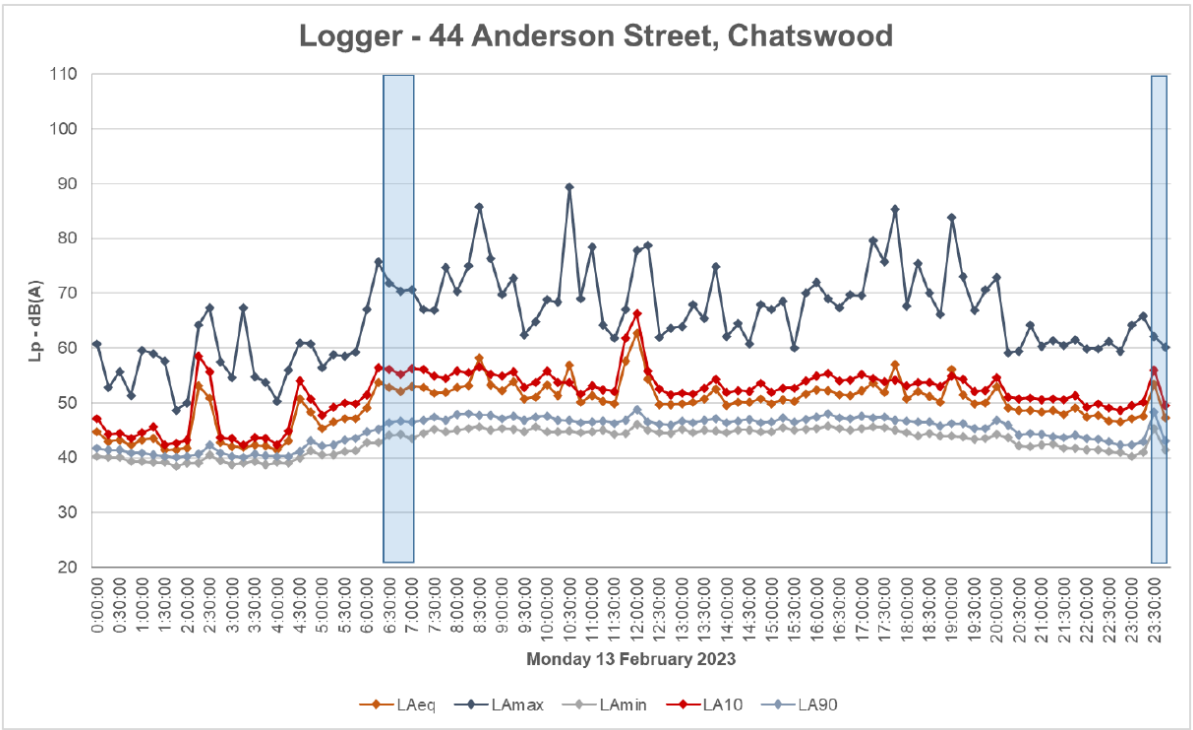
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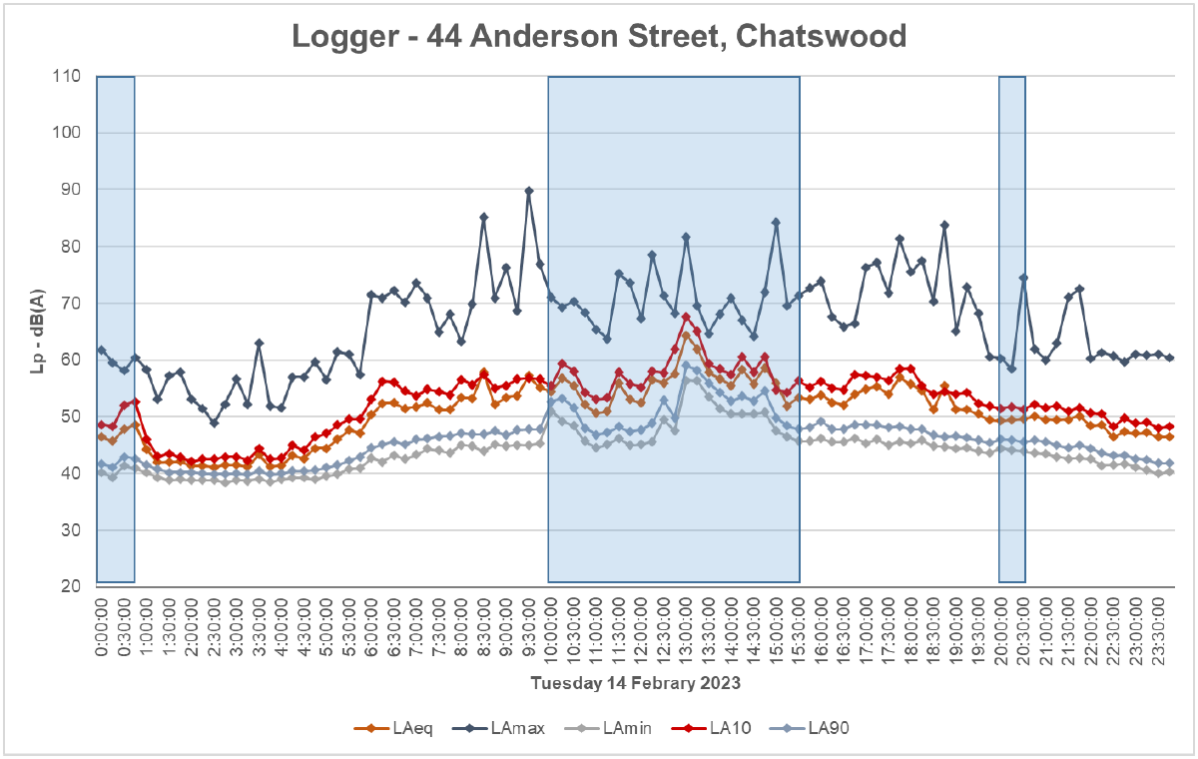
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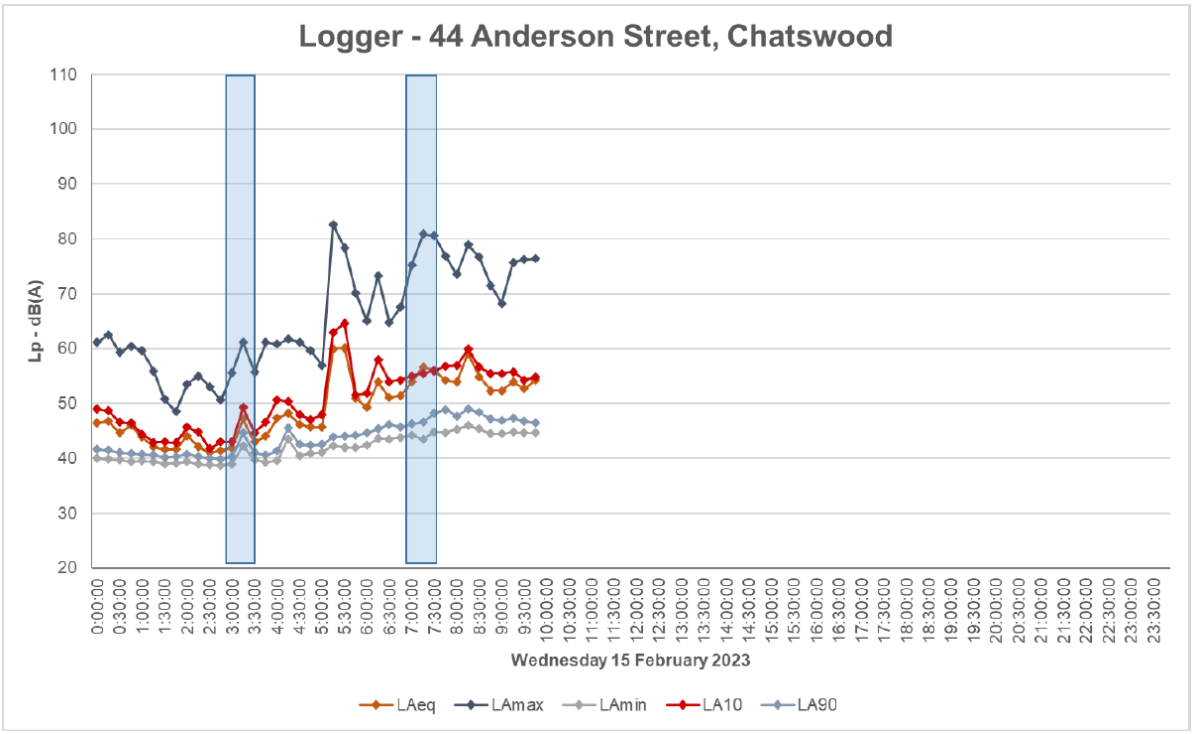
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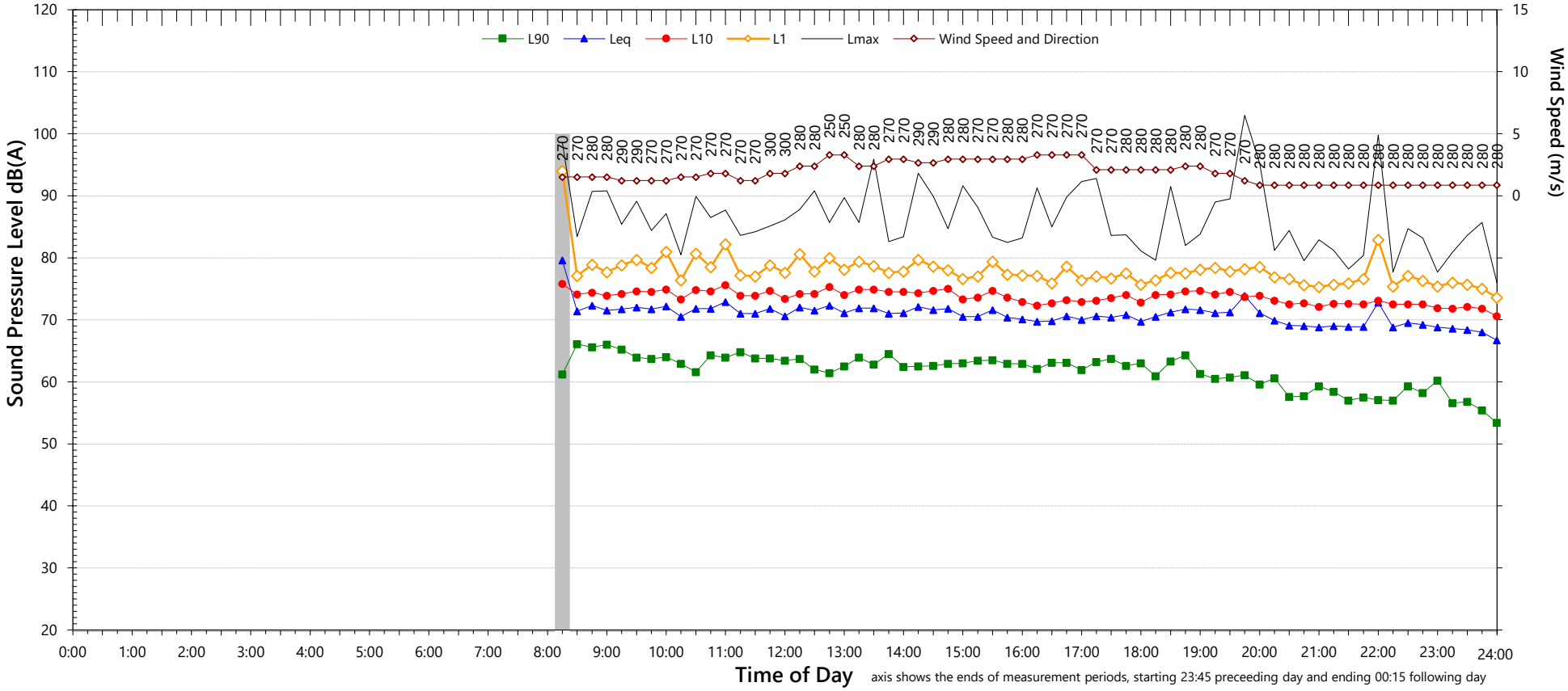
Unattended Noise Monitoring Results

2 Wilson Street, Chatswood (Front)

Friday, 9 October 2020



NSW Noise Policy for Industry (Free Field)			
Descriptor	Day[2]	Evening[3]	Night[4 5]
L_{90}	62	57	46
LAeq	71	71	67

Night Time Maximum Noise Levels			(see note 7)
L_{Max} (Range)	81	to	89
L_{Max} - L_{eq} (Range)	16	to	22

NSW Road Noise Policy (1m from facade)		(see note 6)
Descriptor	Day	Night[5]
	7am-10pm	10pm-7am
$L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$	74	70
$L_{eq\ 1hr}$ upper 10 percentile	74	72
$L_{eq\ 1hr}$ lower 10 percentile	73	67

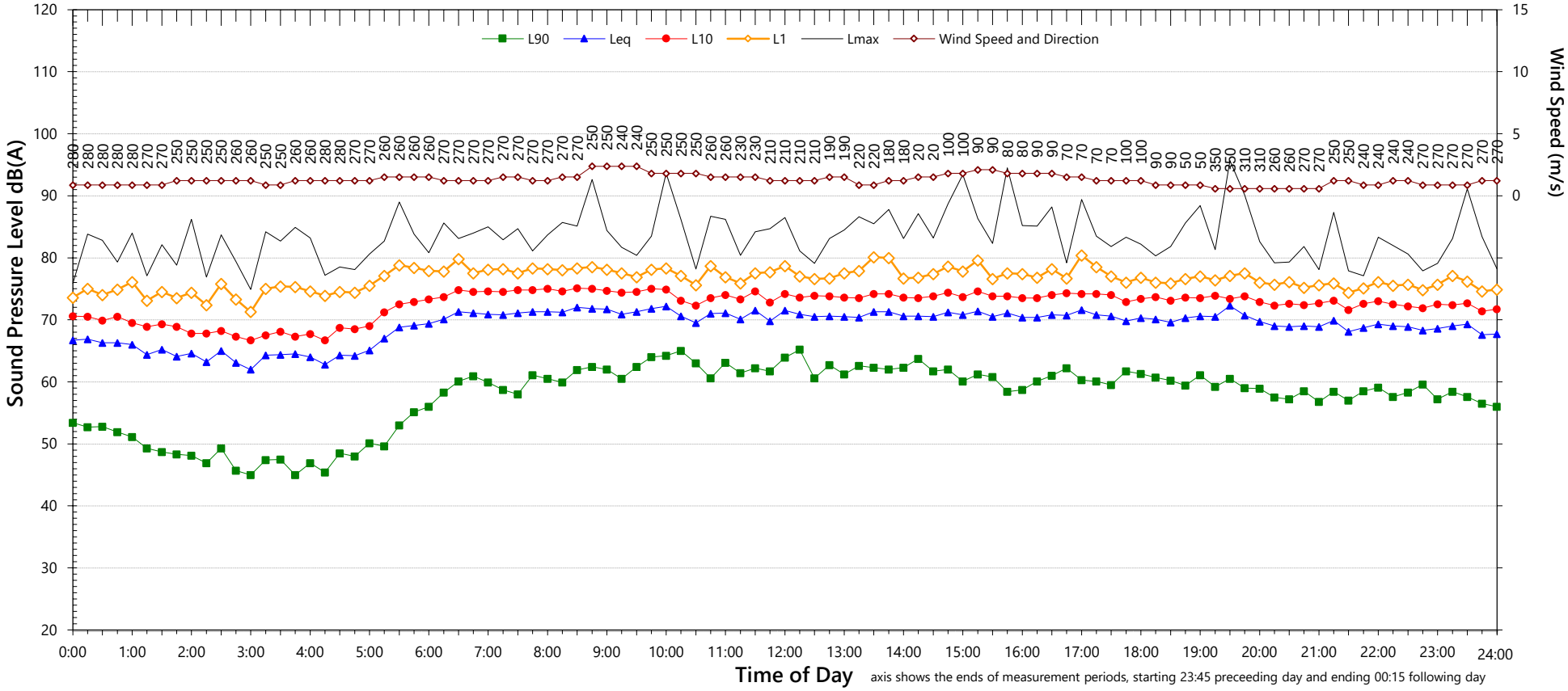
Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Day" is the period from 8am till 6pm on Sundays and 7am til 6pm on other days
3. "Evening" is the period from 6pm till 10pm
4. "Night" relates to the remaining periods
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)

Unattended Noise Monitoring Results

2 Wilson Street, Chatswood (Front)

Saturday, 10 October 2020



NSW Noise Policy for Industry (Free Field)			
Descriptor	Day[2]	Evening[3]	Night[4 5]
L_{90}	60	57	45
LAeq	71	70	67

Night Time Maximum Noise Levels			(see note 7)
L_{Max} (Range)	82	to	91
L_{Max} - L_{eq} (Range)	16	to	23

NSW Road Noise Policy (1m from facade)		(see note 6)
Descriptor	Day	Night[5]
	7am-10pm	10pm-7am
$L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$	73	69
$L_{eq\ 1hr}$ upper 10 percentile	74	71
$L_{eq\ 1hr}$ lower 10 percentile	72	65

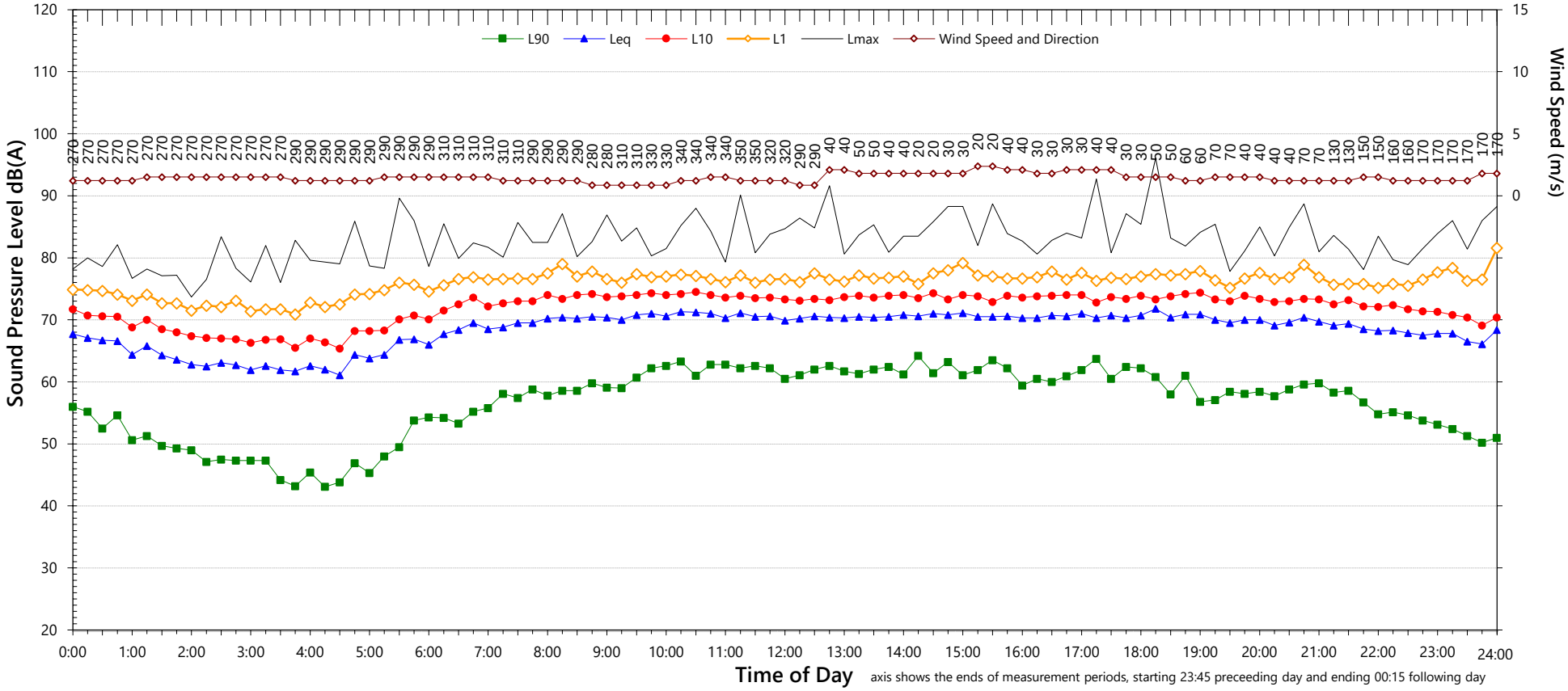
Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Day" is the period from 8am till 6pm on Sundays and 7am til 6pm on other days
3. "Evening" is the period from 6pm till 10pm
4. "Night" relates to the remaining periods
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)

Unattended Noise Monitoring Results

2 Wilson Street, Chatswood (Front)

Sunday, 11 October 2020



NSW Noise Policy for Industry (Free Field)			
Descriptor	Day[2]	Evening[3]	Night[4 5]
L_{90}	59	57	44
LAeq	71	70	68

Night Time Maximum Noise Levels			(see note 7)
L_{Max} (Range)	84	to	93
L_{Max} - L_{eq} (Range)	16	to	27

NSW Road Noise Policy (1m from facade)		(see note 6)
Descriptor	Day	Night[5]
	7am-10pm	10pm-7am
$L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$	73	71
$L_{eq\ 1hr}$ upper 10 percentile	73	75
$L_{eq\ 1hr}$ lower 10 percentile	72	66

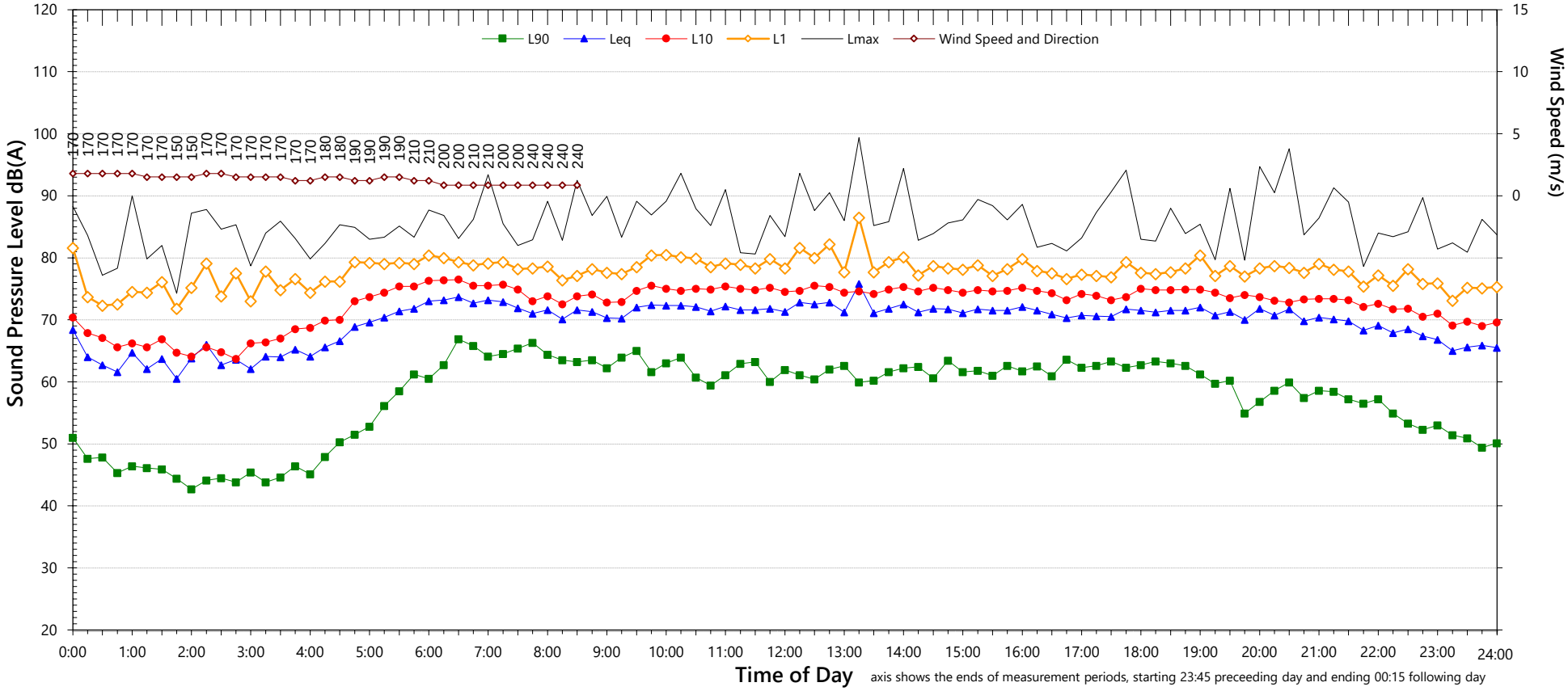
Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Day" is the period from 8am till 6pm on Sundays and 7am til 6pm on other days
3. "Evening" is the period from 6pm till 10pm
4. "Night" relates to the remaining periods
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)

Unattended Noise Monitoring Results

2 Wilson Street, Chatswood (Front)

Monday, 12 October 2020



NSW Noise Policy for Industry (Free Field)			
Descriptor	Day[2]	Evening[3]	Night[4 5]
L_{90}	60	57	42
LAeq	72	71	68

Night Time Maximum Noise Levels			(see note 7)
L_{Max} (Range)	83	to	90
L_{Max} - L_{eq} (Range)	16	to	26

NSW Road Noise Policy (1m from facade)		(see note 6)
Descriptor	Day	Night[5]
	7am-10pm	10pm-7am
$L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$	74	71
$L_{eq\ 1hr}$ upper 10 percentile	75	75
$L_{eq\ 1hr}$ lower 10 percentile	73	66

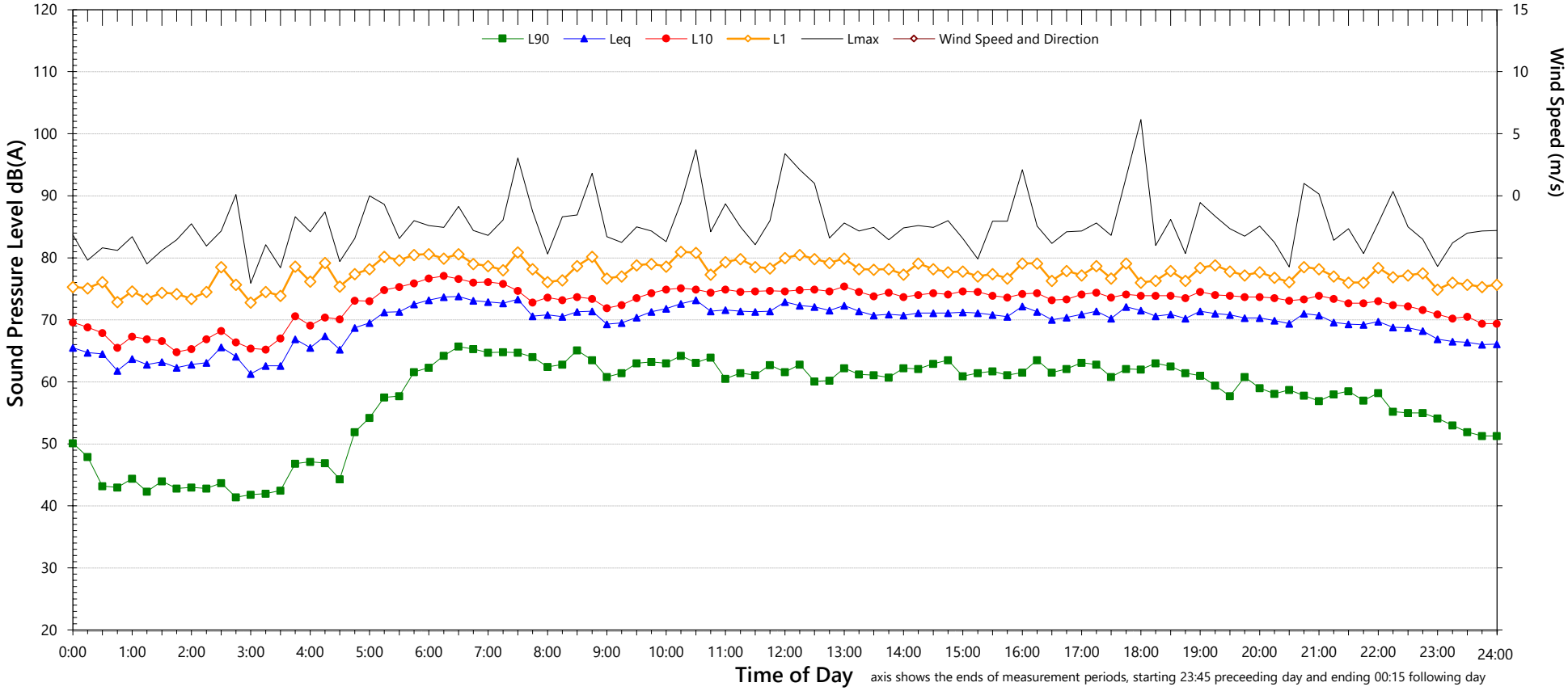
Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Day" is the period from 8am till 6pm on Sundays and 7am til 6pm on other days
3. "Evening" is the period from 6pm till 10pm
4. "Night" relates to the remaining periods
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)

Unattended Noise Monitoring Results

2 Wilson Street, Chatswood (Front)

Tuesday, 13 October 2020



NSW Noise Policy for Industry (Free Field)			
Descriptor	Day[2]	Evening[3]	Night[4 5]
L_{90}	61	57	44
LAeq	71	70	69

Night Time Maximum Noise Levels			(see note 7)
L_{Max} (Range)	82	to	104
L_{Max} - L_{eq} (Range)	18	to	30

NSW Road Noise Policy (1m from facade)		(see note 6)
Descriptor	Day	Night[5]
	7am-10pm	10pm-7am
$L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$	74	71
$L_{eq\ 1hr}$ upper 10 percentile	75	75
$L_{eq\ 1hr}$ lower 10 percentile	73	66

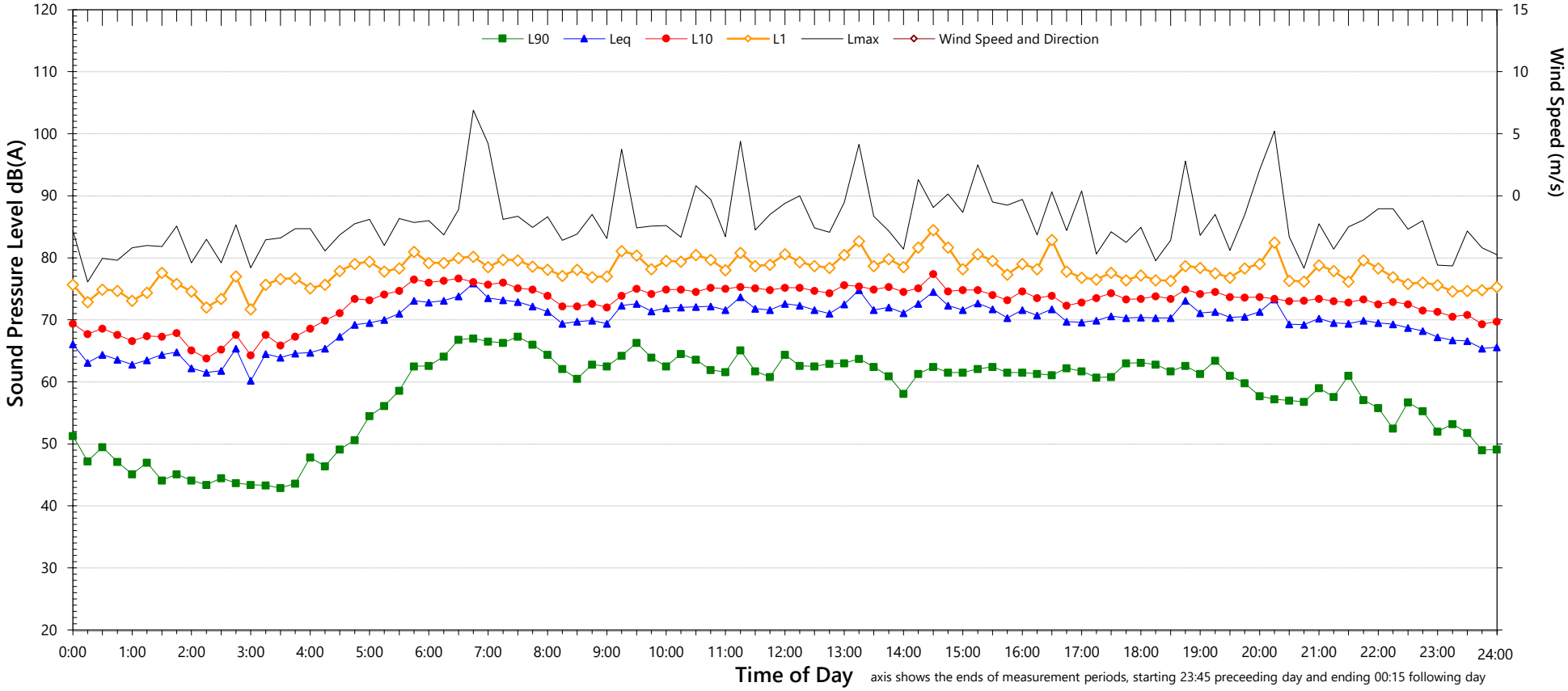
Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Day" is the period from 8am till 6pm on Sundays and 7am til 6pm on other days
3. "Evening" is the period from 6pm till 10pm
4. "Night" relates to the remaining periods
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)

Unattended Noise Monitoring Results

2 Wilson Street, Chatswood (Front)

Wednesday, 14 October 2020



NSW Noise Policy for Industry (Free Field)			
Descriptor	**Day[2]**	**Evening[3]**	**Night[4 5]**
L_{90}	61	57	43
LAeq	72	71	69

Night Time Maximum Noise Levels			(see note 7)
L_{Max} (Range)	82	to	98
L_{Max} - L_{eq} (Range)	18	to	33

NSW Road Noise Policy (1m from facade)		(see note 6)
Descriptor	**Day**	**Night[5]**
	7am-10pm	**10pm-7am**
$L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$	74	71
$L_{eq\ 1hr}$ upper 10 percentile	75	75
$L_{eq\ 1hr}$ lower 10 percentile	72	67

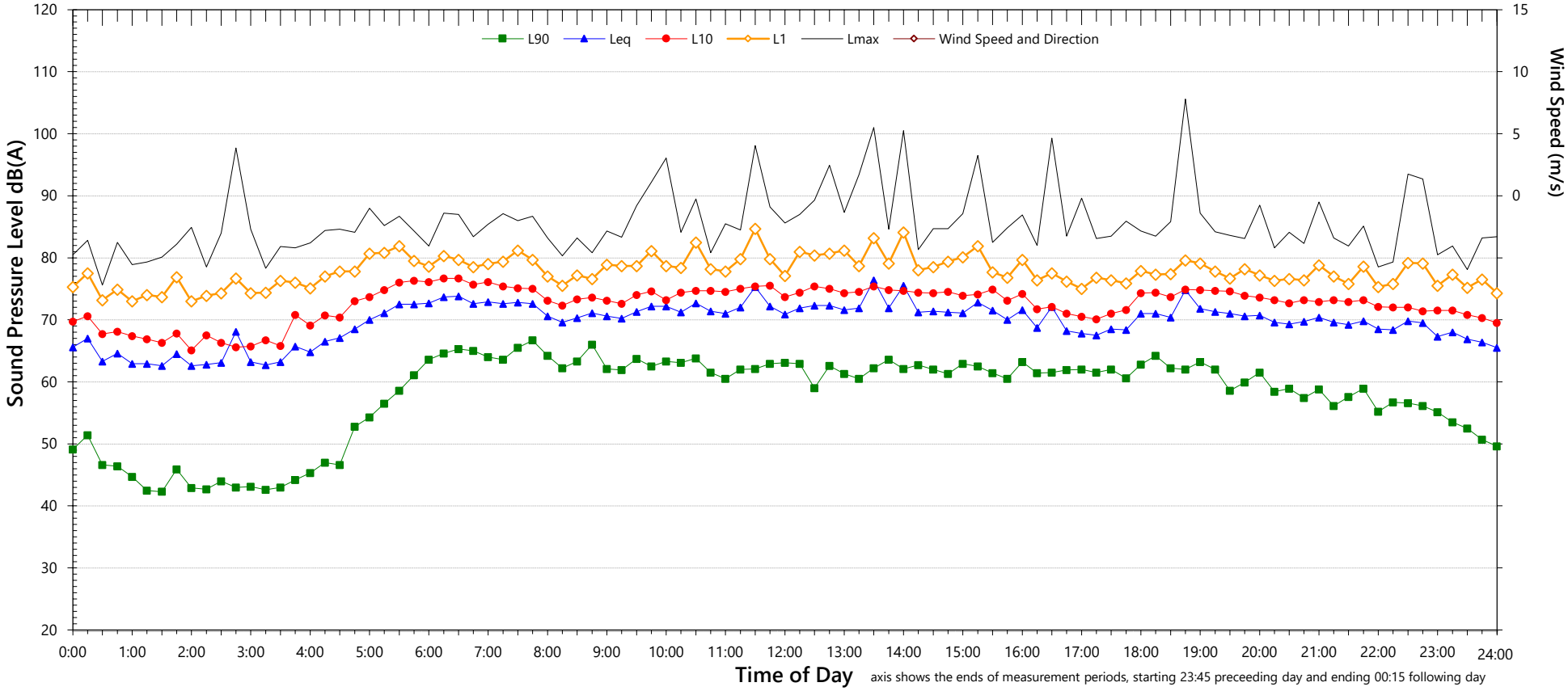
Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Day" is the period from 8am till 6pm on Sundays and 7am til 6pm on other days
3. "Evening" is the period from 6pm till 10pm
4. "Night" relates to the remaining periods
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)

Unattended Noise Monitoring Results

2 Wilson Street, Chatswood (Front)

Thursday, 15 October 2020



NSW Noise Policy for Industry (Free Field)			
Descriptor	Day[2]	Evening[3]	Night[4 5]
L_{90}	61	57	46
LAeq	72	71	69

Night Time Maximum Noise Levels			(see note 7)
L_{Max} (Range)	83	to	94
L_{Max} - L_{eq} (Range)	16	to	25

NSW Road Noise Policy (1m from facade)		(see note 6)
Descriptor	Day	Night[5]
	7am-10pm	10pm-7am
$L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$	74	71
$L_{eq\ 1hr}$ upper 10 percentile	75	75
$L_{eq\ 1hr}$ lower 10 percentile	72	66

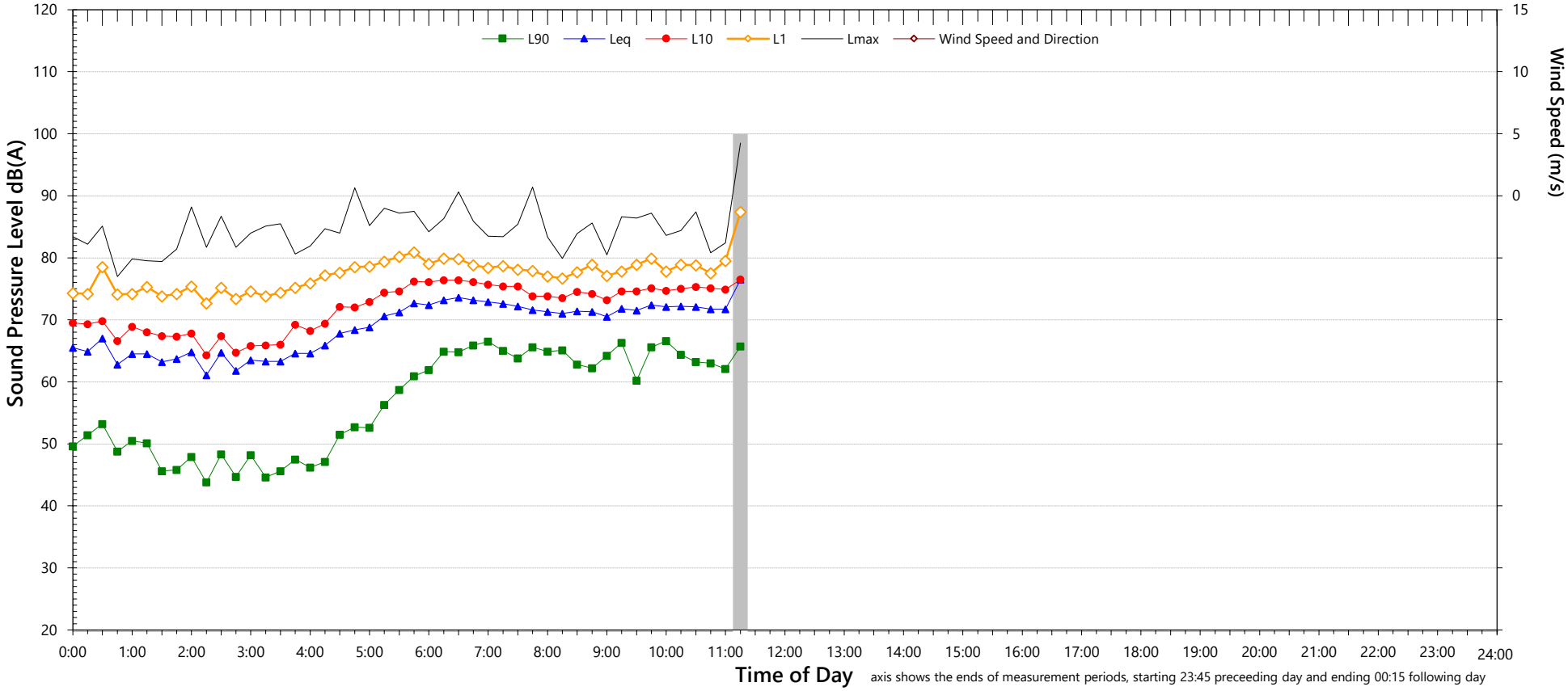
Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Day" is the period from 8am till 6pm on Sundays and 7am til 6pm on other days
3. "Evening" is the period from 6pm till 10pm
4. "Night" relates to the remaining periods
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)

Unattended Noise Monitoring Results

2 Wilson Street, Chatswood (Front)

Friday, 16 October 2020



NSW Noise Policy for Industry (Free Field)			
Descriptor	Day[2]	Evening[3]	Night[4 5]
L_{90}	-	-	-
LAeq	-	-	-

Night Time Maximum Noise Levels			(see note 7)
L_{Max} (Range)	-	to	-
L_{Max} - L_{eq} (Range)	-	to	-

NSW Road Noise Policy (1m from facade)		(see note 6)
Descriptor	Day	Night[5]
	7am-10pm	10pm-7am
$L_{eq\ 15\ hr}$ and $L_{eq\ 9\ hr}$	74	-
$L_{eq\ 1hr}$ upper 10 percentile	74	-
$L_{eq\ 1hr}$ lower 10 percentile	74	-

Notes:

1. Shaded periods denote measurements adversely affected by rain, wind or extraneous noise - data in these periods are excluded from calculations.
2. "Day" is the period from 8am till 6pm on Sundays and 7am til 6pm on other days
3. "Evening" is the period from 6pm till 10pm
4. "Night" relates to the remaining periods
5. "Night" relates to period from 10pm on this graph to morning on the following graph.
6. Graphed data measured in free-field; tabulated results facade corrected
7. Night time L_{Max} values are shown only where L_{Max} >65dB(A) and where L_{Max}- Leq ≥15dB(A)