Mirvac

ATP Locomotive Workshops - Bays 1-4a

SSD 8517 Acoustic Assessment

AC06

Issue 2 | 10 November 2017

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Job number 255972-00

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1 Introduction

This report supports a State Significant Development Application (SSDA) submitted to the Minister for Planning pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act).

The Application (referred to as SSDA 8517) seeks approval for the adaptive reuse and redevelopment of the eastern portion of the Locomotive Workshop (being Bays 1-4a) within the Australian Technology Park (ATP), Eveleigh as described in the Proposed Development Description section of this report.

1.1 Background

Historically, ATP was used for railway maintenance, storage and other associated industries. Use of the site as marshalling yards and workshops formed part of a large railway-based precinct on both sides of the main railway line, dating from 1882 and growing in size until its closure in 1989. Since this time, the precinct has been progressively redeveloped and repurposed.

In 2014, the NSW Government resolved to offer development sites within the ATP for sale through a selective tender process conducted by Urban Growth NSW Development Corporation (UGDC). In November 2015 Mirvac Projects Pty Ltd (Mirvac) was named as the successful party and ownership and development rights of the precinct were subsequently transferred.

In December 2015, an SSDA was submitted to the Department of Planning & Environment for a multi-building redevelopment (i.e. Buildings 1, 2 and 3 shown in Figure 2) of the ATP to provide new commercial office, retail and community uses and a significant upgrade to the ATP public domain. Following public exhibition, and the submission of additional information, the development was approved by the Planning Assessment Commission on 20 December 2016. The construction of Buildings 1, 2 and 3 is currently underway.

The redevelopment of the Locomotive Workshop is also part of Mirvac's redevelopment strategy for the ATP. The Locomotive Workshop is to be redeveloped in its entirety, however planning approvals are sought through the submission of two separate SSDAs. This Application relates to the eastern portion encompasses the heritage Bays 1 and 2, the existing Blacksmith operation and Bays 3, 4 and 4a. In conjunction with SSDA 8449 that relates to Bays 5-15, this Application is envisaged to be the next phase of urban regeneration within the ATP.

1.2 Site description

The Locomotive Workshop is located within the Australian Technology Park (ATP), Eveleigh. The ATP precinct is located approximately 5 km south of the Sydney CBD, 8 km north of Sydney airport and within 200 m of Redfern Railway Station and has an overall area of approximately 13.2 hectares. An aerial photograph of the ATP precinct is shown in Figure 1 and the locational context of the Locomotive Workshop building is identified in Figure 2.

Figure 1: ATP Precinct

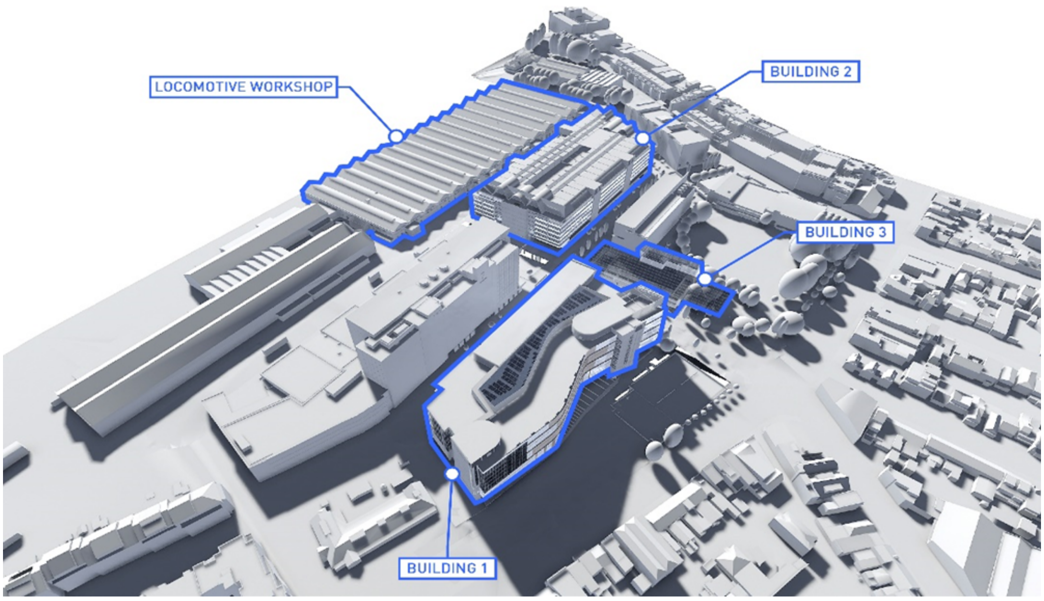


Figure 2: Locational context of the Locomotive Workshop

1.3 Proposed development description

This SSDA seeks approval for the following:

- demolition of existing 'modern' infill fit-out elements to Bays 3-4a, including display barriers in Bays 1 & 2;
- relocation of moveable heritage items;
- adaptive reuse of the Bays 1-4a and two annex structures for retail premises uses, function centre uses, information and education facility uses, general industrial uses, recreation facility (indoor) uses and associated back of house facilities;
- construction of internal and external alterations to Bays 1-4a;
- heritage interpretation and conservation works;
- public domain improvements within the curtilage of Bays 1-4a;
- provision of an external building illumination system;
- signage; and
- associated utilities and infrastructure.

A more detailed and comprehensive description of the proposal is contained in the EIS prepared by Ethos Urban.

1.4 Acoustic assessment requirements

Arup Acoustics has been engaged to prepare a construction and operational noise and vibration assessment to address the requirements for the SSD 8517 application for the redevelopment of the Australian Technology Park (ATP) Locomotive Workshop Bays 1 to 4a.

Key Issue 6 of the SEARs for application SSD 8517 sets out the following requirements with regard to the assessment of noise and vibration:

> *The EIS shall:*
>
> - *Identify the main noise generating sources and activities at all stages of construction;*
> - *Identify any noise sources during operation, including potential operation of the Blacksmith, and potential impacts on receivers elsewhere in the Locomotive Workshop and the surrounding occupiers of land; and*
> - *Outline measures to minimise and mitigate the potential noise impacts within the Locomotive Workshop and on surrounding occupiers of land during construction and operational activities.*

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

- NSW Industrial Noise Policy [1]
- Interim Construction Noise Guideline [2]

- Assessing Vibration: A Technical Guideline [3]
- Road Noise Policy [4]

The above policies and guidelines have been addressed in this report as follows:

Acoustic aspect	Policy or guideline	Report section
Operational noise from site	NSW Industrial Noise Policy [1]	Section 4
Operational road traffic generated on local road network	Road Noise Policy [4]	Section 5
Rail noise and vibration impacts onto site	Development Near Rail Corridors and Busy Road-Interim Guideline [5]	Section 6
	Assessing Vibration: A Technical Guideline [3]	
Construction noise & vibration	Interim Construction Noise Guideline [2]	Section 7
	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 in Figure 3 and Table 1.

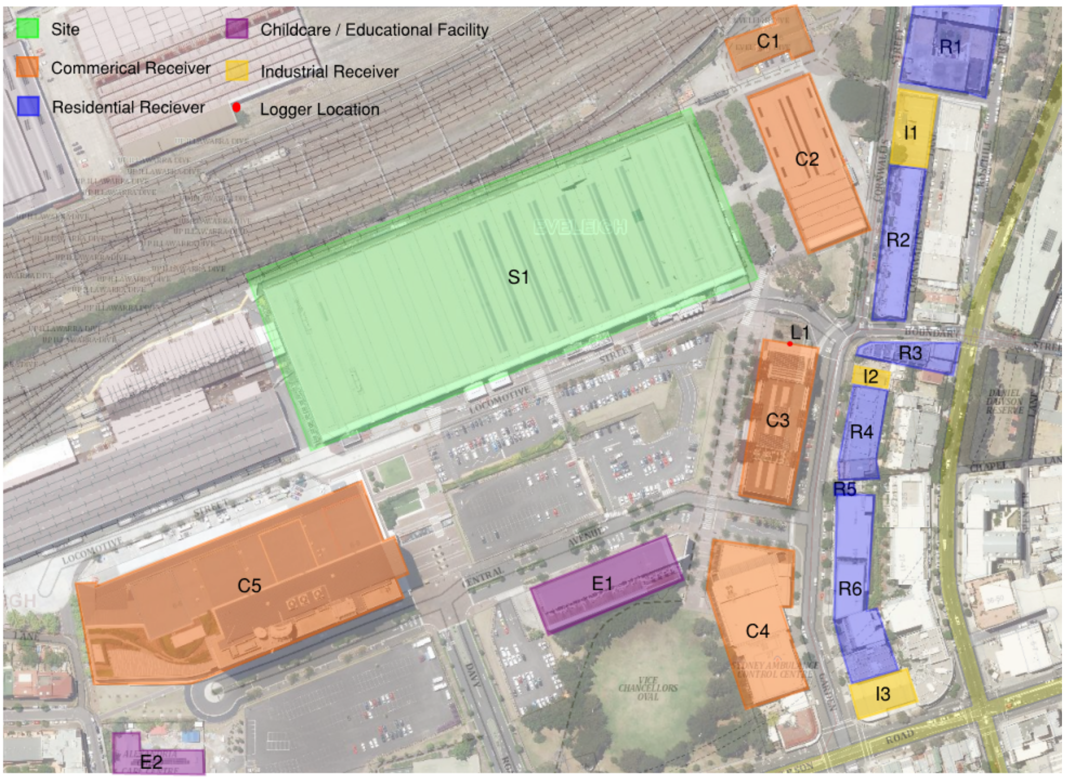


Figure 3: Site and receiver locations

Table 1: Receiver and logger locations

Type	ID	Description
Residential	R1	4-5 storey residential apartments, 32 Rosehill Street and 1-9 Marian Street, Redfern
	R2	3-4 storey residential apartments, 31-41 Rosehill Street, Redfern
	R3	3 storey residential apartments, 2&4 Boundary Street, Alexandria
	R4	3 storey residential apartments, 10-20 Garden Street, Alexandria
	R5	2 x 2 storey houses, 26 & 28 Garden Street, Alexandria
	R6	4-5 storey residential apartments, 30-44, 48 Garden Street, Alexandria
Commercial	C1	Mixed commercial (2 storeys); 6 Cornwallis Street, Eveleigh
	C2	Mixed Commercial (3 storeys); 2-4 Cornwallis Street, Eveleigh
	C3	CSIRO building (6 storeys); 13 Garden Street, Eveleigh
	C4	NSW Transport Management Centre (3 storeys), 25 & 27 Garden Street, Eveleigh
	C5	Mixed commercial (media; 4 storeys), 6-8 Central Avenue, Eveleigh
Childcare / Educational	E1	TOP Education Institute (7 storeys), 1 Central Avenue, Eveleigh It is noted that E1 will be significantly shielded by a building currently under construction.

Type	ID	Description
	E2	Alexandria childcare centre (1 storey), 41 Henderson Road, Eveleigh
Industrial	I1	Paper company (1 storey), 15 Cornwallis Street, Redfern
	I2	Welding company (1 storey), 6-8 Garden Street Alexandria
	I3	Teak company (1 storey), 50 Garden Street, Alexandria
Logger	L1	Logger located at edge of 3rd storey balcony in receiver location C3

3 Existing noise environment

Criteria for the assessment of operational and construction noise are usually derived from the existing noise environment of an area, excluding noise from the subject development.

Appendix B of the NSW EPA Industrial Noise Policy (INP) outlines two methods for determining the background noise level of an area, being 'B1 – Long-term background noise method' and 'B2 – Short-term background noise method' [1]. This assessment has used long-term noise monitoring.

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 long-term measurement locations are outlined in Table 2 and shown in Figure 3.

Table 2: Noise monitoring location

ID	Address	Description
L1	CSIRO building 13 Garden Street, Eveleigh	Logger located at edge of 3rd storey balcony. Location representative of the nearest residential receiver locations R1 to R5.

3.2 Long-term noise measurement results

Long-term noise monitoring was carried out from Thursday, 29 June to Wednesday, 5 July 2017. The long-term noise monitoring methodology and noise level-vs-time graphs of the data are included in Appendix C.

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 INP.

It is noted that day time levels during weekdays and Saturday would have been affected by construction activities.

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

Location	Time period	Rating background noise levels, dBL_{A90}	Ambient dBL_{Aeq} noise levels
L1	Day	51	60
	Evening	46	55
	10 pm to 12 am	43	53
	Night	42	52

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

The shoulder period has been established for 22:00-00:00. The shoulder period rating background level is taken to be the mid-point between the rating background levels between the two assessment periods that are on either side of the shoulder period.

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

4 Operational noise

4.1 Overview

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

- Retail and associated outdoor patron areas
- Loading dock operations
- Blacksmith
- Mechanical plant and equipment serving the development.

With regard to the Blacksmith, while the SEARs requires consideration, given the current use rights, it is assumed that the considerations for the project are with regard to protecting future uses within the redevelopment, so as not to compromise the continued operation of the Blacksmith. In order to address this concern, a specific section relating to the interface of the Blacksmith and proposed future uses is included in Section 6.

4.2 Environmental noise criteria (INP)

Operational noise emission from the project has been assessed in accordance with the NSW *Industrial Noise Policy* (INP), which 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.

4.2.1 Intrusive noise criteria

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

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

As the intrusiveness criteria is established from the prevailing background noise levels at the residential receiver locations, the rating background noise level is required to be quantified in order to establish Project noise goals.

4.2.2 Amenity noise criteria

The INP amenity criteria are for the purpose of maintaining noise amenity, for which the INP recommends 'acceptable' and 'recommended maximum' cumulative noise levels for all industrial noise at different receiver types, including residential, commercial, industrial receivers and other sensitive receivers.

Table 4: INP Amenity Criteria - Recommended L_{Aeq} industrial noise (INP Table 2.1)

Type of receiver	Indicative Noise Amenity Area	Time of day[1]	Recommended $L_{Aeq(Period)}$ noise level	
			Acceptable	Recommended maximum
Residence	Urban	Day	60	65
		Evening	50	55
		Night	45	50
School classrooms - internal	All	Noisiest 1 hour period when in use	35	40
Area specifically reserved for passive recreation (e.g. National Park)	All	When in use	50	55
Active recreation area (e.g. school playground, golf course)	All	When in use	55	60
Commercial premises	All	When in use	65	70
Industrial premises	All	When in use	70	75

1 – Day, 7.00am to 6.00pm; Evening 6.00pm to 10.00pm; Night 10.00pm to 7.00am
Sundays & Public Holidays, Day 8.00am - 6.00pm; Evening 6.00pm - 10.00pm; Night 10.00pm - 8.00 am.

Reference should be made to the INP for full assessment procedures, including modifying factor adjustments, background measurement procedures, adverse meteorological effects as well as assessment of sleep disturbance.

4.2.3 Project specific noise criteria

Based on the background and ambient noise monitoring, Table 5 summarises the derived project noise criteria based on the INP.

Table 5: INP project noise goals

Receiver	Time period	Existing noise levels[1]			Project goals		
		RBL	Industry[2] dBL_{Aeq}	Traffic[3] dBL_{Aeq}	Intrusive	Base Amenity	Amenity, w/ mod
Residential receivers							
R1-R6	Day	46*	-	60	51	60	60
	Evening	46	-	55	51	50	50
	Shoulder[4] 10pm-12am	43	-	53	48	47	47
	Night	42	-	52	47	45	45
Other sensitive receivers							
C1-C5	Use hours	-	-	-	-	65	65

Receiver	Time period	Existing noise levels[1]			Project goals		
		RBL	Industry[2] dBL_{Aeq}	Traffic[3] dBL_{Aeq}	Intrusive	Base Amenity	Amenity, w/ mod
I1-I3	Use hours	-	-	-	-	70	70
E1-E2 (internal)	Use hours	-	-	-	-	35	35

1 – Free-field noise levels

2 – No significant existing industrial noises were identified at the receptor or measurement location(s).

3 – Traffic noise levels not more than 10 dB above amenity goals.

4 – Shoulder period amenity goals taken as average between evening and night time.

* - Evening background noise levels adopted due to construction noise affecting measurements.

4.3 Operational noise review

The primary operational noise associated with the use of Bays 1 to 4a as retail uses relates to building services equipment, such as air-conditioning and ventilation systems.

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 Project goals.

The project will require some additional equipment, for which external items are located on the roof of the building. Given the distance to surrounding noise sensitive receivers, with appropriate selection of equipment, building services can be designed to readily comply with the project noise goals. Where low noise equipment selection alone is insufficient, standard noise control methods can be adopted such as attenuators, acoustic louvres, acoustic screening around plant areas and use of sound absorptive treatments to screens and plant rooms.

Further detailed acoustic design will be required following confirmation of the building services equipment selections.

Therefore, at this stage of the development, a quantitative assessment has been limited to retail tenancies at the eastern end of the building. It is noted that the assessment is indicative only, as the specific tenancies and proposed uses are not known at this stage.

Traffic noise generated from the site, as well as loading dock access are assessed in Section 5.

Quantitative assessment retail activation areas are addressed in the following subsections.

4.3.1 Source noise levels

The operation of the retail uses, particularly food and beverage uses, will primarily involve patron activity and potentially some background music.

Background music would be expected to be contained to internal areas of the development. For internal areas, the average sound pressure level presented in Table 6 has been adopted. It is noted that lower sound pressure levels would be expected at the roof level. Noise emission is predominately via the metal deck roof and open doors to the tenancies. The noise level spectrum is considered representative of a busy bar or restaurant.

Table 6: 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	64	74	75	76	82	81	78	71	66

Noise levels from patrons in outdoor areas have been predicted using formula established in Hayne et al. [6], which is considered appropriate for the general restaurant and food & beverage uses:

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

This methodology has been adopted for outdoor seating along Locomotive street, including the retail tenancy on the southeast corner of Bay 1. A group of 60 patrons has been assumed for the retail tenancy, while smaller groups of 16 have been adopted where seating is shown in Figure 4.

For comparison to other common methods of patron noise calculation, the method results in levels higher than 50% of people talking with a raised voice, but marginally less than loud voice. Spectra have been based on Cushing et al. [7] using an energy average of the male and female raised voice spectrum. The vocal spectrum has been normalised to the calculated sound power level for the assessment.

Table 7: 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

Figure 4: Ground floor plan, SA-AR-DWG-BB-B4-0290 [A]

4.3.2 Noise predictions

Noise predictions have been carried out to the nearest most potentially affected receiver locations.

Table 8: Predicted noise levels

Location	Predicted noise level, $L_{Aeq(15\ min)}$	Criteria		Complies?
		Period	Level, $L_{Aeq(period)}$	
R2-R3	48	Day	51	YES
		Evening	51	YES
		10pm to 12am	48	YES
		Night	47	NO
C2	57	When in use	65	YES

4.3.3 Discussion

Further detailed acoustic design will be required following confirmation of the intended uses for the retail spaces, particularly those at the eastern end of the building, along with any temporary activation of Innovation Plaza.

Detailed review of the current building envelope should also be carried out to ensure that any opportunities to improve the sound insulation of the envelope identified, particularly open vents or openings at existing windows or doors. It is noted that higher internal sound levels from entertainment is unlikely to be achieved with the current roof construction.

With regard to the retail use at the southeast corner, operable facades that can be closed, will maximise usage of the premises. Consideration of acoustically absorptive finishes into the fitout of new spaces should also be considered, however this is unlikely to feasible in the main Bay 1 and 2 space.

5 Road traffic generated by development

5.1 Noise criteria

Increased traffic generated on the surrounding road network is assessed in accordance with the NSW Road Noise Policy (RNP) [4]. Table 3 of the RNP sets out the assessment criteria for particular types of project, road category and land use.

Table 9: Road traffic criteria for traffic generating development - residential receivers

Road category	**Type of project / land use**	**Assessment criteria – dB(A)**	
		Day (7:00am-10:00pm)	**Night (10:00pm-7:00am)**
Freeway/arterial/sub-arterial roads - Henderson Rd - Garden St	Existing residences affected by additional traffic on existing freeways / arterial / sub-arterial roads generated by land use developments	$L_{Aeq,(15\ hour)}$ 60 (external)	$L_{Aeq,(9\ hour)}$ 55 (external)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq,}$(1 hour) 55 (external)	$L_{Aeq,(1\ hour)}$ 50 (external)

Notes: These criteria are for assessment against façade corrected noise levels when measured in front of a building façade.

Where existing traffic noise levels are above the noise assessment criteria, the primary objective is to reduce these through feasible and reasonable measures to meet the assessment criteria. For existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'no build option'.

5.2 Assessment

5.2.1 Transport Impact Report – Summary of key aspects

According to Section 4.2 of GTA Consultants' Locomotive Workshop (Retail Development) Australian Technology Park Transport Impact Assessment N117430 (10/11/17):

> *For the purposes of presenting a comprehensive assessment of transport impacts, this report has regard to the likely overall development of the Locomotive Workshop.*

For this reason, the traffic noise impact the retail bays 5-15 and commercial bays 1-4a will also be assessed collectively.

Regarding general parking provision, N117430 (Retail Development) states:

> *With the exception of the four DDA compliant bays proposed in SSD 8449, it is not proposed to provide any additional standard car parking as part of the repurposing of the Locomotive Workshops.*

The N117430 (Retail Development) report also notes the following will be provided:

- Two taxi bays and one pick-up / drop-off bays along Locomotive Street.
- Approximately eight small vehicle on-street loading bays along Locomotive Street.
- A designated loading dock with five loading bays in the northeast corner of Bay 1 that will be shared between the commercial and retail floor area. This will be used to transport waste and major deliveries.

Section 8.1 in N117430 concludes that:

- The primary traffic generation is associated with the Locomotive Street pick up/drop-off, taxi bays and small vehicle loading bays, generating an additional 42 vehicles (i.e. 84 vehicle movements) to the external road network during the AM and PM peak hours.

Other key traffic related proposals include:

> *The street is required to provide access for Channel 7 and the Sydney Trains Large Erecting Sheds. ... Additional traffic will be discouraged from using Locomotive Street.*
>
> *Heavy and medium rigid vehicle bays are proposed to be utilised between 10 pm and 7 am only.*
>
> *Waste collection is proposed to occur through the proposed loading dock location in the north east corner of the site. A compactor is location within the dock. …compactor vehicles will only be able to access the site between 10 pm – 7 am.*
>
> *Other vehicles to access the dock between the times of 9:30 am – 11:30 am and 2 pm – 4 pm.*

Regarding the loading dock access, the traffic report assessment four options, which are shown in Figure 5. It is noted that Option 1 is the current access route to the waste compound. The traffic report generally recommends Option 1 or 2 as they reduce conflict with pedestrian movements in Innovation Plaza.

Basemap source: Google Maps

Figure 5: Loading dock vehicle access routes (Figure 7.1 from Traffic Report)

5.2.2 Traffic to Garden Street

The primary vehicle movements associated with the development, and in proximity to residential premises is that which will occur on Garden Street.

Based on Figure 2.4 in N117430, existing peak hour movements along Garden Street between Central Avenue and Locomotive Street are 469 in the AM and 355 in the PM two-way.

Based on the above points, the proposed development will not result in any significant increase in traffic noise at surrounding noise sensitive premises, with the additional vehicle movements representing a less than 1 dB increase in noise level.

5.2.3 Traffic to Bay 1 and 2 Loading dock access

During the daytime period, access to the loading dock in Bay 1 and 2 is expected to be via Rosehill Street and Cornwallis Street (Options 1 or 2). Usage will be limited to light vehicles and small rigids (<8.8 m long) with a peak generation of up to 4 vehicles per hour. Such a frequency will readily satisfy traffic noise criteria. It is noted that maintaining the existing access route of Option 1, or utilising the alternative Option 2 will limit exposure of residential premises to only one direction of travel.

Use during the night period (10 pm to 7am), will primarily relate to waste collection services. Currently, waste is collected from the external waste compound on Mondays, Wednesdays and Fridays between 4 am and 5 am, with nine vehicle trips. Access to the site is via Rosehill Street (entry) and Cornwallis Street (exit) (Option 1).

For the proposed development, a single waste contractor is proposed, enabling single vehicles for pickup of multiple waste types. In addition, a compactor is proposed, which will minimise the volume of waste. With these measures in place, the minimum collection cycles are forecast to be consistent with current movements, however a marginal increase in movements is expected to be negligible with regard to noise impacts on surrounding development. It is noted that with separate waste contractors and no compactor, waste vehicle movements would have increased to 30 per week.

Certain retail tenants may require HGV / MGV deliveries to the loading dock before 7 am, however the frequency of these deliveries is expected to be low due to access constraints in the dock. In terms of access routes for heavy vehicles to and from the dock, Options 1 and 3 in Figure 5 above are preferable from an acoustic perspective, as they allow the heavy vehicles to avoid passing too close to nearby residential properties. However, it is understood that Option 2, has been developed in response to community consultation. While vehicles will need to travel in closer proximity to residential properties, the number of dwelling exposed as a result of the shorter route will be reduced from current.

6 Impacts upon the development

6.1 Rail noise and vibration

The site is located to the south of several lines associated with the main T2 and T3 suburban lines, with the nearest track being approximately 25 m from the building façade. A rail siding is also located between the main lines and the building, being approximately 8 m from the building façade and separated by a rail siding. The T4 Eastern Suburbs and Illawarra line tunnel is approximately 130-140 m from the nearest corner of the building.

It is noted that NSW Department of Planning *Development in Rail Corridors and Busy Roads – Interim Guideline* [5] is not relevant to this development, since the development does not include residential, place of worship, hospital or educational establishment or child care centre uses and therefore the subject criteria is not relevant to the subject development.

It is also noted that the guideline refers to development along busy roads, being those with an annual average daily traffic (AADT) volume of more than 40,000 vehicles (based on the traffic volume data published on the website of the RTA). The site is also not surrounded by roads warranting such assessment.

Notwithstanding, it is expected that during the detailed design of the building, noise intrusion from external sources, such as the rail corridor will be considered. The primary consideration will be airborne noise ingress from the T2 and T3 surface lines. Vibration, particularly from the more distant T4 tunnel is not expected to impact the development, particularly given the nature of proposed uses. It addition, it would not be considered feasible or reasonable to provide any vibration mitigation to an existing building.

6.2 Blacksmith

6.2.1 Sound levels

Short-term noise measurements were carried out within the Bay 2 during a workshop in the Blacksmith. The measurement location and area of activity is shown in Figure 6, while the measured noise levels are presented in Table 10.

The measured noise levels are considered representative of what might be experienced by future adjacent tenants, should there be no physical separation between the spaces.

Figure 6: Blacksmith measurement location and activity

Table 10: Blacksmith - Measured sound pressure levels

Description	Time Period	dB(A)	Octave Band Centre Frequency, Hz, dBZ							
			63	125	250	500	1k	2k	4k	8k
Lp - L_{Aeq}	5 mins	81	67	71	75	75	72	74	75	68
Lp - L_{Amax}	5 mins	94	74	79	88	86	86	92	93	85

6.2.2 Assessment

Whether additional sound insulation is required to separate the Blacksmith operations from the Blacksmith from future uses will depend on the receiver occupancy type and its sensitivity to noise ingress.

For the food & beverage uses likely to occur within Bays 1 and 2, design targets would not need to be overly onerous, and may be relative to the expected occupant noise levels, rather than the internal background noise level. Given that a busy café or bar would likely equal or exceed the noise levels emitted from the Blacksmith, it may be considered acceptable to omit any physical separation. It is noted that the measured noise levels do not exceed general work health safety regulations assuming a typical 8-hour work day for those that may occupy the adjacent spaces.

Should a degree of sound separation be desired, full height partitions may be required, however partial partitions could be pursued for minor noise reductions. It is assumed that visual connection with the Blacksmith area and equipment will be desired, and therefore glazing would be expected, at least at low levels.

It is noted some consideration of uses in the upper level of Bay 3, may also be required as flanking transmission was identified between the roof and brick wall separating the bays. Dependent upon the occupancy type, this may be limited to acoustic sealing of the junction, or inclusion of a sound insulating ceiling within the receptor space.

7 Construction

A Construction and Environment Management Plan (CEMP) has been prepared by Mirvac for the ATP Locomotive Workshop redevelopment. This assessment supplements the CEMP and has been used to inform the proposed work practices and management measures contained in the CEMP. The CEMP will be further developed as the construction methodologies and processes are confirmed during the design development process.

7.1 Construction stages and activities

Table 11 gives a high-level outline of the general stages of work and an outline of the activities that will be carried out as part of the construction works associated with the Locomotive Workshop redevelopment.

Table 11: General Stages of Work – Locomotive Workshops

Element	Description	Duration
Site Establishment	Set up hoardings and site amenities	1 month
Strip out / demolition	Demolition of existing fit-out including upper deck, stairs, internal partitions and balustrade	3 months
Structure and roof works	Compliance upgrades to roof and construction of level 1 deck structural steel	6 months
Fit-out / commissioning	Fit-out of commercial, retail and common areas	8 months

7.2 Projected program and schedule

The projected construction schedules for ATP Building 1, Building 2, Building 3 and the Locomotive Workshop are shown in Figure 7, with the detail of Phases overlapping with the Locomotive Workshop outlined in Table 12.

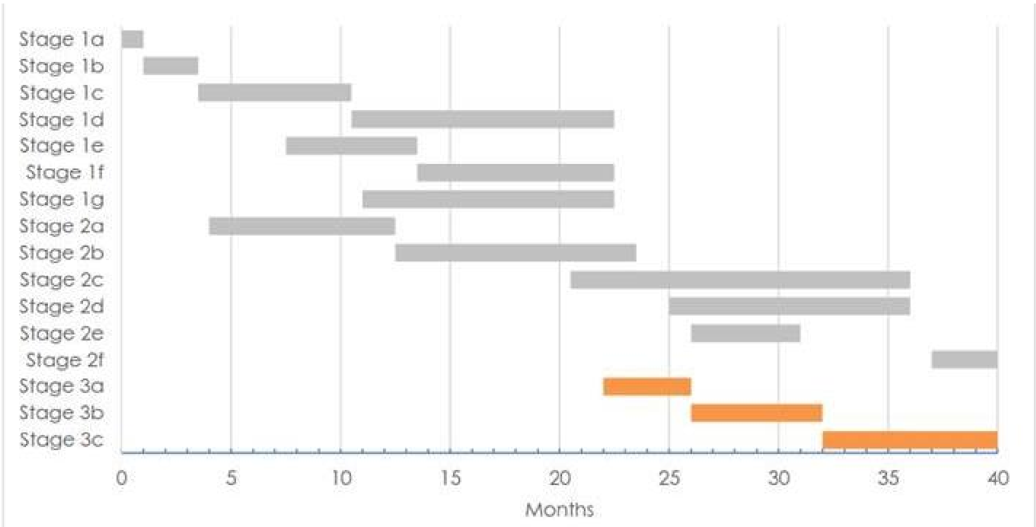


Figure 7: Projected construction schedule for Building 1, Building 2, Building 3 and the Locomotive Workshop

Table 12: Projected Construction Schedules

Stage	Phase	Description	Duration
Stage 3 (Locomotive Workshop)	3a. Site Establishment	Strip-out / Demolition	4 months
	3b. Structure and Roof works	Above ground structural works Roofing improvement works	6 months
	3c. Locomotive Workshop fit-out	Fit our works for commercial uses	8 months
Stage 2 (approved works – currently under construction)	2c. Building 2 and Building 3 Fit out	Fit out works for commercial and retail uses Fit out works for commercial, retail and childcare uses for Building 3	15.5 months
	2d. Public Domain Works – Building 2	Public Domain works surrounding Building 2 including roads	11 months
	2e. Public Domain Works – Leisure Courts	Public Domain works to Leisure Courts	5 months
	2f. Public Domain Works – Vice Chancellor's Oval	Public Domain works to Oval	3 months

Based on the above schedule and details, by the time works on the Locomotive Workshops commence, Building 1 is to be complete, while Building 2 and Building 3 will be at fitout stage.

With regard to the public domain works, Phase 2e and 2f relate to sites removed from the Locomotive Workshop. Phase 2d, being public domain and roads surrounding Building 2, has the greatest potential for cumulative impacts.

7.3 Construction hours

Consistent with SSD 7317 approval relating to other construction work at Australian Technology Park, the following construction hours are proposed:

> *The hours of construction, including the delivery of materials to and from the Site, shall be restricted as follows:*
>
> *a) Between 7:30 am and 5:30pm, Monday to Fridays inclusive*
>
> *b) Between 7:30 am and 3:30pm, Saturdays*
>
> *c) No work on Sundays and public holidays*
>
> *d) Works may be undertaken outside these hours where;*
>
> > *a. The delivery of vehicles, plant or materials is required outside these hours by the Police or other authorities*
> >
> > *b. It is required in an emergency to avoid the loss of life, damage to property and/or to prevent environmental harm; and*
> >
> > *c. A variation is approved in advance in writing by the Secretary (or nominee)*

The following works may be undertaken outside the hours of work (above) and may occur on a 24-hour-a-day, 7-days-of-the-week basis:

a) Essential maintenance (e.g. dust suppression and emergency works)

b) Internal fit out, furnishings, such as assembling furniture, electrical and painting, as long as this is not audible outside of the building

c) Delivery of materials as required by police/RMS for safety reasons

d) Works to various authorities' utilities; and

e) Environmental monitoring equipment

It is noted that the above construction hours are more restrictive than recommended in the NSW ICNG on weekdays, however this has potentially been offset by extended hours on Saturdays.

7.4 Construction noise criteria

The ICNG [2] 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. It is expected that a more detailed quantitative assessment may be warranted prior to commencement of works, so as to confirm mitigation and management processes.

7.4.1 Management levels

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

Table 13: Construction noise management levels at residential receivers

Time of day	Management level [1] $L_{Aeq\ (15\ min)}$	How to apply
Recommended standard hours: Refer to Section 7.3	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.

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: Construction noise management levels 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)

Land use	Where objective applies	Management level $L_{Aeq(15\ min)}$[1]
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 – since there is no further scope for noise mitigation.

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.

7.4.2 Project construction noise targets

Based on the ICNG guideline and the monitoring carried out, Table 15 outlines the project specific targets for the surrounding receivers.

Table 15: Construction noise management levels

Receiver	Standard hours $L_{Aeq(15\ min)}$[1]		Outside standard hours
	Noise affected	Highly affected	
R1-R6	56	75	51 (evening) /47 (night)
C1-C5	70	75[2]	-
I1-I3	75	80[2]	-
E1-E2	45	-	-

Notes: 1 – Refer to Section 7.3

2 – It is noted that highly affected targets are not outlined for 'other receivers', however targets for commercial receivers have been set no lower than residential receivers, and industrial type receivers to 5 dB higher than the noise affected level.

It is noted that the tenancy in Bay 14 ('Post Op') will require specific attention during the works. It is understood that the business includes sound recording and editing suites that could be impacted during works. Mirvac has already commenced consultation with the tenants, and will continue to do so to address construction noise and vibration management during the works. This may involve appropriate scheduling of noisy/vibration generating activities around recording times. A project specific criteria has thus not been outlined for this receiver, as it is not current deemed necessary for the proposed management strategy.

7.5 Construction vibration criteria

7.5.1 Disturbance to buildings occupants

Concerns regarding impacts on human occupants to buildings would generally be assessed in accordance with the 'intermittent' vibration criteria outlined in the DEC Guideline [3], however reference would typically be made to the Maximum levels. However due to the intermittent and low intensity works proposed, focus for management purposes is on structural damage, as outlined below.

7.5.2 Structural damage

7.5.2.1 Definition

Potential structural or cosmetic damage to buildings as a result of vibration is typically assessed in accordance with British Standard 7385 Part 2 [8] and/or German Standard DIN4150-3 [9]. British Standard 7385 Part 1: 1990, 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 British Standard 7385 Part 2 (1993) 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.*

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.

7.5.2.2 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 16 sets out the BS7385 criteria for cosmetic, minor and major damage. Regarding heritage buildings, British Standard 7385 Part 2 [8, p. 5] notes that "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*".

Table 16: 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

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%.

7.5.2.3 German Standard

German Standard DIN 4150 - Part 3 '*Structural vibration in buildings - Effects on Structure*' [9] 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.

7.5.3 Vibration sensitive equipment or receivers

Some high technology manufacturing facilities, hospitals and laboratories use equipment and processes that are highly sensitive to vibration, such as high magnification microscopy (including optical and electron microscopes) and high resolution imaging equipment (e.g. MRI). Buildings housing sensitive computer or telecommunications equipment may also require assessment against stricter criteria than those nominated for building damage.

While the acceptable vibration levels for such equipment are recommended to be obtained from the instrument manufacturers, generic criteria such as the ASHRAE Vibration Criteria for Vibration Sensitive Equipment (VC-curves) can be adopted for planning purposes, however no relevant equipment has been identified.

With regard to the Channel 7 studios located at 6-8 Central Ave, the noise intrusion from airborne noise is expected to be sufficiently reduced so as not to affect the use. The primary concern would be impacts on the studios as a result of any structure-borne noise generated by vibration intensive works. It is noted however that the works associated with the Locomotive Workshop redevelopment are of significantly lower intensity to other building works occurring on site and vibration intensive work is not expected.

The tenancy in Bay 14 ('Post Op') has also been identified as potentially sensitive to vibration. It is understood that the business includes sound recording and editing suites that could be impacted during works. Mirvac has already commenced consultation with the tenants, and will continue to do so to address construction noise and vibration management during the works. This may involve appropriate scheduling of noisy/vibration generating activities around recording times. A project specific criteria has thus not been outlined for this receiver, as it is not current deemed necessary for the proposed management strategy.

7.5.4 Buried services

It is not expected that the proposed works will impact upon buried services, however the following is nonetheless provided for guidance. DIN 4150-2:1999 sets out guideline values for vibration effects on buried pipework (see Table 17).

Table 17: 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 DIN4150-3 [9] 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 meters 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/sec 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 50mm/s and 100mm/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.

7.6 Construction noise and vibration assessment

7.6.1 Construction works – Noise impact

The construction works associated with the Locomotive workshop are generally internal, including strip out and fitout. As such, noise emission from the works is not expected to be significant.

Roof upgrades will likely require use of larger equipment for lifting, though install will be with hand tools. Works are to be carried out Bay by Bay, and it is expected that only the external skin will be replaced. The lower skin of the roof will therefore be retained where practicable for control emissions from internal works.

Large openings in the building fabric, inclusive of timber and larger roller doors should be sealed for the control of noise emission, where they are not utilised for site access.

It is noted that construction traffic has been assessed separately in Section 7.6.3.

The SEARs also requires that potential cumulative noise impact with Buildings 1, 2 and 3 work be considered. As outlined in Section 7.2, this is limited to Phase 2c (Building 2 fitout) and Phase 2d (public domain and roads surrounding Building 2).

Reference has been made to the CNVMP for Buildings 1, 2 and 3, which presented details of surrounding noise sensitive receivers per Figure 8 and Table 18. Regarding works at the Locomotive Workshop, receivers A4, A5, A8, A10 and A11 are considered most relevant to considerations of cumulative impact.

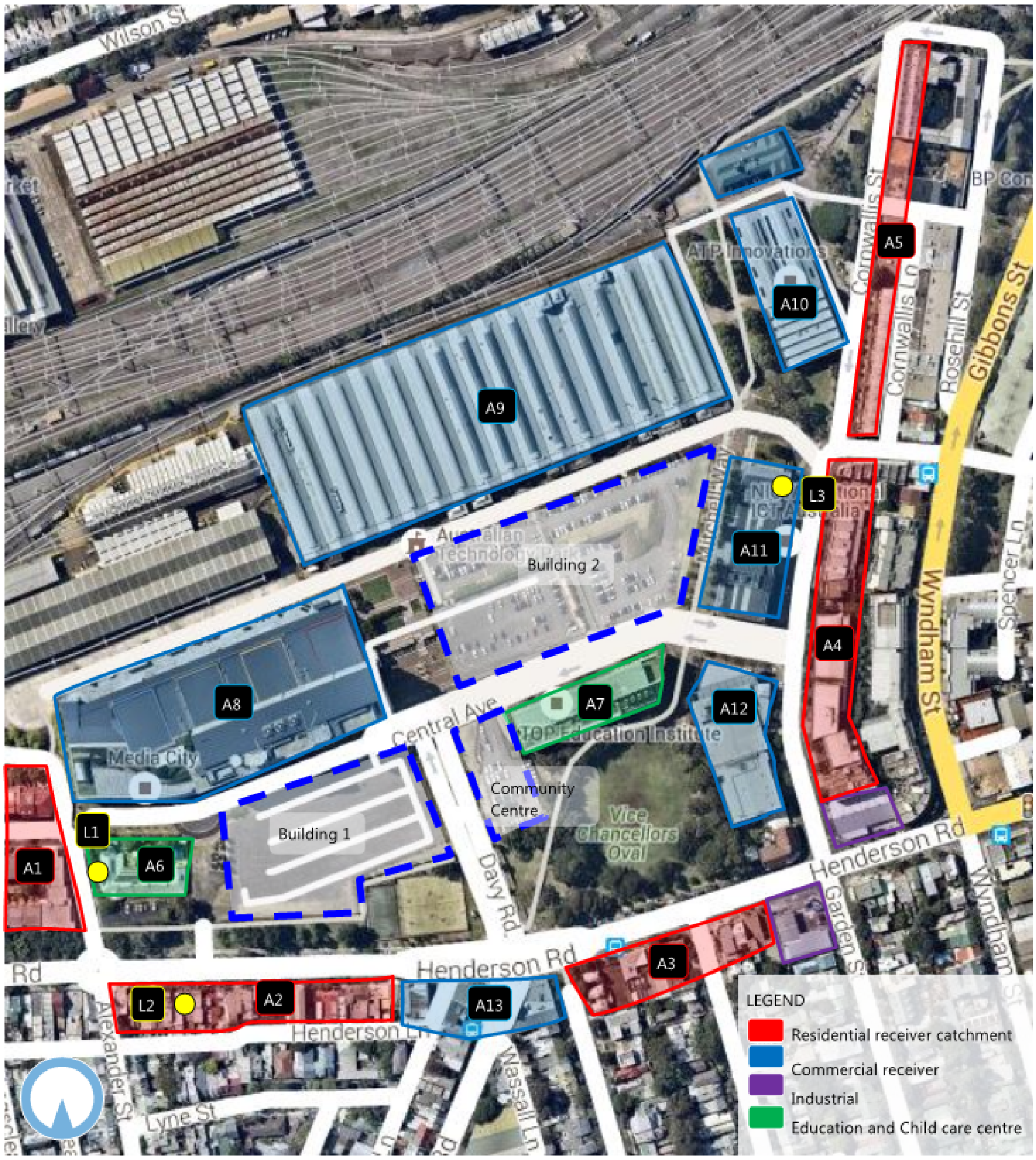


Figure 8: Noise Sensitive Receivers (ref: CNVMP for Buildings 1, 2 and 3)

Table 18: Noise Sensitive Receiver Locations (ref: CNVMP for Buildings 1, 2 and 3)

ID	Receiver Type	Address/Location
A4	Residential Noise Catchment	East of Garden St, between Henderson Rd & Boundary St
A8	Commercial – Channel 7	8 Henderson Rd, Eveleigh
A10	Commercial Premises	145/4 Cornwallis St, Eveleigh
A11	Commercial Premises	13 Garden St, Eveleigh

The predicted noise levels at the relevant noise sensitive receivers for Stages 2c-2e (exclusive of Stage 3) are shown in Table 19.

Table 19: Predicted Noise Levels for Noise Sensitive Receivers (ref: CNVMP for Buildings 1, 2 and 3)

ID	Minimum Criteria, $L_{Aeq,15min}$	Predicted Noise Level Range, $L_{Aeq,15min}$ Stages 2c-2d)	
		Max	Min
A4	56	**58**	48
A5	56	54	44
A8 Recording	45	**66**	**56**
A10	70	60	50
A11	70	69	59

With Building 2 works exceeding criteria only at locations A4 and A8, and that works associated with the Locomotive Workshops will be of lower intensity to Building 2 public domain works, limited cumulative impact is anticipated. Since Stage 3 consists of the internal fit out of the Locomotive Workshop (as opposed to external construction works), it is expected that the cumulative noise levels will not exceed the peak cumulative noise levels caused by earlier stages of the works.

A detailed Construction Noise and Vibration Report for the Locomotive Workshop will be required, and Locations A4, A8 and A10 are deemed most sensitive to works from the Locomotive Workshop and should be the focus in detailing the CNVMP. In-principle recommendations are discussed in Section 7.7.

7.6.2 Construction works – Vibration

Given that the works on the Locomotive Workshop are primarily internal fit-out, it is expected that the vibration impact to sensitive receivers will be cumulatively less during Stage 3 of the development than during the earlier stages of the construction of Buildings 1 and 2.

A detailed Construction Noise and Vibration Report for the Locomotive Workshop will be required at a later design Stage. Therefore, the relevant vibration mitigation recommendations outlined in the CNVMP for Buildings 1, 2 and 3 should also be applied to Stage 3 of the development, as well as the procedures outlined in Section 7.7.

7.6.3 Construction traffic

According to the Construction Pedestrian and Traffic (CTMP) report by GTA Consultants:

> *[Locomotive Street] will provide the only site construction vehicle access for both entry and egress.*
>
> *[A work zone is] proposed to be provided to facilitate [construction] activities…located along the southern end of the building at bays 12-13. Access to this work zone will require construction vehicles to travel to the western end of Locomotive Street and perform a U-turn.*

The work zone proposed is along an internal road within the ATP site.

The largest truck would be a 12.5-metre heavy rigid vehicle. Use of any larger vehicles will require approval from Council in a separate application.

Table 20: Construction vehicle movements

Construction Stage	**Average No. of Trucks per Day**	**Average No. of Truck Movements per Day**	**Cumulative Truck Movements per Day [1]**	**Cumulative Truck Movements per Hour [1]**	**Vehicle Type / Size**
3a. Site Establishment	4	8	40	4	8.8m Medium Rigid 12.5m Large Rigid
3b. Structure and Roof Works	8	16	36	4	8.8m Medium Rigid 12.5m Large Rigid
3c. Locomotive Workshop Fit-out	8	16	16	2	8.8m Medium Rigid 12.5m Large Rigid

[1] These volumes indicate the cumulative truck movements per day / hour at the commencement of each stage.

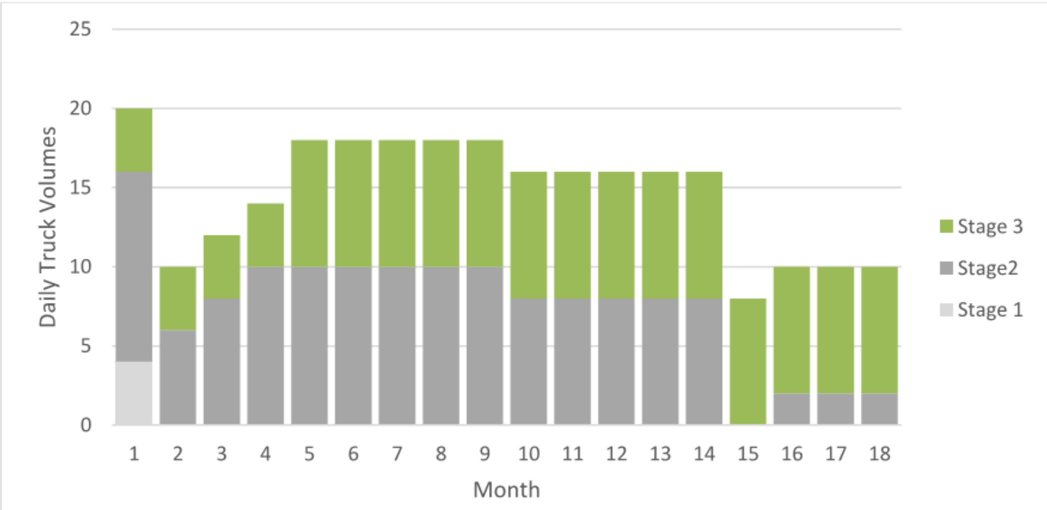


Figure 9: Daily Cumulative Truck Volumes for Construction Stages 1 - 3

Based on the above table and taking cumulative works into consideration, the average peak construction vehicle volumes would be 20 vehicles per day, being negligible by comparison to the current traffic volumes. Compared with the earlier works for Building 1, 2 and 3, the cumulative average peak vehicle truck movements to/from the site were anticipated to be of the order of 100 per day (with no truck movement in the evening or at night) without significantly altering traffic noise.

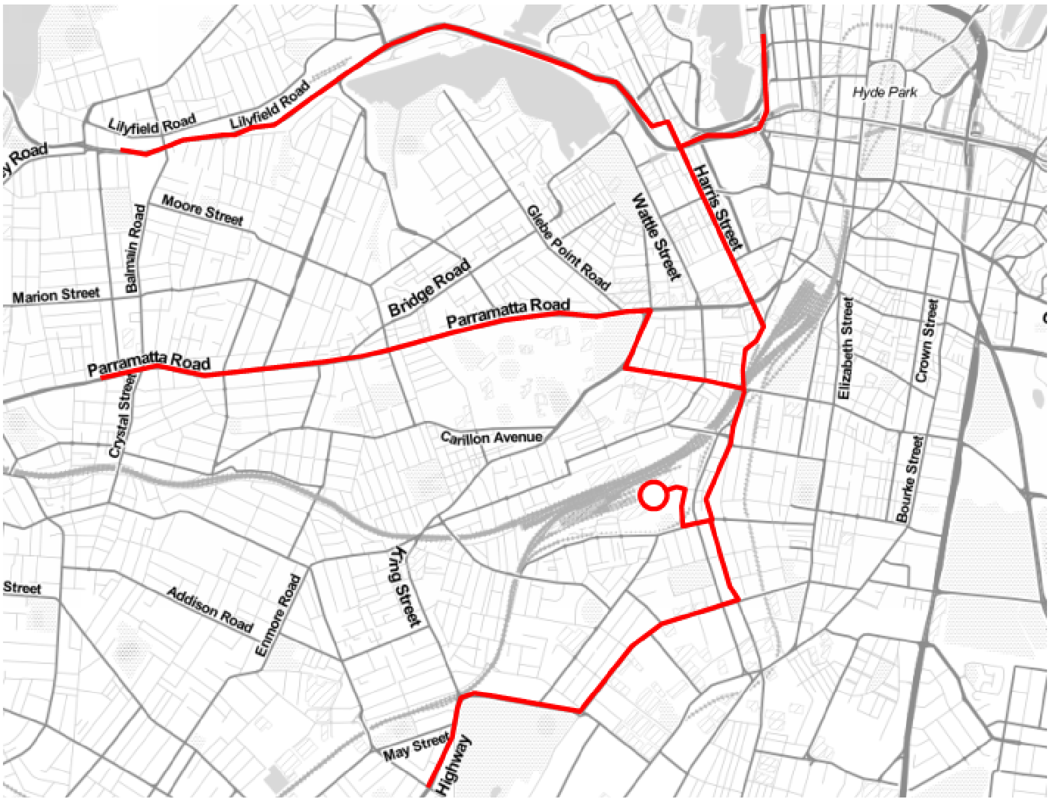
For Stages 1 and 2 of the development, the access routes to each building site for construction vehicles are as follows:

- Building 1 – entry from Henderson Road via the Davy Road access, exit from Central Avenue to temporary egress road to Henderson Road
- Building 2 and 3 – entry from Henderson Road via the Garden Street access, exit from Central Avenue to Henderson Road via Davey Road

Figure 10 demonstrates that the construction vehicle access routes for Stage 3 arrive at Locomotive Street via north Garden Street, Garden Street and Henderson Road. This access route is only a slight alteration of the access routes for Buildings 1, 2 and 3.

Additional light traffic will also be generated in the area as a result of construction workers travelling to and from the site, however this is expected to be minimal due to the absence of on-site parking for construction staff and adoption of the Green Travel Plan.

Based on the similar access routes and the lower cumulative peak vehicle volumes for Stage 3 of the development (i.e. 20 vehicles per day), the Locomotive Workshop construction phase is not expected to significantly alter the traffic noise to the surrounding area.



Basemap Source: OpenStreetMaps, Stamen

Figure 10: Access routes for Stage 3 of the development (taken from the CTMP)

7.7 Construction noise and vibration mitigation

Noise mitigation measures for each major 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.

7.7.1 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
- Monitoring methodology
- Community engagement strategy.

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

7.7.2 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.
- Manage noise from construction work that might be undertaken outside the recommended standard hours
- The location of stationary plant (concrete pumps, air-compressors, generators, etc.) as far away as possible from sensitive receivers
- Using site sheds and other temporary structures or screens/hoarding to limit noise exposure where possible, for example around the eastern construction compound.
- Sealing of openings in the building (temporary or permanent) prior to commencement of internal works to limit noise emission.
- 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. Of particular importance would be Channel 7 studios, and works that may be required at the western end of the building.

7.7.3 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.
- The implementation of the traffic control plans contained in Section 4.6 of the CTMP, notably:
  - Construction vehicle activity, including the loading / unloading of trucks to be conducted within the work site and the designated work zones for each building site.
  - All construction vehicle activity will be minimised, where possible, during peak periods.

7.7.4 Vibration – minimum working distances

Recommended minimum working distances for vibration intensive plant, which are based on international standards and guidance and reproduced in Table 21 below for reference. With regard to the proposed development works, vibration is not expected to impact upon surrounding development.

Table 21: 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

8 Conclusion

Arup has completed an acoustic assessment for the proposed redevelopment of the Australian Technology Locomotive Workshops to address the SEARs for SSD 8517, which relate to operational and construction related environmental noise and vibration emissions.

With regard to operations, the assessment concludes that the proposed redevelopment is capable of satisfying the standard NSW EPA noise policy requirements. Notwithstanding, further detailed acoustic assessment is warranted during the design development, particularly with regard to building services noise control and management of retail activation areas.

Regarding construction, the proposed redevelopment primarily relates to internal works, and is not expected to result in any cumulative impact when considering activities associated with the current ATP development. By comparison to earlier stages of Building 1, 2 and 3 development, such as earthworks and excavation, the proposed development represents less intensive construction activity and related traffic movements. A detailed Construction Noise and Vibration Report for the Locomotive Workshop will nonetheless be required, in which specific attention should be given to activities at the western end of the Building (SSD 8449) in proximity to Channel 7 studios and Post Op tenancy (Bay 14).

References

[1] NSW Environmental Protection Authority, “NSW Industrial Noise Policy,” Environmental Protection Authority, Sydney, 1999.

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

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

[5] NSW Department of Planning, “Development Near Rail Corridors and Busy Roads - Interim Guideline,” NSW Department of Planning, Sydney, 2008.

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

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

[10] NSW Government, “State Environmental Planning Policy (Infrastructure) 2007,” 2007.

[11] Bristish Standards Institution, “BS 6472-1992 Evaluation of human exposure to vibration in buildings (1-80Hz),” Bristish Standards Institution, London, 1992.

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 m^2) 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.

Clarity Index (C_{80})

The clarity index, expressed in dB, is used to objectively evaluate orchestral or vocal (musical, not speech) clarity. Measured in decibels, it is 10 times the logarithm of the ratio of the total sound energy received in the first 80 ms following (and including) the direct sound energy to the sound energy received after 80 ms – i.e. the ratio of “early” to “late” sound. The higher the value of C_{80}, the greater the expected subjective clarity.

Comb Filtering

Comb filtering is an acoustic defect that leads to acoustic colouration. Comb filtering occurs from coherent interference between a sound and its reflection from a large smooth surface, and is most prominent in small rooms. Comb filtering imparts a “ragged” harshness to the sound.

Comb filtering may be treated by adding absorption (which reduces the amplitude of the reflected sound and reduces the strength of the interference) or by adding diffusion (which breaks up the reflection so that the sound waves do not interfere coherently).

Colouration

Colouration refers to an acoustic defect within a room where particular frequencies are either enhanced or reduced so that the frequency balance of the room is distorted, adding an acoustic "tinge" to the sound quality (analogous to particular colours in a visual image being either enhanced or reduced and skewing the colour balance of the image). Colouration most commonly occurs from strong individual sound reflections that are not distinct enough to be perceived as a separate sound (an echo) but are nevertheless strong enough to be heard by the ear.

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

Sound Pressure Level dB(A)	Example
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.

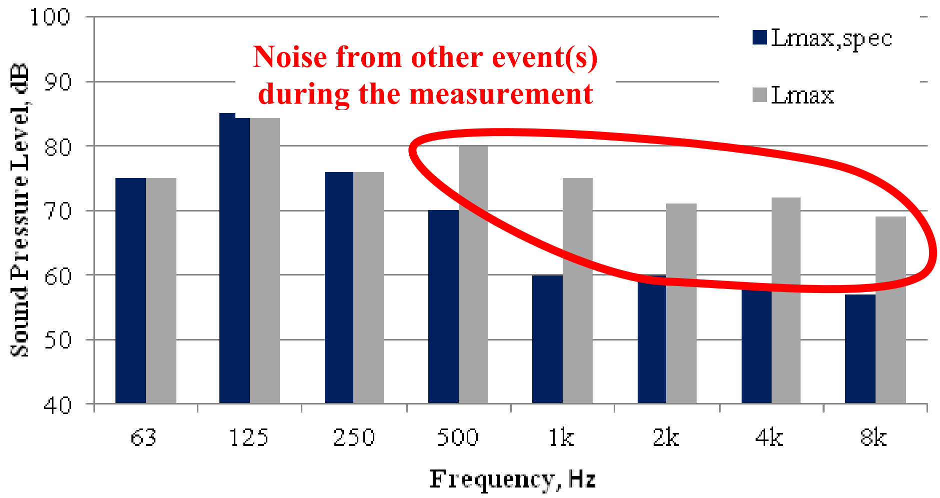
Mathematically, L_{max} is the highest value recorded during the measurement period. As an example, 94 dB L_{Amax} is a highest value of 94 dB(A) during the measurement period.

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”.

Impact Sound Pressure Level

The technical parameter used to determine impact sound isolation of floors is the impact sound pressure level, L_i.

In the laboratory, the weighted normalised impact sound pressure level, $L_{n,w}$, is used to represent the impact sound isolation as a single figure.

On site, the weighted normalised apparent impact sound pressure level, $L'_{n,w,}$ and the weighted standardised apparent impact sound pressure level, $L'_{n,Tw}$, are used to represent the impact sound isolation of a floor as a single figure.

These single weighted values are determined by comparing the spectral impact sound pressure levels (as defined in ISO 140-6 & ISO 140-7) with reference values outlined in AS/NZS ISO 717.2.

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.

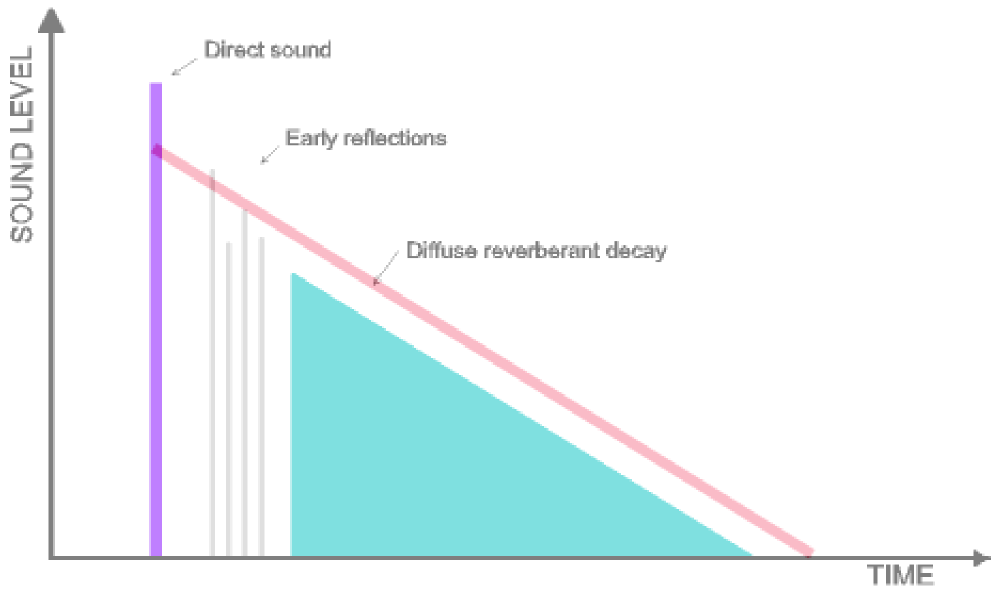
Reverberation Time (T_{60})

The time, in seconds, taken for a sound within a space to decay by 60 dB after the sound source has stopped is denoted at the reverberation time. The RT is an important indicator of the subjective acoustic within an auditorium. A large RT subjectively corresponds to an acoustically ‘live’ or ‘boomy’ space, while a small RT subjectively corresponds to an acoustically ‘dead’ or ‘flat’ space.

Examples of typical design reverberation times are provided below:

Mid-frequency Reverberation Time, s	Example
< 0.1	Anechoic
0.1 – 0.4	Call centres
0.4 – 0.6	Library
0.6 – 0.8	Offices / board rooms
0.8 – 1.0	Small auditorium for speech

Mid-frequency Reverberation Time, s	Example
1.0 – 1.2	Music studios
1.2 – 1.5	Chamber music venues
1.5 – 2.0	Orchestral music venues
2.0 – 3.0	Church
3.0 – 8.0	Cathedral



Sound Exposure Level (SEL)

The Sound Exposure Level or Single Event Noise Exposure Level, denoted SEL or L_{AE}, is a measure of the total amount of acoustic energy contained in an acoustic event. The SEL is the constant sound pressure level that would produce in a period of one second the same amount of acoustic energy contained in the acoustic event. SEL is commonly used to quantify the total acoustic energy contained in transient events such as a vehicle pass-by.

Sound Level Difference (D)

Sound level difference is used to quantify the sound insulation between two spaces, and is equal to the difference in sound level between the two rooms at a particular frequency (e.g. if the sound level in the source room is 100 dB and the sound level in the adjacent room is 75 dB, the sound level difference is 25 dB). The weighted sound level difference, D_w, (as defined in AS/NZS ISO 717.1) is commonly used to provide a single-number descriptor to describe the overall performance of a partition across a wider frequency range.

The terms used to describe the airborne sound insulation rating of a building element when tested on-site are the weighted normalised level difference ($D_{n,w}$), which corrects the measured sound level difference to a reference absorption area in the receiving room, or the weighted standardized level difference ($D_{nT,w}$), which corrects the measurements to a reference reverberation time in the receiving room. These single numbers are determined by comparing the spectral sound insulation test results (as defined in ISO 140-4) with reference values, as outlined in AS/NZS ISO 717.1.

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.

Strength (also called Loudness) (G)

This parameter is used to compare the loudness of halls. It is the ratio of the measured sound pressure level at a location to the free-field (open air) sound pressure level from the same source, measured at 10m from the source – i.e. how much the hall “amplifies” or “reduces” the loudness of a source. An omni-directional source is used and the parameter unit is dB.

Speech Transmission Index (STI)

STI is a technical index, predictable and measurable using specialised equipment, for assessing speech and vocal intelligibility. STI takes into account the signal/noise ratio of the speech signal and the reverberation of the receiving environment. The higher the value of STI, the higher the expected speech intelligibility.

STI ratings are assigned subjective categories, as follows:

STI Range	Subjective Category
< 0.3	Bad
0.3 – 0.45	Poor
0.45 – 0.6	Fair
0.6 – 0.75	Good
0.8 – 1.0	Excellent

Spectrum Adaptation Terms (C and C_{tr})

The terms C and C_{tr} are spectrum adaptation terms (in dB) that are added to the R_w or D_w value of a partition in order to determine the overall sound insulation rating of a partition for various conditions. The overall performance of the partition is quoted as the sum of the Rw value and the spectrum adaptation terms, e.g. D_w + C 55 dB; R_w + C_{tr} 60 dB.

C is a spectrum adaptation term used to measure the performance of a partition for medium to high-frequency noise sources, such as speech.

C_{tr} is a spectrum adaptation term used to measure the performance of a partition for low-frequency noise sources such as traffic noise.

The values of C and C_{tr} are dependent on the construction of the partition. Because C and C_{tr} are (usually) negative quantities, they typically increase the Rw requirement of a partition (eg if C_{tr} is -6 dB, an R_w of 56 dB is required to achieve a rating of R_w + C_{tr} 50 dB).

Structureborne Noise

The transmission of noise energy as vibration of building elements. The energy may then be re-radiated as airborne noise. Structureborne noise is controlled by structural discontinuities, i.e. expansion joints and floating floors.

Room Criteria (RC) Mark II Curves

Room criteria Mark II (RC-II) curves were developed by the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), as an improved method of assessing mechanical services noise. RC curves are shaped so as to achieve a bland, neutral sound spectrum, and extend to lower frequencies than NC or NR curves. The RC curves allow the spectral balance of the noise spectrum to be assessed as Neutral (N), Rumble (LF), Roar (MF) or Hiss (HF).

The RC value of a noise spectrum is obtained by averaging the octave band spectra values in the 500 Hz, 1 kHz and 2 kHz octave bands. This number gives the RC-II curve rating of the spectrum.

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/s^2) 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	RTA04 (CESVA SC310)		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, wind (greater than 5m/s) or rain were excluded from the recorded data in accordance with the procedures outlined in Appendix B of the NSW Industrial Noise Policy (INP).

Data provided by the Bureau of Meteorology (BOM), for 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

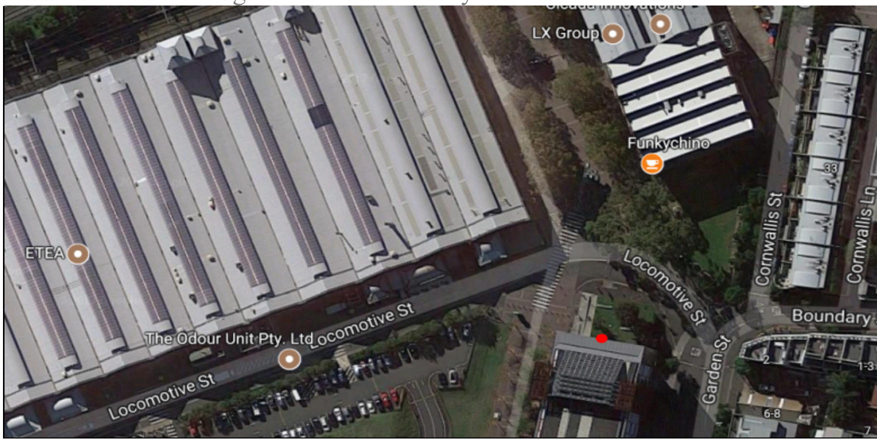
The following noise level vs time graphs present overall dB(A) levels recorded by the unattended logger(s) for a range of noise descriptors, including L_{Aeq}, L_{A90}, L_{A10} and L_{Amax}, While line graphs are presented, sampling is typically at 15 minute intervals.

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

ARUP

L1 - Level 3, CSIRO building (Free Field)

Additional detail: Edge of northern balcony



Background and ambient noise monitoring results - NSW 'Industrial Noise Policy', 2000

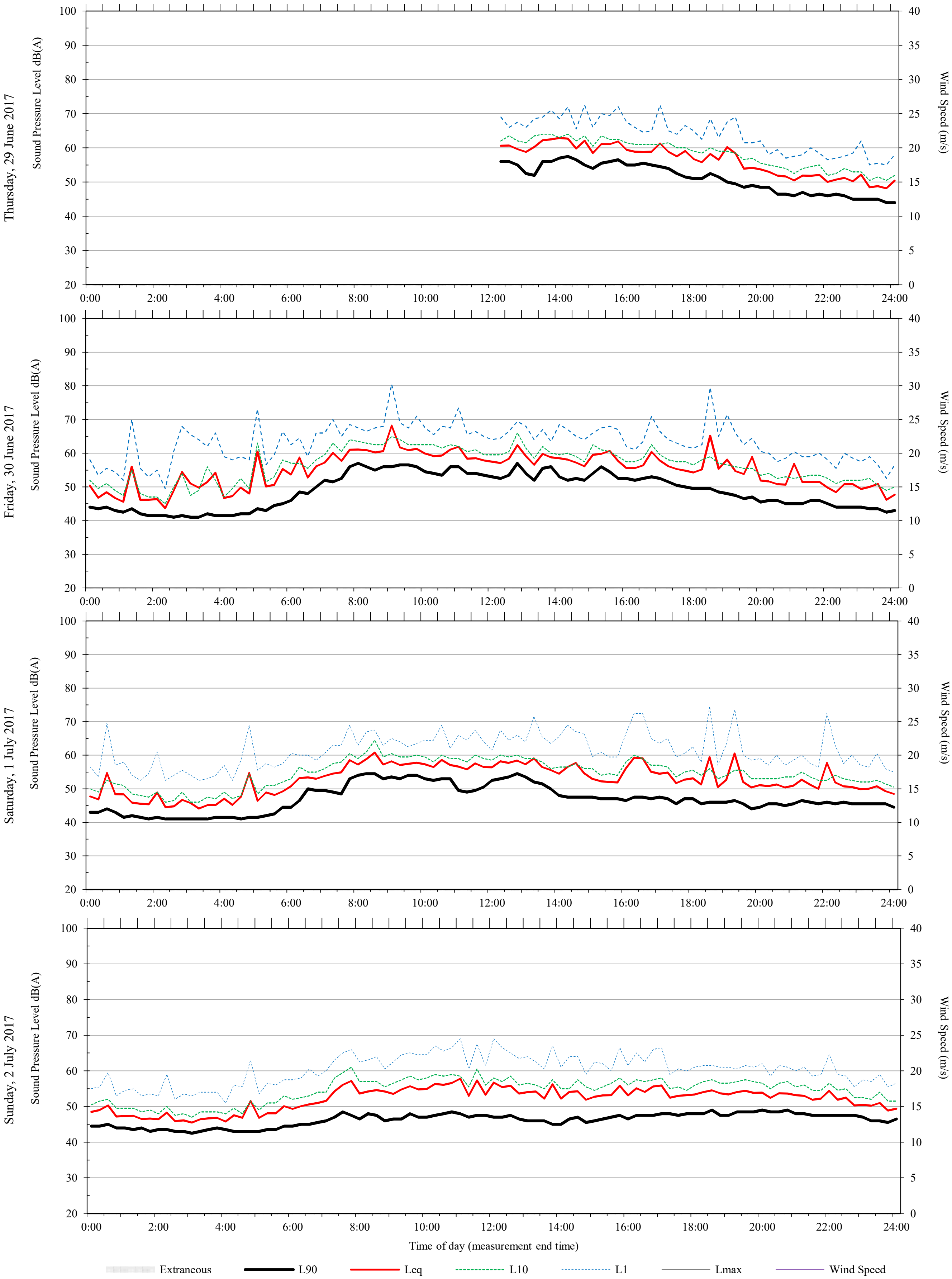
Date	L_{A90} Background noise levels[4]			L_{Aeq} Ambient noise levels		
	Day[1]	Evening[2]	Night[3]	Day[1]	Evening[2]	Night[3]
Thursday-29-June-2017		46	42		55	53
Friday-30-June-2017	52	45	41	60	57	50
Saturday-01-July-2017	47	45	43	57	54	50
Sunday-02-July-2017	46	48	46	55	54	54
Monday-03-July-2017	53	48	45	59	56	53
Tuesday-04-July-2017	53	47	44	61	55	53
Wednesday-05-July-2017	51	46	41	59	55	52
Thursday-06-July-2017	52	45	42	60	55	53
Friday-07-July-2017	53	47	42	61	55	51
Saturday-08-July-2017	48	46	44	59	52	51
Sunday-09-July-2017	46	46	43	56	53	53
Monday-10-July-2017	51	45	41	63	56	51
Tuesday-11-July-2017	53	45	42	63	54	52
Wednesday-12-July-2017	51	45	42	60	54	54
Thursday-13-July-2017						
Representative Week[5]	**51**	**46**	**42**	**60**	**55**	**52**

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: L1 - Level 3, CSIRO building (Free Field)

ARUP



Unattended monitoring: L1 - Level 3, CSIRO building (Free Field)

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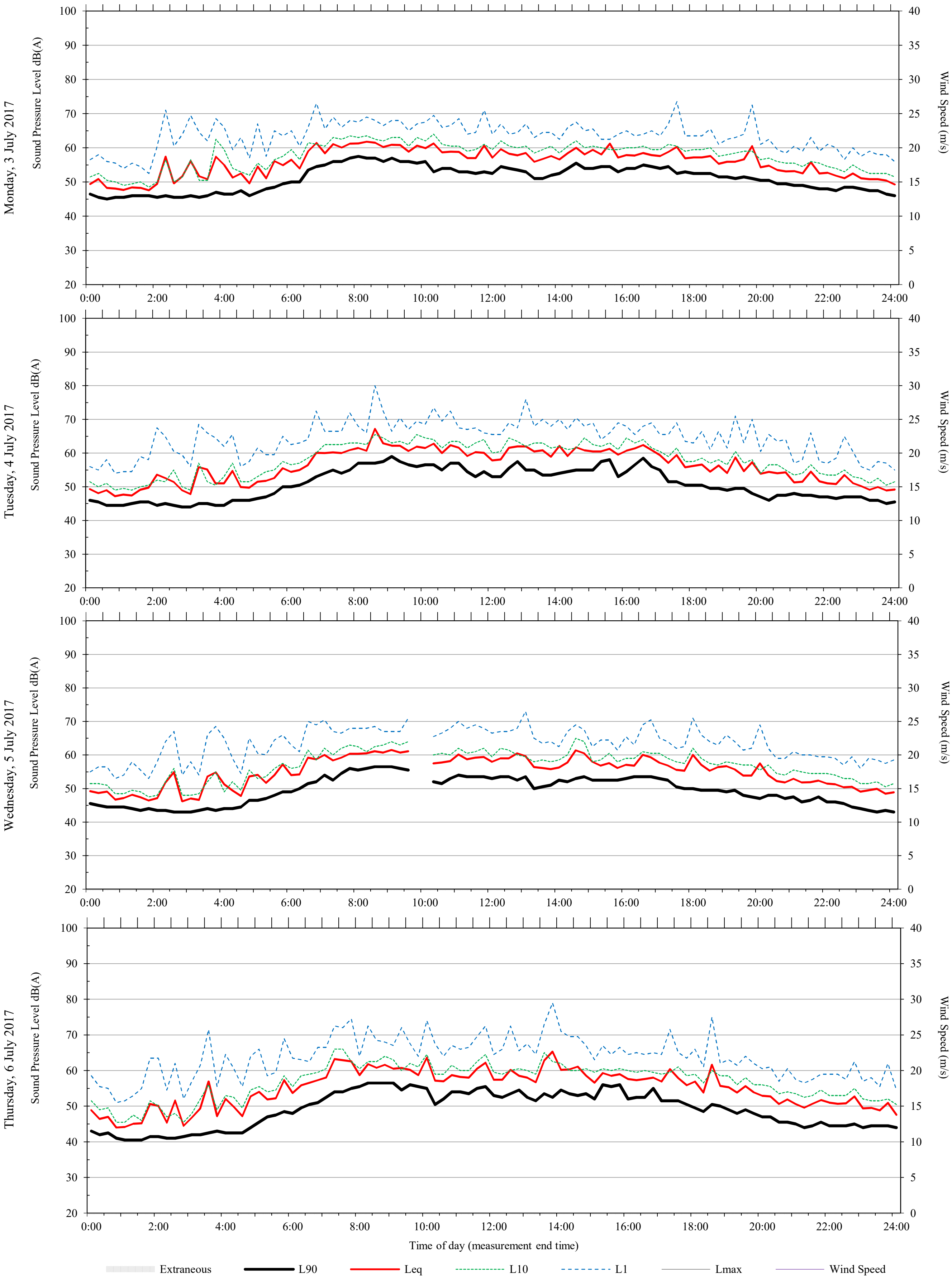

Unattended monitoring: L1 - Level 3, CSIRO building (Free Field)

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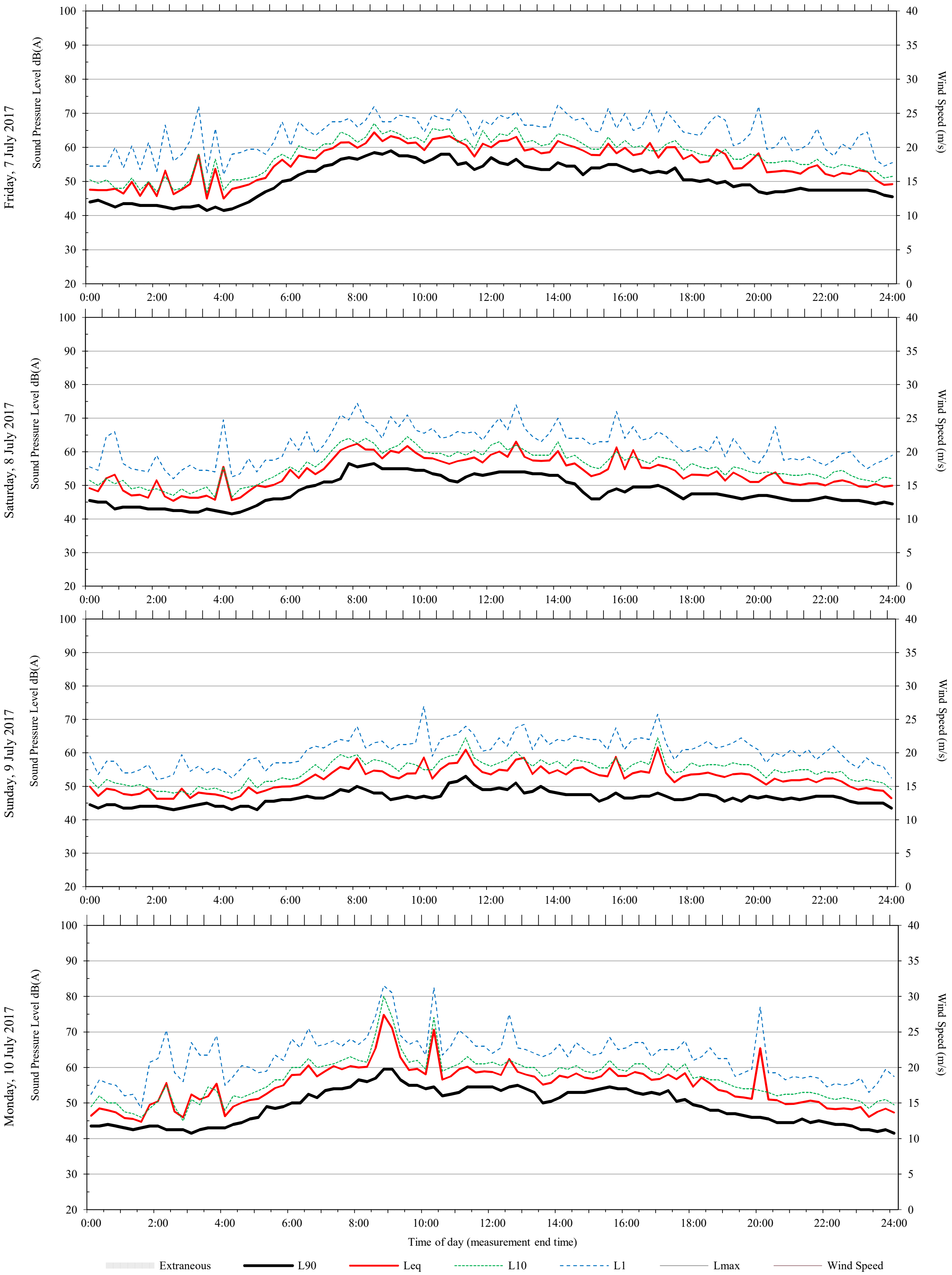

Unattended monitoring: L1 - Level 3, CSIRO building (Free Field)

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