University of New South Wales, c/o Capital Insight Pty Ltd

Tyree Energy Technologies Building Project

Acoustic Assessment Development Application Report

FINAL

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Acoustic Assessment Development Application Report

December 2009

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Job number 206715-04

Job title	Tyree Energy Technologies Building Project	Job number	206715-04
Document title	Acoustic Assessment Development Application Report	File reference	
Document ref	AAc/206715-04/R01		

Revision	Date	Filename	02_Acoustic_DA_Issue.doc		
Issue	02/12/09	Description	Issue		
			Prepared by	Checked by	Approved by
		Name	Stephanie Harper	Frank Butera	Frank Butera
		Signature			
Final	04/12/09	Filename	0003Report DA Acoustic Submission Final .doc		
		Description	Final Report		
			Prepared by	Checked by	Approved by
		Name	Stephanie Harper	Frank Butera	Frank Butera
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			
		Filename			
		Description			
			Prepared by	Checked by	Approved by
		Name			
		Signature			

Issue Document Verification with Document ✓

Contents

Appendices

Attended Noise Measurements

Appendix C

Sound Level Data

Executive Summary

Noise emitted from the proposed development has been assessed in accordance with appropriate noise legislation and guidelines to noise sensitive receivers in the vicinity of the subject site.

To ensure that noise levels comply with the project noise limits, the following roof top mechanical services equipment will require further investigation, and may require noise control treatment:

- Emergency generator
- Cooling towers
- Smoke exhaust fans

Suggested noise control treatments to be investigated during detail design include:

- Vibration isolation for reciprocating plant, including the gas and emergency generators.
- Locating the emergency generator in a separate plantroom.
- Smoke exhaust fans to be located in a separate plantroom, with acoustic louvres in the ventilation openings.
- Noise control options for the cooling towers, such as attenuators, plantroom spaces to form a noise barrier around the cooling towers.

By implementing the above recommendations, the noise impact of the proposed development on the community will be minimised, and noise levels at nearest noise sensitive receivers are expected to meet the applicable criteria.

1 Introduction

Arup Acoustics has been retained by the University of New South Wales (UNSW) to provide acoustic advice for the development of the Tyree Energy Technologies Building (ETB) to be located at their Kensington Campus, Sydney.

This report is the acoustic assessment to accompany the Project Application. The report provides the following information:

- Identifies nearest noise sensitive receivers.
- Contains results of attended background noise measurements conducted at the subject site and the surrounding area.
- Establishes relevant noise criteria for the project in accordance with relevant legislation, Australian Standards and guidelines.
- Assesses noise levels from the development against the project noise limits.
- Provides typical noise control recommendations where required.

A glossary of acoustic terminology used throughout this report is included in Appendix A.

2 Site Description

2.1 General

The Kensington campus of UNSW is the primary Sydney campus of the University, and is located on Anzac Parade approximately 6 km south of Sydney CBD. The proposed ETB is to be located on the western edge of the existing campus and is bounded by:

- Anzac Parade to the west.
- University Mall to the north.
- Sam Cracknell Pavillion to the east.
- New College Residential Building (Anzac Parade, near Southern Drive) to the south.

The proposed location for the ETB is shown below in Figure 1. Currently, tennis courts and a storage shed are located on the subject site.

Nearest noise sensitive receivers to the site are identified below in Table 1 and Figure 1.

Table 1: Nearest residential receivers

Ref	Receiver	Direction from subject site
1	5 storey New College Campus residential building, Anzac Parade, Kensington Campus	South
2	7 storey New College Campus residential building, 215 Anzac Parade, Kensington	North-west
3	2 storey UNSW Multipurpose Building, Blockhouse, University Mall, Kensington Campus	North
4	3 storey residential apartments, 217 Anzac Parade, Kensington,	West

2.2 Project Background

The new building will support the University's internationally recognised research and technology in key energy areas including photovoltaics, carbon capture and storage, oil and gas reservoir characterisation, nanomaterials and energy policy and market analysis.

The ETB is to be a multi-purpose 5-storey building with roof top plant with the following spaces:

- Research laboratories
- Support spaces and offices
- Lecture theatres and teaching spaces
- Collaborative working spaces
- Computer laboratories
- Quiet study spaces
- Showcase area (ground level)
- Cafeteria (ground level)
- Open atrium (ground level)
- Loading dock (ground level)

It is proposed that the building is to be serviced by air handling units located in plantrooms on each level of the building, with operational building mechanical plant to be located on the rooftop, including:

- Chillers
- Cooling towers
- Gas generator
- Emergency diesel generator
- Smoke exhaust fans
- Fume hood exhaust fans
- Building exhaust fans

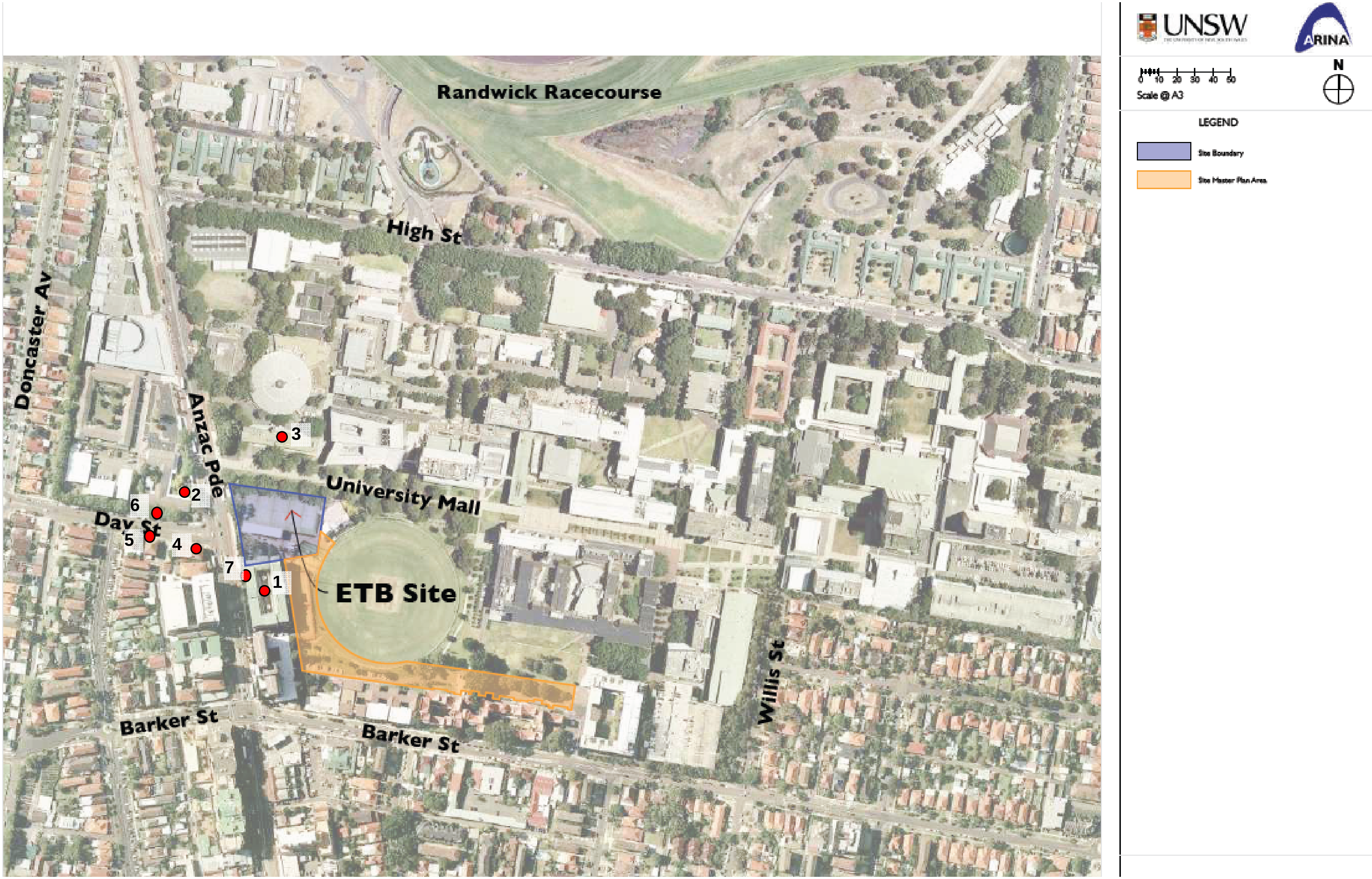

Figure 1 Subject site, nearest noise sensitive receivers and noise measurement locations

3 Noise Survey

3.1 Attended Noise Measurements

Attended noise measurements were conducted at the subject site to determine existing industry and road traffic noise levels.

The L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} noise parameters were measured for 15 minute periods covering the day/evening and night-time periods as defined in the NSW *Industrial Noise Policy*, 2000, discussed further in Section 4.1.1. A Brüel and Kjær 2250 sound level meter (Serial No 2449851) was used to take the measurements. The sound level meter was checked for calibration before and after the measurements, with no deviation occurring.

The attended measurement locations are identified in Figure 1 and Table 2, and the results of the noise measurements are given in Appendix B.

Table 2: Attended noise measurement locations

Ref	Receiver	Noise Measurement
5	45 Day Avenue, Kensington	Existing industry noise.
6	New College Campus residential building, 215 Anzac Parade, Kensington	Existing industry noise.
7	New College Campus, residential building, Anzac, Kensington Campus	Traffic noise, at representative location for proposed building, due to pedestrian noise surrounding bus stops.

At the time of writing this report, unattended long term measurements were being conducted. These ambient noise measurements will be available on request.

3.2 Existing Ambient Environment

The existing ambient environment at the subject site and surrounding noise sensitive receivers is dominated by road traffic noise on Anzac Parade and Day Avenue. Bus routes along both these roads provide constant heavy vehicle traffic throughout the day. Other audible noise sources in the area include:

- Air traffic
- Local wildlife (birds)
- Pedestrian traffic, mainly directed to / from the university campus

There are no audible existing industry noise sources in the area.

4 Noise Criteria

4.1 Design Targets for Control of Noise Breakout to the Community

Noise criteria for the operation of the ETB have been determined from Department of Environment, Climate Change and Water (DECCW) policy:

- NSW Department of Environment, Climate Change and Water, (DECCW, former EPA) Industrial Noise Policy (INP), 2000

The INP has been followed in determining the acoustic criteria for the impact of the project on the community.

4.1.1 NSW Industrial Noise Policy (INP)

The New South Wales environmental noise policy relating to industrial noise is the *New South Wales Environment Protection Authority (EPA) Industrial Noise Policy* (INP) dated January 2000. Noise emission from plant on the subject site is required to comply with the noise limits assessed in accordance with the INP.

The objective of the INP is to protect residential areas from noise generated by commercial, industrial or trade premises. Noise limits are based on land use in the area and existing background levels. Compliance is achieved if the adjusted L_{eq} noise level at any residence affected by noise from the facility is below the noise limit. The adjusted L_{eq} is determined by applying corrections for such noise characteristics as duration, intermittency, tonality and impulsiveness.

The assessment of noise emission under the INP is based on the calculation of a noise limit at a receiver position, taking into account the land use in the surrounding area and the background noise level.

The INP separates the day into three different time periods – day, evening and night, as detailed below in Table 3.

Table 3: INP Time Periods

Period	Day of Week	Time period
Day	Monday-Saturday	0700-1800hrs
	Sunday, Public Holidays	0800-1800hrs
Evening	Monday-Sunday	1800-2200hrs
Night	Monday-Saturday	2200-0700hrs
	Sunday, Public Holidays	2200-0800hrs

The INP provides guidance on acceptable noise levels from the introduction of new industrial noise sources to an area. The assessment procedure for industrial noise sources has two components:

- Controlling intrusive noise impacts in the short term for residences.
- Maintaining overall noise level amenity for particular land uses such as residences.

Both of these components result in noise criteria that should not be exceeded in order to avoid any adverse noise impacts on the affected areas. Both criteria should be taken into account when assessing the noise impact of industrial source(s) associated with the proposed development, and where the intrusiveness and the amenity criterion differ, the lower of the noise criteria is adopted as the project-specific noise criterion.

These criteria will be used to assess noise breakout from the facility. New College Campus, residential building, Anzac Parade, Kensington Campus, is the nearest noise sensitive receiver to the subject site. The industrial noise criteria have been calculated at this receiver, as it is the most stringent location where criteria must be met.

4.1.2 Intrusiveness Criterion

The intrusiveness criterion essentially means that the equivalent continuous noise level, L_{eq}, of the source should not be more than 5 dB above the measured background level. A 15-minute sampling period is typically used when measuring the level of intrusive noise. This is taken to be a reasonable estimate of the period over which annoyance may occur.

The intrusiveness criterion is summarised as:

$$\mathbf{L_{Aeq\ (15\ min)} \leq L_{A90\ (15\ min)}}\ \textbf{Rating Background Level + 5 dB}$$

Because of the variable nature of background noise levels, the INP specifies single number background noise levels for use in setting the intrusiveness noise criterion. The **Assessment Background Level (ABL)** for each time period of a day is the level exceeded by 90% of the $L_{A90,15min}$ measurements during that time period. The **Rating Background Level (RBL)** for a particular time period is the median of the ABL values for that time period for each day of the measurement period.

Industrial noise from the development should be controlled to not exceed the RBL + 5 dB at the boundary of any noise sensitive receiver.

At this stage long term ambient noise measurements have not been completed at the subject site, the intrusiveness criteria have been calculated using background levels from Appendix A of AS1055.2-1997[1]. This is considered to be acceptable in the absence of long term unattended noise measurements.

The intrusiveness criteria is summarised below in Table 4.

Table 4: Intrusiveness noise criteria, $L_{Aeq,15min}$, dB re 20μPa.

Receivers	Day	Evening	Night
New College Residential Building, Anzac Parade, Kensington	59	55	49

4.1.3 Amenity Criterion

Criteria for the protection of amenity are given for various types of receiver and different times of the day. The amenity criterion is set so that the L_{Aeq} noise level from the industrial noise source does not increase the total industrial noise levels at the receiver above the acceptable noise level (ANL) for that receiver.

The criteria relate only to industrial-type noise and do not include road, rail or community noise. The criteria are set based on how close the existing L_{Aeq} industrial noise levels are to the ANL, using the adjustment factors given in Table 2.2 of the INP to account for existing level of industrial noise.

A summary of the amenity noise criteria for noise sensitive receivers for the development are given in Table 5. As there are currently no audible industrial noise sources in the area, the amenity criteria used is the ANL, as defined in the INP.

Table 5: Amenity Noise Criteria, $L_{Aeq,15min}$, dB re 20μPa.

Receivers	Day	Evening	Night
New College Residential Building,	60	50	45

[1] Australian Standard AS1055.2-1997, *Acoustics – Description and measurement of environmental noise, Part 2: Application to specific situations*

Anzac Parade, Kensington

4.1.4 Applicable Criteria

From the amenity and intrusiveness criteria, the more stringent of the two is applied to determine project specific criteria for the development. Summarised below in Table 6 are the operational criteria for the project at nearest noise sensitive receivers. This criteria does not include the testing of the emergency generator.

Table 6: Project specific criteria for "normal operation" noise levels $L_{Aeq,15min}$, dB re 20 µPa

Receivers	Day	Evening	Night
New College Residential Building, Anzac Parade, Kensington	59	50	45

4.2 Emergency Generator Criteria

4.2.1 Emergency Operation

Noise levels caused by emergency generators will be designed to meet the requirements of Chapter 151 of the Environmental Protection Agency's EPA NSW Environmental noise Control Manual (ENCM: 1994). This document states:

Emergency electricity generators which are used in the event of power shortages should not exceed the following maximum noise levels, in order to minimise disturbance to the community. These criteria are for guidance only and variations may be made where necessary.

Residential Receiving Areas

Daytime and evening

- *From 07:00 to 22:00 any day of the week, the L_{A10} sound pressure level should not exceed the L_{A90} background level by more than 10 dB(A) at the boundary of any nearby affected residence, and in any case;*
- *The L_{A10} level at any residential boundary should not exceed 55 dB(A) (from 07:00 to 22:00).*
- *From 22:00 to 07:00 any day of the week, the L_{A10} sound pressure level should not exceed the L_{A90} background level by more than 5 dB(A) at the boundary of any nearby affected residence, and in any case;*
- *The L_{A10} level at any residential boundary should not exceed 45 dB(A) (from 22:00 to 07:00).*

Due to the high level of background noise in the area, it is not reasonable or feasible to apply the lower ENCM limits. As such, the limits summarised below in Table 7 are recommended during emergency operation.

Table 7: Emergency generator criteria, $L_{A10,15min}$, dB re 20µPa

Receivers	Day	Evening	Night
New College Residential Building, Anzac Parade, Kensington	66	63	56

4.2.2 Testing Criteria

Other instances where the emergency generators are likely to be running is during regular testing of the equipment to ensure the generator is in working order in case of an emergency situation. This means that the testing of the emergency generators must be assessed as part of the normal operation of the building. The criteria detailed in Table 6 within the INP will be used to assess noise breakout from the testing of the emergency generator, with a modifying factor applied to account for duration. This criteria applies when the emergency generator is tested and all other plant is operating as normal.

Modifying Factors

The particular character of noise, such as tonality, duration and impulsiveness can make the noise more noticeable and annoying. Therefore, the INP applies a penalty to the noise source under investigation to account for the character of the noise in accordance with table 4.2 of the INP.

A modifying factor of 5 dB has been added to daytime and evening criteria, to account for duration, as testing of generators is to be a single-event noise duration less than 1 hour in any 24 hour period.

Summarised in Table 8 below is the project specific criteria for the total noise emission from plant when testing the emergency generator.

Table 8: Emergency generator testing noise criteria, $L_{Aeq,15min}$, dB re 20 µPa

Receivers	Day	Evening	Night
New College Residential Building, Anzac Parade, Kensington	64	55	50

4.3 Design Targets for Background Noise in the Building

The source of background noise in office / educational buildings is generally from building services such as air-conditioning and hydraulic systems. By the careful design of these systems the background noise level can be controlled to meet the recommended criteria in the relevant spaces.

Excessive background noise can create a distracting and annoying working environment, lead to poor concentration and result in poor productivity. However, a reasonable level of background noise enhances speech privacy by masking intrusive noise from adjacent spaces and therefore background noise levels should not be too low.

Excessive background noise in conference rooms can interfere with speech audibility and intelligibility. While background noise in conference rooms also helps mask intrusive noise from external sources, lecture / conference rooms are considered noise critical spaces with low background noise criteria.

4.3.1 Internal Noise Level Targets

AS 2107[2] provides guidance for design background noise levels for various types of occupancy. The limits apply to steady-state or quasi steady-state sounds such as noise from air conditioning systems, and are given as overall dB(A) limits for many types of room.

Noise Rating (NR) curves are an internationally-agreed set of sound pressure levels in octave bands, corresponding roughly with human perception of loudness[3]. NR curves also provide useful reference for recommended background noise levels in various room types, as they are related to human hearing sensitivity and because they are in octave bands.

Arup Acoustics recommends the use of NR curves for the control of building services noise levels. The recommended dBL_{Aeq} levels and reverberation times are taken from AS2107:2000. The recommended NR curve values have been adopted by Arup Acoustics to reflect human hearing sensitivity and relate to octave band noise measurements, and are based on the dBL_{Aeq} levels given in AS2107:2000. For common building services noise

[2] AS2107: 2000 - *Recommended design sound levels and reverberation times for building interiors*, Standards Australia.
[3] ISO/R 1996-1971, *Acoustics – Assessment of noise with respect to community response*

spectra, the NR rating is typically approximately 5 dB below the equivalent dB(A) level (eg. a noise limit of NR 30 is approximately equivalent to 35 dB(A)).

Target noise limits for steady-state (i.e. L_{eq}) noise generated by building services have been determined by a combination of guidance from AS 2107 and experience from similar projects. Table 9 below outlines noise level targets for the various spaces to be achieved by all services running normally and together.

Table 9: Summary of recommended design sound levels

Type of occupancy	Recommended design Sound level, NR (Adapted from Table 1, AS2107)	
	Satisfactory	**Maximum**
Conference rooms / collaborative classrooms	NR 30	NR 35
Laboratories – Teaching	NR 30	NR 40
Laboratories – Working	NR 35	NR 45
Lecture rooms – up to 50 seats	NR 25	NR 30
Lecture theatres – without speech reinforcement	NR 25	NR 30
Lecture theatres – with speech reinforcement	NR 30	NR 40
Office areas	NR 35	NR 40
Cafeterias, computer rooms, open plan offices / workstations, corridors and lobbies	NR 40	NR 45
Toilets	NR40	NR50
Lobbies	NR 40	NR 45

Note: The recommended design sound levels given in Table 9 are used 'traditionally' for sealed, air-conditioned buildings, and apply only to the steady-state noise – predominantly from mechanical plant.

At this stage of the building design, the location or existence of all the spaces given in Table 9 have not been finalised. The table will therefore be updated as the design evolves.

4.4 External Noise Break-in

Break-in of typical external noise sources should be controlled to the recommended background noise levels given in Table 9, to be consistent with AS2107-2000, and to ensure occupant comfort. As the dominant external noise source is road traffic noise, this is also in accordance with recommendations within the Environmental Criteria for Road Traffic Noise, 1999 (ECRTN). The recommendations are based on achieving a noise level that ensures adequate privacy while not causing disturbance. This level is representative of the noise in the space during normal hours of occupation. It does not include noise generated by its occupants.

A noise survey has been carried out around the subject site to ascertain the existing background noise environment and to assess likely external noise sources that may cause disturbance to office workers.

In general, glazing is a critical element of building facades, in terms of acoustic performance, due to the relatively large areas used compared to other facade materials.

4.5 Control of Vibration and Structureborne Noise

Vibration levels arising from the operations of the ETB (plant) will be limited to prevent undue disturbance to building occupants.

Based on the requirements of AS2670.2[4] surface vibration velocity levels in occupied areas will not exceed 0.4 mm/s Root Mean Squared (RMS) (taken to be Curve 4 of the combined-direction vibration velocity limit). These vibration levels are unlikely to cause adverse comment in offices. Surface vibration levels in plant rooms will be limited to 0.8 mm/s RMS.

Structure-borne noise (also called Regenerated Noise) due to building vibration will also meet the noise level targets given in Table 2.1.

4.6 Construction Activity Noise

4.6.1 DECC Interim Construction Noise Guidelines[5]

The DECCW interim guideline provides recommended noise levels for airborne construction noise at sensitive land uses. The guideline provides construction managers noise levels above which all feasible and reasonable work practices should be applied to minimise the construction noise impact.

The DECCW interim guideline sets out management levels for noise at noise sensitive receivers, and how they are to be applied.

DECCW recommended standard working hours are:

- Monday to Friday 0700 to 1800 hours
- Saturday 0800 to 1300 hours

Two noise criteria components are set out in Table 4.1 of the Guideline for residential receivers:

- A “Noise affected” level ($L_{Aeq,15min}$) of the Rating Background Level (RBL) + 10 dB(A) during standard construction hours, which “represents the point above which there may be some community reaction to noise”.
- A “Highly noise affected level” of 75 dB $L_{Aeq,15min}$, which “represents the point above which there may be strong community reaction to noise”.

For works outside standard hours, a criterion of RBL + 5 dB(A) applies, but works outside the standard hours would not normally be acceptable without “strong justification”.

The Guideline also presents criteria for groundborne noise and sleep disturbance’ however these criteria only apply for the “Evening” and/or “Night” time periods of the INP (i.e. outside standard construction hours).

4.7 Aircraft Noise

Aircraft noise is assessed in accordance with AS 2021[6]. Australian Noise Exposure Forecast (ANEF) contours have been referenced from the Sydney Airport Master Plan 2003/04, 2023/24 ANEF.

The subject site is located outside the ANEF 20 contour, which means that it is within an “acceptable” zone of building site acceptability. In accordance with AS 2021, no further consideration of aircraft noise break-in is required.

[4] AS 2670.2-1990 *Evaluation of human exposure to whole-body vibration - Continuous and shock-induced vibration in buildings (1 to 80 Hz)*, Standards Australia
[5] DECCW Interim Construction Noise Guidelines: 2009
[6] Australian Standard AS2021-2000, *Acoustics – Aircraft noise intrusion – Building siting and construction*

4.8 Summary of Criteria

A summary of the applicable criteria for the project is included below in Table 10.

Table 10: Applicable criteria for the project

Criteria		Reference
Noise break-out to the community	Standard operation	Table 6
	Standard operation and testing of the emergency generator	Table 8
	Emergency generator operation	Table 7
Internal background noise / noise break-in		Table 9
Vibration		Section 4.5
Construction		Section 4.6
Aircraft	The subject site is within the "acceptable" zone. No further analysis is required.	

5 Acoustic Considerations

5.1 Noise from the Development Affecting the Community

5.1.1 Mechanical Services Plant

Noise from mechanical plant will be controlled to meet the NSW INP criteria given in Table 5.

Source noise levels of the rooftop plant will be assessed and plant will be selected taking the Guideline into consideration. Particular care will be taken to ensure that rooftop plant will not lead to noise exceedances at the on-campus New College residential apartments and residential dwellings at 217 Anzac Parade, Kensington. If it is found that noise control treatment is required, then acoustic louvres will be effective for enclosed areas of plant rooms, and attenuators fitted to plant located within outdoor areas will be specified during detail design. If further treatments are required, in terms of individual enclosures, or barriers then these will be implemented.

The emergency generator is to be located in a rooftop plantroom that also contains the Fume Hood Exhaust Fans. As a management measure to control the impact on the community, testing of the generator should be restricted to daytime periods (0700 – 1800 hours), for a duration of less than 1-hour in any one 24-hour period.

5.1.2 Loading Dock

The loading dock is to be located at ground level on the south-eastern corner of the subject site.

Traffic entering and leaving the carpark on the site has the potential to cause noise disturbance to neighbouring areas. Noise will be controlled to achieve the appropriate criteria by controlling the speed of the traffic, timing of access, the location of the access roads and informing building occupants to enter and leave the development quietly.

5.1.3 Waste Collection

Noise generated by waste collection will be controlled by management of the collection times to ensure that disturbance to nearby residences during typical sleeping hours is avoided.

5.2 Noise from the Community Affecting the Development

5.2.1 Road Traffic

Road traffic on Anzac Parade is constant and typical for an arterial road during peak hour periods, with multiple bus routes and stops adjacent to the subject site. Attended surveys indicate that most traffic along this section of Anzac Parade is free-flowing, and at relatively constant speeds. This is largely due to the road curvature and flat grade. The façade of the building will be designed to ensure that break-in of general traffic noise will be controlled to meet background noise criteria given in Section 4.3.

5.2.2 Pedestrians

The acoustic design of the building façade to control the break-in of general road traffic noise will be sufficient to control the break-in of noise caused by pedestrian activities outside the building.

5.3 Inter-tenancy Noise within the Development

5.3.1 Mechanical Services Plant

Noise from mechanical plant will be controlled to meet the internal noise criteria given in Section 4.3.

5.3.2 Building Activities

Noise levels generated by building activities are not expected to be significant. Appropriate slab thicknesses and floor coverings will be recommended to avoid airborne or impact noise issues.

6 Results and Acoustic Design Requirements

6.1 Mechanical Services Plant

Proposed rooftop mechanical services plant includes:

- A gas-fired cogeneration plant and two chillers located in a naturally ventilated plantroom.
- Four cooling towers located in an open roof plantroom.
- An emergency diesel generator, five smoke exhaust fans and 70 fume hood exhaust fans and stacks located in a naturally ventilated plantroom.

Without treatment, noise levels from rooftop mechanical services plant to the New College residential building are predicted to exceed the criteria.

Sound power levels of equipment used in calculations have been supplied by Steensen Varming and are included in Appendix C.

Preliminary recommended mitigation for roof top plant is identified below in Table 11. This treatment is to be investigation further during detail design.

It is predicted that with appropriate noise control treatment, the recommended criteria at the New College residential building will be met.

Table 11: Recommended noise control for rooftop plant

Plant	Recommended Noise Control Treatment
Emergency Generator	Enclosed in separate plantroom to exhaust fans, acoustic louvres to be applied to ventilation openings. Vibration isolated from the roof slab. Timing of testing restricted to daytime periods only.
Muller Cooling Towers	Cooling towers will require further noise mitigation to meet design criteria. Options to be investigated during detail design include: • Noise barriers – increasing the height of the FHEF plantroom to act as a noise barrier • Attenuators • Plantroom design incorporating noise control features • Re-selecting equipment
Smoke Exhaust Fans	Options for noise control treatment to be investigated during detail design include: • Located in separate plantroom to FHEF with acoustic louvres to ventilation openings. • Re-selecting equipment
Rooftop Exhaust Fans	Details of rooftop exhaust fans have not yet been specified. The location and sizing of roof exhaust fans must be reviewed during the detail design phase of the project.

6.2 Vibration

6.2.1 Plant

Vibration sources, such as reciprocating mechanical plant, will generally require isolation to reduce vibration input into the building structure. Usually this is provided by local stiffening of the plantroom floor, and the use of specialist vibration isolators to support the equipment.

Pipe work on main distribution routes (horizontal and vertical) will be suspended on resilient hangers or use resilient fixings.

6.3 Sound Insulation

6.3.1 Facade Sound Insulation

With a fully sealed facade, relying totally on a mechanical ventilation system, the sound insulation performance of facade glazing is critical to control external noise break-in. Glazing will be selected to meet background noise limits given in Table 9.

Based on existing traffic noise levels, the noise limit for private offices adjacent to Anzac Parade can be met with a minimum glazing construction of 10 mm thick glazing or equivalent thermal double glazed construction.

6.4 Internal Airborne Sound Insulation

6.4.1 Office floors

It is assumed that the structural floor requirements of the building will be sufficient to provide adequate airborne sound insulation between floors. However, this will be reviewed during the design process.

6.4.2 Plant Rooms

Transmission of airborne noise from the plant rooms to office areas via floor slabs and walls will be adequately controlled to meet background noise limits given in Table 9. Generally, solid concrete slabs of 200 mm minimum thickness (460 kg/m^2) will be required.

Attention will be paid to penetrations of sound insulating constructions. All penetrations will be appropriately sized and sleeved, packed and sealed. Each service, duct or pipe etc, will have its own penetration with suitable spacing to allow good sealing.

Generally, all air handling plant room doors will have a minimum rating of R_w 35 dB. This rating may need to be increased depending on the proximity of plant rooms to office areas.

6.5 Impact Sound Insulation

To ensure minimum disturbance to occupants of offices and meeting rooms below, the transmission of impact noise will be adequately controlled. A carpeted floor will be sufficient to control impact noise. In areas where hard finishes are proposed, a resilient underlay will be used.

7 Summary of Recommendations

A summary of the recommended actions to ensure the development complies with the criteria is included below in Table 12.

Table 12: Summary of recommended noise control treatments

Area	Recommended Noise Control Treatment
Rooftop plant	Specific measures for items of rooftop plant detailed in Table 11. Specific measures to be investigated further during detail design. Generators to be vibration isolated.
Traffic noise break-in	Façade constructed of minimum 10 mm thick glazing or equivalent thermal double glazed construction.
Air handling unit plantrooms	200 mm concrete slab thickness, doors will have a minimum rating of R_w 35 dB

8 Conclusion

Noise levels to the nearest noise sensitive receivers have been calculated and assessed against the criteria.

To ensure that noise levels from rooftop plant comply with the recommended criteria, further noise control treatment will be required, as discussed in Section 6.

Noise break-in to the development has also been assessed against the criteria, with recommendations as detail in Section 6.3.1, it is predicted that internal noise targets will be met.

It is expected that with further investigation into specific noise control measures during detail design, the impact of the development on the community can be controlled, and noise levels will meet the recommended criteria.

Appendix A

Acoustic Terminology

A1 Acoustic Terminology

ASSESSMENT BACKGROUND LEVEL (ABL)

A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night time period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background L_{A90} noise levels – i.e. the measured background noise is above the ABL 90% of the time.

'A'-WEIGHTED SOUND LEVEL dB(A)

The unit generally used for measuring environmental, traffic or industrial noise is the A-weighted sound pressure level in decibels, denoted dB(A). An A-weighting network can be built into a sound level measuring instrument such that sound levels in dB(A) can be read directly from a meter. The weighting is based on the frequency response of the human ear and has been found to correlate well with human subjective reactions to various sounds. An increase or decrease of approximately 10 dB corresponds to a subjective doubling or halving of the loudness of a noise. A change of 2 to 3 dB is subjectively barely perceptible.

DECIBEL

The ratio of sound pressures which we can hear is a ratio of 10^6:1 (one million : one). For convenience, therefore, a logarithmic measurement scale is used. The resulting parameter is called the 'sound level' (L) and the associated measurement unit is the decibel (dB). As the decibel is a logarithmic ratio, the laws of logarithmic addition and subtraction apply.

Some typical noise levels are given below:

Noise Level dB(A)	Example
130	Threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside disco
90	Heavy lorries at 5 m
80	Kerbside of busy street
70	Loud radio (in typical domestic room)
60	Office or restaurant
50	Domestic fan heater at 1m
40	Living room
30	Theatre
20	Remote countryside on still night
10	Sound insulated test chamber
0	Threshold of hearing

EQUIVALENT CONTINUOUS SOUND LEVEL (L_{Aeq})

Another index for assessment for overall noise exposure is the equivalent continuous sound level, L_{eq}. This is a notional steady level, which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating levels can be described in terms of a single figure level.

FREQUENCY

The rate of repetition of a sound wave. The subjective equivalent in music is pitch. The unit of frequency is the Hertz (Hz), which is identical to cycles per second. A thousand hertz is often denoted kilohertz (kHz), eg 2 kHz = 2000 Hz. Human hearing ranges from approximately 20 Hz to 20 kHz. The most commonly used frequency bands are octave bands, in which the mid frequency of each band is twice that of the band below it. For design purposes, the octave bands between 63 Hz to 8 kHz are generally used. For more detailed analysis, each octave band may be split into three one-third octave bands or, in some cases, narrow frequency bands.

RATING BACKGROUND LEVEL (RBL)

A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey.

SOUND POWER AND SOUND PRESSURE

The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of distance from a source. However, the sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.

SOUND REDUCTION INDEX (R)

The sound reduction index (or transmission loss) of a building element is a measure of the loss of sound through the material, i.e. its sound attenuation properties. It is a property of the component, unlike the sound level difference, which is affected by the common area between the rooms and the acoustics of the receiving room. The weighted sound reduction index, R_w, is a single figure description of sound reduction index and is defined in BS EN ISO 717-1: 1997. R_w values are calculated from measurements in an acoustic laboratory. Sound insulation ratings derived from site (which are invariably lower than the laboratory figures) are referred to as apparent sound reduction index (R'_w) ratings.

STATISTICAL NOISE LEVELS

For levels of noise that vary widely with time, for example road traffic noise, it is necessary to employ an index that allows for this variation. 'A'-weighted statistical noise levels are denoted L_{A10}, dBL_{A90} etc. The reference time period (T) is normally included, eg. $dBL_{A10, 5min}$ or $dBL_{A90, 8hr}$.

$L_{A90(T)}$

Refers to the sound pressure level measured in dB(A), exceeded for 90% of the time interval (T) –i.e. measured noise levels were greater than this value for 90% of the time interval. This is also often referred to the background noise level.

$L_{A10(T)}$

Refers to the sound pressure level measured in dB(A), exceeded for 10% of the time interval (T). This is often referred to as the average maximum noise level and is frequently used to describe traffic noise.

$L_{A1(T)}$

Refers to the sound pressure level measured in dB(A), exceeded for 1% of the time interval (T). This is often used to represent the maximum noise level from a period of measurement.

STRUCTUREBORNE NOISE

The transmission of noise energy as vibration of building elements. The energy may then be re-radiated as airborne noise. Structureborne noise is controlled by structural discontinuities, i.e. expansion joints and floating floors.

VIBRATION

Vibration may be expressed in terms of displacement, velocity and acceleration. Velocity and acceleration are most commonly used when assessing structureborne noise or human comfort issues respectively. Vibration amplitude may be quantified as a peak value, or as a root mean squared (rms) value.

Vibration amplitude can be expressed as an engineering unit value eg $1mms^{-1}$ or as a ratio on a logarithmic scale in decibels:

Vibration velocity level, L_V (dB) = 20 log (V/V_{ref}),

(where the preferred reference level, V_{ref}, for vibration velocity = 10^{-9} m/s).

The decibel approach has advantages for manipulation and comparison of data.

Appendix B

Attended Noise Measurements

B1 Attended Noise Measurements

Table 13: Attended noise measurements conducted 26 November 2009

Time of Measurement (hr:min)	Measurement Period	Measurement Location	Noise Levels, dB(A)				
			L_{Aeq}	L_{A1}	L_{A10}	L_{A90}	Description
16:56 hrs	Day	5	64	70	66	56	Traffic on Day Avenue intermittent. Buses dominant noise source. Other audible sources include birds, Anzac Avenue traffic, air traffic. No audible industry noise.
17:20 hrs	Day	7	73	81	75	63	Peak hour traffic, 4 m from edge of Anzac Ave carriageway, adjacent to New college building (east of building), representative location for traffic noise measurement. Traffic is constant. Buses dominant, bus lane is closest to curb. Traffic noise is dominant noise source. No audible industry noise.
19:07 hrs	Evening	6	63	71	65	54	Plane overhead. Less traffic on Day Avenue compared to daytime measurements, intermittent traffic, pedestrian traffic. Buses on Day Avenue and aircraft noise dominant. No audible industry noise.
20:50 hrs	Evening	6	58	66	61	51	Measurement at New College (corner of Day Avenue and Anzac parade), directly north of 45 Day Avenue, 3 m from edge of Day Avenue carriageway. Plane overhead 71 dB(A). Main noise sources are Anzac Avenue traffic, buses on Day Avenue, local cars are parking on Day Avenue.
22:10 hrs	Night	6	58	66	62	51	Measurement as for previous location, air traffic and buses dominant noise sources. Road traffic Anzac Parade audible. No audible industry noise.

Appendix C

Sound Level Data

C1 Sound Levels

Sound level data has been provided by Steensen Varming. Where noise level data is not available, empirical method[7] has been used to calculate sound power levels.

Equipment	Reference	dB(A)	Octave Band Centre Frequency, dB							
			63	125	250	500	1k	2k	4k	8k
Gas Generator (Cogen)	Sound pressure level at 1 m	107	103	111	104	105	103	99	88	67
Chillers in plantroom	Sound power	99	88	88	93	97	97	88	73	73
Smoke exhaust fans	Sound power	91	91	92	87	89	84	83	81	75
Fume cupboard exhaust fans	Sound power	60**	72	67	62	57	52	47	43	43
Muller cooling towers	Sound pressure level at 3m	79	80	80	78	77	75	68	61	61
Emergency generator**, 800 kW	Sound power	99	95	96	96	96	94	92	89	84

* Overall A-weighted sound power level provided by manufacturer, octave band sound power levels have been calculated using empirical method

** Calculated using empirical method

[7] Bies and Hanson, Engineering Noise Control