Noise and Sound Services

Charlestown Leisure Centre - Noise Assessment

For the: -
Proposed Redevelopment of Charlestown Swimming Pool at Dickinson Street,
Charlestown, NSW 2290

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Report No. nss 22141 – Final Rev A

Prepared at the Request of:-

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C O N T E N T S

SUMMARY

A noise assessment has been carried out for the proposed Charlestown Leisure Centre to be located at the current Charlestown swimming complex. The purpose of this report is to provide an independent and accurate assessment of the potential noise impact generated by the leisure centre, compare these to relevant noise criteria and/or guidelines and provide recommendations for noise amelioration measures where necessary.

The proposed design includes a 50 metre outdoor pool and indoor 25 metre pool, 15 metre learning pool and an adventure water pool. Additional indoor facilities include a spa with sauna and steam room, male and female amenities, staff rooms and store rooms. The indoor area will be fully enclosed. Plant rooms are located at the eastern and western end of the indoor facilities. The eastern plant room houses the pool filtration equipment with pool heat pumps located on the roof of the plant room. The heat pumps will be enclosed by 2.4 metre high acoustic louvres. The western plant room houses the air conditioning equipment for the fitness rooms, administration rooms and amenities. The smaller plant room at the south west corner encloses additional pool filtration equipment. Heat exchangers serving the air conditioning for the pool hall will be located centrally on the roof and will be sunk below the roof line with surrounding acoustic louvres.

Proposed hours of operation are Monday to Saturday 5.30am – 10.00pm, Sunday and Public Holidays 6.00am – 10.00pm.

The existing noise environment has been measured and recorded over a period of 9 days. Noise goals for the proposed development have been based on the recorded levels. Noise models have been developed for each of the noise sources which include the use of the pool hall and the outdoor 50 metre pool.

Noise emissions from plant rooms, external mechanical equipment, pool hall, outdoor pool, fitness rooms and the car park have been calculated and predicted levels compared to the noise goals and noise criteria.

To achieve the noise criteria at the residential boundaries and the child care centre boundary, maximum sound power levels for outdoor mechanical equipment have been specified. Noise emissions from the plantrooms and the use of the indoor pool hall, fitness rooms and the car park will comply with the noise criteria. Typical daily noise emissions from the 50 metre outdoor pool will also comply with noise criteria whilst noise emissions from school carnival days will be below the existing day time levels experienced by the surrounding residential properties.

Providing the recommendations are incorporated into the design and construction of the Charlestown Leisure Centre, noise emissions are predicted to comply with the noise criteria provided by the NSW EPA for the outside environment.

1. INTRODUCTION

Noise and Sound Services was requested by Facility Design Group, 19 The Terrace, Cambewarra, NSW 2540 to carry out a noise assessment for the proposed Charlestown Leisure Centre to be located at Dickinson Street, Charlestown, NSW 2290.

The purpose of this report is to provide an independent and accurate assessment of the potential noise impact generated by activities within the centre, compare these to relevant noise criteria and/or guidelines and provide recommendations for noise amelioration measures where necessary.

2. PROPOSED LEISURE CENTRE LOCATION

2.1 Location

The proposed leisure centre is to be located at the existing location of Charlestown swimming pool. The existing site is shown in Figure 1 below. The existing facility consists of a 50 metre pool, a 25 metre pool and all the necessary facilities such as changing rooms, offices, plant rooms and amenities. Residential properties are located on the northern and eastern boundaries of the centre with further residential properties located to the west on the opposite side of Dickinson Street and to the south across Mulbinga Street.

Existing hours of operation are as follows
Monday to Friday 5.30am – 7.00pm
Saturday, Sunday and Public Holidays 7.00am – 6.00pm

A child care centre is located 12 metres to the east of the existing swimming pool plant room. Charlestown SDA Church is located directly opposite the existing car parking entrance, 47 metres from the building entrance and 32 metres from the current casual parking locations. Casual parking locations are approximately 30 metres from the nearest residential boundaries on Dickinson Street.

Surrounding streets are classified as local roads (ref: NSW Road Noise Policy 2011) which provide vehicular access to abutting properties.

The general noise environment is dominated by local vehicle traffic, community noise and fauna.

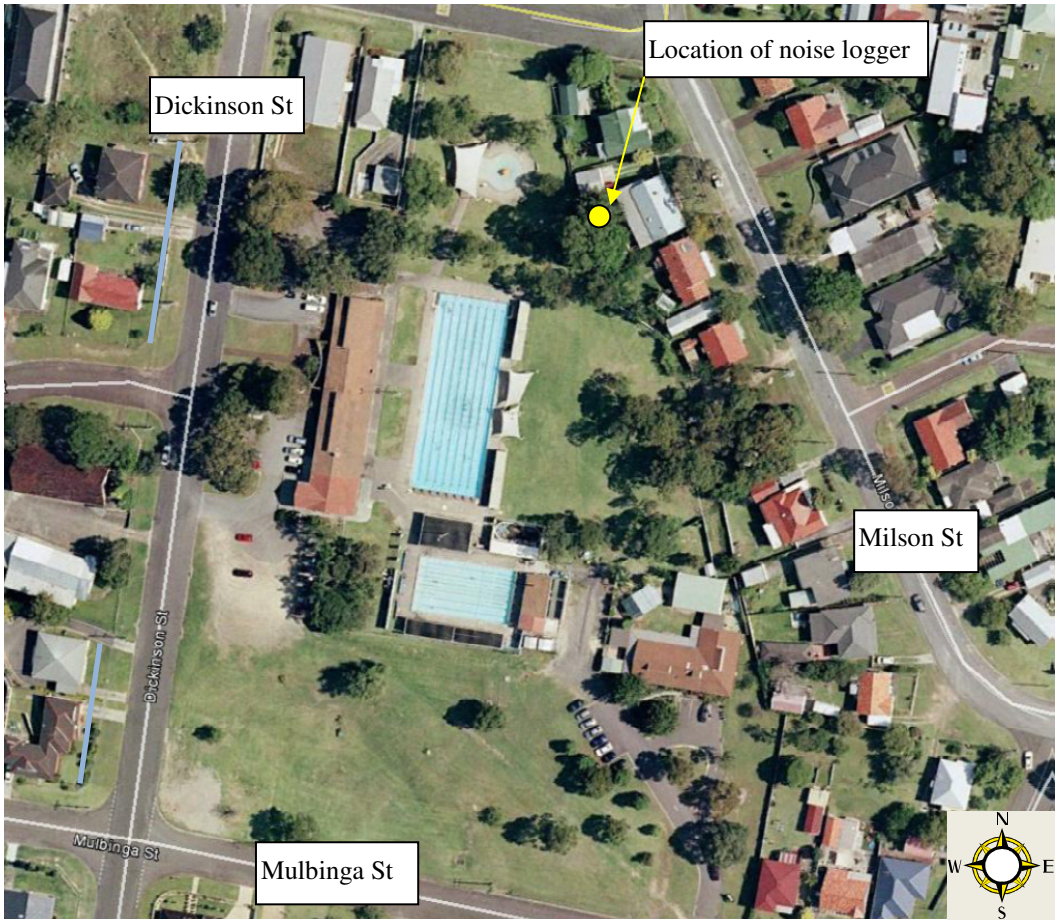

Figure 1. Site & Noise Logger Location. Source: Google Earth.

2.2 Proposed Development

The plan of the proposed Charlestown Leisure Centre is reproduced below in Figure 2. The noise assessment is based on Revision A of drawings DA001-008 and DA101-104 issued and produced by Peddle Thorp Facility Design Group Architects. The proposed design includes a 50 metre outdoor pool and indoor 25 metre pool, 15 metre learning pool and an adventure water pool.

Additional indoor facilities include a spa with sauna and steam room, male and female amenities, staff rooms and store rooms. The indoor area will be enclosed by thermal double glazing with the upper walls on the southern façade constructed of 150mm steel stud with internal CFC sheet, external aluminium composite panel and insulation to the cavity. The roof structure will include Ritek powder coated metal cladding panels.

Plant rooms are located at the eastern and western end of the indoor facilities. The eastern plant room houses the pool filtration equipment with pool heat pumps located on the roof of the plant room. The heat pumps will be enclosed by 2.4 metre high acoustic louvres. The western plant room houses the air conditioning equipment for the fitness rooms, administration rooms and

amenities. The smaller plant room at the south west corner encloses additional pool filtration equipment.
Heat exchangers serving the air conditioning for the pool hall will be located centrally on the roof and will be sunk below the roof line with surrounding acoustic louvres.

Solar panels will also be provided on the roof which will reduce the need for pool heat pumps to be operated on a continual basis.

Proposed hours of operation are as follows:
Monday to Saturday 5.30am – 10.00pm
Sunday and Public Holidays 6.00am – 10.00pm

The 50 metre outdoor pool is rotated 90 degrees from the existing location. In addition to typical swimming activities the 50 metre pool will also provide water polo training and school carnival swimming competitions.

Indoor facilities located to the west of the pool include the entry foyer, male and female amenities, crèche and a meeting room, all located on ground level.

The first floor level will accommodate a fitness room, fitness program rooms and male/female amenities.

Potential significant noise sources to be included within the noise assessment relate to the following:

- Mechanical services plant rooms located on the east and west of the site;
- Heat exchangers located on the roof of the pool hall and the roof of the eastern plant room.
- Potential noise emissions from the indoor pool hall
- Public address systems;
- Whistle and audience noise during water polo training and swimming carnivals;
- Exercise rooms;
- 126 space car park;

Figure 2. Proposed Development with Distance to Noise Sensitive Locations. Plan produced Peddle Thorp/Facility Design Group.

3. NOISE CRITERIA

The objectives of the noise assessment is to ensure surrounding noise sensitive locations and internal sensitive spaces are not unduly affected by noise emissions from the leisure centre.

There are no specific Council, State or Federal criteria for noise emissions from leisure centres. However, this section reviews the NSW Government criteria for

other noise sources and developments. These may be used as a basis for realistic noise goals for the leisure centre.

3.1 NSW Government Criteria

The NSW Government, via the Environment Protection Authority (EPA), provide guidelines for many industrial, commercial and domestic types of noise sources. The primary aim of environmental noise control is to minimise the occurrence of offensive noise in the community. To be both effective and equitable, the determination and application of environmental noise control measures must take into account many factors for example: -

- the variation in response between individuals to any noise;
- the inherently noisy characteristics of many activities;
- the circumstances within which the noise occurs;
- the technical and economic feasibility for noise control; and
- the social worth of the activity.

Offensive noise is defined in the NSW Protection of the Environment Operations Act 1997 (POEO Act) as being noise:-

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

b) *that, is of a level, nature, character or quality prescribed by the regulations or that is made at a time or in other circumstances, prescribed by the regulations.'*

The NSW Government, also state that social surveys have indicated that noise from any particular source will be audible to many people in the community when that noise exceeds the background level by more than 5 decibels (dB). The noise may have characteristics which are pleasant or unpleasant to the listener.

Technically the background is found from the noise level that is present for 90% of the measurement time periods (usually 15 minutes each) and this is known as the $L_{AF90,\ 15\ minute.}$ The source noise is found from the average of the sound energy (again usually 15 minutes samples), which is known as the $L_{Aeq,\ 15\ minute.}$ The 5 dB over background criterion is primarily aimed at industrial or commercial machine noise or domestic machine noise such as air conditioners.

3.2 NSW Noise Guide for Local Government

The NSW Government's Noise Guide for Local Government (NGLG) provides guidelines for the assessment of offensive and intrusive noise levels. Local councils are encouraged to develop noise policies which specify intrusive noise levels and appropriate descriptors for particular activities in certain situations and locations. Such a policy could, for example, specify that noise from mechanical plant located at commercial or industrial premises that exceeds the background noise at a residential boundary by more than 5 dB as measured over a 15-minute period ($L_{Aeq,\ 15\ minute}$) is intrusive.

The noise is assessed at the most affected point on or within the neighbouring residential property (unless that residence is more than 30 metres from the boundary). Intrusive noise is not the same as offensive noise as defined in the POEO Act 1997. Intrusive noise can represent offensive noise, but whether this is always the case depends on the source of the noise, noise characteristics and cumulative noise levels.

For non-tonal air conditioners the intrusive noise criteria can be taken as a measure of offensive noise, however sound from community activity within a leisure centre should not be automatically considered to be offensive just because it may exceed the 5 dB on background criterion.

3.3 NSW Government Industrial Noise Policy

The assessment procedure for industrial and commercial noise sources given in the Industrial Noise Policy (2000) has two components:-

- **Controlling intrusive noise impacts; and**
- **Maintaining noise level amenity;**

In assessing the noise impact of industrial or commercial noise sources both components must be taken into account for residential receivers, but, in most cases, only one will become the limiting criterion. The project-specific noise goals reflect the most stringent noise level requirement. It is derived from intrusive and amenity criteria and this is used to set a benchmark against which noise impacts and the need for noise mitigation are assessed.

3.3.1 Intrusive Noise Impacts

The NSW Government in their Industrial Noise Policy (2000) states that:- *'The intrusiveness of an industrial noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the L_{Aeq} descriptor) measured over a 15 minute period, does not exceed the background noise level measured in the*

absence of the source by more than 5 dB.' Thus, when considering the environmental consequence of noise from a specific source, any increase above the background sound pressure level, which exceeds 5 dB, may be offensive.

The perception of noise and its level of offensiveness depend greatly on the broader situation within which it occurs. Noise that might intrude into a resting or sleeping place may be found offensive whereas the same noise occurring in a market place or noisy working area may pass unnoticed. The concept of *'background + 5 dB'* derives from this consideration.

The NSW Government state that where the existing background noise level at the receptor is less than 30 dBA, as may occur in a quiet suburban or rural area, then 30 dBA should be assumed to be the existing background noise level.

Where the noise source contains characteristics such as prominent tonal components, impulsiveness, intermittency, irregularity or dominant low-frequency content, adjustments to the measured level are applied to allow for the increase in the annoyance value.

3.3.2 Protecting Noise Amenity

In the Industrial Noise Policy it is stated that *'To limit continuing increases in noise levels, the maximum ambient noise level within an area from industrial noise sources should not normally exceed the acceptable noise levels specified in Table 2.1."*

The relevant part of the NSW Government's recommended levels are given in Table 1. According to the Industrial Noise Policy, the location of the proposed leisure centre is within a suburban area. Hence the acceptable amenity noise level (L_{Aeq}) for a suburban area is **55 dBA** for the day time, **45 dBA** for the evening and **40 dBA** for the night.

TABLE 1 – RECOMMENDED NOISE LEVELS FROM INDUSTRIAL NOISE SOURCES.

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level (dBA)	
			Acceptable	Recommend Maximum
Residence	Rural	Day Evening Night	50 45 40	55 50 45
Residence	Suburban	Day Evening Night	55 45 40	60 50 45
Residence	Urban	Day Evening Night	60 50 45	65 55 50
Residence	Urban/Industrial Interface – for existing situations only	Day Evening Night	65 55 50	70 60 55
Commercial premises	All	When in use	65	70
Industrial premises	All	When in use	70	75

3.3.3 Modifying Factor Adjustments

Where a noise source contains certain characteristics, such as tonality, impulsiveness, intermittency, irregularity or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same sound pressure level. A correction should be applied to both the intrusive and the amenity measurement before a comparison is made with the criteria. An abbreviated version of the correction factors is shown in Table 2.

TABLE 2 – MODIFYING FACTOR CORRECTIONS.

Factor	Assessment/ Measurement	When to Apply	Correction	Comments
Tonal Noise	One-third octave band or narrow band analysis	Level of one third octave band exceeds the level of the adjacent bands by 5 dB or more (above 400 Hz)	+ 5 dB	Narrow band frequency analysis may be required to precisely detect occurrence
Low Frequency Noise	Measurement of C-weighted and A-weighted Level	Measure/assess C and A-weighted levels over same time period. Correction to be applied if the difference between the two is 15 dB or more	+ 5 dB	C-weighted is designed to be more responsive to low frequency noise
Impulsive Noise	Time weighting fast and impulse	If the difference in the A weighted maximum levels between 'fast' and 'impulse' are greater than 2 dB	Apply the difference in measured levels as the correction up to a maximum of 5 dB	Impulse time weighting is characterised by a short rise time (35msec) compared to 125msec for 'fast'.
Intermittent Noise	Subjectively Assessed	Level varies by more than 5 dB	+ 5 dB	Adjustment to be applied for night time only

Note: Tonal - Level of one third octave band exceeds the level of the adjacent bands by 5 dB or more (above 400 Hz); 8 dB or more if the centre frequency of the band containing the tone is 160 to 400 Hz; or 15 dB or more if centre frequency of the band containing the tone is below 160 Hz.

3.4 Sleep Disturbance – Noise Guide for Local Government

Section 2.2.4 of Part 2 of the Noise Guide for Local Government (2013) addresses the issue of sleep disturbance. The document acknowledges that there is no definitive guideline that would indicate the potential for sleep disturbance. However, where disturbance to sleep is being assessed, a screening test can be applied that would indicate the potential for this to occur.

The screening test relates to where the subject noise exceeds the 'A' frequency weighted background noise level by more than 15 dB. The most appropriate descriptors for a source relating to sleep disturbance would be $L_{A1,\ 1\ minute}$ (the level exceeded for 1% of the specified time period of 1 minute) or L_{AFmax} (the maximum level during the specified time period) with measurement outside the bedroom window. Sleep disturbance relates to the night time period of 10.00pm to 7.00 am only.

3.5 Australian Standard AS 2107

The Australian Standard AS 2107 – 2000 *'Acoustic – Recommended Design Sound Levels and Reverberation Times for Building Interiors'* provides recommended design sound levels for different areas of occupancy in buildings. This includes recommended internal design sound levels for steady-state or

quasi-steady-state sounds typically originating from traffic or building services. Examples of the recommended design sound levels for building interiors applicable to the development are shown in Table 3 below.

TABLE 3: RECOMMENDED DESIGN SOUND LEVELS FOR BUILDING INTERIORS FROM AS 2107 (2000).

Type of Occupancy	Recommended Design Sound Level ($L_{Aeq,}$) dBA	
	Satisfactory	Maximum
Indoor Sports Buildings		
With coaching	45	50
Without coaching	50	55
Public Buildings		
Cafeteria & kiosk	45	55
Meeting Room	40	45
General office areas	40	45
Change rooms and toilets	50	55

3.6 Intermittent Noise Transfer to Adjacent Spaces

Acceptable levels of intermittent noise transferred to adjacent occupied spaces (controlled by the same tenancy), as a result of activity within the space, are based on experience and knowledge of measured levels from many previous projects. To avoid disturbance within a commercial environment occasional $L_{Aeq,\ 15\ minute}$ noise levels should not exceed 50 dBA within the adjacent occupancy with a maximum (L_{Amax}) level of 55 dBA. This would be applicable to the transfer of noise from the exercise rooms to the office accommodation below.

4. BACKGROUND NOISE MEASUREMENTS

Existing ambient and background noise levels have been monitored at the boundary of 29 Milson Street and the Charlestown swimming pool for a period of 9 days. The instrumentation, procedure and results are described below.

4.1 Background and Ambient Noise Monitoring Procedure

Free field continuous noise monitoring was carried out from Tuesday 30 September 2014 through to Wednesday 8th October 2014. The noise logger was located on the western residential boundary of 29 Milson Street, approximately 29 metres from the edge of the 50 metre pool.

Recorded background noise levels ($L_{AF90,\ 15\ minute}$) are considered to be representative of background noise at all potentially affected residences surrounding the swimming pool. $L_{Aeq,\ 15\ minute}$ energy average noise levels at the logger location include the intermittent noise generated by the existing occupancy of the swimming centre, local and distant traffic noise, fauna and community noise. Residential boundaries at greater distance from the swimming centre would experience lower $L_{Aeq,\ 15\ minute}$ noise levels subject to the noise contribution from the centre as opposed to traffic and fauna noise levels.

Ambient noise levels are primarily dominated by near and far traffic noise, community noise and fauna. Mechanical services noise was not audible at the boundary or at the site during the site inspection.

4.2 Instrumentation

The instrumentation used for measurement of the existing environment consisted of an 'ARL' - Type 2 Environmental Noise Logger serial number 194550. This instrument conforms to Australian Standard 1259 "Acoustics - Sound Level Meters", (1990) and has an accuracy suitable for both field and laboratory use. The logger was set for the 'A' frequency weighting and 'fast' time weighting.

The calibration of the logger was checked before and after the measurement period with a Brüel and Kjær acoustical calibrator model 4230 (serial no. 2445349). No significant system drift occurred over the measurement periods.

The environmental noise logger and calibrator have been checked, adjusted and aligned to conform to the Brüel and Kjær or RTA factory specifications and issued with conformance certificates within the last 24 months as required by the regulations. The internal test equipment used is traceable to the National Measurement Laboratory at C.S.I.R.O., Lindfield, NSW 2070.

4.3 Noise Monitoring Results

Measured ambient noise levels are assessed according to the NSW Industrial Noise Policy in terms of ambient noise (L_{Aeq}) and background noise (L_{AF90}) for the time periods defined as: Day: 7:00 am – 6:00 pm, Evening: 6:00 pm – 10:00 pm and Night: 10:00 pm – 7:00 am.

The recorded L_{AF90} levels determine the Rating Background Level (RBL). The RBL is defined as the median value of the tenth percentile value for the recorded L_{AF90} levels for the complete monitoring period. The tenth percentile is also referred to as the Assessment Background Level (ABL).

The resultant RBL (L_{AF90}) and ambient (L_{Aeq}) levels for each period are summarised below in Table 4. The full statistical noise measurement results are shown in graphical form in Appendix A.

TABLE 4 – SUMMARY OF EXISTING NOISE LEVELS.

Time of Day	Rating Background Noise Levels (L_{A90}) dBA	Log Average Existing Ambient Noise Levels (L_{Aeq}) dBA
Day (07:00 – 18:00)	43	55
Evening (18:00 – 22:00)	39	46
Night (22:00 – 07:00)	38	50

Note 1- All levels rounded to the nearest whole decibel

The average minimum background $L_{AF90,\ 15\ minute}$ noise level for the shoulder period of 5.30am to 7.00am was recorded at 43 dBA.

5. ENVIRONMENTAL NOISE GOALS

As discussed in Section 3.3 above the assessment procedure given in the Industrial Noise Policy (2000) has two components to determine project-specific noise goals: Intrusive noise impacts and noise level amenity. The noise goals relevant to each assessment period based on logged noise levels are given below. The more stringent of the two apply.

5.1 Intrusive Criteria

To ensure that on-site noise sources are not intrusive, the $L_{Aeq,\ 15\ minute}$ noise level due to stationary sources should not exceed the background $L_{AF90,\ 15\ minute}$ level by more than 5 dB when measured at the affected residential property boundary. The intrusive noise goal is based upon the RBL level of 43 dBA for the day period, 39 dBA for the evening and 38 dBA for the night period. The intrusive $L_{Aeq,\ 15\ minute}$ noise goal for noise generated by the development is therefore 48 dBA for the day period, 44 dBA for the evening and 43 dBA for the night period at or within the nearest residential boundaries.

5.2 Amenity Criteria

The amenity criteria are used to limit the maximum ambient noise levels within an area from stationary noise sources associated with the proposed development. To protect the acoustic amenity of land users the combined noise from all stationary noise sources should not exceed the Acceptable Noise Level (ANL) calculated according to the procedures as given in chapter 2 of the NSW Industrial Noise Policy. The amenity assessment relates only to industrial-type noise and does not include road, rail or community noise. Modifications are made to the recommended ANL to account for the existing level of industrial (or commercial) noise. As the existing environment is unaffected by industrial or

commercial type noise (including mechanical services) the ANL is not modified are therefore represents the amenity criteria.

The unusually high $L_{Aeq,\ 15\ minute}$ noise levels recorded during the night period are attributed to the sounds of fauna such as frogs, crickets, and birds. These are seasonal noise levels and are treated as extraneous noise and excluded from the assessment.

TABLE 5 – SUMMARY OF AMENITY CRITERIA.

Type of Receiver	Time of Day	Recommended Acceptable Noise Level ($L_{Aeq,\ period}$)	Existing Amenity Level ($L_{Aeq,\ period}$)	Amenity Criterion ($L_{Aeq,\ period}$)
Residence urban location	Day	55	55	55
	Evening	45	46	45
	Night	40	50	40

Note - All levels rounded to the nearest whole decibel

5.3 Project Specific Noise Criteria

Project specific noise criteria apply to noise emissions from mechanical services. Applying both the amenity and intrusive criteria to the development and adopting the more stringent of the two, determines the project specific noise levels. Project specific noise criteria based on logged data are provided below in Table 6.

TABLE 6 – PROJECT SPECIFIC NOISE CRITERIA.

Time of Day	Intrusive Noise Criteria dB - ($L_{Aeq,15\ minute}$)	Amenity Noise Criterion dB - ($L_{Aeq,\ period}$)	Project Specific Noise Criterion dB - ($L_{Aeq,15\ minute}$)
Day (07:00 – 18:00)	48	55	**48**
Evening (18:00 – 22:00)	44	45	**44**
Night (22:00 – 07:00)	43	40	**40**

5.4 Sleep Disturbance

The screening test for sleep disturbance relates to the operating hours of 5.30am to 7.00am. The average minimum background $L_{AF90,\ 15\ minute}$ noise level recorded for this period was 43 dBA. $L_{AF1,\ 1\ minute}$ (the level exceeded for 1% of the specified time period of 1 minute) or L_{AFmax} (the maximum level during the specified time period) noise levels measured outside the bedroom windows of the nearest residence should not exceed 15 dB above the 'A' frequency weighted

background noise level. The screening test level is therefore 58 dBA (43dBA + 15) at the nearest residence.

6. NOISE SOURCE MODELS

Noise models have been prepared for the occurrence of noise emissions from the leisure centre. This section provides details of the calculations and noise models for each scenario.

6.1 Noise Modelling Specifications

The sound pressure level from a source noise has been modelled using the International Standard ISO 9613-2 (1996(E)) '*Acoustic – Attenuation of sound during propagation outdoors Part 2 General method of calculation'*. This Standard specifies methods for the description of noise outdoors in community environments. The method described in the Standard is general in the sense that it may be applied to a wide variety of noise sources, and covers the major mechanism of attenuation. The method allows for downwind propagation conditions within an angle of ± 45° of the direction connecting the centre of the dominant sound source and the centre of the specified receiver region with the wind blowing from source to receiver, and wind speed between approximately 1 m/s and 5 m/s measured at a height of 3 m to 11 m above the ground.

6.2 Basic Noise Modelling Equation

The equivalent continuous downwind sound pressure level (L_{Aeq}) at each receiver point has been calculated for each noise source using the equation below:-

$$\mathbf{L_{Aeq} = L_w + D_c - \mathit{A}}$$

Where:

- L_w is the sound power level of the noise source;
- D_c is directivity correction; and
- A is the attenuation that occurs during the propagation from source to receiver.

The attenuation term A in the equation above is given by:-

$$\boldsymbol{A = A_{div} + A_{atm} + A_{gr} + A_{bar} + A_{misc}}$$

Where:

- A_{div} is the attenuation due to geometric divergence;
- A_{atm} is the attenuation due to atmospheric absorption;
- A_{gr} is the attenuation due to the ground effects;
- A_{bar} is the attenuation due to a barrier; and
- A_{misc} is the attenuation due to miscellaneous other effects.

The last term *(A_{misc})* generally refers to miscellaneous propagation through foliage, industrial sites and areas of houses. Due to the vicinity of the development to the neighbouring dwellings the attenuation due to atmospheric absorption, ground effects and other miscellaneous effects are of minor significance at this site.
For noise generated within a building structure the following formula is used to predict the sound pressure level at each receiver point.

$$\mathbf{L_{Aeq} = (L_{Aeq,\,int} + 10\log_{10} S - R) - 14 + D_c - \mathit{A}}$$

Where: $L_{Aeq,\,int}$ is the sound pressure level within the space;
S is the area of the building envelope radiating noise;
R is the sound reduction index of the building envelope component;
D_c is directivity correction; and
A is the attenuation that occurs during the propagation from source to receiver.

6.3 Noise Models

6.3.1 Indoor Pool Hall

Noise source modelling is applied to the indoor pool hall and the outdoor 50 metre pool to determine the level of noise generated by children and adults. The modelling predicts the potential indoor reverberant noise level and forms the basis of noise breakout calculations to the environment. The model has recently been verified by noise measurements taken within an indoor play centre occupied by approximately 100 children and their parents. Measured noise levels were within ±3dB of the calculated level.

Noise criteria are based on a measurement period of 15 minutes. A typical number of children and adults attending the indoor pool hall during any 15 minute period at peak times is predicted based on an 80% occupancy of the available car park spaces. 126 spaces are provided which equates to 101 spaces typically occupied during peak times. Assuming 2.5 people per car arrive at the centre, the number of people within the indoor pool hall is predicted to be 253 during any 15 minute period.

The range of 'A' weighted sound levels from a single person varies from 40 dBA (whisper) to 88 dBA (maximum vocal effort) at 1 metre. For practical purposes an average level of 70 dBA at 1 metre is used to assess speech levels within the indoor pool hall. This is equivalent to a sound power level of 75 dBA for one adult.

An adjustment is made for the number of people vocal at any one time. This is typically 20% to 35% of the number of people within the pool hall. Hence for the pool hall with 253 people, 89 people could be expected to be vocal at any one

time. The sound power level of 89 people vocal at any one time is calculated to be 95 dBA.

The reverberant noise level within the space is calculated from the following formula:

$$L_{p1} = SWL + 10\log_{10} RT - 10\log_{10} V + 14 \quad dBA$$

Where: L_{p1} is the internal reverberant noise level;
SWL is the sound power level of the source re 10^{-12} W
RT is the reverberation time of the space in secs;
V is the volume of the space (m^3);

The reverberation time is predicted to be in the order of 3 seconds with a room volume of approximately 19200m^3. The predicted typical reverberant sound pressure level within the pool hall is 71 dBA during peak periods with octave band levels as shown in Table 7 below.

TABLE 7 – POOL HALL INDOOR REVERBERANT NOISE LEVELS.

A Weighted Octave Band Centre Frequency L_{Aeq} dB							**Overall 'A' Frequency Weighted L_{Aeq} dB**
125	250	500	1k	2k	4k	8k	
46	61	65	69	64	54	47	71

6.3.2 *Outdoor 50m Pool*

Typical use of the 50 metre pool would relate to lap swimming which is a relatively quiet activity. On occasions younger adults may gather and generate higher noise levels but this should be considered as an infrequent occurrence considering the facilities available within the pool hall. Higher noise levels are likely to be generated during water polo training and school swimming carnivals. Each activity would involve the use of whistles and high voice levels from the supporting audience in the case of swimming carnivals. Water polo training is unlikely to attract a significant number of people but verbal instructions from the trainer and the players are likely to be audible.

Swimming carnivals would occur on a week day during the day period whereas water polo training could occur any day, day, evening or during the night/morning shoulder period (5.30am to 7.00am). The two considerations are therefore the noise generated during swimming carnivals and the potential for sleep disturbance occurring as a result of the use of whistles during the night/morning shoulder period.

The level of noise generated by a swimming carnival is subject to the number of people attending the event and the use of whistles. As the number of people is unpredictable, noise levels measured at a similar sporting event can be used as a guide to the level of noise generated. Similar events would be netball games, basketball games, hockey or futsal (7 a side soccer) games.

Two futsal games, played simultaneously, were measured for the previous assessment of a sporting venue. The games involved 20 players and 32 spectators with frequent impulses from the whistle. A consistent $L_{Aeq,\ 15\ minute}$ noise level of 64 dBA was recorded at a distance of 6 metres from the pitch. The whistle sound recorded a maximum (L_{Amax}) level of 75 to 79 dBA at 6 metres.

The above measured levels are supported by equivalent noise measurements taken during a hockey game with a small crowd and the coaches shouting instructions. The $L_{Aeq,\ 15\ minute}$ level of 64 dBA at 6 metres for a school carnival is therefore adopted for the assessment of the 50 metre pool. Additionally, the L_{Amax} level of 79 dBA at 6 metres generated by whistles is used for the potential of sleep disturbance.

6.3.3 *Level 1 Exercise Rooms*

Exercise rooms on level 1 include a spin room, two program rooms for group classes and a general exercise area that would accommodate typical equipment such as treadmills, rowing machines, free weights and weight guided equipment.

Group classes within the Program rooms would include Pilates, yoga and aerobics with the later potentially using amplified speech and music. Program rooms are located on the pool side (east) of the development with the spin room and general exercise areas on the west side closest to the residential properties of Dickenson Street.

Significant noise sources include the following, with the L_{AFmax} noise levels extracted from Noise and Sound Services database.

- Speech levels 65 dBA at 1 metre
- Treadmill 72 dBA at 1 metre
- Rowing Machine 75 dBA at 1 metre
- Bicep Curl Machine 83 dBA at 1 metre
- Instructor's loud voice level (no amplification) 74 dBA at 1 metre

Background music may potentially be played in the general exercise area at a level below the instructor's voice level (no amplification to instructor). Typically internal noise levels are predicted to not exceed an energy average level ($L_{Aeq,\ 15\ minute}$) of 74 dBA and a maximum (L_{AFmax}) level of 84 dBA within the general exercise area.

The highest noise levels generated would occur within the spin room with typical exercises involving amplified music and amplification for the instructor's voice.

For music to be intelligible to the occupants the music level would typically be 5 to 8 dB above the equipment level which would equate to a L_{AF10} level of 79 to 83 dBA. The L_{AF10} level of the instructor's voice is predicted to be 5 dB higher than the music level. A conservative estimate of the L_{AF10} level for the instructor's voice is therefore 88 dBA.

Adopting internal L_{AF10} levels as opposed to L_{Aeq} levels and assessing the emitted level to the $L_{Aeq,\ 15\ minute}$ noise goal at the residences provides an allowance for the potential increased annoyance factor resulting from tonality and a greater degree of certainty in achieving the noise goal.

L_{AF10} octave band spectra for amplified speech and music levels for the spin room are shown below in Table 8.

TABLE 8 – DESIGN AMPLIFIED MUSIC AND SPEECH SPECTRA.

Source	dBA	Octave Band Centre Frequencies - Hz								
		31	63	125	250	500	1k	2k	4k	8k
Music	83	74	79	84	82	83	77	70	66	58
Voice	88	40	50	63	78	82	86	81	71	64

6.3.4 Car Park Activity

Table 9 below provides $L_{A1,\ 1\ minute}$ measured noise levels of intermittent and impulsive noise from typical car activities, normalised to 5 metres. Raised speech levels are also provided for a comparison. Speech levels are based on the sound pressure level data for one raised male voice child as given by Karl Kryter in *'The Effects of Noise on Man'* Academic Press (1985). The raised speech level is normalised to 5 metres for consistency. These levels are used as the basis for the assessment of sleep disturbance. Specific distances to residences will be considered in the assessment.

TABLE 9 – $L_{A1,\ 1\ minute}$ SOUND PRESSURE LEVELS AT 5 METRES FOR CAR MOVEMENTS AND SPEECH

Source	Sound Pressure Level ($L_{A1,\ 1\ minute}$) at 5 metres (dBA)
Car Starting	57
Car Door Closing	65
Car Accelerating	65
Male raised voice	51

Table 10 below provides measured $L_{Aeq,\ T}$ noise levels of cars parking and departing from parking spaces, normalised to 3 metres. The measured levels include cars starting, doors closing and accelerating when departing. Specific distances to residences will be considered in the assessment.

TABLE 10 – $L_{Aeq,\ T}$ SOUND PRESSURE LEVELS AT 3 METRES FOR CAR MOVEMENTS.

Source	Duration	Sound Pressure Level ($L_{Aeq,\ T}$) at 3 metres (dBA)
Car Parking	45 secs	57
Car Departure	40 secs	62
Car Accelerating	45 secs	58

7. NOISE ASSESSMENT

Noise emissions to the outside environment and the transfer of noise between internal spaces are assessed below. Noise goals are firstly determined for each type of receiver and the potential characteristic noise emission. Maximum permissible sound power levels are calculated for mechanical services equipment in order to achieve the noise criteria. Patron noise is assessed and considered against the existing and potential future noise environment to determine if additional noise amelioration measures are necessary.

7.1 Noise Goals

7.1.1 Residential – Mechanical Noise

Mechanical noise emissions relate to the eastern water filtration plant room, eastern water heating plant, central air conditioning heat pumps, western air conditioning plant room and the south western water filtration plant. All plant is considered to operate on a 24/7 basis. To ensure that noise emissions are not intrusive, the $L_{Aeq,\ 15\ minute}$ noise level should not exceed the background $L_{AF90,\ 15\ minute}$ level by more than 5 dB when measured at the nearest affected residential property boundary.

The $L_{Aeq,\ 15\ minute}$ noise goal for noise generated by mechanical equipment is therefore 48 dBA for the day period, 44 dBA for the evening and 40 dBA for the night period. The $L_{Aeq,\ 15\ minute}$ design goal is therefore the most stringent level of **40 dBA**.

7.1.2 Child Care Centre – Mechanical Noise

The child care centre is considered as a noise sensitive receiver. Typical operating hours of the child care centre are from 7.00am to 6.00pm. The noise goal for mechanical noise emissions at the child care centre boundary is therefore the day time $L_{Aeq,\ 15\ minute}$ level of **48 dBA**.

7.1.3 Patron Noise

There are no specific Council, State or Federal noise criteria for noise emissions originating from the use of swimming leisure centres. Residences surrounding the existing pool complex are accustomed to the sounds originating from the use. It is reasonable to design the future swimming leisure centre to not exceed existing $L_{Aeq,\ 15\ minute}$ noise levels.

The existing noise environment has been recorded over a 9 day period at the western residential boundary (common to the swimming complex) of 29 Milson Street, approximately 29 metres from the edge of the 50 metre pool. All the facilities of the complex were in operation throughout the monitoring period. The day time RBL (7.00am to 6.00pm) was recorded at 43 dBA with an average $L_{Aeq,\ 15\ minute}$ level of 55 dBA. That is, existing $L_{Aeq,\ 15\ minute}$ noise levels are 12 dB above the background noise level for the day period. The nearest residential boundary to the existing 50 metre pool is located at 22 metres. The average $L_{Aeq,\ 15\ minute}$ level is predicted to be **57 dBA** at the nearest residential boundary to the 50 metre pool. This equates to 14 dB above the background noise level for the day period.

The evening RBL (6.00pm to 10.00pm) was recorded at 39 dBA with an average $L_{Aeq,\ 15\ minute}$ level of 46 dBA. However, operations at the existing swimming complex cease at 7.00pm. The existing noise environment has therefore been assessed in detail for the time periods 6.00pm to 7.00pm and 7.00pm to 10.00pm.

The average $L_{AF90,\ 15\ minute}$ background noise level between 6.00pm and 7.00pm was 45 dBA with an average $L_{Aeq,\ 15\ minute}$ noise level of 49 dBA. Between 7.00pm and 10.00pm the average $L_{AF90,\ 15\ minute}$ background noise level was 40 dBA with an average $L_{Aeq,\ 15\ minute}$ noise level of 45 dBA.

Limiting $L_{Aeq,\ 15\ minute}$ noise emissions from the use of the leisure centre to **44 dBA** would achieve a level 4 dB below the existing $L_{Aeq,\ 15\ minute}$ between 6.00pm and 7.00pm and achieve the guideline criteria of 'background plus 5 dB for the complete evening period.

7.1.4 Car Park Activity

The proposed development includes a new 126 space car park located to the south of the site with access from Mulbinga Street. Car park activity will occur throughout the operating hours of 5.30am to 10.00pm. Noise generated by car park activity is assessed for the lowest project specific $L_{Aeq,\ 15\ minute}$ noise goal of

44 dBA for the time period of 7.00am to 10.00pm which includes the peak period of activity, and for the sleep disturbance $L_{A1,\ 1\ minute}$ noise goal of **58 dBA** for the time period of 5.30am to 7.00am.

7.2 Residential – Mechanical Noise Assessment

7.2.1 East Plant room

The east plant room is located 11 metres from the childcare boundary and 31 metres from the nearest residential boundary. The walls are constructed of 200mm concrete blocks. Internal L_{Aeq} reverberant noise levels within a water filtration plant room are typically in the order of 80-85 dBA.

Noise emissions through the walls are predicted to be less than L_{Aeq} 30 dBA at the childcare boundary which will be an inaudible level. Noise emissions through the roller door are predicted to be L_{Aeq} 43 dBA at the childcare boundary and 34 dBA at the nearest residential boundary.

Heating plant located on the roof of the plant room are proposed to be installed with surrounding acoustic louvres, typically 300mm deep. To achieve the night time noise criteria at the nearest residential boundary and the day time noise goal at the childcare boundary the combined total sound power level for the heating plant should not exceed 85 dBA (re 10^{-12} watts) with the 300mm deep acoustic louvres installed. Combined total sound power levels in excess of 85 dBA will require additional noise amelioration measures such as 600mm deep acoustic louvres and potential discharge air silencers.

7.2.2 Central Roof Plant

Heat exchangers serving the pool hall are proposed to be located centrally on the roof and be enclosed with 300mm deep acoustic louvres. Noise emissions have been calculated to the childcare centre and the nearest residential boundary at a distance of 69 metres. The total combined sound power level of the heat exchangers should not exceed 85 dBA (re 10^{-12} watts) with the 300 mm deep acoustic louvres installed. Combined total sound power levels in excess of 85 dBA will require additional noise amelioration measures such as acoustic louvres 600 mm deep and potential discharge air silencers.

7.2.3 Southwest Corner Plant room

The southwest corner plant room encloses water treatment equipment and is located 30 metres from the nearest residential boundary. The walls are to be constructed of 200 mm concrete blocks. Internal L_{Aeq} reverberant noise levels are typically in the order of 80-85 dBA. Noise emissions through the walls will be less than 10 dBA at all residential boundaries which is well below background noise levels including throughout the night period.

7.2.4 West Plant room

The west plant room encloses the air conditioning equipment serving the fitness and administration areas. The plant room is located 27 metres from the nearest residential boundary and the walls will be constructed of 200mm concrete blocks. Two windows 600mm x 6.4m will be located within the western façade and be constructed of thermal double glazing, typically two sheets of 6mm glass separated by a 12mm airspace.

Internal L_{Aeq} reverberant noise levels are typically in the order of 70-75 dBA. Noise emissions through the walls and windows of the plant room are predicted to be less than 15 dBA at all residential boundaries which is well below background noise levels including throughout the night period.

Intake and exhaust louvres are likely to be provided on the façade of the plant room. Noise levels at the face of intake and exhaust louvres should not exceed a total combined sound power level of 74 dBA (re 10^{-12} watts). Noise amelioration measures such as acoustic louvres and duct attenuators may be required if the sound power level exceeds the level of 74 dBA.

7.3 Noise Emissions from Patron Use

7.3.1 Pool Hall

The pool hall construction includes 200mm thick Ritek sandwich panel roof construction, thermal double glazing typically two sheets of 6mm glass separated by a 12mm airspace, and 150mm steel studs with internal cfc sheet plus insulation to the cavity and an external aluminium composite panel.

Noise emissions through the structure have been calculated based on the internal reverberant noise level as developed in section 6.3.1. The nearest residential boundary to the pool hall is located at 50 metres from the structure. $L_{Aeq,\ 15\ minute}$ noise emissions at the nearest residential boundary are predicted to be less than 30 dBA which complies with the noise goals and considerably lower than existing noise levels resulting from the use of the facility.

Noise emissions through the structure will be less than 30 dBA which will be inaudible at the nearest residential boundaries 50 metre from the façade of the pool hall.

7.3.2 Outdoor 50m Pool

The noise assessment of the 50 metre outdoor pool is based on a $L_{Aeq,\ 15\ minute}$ noise level of 64 dBA at 6 metre which would be similar to the noise level generated by a school carnival and is used as a guide to the potential impact at the nearest residential boundary. The sound of whistles is assessed based on a maximum (L_{Amax}) level of 79 dBA at 6 metres.

School carnivals would occur infrequently during the summer months and $L_{Aeq,\ 15\ minute}$ noise emissions are predicted to be in the order of 51 dBA at the nearest residential boundary (26 metres from the pool). Typical days would involve lap swimming which generates considerably lower noise levels with a predicted $L_{Aeq,\ 15\ minute\ noise\ level}$ 45 to 48 dBA. Existing average day time $L_{Aeq,\ 15\ minute}$ noise levels have been measured at 55 dBA with the calculated level to the nearest residential boundary at 57 dBA. The proposed design will therefore provide less noise impact on the surrounding residences and the child care centre than present conditions. No further noise amelioration measures are necessary.

To avoid sleep disturbance during the hours of 5.30am to 7.00pm whistles should not be used in the external environment. We recommend whistles for training or carnival purposes should only be used between the hours of 7.00am to 8.00pm.

7.4 Car Park Activity Noise

Noise levels generated by car movements within the car park are provided in section 6.3.4. Car parking spaces closest to the residences on Mulbinga Street are located at a distance of 26 metres from the residential boundary. The entrance/exit to the car park is located at 18 metres from the residential boundary. Residential windows are located at 5 metres inside the residential boundary at the closest point.

The assessment considers one car arriving or departing each minute within a 15 minute period which may occur during peak periods of use. The applicable noise goal is the evening $L_{Aeq,\ 15\ minute}$ level of 44 dBA.

$L_{Aeq,\ 15\ minute}$ noise emissions to the residential boundaries on Mulbinga Street from the car parking spaces, without noise amelioration measures, are predicted to be 42 dBA from cars parking and departing with car doors closing, engine starts and initial acceleration. Car entering and exiting on Mulbinga Street are predicted to generate a $L_{Aeq,\ 15\ minute}$ noise level of 41 dBA at the residential boundaries. Noise emissions from the car park are therefore predicted to comply with the noise goal of 44 dBA.

7.5 Sleep Disturbance

As stated in section 5.4 the screening test for sleep disturbance relates to the operating hours of 5.30am to 7.00am. The average minimum background $L_{AF90,\ 15\ minute}$ noise level recorded for this period was 43 dBA. $L_{AF1,\ 1\ minute}$ (the level exceeded for 1% of the specified time period of 1 minute) or L_{AFmax} (the maximum level during the specified time period) noise levels measured outside the bedroom windows of the nearest residence should not exceed 15 dB above the 'A' frequency weighted background noise level. The screening test level is 58 dBA (43dBA + 15) at the nearest residence windows.

The highest $L_{AF1,\ 1\ minute}$ noise levels emitted from the development would be generated within the car park and at the entry/exit to the car park on Mulbinga Street. Table 9 presents the normalised $L_{AF1,\ 1\ minute}$ noise levels generated by a typical car movement and the level of a raised male voice level.

Sound pressure levels outside residential windows have been calculated based on a distance of 31 metres from the nearest parking space and 23 metres from the entry/exit to the car park. $L_{AF1,\ 1\ minute}$ noise levels from the closest car parking spaces are predicted to be 51 dBA and from the entry/exit 47 dBA. $L_{AF1,\ 1\ minute}$ raised speech levels are predicted to be 38 dBA.

Predicted noise levels are 7 dB or more below the test level of 58 dBA at the residential windows. Sleep disturbance resulting from car park activities is therefore unlikely to occur.

7.6 General Exercise Area

Internal noise levels are predicted to not exceed an energy average level ($L_{Aeq,\ 15\ minute}$) of 74 dBA and a maximum (L_{AFmax}) level of 84 dBA within the general exercise area during peak occupancy. The windows of the general exercise area are located 30 metres from the nearest residential boundary and will be constructed of thermal double glazing, typically two sheets of 6mm glass separated by a 12mm airspace.

$L_{Aeq,\ 15\ minute}$ noise emissions through the façade are predicted to be no more than 23 dBA with L_{AFmax} levels at 33 dBA. Noise emissions from the larger general gymnasium area will therefore comply with the noise goal and will be below background noise levels throughout the operating hours.

Impact rubber flooring manufactured from recycled rubber and specifically designed for gymnasium floors should be provided to the floor area where weights are lifted and dropped or impact exercises occur (including the cable loaded weight machines and cardio area). The floor surface should be equal to A1 Rubber 25mm "Olympact" tiles (density 600 kg/m^3) covered with 15mm Impact tile (density 760 kg/m^3).

Exercises involving the lifting and dropping of weights from shoulder or above head height should not be permitted unless a specifically designed vibration isolated raised floor is installed for this purpose. Further design details can be provided should this be necessary.

7.7 Spin Room

Internal noise levels within the spin room are based on the data provided in Table 8, section 6.3.3. The highest level in each octave band for speech and music is

used as the basis to calculate potential noise emissions through the windows of the spin room. Two residential properties are located to the north at the corner of Frederick and Dickinson Streets, with the nearest residential boundary located approximately 23 metres from the façade of the spin room. Noise emissions are also calculated to the west at the nearest residential boundary on Dickinson Street located approximately 32 metres from the façade.

$L_{Aeq,\ 15\ minute}$ noise emissions through the walls and windows of the spin room are predicted to be less than 24 dBA at the boundary of the residences located at the corner of Frederick Street and Dickinson Street and less than 22 dBA at the boundary of the residences located to the west on Dickinson Street.

The worst case scenario for L_{AFmax} or $L_{AF1,\ 1\ minute}$ levels would be 10 dB above the $L_{Aeq,\ 15\ minute}$ level. That is, L_{AFmax} or $L_{AF1,\ 1\ minute}$ levels are predicted to not exceed 34 dBA at the residential boundary and would therefore be of a sufficiently low level not to be considered for potential sleep disturbance.

Noise emissions from the spin room are therefore predicted to comply with the noise goal of 44 dBA and would not be of a level to potentially cause sleep disturbance.

7.8 Program Rooms

Program room 1 is located on the eastern side of the building overlooking the 50 metre pool with no direct line of sight to residential properties. Noise emissions from program room 1 would therefore not impact on noise sensitive locations.

Noise emissions from Program room 2 through the windows on the northern façade of the development are calculated to the two residential properties located to the north at the corner of Frederick and Dickinson Streets, with the nearest residential boundary located approximately 23 metres from the façade.

Activities within the program rooms would most likely be related to Pilates, yoga and group aerobics. To ensure the worst case scenario is considered, the internal level adopted for the calculation is equal to the internal level for the spin room and therefore relates to the production of music with the instructors voice overriding the level of music, i.e. 88 dBA.

$L_{Aeq,\ 15\ minute}$ noise emissions through the walls and windows of Program room 2 are predicted to be less than 26 dBA at the boundary of the residences located at the corner of Frederick Street and Dickinson Street. L_{AFmax} or $L_{AF1,\ 1\ minute}$ levels are predicted to not exceed 36 dBA at the residential boundary and would therefore be of a sufficiently low level not to be considered for potential sleep disturbance.

Noise emissions from the program rooms are therefore predicted to comply with the noise goal of 44 dBA and would not be of a level to potentially cause sleep disturbance.

7.9 External Public Address System

The main noise controls for public address systems are the selection and placement of the speakers. Additionally, the use of PA systems should be minimised where possible and not be used for staff announcements or commentary during school carnivals. The potential for sleep disturbance to the residential properties located along the eastern boundary, resulting from the use of the PA system during the morning/night shoulder period of 5.30am to 7.00am remains, subject to the volume level of announcements. To ensure sleep disturbance is avoided, the outdoor PA systems should not be operated during the hours of 5.30am to 7.00pm. These conditions should be clearly stated alongside the PA control panel and within staff manuals.

Small low-powered speakers (horn <20 cm across and amp < 30 watts) should be used in an array in preference to fewer, more powerful loudspeakers. Speakers should be orientated away from residential areas, be mounted at a downward 45° angle and as far down the poles as possible.

8. CONCLUSIONS

The proposed design of the Charlestown Leisure Centre has a positive outcome for the noise environment at the surrounding residential and child care premises. Subjectively, noise emissions from the use of the indoor pool hall are unlikely to be noticeable at the nearest residential boundaries and the child care centre boundary. Typical daily noise emissions from the 50 metre outdoor pool are predicted to be 9 to 12 dBA lower than existing noise levels. Noise emissions from school carnivals may exceed day time background noise levels by 8 dB but would occur infrequently and are predicted to be 4 dB below the existing daily day time $L_{Aeq,\ 15\ minute}$ noise level of 55 dBA.

Noise emissions from the gymnasium and fitness rooms are predicted to comply with the noise goals for the day, evening and morning/night shoulder periods. Noise emissions from the car park are also predicted to comply with the noise goals for the same periods. Calculations have demonstrated that noise emissions from the complete development should not exceed the screening test level for sleep disturbance at any residential property throughout the morning/evening shoulder period of 5.30am to 7.00am.

Outdoor mechanical equipment is designed to be enclosed by 300mm deep acoustic louvres. To achieve the noise criteria at the residential boundaries and the child care boundary, maximum sound power levels for the equipment have been specified. The proposed and existing construction of plant rooms will

provide sufficient noise reduction to prevent noise emissions contributing to the noise environment at the child care boundary and residential boundaries.

Providing the recommendations are incorporated into the design and construction of the Charlestown Leisure Centre, noise emissions are predicted to comply with the noise criteria provided by the NSW EPA for the outside environment.

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Date	**Checked by:**	**Status**
18 March 2015	Ken Scannell MSc M.A.A.S. MIOA	Draft
Date	**Issued by:**	**Status**
20 March 2015	Ken Scannell MSc M.A.A.S. MIOA	Final
Date	**Issued by:**	**Status**
11 April 2016	Ken Scannell MSc M.A.A.S. MIOA	Final Rev A

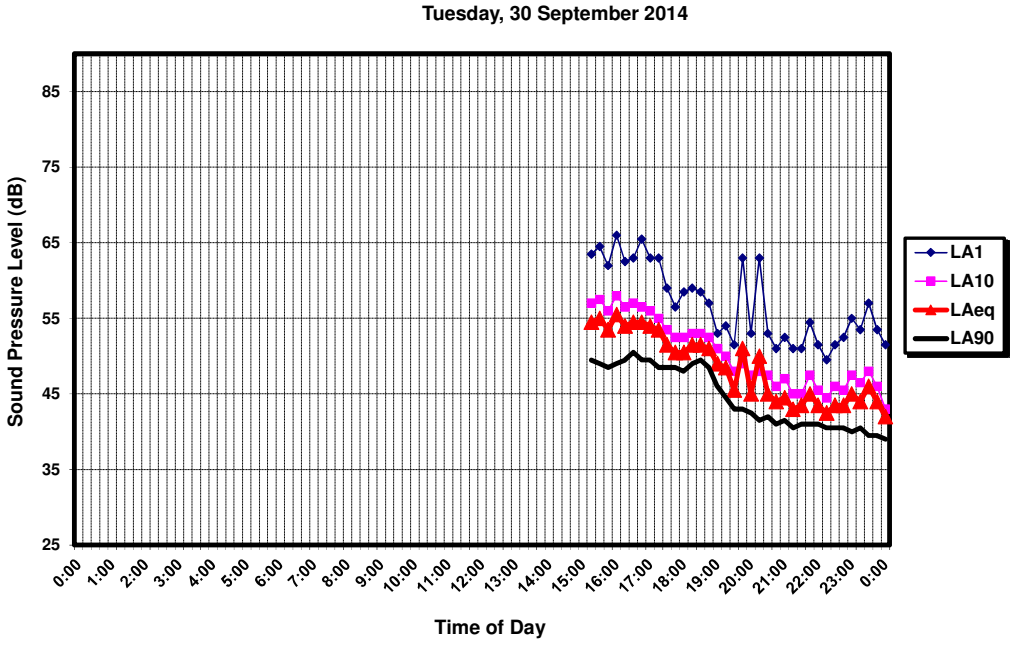
Important Note. *All products and materials suggested by 'Noise and Sound Services' are selected for their acoustical properties only. All other properties such as airflow, aesthetics, chemical, corrosion, combustion, construction details, decomposition, expansion, fire rating, grout or tile cracking, loading, shrinkage, ventilation, etc are outside of 'Noise and Sound Services' field of expertise and* ***must be*** *checked with the supplier or suitably qualified specialist before purchase.*

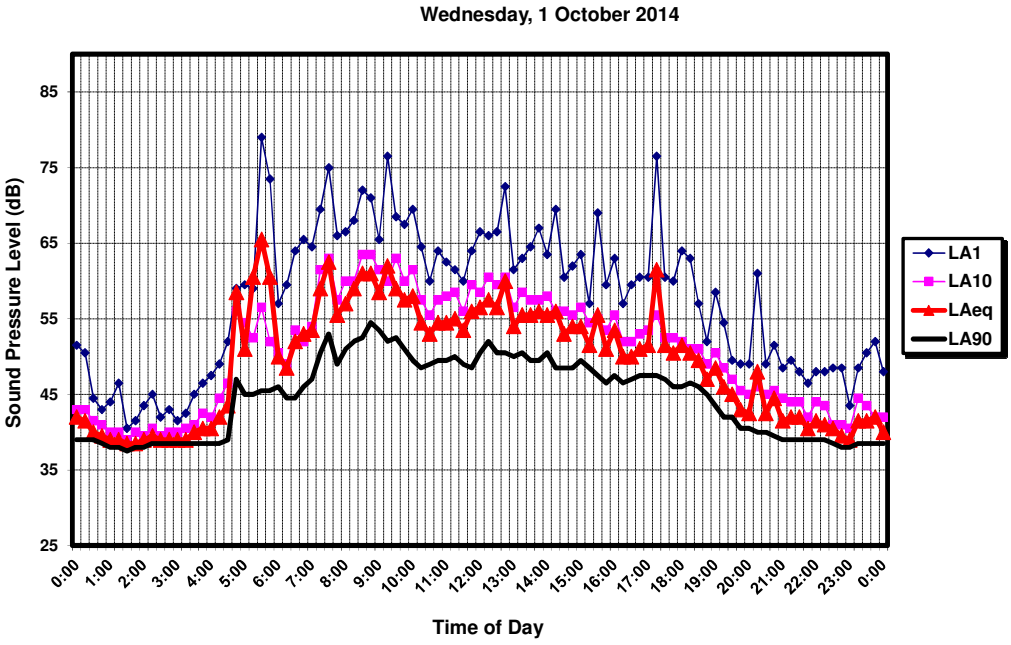
APPENDIX A – MEASURED AMBIENT NOISE LEVELS

Environmental noise levels can vary considerably with time; therefore it is not adequate to use a single number to fully describe the acoustic environment. The preferred, and now generally accepted, method of recording and presenting noise measurements is based upon a statistical approach. For example, the L_{AF10} noise level is the level exceeded for 10% of the time, and is approximately the average maximum noise level. The L_{AF90} level is the noise level that is exceeded for 90% of the time, and is considered to be approximately the average of the minimum noise level recorded. This level is often referred to as the "background" noise level. The L_{Aeq} level represents the average noise energy during the measurement period. This level is often referred to as the 'ambient' noise level.

The measurements results from ambient noise monitoring are shown below.

Logged Ambient Noise Levels
29 Milson Street, Charlestown, NSW 2290
Boundary with Swimming Pool

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Sound Pressure Level (dB)
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75
65
55
45
35
25
0:00
1:00
2:00
3:00
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6:00
7:00
8:00
9:00
10:00
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12:00
13:00
14:00
15:00
16:00
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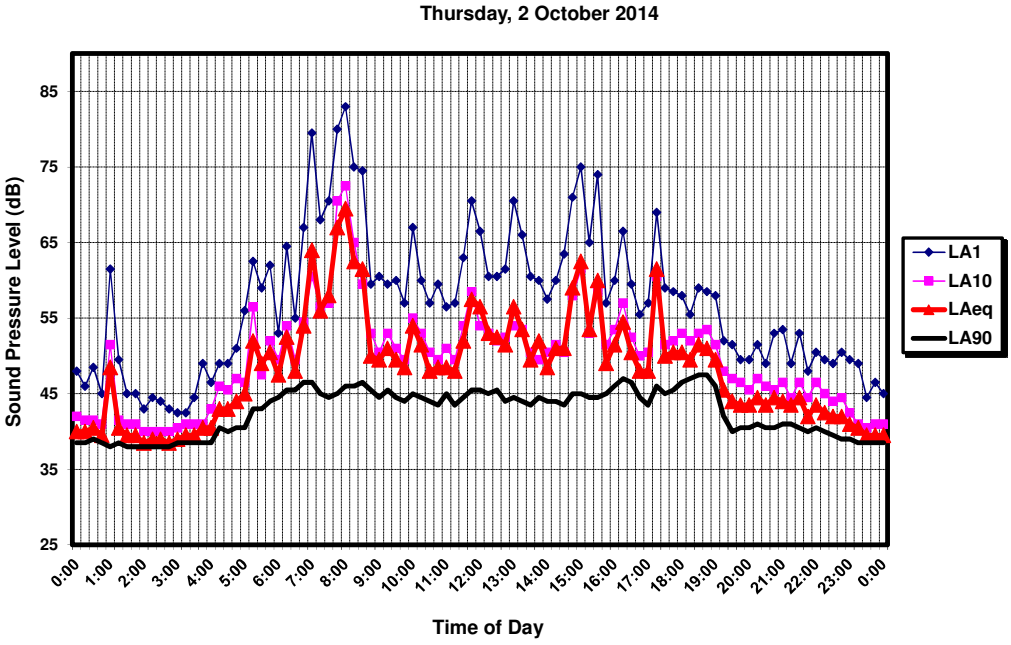
0:00
Time of Day
LA1
LA10
LAeq
LA90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45
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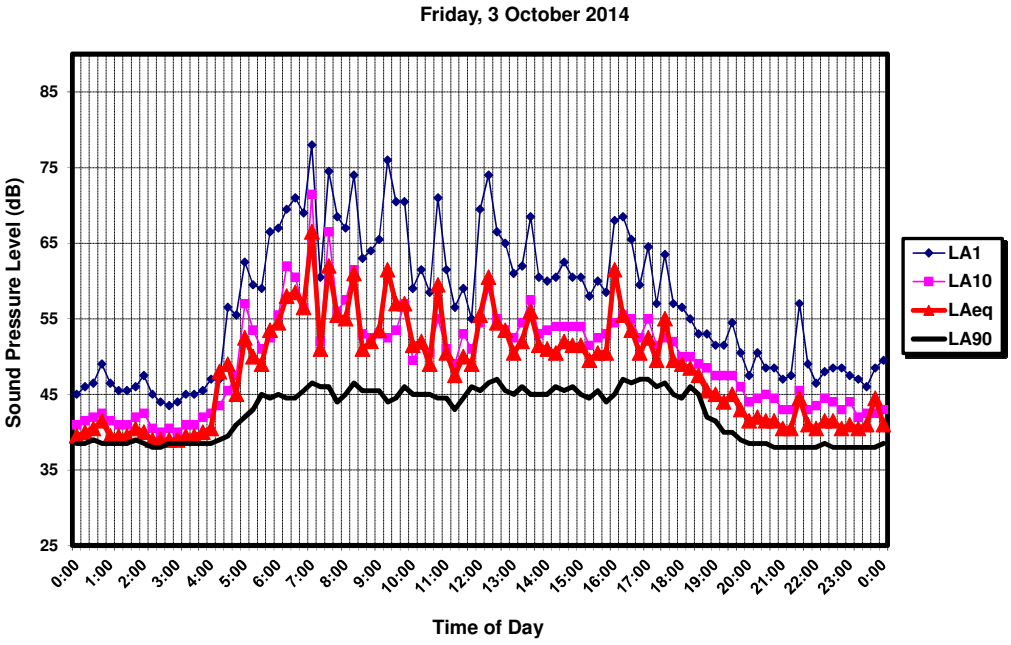
LAeq
LA90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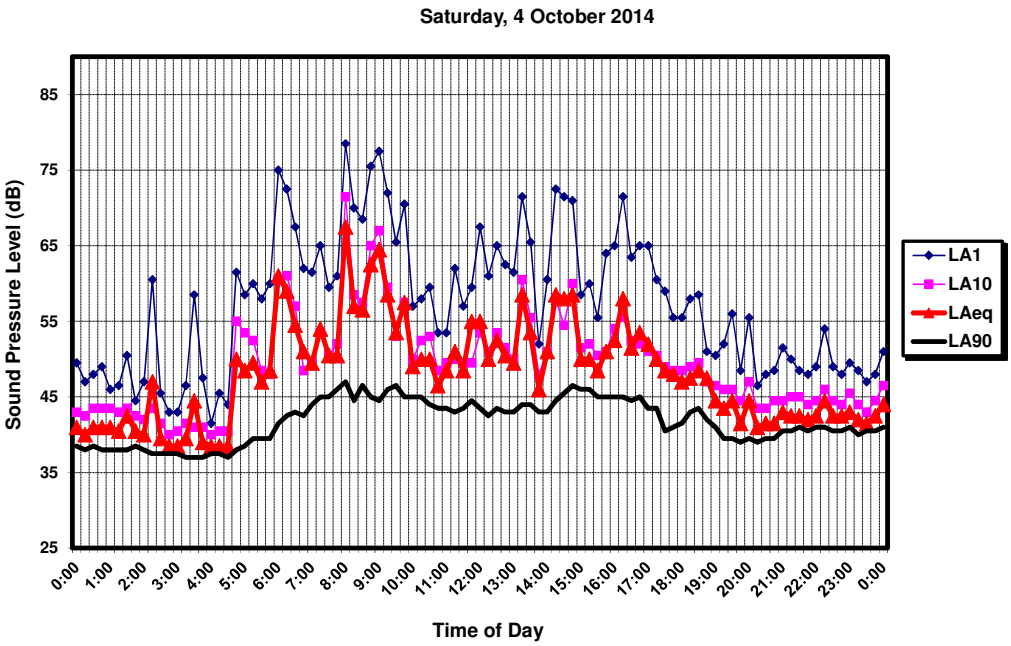
Time of Day
LA1
LA10
LAeq
LA90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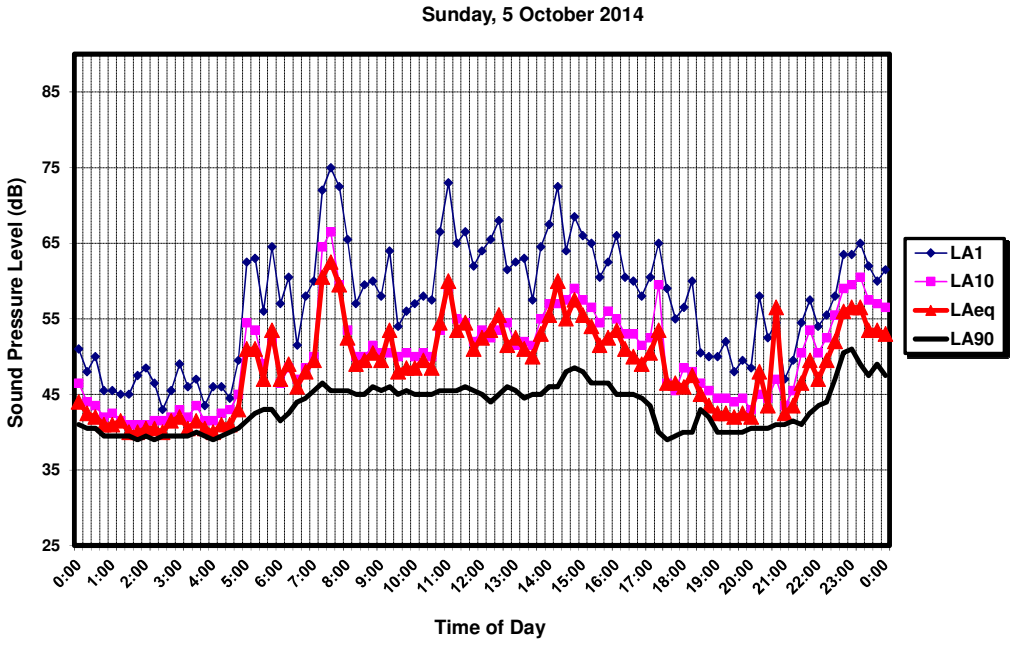
Time of Day
LA1
LA10
LAeq
LA90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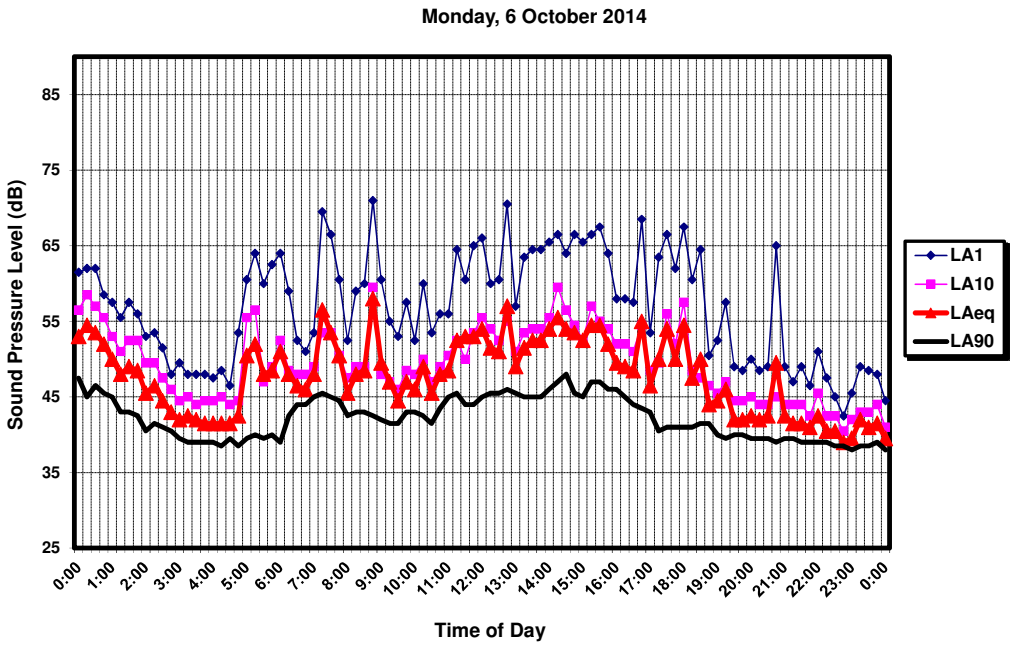
0:00
Time of Day
LA1
LA10
LAeq
LA90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Sound Pressure Level (dB)
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55
45
35
25
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2:00
3:00
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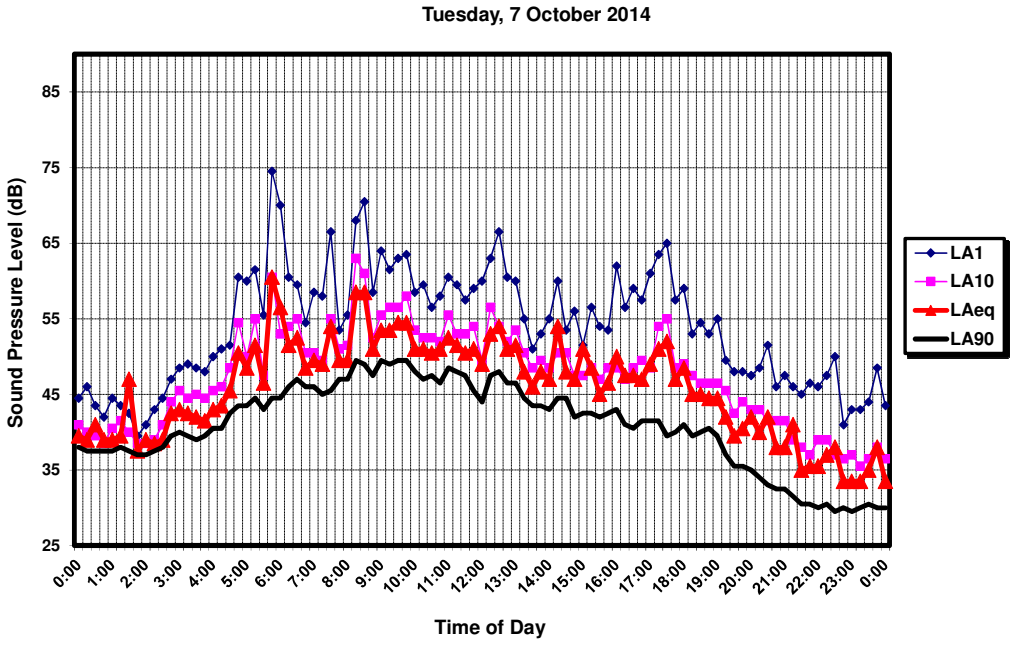
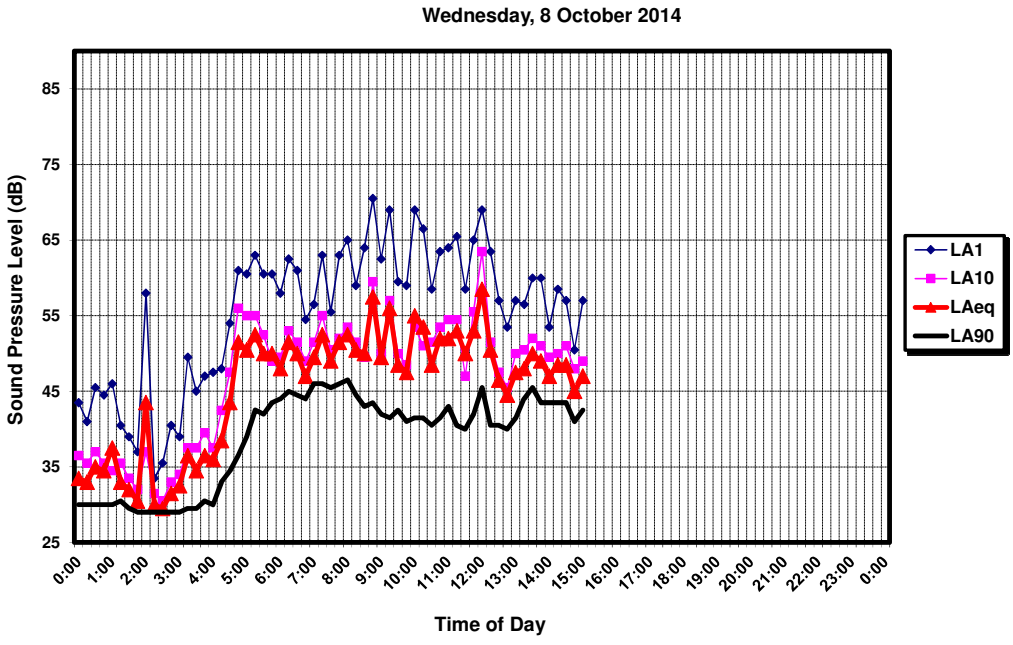
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
0:00
Time of Day
LA1
LA10
LAeq
LA90


Tuesday, 7 October 2014
Sound Pressure Level (dB)
85
75
65
55
45
35
25
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
0:00
Time of Day
LA1
LA10
LAeq
LA90


Wednesday, 8 October 2014
Sound Pressure Level (dB)
85
75
65
55
45
35
25
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
0:00
Time of Day
LA1
LA10
LAeq
LA90

APPENDIX B - EXAMPLE MATERIAL SUPPLIERS

Impact Rubber Tiles

A1 Rubber Pty Ltd a1rubber.com
Product: Impact-tile Tel: 9756 2146 or 0408 070 734
Material: Polymerically bound recycled rubber
Density: 760kg/m^3
Thickness: 15mm
Dimensions: 1m x 1m, bevelled edges

Alternative supplier:

Regupol (Australia) Pty Ltd regupol.com.au
Product: E Tiles Tel: 02 4624 0050
Material: Recycled SBR rubber
Thickness: 15mm

APPENDIX C – GLOSSARY OF TECHNICAL TERMS

'A' Frequency Weighting – The most widely used sound level frequency filter is the A scale, which roughly corresponds to the inverse of the 40 dB (at 1 kHz) equal-loudness curve. Using this filter, the sound level meter is less sensitive to very high and, in particular, very low frequencies. Sound pressure level measurements made with this filter are commonly expressed as **dBA.**

Acoustic Fence – A fence which has enough mass to reflect a significant amount of sound and has no holes or gaps (including at the base).

Ambient Sound – The all-encompassing sound associated with that environment being a composite of sounds from many sources, near and far.

Assessment Background Level (ABL) – The tenth percentile value of the recorded L_{AF90} level for each day, evening and night period.

Background Noise Level ($L_{AF90, T}$) – A statistical parameter used for assessments of constantly varying noise levels. The L_{AF90} is the 'A' frequency weighted noise level that is exceeded for 90 % of the measurement period, 'T'. The measurement period is normally 15 minutes. The background noise is therefore the lowest noise level that occurs for 1.5 minutes in any 15 minute period.

Decibel (dB) – The logarithmic ratio of any two quantities and relates to the flow of energy (power). A scale used in acoustical measurement related to power, pressure or intensity. Expressed in dB, relative to standard reference values.

Energy Average Noise Level ($L_{Aeq, T}$) – The L_{Aeq} noise level is also known as the equivalent continuous sound pressure level. This is the 'A' frequency weighted logarithmic average of the sound energy of the measurement time 'T'. When measured over a 15 minute time period the symbol $L_{Aeq, 15\ minute}$ is used. This is the standard descriptor used for source noise measurements and ambient noise measurements.

Percentile Level (L_{90}, L_{10}, etc) – A statistical measurement giving the sound pressure level which is exceeded for the given percentile of a specified time period, e.g. L_{90} is the level which is exceeded for 90% of a measurement period.

Rating Background Level (RBL) – The median value of the tenth percentile value (ABL) for the recorded L_{AF90} levels for each day, evening and night period over the complete 7 days or more of noise monitoring. The tenth percentile is also referred to as the Assessment Background Level (ABL).

Sound Pressure Level (SPL) – 20 times the logarithm to the base 10 of the ratio of the r.m.s. sound pressure of 20 micro Pascals.