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UNSW Material Science & Engineering Building

Acoustic Report in Response to DGRs

Operational and Construction Phases

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UNSW Material Science & Engineering Building

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Operational and Construction Phases

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1 INTRODUCTION

Details of an environmental noise and vibration assessment, carried out for all stages of the UNSW Material Science and Engineering Building development, is contained in this report.

The purpose of this report is to comply with the Director General's Requirements (DGRs) issued by the Department of Planning, ie:

> *"4. Amenity*
>
> *Provide information detailing … acoustic impacts …. A high level of environmental amenity must be demonstrated."*
>
> *"6. Noise*
>
> *Identify the main noise generating sources and activities at all stages of construction, and any noise sources during operation. Outline measures to minimise and mitigate the potential noise impacts on surrounding occupiers of land."*

The purpose of the DGRs is to safeguard the amenity of neighbouring, off-site premises.

While neither operational nor construction noise need to be addressed in terms of impact to the University itself, operational noise from mechanical plant is addressed through preliminary environmental (external) noise criteria to control the noise emissions to adjacent University buildings. Construction noise to the University, however, is not addressed as this will be relatively short-lived and may be addressed through the implementation of a Construction Noise Management Plan, if necessary.

The results of environmental noise logging (on the University within grounds), and a short-term noise survey on High Street are presented.

2 STANDARDS AND GUIDELINES

In relation to planning, the primary acoustic concerns are of noise to the environment. Standards and guidelines relating to this aspect are listed below, as identified in the DGRs.

NSW EPA Industrial Noise Policy (INP)

A framework and process for deriving noise limit conditions for consents and licences. The Policy establishes noise criteria to protect the community from excessive intrusive noise and preserve acoustic amenity for specific land uses.

This is the primary means by which to set criteria in relation to the noise emissions and relates to fixed plant (and, where applicable, vehicle movements on access roads and in loading docks).

NSW EPA Interim Construction Noise Guideline (ICNG)

A framework and process for dealing with the impacts of construction noise on residences and other sensitive land uses by presenting assessment approaches that are tailored to the scale of construction projects.

The guideline is non-mandatory, but has been adopted for the assessment of construction noise.

3 POTENTIAL NOISE TO NEARBY RECEIVERS

3.1 Operational Noise

The DGRs require both operational and construction noise be addressed in terms of noise to neighbouring, off-site premises. Neither aspect need be addressed in terms of noise to the University itself. Noise to the University will be addressed by the implementation of a Noise Management Plan by the successful contractor.

3.1.1 Fixed Mechanical Plant

It is recognised that noise from mechanical services plant will, when operational, be incident on the University and indicative /preliminary criteria have been developed to control plant noise to University buildings (see **Section 5**).

Compliance with these criteria (at the University's residential accommodation approximately 65 m to the north) will ensure compliance at off-site residences approximately 330 m to the west, and at the stables belonging to the Royal Randwick Racecourse, located approximately 180 m to the north.

Other teaching / educational buildings are closer to the site, at approximately 10m to the west (the existing Material Sciences Building, which will subsequently be demolished), and 15 m to the south (the Law and the Chemical Sciences Building.

3.2 Construction Noise

The closest neighbouring, off-site premises are stables belonging to the Royal Randwick Racecourse, located approximately 110 m (from the closest point of the buildings to be demolished) to the north.

The closest off-site residential premises are situated approximately 330 m to the west on Doncaster Avenue.

4 ENVIRONMENTAL NOISE SURVEYS

4.1 Long-term Noise Survey

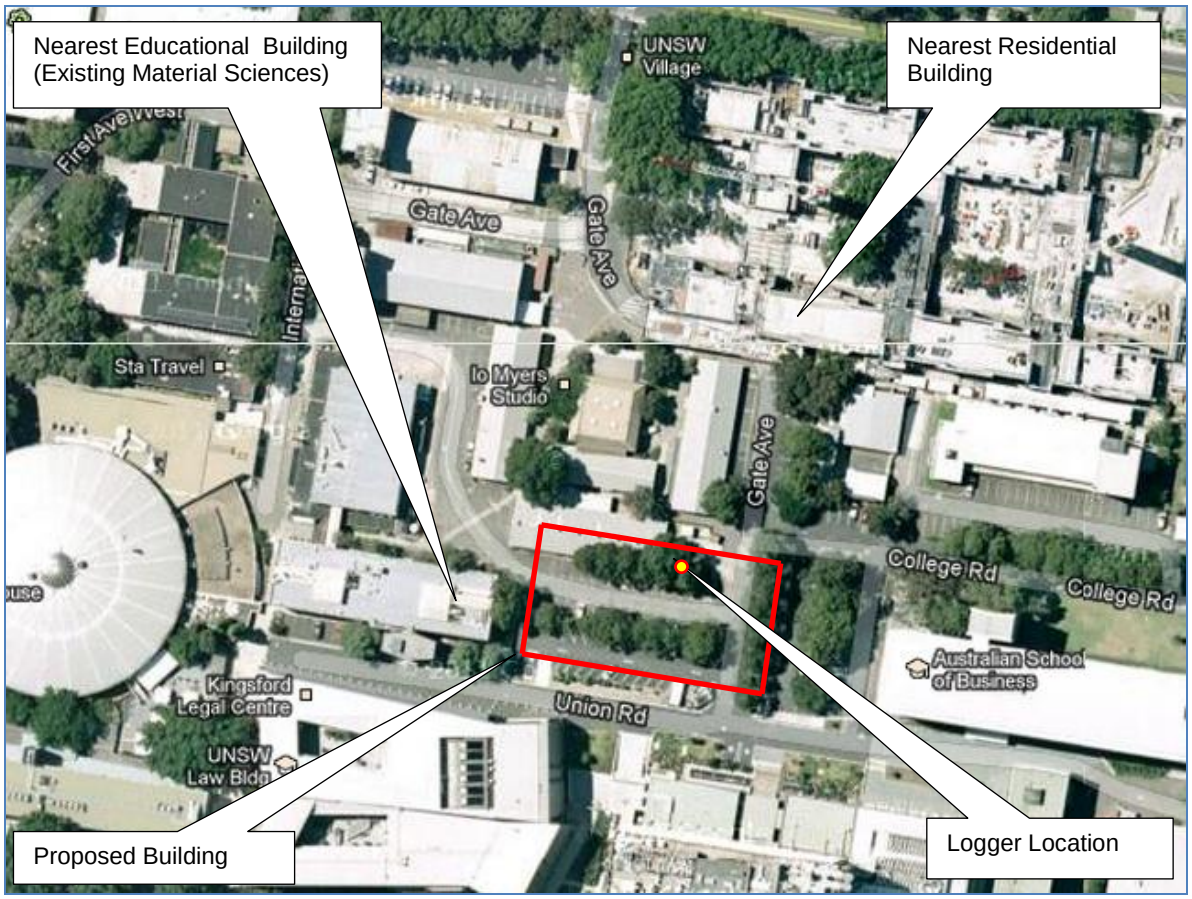
Environmental noise logging was conducted at a single location, towards the northern side of the site (**Figure 1** refers) to establish noise criteria for the control of noise to the environment.

- Location 1: Svan Type 1 Environmental Noise Logger, Serial Number 27522.

The loggers was calibrated before and after the measurement period and the recorded drift in calibration was less than 0.5 dB.

It was lightly raining for large periods of time but rain volume was below 0.5mm in most 15 minute intervals. The noise data obtained does not appear correlated with wind speed and, accordingly, has not been filtered based on wind.

Figure 1 Site and Noise Logging Locations



4.1.1 Survey Results

The full, 7-day, graphical results of the survey are shown in **Appendix A**, and summarised in **Figure 2**.

The statistical descriptors shown on the graph are:

L_{A1} The noise level exceeded for 1% of the sample time (15 minutes) and representative of the highest noise level events (eg passing heavy vehicles, aircraft, etc).

L_{A10} The noise level exceeded for 10% of the sample time (15 minutes) and is typically described as the average maximum noise level.

L_{Aeq} The L_{Aeq} is the energy-average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time varying sound.

L_{A90} The L_{A90} is the level of noise exceeded for 90% of the sample time (15 minutes). The L_{A90} noise level is described as the average minimum background sound level or simply the "background level".

The median values of the L_{A1}, L_{A10} and L_{A90} levels are shown, together with the logarithmic average of the L_{Aeq} levels - for each 15 minute period of the entire long-term monitoring.

Spurious and Uncharacteristic Data

The full, 7-day, graphical results shown in Appendix A include two peculiar "spikes" (at 20:15 on Thursday 26 and 22:15 on Tuesday 31 July).

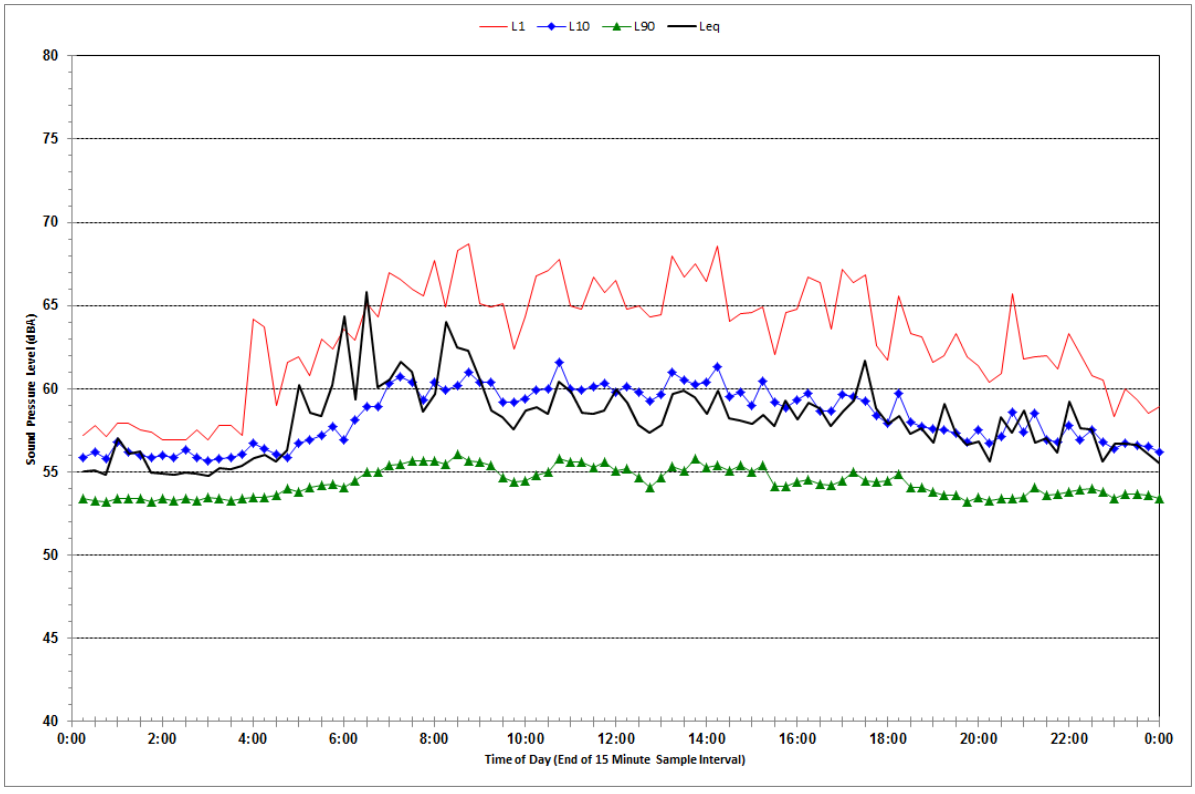
It is clear (because of the relationship of the statistical parameters, together with the maximum levels and their occurrence) that these events are spurious and uncharacteristic - and were probably caused by very loud noises, of very short duration, very close to the logger microphone. As such, these peculiar events have been excluded from the data presented in **Figure 2**, and also excluded from the data used to determine the noise emission criteria.

4.1.2 Noise Environment

It is clear, from the unwavering level of noise - particularly during the early hours of the morning - that the background noise level at the logging location was predominantly controlled by some local mechanical plant noise. (**Figure 2** refers.)

Figure 2 Long-Term Statistical Noise Levels: Monday 23 July to Wednesday 1 August, 2012

Logger Location 1: North side of site



4.1.3 Summary of Existing Noise Levels

The data obtained from the noise monitoring has been processed in accordance with the procedures set out in the NSW EPA's Industrial Noise Policy (INP) and are presented in **Table 1**.

Table 1 Measured Ambient Noise Levels Corresponding to Defined INP Periods

Location	Measurement Descriptor	Measured Noise Level - dBA re 20 µPa		
		Daytime	Evening	Night-time
		7.00 am - 6.00 pm	6.00 pm - 10.00 pm	10.00 pm - 7.00 am
Logger 1	LAeq	60	58	58
	RBL (Background)	54	53	53

4.2 Short-term Noise Survey

A short-term (15 minute) noise survey was conducted at the High Street entrance to the Royal Randwick Racecourse, on 24 August 2012, to obtain indicative environmental noise levels for the area.

The weather was clear, dry and sunny, with a light easterly wind (of approximately 3 m/s). The following levels (rounded to the nearest dB) were obtained:

- 75 L_{A1}
- 67 L_{A10}
- 65 L_{Aeq}
- 57 L_{A90}

The environment noise included: road traffic on High Street (with busses at 70 to 78 dBA); aeroplane (64 dBA); construction on High Street (61 to 76 dBA). The background (or underlying) noise (57 L_{A90}) was primarily due to distant road traffic (on Anzac Parade).

5 NOISE CRITERIA

5.1 Operational Noise Criteria

5.1.1 Site Activity Noise

"Industrial" noise emissions from on-site activities associated with the proposed development (such as on-site vehicle movements, air-conditioning equipment, exhaust fans and other mechanical plant) must be controlled to avoid impacting upon the acoustic amenity of nearby premises which, in this case, are either nearby teaching areas or more distant residential accommodation.

Responsibility for the control of noise emission in New South Wales is vested in Local Government and the Environmental Protection Authority (EPA).

The EPA oversees the Industrial Noise Policy (INP) which provides a framework and process for deriving noise criteria designed to:

- Control the intrusive noise impacts for residents and other sensitive receivers in the short term; and

- Maintain noise level amenity for particular land uses for residents and sensitive receivers in other land uses

5.1.2 Assessing Intrusiveness

The intrusiveness criterion essentially requires that the equivalent continuous noise level (L_{Aeq}) of the source should be no more than 5 dBA above the background noise level over any 15 minute period.

In instances where "industrial noise" from a site occurs in short bursts followed by much longer periods of relative quiet (which is unlikely to be the case here) the impact of the industrial noise must be assessed on the basis of the level of that noise against the background noise during the period that the activity occurs (if the L_{Aeq} level of the industrial noise was "averaged" over the whole day, evening or night period – it is possible that impact of the activity could potentially be under-estimated).

For steady-state noise sources (ie where the industrial noise is fairly uniform, over the whole day, evening or night period - as is the case here) the intrusiveness criterion requires that the equivalent continuous noise level (L_{Aeq}) of the source should be no more than 5 dBA above the Rated Background Level (RBL). The RBL is established through environmental monitoring (see **Section 4.1.3)**.

5.1.3 Assessing Amenity

The amenity criterion is based on land use and associated activities (and their sensitivity to noise emission). The cumulative effect of noise from industrial sources needs to be considered in assessing the impact. The criterion relates only to other industrial-type noise sources and does not include road, rail or community noise.

The existing noise level from industry is measured. If it approaches the criterion value, then noise levels from new industrial-type noise sources (including air-conditioning mechanical plant and vehicle movement) need to be controlled so that the cumulative effect does not significantly exceed the criterion. If, on the other hand, the existing level of industrial noise is below the criterion value, then noise levels from new industrial-type are controlled so that the cumulative effect approaches the criterion.

(For areas of high road traffic, there are further considerations that influence the selection of the noise criterion - but that is not the case here.)

5.1.4 Area Classification

Residential Accommodation

We have deemed this area to fall under the "Urban Area" classification. The INP characterises an urban area as, inter alia:

> "*an area with an acoustical environment that:*
>
> - *is dominated by "urban hum" or industrial source noise*
> - *has through traffic with characteristically heavy and continuous traffic flows during peak periods*
> - *is near commercial districts or industrial districts*
> - *has any combination of the above.*"

Educational Areas

The INP requires an internal noise level of no greater than 35 L_{Aeq}, during the noisiest 1-hour period when the educational facility is in use.

Current Materials Sciences Building

The adjacent (and current Materials Sciences Building) has openable windows. Allowing for an outside-to-inside noise reduction of (at least) 10 dBA for a façade with openable windows, this requires the external levels incident on the adjacent buildings to be no greater than 45 L_{Aeq}.

It is noted that this building will eventually be demolished, leaving the Law and Chemistry Buildings as the closest to the proposed Materials Sciences and Engineering Building.

Law and Chemistry Buildings

The nearby (but slightly further away) Law and Chemistry Buildings have closed glazing, which can be expected to provide an outside-to-inside noise reduction of (at least) 20 dBA, thereby requiring the external levels to be no greater than 65 L_{Aeq}.

Therefore, the over-riding criterion will be that external levels incident on the current Materials Sciences Building are to be no greater than 45 L_{Aeq}.

5.1.5 Preliminary Project Specific Noise Levels

Having defined the area type, the processed results of the unattended noise monitoring have been used to generate project-specific noise criteria.

In this case (since the noise from equipment is anticipated as being fairly steady) the project-specific noise levels, which are shown in bold in **Table 2**, are the lower of the intrusive and amenity criteria.

Where the noise source contains annoying characteristics (such as prominent tonal components, impulsiveness, intermittency, irregularity and dominant low-frequency content) adjustments are applied to the level of noise that is received at the assessment point before comparison with the criteria.

The Amenity criteria given in **Table 2** assumes the existing level of industrial type noise (L_{Aeq}) at the residential accommodation currently matches the ANL, so as to result in the most stringent criteria. These criteria should therefore be considered as preliminary and further testing should be conducted to verify the measured levels, and the developed criteria, during the detailed design stage.

Table 2 Criteria for Noise Emissions to Nearby Residential Receivers

Time of Day		Noise Level dBA re 20 µPa				
		ANL[1] (Period)	Measured RBL $L_{A90(Period)}$[2]	Measured $L_{Aeq(Period)}$	INP Criteria	
					Intrusive	Amenity
					$L_{Aeq(15minute)}$ Criterion for New Sources	$L_{Aeq(Period)}$ Criterion for New Sources[3]
Location 1						
Day	7.00 am - 6.00 pm	60	54	60	59	**52**
Evening	6.00 pm - 10.00 pm	50	53	58	58	**42**
Night	10.00 pm - 7.00 am	45	53	58	58	**37**

Note 1: ANL: Acceptable Noise Level for an "Urban" area.

Note 2: RBL: Rating Background Level.

Note 3: Assuming existing noise levels are unlikely to decrease.

Note 4: Project Specific Criteria are shown in bold.

Note 5: The Amenity criteria given assumes the existing level of "industrial" noise (L_{Aeq}) at the residential accommodation currently matches the ANL, so as to result in the most conservative (ie most stringent) criteria.

Summarised Criteria

The following criteria are proposed (subject to verification during the detailed design stage):

Closest Residential Accommodation

- Day 52 dBA (Externally)
- Evening 42 dBA (Externally)
- Night 37 dBA (Externally)

Closest Educational Accommodation

While the existing Materials Sciences Building is in use: 45 L_{Aeq} (Externally - openable glazing)

5.1.6 Discussion

University Accommodation

Given the increased distance to the residential accommodation (approximately 65m) compared to the adjacent educational areas (as close as 10m), complying with the noise criterion to the nearby educational areas will also result in compliance at the residential accommodation – during the daytime.

Further, given that most mechanical plant will not operate during the night-time, controlling noise to the evening criterion at the adjacent educational areas will guarantee compliance at the residential accommodation – during the night-time.

Off-site Premises

Given the increased distance (a further 100 m) to the stables to the north, and (a further 270 m) to the residential accommodation to the west, complying with the noise criteria at the University's residential accommodation will also result in compliance at the neighbouring premises.

5.2 Construction Noise Criteria

The EPA's Interim Construction Noise Guideline, 2009 (ICNG) sets out ways to deal with the impacts of construction noise on residences and other sensitive land uses by presenting assessment approaches that are tailored to the scale of construction projects.

The main objectives of the ICNG are stated in Section 1.3 of the INCG. The relevant items are presented below:

- Promote a clear understanding of ways to identify and minimise noise from construction works
- Focus on applying all 'feasible' and 'reasonable' work practices to minimise construction noise impacts.
- Encourage construction to be undertaken only during the recommended standard hours unless approval is given for works that cannot be undertaken during these hours.
- Streamline the assessment and approval stages and reduce time spent dealing with complaints at the project implementation stage.
- Provide flexibility in selecting site-specific feasible and reasonable work practices in order to minimise noise impacts.

Whilst it is recognised the guideline is non-mandatory, it is applicable to this project and has been adopted for the assessment of construction noise.

Guidance noise levels are given for airborne noise at sensitive land uses, including passive recreation, commercial and industrial premises. Guidance levels are also given for ground-borne noise and sleep disturbance. The assessment method involves predicting noise levels and comparing them with the guidance, or management levels.

The 'management levels' will be referred to as 'Noise Management Levels' (NMLs). The NMLs have been reproduced from the guideline and are presented in **Table 3**.

Specific non-residential receivers in the vicinity of the proposed construction site, and their recommended 'management levels' are presented in **Table 4**.

Table 3 Guideline Management Levels for Construction Noise

Time of day	Management Level $L_{Aeq\ (15\ min)}$ [1]	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq(15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. 2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

Note 1 The noise levels apply at the property boundary that is the most exposed to the construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Table 4 Noise at Sensitive Land Uses (other than Residences) and Commercial and Industrial Premises

Land use	$L_{Aeq(15minute)}$ Construction NML
Classrooms at schools and other educational institutions	Internal noise level 45 dBA
Hospital wards and operating theatres	Internal noise level 45 dBA
Places of worship	Internal noise level 45 dBA
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)	External noise level 65 dBA
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading, meditation)	External noise level 60 dBA
Offices, retail outlets	External noise level 70 dBA
Industrial premises	External noise level 75 dBA

5.2.1 Summary of Construction Noise Criteria

For the stables to the north, the NML is taken as 65 dBA (see active recreation areas in Table 4 above).

For the closest off-site residential receivers (330 m to the west) the NML can be expected to be in the order of 67 dBA, assuming a daytime background noise similar to that measured at the stables of 57 dBA (see Section 4.2 and Table 3).

The NML is 45 dBA (internally) for the adjacent educational University accommodation, which translates to an external level (incident on the buildings) of 55 dBA.

Note, however, these criteria should be considered as preliminary and further testing will be conducted to verify the measured levels, and the developed criteria, during the detailed design stage (see **Section 5.1.5**).

5.3 Construction Vibration Criteria

Guidance in relation to acceptable vibration levels for human comfort are provided in the EPA's "Assessing Vibration: a technical guideline" (2006). The EPA guideline provides three assessment methods, depending on whether the vibration is continuous, impulsive or intermittent. The preferred and maximum values are provided in **Table 5**.

- Continuous vibration would normally be generated by fixed plant items such as generators, fans and the like where the vibration emissions continue uninterrupted (usually throughout the daytime or night-time period).
- Impulsive vibration would normally be generated by short duration (ie less than two second) events with no more than three occurrences in an assessment period. A typical example would be ground compaction by dropping a large mass. Higher levels are allowed for impulsive vibration, however if more than three impulsive vibration events occur during the assessment period, the more stringent intermittent objectives are applied.
- Intermittent vibration can be defined as interrupted periods of continuous vibration (eg vibratory rolling, heavy truck passbys or rock breaking) or continuous periods of impulsive vibration (eg impact pile driving). Higher vibration levels are allowed for intermittent vibration compared with continuous vibration on the basis that the higher levels occur over a shorter time period. Hence, for intermittent vibration, human comfort vibration levels are assessed on the basis of the Vibration Dose Value (VDV), based on the level and the duration of the vibration events.

Table 5 Preferred and Maximum Vibration Levels for Human Comfort

Location	Assessment Period	Preferred Values		Maximum Values	
Continuous Vibration		**z axis**	**x and y axes**	**z axis**	**x and y axes**
Critical areas	Day- or night-time	0.005 m/s^2	0.0036 m/s^2	0.010 m/s^2	0.0072 m/s^2
Residences	Daytime	0.010 m/s^2	0.0071 m/s^2	0.020 m/s^2	0.014 m/s^2
	Night-time	0.007 m/s^2	0.005 m/s^2	0.014 m/s^2	0.010 m/s^2
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020 m/s^2	0.014 m/s^2	0.040 m/s^2	0.028 m/s^2
Workshops	Day- or night-time	0.040 m/s^2	0.029 m/s^2	0.080 m/s^2	0.058 m/s^2
Impulsive Vibration		**z axis**	**x and y axes**	**z axis**	**x and y axes**
Critical areas	Day- or night-time	0.005 m/s^2	0.0036 m/s^2	0.010 m/s^2	0.0072 m/s^2
Residences	Daytime	0.30 m/s^2	0.21 m/s^2	0.60 m/s^2	0.42 m/s^2
	Night-time	0.10 m/s^2	0.071 m/s^2	0.20 m/s^2	0.14 m/s^2
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64 m/s^2	0.46 m/s^2	1.28 m/s^2	0.92 m/s^2
Workshops	Day- or night-time	0.64 m/s^2	0.46 m/s^2	1.28 m/s^2	0.92 m/s^2
Intermittent Vibration		**x, y and z axes**		**x, y and z axes**	
Critical Areas	Day- or night-time	0.10 m/s$^{1.75}$		0.20 m/s$^{1.75}$	
Residences	Daytime	0.20 m/s$^{1.75}$		0.40 m/s$^{1.75}$	
	Night-time	0.13 m/s$^{1.75}$		0.26 m/s$^{1.75}$	
Offices, schools, educational institutions and places of worship	Day- or night-time	0.40 m/s1.75		0.80 m/s$^{1.75}$	
Workshops	Day- or night-time	0.80 m/s$^{1.75}$		1.60 m/s$^{1.75}$	

Notes: For continuous and intermittent vibration, the preferred and maximum values are weighted acceleration values (Wg for z axis and Wd for x and y axes).
For intermittent vibration, the preferred and maximum values are Vibration Dose Values (VDVs), based on the weighted acceleration values

5.3.1 Effects on Building Contents

People can perceive floor vibration at levels well below those likely to cause damage to building contents or affect their operation. For most receivers, the controlling vibration criterion is therefore the human comfort criterion and separate objectives are not normally required in relation to the effect of construction vibration on building contents.

Some scientific equipment (eg electron microscopes and microelectronics manufacturing equipment) can require more stringent objectives than those applicable to human comfort. Where appropriate, objectives for the satisfactory operation of critical instruments or manufacturing processes should be sourced from manufacturer's data and /or other published objectives.

5.3.2 Effects of Vibration on Structures

The levels of vibration required to cause cosmetic damage to buildings tend to be at least an order of magnitude (ie, 10 times) higher than those at which people may consider the vibration to be intrusive.

In terms of the most recent relevant vibration damage objectives, Australian Standard AS 2187: Part 2-2006 "*Explosives - Storage and Use - Part 2: Use of Explosives*" recommends the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 "*Evaluation and measurement for vibration in buildings Part 2*" as they "are applicable to Australian conditions".

The British Standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

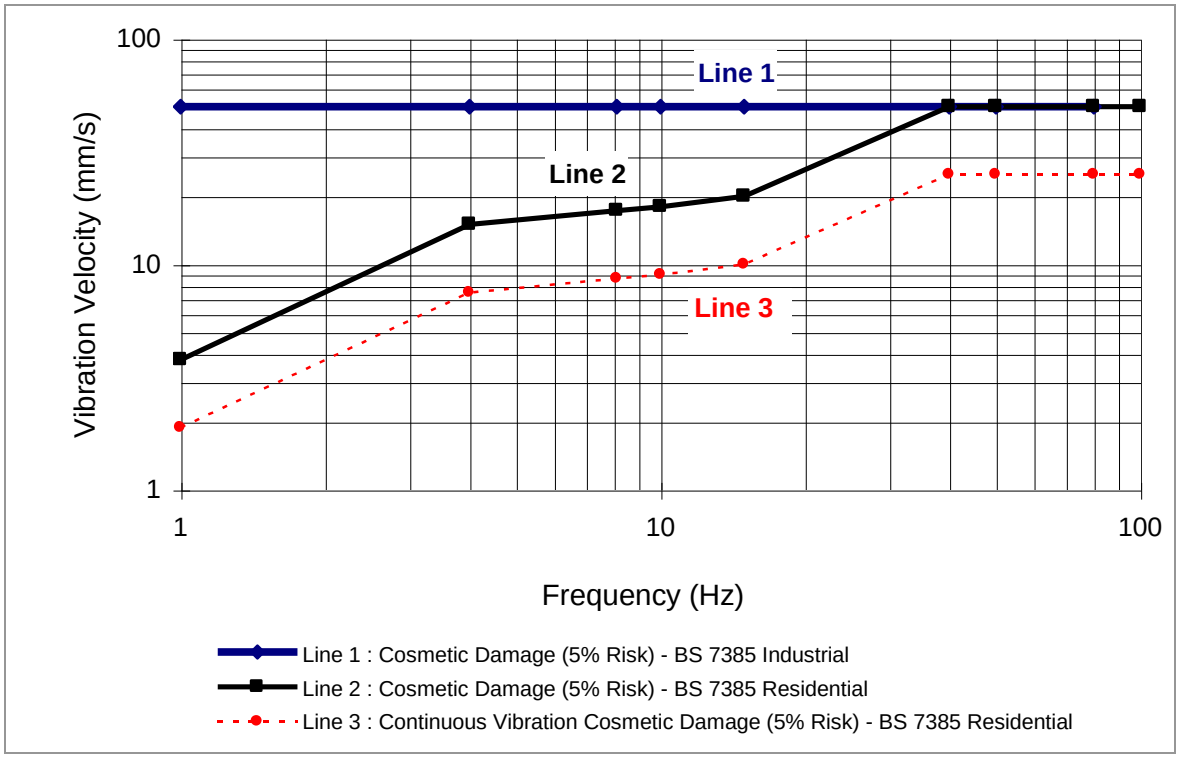
The recommended limits (guide values) from BS7385 for transient vibration to ensure minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in **Table 6** and graphically in **Figure 3**.

The standard states that the guide values in **Table 6** relate predominantly to transient vibration which does not give rise to resonant responses in structures, and to low-rise buildings. Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in **Table 6** may need to be reduced by up to 50% - ie 7.5 mm/s at 4 Hz (as shown by Line 3 of **Figure 3** for Residential Buildings).

Table 6 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

Line	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and Above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Figure 3 Graph of Transient Vibration Guide Values for Cosmetic Damage



In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz.

The standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in **Table 6** and major damage to a building structure may occur at values greater than 4 times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculations indicate that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in **Table 6** should not be reduced for fatigue considerations.

It is noteworthy that, in addition to the guide values nominated in **Table 6**, the standard states that:

> *"Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK."*

6 OPERATIONAL NOISE ASSESSMENT (MECHANICAL PLANT)

Potential acoustic concerns, in relation to controlling mechanical plant, together with conceptual design solutions, are discussed below.

6.1 Noisy Equipment

Typically large airconditioning equipment will have Sound Power Levels in the order of 100 dBA. Such plant may require some perimeter screening to satisfy the evening and daytime criteria at the residential accommodation to the north - depending upon the plant's location, and its operational load.

Although adjacent educational areas are closer, noise to these may be reduced by the shielding effect from the building's roof-top edge. Thus, the plant may similarly require some perimeter screening to satisfy the criterion at these locations.

Plant of less acoustic power is unlikely to be problematic with regard to noise to the environment.

Any tri-generation plant (the feasibility of which is currently being investigated) would likely require large-section, long attenuators to control breakout noise to the environment - and space for these should be allowed for in the early stages of the design.

7 CONSTRUCTION NOISE ASSESSMENT

The conceptual construction program is expected to last for a total period of approximately 18 months and comprises the major elements shown in **Table 7**.

Table 7 Proposed Construction Program

Activity		Equipment Used
1.	Site establishment including the construction of access roads and carparking facilities	Earthmoving equipment and paving machinery
2.	General excavation work	Earthmoving equipment, trucks, rockbreakers, piling
3.	Building shell construction	Trucks, concrete pumps, crane
4.	Basic Fitout, including electrical and mechanical services	General construction, crane
5.	Detailed Fitout, such as partitions, communications and security systems	Hand tools, cranes
6.	Landscaping and Commissioning	Hand tools, trucks, crane

7.1 Construction Noise

To assess the impact of the construction of the proposed building (including the demolition of existing buildings), noise levels have been calculated at both the stables to the north and at the residences on Doncaster Avenue to the west. Calculations included distance attenuation and a nominal 15 dBA reduction for shielding from intervening buildings.

Typical Equipment Sound Power Levels of the noisiest equipment likely to be used during the construction phase are shown in **Table 8** together with the predicted noise levels at the affected receivers.

Table 8 Typical Equipment Sound Power Levels and Predicted Noise Levels at the nearest Receivers

Operation/ Activity	Range of typical Maximum [1] Sound Power Levels (dBA)	Randwick Racecourse Stables		Residences on Doncaster Avenue	
		Attenuation Distance (m)	Receiver Noise Level in dBA [1]	Attenuation Distance (m)	Receiver Noise Level in dBA [1]
Concrete Mixers	107 to 112	110	40 to 45	330	31 to 36
Dump trucks on site	108	110	41	330	32
Excavators/Loaders	108 to 112	110	41 to 45	330	32 to 36
Rockbreaker	120	110	58 [2]	330	49 [2]
Vibrating Roller	107	110	40	330	31
Bored piling rig	105	110	38	330	29
Compressor	94	110	27	330	18
Jackhammer - pneumatic	109	110	47 [2]	330	38 [2]
Fixed Crane	104 to 108	110	37 to 41	330	28 to 32
Mobile Crane	100 to 110	110	33 to 43	330	24 to 34
General hand tools	93 to 98	110	26 to 31	330	17 to 22

Note 1: L_{Aeq} noise levels are typically 3 dB below maximum noise levels.
Note 2: The resultant noise levels from the rockbreaker and jackhammer include a 5dB 'impulsive' noise penalty.

At the stables, the levels are expected to fall within the "noise affected" NML of 65 dBA (for "*Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion)*". Further, the predicted noise levels are well below the general ambient daytime levels at that location (in the order of 57 L_{A90} to 67 L_{A10}) and are likely to go mostly unnoticed.

At the nearest off-site residences (330 m to the west), the levels are expected to fall within the "Noise Affected" NML of 67 dBA (**Section 5.2.1** refers). Further, the predicted noise levels are well below the ambient daytime levels at that location and, again, are likely to go mostly unnoticed.

7.2 Construction Vibration

The major potential sources of construction vibration include driven piles, rockbreakers and vibratory rollers. The distance to the nearest building (the Royal Randwick stables) is potentially 110 m.

It should be noted that vibration levels from vehicles travelling along High Street will produce greater vibration levels than are likely to occur from the demolition and construction works.

It should be noted that a new University building has recently been completed just to the north of the proposed building, approximately 40 m away from the stables.

7.2.1 Hydraulic Rockbreakers

Table 9 sets out the typical ground vibration levels at various distances from a large rockbreaker operating in hard sandstone. We understand that the University is constructed on sand and the following vibration levels should therefore be considered very conservative (ie "worst-case").

Table 9 Typical Rockbreaker Vibration Levels (mm/s) versus Distance

Operation	Vibration Level (mm/s) at Given Distance					
	5 m	10 m	20 m	30 m	40 m	50 m
Heavy Rockhammering	5	1.5	0.50	0.20	0.15	0.10

Given the criterion of 7.5 mm/s (**Section 5.3.2** and **Figure 3**), the use of standard hammers is permissible within 5 m of "Unreinforced or light framed structures" or "Residential or light commercial type buildings".

7.2.2 Vibratory Rollers

Levels of ground vibration caused by vibratory rollers can be up to 1.5 mm/s at 25 m. The highest levels of vibration usually occur as the roller is brought to rest and the frequency of the centrifugal forces passes through resonance with the natural frequency of the roller/ground structure.

Based on recommendations used by the NSW Roads and Traffic Authority, **Table 10** sets out safe working distances for the use of vibratory rollers adjacent to buildings (from ARRB Special Report No.11, *"Ground Vibrations: Damaging Effects to Buildings"*).

Table 10 Safe Working Distances for Vibratory Rollers [1]

Roller Class		Weight Range	Centrifugal Force Range	Distance from Building	
				See Note [1]	See Note [2]
I	Very Light	Less than 1.25 tonnes	10 - 20 kN	3 m	No effect
II	Light	1 to 2 tonnes	20 - 50 kN	5 m	No effect
III	Medium	2 to 4 tonnes	50 - 100 kN	6 m	12 m
IV	Medium Heavy	4 to 6 tonnes	100 - 200 kN	12 m	24 m
V	Heavy	7 to 11 tonnes	200 - 300 kN	25 m	50 m
VI	Very Heavy	12 tonnes and over	Over 300 kN	25 m	50 m

Note 1: Values suggested to prevent damage to buildings.
Note 2: Values suggested to minimise strongly adverse comment from residents.

To reduce the vibration impact during use of the vibratory roller, **Table 10** permits the use of a "Very Heavy" roller classification operating as close as 25 m from buildings.

7.2.3 Expected Vibration Impacts

There is no risk of damage to off-site buildings, or even to the closest University buildings, from rock breaking.

Vibratory rollers present no risk of damage to off-site buildings, but the University may wish to consider implementing a Noise Management Plan to minimise the risk of damage to the closest of their buildings and /or interference to the operation of nearby sensitive equipment.

Vibration may be perceptible for relatively short periods of time when construction activities are immediately adjacent to specific buildings.

8 RECOMMENDATIONS

8.1 Operational Noise

Noise control measures must be developed during the design stages to ensure noise from mechanical equipment will meet the noise criteria.

However, given the location of the proposed development in relation to teaching /educational areas to the west (the existing Materials Sciences Building) and the residential accommodation to the north, it is likely that noise from mechanical services plant will be adequately controlled through conventional means - such as attenuators, acoustic louvres, barriers, enclosures, and the careful location and orientation of the plant and of air inlets and outlets.

Given the distance and screening to the stables to the north (180 m), the residential accommodation to the west (330 m), complying with the noise criteria at the University's residential accommodation will also result in compliance at these neighbouring premises.

The criteria given should be considered as preliminary and further testing should be conducted during the detailed design stage to verify the measured levels, and the developed criteria.

8.2 Construction Noise and Vibration

There is no need for any particular control measures in relation to off-site locations: noise to the at both the stables and at residences in Doncaster Avenue, are expected to be less than the "Noise Affected" Noise Management Level, and less than the respective ambient daytime noise levels in these locations.

There will clearly be no risk of vibration damage to off-site buildings.

However, the University may wish to consider implementing a Noise (and Vibration) Management Plan to minimise the disruption /interference to their own, nearby, accommodation and the risk of damage to the closest of the University buildings and / or interference to the operation of nearby vibration-sensitive equipment.

9 CONCLUSION

This report addressed the Director General's Requirements in terms of acoustic amenity due to operational and construction activity.

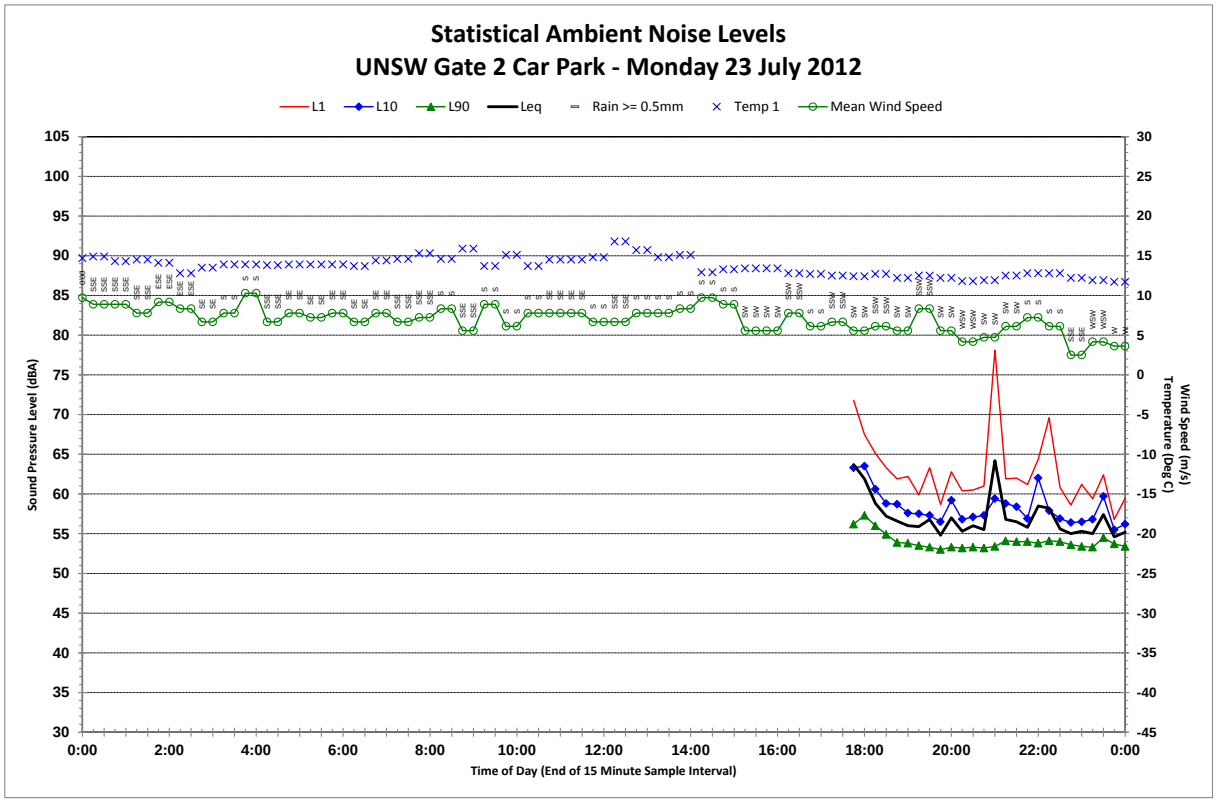
The results of environmental noise logging are presented, together with preliminary noise criteria for the development's own noise emissions to the environment from fixed plant.

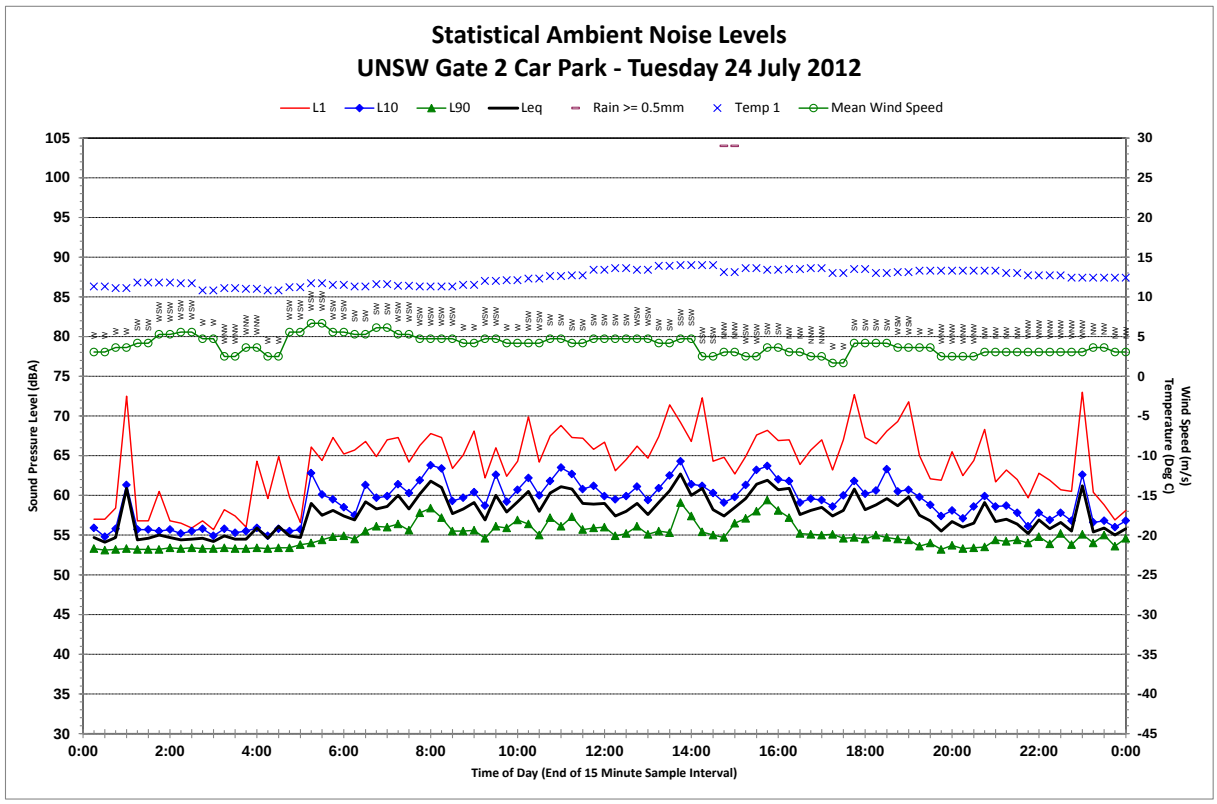
Recommendations are given with regard to further noise logging during the design stages – to verify these preliminary criteria.

Noise arising from the operational phase should not result in any significant or unacceptable impacts on the site or the surrounding premises.

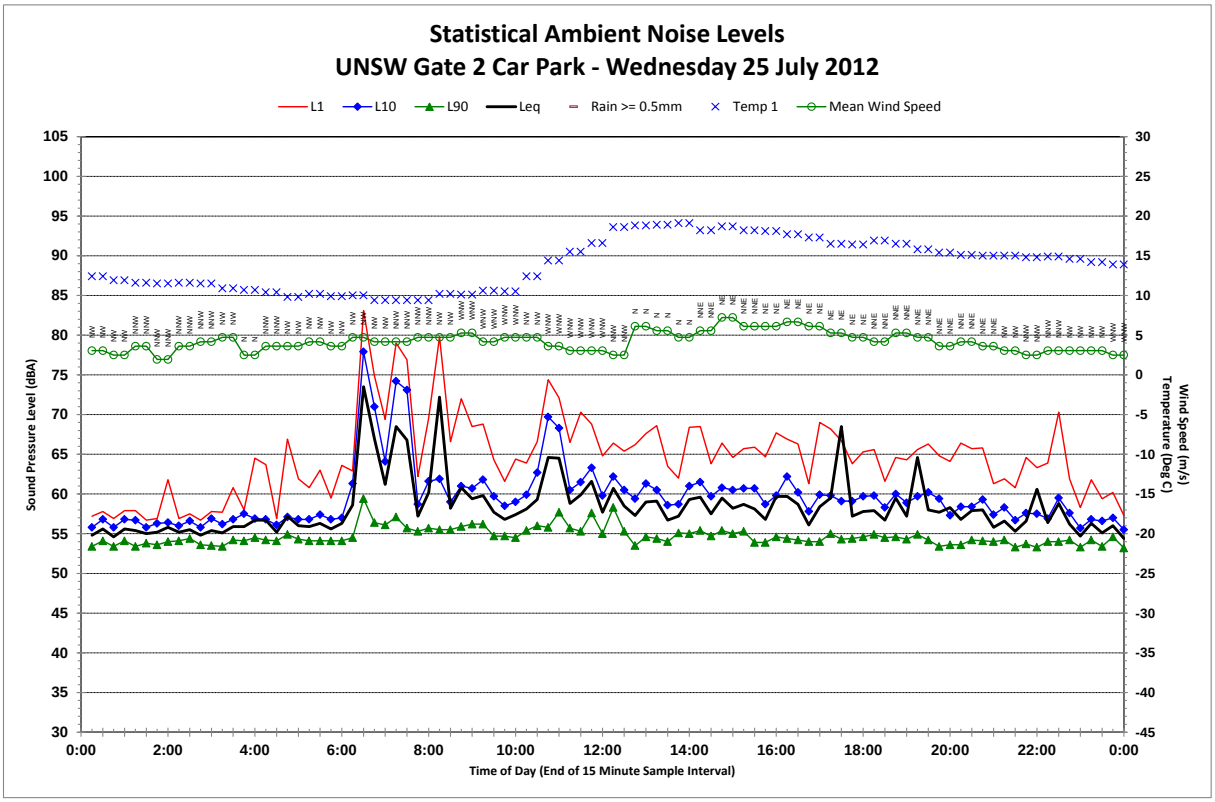
Noise and vibration arising from the construction phase should not result in any significant or unacceptable impacts on the surrounding premises. However, the implementation of a Noise (and Vibration) Management Plan would minimise the disruption, and the risk of structural damage to the closest of the University buildings.

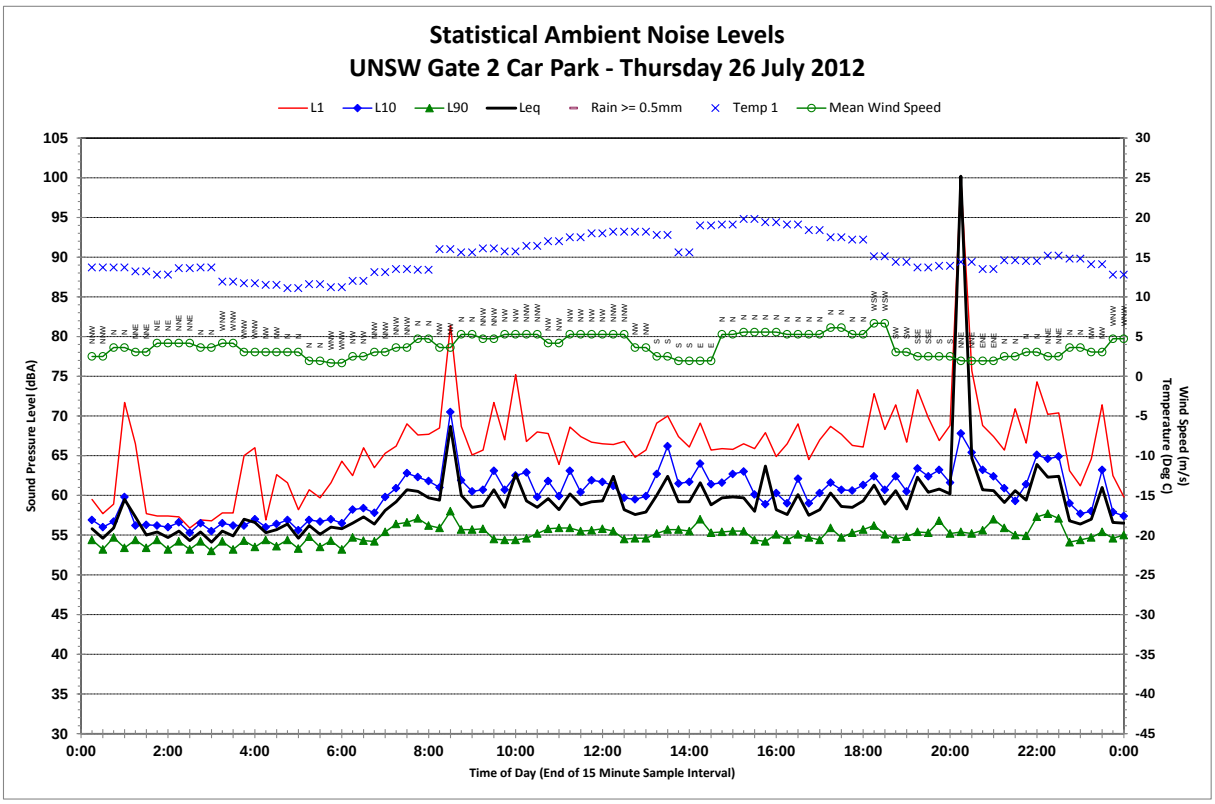
Existing Background Noise Levels - Logger Location 1: Union Street



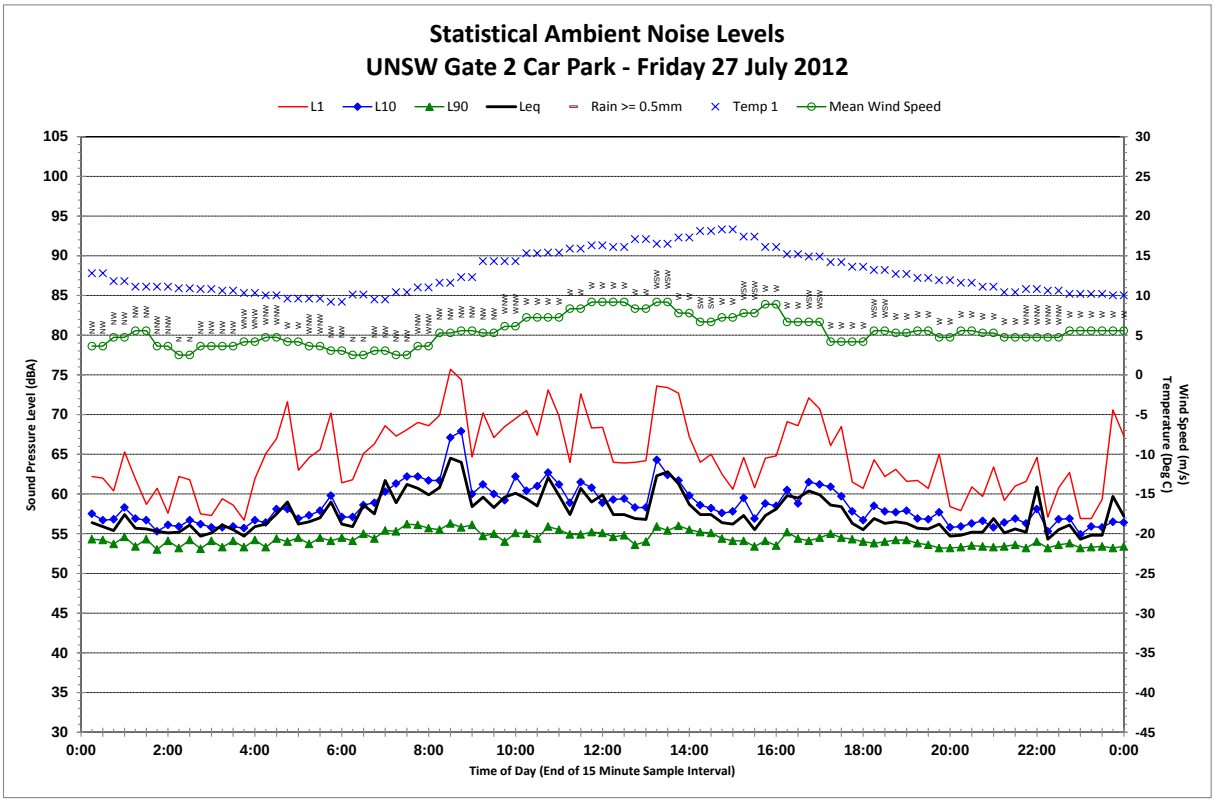


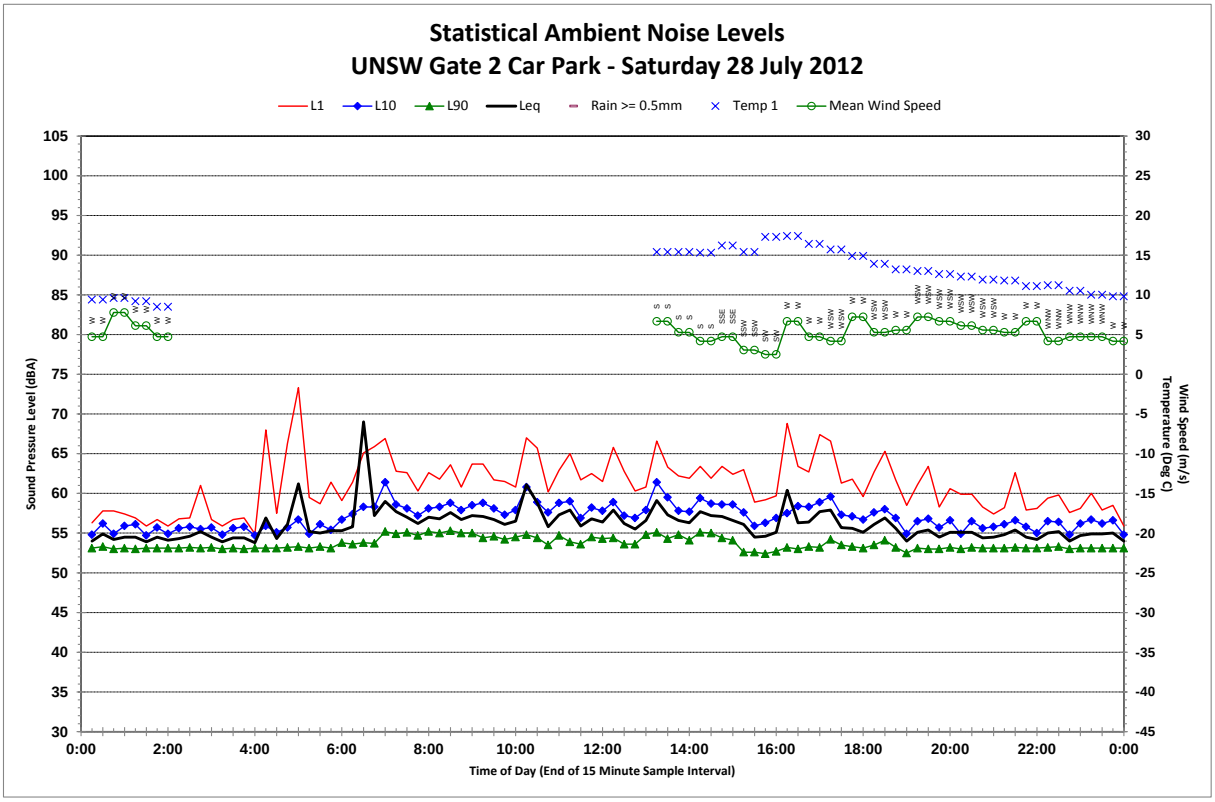
Existing Background Noise Levels - Logger Location 1: Union Street





Existing Background Noise Levels - Logger Location 1: Union Street





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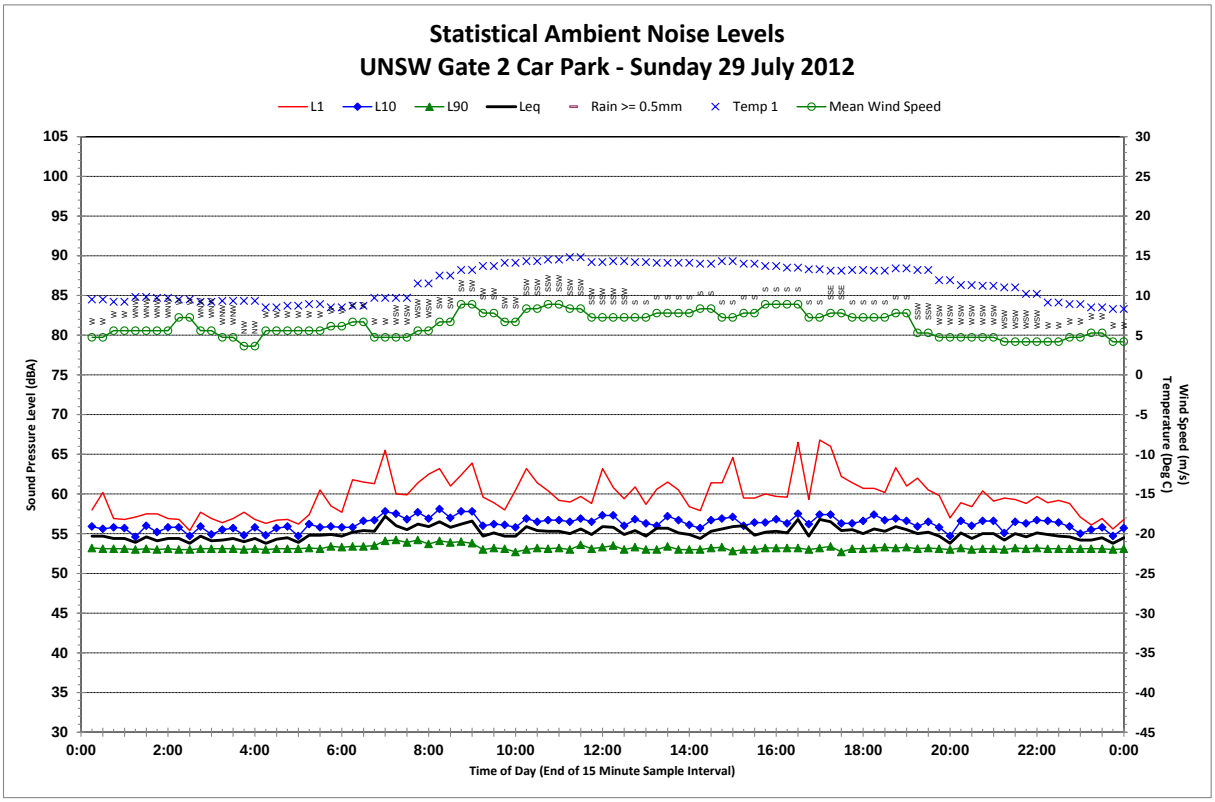

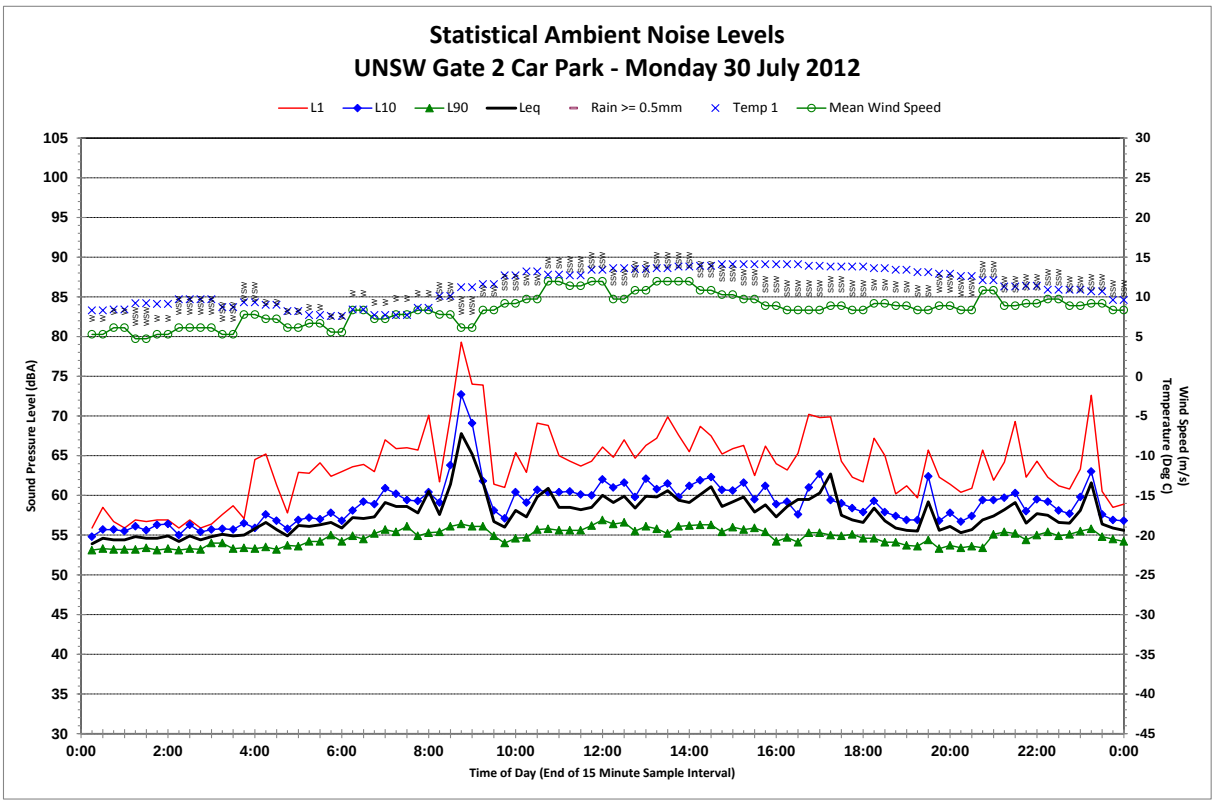

Existing Background Noise Levels - Logger Location 1: Union Street