UNSW Cliffbrook Campus Redevelopment

DEMOLITION, EXCAVATION & CONSTRUCTION NOISE AND VIBRATION IMPACT ASSESSMENT & MANAGEMENT PLAN

JHA

CONSULTING ENGINEERS

DOCUMENT CONTROL SHEET

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Project	Cliffbrook Campus Coogee
Description	Noise and Vibration Impact Assessment
Key Contact	Riduan Osman

Prepared By

Company	JHA
Address	Level 23, 101 Miller Street, North Sydney NSW 2060
Phone	61-2-9437 1000
Email	Riduan.Osman@jhaengineers.com.au
Website	www.jhaservices.com
Author	IA
Checked	RO
Authorised	RO

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1. EXECUTIVE SUMMARY

JHA Engineers was engaged by Root Partnerships to prepare a Demolition & Construction Noise and Vibration Management Plan with respect to the proposed works at the UNSW Cliffbrook Campus Coogee.

The plan identifies the noise and vibration impact of the proposed demolition and construction at the UNSW Cliffbrook Campus at the nearest affected residences and provides recommendations on how to manage and control the noise and vibration during the demolition and construction works. The demolition and construction works will be carried out in accordance with the requirements of the NSW EPA Interim Construction Noise Guideline (2009).

Residential properties closest to the works site are located to the east at No.10 & 12 Battery Street, and to the south at No.1 and 2 Gordon Avenue. The demolition and construction noise criteria at the surrounding residences is determined to be 60dB $_{LAeq,15min}$.at the southern end of 12 Battery St and 1 & 2 Gordon Ave and 55dB LAeq,15min at the northern end of 10 Battery St.

The demolition continuous vibration criteria at the surrounding residences is determined to be 0.020m/s^2 in the z-axis and 0.014 m/s^2 in the x & y axis and 0.60m/s^2 in the z-axis and 0.42m/s^2 in the x & y axis for the demolition impulsive vibration criteria. The maximum allowable daily vibration dose value (VDV) is 0.4mm/s$^{1.75}$.

The appointed demolition and construction Contractor shall provide a more detailed Noise and Vibration Management Plan once the Contractor has finalised developing the demolition and construction plan and provides details and methodology (including noise levels of plant and equipment proposed to be used) of the demolition and construction works.

2. INTRODUCTION

The following provides information and a high level approach on the anticipated management techniques of construction noise and vibration management throughout the construction phase. It is noted that at the time of writing this plan, a Contractor has not yet been appointed. Therefore the information provided below is subject to review and possible amendments in methodology by the appointed Contractor, noting that the Contractor's chosen methodologies would still be required to comply with the requirement of the applicable noise and vibration management standards and Project Approval Conditions.

3. PROJECT DESCRIPTION

3.1 Development Information

UNSW is undertaking a renewal of its Cliffbrook campus to create a bespoke residential and educational retreat.

- The new campus will primarily accommodate the UNSW Australian Graduate School of Management (AGSM) residential program. It will provide a maximum of 52 bedrooms, supporting amenities and a customised suite of learning spaces.
- The design will be empathetic to the highly sensitive heritage fabric, adjacent environment, the unique outlook and neighbourhood amenity.
- A carefully selected team of consultants and experts have been tasked with the design and delivery of this unique facility.
- The new campus will align with the University's 2025 Strategy to establish UNSW as Australia's global university, providing world-class environments to deliver distinctive educational experience

The Cliffbrook retreat will predominantly cater for the AGSM's Masters of Business Administration (MBA) residential candidates and Executive Education short course residential candidates. The site will also be used for UNSW activities such as internal management courses and strategy retreats for the University's faculties and divisions.

The site is divided into two zones: an Infrastructure (Educational Establishment), and a Private Recreation Zone that forms part of a Foreshore Protection Area. Building development is permissible on the Infrastructure Zone and smaller, sympathetic structures are permitted on the remainder of the site.

3.2 Site Description

The proposed development site is located at 45 Beach Street, Coogee 2034 NSW, at the corner of Beach Street and Battery Street.

This campus, with the historic Cliffbrook House, surrounding buildings and coastal reserve is an important part of Coogee's history.

Nearest affected receivers located at 1 & 2 Gordon Avenue and 10 & 12 Battery Street, Coogee are shown in Figure 1 below (marked in yellow). Figure 2 below shows the ground floor plan of the proposed development.

Figure 1 Aerial View of the Site with Existing Buildings, Nearest Affected Receiver Locations at Nos.1 & 2 Gordon Avenue and No.10 Battery Street

Figure 2 Ground Floor Architectural Drawing of Partial Site and Surrounding Residencies with Proposed New Building

4. HIGH LEVEL ANTICIPATED METHODOLOGY

4.1 Preliminaries and Site Establishment

After the preliminaries and site establishment, the following are to be implemented.

• The existing building (CC4) will be checked for hazardous items through referencing the existing investigative reports and through the Contractor undertaking its own due diligence and those will be removed before soft stripping takes place. Air monitors will be installed for the duration of the demolition works to ensure the safety of workers and occupants in the neighbouring properties.

• Noise monitors will also be implemented (refer following section);

• Internal stripping works is the anticipated to commence, after all the services are disconnected and the hazardous materials have been removed.

• The existing CC4 is a three storey double brick building which will be mechanically demolished from the roof level down. It is anticipated that a smaller size mechanical equipment will be established on the upper deck and undertake removal of roof and upper walls, followed by demolition of concrete slabs (likely mechanical hammering and / or mechanical nibblers). The same process would then be followed for level 2. It is anticipated the demolition of Ground Level and 1st Floor will be undertaken from the ground via mechanical equipment.

• Demolished materials would be loaded out via a 20t excavator and loaded into trucks within the site.

• The demolished material will be separately tipped for disposal/recycling to the facilities as per EPA requirement.

• At this stage, the Contractor is anticipated to assess the existing site ground strata and proceed to locally demolish the existing ground slab.

• No loading out of demolished materials would occur on the road system outside the site unless explicitly approved by the local Authority.

4.2 Anticipated Machinery

Anticipated machinery that would be used as part of the demolition activities are as follows.

• 22T excavator
• 15T excavator
• 8T excavator
• Bobcat
• Truck

4.3 Noise & Vibration Management

Noise and vibration control shall be in accordance with the Protection of the Environment Operations Act 1997 and in accordance with the DA conditions. No noisy work will occur outside the specified work hours unless prior approval has been given in writing by the relevant authorities.

Work shall be in accordance with the AS/NZS 2436 1981 – Guide to Noise Control on Construction, Maintenance and Demolition Sites The noise and vibration from the use of any plant and equipment associated with the premises shall not give rise to an offensive noise as defined in the Noise Control Act 1975. As part of the noise control process all trucks and machinery involved with the works will be checked for defective exhaust systems and general servicing.

The Contractor's Project Manager in consultation with the Site Supervisor, shall ensure wherever practicable, the impact of noise and vibration on the public is minimised through adoption of alternative methods/equipment or programming:

- For example, compressors for pneumatic equipment can often cause problem noise levels and should be silenced, enclosed and located appropriately. Hydraulic or electrical equipment may be a viable alternative. Electrical equipment may also be used in place of diesel or petrol engines, but care must be taken with the location of the generator and supply line

- Impacts from noisy excavation and demolition works may be reduced by alternative work methods. Alternatives to rock-breaking include hydraulic splitters for rock and concrete, hydraulic jaw crushers, rock and concrete sawing. Smaller rock breakers/excavators are generally preferable to larger machines, but increased time on the job should be considered.

- When noisy works involve demolition or excavation, there may be opportunities to use existing building structures as a shield for noise. For example, during early demolition stages it may be possible to leave sections of an existing building façade/structure in place, acting as a barrier between noisy works and the noise sensitive areas. Similar benefits may be gained if permanent walls are built early to act as a noise barrier.

At the site level, the Site Supervisor shall be responsible for minimising noise and vibration:

- Where a hired plant or equipment is causing excessive noise in a manner that is not typical for the equipment, it should be replaced.

- Where there is a fault or maintenance issue with a subcontractor's plant or equipment causing excessive noise, the subcontractor must be ordered to deal with it immediately.

- Minimise metal-on-metal contact. Bins, skips and chutes can be lined with material such as carpet, which helps to deaden the sound of metal and other waste disposal.

- Avoid dropping items from a height.

- Use equipment sensibly. Turn off equipment when not in use. Switch off vehicles when idling for extended period of time.

- Encourage appropriate conduct of workers. Workers should not shout, talk loud or slam vehicle doors in a sensitive area (such as residential area, school, and hospital).

- Manage truck noise. Noise from trucks is a common issue, especially near residences. The scheduling and management of truck movements is important to reduce issues associated with reversing beepers, engine noise and general off-site activity.

More information can be found in AS 2436-1981 Guide to Noise Control on Construction, Maintenance and Demolition Sites.

Due to number of heritage listed buildings on site, vibration monitoring, performed by suitably qualified vibration consultant, is to be performed on all heritage items in the vicinity of proposed demolition to ensure that vibrations generated by demolition works do not impact the façade or structural integrity of the heritage listed buildings and to satisfy requirements of section 60. As a result of this 5 vibration loggers will be installed on site for the duration of demolition works.

Vibration measurements will be carried out using vibration meters. These instruments are specifically designed for construction and demolition site work. These meters use geophones to directly measure PPV (peak particle velocity) and they also provide acceleration levels. The long battery life (up to 4 weeks on 3 standard alkaline D cells) ensures that the power remains continuous and does not rely on mains supply power to solar panels. The data is logged against the real time clock in the instruments' memory. The measurement period is user-selectable and the dominant frequency component is recorded for each period PPV. Measurements can be taken only during specified periods when demolition works are actively being undertaken. It is envisaged that a continuous 30 second vibration measurements will be obtained within

the Project Approval hours. The instruments can also save the waveforms of the highest, (up to) nine noise events per hour. The meters will be placed near the footings of the nearest buildings identified in the vibration plan.

The number of vibration monitors required for the site will be determined in consultation with the Contractor and Principal's Acoustic consultant via discussions during the site walkthrough. These will be indicated on a location plan.

All loggers will be fitted with visual alarm beacons and SMS alerts to indicate when levels are exceeded. All loggers are to remain in place for the duration of works that is affecting that location.

The Contractor is to supply all vibration monitoring instruments to be used on site as well as providing trained personnel to operate and maintain these devices for the duration of works which includes setup the monitors, conduct weekly downloads and to formulate weekly reports.

Where exceeding vibrations levels are occurring, the Contractor's Vibration Consultant will assist in providing feedback on how best to reduce the levels of vibration in consultation with the Principal Contractor on site.

In the event of harm to adjacent heritage items is identified, vibratory activities are to cease and alternative work methods are to be implemented.

5. DETERMINATION OF APPLICABLE NOISE CRITERIA DURING DEMOLITION & CONSTRUCTION

The determination of the applicable noise and vibration criteria during demolition and construction works are described below.

5.1 Existing Noise Levels at Residential Boundaries & Long Term Noise Monitoring

Long term noise monitoring with a Rion NL-52 Type 1 noise logging sound level meter were conducted between Wednesday 3rd of February 2016 and Thursday 11th of February 2016 at Logger location A and between Friday 25th August 2017 and Tuesday 5th September 2017 at Logger location B shown in Figures 1, 2 and 3.

Figure 3: *Aerial view of site. Logger locations L1 and L2 shown in red, and nearest affected receivers are outlined in yellow.*

To determine the rated background noise level (RBL) in accordance with the NSW Industrial Noise Policy (INP) 2000, long term noise logger monitoring measurements were conducted at the proposed development site. Automatic logging noise measurements were performed at the site to document the existing acoustic environment, including traffic noise.

Figure 4 Noise Logger A located at the at southern end boundary with 10 & 12 Battery St

Figure 5 Noise Logger B located at the at northern end boundary with 10 Battery St

The results of the automatic logging measurements and the site notes are tabulated below:

Start Date and Time	End Date and Time	Logging Period	Assessment Period	$L_{A90,15min}$ dB (RBL)	$L_{Aeq,15min}$ dB	Logger Location
19/04/2016 at 11.45 AM	27/04/2016 at 1.00 PM	15 min intervals	Day Period	50	53	Logger A at boundary with 12 Battery Street, Southern End
25/08/2017 at 11.30 AM	05/09/2017 at 12.30 PM	15 min intervals	Day Period	45	52	Logger B at boundary with 10 Battery Street, Northern End

Table 1 Results for Long Term Noise Monitoring

5.2 Noise Criteria at the nearest Residential Boundary during Demolition and Construction

The NSW Environmental Protection Authority (EPA) Interim Construction Noise Guideline (2009) notes that there may be some community reaction to noise from major demolition and construction projects where this is more than 10 decibels above the rated background noise level (RBL) for work during the daytime. This recognises that demolition and construction noise is generally temporary with the community having a slightly higher tolerance for it.

Based on the above measurements and assessment in accordance with the NSW Industrial Noise Policy (INP) 2000 and the NSW EPA Interim Construction Noise Guideline (2009), the demolition and construction noise criteria for the project is the northern boundary of the residence at 10 Battery Street, southern boundary of the residence at 12 Battery Street and the boundary with 1 & 2 Gordon Ave is shown in Table 2 below:

Time of Day	Demolition & Construction Noise Criteria
Monday-Friday: 7am to 6pm Saturday: 7am to 5pm	**At southern end of 12 Battery St and 1 & 2 Gordon Ave. 60dB $L_{Aeq,15min}$** (50+10)
Monday-Friday: 7am to 6pm Saturday: 7am to 5pm	**At northern end of 10 Battery St 55dB $L_{Aeq,15min}$** (45+10)

Table 2 Noise Criteria at Nearest Affected Receivers

6. EXISTING ACOUSTIC CONSTRAINTS

Noise and vibration can be a major source of annoyance for residents and other land users near the development site during demolition and construction if not adequately managed. To minimise the level of complaints from neighbouring residents and other land users, the following are the acceptable noise and vibration criteria at the nearest residence (10 Battery Street and 1&2 Gordon Ave).

Figure 5 Most affected noise receivers during demolition and construction

6.1 Noise Criteria at the nearest Residential Boundary during Demolition and Construction

Based on the noise measurements and assessment at the proposed development site in accordance with the NSW Industrial Noise Policy (INP) 2000 and the NSW EPA Interim Construction Noise Guideline (2009), the demolition and construction noise criteria for the project at the surrounding residences is determined to be **60dB** $_{LAeq,15min}$ at the southern end of 12 Battery St and 1 & 2 Gordon Ave and **55dB** $_{LAeq,15min}$ at the northern end of 10 Battery St. during the permissible demolition and construction periods determined as shown in Section 5.2 and Table 2 above.

6.2 Vibration Criteria at the nearest Residential Boundary during Demolition and Construction

The demolition and construction continuous vibration comfort criteria at the surrounding residences is determined to be 0.020m/s^2 in the z-axis and 0.014 m/s^2 in the x & y axis, and 0.60m/s^2 in the z-axis and 0.42m/s^2 in the x & y axis for the demolition impulsive vibration criteria. Refer to Appendix B on the determination of the vibration criteria.

7. DEMOLITION & CONSTRUCTION NOISE AND VIBRATION CONTROL

7.1 Noise and Vibration Regulations and Approval Conditions for the Demolition and Construction Works

Demolition and construction site operators must comply with demolition and construction noise and vibration control requirements of the NSW statutory requirements.

The Protection of the Environment Operations Act 1997 (NSW) Act is the key piece of environment protection legislation, and the Protection of the Environment Operations (Noise Control) Regulation 2008 (NSW) provides for inspection and testing of noise emissions.

The “Interim Construction Noise Guidelines” (2009) published by the NSW EPA, deals with the assessment of noise from demolition and construction activities and advises on best practice approaches to minimise noise impacts. It is aimed at managing noise from demolition and construction works regulated by the Office of Environment and Heritage, and is used to set statutory conditions in licences or other regulatory instruments.

The “Assessing vibration: A Technical Guideline” (2006) published by the NSW EPA, is based on guidelines contained in BS 6472-1992, and presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. It does not address motion sickness, occupational vibration, blasting vibration effects or vibration-induced damage to buildings or structures.

7.2 Hours of Work

Hours of work permissible during the course of the project are proposed to be:
Monday to Friday: 7.00am to 6.00pm, Saturday: 7.00am to 5.00pm
These working hours are preliminary and subject to the hours of work granted under the development approval process.
No works will be undertaken on Sundays and Public Holidays unless otherwise notified in accordance with the development approvals.
Out of hours work will be considered for special applications only when it becomes necessary. Relevant authority approvals will be obtained by the contractors prior to any work being performed outside the approved development consent working hours. None are envisaged for this site.

7.3 Demolition and Construction Plant and Equipment Noise Levels

The following are the noise levels of the proposed plant and equipment to be used at the Cliffbrook Campus site during the demolition phase as advised by Root Partnerships and the associated anticipated noise levels.

Plant	Sound Power Level dBW	Estimated Sound Pressure Level dB(A) at	
		7m	18m
Excavators (22, 15 and 8 Tonne)	108 - 110	83 - 85	75 - 77
Dump Truck	108	83	75
Bobcat	103	78	70

Table 3 Proposed Equipment for the Demolition and Excavation Phase

At this stage we have not been provided with the information on any other proposed demolition or construction plant and equipment as the building construction Contractor has not been appointed. The following are the noise levels of plant and equipment that are used at a typical demolition and construction site.

Plant	Sound Power Level dBW	Estimated Sound Pressure Level dB(A) at	
		7m	18m
Excavator	108	83	75
Mobile Crane	104	79	71
Concrete Truck	109	84	76
Mobile Crane	98	73	65
Site Cranes	104	79	71
Dump Truck	108	83	75
Excavator	107	82	74
Concrete Saw	113	88	80
Compressor	100	75	67
Concrete Pump	112	87	79
Jackhammer	105	80	72

Table 4 Noisy Equipment and Plant for the Demolition and Construction Phases

Note that when used continuously, the above equipment can generate significant noise and vibration at the nearest affected residences. The planning of the works is crucial in the minimisation of noise and vibration at the residences.

7.4 Recommended Scheduling of the Demolition and Construction Works.

The following are the recommended demolition and construction work scheduling strategies that would minimise the noise and vibration impact at the affected residences.

- Demolition material removal trucks shall not arrive at the site before 7.00am. The noise of trucks arriving before 7.00am and the noise of the trucks reversing and idling waiting to access the site is usually a major source of noise complaints.

- It is recommended that very noisy works be carried out between the hours of 8.30am and 5.00pm as most residents would have left for work, or woken from their sleep. Refer to Plant and Equipment noise in Table 3 & 4 as a guide.
- Very noisy works shall be limited to short periods (e.g. 5 minutes of high noise generation) and mixed with less noisy activities. Note that the total noise levels are integrated over a 15 minute period.
- Where very noisy works cannot be avoided, the demolition Contractor shall advise the affected residents of the noisy work and agree to a mutually acceptable time when the works can be carried out.
- The demolition and construction site workers should be continuously reminded to be aware of the excessive noise and vibration they may producing. Enforced site closure may result in delays of the demolition works and extra costs to the demolition Contractor.

7.5 Temporary Sound Barrier Walls

It is recommended that a temporary sound barrier wall be erected enclosing the construction site, along all boundaries to block the direct line of sight between the noise generating activities on site and adjoining buildings, in particular the property boundaries at 1 & 2 Gordon Avenue and 10 & 12 Battery Street. The erection of the barrier is subject to prior consultation with the affected residents.

The height of the barrier shall be a minimum of 2.4 metre high and constructed using steel posts and 19mm thick plywood. The barrier would also serve as a dust barrier and site security fencing.

The barrier shall be erected prior to commencement of demolition and earthworks. The extent of the 2.4 metre high barrier is as shown in the Figure 6 below. The anticipated attenuation of the 2.4 metre high barrier is 10dB.

7.6 Noise Monitoring during demolition, excavation and construction

It is recommended that three noise loggers (minimum Type 2 sound level meters with current calibration certificates) be installed at the locations shown in Figure 6 below. The loggers shall be capable of logging and storing the noise level 15-minute statistics and relaying the noise statistics at the site manager's workstation immediately via communications cable or internet. The noise level statistics to be stored and recorded are $L_{Aeq,15min}$, $L_{A01,15min}$, $L_{A10,15min}$, $L_{A50,15min}$ & $L_{A90,15min}$.

Figure 6 Recommended barrier hoarding and noise monitoring locations

8. NOISE & VIBRATION IMPACT ASSESSMENT AND MANAGEMENT

8.1 Duration of Demolition and Construction Phases

The following are the estimated durations of the demolition and construction phases of the project. The noisiest phase of the project is anticipated to occur during the demolition and excavation phase.

TASK	DURATION
Demolition and Excavation	2 months
Construction Works	15 months
Fitout and Landscaping	3 months
Overall Construction Duration	20 months

As shown in Table 2 above the demolition and construction phases noise criteria are as follows.

- At the southern end boundary with 12 Battery St - **60dBL$_{Aeq,15min}$**
- At the boundary with 1 & 2 Gordon Ave - **60dBL$_{Aeq,15min}$**
- At the northern end boundary with 10 Battery St - **55dBL$_{Aeq,15min}$**

The EPA "Interim Construction Noise Guideline" (2009) also advise that where the predicted or measured above **L$_{Aeq,15min}$** is greater than the above specified criteria, the Contractor shall apply all feasible and reasonable work practices to minimise noise. Refer to Appendix A Section 13.2 below.

8.2 Noise Impact during Demolition and Excavation Works

The following are the proposed plant and equipment for the demolition & excavation phase.

Plant	Sound Power Level dBW	Estimated Sound Pressure Level dB(A) at	
		7m	18m
Excavators (22, 15 and 8 Tonne)	108 - 110	83 - 85	75 - 77
Dump Truck	108	83	75
Bobcat	103	78	70

Table 5 Proposed Equipment for the Demolition and Excavation Phase

Indicative demolition and excavation works scenario includes building demolition, excavation and spoil removal. The equipment anticipated to be used for the works are 1 x Bobcat, 2 x Dump Truck & 3 x Excavators. The truck movements are assumed to be 3 movements in 15 minutes. The typical predicted noise levels at the nearest boundary (i.e. noise logging points, 1.2m above ground level & behind the barrier fencing) based on the diversified equipment usage are as follows:

- At the southern end boundary with 12 Battery St - **56dBL$_{Aeq,15min}$**
- At the boundary with 1 & 2 Gordon Ave - **59dBL$_{Aeq,15min}$**
- At the northern end boundary with 10 Battery St - **54dBL$_{Aeq,15min}$**

As outlined in section 7.6 above, the required noise loggers shall be continuously monitoring during the demolition and excavation works periods and an alarm shall be triggered at the site office management computer when the noise levels specified in Section 8.1 are exceeded. Where the noise levels are exceeded, the works shall stop and work shall only proceed after the Contractor have applied all feasible and reasonable work practices to minimise noise. Refer to Appendix A Section 13.2 below.

8.3 Noise Impact during Construction Works

Indicative construction works scenario includes the building construction works and glazing & façade installations. The major noisy plant and equipment likely to be used for this phase are 1 concrete pump, 2 forklifts, 1 crane, and a boom truck. Also concrete trucks and normal delivery trucks activities are assumed to be 5 movements in 15 minutes. Where feasible, the noisy plant and equipment should be located and operated as far as possible from the residential boundaries and with additional secondary barrier where required.

The typical predicted noise levels during the construction phase at the nearest boundary (i.e. noise logging points 1.2m above ground level & behind the barrier fencing) based on the anticipated diversified equipment usage are as follows:

- At the southern end boundary with 12 Battery St - **56dBL$_{Aeq,15min}$**
- At the boundary with 1 & 2 Gordon Ave - **60dBL$_{Aeq,15min}$**
- At the northern end boundary with 10 Battery St - **55dBL$_{Aeq,15min}$**

As outlined in section 7.6 above, the required noise loggers shall be continuously monitoring during the construction works periods and an alarm shall be triggered at the site office management computer when the noise levels specified in Section 8.1 are exceeded. Where the noise levels are exceeded, the works shall stop and work shall only proceed after the Contractor have applied all feasible and reasonable work practices to minimise noise. Refer to Appendix A Section 13.2 below.

8.4 Vibration Impact during Demolition and Construction Works

Within the UNSW Cliffbrook development site are historic buildings that have to be preserved and renovated. Accordingly, blasting and heavy rock hammers (more than 600kg) are not allowed on the development site as they could undermine the historic buildings on the site and could generate undesirable levels of vibration at the neighbouring residences. Where rock has to be cut up and removed, it is recommended that concrete saws and medium rock hammer (no more than 600kg) be used.

Typical vibration levels from the vibration generating plant and equipment most likely to cause significant vibration at the UNSW Cliffbrook development site are summarised in the Table 6 below.

Activity	Typical ground vibration
Bulldozers/ Excavators	Typical ground vibration from bulldozers range from 1mm/s to 2mm/s at distances of approximately 5m and at distances greater than 20m, vibration levels are usually below 0.2mm/s.
Medium Rock Hammer (<600kg)	Typical ground vibration from Medium Rock Hammer (<600kg) range from 0.2mm/s at distances of approximately 5m and at distances greater than 20m, vibration levels are usually below 0.02mm/s.
Truck traffic	Typical vibration from heavy trucks passing over normal (smooth) road surfaces generate relatively low vibration in the range 0.01-0.2mm/s at the footings of buildings located 10-20m from a roadway. In general ground vibration from trucks is usually imperceptible in nearby buildings.

Table 6 Typical ground vibration generated by demolition, excavation and construction plant

The above vibration levels would not generate unacceptable vibration discomfort (vibration dose (VDV) of 0.4mm/s$^{1.75}$) at the neighbouring residences and structural damage to the historic buildings on the site when operated over a typical demolition, excavation and construction works day.

9. COMMUNITY ENGAGEMENT DURING DEMOLITION & CONSTRUCTION WORKS

9.1 Neighbouring Community Engagement

The most impacted community during the demolition and construction phase of the UNSW Cliffbrook Campus are the residents at Battery Street and Gordon Avenue facing the proposed demolition and construction site.

From a community point of view, there is a need for a range of actions and processes which are required by the NSW "EPA Interim Construction Noise Guideline (2009)" for the demolition works that aim to reduce noise and vibration impacts from the demolition activities while encouraging community involvement.

For the proposed UNSW Cliffbrook Campus demolition and construction works, contact with the nearest affected community is desirable once approval has been given to commence works and should be undertaken prior to any work beginning. The type of community engagement should relate to the likelihood and extent of noise and vibration impacts from the demolition works.

The aim of community engagement is to:

- Establish good working relationships between the development owner, the Contractor, the community and other stakeholders in relation to the project
- Receive feedback on the project's environmental performance, discuss community concerns and identify opportunities for the resolution of community complaints and concerns
- Gain advice on how best to communicate relevant information on the project and its environmental performance to the broader community
- Work cooperatively towards outcomes of benefit to the project, immediate neighbours and the local and regional community.

The UNSW Cliffbrook Campus nominated demolition and construction Contractor shall nominate the site manager as a community liaison officer for the project as a point of contact for the community regarding issues related to the demolition at the site, including issues relating to noise and vibration. Any formal complaints received regarding noise and vibration matters at the site shall be passed on to the Contractor for the complaints to be addressed and resolved.

9.2 Keeping the Noise Affected Community Informed

Being up-front with the noise affected community from the outset can assist in transferring information to the affected community. An example of being up-front is to present noise and vibration related information on the demolition works to noise affected community before commencing works.

9.3 Dealing with Community and Public Complaints during Demolition Works

Complaints from the community and public can arise when accidental or unintentional noise and/or vibration are generated due to unforeseen circumstances or error of judgement made by the site demolition team. The community and public generally understand when this happens once or not too often. The complaints must be handled in a serious and respectful way. The complaints should be recorded and logged in a noise and vibration complaints log book and followed up by the demolition site manager.

Following resolution of the noise or vibration problem, the complainant should be informed of the remedial actions taken before the complaint can be recorded as being resolved.

10. DEMOLITION AND CONSTRUCTION WORK SCHEDULE AND TRAFFIC MANAGEMENT

The demolition work schedules and proposed material removal traffic routes to minimise noise intrusion into neighbouring residential properties will be confirmed following engagement of a builder for the project. To minimise demolition traffic noise at the residences, trucks and equipment are to enter and exit the site via Beach Street.

The builder will be required to provide a demolition and construction programme for the works, from site establishment and demolition works completion. The noisy phases will be monitored so as to avoid and minimise potential complaints from neighbouring and other affected properties.

The Contractor will be required to provide demolition material removal traffic routes, proposed frequency of vehicular movements and the estimated total gross weights of the vehicles to assess the traffic generated noise in the vicinity of the development. Traffic noise will be monitored where potentially noisy demolition works traffic movement periods could cause complaints to arise from the affected residential properties.

11. TRAINING

The site manager for the demolition and construction works shall implement appropriate training and induction in the requirements of this demolition and construction noise and vibration management plan. All employees, contractors and utility staff working on site will undergo site induction training which includes Environmental Due Diligence Training. The induction will address:

- This Demolition and Construction Noise Management Plan
- The existence of noise legislation and what this means for the project, i.e. EPA guidelines and Noise Management Levels for the project.
- Delivery hours and locations.
- Reporting and recording environmental incidents related to noise and vibration.
- Noise and vibration minimisation measures.
- The importance of regular maintenance to noise and vibration generating plant.

Records will be kept of all personnel undertaking the site induction and training, including the contents of the training, date and name of trainer/s.

Key staff will undertake more comprehensive training relevant to their position and/or responsibility. This training may be provided as “toolbox” talk training.

12. CONCLUSION

The NSW Protection of the Environment Operations Act 1997 (NSW) Act is the key piece of environment protection legislation, and the Protection of the Environment Operations (Noise Control) Regulation 2008 (NSW) provides for inspection and testing of noise emissions. The NSW EPA “Interim Construction Noise Guidelines” (2009) and the NSW Industrial Noise Policy (INP) 2000 requirements pertaining to the environmental noise impact of the proposed demolition and construction works of the existing UNSW Cliffbrook Campus, in particular on the noise and vibration impact of the demolition and construction works at the nearest affected residences, has been addressed.

The UNSW Cliffbrook Campus demolition and construction noise criteria at the surrounding residences is determined to be 60dB $_{LAeq,15min}$.at the southern end of 12 Battery St and 1 & 2 Gordon Ave and 55dB LAeq,15min at the northern end of 10 Battery St.

The UNSW Cliffbrook Campus demolition and construction works continuous vibration criteria at the surrounding residences is determined to be 0.020m/s^2 in the z-axis and 0.014 m/s^2 in the x & y axis, and 0.60m/s^2 in the z-axis and 0.42m/s^2 in the x & y axis for the demolition and construction impulsive vibration criteria. The maximum allowable daily vibration dose value (VDV) is 0.4mm/s$^{1.75}$.

The recommended noise and vibration impact assessment and management strategies have been provided for the proposed demolition and construction works at the UNSW Cliffbrook Campus to meet the criteria outlined in the NSW EPA “Interim Construction Noise Guidelines” (2009).

The appointed demolition and construction Contractor shall provide a more detailed Noise and Vibration Management Plan once the Contractor has finalised developing the demolition, excavation and construction plan and provide details and methodology (including noise levels of plant and equipment proposed to be used) of the demolition, excavation and construction works.

13. APPENDIX A – DEMOLITION AND CONSTRUCTION NOISE MANAGEMENT GUIDELINES

The following section addresses the site specific construction noise and vibration criteria, measurement procedures and the various noise levels of construction equipment likely to be used at the site.

13.1 Recommended Standard Hours for Construction Work

The hours for construction work shall be as described in Paragraph 7.2 above.

Section 2.2 of the EPA "Interim Construction Noise Guideline" (2009) specifies categories of work that might be taken outside the standard hours. The categories relevant to this project are:

- The delivery of oversized plant or structures that police or other authorities determine requires special arrangements to transport along public roads.
- Emergency work to avoid loss of life or damage to property, or to prevent environmental harm.
- Maintenance and repair of public infrastructure where disruption to essential services and/or consideration of worker safety do not allow work within the standard hours.

13.2 Airborne Construction Affecting Nearby Properties

Table 7 below shows an extract from Table 2 of Section 4.1.1 of the EPA "Interim Construction Noise Guideline" (2009) which sets out the management levels for construction noise at residences and nearby properties. The determination of the Rated Background Noise Level (RBL) is in accordance with the NSW Industrial Noise Policy (INP) 2000. For construction hours for this project refer to Paragraph 7.2 above.

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

Table 7 Extracted from Table 2 of Section 4.1.1 of the EPA "Interim Construction Noise Guideline (2009)".

The Interim Construction Noise Guideline (2009) notes that there may be some community reaction to noise from major construction projects where this is more than 10 decibels above the background noise level for work during the daytime. This recognises that construction noise is generally temporary with the community having a slightly higher tolerance for it.

The best management practices involve adopting particular operational procedures that minimise noise while retaining production efficiency. Some common noise reduction strategies include:

- Changing the activity to reduce the noise impact or disturbance (e.g. reorganising the way the activity is carried out).
- Choosing a suitable time — schedule noisy activity to less sensitive times of the day. There are sensitive times of the day for different people, for example, residences during evenings, night and weekends. Where several noisy pieces of equipment are used, their operation should be scheduled to minimise impacts.
- Keeping neighbours informed of a planned noisy activity, its duration and the reasons for the activity. Neighbours may be more accepting of temporary noise if they know when and why the noise is happening, and how long it will last.
- Educating staff and contractors about noise and quiet work practices. This could include signage, for example, some construction sites have signs reminding contractors to consider neighbours and be quiet, and to not start noisy work too early (e.g. before 7.00 am).

Noise can be controlled in the transmission path by using separation distances, barriers and sound absorptive materials.

- Increasing the separation distance (distance attenuation) between the noise source and receiver reduces the noise level. As a rule of thumb, each doubling of the distance from a noise source equates to a reduction of sound pressure level of 6 dB (the inverse square law). This does not apply close to a loud noise source.
- Careful site selection for a new noisy activity can help minimise noise impacts where it is possible to provide adequate separation distances.
- Barriers are most effective when they are located close to the noise source and block the line of sight between the source and receiver. The amount of noise reduction achieved depends on the height and mass of the barrier and the frequency of the noise (barriers are less effective for low-frequency noise). Noise barriers should have no gaps. Use of absorptive material on the side of the barrier facing the noise source can also help to reduce noise levels by reducing noise reflections. Trees or other vegetation do not provide an effective noise barrier. Some limited attenuation may be gained where trees are densely planted but little attenuation is achieved for low frequencies.
- Sound-absorptive materials reduce the level of reflected sound. They are porous materials such as glass fibre, wool and mineral wool. Thin layers are capable of absorbing only high frequencies, whereas thicker layers can absorb a wider frequency range.

13.3 Equipment Noise Levels for the Proposed Construction works

The construction activities associated with the proposed development will consist of various plant and equipment as detailed above. The sound power levels of the noisy plant and equipment likely to be used during the construction works are provided in Section 7.3 above.

14. APPENDIX B – DEMOLITION AND CONSTRUCTION VIBRATION MANAGEMENT GUIDELINES

14.1 Vibration Criteria Objectives

The management objective for the site is to limit vibration from demolition and construction activities so as to avoid building damage and human discomfort associated with the demolition works. It is noted that buildings in the vicinity of development are residential. Vibration impacts on the buildings and their occupants should be considered for the assessment of structural damage and human annoyance, respectively.

14.2 Vibration Sources

Typical vibration levels from demolition plant equipment most likely to cause significant vibration are summarised in the Table 8 below.

Activity	Typical ground vibration
Bulldozers/ Excavators	Typical ground vibration from bulldozers range from 1mm/s to 2mm/s at distances of approximately 5m and at distances greater than 20m, vibration levels are usually below 0.2mm/s.
Medium Rock Hammer (<600kg)	Typical ground vibration from Medium Rock Hammer (<600kg) range from 0.2mm/s at distances of approximately 5m and at distances greater than 20m, vibration levels are usually below 0.02mm/s.
Truck traffic	Typical vibration from heavy trucks passing over normal (smooth) road surfaces generate relatively low vibration in the range 0.01-0.2mm/s at the footings of buildings located 10-20m from a roadway. In general ground vibration from trucks is usually imperceptible in nearby buildings.

Table 8 Typical ground vibration generated by demolition plant

Therefore, vibration management strategies implemented on site shall consider these items of plant and demolition activities involving these items of plant.

14.3 Vibration Criteria

The following criteria are considered applicable when assessing vibration emission levels from the demolition works.

The effects of ground vibration on buildings near demolition sites may be broadly defined by the following three categories:

1. Disturbance to building occupants - Vibration in which the occupants or users of the building are inconvenienced or possibly disturbed,
2. Effects on building contents - Vibration where the building contents may be affected, and,
3. Effects on building structures - Vibration in which the integrity of the building or structure itself may be prejudiced.

In general, vibration criteria for human disturbance (1) are more stringent than vibration criteria for effects on building contents (2) and building structural damage (3). Hence, compliance with the more stringent limits dictated by Category 1, would allow for compliance to be achieved for the other two categories.

<u>Category 1</u> – Disturbance to Buildings Occupants

For disturbance to human occupants of buildings, we refer to the EPA's *'Assessing Vibration; a technical guideline'*, published in February 2006. This document provides criteria which are based on the British Standard BS 6472-1992, *'Evaluation of human exposure to vibration in buildings (1-80Hz)'*.

Vibration sources are defined as C*ontinuous, Impulsive or Intermittent.* Section 2 of the technical guideline defines each type of vibration as follows:

> ***'Continuous*** *vibration continues uninterrupted for a defined period (usually throughout the day-time 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 or repeated periods of impulsive vibration that varies significantly in magnitude'.*

The criteria are to be applied to a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

> *'Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472).'*

Preferred and maximum values for continuous and impulsive vibration are defined in below in Table 9 extracted from "Table 2.2 of the guideline" and the values for residential type buildings are reproduced below.

Location	Assessment period[1]	Preferred values		Maximum values	
		z axis	x & y axis	z axis	x & y axis
Continuous vibration					
Residences	Daytime (7am-10pm)	0.010	0.0071	0.020	0.014
Impulsive vibration					
Residences	Daytime (7am-10pm)	0.30	0.21	0.60	0.42

Notes: 1. Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am

Table 9 Preferred and Maximum Weighted RMS Values for Continuous and Impulsive Vibration Acceleration (m/s2) 1 to 80Hz

Intermittent vibration is to be assessed using vibration dose values (VDVs). The VDV method is a fourth power approach which is more sensitive to peaks in the acceleration waveform and makes corrections to the criteria based on the duration of the source's operation.

The VDV can be calculated using the overall weighted rms acceleration of the vibrating source in each orthogonal axis and the total period during which the vibration may occur. Weighting curves are provided in each orthogonal axis in the guideline.

Preferred and maximum VDV values are defined in Table 10 below extracted from "Table 2.4 of the guideline" and VDV values for residential type buildings are reproduced below.

Location	Daytime (7am-10pm) [1]		Night-time (10pm-7am) [1]	
	Preferred values	Maximum values	Preferred values	Maximum values
Residences	0.20	0.40	0.13	0.26

Notes: 1. Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am

Table 10 Preferred and Maximum VDV Values

14.3.1 Buffer Distances for Vibration Control

The relationship between vibration and the probability of causing human annoyance or damage to structures is complex. This complexity is mostly due to the magnitude of the vibration source, the particular ground conditions between the source and receiver, the foundation-to-footing interaction and the large range of structures that exist in terms of design (i.e. dimensions, materials, type and quality of structure and footing conditions).

The intensity, duration, frequency content and number of occurrences of a vibration, all play an important role in both the annoyance caused and the strains induced in structures.

As the pattern of vibration radiation is very different to the pattern of airborne noise radiation, and is very site specific, below are some indicative minimum 'buffer' distances determined for some common demolition plant with data available from recent projects, which assist to avoid human discomfort in terms of perceptible (or tactile) vibration during daytime demolition hours:

Plant Item	Recommended Minimum Buffer Distance (m)
CFA (Continuous Flight Auger) Piling rig	10
Excavators	10
Jack hammers	5

Table 11 Recommended Minimum Buffer Distances for demolition and construction plant

From the above Table 11 it can be seen that the nearest receivers are less than 10m from the site, and as such, vibration may cause discomfort to occupants during piling activities.

Therefore, site specific buffer distances should be determined for piling activities once vibration emission levels are measured from the piling rig prior to the commencement of its regular use on site.

14.3.2 Vibration Management Measures

Further to buffer distances, to ensure vibration impacts are minimised during the demolition period, the following vibration management control measures are provided:

1. The proper implementation of a vibration management plan is required to avoid adverse vibration disturbance to affected occupancies. Consultation with occupants and property owners is recommended and should be aimed at providing a communication path directly to the Contractor.
2. A management procedure will be implemented to deal with vibration complaints. Each complaint will be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures shall be put in place to mitigate future occurrences
3. Where vibration is found to be excessive, management measures shall be implemented to ensure vibration compliance is achieved. Management measures may include modification of demolition methods such as using smaller units, establishment of safe buffer zones and if necessary, time restrictions for the most excessive vibration activities. Time restrictions are to be negotiated with affected receivers.