Appendix D. Updated Acoustic Report

THE UNIVERSITY OF WOLLONGONG

MOLECULAR AND LIFE SCIENCES BUILDING

Acoustic Report for State Significant Development Application

Issued

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Executive Summary

The University of Wollongong proposes to build a new Molecular and Life Sciences (MLS) Building at the main Wollongong campus. In particular, the development seeks to provide a key integrating feature of the Sciences Precinct on the Wollongong Campus.

The proposal involves five levels of laboratories and research areas, with building services plant located on the ground level and on the rooftop.

Acoustic Studio has been engaged by the proponent to provide acoustic engineering services for the development of the acoustic design of the building, excluding specific vibration isolation design controls for electron microscopes and similar sensitive equipment to be located at ground level.

The MLS Building Project has been categorised as a "State Significant Development" and, as such Secretary's Environmental Assessment Requirements (SEARs) SSD-8096 has been issued for the project. This acoustic assessment report has been prepared in support of the EIS for the proposed project.

This acoustic report presents a noise and vibration assessment that has been undertaken to establish the potential impacts of operational noise, including mechanical services impacts, and a high level construction noise and vibration review for the proposed MLS Building project.

The existing noise environment has been established based on long-term and short-term monitoring data. Appropriate criteria for both noise and vibration have been discussed and set according to established guidelines and standards.

Noise and vibration generated by the development is addressed in this report according to the following Environment Protection Authority (EPA) guidelines:

- Industrial Noise Policy 2000
- Interim Construction Noise Guideline 2009
- Assessing Vibration: A Technical Guideline 2006
- Road Noise Policy 2011

A summary of the outcomes and recommendations of the noise and vibration assessment are as follows:

- Mechanical services noise

  At this stage, final plant selections have not been made; therefore a detailed assessment has not been carried out. A preliminary review has been carried out for the main plant room located on the roof, Level 4 and at ground level. Based on the

plant room locations and the most restrictive criteria, noise emissions from the rooftop plant room shall to be limited to 75-80 dBA at 1 metre of the rooftop boundary.

Noise controls will be incorporated within the design of the rooftop plant room and any other plant located outdoors or on other levels of the proposed building to ensure that the cumulative noise output from plant at the nearest affected receivers is within the allowable limits. General design consideration and controls implemented will typically include strategic selection and location of plant and/or acoustic noise control measures such as enclosures, barriers, acoustic louvres, sound absorptive panels, etc.

- Operational noise

  On the basis that activities associated with the future operations of the MLS Building, estimated operational noise levels are expected to comply with the stated criteria at the nearest residential sensitive receivers.

  Traffic noise associated with the development, including the potential for sleep disturbance from noise from individual road traffic noise events such as waste or delivery vehicles, is expected to comply with the applicable criteria.

- Construction airborne noise

  Continuous construction noise associated with most demolition and new-build works is expected to comply with stated criteria for nearest noise-sensitive residential and educational receivers.

  However, there may be times / situations when excavation and piling works are likely to exceed stated criteria at university receivers, particularly when works occur in the areas closer to nearby sensitive receivers on campus.

  If, during construction works, an item of equipment exceeds the stated airborne noise criteria at any sensitive location, the additional noise control measures presented in Section 6.4.4, together with construction best practices presented in Section 6.4.1, shall be considered to minimise the noise impacts on the neighbourhood. Construction noise monitoring for piling and demolition will be carried out at the nearest residential receivers, including graduate housing, to confirm the predicted noise levels (which are expected to comply with applicable residential criteria). Construction noise monitoring will also be carried out at university receivers as required to manage noise impacts on campus.

  Road traffic generated by construction activities will be managed to minimise disturbances to residential and other sensitive receivers. This includes access routes away from local residential roads, and either avoiding reversing on and near the works site or employing non-tonal reversing alarms.

- Construction vibration

  Vibration levels are expected to comply with the human comfort continuous vibration criteria at all sensitive receiver locations for all likely scenarios considered for the MLS Building works. Further reviews will be conducted once the construction methods are developed, to ensure that any vibration-sensitive equipment areas in nearby noise sensitive educational buildings are not affected by the works.

  Furthermore, anticipated vibration levels due to ‘vibration intensive’ works also comply with the building damage criteria.

1 Introduction

The University of Wollongong is currently proposing to build a new MLS Building at the main Wollongong campus. In particular, the development seeks to provide a key integrating feature of the Sciences Precinct on the Wollongong Campus.

The new building is to house world class research facilities and approximately 150 research staff. Facilities include high-sensitivity microscope laboratories, research laboratories with associated freezer, cool room and storage rooms, animal housing, and academic and administrative offices.

Acoustic Studio has been engaged by the proponent to provide acoustic engineering services for the duration of the project.

The MLS Building project has been categorised as a "State Significant Development" and, as such SEARs have been issued for the preparation of an Environmental Impact Assessment for the proposed development. This acoustic assessment report has been prepared in support of the EIS for the proposed MLS Building project.

The acoustic report assesses noise impacts at nearby on-campus and off-campus sensitive receivers due to operation of the MLS Building project once it is completed.

Furthermore, a high level construction noise and vibration assessment has been conducted for the proposed construction stage of the MLS Building project.

This report presents the findings of both the operational and construction noise assessment. It includes measured environmental noise survey data and environmental noise limits based on the measured noise levels in the area. Compliance with these limits will ensure that any noise from the overall development will not impact negatively on the nearest existing residences. The report also provides recommendations for appropriate vibration level criteria during construction.

2 Description of Proposal

2.1 Project background

Located in Wollongong, The University of Wollongong (UoW) has over 27,000 students. The 38-hectare Wollongong site is the main campus and provides state-of-the-art faculty and services facilities.

The MLS Building project is proposed to accommodate the immediate needs of the Faculty, while also providing a strategic and flexible facility that responds to UoW's overall long term needs as defined in the Wollongong Campus Master Plan.

The proposal involves the demolition of an existing car park area and constructing a brand new building.

Figures 1 and 2 below show the location of the project and the surrounding area.

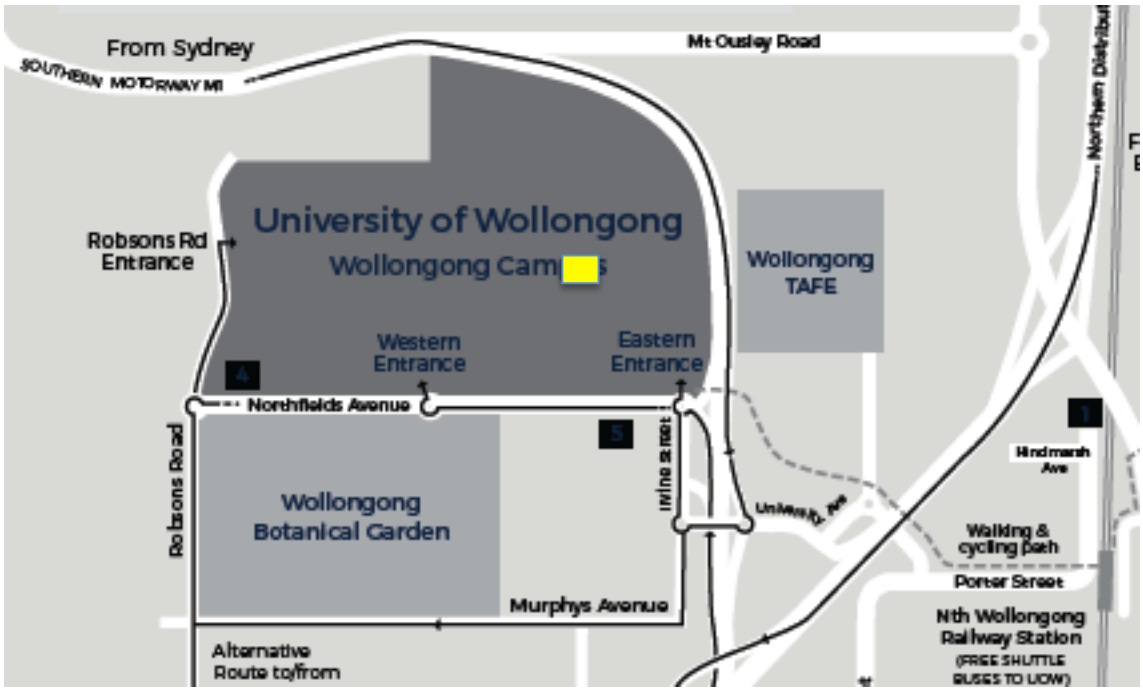


Figure 1: University of Wollongong campus map, with approximate MLS location shown in yellow.

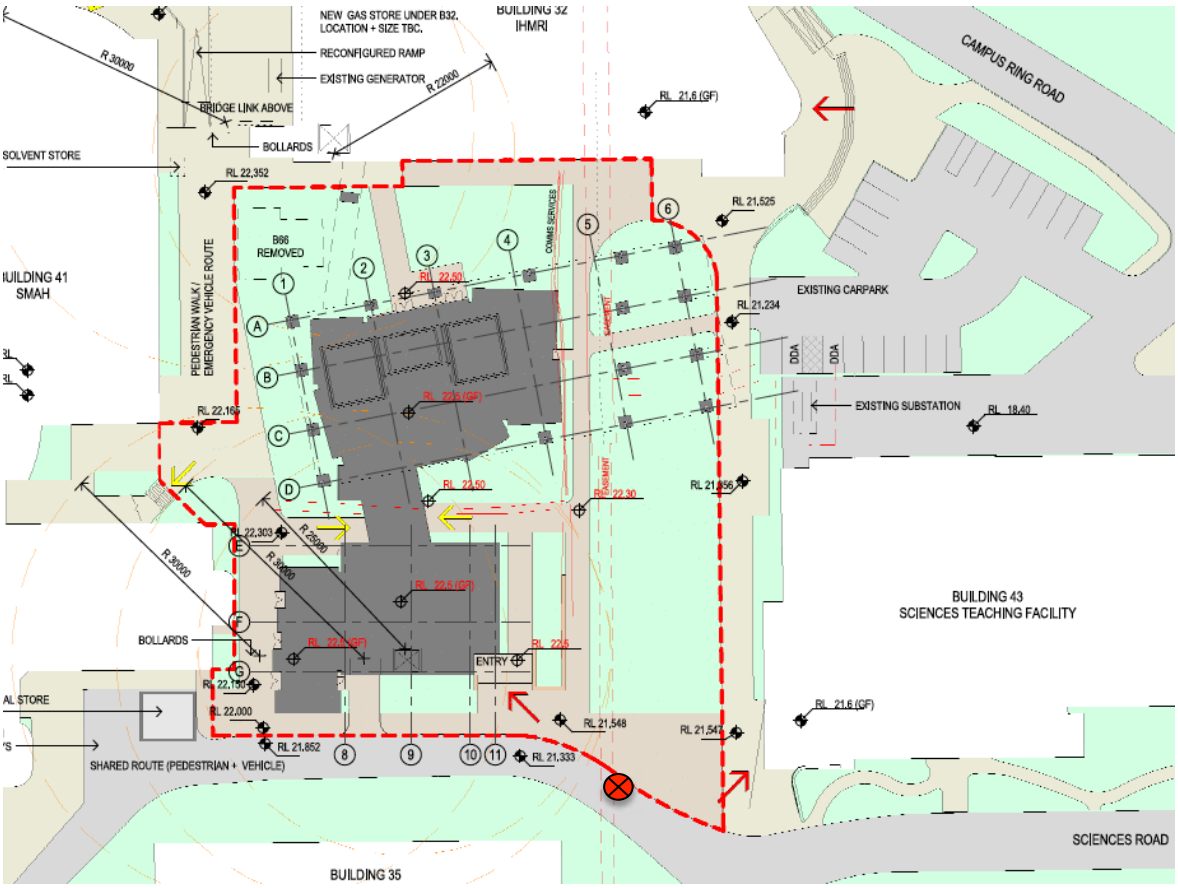


Figure 2: Project building outline shown in grey, and surrounds. Noise logger location shown in red.

2.2 Sensitive receivers

The nearest residential receivers adjacent the site over 300m distant from the site, as follows:

- To the east, on the far side of the Southern Motorway
- To the south, on the far side of Northfields Avenue

The noise sensitive educational receivers surrounding the site are as follows:

- Sciences Teaching Facility (south-east, Building 43)
- Sciences Building (west, Building 41)
- IHMRI Gerard Sutton Building (north, Building 32)
- SMART Infrastructure Facility (south, Building 6)
- Biology / Information Sciences (south, Building 35)

These receiver buildings also generate noise, with rooftop plant dominating the local ambient noise environment.

2.3 Operating hours

The building and facilities are expected to be operational 24 hours, seven days a week, with most activities expected during daytime and evening hours 5 days a week.

However, it is understood that there may be after hours activities depending on UoW requirements, but that any after hours activities will not be noise intensive in nature (such as research activities within indoor laboratories, etc.). The major operational noise source would be from delivery and waste vehicles accessing the site.

However, plant may operate on a 24 hour basis and noise controls as required will be included to meet the environmental noise limits set in this report.

3 Existing Noise Environment

3.1 General survey information

A survey of the existing noise environment around the MLS site was conducted with an unattended noise monitor used to continuously record the noise levels on the site. Long term noise monitoring was carried out at two locations from Friday 2nd to Monday 12th December 2016 to establish the typical range of ambient noise levels of the proposed site and surrounds.

Long term noise monitoring was carried out with an Acoustic Research Lab Noise Logger RTA 02, Serial number 038. The logger recorded L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} noise parameters at 15-minute intervals continuously for the two measurement periods. The calibration of the logger was checked before and after use and no variation was noted.

Operator attended short-term monitoring was also carried out on Friday 2nd December 2016 in order to confirm the validity of the long-term outdoor data across the site and to sample background and ambient noise levels at key surrounding noise-sensitive residential and educational receivers during daytime periods.

Short-term measurements were made with a Brüel & Kjær Hand-held Analyser Type 2250 (Serial Number 2832406). The calibration of the analyser was checked before and after the survey and no variation in level occurred.

A windshield was used to protect the microphone of both the logger and the analyser. Weather conditions were calm and dry during the attended noise survey.

Saiham Siraj of Acoustic Studio Pty Ltd carried out the surveys.

The long and short-term noise monitoring locations are shown in Figure 2 in Section 2.1 and Figure 3 in Section 3.3.

3.2 Long-term monitoring results

One logger location was selected for a week-long noise monitoring period period. The long-term noise monitoring location is shown in Figure 2 in Section 2.

The noise logger was located outside the north-eastern façade of Building 35 (Biology / Information Sciences).

This position was chosen since it represented a secure place to leave the noise logger unattended whilst obtaining typical representative background and ambient noise levels around for the nearest noise-sensitive educational receivers.

The location was relatively well shielded from existing rooftop plant noise and therefore obtain ambient noise levels which are not affected by existing industrial-type noise. This is an important factor in determining appropriate noise criteria which consider the cumulative effects of developments, in accordance with the NSW Industrial Noise Policy.

The detailed results of the long term noise monitoring are shown graphically in Appendix A.

Weather patterns were monitored during the survey period and were typically calm and dry during the unattended noise survey. Graphs in Appendix A show (highlighted in grey) the times where logged data is likely to be affected by rain, wind or other extraneous noises. Periods highlighted in yellow show where the entire day / evening / night period measurements cannot be used due to having too many weather-affected 15-minute samples. This is in accordance with the NSW INP data exclusion rules.

The logged data shows the background and ambient noise levels of the area. The recorded background and ambient noise levels have been used to establish limiting criteria for noise emitted from the proposed buildings.

The background sound level is defined as the sound level exceeded 90% of the time, and is designated as the L_{90}. The ambient noise level impacting on the buildings is referred to as the equivalent continuous sound level (L_{eq}). This parameter is commonly used to describe a time varying noise such as traffic noise.

The background sound levels have been established in general accordance with the methodology described in the NSW INP (see Appendix B for details), i.e. the 10th percentile background sound level for each period for each day of the ambient noise survey. The median of these levels is then presented as the background sound level for each assessment period. These background noise levels are shown in Table 1 below together with the L_{Aeq} ambient noise levels measured for each period.

As stated in the INP, any data likely to be affected by rain, wind or other extraneous noises has been excluded from the calculations.

Location	RBL (L_{90}) Background Noise Levels, dB(A)			L_{eq} Ambient Noise Levels, dB(A)		
	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am
L1 – Building 35 (north-east)	50	48	47	56	54	53

Table 1 : Long-term background and ambient noise levels measured around the MLS Building site

From observations during our site visit, it is noted that both ambient and background noise levels around the site were currently dominated by mechanical plant noise from surrounding UoW buildings. During session, it is likely that local road traffic and

pedestrian noise will increase the ambient noise levels somewhat. The NSW Industrial Noise Policy recommends noise logging in the absence of the facility noise, which means that logging out of session is appropriate. However the influence of university activity noise during session should be considered as part of construction noise management plans when assessing “reasonable” noise mitigation for works.

3.3 Short-term monitoring results

Five (5) short-term noise monitoring locations were chosen as representative of the site and surrounds as follows:

- **Location S1** on the eastern side of Building 43, facing the project site.

  Location S1 is representative of current background and ambient noise levels currently impacting nearest on-campus noise-sensitive educational receivers to the west of the proposal. Measured levels include existing plant noise from UoW buildings, particularly Building 41, and to a lesser degree from Building 35.

- **Location S2** on north-eastern façade of Building 35 (Biology / Information Sciences).

  Location S2 was chosen to conduct side by side measurements with the noise logger, for verification purposes as well as to observe existing noise sources.

- **Location S3** on the northern side of Graduate House on Northfields Avenue.

  Location S3 is representative of the nearest residential receiver to the project site, and is located approximately 300m south of the site.

- **Location S4** on Ashcroft Place, on the southern side of Princes Motorway.

  Location S4 is representative of the private residential receivers in the area, and is located over 500m to the north-west.

- **Location S5** on Gowan Brae Avenue the eastern side of Princes Motorway.

  Location S5 is representative of the nearest private residential receivers to the site, and is located over 400m to the east.

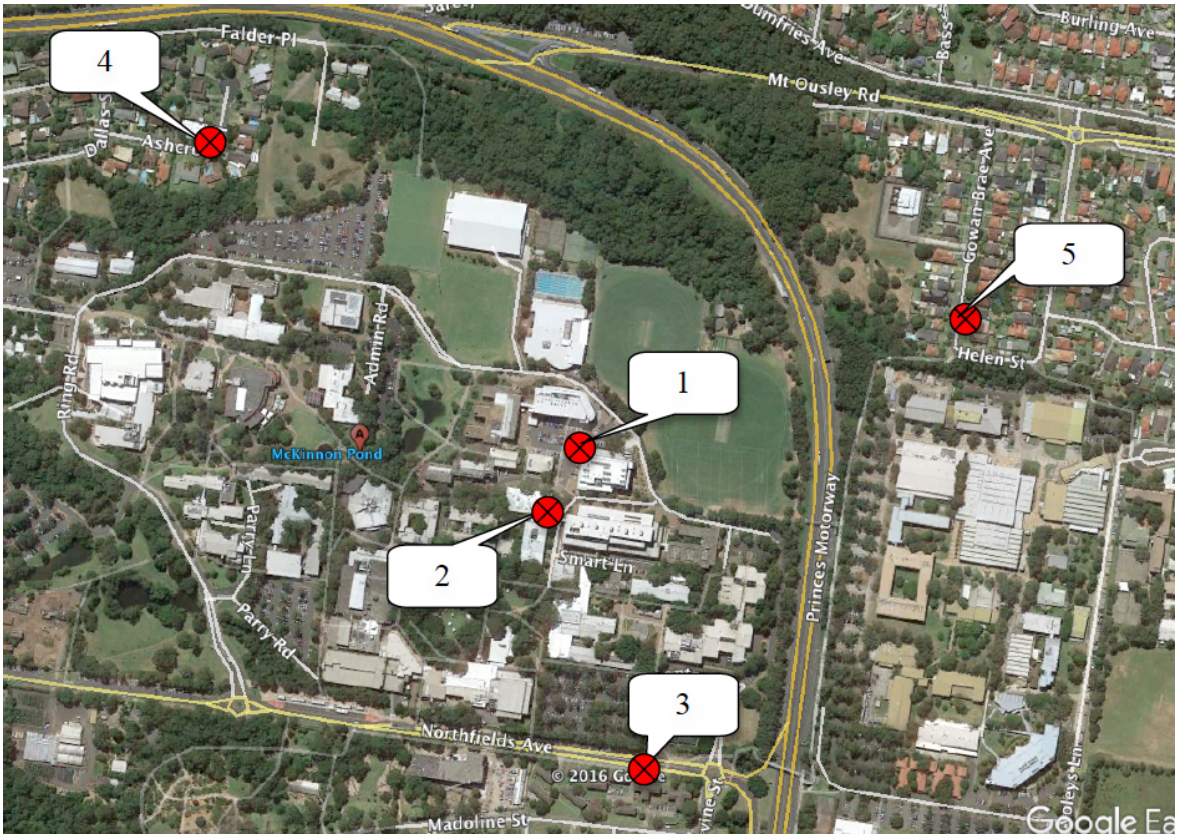


Figure 3: Approximate attended measurement locations shown in red.

The existing ambient noise levels at these locations were dominated by continuous mechanical plant noise from various buildings on campus.

Mid-afternoon measurements were taken.

The results of the short-term background and ambient noise monitoring around the existing site are shown in Table 2.

Location	Time of Measurements	$L_{eq,15min}$ Ambient Noise, dB(A)	$L_{90,15min}$ Background Noise, dB(A)	Notes
S1 – eastern side of Building 43 (Sciences Teaching Facility)	Friday 2/12/16 12-1pm	53	52	Dominated by plant noise from Buildings 41 and 35. Car passby on local university road measured 59dB(A).
S2 – Building 35 (Biology / Information Sciences)	Friday 2/12/16 12-1pm	57	51	Dominated by plant noise from university buildings, but in a position which was less exposed to existing industrial noise in accordance with NSW INP measurement methods.
S3 – Graduate House on Northfield Ave	Friday 2/12/16 2-3pm	58	52	Dominated by road traffic noise along Northfield Avenue. Construction noise audible from the works site located to the west.
S4 – 13 Ashcroft Place	Friday 2/12/16 2-3pm	52	50	Dominated by Princes Motorway to the north. Individual truck passby event measured 57dB(A).
S5 – 18 Gowan Brae Avenue	Friday 2/12/16 3-4pm	48	44	Dominated by Princes Motorway to the west. Individual truck passby event measured 57dB(A).

Table 2 : Short-term background and ambient noise levels measured around the MLS Building site

4 Mechanical Plant Noise Impact Assessment

4.1 Environmental noise limits

The NSW INP is specifically aimed at assessing noise from industrial noise sources, including plant, scheduled under the Protection of the Environment Operations Act 1997.

It is noted that the Policy is designed for large and complex industrial sources.

However, the general objectives of an assessment carried out in accordance with the INP do apply in any noise assessment and have been considered in this assessment:

- Identify any beneficial or adverse noise impacts that might result in the surrounding community.
- Describe any noise mitigation measures and strategies that will be necessary to protect the acoustic amenity of the area.
- Describe the methods by which compliance with the acoustic criteria can be determined after the facility is operational.

The INP applies to fixed facilities, commercial premises and individual industrial sources such as heating, ventilating and air conditioning (HVAC) equipment. It is also typically applied for general maintenance noise such as cleaning activities. It provides guidance on the methodology for determining limiting noise criteria designed for external noise emissions typically associated with mechanical plant.

The NSW INP defines environmental industrial noise goals in two ways. The goals apply at the most-affected point on or within the residential boundary and are location-dependent. They also depend on the occupancy: residential, commercial, educational, etc.

The INP considers the following when establishing the criteria:

- The *time of day* that the noise generating development will be in operation, defined by the following:
    - Day (7am to 6pm)
    - Evening (6pm to 10pm)
    - Night (10pm to 7am)
- The existing *Ambient* (L_{eq}) and *Background* noise levels (L_{90}) that surround the site.
- The *type of noise source* and its characteristics. The INP provides modifying factors for noise sources with certain characteristics that may potentially cause greater annoyance than other noise sources of the same level.

The residential ***intrusiveness*** criterion aims to control short duration noise impacts and is based on the existing background noise level, and is defined as:

$L_{Aeq,15\ minute}$ from new noise source ≤ Existing long-term $L_{A90,Day/Evening/Night}$ + 5.

The ***amenity*** criterion aims to maintain noise amenity for a particular land use, including non-residential uses. It defines recommended noise levels, called Acceptable Noise Levels (ANL), for different neighbourhood types. The suburban residential ANLs are applicable to the UoS MLSB project and are:

- Day time (7am to 6pm): 55 $dBL_{Aeq\ (11hrs)}$
- Evening (6pm to 10pm): 45 $dBL_{Aeq\ (4hrs)}$
- Night time (10pm to 7am): 40 $dBL_{Aeq\ (9hrs)}$

Based on the existing noise levels from the unattended noise monitoring, Table 3 presents the environmental noise limits for the MLS Building proposal at surrounding residential and commercial property boundaries. Details of measured levels on-site and the process to obtain the project specific noise levels are provided in Appendix B.

The criteria presented in the table below apply to operational noise break-out from the new building, including mechanical plant noise. Derived external noise management levels assume that windows can be kept open sufficiently to provide natural ventilation.

Type of Receiver	Period	Noise Criteria ($L_{Aeq,\ period}$)
Residential – Suburban (external) – includes graduate housing	Day	55 intrusive, 55 amenity
	Evening	53 intrusive, 45 amenity
	Night	52 intrusive, 40 amenity
Commercial (external)	When in use	65 amenity
Classroom (Internal) (derived external, windows open)	Noisiest 1-hr period when in use	40 amenity (internal)
	Noisiest 1-hr period when in use	50 amenity (external)

Table 3 : Summary of noise criteria for Molecular and Life Sciences mechanical plant noise assessment

4.2 Noise sources

At this stage, final plant selections have not been made. However, the mechanical and electrical services engineer for the project (Arup) has provided Acoustic Studio with a general layout and rooftop plant room equipment list to be installed.

A general summary of proposed rooftop mechanical plant for the Molecular and Life Sciences Building is shown below:

- Rooftop: Cooling tower(s), water-cooled chiller(s)
- Rooftop: General heating plant – boilers, pumps, etc

- Rooftop: General plant serving risers, eg exhaust fans, air handling units, condenser units
- Level 4 plant room: General plant serving risers, eg exhaust fans, air handling units, condenser units
- Ground floor: Substation, emergency generator

It is likely that most rooftop mechanical plant will operate day and evening hours, Monday to Friday. However, there may be some after hours plant operating depending on UoW requirements. Therefore the assessment considers 24-hour operation, seven days a week.

The proposed plant room indicative layout is shown in the Architectural rooftop drawings.

4.3 Noise assessment and noise control recommendations

Plant associated with the operation of the proposed buildings should be controlled to ensure external noise emissions are not intrusive and do not impact on the amenity of neighbouring receivers.

At this stage, final plant selections have not been made for each plant item; therefore a detailed assessment has not been carried out.

A preliminary review has been carried out for the rooftop plant and we make the following comments:

- Based on the plant room location, the most restrictive criteria (see Section 4.1) is 50dB(A) at noise-sensitive educational receivers during the day, evening and night-time periods, assuming windows may be kept open sufficiently to provide natural ventilation, or 60dB(A) if windows can be kept closed.
- Based on the plant room location, compliance with the educational criteria on campus will result in compliance with the residential criteria, ie 55 dBA, 45 dBA and 40 dBA during the day, evening and night-time periods respectively.
- Considering the distance attenuation between the plant room to the nearest noise-sensitive receivers at IHMRI, noise emissions from the rooftop plant room shall be limited to 80 dBA at 1 metre from the plant room boundaries to comply with the applicable criteria. The attenuation required for each plant item will depend on their location and orientation on the rooftop.

Noise controls will be incorporated with the design of the rooftop plant room and any other plant located outdoors on other levels of the proposed building to ensure that the cumulative noise output from plant at the nearest affected receivers is within the allowable limits.

The Mechanical Engineer for the MLS Building (Arup) has provided manufacturer sound level data for the main noise sources on the MLS Building rooftop.

General design considerations and controls that may need to be implemented typically include, but are not limited to:

- Strategic selection and location of plant to ensure the cumulative noise contribution at the receiver boundary is achieved, and/or
- Acoustic noise control measures to be put in place to minimise noise impacts such as:
  - Noise enclosures as required
  - Noise barriers as required
  - Acoustics as required
  - In-duct attenuation
  - In-built attenuation for noisy equipment
  - Sound absorptive panels

The preliminary rooftop plant selection does not require any acoustic louvres but these will continue to be considered as an option if plant selections change during detailed design.

In addition, plant such as pumps and chillers are likely to require acoustic plinths and vibration isolation mounts to protect the occupied floors below from structure-borne vibration and noise.

Ground floor plant may require acoustic louvres or screens to meet applicable noise targets for students or staff walking past the building.

5 Operational Noise Impact Assessment

5.1 Noise sources

It is anticipated that any noise impacts to residential receivers from the operations of the proposed will be due to activities that currently occur in the existing buildings.

Anticipated 'worst-case' noisy activities associated within MLS operations are the laboratories and workshop operations. These are not likely to present acoustic impacts on nearby noise-sensitive educational receivers on campus.

Traffic noise associated with the development needs to be assessed in the context of the existing road traffic noise environment and in accordance with the NSW EPA Road Noise Policy. This includes the potential for sleep disturbance from noise from individual road traffic noise events such as waste or delivery vehicles.

5.2 Traffic noise criteria

This report needs to assess changes in character, location and potential increase in traffic noise associated with the project.

Any additional traffic generated by this proposal needs to be assessed in accordance with the following guidelines:

- NSW EPA *Road Noise Policy* (2011).
- Australian Standard AS 3671-1989 *Acoustics – Road traffic noise intrusion – Building Siting and Construction* (for guidance only; applies to siting of the receiver buildings).

The Road Noise Policy is applicable to traffic-generating developments including major road infrastructure developments. The emphasis is on achieving a reasonable balance between what is achievable on different road types and the sensitivity of different receiver types to road traffic noise. This is not directly relevant to the UoW MLSB proposal as it does not include any new or upgraded road infrastructure. Nevertheless, some changes to existing car parking arrangements will occur due to the removal of the existing P7 car park and relocation of parking to the upgraded P5 car park.

The Australian Standard has a different emphasis, in that it aims to identify appropriate intrusive road traffic noise criteria in different building types. This will become important during the detailed design of the school buildings.

5.3 Noise assessment and noise control recommendations

For the purpose of this operational noise assessment, the workshop and laboratory operational scenarios have been considered.

The Traffic Noise Assessment prepared by Caldwell and Kent (24 January 2017) predicts a maximum of 78 additional cars during AM or PM peak hour due to the MLS project. This is a minor increase in existing traffic numbers and represents less than 0.2dB increase in overall traffic noise levels at nearest affected receivers.

The operations inside the proposed MLS project operations are not expected to result in any change to, or increase in, current UoW operational noise impacts for the most affected residential receivers, for any of the scenarios considered.

Therefore no operational noise controls are recommended at this stage.

During Design Development stage, the internal source levels of each type of laboratory, workshop and any other noisy spaces will be identified, and the sound insulation performance requirements of the building envelope (façade and roof systems) will be examined in detail to ensure that operational noise emissions to affected sensitive receivers meet applicable criteria.

6 Construction Noise and Vibration Assessment

Currently the project is at a preliminary design stage and the detailed construction program is not yet fully defined. This report provides general recommendations only and provides applicable criteria together with best noise and vibration control practices to be observed during the construction of the MLS Building project.

6.1 Relevant codes and standards

In preparing this construction noise and vibration assessment, the following legislation, codes and standards have been found to be relevant for the Molecular and Life Science Building project:

- The Office of Environment and Heritage (OEH, formerly EPA) "Interim Construction Noise Guideline", 2009
- The Office of Environment and Heritage (OEH, formerly EPA) "Assessing Vibration: A Technical Guideline", 2006
- Standards Association of Australia "AS 2436-198: Guide to Noise Control on Construction, Maintenance & Demolition Sites", 1981
- Standards Association of Australia "AS 2670.2-1990: Evaluation of human exposure to whole-body vibration – Part 2: Continuous and shock-induced vibration in buildings (1 to 80 Hz)", 1990
- British Standards Institution "BS 6472:1992 – Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)", 1992
- Protection of the Environment Operations Act 1997

6.2 Construction noise and vibration criteria and limits

6.2.1 Airborne construction noise

Recommended standard hours of work in the OEH / EPA Interim Construction Noise Guideline (ICNG) are as follows:

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

The OEH / EPA suggests construction noise management levels that may minimise the likelihood of annoyance being caused to noise sensitive residential receivers depending on

the duration of works. The management levels for long-term duration works, such as those proposed for the MLS Project, are as follows:

- Within recommended standard hours.

  The $L_{Aeq,15min}$ level measured at the most exposed boundary of any affected residential receiver when the construction site is in operation must not exceed the background noise level by more than 10 dBA. This noise level represents the point above which there may be some community reaction to noise.

  However, in the case of a highly noise affected area, the construction noise level ($L_{Aeq,15min}$) at the most exposed boundary of any affected residential receiver when the construction site is in operation should not exceed 75 dBA. This level represents the point above which there may be strong community reaction to noise.

  For out of hours works, Acoustic Studio adopts a Sleep Disturbance screening level as the High Affected airborne noise limit. This is equal to 15dB above the background noise level.

- Outside recommended standard hours.

  The $L_{Aeq,15min}$ level measured at the most exposed boundary of any affected residential receiver when the construction site is in operation must not exceed the background level by more than 5 dBA.

  It is noted that a strong justification is required for works outside the recommended standard hours.

  For the MLS Building, it is be appropriate to plan for out of hours works on Saturdays, eg 1pm to 6pm, to account for the fact that site access will be safer and construction impacts on university receivers will be reduced when classes are not in session. This acoustic assessment presents noise management levels for out of hours works to help inform works planning decisions.

The ICNG also suggests construction noise management levels for commercial and retail premises and for recreation areas surrounding construction sites. These levels are applicable to the noise-sensitive commercial / retail and educational premises within and around the UoW Wollongong main campus. They are as follows:

- Commercial and retail premises : $L_{Aeq,15min}$ 70 dBA (external)
- Educational institutions : $L_{Aeq,15min}$ 45 dBA (internal)

Table 4 below summarises the airborne construction noise criteria for most-affected noise sensitive receivers surrounding the MLS Building site.

Sensitive Receiver	Airborne Construction Noise Criteria, in dB L_{Aeq}	
	Within Standard Hours	Outside Standard Hours
Residential properties including graduate housing		
Noise affected	51 + 10 = **61 M-F** 48 + 10 = **58 Sat**	49 + 5 = **54 M-F eve, Sat 1-6pm afternoon** 47 + 5 = **52 Sat 7-8am / 6-10pm eve** 46 + 5 = **51 Night 10pm – 7am**
Highly noise affected	75	46 + 15 = **61 Night 10pm – 7am sleep disturbance screening level**
Commercial and retail		70
Educational premises	45 (internal). Approximately 65 external with windows closed.	

Table 4 : ICNG construction airborne noise criteria for sensitive receivers surrounding MLS Building site

6.2.2 Ground-borne construction noise

The ICNG recommends internal ground-borne noise maximum levels at residences affected by nearby construction activities. Ground-borne noise is noise generated by vibration transmitted through the ground into a structure and can be more noticeable than airborne noise for some sensitive receivers. The ground-borne noise levels presented below from the OEH / EPA ICNG are for residential receivers during evening and night-time periods only, as the objective is to protect the amenity and sleep of people when they are at home.

- Evening: $L_{eq,15min}$ 40 dB(A) (internal)
- Night: $L_{eq,15min}$ 35 dB(A) (internal)

The internal noise levels are assessed at the centre of the most affected habitable room.

The ICNG only provides Evening and Night time ground borne noise criteria, and at residences only, stating that the objective of the ground borne noise criteria are to protect amenity and sleep when people are at home.

However it is important to consider the potential for structure-borne noise to cause disturbance to noise-sensitive educational receivers. Typically, structure-borne noise may become disturbing if:

- The noise is continuous (eg lasting more than 15 minutes in duration, with no respite), and is more than 5dB above the background or ambient noise level in the receiver room. This is more likely when the receiver building is shielded from airborne construction noise, so that the structure-borne component becomes dominant.
- The noise is intermittent, and is more than 10dB above the background or ambient noise level in the receiver room.

Acoustic Studio has assumed background noise levels in nearby buildings meet the internal ICNG Noise Management Levels, ie 45dB(A) for classrooms.

Acoustic Studio therefore recommends a day-time structure-borne construction noise management level in noise-sensitive educational receivers of 50dB(A) for continuous-type noise, or 55dB(A) for intermittent-type noise. This target will be reviewed in detail in consultation with affected university receivers during detailed construction method and planning stage.

6.2.3 Construction vibration

Vibration criteria for human comfort

The OEH / EPA *"Assessing Vibration: A Technical Guideline"* is based on the guidelines contained in BS 6472–1992, Evaluation of human exposure to vibration in buildings (1–80 Hz).

This guideline presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques.

Vibration in buildings can be caused by many different external sources, including construction works. The vibration may be continuous (with magnitudes varying or remaining constant with time), impulsive (such as in shocks) or intermittent (with the magnitude of each event being either constant or varying with time).

Vibration and its associated effects are usually classified as continuous, impulsive or intermittent:

- Continuous vibration continues uninterrupted for a defined period (usually throughout daytime and/or night-time).
- Impulsive vibration is a rapid build up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds.
- Intermittent vibration can be defined as interrupted periods of continuous (e.g. a drill) or repeated periods of impulsive vibration (e.g. a pile driver), or continuous vibration that varies significantly in magnitude. It may originate from impulse sources (e.g. pile drivers and forging presses) or repetitive sources (e.g. pavement breakers), or sources which operate intermittently, but which would produce continuous vibration if operated continuously (for example, intermittent machinery). This type of vibration is assessed on the basis of vibration dose values.

Vibration criteria for continuous and impulsive vibration is presented in Tables 5 and 6 below.

Location	Assessment Period	RMS velocity, mm/s(dB re 10^{-6} mm/s)		Peak velocity, mm/s(dB re 10^{-6} mm/s)	
		Preferred	Maximum	Preferred	Maximum
Residences	Daytime	0.20mm/s (106dB)	0.40mm/s (112dB)	0.28mm/s (109dB)	0.56mm/s (115dB)
	Night-time	0.14mm/s (103dB)	0.28mm/s (109dB)	0.20mm/s (106dB)	0.40mm/s (112dB)
UoW Precision laboratories	When in use	0.10mm/s (100dB)	0.20mm/s (106dB)	0.14mm/s (103dB)	0.28mm/s (109dB)
UoW Classrooms and other laboratories	When in use	0.40mm/s (112dB)	0.80mm/s (118dB)	0.56mm/s (115dB)	1.1mm/s (121dB)
Commercial and retail	When in use	0.40mm/s (112dB)	0.80mm/s (118dB)	0.56mm/s (115dB)	1.1mm/s (121dB)

Notes: *Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am*

Table 5 : Continuous vibration criteria applicable to the MLS Building Project

Location	Assessment Period	RMS velocity, mm/s(dB re 10^{-6} mm/s)		Peak velocity, mm/s(dB re 10^{-6} mm/s)	
		Preferred	Maximum	Preferred	Maximum
Residences	Daytime	6.0mm/s (136dB)	12mm/s (142dB)	8.6mm/s (139dB)	17mm/s (145dB)
	Night-time	2.0mm/s (126dB)	4mm/s (132dB)	2.8mm/s (129dB)	5.6mm/s (135dB)
UoW Precision Laboratories	When in use	0.10mm/s (100dB)	0.20mm/s (106dB)	0.14mm/s (103dB)	0.28mm/s (109dB)
UoW Classrooms and other laboratories	When in use	13mm/s (142dB)	26mm/s (148dB)	18mm/s (145dB)	36mm/s (151dB)
Commercial and retail	When in use	13mm/s (142dB)	26mm/s (148dB)	18mm/s (145dB)	36mm/s (151dB)

Notes: *Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am*

Table 6 : Impulsive vibration criteria applicable to the MLS Building Project

When assessing intermittent vibration comprising a number of events, the vibration dose value (VDV) should be used. The VDV is given by the fourth root of the integral with respect to time of the fourth power of the acceleration after it has been weighted. This is the root-mean-quad approach. The use of the fourth power method makes VDV more sensitive to peaks in the acceleration waveform. VDV accumulates the vibration energy received over the daytime and night-time periods.

VDV_e may be calculated for each event as:

$$VDV_e = 1.4 \times a_{rms} \times t^{0.25}$$

Where VDV_e is the vibration dose value in $m/s^{1.75}$, a is the frequency-weighted acceleration in m/s^2 and t is the total period of the day (in seconds) during which vibration may occur.

The total VDV is then calculated using the following formula:

$$VDV = \left(\sum_{n=1}^{n=N} VDV_{e_n}^4 \right)$$

where VDV is the total vibration dose for the day in $m/s^{1.75}$, VDV_e is the vibration dose for each event ($m/s^{1.75}$) and N is the total number of vibration dose events.

Acceptable values of vibration dose for the MLS Building Project are presented in Table 7.

Location	Assessment Period	Vibration Dose Values, $m/s^{1.75}$	
		Preferred	Maximum
Residences	Daytime	0.20	0.40
	Night-time	0.13	0.26
UoW Precision Laboratories	When in use	0.10	0.20
UoW Offices, Standard laboratories	When in use	0.40	0.80

Table 7 : Intermittent vibration criteria applicable to the MLS Building Project

Vibration criteria for building damage

The criteria given in Table 5 for Human Comfort shall generally form the limiting vibration criteria for the Project.

Further criteria to prevent building damage and disruption to equipment and processes are discussed in Appendix C.

For unoccupied buildings or during periods when the buildings are unoccupied, the most conservative criteria for building damage should be adopted as a preliminary screening criterion. Levels suggested by German Standard DIN 4150 are to be adopted as follows:

- 5 mm/s (134 dB re 10^{-6} mm/s) for residential dwellings
- 20 mm/s (146 dB re 10^{-6} mm/s) for UoW educational buildings

6.3 Noise and vibration assessment

6.3.1 Sensitive receivers

Nearest sensitive receivers to the MLS Building site that will be potentially affected by noise and vibration associated with proposed construction works are surrounding noise-sensitive residential and educational premises as presented in Section 2.2.

In summary, the most critical receivers surrounding the site for each type of impact are as follows:

- Airborne noise– Human comfort
  - Student residences approximately 300m to the south with university buildings shielding direct line of sight, 24 hours a day, 7 days a week.
  - Residences more than 300m distant with buildings shielding direct line of sight, 24 hours a day, 7 days a week.
  - Staff and students within the UoW noise-sensitive educational buildings closer to the construction works areas, when in use.
- Ground borne noise and vibration – Human comfort and sensitive equipment
  - Staff and students within the UoW sensitive educational buildings closer to the construction works areas, when in use.
- Vibration – Building damage
  - The UoW buildings structure closer to the construction works areas, 24 hours a day, 7 days a week.

6.3.2 Description of proposed works

It is anticipated that the key construction activities to occur for each area / stage are as follows:

- Site establishment and building hoardings (if required)
- Demolition, excavation, foundation and piling
- New build and fit-out works.
- Landscaping

The main phases of work have been broken up in terms of the following indicative "noise scenarios". A scenario is a work phase, characterised by the type of plant and equipment used, concurrent activities, location of works, and timing of works.

The Contractor will be responsible for preparing a Works Plan and Schedule, including updated noise and vibration impact assessments for proposed methods and timing of each stage of work.

Noise Scenario / Activity Description	List of plant	Notes about subjective impact
A. Site preparation and set up, including site amenities	Generators Trucks Hammers Hand tools	High vibration: N Tones or impulses: Y - reversing alarms
B. Demolition of existing structures	Concrete saws Sledgehammers Jackhammers Removal of building waste	High vibration: Y Tones or impulses: Y
C. Piling and excavation	Piling Rig Excavator Removal of material waste	High vibration: Y Tones or impulses: Y
D. Construction of new buildings	Truck Crane Concrete pump truck Hand tools Removal of building waste	High vibration: N Tones or impulses: Y - reversing alarms
E. Landscaping	Truck Crane Diggers, excavators Concrete mixer Hand tools	High vibration: Y – digger / excavator Tones or impulses: Y - reversing alarms
F. Flooring, partitions, electrical + mechanical works	Hand tools	High vibration: N Tones or impulses: N
G. Internal fit-out, fixtures, joinery	Hand tools	High vibration: N Tones or impulses: N

Table 8 : Indicative work phases, subjective impact considerations and timing

6.3.3 Noise and vibration sources

As detail of construction noise equipment / plant to be used during the construction stages of the project is not known at the time of this assessment, a generic approach has been adopted and noise sources normally found on construction sites similar to the MLS Building site have been considered.

Potential sources of vibration and ground-borne noise during the MLS Building project works include:

- Demolition, excavation, foundation preparation and piling
- Installation of structural steel work
- Grinding, cutting and drilling of existing building structures.

Vibration and ground-borne noise impacts are likely to be highest during the demolition, excavation and piling stages of the project.

The anticipated airborne noise levels for the likely construction noise sources for the MLS Building project are listed in Table 9.

Noise Source / Plant	Sound Power Level, $L_{eq,T}$ dB(A)	Sound Pressure Level, $L_{eq,T}$ dB(A), at 10m
Dump Truck (tipping material)	117	89 (+5dB penalty – tonal reversing alarm)
Truck, Forklift *(vibration source)*	107	79 (+5dB penalty– tonal reversing alarm)
Front end / Wheeled loader *(vibration source)*	111	83 (+5dB penalty– tonal reversing alarm)
Skidsteer loader (½ tonne) *(vibration source)*	104	76 (+5dB penalty– tonal reversing alarm)
Generator, 4 stroke portable petrol	103	75
Generator, diesel	113	85
Concrete Saw, handheld *(vibration source)*	117	89 (+5dB penalty)
Jack Hammer *(vibration source)*	121	93 (+5dB penalty)
Bulldozer	108	80
Piler (bored)	111	83
Piler (impact sheet) *(vibration source)*	137	109 (+5dB penalty)
Piler (vibratory) *(vibration source)*	125	97 (+5dB penalty)
Excavator *(vibration source)*	107	79
Compactor *(vibration source)*	113	85
Vibratory roller *(vibration source)*	108	80
Concrete pump truck	108	80
Asphalt Paver *(vibration source)*	108	80
Asphalt Rotomill (scabbler)	111	83
Hammer / percussive drill	112	84 (+5dB penalty)
Electric drill	91	63
Electric hand tools	102	74
Welder	105	77
Mobile crane	106	78

Table 9 : Typical mid-point sound power and pressure levels of plant typical to the proposed construction

6.3.4 Noise assessment results

At this stage of the project there is no detailed information on the types of plant and equipment that will be used during construction, and only high level information regarding the construction scheduling or program. Therefore, this construction noise assessment examines potential noise impact of various generic items of plant and equipment listed in Table 9 above, at the most affected receivers.

In order to meet the applicable construction noise criteria at all affected receivers during standard construction hours, the maximum allowable sound pressure level at the boundary of the construction site are listed in Table 10 below. The table indicates that for all construction scenarios, residential criteria are met, including out of standard work hours. Educational receivers on campus may experience excessive noise for some works activities, and these will need to be managed.

Allowances have been made for distance attenuation, shielding, ground reflections and reflections from existing structures.

Receiver location	Noise Criteria	Distance from nearest site boundary (m)	Maximum sound pressure level ($L_{Aeq,15min}$) at the site boundary to meet noise criterion
Residences > 300m from site boundary (external noise level)	61 – Weekday standard 58 – Saturday standard 52 to 54 – Saturday Out of hours	> 300	110 107 101
Educational Buildings	65 (external – windows closed) 55 (external – windows open) 45 (internal)	> 20	**91** – Windows closed **81** – Windows open

Table 10 : Maximum allowable construction noise levels at the nearest construction site boundary to the most affected sensitive receivers. **Bold** indicates the applicable noise criteria.

While the UoW is operational, with nearby buildings being used (particularly on weekdays), the allowable sound pressure levels at the site boundaries are approximately 80dB$L_{Aeq,15min}$ if nearby receiver windows are open, and 90dB$L_{Aeq,15min}$ if windows are kept closed. This equates to equipment sound power levels of approximately 107dB$L_{Aeq(15min)}$, if the equipment is located near the site boundary.

Table 8 indicates that activities likely to require additional noise controls to protect the amenity of receivers on campus include rock / concrete cutting, piling, jackhammering, drilling, and tipping material. Noise from these activities can be controlled through localised hoarding or screening, management controls to ensure that university receiver

buildings keep windows closed during noisy works, and timing of noisy works when the most affected educational receivers are not in use.

In order to minimise disruption to university business, as well as minimising hearing and safety risks to university students and staff, works may be conducted on Saturdays.

Saturdays would be a justifiable option for noisier works as fewer educational buildings will be operating, and the Saturday out of hours noise management level will be met with site boundary works noise levels of 100dB$L_{Aeq(15min)}$ at the nearest residential receivers over 300m away. The out-of hours Saturday residential noise limit will be achieved for all the proposed works plant and activities.

At ground level, the 90dB$L_{Aeq,15min}$ level would be considered excessive at university walkways, and site hoarding should be installed for external works involving equipment with a sound power level of greater than 100dBL_{Aeq}, such as rock / concrete cutting, piling, jackhammering, drilling, and tipping material.

Continuous noise associated with standard deliveries and internal construction works are expected to comply with stated standard hours criteria for residences.

However, there will be times / situations when external demolition and construction works are likely to exceed stated criteria at UoW educational receivers.

For each of these activities and assuming that, in fact, these activities are found to exceed the noise criteria, then the noise control measures in 6.4.1 shall be considered and implemented wherever reasonable and feasible. In addition, the construction best practices presented in Section 6.4.4 shall be considered to minimise the noise impacts on nearby receivers.

The table below recommends typical noise controls that should be considered for the construction stages.

Noise Scenario / Activity Description	List of plant (dB(A) at 10m)	Desired outcome	Mitigation measures
A. Site preparation and set up, including erection of hoarding and site amenities	Generators (75 petrol, 85 diesel) Trucks (79) Hammers (70) Hand tools (74)	Use site preparation to prepare for subsequent works stages which will require noise mitigation.	Hoarding is to be erected as close to commencement of construction as possible, particularly if required to protect pedestrian walkways from excessive noise. If a generator is required, use petrol generator rather than diesel, or inside an enclosure to reduce noise by at least 10dB. Use mains power as soon as practicable during works. Truck movements to be minimised. Avoid unnecessary idling and reversing.

Noise Scenario / Activity Description	List of plant (dB(A) at 10m)	Desired outcome	Mitigation measures
B. Demolition of existing structures	Concrete saws (89) Sledgehammers (80) Jackhammers (93) Removal of building waste (84)	Aim for 15 dB noise reduction around concrete saws and jackhammers.	Use local noise curtains around noisy equipment such as concrete saws / jackhammers.
C. Piling and excavation	Piling (bored 83 / vibratory 97 / impact 109) Removal of building waste (84) Compactor (85) Excavator (79)	Aim to minimise vibration effects on underground services – bored piling may be required. For airborne noise, aim for 15-20dB noise reduction.	Low noise and vibration piling should be considered. Excavation and piling activities may require vibration monitoring for the nearby UoW buildings and underground services if they are identified as vibration-sensitive.
D. Construction of new building	Truck (79) Crane (78) Hand tools (74) Concrete pump truck (80)	May meet noise management levels without mitigation, depending on the equipment.	Use local noise curtains (eg mass loaded vinyl) around noisy hand tools if required. Truck movements to be minimised. Avoid unnecessary idling and reversing.
E. Landscaping (may be concurrent with internal works)	Truck (79) Truck (tipping fill) (89) Diggers, excavators (79) Hand tools (74) Asphalt paver (80)	Aim for 10-15dB noise reduction for trucks, excavators and tipping fill.	Use local noise curtains (eg mass loaded vinyl) around noisy hand tools if required. Consider quieter methods for compacting and tipping fill.
F. Flooring, partitions, electrical + mechanical internal works	Hand tools - external works (74) Hand tools – internal works	Likely meet noise management levels without mitigation, depending on the equipment.	Keep windows closed during internal works.
G. Internal fit-out, fixtures, joinery	Hand tools - internal works (74)	Likely meet noise management levels without mitigation, depending on the equipment.	Keep windows closed during internal works.

Table 11: Typical source noise levels for works stages, and examples of noise control works practices.

6.3.5 Vibration assessment results

At this stage of the project there is no detailed information on the types of plant and equipment that will be used during construction, or on the construction scheduling or program. Therefore, this construction vibration assessment provides potential vibration impact of various generic 'vibration-intensive' activities at most affected receivers surrounding the site, based on vibration measured data recorded on-site during preliminary works.

Vibration construction impacts at sensitive surrounding receivers will also depend on the ground conditions as the type of terrain determines the vibration propagation and the

amount of attenuation in between the vibration sources and the receiver. As detailed in Sections 6.4.3 and 6.5.6 below, the Contractor should conduct vibration monitoring at nearest sensitive receivers prior to commencement of any 'vibration-intensive' activities in order to guarantee that no adverse impacts occur when the construction works start.

6.4 Control elements

6.4.1 Noise

As a general rule, noise controls should be applied as universal work practice at any time of day, but especially for the occasional construction works to be undertaken at critical times outside normal daytime/weekday periods.

It is noted that the reduction of noise at the source and the control of the transmission path between the construction site and the receiver(s) are the preferred options for noise minimisation. Providing treatments at the affected residences or other sensitive land uses should only be considered as a last resort.

Construction noise shall be managed by implementing the strategies listed below:

- Plant and equipment
  - Use quieter methods.
  - Use quieter equipment.
  - Operate plant in a quiet and effective manner.
  - Where appropriate, limit the operating noise of equipment.
  - Maintain equipment regularly.
  - Where appropriate, obtain acoustic test certificates for equipment.
- On site noise management
  - Strategically locate equipment and plant.
  - Avoid the use of reversing alarms or provide for alternative systems.
  - Maximise shielding in the form of existing structures or temporary barriers.
  - Schedule the construction of barriers and structures so they can be used as early as possible.
- Consultation, notification and complaints handling
  - Provide information to neighbours before and during construction.
  - Maintain good communication between the community and Project staff.
  - Have a documented complaints process and keep register of any complaints.
  - Give complaints a fair hearing and provide for a quick response.
  - Implement all feasible and reasonable measures to address the source of complaint.

- Work scheduling
  - Schedule activities to minimise noise impacts.
  - Ensure periods of respite are provided in the case of unavoidable maximum noise levels events.
  - Keep truck drivers informed of designated routes, parking locations and delivery hours.

6.4.2 Vibration

The Contractor shall carry out a preliminary vibration assessment at the commencement of operations for each vibration generating plant to determine whether the existence of significant vibration levels justifies a more detailed investigation.

A more detailed investigation will involve methods of constraining activities generating high vibration levels. A method of monitoring vibration levels will then need to be put in place. Vibration mitigation measures and a review of vibration criteria may then be necessary.

All practical means should be used to minimise impacts on the affected buildings and occupants from activities generating significant levels of vibration on site.

The following considerations shall be taken into account:

- Modifications to construction equipment used.
- Modifications to methods of construction.
- Rescheduling of activities to less sensitive times.

If the measures given above cannot be implemented or have no effect on vibration levels or impact generated, a review of the vibration criteria should be undertaken and the vibration management strategy amended.

6.4.3 Vibration surveys

Since the actual vibration levels experienced will be dependent upon the site characteristics and the specific equipment being used, early vibration level checks should be carried out on site at the outset of each key vibration generating activity (if vibration is considered to be an issue).

Shortly before the commencement of each activity the background vibration level could be measured and again once the activity has begun. If the survey indicates levels of vibration exceeding those expected, the vibration management strategy for that process could be re-assessed.

6.4.4 Additional noise and vibration control measures

If, during construction, an item of equipment exceeds ether the noise criteria at any location or the equipment noise level limits, the following noise control measures, together with construction best practices presented in Section 6.4.1, shall be considered to minimise the noise impacts on the neighbourhood.

- Schedule noisy activities to occur outside of the most sensitive times of the day for each nominated receiver. For example, the residential receivers are likely to be more sensitive to noise before 9 am than the UoW campus receivers.
- Consider implementing equipment-specific screening or other noise control measures recommended in Appendix E of AS2436.
- Limit the number of trucks on site at the commencement of site activities to the minimum required by the loading facilities on site.
- When loading trucks, adopt best practice noise management strategies to avoid materials being dropped from height into dump trucks.
- Avoid unnecessary idling of trucks and equipment.
- Ensure that any miscellaneous equipment (extraction fans, hand tools, etc) not specifically identified in this plan incorporates silencing/shielding equipment as required to meet the noise criteria.

Implementation of all reasonable and feasible mitigation measures for all internal and underground works will ensure that any adverse noise impacts to surrounding residential, commercial and recreational receivers are minimised when noise goals cannot be met due to safety or space constraints.

6.5 Noise and vibration monitoring

6.5.5 Noise monitoring

The Contractor may implement environmental noise monitoring at the locations described below.

- North-facing graduate residential colleges.
- Nearest off campus residential receivers

The proposed noise monitoring locations match those used for the acoustic assessment (refer Figure 3). These locations represent the nearest affected residential and educational receivers to the works. All works are expected to comply with the residential construction noise criteria, even for early morning and evening works. However, this will be confirmed through noise monitoring at residential locations for the noisiest works (excavation, piling and demolition).

An allowance of 1.5 days per week, at least, should be dedicated to monitoring of noise and vibration for the first four weeks of demolition and construction. Further monitoring should be reviewed after this time or sooner should it be deemed necessary by the Acoustic Consultant and the Project Manager. This should take place mainly at the above locations although other locations and plant and equipment monitoring should take place as and when necessary. If results indicate vibration levels exceeding allowable limits appropriate action should be taken.

6.5.6 Vibration monitoring

A vibration monitoring system may be implemented during vibration-intensive activities such as excavation and piling. This system would monitor vibration levels when there is potential for them to change. This could happen in various situations, such as, changes in equipment and activities or changes to work procedures that might affect existing vibration control measures. The monitoring procedure would be carried out with appropriate equipment so that results obtained are readily comparable with results obtained earlier. If results indicate vibration levels exceeding allowable limits appropriate action should be taken.

6.5.7 Reporting

The Contractor should prepare a noise monitoring report each month for review by the Project Manager. The reports should summarise and interpret the results of the noise and vibration monitoring carried out during the past month.

6.6 Construction-related traffic noise

Construction-related road traffic noise can affect receivers far from the site, if heavy good vehicles and site vehicles use routes near noise-sensitive receivers. The Preliminary Construction Management Plan for the project (27 February 2017) identifies likely routes for construction-related road traffic which are unlikely to increase existing road noise. Major roads such as the Princes Motorway will be used as vehicle access routes rather than local roads where possible.

Braking and accelerating noise will need to be managed for heavy good vehicles travelling to or from the works site.

The works site should be set out in a way that minimises vehicle reversing so that reversing alarms are generally not required. Non-tonal reversing alarms should be used where practicable.

6.7 Communication and complaints

The Contractor should establish a communications register for recording incoming complaints. Although it is highly unlikely that residential noise management levels will be exceeded for any of the proposed works, the Contractor will make public a telephone number and email address to direct any communications or other feedback about the works.

The registration of a particular item will remain open until the complaint has been appropriately dealt with.

In addition the following procedures are an example of the procedures that should be specifically adopted for complaints relating to noise.

Upon receipt of a complaint The Contractor should:

- Try to ascertain from the complaint which appliance is causing the problem i.e. inside or outside the site and in what position.
- Establish from the noise monitoring equipment if the allowable noise levels have been complied with.
- Establish if the appliance or equipment positioning has previously been highlighted as a problem area. If not and the noise levels are above the allowable limit, then the equipment and its position shall be noted.
- Move machinery if the allowable levels have been exceeded or take other acoustic remedial action.

If the activity is occurring outside normal working hours, the activity should be immediately stopped. Where stopping the activity would create a safety issue the activity may be permitted to continue only as long as is necessary to make the area safe. The activity should then cease.

Any activity which is directed to cease due to excessive noise should not recommence until the Project Manager is satisfied that the noise and vibration limits requirements can be met and has given permission to recommence the activity.

The Site Supervisor should ensure that a report of any incident is provided to the Project Manager.

The Project Manager should provide a report on the incident to the relevant stakeholders.

The Contractor should provide a 24 hour telephone contact number and this number should be prominently displayed on the site.

6.8 Non-compliances

Non-compliance reports can be used as appropriate to deal with failures to meet the construction vibration management and control requirements.

7 Conclusion

A noise and vibration assessment report has been produced to establish the potential impacts of operational noise, including mechanical services impacts, and construction noise and vibration of the proposed MLS Building project.

The existing noise environment has been established based in long-term and short-term monitoring data.

Appropriate criteria for both noise and vibration have been discussed and set according to established guidelines and standards. Noise and vibration criteria in this assessment report are consistent with SEAR for the Project.

A summary of the outcomes and recommendations of this noise and vibration assessment are as follows:

- Mechanical services noise

  At this stage, final plant selections have not been made; therefore a detailed assessment has not been able to be carried out. A preliminary review has been carried out for the main plant room located on the roof and, based on the plant room location and the most restrictive criteria, noise emissions from the rooftop plant room shall to be limited to 80 dBA at 1 metre of the rooftop plant room boundaries.

  Noise controls will be incorporated within the design of the rooftop plant room and any other plant located outdoors or on other levels of the proposed building to ensure that the cumulative noise output from plant at the nearest affected receivers is within the allowable limits. General design consideration and controls implemented will typically include; strategic selection and location of plant and/or acoustic noise control measures such as enclosures, barriers, acoustic louvres, sound absorptive panels, etc.

- Operational noise

  On the basis that activities associated with the future operations of the MLS Building, estimated operational noise levels are expected to comply with the stated criteria at the nearest residential sensitive receivers.

- Construction airborne noise

  Continuous construction noise associated with demolition, excavation, piling, new-build works are likely to generate noise levels which require some noise and vibration mitigation and management controls. Internal fitout works are expected to comply with stated criteria for nearest noise sensitive residential and educational receivers when these activities occur indoors.

If, during construction works, an item of equipment exceeds the stated airborne noise criteria at any sensitive location, the additional noise control measures presented in Section 6.4.4, together with construction best practices presented in Section 6.4.1, shall be considered to minimise the noise impacts on the neighbourhood.

- Vibration

  Vibration levels are expected to comply with the human comfort continuous vibration criteria at all sensitive receiver locations for all likely scenarios considered for the MLS works.

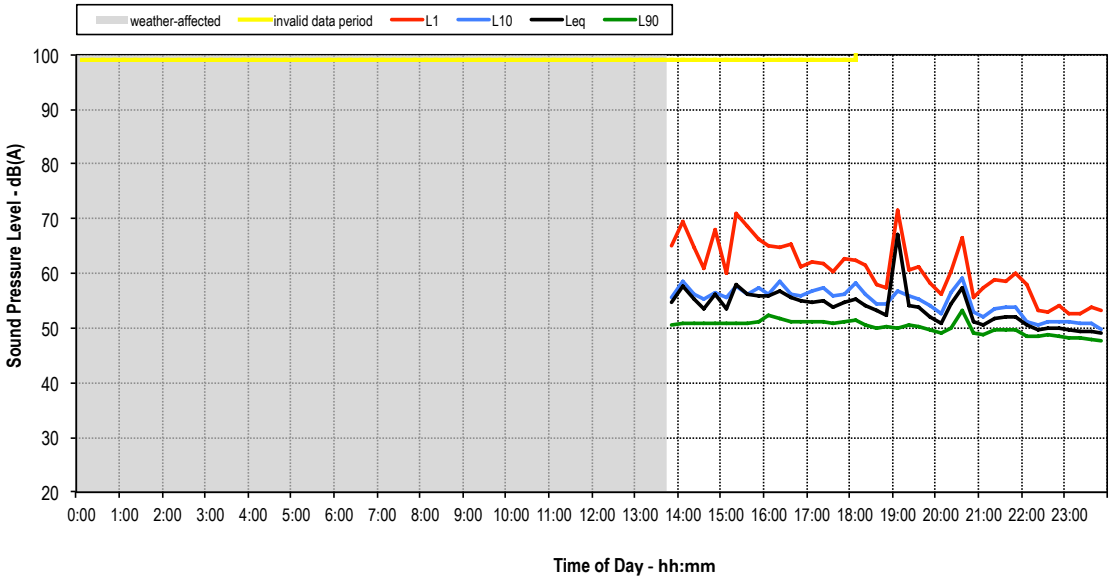
  Furthermore, anticipated vibration levels due to 'vibration intensive' works also comply with the building damage criteria.

  Further reviews of vibration impacts will be conducted as the works methods are developed, to ensure that vibration-sensitive receivers on campus are all identified and are adequately protected from the effects of excavation, piling and construction activities.

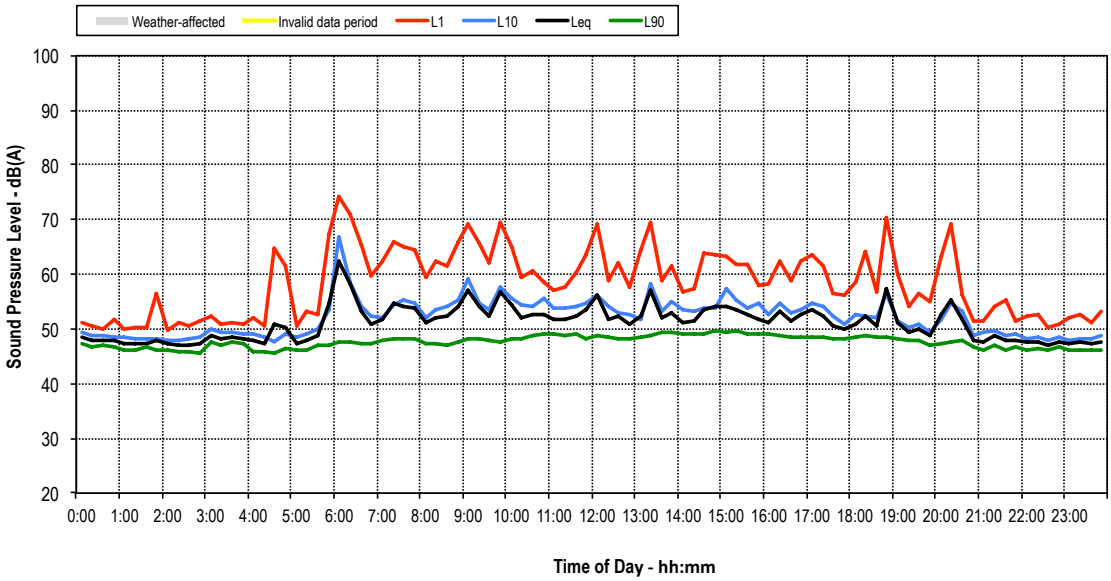
Appendices

Appendix A : Long-term monitoring results

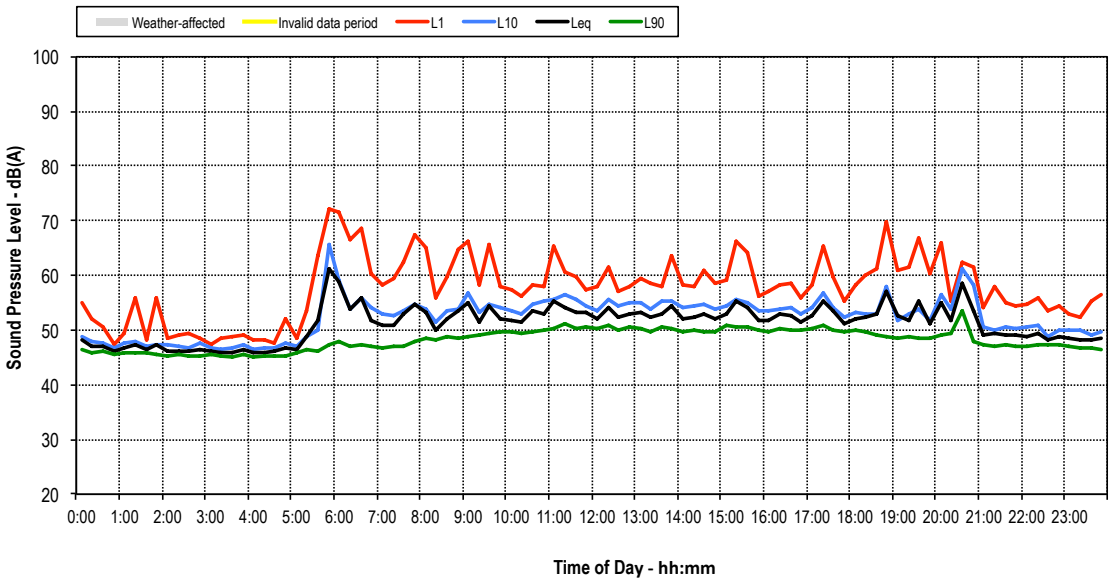
UoW Building 35 (north-east) - Friday 02 December 2016



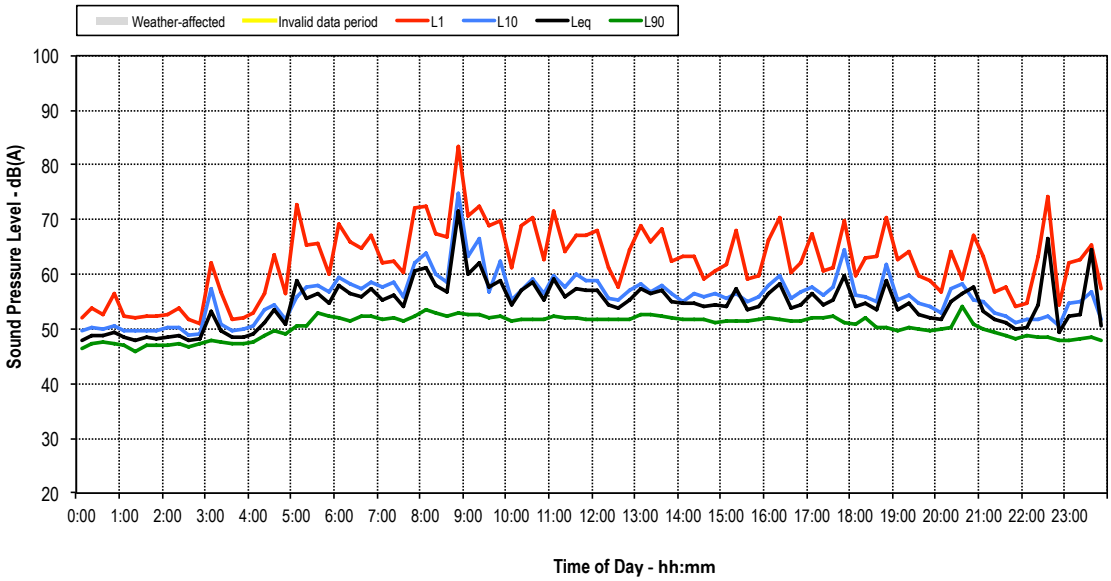
UoW Building 35 (north-east) - Saturday 03 December 2016



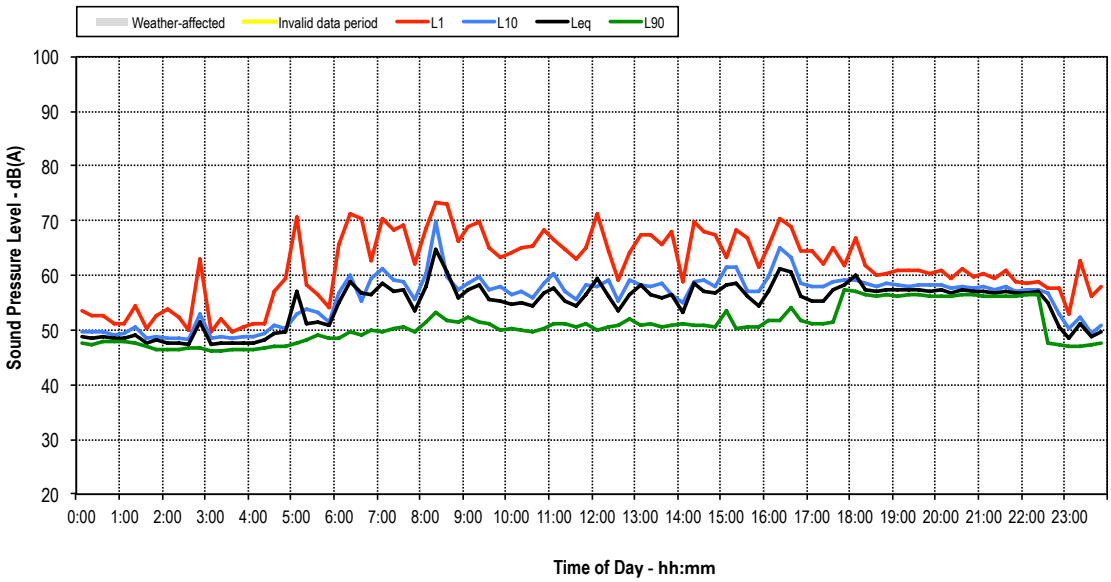
UoW Building 35 (north-east) - Sunday 04 December 2016



UoW Building 35 (north-east) - Monday 05 December 2016



UoW Building 35 (north-east) - Tuesday 06 December 2016



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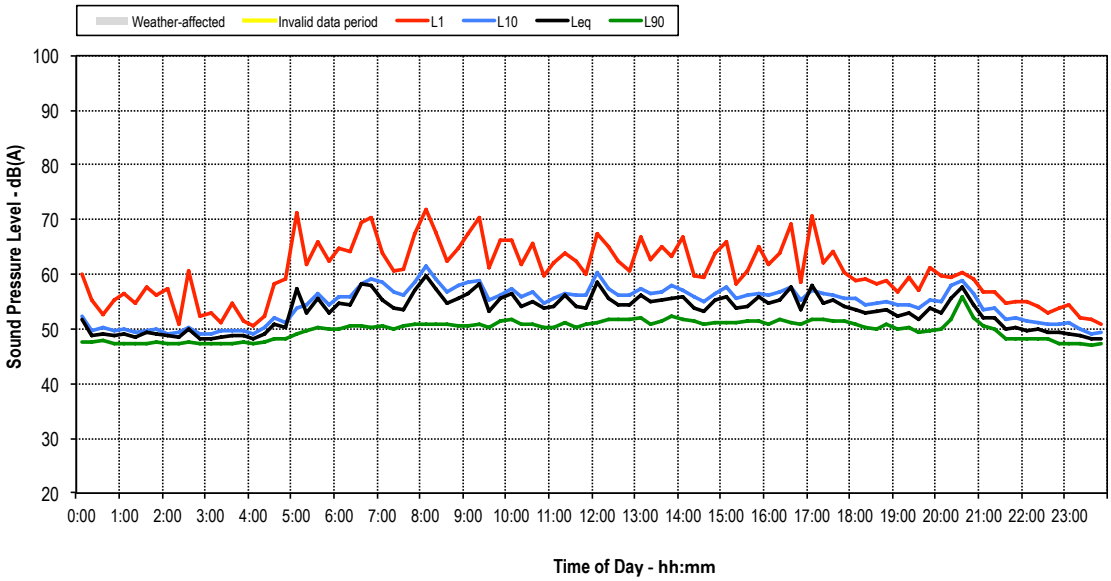
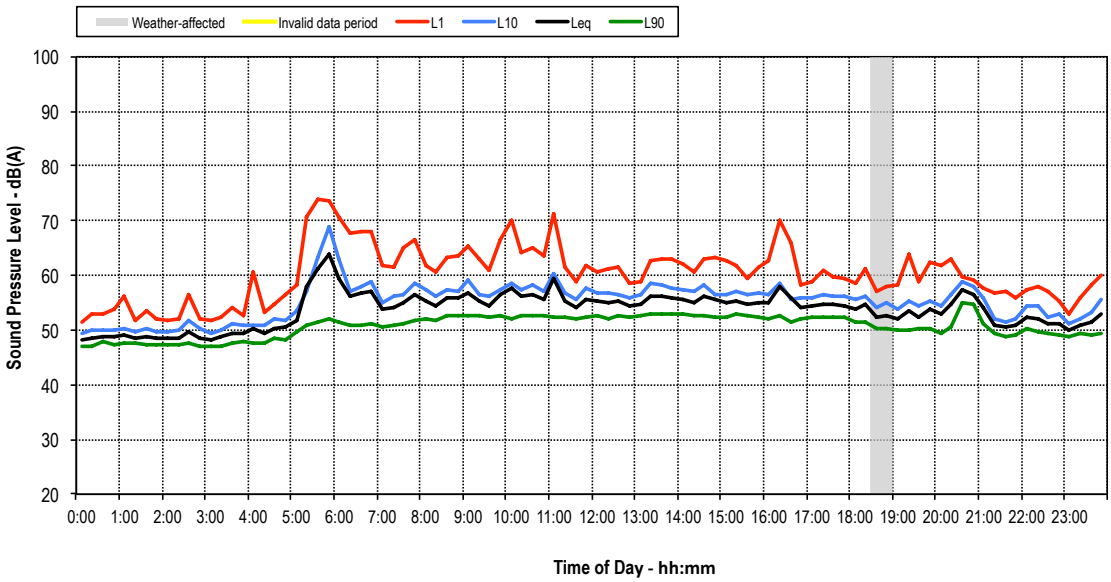
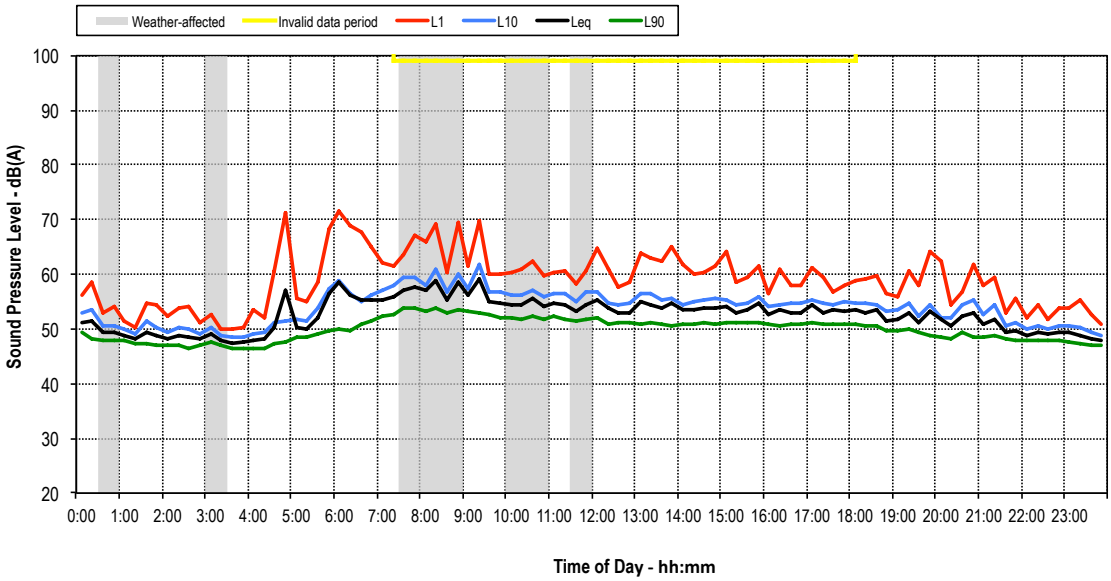


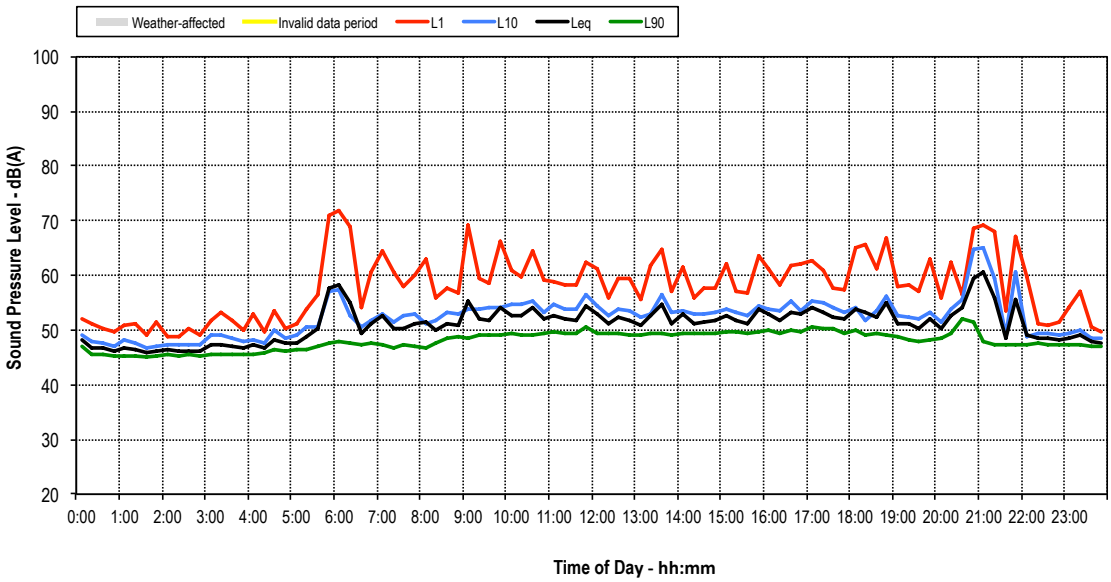
UoW Building 35 (north-east) - Thursday 08 December 2016



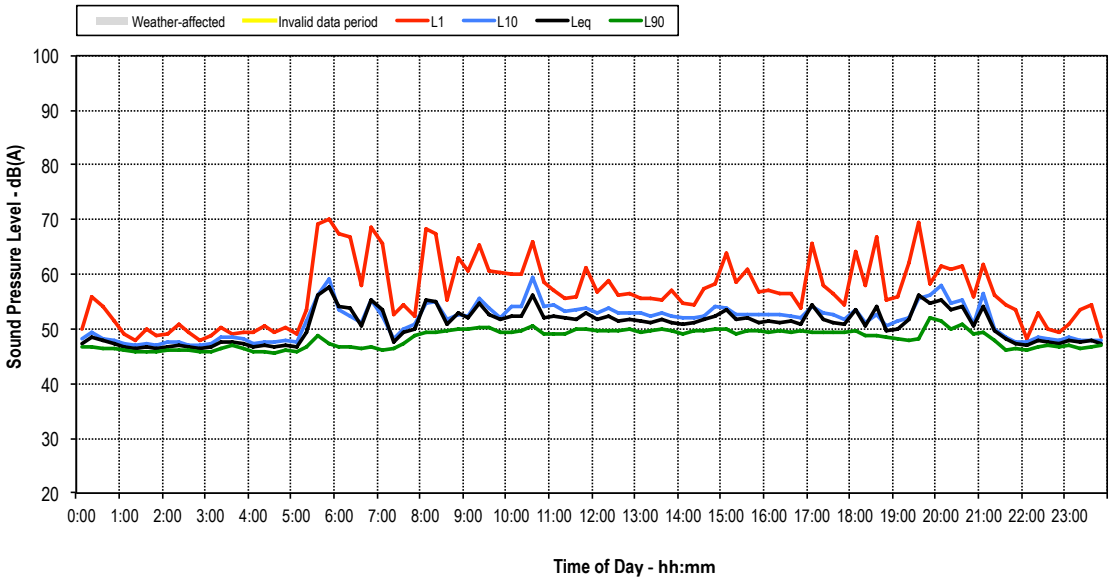
UoW Building 35 (north-east) - Friday 09 December 2016



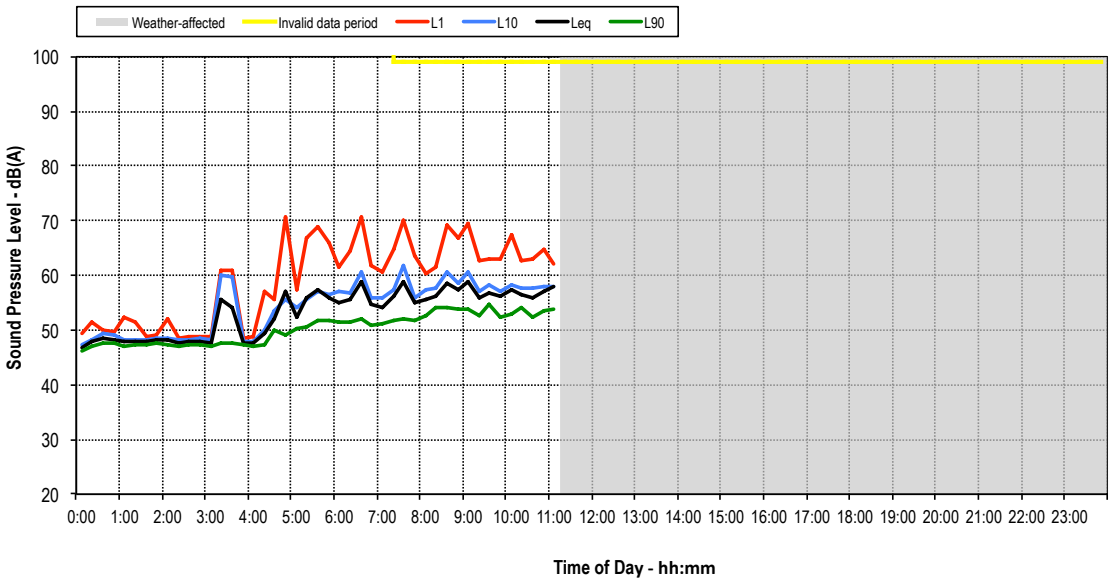
UoW Building 35 (north-east) - Saturday 10 December 2016



UoW Building 35 (north-east) - Sunday 11 December 2016



UoW Building 35 (north-east) - Monday 12 December 2016



Appendix B : Derivation of Environmental Noise Break-out Limits

The one of the main sources of noise break-out from the Molecular and Life Sciences Building site to the environment will be mechanical services plant – particularly roof plant.

The environmental noise impact of the proposed roof plant will be assessed in accordance with the NSW Industrial Noise Policy 2000 (NSW INP).

The NSW INP sets two separate noise criteria to meet environmental noise objectives: one to account for intrusive noise and the other to protect the amenity of particular land uses. Both are used to derive the project specific noise level.

Assessing intrusiveness

The intrusiveness criterion essentially means that the equivalent continuous noise level of the source should not be more than 5 dB above the measured existing background noise level.

Assessing amenity

The amenity assessment is based on noise criteria specific to land use and associated activities. The criteria relate only to industrial-type noise, including plant. The existing noise level from industry (or plant) is measured - if it approaches the criterion value, then the noise levels from new plant need to be designed so that the cumulative effect does not produce noise levels that would significantly exceed the criterion.

The cumulative effect of noise from all industrial or plant sources is considered in assessing impact.

Project specific noise level

For the new roof plant, the more stringent of the intrusive and the amenity criteria sets the project specific noise level.

The derivation of the project specific noise levels is provided below.

B.1 Existing Background and Ambient Noise Levels

The rating background level (RBL) has been determined from $L_{A90,15min}$ measured during the long-term noise survey in accordance with the methodology prescribed in NSW INP.

Three time periods are considered (consistent with the operating times of the plant associated with the development and the time of day classifications in the Policy):

- Day - 7 am to 6 pm
- Evening - 6 pm to 10 pm
- Night - 10 pm to 7 am

From the noise logger data presented in Appendix A, the calculated RBLs and measured ambient noise levels are shown below in Table B1.

Location	RBL (L_{90}) Background Noise Levels, dB(A)			L_{eq} Ambient Noise Levels, dB(A)		
	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am	Day 7am-6pm	Evening 6pm-10pm	Night 10pm-7am
L1	50	48	47	56	54	53

Table B1: Long-term background and ambient noise levels measured around the Molecular and Life Sciences Building site

From observations during our site visit, it is noted that both ambient and background noise levels around the Molecular and Life Sciences site were currently dominated by mechanical plant noise from surrounding UoW buildings, mainly from rooftop plant.

B.2 Determination of intrusiveness criterion

The intrusiveness criterion is defined as:

$$L_{Aeq,15\ minute} \leq \text{rating background level plus 5}$$

The intrusiveness criterion has been determined from the RBLs presented in Table A.1 for each period and from the short-term measurements presented in Section 3.3.

Residential receivers including graduate housing:

- Day Intrusiveness criterion of 50 + 5 = **55 dB(A)**
- Evening Intrusiveness criterion of 48 + 5 = **53 dB(A)**
- Night Intrusiveness criterion of 47 + 5 = **52 dB(A)**

B.3 Determination of amenity criterion

To limit continuing increases in noise levels, the maximum ambient noise levels within an area from industrial noise sources should not normally exceed the acceptable noise levels appropriate for the type of area (e.g. the acceptable noise level in a rural area would be less than that in an urban or industrial area).

The NSW INP Amenity Level approach aims to limit "creeping background" or cumulative impacts from industrial developments.

Acceptable L_{Aeq} noise levels from industrial noise sources

The Acceptable Noise Levels (ANLs) for each land use type under consideration (as detailed in Table 2.1 of the NSW Industrial Noise Policy) are given in Table B2 below.

The nearest residential receivers to the project are considered to be in a Noise Amenity Area characterised by the NSW Industrial Noise Policy as Suburban.

Type of Receiver	Period	Recommended $L_{Aeq, period}$ Noise Level (ANL)	
		Acceptable	Recommended Maximum
Residential – Suburban (external)	Day	55	60
	Evening	45	50
	Night	40	45
Commercial (external)	When in use	65	70
Classroom (Internal)	Noisiest 1-hr period when in use	40	40

Table B2 : Recommended L_{Aeq} noise levels from industrial noise sources at residential, commercial and educational receivers

For the purpose of this assessment, "Acceptable" noise levels as presented in the table above are to be adopted.

B.4 Project specific noise level

The Project Specific Noise Level is defined as the lower of the intrusiveness and the amenity criteria. On this basis, the Project Specific Noise Levels (PSNLs) for new roof plant associated with the site are shown in Table B5 below (PSNLs shown shaded in grey).

Type of Receiver	Period	Intrusiveness Criterion	Amenity Criterion
Residential – Suburban (external) – including residential colleges	Day	55	55
	Evening	53	50
	Night	52	40
Commercial (external)	When in use	-	65
Classroom (Internal)	Noisiest 1-hr period when in use	-	40

Table B3 : Determination of project specific noise levels for the Molecular and Life Sciences Building

Appendix C : Building damage vibration criteria

There is little reliable data on the threshold of vibration-induced damage in buildings. Although vibrations induced in buildings by ground-borne excitation are often noticeable, there is little evidence that they produce even cosmetic damage. This lack of data is one of the reasons that there is variation between international standards, why the British Standards Institution (BSI) did not provide guidance before 1992 and why there are still no International Organisation for Standardisation (ISO) guidance limits.

There are however several standards that can be referred to.

German Standard

The relevant German standard is DIN 4150: Part 3: 19862. This standard gives guidelines for short-term and steady state structural vibration. For short-term vibration in buildings the following limits are given:

Structural type	Vibration Velocity, v_i, in mm/s			
	Foundation			Plane of floor of uppermost full storey
	less than 10Hz	10 to 50 Hz	50 to 100 Hz	Frequency mixture
Commercial, Industrial or Similar	20	20 to 40	40 to 50	40
Dwellings or Similar	5	5 to 15	15 to 20	15
Particularly Sensitive	3	3 to 8	8 to 10	8

Table C1: Guideline Values of Vibration Velocity, v_i, for Evaluating the Effects of Short-term Vibration

The guidelines state that:

Experience to date has shown that, provided the values given in Table D2 are observed, damage due to vibration, in terms of a reduction in utility value, is unlikely to occur. If the values of table D2 are exceeded, it does not necessarily follow that damage will occur. Should these values be significantly exceeded, further investigation is necessary.

Swiss Standard

The relevant Swiss standard is SN 640 312:1978. For steady state vibration, form machines, traffic and construction in buildings the following limits are given:

Structural type	Vibration Velocity, v_i, in mm/s	
	Foundation	
	10 to 30Hz	30 to 60Hz
Commercial, Industrial including retaining walls	12	12 to 18
Foundation walls and floors in concrete or masonry. Retaining walls and ashlar construction	8	8 to 12
Foundations and basement floors concrete, with wooden beams on upper floors. Brick walls.	5	5 to 8
Particularly sensitive	3	3 to 5

Table C2: Guideline Values of Vibration Velocity, v_i, for Evaluating the Effects of Steady State Vibration

British Standard

The relevant standard is BS7385: Part 2: 1993[1]. This standard was developed from an extensive review of UK data, relevant national and international documents and other published data, which yielded very few cases of vibration-induced damage. This standard contains the most up-to-date research on vibration damage in structures. Part 2 of the standard gives specific guidance on the levels of vibration below which building structures are considered to be at minimal risk.

The Standard proposes the following limits on the foundations of the building:

Structural type	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15Hz and above
Unreinforced or light framed structures Residential or light commercial type buildings	15mm/s @ 4Hz increasing to 20mm/s @ 15Hz	20mm/s @ 15Hz increasing to 50mm/s @ 40Hz and above

Table C3: Transient Vibration Guide Values for Cosmetic Damage

[1] British Standards 7385:1993 Part 2 "*Evaluation and Measurement for vibration in Buildings. Guide to damage levels from ground-borne vibration"*

The standard states in Annex A, that … *the age and existing condition of a building are factors to consider in assessing the tolerance to vibration. If a building is in a very unstable state, then it will tend to be more vulnerable to the possibility of damage arising from vibration or any other ground-borne disturbance.* It is recommended that buildings of importance be considered on a case-by-case basis with detailed engineering analysis being carried out if necessary.

Annex B of the Standard gives a breakdown of data that should be recorded. Included in this are details of the building structure, such as general condition of the structure, list of defects, photographs, details of all major extensions, repairs and renovations. A crack exposure report should be prepared both pre and post exposure, both internally and externally.

Australian Standard

There is no specific Australian Standard referring to structural vibration in buildings. There is however AS 2187.2 - 1993[2], which, in Appendix J, recommends maximum peak particle velocities, measured at the ground surface due to blasting. The lower recommended peak particle velocity is 10 mm/s. The standard states however, that structures that may be particularly susceptible to ground-borne vibration should be examined on an individual basis. It is suggested that in the absence of a particular site-specific study then a maximum peak particle velocity of 5 mm/s is used.

[2] AS 2187.2 - 1993 Explosives - Storage, transport and use. Part 2: Use of explosives