

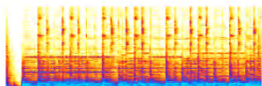
85 HARRINGTON STREET

85 HARRINGTON STREET, THE ROCKS

Acoustic Assessment for Development Application

Issued

7 January 2016

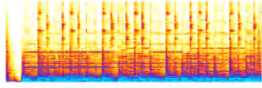


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Executive Summary

A mixed-use development is proposed by Golden Age Development & Hannas The Rocks Pty Ltd at 85 Harrington Street, the Rocks. The proposal involves demolition of the existing building and constructs a group of three buildings plus a plaza.

Secretary's Environmental Assessment Requirements (SEARs) have been issued, requiring the preparation of an Environmental Impact Statement (EIS) for the proposed development. An acoustic assessment has been carried out and is detailed in this report along with the findings and recommendations. This acoustic report has been prepared in support of the EIS for the proposed development.

As per Item 14 of the SEARs, noise and vibration generated by the development is addressed in this report to the following guidelines, plus other relevant guidelines and standards:

- EPA/OEH NSW Industrial Noise Policy 2000 (INP)
- EPA/OEH NSW Industrial Noise Policy – Application Notes 2013
- DECCW Interim Construction Noise Guideline 2009 (ICNG)
- DECC Assessing Vibration: A Technical Guideline 2006
- DECCW NSW Road Noise Policy 2011 (NRP)
- EPA/OEH NSW Road Noise Policy – Application Notes 2013

The existing noise and vibration environment has been established based on long-term and short-term noise and vibration monitoring. Appropriate criteria for both noise and vibration have been discussed and set according to established guidelines and standards as per the SEARs.

A summary of the outcomes and recommendations of the noise and vibration assessment is as follows:

- Operational Noise and Vibration Assessment

At this stage the plant selections have not been made; therefore a detailed assessment of plant noise emissions has not been able to be carried out. A preliminary review has been carried out for the plant room and the electrical substation, and based on the proposed locations and the most restrictive criteria, noise emissions shall be limited to 69 dB(A) at 1 meter from the plant / electrical substation boundaries.

Noise controls will be incorporated within the design of the mechanical plant to ensure that the cumulative noise output at the nearest affected receivers is

within the allowable limits. General design consideration and controls implemented will typically include: strategic selection and location of the plant and/or acoustic noise control measures such as enclosures, barriers, acoustic louvres, etc.

The final façade composition is not yet resolved. A minimum Sound Reduction assessment has been undertaken for the southern, eastern and western facades – which are affected by traffic noise from the Cahill Expressway and Bradfield Highway. This assessment has considered the measured traffic noise levels from the Cahill Expressway, the recommended background noise levels and reverberation times for the internal spaces, areas of façade for each space plus the distance to the Cahill Expressway and Bradfield Highway.

Based on the above, the minimum overall in-situ sound reduction rating for the southern, eastern and western façade systems in order to achieve the design sound levels within the affected spaces shall be approximately R'_w 36.

Noise emissions from patrons inside the retail areas will meet the relevant noise criteria.

The assessment of noise emissions from patrons in the outdoor retail areas shows a marginal exceedance of the CoS/OLGR criteria in some octave bands. Given that this exceedance is predicted based on a worst-case scenario (ie maximum occupancy of outdoor area, maximum noise generated by patrons and lowest measured background noise level for the 9am to 8pm time period), the typical use of the outdoor areas is expected to not generate an adverse noise impact. However, this does highlight the need to minimise and manage noise emissions / impact of outdoor retail patrons wherever possible. This will require management on an ongoing basis. Appropriate strategies are outlined in this report.

- Transportation Noise and Vibration Assessment

It is expected that the increase in noise level resulting from the new car park and associated vehicle movements will be inaudible and insignificant. As a consequence of the modest changes in traffic flows and vehicle movements associated with the proposed development, the design criteria of an increase in traffic noise levels of no more than 2 dB will be met.

Vibration levels obtained from City Circle Rail Line train pass-bys show that, despite being further from the site, westbound trains generate higher vibration levels than eastbound trains. The difference is approximately 10 dB, which is significant.

Estimated ground-borne noise and vibration levels in the proposed development have been derived, and predicted vibration levels indicate that all of the measured train events would result in vibration levels below the vibration criterion. However, predicted ground-borne noise levels for westbound trains are very close to the ground-borne noise criterion of 35 dBA for the residential accommodation.

On one hand, the prediction results suggest that ground-borne noise levels will be within the applicable criterion and that no mitigation will be required. However, on the other hand, consideration should be given to the following:

- The predicted levels are close to the criterion (with one measured train indicating an exceedance).
- The ground-borne noise estimates are preliminary, based on vibration measurements at one part of the site, and are subject to a margin of uncertainty.
- The westbound trains generate significantly higher vibration levels, despite being further from the site.

These issues are discussed in detail in this report.

We consider that, if some form of rail vibration mitigation does turn out to be necessary, it will not need to be a high performance system and would only be necessary on the most exposed part of the site (at the southern end of the site).

In any case, it is recommended that additional vibration measurements shall be carried out on the development site during the next phase of the design, to confirm the findings and determine the extent of any affected area. However, we also recommend that such measurements are done once attempts have been made to clarify the issues discussed in this report regarding the stage of the maintenance cycle the tracks are in, and whether there is any geo-tech evidence suggesting a buried structure.

- **Construction Noise and Vibration Assessment**

Potential construction noise and vibration impacts on the surrounding community have been presented in this report and recommendations based on the relevant guidelines are provided.

There will be times / situations when construction noise associated with demolition, earthworks, excavation and new-build works are likely to exceed the stated criteria, particularly when works occur in the areas closer to sensitive receivers or with direct view between the receivers and the works.

If, during construction works, an item of equipment exceeds the stated airborne noise and / or vibration criteria at any sensitive location, the additional noise / vibration control measures presented in this report, together with construction best practices, shall be considered to minimise noise and vibration impacts on the sensitive receivers.

1 Introduction

A mixed-use development is proposed by Golden Age Development & Hannas The Rocks Pty Ltd at 85 Harrington Street, the Rocks. The proposal involves demolition of the existing building and constructs a group of three buildings plus a plaza.

Acoustic Studio has been engaged by the Golden Age Development & Hannas The Rocks to provide acoustic engineering services for the Development Application. Francis-Jones Morehen Thorp (FJMT) is the Architect, and Savills is the Project Manager.

Secretary's Environmental Assessment Requirements (SEARs) have been issued, requiring the preparation of an Environmental Impact Statement (EIS) for the proposed development. An acoustic assessment has been carried out and is detailed in this report along with the findings and recommendations. This acoustic report has been prepared in support of the EIS for the proposed development.

As per Item 14 of the SEARs, a Noise and Vibration Assessment of the construction, operation, traffic and cumulative noise impacts must be prepared in accordance with the relevant EPA guidelines. This assessment considers any potential noise impacts on nearby noise sensitive receivers and outlines proposed noise mitigation and monitoring issues. The following relevant policies and guidelines has been considered among others:

- EPA/OEH NSW Industrial Noise Policy 2000 (INP)
- EPA/OEH NSW Industrial Noise Policy – Application Notes 2013
- DECCW Interim Construction Noise Guideline 2009 (ICNG)
- DECC Assessing Vibration: A Technical Guideline 2006
- DECCW NSW Road Noise Policy 2011.
- EPA/OEH NSW Road Noise Policy – Application Notes 2013

This acoustic report assesses noise impacts at nearby sensitive receivers due to operation of the project once it is completed, and presents the findings of a construction noise and vibration assessment.

It also assesses potential noise and vibration impacts on the proposed development (from traffic, rail, etc.). These are in accordance with the SEARs' Item 14, and the objectives of this assessment are to:

- Identify noise sensitive receivers that will potentially be affected by the operation of the proposed development.
- Identify external noise sources that surround the site with potential to impact the proposed development.
- Carry out noise surveys to determine existing ambient and background noise levels at the nearest noise sensitive receivers that surround the site, plus external noise sources with potential to impact on the proposed development.
- Establish the appropriate noise assessment criteria in accordance with the relevant standards and guidelines for the following acoustic issues:
 - Noise emissions from the proposed development.
 - Noise intrusion into the proposed development.
 - Internal acoustic issues specific to the proposed development.
- Determine whether the relevant criteria can be achieved based on proposed operations. Where applicable, provide recommendations for any necessary acoustic control measures that will need to be incorporated into the development or use in order to ensure with the assessment criteria.
- Provide recommendations for Construction Noise and Vibration Planning.

2 Description of Proposal

A mixed-use development is proposed by Golden Age Development & Hannas The Rocks Pty Ltd at 85 Harrington Street, the Rocks. The proposal involves demolition of the existing building and constructs a group of three buildings plus a plaza.

The proposed development is located at 85 Harrington Street The Rocks, and is bordered by the Cahill Expressway, Harrington Street and Gloucester Street. On the southern boundary is the City Circle Rail Line corridor exit tunnel (below the Cahill Expressway) consisting of two parallel rail tracks servicing trains between Circular Quay and Wynyard stations.

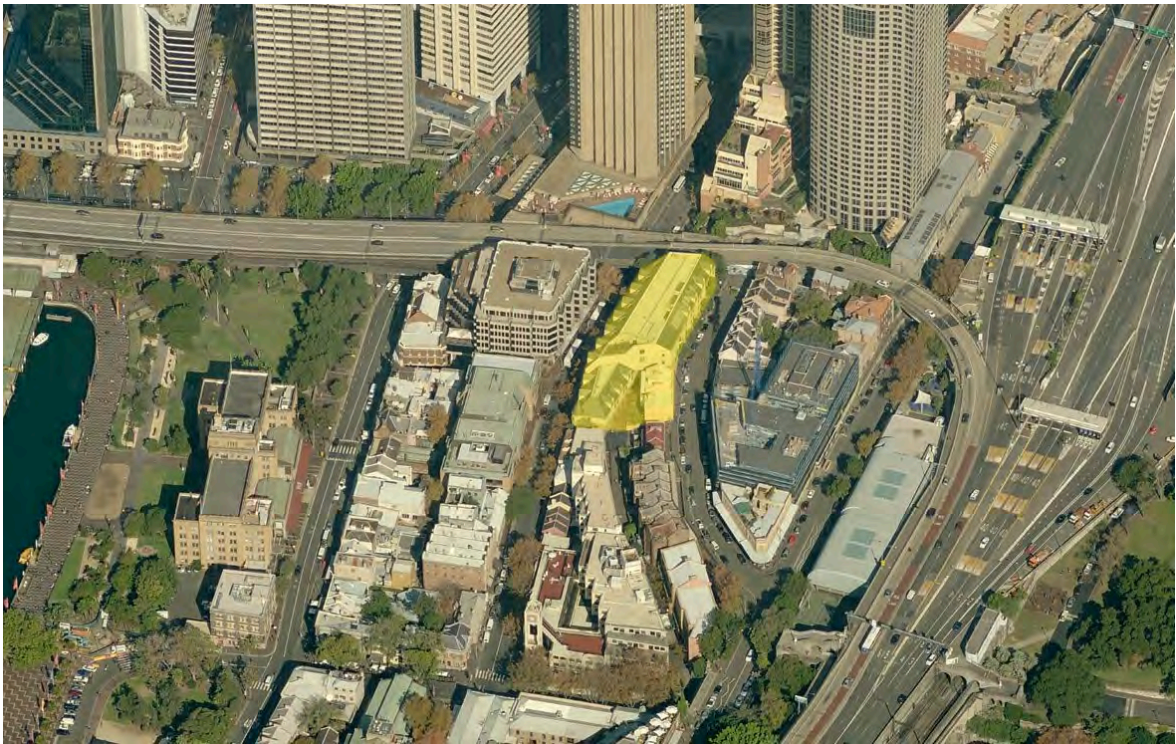


Figure 1: Project site (yellow shading) viewed from north with the Bradfield Highway (right side) and Cahill Expressway

The existing building is a 6-storey office building with two level basement carpark.

The proposed development will have nine levels of residential, commercial and retail use plus three levels of basement carpark.

Figure 2 shows a 3D view of the proposed development.

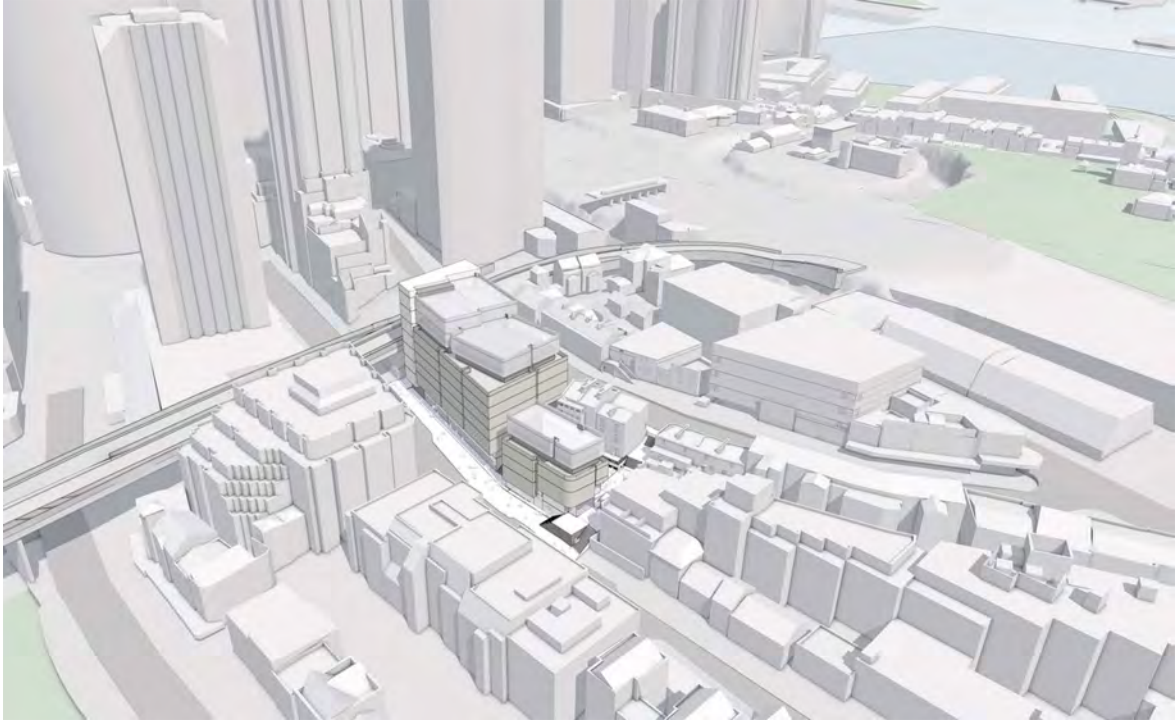


Figure 2: 3D view of the proposed development

The site is located within an urban environment characterised by medium levels of activity throughout the day and evening, and decreasing noise levels at night. A mix of residential and commercial activities dominates around the site.

There is intermittent flow of traffic along Harrington Street. To the south and west of the site, at an elevated position, is the Cahill Expressway and the Bradfield Highway respectively, with a continuous heavy flow of traffic during the day and night. The City Circle Rail Line to the south of the site has intermittent train movements.

Figure 3 shows the noise sensitive receivers surrounding the site. These are:

- The nearest residential receivers are town houses located to the west of the proposed project, at Gloucester Street.
- Hotel Rendezvous is located to the north of the proposed site at 75 Harrington Street.
- The nearest commercial receivers are located to the east of the proposed site at Harrington Street, being the SHFA at 66 Harrington Street and an office building at 2 Globe Street.
- Educational receiver to the west, Big Dig Archaeology Educational Centre at 110 Cumberland Street.
- The Susannah Place Museum at 58-64 Gloucester Street to the north of the site.



Figure 3: Project site and surrounds. 85 Harrington Street (yellow shading), office buildings (blue shading), residential / hotel buildings (red shading) and educational / museum buildings (green shading)

3 The Key Acoustic Issues

The design of the proposed development (and as per the SEARs requirements for the EIS) should address the following acoustic issues:

External Noise Emissions – Noise emissions from the proposed development will need to be managed to limit environmental noise impacts on nearby buildings resulting from the operation of the proposed development. In particular this applies to:

- Retail noise emissions from patrons.
- Building services and plant.
- Traffic noise.

Internal Sound Insulation – This deals with the way is controlled between separate internal spaces – particularly between adjoining apartments. Both vertical and horizontal noise transfer will need to be considered as well as impact isolation of floors. This also needs to consider the impact of penetrations through building elements for building services.

Internal Design Sound Levels – Consideration of internal design sound levels is important to ensure that a satisfactory acoustic environment can be achieved for each area. Internal noise levels are controlled through addressing the following key noise sources:

- Inter-tenancy noise. Addressed through internal sound insulation as above.
- External noise intrusion. The building envelope must limit external noise intrusion levels so that appropriate internal noise levels are achieved within the sensitive spaces.
- External ground-borne noise intrusion. The building structure must limit external vibration intrusion levels so that appropriate internal ground-borne noise levels are achieved within the sensitive spaces.
- Building services. This includes air conditioning and mechanical services noise control. The control of hydraulic services noise and vibration, and transfer of structure-borne hydraulic services noise between apartments are critical. The building services can also have a significant impact on other architectural acoustic aspects, such as external noise control and internal sound insulation, particularly at service penetrations.

Control of Vibration – This deals with preventing perceptible vibration within the building structure, and elimination of structure-borne noise. Vibration may be generated by plant and services located within the building, or by the nearby rail lines. Vibration and structure-borne noise generated by lifts is also a consideration.

Management of Construction Noise and Vibration – This deals with the impact of noise and vibration generated during the construction stage of the project on surrounding residential premises and other sensitive land uses. The development will contribute noise and vibration to the surrounding environment during the construction stage. Typically, this will result from intermittent noise from construction equipment and plant commonly used on construction sites.

4 Existing Noise and Vibration Environment

4.1 Noise

4.1.1 General Survey Information

A survey of the existing noise environment around the site was conducted with unattended noise monitors used to continuously record the noise levels on the site. Long-term noise monitoring was carried out from Tuesday 8th September to Tuesday 15th September 2015 to establish the typical range of ambient noise levels of the proposed site and surrounds.

Long-term noise monitoring was carried out with two Ngara ARL loggers (Serial Numbers 878002 & 878007). The loggers recorded L_{A1} , L_{A10} , L_{A90} , and L_{Aeq} noise parameters at 15-minute intervals continuously for the eight-day measurement period. The calibration of the loggers was checked before and after use and no variation was noted.

Operator attended short-term monitoring was also carried out on Tuesday 8th September and Wednesday 16th September 2015 in order to confirm the validity of the long-term outdoor data across the site, to sample octave band background and ambient noise levels at key surrounding residential receivers during the early morning period, and to determine traffic noise levels affecting the site.

Short-term measurements were made with two Brüel&Kjær Hand-held Analysers Type 2250 (Serial Numbers 2446899 & 2832406). The calibration of the analysers was checked before and after the surveys using a Brüel&Kjær Sound Level Calibrator Type 4231 (Serial Number 2438997) and no variation in levels occurred.

A windshield was used to protect the microphone of noise loggers and the analysers. Weather conditions were calm and dry during the noise survey. The analyser and logger microphones were mounted 1.5 metres above ground.

Jorge Reverter and Saiham Siraj of Acoustic Studio Pty Ltd carried out the surveys, in accordance with the method of measurement described in the *AS/NZS 1055:1997 'Description and measurement of environmental noise', parts 1 and 2*.

The long-term and short-term noise monitoring locations are shown in Figure 4.



Figure 4: Noise monitoring locations. Blue circles are long-term locations and red circles are short-term locations

4.1.2 Long-term Monitoring Results

The noise loggers were located on the existing rooftop and on an awning of the 85 Harrington Street building. These locations were chosen since they represent a secure place to leave the noise loggers unattended whilst obtaining typical representative background and ambient noise levels. The long-term noise monitoring locations (L1 and L2) are shown in Figure 4.

The detailed results of the long term noise monitoring at Location L1 and L2 are shown graphically in Appendix A.

Weather patterns were monitored during the survey period and were typically calm and dry during the unattended noise survey.

The logged data shows the background and ambient noise levels of the area. The recorded background noise levels have been used to establish the limiting criteria for noise emitted from the building.

The logger locations were also used to obtain octave band traffic noise levels affecting the building for the purpose of determining the façade sound reduction performance requirements. This applies, in particular, to the southern and western facades which are affected by traffic noise from the Eastern Distributor and Bradfield Highway.

The background sound level is defined as the sound level exceeded 90% of the time, and is designated as the L_{A90} . The ambient noise level impacting on the building is referred to as the equivalent continuous sound level (L_{Aeq}). This parameter is commonly used to describe a time varying noise such as traffic noise.

The background sound levels have been established in general accordance with the methodology described in the NSW INP (see Appendix B for details), i.e. the 10th percentile background sound level for each period for each day of the ambient noise survey. The median of these levels is then presented as the background sound level for each assessment period. These background noise levels are shown in Table 1 below together with the L_{Aeq} ambient noise levels measured for each period.

As stated in the INP, any data likely to be affected by rain, wind or other extraneous noises has been excluded from the calculations.

Location	L_{A90} Background Noise Levels, dB(A)			L_{Aeq} Ambient Noise Levels, dB(A)		
	Day	Evening	Night	Day	Evening	Night
	7am-6pm	6pm-10pm	10pm-7am	7am-6pm	6pm-10pm	10pm-7am
L1 – Rooftop 85 Harrington St	63	61	54	67	66	62
L2 – Awning 85 Harrington St	56	54	48	65	58	53

Table 1: Long-term background and ambient noise levels measured around the site

From observations during our site visits, it is noted that both ambient and background noise levels around the site are currently dominated by traffic noise from the Cahill Expressway and Bradfield Highway located to the south and west of the project site.

Table 2 shows the predicted $L_{10,1h}$ sound pressure levels at location L1 based on the Table 1 results plus the Cahill Expressway Traffic AADT (refer to Section 6.1.2). These traffic noise levels are used as the basis of the assessment of the sound reduction performance requirements for the southern and western facades of the new building – both of which are affected by traffic noise from the Cahill Expressway and Bradfield Highway.

Description	Overall dB(A)	Sound Pressure Level, dB re 20 μ Pa								
		Octave Band Centre Frequency, Hz								
		31.5	63	125	250	500	1k	2k	4k	8k
$L_{10,1}$ hour of Cahill Expressway	70	73	75	72	68	66	66	61	54	46

Table 2: Predicted traffic noise levels at location L1

4.1.3 Short-term Monitoring Results

Four (4) short-term noise monitoring locations were chosen as representative of the site and surrounds as follows:

- **Location S1** at 109 Gloucester Street. This location is representative of current background and ambient noise levels currently impacting the nearest residential receivers to the west of the proposal, and noise levels at the noise logger location L2. The location was dominated by traffic noise from Cahill Expressway.
- **Location S2** at 52 Gloucester Street. Location S2 is representative of current background and ambient noise levels at the nearest residential receiver to the north of the site.
- **Location S3** at 85 Harrington Street. This location is representative of current background and ambient noise levels currently impacting the eastern façade of the proposal. The location was dominated by traffic noise from Harrington Street.
- **Location S4** at 75 Harrington Street. Location S4 is representative of current background and ambient noise levels at the Rendezvous Hotel to the north of the proposed building. The location was dominated by traffic noise from Harrington Street.

A summary of the results of the short-term background and ambient noise monitoring around the existing site are shown in Table 3.

Location	Date and time	Parameter	Sound Pressure Level, dB re 20 μ Pa									
			Overall dB(A)	Octave Band Centre Frequency, Hz								
				31.5	63	125	250	500	1k	2k	4k	8k
S1	08/09/2015 10:32 am	L _{90,15min}	57	64	62	58	58	54	53	46	38	28
		L _{eq,15min}	59	71	68	63	60	56	55	49	42	34
		L _{10,15min}	60	75	71	65	62	57	56	50	42	33
	16/09/2015 10:06 pm	L _{90,15min}	52	59	57	51	49	48	49	43	34	24
		L _{eq,15min}	55	63	63	55	52	51	51	46	38	34
		L _{10,15min}	56	65	64	56	53	52	53	47	39	29
S2	08/09/2015 10:30 am	L _{90,15min}	55	59	61	56	54	52	51	44	32	20
		L _{eq,15min}	58	64	67	60	57	55	54	48	41	32
		L _{10,15min}	60	67	70	62	59	57	56	51	43	33
S3	08/09/2015 10:49 am	L _{90,15min}	59	66	64	60	58	56	55	49	40	28
		L _{eq,15min}	66	79	77	71	65	62	62	58	53	46
		L _{10,15min}	70	81	79	73	67	65	65	61	55	47
S4	08/09/2015 10:51 am	L _{90,15min}	57	65	61	57	56	54	52	47	38	30
		L _{eq,15min}	65	72	71	66	62	60	60	57	53	46
		L _{10,15min}	68	74	72	68	65	63	64	60	54	46
	16/09/2015 10:22 pm	L _{90,15min}	54	59	57	54	52	50	50	45	36	28
		L _{eq,15min}	63	64	66	60	59	59	60	56	47	40
		L _{10,15min}	67	67	69	63	62	62	64	59	50	42

Table 3: Summary of short-term background and ambient noise levels measured around the site

4.2 Vibration

4.2.1 General Survey Information

A survey of the existing vibration levels from the City Circle Railway Line adjacent to the site was conducted via attended vibration level measurements on the site. This vibration monitoring was carried out on Tuesday 8th September 2015 to predict the ground-borne noise and vibration from the City Circle Railway Line affecting the proposed development.

Short-term measurements were made with two Brüel&Kjær Hand-held Analysers Type 2250 (Serial Numbers 2446899 & 2832406). One was located next to the rail line measuring reference noise levels, and the other was located in the lower

carpark level of the existing building at 85 Harrington Street measuring vibration levels. The accelerometer used for the vibration measurements is an Endveco 752A13 (Serial Number 15828). The calibration of the analysers were checked before and after the surveys using a Brüel&Kjær Calibrator Exciter Type 4294 (Serial Number 2989501) and a Brüel&Kjær Sound Level Calibrator Type 4231 (Serial Number 2438997). No variation in levels occurred.

Jorge Reverter and Saiham Siraj of Acoustic Studio Pty Ltd carried out the surveys, in accordance with the method of measurement described in the *NSW EPA "Assessing vibration: a technical guideline" 2008* and *ISO 4866:2010 "Mechanical vibration and shock – Vibration of buildings – Guidelines for the measurements of vibrations and evaluation of their effects on buildings"*.

4.2.2 Short-term Vibration Monitoring Results

Vertical acceleration (z-axis) was measured on a column at the lower carpark level during train pass-bys. The accelerometer was mounted following the recommendations of Australian Standard 2775:2004 *"Mechanical vibration and shock – Mechanical mounting of accelerometers"*. The column used for measurements is closest to the rail tracks at the southern boundary of the site. 20 train events were measured and their direction (eastbound / westbound), approximate velocity and train number were also recorded.

The measured vibration levels form a key input for the predictions of the ground borne noise and vibration affecting the proposed development. The results are summarised as per train directions in Figure 5, which also shows the maximum vibration level for each third octave band.

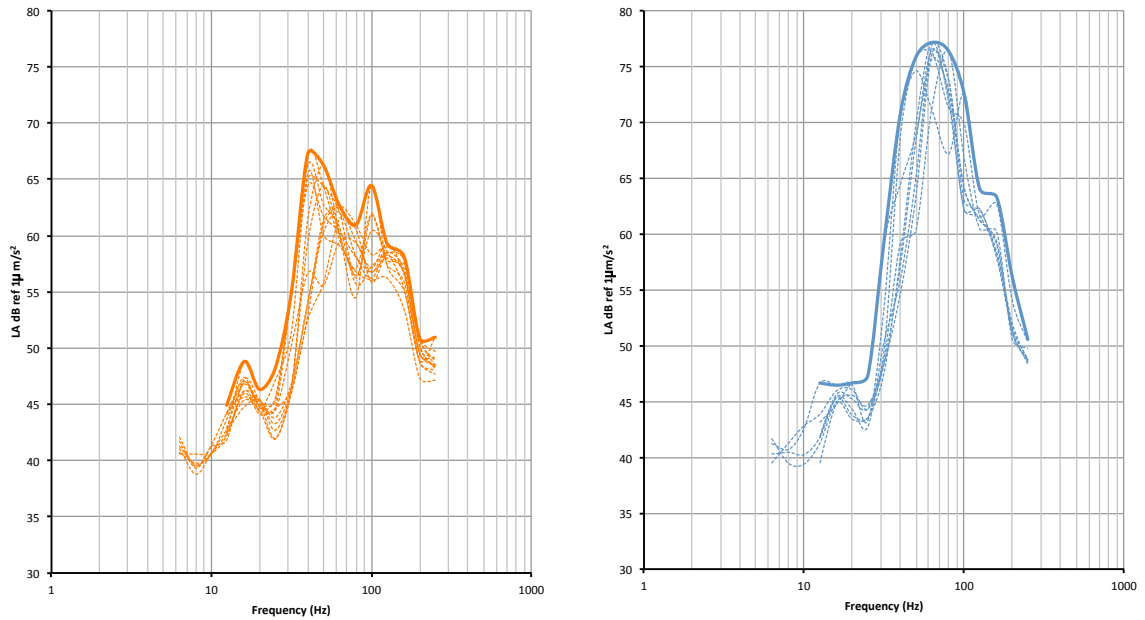


Figure 5: Measured Vibration Levels (rms acceleration) in third octave bands and their maximum values (thick line) for eastbound trains (left) and westbound trains (right)

Direction	Maximum Vibration Acceleration Level, dB re 1µm/s ²													
	Third Octave Band Centre Frequency, Hz													
	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250
Eastbound	45	49	46	48	55	67	66	63	61	64	59	58	51	51
Westbound	47	46	47	47	59	71	76	77	76	73	64	63	56	51

Table 4: Maximum Vibration Acceleration Levels measured on site, from train pass-bys

The results show that, despite being further from the site, westbound trains generate higher vibration levels than eastbound trains. The difference is approximately 10 dB, which is significant. The potential explanations and implications are discussed further in Section 7.

5 Relevant Standards and Guidelines

The following standards and guidelines are considered relevant to the project and have been referenced in developing the project noise criteria:

- Operational Noise
 - Environmental Planning and Assessment Act 1979.
 - Protection of the Environmental Operations (POEO) Act 1997.
 - NSW OEH Industrial Noise Policy (INP) 2000.
 - NSW OEH Industrial Noise Policy (INP) Application Notes (Sleep Disturbance).
 - City of Sydney (CoS) Standard Conditions of Development Consent (SCDC) 2012.
 - NSW Office of Liquor Gaming and Racing (OLGR).
 - National Construction Code (NCC) 2012¹.
 - City of Sydney (CoS) Development Control Plan (DCP) 2012.
 - DECC ‘*Assessing vibration: a technical guideline*’ 2006.
 - Australian Standard 2670:1990 ‘*Evaluation of human exposure to whole-body vibration – Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz)*’.
 - Australian Standard 2107:2000 ‘*Recommended design sound levels and reverberation times for building interiors*’.
- Construction Noise and Vibration
 - DECCW ‘*Interim Construction Noise Guideline*’ 2009 (ICNG)
 - DECC ‘*Assessing Vibration: A Technical Guideline*’ 2006.
 - City of Sydney ‘*Construction Hours/Noise. Code of Practice*’ 1992
- Traffic Noise
 - DECCW NSW Road Noise Policy 2011.
 - NSW Department of Planning (DoP) ‘*Development Near Rail Corridors or Busy Roads – Interim Guideline*’ 2008.
 - Infrastructure State Environmental Planning Policy (SEPP) 2007.

¹ Also referred to the Building Code of Australia (BCA)

5.1 Operational Noise Criteria

5.1.1 External Noise Emission Criteria

a) Protection of the Environment Operations Act (POEO) 1997

The Protection of the Environment Operations (POEO) Act 1997 defines “Offensive Noise” as follows:

“ ...

- (a) *that, by reason of its level, nature, character or quality, or the time at which it is made, or any other circumstances:*
- (i) *is harmful to (or is likely to be harmful to) a person who is outside the premises from which it is emitted, or*
 - (ii) *interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted, or*
- (b) *that is of a level, nature, character or quality prescribed by the regulations or that is made at a time, or in other circumstances, prescribed by the regulations. ...”*

The definition provided by the POEO is generally focused around a subjective assessment. Acoustic Studio recommends that a suitable objective criterion for assessing offensive noise at residential receivers before midnight is “*Background + 5 dB*”. After midnight, “*Background + 0 dB*” is suitable, plus the noise should be inaudible within any habitable areas. These criteria have previously been supported by environmental officers for other similar projects and, therefore, will be adopted for this assessment. Refer also to Sections 5.1.2 and 5.1.4, where these criteria are supported by the NSW OEH INP and CoS-SCDC.

b) NSW OEH Industrial Noise Policy (INP)

The NSW OEH (previously EPA) Industrial Noise Policy 2000 of the NSW Department of Environmental and Heritage is specifically aimed at assessing noise from industrial noise sources scheduled under the Protection of the Environment Operations (POEO) Act 1997.

An assessment carried out in accordance with the requirements of the Policy must:

- Identify any beneficial or adverse noise impacts that might result in the surrounding community.

- Describe any noise mitigation measures and strategies that will be necessary to protect the acoustic amenity of the area.
- Describe the methods by which compliance with the acoustic criteria can be determined after the facility is operational.

The assessment is carried out by comparing the new predicted intrusive noise level against the criterion based on the pre-existing background noise level.

Where the intrusive noise is greater than the pre-existing background noise level, the potential exists for disturbance and annoyance. However, the impact is considered marginal if the difference between the pre-existing background noise level and the intrusive noise is 5 dB(A) or less. This concept has resulted in the commonly used criterion of “*background noise level + 5 dB*” – applicable between 7:00 am and midnight.

Often the criterion becomes more stringent after midnight, recognising the increased sensitivity of this late night period in residential neighbourhoods. This has resulted in the commonly used criterion of “*background noise level + 0 dB*” between midnight and 7:00 am.

These noise level limits are assessed at the boundary of the neighbouring residential properties.

Appendix B contains an extended NSW INP analysis and the derivation of the environmental noise break-out limits shown in Table 5.

<i>Indicative Noise Amenity Area</i>	<i>Period</i>	<i>Intrusiveness Criterion</i>	<i>Amenity Criterion</i>
<i>Residential</i>	Day	61	57
	Evening	59	56
	Night	53	52
<i>Commercial</i>	When in use	---	57

Table 5: Determination of project specific noise levels for the site

c) NSW INP Application Notes, Sleep Arousal

Some short-duration noises that occur at night may comply with the criteria described above, and yet be undesirable because of the sleep arousal effect, particularly between the hours of 10:00pm and 7:00am.

Sleep arousal is a function of both the noise level and the duration of the noise. Not all people are affected to the same degree by noise, and at different times, a person will be more or less affected by the same noise. Even though a person is

not actually awoken by a noise, one's rest may be significantly disturbed by noise that occurs while one is asleep.

The NSW INP application notes consider potential for sleep disturbance for residential receivers from noise during night periods between 10:00pm and 7:00am, which states the following:

“...OEH reviewed research on sleep disturbance in the NSW Environmental Criteria for Road Traffic Noise (ECRTN) (EPA, 1999). This review concluded that the range of results is sufficiently diverse that it was not reasonable to issue new noise criteria for sleep disturbance.

From the research, OEH recognised that current sleep disturbance criterion of an $L_{A1,1minute}$ not exceeding the $L_{A90,15minute}$ by more than 15 dB(A) is not ideal. Nevertheless, as there is insufficient evidence to determine what should replace it, OEH will continue to use it as a guide to identify the likelihood of sleep disturbance. This means that where the criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.

The detailed analysis should cover the maximum noise level or $L_{A1,1minute}$, that is, the extent to which the maximum noise level exceeds the background level and the number of times this happens during the night-time period. Some guidance on possible impact is contained in the review of research results in the appendices to the ECRTN. Other factors that may be important in assessing the extent of impacts on sleep include:

- how often high noise events will occur*
- time of day (normally between 10:00pm and 7:00am)*
- whether there are times of day when there is a clear change in the noise environment (such as during early morning shoulder periods).*

The $L_{A1,1minute}$ descriptor is meant to represent a maximum noise level measured under 'fast' time response. OEH will accept analysis based on either $L_{A1,1minute}$ or $L_{AMax...}$ ”

Based on the measured noise levels detailed in Section 4 and the sleep disturbance assessment methodology outlined above, Table 6 details the corresponding project specific sleep disturbance criteria. Note that the criteria have been determined using the background noise level (L_{90}) value at the relevant time period, for residential receivers.

Location	Receiver type	Background noise level L_{A90} dBA	Sleep Disturbance Criteria $L_{Amax} = L_{A90} + 15$ dBA
S1	Residential (urban)	52	67

Table 6: INP project specific sleep disturbance criteria for external noise emissions from proposed development

It is noted that the criteria outlined above must be achieved external to the bedroom window of the nearest sensitive residential receiver, as opposed to the receiver boundary – which is applied for most other criteria.

d) City of Sydney Standard Conditions of Development Consent (CoS-SCDC)

The CoS-SCDC outlines noise criteria specific to the operation of a licenced premise. This criteria is adopted from the Office of Liquor, Gaming and Racing (OLGR) L_{A10} criteria, which considers noise impacts across individual octave bands and is defined as follows:

“... NOISE – ENTERTAINMENT USES

- 1) *The $L_{A10,15minute}$ noise level emitted from the use must not exceed the background noise level ($L_{A90,15minute}$) in any Octave Band Centre Frequency (31.5 Hz to 8 kHz inclusive) by more than 5 dB between the hours of 7:00am and 12:00 midnight when assessed at the boundary of any affected residence.*
- 2) *The $L_{A10,15minute}$ noise level emitted from the use must not exceed the background noise level ($L_{A90,15minute}$) in any Octave Band Centre Frequency (31.5 Hz to 8 kHz inclusive) between the hours of 12:00 midnight and 7:00am when assessed at the boundary of any affected residence.*
- 3) *Notwithstanding compliance with (1) and (2) above, the noise from the use when assessed as an $L_{A10,15minute}$ enters any residential use through an internal to internal transmission path is not to exceed the existing internal $L_{A90,15minute}$ (from external sources excluding the use) in any Octave Band Centre Frequency (31.5 Hz to 8 kHz inclusive) when assessed within the habitable room at between the hours of 7:00am to 12:00 midnight. Where the $L_{A90,15minute}$ noise level is below the threshold of hearing, T_f at any Octave Band Centre Frequency as defined in Table 1 of International Standard ISO 266:2003 – Normal Equal-Loudness-Level Contours then the value of T_f corresponding to that Octave Band Centre Frequency shall be used instead.*

- 4) *Notwithstanding compliance with (1), (2) and (3) above, the noise from the use must not be audible within any habitable room in any residential use between the hours of 12:00 midnight and 7:00am regardless of transmission path.*
- 5) *The $L_{A10,15\text{minute}}$ noise level emitted from the use must not exceed the background noise level ($L_{A90,15\text{minute}}$) in any Octave Band Centre Frequency (31.5 Hz to 8 kHz inclusive) by more than 3 dB when assessed indoors at any affected commercial premises.”*

“... NOISE – GENERAL

General criteria

- 1) *The cumulative emission of noise associated with the use of the premises including the cumulative operation of any mechanical plant, equipment, air conditioning / ventilation, apparatus, tool, device, machine or mechanism shall comply with the following:*
 - i) *The $L_{Aeq,15\text{min}}$ noise level emitted from the use must not exceed the project specific noise level for that receiver as determined in accordance with the NSW EPA Industrial Noise Policy and relevant requirements of Australian Standard AS 1055.1:1997 Acoustics – Description and measurement of environmental noise.*
 - ii) *Project specific noise levels shall be determined by establishing the existing environmental noise levels, in complete accordance with the assessment $L_{A90,15\text{min}}$ / rating $L_{A90,15\text{min}}$ process to be in accordance with the requirements for noise monitoring listed in the NSW EPA Industrial Noise Policy and relevant of Australian Standard AS 1055.1:1997 Description and measurement of environmental noise.*
 - iii) *Modifying factors in Table 4.1 of the NSW EPA Industrial Noise Policy are applicable.*
- 2) *A cumulative $L_{Aeq,15\text{min}}$ noise level emitted from the use consistent with the operation of any mechanical plant, equipment, air condition / ventilation, apparatus, tool, device, machine or mechanism must not exceed the $L_{A90,15\text{min}}$ noise level by more than 3 dB in any Octave Band Centre Frequency (31.5 Hz to 8 kHz inclusive) when assessed inside any habitable room of any affected residence or noise sensitive commercial receiver provided that;*
 - i) *The $L_{Aeq,15\text{min}}$ noise level and the $L_{A90,15\text{min}}$ noise level shall both be measured with all external doors and windows of the affected residence closed.*
 - ii) *Where assessed at the façade, the relevant background noise level ($L_{A90,15\text{min}}$) is taken to mean the day, evening or night rating background*

noise level determined in complete accordance with the methodology outlined in the NSW EPA Industrial Noise Policy and Australian Standard AS 1055.1:1997 Acoustics – Description and measurement of environmental noise.

- iii) Where assessed internally at a location with limited or no external environment noise intrusion, background noise shall be established in the absence of all noise from use and with only necessary ventilation equipment servicing the affected location operating. Background noise measurements are to be representative of the lower internal noise levels experienced at the affected location.
- iv) Where the $L_{A90,15min}$ noise level is below the threshold of hearing (T_f) at any Octave Band Centre Frequency as defined in Table 1 of International Standard ISO 226:2003 – Normal Equal-Loudness-Level contours, then the value of T_f corresponding to that Octave Band Centre Frequency shall be used instead.
- v) Modifying factors in Table 4.1 of the NSW EPA Industrial Noise Policy are applicable. Internal noise measurements are not to be corrected for duration.

The adopted CoS-SCDC criteria for patron noise emissions are detailed in Table 7. For the purpose of this assessment the CoS-SCDC criteria are limited to operational noise breakout from the retail spaces at residential receivers.

Parameter	Period	Sound Pressure Level, dB re 20 μ Pa									
		Overall dB(A)	Octave Band Centre Frequency, Hz								8k
			31.5	63	125	250	500	1k	2k	4k	
Criteria $L_{10,15min} \leq$ $L_{90,15min} +$ 5dB	7:00am to midnight	57	64	62	56	54	53	54	48	39	29
Criteria $L_{10,15min} \leq$ $L_{90,15min}$	Midnight to 7:00am	52	59	57	51	49	48	49	43	34	24

Table 7: Project noise criteria (based on CoS/OLGR) at nearest residential receivers – outdoor patron noise and music

The noise criteria are based on the L_{90} parameter from the attended and unattended noise measurements and apply to the cumulative noise impacts on nearby premises.

e) NSW Office of Liquor Gaming and Racing (OLGR)

It is generally accepted that any venue with music should be assessed using a “Background + 5 dB” octave band criteria for operations up to midnight and “Background + 0 dB” after midnight. The council criteria are also essentially the same as that used by the Office of Liquor, Gaming & Racing (OLGR) for licensed premises.

The noise limits set out in the OLGR’s ‘Standard Noise Condition’ are as follows:

“The $L_{A10}^{()}$ noise level emitted from the licensed premises shall not exceed the background noise level in an Octave Band Centre Frequency (31.5 Hz – 8 kHz inclusive) by more than 5 dB between 7:00am and 12:00 midnight at the boundary of any affected residence.*

The L_{A10} noise level emitted from the licensed premises shall not exceed the background noise level in an Octave Band Centre Frequency (31.5 Hz – 8 kHz inclusive) between 12:00 midnight and 7:00am at the boundary of any affected residence.

Notwithstanding compliance with the above, the noise from the licensed premises shall not be audible within any habitable room in any residential premises between the hours of 12:00 midnight and 7:00am.

Interior noise levels, which still exceed safe hearing levels, are in no way supported or condoned by the NSW Office of Liquor, Gaming and Racing.

This is a minimum standard. In some instances the Board may specify a time earlier than midnight in respect of the above condition.

() For the purposes of this condition, the L_{A10} can be taken as the average maximum deflection of the noise emission from the licensed premises.”*

As noted in the previous section, the CoS-SCDC noise criteria are adopted from the OLGR L_{A10} criteria. The OLGR criteria for patron noise emissions are shown in Table 6. Therefore, compliance with the CoS-SCDC criteria will also ensure that all other OLGR noise criteria will be met.

5.1.2 Internal Design Sound Levels and Sound Insulation Criteria

a) National Construction Code (NCC)

The proposed residential spaces are considered as a Class 2 building in accordance with the NCC. The following tables outline the minimum performance requirements for separating elements between “sole-occupancy units” (SOU) and other spaces in a Class 2 building as per Part F5 of the National Construction Code (NCC) (formerly BCA).

Occupancy 1	Occupancy 2	Minimum Sound Insulation
Habitable	Habitable / Wet Area*	$R_w + C_{tr} \geq 50$ dB
	Shared Corridors and Lobbies / Plant room* / Shared Stairway / Lift Shaft*	$R_w \geq 50$ dB
	Doors between rooms and corridors	$R_w \geq 30$ dB
	Floors / Ceilings and Bulkheads	$R_w + C_{tr} \geq 50$ dB and $L_{nT,w} + C_I \leq 62$ dB
Wet Area	Habitable / Wet Area	$R_w + C_{tr} \geq 50$ dB
	Shared Corridors and Lobbies / Plant room* / Shared Stairway / Lift Shaft*	$R_w \geq 50$ dB
Services Shaft	Habitable**	$R_w + C_{tr} \geq 40$ dB
	Wet Area**	$R_w + C_{tr} \geq 25$ dB

Table 8: Minimum Sound Insulation requirements between adjacent spaces, as set by the current NCC

* In addition, the NCC requires that walls separating adjoining units shall:

- Be constructed in accordance with one of 3 wall systems deemed to comply.
- Be 2 or more separate leaves without rigid mechanical connection except at the periphery (for other than masonry construction).
- Be no less resistant to the transmission of impact sound than the deemed to comply wall systems.

** Where access panels are required in these risers, they shall have the same rating, AND not open into a habitable area, AND meet the specific construction types described in F5.2, 2 (e) - being 33 mm thick wood / particleboard / blockboard, or 9 mm CFC or other material with a weight of 24.4 kg/m². All panels shall have a rebated frame of 10 mm wide on 4-sides to house a sealing gasket.

In addition, the following general requirements shall be met for partitions with respect to services distribution, power outlets, sealing of penetrations and joints, etc:

- Where a duct, storm-water, waste or water supply pipe serves or passes through more than one SOU it shall be installed and enclosed as required by the NCC.

- Electrical power outlets, TV and telephone points on opposite sides of separating walls shall be offset from each other by at least 600 mm and installed within acoustic-rated switch boxes as required to maintain the *in-situ* sound insulation performance of the walls.
- All penetrations made in walls will require patching / sealing to maintain the *in-situ* sound insulation performance of the walls.
- All joints between masonry panels shall be filled solid.
- All joints between wall linings shall be taped and filled solid. Joints between wall linings on one side of a separating wall shall be offset from the joints between linings on the opposite side. Perimeter framing members shall be bedded in resilient compound and joints caulked to ensure that there are no voids between wall linings and the adjoining structure.

b) City of Sydney Development Control Plan (CoS-DCP)

In addition to the NCC requirements, the City of Sydney (CoS-DCP) outlines specific requirements for impact sound insulation between units and internal noise level criteria for noise intrusion. Section 4 of that document outlines the following acoustic requirements in relation to internal noise levels and impact sound insulation.

“... 4.2.3.11 Acoustic Privacy

- (2) *Where necessary, a residential development is to include acoustic measures to reduce the impact of noise from external sources.*
- (7) *The repeatable maximum $L_{Aeq,1hour}$ for residential buildings and serviced apartments must not exceed the following levels:*
 - (a) *For closed windows and doors:*
 - i. *35 dBA for bedrooms (10:00pm to 7:00am); and*
 - ii. *45 dBA for main living areas (24 hours).*
 - (b) *For open windows and doors:*
 - i. *45 dBA for bedrooms (10:00pm to 7:00am); and*
 - ii. *55 dBA for main living areas (24 hours).*
- (8) *Where natural ventilation of a room cannot be achieved, the repeatable maximum $L_{Aeq,1hour}$ level in a dwelling when doors and windows are shut and air conditioning is operating must not exceed:*
 - (a) *38 dBA for bedrooms (10:00pm to 7:00am); and*
 - (b) *48 dBA for main living areas (24 hours).*

(9) *These levels are to include the combined measured level of noise from both external sources and the ventilation system operating normally.*

(10) *To limit the transmission of noise to and between dwellings, all floors are to have a weighted standardised impact sound level ($L'_{nT,w}$) less than or equal to 55 dB where the floor separates a habitable room and another habitable room, bathroom, toilet, laundry, kitchen, plant room, stairway, public corridor, hallway and the like.”*

The acoustic design will ensure that both the NCC and CoS-DCP sound insulation requirements are met.

c) Infrastructure SEPP

The Infrastructure SEPP describes the impact of road (clause 102) and rail (clause 87) noise or vibration on non-road developments near busy roads. Table 9 shows the established noise level criteria as per clause 102.3 and clause 87.3.

Type of Occupancy	Noise Level dBA	Applicable Time Period
Sleeping areas (bedroom)	35	10:00pm to 7:00am
Other habitable rooms (excl. garages, kitchens, bathrooms and hallways)	40	Any time

Table 9: Noise Level criteria as per Infrastructure SEPP

d) NSW DoP Development Near Rail Corridors or Busy Roads – Interim Guideline

For airborne noise from road traffic and the rail corridor, the NSW DoP ‘*Development Near Rail Corridors or Busy Roads – Interim Guideline*’ sets the noise criteria for residential buildings as specified in the Infrastructure SEPP.

For ground-borne noise, residential buildings should be designed so that the 95th percentile of train pass-bys complies with a ground-borne L_{ASmax} noise limit of ;

- 40 dB(A) (day time: 7:00am to 10:00pm), or
- 35 dB(A) (night time: 10:00pm to 7:00am).

e) Australian Standard 2107:2000

Recommendations for the total sound levels are made by reference to Australian Standard AS/NZS 2107:2000, ‘*Recommended design sound levels and reverberation times for building interiors*’. This Standard recommends design criteria for conditions affecting the acoustic environment within occupied spaces of a range of buildings, including houses and apartments near major roads.

The recommended noise level is presented as a range from *satisfactory* to *maximum*.

The *satisfactory* design sound level is defined as: *The level of noise that has been found to be acceptable by most people for the environment in question and also to be not intrusive.*

The *maximum* design sound level is defined as: *The level of noise above which most people occupying the space start to become dissatisfied with the level of noise.* It can also be considered acceptable, but there is a greater perception of intrusion of this noise level and effect on the activities of the space. Beyond this *maximum* level there is a risk of increasing user dissatisfaction with the environment of the space in question.

For spaces affected by external traffic noise, internal noise levels resulting from operation of the building services shall be controlled to meet the *satisfactory* design sound levels for each space. This means that, generally, the total sound level in each space shall fall between the *satisfactory* and *maximum* values recommended for each space.

For all other areas, internal noise levels resulting from operation of the building services shall be controlled to meet the *maximum* design sound levels.

Table 10 shows the AS 2107:2000 recommended design sound levels within the different building spaces.

Type of occupancy / activity	Recommended design sound levels, L_{Aeq} dB(A)	
	Satisfactory sound level	Maximum sound level
Houses and apartments near major roads		
Living areas	35	45
Sleeping areas	30	40
Working areas	35	45
Apartment common areas (e.g. foyer, lift lobby)	45	55
Office buildings		
Board and conference rooms	30	40
General office areas	40	45
Private offices	35	40
Corridors and lobbies	45	50

Table 10: AS 2107:2000 design sound levels for areas relevant to the residential and office spaces within the development

f) Summary of Internal Design Sound Levels

Table 11 provides a summary of the internal noise level criteria. These criteria apply with windows closed.

Type of Occupancy	Noise Level dBA	Applicable Time Period
Sleeping areas (bedroom)	35	10:00pm to 7:00am
Other habitable rooms (excl. garages, kitchens, bathrooms and hallways)	40	Any time
Apartment common areas (e.g. foyer, lift lobby)	45 to 55	Any time
Board and conference rooms	30 to 40	Any time
General office areas	40 to 45	Any time
Private offices	35 to 40	Any time
Corridors and lobbies	45 to 50	Any time

Table 11: Internal noise level criteria with windows closed

5.1.3 Vibration Criteria

Preventing perceptible vibration from building services, plant and all external sources shall be limited so as to ensure the consequent re-radiated structure-borne noise will not cause the noise limits for each space to be exceeded.

Floor impact noise and vibration shall be controlled via the floor / ceiling constructions.

Structure-borne noise and vibration from building services plant and equipment shall be managed via the specifications for vibration isolators for all plant and equipment.

Structure-borne noise and vibration from lifts shall be controlled by the specification of noise and vibration controls for the lifts (isolated lift rails, etc), to achieve the vibration levels set above plus the noise levels.

All plant and equipment will be provided with vibration isolation to ensure that vibration is not perceptible in habitable spaces, and to achieve compliance with vibration levels recommended in AS/NZS 2670.1 & 2:1990.

Vibration criteria have been set in accordance with AS/NZS 2670.1 & 2:1990, 'Acoustics – Evaluation of human exposure to whole-body vibration'.

In addition, The NSW Department of Planning (DoP) document 'Development Near Rail Corridors and Busy Roads – Interim Guideline' discusses vibration criteria to be applied to sensitive developments near rail corridors and busy roads.

Vibration levels from activities such as intermittent vibration emitted by trains should comply with the criteria set in *DECC Assessing Vibration: a technical guideline*. Railway train and road traffic pass-by vibration is classified as intermittent and, therefore, this type of vibration is assessed on the basis of vibration dose values (VDV). Table 12 shows the acceptable VDV for intermittent vibration.

Location	Assessment Period	Vibration Dose Values, m/s ^{1.75}	
		Preferred	Maximum
Residential	Daytime (7am to 10pm)	0.20	0.40
	Night-time (10pm to 7am)	0.13	0.26
Commercial and retail	When in use	0.40	0.80

Table 12: Acceptable vibration dose values (VDV) for intermittent vibration

The standards used for assessing the risk of vibration damage to structures are German Standard DIN 4150 Part 3:1999 and British Standard BS 7385 Part 2:1993. Appendix C contains a summary of these vibration standards. Human comfort should be assessed with reference to the above British Standard or Australian Standard AS 2670.2:1990.

In accordance with these guidelines, the following root mean square (rms) vibration velocity limits apply, in each one-third octave band centre frequency between 1 Hz and 80 Hz:

- Residential (night): 0.14 mm/s (Curve 1.4)
- Residential (day): 0.20 mm/s to 0.40 mm/s (Curves 2 to 4)
- Communal / Other: 0.40 mm/s (Curve 4)

5.2 Construction Noise and Vibration Criteria

The noise and vibration criteria and operational levels presented in this section are for guidance only and do not form part of any legal obligation on the part of the project proponent. However, compliance with these criteria / limits is considered best practice.

5.2.1 Airborne Noise Criteria

The guideline used to assess the airborne construction noise is the *DECCW Interim Construction Noise Guideline*. The ICNG suggests construction noise management levels that may minimise the likelihood of annoyance being caused to noise sensitive residential receivers depending on the duration of works. The management levels for long-term duration works, such as those proposed for the development, are as follows:

- Within recommended standard hours.

The $L_{Aeq,15min}$ level measured at the most exposed boundary of any affected residential receiver when the construction site is in operation must not exceed the background noise level by more than 10 dB(A). This noise level represents the point above which there may be some community reaction to noise.

However, in the case of a highly noise affected area, the construction noise level ($L_{Aeq,15min}$) at the most exposed boundary of any affected residential receiver when the construction site is in operation should not exceed 75 dB(A). This level represents the point above which there may be strong community reaction to noise.

- Outside recommended standard hours.

The $L_{Aeq,15min}$ level measured at the most exposed boundary of any affected residential receiver when the construction site is in operation must not exceed the background level by more than 5 dB(A).

It is noted that a strong justification is required for works outside the recommended standard hours.

The ICNG also suggests construction noise management levels for commercial and retail premises and for recreation areas surrounding construction sites. These levels are applicable to the commercial/retail premises nearby the proposed development. They are as follows:

- Commercial and retail premises: $L_{Aeq,15min}$ 70 dBA (external)

Table 13 below summarises the airborne construction noise criteria for the most-affected noise sensitive receivers surrounding the site.

Sensitive Receiver	Airborne Construction Noise Criteria, L_{Aeq} dB(A)	
	Within Standard Hours	Outside Standard Hours
Residential receivers		
Noise affected	57 + 10 = 67	52 + 5 = 57
Highly noise affected	75	N/A
Commercial and retail	70	

Table 13: ICNG construction airborne noise criteria for sensitive receivers surrounding site

5.2.2 Ground-borne Noise Criteria

The ICNG recommends internal ground-borne noise maximum levels at residences affected by nearby construction activities. Ground-borne noise is noise generated by vibration transmitted through the ground into a structure and can be more noticeable than airborne noise for some sensitive receivers. The ground-borne noise levels presented below from the ICNG are for residential receivers during evening and night-time periods only, as the objective is to protect the amenity and sleep of people when they are at home.

- Evening: $L_{eq,15min}$ 40 dB(A) (internal)
- Night: $L_{eq,15min}$ 35 dB(A) (internal)

The internal noise levels are assessed at the centre of the most affected habitable room.

5.2.3 Vibration Criteria

a) Vibration Criteria for Human Comfort

The DECC “*Assessing Vibration: A Technical Guideline*” is based on the guidelines contained in BS 6472.1:2008, *Guide to evaluation of human exposure to vibration in buildings - Vibration sources other than blasting*.

This guideline presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques.

Vibration in buildings can be caused by many different external sources, including construction works. The vibration may be continuous (with magnitudes varying or remaining constant with time), impulsive (such as in shocks) or intermittent (with the magnitude of each event being either constant or varying with time).

Vibration and its associated effects are usually classified as continuous, impulsive or intermittent:

- Continuous vibration continues uninterrupted for a defined period (usually throughout daytime and/or night-time).
- Impulsive vibration is a rapid build up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds.
- Intermittent vibration can be defined as interrupted periods of continuous (e.g. a drill) or repeated periods of impulsive vibration (e.g. a pile driver), or continuous vibration that varies significantly in magnitude. It may originate from impulse sources (e.g. pile drivers and forging presses) or repetitive sources (e.g. pavement breakers), or sources which operate intermittently, but which would produce continuous vibration if operated continuously (for example, intermittent machinery). This type of vibration is assessed on the basis of vibration dose values (VDV).

Vibration criteria for continuous and impulsive vibration are presented in Tables 14 and 15 below.

Location	Assessment Period	RMS velocity, mm/s (dB ref 10 ⁻⁶ mm/s)		Peak velocity, mm/s (dB ref 10 ⁻⁶ mm/s)	
		Preferred	Maximum	Preferred	Maximum
Residential	Daytime	0.20 mm/s (106 dB)	0.40 mm/s (112 dB)	0.28 mm/s (109 dB)	0.56 mm/s (115 dB)
	Night-time	0.14 mm/s (103 dB)	0.28 mm/s (109 dB)	0.20 mm/s (106 dB)	0.40 mm/s (112 dB)
Commercial and retail	When in use	0.40 mm/s (112 dB)	0.80 mm/s (118 dB)	0.56 mm/s (115 dB)	1.1 mm/s (121 dB)

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

Table 14: Continuous vibration criteria applicable to the site – Human Comfort

Location	Assessment Period	RMS velocity, mm/s (dB ref 10 ⁻⁶ mm/s)		Peak velocity, mm/s (dB ref 10 ⁻⁶ mm/s)	
		Preferred	Maximum	Preferred	Maximum
Residential	Daytime	6.0 mm/s (136 dB)	12 mm/s (142 dB)	8.6 mm/s (139 dB)	17 mm/s (145 dB)
	Night-time	2.0 mm/s (126 dB)	4.0 mm/s (132 dB)	2.8 mm/s (129 dB)	5.6 mm/s (135 dB)
Commercial and retail	When in use	13 mm/s (142 dB)	26 mm/s (148 dB)	18 mm/s (145 dB)	36 mm/s (151 dB)

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

Table 15: Impulsive vibration criteria applicable to the site – Human Comfort

When assessing intermittent vibration comprising a number of events, the VDV should be used. The VDV is given by the fourth root of the integral with respect to time of the fourth power of the acceleration after it has been weighted. This is the root-mean-quad approach. The use of the fourth power method makes VDV more sensitive to peaks in the acceleration waveform. VDV accumulates the vibration energy received over the daytime and night-time periods.

VDV_e may be calculated for each event as:

$$VDV_e = 1.4 \times a_{rms} \times t^{0.25}$$

Where VDV_e is the vibration dose value in m/s^{1.75}, “a_{rms}” is the frequency-weighted acceleration in m/s² and “t” is the total period of the day (in seconds) during which vibration may occur. The total VDV is then calculated using the following formula:

$$VDV = \left(\sum_{n=1}^{n=N} VDV_{e_n}^4 \right)^{0.25}$$

where VDV is the total vibration dose for the day in m/s^{1.75}, “VDV_e” is the vibration dose for each event (m/s^{1.75}) and “N” is the total number of vibration dose events.

Acceptable values of vibration dose for the Project are presented in Table 16.

Location	Assessment Period	Vibration Dose Values, m/s ^{1.75}	
		Preferred	Maximum
Residential	Daytime	0.20	0.40
	Night-time	0.13	0.26
Commercial and retail	When in use	0.40	0.80

Table 16: Intermittent vibration criteria applicable

b) Vibration criteria for building damage

The criteria given in Tables 14 and 15 for Human Comfort shall generally form the limiting vibration criteria for the Project.

Further criteria to prevent building damage and disruption to equipment and processes are discussed in Appendix C.

For unoccupied buildings, or during periods when the buildings are unoccupied, the criteria for building damage suggested by German Standard DIN 4150.3:1993 is to be adopted as follows:

- 5 mm/s (134 dB ref 10^{-6} mm/s) for residential dwellings
- 20 mm/s (146 dB ref 10^{-6} mm/s) for commercial premises

5.3 Transport Noise Emission Criteria

5.3.1 NSW Road Noise Policy

The NSW Road Noise Policy (RNP) provides criteria for traffic noise from new roads or additional traffic generated on roads from land use development. Table 17 sets out the assessment criteria for residential receivers according to road category and use land. These criteria are for assessment against façade corrected noise levels when measured in front of a building façade, and are provided as a guide to assessing impact rather than as achievable targets.

Road category	Type of project/land use	Assessment Criteria $L_{Aeq,1h}$ dBA	
		Day (7:00am to 10:00pm)	Night (10:00pm to 7:00am)
Local Road	Existing residences affected by additional traffic on existing local roads generated by land use developments	55	50

Table 17: Noise Level criteria as per NSW Road Noise Policy

When considering land use redevelopment and the impact on sensitive land uses (residential / schools / hospitals / recreational) the guideline states that an increase of up to 2 dB in relation to existing noise levels is anticipated to be insignificant, as this increase is considered barely perceptible to the average person.

6 Operational Noise and Vibration Assessment and Recommendations

6.1 Source Noise Levels used for Operational Noise Assessment

Noise break-in from road traffic, plant rooms and retail patrons has the potential to impact on the development. Noise break-out from the proposed building has the potential to impact on existing noise sensitive receivers. For the purpose of this assessment, the noise sources are assumed as follows:

- Noise from plant rooms.
- Noise from road traffic.
- Noise from retail patrons.

Each of these noise sources has been considered in the acoustic assessment. A separate assessment of noise and vibration from the rail corridor is presented in Section 7.

6.1.1 Plant Rooms

Plant noise associated with the operation of the proposed development should be controlled to ensure external noise emissions are not intrusive and do not impact on the amenity of neighbouring receivers. In particular, externally located plant, air intake and discharge louvres in the external walls, roof mounted and roof discharging extract and exhaust fans, and externally located chillers or condenser units shall require acoustic attenuation measures.

At this stage, final plant selections have not been made. Based on the general arrangement plans, the proposed plant room locations are:

- Basement Level 3 – will not have an impact as this plantroom will be in the lower level of the building.
- Level 3 – Electrical Substation on Gloucester Street.
- Level 9 – Commercial chillers plus plant room.

6.1.2 Traffic Noise

The southern and western elevations of the building overlook roads that are a source of continuous traffic noise – plus high levels of intermittent noise from large vehicle pass-bys. The key traffic noise source is the Cahill Expressway. Traffic AADTs' are obtained from the Roads and Maritime Services (RMS) and are shown in Table 18.

<i>Cahill Expressway Traffic AADT (veh/day)</i>			
<i>Direction</i>	<i>All Days</i>	<i>Weekdays</i>	<i>Weekends</i>
Northbound	17,600	19,100	15,100
Southbound	20,000	22,400	15,400

Table 18: Cahill Expressway Traffic AADT

Based on the results obtained from the unattended monitoring shown in Table 1 (L1 location) and the Cahill Expressway Traffic AADT; the predicted traffic sound pressure levels affecting the southern and western façades are based on the following:

<i>Description</i>	<i>Overall dB(A)</i>	<i>Sound Pressure Level, dB re 20µPa</i>								
		<i>Octave Band Centre Frequency, Hz</i>								
		31.5	63	125	250	500	1k	2k	4k	8k
<i>L_{10,1 hour} of Cahill Expressway – at Southern Facade</i>	70	73	75	72	68	66	66	61	54	46

Table 19: Cahill Expressway Traffic Noise - Traffic noise levels at southern facade

The potential noise sources associated with the proposed car park operations will be the noise generated by vehicle movements through the car park entrance (i.e. vehicles moving slowly). Car movements within the below ground car park are not considered as they will not have an impact on the development and surrounds.

Based on the information provided by the traffic consultant, the traffic generation figures for the existing site during peak hour are 17 vehicles/hour in the AM and 13 vehicles/hour in the PM. The future traffic during peak hour will be 14 vehicles/hour in the AM and 11 vehicles/hour in the PM.

During the attended short-term monitoring in the S4 monitoring location at Harrington Street, 15-minute traffic counts were undertaken. The results are 120 vehicles/hour in the day-time and 128 vehicles/hour in the night-time.

6.1.3 Retail Noise

a) Indoor and Outdoor Patrons - L₁₀ COS/OLGR Assessment

It is assumed that the vocal effort of patrons communicating inside / outside the retail spaces will generally be “normal” speech. The assessment has generally assumed the following:

- Male patrons talking “normally” to provide a worst-case scenario.
- Assuming 48 patrons outdoors, for every two patrons only one person will be speaking at any given time with a “normal” voice (i.e. 24 people speaking with a “normal” voice).
- Assuming 40 patrons indoors, for every two patrons only one person will be speaking at any given time with a “normal” voice (i.e. 20 people speaking with a “normal” voice).
- As per Section 3.15 of Sydney DCP 2012, the late trading hours for a category B – Low impact Premises within ‘City Living Areas’, the indoor areas trading hours are from 7:00am to 1:00am. For the outdoor areas, the trading hours are from 9:00am to 8:00pm.

The L₁₀ noise source spectra of patrons talking simultaneously are shown below in Table 20.

Description	Overall dB(A)	Sound Power Level, dB re 1pW								
		Octave Band Centre Frequency, Hz								
		31.5	63	125	250	500	1k	2k	4k	8k
<i>L_{A10} of 20 patrons talking “normally”</i>	71	51	54	58	68	71	64	60	56	51
<i>L_{A10} of 24 patrons talking “normally”</i>	72	52	55	59	69	72	65	61	57	52

Table 20: Sound Pressure Levels likely to be generated by patrons of the retail spaces

b) Outdoor Restaurant Patrons - L_{Amax} Sleep Arousal Assessment

The L_{Amax} sound level for patrons is assumed to be approximately 5 dB higher than the L_{A10} level (i.e. the L_{Amax} from 24 patrons talking in the outdoor area would be approximately 77 dB(A) at 1 meter.

c) Background Music

We understand that amplified music at any time within the proposed retail spaces will be limited to background music. The outdoor area will not be provided with amplified music.

On this basis, we have assumed that typical L_{10} music noise levels within the retail spaces will be approximately 10 dB below the sound levels from patrons speaking normally (Table 20).

Therefore, if compliance is achieved for noise levels from patrons speaking, then compliance will also be achieved for amplified background music.

6.2 Assessment Methodology

The acoustic assessment has considered the following:

- Operational noise levels are based on information provided in Section 6.1.
- Noise levels have been considered as continuous over a 15-minute assessment period to provide a worst-case scenario.
- Where relevant, noise predictions at the nearest receiver boundaries consider the cumulative noise contribution from all noise sources occurring simultaneously, including road traffic and background music.
- Distance attenuation, building reflections and directivity.
- Lowest measured background noise levels have been used to provide a worst-case scenario.
- The proposed retail spaces will operate from 7:00am to 1:00am for the indoor areas and from 9:00am to 8:00pm for the outdoor areas. These trading hours are obtained from the CoS-DCP 2012 and apply to Low Impact Premises within City Living Areas.
- The assessment considers the plaza at full capacity with 48 patrons.
- Horizontal and vertical internal partitions, walls and floors / ceilings between retail spaces and adjacent apartments provide sound insulation ratings similar or greater than NCC requirements.

6.3 Assessment and Recommendations

The following sections detail the predicted noise levels at the nearest affected receivers associated with the operation of the proposed spaces and facilities for the expected worst-case scenarios.

6.3.1 External Noise Emissions from Plant

At this stage, final plant selections have not been made; therefore it is not possible to undertake a detailed assessment of plant noise emissions.

A preliminary review has been carried out for the building services / plant rooms and we make the following comments:

- Based on the plant room location – Level 9 – and electrical substation location – Level 3 –, the most restrictive criteria (see Section 5.1.2) are 57 dB(A), 56 dB(A) and 52 dB(A) at residential receivers on Gloucester Street during the day, evening and night-time periods respectively.
- Considering the distance from the electrical substation and plant room to the nearest sensitive receiver on Gloucester Street (S1), noise emissions shall be limited to L_{Aeq} 69 dB(A) at 1 meter from the electrical substation and plant room boundary to comply with the most restrictive criteria.

Noise controls will need to be incorporated with the design of the plant rooms to ensure that the cumulative noise output from plant to the nearest affected receivers is within the allowable limits.

General design considerations and controls that may need to be implemented will typically include, but are not limited to:

- Strategic selection and location of plant to ensure the cumulative noise contribution at the receiver boundaries is achieved, and/or
- Acoustic noise control measures to be put in place to minimise noise impacts such as:
 - Noise enclosures as required.
 - Noise barriers as required.
 - Acoustic louvres as required.
 - In-duct attenuation.
 - In-built attenuation for noisy equipment.
 - Sound absorptive panels.

6.3.2 Internal Sound Insulation

All constructions will be designed to ensure that the acoustic performance satisfies the relevant requirements outlined in Section 5.1.2.

For the apartments, the level of sound insulation provided will be at least equal to the requirements of the NCC, Part F5 as per Table 8. Where plant rooms or other noisy space are located adjacent to apartments, the partition shall provide sufficient sound insulation so that noise levels within the residential areas comply with the established criteria.

6.3.3 Internal Design Sound Levels

a) Traffic Noise Break-in

Noise from the Cahill Expressway (and to a lesser degree from Bradfield Highway) will be the key traffic noise source affecting the building.

From the analysis of the unattended noise monitoring at the rooftop, the L_{10} traffic noise source during a busy traffic hour is used as the basis for the assessment.

These noise levels have been considered as continuous over a 15-minute assessment period to provide a worst-case scenario.

The final façade composition is not yet resolved. A minimum Sound Reduction assessment has been undertaken. This assessment has assumed the traffic noise levels noted above, the recommended internal background sound levels, areas of façade for each space plus distance to Cahill Expressway and Bradfield Highway.

In order to achieve the total internal noise levels proposed for each space in Table 11, the southern, eastern and western façades, other external building elements and ventilation openings will need to be designed to provide a R'_w 36 façade in-situ sound insulation performance.

Calculation	Noise Level dB(A) SPL, South Facade	Noise Level dB(A) SPL, East and West Facade
Predicted $L_{A10, 15min}$ of noise traffic at façade	70	70
Building attenuation / reflections / directivity, dB (assumes windows closed)	-36	-41
Reverberation field correction, dB	6	6
$L_{A10, 15min}$ inside the building	40	35
SEPP/CoS Criteria/AS2107	40	35
Complies?	Yes	Yes

Table 21: SEEP/CoS-DCP noise assessment – Traffic noise break-in via façade

b) Building Services Noise

In the majority of the apartments the background noise level will be dominated by external noise sources. Table 11, Section 5.1.2.f presents the total internal noise levels for each of the internal spaces. Noise levels are the total noise level in each space.

To achieve the total internal noise levels set for each space, the following general design considerations and noise controls will be implemented as required:

- Mechanical services equipment will need to be located either remote from habitable areas of sole-occupancy units, or in sound-insulating enclosure/cupboards.
- Noise controls such as internally lined ductwork and attenuators may need to be provided in the ductwork between the fans and sole-occupancy units.
- Where a duct located in a ceiling void serves or passes through more than one unit, the duct shall be wrapped externally or enclosed to provide a sound insulation performance compliant with the NCC requirements.
- Duct connections to grilles in ceilings shall be acoustically treated as required.
- Note that if access panels are required in service risers, floors, ceilings and/or enclosures, they shall not open into habitable areas.
- Hydraulic services shall not be chased into masonry wall elements.
- Wherever possible, hydraulic services (including storm water pipes) shall not be installed in ceiling voids above habitable areas. Where this is unavoidable, the pipe shall be wrapped externally or enclosed to provide a sound insulation performance compliant with the NCC requirements.
- Water supply pipes shall only be installed in a wall or ceiling cavity of discontinuous construction and, if serving only one unit, shall not be fixed to the wall leaf on the side adjoining any other unit.

6.3.4 Retail Space Noise Emissions

The nearest affected residential receivers from the outdoor retail patron areas are the Rendez-vous Hotel to the north plus residences within Cumberland Place forming a part of this development. The following tables detail the predicted noise levels at the nearest affected receivers associated with the operation of the proposed retail spaces due to patrons in the indoor and outdoor areas.

Calculation	Sound Pressure Level, dB re 20µPa									
	Overall dB(A)	Octave Band Centre Frequency, Hz								
		31.5	63	125	250	500	1k	2k	4k	8k
<i>L₁₀</i> of 20 patrons talking “normally” at 1 m	71	51	54	58	68	71	64	60	56	51
Increase in reverberant field		3	3	3	3	3	3	3	3	3
Reflections / directivity		6	6	6	6	6	6	6	6	6
Distance (8 m) attenuation		-18	-18	-18	-18	-18	-18	-18	-18	-18
Glazing attenuation		-5	-10	-15	-20	-26	-30	-27	-31	-35
Resulting Sound Pressure Level at residential receiver	36	37	35	34	39	36	25	24	16	7
CoS/OLGR Criteria (11pm to 7am)	52	59	57	51	49	48	49	43	34	24
Complies?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 22: CoS/OLGR noise assessment – indoor retail patrons noise break-out to the nearest sensitive receivers

Calculation	Sound Pressure Level, dB re 20µPa									
	Overall dB(A)	Octave Band Centre Frequency, Hz								
		31.5	63	125	250	500	1k	2k	4k	8k
<i>L₁₀</i> of 24 patrons talking “normally” at 1 m	72	52	55	59	69	72	65	61	57	52
Increase in reverberant field		0	0	0	0	0	0	0	0	0
Reflections / directivity		4	4	4	4	4	4	4	4	4
Distance (7 m) attenuation		-17	-17	-17	-17	-17	-17	-17	-17	-17
Resulting Sound Pressure Level at residential receiver	59	39	42	46	56	59	52	48	44	39
CoS/OLGR Criteria (applicable for 9am to 8pm outdoor area hours)	61	68	66	60	60	57	58	52	43	33
Complies?	Yes	Yes	Yes	Yes	Yes	No ¹	Yes	Yes	No ¹	No ¹

Table 23: CoS/OLGR noise assessment – outdoor retail patrons noise break-out to the nearest sensitive receivers

Note 1: The assessment of noise emissions from patrons in the outdoor retail areas shows a marginal exceedance of the CoS/OLGR criteria in some octave bands. Given that this exceedance is predicted based on a worst-case scenario (ie maximum occupancy of outdoor area, maximum noise generated by patrons and lowest measured background noise level for the 9am to 8pm time period), the typical use of the outdoor areas is expected to not generate an adverse noise impact. However, this does highlight the need to minimise and manage noise emissions / impact of outdoor retail patrons wherever possible. This will require management on an ongoing basis – as described below.

Limiting noise nuisance from the retail spaces in the residential areas will require management on an on-going basis. Appropriate strategies include:

- Staff to be briefed on the noise sensitivity of the neighbours and the need to manage the premises such that excessively noisy or rowdy patron activity is not tolerated.
- A policy of open communication with affected neighbours, including contact telephone numbers for use in the event of noisy issues.
- The outdoor area should be managed carefully during the lead-up to closing time to ensure that any remaining patrons are moved quietly indoors to finish their food and drinks before the outdoor area closes.
- Deliveries and waste disposal should be limited to less sensitive periods (day time period) where possible.

The following table details predicted noise levels from patrons in the outdoor areas, which are assessed against the INP Sleep Arousal criteria outlined in Section 5.1.1.

Calculation	Noise Level dB(A) SPL
<i>L_{Amx} of 24 patrons talking with "normal" voice at 1m</i>	77
<i>Increase in the reverberant field</i>	0
<i>Building attenuation / reflections / directivity / propagation</i>	-7
<i>Distance (7 m) attenuation</i>	-17
<i>Resulting level at the residential boundary</i>	53
<i>Sleep Arousal Criteria</i>	67
<i>Complies?</i>	Yes

Table 24: INP Sleep Arousal noise assessment at residential receiver from outdoor patrons, "normal" vocal effort

6.3.5 Control of Vibration

Floor impact noise is controlled via the floor and ceiling constructions to achieve the criteria discussed in Section 5.2.3.

Structure-borne noise from the plant rooms and equipment will be controlled by vibration isolators to ensure that the indoor noise levels are achieved in the internal spaces.

For all plant and equipment, vibration isolator types, methods of mounting and material of mountings shall be selected in accordance with manufacturer specifications to ensure that vibration is not perceptible in habitable spaces, and to achieve compliance with the vibration criteria.

6.3.6 Transportation Noise and Vibration Assessment

Based on the information provided by the traffic consultant, future peak hour traffic generation associated with the car-park of the new development is less than the existing. Existing traffic flows are 17 vehicles/hour in the AM and 14 vehicles/hour in the PM, against 14 vehicles/hour in the AM and 11 vehicles/hour in the PM for the future development. This indicates that there will be no increase in road traffic noise as a result of the development.

As noted in Section 5.3.1, when considering land use redevelopment and the impact on sensitive land uses (residential / schools / hospitals / recreational) the NSW Road Noise Policy (RNP) states that an increase up to 2 dB in relation to existing noise levels is anticipated to be insignificant. Therefore, the decrease in traffic volumes is expected to meet the NSW Road Noise Policy recommendations.

7 Rail Ground-borne Noise and Vibration Assessment

7.1 Predicted Noise and Vibration Levels

Estimated ground-borne noise and vibration levels in the proposed development have been derived by taking into account the likely amplification and attenuation of rail vibration as it propagates in the building.

Predicted vibration levels indicate that all of the measured train events would result in vibration levels below the vibration criterion. This indicates that perceptible vibration will not have an impact on the development.

However, predicted ground borne noise levels are very close to the criterion (35 dBA) with one of the measured train events slightly exceeding the criterion. The predicted noise levels are illustrated in Figure 6, which shows that all westbound trains generated levels that would result in noise levels very close to the criterion.

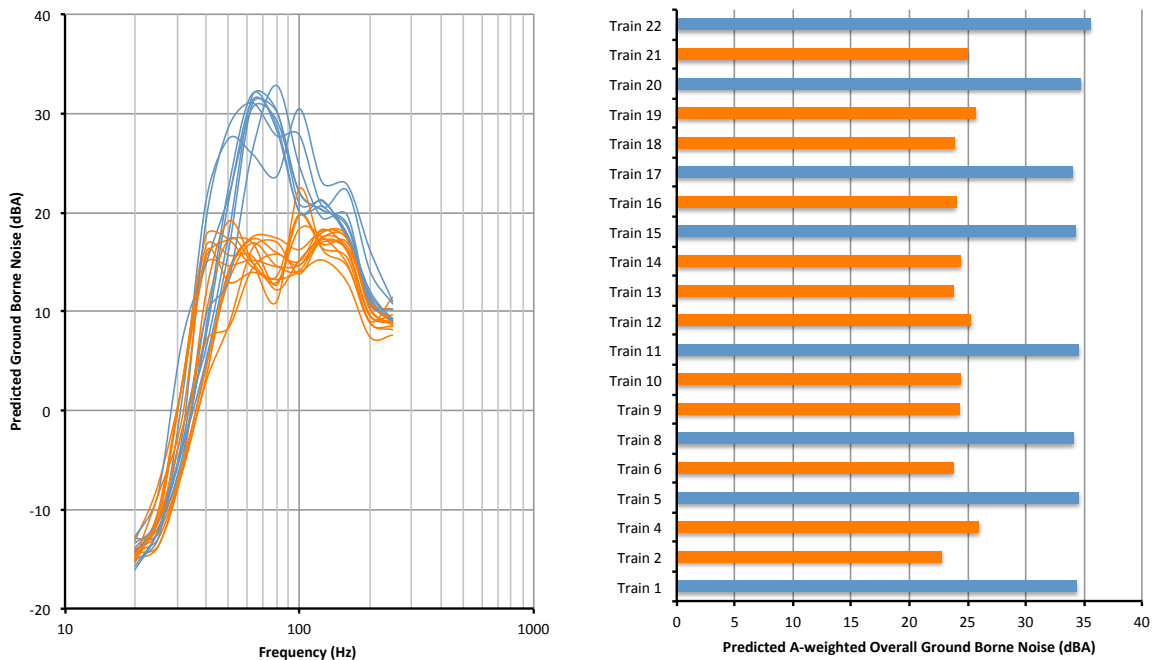


Figure 6: Predicted Ground-borne Noise Levels in third octave bands (left) and their corresponding A-weighted overall noise level (right). Blue identifies westbound trains and orange identifies eastbound trains

7.2 Discussion and Next Steps

The preliminary assessment indicates that perceptible vibration will not be an issue for the development, but the ground-borne noise levels warrant further review and investigation.

On one hand, the prediction results suggest that ground-borne noise levels will be within the applicable criterion and that no mitigation will be required. However, on the other hand, consideration should be given to:

- The predicted levels are close to the criterion (with one measured train indicating an exceedance).
- The ground-borne noise estimates are preliminary, based on vibration measurements at one part of the site, and are subject to a margin of uncertainty.
- The westbound trains generate significantly higher vibration levels, despite being further from the site.

These issues are discussed further below. In the meantime, we consider that, if some form of rail vibration mitigation does turn out to be necessary, it will not need to be a high performance system and would only be necessary on the most exposed part of the site.

A possible explanation for the westbound trains generating significantly higher vibration levels, despite being further from the site, is poor track condition (such as rail corrugation). The rail line has sharp curves at this location which means rail corrugation is likely. Indeed, rail corrugation on the westbound track is clearly visible from Harrington Street.

Corrugation develops over time and leads to deterioration of the rail surface quality, resulting in higher levels of noise and vibration. Rail condition improves (and noise and vibration levels reduce) when the rail is ground (or replaced) periodically, but the cycle then repeats.

At this stage, Acoustic Studio has no basis on which stage on the maintenance cycle the track are in, other than to postulate that the westbound track is in poorer condition than the eastbound. This could mean that, in time, the eastbound track will deteriorate and generate higher vibration levels than the westbound track resulting in non-compliance at the new development.

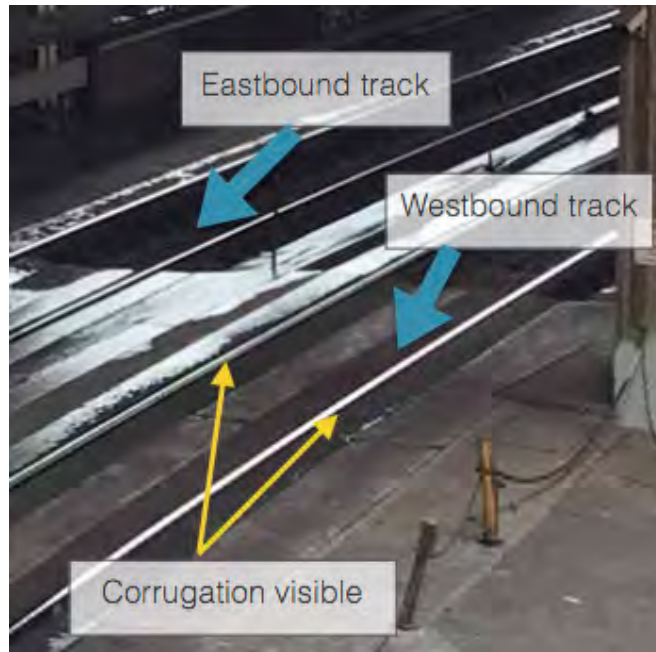


Figure 7: Photo of railway tracks from Harrington Street (the westbound track is the nearest track in this view, but is further from the development site)

An alternative explanation for westbound trains generating significantly higher vibration levels, despite being further from the site, is that there is a buried structure that acts as a conduit for vibration energy between the westbound tunnel and the site. It may be possible to confirm this by carrying out more detailed vibration surveys at various locations surrounding the existing tunnels, should this be deemed necessary.

In any case, it is recommended that additional vibration measurements shall be carried out on the development site during the next phase of the design, to confirm the findings and determine the extent of any affected area. However, we also recommend that such measurements are done once attempts have been made to clarify the issues described above – i.e. which stage of the maintenance cycle the tracks are in, and whether there is any geo-tech evidence suggesting a buried structure.

8 Construction Noise and Vibration Planning

Currently the project is at an early design stage. The detailed construction program and traffic likely to be generated during the construction phases are not yet fully defined. This section of the assessment provides general recommendations only and provides applicable criteria together with best noise and vibration control practices to be observed during the construction of the development.

This preliminary advice in relation to construction noise and vibration management shall form the basis for the Contractor's Construction Noise Management Plan.

8.1 Relevant Codes and Standards

In preparing this construction noise and vibration assessment, the following legislation, codes and standards have been found to be relevant for the project:

- DECCW *Interim Construction Noise Guideline, 2009* (ICGN)
- DECC *Assessing Vibration: A Technical Guideline, 2006*
- City of Sydney *Construction Hours/Noise. Code of Practice, 1992*
- AS 2436:2010 *Guide to noise and vibration control on construction, demolition and maintenance sites*
- AS 2670.2:1990 *Evaluation of human exposure to whole-body vibration – Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz)*
- BS 6472.1:2008 *Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting*
- *Protection of the Environment Operations Act 1997* (POEO)

8.2 Construction Noise and Vibration Criteria

Please, refer to Section 5.2 of this report for the Construction Noise and Vibration Criteria.

8.3 Noise and Vibration Sources

At this stage of the project, preliminary information regarding the proposed equipment and plant for the demolition and excavation works has been provided. Activities and / or program for the demolition and excavation works or subsequent construction phases are not yet available.

The equipment / plant expected to be used for the demolition and excavation works are as follows:

- Large Dozer
- Hydraulic Rock Breaker
- Large Rock Hammers
- Hydraulic Rock Saw
- Pneumatic jack-hammer

It is expected that the demolition and excavation works will take between three and six months. All plant is expected to operate and move within the site boundary area with direct and partial view to nearby residential receivers. All plant is assumed to operate continuously over the assessment period.

8.4 Noise and Vibration Impact Assessment

The following assumptions have been made in order to assess the construction noise and vibration impact:

- The proposed activities (i.e. demolition and excavation) are undertaken continuously during the assessment periods.
- Activity noise impacts have been calculated for all equipment operating concurrently (i.e. maximum noise level in range) and separately (i.e. minimum noise level in range).
- All plant to be operating within the site boundary area.
- Terrain shielding during excavation works has not been considered in the noise impact predictions.

Table 25 compiles the noise level data for the equipment / plant likely to be used during the demolition and excavation works as per AS 2346:2010, plus the predicted sound pressure level at the nearest residential receiver.

Plant	A-weighted Sound Power Level (dB(A) ref 1pW)	Distance, m	A-weighted Sound Pressure Level (dB(A) ref 20µPa)
Large Dozer	108	15	76
Hydraulic Rock Breaker	118	15	86
Large Rock Hammer	121	15	89
Hydraulic Rock Saw	117	15	85
Pneumatic Jack Hammer	116	15	84

Table 25: Noise levels for equipment / plant for the proposed demolition and excavation works, plus equivalent sound pressure level at nearest residential receiver

Results from the proposed demolition and excavation works preliminary noise impact assessment at the nearest residential receiver are shown in Table 28 below. These results represent the worst-case, cumulative noise impact during the demolition and excavation works assuming no noise mitigation or screening is applied.

Activity	Noise Levels at receiver, in dBA	Criteria, in dBA	Complies?
Demolition and excavation works	76 to 92	67 / 75	No

Table 26: Results of demolition and excavation works noise impact assessment at the nearest residential receiver

8.5 Control Elements

In order to meet the noise and vibration requirements of the site, the Contractor will need to prepare a Construction Noise and Vibration Management Plan, and undertake noise and vibration monitoring for the duration of the project.

8.5.1 Working Hours

Recommended standard hours of work in the DECCW Interim Construction Noise Guideline (ICNG) are as follows:

- Monday to Friday 7:00am to 6:00pm
- Saturday 8:00am to 1:00pm
- Sundays or Public Holidays No excavation or construction work

The project construction hours will be in accordance with the SEARs and consent conditions.

8.5.2 Noise

As a general rule, prevention should be applied as universal work practice at any time of day, but especially for any construction works to be undertaken at critical times outside normal daytime/weekday periods.

It is noted that the reduction of noise at the source and the control of the transmission path between the construction site and the receiver(s) are the preferred options for noise minimisation. Providing treatments at the affected residences or other sensitive land uses should only be considered as a last resort.

Construction noise shall be managed by implementing the strategies listed below:

- Plant and equipment
 - Use quieter methods.
 - Use quieter equipment.
 - Operate plant in a quiet and effective manner.
 - Where appropriate, limit the operating noise of equipment.
 - Maintain equipment regularly.
 - Where appropriate, obtain acoustic test certificates for equipment.
- On site noise management
 - Strategically locate equipment and plant.
 - Avoid the use of reversing alarms or provide for alternative systems.
 - Maximise shielding in the form of existing structures or temporary barriers.
 - Schedule the construction of barriers and structures so they can be used as early as possible.
- Consultation, notification and complaints handling
 - Provide information to neighbours before and during construction.
 - Maintain good communication between the community and Project staff.
 - Have a documented complaints process and keep register of any complaints.
 - Give complaints a fair hearing and provide for a quick response.
 - Implement all feasible and reasonable measures to address the source of complaint.
- Work scheduling
 - Schedule activities to minimise noise impacts.

- Ensure periods of respite are provided in the case of unavoidable maximum noise levels events.
- Flexible working hours avoiding noise works during hours that will least adversely affect sensitive receivers.
- Keep truck drivers informed of designated routes, parking locations and delivery hours.

8.5.3 Vibration

The Contractor shall carry out a preliminary vibration assessment at the commencement of operations for each vibration generating plant to determine whether the existence of significant vibration levels justifies a more detailed investigation.

A more detailed investigation will involve methods of constraining activities generating high vibration levels. A method of monitoring vibration levels will then need to be put in place. Vibration mitigation measures and a review of vibration criteria may then be necessary.

All practical means should be used to minimise impacts on the affected buildings and occupants from activities generating significant levels of vibration on site.

The following considerations shall be taken into account:

- Modifications to construction equipment used.
- Modifications to methods of construction.
- Re-scheduling of activities to less sensitive times.

If the measures given above cannot be implemented or have no effect on vibration levels or impact generated, a review of the vibration criteria should be undertaken and the vibration management strategy amended.

8.5.4 Vibration Surveys

Since the actual vibration levels experienced will be dependent upon the site characteristics and the specific equipment being used, early vibration level checks should be carried out on site at the outset of each key vibration generating activity (if vibration is considered to be an issue).

Shortly before the commencement of each activity the background vibration level could be measured and again once the activity has begun. If the survey indicates levels of vibration exceeding those expected, the vibration management strategy for that process could be re-assessed.

8.5.5 Additional Noise and Vibration Control Measures

If, during construction, an item of equipment exceeds either the noise criteria at any location or the equipment noise level limits, the following noise control measures, together with construction best practices, shall be considered to minimise the noise impacts on the neighbourhood.

- Schedule noisy activities to occur outside of the most sensitive times of the day for each nominated receiver.
- Consider implementing equipment-specific screening or other noise control measures recommended in Appendix C of Australian Standard 2436:2010.
- Limit the number of trucks on site at the commencement of site activities to the minimum required by the loading facilities on site.
- When loading trucks, adopt best practice noise management strategies to avoid materials being dropped from height into dump trucks.
- Avoid unnecessary idling of trucks and equipment.
- Ensure that any miscellaneous equipment (extraction fans, hand tools, etc) not specifically identified in this plan incorporates silencing/shielding equipment as required to meet the noise criteria.

Implementation of all reasonable and feasible mitigation measures for all internal and underground works will ensure that any adverse noise impacts to surrounding residential, commercial and recreational receivers are minimised when noise goals cannot be met due to safety or space constraints.

8.6 Noise and Vibration Monitoring

8.6.1 Noise Monitoring

The three phases of the project to be noise monitored are:

- Demolition works phase
- Earthworks and Excavation phase.
- Structure and Finishes phase.

Noise monitoring will be undertaken to monitor and help to minimise construction noise in order to avoid discomfort to occupants of the surrounding areas.

An allowance of 1.5 days per week, at least, should be dedicated to monitoring of noise and vibration for the first four weeks. Further monitoring should be reviewed after this time or sooner should it be deemed necessary by the Acoustic

Consultant and the Project Manager. If results indicate noise levels exceeding allowable limits appropriate action should be taken.

8.6.2 Vibration Monitoring

A vibration monitoring system shall be implemented during the earthworks and excavation phase in order to monitor human discomfort and potential structural damage in and around adjacent buildings.

This system would monitor vibration levels when there is potential for them to change. This could happen in various situations, such as, changes in equipment and activities or changes to work procedures that might affect existing vibration control measures. The monitoring procedure would be carried out with appropriate equipment so that results obtained are readily comparable with results obtained earlier. If results indicate vibration levels exceeding allowable limits appropriate action should be taken.

8.6.3 Reporting

The Contractor should prepare a noise monitoring report each month for review by the Project Manager. The reports should summarise and interpret the results of the noise and vibration monitoring carried out during the past month.

8.7 Communication and Complaints

The Contractor should establish a communications register for recording incoming complaints. The registration of a particular item will remain open until the complaint has been appropriately dealt with.

In addition the following procedures are an example of the procedures that should be specifically adopted for complaints relating to noise.

Upon receipt of a complaint The Contractor should:

- Try to ascertain from the complaint which appliance is causing the problem i.e. inside or outside the site and in what position.
- Establish from the monitoring equipment if the allowable noise levels have been complied with.
- Establish if the appliance positioning has previously been highlighted as a problem area. If not and the noise levels are above the allowable limit, then the equipment and its position shall be noted.

- Move machinery if the allowable levels have been exceeded or take other acoustic remedial action.

If the activity is occurring outside normal working hours, the activity should be immediately stopped. Where stopping the activity would create a safety issue the activity may be permitted to continue only as long as is necessary to make the area safe. The activity should then cease.

Any activity which is directed to cease due to excessive noise should not recommence until the Project Manager is satisfied that the noise and vibration limits requirements can be met and has given permission to recommence the activity.

The Site Supervisor should ensure that a report of any incident is provided to the Project Manager.

The Project Manager should provide a report on the incident to the relevant stakeholders.

The Contractor should provide a 24 hour telephone contact number and this number should be prominently displayed on the site.

8.8 Non-compliances

Non-compliance reports can be used as appropriate to deal with failures to meet the construction vibration management and control requirements.

9 Summary and Conclusions

A noise and vibration assessment has been carried out for the proposed mixed-use development at 85 Harrington Street, The Rocks.

This report establishes relevant noise criteria, details the acoustic assessment and provides comments and recommendations for the proposed development.

Ambient and background noise surveys have been carried out at the existing site to identify potential noise sensitive receivers and to establish the appropriate criteria in accordance with the relevant guidelines in order to protect the amenity of nearby noise receivers that surround the site.

At this stage the plant selections have not been made; therefore a detailed assessment has not been able to be carried out. A preliminary review has been carried out for the plant rooms, and based on the location and the most restrictive criteria, noise emissions from the plant rooms shall be limited to 69 dB(A) SPL at 1 metre from the plant rooms boundaries.

Internal sound insulation requirements have been reviewed in accordance with the NCC and CoS-DCP requirements. All new constructions will be designed to achieve airborne and impact sound insulation requirements.

The final façade composition is not yet resolved. A minimum Sound Reduction assessment has been undertaken. This assessment has assumed the traffic noise levels from Cahill Expressway and Bradfield Highway. In order to achieve the total internal noise levels proposed for each space the final façade for the southern, eastern and western elevations will need to be designed to provide a R'_w 36 in-situ sound insulation performance.

Noise emissions from patrons inside the retail areas will meet the relevant noise criteria. However, the assessment of noise emissions from patrons in the outdoor retail areas shows a marginal exceedance of the CoS/OLGR criteria in some octave bands. Given that this exceedance is predicted based on a worst-case scenario (ie maximum occupancy of outdoor area, maximum noise generated by patrons and lowest measured background noise level for the 9am to 8pm time period), the typical use of the outdoor areas is expected to not generate an adverse noise impact. However, this does highlight the need to minimise and manage noise emissions / impact of outdoor retail patrons wherever possible. This will require management on an ongoing basis. Appropriate strategies are outlined in this report.

The traffic noise impact due to the carpark of the new development – based on information provided by the traffic consultant – is anticipated to be insignificant, as the noise levels increase will be 0 dB.

Estimated ground-borne noise and vibration levels in the proposed development have been derived, and predicted vibration levels indicate that all of the measured train events would result in vibration levels below the vibration criterion. However, predicted ground-borne noise levels for westbound trains are very close to the ground-borne noise criterion of 35 dBA for the residential accommodation.

On one hand, the prediction results suggest that ground-borne noise levels will be within the applicable criterion and that no mitigation will be required. However, on the other hand, consideration should be given to the following:

- The predicted levels are close to the criterion (with one measured train indicating an exceedance).
- The ground-borne noise estimates are preliminary, based on vibration measurements at one part of the site, and are subject to a margin of uncertainty.
- The westbound trains generate significantly higher vibration levels, despite being further from the site.

We consider that, if some form of rail vibration mitigation does turn out to be necessary, it will not need to be a high performance system and would only be necessary on the most exposed part of the site (at the southern end of the site).

In any case, it is recommended that additional vibration measurements shall be carried out on the development site during the next phase of the design, to confirm the findings and determine the extent of any affected area. However, we also recommend that such measurements are done once attempts have been made to clarify the issues discussed in this report regarding the stage of the maintenance cycle the tracks are in, and whether there is any geo-tech evidence suggesting a buried structure.

Potential construction noise and vibration impacts on the surrounding community have been presented in this report and recommendations based on the relevant guidelines are provided.

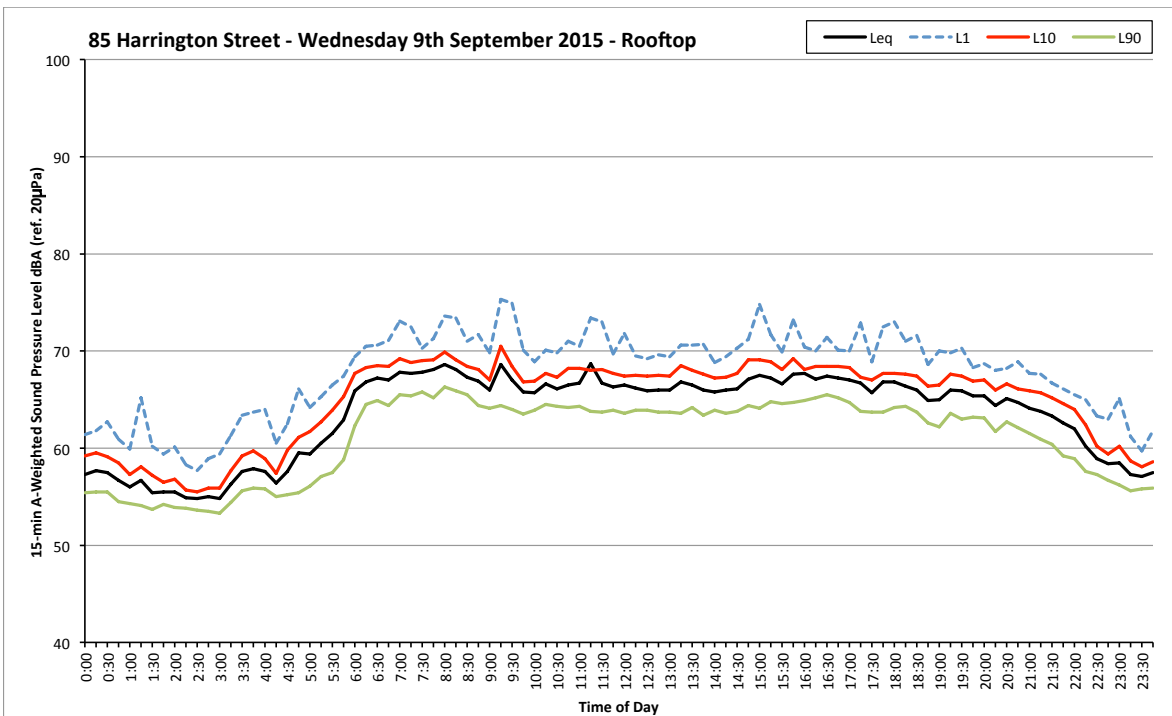
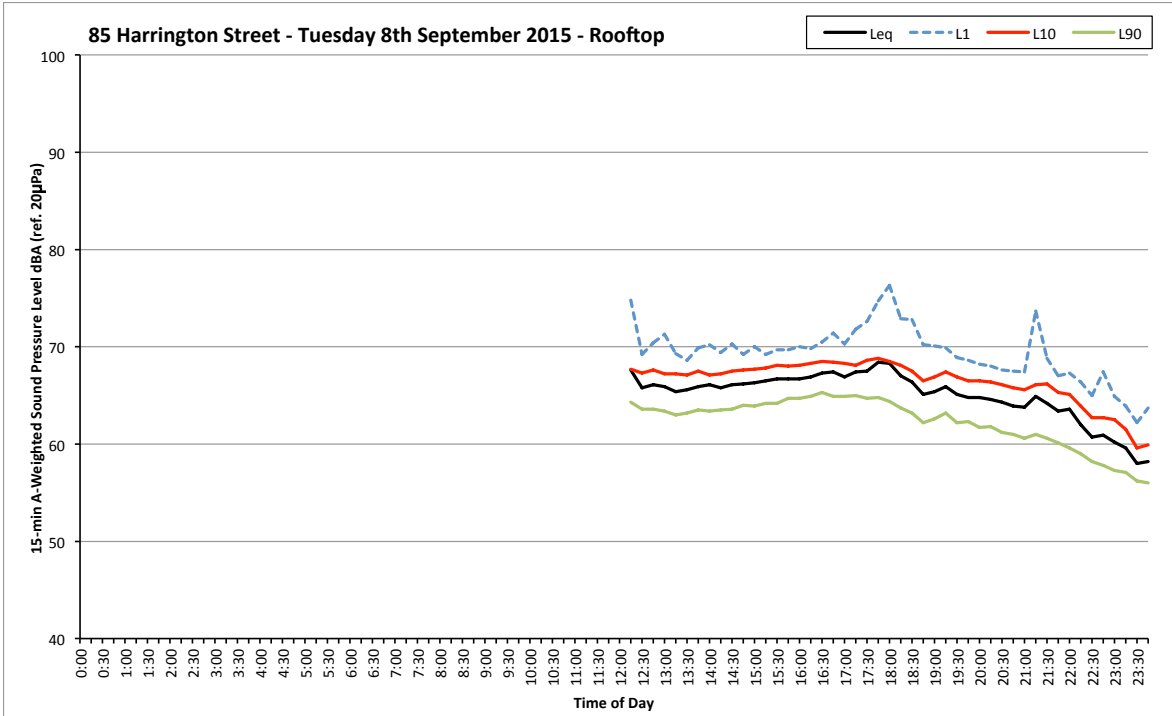
There will be times / situations when construction noise associated with demolition, earthworks, excavation and new-build works are likely to exceed the stated criteria, particularly when works occur in the areas closer to sensitive receivers or with direct view between the receivers and the works.

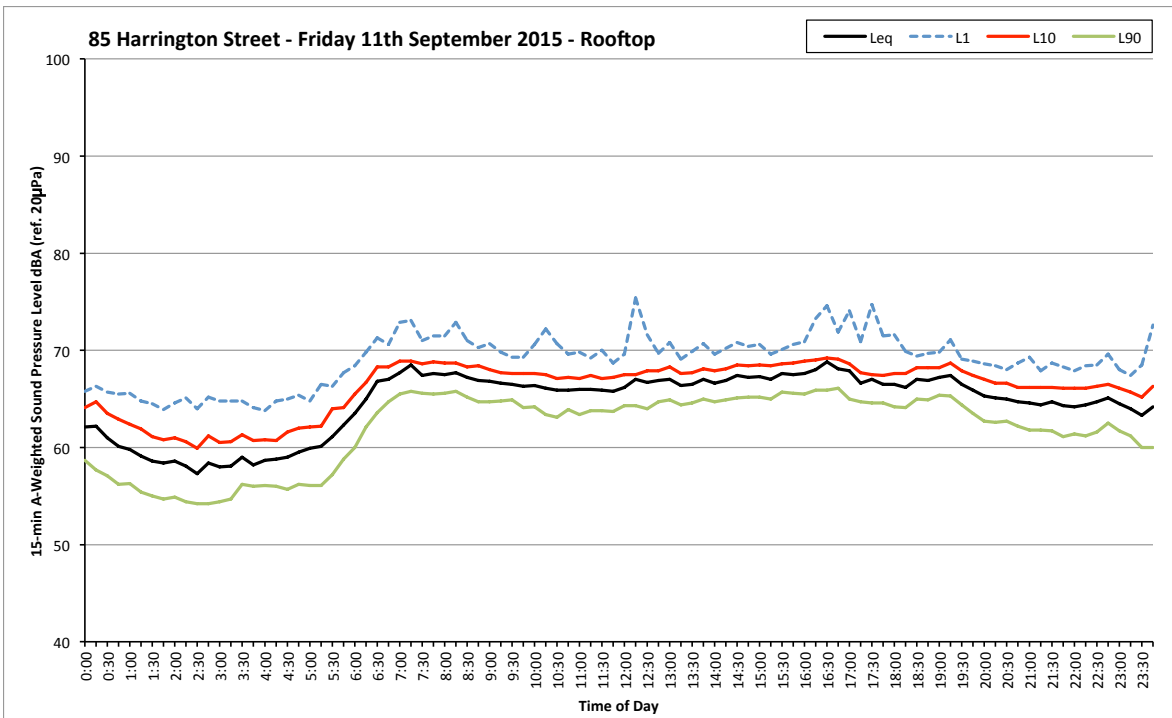
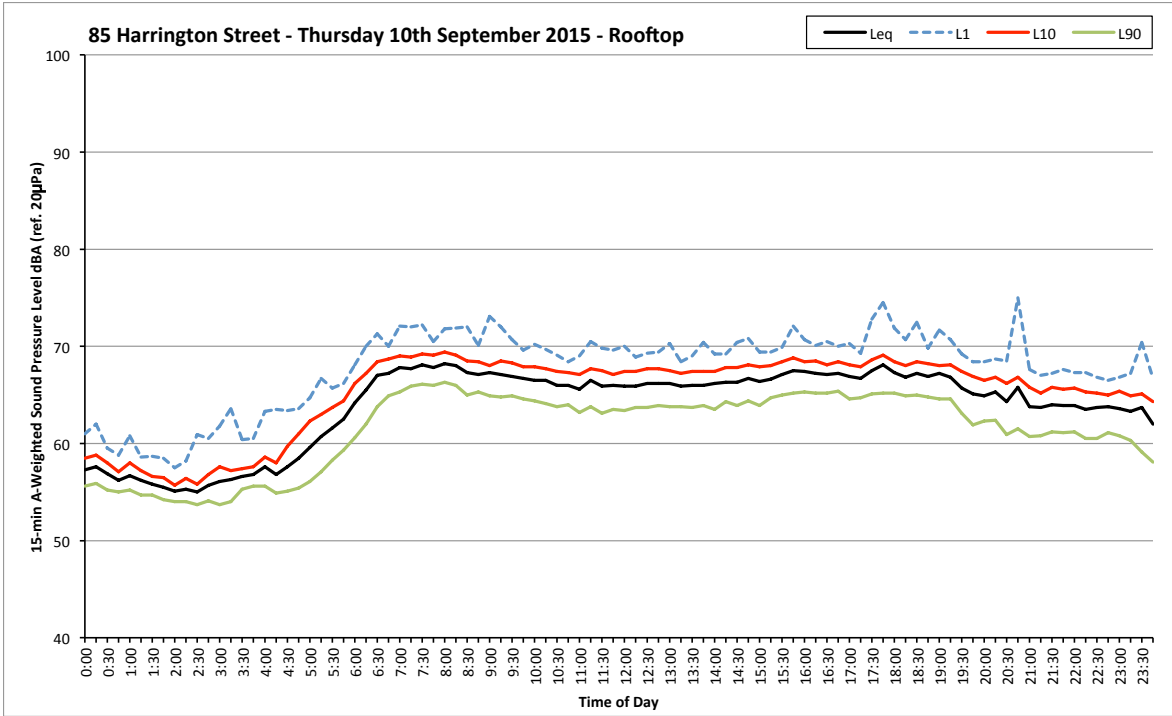
If, during construction works, an item of equipment exceeds the stated airborne noise and / or vibration criteria at any sensitive location, the additional noise / vibration control measures presented in this report, together with construction best practices, shall be considered to minimise noise and vibration impacts on the sensitive receivers.

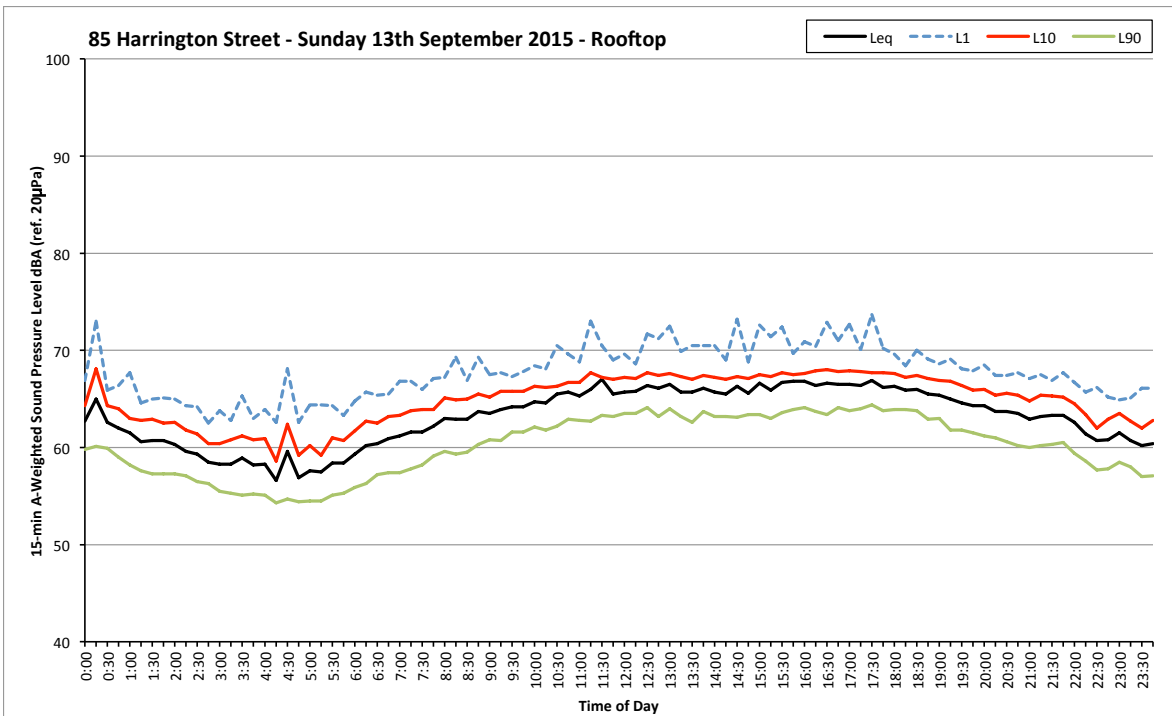
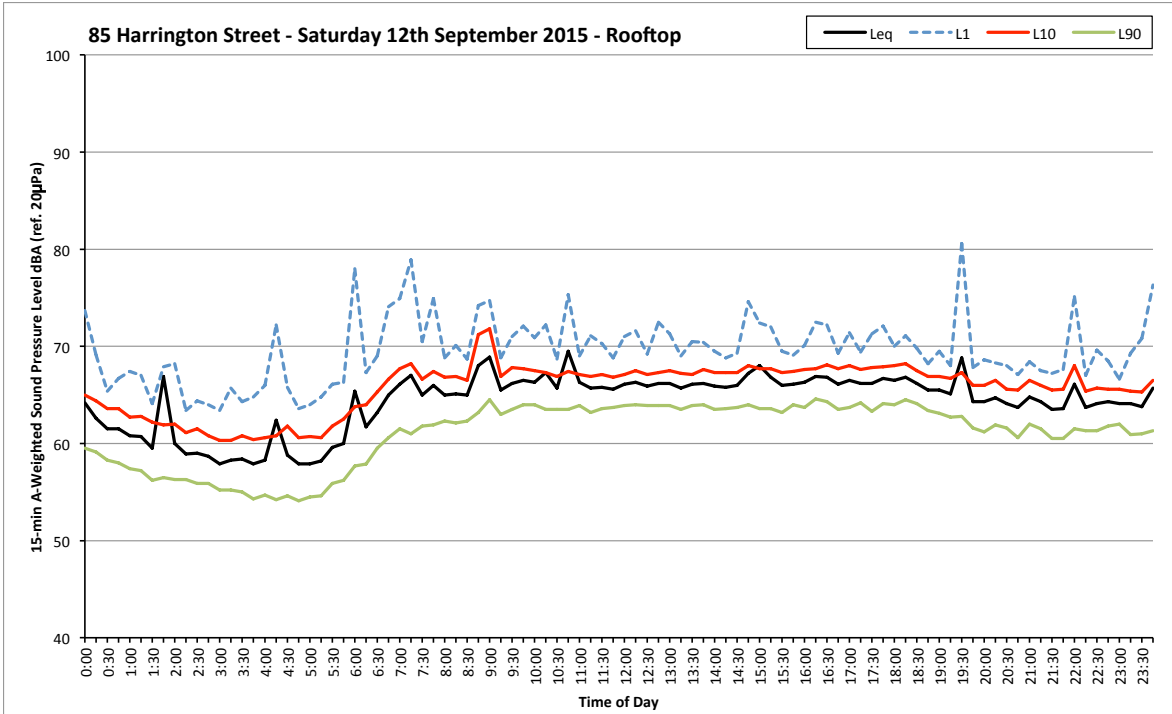
Provided the acoustic issues outlined in this report are addressed in the design and the recommendations are correctly implemented, the proposed development is expected to comply with the City of Sydney, SEARs and Sydney Harbour Foreshore Authority requirements plus relevant standards and guidelines, and will have no adverse noise impact at the nearest affected receivers.

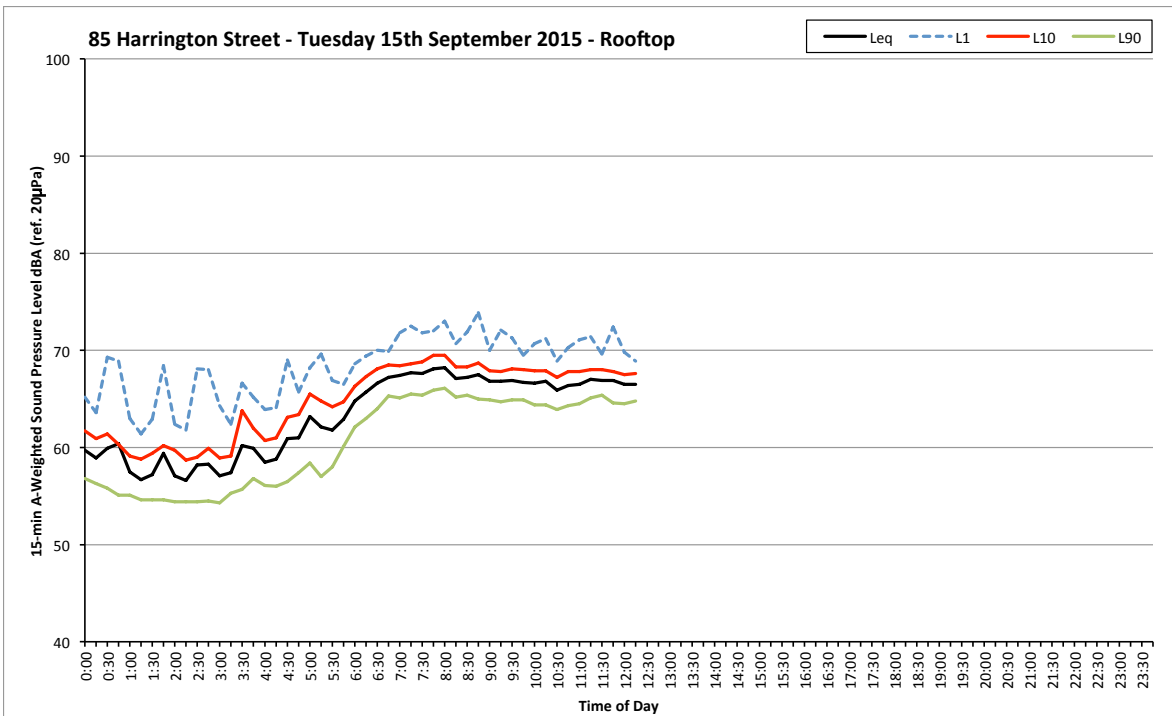
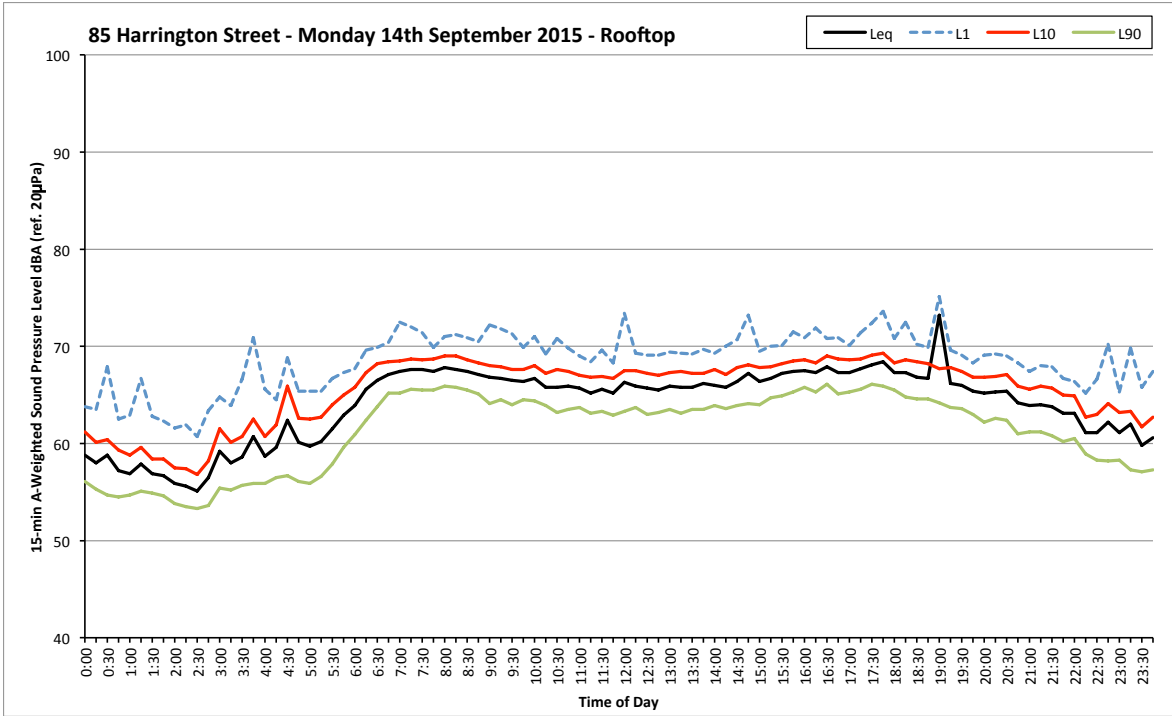
Appendices

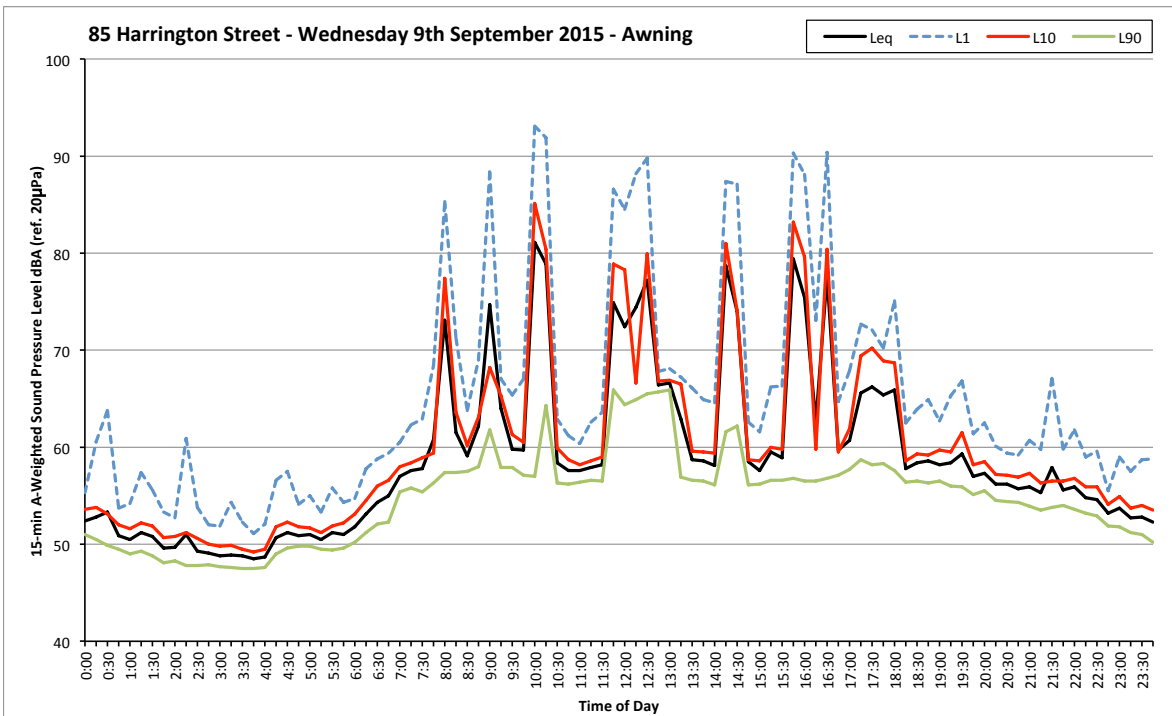
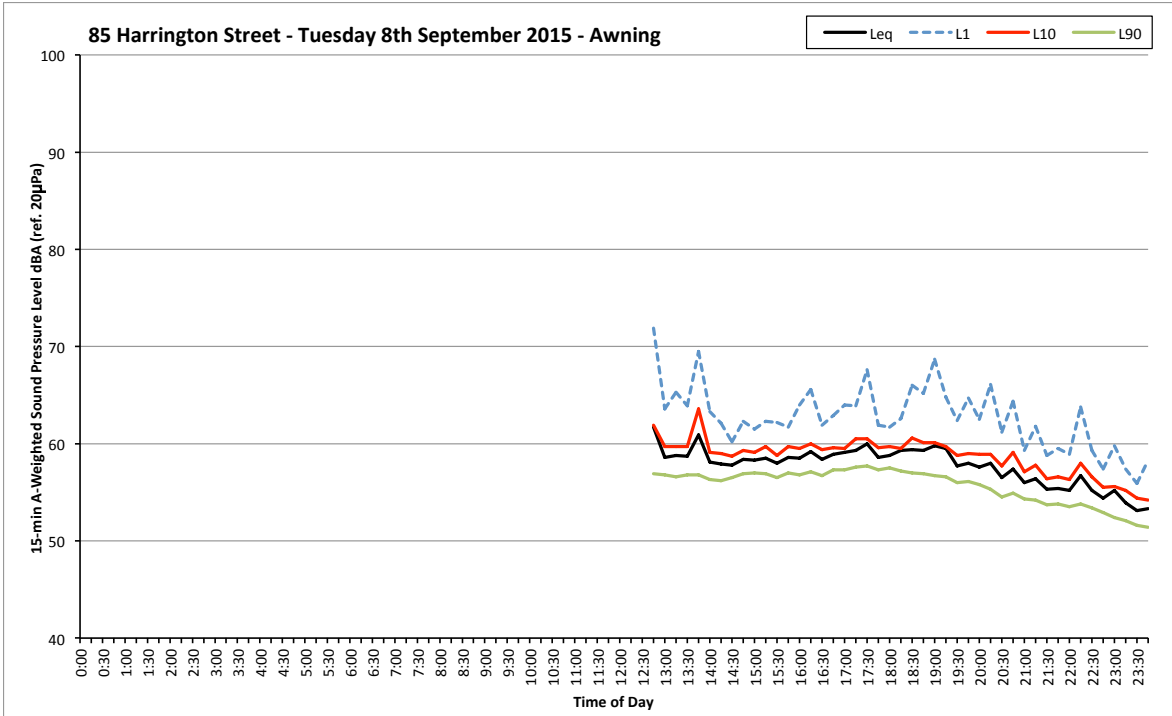
Appendix A: Long-term Monitoring Results

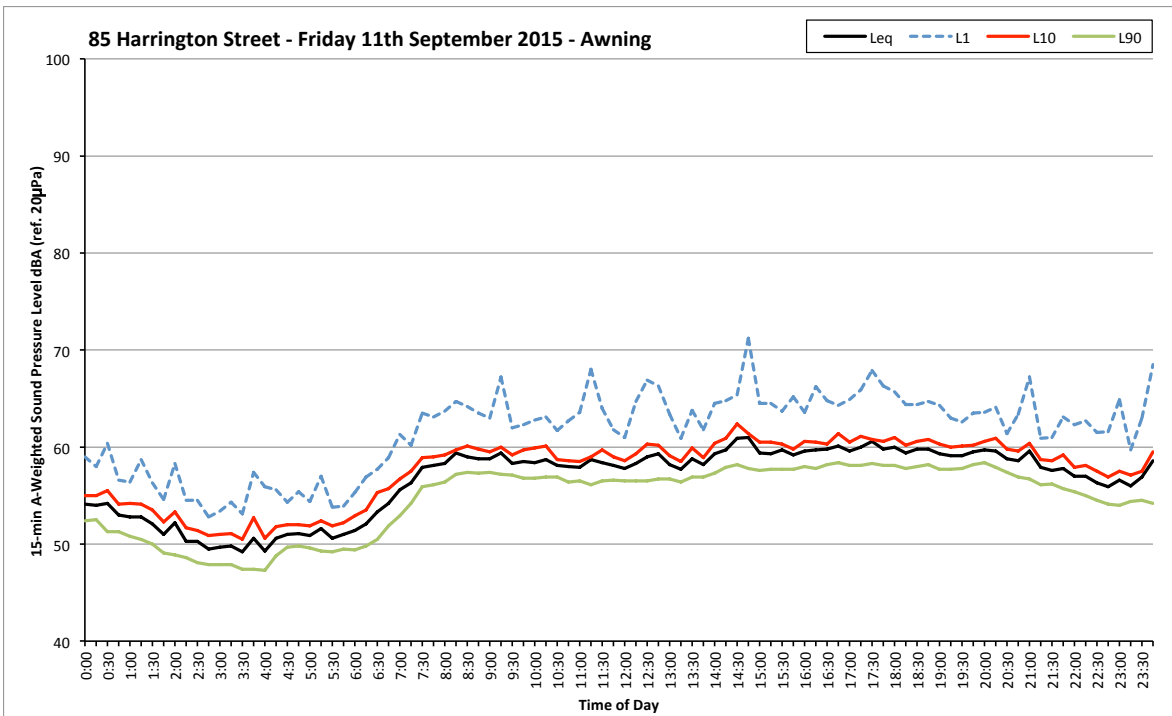
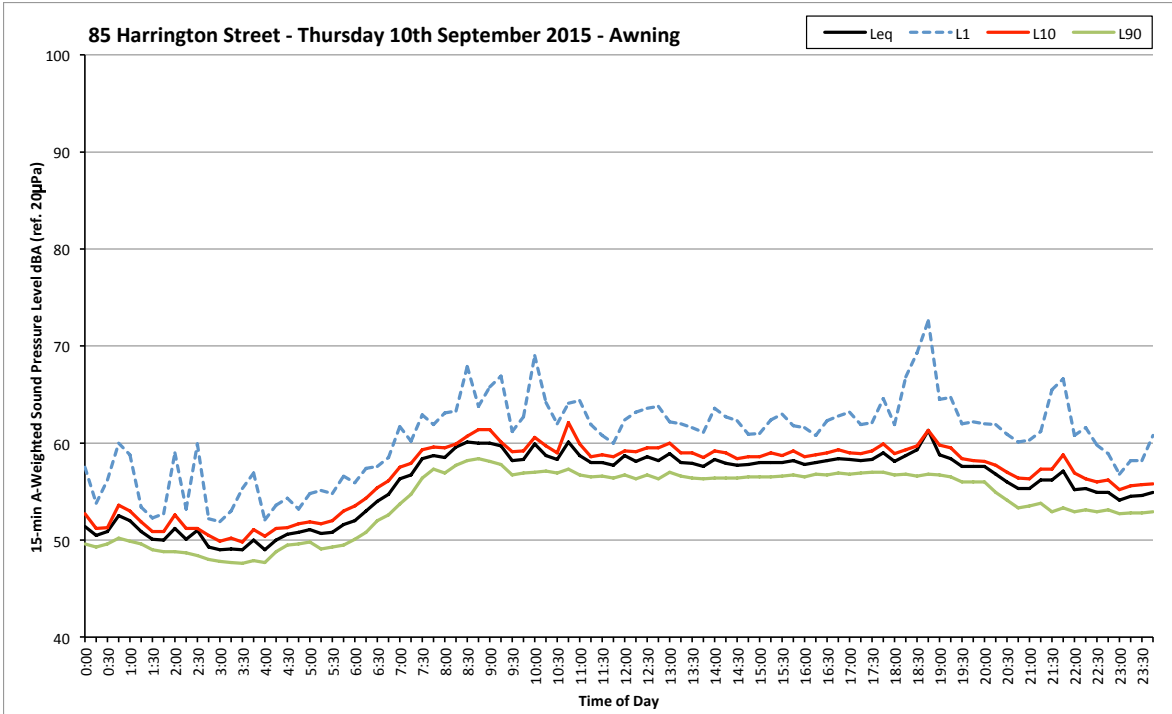


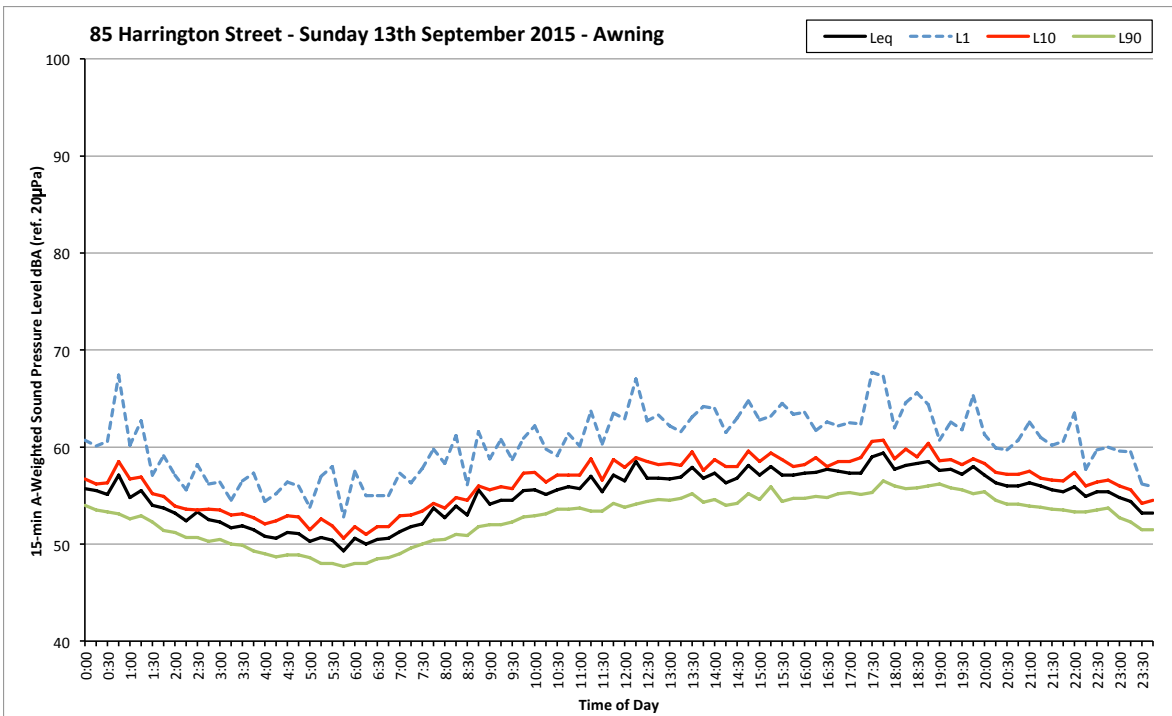
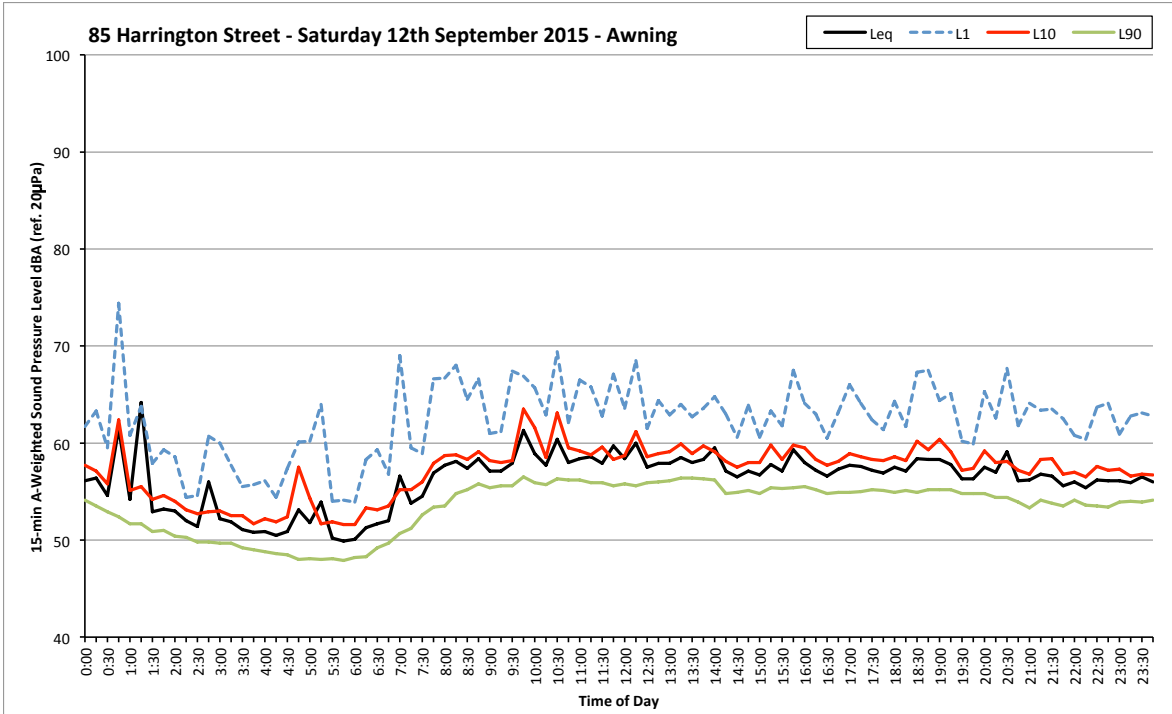


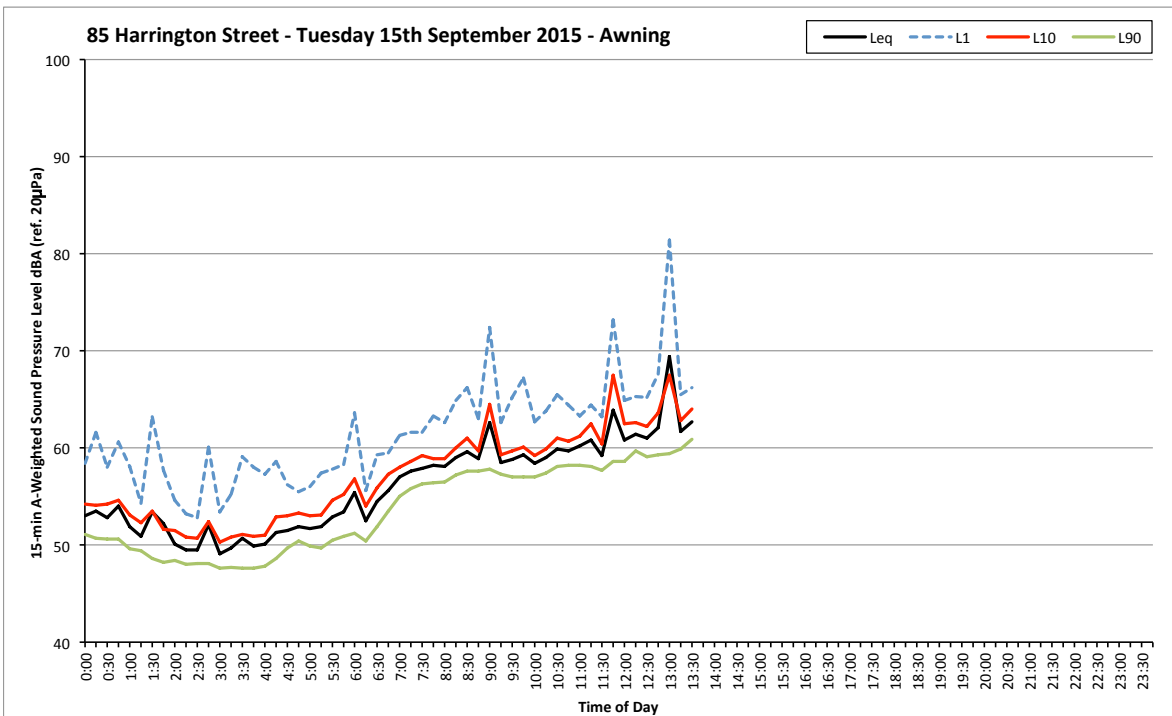
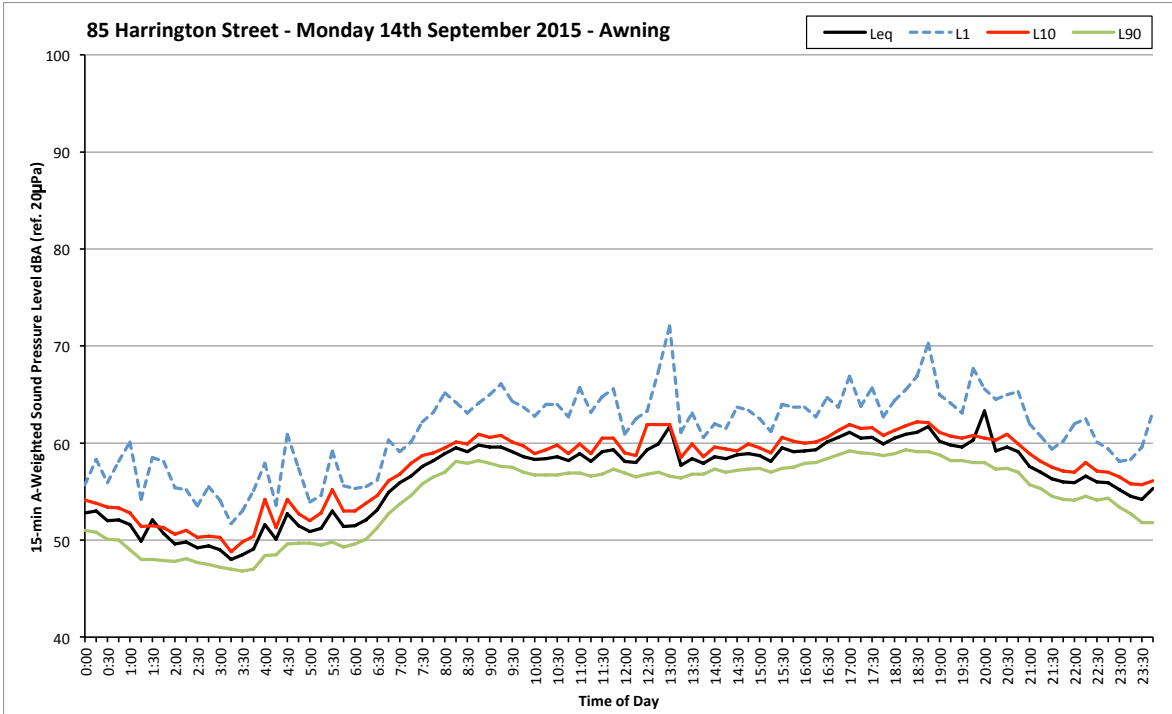












Appendix B: Derivation of Environmental Noise Break-out Limits

The main source of noise break-out from the site to the environment will be mechanical services plant.

The environmental noise impact of the mechanical plant will be assessed in accordance with the NSW Industrial Noise Policy 2000 (NSW INP).

The NSW INP sets two separate noise criteria to meet environmental noise objectives: one to account for intrusive noise and the other to protect the amenity of particular land uses. Both are used to derive the project specific noise level.

a) Assessing intrusiveness

The intrusiveness criterion essentially means that the equivalent continuous noise level of the source should not be more than 5 dB above the measured existing background noise level.

b) Assessing amenity

The amenity assessment is based on noise criteria specific to land use and associated activities. The criteria relate only to industrial-type noise, including plant. The existing noise level from industry (or plant) is measured - if it approaches the criterion value, then the noise levels from new plant need to be designed so that the cumulative effect does not produce noise levels that would significantly exceed the criterion.

The cumulative effect of noise from all industrial or plant sources is considered in assessing impact.

c) Project specific noise level

For the new plant, the more stringent of the intrusive and the amenity criteria sets the project specific noise level.

The derivation of the project specific noise levels is provided below.

B.1 Existing Background and Ambient Noise Levels

The rating background level (RBL) has been determined from $L_{A90,15min}$ measured during the long-term noise survey in accordance with the methodology prescribed in NSW INP. Data affected by adverse weather conditions was removed for the analysis procedure. These data are shaded on the graphs in Appendix A

Three time periods are considered (consistent with the operating times of the plant associated with the development and the time of day classifications in the Policy):

- Day - 7 am to 6 pm
- Evening - 6 pm to 10 pm
- Night - 10 pm to 7 am

From the noise logged data presented in Appendix A, the calculated RBL's and measured ambient noise levels are shown below in Table B1.

Location	<i>L₉₀</i> RBL Background Noise Levels, dB(A)			<i>L_{eq}</i> Ambient Noise Levels, dB(A)		
	Day	Evening	Night	Day	Evening	Night
	7am-6pm	6pm-10pm	10pm-7am	7am-6pm	6pm-10pm	10pm-7am
L1 – Rooftop 85 Harrington St	63	61	54	67	66	62
L2 – Awning 85 Harrington St	56	54	48	65	58	53

Table B1: Long-term background and ambient noise levels measured around the site

From observations during our site visit, it is noted that both ambient and background noise levels around the site are currently dominated by traffic noise from Cahill Expressway and Bradfield Highway.

B.2 Determination of intrusiveness criterion

The intrusiveness criterion is defined as:

$$L_{Aeq,15 \text{ minute}} \leq \text{rating background level plus } 5$$

The intrusiveness criterion has been determined from the RBL's presented in Table B1 for each period and from the short-term measurements presented in Section 4.1.3. The L2 – awning – noise levels are used as they describe the worst-case scenario for the intrusiveness criterion.

- Day Intrusiveness criterion of $56 + 5 = \mathbf{61 \text{ dB(A)}}$
- Evening Intrusiveness criterion of $54 + 5 = \mathbf{59 \text{ dB(A)}}$
- Night Intrusiveness criterion of $48 + 5 = \mathbf{53 \text{ dB(A)}}$

B.3 Determination of amenity criterion

To limit continuing increases in noise levels, the maximum ambient noise levels within an area from industrial noise sources should not normally exceed the acceptable noise levels appropriate for the type of area (e.g. the acceptable noise level in a rural area would be less than that in an urban or industrial area).

a) Recommended L_{Aeq} noise levels from industrial noise sources within NSW INP

The Acceptable Noise Levels (ANLs) for each land use type under consideration (as detailed in Table 2.1 of the NSW Industrial Noise Policy) are given in Table B2 below.

The nearest residential receivers to the project are considered to be in a Noise Amenity Area characterised by the NSW Industrial Noise Policy as Urban.

Indicative Noise Amenity Area	Period	Recommended $L_{Aeq,period}$ Noise Level (ANL)	
		Acceptable	Recommended Maximum
Residential	Day	60	65
	Evening	50	55
	Night	45	50
Commercial	When in use	65	70

Table B2 : Recommended L_{Aeq} noise levels from industrial noise sources at residential and commercial receivers

For the purpose of this assessment, “Acceptable” noise levels as presented in the table above are to be adopted.

b) Amenity criterion

The amenity criterion is determined from the relationship of the existing L_{Aeq} noise level and the Acceptable Noise Levels (ANL’s) for each land use type under consideration using Table 2.2 of the NSW Industrial Noise Policy. This process is summarised below in Table B3 for the closest residential receivers to the site. The L1 – rooftop – noise levels are used as they describe the worst-case scenario for the amenity criterion.

Indicative Noise Amenity Area	Period	Existing L_{Aeq}	ANL	Adjustment	Amenity Criterion
Residential	Day	67	60	Existing L_{Aeq} minus 10	57
	Evening	66	50	Existing L_{Aeq} minus 10	56
	Night	62	45	Existing L_{Aeq} minus 10	52
Commercial	When in use	67	65	Existing L_{Aeq} minus 10	57

Table B3 : Determination of amenity criterion for residential and commercial receivers

B.4 Project specific noise level

The Project Specific Noise Level is defined as the lower of the intrusiveness and the amenity criteria. On this basis, the Project Specific Noise Levels (PNLs) are shown in Table B4 below (PNLs shown shaded).

<i>Indicative Noise Amenity Area</i>	<i>Period</i>	<i>Intrusiveness Criterion</i>	<i>Amenity Criterion</i>
<i>Residential</i>	Day	61	57
	Evening	59	56
	Night	53	52
<i>Commercial</i>	When in use	---	57

Table B4 : Determination of project specific noise levels for the site

Appendix C: Building Damage Vibration Criteria

There is little reliable data on the threshold of vibration-induced damage in buildings. Although vibrations induced in buildings by ground-borne excitation are often noticeable, there is little evidence that they produce even cosmetic damage. This lack of data is one of the reasons that there is variation between international standards.

There are however several standards that can be referred to.

C.1 ISO Standard

There is an international standard ISO 4866:1990² which provides general procedures for the measurement and evaluation of vibration in buildings. It applies to structures built above or below ground, such structures that are used or maintained for buildings.

It classifies damage to structures, as 'cosmetic' (formation of hairline cracks or growth of existing cracks), 'minor' (formation of large cracks or loosening and falling plaster) and 'major' (damage to structural elements). It does not provide levels of permissible vibration to prevent onset of cosmetic damage. This is left to National standards bodies, but does indicate factors which increase sensitivity of a structure to vibration damage such as; category of structure (elderly/modern), foundation types (from piled to no foundation at all), soil type (from rock to fill). It indicates that limits should be approached in a probabilistic way, where minimal risk for a named effect (e.g. cosmetic damage) is usually taken as a 95% probability of no effect.

C.2 German Standard

The relevant German standard is DIN 4150.3:1999³. This standard gives guidelines for short-term and steady state structural vibration. For short-term vibration in buildings the following limits are given:

² ISO 4866:1990 'Mechanical Vibration and Shock – Vibration of Fixed Structures – Guidelines for the Measurement of Vibrations and Evaluation of Their Effects on Structures'

³ DIN 4150.3:1999 'Structural Vibration Part 3: Effects of vibration on structures'

Structural type	Vibration Velocity, v_i , in mm/s			
	Foundation			Plane of floor of uppermost full storey
	Less than 10Hz	10 to 50Hz	50 to 100Hz	Frequency mixture
Commercial, industrial or similar	20	20 to 40	40 to 50	40
Dwellings or similar	5	5 to 15	15 to 20	15
Particularly Sensitive	3	3 to 8	8 to 10	8

Table C1: Guideline Values of Vibration Velocity, v_i , for Evaluating the Effects of Short-term Vibration

The guidelines state that:

“...Experience to date has shown that, provided the values given in Table D2 are observed, damage due to vibration, in terms of a reduction in utility value, is unlikely to occur. If the values of table D2 are exceeded, it does not necessarily follow that damage will occur. Should these values be significantly exceeded, further investigation is necessary.”

C.3 Swiss Standard

The relevant Swiss standard is SN 640312A:1992⁴. For steady state vibration, from machines, traffic and construction in buildings the following limits are given:

Structural type	Vibration Velocity, v_i , in mm/s	
	Foundation	
	10 to 30Hz	30 to 60Hz
Commercial, industrial including retaining walls	12	12 to 18
Foundation walls and floors in concrete or masonry. Retaining walls and ashlar construction	8	8 to 12
Foundations and basement floors concrete, with wooden beams on upper floors. Brick walls	5	5 to 8
Particularly Sensitive	3	3 to 5

Table C2: Guideline Values of Vibration Velocity, v_i , for Evaluating the Effects of Steady State Vibration

⁴ SN 640312A:1992 'Vibrations - Vibration Effects In Buildings'

C.4 British Standard

The relevant standard is BS 7385.2:1993⁵. This standard was developed from an extensive review of UK data, relevant national and international documents and other published data, which yielded very few cases of vibration-induced damage. This standard contains the most up-to-date research on vibration damage in structures. Part 2 of the standard gives specific guidance on the levels of vibration below which building structures are considered to be at minimal risk.

The Standard proposes the following limits on the foundations of the building:

Structural type	Peak component particle velocity in frequency range of predominant pulse	
	4 to 15Hz	15Hz and above
Unreinforced or light framed structures Residential or light commercial type buildings	15mm/s @ 4Hz increasing to 20mm/s @ 15Hz	20mm/s @ 15Hz increasing to 50mm/s @ 40Hz and above

Table C3: Transient Vibration Guide Values for Cosmetic Damage

The standard states in Annex A, that “... *the age and existing condition of a building are factors to consider in assessing the tolerance to vibration. If a building is in a very unstable state, then it will tend to be more vulnerable to the possibility of damage arising from vibration or any other ground-borne disturbance.*”

It is recommended that buildings of importance be considered on a case-by-case basis with detailed engineering analysis being carried out if necessary.

Annex B of the Standard gives a breakdown of data that should be recorded. Included in this are details of the building structure, such as general condition of the structure, list of defects, photographs, details of all major extensions, repairs and renovations. A crack exposure report should be prepared both pre and post exposure, both internally and externally.

⁵ BS 7385.2:1993 'Evaluation and Measurement for vibration in Buildings. Guide to damage levels from ground-borne vibration'

C.5 Australian Standard

There is no specific Australian Standard referring to structural vibration in buildings. There is however AS 2187.2:1993⁶, which, in Appendix J, recommends maximum peak particle velocities, measured at the ground surface due to blasting. The lower recommended peak particle velocity is 10 mm/s. The standard states however, that structures that may be particularly susceptible to ground-borne vibration should be examined on an individual basis. It is suggested that in the absence of a particular site-specific study then a maximum peak particle velocity of 5 mm/s is used.

⁶ AS2187.2:1993 'Explosives - Storage, transport and use. Part 2: Use of explosives'