Richard Crookes Constructions

The Art Gallery of NSW
Sydney Modern Development

Construction Noise and Vibration Management Plan

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1 Introduction

White Noise Acoustics has been engaged to undertake the acoustic assessment of the noise and vibration impacts during the proposed demolition, exaction and construction stages of the Sydney Modern development associated with the Art Gallery of NSW and develop a Construction Noise and Vibration Management Plan.

The assessment has been undertaken in conjunction with the requirements of the EPA's Interim Construction Noise Guideline, the Coffey *Geotechnical Excavation Monitoring Plan (Ref: SYDGE210394-BB)* and the Arup *Environmental Impact Statement – Acoustic Report (Ref: Acoustics SEARS Report rev A.docx)* which is included as part of the SSD 6471 approvals.

This report includes the recommended noise and vibration mitigations and management controls for the operation of demolition, excavation and construction activities on the site to ensure impacts to surrounding receivers are minimised as required by Items C7, C8, C9, C10 and B63 of the projects *Conditions of Consent*.

2 Development Description

The proposed development includes the demolition of existing buildings on the site, excavation of basement in ground works such that the future Sydney Modern project can be constructed. The site is located within the Art Gallery of NSW site and is located to the north of the existing gallery, partly extending over the Eastern Distributor land bridge and includes a disused Navy fuel bunker located to the north east of this land bridge.

The new expansion, known as the Sydney Modern project, comprises a new entry plaza, new exhibition spaces, shop, food and beverage facilities, visitor amenities, art research and education spaces, new roof terraces and landscaping and associated site works and infrastructure, including loading and service areas, services infrastructure and an ancillary seawater heat exchange system.

The surrounding receivers to the site include a number of residential, infrastructure and recreational receivers including the following:

1. 10 Lincoln Crescent, Woolloomooloo (Wharf Terraces) – Residential receiver to the east of the site.
2. 9-31 Lincoln Crescent, Woolloomooloo (Wharf Terraces) – Residential receiver to the east of the site.
3. 6 Lincoln Crescent, Woolloomooloo – Electrical infrastructure building
4. Botanic Gardens – Passive recreational area to the north of the site.
5. The Domain – Active recreational area to the west of the site.
6. The Eastern Distributor – Traffic Roadway located to the west of the site.
7. Existing buildings of the Art Gallery of NSW – to the west of the site.
8. Heritage fuel tank – located on the site on Lincoln Crescent

The site location, in relation to surrounding buildings, is shown in Figure 1 below.

Figure 1 – Site Location and Surrounding Receivers

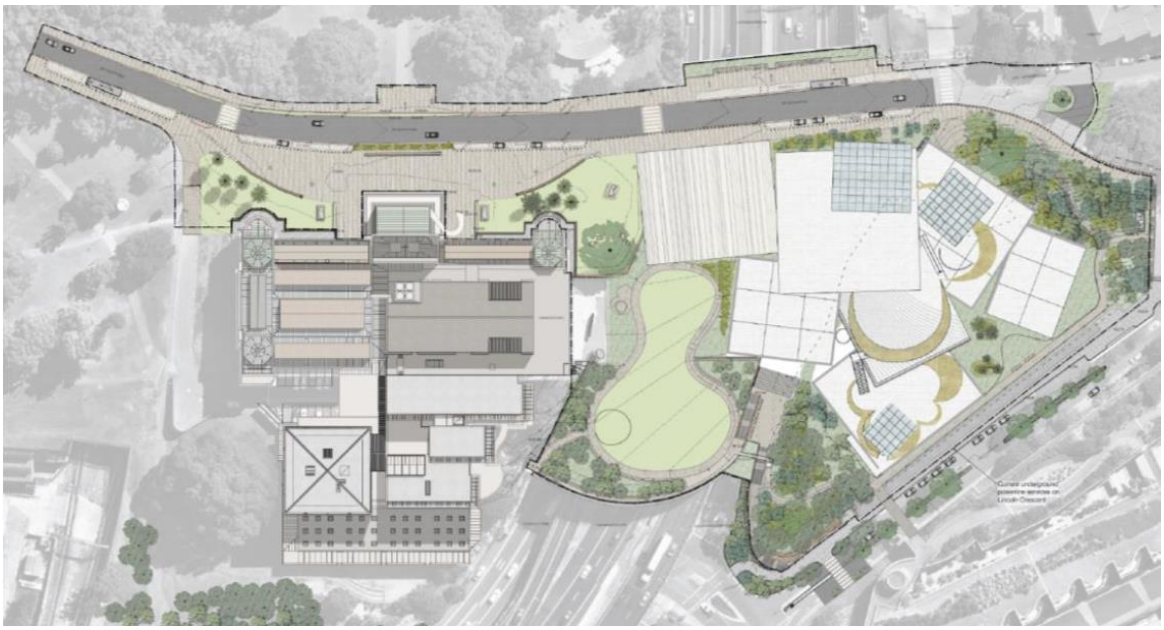


Figure 2 – Proposed Sydney Modern Development

The proposed development includes an expansion to the exiting NSW Art Gallery, known as the Sydney Modern project. The expansion includes a new entry plaza, new exhibition spaces, shop, food and beverage facilities, visitor amenities, art research and education spaces, new roof terraces and landscaping and associated site works and infrastructure, including loading and service areas, services infrastructure and an ancillary seawater heat exchange system.

2.1 Projects Proposed Program

The expected construction programme for the required works on the site is summarised below:

Demolition, Excavation and Construction – Program

1. Soft Demo & Hazardous Materials Removal –approximately 4 weeks
2. Hard Demo (including excavators with hammers and pulverisers) - approximately 12 weeks.
3. Excavation and in ground works – approximately 6 months.
4. Construction stage – approximately 21 months

3 Project Requirements

The projects Construction Noise and Vibration Management plan has been developed in compliance with the project *Conditions of Consent* including the following.

	Noise and Vibration Management
C7	The development must be constructed with the aim of achieving the construction noise management levels detailed in the Interim Construction Noise Guideline (Department of Environment and Climate Change, 2009). All feasible and reasonable noise mitigation measures must be implemented and any activities that could exceed the construction noise management levels must be identified and managed in accordance with the Construction Environmental Management Plan.
C8	Heavy vehicles and oversized vehicles must not queue or idle on Art Gallery Road, Mrs Macquaries Road or Lincoln Crescent outside of construction zones awaiting access to the Subject Site.
C9	The Applicant must schedule intra-day 'respite periods' for construction activities predicted to result in noise levels in excess of the "highly noise affected" levels, including the addition of 5 dB to the predicted levels for those activities identified in the Interim Construction Noise Guideline as being particularly annoying to noise sensitive receivers.
C10	Vibration caused by construction at any residence or structure outside the subject site must be limited to: a) for structural damage vibration to buildings (excluding heritage buildings), British Standard BS 7385 Part 2-1993 Evaluation and Measurement for Vibration in Buildings; b) for structural damage vibration to heritage buildings, German Standard DIN 4150 Part 3 Structural Vibration in Buildings Effects on Structure; and c) for human exposure to vibration, the evaluation criteria presented in British Standard BS 6472-Guide to Evaluate Human Exposure to Vibration in Buildings (1Hz to 80 Hz) for low probability of adverse comment.

	Construction Noise and Vibration Management Plan
B63	Prior to the issue of the relevant Crown Building Works Certificate, a Construction Noise and Vibration Management Plan (CNVMP) prepared by a suitably qualified person shall be submitted to the Certifying Authority. The CNVMP must be prepared in consultation with, and address the relevant requirements of, Council and the EPA. The CNVMP shall address (but not be limited to): a) be prepared in accordance with the EPA's Interim Construction Noise Guideline b) identify nearby sensitive receivers and land uses; c) identify the noise management levels for the project; d) identify the construction methodology and equipment to be used and the key sources of noise and vibration; e) details of all reasonable and feasible management and mitigation measures to be implemented to minimise construction noise and vibration; f) be consistent with and incorporate all relevant recommendations and noise and vibration mitigation measures outlined in the Acoustic Report (dated 28 February 2018) in Appendix P of the RTS; g) ensure all potentially impacted sensitive receivers are informed by letterbox drops prior to the commencement of construction of the nature of works to be carried out, the expected noise levels and duration, as well as contact details for a construction community liaison officer; and h) include a suitable proactive construction noise and vibration monitoring program which aims to ensure the construction noise and vibration criteria in this consent are not exceeded. Prior to the commencement of works, a copy of the CNVMP must be submitted to Council and the Planning Secretary.

And REF condition

- Condition 5.3 which includes the following.

5.3. Construction noise is to comply with the *City of Sydney Code of Practice for Construction Hours/Noise 1992* and *Australian Standard 2436 - 1981 Guide to Noise Control on Construction, Maintenance and Demolition Sites.*

4 Existing Acoustic Environment

The site of the Sydney Modern Project includes the expansion of the Art Gallery of NSW including the area of land to the north of the existing building partly extending over the Eastern Distributor land bridge and includes a disused Navy fuel bunker located to the north east of this land bridge.

Noise levels at the site are predominantly a result of traffic movements of surrounding roadways including the Eastern Distributor which carries high volumes of traffic including heavy vehicles.

As part of the previously conducted *Environmental Impact Statement – Acoustic Report (Ref: Acoustics SEARS Report rev A.docx)* which was included as part of the SSD 6471 approvals a noise survey of the surrounding area has been conducted including an assessment of existing background noise levels. The noise levels detailed within this report have been used as the basis of this report.

4.1 Existing Background Noise Levels at the site

As part of the SSD 6471 approvals a background noise survey of the site and surrounding areas has been conducted and is detailed in the *Environmental Impact Statement – Acoustic Report (Ref: Acoustics SEARS Report rev A.docx).*

The noise levels detailed within this report have been used as the basis of this management plan.

Section 3.2 *Measurement of existing noise levels of the Environmental Impact Statement – Acoustic Report (Ref: Acoustics SEARS Report rev A.docx)* includes details of the noise survey undertaken at the site in 2016. The obtained noise levels undertaken within the *Environmental Impact Statement – Acoustic Report* include noise levels which are suitable for the assessment of the current noise levels at the site. As the main source of noise impacting the site is a result of traffic noise levels from the Eastern Distributor and the number of vehicles using the roadway has not changed significantly since 2016 the resulting noise levels on and surrounding Sydney Modern Development will not have changes significantly.

As part of the *Environmental Impact Statement – Acoustic Report* both long term unattended noise logging as well as short term attended noise level measurements were conducted around the site. A summary of the acoustic survey is detailed in the tables below.

Table 1 – Results of Noise Survey at the Site

Measurement Location	Time of Measurement	$L_{Aeq, 15min}$ dB(A)	$L_{A90, 15min}$ dB(A)	Comments
Location 1 – South East of the existing Art Gallery of NSW building facing Eastern Distributor	Day	65	59	Noise level at the site was dominated by vehicle movements on surrounding roadways including the Eastern Distributor
	Evening	63	58	
	Night	60	47	
Location 2 – West of Lincoln Crescent on the proposed Sydney Modern Development site	Day	60	49	
	Evening	62	49	
	Night	54	44	
Location 3 – To the west of the residence at 731 Bourke Street @ 5.2m above ground level	Day	60	54	
	Evening	58	53	
	Night	55	42	

Noise levels based on levels detailed within the *Environmental Impact Statement – Acoustic Report (Ref: Acoustics SEARS Report rev A.docx)* and included as part of the SSD 6471 approvals.

Measurement locations based on the *Environmental Impact Statement – Acoustic Report* and are detailed within Figure 1 of this report

5 Construction Noise and Vibration Assessment

This section of the report details the assessment of noise associated with the proposed demolition, excavation and construction activities associated with the proposed Sydney Modern Development. The assessment has been undertaken to assess the potential noise and vibration impacts from the proposed demolition, excavation and construction required to deliver the project on surrounding receivers.

The proposed demolition, excavation and construction activities to be undertaken on the site include the site preparation including demolition of the existing structures, excavation and construction of the proposed development. The development will be constructed using normal construction processes.

This management plan has been developed as required by Item B63 of the projects *Conditions of Consent* which includes the following:

Construction Noise and Vibration Management Plan

B63 Prior to the issue of the relevant Crown Building Works Certificate, a **Construction Noise and Vibration Management Plan** (CNVMP) prepared by a suitably qualified person shall be submitted to the Certifying Authority. The CNVMP must be prepared in consultation with, and address the relevant requirements of, Council and the EPA. The CNVMP shall address (but not be limited to):

a) be prepared in accordance with the EPA's *Interim Construction Noise Guideline*

b) identify nearby sensitive receivers and land uses;

c) identify the noise management levels for the project;

d) identify the construction methodology and equipment to be used and the key sources of noise and vibration;

e) details of all reasonable and feasible management and mitigation measures to be implemented to minimise construction noise and vibration;

f) be consistent with and incorporate all relevant recommendations and noise and vibration mitigation measures outlined in the Acoustic Report (dated 28 February 2018) in Appendix P of the RTS;

g) ensure all potentially impacted sensitive receivers are informed by letterbox drops prior to the commencement of construction of the nature of works to be carried out, the expected noise levels and duration, as well as contact details for a construction community liaison officer; and

h) include a suitable proactive construction noise and vibration monitoring program which aims to ensure the construction noise and vibration criteria in this consent are not exceeded.

Prior to the commencement of works, a copy of the CNVMP must be submitted to Council and the Planning Secretary.

And, REF Condition 5.3 which includes the following.

5.3. Construction noise is to comply with the *City of Sydney Code of Practice for Construction Hours/Noise 1992* and *Australian Standard 2436 - 1981 Guide to Noise Control on Construction, Maintenance and Demolition Sites.*

5.1 Construction Noise

The assessment of construction noise impacts generated from works on the site has been undertaken in accordance with the requirements of the Environmental Protection Authorities (EPA) Interim Construction Noise Guideline as required by Item B63 of the *Conditions of Consent*.

The EPA's Interim Construction Noise Guideline defines normal day time hours as the following:

2.2 Recommended standard hours

The recommended standard hours for construction work are shown in Table 1; however, they are not mandatory. There are some situations, as described below, where construction work may need to be undertaken outside of these hours. The likely noise impacts and the ability to undertake works during the recommended standard hours should be considered when scheduling work.

Table 1: Recommended standard hours for construction work

Work type	Recommended standard hours of work*
Normal construction	Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays
Blasting	Monday to Friday 9 am to 5 pm Saturday 9 am to 1 pm No blasting on Sundays or public holidays

* The relevant authority (consent, determining or regulatory) may impose more or less stringent construction hours.

Construction works on the site will be undertaken in accordance with the hours approved and included in the Conditions of Consent which includes the following:

Construction Hours

C2 Construction, including the delivery of materials to and from the site, may only be carried out between the following hours:

a) between 7.00 am and 6.00 pm, Mondays to Fridays inclusive;

b) between 8.00 am and 3.30 pm, Saturdays.

C3 No construction work may be carried out on Sundays or public holidays

C4 Activities may be undertaken outside of these hours if required:

a) by the Police or a public authority for the delivery of vehicles, plant or materials; or

b) in an emergency to avoid the loss of life, damage to property or to prevent environmental harm.

C5 Notification of such activities must be given to affected residents before undertaking the activities or as soon as is practical afterwards.

C6 Rock breaking, rock hammering, sheet piling, pile driving and similar activities may only be carried out between the following hours:

a) 9.00 am to 12.00 pm, Monday to Friday;

b) 2.00 pm to 5.00 pm, Monday to Friday; and

c) 9.00 am to 12.00 pm, Saturday.

5.2 Proposed Appliances

The proposed appliances which will be used as part of the demolition and construction of the project are detailed in the table below.

Table 2 – Noise Level from Expected Demolition Appliances

Tasks	Equipment	Sound Power Levels per task dB(A) L_{10}	Aggregate Sound Power Level per Task dB(A) L_{10}
Site Preparation and Demolition works	Jack hammer mounted on excavator	118	122
	Excavators and bulldozers	115	
	Hand held jack hammer	111	
	Concrete saw	119	
	Skid steer	110	
	Power hand tools	109	
	Materials Movements	105	
Site Excavations	Jack hammer mounted on excavator	118	122
	Saw cutting	119	
	Excavators and bulldozers	115	
	Materials Movements	105	
	Bulldozers	115	
	Trucks	109	
	Piling	115	
Construction Works	Piling	115	120
	Welder	101	
	Saw cutter	109	
	Dump truck	109	
	Concrete saw	119	
	Power hand tools	109	
	Cranes	110	

Notes: Noise levels of proposed equipment to be used on the site based on the Australian Standard AS2436-2010 and noise level measurements previously undertaken of similar equipment on construction sites.

5.3 Construction Noise Criteria

This section of the report details the relevant construction noise criteria which is applicable to the site including the EPA's *Interim Construction Noise Guideline* (ICNG).

5.3.1 Interim Construction Noise Guideline

Noise criteria for construction and demolition activities are discussed in the *Interim Construction Noise Guideline* (ICNG). The ICNG also recommends procedures to address potential impacts of construction noise on residences and other sensitive land uses. The main objectives of the ICNG are summarised as follows:

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

The ICNG contains a quantitative assessment method which is applicable to this project. Guidance levels are given for airborne noise at residences and other sensitive land uses.

The quantitative assessment method involves predicting noise levels at sensitive receivers and comparing them with the Noise Management Levels (NMLs). The NML affectation categories for receivers have been reproduced from the guideline and are listed in the table below.

Table 3 – Noise Management Levels from Construction – Quantitative Assessment

Receiver Type	Time of Day	Noise Management Level LAeq(15minute)[1,2]	How to Apply
Residential	Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 3.30 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 LAeq(15minute) 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 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. 2. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
	Outside recommended standard hours	Noise affected RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB above the noise affected level, the proponent should negotiate with the community.

Table 3 – Continued

Receiver Type	Time of Day	Noise Management Level LAeq(15minute)1,2	How to Apply
Office, retail outlets	When is use	Highly noise affected 70 dBA	The external noise levels should be assessed at the most-affected occupied point of the premises

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

Note 2 *The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours). The term RBL is described in detail in the NSW Industrial Noise Policy (EPA 2000).*

Based on the table above the suitable construction noise management levels for works undertaken on the site is detailed in the table below.

Table 4 – Site Construction Noise Management Levels

Noise Source	Time Period	Receiver Type	Construction Noise Management Level	'High Noise Affected' Level
Construction Noise	Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 3.30pm No work on Sundays or public holidays	Residence to the south of the site	59 dB(A) LAeq (15min)	75 dB(A) LAeq (15min)
		Commercial Receivers	59 dB(A) LAeq (15min) When in use	70 dB(A) LAeq (15min) When in use

Note 1: Construction noise management levels based on the Interim Construction Noise Guideline

5.4 Construction Vibration Assessment

This section of the report details the assessment of construction vibration impacts on surrounding receivers.

Effects of ground borne vibration on buildings may be segregated into the following three categories:

- Human comfort – vibration in which the occupants or users of the building are inconvenienced or possibly disturbed. Refer to further discussion in Section 4.4.1.
- Effects on building contents – where vibration can cause damage to fixtures, fittings and other non-building related objects. Refer to further discussion in Section 4.4.2.
- Effects on building structures – where vibration can compromise the integrity of the building or structure itself. Refer to further discussion in Section 4.4.2.

5.4.1 Vibration Criteria – Human Comfort

Vibration effects relating specifically to the human comfort aspects of the project are taken from the guideline titled *"Assessing Vibration – A Technical Guideline"*. (AVTG) This type of impact can be further categorised and assessed using the appropriate criterion as follows:

- Continuous vibration – from uninterrupted sources (refer to Table 5).
- Impulsive vibration – up to three instances of sudden impact e.g. dropping heavy items, per monitoring period (refer to Table 6).

- Intermittent vibration – such as from drilling, compacting or activities that would result in continuous vibration if operated continuously (refer to Table 7).

Table 5 - Continuous vibration acceleration criteria (m/s2) 1 Hz-80 Hz

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or night-time	0.020	0.014	0.040	0.028
		0.04	0.029	0.080	0.058
Workshops	Day or night-time	0.04	0.029	0.080	0.058

Table 6 - Impulsive vibration acceleration criteria (m/s2) 1 Hz-80 Hz

Location	Assessment period	Preferred Values		Maximum Values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day or night-time	0.64	0.46	1.28	0.92
Workshops	Day or night-time	0.64	0.46	1.28	0.92

Table 7 Intermittent vibration impacts criteria (m/s1.75) 1 Hz-80 Hz

Location	Daytime		Night-time	
	Preferred Values	Maximum Values	Preferred Values	Maximum Values
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

5.4.2 Vibration Criteria – Building Contents and Structure

The vibration effects on the building itself are assessed against international standards as follows:

- For transient vibration: British Standard BS 7385: Part 2-1993 "Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from ground borne vibration" (BSI 1993); and
- For continuous or repetitive vibration: German DIN 4150: Part 3 – 1999 "Effects of Vibration on Structure" (DIN 1999).

5.4.2.1 Standard BS 7385 Part 2 - 1993

For transient vibration, as discussed in standard BS 7385 Part 2-1993, the criteria are based on peak particle velocity (mm/s) which is to be measured at the base of the building. These are summarised in Table 8 and illustrated in the Figure below.

Table 8 - Transient vibration criteria as per standard BS 7385 Part 2 - 1993

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

Standard BS 7385 Part 2 – 1993 states that the values in Table 8 relate to transient vibration which does not cause resonant responses in buildings. Where the dynamic loading caused by continuous vibration events is such as that results in dynamic magnification due to resonance (especially at the lower frequencies where lower guide values apply), then the values in Table 8 may need to be reduced by up to 50% (refer to Line 3 in the Figure below).

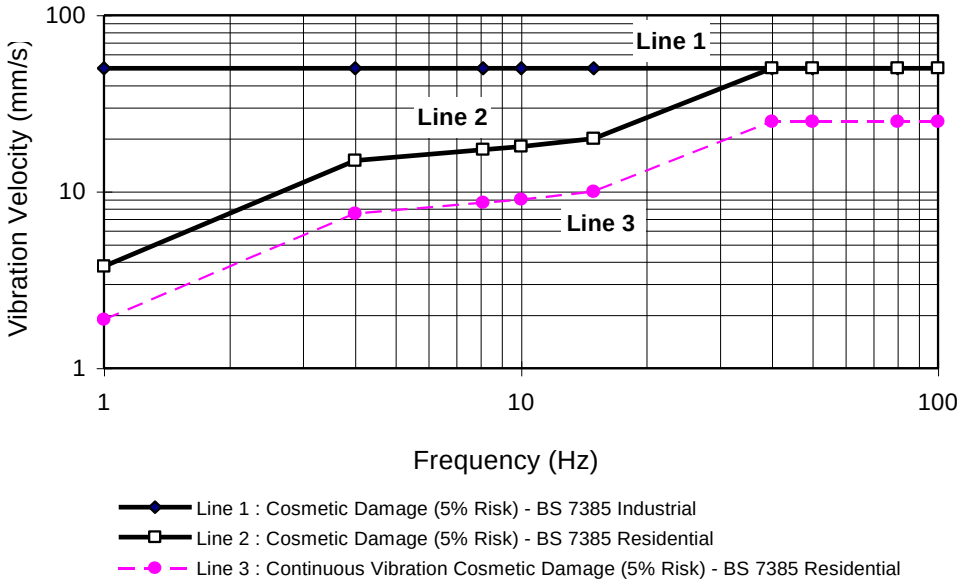


Figure 10 - BS 7385 Part 2 – 1993, graph of transient vibration values for cosmetic damage

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

The standard also states that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 8, and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the values in Table 8 should not be reduced for fatigue considerations.

5.4.2.2 Standard DIN 4150 Part 3 - 1999

For continuous or repetitive vibration, standard DIN 4150 Part 3-1999 provides criteria based on values for peak particle velocity (mm/s) measured at the foundation of the building; these are summarised in Table 9. The criteria are frequency dependent and specific to particular categories of structures.

Table 9 - Structural damage criteria as per standard DIN 4150 Part 3 - 1999

Type of Structure	Peak Component Particle Velocity, mm/s			
	Vibration at the foundation at a frequency of			Vibration of horizontal plane of highest floor at all frequencies
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]	
Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8
Note 1: For frequencies above 100Hz, at least the values specified in this column shall be applied.				

5.5 Summary of Construction Vibration Criteria

The existing buildings which neighbour the project site are detailed below:

1. North – Electrical infrastructure building.
2. East – residential buildings including Wharf Terraces.
3. West – Existing Art Gallery of NSW.
4. Heritage storage tanks on the site.
5. The Eastern Distributor road infrastructure.

Based on the details of the vibration criteria detailed in the sections above and the Coffey *Geotechnical Excavation Monitoring Plan* the recommended construction vibration impact criteria to protect the neighbouring receivers to the site includes the following:

1. Electrical infrastructure building - 7mm/s or specific criteria provided by the Ausgrid.
2. Residential Receivers (Wharf residence) – 5mm/s.
3. Eastern Distributor road infrastructure - 10mm/s.
4. Existing Art Gallery Buildings – 2.5mm/s.
5. Heritage storage tanks – 5mm/s

5.6 Construction Noise Management

Based on the assessment conducted of the expected construction noise levels generated from the demolition and excavation to be conducted on the site, levels are generally expected to require the building contractor to engage in management of activities on the site and engagement with the local community.

Notwithstanding, the following management controls are recommended to mitigate construction noise levels on the site:

1. Toolbox meetings should be undertaken with all contractors commencing works on the site detailing the requirements to limit noise impacts to neighbouring including their responsibilities detailed in this report.
2. All plant and equipment are to be maintained such that they are in good working order.
3. A register of complaints is to be recorded in the event of complaints being received, including location, time of complaint, nature of the complaint and actions resulting from the complaint.
4. If required a noise level measurement of the offending plant item generating complaints is to be conducted and noise mitigations undertaken to reduce noise levels to within Noise Management levels in the event magnitude of noise levels is found to be above suitable levels.
5. The use of percussive and concrete sawing should be undertaken behind the existing façades of buildings when possible.
6. The use of percussive equipment including hydraulic hammering should be limited such that they comply with the requirements of the projects *Conditions of Consent*.
7. Where possible any excavation to be undertaken on the site is to include ripping of material where possible.
8. Where possible the removal of concrete slabs to be undertaken using pulverising rather than hydraulic hammering.
9. Access for trucks entering and exiting the site should use Lincoln Street and then the Eastern Distributor as possible.
10. Respite periods are to be scheduled for activities which generate noise levels in excess of the *High Noise Affected* levels detailed in Table 3 above. Respite period should include a 30 minute period of respite in every 2 hour periods for *High Noise Affected* generating appliances. Equipment which is expected to generate *High Noise Affected* levels includes the following:
    a. Excavators fitted with hydraulic hammering within 50m of the Wharf Terraces
    b. Saw cutting of rock or concrete within 50 of the Wharf Terraces.

In addition to the recommended mitigations above details of the proposed construction (including demolition) works to be conducted on the site, including type of activities to be conducted as well as the expected duration of activities should be provided to the neighbouring receivers.

In the event noise levels are found to required additional noise reduction then all possible and practical mitigations are required to be included in the construction of the project. Possible acoustic treatments and controls may include the following:

1. Use of alternative appliances to complete the required works which result in reduced noise impacts on surrounding neighbours.
2. Period when noisy appliances are undertaken, such as undertaking noisy works on locations with the greatest distance to residential receivers during morning periods if possible.
3. Construction of acoustic screening to permanently located high noise generating equipment such as pumps and generators.
4. Scheduling of high noise generating works outside of noise sensitive periods if possible.
5. Other site-specific treatments and controls which may become possible once works commence.

5.7 Construction Traffic

Construction traffic accessing the site including the movements of heavy vehicles are required to comply with item C8 of the projects *Conditions of Consent* that includes the following

> C8 - *Heavy vehicles and oversized vehicles must not queue or idle on Art Gallery Road, Mrs Macquaries Road or Lincoln Crescent outside of construction zones awaiting access to the Subject Site.*

5.8 Construction Vibration Management

An assessment of the potential for vibration generated as part of the required construction activities on the project (including excavation and demolition) has been undertaken.

To ensure the vibration impact criteria detailed in this report are complied with the following safe working mitigations and/or working distances should be implemented as detailed in the table below.

Table 10 – Vibration Mitigation

Construction Phase	Activity	Vibration Mitigation
Demolition	Hydraulic Hammering	Separation to the neighbouring buildings is to be established prior to hammering of the existing building structures and maintained at all times during demolition
	Materials and Equipment Movement	Ensure no contact with the neighbouring building structures occur during materials movement or equipment movements
Excavation	Hydraulic hammering of rock	A saw cut to the perimeter of the exaction is required to be conducted prior to hammering of rock is undertaken in the event rock breaking is to occur within 10m of neighbouring residential buildings and 15m of the existing Art Gallery of NSW buildings. Saw cutting to be recurring for each level of removal of rock
Construction	General Construction activities	General construction activities are not expected to exceed project vibration limits detailed in this report.

In addition to the above Toolbox meetings should be undertaken with all contractors commencing works on the site detailing the requirements to limit vibration impacts to neighbouring including their responsibilities detailed in this report and the required responses to vibration events.

6 Noise and Vibration Monitoring

As part of the management of noise and vibration from the proposed demolition and excavation activities to be undertaken on the site the following noise and vibration measurements are recommended to be undertaken:

1. Noise –
    a. Attended noise level measurements of typical demolition and excavation activities should be undertaken at site.

       Attended construction noise surveys of the site and surrounding impacts on neighbours should be undertaken during the following as a minimum:
        i. Start of Demolition
        ii. Commencement of any rock breaking or sawing on the site.
        iii. In response to any ongoing complaints received from neighbours.

    b. Long term noise monitoring – long tern unattended noise monitoring should be undertaken at the site to record impacts to the surrounding receivers. Monitoring location should include the following minimum locations:
        i. To the east of the site – Representative location for the Wharf Terraces residential dwellings.
        ii. To the south of the site – Representative location for the existing Art Gallery of NSW buildings and Domain.

       Noise monitoring should be undertaken including the following:
        i. Monitoring to include long term continuous noise logging.
        ii. Monitors set to record noise levels over 15 minute periods and include as a minimum $L_{10,}$ L_{90} and L_{eq} noise levels.
        iii. The results of noise levels are to be periodically reported including a monthly report as a minimum. The reported noise levels should include comments regarding magnitude of noise levels and triggers for required mitigation and management controls if required. Additional reporting may be required in the event complaints from neighbouring receivers are received.

2. Vibration – To confirm vibration magnitudes are within the expected levels the following attended vibration measurements are required:
    a. Short term attended vibration measurements –
        i. Attended short term vibration measurement of activities with the potential to generate maximum vibration to be undertaken on commencement at the site, including the following:
            - Measurements to be undertaken at a representative location from the activity being conducted with a similar distance to the potentially affected receiver.
            - Activities with the potential to generate the greatest magnitudes of vibration include:
                a. Hydraulic hammering of concrete slabs.
                b. Hydraulic hammering during excavation within rock.
    b. Long term vibration monitoring – long tern unattended vibration monitoring should be undertaken at the site to record impacts to the surrounding receivers. Monitoring location should include the following minimum locations:
        i. To the east of the site – Representative location for the Wharf Terraces residential dwellings and storage tanks.
        ii. To the south of the site – Representative location for the existing Art Gallery of NSW buildings and Domain.
        iii. Centrally within the site – Representative location for the Eastern Distributor and Storage Tanks.
        iv. To the north of the site for a representative location for the electrical infrastructure.

        Vibration monitoring should be undertaken including the following:
        i. Vibration Monitoring to include long term continuous vibration logging.
        ii. Monitors set to record maximum vibration levels including Peak Particle Velocity (PPV) magnitudes.
        iii. Monitors are required to be SMS enabled such that any events recorded above 'trigger' levels can be instantaneously sent to suitable builder, acoustic consultant and contractor representatives.
        iv. In the event results re received above 'trigger' levels the following response to events are required as detailed in the table below.
        v. Vibration monitoring should be undertaken for the periods including site preparation, demolition, exaction and construction of the building structure as a minimum or on agreement with neighbouring stake holders in the event monitoring details no negative impacts during the construction of the project.

See details in Appendix B for the required noise and vibration monitoring locations.

Table 11 – Required Response to Vibration Events

Location/ Receiver Type	Event Type		
	Trigger	Alert	Alarm, Stop Work
Eastern Distributor – Roadway infrastructure	7mm/s	10 mm/s	15 mm/s
Electrical infrastructure – to the north of the site	6mm/s	7 mm/s	10 mm/s
Residential Dwellings – Wharf Residence	3 mm/s	5 mm/s	10 mm/s
Heritage Structures – Art Gallery of NSW	2 mm/s	2.5 mm/s	3 mm/s
Heritage storage tanks	2.5 mm/s	3 mm/s	5 mm/s
See Section below for response to Event Types			

The required response to recorded event types detailed in the table above are included in the following table.

Table 12 – Required Response to Vibration Events

Event Type	Required Response
Trigger level	All events above the trigger level are required to be recorded by the vibration monitors.
Alert	Temporarily cease the vibration generating activity and assess the reason for vibration exceedances. Modify the related construction practice to prevent future exceedances. Keep records of subsequent breaches to demonstrate that vibrations for modified activity do not reach Alert Level. All *Alarm* events are to be SMS messaged to Richard Crookes site manager, subcontractor and acoustic consultant Geotechnical engineer . In the event more than 3 *Alert* events are recorded in any give hour then the requirements of an *Alarm* event detailed below are required to be followed.
Alarm	**Stop Work Event** All *Alarm* events are to be SMS messaged to a relevant Richard Crookes, subcontractor and acoustic consultant. The activity generating the vibration levels is to be stopped immediately. Suitable representatives of Richard Crookes Construction, the relevant Subcontractor and acoustic consultant (and other stake holders if required) are to assess likely causes, alternative options and possible contingency measures. Vibration monitoring report to be completed. Visual assessment of affected property will be conducted to assess whether damage is evident. The item/s of work generating the vibration events is not be recommenced until an action plan is agreed and implemented. The subsequent 3 hours vibration generating work activity will be scrutinized by stakeholders to confirm that the action plan has achieved the desired outcome.

7 Community Engagement

During the proposed construction of the project (including demolition, excavation and construction) the building contractor is required to engage in community interaction. The community interaction and notification is required to include the following:

1. Notification of the proposed works to be undertaken on the site and the periods when works will be conducted, including information regarding the programme of works such as demolition and excavation.
2. Details of the relevant site representative where complaints can be registered.
3. Details of the methodology to respond to complaints raised from the surrounding receivers.
4. A register of complaints, to be kept on site including record of time and nature of the complaint as well as the outcomes and comments regarding investigations resulting from the complaint.
5. Details of a site representative and contact numbers in the event of a complaint should be included on the perimeter of the site.

7.1 Proposed Program

The proposed program for the required works on the project is detailed in Section 2.1 of this report.

7.2 Community Notification

Community notification of the proposed construction period and periodic updates regarding scheduled works is required to be conducted. The community notification is to be undertaken using letter drops or electronic notification using emails to relevant stakeholders. The notification should be provided monthly and include the following:

1. expected works to be undertaken in the upcoming month,
2. Proposed period when works to be conducted including the expected noise levels and duration,
3. Contact information of relevant Richard Crookes Construction personnel regarding complaints including the construction community liaison officer.

Notifications should be provided to the following as a minimum:

- Residence of the Wharf Terraces
- Suitable representative of the Art Gallery of NSW
- Suitable representative of the Botanic Gardens.

8 Conclusion

This report details the construction noise and vibration assessment of the proposed demolition, excavation and construction activities to be undertaken as part of the Sydney Modern Development at the Art Gallery of NSW.

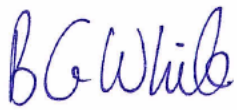
An assessment of noise and vibration impacts from the required processes to be undertaken during the demolition and excavation period of the project has been undertaken and suitable treatments, management controls, perioding measurements and community engagement has been detailed in this report.

The assessment has been undertaken in conjunction with the requirements of the EPA's Interim Construction Noise Guideline, the Coffey *Geotechnical Excavation Monitoring Plan (Ref: SYDGE210394-BB)* and the Arup *Environmental Impact Statement – Acoustic Report (Ref: Acoustics SEARS Report rev A.docx)* which is included as part of the SSD 6471 approvals.

This report includes the recommended noise and vibration mitigations and management controls for the operation of demolition, excavation and construction activities on the site to ensure impacts to surrounding receivers are minimised as required by Item B63 of the projects *Conditions of Consent*.

For any additional information please do not hesitate to contact the person below.

Regards



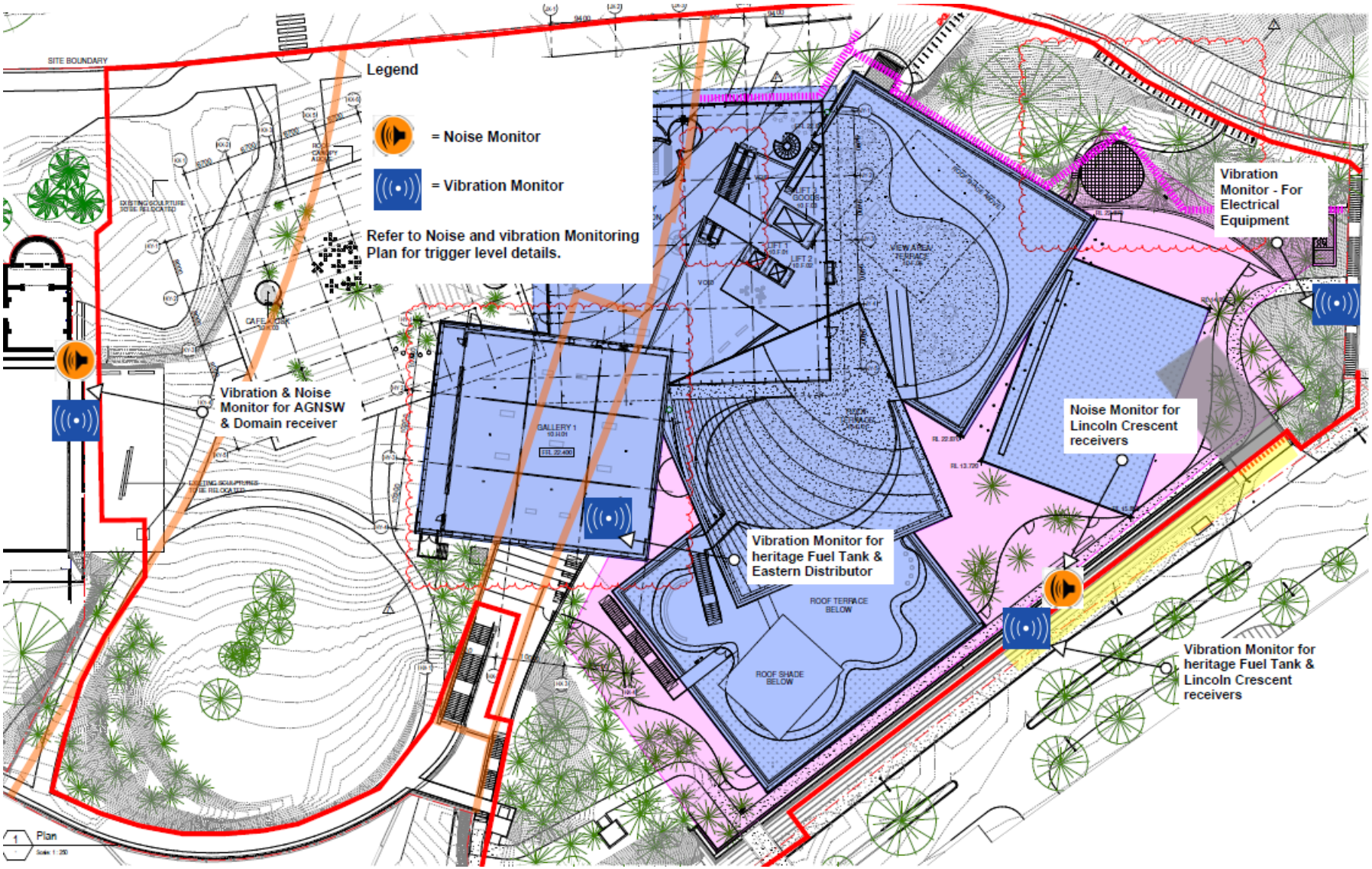
Ben White
Director
White Noise Acoustics

9 Appendix A – Glossary of Terms

Ambient Sound	The totally encompassing sound in a given situation at a given time, usually composed of sound from all sources near and far.
Audible Range	The limits of frequency which are audible or heard as sound. The normal ear in young adults detects sound having frequencies in the region 20 Hz to 20 kHz, although it is possible for some people to detect frequencies outside these limits.
Character, acoustic	The total of the qualities making up the individuality of the noise. The pitch or shape of a sound's frequency content (spectrum) dictate a sound's character.
Decibel [dB]	The level of noise is measured objectively using a Sound Level Meter. The following are examples of the decibel readings of every day sounds; 0dB the faintest sound we can hear 30dB a quiet library or in a quiet location in the country 45dB typical office space. Ambience in the city at night 60dB Martin Place at lunch time 70dB the sound of a car passing on the street 80dB loud music played at home 90dB the sound of a truck passing on the street 100dB the sound of a rock band 115dB limit of sound permitted in industry 120dB deafening
dB(A)	*A-weighted decibels* The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter. The sound pressure level in dB(A) gives a close indication of the subjective loudness of the noise.
Frequency	Frequency is synonymous to *pitch*. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Loudness	A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.
L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{90} noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Background Sound Low	The average of the lowest levels of the sound levels measured in an affected area in the absence of noise from occupants and from unwanted, external ambient noise sources. Usually taken to mean the L_{A90} value
Ctr	A frequency adaptation term applied in accordance with the procedures described in ISO 717.
dB (A)	'A' Weighted overall sound pressure level

Noise Reduction	The difference in sound pressure level between any two areas. The term “noise reduction” does not specify any grade or performance quality unless accompanied by a specification of the units and conditions under which the units shall apply
NR Noise Rating	Single number evaluation of the background noise level. The NR level is normally around 5 to 6 dB below the “A” weighted noise level. The NR curve describes a spectrum of noise levels and is categorised by the level at 1000 Hz ie the NR 50 curve has a value of 50 dB at 1000 Hz. The NR rating is a tangential system where a noise spectrum is classified by the NR curve that just encompasses the entire noise spectrum consideration.
R_w	Weighted Sound Reduction Index - Laboratory test measurement procedure that provides a single number indication of the acoustic performance of a partition or single element. Calculation procedures for Rw are defined in ISO 140-2:1991 “Measurement of Sound Insulation in Buildings and of Building Elements Part 2: Determination, verification and application of precision data”.
R'_w	Field obtained Weighted Sound Reduction Index - this figure is generally up to 3-5 lower than the laboratory test determined level data due to flanked sound transmission and imperfect site construction.
Sound Isolation	A reference to the degree of acoustical separation between any two areas. Sound isolation may refer to sound transmission loss of a partition or to noise reduction from any unwanted noise source. The term “sound isolation” does not specify any grade or performance quality and requires the units to be specified for any contractual condition
Sound Pressure Level, L_P dB	A measurement obtained directly using a microphone and sound level meter. Sound pressure level varies with distance from a source and with changes to the measuring environment. Sound pressure level equals 20 times the logarithm to the base 10 of the ratio of the rms sound pressure to the reference sound pressure of 20 micro Pascals.
Sound Power Level, L_W dB	Sound power level is a measure of the sound energy emitted by a source, does not change with distance, and cannot be directly measured. Sound power level of a machine may vary depending on the actual operating load and is calculated from sound pressure level measurements with appropriate corrections for distance and/or environmental conditions. Sound power levels is equal to 10 times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power of 1 picoWatt
Speech Privacy	A non-technical term but one of common usage. Speech privacy and speech intelligibility are opposites and a high level of speech privacy means a low level of speech intelligibility. It should be recognised that acceptable levels of speech privacy do not require that speech from an adjacent room is inaudible.
Transmission Loss	Equivalent to Sound Transmission Loss and to Sound Reduction Index in terminology used in countries other than Australia. A formal test rating of sound transmission properties of any construction, by usually a wall, floor, roof etc. The transmission loss of all materials varies with frequency and may be determined by either laboratory or field tests. Australian Standards apply to test methods for both situations.

10 Appendix B – Noise and Vibration Monitoring Locations


SITE BOUNDARY
Legend
= Noise Monitor
= Vibration Monitor
Refer to Noise and vibration Monitoring Plan for trigger level details.
Vibration & Noise Monitor for AGNSW & Domain receiver
Vibration Monitor - For Electrical Equipment
Noise Monitor for Lincoln Crescent receivers
Vibration Monitor for heritage Fuel Tank & Eastern Distributor
Vibration Monitor for heritage Fuel Tank & Lincoln Crescent receivers
GALLERY 1
ROOF TERRACE BELOW
ROOF SHADE BELOW
CAFE
1 Plan

11 Appendix C – Community Engagement