WOOD & GRIEVE ENGINEERS

The Brewery Yard

Acoustic Report

Noise & Vibration Impact Assessment for State Significant Development Application

Prepared for:

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Date:
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Revision

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1. Introduction

As part of the documentation package to be submitted for the State Significant Development Application, Wood & Grieve Engineers has been engaged by Johnstaff Projects (NSW) Pty Ltd to provide an acoustic assessment for the redevelopment/refurbishment of the existing heritage building at The Brewery Yard.

The proposed work is to include:

- Conversion of existing building to 'cold shell' suitable for commercial, retail and potentially hospitality
- Two (2) additional levels of commercial tenancies

This assessment has been prepared considering the following documents:

- City of Sydney Development Control Plan (DCP) 2012
- Interim Construction Noise Guideline (NSW Department of Environment and Climate Change)
- Transport for NSW's Construction Noise Strategy 2013
- AS2436:2010 "Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites"
- NSW Noise Policy for Industry (NPI)
- The NSW OEH "Assessing Vibration: A Technical Guideline (2006)
- British Standard BS5228: Part 1:1997 "Noise and Vibration Control on Construction and Open Sites."
- British Standard BS7358:1993 "Evaluation and Measurement for Vibration in Buildings" – Part 2: "Guide to Damage Levels from Groundborne Vibration"
- German Standard DIN4150-Part 3 "Structural vibration in buildings – Effects on structures"
- AS/NZS 2107:2016: Acoustics – Recommended design sound levels and reverberation times for building
- Secretary's Environmental Assessment Requirements (SEARs)

This assessment discusses the likely noise impact of the proposed development upon the nearest most-affected receivers.

This report provides:

- A statement of compliance with the City of Sydney and SEARs for the proposed development within the vicinity of the nearest potentially affected residential and commercial receivers.
- Recommendations for achieving the outlined criteria.

This report is based on our understanding of the proposed project, application of the relevant state guidelines and professional experience within the acoustic field. Therefore, this report shall not be relied upon as providing any warranties or guarantees.

2. Background

2.1 Information Sources

The following documentation has been used for the preparation of this report:

- Site drawings presenting the location of the proposed development in relation to the nearest receivers.
- Architectural drawings provided by Tzannes
- Noise data collected on site through the use of noise loggers and a hand held type 1 spectrum analyser.

3. Project Overview

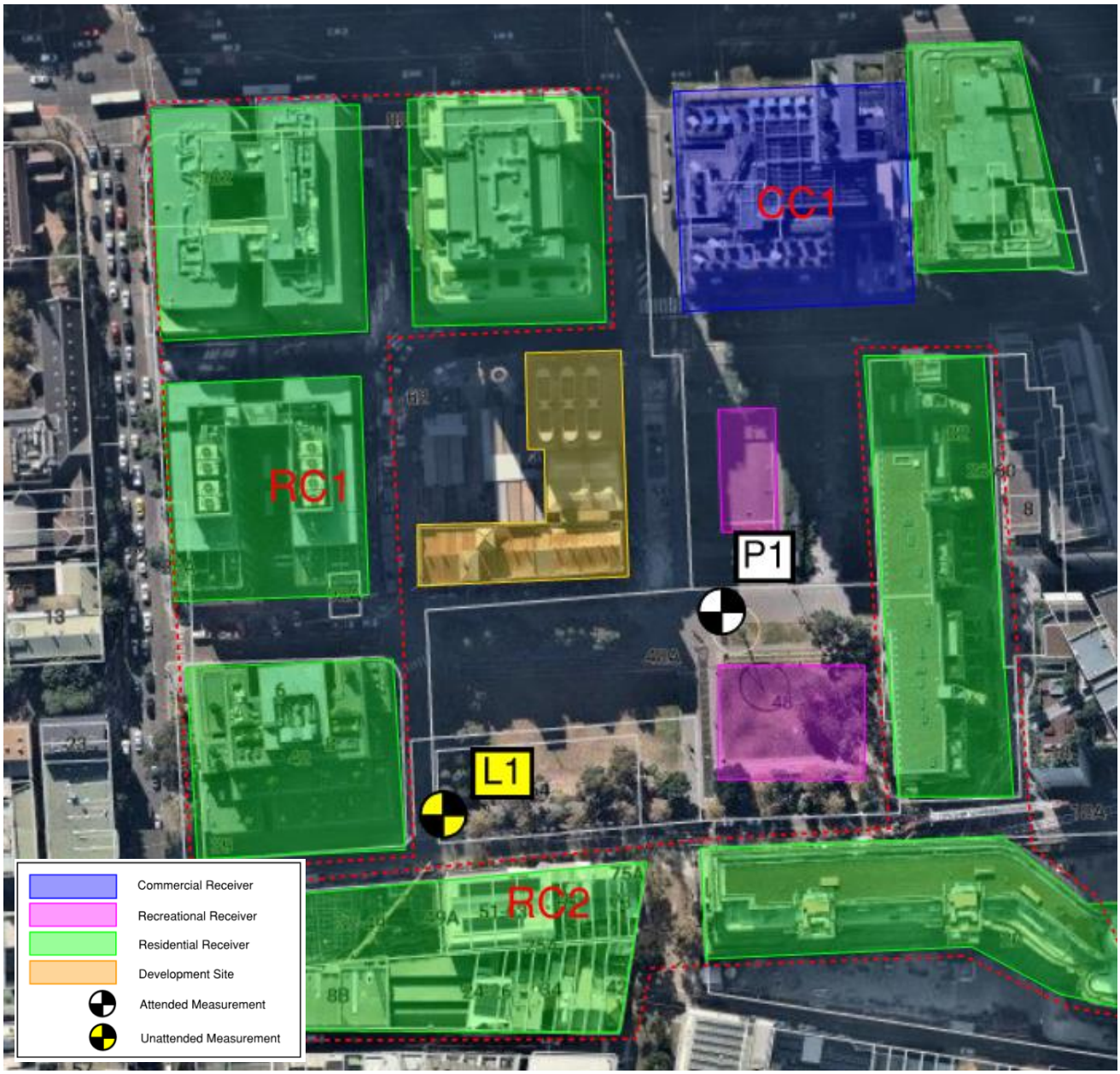
The site is located in Chippendale at the existing Brewery Yard and is bound by residential accommodation to the North and West, and Chippendale Green and park areas to the South and East. The site location, measurement positions and surrounding residential receivers are shown in Figure 1. The residential noise receivers have been grouped into two catchment areas, designated RC1 and RC2 with the boundary shown as a red dashed line. There is a single commercial receiver designated CC1, and for the operational noise assessment the two areas indicated have been classified as recreational areas (as per the NPI).

3.1.1 Acoustic Issues

The acoustic issues relating to the operation of the development are as follows:

- Noise emissions from mechanical services from the development to surrounding receivers
- Noise intrusion to the internal spaces of the development
- Construction noise and vibration to surrounding receviers

Figure 1: Overview of the site and measurement locations



Source: nearmap.com

3.2 Instrumentation

The following equipment was used for the noise surveys:

- ARL Environmental Noise Logger NL-42EX S/N 00521657;
- Hand-held sound spectrum analyzer B&K 2250, S/N 2709742;
- Sound Calibrator B&K Type 4231, S/N 2709826;

All equipment was calibrated before and after the measurements and no significant drift was found. All equipment carries current traceable calibration certificates that can be provided upon request.

3.3 Unattended Noise Survey Results

This assessment will consider the method for determining the rating background level (RBL) for each period of the day in accordance with the NSW Noise Policy for Industry (NPI). The NPI defines background and ambient noise for the daytime, evening and night time periods as follows:

Day: is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.

Evening: is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.

Night: is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays**.**

3.3.1 Background and Ambient Noise Monitoring

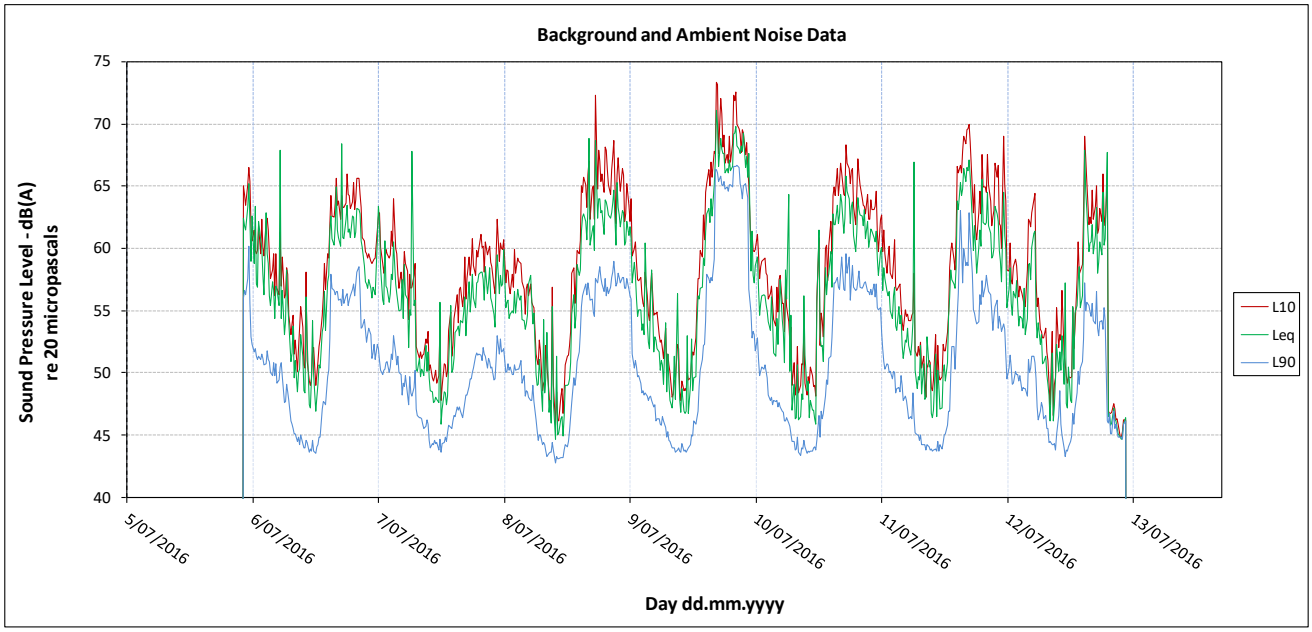
A noise logger was placed at position L1 as shown in Figure 1 to measure the background and ambient noise that is representative of RC1 and RC2 residential receivers. The logger was installed from the 6th to the 13th of July 2018. The results of the unattended background noise survey is shown in Table 1 below (for the day, evening and night periods). Note that any extraneous data or rain affected data has been excluded from the calculations.

Table 1: Unattended noise measurements L1

Location	Equivalent Continuous Noise Level $L_{Aeq,period}$ - dB(A)			Background Noise Level RBL - dB(A)		
	Day	Evening	Night	Day	Evening	Night
L1	63	56	54	52	48	44

Refer to Figure 2 for the logger data. Note that the daytime may be impacted by construction noise from surrounding works.

Figure 2: Logger data L1



3.1 Attended Noise Survey Results

Attended noise measurements of 15-minute period were conducted on site in order to characterize the acoustic environment for the noise intrusion into the development and to determine any noise impact on the surrounding receivers. A summary of the attended noise measurements taken at the site are shown on Table 2 below. Refer to Figure 1 for the measurements location.

Table 2: Attended noise measurements

Measurement Location	Measurement Time	$L_{Aeq, 15mins}$, dB(A)	$L_{A90, 15mins}$, dB(A)	Comments
P1	13/07/18 12:28pm	61	57	Noise from people, intermittent construction noise

4. Noise & Vibration Criteria

4.1 Secretary's Environmental Assessment Requirements (SEARs)

The following SEARs requirement have been addressed in this report:

- *Identify the main noise generating sources and activities of construction*
- *Identify any noise sources during operation, and potential impacts on the surrounding residential development*
- *Outline measures to minimise and mitigate the potential noise impacts on surrounding occupiers of land*

The following criteria has been outlined in order to address the above requirements in addition to any council and state requirements.

4.2 Internal Noise Criteria

In the absence of any specific requirements from the City of Sydney regarding internal noise levels for mixed use developments, Australian Standard AS/NZS 2107:2016 – *'Acoustics- Recommended design sound levels and reverberation times for building interiors'* has been used. AS/NZS2107:2016 specifies target noise levels for internal spaces for the proposed development, as summarised below Table 3.

Table 3: Recommended noise levels according to AS/NZS 2107:2016

Type of occupancy / activity	Design sound level L_{Aeq}, dB(A) range
Meeting room	40-45
Function areas	40-45
Small retail stores	<50
Open plan office	40-45
General office areas	40-45
Board and conference rooms	30-40

4.3 Site Noise Emission

4.3.1 City of Sydney Noise Criteria

City of Sydney state the following in regards to mechanical plant noise emissions:

a) *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 LAeq, 15minute 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. Noise must be measured in accordance with the Industrial Noise Policy and relevant requirements of Australian Standard AS 1055-1997 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 LA90, 15 minute / rating LA90, 15 minute process to be in accordance with the requirements for noise monitoring listed in the NSW EPA Industrial Noise Policy and relevant requirements of Australian Standard AS1055-1997 Standard AS 1055-1997 Acoustics – Description and measurement of environmental noise.*
   III. *Modifying factors in Table 4.1 of the NSW EPA Industrial Noise Policy are applicable*.

b) *A cumulative LAeq,15minute noise level emitted from the use consistent with the operation of any mechanical plant, equipment, air conditioning / ventilation, apparatus, tool, device machine or mechanism must not exceed the LA90, 15minute noise level by more than 3dB 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 LAeq,15minute noise level and the LA90,15minute 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 (LA90, 15 minute) 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 AS1055.1 Acoustics – Description and measurement of environmental noise.*
   III. *Where assessed internally at a location with limited or no external environmental 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 LA90, 15minute noise level is below the threshold of hearing, Tf 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 Tf corresponding to that Octave Band Centre Frequency shall be used instead.*

As per the City of Sydney condition, the windows of the residence have been assumed closed. To assess noise the internally, it is assumed windows are 4mm glass and internal noise levels are equivalent to NR25 which is typical for an air conditioned space i.e. an internal noise level of 35dB(A).

Note that the NSW Noise Policy for Industry has been used as this supersedes the NSW Industrial Noise Policy.

4.3.2 NSW Noise Policy for Industry

The NSW Noise Policy for Industry has been applied to the address the noise emissions from the development to the surrounding sensitive receivers. The NSW NPI sets out noise criteria to control the noise emission from industrial noise sources. Mechanical and operational noise from the development shall be addressed following the guideline in the NSW NPI.

The calculation is based on the results of the ambient and background noise unattended monitoring, addressing two components:

- Controlling intrusive noise into nearby residences (Intrusiveness Criteria)
- Maintaining noise level amenity for particular land uses (Amenity Criteria)

Once both criteria are established, the most stringent for each considered assessment period (day, evening, night) is adopted as the project-specific noise level (PSNL).

Intrusiveness Criteria

The NSW NPI states the following:

> *"The intrusiveness of an industrial noise source may generally be considered acceptable if the level of noise from the source (represented by the LAeq descriptor), measured over a 15minute period, does not exceed the background noise level by more than 5 dB when beyond a minimum threshold."*

The intrusiveness criterion can be summarised as L_{Aeq}, 15 minute $\leq$ RBL background noise level plus 5 dB(A).

Table 4: NSW NPI intrusiveness criteria

Period	Noise Descriptor – dB(A)	Noise Criteria – dB(A)
Day (7:00am to 6:00pm)	$L_{Aeq,15min} \leq$ RBL + 5	57
Evening (6:00pm to 10:00pm)	$L_{Aeq,15min} \leq$ RBL + 5	53
Night (10:00pm to 7:00am)	$L_{Aeq,15min} \leq$ RBL + 5	49

Amenity Criteria

The NSW NPI states the following:

> *"To limit continuing increases in noise levels from application of the intrusiveness level alone, the ambient noise level within an area from all industrial noise sources combined should remain below the recommended amenity noise levels specified in Table 2.2 where feasible and reasonable. The recommended amenity noise levels will protect against noise impacts such as speech interference, community annoyance and some sleep disturbance. The recommended amenity noise levels have been selected on the basis of studies that relate industrial noise to annoyance in communities (Miedema and Voss, 2004).*

The applicable parts of Table 2.2: Amenity noise levels from Industrial Noise Sources – L_{Aeq}, dB(A) which are relevant to the project are reproduced below:

Table 5: NSW NPI amenity criteria for external noise levels

Type of Receiver	Noise amenity area	Time of Day	L_{Aeq}, dB(A)	Project amenity noise level $L_{Aeq,period}$
			Recommended amenity noise level	
Residential	Urban	Day	60	55
		Evening	50	46
		Night	45	44
Commercial	All	When in use	65	60
Active recreation	All	When in use	55	53

Note: Urban area as defined in EPA INP 2. 2.1.6.

Note that where the resultant project amenity noise level is 10dB or more lower than the existing industrial noise level the project amenity noise levels can be set at 10dB below existing industrial noise levels if it can be demonstrated that existing industrial noise levels are unlikely to reduce over time.

'Modifying Factor' Adjustments

The NSW NPI also states:

> *"Where a noise source contains certain characteristics, such as tonality, intermittency, irregularity or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same noise level."*

In order to take into account the potential annoying character of the noise an adjustment of 5 dB(A) for each annoying character aspect and cumulative of up to a total of 10 dB(A), is to be added to the measured value to penalise the noise for its potentially greater annoyance aspect.

Table C1 of Fact Sheet C of the NSW NPI (see Table 6 below) provides procedures for determining whether an adjustment should be applied for greater annoyance aspect.

Table 6: Table C1 from the NSW NPI – Modifying factor corrections

Factor	Assessment / Measurement	When to Apply	Correction[1]	Comments
Tonal Noise	One-third octave band analysis using the objective method for assessing the audibility of tones in noise – simplified method *(ISO1996.2-2007 – Annex D)*.	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: • 5 dB or more if the centre frequency of the band containing the tone is in the range 500–10,000 Hz • 8 dB or more if the centre frequency of the band containing the tone is in the range 160–400 Hz • 15 dB or more if the centre frequency of the band containing the tone is in the range 25–125 Hz.	5 dB[2,3]	Third octave measurements should be undertaken using unweighted or Z-weighted measurements. **Note**: Narrow-band analysis using the reference method in *ISO1996-2:2007, Annex C* may be required by the consent/regulatory authority where it appears that a tone is not being adequately identified, e.g. where it appears that the tonal energy is at or close to the third octave band limits of contiguous bands.
Low Frequency Noise	Measurement of source contribution C-weighted and A-weighted level and one-third octave measurements in the range 10–160 Hz	Measure/assess source contribution C- and A-weighted $L_{eq,T}$ levels over same time period. Correction to be applied where the C minus A level is 15dB or more and: • where any of the one-third octave noise levels in Table C2 are exceeded by up to and including 5 dB and cannot be mitigated, a 2dB(A) positive adjustment to measured/predicted A-weighted levels applies for the evening/night period • where any of the one-third octave noise levels in Table C2 are exceeded by more than 5 dB and cannot be mitigated, a 5-dB(A) positive adjustment to measured/predicted A-weighted levels applies for the evening/night period and a 2dB(A) positive adjustment applies for the daytime period.	2 or 5 dB[2]	A difference of 15 dB or more between C- and A-weighted measurements identifies the potential for an unbalance spectrum and potential increased annoyance. The values in Table C2 are derived from Moorhouse (2011) for DEFRA fluctuating low-frequency noise criteria with corrections to reflect external assessment locations.
Intermittent Noise	Subjectively assessed but should be assisted with measurement to gauge the extent of change in noise level.	The source noise heard at the receiver varies by more than 5 dB(A) and the intermittent nature of the noise is clearly audible.\	5 dB	Adjustment to be applied for **night-time only.**
Duration	Single-event noise duration may range from 1.5 min to 2.5 h	One event in any assessment period.	0 to 20 dB(A)	The project noise trigger level may be increased by an adjustment depending on duration of noise (see Table C3).
Maximum Adjustment	Refer to individual modifying factors	Where two or more modifying factors are indicated	Maximum correction of 10dB(A)[2] (excluding duration correction)	

1. Corrections to be added to the measured or predicted levels, except in the case of duration where the adjustment is to be made to the criterion.

2. Where a source emits tonal and low-frequency noise, only one 5-dB correction should be applied if the tone is in the low-frequency range, that is, at or below 160 Hz.

3. Where narrow-band analysis using the reference method is required, as outlined in column 5, the correction will be determined by the ISO1996-2:2007 standard.

4.4 Project criteria

4.4.1 Project specific noise levels

Refer to Table 7 for the NSW NPI criteria applicable to the mechanical noise emissions from the proposed development. These project specific noise levels are in accordance with the requirements of the NSW NPI, and shall be assessed to the most affected point on or within the residential boundary. Note that as per the NSW NPI, 3dB was used to convert period levels to 15-minute levels.

Table 7: Project specific noise levels

Period	Descriptor	PSNL dB(A)
Residential receivers		
Day (7:00am to 6:00pm)	$L_{Aeq,15min}$	57
Evening (6:00pm to 10:00pm)	$L_{Aeq,15min}$	49
Night (10:00pm to 7:00am)	$L_{Aeq,15min}$	47
Commercial receivers		
When in use	$L_{Aeq,15min}$	63
Active recreation		
When in use	$L_{Aeq,15min}$	56

4.4.2 City of Sydney

Refer to Table 8 for the criteria for mechanical noise emissions as per the requirements of City of Sydney Condition A and B. The criteria has been presented as an external noise level that has been calculated through 4mm glass (insertion loss of 4mm glass into a typical bedroom), in order to achieve the internal noise level requirements.

Table 8: City of Sydney criteria

Criteria	Frequency (Hz)									Overall
	31.5	63	125	250	500	1000	2000	4000	8000	dB(A)
Internal Background NR25	-	55	44	35	29	25	22	19	18	35
Internal Criteria	-	58	47	38	32	28	25	22	21	38
External Criteria (Based on 4mm glass)	-	66	58	53	52	53	53	47	46	59

4.5 Traffic Noise Generation Criteria

The L_{Aeq} noise level or the "equivalent continuous noise level" correlates best with the human perception of annoyance associated with traffic noise.

Road traffic noise impact is assessed in accordance with the introduced NSW Road Noise Policy which supersedes the *NSW Environmental Criteria for Road Traffic Noise* (ECRTN, Department of Environment Climate Change and Water 1999). The criterion (Table 3 – Road Traffic Noise Assessment Criteria for Residential Land Uses) divides land use developments into different categories and lists the respective criteria for each case. The category that is relevant to the proposed use of the site is shown below in Table 9.

Table 9: NSW Road Noise Policy – Traffic noise assessment criteria

Road Category	Type of project/land use	Assessment Criteria – dB(A)	
		Day (7am – 10pm)	Night (10pm – 7am)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq,1\ hour}$ 55 (external)	$L_{Aeq,1\ hour}$ 50 (external)

In the event that the traffic noise at the site is already in excess of the criteria noted above, the NSW RNP states that the primary objective is to reduce the existing level through feasible and reasonable measures to meet the criteria above.

If this is not achievable, Section 3.4.1 Process for applying the criteria – Step 4 states that for existing residences affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise should be limited to 2 dB above that of the corresponding 'no build option'.

4.6 Construction Noise Criteria

Noise criteria for construction sites are established in accordance with the Interim Construction Noise Guideline (*ICNG July 2009*) by the NSW Office of Environment & Heritage (NSW OE&H) currently under the NSW Environment Protection Authority (EPA). It is important to note that the recommended criteria are for planning purposes only. Numerous other factors need to be considered when assessing potential noise impacts from construction works.

However, in undertaking the assessment of potential noise intrusion associated with the proposed construction activities, Chapter 4 of the NSW EPA ICNG (July 2009) were specifically referenced. The noise limits are presented in Table 10, and are applicable to the development.

Table 10: NSW ICNG Construction noise criteria

Time of Day	**Management Level** $L_{Aeq,15min}$ *	**How to Apply**
Recommended Standard Hours: Mon – Fri (7am – 6pm) Sat (8am – 1pm) No work on Sunday & Public Holidays	Noise Affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq,15min}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residences of the nature of works to be carried out, the expected noise levels and duration as well as contact details.
	Highly Noise Affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur in, taking into account: • Times identified by the community when they are less sensitive to noise (such as before and after school, for works near schools, or mid-morning or mid-afternoon for works near residences) • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside Recommended Standard Hours	Noise Affected RBL + 5dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see section 7.2.2.

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

Source: Chapter 4 (Table 2 Sec 4.1.1) of NSW EPA ICNG

4.7 Construction Vibration Criteria

The office of Environment and Heritage (OEH) developed a document, "Assessing vibration: A technical guideline" in February 2006 to assist in preventing people from exposure to excessive vibration levels from construction and operation of a development within buildings. The guideline does not however address vibration induced damage to structures or structure-borne noise effects. Vibration and its associated effects are usually classified as continuous, impulsive or intermittent.

4.7.1 Human Comfort – Continuous and Impulsive Vibration Criteria

Structural vibration in buildings can be detected by occupants and can affect them in many ways including reducing their quality of life and also their working efficiency. Complaint levels from occupants of buildings subject to vibration depend upon their use of the building and the time of the day.

Maximum allowable magnitudes of building vibration with respect to human response are shown in Table 11. It should be noted that the human comfort for vibration are more stringent than the building damage criteria.

Table 11: Preferred and maximum weighted RMS values for continuous and impulsive vibration (m/s^2)

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration					
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and place of worship	Day or night time	0.020	0.014	0.040	0.028
Impulsive vibration					
Residences	Daytime	0.30	0.21	0.60	0.42
	Night time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and place of worship	Day or night time	0.64	0.46	1.28	0.92

4.7.2 Human Comfort – Intermittent Vibration Criteria

Disturbance caused by vibration will depend on its duration and its magnitude. This methodology of assessing intermittent vibration levels involves the calculation of a parameter called the Vibration Dose Value (VDV) which is used to evaluate the cumulative effects of intermittent vibration. Various studies support the fact that VDV assessment methods are far more accurate in assessing the level of disturbance than methods which is only based on the vibration magnitude.

Table 12: Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime (7:00am to 10:00pm)		Night-time (10:00pm to 7:00am)	
	Preferred value	Maximum value	Preferred value	Maximum value
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and place of worship	0.40	0.80	0.40	0.80

4.7.3 Structural Damage – Vibration Criteria

Ground vibration criteria are defined in terms of levels of vibration emission from the construction activities which will avoid the risk of damaging surrounding buildings or structures. It should be noted that human comfort criteria are normally expressed in terms of acceleration whereas structural damage criteria are normally expressed in terms of velocity.

Most commonly specified structural vibration levels are defined to minimize the risk of cosmetic surface cracks and are set below the levels that have the potential to cause damage to the main structure. Structural damage criteria are presented in German Standard DIN4150-Part 3 "Structural vibration in buildings – Effects on structures" and British Standard BS7385-Part 2: 1993 "Evaluation and Measurement for Vibration in Buildings". Table 13 indicates the vibration limits presented in DIN4150-Part 3 to ensure structural damage doesn't occur.

Table 13: Guideline value of vibration velocity, vi, for evaluating the effects of short-term vibration

Line	Type of Structure	Vibration velocity, vi, in mm/s			
		Foundation			Plane of floor of uppermost full storey
		At a frequency of			
		Less than 10Hz	10 to 50Hz	50 to 100*Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8
*For frequencies above 100Hz, at least the values specified in this column shall be applied					

Table 14 presents guide values for building vibration, based on the lowest vibration levels above which cosmetic damage has been demonstrated as per BS7385-Part 2:1993.

Table 14: Transient vibration guide values for cosmetic damage

Type of Building	Peak Particle Velocity in frequency range of predominant pulse (PPV)	
Residential or light commercial type buildings	4 Hz to 15 Hz	15 Hz and above
	15mm/s at 4Hz increasing to 20mm/s at 15Hz	20mm/s at 15Hz increasing to 50mm/s at 40Hz and above

4.7.4 Vibration Objectives

Table 15 indicates the vibration criteria for the nearest residential properties to the development.

Table 15: Construction vibration criteria summary

Location	Period	Human Comfort Vibration Objectives			Building damage Objectives – Velocity (mm/s)
		Continuous mm/s^2 (RMS)		Intermittent $m/s^{1.75}$ (VDV)	
		z-axis	x- and y-axis		
Residential	Daytime	10 - 20	7 - 14	0.20 - 0.40	5
	Night time	7 - 14	5 - 10	0.13 - 0.26	5

5. External Traffic Noise Intrusion

The general limiting factor of the performance of a building façade in term of noise attenuation is the glazing. The site is generally affected by noise from Broadway and surrounding retail. In order to achieve the internal noise levels specified, the minimum recommended glazing selection for the façades of the proposed development is presented Table 16. The required Rw ratings have been provided which takes into account the performance when installed in a frame. The glazing thicknesses corresponding to the Rw ratings are presented below in Table 16, and should be considered as the minimum thicknesses to achieve acoustical ratings. Greater glazing thicknesses may be required for structural loading, wind loading, thermal requirements etc.

Table 16: Recommended acoustic performance of glazing system

Facade	Level	Glazing configuration	Required Acoustic Rating of Glazing Assembly, Rw[1]
All	All	6.38mm laminated glass	32
The required acoustic rating of glazing assembly, refers to the acoustic performance of the glazing once installed on site (including the frame)			

During the detailed design stage of the project the acoustic performance of the glazing facade should be reviewed as the combined noise from external sources and mechanical services could result in the internal noise level exceeding the design sound level.

[1] See Appendix 1 for Rw definition

6. Operational Noise Assessments

6.1 Mechanical Services Noise

This assessment has considered the noise emissions from the mechanical plant serving the internal spaces of the development. These noise sources have been used to predict the worst case scenario noise impact of the proposed use of the site to the nearby residential and commercial receivers. The assessment has been conducted as per the City of Sydney requirements to achieve noise levels as per the NSW NPI, and achieve the internal noise levels to the residences as per City of Sydney Condition B. Both have been assessed at the most affected external point at the surrounding residential receivers. The commercial receiver and the recreational receiver areas have been assessed as per the NPI.

The main mechanical sources associated with the development will include:

- Outside air fans with intake from louvres at the facades of the development

In order to assess the worst case scenario, it was assumed that the mechanical services associated with the development are running at any time throughout the day time. The units have been calculated from all building façades to the most affected external residential receiver. Refer to Table 17 for the maximum permissible sound power levels at the louvre locations such that the aforementioned criteria is achieved.

Table 17: Sound power levels at louvres

Louvre (Level - Façade)	SWL re 10^{-12} W dB								
	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	Overall dB(A)
Level 1 West	73	65	60	59	60	60	54	53	65
Level 1 West	73	65	60	59	60	60	54	53	65
Level 2 West	73	65	60	59	60	60	54	53	65
Level 2 West	73	65	60	59	60	60	54	53	65
Level 3 West	73	65	60	59	60	60	54	53	65
Level 3 West	73	65	60	59	60	60	54	53	65
Level 4 and 5 West	73	65	60	59	60	60	54	53	65
Level 6 West	73	65	60	59	60	60	54	53	65
Ground East	85	77	72	71	72	72	66	65	77
Level 1 East	85	77	72	71	72	72	66	65	77
Level 1 East	85	77	72	71	72	72	66	65	77
Level 1 East	85	77	72	71	72	72	66	65	77
Level 1 East	85	77	72	71	72	72	66	65	77
Level 2 East	85	77	72	71	72	72	66	65	77
Level 2 East	85	77	72	71	72	72	66	65	77
Level 2 East	85	77	72	71	72	72	66	65	77
Level 2 East	85	77	72	71	72	72	66	65	77
Level 3 East	85	77	72	71	72	72	66	65	77
Level 3 East	85	77	72	71	72	72	66	65	77
Level 6 East	85	77	72	71	72	72	66	65	77

Based on the maximum sound power levels at the louvres, the mechanical services noise emissions from the operation of the development are expected to comply with the requirements of the NSW NPI and the City of Sydney. Acoustic attenuation may be required to achieve the limits.

6.1.1 General Mechanical Services Mitigation Measures

Mitigation measures for the mechanical plant should be considered during the design development stage so as to comply with the outlined criteria at the nearest sensitive receivers. These amelioration measures could include but not limited to the following:

- Positioning mechanical plant away from nearby receivers
- Acoustic attenuators fitted to duct work
- Screening around mechanical plant
- Acoustic insulation within duct work
- Acoustic louvres

6.2 Waste collection

Waste collection shall be conducted with the implementation of the following management practices:

- Not operating before 7am or after 10pm
- Using up to date equipment that uses ‘quieter’ technology such as low noise bin filters
- Maintaining rubbish trucks and braking materials to minimize or eliminate noise such as squeaky brakes
- Educating drivers and collectors to be careful and to implement quiet work practices

7. Construction Noise & Vibration Assessment

7.1 Construction Noise Assessment

A noise assessment has been conducted as per the SEARs in order to addresses the construction noise impact on the surrounding receivers. The assessment has been based on the following information regarding the proposed construction works:

- Construction of new external stairs
- Concrete pouring
- Construction of façade openings
- Removal of silos to the south side of the building
- General construction activity

The hours of work are expected to occur during standard daytime hours as per the NSW ICNG.

7.2 Expected Construction Equipment

The noise sources likely to be associated with the works listed in the previous section of this report are presented in Table 18. In order to assess potential noise and vibration impacts during construction from a quantitative point of view, the worst case 15 minute scenario has been considered. The equipment noise levels have been extracted from AS2436:2010 Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites and construction noise and vibration guidelines from Transport for NSW and RMS.

Table 18: Construction Equipment Noise Levels

Phases	Equipment	Sound Power Level dB(A)
Demolition	Bobcat	104
	Jackhammer	113
	Demolition saw	117
	Truck	107
	Generator	104
	Powered hand tools	102
Construction	Rattle gun	104
	Generator	104
	Concrete pump	108
	Powered hand tools	102
	Bobcat	104
	Welder equipment	105
	Truck	107

7.3 Assumptions

In order to assess the noise impact from the site during construction, a noise model was established to represent the 'reasonable' worst case periods of construction activities.

The assumptions that were made within the assessment include the following:

- The predicted noise levels represent the worst case scenario for each receiver based on the location of the work being in nearest proximity, therefore typically the noise levels will be lower than predicted
- The height of the receiver has been assessed at 1.5m from ground level
- The predicted noise levels at the nearby sensitive receivers have been assessed with the acoustic recommendations as shown in Section 7.5 implemented.
- The noise levels have been assessed using neutral weather conditions.

The noise levels at the surrounding sensitive receivers has been based on the assumptions and aforementioned sound power levels of the equipment. The results of the predicted noise levels are presented in the following section. The assessment has presented the noise levels for the most affected point at the residences for the two catchment area. It is expected that each residential receiver within RC1 and RC2 is expected to have a similar level of impact.

7.3.1 Predicted Noise Levels

Refer to Table 19 for the predicted noise levels to the receiver catchment areas, assessed at 1.5m above ground level at the boundaries.

Table 19: Predicted Noise Levels Stage 1

ID	Receiver Type	Predicted Noise Level $L_{eq,15min}$ dB(A)	Noise Management Level $L_{eq,15min}$ dB(A)	Noise Management Level Exceedance (dB)	Compliance with highly noise affected (Yes/No)
Demolition					
RC1	Residential	72	62	10	Yes
RC2	Residential	68	62	6	Yes
CC1	Commercial	68	55	13	Yes
Construction					
RC1	Residential	71	62	9	Yes
RC2	Residential	69	62	7	Yes
CC1	Commercial	69	55	14	Yes

Compliance is achieved through a qualitative assessment. The contractor is to implement the acoustic measures shown in Section 7 as well as any other feasible and reasonable measures in order to reduce any potential adverse noise impact.

Based on this assessment the following conclusions have been made:

- The noise level at the façades of the residential receivers are predicted to be less than the highly noise affected level. The exceedances of the Noise Management Level (NML) are up to 10dB for the residential receivers in RC1 and 7dB for RC2, and up to 14dB for the commercial receiver.
- The equipment which is predicted to have the highest impact in a 15 minute period are demolition sawing and jackhammering.
- The predictions are based on assessing at 1.5m above ground. Due to the potential varying height of works, there is expected to be greater impact at the higher levels during certain times of construction.

7.4 Construction Vibration Assessment

The vibration associated with construction is dependent on a number of variables including the types of machinery, the proximity to the nearby receivers as well as the ground type. Generic safe working distances for vibration impacts associated with various types of machinery at given distances are presented within the transport for NSW 'Construction Noise Strategy' document. This document presents the safe construction working limits for Cosmetic Damage to adjacent structures (in accordance with BS 7385) and Human Comfort (OH&E).

Table 20: Working Distances for Vibration Intensive Plant

Plant Item	Rating/Description	Safe Working Distance	
		Cosmetic Damage (BS 7385)	Human Response (OH&E Vibration Guideline)
Vibratory Roller	<50 kN (Typically 1-2 tonnes)	5m	15m to 20m
	<100 kN (Typically 2-4 tonnes)	6m	20m
	<200 kN (Typically 4-6 tonnes)	12m	40m
	<300 kN (Typically 7-13 tonnes)	15m	100m
	>300 kN (Typically 13-18 tonnes)	20m	100m
	>300 kN (> 18 tonnes)	25m	100m
Small Hydraulic Hammer	(300kg – 5 to 12t excavator)	2m	7m
Medium Hydraulic Hammer	(900kg – 12 to 18t excavator)	7m	23m
Large Hydraulic Hammer	(1600kg – 18 to 34t excavator)	22m	73m
Vibratory Pile Driver	Sheet Piles	2m to 20m	20m
Pile Boring	≤800mm	2m	N/A
Jackhammer	Hand held	1m	Avoid contact with structure
Compactor	852G	10	20
Dozer	D810 with ripper	2 (nominal)	10
Excavator	≤30 Tonne	10	15
Grader	≤20 Tonne	2 (nominal)	10
Truck Movements	-	-	10m

The only equipment from Table 20 proposed to be used will be a jackhammer. It is recommended that attended vibration measurements be conducted at the nearest point on the heritage structure of the development and the levels be assessed against BS 7385 and DIN 4150 prior to commencement due to the sensitivity of the heritage structures.

7.5 Project Specific Acoustic and Vibration Recommendations

7.5.1 Noise

All reasonable and feasible measures shall be implemented as required to the equipment. The flow chart as shown in Figure 3 should be used to assist with noise mitigation and management measures in order to comply with the standards outlined in this report.

7.5.2 Vibration

Prior to the commencement of jackhammering, attended vibration measurements should be conducted to ensure the levels are acceptable on the heritage structure in respect to the criteria from BS 7385 and DIN 4150 due to the sensitive nature and the more stringent requirements for heritage structures.

7.6 General Acoustic Recommendations for Construction

According to AS 2436 – 2010 *"Guide to noise and vibration control on construction, demolition and maintenance sites"* the following techniques could be applied to minimize the spread of noise and vibrations to the potential receivers.

NOISE

If a process that generates significant noise levels cannot be avoided, the amount of noise reaching the receiver should be minimized. Two ways of achieving this are to either increase the distance between the noise source and the receiver or to introduce noise reduction measures such as screens.

Physical methods to reduce the transmission of noise between the site works and residences, or other sensitive land uses, are generally suited to works where there is longer-term exposure to the noise. Practices that will reduce noise from the site include:

(a) Increasing the distance between noise sources and sensitive receivers.
(b) Reducing the line-of-sight noise transmission to residences or other sensitive land uses using temporary barriers (stockpiles, shipping containers and site office transportables can be effective barriers).
(c) Constructing barriers that are part of the project design early in the project to introduce the mitigation of site noise.
(d) Installing purpose built noise barriers, acoustic sheds and enclosures.

Screening

On sites where distance is limited, the screening of noise may be beneficial and this should be taken into account during the planning stages.

If structures such as stores, site offices and other temporary buildings are situated between the noisiest part of the site and the nearest dwellings, some of the noise emission from the site can be reduced. If these buildings are occupied, sound insulation measures may be necessary to protect workers inside the buildings.

A hoarding that includes a site office on an elevated structure offers superior noise reduction when compared with a standard (simple) hoarding. The acoustic performance is further enhanced when the hoarding is a continuous barrier.

Storage of building materials or the placement of shipping containers between the noise source and any noise-sensitive area may also provide useful screening and the same is true of partially completed or demolished buildings. A noisy, stationary plant can be placed in a basement, the shell of which has been completed, provided reverberant noise can be controlled. Where compressors or generators are used in closed areas, it is necessary to ensure that the exhaust gases are discharged directly to the outside air and that there is good cross-ventilation to prevent the build-up of poisonous carbon monoxide fumes and to allow an adequate air supply to maintain efficiency when operating the equipment.

Where such noise barriers are not practical, a worthwhile reduction in noise can be obtained by siting the plant behind and as close as possible to mounds of earth, which may effectively screen any noise-sensitive areas from the plant. These can often be designed into the construction schedule or site arrangement for future landscaping.

Water pumps, fans and other plant equipment that operate on a 24-hour basis may not be an irritating source of noise during the day but may be problematic at night. They should therefore be effectively screened by either situating them behind a noise barrier or by being positioned in a trench or a hollow in the ground provided this does not generate reverberant noise. In such cases, however, adequate ventilation should also be ensured. Long, temporary earth embankments can provide quite an effective noise screen for mobile equipment moving, for example, on a haulage road. When the earthworks are complete, the earth mounds should be removed if possible with smaller, quieter excavators. A noise barrier may be a more reliable method of noise control than the imposition of restrictions on throttle settings.

In many cases it is not be practical to screen earthmoving operations effectively, but it may be possible to partially shield a construction plant or to build-in at the early stages protective features required to screen traffic noise. Where earth noise barriers are not practical due to lack of space, consideration should be given to the possibility of constructing temporary screens from wood or any equivalent material in surface density.

The usefulness of a noise barrier will depend upon its length, its height, its position relative to the source and to the receiver, and the material from which it is made. A barrier designed to reduce noise from a moving source should extend beyond the last property to be protected to a distance of not less than ten times the shortest measurement from the property to the barrier. A barrier designed to reduce noise from a stationary source should, where possible, extend to a distance beyond the direct line between the noise source and the receiver to a distance equal to ten times the effective barrier height, which is the height above the direct line between source and receiver.

If the works are predominately within nominally closed structures, careful consideration should be given to reducing noise breakout at any openings.

Crane (diesel operated)

An appropriate silencer on the muffler and acoustic screen around the engine bay are recommended to attenuate the noise from it.

Reversing and warning alarms

Community complaints often involve the intrusive noise of alarms commonly used to provide a safe system of work for vehicles operating on a site. Beeper reversing alarm noise is generally tonal and may cause annoyance at significant distances from the work site.

There are alternative warning alarms capable of providing a safe system of work that are equal to or better than the traditional ‘beeper’, while also reducing environmental noise impacts. The following alternatives should be considered for use on construction sites as appropriate:

(a) Broadband audible alarms incorporating a wide range of sound frequencies (as opposed to the tonal-frequency ‘beep’) are less intrusive when heard in the neighbourhood.

(b) Variable-level alarms reduce the emitted noise levels by detecting the background noise level and adjusting the alarm level accordingly.

(c) Non-audible warning systems (e.g. flashing lights, reversing cameras) may also be employed, providing safety considerations, are not compromised.

(d) Proximity alarms that use sensors to determine the distance from objects, such as people or structures, and generate an audible alarm in cabin for the driver.

(e) Spotters or observers.

The above methods should be combined, where appropriate.

Figure 3: Noise mitigation management flow chart

7.7 Noise & Vibration Monitoring Strategy

7.7.1 General Methodology

Noise and vibration levels should be monitored from time to time to ensure that noise generated as a result of remediation and construction activities does not disturb local businesses and residents.

Monitoring may be in the form of regular checks by the builder or indirectly by an acoustic consultant engaged by the builder and in response to any noise or vibration complaints. Where noise and vibration criteria are being exceeded or in response to valid complaints, noise and / or vibration monitoring should be undertaken. This would be performed inside the premises of the affected property and on site adjacent to the affected receivers.

Monitoring is to be undertaken by an experienced noise and vibration monitoring professional or an acoustic consultant. The results of any noise or vibration monitoring are to be provided to the relevant party or person in a timely manner allowing the builder to address the issue and respond to the complaints.

Noise and vibration monitoring can take two forms:

1. Short term monitoring
2. Long-term monitoring

Short-term monitoring

Short-term monitoring consists of attended monitoring when critical stages of the construction are occurring. This normally provides real-time assistance and guidance to the subcontractor on site letting them know when the noise and vibration criteria are exceeded allowing the selection of alternative method on construction or equipment selection in order to minimise noise and vibration impacts.

Long-term monitoring

Similarly long-term monitoring uses noise and vibration loggers providing real-time alerts to the builder / site manager when the noise and vibration criteria are exceeded.

Typically, the noise and vibration loggers stay on site for a period of several months for the critical construction stages of the project. Sometimes the period of construction noise and vibration monitoring is dictated by the local authorities through the DA conditions.

Both methodology are complementary and normally used simultaneously providing a significant of amount of data via the long-term monitoring but also providing information on the sources of noise and vibration generating exceedances via the short-term or attended monitoring.

7.7.2 Noise & Vibration Monitoring Programme

The following monitoring program is proposed for this project:

1. Attended vibration measurements prior to commencement of jackhammering. Location to be confirmed with an acoustic consultant at commencement.
2. Unattended noise monitor installed at most affected point at RC1 for a period during construction in order to confirm levels are consistent with this CNVMP.

The monitoring programme as shown above is to be carried out during the likely noisiest stages as agreed with the Acoustic engineer and Contractor.

8. Conclusion

An acoustic assessment for the proposed redevelopment/refurbishment of The Brewery Yard has been conducted. This document forms part of the documentation package to be submitted for the State Significant Development Application.

This report has provided criteria, in-principle treatment and design requirements, which aim to achieve the statutory criteria as discussed in the report. In terms of noise criteria, the following have been provided:

- Internal noise levels in accordance with AS2107:2016
- Criteria for external noise emissions in accordance with City of Sydney and NSW NPI
- Construction noise criteria
- Construction vibration criteria
- Construction noise and vibration management measures

The external glazing requirements have been provided in order to achieve the recommended internal noise goals, based on the external noise levels the site is exposed to.

The mechanical services have been reviewed and maximum sound power levels at the louvres have been provided to achieve the noise emissions limits as stipulated by City of Sydney and the NSW NPI. This is a preliminary assessment and further acoustic mitigation measures will be provided to meet the requirements.

A construction noise and vibration assessment has been conducted as per the requirements of the NSW ICNG. A general management plan has been outlined as to any specific acoustic mitigation measures that should be implemented during construction.

Even though no assessment can be considered as being thorough enough to preclude all potential environmental impacts, having given regard to the above listed conclusions, it is the finding of this assessment that the development application should not be refused on the grounds of excessive noise generation.

The information presented in this report shall be reviewed if any modifications to the features of the development specified in this report occur, including and not restricted to selection of air-conditioning units, layout of equipment, modifications to the building and introduction of any additional noise sources.

APPENDIX A Glossary of Acoustic Terms

NOISE	
Acceptable Noise Level:	The acceptable LAeq noise level from industrial sources, recommended by the EPA (Table 2.1, INP). Note that this noise level refers to all industrial sources at the receiver location, and not only noise due to a specific project under consideration.
Adverse Weather:	Weather conditions that affect noise (wind and temperature inversions) that occur at a particular site for a significant period of time. The previous conditions are for wind occurring more than 30% of the time in any assessment period in any season and/or for temperature inversions occurring more than 30% of the nights in winter).
Acoustic Barrier:	Solid walls or partitions, solid fences, earth mounds, earth berms, buildings, etc. used to reduce noise.
Ambient Noise:	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment Period:	The period in a day over which assessments are made.
Assessment Location	The position at which noise measurements are undertaken or estimated.
Background Noise:	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level.
Decibel [dB]:	The units of sound pressure level.
dB(A):	A-weighted decibels. Noise measured using the A filter.
Extraneous Noise:	Noise resulting from activities that are not typical of the area. Atypical activities include construction, and traffic generated by holidays period and by special events such as concert or sporting events. Normal daily traffic is not considered to be extraneous.
Free Field:	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground
Frequency:	Frequency is synonymous to pitch. Frequency or pitch can be measured on a scale in units of Hertz (Hz).
Impulsive Noise:	Noise having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent Noise:	Level that drops to the background noise level several times during the period of observation.

LAmax	The maximum A-weighted sound pressure level measured over a period.
LAmin	The minimum A-weighted sound pressure level measured over a period.
LA1	The A-weighted sound pressure level that is exceeded for 1% of the time for which the sound is measured.
LA10	The A-weighted sound pressure level that is exceeded for 10% of the time for which the sound is measured.
LA90	The A-weighted level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
LAeq	The A-weighted "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
LAeqT	The constant A-weighted sound which has the same energy as the fluctuating sound of the traffic, averaged over time T.
Reflection:	Sound wave changed in direction of propagation due to a solid object met on its path.
R-w:	The Sound Insulation Rating R-w is a measure of the noise reduction performance of the partition.
SEL:	Sound Exposure Level is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound Absorption:	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound Level Meter:	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound Pressure Level:	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound Power Level:	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise:	Containing a prominent frequency and characterised by a definite pitch.