REVERB ACOUSTICS

Noise and Vibration Consultants

Noise Impact Assessment
Wests Newcastle Development
309 King Street
Newcastle NSW

August 2018

Prepared for Graph Building Pty Ltd
Report No. 17-2090-R2

Building Acoustics - Council/EPA Submissions - Modelling - Compliance - Certification

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1 INTRODUCTION

Reverb Acoustics has been commissioned to conduct a noise impact assessment for the proposed Wests Newcastle Development at 309 King Street, Newcastle. The purpose of this assessment is to determine the noise impact from passing road traffic, and commercial activity within habitable spaces of the development and to ensure that noise levels comply with the requirements of the Roads and Maritime Services (RMS), Department of Planning and Environment (DPE), NSW Environment Protection Authority (EPA) and Newcastle City Council (NCC). Further assessment has also been carried out to determine the noise impact activities and equipment associated with the development may have on nearby neighbours (i.e. vehicle movements, mechanical plant, etc).

The assessment was requested by Graph Building Pty Ltd to form part of and in support of a Development Application to NCC and to ensure any noise control measures are incorporated into the design of the new buildings and site.

2 TECHNICAL REFERENCE / DOCUMENTS

AS 2107-2016 *"Acoustics-Recommended Design Sound Levels and Reverberation Times for Building Interiors".*

AS 1276.1-1999 *"Acoustics – Rating of sound insulation in buildings and of building elements. Part 1: Airborne sound insulation".*

NSW Environment Protection Authority (2013). *Rail Infrastructure Noise Guideline.*

NSW Environment Protection Authority (1999). *Environmental Criteria for Road Traffic Noise*

NSW Environment Protection Authority (2017). *Noise Policy for Industry*

Department of Environment and Climate Change NSW (2007). *Noise Guide for Local Government.*

NSW Environment Protection Authority (1992). *Environmental Noise Control Manual*

Plans supplied by Fender Katsalidis Pty Ltd, dated 18 May 2018. Note that variations from the design supplied to us may affect our acoustic recommendations.

A Glossary of commonly used acoustical terms is presented in Appendix A to aid the reader in understanding the Report.

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3 EXISTING ACOUSTIC ENVIRONMENT

A background noise level survey was conducted using a Type 1, Svan 949 environmental noise logging monitor, installed in a weatherproof security cage on the south side of Bull Street, approximately 8 metres from the near lane of traffic (see M1 - Figure 1). Sound levels were continuously monitored for 7 days of suitable weather conditions. The instrument was programmed to accumulate environmental noise data continuously and store results in internal memory. The data were then analysed to determine 15 minute Leq and statistical noise levels using dedicated software supplied with the instrument.

The instrument was calibrated with a Brüel and Kjaer 4230 sound level calibrator producing 94dB at 1kHz before and after the monitoring period, as part of the instrument's programming and downloading procedure, and showed an error less than 0.5dB.

Additional attended noise level monitoring was conducted at the existing facade on King Street, approximately 7 metres from the near lane of traffic, during peak periods (see M2 – Figure 1).

Long-term background and traffic noise level measurements were also taken by Muller Acoustic Consulting in March 2018 on the roof of an existing building at 426 King Street, approximately 11 metres from the near lane of traffic for the proposed City Exchange Apartments (see M3 – Figure 1).

Table 1 shows a summary of all noise surveys, including the Assessment Background Level's (ABL's), which were determined according to the procedures described in the EPA's Noise Policy for Industry (NPI) and with reference to guidelines detailed in Australian Standard AS1055-1997, "Acoustics - Description and Measurement of Environmental Noise, Part 1 General Procedures".

Table 1: Measured Noise Levels, dB(A)

Time	Date	Lmax	L90	Leq
Monitoring Location M1 – Bull Street				
DAY	May 2018	78	50 #	61
EVENING	May 2018	79	46 #	59
NIGHT	May 2018	68	41 #	55
Monitoring Location M2 – South Side of King Street				
08:45	25/05/18	80.6	54	66
01:30	26/05/18	78.5	47	62
Monitoring Location M3 – North Side of King Street				
DAY	March 2018	75	56 #	64
EVENING	March 2018	74	53 #	62
NIGHT	March 2018	73	47 #	59

Site, weather and measuring conditions were all satisfactory during our noise surveys. We therefore see no serious reason to modify the results because of influencing factors related to the site, weather or our measuring techniques.

Figure 1: Site Plan

LEGEND:

R1. DA Approved City Exchange Apartments
R2. Quest Apartments
R3. Wests Newcastle
R4. Government Offices
R5. Commercial Dev'p & Parking Station
R6. F45 Gym
R7. Marketown Apartments
R8. McDonalds Restaurant

The Sound Pressure Level's (SPL's) of additional noise sources identified during our site visits are listed below:

Item	*SPL dB(A),Lmax*	*Comments*
Pedestrians/Patrons (S1)	50	@ 10m
Roof-Top Mech Plant (S2)	60	@ 20m
Gym Activities (S3)	46	@ 20m
Cars/Customers in Carpark (S4)	56	@ 20m
Cars in carpark (S5)	54	@ 10m
Patrons in courtyard (S6)	52	@ 10m
Cars entering/leaving carpark (S7)	62	@ 10m
Dock, Trucks, etc (S8)	68	@ 10m
Cars enter/leave carpark (S9)	54	@ 10m

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4 CRITERIA

4.1 Road Traffic

Criteria for the assessment of quasi-steady-state noise sources, such as continuous road traffic and mechanical services, are sourced from AS/NZS 2107-2016 *"Acoustics-Recommended Design Sound Levels and Reverberation Times for Building Interiors"* and are detailed below.

Room Type	dBA
RESIDENTIAL BUILDINGS	
Houses and apartments near major roads	
Living areas	35 – 45
Sleeping areas	35 – 40
Common areas (foyer, lobby)	45 – 50
SHOP BUILDINGS	
Small retail stores	<50
OFFICE BUILDINGS	
Reception areas	40 – 45
General office areas	40 – 45
Executive offices	35 – 40

Department of Planning and Environment's (DPE's) *"Development near Rail Corridors and Busy Roads - Interim Guidelines*" (released in December 2008) is arguably the most acceptable document used for the assessment of road traffic noise impacts on residential developments. Limits specified within the Policy, which are virtually identical to those in AS/NZS2107-2016 are shown below:

Type of Occupancy	*Noise Level in dB(A)*	*Applicable Time Period*
Sleeping areas (bedroom)	35	Night 10pm to 7am
Other habitable rooms (excluding garages, kitchens bathrooms & hallways)	40	At any time

Section C10 of the Roads and Maritime Services (RMS') NSW Road Noise Policy (RNP) also recommends that the DPE's Guideline should be used for assessment of road traffic noise on residential developments. Table 2 summarises satisfactory internal noise levels for residences, used for the basis of this assessment.

Table 2: Internal Traffic Noise Level Criteria (Residential)

Location	Criteria – dB(A),Leq		Remarks
	Day	Night	
Sleeping areas	-	35	Windows closed
	-	40	Windows open
Other habitable rooms	40	-	Windows closed
	45	-	Windows open

Note: Provision for air conditioning will be available, therefore windows open criteria do not apply in this case.

Note that limits specified in the EPA documents are in agreement with those contained in AS/NZS 2107-2016 and DPE's Guideline. Therefore, the aim of the assessment is to ensure that the allowable noise levels shown above and in Table 2 are not (theoretically) exceeded within any habitable room due to road traffic noise. Transmission paths considered in the assessment are windows and doors with allowances made for shielding by balconies, intervening acoustic barriers, buildings/terraces, etc.

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4.2 Site Noise/Mechanical Plant/Commercial Activity

Noise from industrial noise sources scheduled under the Protection of Environment Operations Act (PoEO Act) is assessed using the EPA's NPI. However, local Councils and Government Departments may also apply the criteria for land use planning, compliance and complaints management. The NPI specifies two separate criteria designed to ensure existing and future developments meet environmental noise objectives. The first limits intrusive noise to 5dB(A) above the background noise level and the other aims to protect against progressively increasing noise in developing areas, based on the existing (Leq) noise level from industrial noise sources. Project Noise trigger levels are established for new developments by applying both criteria to the situation and adopting the more stringent of the two.

The existing L(A)eq for the receiver areas is dominated by traffic on nearby roads and commercial activity during the day, evening and night. Reference to Table 2.2 of the NPI shows that all receiver areas are classified as urban.

The Project Amenity Level is derived by subtracting 5dB(A) from the recommended amenity level shown in Table 2.2. A further +3dB(A) adjustment is required to standardise the time periods to LAeq, 15 minute. The adjustments are carried out as follows:

Recommended Amenity Noise Level (Table 2.2) – 5dB(A) +3dB(A)

The following Table specifies the applicable project intrusiveness and amenity noise trigger levels for the proposed redevelopment.

Table 3: - Intrusiveness and Amenity Noise levels

Period	Intrusiveness Criteria	Amenity Criteria
KING STREET		
Day	59 (54+5)	58 (60-5+3)
Evening	58 (53+5)	48 (50-5+3)
Night	52 (47+5)	44 (59-15)
BULL STREET		
Day	55 (50+5)	58 (60-5+3)
Evening	51 (46+5)	48 (50-5+3)
Night	46 (41+5)	43 (45-5+3)
Receiver Type: Urban (See EPA's NPI - Table 2.1)		

Project Noise Trigger Levels, determined as the more stringent of the intrusiveness criteria and the amenity / high traffic criteria, are as follows:

KING STREET
Day **58dB LAeq,15 Minute** 7am to 6pm Mon to Sat or 8am to 6pm Sun and Pub Hol.
Evening **48dB LAeq,15 Minute** 6pm to 10pm
Night **44dB LAeq,15 Minute** 10pm to 7am Mon to Sat or 10pm to 8am Sun and Pub Hol.

BULL STREET
Day **55dB LAeq,15 Minute** 7am to 6pm Mon to Sat or 8am to 6pm Sun and Pub Hol.
Evening **48dB LAeq,15 Minute** 6pm to 10pm
Night **43dB LAeq,15 Minute** 10pm to 7am Mon to Sat or 10pm to 8am Sun and Pub Hol.

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4.3 Short-Term Events - Sleep Arousal

Section 2.5 of EPA's NPI states, *"the LAmax level of any specific noise source should not exceed the background noise level (L90) by more than 15dB(A) or 52dB(A),Lmax, whichever is lowest, when measured outside the bedroom window"*. This criterion is applied to residential situations between the hours of 10.00pm and 7.00am where a receptor's sleep may be interrupted by noise. It is applied in this case to nearby neighbours likely to receive noise from vehicle movements associated with the proposed development.

Based on the measured background noise level of 41dB(A),L90 for night at the site (10pm to 7am), the sleep arousal criterion is set at **52dB(A),Lmax** at the bedroom window of any affected residence.

4.4 Construction Noise

Various authorities have set maximum limits on allowable levels of construction noise in different situations. Arguably the most universally acceptable criteria, and those which will be used in this Report, are taken from the NSW Environment Protection Authority's (EPA's) Interim NSW Construction Noise Guideline (ICNG). Since the project involves a significant period of construction activity, a "quantitative assessment" is required, i.e. comparison of predicted construction noise levels with relevant criteria. For assessment of noise impacts at residential receivers Table 3 of the ICNG is reproduced below in Table 4:

Table 4: - Table 3 of ICNG Showing Relevant Criteria at Residences

Time of Day	Management Level Leq (15min)	How to Apply
Recommended Standard Hours: Monday to Friday 7am to 6pm Saturday 8am to 1pm No work on Sundays or Public holidays	Noise affected RBL +10dB(A) i.e**. 65dB(A) day**	- The noise affected level represents the point above which there may be some community reaction to noise. - Where the predicted or measured LAEQ (15min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. - The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details
	Highly noise affected 75dB(A)	- The highly noise affected level represents the point above which there may be strong community reaction to noise. - Where noise is above this level, the proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. - If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining duration and noise level of the works, and by describing any respite periods that will be provided.
Outside recommended Standard hours	Noise affected RBL +5dB(A)	- A strong justification would typically be required for works outside the recommended standard hours. - Proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. - For guidance on negotiating agreements see Section 7.2.2

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Section 4.2 of the ICNG also specifies the following external noise level limits for commercial and industrial premises.

Industrial premises	**75dB(A),Leq (15 min)**
Offices, retail outlets	**70dB(A),Leq (15 min)**

Construction will only occur during standard construction hours, i.e. 7am to 6pm Monday to Friday and 8am to 1pm on Saturday, with no construction permitted on Sundays or public holidays. Table 5 relevant for potentially affected existing receivers (also see Figure 1).

Table 5: Criteria Summary

Assessment Location	Standard Construction Hours		Outside Standard Hours
	Noise Affected	Highly Noise Affected	
Residential Dev'p	65	75	51/46 #
Commercial Dev'p	70	75	70

#Evening and night periods.

4.5 Construction Vibration

Personal Comfort

The majority of maximum limits on allowable ground and building vibration in different circumstances and situations are directed at personal comfort rather than building damage. This usually leads, in virtually every situation, to people who interpret the effects of a vibration to ultimately determine its acceptability. The ICNG recommends that the EPA guideline, *Assessing Vibration: A Technical Guideline (2006),* should be used for assessing construction vibration. Limits set out in the Guideline are for vibration in buildings, and are directed at personal comfort for continuous, impulsive and intermittent vibrations. Table 6 shows the Vibration Dose Values for intermittent vibration activities such as pile driving and use of vibrating rollers etc, taken from Table 2.4 of the Guideline, above which various degrees of adverse comment may be expected.

Table 6: Acceptable Vibration Dose Values ($m/s^{1.75}$)
Above which Degrees of Adverse Comment are Possible

Location	Day (7am-10pm)		Night (10pm-7am)	
	Preferred	Maximum	Preferred	Maximum
Critical areas #	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Hospital operating theatres, precision laboratories, etc.

Building Safety:

Other criteria specifically dealing with Building Safety Criteria include Australian Standard AS2187.2-1993, dealing specifically with blasting vibration, specifies a maximum peak particle velocity of 10mm/sec for houses and a preferred limit of 5mm/sec where site specific studies have not been undertaken.

German Standard DIN 4150 - 1986, Part 3 Page 2, specifies a maximum vibration velocity of 5 to 15 mm/sec in the foundations for dwellings and 3 to 8 mm/sec for historical and sensitive buildings, for the range 10 to 50Hz. British Standard BS 7385 Part 2, specifies a maximum vibration velocity of 15mm/sec at 4Hz increasing to 20mm/sec at 15Hz increasing to 50mm/sec at 40Hz and above, measured at the base of the building.

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Additionally, The Australian and New Zealand Environment Conservation Council (ANZECC) guideline *"Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration"* limit peak particle velocities from blasting to below 5mm/sec at residential receivers, with a long term regulatory goal of 2mm/sec.

The above listed criteria vary from 3mm/sec up to 15mm/sec, therefore, the more conservative limit of **3mm/sec** will be adopted for the purposes of Building Safety Criteria. It should be acknowledged, however, that intermittent ground vibration velocities at 5mm/sec are generally considered the threshold at which architectural (cosmetic) damage to normal dwellings may occur and velocities at 10mm/sec should not cause any significant structural damage, with the exception of the most fragile and brittle of buildings.

5 METHODOLOGY

5.1 Road Traffic

Applicable noise level metrics, namely, Leq (day peak) and Leq (night) are those calculated from our measurements at the site, following the methodology outlined in the EPA's RNP. A +2.5dB(A) facade adjustment is not required as all measurements were taken 1 metre from existing building facades.

received noise (free field) + *facade correction* = *received noise*

Applying the above formula gives:

King Street:

Day	66.0dB(A)	+	0.0dB(A)	=	**66.0dB(A) Leq15hr**	7am – 10pm
Night	62.0dB(A)	+	0.0dB(A)	=	**62.0dB(A) Leq9hr**	10pm – 7am

Bull Street:

Day	61.0dB(A)	+	0.0dB(A)	=	**61.0dB(A) Leq15hr**	7am – 10pm
Night	55.0dB(A)	+	0.0dB(A)	=	**55.0dB(A) Leq9hr**	10pm – 7am

No current RTA traffic station is located near the site along nearby roads. We have therefore assumed 15,000 vehicles pass the site each day along King Street and 8,000 vehicles along Bul Street for the year 2018. A figure of 5% heavy vehicles has been adopted. The AADT's for the year 2018 were applied to our computer programme, based on the EPA and RMS approved CoRTN Method of Traffic Noise Prediction, and noise levels were calculated to the theoretical facade at each level of the development. The adopted AADT figures are merely arbitrary, as calculated noise levels are adjusted to correlate with our measured peak external noise levels, with the intention is to provide a (theoretical) means of determining the degree of noise control required for a particular building component.

5.1.1 CoRTN Model Conversion

The EPA released their ECRTN in June 1999 and RNP in 2011, which specify modified assessment periods for day and night, namely, Leq,15hr (7am to 10pm) and Leq,9hr (10pm to 7am). These assessment periods have rendered the original Australian version of the CoRTN model invalid, which was designed to assess the impact over a single 24 or 18 hour period. Consequently, modification of the Model is required to adequately describe the new metrics.

The CoRTN algorithm pertaining to traffic flow percentages has been modified by inserting all AADT figures for arterial roads, contained in RMS publications - Traffic Volume Data for Hunter and Northern Regions, 1998, and establishing AADT figures for the applicable day and night periods. Our CoRTN model was then calibrated against long term measurements made at locations with reliable AADT figures.

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5.2 Site Activities/Mechanical Plant

The sound power level of each activity impacting on the site was determined according to the procedures described in AS2102 or AS1217 as appropriate, and theoretically propagated at to nearby receivers. Propagation calculations were carried out using the following in-house equation. Where noise impacts above the criteria are identified, suitable noise control measures are implemented and reassessed to demonstrate satisfactory received noise levels in the residential area.

Equation 1:

$$L_{eq},T = Lw - 10 \log (2 \pi r^2) + 10 \log \frac{(D \times N)}{T}$$

Where Lw is sound power level of source (dB(A))
R distance to receiver (m)
D is duration of noise for each event (sec)
N is number of events
T is total assessment period (sec)

5.3 Construction Plant & Equipment

Future noise and vibration sources on the site cannot be measured at this time, consequently noise and vibration levels produced by plant and machinery to be used on the site have been sourced from the DEFRA database and/or our library of technical data, which has been accumulated from measurements taken in many similar situations on other sites for others.

All noise level measurements were taken with a Svan 912A Sound & Vibration Analyser. This instrument has the capability to measure steady, fluctuating, intermittent and/or impulsive sound, and to compute and display percentile noise levels for the measuring period. A calibration signal was used to align the instrument train prior to measuring and checked at the conclusion. Difference in the two measurements was less than 0.5dB. Each measurement was taken over a representative time period to include all aspects of machine/process operation, including additional start-up noise where applicable. Sound measurements were generally made around all sides of each machine, to enable the acoustic sound power (dB re 1pW) to be calculated. The sound power level is then theoretically propagated to the receiver, with allowances made for spherical spreading.

Atmospheric absorption, directivity and ground absorption have been ignored in the calculations. As a result, predicted received noise levels are expected to slightly overstate actual received levels, thus providing a measure of conservatism. Addition of the received noise level for each of the individual operating sources gives the total SPL at each receiver, which is then compared to the criteria. Where noise impacts above the criterion are identified, suitable noise control measures are implemented and reassessed to demonstrate satisfactory received noise levels.

Typical vibration levels for construction activities were measured at other sites for various ground types and situations primarily using a Vibroch V801 Seismograph coupled to a triaxial geophone. A sandbag was placed over the geophone or it was glued to the surface location during each measurement to ensure elevated readings were not recorded due to bouncing and movement, which may occur at higher vibration amplitudes. The unit is capable of measuring and storing peak Z-axis vibration velocities, as well as vibration in three directions simultaneously and gives peak velocity and acceleration on the x, y and z axes.

This theoretical assessment is based on a worst-case scenario, where all plant items are operating simultaneously in locations most exposed to the receiver. In reality, most plant will be located in shielded areas, so actual received noise is expected to be less than the predictions shown in this report, or at worst equal to the predicted noise levels for only part of the time.

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6 ANALYSIS AND DISCUSSION

6.1 Received Noise Levels – Road Traffic (Impact on Dev'p)

Shown below are sample calculations detailing the procedure followed in order to calculate required glazing for the Residential Apartment Bedroom 1BR on the north facade of Level 1, facing King Street. The traffic noise level at the outer face of the glazing is calculated as follows,

Table 7: Sample Calculation - Traffic Impact at Residential Apartment Bedroom 1BR Level 1 North Facade

		Octave band Sound Pressure Levels, dB(A)							
Propagation calculation	**dB(A)**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Facade traffic noise, Leq[1]	62	42	50	51	55	57	54	48	40
Architectural shielding[2]		0	0	0	0	0	0	0	0
Directivity/distance Correction[3]		-1	-1	-1	-1	-1	-1	-1	-1
Traffic noise at window	61	41	49	50	54	56	53	47	39

1. Measured noise level. 2. Intervening structures/enclosed balustrade. 3. Includes angle of incidence & distance correction.

As the criterion for the Bedroom is 35dB(A), see Section 4.1, the required traffic noise reduction is *TNR* = 61-35 = 26dB(A). The traffic noise attenuation, *TNA*, required of the glazing is calculated according to the equation given in Clause 3.4.2.6 of AS 3671,

$$TNA = TNR + 10\log_{10}[(S/S_f) \times 3/h \times 2T_{60} \times C] \qquad \textit{equation 1}$$

where
- S = Surface area of glazing = 5m^2
- S_f = Surface area of floor = 15m^2
- h = Ceiling height, assumed to be 2.5m
- T_{60} = Reverberation time, s
- C = No. of components = 2 (glazing, wall)

Assuming that the room is acoustically average (neither too 'live' nor too 'dead') equation 9.26 in *Noise and Vibration Control*, L.L. Beranek, 1971, gives a reverberation time of 0.46s. Consequently, the value of 0.5s was used in equation 1.

Using the values listed above gives

TNA = 25dB(A) for the glazing

Substituting this value into the equation given in Clause 3.4.3.1 of AS3671 gives

Rw = $TNA + 6 \approx 31$.

As can be seen by the above results, the glazing must have a tested Rw31 rating. Published sound insulation performance in terms of Rw or STC ratings relate to partitions tested in ideal laboratory conditions or opinions based on such measurements. Field conditions (eg. flanking paths, penetrations, air leaks etc) caused by lack of supervision of workmanship or inadequate attention to detail at design/specification stage can reduce the Rw rating. For this reason, we recommend selecting partition systems with a laboratory Rw rating 1-2dB higher than required on site. Therefore, the glazing in the Bedroom must have a tested Rw33 rating. Based on typical laboratory performance data the glazing would consist of single-glaze laminated glass fitted with acoustic seals at sliders.

Similar calculations to those above have been performed for windows and doors on affected facades. From these calculations, a glazing schedule has been compiled. See Section 7.

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DPE's Guideline states that if road traffic noise criteria cannot be met with windows open then they must be shut, if desired, while also meeting the ventilation requirements of the Building Code of Australia (BCA). This does not preclude the use of operable windows, however, the National Construction Code (NCC) states that when the minimum criteria cannot be met, mechanical ventilation is required (ref: Section 3.1.2 ABCB Indoor Air Quality, 2016). In respect to the above, mechanical ventilation will be required for habitable rooms.

6.2 Received Noise – Nearby Noise Sources (Impact on Dev'p)

The following Tables show sample calculations to predict noise levels from activities/equipment associated with nearby commercial developments, propagated to Residential Apartment Bedroom 2BR on the east facade of Level 1, facing Wests Club. All calculations are based on distances scaled from plans supplied by Fender Katsalidis and through measurement during our site visits.

Table 8: Received Noise – External Noise Sources, dB(A),Leq
Residential Apartment Bedroom 2BR, East Facade, Level 1

Item/Activity	Lw dB(A)	Dist to Rec (m)	Duration (sec)	No. of Events	Barrier Loss/Dir	Received dB(A)
Pedestrians/Patrons (S1)	78	10	900	1	0	
Roof-Top Plant (S2) #	79	50	900	1	8	
Gym Activities (S3)	80	90	300	1	24	
Cars/Cust in C'park (S4)	90	140	10	80	24	
Cars in C'park (S5)	82	60	10	30	12	
Patrons in Courtyard (S6)	80	25	900	1	4	
Cars enter/leave C'park (S7)	90	65	10	60	5	
Dock, Trucks, etc (S8)	96	85	300	2	8	
Cars enter/leave C'park (S9)	82	20	5	20	8	
				Combined		**50**
				Criteria (Night)		**44**
				Impact		**6**

 # Plant will be acoustically treated, assumed 15dB(A) reduction.

Table 9: Received Noise – Short Duration Events dB(A),Lmax
Residential Apartment Bedroom 2BR, East Facade, Level 1

Item/Activity	Lw dB(A)	Dist to Rec (m)	Duration (sec)	No. of Events	Barrier Loss/Dir	Received dB(A)
Pedestrians/Patrons (S1)	78	10	900	1	0	**50**
Roof-Top Plant (S2) #	79	50	900	1	8	29
Gym Activities (S3)	80	90	300	1	24	9
Cars/Cust in C'park (S4)	90	140	10	80	24	15
Cars in C'park (S5)	82	60	10	30	12	26
Patrons in Courtyard (S6)	80	25	900	1	4	40
Cars enter/leave C'park (S7)	90	65	10	60	5	41
Dock, Trucks, etc (S8)	96	85	300	2	8	41
Cars enter/leave C'park (S9)	82	20	5	20	8	40
				Criteria (Night)		**44**

 # Plant will be acoustically treated, assumed 15dB(A) reduction.

As can be seen by the above results, noise from nearby external activities/equipment is predicted to be exceed the criteria by up to 6dB(A) during the night at nearest facades. A standard window will only attenuate up to 10-15dB(A) when closed, therefore glazing must be modified acoustically. Theoretical calculations reveal that all glazing within bedrooms in some instances must achieve >Rw33-34 rating. This can typically be achieved with laminated glass and acoustic seals fitted at sliders. See Section 7 for glazing schedule and required design modifications.

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6.3 Received Noise Mechanical Plant (Impact of Dev'p on Neighbours)

Council prefers the background noise level of the area to be maintained, although, in certain circumstances may permit the noise level in question to exceed the prevailing background noise level by 5dB(A), provided the sound is bland and free from impulsive and/or tonal components. This is in agreement with conditions contained within EPA's NPI. In respect to the above, a planning limit of **43dB(A),Leq** for night (10pm-7am) applies at the boundary of nearest residences.

The number and location of noise generating items associated with the development is unknown at this time. For assessment purposes, we have assumed that the majority of commercial mechanical plant will be located on the roof of each building or in the carpark, while individual residential air conditioning condensers will be located on balconies. We have further assumed that carpark exhaust outlets may also be located on the roof. Listed below is the anticipated type and number of plant items for a typical development of this size.

Location	*Plant Item*
Basement Carparks	Commercial Air Con Condensers (x10)
Roof	Commercial Air Con Condensers (x10)
	Carpark Exhaust (x4)
	Pool Pumps, etc
Individual Balconies	Residential Air Con Condensers

As the exact type of plant is not known at this stage, we have sourced information from our library of technical data. The sound power of the proposed plant is propagated to residential locations taking into account sound intensity losses due to geometric spreading and barrier insertion loss provided by intervening structures, with additional minor losses such as molecular absorption, directivity and ground absorption ignored in the calculations. As a result, predicted received noise levels are expected to slightly overstate actual received levels and thus provide a measure of conservatism. Comparison of the predicted noise levels produced by the plant and the allowable level are then compared to give the noise impact at the receiver.

Sample calculations of noise produced by roof-top air conditioning condensers is shown in following Table, propagated to nearest residential apartments north of the site across King Street (R1-R2).

Table 10: Calculated SPL – Roof-Air Conditioning Top Plant Propagated to Nearest Residential Apartments (R1-R2)

		Octave Band Centre Frequency, Hz							
Item	**dB(A)**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Combined Lw	**85**	59	68	73	77	79	80	75	65
Barrier loss[1]		0	0	0	0	0	0	0	0
SPL at receiver	**41**	15	24	29	33	35	36	31	21
Criterion (night)	**43**								
Impact	**-**								

1. Intervening structures.

Results in the above Table show that noise emissions from anticipated air conditioning plant is predicted to be compliant with the EPA (and therefore Council) criteria at nearest residences, based on typical source noise levels and providing plant is installed at the specified location of the roof.

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No acoustic barriers are required adjacent to roof-top air conditioning plant or exhaust plant providing noise emissions for individual items are below the specified limits:

Item	*Max SPL at a Dist of 1 metre*	*Lw*
Air Conditioning Condenser	66dB(A)	72dB(A)
Exhaust Discharge	68dB(A)	74dB(A)
Pool Pumps, Ancillary Equipment	68dB(A)	74dB(A)

If noise emission levels exceed the above limits, acoustic barriers must be erected between the plant and residential locations, extending equal in height to the highest plant item. If ventilation issues arise acoustic louvres may be installed in preference to solid walls. See Section 7 for design specifications.

6.4 Basement Level Carparks (Impact of Dev'p on Neighbours)

Vehicles entering, leaving and manoeuvring within the basement level carparks of the proposed development have the potential to cause disturbance to nearby neighbours. Natural ventilation grills may be incorporated along exposed facades, which also provide a means of noise leakage. Vehicles within the carparks will be travelling at approximately 10km/h and will be under slight acceleration at times as they negotiate ramps. Previous noise tests by Reverb Acoustics suggest that a vehicle in good mechanical order will produce a sound power level of 83-85dB(A) under these conditions, thus resulting in an acceptable level of approximately 36dB(A)Leq or <46dB(A),Lmax at the nearest residential receivers. It should be noted that, if more than one vehicle were to enter the carparks simultaneously, received noise levels would be raised. For instance, if 3 cars were travelling within the car park, in exposed locations, a combined noise level as high as 40dB(A) may be experienced at nearest receivers. To further reduce noise levels, we recommend positioning ventilation grills behind retaining walls or along facades facing away from residences.

6.5 Substation Kiosk (Impact of Dev'p on Neighbours)

As no information is available concerning the exact type of substation kiosk equipment (transformers, cooling operation, fans, etc), a limiting sound pressure level (SPL) has been specified at 3 metres from the surface of the kiosk, as shown in the following Table.

Table 11: Maximum Allowable SPL 3 metres from Kiosk – dB(A),Leq

Night Planning Level	40dB(A),Leq #
Maximum Plant Noise Level (SPL) at 3 metres	68

3dB(A) penalty applied to account for cumulative impact from all plant associated with the site.

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6.6 Construction Plant & Equipment (Impact of Dev'p on Neighbours)

6.6.1 Predicted Noise levels - Construction Plant and Equipment

Received noise produced by anticipated construction activities is shown in Table 12 below, for a variety of distances to a typical receiver, with no noise barriers or acoustic shielding in place and with each item of plant operating at full power. Entries in bold type highlight exceedances of the day Highly Noise Affected criteria of **75dB(A),Leq**.

Table 12: Predicted Plant Item Noise Levels, dB(A)Leq

		Distance to Residence			
Plant/Activity	(Lw)	40m	80m	100m	200m
Tower crane	(104)	64	58	56	50
Hammering	(98)	58	52	50	44
Angle grinder	(106)	66	60	58	52
Air wrench (silenced)	(98)	58	52	50	44
Compactor	(111)	71	65	63	57
Road truck	(104)	64	58	56	50
Grader	(102)	62	56	54	48
Air compressor	(98)	58	52	50	44
Concrete Agitator	(112)	72	66	64	58
Concrete Pump	(110)	70	64	62	56
Pile boring machine	(112)	72	66	64	58
Excavator	(104)	64	58	56	50

6.6.2 Predicted Noise Impacts

Residential apartments are within 50 metres of the site and some construction activities are expected to exceed the criteria, particularly mobile plant. Noise levels above 70dB(A) are possible at closest locations, and community reaction is possible. The ICNG recommends that as a first course of action, consideration should be given as to whether any alternate feasible or reasonable method of construction is possible. Consultation with the construction contractor confirms that due to the nature of ground conditions there are no quieter alternates available. The ICNG further recommends that when alternate feasible and reasonable options have been considered the proponent then should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and any respite periods that will be provided. These strategies will be discussed in more detail in Section 7.

When pile boring occurs noise levels in the order of 69-72dB(A) are possible at nearest locations, which we acknowledge is high. To reduce noise levels any appreciable amount a physical barrier would be required to intercept the line of site between the source and receivers. We suggest that temporary acoustic barriers between the source and receiver. Placing shipping containers or similar moveable barriers adjacent to a rig is another practical method of noise control. Note that barriers will not be required in situations where intervening structures provide acoustic barriers between the source and receiver. The above strategies may reduce noise levels at residential locations by up to 10dB(A),

It should be noted that calculations are based on plant items operating in exposed locations and at full power, with no allowances made for intervening topography or shielding provided by intervening structures. Cumulative impacts, from several machines operating simultaneously, may be reduced when machines are operating in shielded areas not wholly visible to receivers. In saying this, if two or more machines were to operate simultaneously on the site, received noise levels would be raised and higher exceedances may occur.

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Initial earthworks are expected to employ an excavator, and 1-2 dump trucks. The combined acoustic power level of these machines, assuming normal contractor's machines up to 10 years old in reasonably good condition, is expected to be in the range 100 to 104B(A),Leq. However, the machines will typically be spread over the site, and noise at any receiver is typically dominated by the few closest machines, such as an excavator loading a truck, while a second truck reverses into position to be loaded by an excavator. With a combined acoustic power level of 102 dB(A) for 3 typical machines operating at full power, above 60dB(A) is expected at the closest residence during peak activity.

Constructing temporary barriers of plywood, excess fill, etc, at least 2m high, at the perimeter of the construction site (or at least adjacent to noisy plant items) may be considered for mitigating some of the construction noise at nearest receivers. These barriers will offer the additional benefit of securing the site from unwanted visitors. With barriers in place, worst case construction will reduce by up to 10dB(A), although, as previously stated, these noise levels are expected to occur for a relatively short time and reduce as work progresses to a new area.

It should be acknowledged that construction activities that produce higher noise for a shorter period are often more desirable than alternate construction techniques that produce lower noise for a much longer period. This combined with noise control strategies discussed in Section 8 will ensure that minimum disruption occurs.

6.6.3 Predicted Vibration Impacts

Occupants of nearby buildings may also have concerns about ground vibration levels from vibrating machinery (excavators, compactors, etc). Ground vibration measurements carried out previously, on other sites, can be used to indicate the likely range of vibration levels produced by construction activities. Previous results do not necessarily apply to this site without considering influencing factors such as ground resonant frequency, energy produced, etc. Table 13 lists the results of previous vibration measurements, with each measurement corrected to a standard distance of 20m to represent nearest residential receivers.

Table 13: Average Maximum Ground Vibration Measurement Results, mm/s Peak.

Ground Type	Measured Distance to Vibration mm/sec	Minimum 40m to Receiver mm/sec
Excavator on clay soil	80m, 0.012	0.14
Excavator on dry alluvial soil	15m, 0.23	0.16
Excavator on wet alluvial soil	10m, 0.52	0.28
Road truck on potholes	10m, 0.15-2.7	0.1-1.2
Compactor on clay	40m, 0.20	0.20

Measured at construction sites in Newcastle CBD.

Table 5 shows a variety of vibration levels mainly due to differences in ground conditions from one site to the next. The Table shows a marked difference between clay and dry ground, with low resulting vibration, and water saturated ground with vibration levels an order of magnitude higher. Results from measurements on wet alluvial or clay soil are likely to apply to the site.

Since vibration varies over time for each process the EPA Guideline recommends that the following formula be used to estimate the vibration dose at the receiver location:

Equation 1: $eVDV = 1.4 \times a \times t^{0.25}$

where: k is nominally 1.4 for crest factors below 6 a_{rms} = weighted rms accel (m/s²)
t = total cumulative time (seconds) of the vibration event(s)

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The following estimated vibration doses are expected at nearest receivers:

	eVDV
Excavator	0.18
Compactor	0.24

Based on the above results, adverse comment is possible, particularly when earthworks take place. We therefore recommend that these activities are not carried out unless simultaneous attended vibration monitoring is conducted when within safe working distances noted in Table 7. As previously stated, in many cases higher levels of vibration (and noise) are preferable that occur for only a short period of time than processes producing lower amplitudes for a much longer time period.

The effect of vibration in a building is observed in two ways, namely, it is felt by the occupant, or it causes physical damage to the structure. Subjective detection can be one of direct perception from rattling of windows and ornaments, or dislodgement of hanging pictures and other loose objects. The second is structural damage which may be either architectural (or cosmetic) such as plaster cracking, movement or dislodgement of wall tiles, cracked glass etc, or major such as cracking walls, complete falls of ceilings, etc, which is generally considered to impair the function or use of the dwelling. Vibration can be felt at levels well below those considered to cause structural damage. Complaints from occupiers are usually due to the belief that if vibration can be felt then it is likely to cause damage. Slamming of doors or footfall within a building can produce vibration levels above those produced by construction activities.

Any future structural damage, whether cosmetic or major, which may occur to any building will only be a result of natural causes such as differential settlement of foundations (particularly if on poorly compacted fill), expansion and contraction cycles due to changes in temperature, shrinkage due to drying out of timber framing and pre-stressed areas of the building. Obvious structural damage from any of these sources can usually be identified with the particular cause. Generally, one particular source is not the cause of damage to a structure, but rather a combination of two or more.

Vibration levels are unlikely to cause direct failure, and it is considered the main action is triggering cracks in materials already subjected to stress or natural forces, however, as previously mentioned, this may also arise from internal forces such as slamming of doors. In our experience, vibration will only begin to trigger "natural cracking" at levels above 1mm/sec. Findings by the Road Research Laboratory in the early 1970's, reproduced in Table 14, gives an indication of the effects from varying magnitudes of vibration.

Table 14: Reaction of People and Damage to Buildings

Peak Vel (mm/s)	Human Reaction	Effect on Buildings
0 to 0.15	Imperceptible by people – no intrusion	Highly unlikely to cause damage
0.15 to 0.3	Threshold of perception – possibility of intrusion	Highly unlikely to cause damage
2.0	Vibrations perceptible	Recommended upper level of vibration for historical buildings
2.5	Level at which vibration becomes annoying	Very little risk of damage
5	Annoying to occupants	Threshold at which the risk of damage to houses is possible
10 to 15	Vibrations considered unpleasant and unacceptable	Will cause cosmetic damage and possibly structural damage

Construction noise and vibration strategies are discussed in detail in Section 8.

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7 NOISE CONTROL RECOMMENDATIONS

7.1 Glazing Construction

7.1.1 Similar calculations to those in Section 6 were performed for all building elements. From these calculations, a schedule of required glazing has been compiled, shown below. The glazing systems, sighted in the following Tables, are presented as a guide for the supplier:

Glazing Systems:

Type A: Standard glazing. No acoustic requirement.
Type B: Single-glaze 5-8mm clear float glass.
Type C: Single glaze laminated glass.
Type D: Double-glaze or Insulating Glass Unit (IGU).

Note: The typical glazing shown in the following Tables should be used as a guide only. The supplier of the window/door must be able to provide evidence from a registered laboratory that the complete system will achieve the specified Rw performance, i.e. do not simply install our recommended glass in a standard window frame.

Table 15: Glazing Schedule – Tower A

Facade	Location	Room Use	Required Rw Must Achieve for Compliance	Typical Glazing System. Not for Specification
North *Facing King Street*	Commercial	All	**30**	Type C
	Medical Wait/Rec	All	**28**	Type B or C
	Medical Consult	All	**31**	Type C
	Transitory	Entry/Lobby	**-**	No acoustic requirement
	Retail	All	**-**	
	Aged Care Rooms	All	**33**	Type C or D
	Communal Facilities	All	**28**	Type B or C
	IL Units	Bedroom	**32**	Type C
		Living/Lnge	**30**	Type C
East *Facing Centre*	Transitory	Entry/Lobby	**-**	No acoustic requirement
	Retail	All	**-**	No acoustic requirement
	Cnr Aged Care Rms (North/South End)	Bedroom	**32**	Type C
		Living/Lnge	**30**	Type C
	Aged Care Rms (Internal Passage)	Bedroom	**30**	Type C
		Living/Lnge	**28**	Type B or C
	Cnr IL Units (North/South End)	Bedroom	**31**	Type C
		Living/Lnge	**29**	Type B or C
	IL Units (Internal Passage)	Bedroom	**28**	Type B or C
		Living/Lnge	**26**	Type B
South *Facing Bull Street*	Aged Care Rooms	Bedroom	**30**	Type C
		Living/Lnge	**29**	Type B or C
	IL Units	Bedroom	**30**	Type C
		Living/Lnge	**28**	Type B or C
	Communal Facilities	Lib,Gms,Lnge	**28**	Type B or C
West *Facing Ravenshaw St*	Aged Care Rooms	Bedroom	**30**	Type C
		Living/Lnge	**28**	Type B or C
	IL Units	Bedroom	**30**	Type C
		Living/Lnge	**27**	Type B

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Table 16: Glazing Schedule – Tower B

Facade	Location	Room Use	Required Rw Must Achieve for Compliance	Typical Glazing System. Not for Specification
North *Facing King Street*	Transitory	Entry/Lobby	**-**	No acoustic requirement
	Retail	All	**-**	No acoustic requirement
	Podium Res Apmts	Bedroom	**33**	Type C or D
		Living/Lnge	**32**	Type C
	Tower Res Apmts	Bedroom	**32**	Type C
		Living/Lnge	**30**	Type C
East *Facing Club*	Transitory	Entry/Lobby	**-**	No acoustic requirement
	Retail	All	**-**	No acoustic requirement
	Podium Res Apmts	Bedroom	**33**	Type C or D
		Living/Lnge	**32**	Type C
	Cnr Podium Res Ap (North/South End)	Bedroom	**34**	Type C or D
		Living/Lnge	**32**	Type C
	Tower Res Apmts	Bedroom	**32**	Type C
		Living/Lnge	**31**	Type C
	Cnr Tower Res Ap (North/South End)	Bedroom	**33**	Type C or D
		Living/Lnge	**31**	Type C
South *Facing Bull Street*	Podium Res Apmts	Bedroom	**31**	Type C
		Living/Lnge	**30**	Type C
	Transitory	Entry, Foyer	**-**	No acoustic requirement
	Tower Res Apmts	Bedroom	**30**	Type C
		Living/Lnge	**28**	Type B or C
West *Facing Centre*	Cnr Podium Res Ap (North/South End)	Bedroom	**32**	Type C
		Living/Lnge	**30**	Type C
	Podium Res Apmts (Internal Passage)	Bedroom	**30**	Type C
		Living/Lnge	**28**	Type B or C
	Cnr Tower Res Ap (North/South End)	Bedroom	**31**	Type C
		Living/Lnge	**29**	Type B or C
	Tower Res Apmts (Internal Passage)	Bedroom	**28**	Type B or C
		Living/Lnge	**26**	Type B or C

7.1.2 This assessment is based on the assumption that roof-top mechanical plant associated with the adjacent club (see Figure 1 "S2") will be acoustically treated to ensure noise emissions are acceptable at nearest facades of the proposed development. This must be certified by the acoustic consultant.

7.2 Roof/Ceiling Construction

7.2.1 Roof construction may consist of *either* reinforced concrete *or* sisalation or wire mesh laid down on roof purlins. This is to be completely covered with a 30-40mm foil faced building blanket hard under the roof sheeting (in situations where joists are at centres close enough to avoid excessive sagging of the blanket, the sisalation/wire mesh may be omitted). Close off gaps between purlins and roof sheeting with Unisil Eaves Filler Strips, bituminous compound, or similar. Install an impervious ceiling of 1 sheet of taped and set 10mm plasterboard. To further assist in low frequency attenuation, all ceiling voids should contain a layer of fibreglass or rockwool insulation. The insulation is to be installed in addition to, not in lieu of the building blanket. Specialised acoustic insulation is preferred, however, dense thermal insulation (eg, R3 batts) will suffice and is much less expensive ($15/m^2 for Rockwool 350 and $5/m^2 for R3 batts).

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7.3 Wall Construction

7.3.1 Brick veneer/cavity brick//masonry construction is acceptable. Where external brickwork stops below the height of the stud frame, plasterboard, Villaboard, or similar, is to be fixed to the outside of the stud frame to fill the void. The infill material is to extend from the top of the top plate to a point in line with the bottom of the top course of brickwork. Alternatively, an overside noggin is to be fixed to the underside of the top plate to project within 10-20mm of the inside surface of the external wall.

7.3.2 Lightweight cladding (i.e. Shadowclad, Colorbond, or similar) should include internal lining 1 sheet taped and set 13mm fire rated plasterboard, and a cavity infill of R1.5/S1.5 fibreglass or polyester insulation. The external face of all lightweight cladding should also be backed with either 6mm fibre cement sheeting (Villaboard, Hardiflex) or 10mm construction plywood.

7.4 Balconies

7.4.1 To reduce the field of view of the noise source (i.e. traffic), enclosed balustrade is required for all residential apartments, aged care rooms and IL units, consisting of stud wall, masonry or fixed glass panels to a height of minimum 900mm. Vertical gaps between each panel that do not exceed 75mm are permitted. A gap of say 50-100mm is permitted at floor level to allow cleaning, hosing, etc

7.5 Mechanical Plant

7.5.1 No acoustic barriers are required adjacent to roof-top mechanical plant providing noise emissions for individual items are below the specified limits:

Item	*Max SPL at a Dist of 1 metre*	*Lw*
Air Conditioning Condenser	66dB(A)	72dB(A)
Exhaust Discharge	68dB(A)	74dB(A)
Pool Pumps, Ancillary Equipment	68dB(A)	74dB(A)

7.5.2 Acoustic barriers are to be constructed at the fan discharge of exhaust plant that exceeds the limits specified in 7.5.1 above. Barriers must fully enclose at least three sides towards any residence. In our experience, a more efficient and structurally secure barrier is one that encloses all four sides. The barrier must extend at least 600mm above and below the fan centre and/or the discharge outlet and must be no further than 1200mm from the edges of the exhaust. Barrier construction should consist of *either* Acoustisorb panels (available through Modular Walls) *or* an outer layer of one sheet of 12mm fibre cement sheeting (Villaboard, Hardiflex), or 19mm marine plywood. The inside (plant side) is to be lined with an absorbent foam to reduce reverberant sound (fibrous infills are not recommended as they will deteriorate if wet), Note that variations to barrier construction or alternate materials are not permitted without approval from the acoustical consultant. Barrier construction is based solely on acoustic issues. Visual, wind load issues must be considered and designed by appropriately qualified engineers.

7.5.3 Acoustic barriers are to be constructed adjacent to air conditioning, refrigeration and pool plant that exceeds the limits specified in 7.5.1 above. Acoustic barriers must be equal in height to the highest plant item must be erected between the plant and residences. Barrier construction is to consist of *either* Acoustisorb panels (available through Modular Walls) *or* an outer layer of 12mm fibre cement sheeting, 25mm construction plywood, Hebel Powerpanel, or similar material, with an absorbent inner surface of perforated metal (minimum 10-15% open area) backed with a water resistant acrylic batt or blanket. The acoustic barrier must continue at least 300mm below the top of the plant deck.

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7.5.4 No acoustic modifications are required for air conditioning condensers located on individual balconies of residential apartments, providing solid balustrade is used (see Item 7.4.1 above).

7.5.5 Noise emissions from the substation kiosk must not exceed a sound pressure level of 68dB(A),Leq at a distance of 3 metres. Where plant intended to be installed on the site produces noise in excess of specified levels, noise control will be required to ensure satisfactory noise emissions.

7.5.6 Where plant intended to be installed on the site produces noise in excess of specified levels, noise control will be required to ensure satisfactory noise emissions. The contractor responsible for supplying and installing the plant should be asked to supply evidence that installed plant meets this noise emission limit, or that noise control included with the plant is effective in reducing the sound level to the specified limit.

7.5.7 It should be noted that no penalties have been applied for tonality in our calculations, therefore the tenderer's attention is drawn to the fact that mechanical plant may be near sensitive receivers and it is vitally important that units are free from specifically annoying characteristics (eg. tones, squeaks, pulsations etc). Careful selection of plant, equipment, piping and ducting systems is recommended to ensure quiet and vibration free operation in compliance with the specified noise criteria. Replacement and/or modification will be necessary to all systems causing undue noise or vibration exceeding the specified criteria.

7.5.8 Once the plant layout and selection has been finalised, details should be forwarded to the acoustic consultant for approval. Revision of the plant layout may result in modification to acoustic recommendations.

7.6 Basement Carpark

7.6.1 Any louvres in external walls of carparks that are required to provide natural ventilation should be positioned on facades facing away from residences. Alternatively, acoustic louvres will be required in preference to standard louvres. The louvres must have the following insertion loss values (typically Fantech SBL1, Nap Silentflo 300S Line or Robertson Type 7010):

Required Insertion Loss Values for Acoustic Barriers/Plant Room Louvres – dB

	Octave Band Centre Frequency, Hz							
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
NR	10	12	15	19	20	18	18	14
STL	4	6	9	13	14	12	12	8

These are probably the easiest and most economical methods of construction currently to hand, although many other combinations can be made to achieve the same result. Discussions with either your building consultant or architect may give rise to other more economical noise control options for carrying out the work, subject to review by us.

7.7 Commercial/Retail Tenancies

7.7.1 Given the variability of the proposed commercial/retail occupancies, it is not possible to specify exact acoustic controls on a case-to-case basis. For example, a cafe may require exhaust or refrigeration plant, while no significant noise is expected from an office. In addition, the tenancy of retail outlets is usually dynamic dependent upon the success or otherwise of the occupant. For this reason, the onus is upon the tenant to ensure noise emission is kept to a minimum.

Future tenants should be assessed on a case to case basis and required to submit their own Noise Impact Assessment to Council, if noise generating activities are anticipated.

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7.8 Construction Noise & Vibration Control Strategies

7.8.1 Noise & Vibration Monitoring Program

We recommend that attended noise and vibration should be carried out at commencement of each process/activity that has the potential to produce excessive noise and/or vibration. Attended monitoring offers the advantage of immediate identification of noise or vibration exceedances at the receiver and ameliorative action required to minimise the duration of exposure. Unattended long-term monitoring only identifies a problem at a later date and is not recommended. Table 16 should be used as a guide for the construction team to consider and follow. When the nominated activity occurs within the safe working distance, attended vibration monitoring should be conducted at the relevant receiver type. It is usual practice to conduct attended noise monitoring in conjunction with vibration monitoring, as activities that produce high vibration amplitudes also regularly produce high levels of noise.

Table 17: Vibration Monitoring Program - Minimum Distance when Monitoring is Required

Activity/Process	Receiver Type	Distance to Receiver (m)
Tracked machine	Heritage structure	40
	Residential building	20
	Commercial	10
Pile boring	Heritage structure	40
	Residential building	20
	Commercial	10
Crane	Heritage structure	20
	Residential building	10
	Commercial	5
Concrete pours	Heritage structure	20
	Residential building	10
	Commercial	5
Truck movements	Heritage structure	20
	Residential building	10
	Commercial	5

Note: Attended vibration monitoring should also be conducted for other activities identified by the contractor that have the potential to create vibration, not noted in the above Table.

7.8.2 Vibration Management Strategies

In addition to vibration monitoring, the following management strategies should also be considered:

Dilapidation Survey: We understand that this has been done as part of the management process.

Monitoring Changes in Building: Use of callipers, tell tales, etc, prior to commencement of major vibration generating works.

Underpinning, Reinforcement, Bracing, etc: Additional structural support to adjoining buildings, excavations, etc.

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7.8.3 Equipment Selection

All combustion engine plant, such as generators, compressors and welders, should be carefully checked to ensure they produce minimal noise, with particular attention to residential grade exhaust silencers and shielding around motors.

Trucks and other machines should not be left idling unnecessarily, particularly when close to residences. Machines found to produce excessive noise compared to industry best practice should be removed from the site or stood down until repairs or modifications can be made. Framing guns and impact wrenches should be used sparingly, particularly in elevated locations, with assembly of modules on the ground preferred.

Table 17 shows some common construction equipment, together with noise control options and possible alternatives.

Table 18: - Noise Control, Common Noise Sources

Equipment / Process	Noise Source	Noise Control	Possible Alternatives
Compressor Generator	Engine	Fit residential muffler. Acoustic enclosure.	Electric in preference to petrol/diesel. Plant to be Located outside building Centralised system.
	Casing	Shielding around motor.	
Concrete breaking Drilling Core Holing	Hand piece	Fit silencer, reduces noise but not efficiency Enclosure / Screening	Use rotary drill or thermic lance (used to burn holes in and cut concrete) Laser cutting technology
	Bit	Dampened bit to eliminate ringing. Once surface broken, noise reduces. Enclosure / Screening.	
	Air line	Seal air leaks, lag joints	
	Motor	Fit residential mufflers.	
Drop/Circular saw Brick saw	Vibration of blade/product.	Use sharp saws. Dampen blade. Clamp product.	Use handsaws where possible. Retro-fitting.
Hammering	Impact on nail		Screws
Brick bolster	Impact on brick	Rubber matting under brick	Shielded area.
Rotary drills Boring	Drive motor and bit.	Acoustic screens and enclosures	Thermic lance Laser cutting technology.
Explosive tools (i.e. ramset gun)	Cartridge explosion	Use silenced gun	Drill fixing.
Material handling	Material impact	Cushioning by placing mattresses, foam, waffle matting on floor. Acoustic screening.	
Waste disposal	Dropping material in bin, trolley wheels.	Internally line bins/chutes with insertion rubber, conveyor belting, or similar.	
Dozer, Excavator, Truck, Grader, Crane	Engine, track noise	Residential mufflers, shielding around engine, rubber tyred machinery.	
Pile driving/boring	Hammer impact engine	Shipping containers between pile & receiver	Manual boring techniques

Note: Generally, noise reductions of 7-10dB will be achieved with the use of barriers, 15-30dB by enclosures, 5-10dB from silencers and up to 20-25dB by substitution with an alternate process.

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7.8.4 Acoustic Barriers/Screening

To minimise noise impacts during construction, early work should concentrate on grading and levelling the areas closest to buildings. In the event of complaints arising from occupants of nearby buildings, we offer the following additional strategies for consideration:

- Place acoustic enclosures or screens directly adjacent to stationary noise sources such as compressors, generators, drill rigs, etc.
- Temporary barriers of plywood, excess fill, etc, at least 2m high, at the perimeter of the construction site

7.8.5 Consultation/Complaints Handling Procedure

The construction contractor should analyse proposed noise control strategies in consultation with the Acoustic Consultant as part of project pre-planning. This will identify potential noise problems and eliminate them in the planning phase prior to site works commencing.

Occupants of nearby buildings should be notified of the intended construction timetable and kept up to date as work progresses, particularly as work changes from one set of machines and processes to another. In particular, occupants should understand how long they will be exposed to each source of noise and be given the opportunity to inspect plans of the completed development. Encouraging resident understanding and "participation" gives the local community a sense of ownership in the development and promotes a good working relationship with construction staff. Programming noisy activities (such as sheet piling) outside critical times for court buildings should be arranged.

We recommend that construction noise management strategies should be implemented to ensure disruption to the occupants of nearby buildings is kept to a minimum. Noise control strategies include co-ordination between the construction team and building occupants to ensure the timetable for noisy activities does not coincide with sensitive activities.

The site manager/environmental officer and construction contractor should take responsibility and be available to consult with community representatives, perhaps only during working hours. Response to complaints or comments should be made in a timely manner and action reported to the concerned party.

All staff and employees directly involved with the construction project should receive informal training with regard to noise control procedures. Additional ongoing on the job environmental training should be incorporated with the introduction of any new process or procedure. This training should flow down contractually to all sub contractors.

7.8.6 Risk Assessment

A risk assessment should be undertaken for all noisy activities and at the change of each process. This will help identify the degree of noise and/or vibration impact at nearby receivers and ameliorative action necessary. A sample Risk Assessment Check Sheet is included in Appendix B as a guide.

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8 CONCLUSION

A noise impact assessment for the Wests Newcastle Development at 309 King Street, Newcastle has been completed. The report has shown that the site is suitable for the intended purpose, providing our recommendations are implemented. An assessment of external noise impacting on the development has resulted in the compilation of a schedule of minimum glazing, wall, roof construction, etc, to meet the requirements of the EPA and RMS. The recommended construction shown in Tables 15 and 16 should be used as a guide only. The supplier of the window/door must be able to provide evidence from a registered laboratory that the complete system will achieve the specified Rw performance. Do not simply install the recommended glazing in a standard frame.

The guidelines herein are preliminary in that the selection of building materials depends on user/client requirements, space limitations, budgetary constraints and practicalities that relate to the acoustic design of suites. Adequate building facade design may be achieved through many different combinations of materials, all of which may achieve the same result, subject to review by us.

We have designed exposed facades of the building to ensure maximum noise level passbys from heavy vehicles are below 55-60dB(A). This upper limit is generally considered the threshold at which awakenings may occur.

In conclusion, providing the recommendations given in this report are implemented, external noise impacts (i.e. road traffic, light rail traffic, etc), will comply with the requirements of the EPA, RMS, DPE and NCC within habitable spaces of the proposed development. We therefore see no acoustic reason why the proposal should be denied.

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Principal Consultant

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APPENDIX A
Definition of Acoustic Terms

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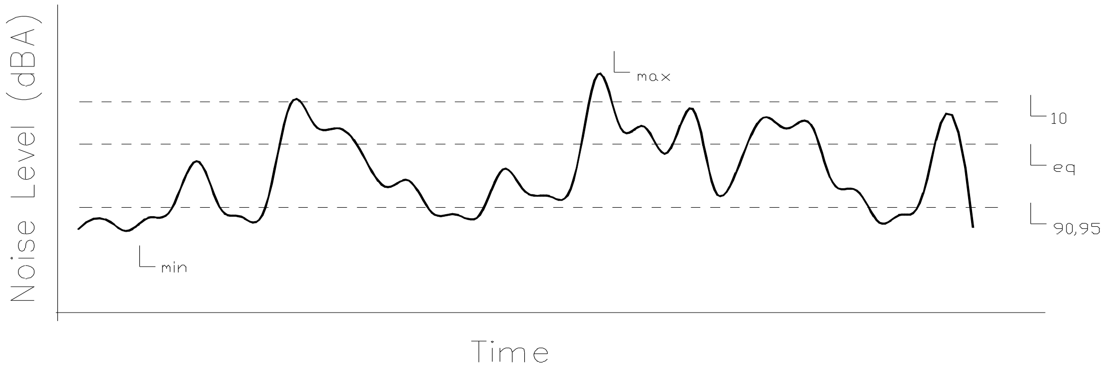
Definition of Acoustic Terms

Term	Definition
dB(A)	A unit of measurement in decibels (A), of sound pressure level which has its frequency characteristics modified by a filter ("A-weighted") so as to more closely approximate the frequency response of the human ear.
ABL	*Assessment Background Level* – A single figure representing each individual assessment period (day, evening, night). Determined as the L90 of the L90's for each separate period.
RBL	*Rating Background Level* – The overall single figure background level for each assessment period (day, evening, night) over the entire monitoring period.
Leq	Equivalent Continuous Noise Level - which, lasting for as long as a given noise event has the same amount of acoustic energy as the given event.
L90	The noise level which is equalled or exceeded for 90% of the measurement period. An indicator of the mean minimum noise level, and is used in Australia as the descriptor for background or ambient noise (usually in dBA).
L10	The noise level which is equalled or exceeded for 10% of the measurement period. L_{10} is an indicator of the mean maximum noise level, and is generally used in Australia as the descriptor for intrusive noise (usually in dBA).



APPENDIX B
Risk Assessment Checklist

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Risk Assessment Checklist

Item/Date	Risk Identified (Yes/No)	Risk Level (H/M/L)	Noise Control Required (Yes/No)	Noise Control Strategy

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