REVERB ACOUSTICS

Noise and Vibration Consultants

Noise Impact Assessment
Merewether Golf Course Redevelopment
40 King Street
Adamstown NSW

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Prepared for Catalyst Project Consulting Pty Ltd
Report No. 19-2302-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 redevelopment of Merewether Golf Course, 40 King Street, Adamstown. The assessment considers likely sources of noise that may impact upon nearby residential receivers from activities and equipment associated with the new club (i.e. entertainment, patrons, mechanical plant), commercial/residential buildings (mechanical plant) and vehicles entering, leaving and manoeuvring on the site. The purpose of this report is to recommend appropriate acoustic measures that must be implemented to ensure compliance with the requirements of Office of Liquor Gaming and Racing (OLGR), the NSW Environment Protection Authority (EPA), Department of Planning and Environment (DPE) and Newcastle City Council (NCC).

The assessment was requested by Catalyst Project Consulting Pty Ltd in support of and to accompany a Development Application to NCC and to ensure any required noise control measures are incorporated during the design stages.

2 TECHNICAL REFERENCE / DOCUMENTS

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

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

Liquor Administration Board *"Noise Control Guidelines"*

Van den Berg G.P. and Passchier-Vermeer W. (1999). *Assessment of low frequency noise complaints, Proc, Internoise 99.*

W.J. Davies, P. Hepworth, A. Moorhouse, R. Oldfield (2005). *Noise from Pubs and Clubs, Ph 1.*

A. Moorhouse, D. Waddington, M. Adams (2005). *Proposed criteria for the assessment of low frequency noise disturbance.*

Plans supplied by EJE Architecture Pty Ltd, Rev B, dated 29 January 2019, and Marchese Partners. 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.

3 PROJECT DESCRIPTION

The redevelopment will consist of the following:

NEW CLUB:

Lower Level:	- Buggy and cart storage rooms.
	- Plant and storage rooms
	- Carparking (also includes on grade parking)
Ground Level:	- Pro shop and change rooms.
	- Foyer and reception.
	- Bar, dining and lounge areas.
	- Alfresco gaming.
	- Cool rooms, keg room and loading area.
First Level:	- Amenities and storage areas.
	- Pre-function area and 2 function rooms.
	- Outdoor terrace off function rooms.
	- Air conditioning and exhaust plant

COMMERCIAL RESIDENTIAL BUILDINGS

Lower Level:	- Carparking
	- Workshop
	- Residential apartments
Ground Level:	- Pool
	- Gym & change rooms
	- Consulting rooms
	- Foyer & reception
	- Residential apartments
Levels 1-5:	- Residential apartments

We understand that entertainment in the club function rooms will cease prior to 12am and only low level "house" music continues until closing time. The function rooms will only be used during the day and early evening for sedate activities such as presentations, meetings, etc. An airlock will be constructed between the function rooms and adjoining areas to prevent noise leakage.

Nearest residential receivers are located to the north along King Street and Ella Street, and to the south in Henry Street. Future residential apartments are also proposed by the club on the golf course to the south and west.

Potential noise sources associated with the redevelopment, which may impact upon nearby residential receivers, include activities and equipment associated with the new club (i.e. entertainment, patrons, mechanical plant), commercial/residential buildings (mechanical plant) and vehicles entering, leaving and manoeuvring on the site. Nearest receivers identified during our site visits are shown below on Figure 1.

Figure 1: Site Plan

4 EXISTING ACOUSTIC ENVIRONMENT

A background noise level survey was conducted using a Class 1, Svan 977 environmental noise logging monitor, installed along the north boundary of the golf course, approximately 20 metres from King Street. The selected location is representative of the acoustic environment in the receiver area and is considered an acceptable location for determination of the background noise in accordance with Appendix B of the NSW Environment Protection Authority's (EPA's) – Noise Policy for Industry (NPI).

Noise levels were continuously monitored from 6 April to 13 April 2019, to determine the existing background and ambient noise levels for the area. 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.

Table 1 shows a summary of our noise survey, including the Assessment Background Levels (ABL's), for the day, evening and night periods. From these ABL's the Rating Background Level (RBL) has been calculated, according to the procedures described in the EPA's NPI and by following the procedures and guidelines detailed in Australian Standard AS1055-1997, "Acoustics - Description and Measurement of Environmental Noise, Part 1 General Procedures". A complete set of logger results is not shown, but available on request. Measured road traffic noise levels at the site are shown in Table 2.

Table 1: Summary of Noise Logger Results, dB(A)

Time Period	Background L90			Ambient Leq		
	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am
31 Jul-1 Au	40.2	39.8	34.6	53.8	52.4	44.5
1-2 Aug	36.2	35.0	34.8	54.9	50.5	48.1
2-3 Aug	38.2	35.8	34.6	58.5	52.0	48.0
3-4 Aug	39.6	35.1	34.6	57.8	49.3	45.3
4-5 Aug	38.8	35.5	34.1	56.6	50.5	46.7
5-6 Aug	38.4	36.2	36.1	58.3	49.8	43.6
6-7 Aug	38.2	-	-	56.6	-	-
RBL	**38**	**36**	**35**	**--**	**--**	**--**
LAeq	**--**	**--**	**--**	**57**	**51**	**46**

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

A summary of the measured noise environment at the site appears in Table 2, taken from our logger results. The measured noise levels are typical for residential areas near a busy road, and a commercial district.

Table 2: Existing Source Noise levels

Time Period	Leq		Lmax		L10		L90	
	Range	Average	Range	Average	Range	Average	Range	Average
Day	46-72	56	65-97	75	48-64	56	37-53	42
Evening	36-67	49	42-95	70	37-60	45	35-45	38
Night	35-68	42	36-85	56	35-64	41	34-48	37

Reverb Acoustics conducted additional attended monitoring to record a typical frequency spectrum of the background noise environment. This typical background frequency spectrum has been adjusted to give a total level equivalent to the average background noise level in the receiver from 6pm to midnight.

Table 3: Adopted Background Noise Level Spectrum, L(A)90 – 6pm-12am

Octave Band Centre Frequency, Hz									
dB(A)	31.5	63	125	250	500	1k	2k	4k	8k
35	19	24	26	28	30	28	26	20	18

5 CRITERIA

5.1 Road Traffic Noise – Club & Commercial/Residential Buildings

The Roads and Maritime Services (RMS) base their assessment criteria on those outlined by EPA. Reference to Page 160 of the Environmental Noise Management Manual released in December 2001, indicates that noise reduction measures for new and existing developments should endeavour to meet the noise level targets set out in the EPA's Environmental Criteria for Road Traffic Noise (ECRTN). The ECRTN has been superceded by the NSW Road Noise Policy (RNP) which contains a number of criteria applied to a variety of road categories (freeway, arterial, sub-arterial and local roads) and situations (new, upgraded roads and new developments affected by road traffic). Table 4 shows the relevant categories, taken from Table 3 of the RNP:

Table 4: - Extract from Table 3 of RNP Showing Relevant Criteria.

Road Category	Day	Night
Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments.	60 LAeq,15hr (external)	55 LAeq,9hr (external
Existing residences affected by additional traffic on existing local roads generated by land use developments.	55 LAeq,1hr (external)	50 LAeq,1hr (external)

In addition to the assessment criteria detailed above, the increase in total traffic noise must also be considered. Reproduced below in Table 5 are the relative increase criteria that trigger consideration of mitigation measures:

Table 5: - Reproduced Table 6 of RNP
Relative Increase Criteria for Residential Land Uses

Road Category	Type of Project/Development	Total Traffic Noise Level Increase–dB(A)	
		Day (7am-10pm)	Night (10pm-7am)
Freeway/arterial/sub-arterial roads & transitways	New road corridor / redevelopment of existing road/land use development with the potential to generate additional traffic on existing road	Existing traffic LAeq,(15hr)+12dB	Existing traffic LAeq,(9hr)+12dB

Road categories are defined in the RNP are as follows:

Freeway/arterial	Support major regional and inter-regional traffic movement. Freeways and motorways usually feature strict access control via grade separated interchanges.
Sub-arterial	Provide connection between arterial roads and local roads. May provide a support role to arterial roads during peak periods. May have been designed as local streets but can serve major traffic generators or non-local traffic functions. Previously designated as "collector" roads in ECRTN.
Local Road	Provide vehicular access to abutting property and surrounding streets. Provide a network for the movement of pedestrians and cyclists, and enable social interaction in a neighbourhood. Should connect, where practicable, only to sub-arterial roads.

Based on the above definitions, King Street is classified as a local road.

5.2 OLGR/LAB Criteria – New Club Activities & Equipment

Since this assessment relates to control of noise from licensed premises, together with determination of a Development Application to NCC, two relevant criteria apply. Reproduced below are the Standard Noise Conditions imposed by the LAB:

"The LA10 noise level emitted from the licensed premises shall not exceed the background noise level in any Octave Band Centre Frequency (31.5Hz - 8kHz inclusive) by more than 5dB between 07:00 am and 12:00 midnight at the boundary of any affected residence.

The LA10 noise level emitted from the licensed premises shall not exceed the background noise level in any Octave Band Centre Frequency (31.5Hz - 8kHz inclusive) between 12:00 midnight and 07:00 am at the boundary of any affected residence.

Notwithstanding compliance with the above, the noise from the licensed premises shall not be audible within any habitable room in any residential premises between the hours of 12:00 midnight and 07:00 am."

To ensure the requirements of the LAB are satisfied, we have adopted a planning level, in the adjacent residential area, before midnight of **40dB(A),L10** being 5dB(A) above the measured background noise level in the area between 6pm and midnight. Clauses relating to limits after midnight do not apply, as the club will be closed.

Table 6: Entertainment Noise Planning Level, L(A)10 – Before Midnight

Octave Band Centre Frequency, Hz									
dB(A)	**31.5**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
40	24	29	31	33	35	33	31	25	23

Alternate criteria that may apply are those taken from the EPA's Noise Policy for Industry (NPI), which considers noise from industrial noise sources scheduled under the Protection of Environment Operations Act. Since the premises is licensed and the LAB Conditions are more stringent in this case, we have adopted criteria shown in the above Tables for assessment purposes.

5.3 EPA Criteria - Site Activities & Mechanical Plant Commercial/Residential Buildings

Noise from industrial noise sources scheduled under the Protection of Environment Operations 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 is based on the total industrial noise in an area in relation to the noise levels from the development to be assessed. 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/light industrial 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. However, the 5dB(A) does not need to be subtracted where cumulative industrial noise is not a necessary consideration because no other industries are present in the area, or likely to be introduced into the area in the future.

Table 7 below specifies the applicable project intrusiveness and amenity noise trigger levels for the proposed redevelopment.

Table 7: - Base Noise Level Objectives

Period	Intrusiveness Criteria	Amenity Criteria
Day	43 (38+5)	55
Evening	41 (36+5)	45
Night	40 (35+5)	40
Receiver Type: Suburban (See EPA's NPI - Table 2.2)		

Project specific noise levels, determined as the more stringent of the intrusiveness criteria and the amenity / high traffic criteria, are as follows:

Day **43dB LAeq,15 Minute** 7am to 6pm Mon to Sat or 8am to 6pm Sun and Pub Hol.
Evening **41dB LAeq,15 Minute** 6pm to 10pm
Night **40dB LAeq,15 Minute** 10pm to 7am Mon to Sat or 10pm to 8am Sun and Pub Hol.

5.4 Maximum Noise Level Event Assessment - Sleep Arousal

Section 2.5 of EPA's NPI requires a detailed maximum noise level event assessment to be undertaken where the subject development/premises night-time noise levels exceed the following:

- LAeq (15 minute) 40dB(A) or the prevailing RBL plus 5dB whichever is greater, and/or
- LAFmax 52dB(A) or the prevailing RBL plus 15dB, whichever is greater.

The detailed assessment should cover the maximum noise level, the extent to which the maximum noise level exceeds the RBL, and the number of times this happens during the night period.

5.5 Construction Noise – Residential Receivers

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 8:

Table 8: - 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**. 48dB(A) day**	- 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 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

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 9 details relevant criteria for potentially affected receivers (also see Figure 1).

Table 9: Criteria Summary

Assessment Location	Standard Construction Hours		Outside
	Noise Affected	Highly Noise Affected	Standard Hours
Residential Dev'p	48	75	41/40 #
Commercial Dev'p	70	75	70

#Evening and night periods.

5.6 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 10 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 10: 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.

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.

6 METHODOLOGY

6.1 Club Outdoor Areas

Reverb Acoustics has completed a detailed analysis of patron noise levels under various situations in licensed premises with the following findings:

Table 11: Noise Levels from Various Types of Occupied Areas within Licensed Premises

Situation/Location	Noise Rating	Typical Noise Levels dB(A),L10 #	Comments
Auditorium courtyard *Breakout for patrons during functions*	1	85+	During functions up to 1/3 of patrons may occupy outdoor area. Monitoring recommended.
General courtyard *Servicing lounge areas, public bars, etc*	2	80	Patrons may remain in area for extended periods. Monitoring recommended.
Bistros *Internal eating area*	3	75-80	Continuous conversation typical at self-service areas.
Alfresco dining *Seating outdoors*	4	70-75	Patrons generally quiet, although may remain for extended periods and produce higher noise levels.
Restaurant *Internal eating area with open doorway*	5	65-70	Generally quiet. Only low level conversation. Patrons typically vacate area once meal completed.
Club Gaming area *Poker machine, TAB areas*	6	60-65	Patrons typically quiet. Rarely talk. Some noise from machines, TV's, monitors, etc.
Gaming courtyard *Smokers breakout*	7	<60	Patrons typically quiet. Rarely talk. Anxious to return to gaming area.

 # Typical noise level at inside surfaces.

Table 11 reveals noise from patrons on the first level terrace would have a noise rating of 1, i.e. 85dB(A) and noise from patrons on the ground level terrace would have a rating of 2, i.e. 80dB(A). The above assumptions are in agreement with CM Harris Handbook of Acoustical Measurements & Noise Control, which nominates a Sound Pressure Level (SPL) of 80-83dB(A) at 1 metre for 50-60 patrons talking with raised voices. To create our acoustic model, we have assumed a worst-case situation where the area is operating at full capacity. The sources were placed randomly over the available areas and the resulting sound pressure level at each surface opening was propagated to nearest residences using an equation[1] giving the sound field due to an incoherent plane radiator.

The combined sound pressure level (SPL) at the receiver is then compared to the criteria. Where noise impacts above the criteria are identified, suitable noise control measures are implemented and reassessed to demonstrate satisfactory received noise levels.

[1] Equation (5.104), DA Bies and CH Hansen, *Engineering Noise Control*, E & FN Spon, 1996.

6.2 Club Entertainment

A theoretical assessment of amplified entertainment in the function rooms has been carried out to predict the noise level at the nearest potentially affected residential boundaries. Using noise data for a live band and the known criteria at nearby receivers enabled calculation of the required transmission loss of each building element. Inspection of the supplied plans has identified that west glazing and doors, and the roof/ceiling are the main noise leakage paths of concern.

The Sound Power Levels, Lw dB(A), of proposed entertainment types are shown in the following Table. From consideration of the known dimensions and orientation of each building component the sound pressure level immediately outside was propagated to nearest residences using an equation[2] giving the sound field due to an incoherent plane radiator.

Table 12: Lw, Disco dB(A),L10

Octave Band Centre Frequency, Hz									
dB(A)	**31.5**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
108	68	82	90	95	101	103	102	98	82

6.3 Road Traffic Noise

Due to the non-continuous nature of traffic flow to and from the site, noise generated by traffic associated with the development, on public roads, is assessed using the EPA approved US Environment Protection Agency's Intermittent Traffic Noise guidelines.

Equation 1 outlines the mathematical formula used in calculating the Leq,T noise level for intermittent traffic noise.

Equation 1:

$$L_{eq},T = L_b + 10\log\left[1+\frac{ND}{T}\left(\frac{10^{(L\max - Lb)/10}-1}{2.3}-\frac{\left(L_{\max}-L_b\right)}{10}\right)\right]$$

Where L_b background noise level (dB(A))
T is the time for each group of vehicles (min)
D is duration of noise of each vehicle (min)
L_{MAX} is vehicle noise (dB(A))
N is number of vehicle trips

Typical vehicle noise levels were sourced from our library of technical data, while background noise levels are those described in Section 2.1. The Lmax vehicle noise levels used in Equation 1 are the maximum predicted noise levels produced at the facade of the residence by vehicles entering and departing the site.

[2] Equation (5.104), DA Bies and CH Hansen, *Engineering Noise Control*, E & FN Spon, 1996.

7 ANALYSIS AND DISCUSSION

7.1 Received Noise Levels - Road Traffic

Traffic due to the proposal travelling on nearby public roads is assessed separate to site noise and is subject to the criteria described in Section 5.1 of this Report. All delivery trucks and vehicles will access the site along King Street.

Delivery Trucks
The anticipated frequency of delivery vehicles is taken from counts for similar sized developments. Assuming, liquor, food, and miscellaneous deliveries, up to 5-6 deliveries are expected each day, with perhaps 2-3 trucks or vans during peak hourly periods (4-6 movements).

Truck noise varies from one machine to another, with more modern larger trucks consistently producing a sound power in the range 98dB(A) to 102dB(A) at full power. This assessment assumes a typical delivery truck sound power of 100dB(A), as full engine power is not typically required to approach and depart the site at low speed.

Customers'/Resident's Vehicles
We expect a comprehensive Traffic Assessment to be completed for the redevelopment in support of the Application. Recalculation of traffic noise impacts will be based on the report when available. In the interim we have assumed that maximum vehicle numbers will occur at the completion of a function at the club, with perhaps 150 vehicle movements in a peak hourly period. Based on the number of proposed residential units, the RMS Guide to Traffic Generating Developments indicates that a further 20-30 vehicle movements may occur each hour. Based on the above, approximately 180 vehicle movements may occur during peak hourly periods

Cars typically produce an average sound power of 90dB(A), however wide variations are noted particularly with smaller modern cars and larger V8 or diesel powered vehicles. Our calculations present the worst case for the situation, as the noise produced by a typical car accelerating at full power is used to determine the received noise level. In reality, many people will not leave the site at full acceleration but will depart more sedately. The following Table shows calculations to determine received traffic noise levels at typical residential receivers along King Street for peak day and night periods.

Table 13: Traffic Noise Calculations King Street - dB(A)Leq (T)

Traffic and Receiver	Peak Day		Peak Night	
Vehicle Type	Cars	Trucks	Cars	Trucks
Movements per hour	180	6	180	-
Vehicle Sound Power	90	100	90	100
Received Noise Level, Lmax	59	69	59	69
Average Distance to Rec, m	15	15	15	15
Received Noise Level	50.0	46.2	52.0	-
Total Received	**51.5**		**52.0**	
Criteria	**55dB(A),Leq 1hr**		**50dB(A),Leq 1hr**	
Impact	**0**		**0**	
Existing Noise Level	**57**		**51**	
Relative Noise Increase	**1.1**		**3.5**	

The above Table shows the noise impact from traffic movements associated with the development are predicted to compliant with the criteria during day and night periods. The RNP also recommends that the increase in road traffic noise levels due to a proposed project or traffic generating development should be considered. The relative increase applicable to freeways and sub-arterial roads must not exceed 12dB(A) during the day and night. As can be seen by the results in the above Table, the relative increase due to the development is 1.1-3.5dB(A) and considered acceptable.

7.2 Received Noise Levels – Club Outdoor Areas

Table 14 shows sample calculations to predict the noise impact from patrons on the first level terrace, propagated to the nearest residences north of the site (R1). Tables 11 and 12 show summaries of calculations to predict the noise impact from all new outdoor areas at all nearby receivers.

Table 14: Sample Calculations - Noise Impact, Patrons First Level Terrace Propagated North to Nearest Residential Boundaries (R1) dB(A),L10

		Octave Band Centre Frequency, Hz								
Item	**dB(A)**	**31.5**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
SPL at perimeter	85	21	38	74	78	80	77	78	67	59
Barrier loss[1]		5	5	4	3	2	1	0	0	0
SPL at rec	**38**	**-**	**-**	**27**	**31**	**33**	**30**	**29**	**20**	**12**
Crit (before 12am)	**41**	**24**	**29**	**31**	**33**	**35**	**33**	**31**	**25**	**23**
Impact	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

1. Enclosed balustrade 800-900mm above FFL.

Table 15: Combined Noise Impact – All Outdoor Areas Propagated to Nearest Receivers, dB(A),L10

		Octave Band Centre Frequency, Hz								
Location	**dB(A)**	**31.5**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
R1. Residences N	38	-	-	27	31	33	30	29	20	12
R2. Residence NE	34	-	-	21	26	29	26	26	18	11
R3. Residence S	26	-	-	13	18	21	18	18	10	3
R4. Future Res's S	46	-	-	33	38	41	38	38	30	23
Crit (before 12am)	**41**	**24**	**29**	**31**	**33**	**35**	**33**	**31**	**25**	**23**

Table 16: SPL Patrons in Outdoor Areas – Short Term Noise Events Propagated to Nearest Residences dB(A),Lmax

Location	**First Level Terrace**	**Ground Level Terrace**
R1. Residences N	46	45
R2. Residence NE	41	41
R3. Residence S	34	32
R4. Future Res's S	50	41
Crit. (10pm-12am)	**52dB(A),Lmax**	

Theoretical results in the above Tables show that the combined noise impact from patrons in all outdoor areas will be compliant with the LAB (and therefore Council) criteria at nearest existing residential receivers, subject to acoustic modifications detailed in Section 8. However, exceedances of up to 5dB(A) are predicted at nearest future residential apartments (R4). Therefore, in order to achieve compliance, acoustic modifications will need to be incorporated in the design of affected apartments. Section 8.7 for required construction details for future apartments.

7.3 Received Noise Levels – Club Entertainment

The following Table shows calculations to predict noise propagated through the roof/ceiling of a first level Function Room, while a Disco is operating, and the resulting impact at the nearest residential boundary north of the site (R1). Table 18 shows a summary of calculations to predict the resulting noise impact at nearest residential receivers from entertainment.

Table 17: Calculated SPL (Entertainment) – North Residences (R1)
Propagated through Roof/Ceiling

		Octave Band Centre Frequency, Hz								
Item	**dB(A)**	**31.5**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Source Lw	**108**	62	74	85	96	100	101	96	97	82
TL[1] roof/ceiling		12	16	28	36	40	44	48	45	51
Exterior SPL	60	44	52	51	54	54	51	42	46	25
SPL at rec	**35**	**19**	**27**	**29**	**29**	**29**	**26**	**17**	**21**	**-**
Crit (before 12am)	**41**	**24**	**29**	**31**	**33**	**35**	**33**	**31**	**25**	**23**
Impact	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

1. Metaldeck roof, Building Blanket, 300mm cavity to 13mm FR Pb with insulation.

Table 18: Calculated SPL Entertainment
Propagated to Nearest Residential Receivers dB(A),L10

		Octave Band Centre Frequency, Hz								
Noise Path	**dB(A)**	**31.5**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
R1. Residences N	35	19	27	29	29	29	26	17	21	-
R2. Residence NE	33	17	25	24	27	27	24	15	19	-2
R3. Residence S	29	13	21	20	23	23	20	11	15	-6
R4. Future Res's S	43	27	35	34	37	37	34	25	29	8
Crit (before 12am)	**41**	**24**	**29**	**31**	**33**	**35**	**33**	**31**	**25**	**23**

Theoretical results in the above Table shows that noise emissions from entertainment will be compliant with the overall LAB criteria at all nearby existing residential receivers. However, exceedances of 2dB(A) of the overall criteria are predicted at future residential apartments (R4), with exceedance of up to 6dB(A) at 31.5Hz-8kHz. In order to achieve compliance, acoustic modifications will need to be incorporated in the design of affected apartments. See Section 8 for required construction details and strategies.

While we consider that the controls recommended to reduce entertainment noise to acceptable levels will be satisfactory, the wide variation in output from entertainment providers may cause higher than predicted noise in the residential area. Should this occur, we recommend the installation of an electronic TecSound noise monitor in the affected area. These devices have been proven capable of controlling low frequency emissions and are a cost effective solution for minor noise exceedances.

7.4 Received Noise Levels – Mechanical Plant

The club will require air conditioning plant to ventilate habitable spaces, refrigeration plant for cool rooms/cold storage, and exhaust plant for the kitchen, while residential buildings will require air conditioning and exhaust, all which have the potential to disturb nearby residents. Plant selection has not been finalised at this stage; therefore, this assessment is based on a typical noise levels for similar situations.

Location	*Plant Item*
Club First Level Deck	Refrig condensers (x2) Air con condensers (x2)
Club Roof	Exhaust Fan (x2) Air con condensers (x2)
Residential Blgs Roof	Exhaust Fan (x6) Air con condensers (x20) and/or air con on balconies

The following Table shows sample calculations to predict noise from anticipated kitchen exhaust on the roof above the kitchen, propagated north to nearest residential boundaries (R1).

Table 19: Calculated SPL, Kitchen Exhaust dB(A),L10
Propagated to Nearest Residential Boundaries (R1)

		Octave Band Centre Frequency, Hz								
Item	**dB(A)**	**31.5**	**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Exhaust Lw (x2)	80	44	51	62	68	75	74	73	67	54
Barrier loss		0	0	0	0	0	0	0	0	0
SPL at Receiver	**34**	**-**	**5**	**16**	**22**	**29**	**28**	**27**	**21**	**8**
Crit (before 12am)	**41**	**24**	**29**	**31**	**33**	**35**	**33**	**31**	**25**	**23**
Impact	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

As can be seen by the results in Table 19, noise emissions from kitchen exhaust on the roof is predicted to be compliant with the night criterion of 41dB(A) at nearest residences north of the site. See Section 7.6 for a summary of predicted noise impacts at all residential receivers and Section 8 for barrier details for all plant areas to ensure compliance.

7.5 Deliveries

Vans and light trucks are expected to deliver goods to the loading docks. Typical noise sources include the vehicle entering and leaving unloading of the vehicle and roller door operation. The following Table shows calculations to predict the noise impact at nearest residences.

Table 20: Noise Impact from Deliveries - dB(A),Leq
Propagated to Nearest Residential Boundaries (R1/R2)

Activity	Van/Truck Enter/Leave	Roller Door	Unloading
Lw dB(A),Leq	86	82	74
Ave Dist to rec (m)	10	90	90
Duration	10 sec	30 sec	5 min
No. of Events	2	2	1
Barrier loss/Directivity	0	5	5
Rec dB(A),Leq	**39**	**18**	**17**
Combined	**39**		
Criteria (day/even)	**41dB(A)**		
Impact	**-**		

As can be seen by the above results, noise from deliveries are predicted to be compliant with the criteria, subject to time restrictions detailed in Section 8.

7.6 Cumulative Noise Impact

The noise impact from all noise sources activities associated with the development must be considered to confirm compliance. The cumulative noise impact from all sources is shown in the following Table. Attended measurements at the site revealed that noise emissions from existing mechanical plant were inaudible and do not contribute to the overall noise level at the receivers.

Table 21: Cumulative Noise Impact-Propagated to Nearest Res's, dB(A),L10 (DAY/EVEN)

Receiver/Item	Terraces	Entertainment	Mech Plant	Deliveries	Sum
R1. Residences N	38	35	34	34	**42**
R2. Residence NE	34	33	33	34	**39**
R3. Residence S	26	29	29	<20	**33**
R4. Future Res's S	46	43	39	32	**48**
Crit (before 12am)	**41**				

Table 22: Cumulative Noise Impact-Propagated to Nearest Res's, dB(A),L10 (NIGHT)

Receiver/Item	Terraces	Entertainment	Mech Plant	Deliveries	Sum
R1. Residences N	38	35	34	-	**41**
R2. Residence NE	34	33	33	-	**38**
R3. Residence S	26	29	29	-	**33**
R4. Future Res's S	46	43	39	-	**48**
Crit (before 12am)	**41**				

As can be seen by the above results, the cumulative noise impact from activities and equipment associated with operation of the new golf club is predicted to be compliant with the criteria at all nearby residences during trading hours, subject to recommendations detailed in Section 8. It is noted however, that exceedances of up to 7dB(A) are predicted at nearest future residential apartments south of the site (R4). As such acoustic windows and doors will be required for affected apartments.

Noise impacts at future apartments reaches the receiver room by way of inadequate windows, doors, facades and ceiling structures. Details of required construction details for future residential apartments are shown in Section 8.7.

7.7 Construction Noise & Vibration

7.7.1 Predicted Noise Impacts

Received noise produced by anticipated construction activities is shown in Table 23 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.

Table 23: Predicted Plant Item Noise Levels, dB(A)Leq

Plant/Activity	(Lw)	Distance to Residence		
		50m	75m	100m
Mobile crane	(104)	62	58	56
Excavator with j'hammer	(114)	72	68	66
Excavator	(104)	62	58	56
J'hammer (internal)	(98)	56	52	50
Positrack	(108)	66	62	60
Hammering	(98)	56	52	50
Angle grinder	(106)	64	60	58
Air wrench (silenced)	(98)	56	52	50
Compactor	(111)	69	65	63
Road truck	(104)	62	58	56
Grader	(102)	60	56	54
Air compressor	(94)	52	48	46
Framing gun	(95)	53	49	47
Concrete Agitator	(112)	70	66	64
Concrete Pump	(110)	68	64	62
Circular saw	(109)	67	63	61

Nearest residences 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 8.

When earthworks or demolition occurs noise levels above 70dB(A) are possible at nearest locations, which may produce some adverse comment. 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. Barriers will not be required in situations where intervening structures provide 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. 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.

7.7.2 Predicted Vibration Impacts - Construction Plant and Equipment

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 24 lists the results of previous vibration measurements, with each measurement corrected to a standard distance of 20m to represent nearest residential receivers.

Table 24: 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

Table 24 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/s^2)
t = total cumulative time (seconds) of the vibration event(s)

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 22. 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 25, gives an indication of the effects from varying magnitudes of vibration.

Table 25: 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.

8 NOISE CONTROL RECOMMENDATIONS

8.1 Club Function Rooms

8.1.1 Function room ceilings to consist of sisalation or wire mesh laid down on roof purlins. This is to be completely covered with a 30-40mm foil faced building blanket or similar (in situations where purlins/battens are at centres close enough to avoid excessive sagging of the blanket, the sisalation/wire mesh may be omitted). Fix one (1) layer 16mm fire rated plasterboard or 13mm sound rated plasterboard to underside of purlins, plus cavity insulation (R3/S3). The cavity insulation is to be installed in addition to, not in lieu of the building blanket. Excessive reverberation may be an issue in the function rooms, which can be addressed by installing a secondary suspended acoustic tile ceiling, applying adhesive backed acoustic tiles to the plasterboard ceiling, or similar, together with generous application of absorption to available wall surfaces (this recommendation is not mandatory but recommended to ensure occupant comfort).

8.1.2 To reduce noise transmission from the Function Rooms to adjoining areas in the club, we recommend *either* installing full height internal walls *or* suspend 6kg/m² Nuwave Noise Barrier or Wavebar from the roof to the top of the top plate.

8.1.3 External doors to the function rooms must be kept closed when amplified entertainment takes place. No restrictions are required when sedate activities producing minimal noise take place.

8.1.4 There are no restriction on entertainment types, i.e. live bands, Discos, duo, jazz bands, etc, are permitted during trading hours. However, in the event that complaints arise from amplified music, we recommend installing an electronic TecSound noise monitor. These devices have been proven capable of controlling low frequency emissions and are a cost effective solution for minor noise exceedances.

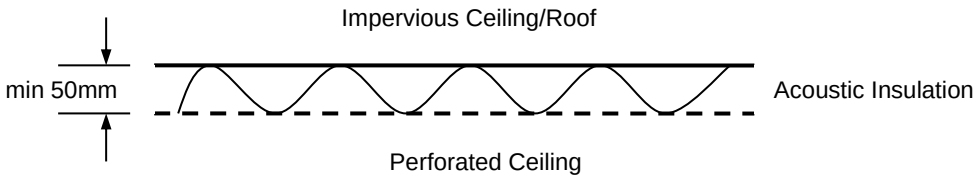
8.1.5 Amplified entertainment is to cease in the function rooms 30 minutes prior to closing time. Incidental "background" music is permitted after this time until function rooms are vacated.

8.2 Club Outdoor Terraces

8.2.1 Outdoor areas may be used at all times during trading hours.

8.2.2 An absorbent ceiling must be installed to any external roof/ceiling of outdoor terraces to reduce reflected sound. We recommend a perforated metal ceiling to the underside of the roof, i.e. Luxalon, Renhurst, or similar, minimum, 10-15% open area, backed with R2/S2 fibreglass or polyester insulation. Alternatively, a perforated plasterboard or perforated FC sheet ceiling may be installed with cavity insulation. If the insulation is exposed to the weather, hosing, washing, etc, we recommend using a water resistant acrylic blanket (available through the supplier).

Figure 2: Absorbent Ceiling Detail to Outdoor Decks



8.3 Mechanical Plant

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

Location	Plant Item	Maximum Allowable Noise level	
		SPL @ 1m	Lw
Club	Refrig/Air Con condenser	76	82
	Exhaust/Supply Air Fan	74	80
Commercial Buildings	Refrig/Air Con condenser	76	82
	Exhaust/Supply Air Fan	74	80
Pool (internal)	Pool pumps	68	74
Res Blocks Roof	C'park Exhaust each Block	70	76
Residential Air Con	Individual balconies	62	68
	Roof	74	80

8.3.2 Acoustic barriers are to be constructed adjacent to air conditioning, refrigeration and pool plant that exceeds the limits specified in 8.2.1 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.

8.3.3 Acoustic barriers are to be constructed at the fan discharge of exhaust plant that exceeds the limits specified in 8.2.1 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.

8.3.4 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.

8.3.5 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.

8.3.6 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.

8.4 Deliveries

8.4.1 Deliveries are to be restricted to the day (7am-6pm) and early evening (6pm-8pm). No deliveries are permitted outside these times, as exceedances of the criteria may occur.

8.5 Proposed Gym

8.5.1 No amplified music or PA System is permitted in any section of the gym.

8.5.2 Background (incidental) music is permitted. Output must be limited to 70dB(A) at a distance of 3m from each speaker. Once this level is achieved, corresponding references should be assigned to the sound system controls.

8.5.3 Rubber gym flooring is to be installed in areas where free weights are used to reduce impact noise.

8.5.4 All equipment racks and training machines must be isolated from the building structure to prevent structure-borne noise transmission to apartments above.

8.5.5 No training activities are permitted outside the premises prior to 7am or after 8pm.

8.5.6 A comprehensive noise impact assessment for gym activities is recommended once details are finalised.

8.6 Proposed Pool

8.6.1 No amplified music is permitted in any section of the swim centre.

8.6.2 Background (incidental) music is permitted. Output must be limited to 70dB(A) at a distance of 3m from each speaker. Once this level is achieved, corresponding references should be assigned to the sound system controls.

8.6.3 Acoustic louvres are to be installed in preference to standard louvres for any ventilation openings in the external walls. 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

8.6.4 A comprehensive noise impact assessment for pool activities and equipment is recommended once details are finalised.

8.7 Future Residential Apartments

Similar calculations to those in Section 7 were performed for all building elements of future residential apartments (R4) to achieve compliance with the criteria. From these calculations, a schedule of required glazing, and building construction has been compiled, shown below.

8.7.1 Glazing: The following construction details must be incorporated into the design of future residential apartments south of the site (R4):

The glazing systems sighted in the following Table 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 or Vlam Hush glass.
Type D: Double-glaze or Insulating Glass Unit (IGU).

The typical glazing shown in the following Table 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 26: Glazing Schedule

Facade	Location	Required Rw Compliance Requirement	Typical Glazing System (Not for Specification)
East Apartment Building			
North	Commercial/Retail	**28**	Type B
	Apartments	**31-34**	Type C
East	Commercial/Retail	**29**	Type B or C
	Apartments	**32-34**	Type C or D
South	Commercial/Retail	**-**	No acoustic requirement
	Apartments	**29-31**	Type B or C
West	Commercial/Retail	**-**	No acoustic requirement
	Apartments	**-**	No acoustic requirement
Centre & West Apartment Buildings			
North	Apartments	**26-29**	Type B or C
East	Apartments	**26-30**	Type B or C
South	Apartments	**-**	No acoustic requirement
West	Apartments	**-**	No acoustic requirement

8.7.2 Roof Construction: Roof construction should consist of either concrete or sisalation or wire mesh laid down on roof trusses. This is to be completely covered with a 30-40mm foil faced building blanket or similar (in situations where trusses are at centres close enough to avoid excessive sagging of the blanket, the sisalation/wire mesh may be omitted). If Terra Cotta or concrete roof tiles are preferred, the building blanket may be omitted. All upper level ceilings are to consist of an impervious ceiling of 1 sheet 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 and $6/m^2 for R3 batts). Generally, Councils now require new dwellings to achieve an adequate energy rating, which will usually only be achieved if thermal insulation is installed in the ceiling void, therefore, builders would be obliged to install insulation in any case.

8.7.3 Wall Construction: We strongly recommend brick veneer or cavity-brick construction. These high-mass building elements will provide attenuation of the lower frequencies, typically around 125 to 500Hz, typically generated by mechanical plant, heavy vehicles, etc. All internal lining for brick veneer to be minimum 1 sheet 10mm plasterboard. All lightweight cladding (i.e. vinyl weatherboards, Colorbond, Weathertex, etc) is to be backed with either 6mm fibre cement sheeting (Villaboard, Hardiflex) or 10mm construction plywood. If upper level lightweight construction is preferred (i.e. Hebel Powerpanel, weatherboard, etc) modification to facades will be required consisting of cavity infill of R2/S2 insulation, together with internal lining 1 sheet 13mm fire plasterboard.

8.7.4 Ventilation: 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, although, 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). However. the DPE's Apartment Design Guide Objective 4B-1 specifies all habitable rooms should be naturally ventilated in apartment complexes. A typical open window will reduce noise by 15dB(A) or more when contained within a masonry structure, therefore the windows open criteria will be met. Nonetheless, we recommend that mechanical ventilation is installed in all future residential apartments.

8.7.5 Once apartments layouts have been finalised revised construction details will be required, based on room use, apartment location, and orientation of each building component.

9 NOISE MANAGEMENT PLAN – NEW CLUB

9.1 Noise Management Objectives

The objectives of the NMP are to minimise noise related impacts during operation of the club by:

9.1.1 Complying with strategies detailed in Section 8.

9.1.2 Operating within prescribed time limits.

9.1.3 Responding to complaints and documenting action taken.

9.1.4 Identifying and implementing alternate measures where necessary on an annual basis.

9.2 Noise Control Strategies

9.2.1 All areas may operate during approved trading hours.

9.2.2 Acceptable entertainment types include live club bands, Discos, soloists, duos, recorded music, etc.

9.2.3 Only acoustic or "incidental" background music is permitted in outdoor areas (no amplification, bass, drums, etc). A limiting SPL of **70dB(A),L10** is to be set at a distance of 3 metres from the speakers. Once this level is achieved, corresponding references should be assigned to the sound system controls.

9.2.4 A suitable complaints handling procedure is to be implemented. See Section 9.3.

9.2.5 All staff and employees directly involved with operating the club 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 promoters or sub-contractors.

9.3 Complaints Handling Procedure

9.3.2 In the event of complaint, a subjective audibility assessment of noise emissions should be undertaken at the facade or boundary of the residence of the complainant.

9.3.3 If noise emissions at any residence are deemed to be unacceptable, then the staff member must immediately investigate the source of noise and rectify the problem. The results and recommendations from the staff audibility survey must be recorded in a Complaints Handling Register for future reference and presentation to Council on request. The log book should contain the following:

i) Time and date of survey.
ii) Name, address and contact details of complainant.
iii) Description of noise source(s) audible during subjective assessment.
iv) In the event of unsatisfactory noise emissions, a description of action taken.
v) Action reported to complainant.
vi) Signature.

9.3.4 The Manager should take responsibility and be available to consult with residents, perhaps only during trading hours. Response to complaints or comments should be made in a timely manner and action reported to the concerned party.

10 CONSTRUCTION NOISE & VIBRATION CONTROL STRATEGIES

10.1 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 22 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 22: 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
Jackhammer	Heritage structure	15
	Residential building	10
	Commercial	5
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.

10.2 Vibration Management Strategies

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

Noise & Vibration Monitoring: Monitoring is to be conducted at all adjoining residential boundaries in the early stages of construction and at any change in process, particularly when vibration generating activities occur. Once compliance is verified monitoring may be suspended if outside minimum offset distance nominated in Table 7.

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

10.3 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 23 shows some common construction equipment, together with noise control options and possible alternatives.

Table 23: - 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.

10.4 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, etc.
- Temporary barriers of plywood, excess fill, etc, at least 2m high, at the perimeter of the construction site

10.5 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.

10.6 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.

11 CONCLUSION

A noise impact assessment for the Merewether Golf Course Redevelopment, has been completed, resulting in noise control recommendations summarised in Sections 8, 9 and 10 of this Report. The site is suitable for the intended purpose providing recommendations outlined in this report are incorporated into the design. With these or equivalent measures in place, noise from the site will be either within the criteria or generally below the existing background noise level in the area for the majority of the time.

An assessment of external noise impacting upon future residential apartments south of the site has resulted in the compilation of a schedule of minimum glazing thicknesses and types, roof/ceiling and wall construction, etc, to ensure the acoustic amenity of future occupants is ensured. Note: The typical glazing shown in Table 26 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.

The existing average Leq noise levels already impacting the residential areas is above that predicted by the proposal and since the character and amplitude of activities associated with the extended site will be similar to those already impacting the area, it will be less intrusive than an unfamiliar introduced source.

Theoretical results show no exceedance of the LAB (and therefore Council) noise criteria, during allowable time periods, due to entertainment, patron activity and mechanical plant, however, in the unlikely event of complaints arising, appropriate noise management strategies are available and described in Section 8.

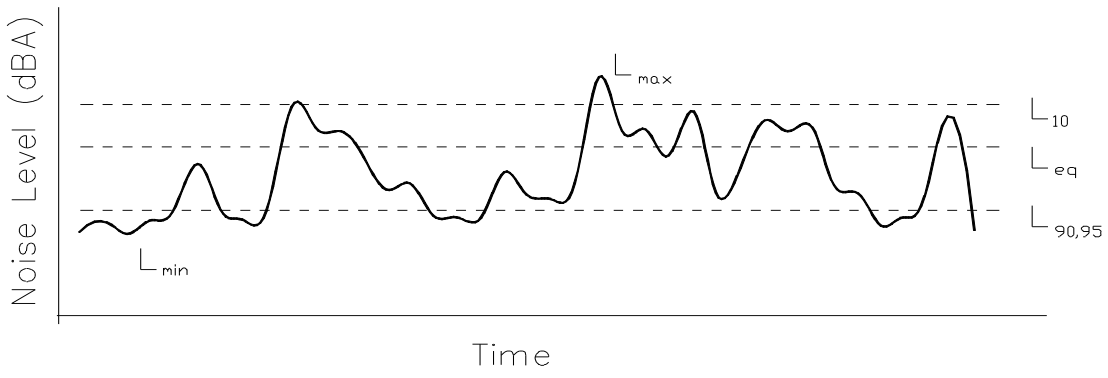
Providing the recommendations presented in this report are implemented, operation of the new club and commercial/residential buildings will not have any long term adverse noise impact upon the acoustic amenity of nearby residents. We therefore see no acoustic reason why the proposal should be denied.

Steve Brady M.A.S.A. A.A.A.S.
Principal Consultant

APPENDIX A
Definition of Acoustic Terms

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 was previously used in Australia as the descriptor for intrusive noise (usually in dBA).



APPENDIX B
Risk Assessment Checklist

Risk Assessment Checklist

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