University of Sydney
Engineering & Technology Precinct
SEARs Noise and Vibration Assessment

Report Date: Tuesday, 28 November 2017
Reference: S16785RP1, Revision A

Document Information

Project	University of Sydney – Engineering & Technology Precinct	
Client	Laing O'Rourke	
Report title	SEARs Noise and Vibration Assessment	
Project Number	S16785	
Author	Tom Evans Associate Director p+61 3 9020 3888 m+61 421 279 929 tom.evans@resonateacoustics.com	
Reviewed by	Damien van Raaphorst / Andrew Parker	

Revision Table

Report revision	Date	Comments
0	16 November 2017	Draft Issue
A	28 November 2017	For Issue

Glossary

A-weighting	A spectrum adaption that is applied to measured noise levels to represent human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
Daytime	Between 7 am and 6 pm as defined in the INP.
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of that sound level.
dB(A)	'A' Weighted sound level in dB.
Evening	Between 6 pm and 10 pm as defined in the INP.
Frequency (Hz)	The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone), but slow movements mean the frequency (pitch/tone) is low. 1 Hz is equal to 1 cycle per second. The human ear responds to sound in the frequency range of 20 to 20,000 Hz.
INCG	New South Wales Department of Environment & Climate Change (now Environment Protection Authority) *Interim Construction Noise Guideline*, 2009.
INP	New South Wales *Industrial Noise Policy*, 2000.
Intrusive Noise	Noise emission that when assessed at a noise-sensitive receiver (principally a residential premises boundary) is greater than 5 dB(A) above the background noise level.
L_{10}	Noise level exceeded for 10% of the measurement time. The L_{10} level is commonly referred to as the average maximum noise level.
L_{90}	Noise level exceeded for 90% of the measurement time. The L90 level is commonly referred to as the background noise level.
L_{eq}	Equivalent Noise Level—Energy averaged noise level over the measurement time.
L_{max}	Maximum measured sound pressure level in the time period.
mm/s	Millimetres per second—units of vibration velocity.
Night-time	Between 10 pm on one day and 7 am on the following day as defined in the INP.
Rating Background Level (RBL)	Overall single-figure A-weighted background level representing an assessment period (Day/Evening/Night). For the short-term method, the RBL is simply the measured $L_{90,15min}$ noise level. For the long-term method, it is the median value of all measured background levels during the relevant assessment period.

Table of Contents

Executive summary

The University of Sydney is proposing to develop an Engineering Technology Precinct (ETP) within the existing campus in Darlington, which will provide a new contemporary, flexible and collaborative facility. The proposed building will enable the Engineering and Technology faculty to expand its research and teaching facilities.

The Department of Planning & Environment (DPE) has issued the ETP with Secretary's Environmental Assessment Requirements (SEARs) for the preparation of an Environmental Impact Statement (EIS). SEAR 7 defines the requirement for a Noise and Vibration Assessment as part of the EIS, to consider construction and operational noise and vibration from the development. This report has been prepared to address SEAR 7.

Construction phase

A preliminary construction noise and vibration assessment has been conducted against noise and vibration criteria determined from:

- existing noise monitoring data for the site
- the *Interim Construction Noise Guideline* (ICNG)
- *Assessing Vibration – a technical guideline* (the Vibration Guideline).

Based on the preliminary assessment, it is likely that construction works may have some noise impact on University student accommodation land uses at Urbanest Darlington and International House during major external works. The University will also manage the noise and vibration impacts of works on adjoining University teaching and office uses.

The construction noise and vibration impacts are considered to be manageable through:

- the development and implementation of a Construction Noise and Vibration Management Plan
- carrying out noisier works during daytime Standard Working Hours wherever possible
- appropriate stakeholder consultation and complaint handling procedures for noise and vibration
- the implementation of all feasible and reasonable work practices to minimise noise and vibration from the site in accordance with the ICNG and Vibration Guideline.

Operational phase

Operational noise emission criteria for the development have been established in accordance with the NSW *Industrial Noise Policy* (INP). The noise emission criteria for the nearest noise-sensitive land uses are shown in Table 1.

Table 1 INP noise emission criteria for residential land uses and Colleges

Location	INP noise emission criteria, dB(A) $L_{eq,15min}$		
	Day 7 am–6 pm	Evening 6 pm–10 pm	Night 10 pm–7 am
Residential land uses including Urbanest Darlington and International House	53	40	40

Noise emissions from the development will predominantly be a result of rooftop mechanical plant including a rooftop plant room, water-cooled chiller and cooling towers, and emergency generator. A preliminary rooftop plant layout and selection has been assessed and the following recommendations provided such that noise emissions can achieve the INP criteria for both normal and emergency operations:

- The Chillers should be located in an enclosed plant room on Level 10. The plant room should be constructed with a solid roof achieving no less than an R_W 35 rating and solid walls achieving no less than R_W 40.
- The CAT C13 generator should be installed in an acoustic enclosure that achieves a rating of 80 dB(A) at 1 m.
- Outlet attenuators are required for the Stair Pressurisation fans and Toilet Exhaust fans, acoustically equivalent to Fantech RS07C. Alternatively, the outlet ductwork from the fans is required be at least 3 m in length, 50 mm thick internally lined, incorporate at least one 90-degree bend, with the outlets facing north or south.

As the design progresses, noise mitigation measures should be reviewed to ensure that noise from rooftop plant in particular can comply with the INP noise emission criteria at neighbouring noise-sensitive land uses.

1 Introduction

The University of Sydney is proposing to develop an Engineering Technology Precinct (ETP) on the within the existing campus in Darlington, which will provide a new contemporary, flexible and collaborative facility. The proposed building will enable the Engineering and Technology faculty to expand its research and teaching facilities.

The ETP will involve the provision of a new building extension to the north of, and integration, with the 'South Tower' of the Engineering Precinct. The building will accommodate a range of uses including teaching and research laboratories, workplaces, offices, lecture theatres and other teaching spaces, administration areas and a loading dock and storage area. To facilitate the new structure and linkages, the existing north tower of the J03 Electrical Engineering Building will be demolished.

The Department of Planning & Environment (DPE) has issued the ETP with Secretary's Environmental Assessment Requirements (SEARs) for the preparation of an Environmental Impact Statement (EIS). SEAR 7 defines the requirement for a Noise and Vibration Assessment as part of the EIS:

> Identify and provide a quantitative assessment of the main noise and vibration generating sources during construction and operation. Outline measures to minimise and mitigate the potential noise impacts on surrounding sensitive receivers.
>
> *Relevant Policies and Guidelines:*
>
> - *NSW Industrial Noise Policy (EPA)*
> - *Interim Construction Noise Guideline (DECC)*
> - *Assessing Vibration: A Technical Guideline 2006*

This report has been prepared to address SEAR 7 and:

- Defines noise and vibration assessment criteria for the construction and operation of the ETP.
- Identifies likely construction phase noise and vibration impacts and recommends management procedures to be implemented during construction.
- Provides a preliminary assessment of operational noise from the development.

2 Project description

2.1 Location

The ETP will be constructed on the Darlington campus. The site is bounded by the Mechanical Engineering Building and Seymour Centre to the north, the Peter Nicol Russell (PNR) Building to the south and the Engineering Link Building to the east. Figure 1 shows the proposed site location.

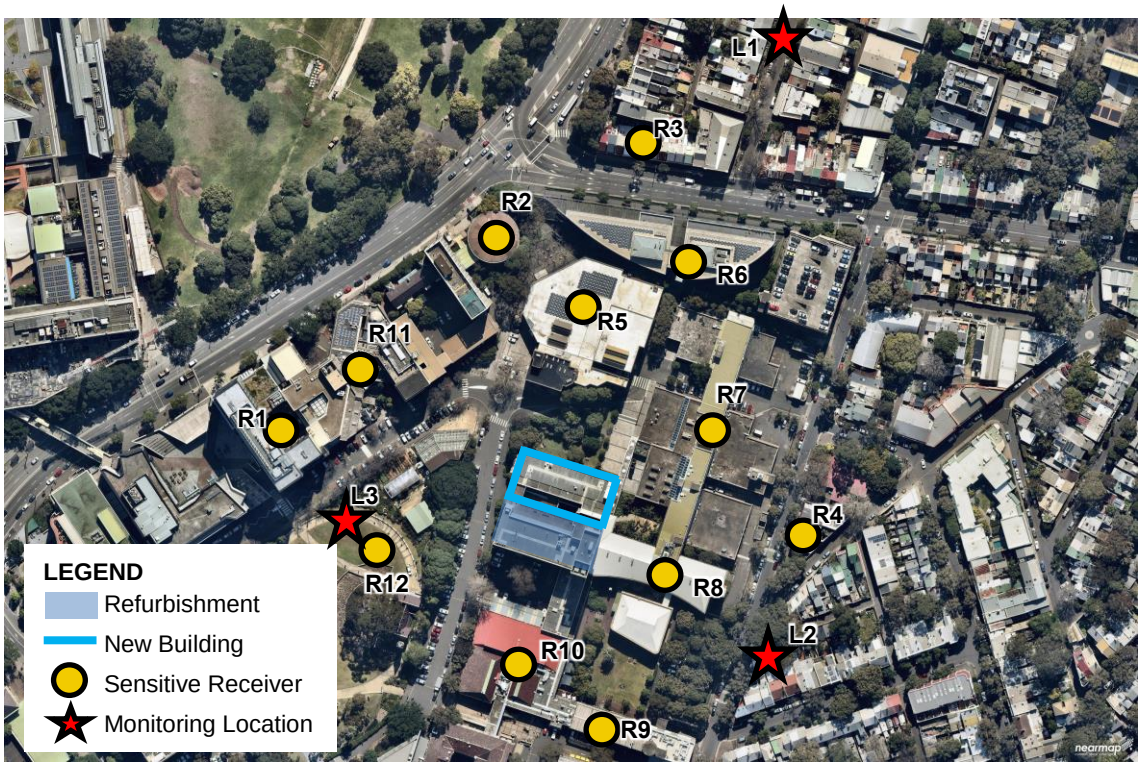

Figure 1 ETP site location

A number of noise and vibration-sensitive land uses are located in the immediate vicinity of the Stage 1 site as shown in Figure 1, with the most significant being existing University buildings. The nearest residential land uses are the Urbanest Darlington Student Accommodation to the west, the residences on the eastern side of Shepherd Street (R4) and the residences on the northern side of Cleveland Street (R3).

The sensitive land uses are summarised in Table 2 alongside a description of the land use.

Table 2 Noise and vibration sensitive land uses

Reference (see Figure 1) and name	Description
Residential buildings	
R1 – Urbanest Darlington	Residential land uses 80 m away or more from new building. Cleveland Street and Shepherd Street residences shielded by intervening buildings.
R2 – International House	
R3 – Cleveland Street residences	
R4 – Shepherd Street residences	
University of Sydney buildings	
R5 – Seymour Centre	Performing Arts Centre within the University of Sydney, approximately 45 m north of the new building.
R6 – Warren Centre	Various University buildings associated with Engineering Faculty that surround the project site.
R7 – Mechanical Engineering	
R8 – Engineering Link Building	
R9 – Civil Engineering	
R10 – PNR Building	
R11 – Wentworth Building	Faculty of Architecture, Design and Planning
Recreational land uses	
R12 – Cadigal Green	Public recreation area. Includes heritage-listed Old School building on Maze Crescent.

2.2 ETP development

The ETP will involve the construction of a ten-level new building on the footprint shown in Figure 1. The neighbouring building will be refurbished and linkages created between the two buildings. Landscaping will also occur around the Precinct area.

Construction

Construction of the ETP development is scheduled to commence in the first quarter of 2018 and be completed by mid-2020. The construction staging has been broadly summarised in Table 3.

Table 3 Anticipated construction schedule

Stage	Description
Site establishment and enabling works	Services diversions, initial demolition works (Engineering Walk) and vegetation clearance. March – August 2018
Demolition	Demolition of north tower May – August 2018
Retaining piles and excavation	Piling works and bulk excavation December 2018 – February 2019
Substructure	Creation of substructure. February – March 2019
Frame	Creation of building superstructure. April – August 2019
Facade works	Construction of building façade August – October 2019
Internal works and fitout	Internal works and fitout of all levels. Will commence progressively as Level superstructures completed. May 2019 – March 2020

It is planned that works would be undertaken during the hours of:

- Monday to Friday 7 am to 6 pm
- Saturday 8 am to 3:30 pm
- No work on Sundays or public holidays.

Operation

The ETP building will house teaching, research, office and support spaces that are not expected to have a noise and vibration impact outside of the building footprint.

The predominant operational noise consideration for the development will be the rooftop plant, which will include water-cooled chillers and cooling towers. An emergency standby generator will also be installed on the roof level.

3 Existing environment

The existing environment in the area immediately around the site is typical of an urban University campus, with a level of steady background noise from distant traffic and mechanical plant, with short-term noise from pedestrians and occasional vehicles on and around the campus. At the nearest residential uses, noise from traffic on Shepherd Street, Cleveland Street and the Princes Highway contributes to the ambient environment.

Attended monitoring was conducted at locations around the site on Wednesday, 8 November 2017 between 11:00 am and 1:00 pm. The monitoring was conducted during the study break prior to University exam period and therefore there were fewer pedestrians on campus at the time of the measurements than would be during teaching times.

The measured noise levels at each location are shown in Table 4, with the measurement locations shown on Figure 1.

Table 4 Attended monitoring results on Wednesday, 8 November 2017

Location	Measured noise level, dB(A)				Description
	L_{max}	L_{10}	L_{eq}	L_{90}	
Rose Street to north L1	79	56	53	50	15-minute measurement at 12:10 pm. Well-shielded from proposed development site. Road traffic noise contribution from Cleveland Street and City Road.
Rose Street to north L1	58	52	50	48	Short-term measurement at 12:30 pm with no local car movements. Controlled by steady background noise including mechanical plant noise.
Cnr of Boundary and Shepherd St L2	70	60	56	52	15-minute measurement at 11:15 am. Steady background noise from mechanical plant serving various University buildings, with short-term noise from car pass-bys.
Cadigal Green L3	67	58	55	52	15-minute measurement at 11:40 am. Steady background noise from mechanical plant serving various University buildings, with distant traffic from City Road.

The measurements indicate that there is a moderate level of existing noise in the environment during the daytime period, due largely to mechanical plant noise from the University of Sydney and local and distant traffic. Even without significant contribution from traffic noise, the measured background noise at Rose Street to the north was 48 dB(A) L_{90} and controlled by mechanical plant from University uses.

Measurements at Location 1 and Location 2 were repeated on the morning of Friday, 17 November, in order to determine the typical noise environment between 6 am and 7 am which would be the earliest time that mechanical plant on the ETP would be expected to operate. The measured noise levels at each location for this time period are shown in Table 5.

Table 5 Attended monitoring results on morning of Friday, 17 November 2017

Location	Measured noise level, dB(A)				Description
	L_{max}	L_{10}	L_{eq}	L_{90}	
Rose Street to north L1	75	55	52	49	15-minute measurement at 6:15 am. Well-shielded from proposed development site. Distant road traffic noise contribution from Cleveland Street and City Road.
Cnr of Boundary and Shepherd St L2	72	57	54	50	15-minute measurement at 6:40 am. Steady background noise from mechanical plant serving various University buildings, with short-term noise from car pass-bys.

The measurement results presented in Table 5 indicate that noise levels were not markedly different between the early morning and midday periods. The consistent level of background noise demonstrated across both measurement periods is representative of the steady level of mechanical plant noise from various sources, including existing University of Sydney buildings.

4 Assessment criteria

4.1 Construction noise

Construction noise in New South Wales is assessed using the Department of Environment & Climate Change (now Environment Protection Authority) *Interim Construction Noise Guideline* (ICNG). The ICNG is also defined as the relevant guideline for construction noise by the SEARs issued by DPE.

The ICNG aims to manage noise from construction works regulated by the EPA. It is also intended to provide guidance to other interested parties in the management of construction noise, and has therefore been adopted for this construction noise assessment.

The ICNG prescribes $L_{eq,15min}$ Noise Management Levels (NML) for sensitive receivers as part of a quantitative construction noise assessment. Where the predicted or measured construction noise level exceeds these management levels, then all feasible and reasonable work practices should be implemented to reduce construction noise, and community consultation regarding construction noise is required to be undertaken.

Standard Working Hours

The ICNG recommends standard working hours for construction as follows:

- Monday to Friday, 7 am to 6 pm
- Saturday, 8 am to 1 pm
- No work on Sundays or Public Holidays

To encourage work during the Standard Working Hours, and to reflect the lower impact of work at these times, the ICNG prescribes less stringent Standard Working Hours NMLs. More stringent NMLs are prescribed for work outside of these times, as well as more onerous management requirements.

Generally, the proposed working hours for the ETP align with the ICNG Standard Working Hours, with the exception of the period from 1 pm to 3:30 pm on Saturday afternoon. While this is generally a lower impact out of hours period, more stringent noise management requirements will apply to work at this time.

It should be noted that the Standard Working Hours are only applicable to residential (or similar) land uses. At educational or commercial land uses, where evening amenity and sleeping is not a concern, the impact of construction noise is assessed based on the times that the land use operates.

Residential land uses

The NMLs prescribed for residential land uses by the ICNG are presented in Table 6. The levels apply at the most exposed property boundary of the noise sensitive receiver at a height of 1.5 metres above ground level.

The NMLs have also been adopted for the International House and Urbanest student accommodation sites around the site.

Table 6 Noise management levels for residential land uses

Time of day	NML, $L_{eq,15min}$	Application notes
Recommended Standard Working Hours	Noise affected: RBL + 10 dB(A)	May be some community reaction to noise. • Where the predicted or measured construction noise level exceeds the noise affected level, all feasible and reasonable work practices should be applied to meet the noise affected level. • All residents potentially impacted by the works should be informed of the nature of the works, the expected noise levels and duration, and provided with site contact details.
	Highly noise affected: 75 dB(A)	May be strong community reaction to noise. • Where construction noise is predicted or measured to be above this level, the relevant authority may require respite periods that restrict the hours that the very noisy activities can occur. • Respite activities would be determined taking into account times identified by the community when they are less sensitive to noise, and if the community is prepared to accept a longer period of construction to accommodate respite periods.
Outside recommended Standard Working Hours	Noise affected: RBL + 5 dB(A)	• 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 affected noise level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the affected noise level, the proponent should negotiate with the affected community.

Other sensitive land uses

The ICNG also prescribes NMLs for other sensitive land uses, including educational buildings and offices. The NMLs for relevant land uses are summarised in Table 7 and apply only when those land uses are in use.

For those receivers where an internal NML applies, it is common to assume an outdoor-to-indoor noise reduction of 25 dB(A). This is based on a standard commercial building facade with windows kept closed, such as that at most University Buildings. Therefore, for this assessment, an external NML of 70 dB(A) $L_{eq,15min}$ will be used for the educational sensitive land uses surrounding the development site.

It is noted that as most of the surrounding buildings are University of Sydney land uses, no specific requirements are applied by the ICNG, which is intended to manage construction noise impacts between uses not managed by the same body. As the relevant uses around the ETP site are all managed by the University of Sydney, management of construction noise impacts on adjoining uses will be undertaken by the University. However, as good practice and to provide guidance to the University, the NMLs recommended by the ICNG have been adopted for the University of Sydney uses in this assessment.

Table 7 ICNG noise management levels for other sensitive land uses

Land use	NML $L_{eq,15min}$ (applies when property in use)
Classrooms at schools and other educational institutions	Internal noise level of 45 dB(A)
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 of 60 dB(A)
Offices, retail outlets	External noise level of 70 dB(A)

Noise Management Levels

Table 8 summarises the NMLs applicable to sensitive land uses around the ETP site during the construction phase. The NMLs are based on the lowest background noise level measured during the attended monitoring conducted around the site.

Table 8 Noise Management Levels applicable to ETP

Land use	NML for time period, dB(A)	
	Standard Working Hours	Outside of Standard Working Hours
Residential land uses	58 (NML) 75 (Highly noise affected)	53
University of Sydney uses	70	70
Cadigal Green	60	60

It is noted that the NMLs for work outside of Standard Working Hours will be applicable to works proposed to be carried out from 1 pm to 3:30 pm on Saturday afternoons.

4.2 Construction vibration

Ground vibration generated by construction can have a range of effects on buildings and building occupants. The main effects are generally classified as:

- human disturbance – disturbance to building occupants: vibration which inconveniences or interferes with the activities of the occupants or users of the building
- effects on building structures – vibration which may compromise the condition of the building structure itself.

In general, vibration criteria for human disturbance are more stringent than vibration criteria for effects on buildings. Building occupants will normally feel vibration readily at levels well below those which may cause a risk of cosmetic or structural damage to a structure. However, it may not always be practical to achieve the human comfort criteria. Furthermore, unnecessary restriction of construction activities can prolong construction works longer than necessary, potentially resulting in other undesirable effects for the local community.

Construction vibration criteria have been adopted from the following sources:

- Cosmetic and structural damage to buildings: German Standard DIN 4150-3[1]
- Human comfort: *Assessing Vibration – A Technical Guideline* (the Vibration Guideline)

Cosmetic and structural damage

DIN 4150-3 summarises structural and cosmetic damage assessment criteria for different types of buildings, which are presented in Table 3, which are widely used for the assessment of construction vibration effects on buildings in Australia. The criteria are specified as Peak Particle Velocity (PPV) levels measured in any direction at or adjacent to the building foundation.

Table 3 DIN 4150-3 vibration cosmetic and structural damage criteria

Structure type	Peak Particle Velocity (PPV), mm/s			
	Foundation of structure			Vibration at horizontal plane of highest floor at all frequencies
	<10 Hz	10-50 Hz	50-100 Hz	
Buildings used for commercial, industrial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwelling and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in rows 1 and 2, and are of great intrinsic value (e.g. heritage-listed buildings)	3	3 to 8	8 to 10	8

[1] German Standard DIN 4150-3, 1999, *Structural Vibration – Part 3: Effects of vibration on structures*.

With respect to the project site, the Old School building on Cadigal Green is heritage-listed and therefore subject to the most stringent vibration limits. It is approximately 50 m from the site.

DIN 4150-3 states that exposing buildings to vibration levels higher than that recommended would not necessarily result in damage. Rather, it recommends these values as maximum levels of short-term construction vibration at which experience has shown damage reducing the serviceability of structures will not occur due to vibration effects.

DIN 4150-3 is considered to be suitable for the assessment of both structural and cosmetic damage as it considers a reduction in serviceability of the structure is deemed to have occurred if:

- cracks form in plastered surfaces of walls
- existing cracks in the building are enlarged
- partitions become detached from loadbearing walls or floors.

Human comfort

The ICNG recommends that vibration from construction works be assessed under *Assessing Vibration – a technical guideline* (the Vibration Guideline), consistent with the SEARs issued by DPE.

The vibration assessment criteria defined in the Vibration Guideline are for human comfort and represent goals that, where predicted or measured to be exceeded, require the application of all feasible and reasonable mitigation measures. Where the maximum value cannot be feasibly and reasonably achieved, the operator would need to negotiate directly with the affected community.

The Vibration Guideline defines vibration assessment criteria for continuous, impulsive and intermittent vibration. Vibration can be classified according to the following definitions:

- Continuous vibration: continues uninterrupted for a defined period. Applies to continuous construction activity such as tunnel boring machinery.
- Impulsive vibration: rapid build-up to a vibration peak followed by a damped decay or the sudden application of several cycles of vibration at approximately the same magnitude providing that the duration is short. Applies to very occasional construction activities that create distinct events such as the occasional dropping of heavy equipment.
- Intermittent vibration: interrupted periods of continuous vibration (such as a drill) or repeated periods of impulsive vibration (such as a pile driver).

The majority of construction activities as part of the proposed works would be expected to be continuous or intermittent in nature.

Table 9 presents the management levels for continuous and impulsive vibration at different land uses. The management levels specified are as overall unweighted RMS vibration velocity levels. The Vibration Guideline specifies the management levels as suitable for vibration sources predominantly in the frequency range 8-80 Hz as would be expected for construction vibration.

For intermittent vibration, the Vibration Dose Value (VDV) is used as the metric for assessment as it accounts for the duration of the source, which will occur intermittently over the assessment period. The VDV management levels at different land uses for intermittent vibration sources are presented in Table 10.

Table 9 RMS velocity management levels for continuous and impulsive vibration

Land use	Continuous vibration – RMS vibration velocity, mm/s		Impulsive vibration – RMS vibration velocity, mm/s	
	Preferred	Maximum	Preferred	Maximum
Critical areas[1]	0.1	0.2	0.1	0.2
Residences and hospital wards – daytime[2]	0.2	0.4	6.0	12.0
Residences and hospital wards – night time[3]	0.14	0.28	2.0	4.0
Offices, schools	0.4	0.8	13.0	26.0
Workshops	0.8	1.6	13.0	26.0

(1) Critical operating areas include hospital operating theatres and precision laboratories where sensitive operations are occurring.

(2) Daytime is defined by the Vibration Guideline to be 7 am to 10 pm.

(3) Night time is defined by the Vibration Guideline to be 10 pm to 7 am.

Table 10 VDV management levels for intermittent vibration

Land use	VDV – intermittent vibration, $m/s^{1.75}$	
	Preferred	Maximum
Critical areas[1]	0.1	0.2
Residences and hospital wards – daytime[2]	0.2	0.4
Residences and hospital wards – night time[3]	0.13	0.26
Offices, schools	0.4	0.8
Workshops	0.8	1.6

(1) Critical operating areas include precision laboratories where sensitive operations are occurring.

(2) Daytime is defined by the Vibration Guideline to be 7 am to 10 pm.

(3) Night time is defined by the Vibration Guideline to be 10 pm to 7 am.

4.3 Operational noise criteria

Noise emissions from the ETP when operational should comply with the requirements of the NSW *Industrial Noise Policy* (INP). It is noted that the INP has recently been superseded by the *Noise Policy for Industry* but, as the SEARs reference the INP, the INP has been adopted for this assessment. This is in accordance with NSW EPA recommendations where existing conditions reference the older document.

The INP sets two separate noise criteria to meet desirable environmental outcomes:

- Intrusiveness – steady-state noise from the site should be controlled to no more than 5 dB(A) above the background noise level in the area. In this case, the steady-state L_{eq} noise level should not exceed the background noise level measured for different time periods in the environment.
- Amenity – amenity criteria are set based on the land use of an area. It requires noise levels from new industrial noise sources to consider the existing industrial noise level such that the cumulative effect of multiple sources does not produce noise levels that would significant exceed the amenity criteria.

The INP applies to noise emissions from rooftop plant and the like at the development. It sets noise emission criteria for the Day, Evening and Night periods. While the ETP will generally operate during the Day period, it is noted that building services may commence operation at 6 am and therefore assessment against the more stringent Night period criteria is required. Note that the lowest measured background noise level at any time has been used for deriving the Night period criteria as the measured noise level was controlled by University of Sydney mechanical plant which would also be operating when the ETP is operating.

Normal operation

Table 11 presents the INP noise emission criteria for residential land uses, including the International House and Urbanest, for the Day, Evening and Night periods.

Table 11 INP noise emission criteria for residential land uses and

Location	**INP noise emission criteria, dB(A) $L_{eq,15min}$**		
Residential land uses	**Day 7 am–6 pm**	**Evening 6 pm–10 pm**	**Night 10 pm–7 am**
Rating Background Level (RBL)	*48*	*48*	*48*
Intrusive criterion (RBL + 5 dB)	53	53	53
Amenity criterion for all sources (Suburban[1])	55 – 60	45 – 50	40 – 45
Existing L_{eq} from industrial sources (University of Sydney)	50	50	50
Amenity criterion for new sources[2]	53	40	40
Project specific criterion for residential land uses	**53**	**40**	**40**

(1) A suburban classification has been adopted for the site, described as an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry.

(2) The Amenity criterion for new sources have been determined on the basis that the lowest background noise level measured was controlled by University of Sydney mechanical plant as was observed during the attended monitoring.

(3) The project-specific criteria are the minimum of the Intrusive criterion and the Amenity criterion for new sources for each time period.

Emergency operation

A rooftop emergency generator will be installed as part of the ETP development. This will only operate in emergencies and during occasional short-duration daytime maintenance periods.

The NSW INP does not specify requirements for emergency equipment but does suggest that short-term exceedances of the approved noise levels may be required depending on the nature of the site. Based on the INP and our previous experience, it is recommended that the applicable noise criteria for the emergency generator be relaxed (increased) by 5 dB(A).

5 Construction assessment

5.1 Construction noise

Construction noise sources

Table 12 summarises the assumed sound power levels (L_W) for the major construction noise sources which we expect would be on site during each phase. The sound power levels have been based on data obtained from previous measurements conducted by Resonate and those within the UK Department for Environment, Food and Rural Affairs (DEFRA) *Update of noise database for prediction of noise on construction and open sites*. An overall sound power level for each phase has also been assumed based on the loudest typical source(s) operating for each works phase.

Table 12 Construction noise source sound power levels

Stage	Typical plant items	Assumed sound power level, dB(A)
Site establishment and enabling works	Large excavator	111
	Vibratory roller	107
	Concrete truck	109
	Concrete pump	107
	Large truck	108
	Chainsaw	114
	Typical overall sound power level	**112**
Demolition	Large excavator	111
	Rockbreaker	121
	Crane	106
	Pneumatic jackhammer	109
	Large truck	108
	Typical overall sound power level	**118**
Retaining piles and excavation	Bored piling rig	111
	Large excavator	111
	Crane	106
	Large truck	108
	Typical overall sound power level	**112**
Substructure	Crane	106
	Large excavator	111

Stage	Typical plant items	Assumed sound power level, dB(A)
	Pneumatic jackhammer	109
	Concrete truck	109
	Concrete pump	107
	Large truck	108
	Typical overall sound power level	**114**
Frame	Concrete truck	109
	Concrete pump	107
	Crane	106
	General hand tools	98
	Large truck	108
	Typical overall sound power level	**111**
Facade works	Crane	106
	General hand tools	98
	Large truck	108
	Typical overall sound power level	**107**
Internal works and fitout	General hand tools	98
	Compressor	94
	Portable generator	95
	Typical overall sound power level	**84[1]**

(1) Includes a 15 dB(A) indoor-to-outdoor reduction in noise levels for internal works.

Typical construction noise levels during Standard Works Hours

Typical worst-case predicted noise levels are shown in Table 13 for each sensitive-receiver location and each phase of works. Predicted noise levels that exceed the relevant Standard Work Hours NML are highlighted in **bold** type.

Based on the predictions, it can be seen that construction noise from the site is predicted to exceed the relevant NMLs at:

- The University of Sydney student accommodation sites during most external works (Urbanest Darlington and International House).
- At the nearest Shepherd Street residences during major demolition works (rock-breaking) only.
- The Seymour Centre during most external works.
- Other Engineering Faculty uses during major external works, in particular areas of the Mechanical Engineering building and the Engineering Link building.

Table 13 Typical worst-case external construction noise levels for Standard Working Hours

Receiver	Typical worst-case external construction noise level for phase during Standard Working Hours, dB(A) L_{eq}						
	Site establishment	Demolition	Retaining piles and excavation	Substructure	Frame	Facade works	Internal works and fitout
R1 – Urbanest Darlington	**63**	**69**	**63**	**65**	**62**	58	35
R2 – International House	**66**	**72**	**66**	**68**	**65**	**61**	38
R3 – Cleveland Street residences	50	56	50	52	49	45	22
R4 – Shepherd Street residences	55	**61**	55	57	54	50	27
R5 – Seymour Centre	**72**	**78**	**72**	**74**	**71**	67	44
R6 – Warren Centre	62	68	62	64	61	57	34
R7 – Mechanical Engineering	**78**	**84**	**78**	**80**	**77**	**73**	50
R8 – Engineering Link Building	**80**	**86**	**80**	**82**	**79**	**75**	52
R9 – Civil Engineering	61	67	61	63	60	56	33
R10 – PNR Building	69	**75**	69	**71**	68	64	41
R11 – Wentworth Building	65	**71**	65	67	64	60	37
R12 – Cadigal Green	66	**72**	66	68	65	61	38

At other locations, no significant noise impacts are expected during the construction phase, particularly if work is only undertaken during standard working hours. Recommendations for construction noise management are provided in Section 5.3.

It is important to note that these predictions are typical worst-case predictions as they assume that:

- The construction works are occurring at the nearest point to each receiver and that the receiver is located at the most exposed position (e.g. the nearest windows of Urbanest Darlington and International House)
- The noisiest construction sources are operating continuously for the entire 15-minute period. This will not occur at all times as equipment will regularly be stood down or idled while other activities are undertaken.

Typical construction noise levels during Out of Hours Works

Table 14 presents typical predicted construction noise levels and highlights NML exceedances for those works occurring outside of Standard Working Hours. Predominantly this relates to works that occur on Saturday afternoons from 1 pm to 3:30 pm but would also reflect any other works that would need to occur out of hours.

Table 14 Typical worst-case external construction noise levels for work outside of Standard Working Hours

Receiver	Typical worst-case external construction noise level for phase outside of Standard Working Hours, dB(A) L_{eq}						
	Site establishment	Demolition	Retaining piles and excavation	Substructure	Frame	Facade works	Internal works and fitout
R1 – Urbanest Darlington	**63**	**69**	**63**	**65**	**62**	**58**	35
R2 – International House	**66**	**72**	**66**	**68**	**65**	**61**	38
R3 – Cleveland Street residences	50	**56**	50	52	49	45	22
R4 – Shepherd Street residences	**55**	**61**	**55**	**57**	**54**	50	27

The predictions indicate that:

- Predicted worst-case construction noise levels exceed the NML for most work phases for Urbanest Darlington and International House.
- Predicted worst-case construction noise levels at the Cleveland Street residences are generally below the out of hours NML, with the exception of demolition works. Predicted noise levels from the demolition works exceed the NML by 3 dB.
- Predicted worst-case construction noise levels at the Shepherd Street residences exceed the out of hours NML for the early work phases but the exceedance is generally below 5 dB. Predicted worst-case noise levels from the demolition works exceed the NML by 8 dB.
- It is expected that internal works and fitout can generally occur outside of Standard Hours without unduly impacting on residential land uses.

Recommendations for construction noise management for works outside of Standard Working Hours are provided in Section 5.3.

Note that the assessment of work outside of standard hours has not considered the commercial and educational land uses as the NMLs for these land uses remain the same regardless of the work hours. It is noted, however, that conducting works on a Saturday afternoon period from 1 pm to 3:30 pm would be expected to reduce the overall noise impact on neighbouring commercial and educational buildings as these uses are typically less sensitive (and often largely unoccupied) at these times.

5.2 Construction vibration

Table 15 summarises recommended safe working distances for key vibration-generating activities that would be expected during the construction phase, based on prior measurements conducted by Resonate Acoustics. We understand that preliminary geotechnical studies have indicated that bored piling will be able to be undertaken.

Table 15 Recommended safe working distances for key vibration generating activities

Plant	Rating	Typical safe working distance for occupant comfort, m		Typical safe working distance for building damage, m	
		Preferred vibration target	Maximum vibration target	Heritage structure	Commercial building
Vibratory roller	< 7t	≥ 35	≥ 20	≥ 10	≥ 2
	7t – 12t	≥ 50	≥ 30	≥ 15	≥ 5
	≥ 13t	≥ 75	≥ 40	≥ 20	≥ 10
Small hydraulic hammer	300 kg – 5 to 12T excavator	≥ 12	≥ 7	≥ 5	≥ 2
Medium hydraulic hammer	900 kg – 12 to 18T excavator	≥ 35	≥ 23	≥ 15	≥ 7
Large hydraulic hammer	1600 kg – 18 to 34T excavator	≥ 65	≥ 45	≥ 35	≥ 22
Excavator	Large excavator digging	≥ 25	≥ 15	≥ 5	≥ 1
Bored piling	≤ 800mm	≥ 20	≥ 10	≥ 2	≥ 1
Jackhammer	Handheld	–(1)	–(1)	≥ 3	≥ 1

Based on the safe working distances above, vibration impacts on buildings are not expected, including to the heritage-listed Old School building. Impacts on occupant comfort are likely to be limited to any vibratory compaction works and rock-breaking works occurring near to existing Engineering Faculty buildings and consultation should be undertaken with the users of these areas during vibration-intensive works. Recommendations are provided in Section 5.3 for the management of construction vibration from the works.

5.3 Recommendations

To manage the potential impact of noise and vibration during construction, reasonable and feasible management measures and work practices should be implemented as detailed below.

Construction Noise and Vibration Management Plan

Prior to the commencement of major construction works for the ETP building being considered as part of this EIS, the contractor should develop a Construction Noise and Vibration Management Plan (CNVMP). The CNVMP should:

- identify relevant construction noise and vibration criteria as detailed in this report
- identify neighbouring sensitive land uses for noise and vibration
- summarise key noise- and vibration-generating construction activities and the associated predicted levels at neighbouring land uses
- identify reasonable and feasible work practices to be implemented during the works
- summarise stakeholder consultation and complaints handling procedures for noise and vibration.

Stakeholder consultation

Nearby stakeholders should be consulted prior to the works and kept regularly informed of potential noise and vibration impacts from the works. Specifically, this would involve:

- Consultation with management of International House and Urbanest Darlington during major external works.
- Specific reference to works occurring until 3:30 pm on a Saturday to be included in the consultation with the above land uses.

The University of Sydney will also consult with various University stakeholders at the Engineering Faculty and the Seymour Centre during the works.

A noise and vibration complaints handling procedure and register should be developed and implemented during construction.

Work programming

Work should be programmed such that particularly noisy works occur during Standard Working Hours wherever feasible, namely:

- Monday to Friday 7 am to 6 pm
- Saturday 8 am to 1 pm
- No work on Sundays or public holidays.

It is proposed that works will also occur during the Saturday afternoon period from 1 pm to 3:30 pm. While this will assist in reducing the noise impact on the nearer commercial and educational land uses, it does result in works occurring outside of the Standard Working Hours for residential land uses. For works conducted during this extended Saturday afternoon period, it is recommended that:

- Wherever feasible, noisier works (in particular noisy rock-breaking or demolition) are not conducted in this extended period.
- Consultation is undertaken with International House and Urbanest Darlington, as detailed above, to inform them of the extended Saturday afternoon working period and to respond to any concerns that they may have with this.

If high noise works are to occur outside of the Standard Working Hours and later than 3:30 pm on a Saturday, then the CNVMP should define an approval process for undertaking out of hours works and for identifying reasonable and feasible mitigation measures to be implemented.

Truck movements and site access

Truck movements during long term construction projects have the potential to cause annoyance for sensitive receivers, even where trucks may be travelling on sealed roads. The design and selection of site access routes shall consider the potential disturbance to residents. In particular:

- site access and delivery points shall be located as far away from residences as possible
- truck movements shall use arterial roads and be diverted away from residential streets where feasible
- deliveries to/from site shall not occur during the night time period where possible.

Site management

Site management procedures should include the following:

- processes that generate lower noise levels should be selected where feasible
- noisy plant should be located as far away from residences as is practical to allow efficient and safe completion of the task
- the potential shielding provided by site topography and intervening buildings should be taken into account in locating equipment
- site compounds should be located as far away as possible from residences
- equipment that is used intermittently should be shut down or throttled down to a minimum during periods where it is not in use
- works should be planned to minimise the reduce the noise from reversing signals
- warning horns should not be used as signalling devices
- two way radios should be set to the minimum effective volume
- noise associated with packing up plant and equipment at the end of works should be minimised.

Equipment management

Equipment management should include the following:

- selection of low-noise plant and equipment where possible
- equipment should be well maintained
- equipment should have quality mufflers and silencers installed where relevant
- equipment not in use on site should be shut down
- tasks should be completed using the minimum feasible power and equipment.

6 Operational assessment

Laing O'Rourke has advised that major rooftop plant as part of the ETP would be expected to include:

Level 10 plant within plant rooms and enclosures

- 3 x BAC CPSC-0716-07M Cooling Towers – sound power level of 99 dB(A)
- 1 x Low Load Chiller – sound pressure level of 80 dB(A) at 1 m
- 2 x High Load Chiller – sound pressure level of 85 dB(A) at 1 m

Assorted rooftop fans

- 33 x Fume Cupboard fans – sound power level of 77 dB(A)
- 2 x Stair Pressurisation fans – sound power level of 106 dB(A)
- 2 x Toilet Exhaust fans – sound power level of 109 dB(A)

Emergency equipment

- 1 x CAT C13 generator in proprietary acoustic enclosure
- 3 x smoke spill fans with sound power level of 102 dB(A).

Based on an assessment of the preliminary rooftop plant layout, it is expected that the following measures would be required based on the current design:

- The Chillers should be located in an enclosed plant room on Level 10. The plant room should be constructed with a solid roof achieving no less than an R_W 35 rating and solid walls achieving no less than R_W 40.
- The CAT C13 generator should be installed in an acoustic enclosure that achieves a rating of 80 dB(A) at 1 m.
- Outlet attenuators are required for the Stair Pressurisation fans and Toilet Exhaust fans, acoustically equivalent to Fantech RS07C. Alternatively, the outlet ductwork from the fans is required be at least 3 m in length, 50 mm thick internally lined, incorporate at least one 90-degree bend, with the outlets facing north or south.

With the incorporation of the above measures, predicted noise levels from the rooftop plant is predicted to achieve the INP criteria for both normal and emergency operation (with 5 dB relaxation).

Noise mitigation techniques will need to be reassessed and further developed as the design of the building and the rooftop progresses. Techniques that will be considered during detailed design will include:

- Selection of lower noise plant and equipment, particularly the chiller and cooling towers.
- Screening of external plant using solid barriers or acoustic louvres.
- Appropriate construction of a rooftop plant room to reduce noise emissions to neighbouring land uses.

The noise levels from mechanical plant, and other noise sources, will be assessed as the design progresses to ensure that compliance with the INP noise emission criteria can be achieved.

7 Conclusion

This report presents a construction and operational noise and vibration assessment for the proposed ETP development at the University of Sydney. The proposed building will enable the Engineering and Technology faculty to expand its research and teaching facilities.

Construction noise and vibration criteria have been determined in accordance with relevant guidance such as the ICNG and Vibration Guideline. It is likely that construction works may have some noise impact on University student accommodation land uses at Urbanest Darlington and International House. It is anticipated that these impacts will be able to be managed through works being carried out during standard working hours and with the implementation of reasonable and feasible work practices. The University will also manage the noise and vibration impacts of works on adjoining University teaching and office uses.

Operational noise emission criteria have been set in accordance with the NSW INP and apply predominantly to mechanical plant noise emissions from the site. A preliminary rooftop plant layout and selection has been assessed and recommendations provided such that noise emissions can achieve the INP criteria for both normal and emergency operations. As the design progresses, noise mitigation measures be reviewed to ensure that noise from rooftop plant in particular can comply with the INP noise emission criteria at neighbouring noise-sensitive land uses.