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64-66 LAVENDER ST & 3-7 MIDDLEMISS ST, LAVENDER BAY

SSDA Acoustic Assessment

5 March 2026

Central Element

TP872-01F02 SSDA Acoustic Assessment (r2).docx

40 YEARS 1982-2022 ACOUSTIC ENGINEERING EXCELLENCE

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Executive summary

Renzo Tonin & Associates conducted a noise and vibration impact assessment for a proposed high-density residential development by Central Element. The project involves the amalgamation of five land parcels and the construction of two high-rise towers (North Tower up to Level 22 and South Tower up to Level 31) and five levels of basement parking . The site is situated in a complex acoustic environment due to its proximity to the T1 North Shore Line on an elevated rail viaduct, the Warringah Freeway, and Lavender Street.

Key findings:

- **External Noise Intrusion:** Road and rail traffic are the dominant noise sources. To achieve internal amenity, the building shell must be designed to meet strict criteria from the North Sydney DCP and the SEPP (Transport and Infrastructure), which generally limit internal noise to 35 dB(A) in bedrooms and 40 dB(A) in living areas with windows closed.
- **Rail Vibration:** Vibration impacts from rail pass-bys were investigated:
    - **Human Comfort:** Measured tactile acceleration vibration levels from train pass-bys comply with residential night-time criteria for human comfort. Estimated vibration dose values from overall train pass-bys for the day and night periods comply with the preferred levels.
    - **Ground-borne Noise:** While most areas are compliant, Level 2 apartments in the North Tower facing away from the rail corridor are at risk of ground-borne noise impacts due to building shielding reducing masking airborne noise.
- **Operational Emissions:** Noise from future mechanical plant and the residential loading dock has the potential to impact both nearby neighbours and future residents within the project.
- **Construction Impacts:** Significant noise and vibration are expected during construction, requiring a site-specific Construction Noise and Vibration Management Plan to protect adjacent residential receivers.

Recommendations:

- **Facade Design:** Internal noise criteria of the *North Sydney DCP* and *Transport and Infrastructure SEPP* for external noise intrusion can be satisfied through external glazing design provided in Section 5.3. Recommended sound insulation ratings for all building facades and at different building levels.
- **Ventilation:** Most habitable rooms require supplementary fresh air to maintain air quality while windows remain closed to block external transport noise in accordance with the *Transport and Infrastructure SEPP*.

- **Vibration Mitigation:** Further internal vibration measurements on the slab of existing buildings on site are recommended during detailed design to refine the need for building vibration isolation.

- **Operational Control:** A detailed acoustic review of mechanical plant (roof and basement) must be conducted once equipment selections are finalized to ensure compliance with Project Noise Trigger Levels in accordance with the *Noise Policy for Industry*.

SEARs Declaration:

Qualified Professional Name	Reymar Victoria	
Qualified Professional Qualifications	Bachelor of Science in Civil Engineering (University of the Philippines), Member of the Australian Acoustical Society	
	The undersigned declares that this *SSDA Acoustic Assessment* has been prepared in response to the following SEARs requirements issued for the Project on 30 June 2025 (EIS) and 2 July 2025 (Rezoning Report) for SSD-86797708:	
SEARs item no.	**SEARs Issue and Assessment Requirement**	**Relevant Section of this Report that addresses SEARs Requirement**
10 (SEARs, dated 30 June 2025)	Noise and Vibration Provide a noise and vibration impact 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.	Section 4 – Presents the results of the noise survey. Section 7.1 – Outlines the noise emissions criteria for operational activities within the project. Section 7.2 – Assessment of noise emissions and impacts to nearby receivers. Section 8 – Assessment of construction noise and vibration impacts.
Additional assessment requirements, item 2 (SEARs cover letter, dated 02 July 2025)	Provide an Acoustic Assessment Report that addresses local internal acoustic requirements for residential amenity given by T1 North Shore and Western railway line.	Section 5 – Outlines internal airborne noise criteria, assessment of transport noise impacts, and provides design recommendations. Section 6 – Outlines internal vibration and ground-borne noise criteria, assessment of rail vibration impacts, and provides design recommendations.
Signed		
Dated	05 March 2026	

1 Introduction

Central Element has engaged Renzo Tonin & Associates to undertake a noise and vibration impact assessment for a proposed residential development located at 64-66 Lavender Street and 3-7 Middlemiss Street, Lavender Bay ('the Project'). This assessment report is prepared to support a State Significant Development Application (SSDA) under the application number SSD-86797708.

The Project, located within the high-density residential area of North Sydney, will involve the amalgamation of five land parcels, demolition of existing multi-storey residential structures, and the construction of a residential development with two high-rise apartment buildings. With its proximity to major transport corridors in the area, including the Warringah Freeway and the T1 North Shore Line travelling on the Sydney Harbour Bridge Viaduct, the site is situated in a complex acoustic environment with regards to external noise and vibration impacts on the project.

Noise generated from the operational activities associated with the development has the potential to impact nearby noise sensitive receivers in the surrounding land, which includes multi-storey residential building and single dwellings, as well as commercial shop-fronts on Lavender Street.

This report identifies the relevant planning and policy controls, and addresses:

- Impacts of external noise to the proposed development, primarily from road traffic on Warringah Freeway and Lavender Street, and rail pass-bys on the rail viaduct, to determine building shell acoustic treatment to ensure suitable levels of acoustic amenity across the different uses of the Project.
- Noise emissions from the operation of the Project, including the operation of building services and the loading dock, and its potential impacts to surround noise sensitive receivers and future receivers within the Project.
- Review of potential construction noise and vibration impacts associated with construction of the development.

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

2 Project and site description

The proposed development seeks approval for the rezoning of the site and development consent for the construction of a residential development. The SSDA specifically involves the following works:

- Demolition of the existing buildings on site;
- Site excavation, and other preparatory site works;
- Construction of a 32 and 23-storey residential flat building including 3% designated affordable housing consisting of approximately a total of 160 dwellings,
- Vehicular access from Lavender Street and loading access from Middlemiss Street,
- Site amalgamation,
- Utility and services augmentation as required.

To accommodate the proposed SSDA, a concurrent rezoning is sought to increase the site's maximum building height.

The architectural design presents a massing strategy composed of a podium base for residential amenities, and two residential towers. The development will consist of:

- five levels of basement parking
- four levels of a central podium with residential amenities and residential units.
- north residential tower up to Level 22
- south residential tower up to Level 32
- a new public accessible open space, including through-site link and site landscaping.

The Project site is bounded by and has frontages to Middlemiss Street to the north and Lavender Street to the South. Figure 2-1 shows the Project site and the surrounding land. The key environmental noise sources affecting the development are the surrounding transport corridors:

- the T1 North Shore Line which carries frequent passenger services running on the elevated viaduct structure near the site on the opposite side of Middlemiss Street
- the Warringah Freeway on the other side of the rail viaduct with high-volume traffic flows
- Lavender Street which is a local collector road under council jurisdiction.

The Project site is zoned for high-density residential (R4) and also surrounded land zoned for medium density residential (R3) and mixed-use (MU1). The development will need to control noise emissions to the environment and potential impacts to nearby sensitive development which consists of:

- three-storey residential building adjacent to the east
- three-storey residential building adjacent to the west
- residential flat buildings to the south, across Lavender Street
- residential dwellings to the west, across Arthur Lane

Figure 2-1: Site boundary, monitoring locations, and sensitive receivers

3 Planning context and references

The development will need to satisfy state and local planning and development control documents, particularly those with relevant noise and vibration provisions, including:

- *State Environmental Planning Policy (Transport and Infrastructure) 2021*, NSW Government, 2021 ('SEPP (Transport and Infrastructure)')
- *Development Near Rail Corridors and Busy Roads – Interim Guideline*, NSW Department of Planning, December 2008 ('Rail & Road Guideline')
- *North Sydney Development Control Plan 2025*, North Sydney Council, 22 September 2025 ('North Sydney DCP')

The development will also need to comply with the following noise and vibration guidelines:

- *Noise Policy for Industry*, NSW Environment Protection Authority, October 2017 ('NPfI')
- *NSW Road Noise Policy*, Department of Environment, Climate Change and Water (NSW), 2011 ('RNP')
- *Interim Construction Noise Guideline*, NSW Department of Environment and Climate Change, July 2009 ('ICNG')
- *Assessing Vibration: A technical guideline*, Department of Environment and Conservation NSW February 2006 ('Assessing Vibration guideline')

This assessment and report was prepared with reference to the following Project documentation:

- Architectural documentation '*FOR APPROVAL*' prepared by SJB Architects dated 03 March 2026

4 Existing noise environment

Criteria for the assessment of operational noise and construction noise from a development are usually derived from the existing background noise levels of an area, measured in the absence of noise from the subject development. The NSW Environmental Protection Authority's (EPA) *Noise Policy for Industry* (NPfI) outlines the methods of determining the representative background and ambient noise levels of an area. For this assessment, long-term noise monitoring was carried out.

As the noise environment of an area varies over time due to changes in human activity, land uses, and traffic volumes, representative background and ambient noise levels need to be determined for different time periods which the proposed development would be operating. The NPfI defines standard time periods over which the background and ambient noise levels are to be determined for the purposes of an acoustic assessment, which is as follows:

- Day: 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays
- Evening: 18:00-22:00 Monday to Sunday & Public Holidays
- Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays

4.1 Measured background and ambient noise levels

Long-term noise monitoring was carried out from Tuesday, 4 November 2025 to Thursday, 20 November 2025 to quantify the existing noise environment. Two unattended long-term noise monitors were installed within the site to measure the ambient and background noise levels. One additional unattended long-term noise monitor was installed in a location with direct line-of-sight to the rail corridor and Waringah Freeway. Table 4-1 outlines the description of the noise monitoring locations and are shown in Figure 2-1.

Table 4-1: Noise monitoring locations

Location ID	Description
L01	Front yard of 66 Lavender Street, Lavender Bay, approximately 7m from Lavender Street. This monitoring location is used to determine traffic noise levels from Lavender Street, and representative background noise levels for sensitive receivers facing Lavender Street.
L02	Backyard of 3 Middlemiss Street, Lavender Bay. This monitoring location is used to determine the representative background noise levels for future sensitive receivers within the development, and for other surrounding sensitive receivers.
L03	Level 13 balcony on 48 Alfred Street, Lavender Bay, with direct line-of-sight to the rail corridor and Waringah Freeway. This monitoring location was used to establish rail and traffic noise level patterns over different relevant time periods.

Note: Although the L03 monitoring position is not readily discernible in Figure 2-1 due to distance and scale, on-site verification confirmed an unobstructed propagation path to the rail corridor and Warringah Freeway.

The noise monitor recorded noise levels on a continuous basis and stores data every fifteen minutes. The noise loggers were calibrated before and after survey and no significant deviation in calibration was

noted. All the instrumentation used complies with IEC 61672[1] and IEC 60942[2] and carries current NATA certification.

The measured representative background and ambient noise levels surrounding the site are presented in Table 4-2, and the noise level-vs-time graphs of the data are included in APPENDIX B. It was noted during the survey that the ambient noise (L_{Aeq}) levels for locations L01 and L02 are dominated by road and rail traffic noise.

Table 4-2: Long-term noise monitoring results

Monitoring location	Rating Background Level (RBL), L_{A90}			Ambient noise levels (4), $L_{Aeq,period}$		
	Day (1)	Evening (2)	Night (3)	Day (1)	Evening (2)	Night (3)
L01 - 66 Lavender Street	56	54	46	63	62	60
L02 - 3 Middlemiss Street	49	47	41	52	52	49

Notes: (1) Day: 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays
(2) Evening: 18:00-22:00 Monday to Sunday & Public Holidays
(3) Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays
(4) As required by the NPfI, the external ambient noise levels presented are free-field noise levels, i.e.. no façade reflection.

4.2 Noise sensitive receivers

Table 4-3 presents the noise-sensitive receiver locations surrounding the development, and are shown in Figure 2-1.

Table 4-3: Noise sensitive receiver locations

Receiver ID	Description
R01	Three-storey residential building located immediately to the east. Background noise levels for this receiver are based on monitoring location L01.
R02	High-rise residential buildings situated to the south across Lavender Street. Background noise levels for this receiver are based on monitoring location L01.
R03	Residential building and nearby dwellings to the west, fronting Lavender Street. Background noise levels for this receiver are based on monitoring location L01.
R04	Residential building and dwellings located to the west, across Arthur Lane. Background noise levels for this receiver are based on monitoring location L02.
R05	Commercial and retail tenancies located within the buildings to the south across Lavender Street.

[1] International Electrotechnical Commission, Electroacoustics—Sound level meters, IEC 61672-1:2013.

[2] International Electrotechnical Commission, Electroacoustics—Sound calibrators, IEC 60942:2017.

5 Noise Intrusion Assessment

This section addresses the intrusion of external noise on the development, primarily the adjacent road corridors surrounding the site, outlines the relevant internal noise criteria for the assessment, and provides recommendations on noise control through facade design.

5.1 Internal noise intrusion criteria

The guidelines, standards, policies, and local planning controls relevant to the assessment of noise intrusion to the development are as follows:

- *State Environmental Planning Policy (Transport and Infrastructure)* ('SEPP (Transport and Infrastructure)') and *Development Near Rail Corridors and Busy Roads – Interim Guideline* ('Rail & Road Guideline')
- *North Sydney Development Control Plan 2025* ('North Sydney DCP')
- *AS NZS 2107-2016 Recommended design sound levels & reverberation for building interiors*

5.1.1 SEPP (Transport and Infrastructure) and Development Near Rail Corridors and Busy Roads Guideline

The SEPP (Transport and Infrastructure) requires an acoustic assessment for developments adjacent to busy roads and the rail corridor. The SEPP (Transport and Infrastructure) specifies a criteria for noise intrusion, which was subsequently included in the Rail & Road Guideline. The development is adjacent to Parramatta Road, and will therefore need comply with the internal noise criteria which is outlined in Table 5-1.

Table 5-1: Internal noise criteria - SEPP (Transport & Infrastructure) & Rail & Road Guideline

Type of occupancy	Window condition	Road and rail internal noise level	
		Day [1], $L_{eq\ (15hour)}$	Night [2], $L_{eq\ (9hour)}$
Bedrooms	Closed	-	35 dB(A)
	Open [3]	-	45 dB(A)
Living areas	Closed	40 dB(A)	40 dB(A)
	Open [3]	50 dB(A)	50 dB(A)

Notes:
(1) Day: 07:00-22:00 Monday to Sunday
(2) Night: 22:00-07:00 Monday to Sunday
(3) Guideline states that where internal noise criteria are exceeded by more than 10dB(A) with windows open, then alternative ventilation is to be provided. 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.

In the event that the internal noise level with the "windows open" is greater than the screening value denoted above, the Rail & Road Guideline recommends that the apartment be designed to have

supplementary ventilation provided to enable the apartment to have fresh air even if the occupant choses to keep their windows closed.

5.1.2 North Sydney DCP

The North Sydney DCP requires the following with respect to noise intrusion into residential development from external noise sources.

> *Part E1 – Residential Development*
>
> *1.4.3 Acoustic privacy*
>
> *New dwellings shall be designed and constructed to comply with the criteria specified in Table E-1.3 for all noise intrusion from external noise sources (including mechanical services noise from within the development itself), with windows and doors closed:*

TABLE E-1.3: Noise intrusion criteria from external sources		
Internal Space	**Time Period**	**Max 1hr noise level (LAeq 1 Hour)**
Living areas	Day or Night	≤ 40 dBA
Sleeping Areas	Day or Night	≤ 35 dBA

Note: *Readings are to be LAeq (1hour), when measured during the noisiest 1 hour period between Day 7am to 10pm; and Night – 10pm to 7am.*

Table 5-2 summarises the noise criteria from the North Sydney DCP. As noted in the DCP, this applies to all external noise sources, including road and rail.

Table 5-2: Internal noise criteria - North Sydney DCP

Type of occupancy	Window condition	Internal noise level	
		Day(1) - $L_{eq\ (worst\ 1hour)}$ (3)	Night(2) - Max $L_{eq\ (worst\ 1hour)}$ (3)
Bedrooms	Closed	35 dB(A)	35 dB(A)
Living areas	Closed	40 dB(A)	40 dB(A)

Notes: (1) Day: 07:00-22:00 Monday to Sunday
(2) Night: 22:00-07:00 Monday to Sunday
(3) Noisiest 1-hr during the time period.

5.1.3 Project noise intrusion criteria

In consideration of the noise criteria from both the SEPP (Transport & Infrastructure) and the North Sydney DCP, the internal noise criteria for the Project is summarised in Table 5-2.

Table 5-3: Project internal noise criteria for residential

Type of occupancy	Window condition	Noise descriptor	Internal noise level	
			Day (1)	Night (1)
Bedrooms	Closed	$L_{eq\ (worst\ 1hour)}$ (2)	35 dB(A)	35 dB(A)
Living areas	Closed	$L_{eq\ (worst\ 1hour)}$ (2)	40 dB(A)	40 dB(A)

Notes: (1) Day: 07:00-22:00 Monday to Sunday. Night: 22:00-07:00 Monday to Sunday
(2) Noisiest 1-hr during the time period. This criteria apply to all external sources, including road, rail and industrial noise.

Table 5-4 summarises the internal noise criteria from AS NZS 2107-2016: Recommended design sound levels & reverberation for building interiors for occupancies other than residential (e.g. foyer, lift lobby, gym etc.)

Table 5-4 Project internal noise criteria for occupancies other than residential – AS 2107

Type of occupancy	Window condition	Internal noise level	
		Day (1), $L_{eq\ (15hour)}$	Night (2), $L_{eq\ (9hour)}$
Common areas (e.g. foyer, lift lobby)	Closed	50 dB(A)	50 dB(A)
Yoga Room, Communal Room	Closed	45 dB(A)	45 dB(A)
Gym	Closed	50 dB(A)	50 dB(A)

Notes: (1) Day: 07:00-22:00 Monday to Sunday
(2) Night: 22:00-07:00 Monday to Sunday

5.2 Noise intrusion assessment

Existing levels of road and rail noise impacting the site was determined from the following:

- traffic noise levels from Lavender Street using the noise survey results from location L01;
- traffic noise levels from Waringah Freeway using additional attended measurements taken during peak-hour traffic (L04);
- rail noise levels using additional attended measurements taken on site,
- rail and traffic noise level patterns for day and night periods, and maximum 1-hour L_{eq} using the noise survey results from L03.

Assessment of potential external noise impacts was carried out using environmental noise modelling with CadnaA noise prediction software and the existing external noise levels, to determine the noise level at the facades of the buildings within the site. Facade noise maps from road and rail noise on the are presented in APPENDIX C.

5.3 Recommendations - Facade noise control

The building shell will need to be designed to control external noise intrusion in order to comply with the internal noise criteria in Section 5.1. The following sections provide the performance requirements for different facade elements.

5.3.1 Glazing design

The following tables provide indicative glazing treatment for each facade of the residential development.

Table 5-5: Recommended glazing treatment - North tower - Apartments

Facade	Building Level	Room Type	Recommended Minimum Sound Insulation Rating of Glazing Assembly	Indicative Glazing Configuration	Laboratory Test Reference
East	Levels 2 to 3	Bedroom	Rw 35	10.38 mm laminated glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
	Level 5	Bedroom	R_w 37	12.38 mm laminated glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
	Levels 6 to 7	Bedroom	R_w 38	12.5 mm VLam Hush glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
	Levels 8 to 19	Bedroom	Rw 43	10.5 mm VLam Hush glass / 16 mm air gap/ 8 mm float glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
	Levels 20 to 22	Bedroom	R_w 38	12.5 mm VLam Hush glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
South	Levels 2 to 3	Bedroom	Rw 35	10.38 mm laminated glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
	Levels 5 to 6	Bedroom	R_w 37	12.38 laminated glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
	Levels 7 to 10	Bedroom	R_w 38	12.5 mm VLam Hush glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
	Levels 11 to 15	Bedroom	Rw 43	10.5 mm VLam Hush glass / 16 mm air gap/ 8 mm float glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
	Levels 16 to 22	Bedroom	R_w 38	12.5 mm VLam Hush glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
North	Levels 2 to 3	Bedroom	R_w 32	6.38 mm laminated glass	ESTIMATE

Facade	Building Level	Room Type	Recommended Minimum Sound Insulation Rating of Glazing Assembly	Indicative Glazing Configuration	Laboratory Test Reference
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
	Levels 5 to 22	Bedroom	Rw 35	10.38 laminated glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
West	Levels 2 to 3	Bedroom	Rw 35	10.38 mm laminated glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
	Levels 5 to 9	Bedroom	Rw 32	6.38 mm laminated glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
	Levels 10 to 22	Bedroom	Rw 35	10.38 mm laminated glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE

Table 5-6: Recommended glazing treatment - South tower - Apartments

Facade	Building Level	Room Type	Recommended Minimum Sound Insulation Rating of Glazing Assembly	Indicative Glazing Configuration	Laboratory Test Reference
East	Levels 2 to 3	Bedroom	Rw 35	10.38 mm laminated glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
	Levels 4 to 6	Bedroom	R_w 37	12.38 mm laminated glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
	Levels 7 to 32	Bedroom	R_w 38	12.5 mm VLam Hush glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
South	Levels 2 to 7	Bedroom	R_w 37	12.38 mm laminated glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
	Levels 8 to 32	Bedroom	Rw 35	10.38 mm laminated glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
West	Levels 2 to 3	Bedroom	Rw 35	10.38 mm laminated glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
	Levels 4 to 9	Bedroom	Rw 32	6.38 mm laminated glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE
	Level 10 to 32	Bedroom	Rw 32	6.38 mm laminated glass	ESTIMATE
		Living Room	Rw 32	6.38 mm laminated glass	ESTIMATE

Table 5-7 Recommended glazing treatment – North and South tower – Non residential areas

Facade	Building Level	Room type	Recommended Minimum Sound Insulation Rating of Glazing Assembly	Indicative Glazing Configuration	Laboratory Test Reference
North Tower					
All	All	Common areas (e.g. foyer, lift lobby)	Rw 29	6 mm monolithic glass	ESTIMATE
		Yoga Room, Communal Room	Rw 29	6 mm monolithic glass	ESTIMATE
		Gym	Rw 29	6 mm monolithic glass	ESTIMATE

Note: The glazing recommendations for the North and South Towers are provided solely from an acoustic performance perspective (Rw rating) to satisfy the acoustic requirements only, and the Client may select alternative glazing systems with an equivalent or higher Rw rating, provided that the applicable internal noise level criteria are satisfied.

5.3.1.1 Glazing assembly and detailing

The following acoustic measures should also be incorporated into the building design:

- All operable 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 glazing thicknesses outlined in Section 5.3 should be considered the minimum thicknesses to achieve acoustical ratings. Greater glazing thicknesses may be required for structural loading, wind loading etc.
- The glazing supplier shall ensure that installation techniques will not diminish the Rw performance of the glazing when installed on site. Sliding door meeting stiles should form an airtight seal when closed and locked.
- The perimeter of all window and door frames are to be sealed airtight in the external facade using the following methods:
    - For gaps less than 10mm - Fill all gaps around the window perimeter with an acoustic mastic sealer (minimum specific gravity 1.6sg) equivalent to Promat Promaseal. The depth of sealer shall be at least equal to the width of the gap.
    - If the gap is greater than 10mm, fill the cavity with polyester insulation and a backing rod. Seal the gap airtight an acoustic mastic sealer (min specific gravity 1.6sg) equivalent to Promat Promaseal. The depth of sealer shall be at least equal to the width of the gap. The gaps between frames shall also be sealed using aluminium angle brackets (approximately 25 x 25 x 3mm).

5.3.1.2 Non-glazed façade elements

In the event that façade elements are not masonry, detailed acoustic review of external wall build up is required to ensure noise transmission to internal areas is adequately controlled to ensure compliance with internal noise level requirements of Section 5.1.

5.3.2 Supplementary ventilation

All habitable rooms except west facing living are to be provided with supplementary fresh air in accordance with the ISEPP Guideline. In addition, it is recommended that the level 2 and 3 western living rooms are provided alternative ventilation due to noise from the use of the loading dock.

Any ventilation system must meet the requirements of AS 1668.1.

6 Rail vibration assessment

Vibration from the train is transmitted through the track structure, through the ground mass and into building structures. This vibration has the potential to be perceptible to building occupants as tactile vibration, and as regenerated ground-borne noise. This section addresses the potential impacts of vibration impacts from train pass-bys on the nearby rail corridor onto the development for tactile vibration and ground-borne noise.

6.1 Rail vibration criteria

Section 3.6.3 of the *Development Near Rail Corridors and Busy Roads – Interim Guideline* ('Rail & Road Guideline') provides the following reference documents for establishing criteria to assess train vibration impacts on buildings:

- *Assessing Vibration: A technical guideline*, Department of Environment and Conservation NSW February 2006 ('Assessing Vibration guideline')
- German Standard DIN 4150 - Part 3 (2016) *Vibration in buildings - Effects on Structures* ('DIN 4150-3:2016')
- British Standard BS 7385-2:1993 *Evaluation and measurement for vibration in buildings—Part 2: Guide to damage levels from groundborne vibration* ('BS 7385-2:1993')
- Australian Standard AS 2670-2:1990 *Evaluation of human exposure to whole-body vibration—Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz)* ('AS 2670-2:1990')

6.1.1 Tactile vibration

The above documents have been reviewed and the criteria for the assessment of tactile vibration from train pass-bys affecting the proposed development is derived from Assessing Vibration guideline.

The Assessing Vibration guideline provides preferred and acceptable levels of vibration inside buildings measured as vibration dose values (VDV) for intermittent sources, including train pass-bys. which is presented in Section 6.1.1.1.

The Assessing Vibration guideline also references British Standard BS 6472: 1992 *Evaluation of Human Exposure to Vibration in Buildings (1Hz to 80Hz)* ('BS 6472: 1992') for potential impacts to human comfort from vibration. BS 6472: 1992 provides limit vibration curves for different building occupancies which is presented in Section 6.1.1.2.

6.1.1.1 Vibration dose values

Table 2.4 of the Assessing Vibration guideline also presents acceptable VDV for the overall exposure from intermittent sources vibration, including train pass-bys, which is summarised in Table 6-1.

Table 6-1: Preferred VDVs values for intermittent vibration in residential buildings

Location	Period	Preferred VDV, $m/s^{1.75}$	Maximum VDV, $m/s^{1.75}$
Residence	Day time (7am – 10pm)	0.20	0.40
	Night time (10pm – 7am)	0.13	0.26

6.1.1.2 Human comfort curves

Criteria for continuous vibration measured as acceleration rms from the BS 6472:1992 for residential spaces are shown in Figure 6-1 below.

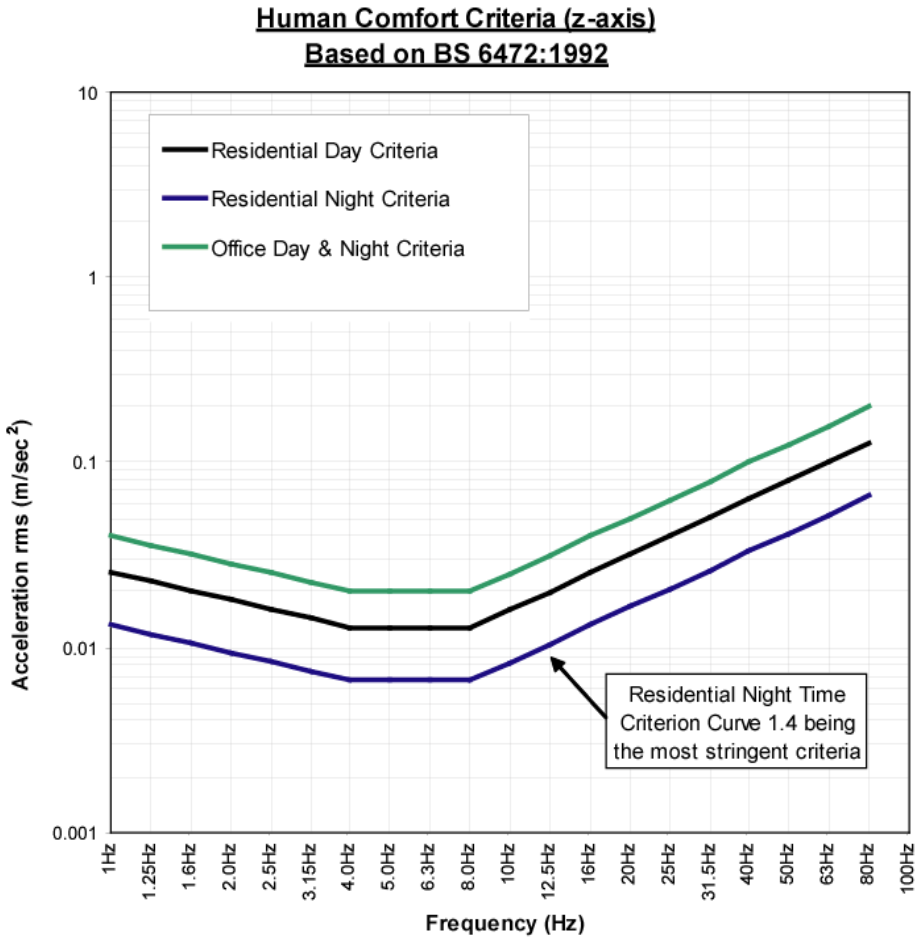


Figure 6-1: Human comfort criteria for residential buildings

6.1.2 Ground-borne noise

Regenerated or ground-borne rail noise is the low rumble heard inside buildings with vicinity of railway tunnels or railway tracks due to ground vibration generated by passing trains which propagate through soil and rock up into building elements such as foundation, wall and floors which re-radiates as audible sound.

The Rail & Road Guideline provides internal noise criteria for ground-borne or regenerated rail noise inside residential buildings which is summarised in Table 6-2.

Table 6-2: Ground-borne rail noise criteria

Type of occupancy	Internal noise criteria, $L_{max,slow}$	
	Day (1)	Night (2)
Bedrooms	-	35 dB(A)
Living areas	40 dB(A)	40 dB(A)

Notes: (1) Day: 07:00-22:00 Monday to Sunday
(2) Night: 22:00-07:00 Monday to Sunday
(3) Guideline states that ground-borne noise is calculated as $L_{max,slow}$ from 95% of rail pass-bys.

6.2 Instrumentation and methodology

Ground-borne vibration (GBV) levels were measured at an external location near the facade of the proposed future buildings. Double-sided adhesive tape was used to fix the accelerometer to a heavy ground spike. The ground spike was positioned such that it was flush-fit with the external ground level. It was measured at two locations, approximately 13m (V01) and 34m (V01) measured horizontally from the elevated rail structure, which represents the façade of the proposed North and South Towers

The Soundbook software (Samurai Version 3.0.2) was used to record a time history of the vibration levels in the x, y and z directions at a sample rate of 12.8 kHz. For all locations, the spectrum analyser (Soundbook) was set up to measure slow response L_{max} vibration velocity levels in one-third octave frequency bands between 6.3 Hz and 1 kHz. The vibration time histories were reviewed to assist in identifying the start and end positions of each passby. This measurement interval was typically five seconds before the front of the train passed the measurement location and five seconds after the end of the train passed the measurement location. During this time period, the maximum vibration levels in each one-third octave frequency band was determined for each train (slow response L_{max}). The maximum 1-second RMS vibration level ($L_{max(1s\ rms)}$) for each passby was determined.

At each measurement site, vibration measurements were undertaken for a minimum of ten train movements, five in each direction. As a minimum, the time and direction of each train passby was recorded. The AnyTrip[3] website and the application was used to confirm the presence of, direction and set number of the train passbys on each track.

6.3 Measured tactile train vibration

Vibration levels from train pass-bys were measured at locations V01 and V02. The measured train vibration levels were used to calculate the overall vibration dosage values (VDV) for the day and night period, taking into account the total number of train movements which. The estimated VDVs are presented in Table 6-3.

[3] https://anytrip.com.au/region/nsw

Table 6-3: Estimated VDVs from train pass-bys

Location	Period	Preferred VDV, m/s$^{1.75}$	Estimated VDV, m/s$^{1.75}$	Complies
V01	Day time (7am – 10pm)	0.20	0.09	Yes
	Night time (10pm – 7am)	0.13	0.06	Yes
V02	Day time (7am – 10pm)	0.20	0.02	Yes
	Night time (10pm – 7am)	0.13	0.01	Yes

The measured acceleration levels were also plotted against night and day criteria curves from BS 6472-1992 which are presented in Figure 6-2 and Figure 6-3 for locations V01 and V02, respectively. The measured acceleration levels from train pass-by vibration are compliant with the residential night criteria curve, which is the most stringent criterion applicable.

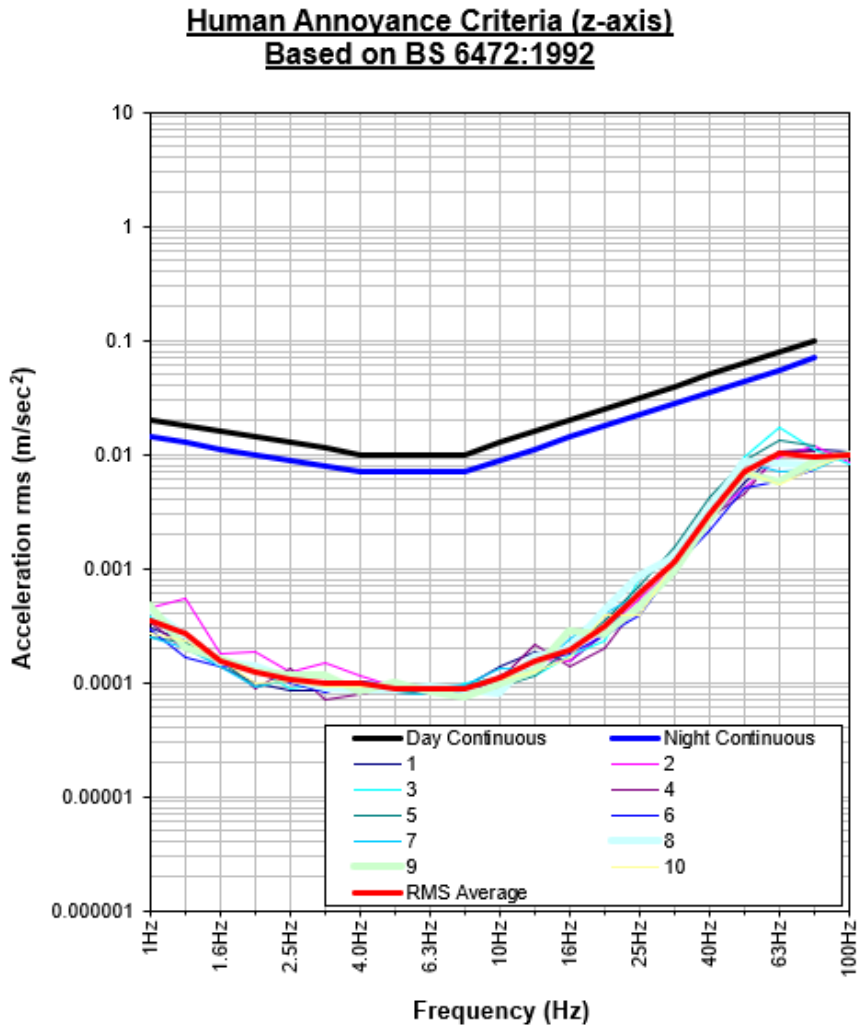


Figure 6-2 Measured train pass-by acceleration - V01

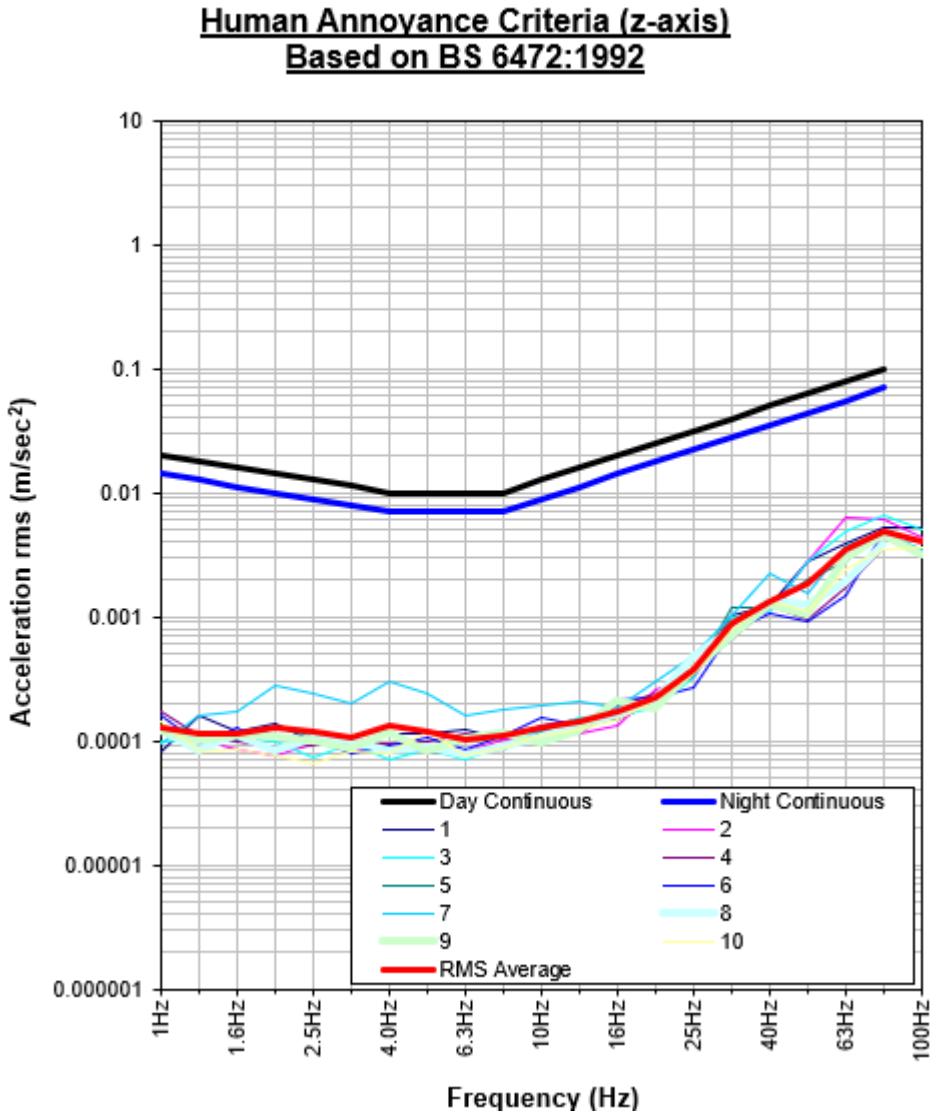


Figure 6-3 Measured train pass-by acceleration - V02

6.4 Predicted ground-borne rail noise

Results of the train vibration measurements were also used to predict the regenerated rail noise inside the proposed building from train pass-bys. These calculated noise levels inside the habitable spaces are summarised below and compared against the ground-borne noise criteria.

For each residential tower, predictions are provided for two locations – for completeness, rooms with direct line-of-sight to the rail corridor, and rooms that are shielded from the rail corridor. However, rooms on the eastern side of the buildings will receive both airborne and ground borne noise. The airborne noise will act as masking for the ground borne noise and so the ground borne noise levels are only critical for the western side of the building due to shielding from the airborne noise component.

Table 6-4: Predicted ground-borne rail noise levels - North Tower

Facade	Level	Internal noise criteria [1], $L_{max,slow}$	Predicted ground-borne rail noise, $L_{Amax,slow}$	Comply?
North tower - East façade				
East (with line-of-sight to rail)	Level 2	Bedrooms - 35 dBA Living areas - 40 dBA	46	See discussion below. [2]
	Level 3		43	See discussion below. [2]
	Level 4		-	-
	Level 5		39	See discussion below. [2]
West (with no line-of-sight to rail)	Level 2	Bedrooms - 35 dBA Living areas - 40 dBA	40 - 42	See discussion below.
	Level 3 - Living areas only		37 - 39	Complies
	Level 4		-	-
	Level 5		32 - 35	Complies

Notes: (1) The presented criteria for Bedrooms during night-time period which is the more stringent.
(2) Facades with line of sight to the rail corridor experience masking from airborne noise.

Table 6-5: Predicted ground-borne rail noise levels - South Tower

Facade	Level	Internal noise criteria [1], $L_{max,slow}$	Predicted ground-borne rail noise, $L_{Amax,slow}$	Comply?
North tower - East facade				
East (with line-of-sight to rail)	Level 2	Bedrooms - 35 dBA Living areas - 40 dBA	40	See discussion below. [2]
	Level 3		37	See discussion below. [2]
	Level 4		35	Complies
	Level 5		32	Complies
West (with no line-of-sight to rail)	Level 2	Bedrooms - 35 dBA Living areas - 40 dBA	33	Complies
	Level 3		31	Complies
	Level 4		28	Complies
	Level 5		26	Complies

Notes: (1) The presented criteria for Bedrooms during night-time period which is the more stringent.
(2) Facades with line of sight to the rail corridor experience masking from airborne noise.

With regards to the predicted ground-borne noise levels:

- For facades with line-of-sight to the rail corridor, Section 3.6.2 of the Rail & Road Guideline provides discussion regarding the masking effect provided by airborne noise over for ground-borne noise.
- The Rail & Road Guideline identifies a risk scenario for rooms facing away from the rail line (with no line-of-sight) where they may experience ground-borne noise but without significant airborne noise impacts due to building shielding.
- For the façades that are shielded from airborne rail noise:

- Additional rail vibration measurements are recommended to be undertaken inside the an existing building on site that is shielded from the rail. The vibration measurements carried out on V01 and V02 were taken on-grade with a spike on the ground. Additional measurements taken on the slab would provide insight to vibration levels with building decoupling from the ground on site. These additional measurements could be used to refine predicted ground-borne noise levels.

- Building vibration isolation may be required to satisfy the ground-borne noise criteria (subject to further review in the detailed design phase).

7 Noise emission assessment

This section addresses the impacts of noise generated by the development on the surrounding environment, outlines the relevant noise emissions criteria, and provides preliminary recommendations on noise control.

7.1 Noise emissions criteria

The guidelines, standards, policies, and local planning controls relevant to the assessment of noise intrusion to the development are as follows:

- *Noise Policy for Industry* ('NPfI')
- *NSW Road Noise Policy* ('RNP')

7.1.1 NPfI - Plant and equipment, loading dock

Noise impacts of industrial sites or industrial sources associated with a development to the existing surroundings is assessed in accordance with the NPfI. The assessment procedure has two components:

- Controlling intrusive noise impacts in the short-term for residences; and
- Maintaining noise level amenity for residences and other land uses.

In accordance with the NPfI, noise impact should be assessed against the 'project noise trigger level' which is the lower value of the project intrusiveness noise levels and project amenity noise levels.

7.1.1.1 Project intrusive noise levels

According to the NPfI, the intrusiveness of a noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the LAeq,15min descriptor) does not exceed the background noise level measured in the absence of the source by more than 5dB(A). The project intrusiveness noise level, which is only applicable to residential receivers, is determined as follows:

Intrusiveness noise level, $L_{Aeq,period}$ = Rating Background Level ('RBL') + 5dB(A)

Based on the background noise monitoring results in Table 4-1, the intrusiveness noise levels for the residential receivers (see Section 0) are determined in the table below.

Table 7-1: Project intrusiveness noise levels

Receiver	Intrusiveness noise level, $L_{Aeq,15min}$		
	Day (1)	Evening (2)	Night (3)
R01 - Adjacent residential building to the east	56 + 5 = 61	54 + 5 = 59	46 + 5 = 51

Receiver	Intrusiveness noise level, $L_{Aeq,15min}$		
	Day (1)	Evening (2)	Night (3)
R02 - High-rise residential buildings across Lavender Street	56 + 5 = 61	54 + 5 = 59	46 + 5 = 51
R03 - Adjacent residential building to the West	56 + 5 = 61	54 + 5 = 59	46 + 5 = 51
R04 - Residential buildings across Arthur Lane	49 + 5 = 54	47 + 5 = 52	41 + 5 = 46

Notes: (1) Day: 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays.
(2) Evening: 18:00-22:00 Monday to Sunday & Public Holidays.
(3) Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays.
(4) The NPfI notes that the intrusiveness noise level for the evening shall not be greater than the intrusiveness level for day time.

7.1.1.2 Amenity noise levels

The project amenity noise levels for different time periods of day are determined in accordance with Section 2.4 of the NPfI. The NPfI recommends amenity noise levels ($L_{Aeq,period}$) for various receivers including residential, commercial, industrial receivers and sensitive receivers such as schools, hotels, hospitals, churches and parks. These "recommended amenity noise levels" represent the objective for total industrial noise experienced at receiver location. However, when assessing a single industrial development and its impact on an area, "project amenity noise levels" apply.

To ensure that the total noise level (existing and new development) remain within the recommended amenity noise levels for an area, the project amenity noise level that applies for each new industrial noise source is determined as follows:

Project amenity noise level, $L_{Aeq,period}$ = Recommended amenity noise level, $L_{Aeq,period}$ – 5dB(A)

The NPfI also notes that the in areas where traffic noise are high enough such that industrial noise can be sufficiently masked, the project amenity level may be adjusted. This adjustment only applies where traffic noise is the dominant source at the site and unlikely to decrease in the future, and the traffic noise level LAeq,period exceeds the Recommended amenity noise level by 10 dB.

Adjusted project amenity noise level, $L_{Aeq,period}$ = Traffic noise level, $L_{Aeq,period}$ – 15dB(A)

Furthermore, given that the intrusiveness noise level is based on a 15-minute assessment period and the project amenity noise level is based on day, evening and night assessment periods, the NPfI provides the following guidance on adjusting the LAeq,period level to a representative LAeq,15minute level in order to standardise the time periods.

$$L_{Aeq,15min} = L_{Aeq,period} + 3dB(A)$$

The project amenity noise levels for residential receivers are derived in Table 7-2.

Table 7-2: Project amenity noise levels for residential receivers

Receiver	Description	Noise descriptor	Amenity noise level, dB(A)		
			Day (1)	Evening (2)	Night (3)
R01	Recommended amenity noise level	$L_{Aeq,Period}$	60	50	45

Receiver	Description	Noise descriptor	Amenity noise level, dB(A)		
			Day (1)	Evening (2)	Night (3)
	Project amenity noise level	$L_{Aeq,Period}$	60 - 5 = 55	50 - 5 = 45	45 - 5 = 40
	Traffic noise level	$L_{Aeq,Period}$	63	62	60
	High traffic noise trigger? (4)		No	Yes	Yes
	Project amenity noise level (5)	**$L_{Aeq,15min}$**	**60 - 5 + 3 = 58**	**62 - 15 + 3 = 50**	**60 - 15 + 3 = 48**
R02	Recommended amenity noise level	$L_{Aeq,Period}$	60	50	45
	Amenity noise level	$L_{Aeq,Period}$	60 - 5 = 55	50 - 5 = 45	45 - 5 = 40
	Traffic noise level	$L_{Aeq,Period}$	63	62	60
	High traffic noise trigger? (4)		No	Yes	Yes
	Project amenity noise level (5)	**$L_{Aeq,15min}$**	**60 - 5 + 3 = 58**	**62 - 15 + 3 = 50**	**60 - 15 + 3 = 48**
R03	Recommended amenity noise level	$L_{Aeq,Period}$	60	50	45
	Amenity noise level	$L_{Aeq,Period}$	60 - 5 = 55	50 - 5 = 45	45 - 5 = 40
	Traffic noise level	$L_{Aeq,Period}$	63	62	60
	High traffic noise trigger? (4)		No	Yes	Yes
	Project amenity noise level (5)	**$L_{Aeq,15min}$**	**60 - 5 + 3 = 58**	**62 - 15 + 3 = 50**	**60 - 15 + 3 = 48**
R04	Recommended amenity noise level	$L_{Aeq,Period}$	60	50	45
	Amenity noise level	$L_{Aeq,Period}$	60 - 5 = 55	50 - 5 = 45	45 - 5 = 40
	Traffic noise level	$L_{Aeq,Period}$	-	-	-
	High traffic noise trigger? (4)		No	No	No
	Project amenity noise level (5)	**$L_{Aeq,15min}$**	**60 - 5 + 3 = 58**	**50 - 5 + 3 = 48**	**45 - 5 + 3 = 43**

Notes: (1) Day: 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays.
(2) Evening: 18:00-22:00 Monday to Sunday & Public Holidays.
(3) Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays.
(4) In accordance with the NPfI, the amenity noise level may be adjusted for areas where traffic noise levels are sufficiently high.
(5) In accordance with the NPfI, a + 3dB(A) correction is made to convert from $L_{Aeq,period}$ to $L_{Aeq,15min}$.

7.1.1.3 Project noise trigger levels

In accordance with the NPfI the project noise trigger levels is taken as the lower and more stringent value of the project intrusiveness noise level (Table 7-1) and project amenity noise level (Table 7-2), have been determined as shown in Table 7-3 below.

Table 7-3: Project noise trigger levels

Receiver	Project noise trigger level, $L_{Aeq,15min}$		
	Day (1)	Evening (2)	Night (3)
R01 - Adjacent residential building to the east	58	50	48
R02 - High-rise residential buildings across Lavender Street	58	50	48
R03 - Adjacent residential building to the West	58	50	48
R04 - Residential buildings across Arthur Lane	54	48	43
R05 - Commercial and retail premises	63 (When in use)		

Receiver	Project noise trigger level, $L_{Aeq,15min}$		
	Day (1)	Evening (2)	Night (3)

Notes: (1) Day: 07:00-18:00 Monday to Saturday and 08:00-18:00 Sundays & Public Holidays.
(2) Evening: 18:00-22:00 Monday to Sunday & Public Holidays.
(3) Night: 22:00-07:00 Monday to Saturday and 22:00-08:00 Sundays & Public Holidays.

7.2 Noise Emission Assessment

7.2.1 Industrial noise – Mechanical plant and equipment

Noise from plant and equipment is assessed with reference to the NPfI. The project noise trigger levels for sensitive receivers surrounding the development are outlined in Table 7-3.

The details of the mechanical plant and equipment servicing development are yet to be finalised at this stage of the Project, and assessment of noise impacts from mechanical plant and equipment should be undertaken during the Detailed Design stage of the Project when equipment selections become available.

However, in-principle:

- It is likely that primary ventilation plant and equipment items will either be located in the basement or at roof level.
- If located within the basement, noise emission control will be achievable using in duct lining or silencers or similar standard treatment for noise emissions to the environment.
- Acoustic treatments must be sufficient such plant noise emissions are compliant with the project noise trigger levels.
- Detailed acoustic review is recommended to be conducted at detailed designed stage, once plant and equipment items are designed and selections finalised.
- In particular, detailed review is needed for any mechanical equipment located on roofs or podiums that will be overlooked by future apartments. This includes residential apartments in the South tower overlooking the North tower roof deck.
- Plantrooms with louvre openings are recommended to be not adjacent to a residential balcony.

7.2.2 Loading dock

It is understood that the podium will incorporate a loading dock for residential use only, and no commercial or retail tenancies are proposed for the development.

- We recommend that the loading dock door is solid, not perforated, to control noise emissions to the nearest sensitive receivers within the development and to the west of the site.

- Acoustic glazing detailed in Section 5.3.1 has been provided to ensure loading dock activities does not impact apartments within the development.
- Roller door to the loading dock shall have motor and guiderail vibration isolation using Embelton NRD and Supershearflex pads isolation respectively, or equivalent.

8 Construction noise and vibration assessment

This section presents an indicative assessment of potential construction noise and vibration impacts from the works associated with the development. A detailed Construction Noise and Vibration Management Plan ('CNVMP') should be prepared for the Project prior to the issue of Construction Certificate detailing the site-specific construction methodologies with input from respective contractors, including plant and equipment to be used, expected periods of construction, and noise and vibration management treatments and procedures to be implemented.

8.1 Construction noise objectives

The NSW *Interim Construction Noise Guideline* ('ICNG') provides a guide for assessing noise generated during the construction phase of developments and shall be utilised to manage construction noise impacts from the site.

The key components of the guideline that are incorporated into this assessment include:

- Use of L_{Aeq} as the descriptor for measuring and assessing construction noise.
- Application of reasonable and feasible 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.

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 duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification. Given the scale of the construction works proposed for the rest area, a quantitative assessment is carried out herein, consistent with the ICNG requirements.

Table 8-1, reproduced from the ICNG, sets out the airborne noise management levels (NMLs) and how they are to be applied for residential receivers.

Table 8-1: Noise management levels at residential receivers

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	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured LAeq (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 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 *[of the ICNG.*

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

The ICNG also provides NMLs for other non-sensitive land uses. Table 8-2 summarises the NMLs for other sensitive receivers in proximity to the Project site.

Table 8-2: Noise management levels at other noise sensitive land uses

Land use	Time of day	Assessment location	Management level $L_{Aeq\ (15\ min)}$
Commercial	When in use	External	70

8.1.1 Project construction Noise Management Levels

A summary of the construction NMLs during Standard Hours was determined based on the objectives of the ICNG and the measured background noise levels (see Section 4.1) is presented in Table 8-3. In the event these Noise Management Levels are exceeded, reasonable and feasible construction noise mitigation is required.

Table 8-3: Construction noise management levels - Standard Hours

Location description	Standard Hours (1)	
	Noise affected NML, $L_{Aeq(15min)}$ (2)	High noise affected level, $L_{Aeq(15min)}$ (2)
R1 - Paramatta Road residential receivers	56 + 10 = 66	75
R2 - Harris Road residential receivers	56 + 10 = 66	75
R3 - Queens Road residential receivers	56 + 10 = 66	75
R4 - Courland Street residential receivers	49 + 10 = 59	75
Commercial	70 (When in use)	N/A

Notes: (1) In accordance with the ICNG, the recommended Standard Hours of construction are: Monday to Friday 7:00am to 6:00pm; Saturday 8:00am to 1:00pm.

(1) Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5m above ground level.

8.2 Construction vibration objectives

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 International System of Units (SI unit) for distance is the metre (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 metres 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 metres per second squared (m/s2).

Construction vibration goals are summarised below.

8.2.1 Disturbance to buildings occupants

Assessment of potential disturbance from vibration on human occupants of buildings is made in accordance with the *Assessing Vibration: a technical guideline* ('Assessing Vibration guideline'). 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 8-4 provides definitions and examples of each type of vibration.

Table 8-4: 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.

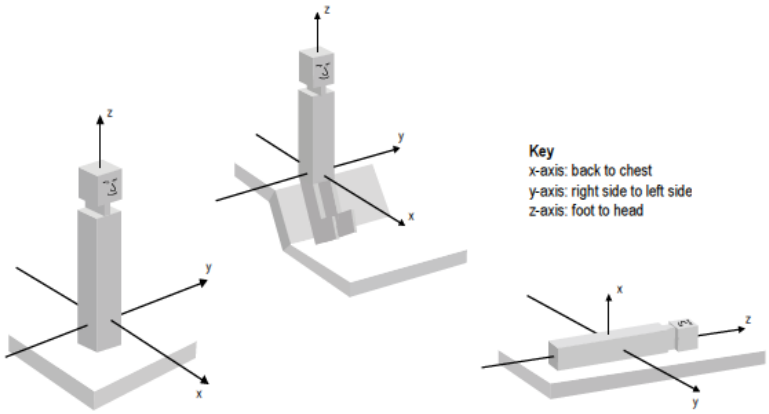
Source: Assessing Vibration; a technical guideline, Department of Environment & Climate Change, 2006

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 8-1. 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 8-1: 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 are reproduced in Table 8-5.

Table 8-5: 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)					
Critical areas[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
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
Workshops	Day- or night-time	0.04	0.029	0.080	0.058
Impulsive vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
Critical areas[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshops	Day- or night-time	0.64	0.46	1.28	0.92

Notes:
- Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am
- Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1992

The acceptable vibration dose values (VDV) for intermittent vibration are defined in Table 2.4 of the guideline and are reproduced in Table 8-6

Table 8-6: 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
Critical areas[2]	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 7:00am to 10:00pm and night-time is 10:00pm to 7:00am
- Examples 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 of impulsive criteria for critical areas.

Source: BS 6472-1992

8.2.2 Building structural 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.

It is noted that vibration levels required to cause minor cosmetic damage are typically 10 x higher than levels that will cause disturbance to building occupants. Many building occupants assume that building damage is occurring when they feel vibration or observe rattling of loose objects, however the level of vibration at which people perceive vibration or at which loose objects may rattle is far lower than vibration levels that can cause damage to structures.

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 consequence of an action that reduces the serviceability of a structure or one of its components" (p.4). The Standard also outlines:

"For buildings as in lines 2 and 3 of Tables 1, 4 or B.1, the serviceability is considered to have been reduced if, for example

cracks form in plastered or rendered surfaces of walls;

existing cracks in a structure are enlarged;

partitions become detached from load-bearing walls or floor slabs.

These effects are deemed 'minor damage. " (DIN4150.3:2016, p.6)

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.

8.2.2.1 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 8-7 sets out the BS7385 criteria for cosmetic, minor and major damage.

Regarding heritage buildings, British Standard 7385 Part 2 (1993) notes that "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*" (p.5).

Table 8-7: BS 7385 structural damage criteria

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

Notes: 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.

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

8.2.2.2 German Standard

German Standard DIN 4150 - Part 3 (2016) '*Vibration in buildings - Effects on Structures*' (DIN 4150-3:2016), 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 4150-3:2016 presents the recommended maximum limits over a range of frequencies (Hz), measured at the foundations, in the plane of the uppermost floor of a building or structure or vertically on floor slabs. The vibration limits at the foundations increase as the frequency content of the vibration increases. The criteria are presented in the table below.

Table 8-8: DIN 4150-3:2016 structural damage criteria

Group	Type of structure	Vibration velocity, mm/s				
		At foundation in all directions at frequency of			Plane of floor uppermost storey in horizontal direction	Floor slabs, vertical direction
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz	All frequencies	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40	20
2	Residential buildings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15	20
3	Structures that because of their particular sensitivity to vibration, cannot be classified under Groups 1 and 2 and are of great intrinsic value (e.g. listed buildings)	3	3 to 8	8 to 10	8	20

8.2.3 Damage to vibration sensitive equipment

Some high technology manufacturing facilities, hospitals and laboratories utilise equipment that is highly sensitive and susceptible to vibration, for example scanning electron microscopes and micro-electronic manufacturing facilities. In addition, buildings housing sensitive computer or telecommunications equipment may require assessment against stricter criteria than those nominated for building damage.

Given that the adjacent premises are dwelling houses, it is highly unlikely any would contain vibration sensitive equipment.

8.2.4 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 8-9 below.

Table 8-9: DIN 4150-3:2016 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 at the pipe, mm/s
1	Steel, welded	100
2	Vitrified clay, concrete, reinforced concrete, prestressed concrete, metal (with or without flange)	80
3	Masonry, plastics	50

Note:

For gas and water supply pipes within 2 m of buildings, the levels given in

Table 8-8 should be applied. Consideration must also be given to pipe junctions with the building structure as potential significant changes in mechanical loads on the pipe must be considered.

For long-term vibration the guideline levels presented in Table 8-9 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 CNVIS addressing impact on the utility and consultation with the utility provider to confirm specific vibration requirements.

8.3 Construction noise assessment

A detailed assessment of construction noise will need to be undertaken at the conclusion of the detailed design phase when there is more certainty on the equipment and methodologies that will be used to construct the building. This section presents a preliminary assessment of noise emissions from the construction stage.

A list of the loudest typical construction items is presented in the table below.

Table 8-10: Typical construction equipment & sound power levels

Plant item	Plant description	Sound power levels, LAeq(15min)
Demolition/Excavation Phase		
1	Excavator (with hydraulic hammer, stop/start use)	120 (inclusive of 5dB(A) penalty for irritating characteristics, and assuming 50% use in 15-minute period)
2	Excavator (no hydraulic hammer)	105
3	Truck	108
4	Piling (augured)	105
Construction Phase		
5	Tower crane (diesel)	105
6	Concrete pump	108
7	Vibrator/Slab Finishing	100
8	Powered Hand tools	103

The sound power levels for the majority of construction plant and equipment presented in the above table are based on maximum noise levels given in Table A1 of Australian Standard 2436 - 2010 *Guide to Noise Control on Construction, Demolition and Maintenance Sites*, the ICNG, information from past projects, and information held in our library files.

Given the proximity of receivers surrounding the site, it is likely that some residential receivers will be classed as 'highly noise affected' for works occurring during Standard Hours (see Table 8-3), particularly when work is undertaken near the shared boundary. Once the façade is installed, it is anticipated that internal fitout would be below the Noise Management Levels at receivers. The detailed construction noise management plan should take into account the construction program and schedule to manage noise impacts to neighbours.

8.3.1 Predicted noise levels

The table below 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 site. The noise level range presented represents the plant item operating at a location furthest from the receiver and a location closest to the receiver.

Table 8-11: Predicted noise levels for typical works

Plant Item	Plant description	Predicted dB(A)$L_{eq(15min)}$ construction noise levels			
		Receiver R01	Receiver R02	Receiver R03	Receiver R04
Noise management level – Standard Hours		**66**	**66**	**66**	**59**
Demolition/Excavation Phase					
1	Excavator (with hydraulic hammer, stop/start use)	74 - 102	74 - 86	82 - 102	74 - 94
2	Excavator (no hydraulic hammer)	59 - 87	59 - 71	67 - 87	59 - 79
3	Truck	62 - 90	62 - 74	70 - 90	62 - 82
4	Piling (augured)	59 - 87	59 - 71	67 - 87	59 - 79
Construction Phase					
5	Tower crane (diesel)	59 - 87	59 - 71	67 - 87	59 - 79
6	Concrete pump	62 - 90	62 - 74	70 - 90	62 - 82
7	Vibrator/Slab Finishing	54 - 82	54 - 66	62 - 82	54 - 74
8	Powered Hand tools	57 - 85	57 - 69	65 - 85	57 - 77

The predicted noise levels presented above indicate that the noise levels during the excavation and construction stages are likely exceed the Noise Management Level and high affected noise level at nearby residential receivers when working near the eastern and southern property boundaries of the site. Exceedance of the 75dB(A) higher noise affected threshold will likely occur when doing demolition works close to residences on the east and western boundary.

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 prior to the issue of Construction Certificate, with detailed input from the contractors. Indicative management measures are detailed below.

8.3.2 General noise management measures

The following general noise management measures are recommended for all receiver locations:

- Solid construction hoarding is recommended along residential interface on western and eastern boundary.
- Use of electric cranes (as opposed to diesel) and bored piling (as opposed to vibrated) whenever feasible. Locate crane as for from east/western boundary as feasible.
- Strategically position plant (concrete pump, or similar) away from the residential boundaries to the east and west (15m).
- If a dewatering pump is required to operate outside of standard construction hours – detailed advice shall be sought regarding pump location and screening.

- Respite periods shall be developed in the final Construction Noise and Vibration Management Plan.
- Generally in principle:
    - Use less noisy plant and equipment, where feasible and reasonable.
    - Plant and equipment must be properly maintained.
    - Strategically position plant on site to reduce the emission of noise to the surrounding neighbourhood and to site personnel where feasible and reasonable.
    - Avoid any unnecessary noise when carrying out manual operations and when operating plant.
    - Any equipment not in use for extended periods during construction work must be switched off.
    - Plant used intermittently to be throttled down or shut down when not in use where practicable.
    - Notification by letterbox drop would be carried out for all occupied buildings surrounding the site.

In addition to the noise mitigation measures outlined above, a management procedure will need to be put in place to deal with noise complaints that may arise from construction activities. Each complaint will need to be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is more than allowable limits.

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 must be adequately trained and experienced in such matters.

8.4 Construction vibration assessment

The vibration generated from construction works will vary depending on the level and type of activity carried out at each site during each activity.

Potential vibration generated at receivers for this project will be dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration and the receiver building's construction and structure. The recommended minimum working distances for vibration intensive plant are presented in Table 8-12, however these should be verified with site measurements

Table 8-12: Recommended minimum working distances for vibration intensive equipment

Plant item	Minimum working distance, m			
	Cosmetic damage			Human disturbance
	Commercial and industrial buildings (1)	Dwellings and similar structures (1)	Sensitive structures (e.g. heritage) (1)	Residences Day (2)
Pneumatic Hammer	5-10	10	20	10
Bored Piling	5	5	10	10

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

Unlike noise, vibration from construction activities is difficult to predict due to many variables from site to site, for example soil type and conditions; sub surface rock; building types and foundations; and actual plant on site. Site-specific minimum working distances for vibration-sensitive plant items must be determined based on the specific construction methodology (i.e.. equipment specification and areas of construction), particularly where equipment is expected to operate near or within the minimum thresholds for cosmetic damage. This assessment is essential to determine whether safe working distances can be maintained or if vibration monitoring will be required.

8.4.1 General vibration mitigation measures

The following vibration in-principle mitigation measures are recommended to minimise vibration impact from construction activities to the nearest affected receivers:

- It is recommended that vibration monitoring is conducted if excavation using hammer, vibrated piling or vibrator compaction is proposed within 20m of the residences on the eastern and western boundary of the site until safe working distance can be established.
- Any monitor is to have SMS notification facility to enable the contractor to have immediate notification in the event that vibration levels reach the threshold in Section 8.2.2.
- Dilapidation surveys should be conducted for any residential dwellings that fall within the relevant minimum buffer distances of the equipment used during the works that are being carried out. This will inform if any of the adjacent development should be subject to vibration criteria different to those identified in Section 8.2.2. This will also document any existing defects with those dwellings/items.
- 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, or use of rock rippers as opposed to hammers (if possible).

  - Use of rock saws to make perimeter cuts to excavation area prior to use of percussive equipment.
  - Establishment of safe buffer zones as mentioned above.

- Notification by letterbox drop would be carried out for all occupied buildings surrounding the site.

9 Conclusion

Renzo Tonin & Associates has completed a noise and vibration impact assessment of the proposed residential development located at 64-66 Lavender Street and 3-7 Middlemiss Street, Lavender Bay. The assessment includes the investigation of external noise impacts on the proposed development, potential noise emissions from the operational use of the development, as well as indicative construction noise and vibration impacts.

The assessment has found that:

- Reasonable design controls can be incorporated into the building design to comply with relevant Council and NSW Planning Guidelines with respect to internal noise levels from road traffic and rail pass-bys. Indicative recommendations are detailed in Section 5.3.

- Residential apartments located on Level 2 North tower that are facing away from the rail corridor has the potential to be impacted by ground-borne noise. Recommendations are made to undertake additional vibration calculations. Ultimately, it is possible that the building may require some vibration measurements on slab within existing buildings on-site to determine vibration levels that are decoupled from the ground at the commencement of the detailed design phase with a view to refine vibration isolation treatment (subject to detailed design).

- The noise emissions criteria for the nearby sensitive receivers are discussed in Section 7.1 in accordance with Noise Policy for Industry which apply to the operation of plant and equipment within the development. A follow up assessment will need to be prepared during the detailed design phase, to ensure ongoing compliance.

- It is recommended that construction noise shall be managed in accordance with Interim Construction Noise Guideline, and construction vibration shall be managed with Assessing Vibration: A Technical Guideline, along with additional international standards, as discussed in Section 8. Prior to the issue of Construction Certificate, a site-specific Construction Noise and Vibration Management Plan is recommended to be prepared.

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 common sounds in our daytime environment:

threshold of hearing	0 dB	The faintest sound we can hear
	10 dB	Human breathing
almost silent	20 dB	
	30 dB	Quiet bedroom or in a quiet national park location
generally quiet	40 dB	Library
	50 dB	Typical office space or ambience in the city at night
moderately loud	60 dB	CBD mall at lunch time
	70 dB	The sound of a car passing on the street
loud	80 dB	Loud music played at home
	90 dB	The sound of a truck passing on the street
very loud	100 dB	Indoor rock band concert
	110 dB	Operating a chainsaw or jackhammer
extremely loud	120 dB	Jet plane take-off at 100m away
threshold of pain	130 dB	
	140 dB	Military jet take-off at 25m away

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 Long-term noise monitoring results

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L01 - 66 Lavender Street, Lavender Bay

Background & Ambient Noise Monitoring Results - NSW 'Noise Policy for Industry', 2017

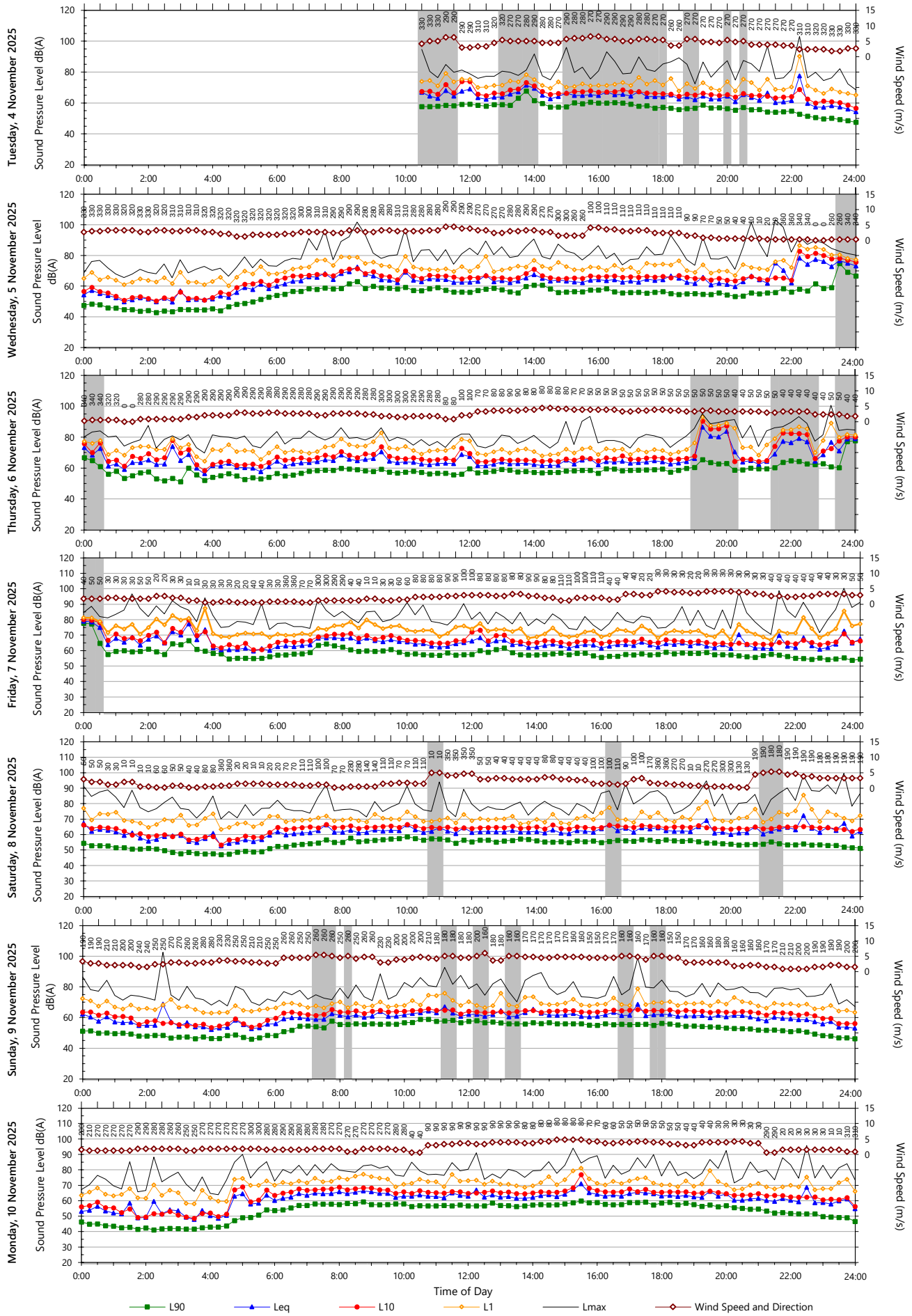
Periods with insufficient results excluded	L_{A90} Background Noise Levels[4]			L_{Aeq} Ambient Noise Levels		
Date	**Day[1]**	**Evening[2]**	**Night[3]**	**Day[1]**	**Evening[2]**	**Night[3]**
Tuesday-04-November-2025	-	-	44	-	-	61
Wednesday-05-November-2025	56	54	-	63	64	-
Thursday-06-November-2025	57	-	-	62	-	-
Friday-07-November-2025	57	56	48	63	62	60
Saturday-08-November-2025	55	-	47	60	-	59
Sunday-09-November-2025	-	52	42	-	58	56
Monday-10-November-2025	57	52	43	62	60	57
Tuesday-11-November-2025	-	-	47	-	-	57
Wednesday-12-November-2025	57	55	46	65	61	57
Thursday-13-November-2025	56	55	46	62	61	57
Friday-14-November-2025	56	54	48	62	61	59
Saturday-15-November-2025	55	-	46	61	-	56
Sunday-16-November-2025	54	52	42	59	60	56
Monday-17-November-2025	56	-	54	62	-	66
Tuesday-18-November-2025	56	53	44	68	63	56
Wednesday-19-November-2025	56	55	49	61	62	61
Thursday-20-November-2025	55	-	-	62	-	-
Representative Weekday[5]	**56**	**54**	**46**	**63**	**62**	**60**
Representative Weekend[5]	**55**	**52**	**44**	**60**	**59**	**57**
Representative Week[5]	**56**	**54**	**46**	**63**	**62**	**60**

Notes:

1. Day is 7:00am to 6:00pm on all days except Sundays and Public Holidays when it is 8:00am to 6:00pm 2. Evening is 6:00pm to 10:00pm 3. Night is the remaining periods 4. Assessment Background Level (ABL) for individual days 5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq} 6. Leq is calculated in the free field. 2.5dB is subtracted from results if logger is placed at façade 7. Number in brackets represents the measured (actual) RBL value, which is below the minimum policy value of 30 dB(A) during the evening or night period or 35 dB(A) during the day period.

Unattended Monitoring Results

Location: L01 - 66 Lavender Street, Lavender Bay - Front yard

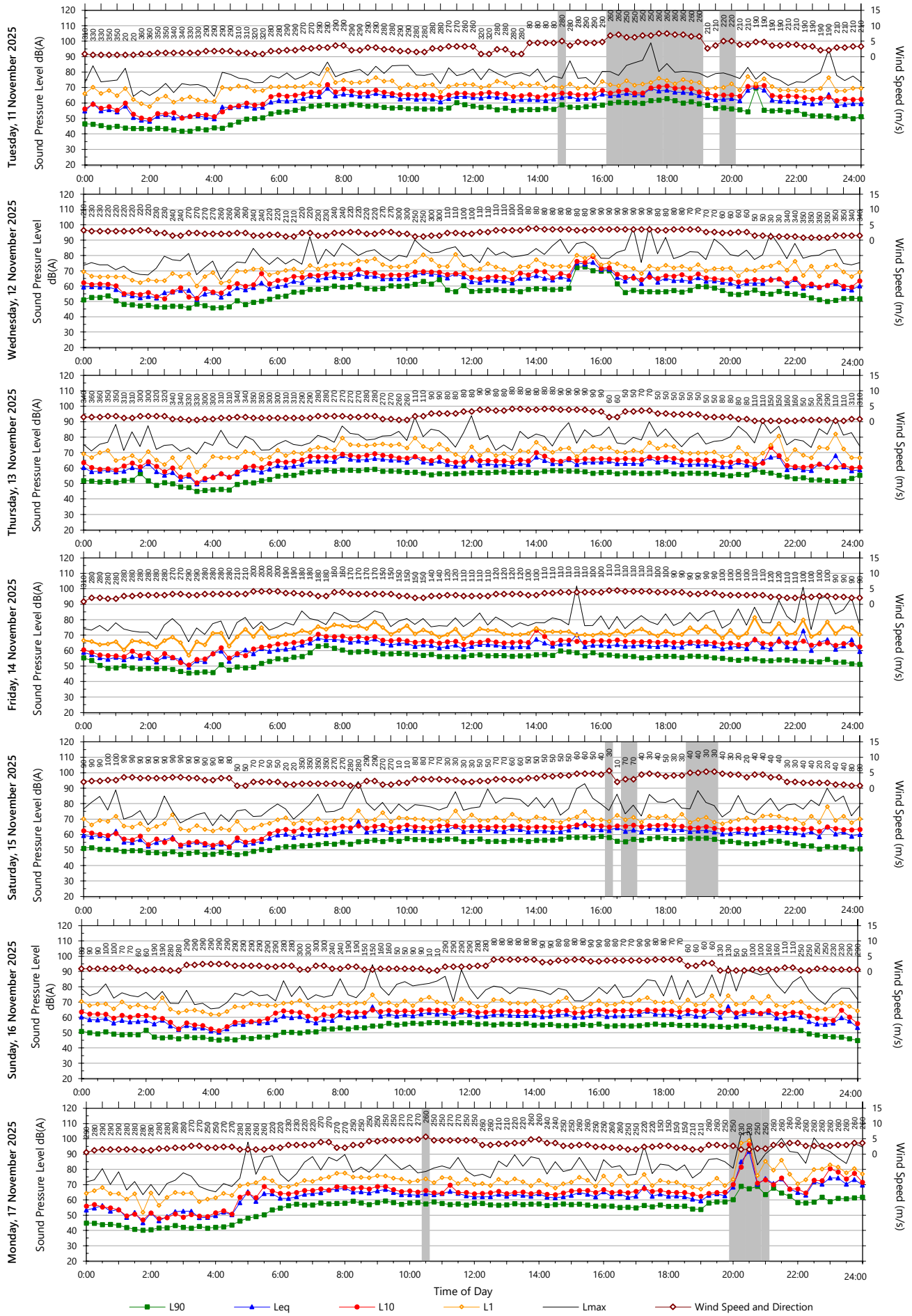


Data File: 2025-11-04_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r47)

Unattended Monitoring Results

Location: L01 - 66 Lavender Street, Lavender Bay - Front yard

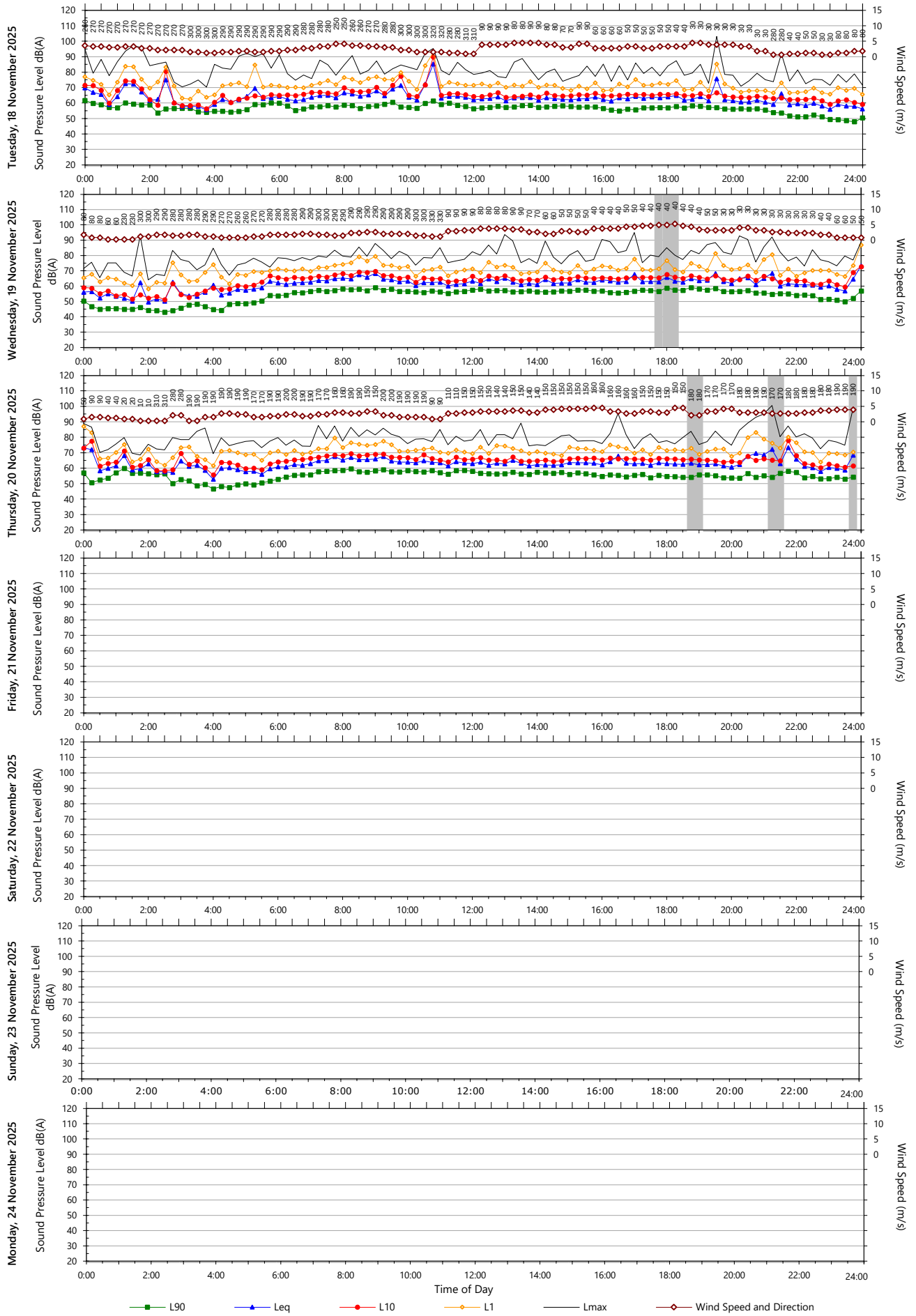


Data File: 2025-11-04_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r47)

Unattended Monitoring Results

Location: L01 - 66 Lavender Street, Lavender Bay - Front yard



Data File: 2025-11-04_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r47)

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Background & Ambient Noise Monitoring Results - NSW 'Noise Policy for Industry', 2017

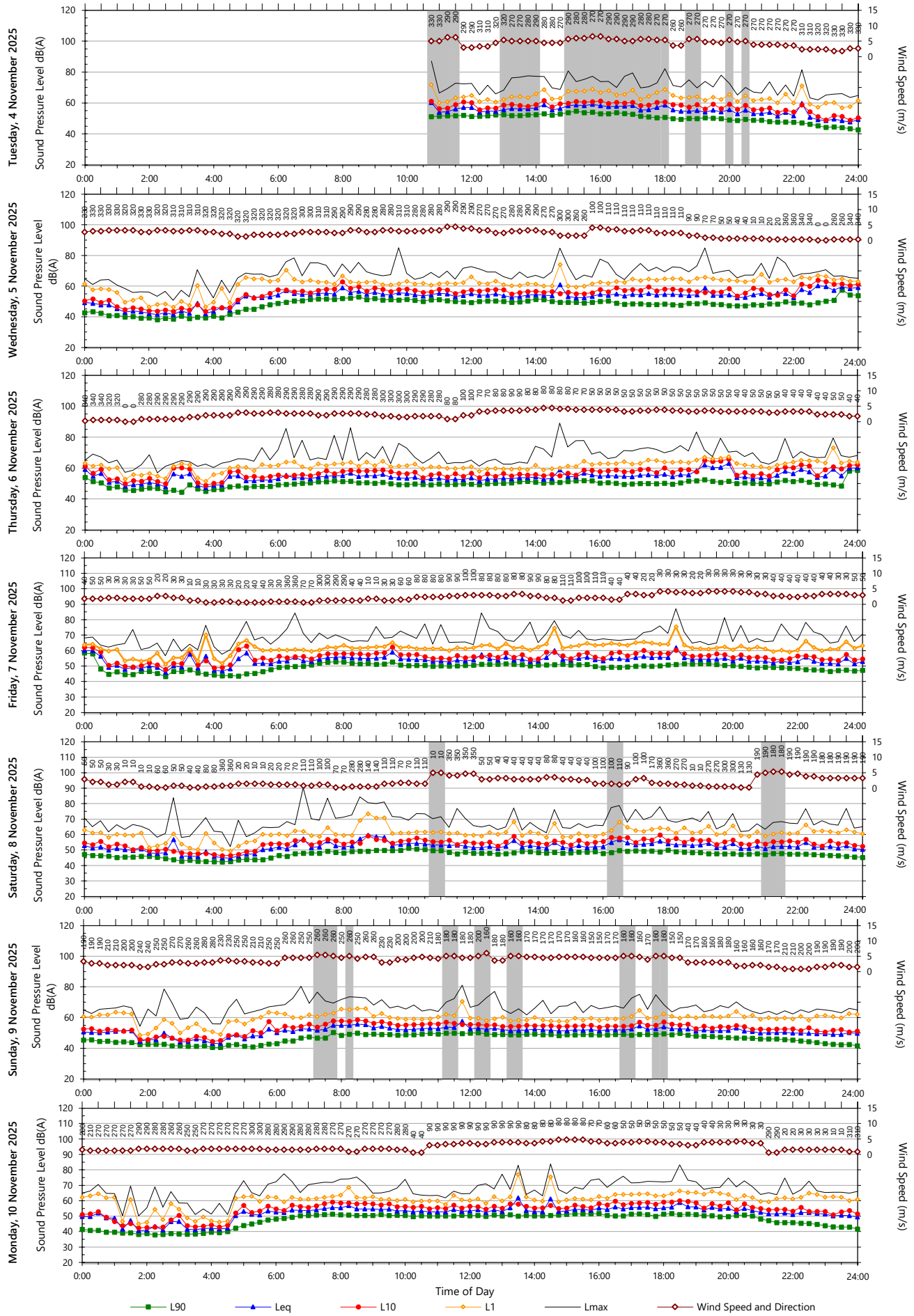
Periods with insufficient results excluded	L_{A90} Background Noise Levels[4]			L_{Aeq} Ambient Noise Levels		
Date	**Day[1]**	**Evening[2]**	**Night[3]**	**Day[1]**	**Evening[2]**	**Night[3]**
Tuesday-04-November-2025	-	-	39	-	-	49
Wednesday-05-November-2025	49	47	46	52	52	52
Thursday-06-November-2025	49	50	44	52	55	52
Friday-07-November-2025	50	49	43	53	53	49
Saturday-08-November-2025	48	-	41	52	-	48
Sunday-09-November-2025	-	46	38	-	49	47
Monday-10-November-2025	50	46	38	53	52	48
Tuesday-11-November-2025	-	-	42	-	-	47
Wednesday-12-November-2025	49	47	41	52	52	48
Thursday-13-November-2025	49	47	41	53	51	52
Friday-14-November-2025	49	47	43	52	51	48
Saturday-15-November-2025	48	-	41	51	-	47
Sunday-16-November-2025	47	46	37	50	51	47
Monday-17-November-2025	49	47	41	53	51	49
Tuesday-18-November-2025	49	47	39	52	52	47
Wednesday-19-November-2025	49	48	43	52	52	48
Thursday-20-November-2025	48	-	42	52	-	49
Friday-21-November-2025	-	48	-	-	51	-
Saturday-22-November-2025	-	-	-	-	-	-
Representative Weekday[5]	**49**	**47**	**42**	**52**	**52**	**50**
Representative Weekend[5]	**48**	**46**	**40**	**51**	**50**	**47**
Representative Week[5]	**49**	**47**	**41**	**52**	**52**	**49**

Notes:

1. Day is 7:00am to 6:00pm on all days except Sundays and Public Holidays when it is 8:00am to 6:00pm 2. Evening is 6:00pm to 10:00pm 3. Night is the remaining periods 4. Assessment Background Level (ABL) for individual days 5. Rating Background Level (RBL) for L_{A90} and logarithmic average for L_{Aeq} 6. Leq is calculated in the free field. 2.5dB is subtracted from results if logger is placed at façade 7. Number in brackets represents the measured (actual) RBL value, which is below the minimum policy value of 30 dB(A) during the evening or night period or 35 dB(A) during the day period.

Unattended Monitoring Results

Location: L02 - 3 Middle Street, Lavender Bay - Back yard

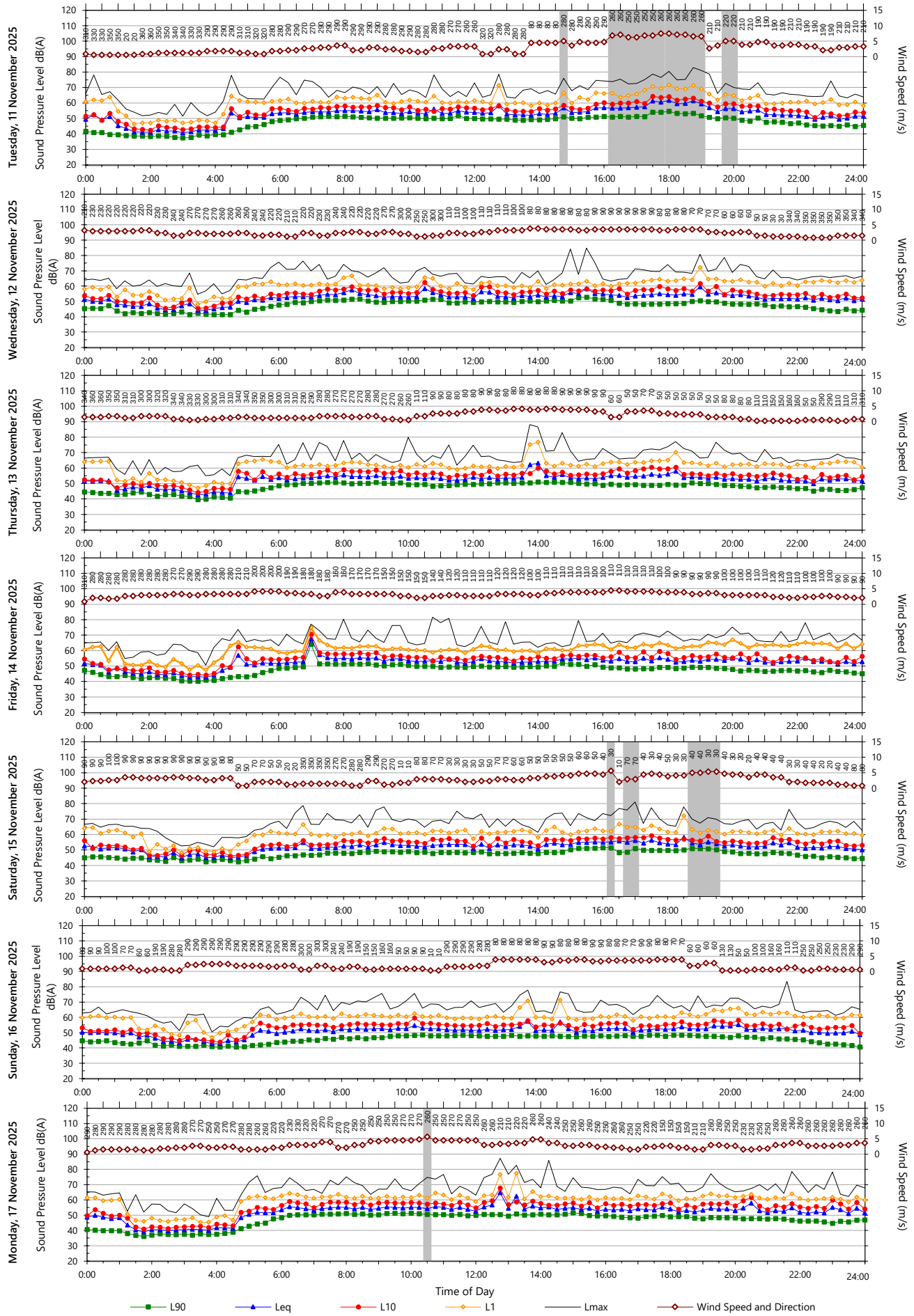


Data File: 2025-11-04_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r47)

Unattended Monitoring Results

Location: L02 - 3 Middle Street, Lavender Bay - Back yard

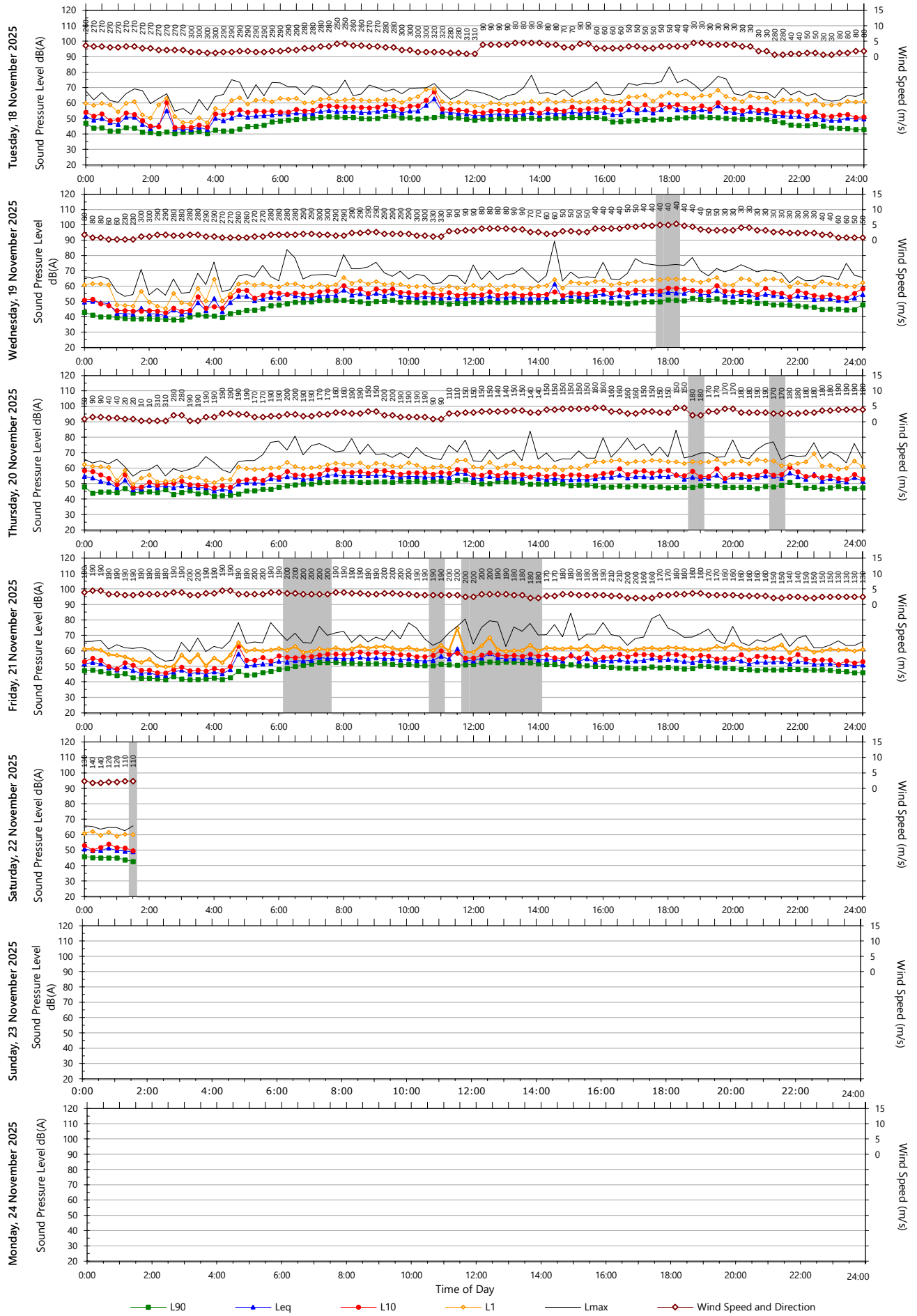


Data File: 2025-11-04_SLM_000_123_Rpt_Report.txt

Template: QTE-26 Logger Graphs Program (r47)

Unattended Monitoring Results

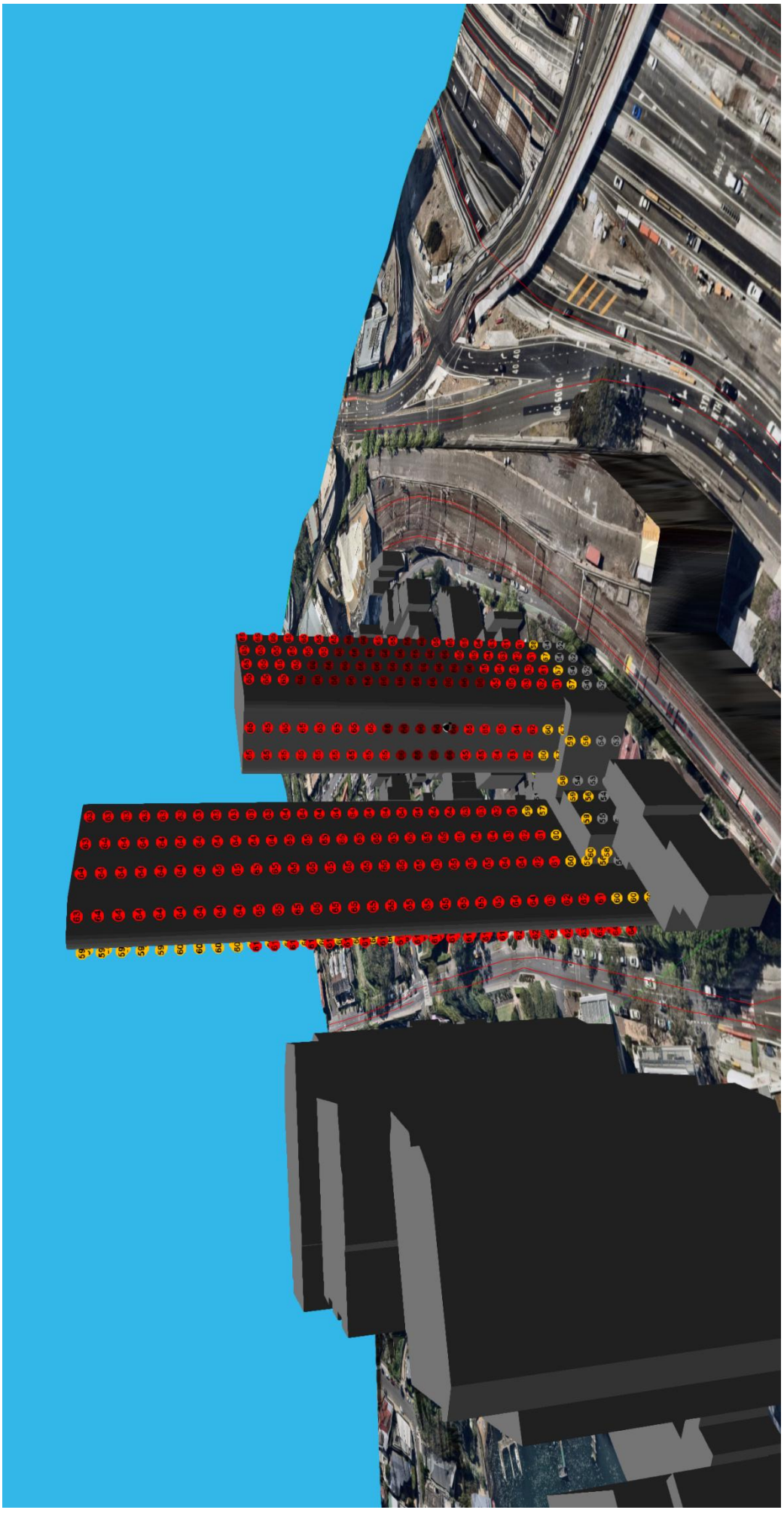
Location: L02 - 3 Middle Street, Lavender Bay - Back yard



Data File: 2025-11-04_SLM_000_123_Rpt_Report.txt

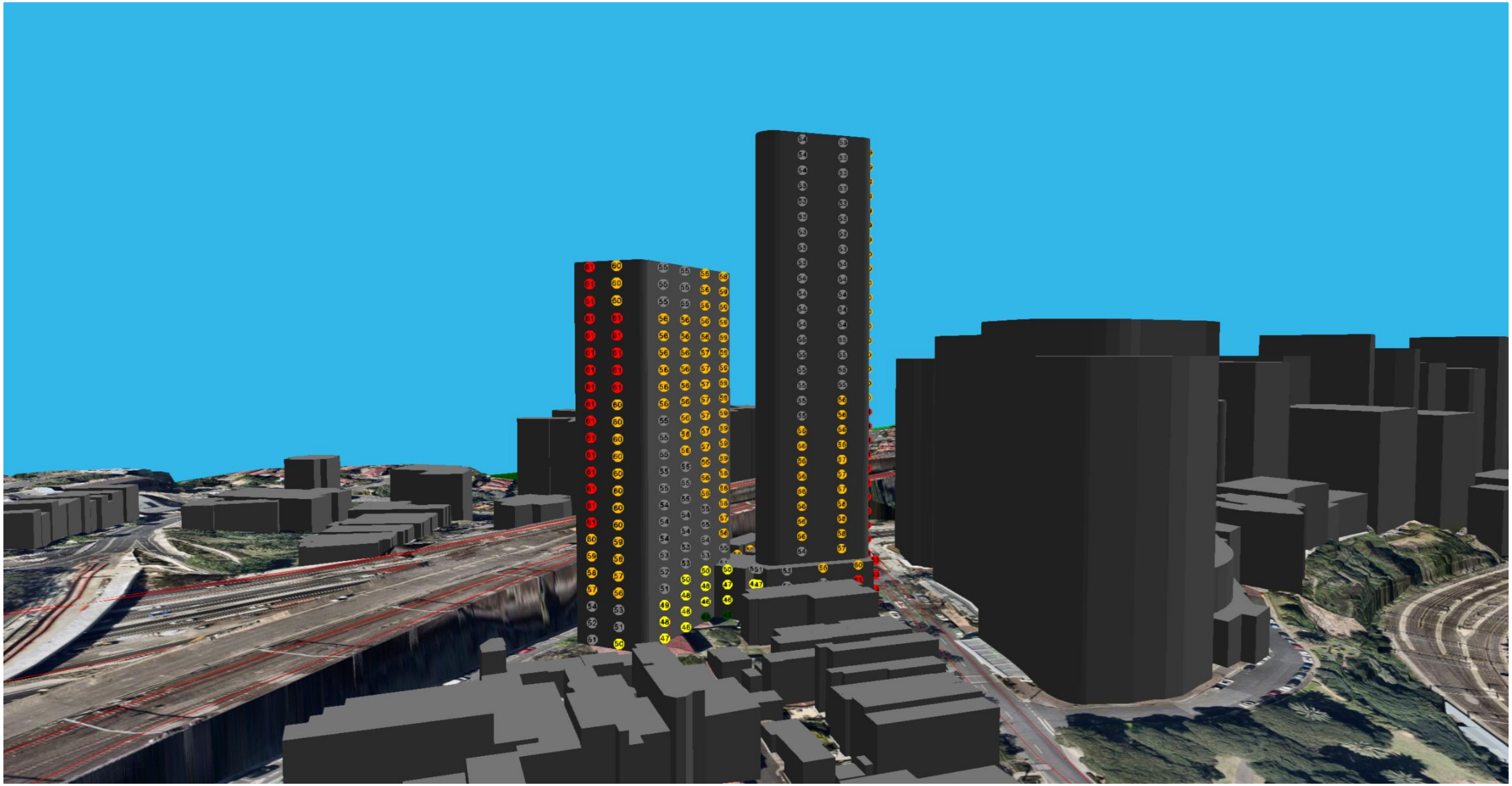
Template: QTE-26 Logger Graphs Program (r47)

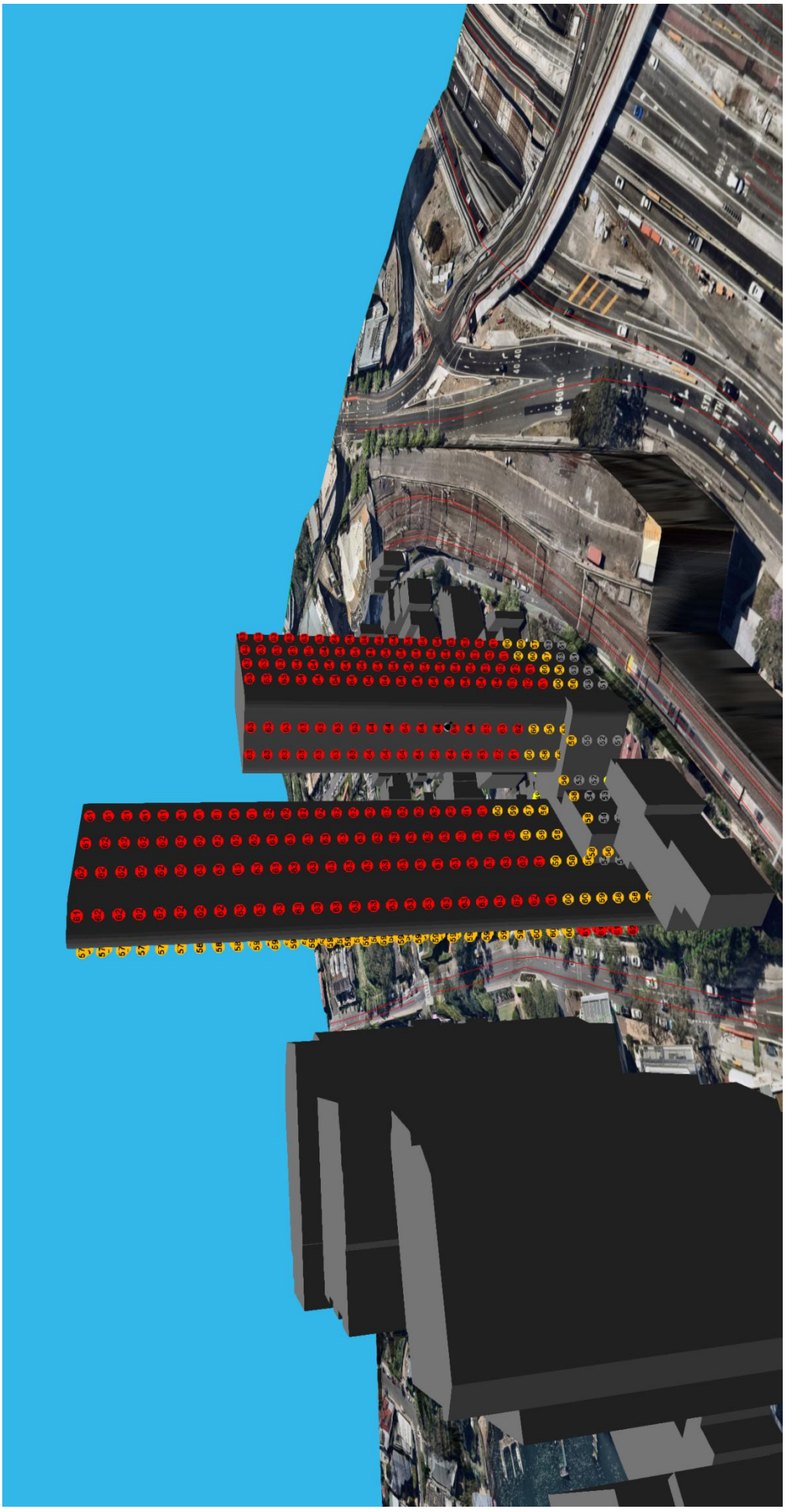
APPENDIX C Facade traffic noise maps



Maximum $L_{Aeq,1hr}$ (Day period) traffic noise levels – South and east facades

Maximum $L_{Aeq,1hr}$ (Day period) traffic noise levels – North and west facades





Maximum $L_{Aeq,1hr}$ (Night period) traffic noise levels – South and east facades

Maximum $L_{Aeq,1hr}$ (Night period) traffic noise levels – North and west facades