Scentre Group

Penrith Mondo

Penrith Mondo Revised DA Report

AC01

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1 Introduction

1.1 Background

The Westfield Penrith Mondo Project (herein referred to as the Project) comprises additions and alterations to the south west corner of the shopping complex.

This report provides an assessment of the acoustic impacts of the construction and operation associated with the proposal.

Acoustic terminology used in this report is given in Appendix A.

1.2 Site description

Westfield Penrith is situated in the heart of Penrith's CBD, positioned off the main arterial roads of Greater Western Highway to the north, High street and Henry Street to the south.

The development area is located adjacent to the Joan Sutherland Performing Arts Centre (JSPAC) and across High Street there are some existing commercial premises and proposed residential block.

The proposed public domain open space development site 'Westfield Mondo' sits within both Westfield Penrith and Penrith City Council property boundaries. The public domain plaza will continue to provide access to Westfield's south-west entrance, Westfield car park and adjacent JSPAC. The proposed works include commercial, food and tavern/bar facilities.

1.3 Overview of proposed development

The intent of the proposed development is to stimulate the existing plaza through upgrades to the existing Westfield's southern façade with food & beverage and health and leisure services. The Food and Beverage facilities will also bring late night activation with pedestrian traffic.

1.4 Acoustic assessment requirements

Arup Acoustics has been engaged to prepare an Acoustic Assessment to address the requirements for DA applications for the Project.

This report presents assessment based on the following NSW noise guidelines:

- NSW Noise Policy for Industry [1]
- Interim Construction Noise Guideline [4]
- Assessing Vibration: A Technical Guideline [3]

1.5 Scope of assessment

The following outlines the scope of assessment with respect to the above acoustic aspects and relevant policies and guidelines:

- Examine the proposed development plans to identify acoustic aspects of the construction and operation of the developments.
- Identify the development surrounding the site, which are to be assessed with regard to construction and operational activities.
- Conduct noise level monitoring to quantify the existing acoustic environment at relevant surrounding receiver locations to set project targets in accordance with relevant policy.
- Where appropriate, carry out a quantitative acoustic assessment of potential impacts and compare against the relevant noise and vibration targets.
- Identify where further design development is required, and identify in-principle mitigation or management methods for the control of noise and vibration where required.
- Outline the processes to be adopted for the continued design development of acoustic aspects for the project.

2 Surrounding land uses

The nearest most potentially affected land uses surrounding the development have been identified and Table 1.

Figure 1: Site and receiver locations

Table 1: Receiver locations

Type	ID	Description
Residential	R1	Residential Apartments – 614-632 High Street It is understood that this development is approved, but not yet under construction.
Commercial	C1	Mixed Commercial (3 storeys); 606 High Street Penrith
	C2	Commercial (1 storey); 600 High Street Penrith
	C3	Joan Sutherland Performing Arts Centre (JSPAC) Adopted for main lobby entry and frontage to plaza.
Educational	E1	Joan Sutherland Performing Arts Centre (JSPAC) - Music Rooms and Recital Rooms

3 Existing noise environment

Criteria for the assessment of operational and construction noise is typically derived from the existing noise environment, excluding noise from the subject development.

3.1 Noise measurement locations

Noise measurements are ideally carried out at the nearest or most potentially affected locations surrounding a development. An alternative, representative location should be established in the case of access restrictions or a safe and secure location cannot be identified. Furthermore, representative locations may be established in the case of multiple receivers as it is usually impractical to carry out measurements at all locations surrounding a site.

The locations for the undertaken long-term and short term attended measurements for Penrith Mondo are shown in Figure 1 below and outlined in Table 2, with internal and external measurement locations defined.

Figure 2: Long Term and Short-term Measurement Locations

Table 2: Noise monitoring locations

ID	Address	Description	Internal/ External	Date
L1	Westfield - Carpark adjacent to Public Plaza	Logger located at edge of carpark Location representative of the commercial receivers including Joan Sutherland PAC	External	27 July 2018 – 3 August 2018
L2	Max Solutions Level 1, 606 High Street, Penrith	Logger located at edge of 2nd storey balcony. Location representative of the nearest residential receiver locations R1	External	27 July 2018 – 3 August 2018
S1	Max Solutions Level 1, 606 High Street, Penrith	15-minute attended measurements	External	27 July and 3 August 2018
S2	Outside Westfield Carpark in Penrith Mondo Public Plaza	15-minute attended measurements	External	
S3	Outside JSPAC– South East facing	15-minute attended measurements	External	27 July 2018
S4	Outside JSPAC – North West facing	15-minute attended measurements	External	
S5	JSPAC - Penrith Conservatorium of Music Room 6	Attended measurements inside JSPAC	Internal	
S6	JSPAC - Q Theatre	Attended measurements inside JSPAC	Internal	3 August 2018
S7	JSPAC- Foyer	Attended measurements inside JSPAC	Internal	
S8	JSPAC - Concert Hall	Attended measurements inside JSPAC	Internal	
S9	JSPAC - Recital Room	Attended measurements inside JSPAC	Internal	

3.2 Long-term noise measurement results

Long-term noise monitoring was carried out from Friday, 27 July to Friday, 3 August 2018. Monitoring was conducted in accordance with Appendix B1 of the NSW *Noise Policy for Industry* (NPfI) [1]. The long-term noise monitoring methodology and noise level-vs-time graphs of the data are included in Appendix B.

Table 3 presents the overall single Rating Background Levels (RBL) and representative ambient L_{eq} noise levels for each assessment period, determined in accordance with the NPfI. In addition to the standard time periods, a shoulder period has been established for 10 pm to 12 am, to reflect the potential operating times of the retail uses.

Table 3: Long-term noise monitoring results, dB(A)

Location	Time period	Rating background noise levels, dBL_{A90}	Ambient dBL_{Aeq} noise levels
L1 – Westfield site	Day	53	60
	Evening	49	62
	10 pm – 12 am	47	56
	Night	47	55
L2 – 606 High Street	Day	49	59
	Evening	49	60
	10 pm – 12 am	44	55
	Night	42	54

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

As required by the NPfI, the external ambient noise levels presented are free-field noise levels. [i.e.. no façade reflection]

3.3 Short-term attended noise measurement results

Short-term operator attended noise measurements were conducted at each logger location on 27 July 2018 (date logging commenced) and 3 August 2018 (date logging finished). Attended measurements were also taken at other locations around the plaza precinct outside the Joan Sutherland Performing Arts Centre. Noise measurements were conducted over a 15-minute period. Weather conditions were warm, still and clear during measurements and would not have adversely affected the results.

Table 4 presents the measured L_{90} and L_{eq} noise levels for at each measurement locations.

Table 4: Short-term noise monitoring results - External

ID	Location	Date / Time	dBL_{A90}	dBL_{Aeq}	dBL_{Amax}	Description of noise environment
S1	At L2 - Max Solutions Level 1, 606 High Street, Penrith	27/07/18 02:03 PM	51	58	81	• Road traffic noise from High Street • Noise from Mechanic behind building (car washing, mechanical work etc) • Some passing foot traffic and noise
		03/08/18 11:35 AM	53	59	69	• Road traffic noise from High Street • Noise from Mechanic behind building (car washing, mechanical work etc) • Some passing foot traffic and noise • Some people on balcony for a short period
S2	Outside Westfield Carpark in Penrith Mondo Public Plaza	27/07/18 02:29 PM	54	58	73	• Noise from passing foot traffic. • High Street traffic and cars entering carpark
		03/08/18 10:55 AM	54	59	71	
S3	Outside JSPAC – North East facing	27/07/18 02:46 PM	52	55	65	• Some passing foot traffic and noise • Bird noises in background • Some traffic noise from Carpark and High Street
S4	Outside JSPAC – North West facing	27/07/18 02:58 PM	50	53	64	• Some passing foot traffic and noise • Bird noises in background • Some traffic noise from High Street

Short-term operator attended noise measurements were also conducted on 3 August 2018 inside the JSPAC to understand the existing noise levels experienced by the centre for assessment purposes. Noise measurements taken inside JSPAC are outlined in Table 5 below.

Table 5: Short-term noise monitoring results - Inside JSPAC

ID	Location	Date / Time	dBL_{A90}	dBL_{Aeq}	dBL_{Amax}	Description of noise environment
S5	JSPAC Penrith Conservatorium of Music Room 6 Windows Closed	03/08/18 12:14 PM	26	30	49	
	JSPAC Penrith Conservatorium of Music Room 6 Windows Open	03/08/18 12:20 PM	37	43	64	• Students generally like windows open during practice
S6	JSPAC Q Theatre Sound Engineer Location	03/08/18 12:30 PM	39	42	56	• Road traffic audible • Ambulance heard from High Street. • HVAC sound in background • Loading dock door open
	JSPAC Q Theatre Audience Location Right Wing	03/08/18 12:38 PM	38	39	52	• Road traffic still audible. • Loading dock door closed during measurements • HVAC sound in background (clicking noise)
S7	JSPAC Foyer	03/08/18 13:07 PM	37	40	48	• HVAC sound in background • Empty room when measurements undertaken • Used for Cabaret and live music performance • Faces Mondo and High Street – can hear road traffic
S8	JSPAC Concert Hall	03/08/18 12:48 PM	39	40	53	• HVAC sound in background • All doors closed
S9	JSPAC Recital Room	03/08/18 12:56 PM	30	36	53	• HVAC sound in background • People passing room heard • Road traffic noise heard from High Street

4 Operational assessment

4.1 Overview

The proposed primary operational noise sources with the potential to impact upon surrounding noise sensitive uses include:

- Patron and potential music from within retail premises
- Outdoor patron areas associated with retail premises
- Mechanical plant and equipment serving the various uses.

The proposed opening times for the retail uses are 7:00 am to 12:00 am.

4.2 Criteria

In accordance with the pre-lodgement advice received from Penrith City Council, the acoustic assessment report was to consider the NSW *Noise Policy for Industry* [1] with regard to operational noise (including music, mechanical plant, children internal play area and patron areas). It is noted that Liquor and Gaming NSW have criteria that may be utilised for the assessment of licensed premises, however as the criteria is not mandatory, assessment has been based on the direction of Penrith City Council.

The NPfI is primarily concerned with controlling intrusive noise impacts in the short-term for residences, and maintaining long-term noise level amenity for residences and other land uses. The NPfI sets out the procedure to determine the project noise trigger levels relevant to a development. The project noise trigger level is a level that, if exceeded would indicate a potential noise impact on the community and so 'trigger' a management response.

4.2.1 Intrusive noise criteria

The intrusiveness criteria is applicable to residential premises only. The intrusiveness criterion is summarised as follows:

- $L_{Aeq,15minute} \leq$ Rating Background Level (RBL) plus 5 dB

  (where $L_{Aeq,15minute}$ represent the equivalent continuous noise level of the source)

4.2.2 Amenity noise criteria – recommended and project specific

To limit continuing increases in noise levels from application of the intrusiveness level alone, the ambient noise level within an area from all industrial noise sources combined should remain below the recommended amenity noise levels specified in Table 2.2 of the NPfI where feasible and reasonable. An extract from the policy pertinent to this assessment is given below in Table 6.

Table 6: NPfI Amenity Criteria Noise Levels (RANLs)

Receiver(s)	**Time Period[1]**	**Recommended amenity noise level (RANLs)[2] $dBL_{Aeq(period)}$**
Residential (Urban)[2]	Day	60
	Evening	50
	Night	45
Commercial premises	When in use	65
School Classroom - internal	Noisiest 1 hour period when in use	35
Industrial Premises	When in use	70

Notes:

1. The NPfI defines day, evening and night time periods as:
   - Day: the period from 7 am to 6 pm Monday to Saturday; or 8 am to 6 pm on Sundays and Public Holidays.
   - Evening: the period from 6 pm to 10 pm.
   - Night: the remaining period.
2. Table 2.2 NPfI (2017). The recommended amenity noise levels (RANLs) refer only to noise from industrial sources. However, they refer to noise from all such sources at the receiver location, and not only noise due to a specific project under consideration. The levels represent outdoor levels except where otherwise stated.
3. Residential receivers classified as urban according to Table 2.3 of NPfI 2017 where the noise environment is dominated by 'urban hum', where urban hum means the aggregate sound of many unidentifiable, mostly traffic and/or industrial related sound sources.

The project amenity noise level (PANL) represents the objective for noise from a single industrial development at a receiver location.

To ensure that any new industrial source of noise is within the RANLs for an area, the PANL applies for each new source of industrial noise as follows:

- *Project Amenity Noise Level (PANL) = Recommended Amenity Noise Level (RANL) minus 5 dB(A)*

The NPfI also provides the following exceptions to the above method for deriving the project amenity noise level in areas of high traffic noise levels, however the traffic noise levels did not exceed the RANL by 10 dB or more.

4.2.3 Sleep Disturbance

The NPfI recommends the following screening criteria for the assessment of potential sleep disturbance, for residential receivers during the night-time period:

- $L_{Aeq,15min}$ 40 dB(A) or the prevailing RBL plus 5 dB, whichever is the greater, and/or;
- L_{AFmax} 52 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater

The first requirement is equivalent to the intrusive noise trigger levels at night. Regarding the $L_{Amax(night)}$ parameter, for the subject proposal it is noted that the maximum noise levels are not anticipated to be more than 10 dB higher than the L_{Aeq} noise emission, and thus separate assessment of the L_{AMax} criteria is not presented.

4.2.4 Project specific noise levels

Based on the background and ambient noise monitoring, the project-specific noise levels for the Project are summarised in Table 7. Regarding the classrooms within the JSPAC: external criteria has been established for both windows open, and windows closed conditions. For the windows open condition, internal criteria have been set 10 dB above the NPfI criteria, being comparable to the measured internal L_{Aeq} noise levels and consistent with Green Star criteria for naturally ventilated spaces.

Table 7: NPfI Project specific noise levels

ID	Time period	Intrusive Noise Trigger Levels ($dBL_{Aeq, 15min}$)	Project Amenity Criterion (PANL) $dBL_{Aeq(period)}$	Sleep Disturbance $dBL_{Amax(night)}$
R1 – 614-632 High Street	Day	54	55	N/A
	Evening	54	45	N/A
	10 pm – 12 am	49	43	59
	Night	47	40	57
E1 – JSPAC windows closed	When in use	N/A	30 (internal)	N/A
E1 – JSPAC windows open	When in use	N/A	40 (internal)	N/A
C1, C2, C3	When in use	N/A	60	N/A

It is noted that the amenity criterion imposes stringent targets at residential premises for the evening and night periods, being below the existing background noise level. While these may be achievable for mechanical plant and equipment, the NSW NPfI amenity criteria do not support the activation of city centres, and nor does the criteria specifically apply to such sources of noise. On this basis, the assessment of patron and music noise has considered the intrusiveness criteria only.

4.3 Prediction methodology

The specific fit out and operations associated with the various retail uses are not determined at this stage. Aspects such as building services equipment and individual fit outs will require evaluation during the detailed design phase, at a time when system designs and equipment selections are known.

At this stage of the development, the quantitative assessment is primarily focuses on external patron areas, while some assessment and discussion of internal areas has also been considered.

Noise emissions have been modelled using SoundPlan® 8 software, incorporating the ISO 9613-2:1996 algorithms. The model included:

- Operational noise sources listed in the following section
- Receivers listed in Table 1
- Ground terrain
- Existing and proposed buildings

Other than noise breakout from open windows, it is assumed that other noise emission will be sufficiently controlled by the sealed building envelope. Where roof structures are indicated, they are assumed to be solid and of sufficient mass to be an effective barrier.

4.3.1 Source noise levels

The operation of the retail uses will primarily involve patron activity and potentially some music noise. Background music or any entertainment would be expected to be contained to internal areas only.

Noise levels from patrons in outdoor areas have been predicted using formula established in Hayne et al. [5], being:

- L_{WAeq} = 15 x log(Crowd size) + 64 dB(A)

Spectra have been based on Cushing et al. [6] using an energy average of the male and female raised voice spectrum as presented in Table 8.

Table 8: Outdoor vocal spectrum

Description	dB(A)	Octave Band Centre Frequency, Hz, dBZ						
		125	250	500	1 k	2 k	4 k	8 k
Vocal spectrum (raised voices)	65	53	61	64	61	57	51	44

The formulas assume that people are not adversely affected by alcohol, and have a random orientation. For all external uses, which are advised to be 'family-friendly' restaurants or cafes, the above formula is considered appropriate.

Noise breakout from internal areas also has the potential to contribute dependant on the use, patron capacities, provision of music, extent of façade openings and acoustic performance of the building envelope. The sound pressure level spectrum presented in **Error! Reference source not found.** has been adopted (which does not exhibit excessive low frequency noise), while overall sound pressure levels have been assumed to vary by tenancy (refer to Table 9). The assumed internal noise levels are based on general assumptions for R2, R3 and R4 of; a patron density in the order of 1 per 1.5 m^2, acoustically moderate levels of acoustic absorption incorporated into the fitout and some background music. The assumed internal noise levels are based on general assumptions for the main mall of; number of proposed seats per food retail, kids playing within the kids play area, acoustically moderate levels of acoustic absorption incorporated into the fitout and some background music.

Table 9 summarises the model inputs. It is noted that the façade open area is restricted so as to minimise additional noise contribution to outdoor areas.

Table 9: Modelling assumptions Patron areas

Outdoor Location	**Assumed patron numbers for modelling**	**Outdoor Sound power level, dB(A)**	**Internal Lp, dB(A)**	**Door/Window open area m^2**
R2 Licensed Area	29	86	80	10
R3 Licensed area L1	16	82	80	5
R4 Licensed area L1	22	84	80	15
Main Mall	120 (R11 Seating) 28 (R6 Seating) Kids playing within kids area	78	77	10

Table 10: Indoor patron and background music noise levels (spatial L_p)

Description	**dB(A)**	**Octave Band Centre Frequency, Hz, dBZ**								
		31.5	**63**	**125**	**250**	**500**	**1 k**	**2 k**	**4 k**	**8 k**
Patron and music	85[1]	64	74	75	76	82	81	78	71	66

Note 1: Overall level is adjusted for each tenancy (refer to column “Internal Lp” of Table 9)

According to drawings “00.D6912 MNDO-DA-Full set” provided on Tuesday 1 October 2019, outdoor and indoor licensed areas are located on the GF only. The following figure show the various licensed areas across the Ground Floor.

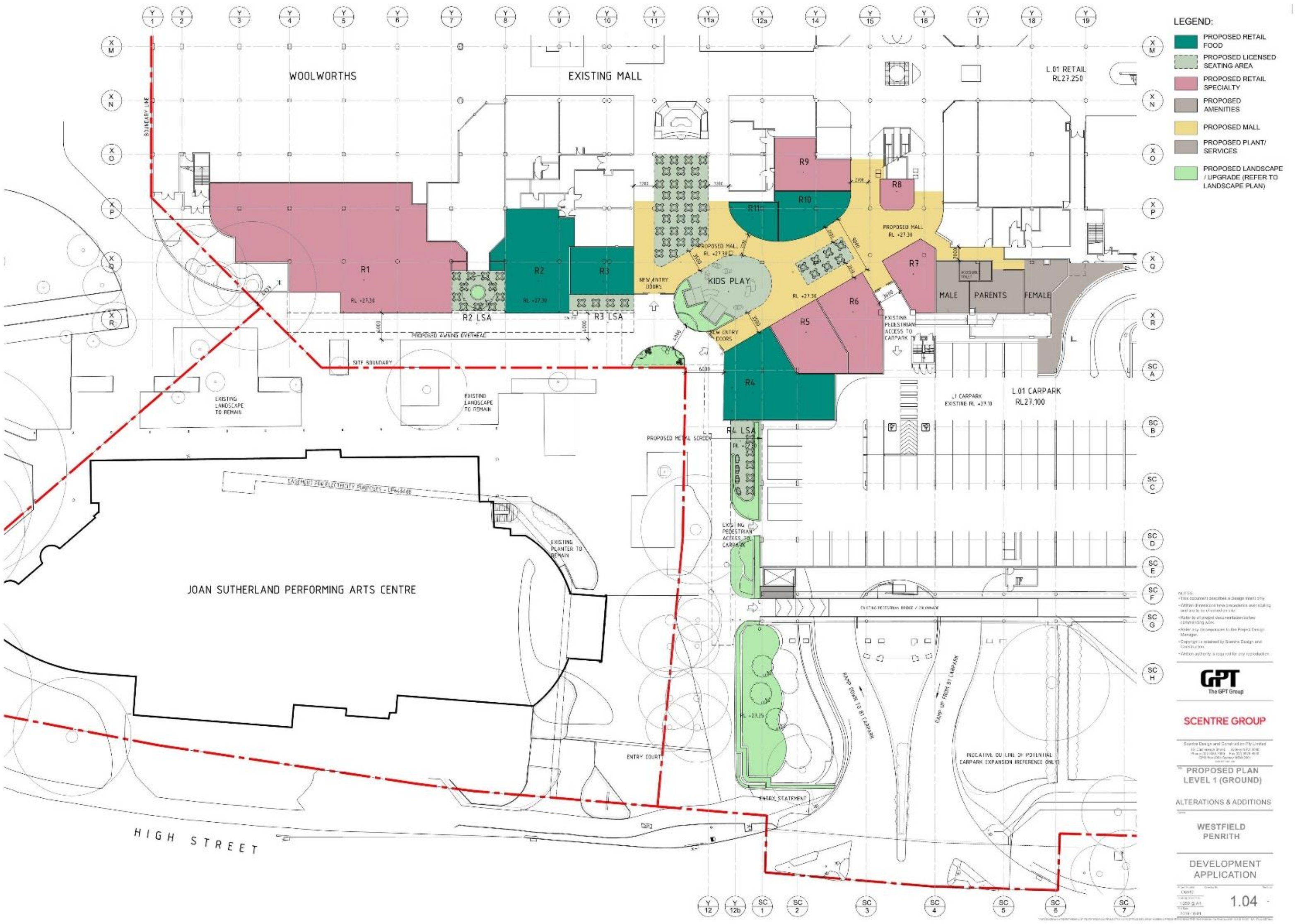


Figure 3: Ground Floor Proposed Layout – Plan SK02.02

4.4 Noise predictions

Noise predictions have been carried out to the nearest most potentially affected receiver locations which include the JSPAC and proposed residential apartments on High Street.

For teaching areas with JSPAC, outside to inside noise reductions have been assessed as 10 dB for open windows and 25 dB for closed windows.

Table 11: Predicted noise levels

Receiver Location		Predicted noise level, $L_{Aeq(15\ min)}$	Determining Criteria, $L_{Aeq(period)}$	Complies?
R1 – New Residential - Level 7		40	54 (Day/Evening) 49 (10 pm to 12 am)	YES YES
C1 – 606 High Street – Level 1		43	60	YES
C2 – 600 High Street – Level 1		42	60	YES
C3 – JSPAC Entry (external)		57	60	YES
C4 – JSPAC South eastern facade		39	60	YES
E1 – JSPAC Teaching spaces	Windows open	46	40	NO
	Windows closed	31	30	NO

Compliance is predicted for all locations with the exception of the JSPAC teaching spaces. While predictions show exceedance of JSPAC teaching spaces criteria with windows closed, the predicted exceedance is less than 1 dBA and is considered negligible. It is also noted that the criteria, along with the open windows condition of the space presents a significant constraint to potential activation of the plaza space. The predicted noise levels are comparable to the current site environment (43 dB(A) L_{Aeq} inside the JSPAC with windows open). Consideration could also be given to whether the learning spaces are likely to be used during times of peak trade of the retail spaces (e.g. evening/night period).

4.5 Discussion and recommendations

It is recommended that further detailed acoustic design be carried out following confirmation of the intended uses for the retail spaces and outdoor areas including licenced venues.

Detailed review of the façade and building envelope, along with interior finishes should also be carried out to ensure that noise break out from internal areas is appropriately controlled. Façade openings may also be reviewed following confirmation of the likely internal noise levels of each use.

4.5.1 Building and fit-out design

The following outlines in-principle mitigation and management measures for the retail spaces:

- Limit background music to internal areas.
- Install noise monitors and/or limiters to sound systems used throughout the retail spaces. In-house sound systems should incorporate limiters, while monitoring systems will be required for any entertainment, should it be provided through other equipment or acoustic instrumentation.
- The buildings envelope design, will need to consider all emission paths, such as walls, roof, mechanical ductwork. Operational requirements, particularly provision of music/entertainment will be the primary driver for the building envelope design.
- Acoustically absorptive finishes should also be incorporated into the interior design of the retail spaces, particularly as windows and doors may be open, as the treatment will aid in reducing the interior sound levels.
- Acoustic review of the building envelope and interior fitout should be carried out prior to construction. As part of this review, the recommended façade open areas should be reviewed, and may be increased or decreased dependent on the expected internal sound levels of each tenancy.

4.5.2 Building services equipment

Building service equipment (e.g. mechanical, hydraulic and electrical equipment) for the development has not been selected at this stage of design. During ongoing design of the development, building services equipment will be selected and provided with noise and vibration attenuation measures as required to meet the cumulative Project goals. In the case of residential receivers, the amenity goals should also be considered.

Noise mitigation treatment is likely to be required, which should give consideration to:

- Specification of maximum sound power levels for all items of plant as part of the project documentation.
- Use of attenuators to control fan noise as required
- Acoustic louvres to control noise from plantroom ventilation openings
- Vibration isolators to reduce vibration input to the building structure
- Acoustic screens around external plant, where required
- Incorporation of sound absorptive treatments in plantroom spaces.

5 Construction assessment

5.1 Criteria

When dealing with noise from construction works, the NSW EPA recognises that higher levels of noise are likely to be tolerated by people in view of the relatively short duration of the works. As a result, the EPA has published guidelines in its *Interim Construction Noise Guideline* (ICNG) [4] for the management of construction works noise.

The ICNG provides recommended noise levels for airborne construction noise at sensitive land uses. The guideline provides construction management noise levels above which all feasible and reasonable work practices should be applied to minimise the construction noise impact. The ICNG works on the principle of a 'screening' criterion – if predicted or measured construction noise exceeds the ICNG levels then the construction activity must implement all 'feasible and reasonable' work practices to reduce noise levels.

The ICNG provides two methods for assessing construction noise, varying typically on the basis of the project duration, being either a quantitative or a qualitative assessment. A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement of background noise levels for determination of management levels and prediction of construction noise levels. 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.

While this project would typically warrant a quantitative assessment due to the duration of works, the lower intensity activities associated with the redevelopment are considered reasonable to justify a qualitative assessment for this project application phase. Furthermore, sufficient detail of the activities and work schedules are not known at this stage to allow quantitative assessment. It is expected that a more detailed quantitative assessment could be carried out prior to commencement of works, so as to confirm mitigation and management processes.

5.1.1 Hours of construction

The ICNG recommend confining permissible work times as outlined in Table 12.

Table 12: Preferred Hours of Construction

Day	Preferred Construction Hours
Monday to Friday	7.00 am to 6.00 pm
Saturdays	8.00 am to 1.00 pm
Sundays or Public Holidays	No construction

5.1.1.1 Quantitative assessment method

The ICNG sets out construction NMLs at noise sensitive receivers, and how they are to be applied. These construction NMLs for residential receivers and other sensitive receivers are reproduced below in Table 13 and Table 14 respectively.

Table 13: Construction NMLs at residential receivers

Time of day	Management level [1] $L_{Aeq\ (15\ min)}$	How to apply
Recommended standard hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm 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 $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB	A 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.

Notes:

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

Table 14: NMLs at other noise sensitive land uses

Land use	Where objective applies	Management level $L_{Aeq(15\ min)}$[1]
Classrooms at schools and other educational institutions	Internal noise level	45 dB(A)
Hospital wards and operating theatres	Internal noise level	45 dB(A)
Places of worship	Internal noise level	45 dB(A)
Active recreation areas	External noise level	65 dB(A)
Passive recreation areas	External noise level	60 dB(A)
Community centres	Depends on the intended use of the centre.	Refer to the 'maximum' internal levels in AS2107 for specific uses.
Commercial premises	External noise level	70 dB(A)
Industrial premises	External noise level	75 dB(A)

1 - Noise management levels apply when receiver areas are in use only.

For work within standard construction hours, if after implementing all 'feasible and reasonable' noise levels the site still exceeds the noise affected level, the ICNG does not require any further action.

For out-of-hours work, the ICNG uses a noise level 5 dB above the noise-affected level as a threshold where the proponent should negotiate with the community. While there is no 'highly-noise affected level' outlined in the ICNG for out-of-hours work, this report adopts the terminology where the construction noise level is 5 dB above the noise affected level.

5.1.1.2 Project Construction NMLs

Construction Noise Management Levels (NMLs) for the project are summarised in Table 15. It is noted that residential apartments are not expected to be completed or occupied at the time of the works.

Table 15: Construction NMLs during intended working hours

Location	Time Period	RBL, dB(A)	NML $dBL_{Aeq\ 15minute}$	
			Noise affected	Highly noise affected
Residences				
R1 – 614-632 High Street	Day	52	62	75
Other sensitive receivers				
Commercial C1-C3	Use hours	-	70	-
Education – E1	Use hours	-	55[1]	-

Notes:

1. External criterion based on a 10 dB reduction through an open window.

5.1.2 Construction vibration criteria

5.1.2.1 Human comfort

The NSW DEC's *Assessing Vibration – a technical guideline* (Vibration Guideline) [3] provides vibration criteria for maintaining human comfort within different space uses. The guideline recommends 'preferred' and 'maximum' weighted vibration levels for both continuous vibration sources, such as steady road traffic and continuous construction activity, and for impulsive vibration sources. The weighting curves are obtained from BS 6472-1:2008 [7]

For intermittent sources (e.g. passing heavy vehicles, impact pile driving, intermittent construction), the guideline uses the vibration dose value (VDV) metric to assess human comfort effects of vibration. VDV takes into account both the magnitude of vibration events and the number of instances of the vibration event. Intermittent events that occur less than 3 times in an assessment period (either day, 7 am to 10 pm, or night, 10 pm to 7 am) are counted as 'impulsive' sources for the purposes of assessment.

As noted in the guideline, situations exist where vibration above the preferred values can be acceptable, particularly for temporary disturbances, such as a construction or excavation projects. Notwithstanding, the recommended vibration limits for maintaining human comfort in residences and other relevant receiver types are given for continuous/impulsive and intermittent vibration in Table 16 and Table 17 respectively.

Table 16: Preferred and maximum weighted root-mean-square (rms) values for continuous and impulsive vibration acceleration (m/s^2) 1-80 Hz

Location	Period	Preferred Values		Maximum Values	
		z-axis	x- and y-axes	z-axis	x- and y-axes
Continuous Vibration					
Residences	Daytime 0700-2200h	0.010	0.0071	0.020	0.014
	Night-time 2200-0700h	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or Night-time	0.020	0.014	0.040	0.028
Impulsive Vibration					
Residences	Daytime 0700-2200h	0.30	0.21	0.60	0.42
	Night-time 2200-0700h	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

Table 17: Acceptable vibration dose values for intermittent vibration (m/s$^{1.75}$)

Location	Daytime 0700-2200 h		Night-time 2200-0700 h	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80

5.1.2.2 Building damage

Potential structural or cosmetic damage to buildings as a result of vibration is typically assessed in accordance with BS7385-2 [8]. BS7385-1 [9], defines different levels of structural damage as:

- *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.*

Table 1 of BS7385-2 sets limits for the protection against cosmetic damage, however the following guidance on 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.*

German Standard DIN 4150 - Part 3 '*Structural vibration in buildings - Effects on Structure'* [10] are generally recognised to be conservative and is often referred to for the purpose of assessing structurally sensitive buildings. For the subject site, surrounding buildings are not deemed structurally sensitive and therefore the British Standard is considered appropriate for vibration management.

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

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

While the DIN Standard defines the above damage as 'minor', the description aligns with BS7385 cosmetic damage, rather than referring to structural failures

5.1.2.3 British Standard BS7835-2

BS7385-2 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4–250 Hz, and a maximum displacement value below 4 Hz is recommended. Table 18 sets out the BS7385-2 criteria for cosmetic, minor and major damage. Regarding heritage buildings, BS7385-2 notes that "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*".

Table 18: BS 7385-2 structural damage criteria

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

Notes:

1. 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.

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

All levels relate to transient vibrations in low-rise buildings. Continuous vibration can give rise to dynamic magnifications that may require levels to be reduced by up to 50%.

5.1.2.4 Buried services

DIN 4150-3:1999 [10] sets out guideline values for vibration effects on buried pipework and reproduced in Table 19 below.

Table 19: Guideline values for short-term vibration impacts on buried pipework

	Pipe material	Guideline values for vibration velocity measured on the pipe, mm/s
1	Steel (including welded pipes)	100
2	Clay, concrete, reinforced concrete, pre-stressed concrete, metal (with or without flange)	80
3	Masonry, plastic	50

Note: For gas and water supply pipes within 2m of buildings, the levels given in Table 18 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.

In addition, specific limits for vibration affecting high-pressure gas pipelines is provided in the UK National Grid's *Specification for Safe Working in the Vicinity of National Grid High Pressure Gas Pipelines and Associated Installations – Requirements for Third Parties* (report T/SP/SSW/22, UK National Grid, Rev 10/06, October 2006). This specification states that no piling is allowed within 15 m of a pipeline without an assessment of the vibration levels at the pipeline. The PPV at the pipeline is limited to a maximum level of 75 mm/s, and where PPV is predicted to exceed 50 mm/s the ground vibration is required to be monitored.

Other services that maybe encountered include electrical cables and telecommunication services such as fibre optic cables. While these may sustain vibration velocity levels from between 50 mm/s and 100 mm/s, the connected services such as transformers and switchgear, may not. Where encountered, site specific vibration assessment in consultation with the utility provider should be carried out.

5.2 Construction assessment

At this early stage of design, noise emissions have been assessed on a qualitative basis, based on the following information:

- Penrith Mondo and surrounding buildings
- Receivers listed in Table 1
- Interim Construction Noise Guideline [4]

A Construction and Environment Management Plan (CEMP) will be further developed as the construction methodologies and processes are confirmed during the design development process. A detailed construction noise impact assessment shall be undertaken when a contractor is appointed to the project.

It is not uncommon for construction activities to exceed the target noise levels outlined in the ICNG, particularly where works occur in close proximity to noise sensitive receptors. For this project, the most sensitive receptor is expected to be the JSPAC, including both the learning and performance spaces. Early consultation is recommended to allow potential scheduling of any high impact works around class and performance times. It is considered reasonable for learning area windows to be closed during construction activities rather than expect acceptable amenity to be achieved with windows open.

Regard vibration, the potential risk for structural damage to surrounding buildings is considered to be low, however use of any vibration intensive equipment may result in exceedance of human comfort criteria and/or result in some ground borne noise transmission to the interior performance spaces within the JSPAC.

In-principle mitigation and management measures are outlined below.

5.3 Construction noise and vibration mitigation

Noise mitigation measures for general construction activity are discussed in the following sections. These mitigation measures are considered to represent 'feasible and reasonable' mitigation measures suitable for implementation during construction of the project.

5.3.1 Construction noise and vibration management plan

For all construction works, the contractor would be expected to prepare a detailed Construction Noise and Vibration Management Plan (CNVMP). This plan should include but not be limited to the following:

- Roles and responsibilities
- Noise sensitive receiver locations
- Areas of potential impact
- Mitigation strategy
- Community engagement strategy.

General guidance on the control of construction noise and vibration impacts relevant to this study are discussed in the following sections.

5.3.2 General

In general, practices to reduce construction noise impacts will be required, and may include:

- Adherence to the standard approved working hours as outlined in the Project Approval.
- The location of stationary plant (concrete pumps, air-compressors, generators, etc.) as far away as possible from sensitive receivers
- Using temporary structures or screens to limit noise exposure where possible.
- The appropriate choice of low-noise construction equipment and/or methods
- Modifications to construction equipment or the construction methodology or programme. This may entail programming activities to occur concurrently where a noisy activity will mask a less noisy activity, or, at different times where more than one noisy activity will significantly increase the noise. The programming should also consider the location of the activities due to occur concurrently.

- Carry out consultation with the community and surrounding building owners/occupants during construction including, but not limited to; advance notification of planned activities and expected disruption/effects, construction noise complaints handling procedures.

5.3.3 Universal work practices

The following noise mitigation work practices are recommended to be adopted at all times on site:

- Regularly train workers and contractors (such as at toolbox talks) to use equipment in ways to minimise noise.
- Site managers to periodically check the site and nearby residences for noise problems so that solutions can be quickly applied.
- Avoid the use of radios or stereos outdoors.
- Avoid the overuse of public address systems.
- Avoid shouting, and minimise talking loudly and slamming vehicle doors.
- Turn off all plant and equipment when not in use.
- Traffic controls implemented

5.3.4 Vibration – minimum working distances

Recommended minimum working distances for vibration intensive plant, which are based on international standards and guidance and reproduced in Table 20 below for reference. With regard to the proposed development works, vibration is not expected to impact upon surrounding development.

Table 20: Recommended minimum working distances for vibration intensive plant

Plant Item	**Rating / Description**	**Minimum working distance**	
		Cosmetic damage (BS 7385)	**Human response (OH&E Vibration Guideline)**
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7 m	23 m
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

Note: More stringent conditions may apply to heritage or other sensitive structures

6 Conclusion

This acoustic assessment of the proposed Penrith Mondo retail development has considered both operational and construction impacts in accordance with the pre-lodgement advice from Penrith City Council.

With regard to operational phase, the assessment has considered potential impacts upon the adjacent Joan Sutherland Performing Arts Centre (JSPAC), along with future residential development on High Street and existing commercial premises. The assessment considered the NSW Noise Policy for Industry as the primary assessment criteria in line with Council advice, however it was the view that the amenity noise targets do not readily support the proposed activation of the plaza space, when considering the criteria applicable to residential premises. In this case, the assessment has solely applied the intrusiveness criteria.

Based on the outlined patron capacities and internal operations, compliance at all locations was predicted, with exception of the JSPAC learning spaces. While predictions show exceedance of JSPAC teaching spaces criteria with windows closed, the predicted exceedance is less than 1 dBA and is considered negligible. It is noted that the criteria, along with the open windows condition of the space presents a significant constraint to potential activation of the plaza space. The predicted noise levels are also comparable to the current site environment, which in turn may see an increase in noise levels of no more than 3 dB(A).

Further detailed acoustic assessment is however warranted once specific uses have been determined, to review interior fitout, building envelope design and building services noise and vibration.

Regarding construction, the proposed redevelopment construction plan will need to consider the impact to surrounding receivers and aim to adhere to the noise management levels. Primary management issues relating to construction hours, equipment use, consultation and scheduling have been outlined and should be further reviewed once the contractor has been nominated and construction activities have been defined in more detail.

It is considered that the additional review of both operational and construction matters could reasonably form conditions of approval to be addressed prior to the commencement of construction.

References

[1] NSW Environment Protection Authority, “NSW Noise Policy for Industry,” NSW Environment Protection Authority , Sydney, 2017.

[2] NSW Environmental Protection Authority, “NSW Road Noise Policy,” NSW Environmental Protection Authority, Sydney, 2012.

[3] Department of Environment and Conservation (NSW), “Assessing Vibration: A technical guideline,” Department of Environment and Conservation (NSW), Sydney, 2006.

[4] Department of Environment and Climate Change NSW, “Interim Construction Noise Guideline,” Department of Environment and Climate Change NSW, Sydney, 2009.

[5] M. Hayne, J. Taylor, R. Rumble and D. Mee, “Prediction of Noise from Small to Medium Sized Crowds,” in *Acoustics 2011*, Gold Coast, 2011.

[6] I. R. Cushing, F. F. Li, T. J. Cox, K. Worral and T. Jackson, “Vocal effort levels in anechoic conditions,” *Applied Acoustics,* vol. 72, pp. 695-701, 2011.

[7] British Standards, “BS 6472-1:2008 Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting,” British Standards, 2008.

[8] British Standards, “BS 7385-2:1993 Evaluation and measurement for vibration in buildings. Guide to damage levels from groundborne vibration,” British Standards, 1993.

[9] British Standards, “BS 7385-1:1990 - Evaluation and measurement for vibration in buildings. Guide for measurement of vibrations and evaluation of their effects on buildings,” British Standards, 1990.

[10] Deutsches Institut fur Normung, “DIN 4150-3 (1999) Structural vibration - Effects of vibration on structures,” Deutsches Institut fur Normung, Berlin, 1999.

Appendix A

Glossary

Absorption Coefficient, α

The amount of sound absorbed by a sample is characterised by the absorption coefficient, α. A perfect absorber (e.g. a sufficiently large opening in a room) from which no sound is reflected has an absorption coefficient of 1.00. There are two common methods for measuring sound absorption coefficients of a material.

One, the impedance tube method, is useful for readily obtaining results and only requires a small sample to be tested, but is limited in that it can only measure the *normal-incidence absorption coefficient* – i.e. the absorption coefficient for a single angle with sound propagating perpendicular to the material.

The other method, the reverberation chamber method, requires more extensive tests and a larger (~10 m²) sample size, but obtains the *random-incidence absorption coefficient*- i.e. the effective absorption coefficient of the material averaged over all angles. The random-incidence absorption coefficient is required for detailed room acoustic calculations.
Note that the reverberation chamber method can legitimately measure coefficients greater than 1.0 due to "edge effects" such as diffraction or scattering from the edges of the sample. These edge effects are reduced by using a barrier around the sample or by using a larger sample.

Weighted absorption coefficient (α_w)

The weighted absorption coefficient, defined in ISO 11654 is a frequency-weighted single number absorption coefficient used to categorise the overall absorption effectiveness of a material.
Descriptors are used to indicate if the material absorbs strongly at high ("H"), mid ("M") and/or low ("L") frequencies – e.g. a material may be rated as α_w 0.85(LH), which indicates that it strongly absorbs at both low and high frequencies.
The weighted-absorption coefficient is also used to assign materials into five absorption classes (materials with very low absorption are not assigned a class): Class A has the highest absorption, with Class E having the lowest absorption.

Noise-reduction Coefficient (NRC)

The noise reduction coefficient (NRC) is the (arithmetical) average of the sound-absorption coefficients of a material at 250Hz, 500Hz, 1kHz and 2kHz. It is intended for use a single-number index of the sound absorbing efficiency of a material.

Ambient Noise Level

The ambient noise level is the overall noise level measured at a location from multiple noise sources. When assessing noise from a particular development, the ambient noise level is defined as the remaining noise level in the absence of the specific noise source being investigated. For example, if a fan located on a city building is being investigated, the ambient noise level is the noise level from all other sources without the fan running. This would include sources such as traffic, birds, people talking and other nearby fans on other buildings.

Background Noise Level

The background noise level is the noise level that is generally present at a location at all or most times. Although the background noise may change over the course of a day, over shorter time periods (e.g. 15 minutes) the background noise is almost-constant. Examples of background noise sources include steady traffic (e.g. motorways or arterial roads), constant mechanical or electrical plant and some natural noise sources such as wind, foliage, water and insects.

Assessment Background Level (ABL)

A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night time period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background L_{A90} noise levels – i.e. the measured background noise is above the ABL 90% of the time.

Rating Background Level (RBL / min$L_{A90,1hour}$)

A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey. This parameter is denoted RBL in NSW, and min$L_{A90,1hour}$ in QLD.

Decibel

The decibel scale is a logarithmic scale which is used to measure sound and vibration levels. Human hearing is not linear and involves hearing over a large range of sound pressure levels, which would be unwieldy if presented on a linear scale. Therefore a logarithmic scale, the decibel (dB) scale, is used to describe sound levels.

An increase of approximately 10 dB corresponds to a subjective doubling of the loudness of a noise. The minimum increase or decrease in noise level that can be noticed is typically 2 to 3 dB.

dB(A)

dB(A) denotes a single-number sound pressure level that includes a frequency weighting (“A-weighting”) to reflect the subjective loudness of the sound level.

The frequency of a sound affects its perceived loudness. Human hearing is less sensitive at low and very high frequencies, and so the A-weighting is used to account for this effect. An A-weighted decibel level is written as dB(A).

Some typical dB(A) levels are shown below.

Sound Pressure Level dB(A)	Example
130	Human threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside nightclub
90	Heavy trucks at 5 m
80	Kerbside of busy street
70	Loud stereo in living room
60	Office or restaurant with people present
50	Domestic fan heater at 1m
40	Living room (without TV, stereo, etc)
30	Background noise in a theatre
20	Remote rural area on still night
10	Acoustic laboratory test chamber
0	Threshold of hearing

L_1

The L_1 statistical level is often used to represent the maximum level of a sound level that varies with time.

Mathematically, the L_1 level is the sound level exceeded for 1% of the measurement duration. As an example, 87 dB $L_{A1,15min}$ is a sound level of 87 dB(A) or higher for 1% of the 15 minute measurement period.

L_{10}

The L_{10} statistical level is often used as the “average maximum” level of a sound level that varies with time.

Mathematically, the L_{10} level is the sound level exceeded for 10% of the measurement duration. L_{10} is often used for road traffic noise assessment. As an example, 63 dB $L_{A10,18hr}$ is a sound level of 63 dB(A) or higher for 10% of the 18 hour measurement period.

L_{90}

The L_{90} statistical level is often used as the “average minimum” or “background” level of a sound level that varies with time.

Mathematically, L_{90} is the sound level exceeded for 90% of the measurement duration. As an example, 45 dB $L_{A90,15min}$ is a sound level of 45 dB(A) or higher for 90% of the 15 minute measurement period.

L_{eq}

The 'equivalent continuous sound level', L_{eq}, is used to describe the level of a time-varying sound or vibration measurement.

L_{eq} is often used as the "average" level for a measurement where the level is fluctuating over time. Mathematically, it is the energy-average level over a period of time (i.e. the constant sound level that contains the same sound energy as the measured level). When the dB(A) weighting is applied, the level is denoted dB $L_{Aeq.}$ Often the measurement duration is quoted, thus $L_{Aeq,15\ min}$ represents the dB(A) weighted energy-average level of a 15 minute measurement.

L_{max}

The L_{max} statistical level can be used to describe the "absolute maximum" level of a sound or vibration level that varies with time.

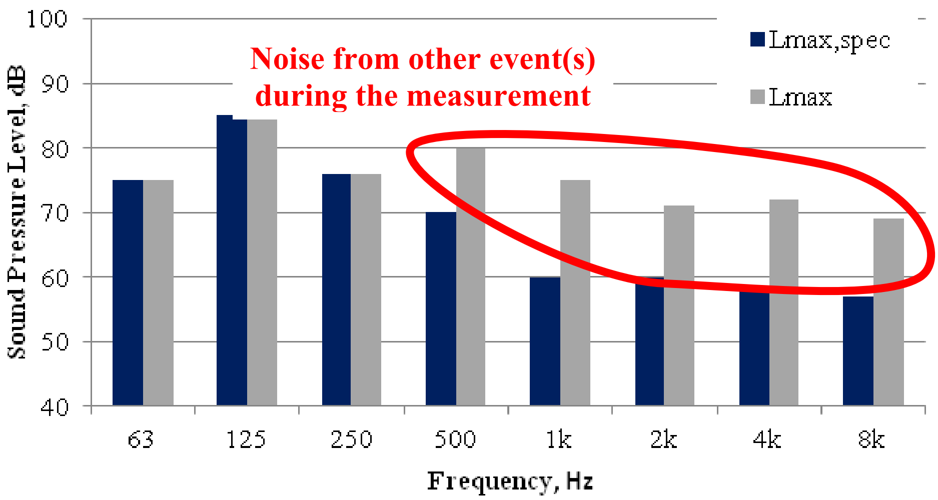
Mathematically, L_{max} is the highest value recorded during the measurement period. As an example, 94 dB L_{Amax} is a highest value of 94 dB(A) during the measurement period.

Since L_{max} is often caused by an instantaneous event, L_{max} levels often vary significantly between measurements.

$L_{max\ spec}$

$L_{max\ spec}$ is another representation of the highest noise or vibration levels during the measurement period.

$L_{max\ spec}$ is the spectrum of the event that caused the highest overall sound or vibration level during the measurement period is denoted by dB $L_{max\ spec}$. An example of the relationship between dB L_{max} and dB $L_{max\ spec}$ is shown below.



L_{max} (see definition above), when measured on an octave band or 1/3 octave band meter, is the spectrum obtained by recording the highest measured value in each band. However, the highest measured values in each band may occur at different times.

Hence, $L_{max\ spec}$ represents a real event, while L_{max} is often the mathematical addition of frequency band values from different times and often does not represent a real-world event.

Since $L_{max\ spec}$ is caused by an instantaneous event, $L_{max\ spec}$ levels often vary significantly between measurements.

Frequency

Frequency is the number of cycles per second of a sound or vibration wave. In musical terms, frequency is described as “pitch”. Sounds towards the lower end of the human hearing frequency range are perceived as “bass” or “low-pitched” and sounds with a higher frequency are perceived as “treble” or “high pitched”.

Peak Particle Velocity (PPV)

Peak Particle Velocity (PPV) is the highest velocity of a particle (such as part of a building structure) as it vibrates. Most sound level meters measure *root mean* *squared* (RMS) values; it is common to approximate the PPV based on an RMS measurement.

PPV is commonly used as a vibration criteria, and is often interpreted as a PPV based on the L_{max} or $L_{max,spec}$ index.

Sound Power and Sound Pressure

The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of distance from a source. However, the sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.

Sound Reduction Index (R)

The sound reduction index (or transmission loss) of a building element is a measure of the loss of sound through the material, i.e. its sound attenuation properties. It is a property of the component, unlike the sound level difference, which is affected by the common area between the rooms and the acoustics of the receiving room. R is the ratio (expressed in decibels) of the sound energy transmitted through the building element to the sound energy incident on the building element for a particular frequency.

The weighted sound reduction index, R_w, is a single figure description of sound reduction index across a wider frequency range and is defined in BS EN ISO 717-1: 1997. R_w values are calculated from measurements in an acoustic laboratory. Sound insulation ratings derived from site measurements (which are invariably lower than the laboratory figures) are referred to as apparent sound reduction index (R'_w) ratings.

Vibration

Waves in a solid material are called “vibration”, as opposed to similar waves in air, which are called “sound” or “noise”. If vibration levels are high enough, they can be felt; usually vibration levels must be much higher to cause structural damage.

A vibrating structure (eg a wall) can cause airborne noise to be radiated, even if the vibration itself is too low to be felt. Structureborne vibration limits are sometimes set to control the noise level in a space.

Vibration levels can be described using measurements of displacement, velocity and acceleration. Velocity and acceleration are commonly used for structureborne noise and human comfort. Vibration is described using either metric units (such as mm, mm/s and mm/s²) or else using a decibel scale.

Appendix B

Unattended Monitoring Results

B1 Noise monitoring equipment

Unattended monitoring was carried out using the following equipment:

Measurement location	Equipment/model	Serial No.	SLM Type
L1	ARL NGARA	8780FB	Type 1
L2	ARL NGARA	8780C7	Type 1

Notes:

All meters comply with AS IEC 61672.1 2004 “Electroacoustics - Sound Level Meters” and designated either Type 1 as per table, and are suitable for field use.

The equipment was calibrated prior and subsequent to the measurement period using a Bruel & Kjaer Type 4231 calibrator. No significant drift in calibration was observed.

B2 Extraneous/weather affected data

Measurement samples affected by extraneous noise and wind (greater than 5m/s) were excluded from the recorded data in accordance with the procedures outlined in Table A1 of the NPfI. No rain was recorded over the duration of the monitoring.

Data was obtained from the Bureau of Meteorology (BOM) for the period of logging from the nearest representative weather station to noise monitoring location(s). Wind speed data was adjusted to account for the difference in measurement height and surrounding environment between the BOM weather station (measured 10 m above ground) and the microphone location based on Table C.1 of ISO 4354:2009 '*Wind actions on structures*'.

B3 Logger graphs

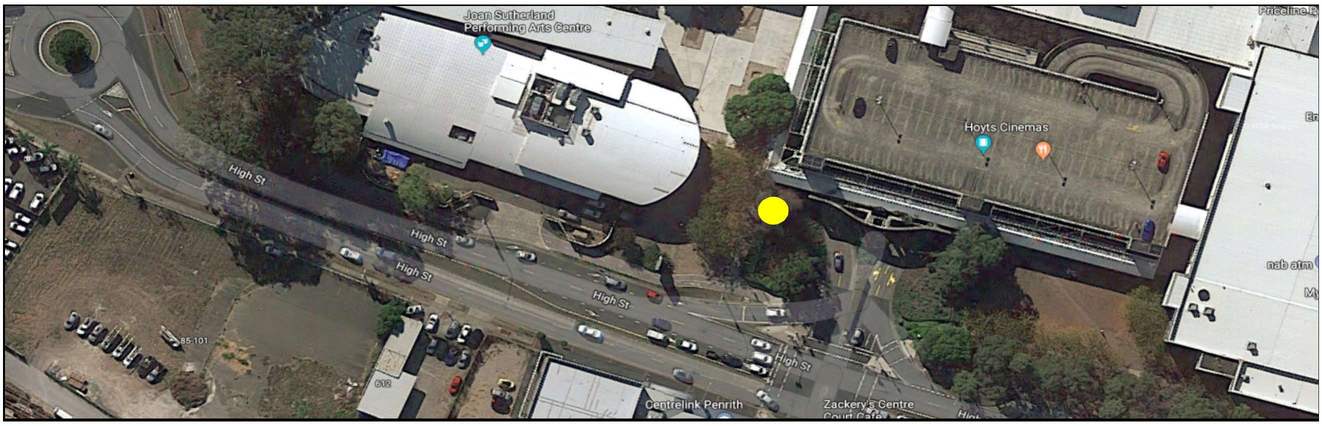
The following noise level vs time graphs present overall dB(A) levels recorded by the unattended logger(s) for a range of noise descriptors, including L_{Aeq}, L_{A90}, L_{A10} and L_{Amax}, While line graphs are presented, sampling is typically at 15 minute intervals.

Wind speeds are also show where relevant, and periods of excluded data are shaded grey.

ARUP

Logger 1 - Westfield - Adjacent carpark entry (Free Field)

Additional detail:



Background and ambient noise monitoring results - NSW 'Noise Policy for Industry', 2017

Date	L_{A90} Background noise levels[4]			L_{Aeq} Ambient noise levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Friday-27-July-2018		51	49		58	55
Saturday-28-July-2018	53	49	47	60	68	53
Sunday-29-July-2018	50	47	46	60	56	55
Monday-30-July-2018	53	48	47	60	59	55
Tuesday-31-July-2018	54	48	47	60	57	55
Wednesday-01-August-2018	53	50	47	60	58	57
Thursday-02-August-2018	52	51	47	61	61	56
Friday-03-August-2018						
Representative Week[5]	**53**	**49**	**47**	**60**	**62**	**55**

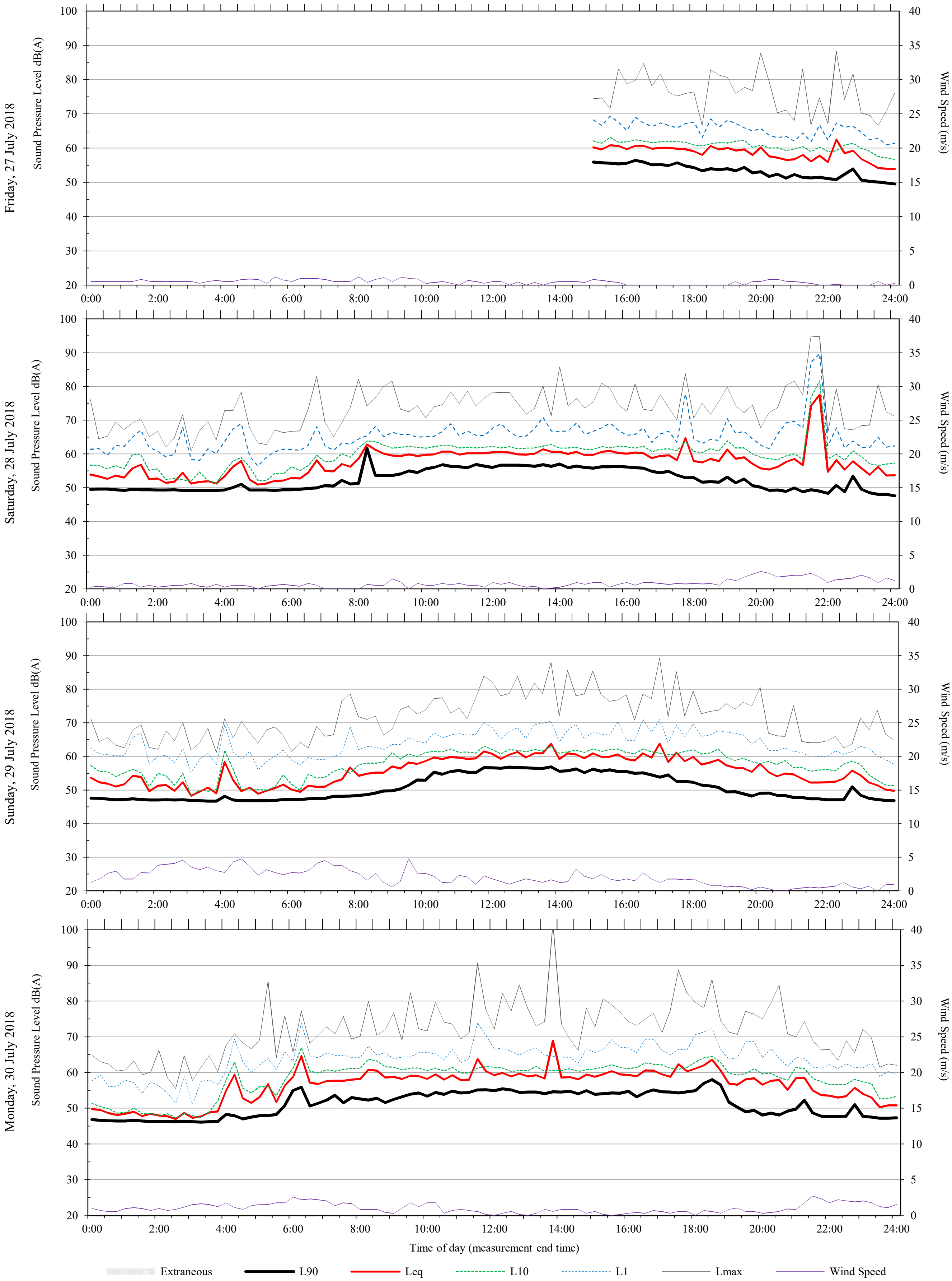
Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
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}

Document Set ID: 8915933
Version: 1, Version Date: 05/11/2019

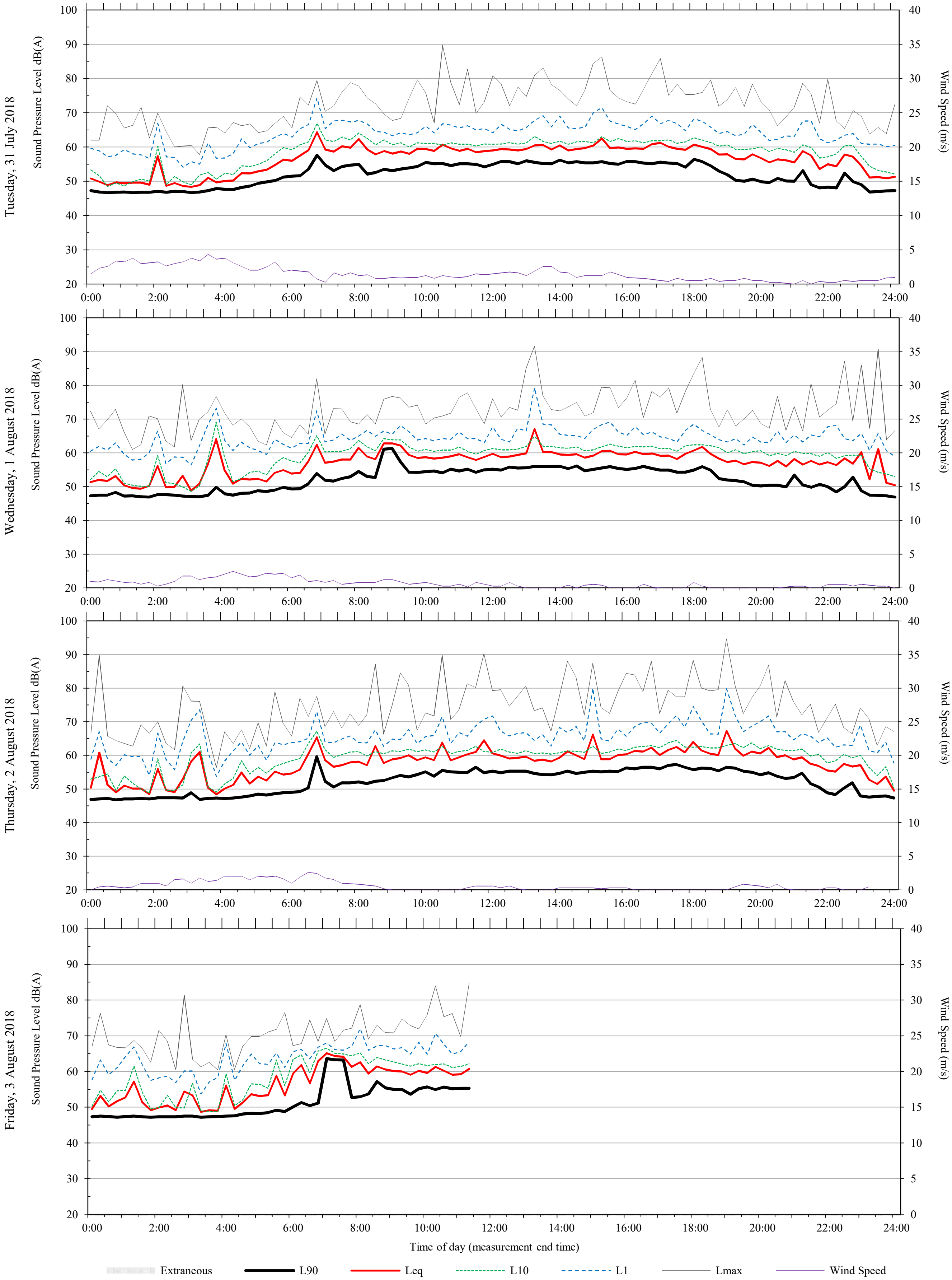
Unattended monitoring: Logger 1 - Westfield - Adjacent carpark entry (Free Field)

ARUP



Unattended monitoring: Logger 1 - Westfield - Adjacent carpark entry (Free Field)

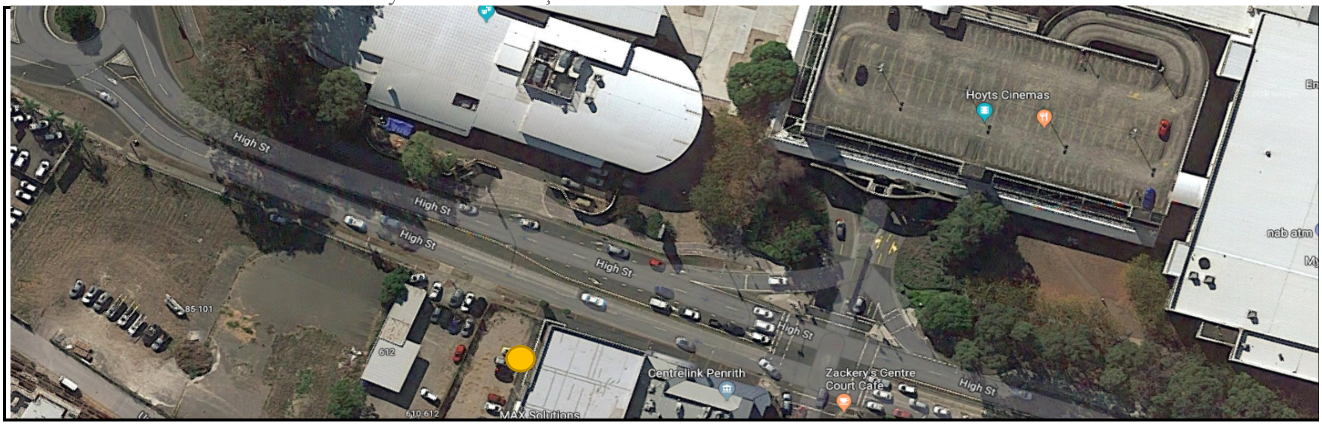
ARUP



ARUP

Logger 2 - 606 High Street (Free Field)

Additional detail: First floor balcony at western façade



Background and ambient noise monitoring results - NSW 'Noise Policy for Industry', 2017

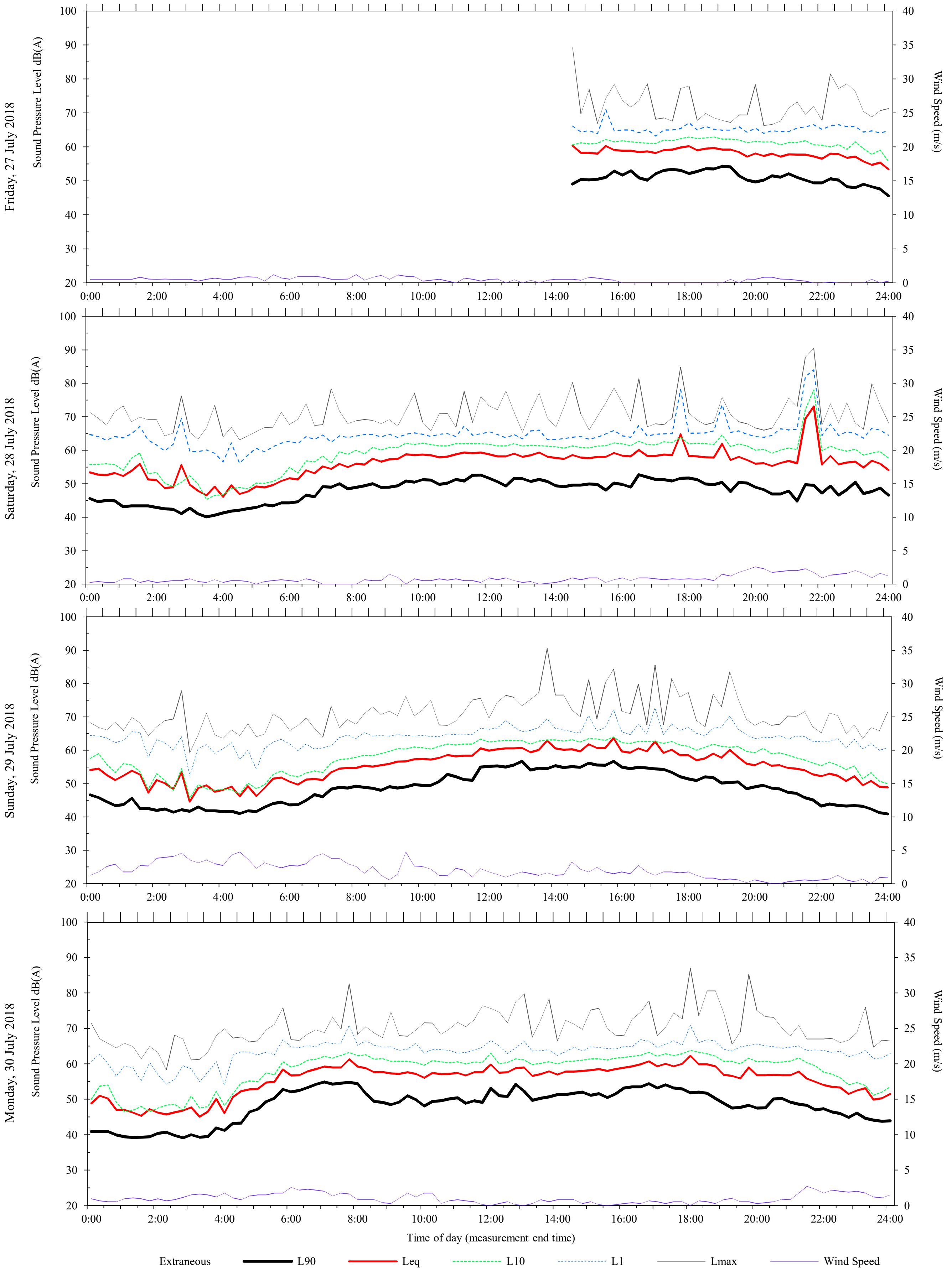
Date	L_{A90} Background noise levels[4]			L_{Aeq} Ambient noise levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Friday-27-July-2018		49	41		58	53
Saturday-28-July-2018	49	47	42	59	64	53
Sunday-29-July-2018	49	45	39	60	57	53
Monday-30-July-2018	49	47	41	59	57	55
Tuesday-31-July-2018	50	50	43	59	59	54
Wednesday-01-August-2018	50	50	43	59	58	55
Thursday-02-August-2018	50	51	42	59	60	54
Friday-03-August-2018						
Representative Week[5]	**49**	**49**	**42**	**59**	**60**	**54**

Notes:

1. Day is 8:00am to 6:00pm on Sunday and 7:00am to 6:00pm at other times
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}

Unattended monitoring: Logger 2 - 606 High Street (Free Field)

ARUP



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