



# NOISE & VIBRATION MANAGEMENT SUB-PLAN

## BARANGAROO STAGE 1

*Document No: H010106LLC004*

MP10_0227	Commercial Building C5	-	Yes
MP11_0044	Commercial Building C3	-	Yes
MP10_0025	Commercial Building C4	MOD1	Yes
MP10_0023	Bulk Excavation and Basement Car Parking	MODS1,3,4	Yes
<i>Approval no.</i>	<i>Project</i>	<i>Modifications</i>	<i>Included in current revision</i>

F	17/12/2012	Revised issue for additional approvals and modifications
E	23/05/2012	Revised issue for additional approvals and modifications
D	13/04/2012	Revised issue for additional approvals and modifications
C	23/09/2011	Revised issue for addition of C4 and authority comment
B	08/04/2011	Revised issue for construction including authority comments
A	10/12/2010	Initial issue for authority comment
<i>Revision</i>	<i>Date</i>	<i>Description of Change</i>

## Table of Contents

NOISE & VIBRATION RELATED ACRONYMS & GLOSSARY .....	1
INTRODUCTION.....	2
GOALS, OUTCOMES, KEY ISSUES.....	5
1 MCOA REQUIREMENTS.....	9
Bulk Excavation and Basement Carparking (MP10_0023) .....	9
Commercial Building C4 (MP10_0025) .....	11
Commercial Building C3 (MP10_0227) .....	12
Commercial Building C5 (MP11_0044) .....	13
2 STATEMENT OF COMMITMENT REQUIREMENTS.....	14
Bulk Excavation and Basement Carparking (MP10_0023) .....	14
Commercial Building C4 (MP10_0025) .....	14
Commercial Building C3 (MP10_0227) .....	16
Commercial Building C5 (MP11_0044) .....	16
3 OTHER COMMITMENTS .....	17
4 LICENCE AND PERMIT REQUIREMENTS .....	17
EPA Licence 13336 .....	17
5 MITIGATION MEASURES .....	19
6 MONITORING.....	23
7 TRAINING AND RESOURCES .....	25
8 CONTACTS.....	25
9 REFERENCES AND REVISIONS.....	26
10 COMPLAINTS HANDLING AND SITUATION PLANNING .....	27
<b>APPENDIX 1:</b> NOISE ASSESSMENT AND MONITORING LOCATIONS	
<b>APPENDIX 2:</b> OUT OF HOURS WORKS APPROVAL PROCEDURE	
<b>APPENDIX 3:</b> REVIEW OF ALTERNATIVES TO ‘BEEPER’ ALARMS FOR CONSTRUCTION EQUIPMENT DECCW – MAY 2009	
<b>APPENDIX 4:</b> WEB-BASED NOISE MONITORING SYSTEM	
<b>APPENDIX 5:</b> ANALYSIS OF POSSIBLE NOISE REDUCTION MEASURES	

## NOISE & VIBRATION RELATED ACRONYMS & GLOSSARY

<b>ABL</b>	The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10th percentile (lowest 10th percent) background level (LA90) for each period.
<b>DECCW</b>	NSW Department of Environment, Climate Change and Water (see EPA).
<b>DP&amp;I</b>	NSW Department of Planning and Infrastructure (formerly DOP).
<b>EPA</b>	Environment Protection Authority (formerly part of OEH, DECCW)
<b>EPL</b>	Environmental Protection Licence, issued by EPA.
<b>LA1</b>	The LA1 level is the noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the LA1 level for 99% of the time.
<b>LA10</b>	The LA10 level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the LA10 level for 90% of the time. The LA10 is a common noise descriptor for environmental noise and road traffic noise.
<b>LAeq</b>	The equivalent continuous sound level (LAeq) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.
<b>LA50</b>	The LA50 level is the noise level which is exceeded for 50% of the sample period. During the sample period, the noise level is below the LA50 level for 50% of the time.
<b>LA90</b>	The LA90 level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the LA90 level for 10% of the time. This measure is commonly referred to as the background noise level.
<b>Maximum Noise Level (L<sub>Amax</sub>)</b>	The maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.
<b>MCOA</b>	Minister's Conditions of Approval.
<b>OEH</b>	Office of Environment and Heritage (see EPA)
<b>RBL</b>	The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period – daytime, evening and night time.

## INTRODUCTION

The Barangaroo site has been divided into three distinct redevelopment areas – the Headland Park, Barangaroo Stage 2 and Barangaroo Stage 1. Lend Lease was successfully appointed as the preferred proponent to develop Barangaroo Stage 1 (otherwise known as Barangaroo South) in 2009.

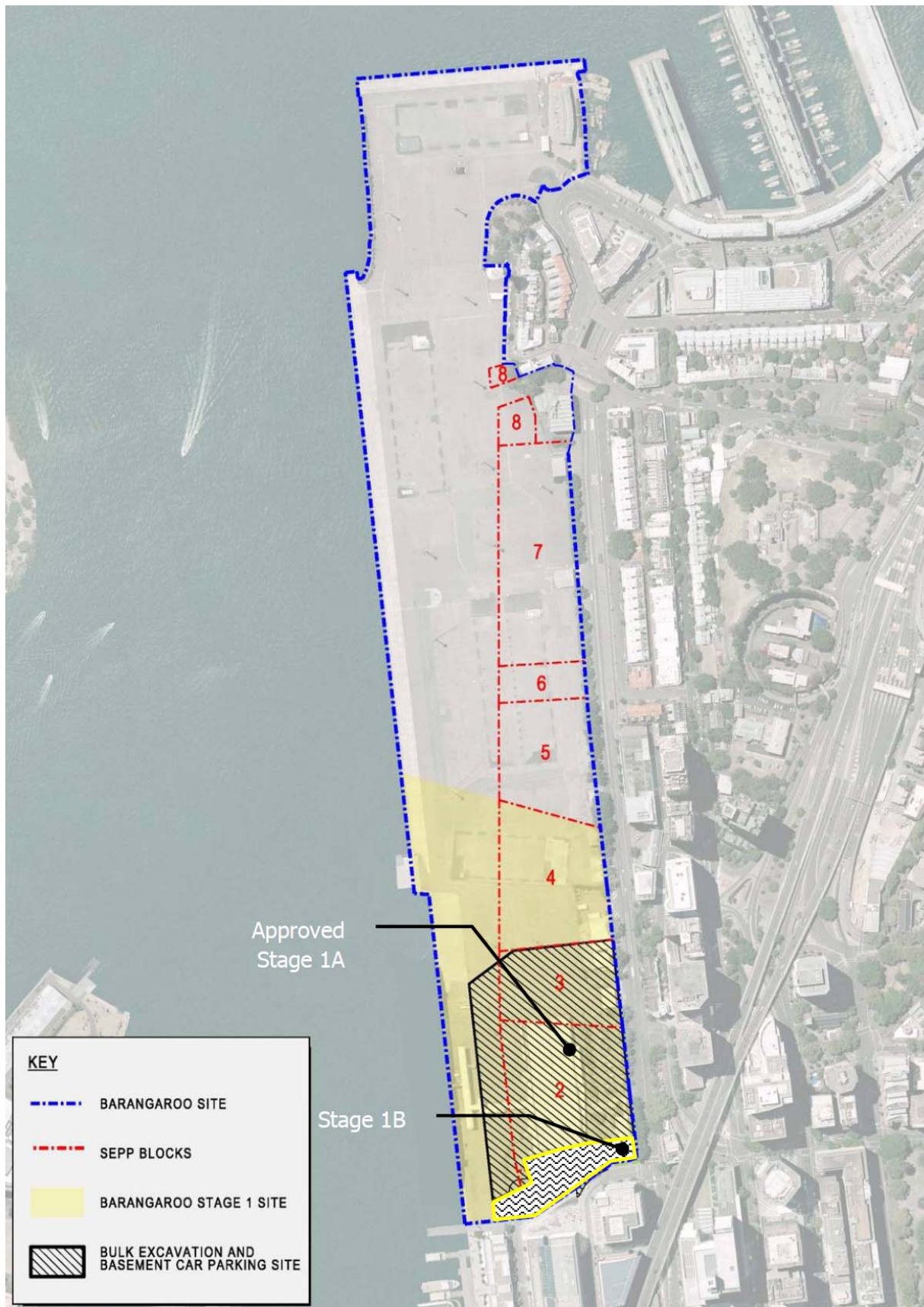
Barangaroo Stage 1 is located on the north western edge of the Sydney Central Business District (CBD). The redevelopment is bounded by Sydney Harbour to the west and north, the historic precinct of Millers Point and The Rocks to the east; and by a range of new commercial development to the south. The location of the Stage 1 construction works in relation to the remainder of the Barangaroo redevelopment area and the CBD is shown in Figure 1 below. The footprint of commercial buildings C3, C4 and C5 are entirely within Barangaroo Stage 1.

The initial phases of Barangaroo Stage 1 consist of retention wall construction and bulk excavation to create building basements, construction of a basement car parking area, and piling and construction of commercial buildings C3, C4 and C5. This management sub-plan covers these phases, and will be revised when needed to reflect the various stages of work. The current scope of this management sub-plan is summarised below.

Approval	Phase	Activities	Included in sub-plan revision
MP10_0023 Bulk Excavation & Basement Carparking Including MOD1 and MOD3	Establishment	<ul style="list-style-type: none"> <li>Site establishment including hoarding, access, amenities, parking and ancillary requirements.</li> <li>Installation of environmental controls including dewatering &amp; water treatment facilities.</li> <li>Demolition of existing in-ground structures, footings &amp; slabs, clearing and grubbing.</li> <li>Removal of existing below ground foundations and structures such as caissons and piles.</li> <li>Archaeological and other investigations.</li> <li>Decommissioning, capping off and relocation of existing services.</li> </ul>	Yes
	Perimeter Retaining Wall (PRW)	<ul style="list-style-type: none"> <li>Construction of the basement PRW using bentonite, concrete and piles.</li> <li>Temporary stockpiling of excavated material.</li> <li>Transportation and disposal of material off-site where is cannot be reused on-site.</li> <li>Dewatering operations, including water treatment and recycling.</li> </ul>	Yes
	Bulk Excavation and Construction	<ul style="list-style-type: none"> <li>Bulk excavation of the basement within Blocks 1, 2, 3 and the adjacent public domain area.</li> <li>Loading and transport of spoil to Headland Park for reuse as fill.</li> <li>Classification and off-site re-use of spoil deemed excess for reuse at Headland Park.</li> <li>Classification and off-site disposal to licensed landfill of spoil deemed unsuitable for re-use.</li> <li>Crushing and screening facilities and operations.</li> <li>Concrete batching.</li> <li>Stormwater works along Hickson Road, Shelley St and Lime St.</li> <li>Structural works, comprising construction of foundations, basement levels, car spaces and</li> </ul>	Yes

		<p>associated elements and structures.</p> <ul style="list-style-type: none"> <li>• Road works, including the extension of Margaret Street and Lime Street.</li> <li>• Construction of temporary vehicle access from Hickson Road and permanent vehicle access from Margaret Street.</li> <li>• Temporary use of the basement for construction related storage and activity.</li> </ul>	
MP10_0025 Commercial Building C4 Including MOD1	Piling, Podium and Tower	<ul style="list-style-type: none"> <li>• Piling for construction of Building C4 foundations.</li> <li>• Construction of the podium and public domain.</li> <li>• Construction of the building and facade.</li> </ul>	<b>Yes</b>
MP11_0044 Commercial Building C3	Piling, Podium and Tower	<ul style="list-style-type: none"> <li>• Piling for construction of Building C3 foundations.</li> <li>• Construction of the podium and public domain.</li> <li>• Construction of the building and facade.</li> </ul>	<b>Yes</b>
MP10_0227 Commercial Building C5	Piling, Podium and Tower	<ul style="list-style-type: none"> <li>• Piling for construction of Building C5 foundations.</li> <li>• Construction of the podium and public domain.</li> <li>• Construction of the building and facade.</li> </ul>	<b>Yes</b>

Figure 1: Site Layout



## GOALS, OUTCOMES, KEY ISSUES

<b>Scope</b>	<p>This <i>Noise &amp; Vibration Management Sub-Plan</i> details prevention and management measures for noise and vibration associated with construction activities. It defines mitigation measures to be implemented, a monitoring program that enables control of the impacts of construction activities on potentially affected receivers, and contingency measures that may be implemented if complaints are received or exceedences are measured.</p> <p>This sub-plan forms part of the Lend Lease Project Management &amp; Construction Environmental Management System and should be read in conjunction with plans shown below in Figure 2.</p>
<b>Goals</b>	<ul style="list-style-type: none"> <li>• Comply with relevant noise guidelines.</li> <li>• Avoid or minimise adverse noise impacts from construction through construction methodology and appropriate management measures.</li> </ul>
<b>Intended Outcomes</b>	<ul style="list-style-type: none"> <li>• Meet construction noise management levels and vibration guideline levels.</li> <li>• Undertake noise and vibration monitoring.</li> <li>• Minimise construction impacts through pro-active and reactive implementation of measures as per Section 5 of this sub-plan.</li> </ul>
<b>Background &amp; Key Issues</b>	<p>During demolition, excavation and construction works, nearby residential and commercial structures (and their occupants) may be affected by related noise and vibration. Residential and commercial receivers that surround the site and may be affected by noise and vibration are detailed in Appendix 1.</p> <p>To establish pre-construction background noise levels, unattended noise loggers were installed at eight representative noise sensitive locations in the area. The Rating Background Level (RBL) was then determined based on the EPA's 2009 Interim Construction Noise Guidelines for each of the locations. The RBL values for each of the time periods (Day/Evening/Night) are provided in Appendix 1.</p> <p><b>Construction Noise Issues</b></p> <p>Noise generating activities and equipment that will occur during construction are described in Appendix 1. Construction noise is regulated by the Department of Planning and Infrastructure (DP&amp;I) based on the Minister's Conditions of Approval (MCOA) requirements.</p> <p>The noise criteria (Noise Management Levels – NMLs) identified in the noise assessment is that the <math>L_{Aeq(15\text{ min})}</math> noise contribution from construction should not exceed Rating Background Level (RBL) plus 5 or 10dB(A), depending on time of day, at sensitive receivers. The noise criteria is only applicable to noise emissions related to the construction activities associated with the project. The noise criteria does not include allowance for contributions from other prevailing noise sources such as road traffic, ships in port, aircraft noise, bird noise, industrial noise, and other construction activities not associated with the project.</p> <p><b>Construction Noise Assessment</b></p> <p>Modelling was undertaken in the noise assessment to estimate construction related noise levels within day, evening and night periods at noise sensitive receivers. It uses construction methodologies, equipment and sequencing to predict noise levels for representative noise scenarios. Information relating to the modelling is included in Appendix 1. The modelled noise levels were assessed against applicable noise goals and limits at the sensitive receivers identified in Appendix 1. With measures in place as specified in Section 5, and discussed in Appendix 1, the modelled noise levels at sensitive receivers indicate that Noise Management Levels would generally be met.</p> <p><b>Vibration</b></p> <p>Vibration can be potentially damaging to structures and annoying to people. The noise and vibration assessment undertaken for the Environmental Assessment concluded that vibration criteria for buildings and comfort would be complied with during construction. Impulsive vibration may be caused by activities such as rock breaking and piling, but is not anticipated to affect any residences, buildings or structures. Dilapidation surveys will be undertaken of</p>

dwellings at Millers Point that are representative of the overall building stock and offer an appropriate benchmark of the condition of all properties.

Vibration monitoring is discussed further in Section 6.

#### **Hours of operation**

The most intensive noise and vibration works are most likely to occur during the excavation stage of the project. Construction will generally be undertaken during the City of Sydney Council's preferred hours for construction being:

- 7.00 am to 6.00 pm Monday to Friday (construction on Building C4 can continue until 7pm).
- 7.00 am to 5.00 pm on Saturdays.
- No work to be undertaken on Sundays or Public Holidays.

#### **Out of Hours Works**

Anticipated out of hours works to be undertaken during construction include:

- Groundwater pumping and operation of the water treatment plant throughout construction, requiring the use of generators.
- Operation of bentonite plant during piling and construction of the retaining wall, also requiring the use of generators.
- Operation of continuous or intermittent environmental monitoring such as dust and noise sampling equipment.
- Concrete pours that need to be completed to prevent waste and re-working.
- Service installation works and cut-overs during temporary utility shutdowns or off peak periods.
- Delivery to site, and removal from site, of over-sized plant and equipment to conform to RTA requirements.
- Dust suppression, where required over and above measures in the Air Quality and Odour Management Sub-Plan.

Some other out of hours activities may be required throughout construction. These activities may be required to be undertaken out of hours to:

- undertake works for safety reasons for the protection of workers and members of the public.
- reduce disruption to traffic and the community.
- satisfy operational requirements of government agencies or authorities.
- due to unforeseen circumstances.

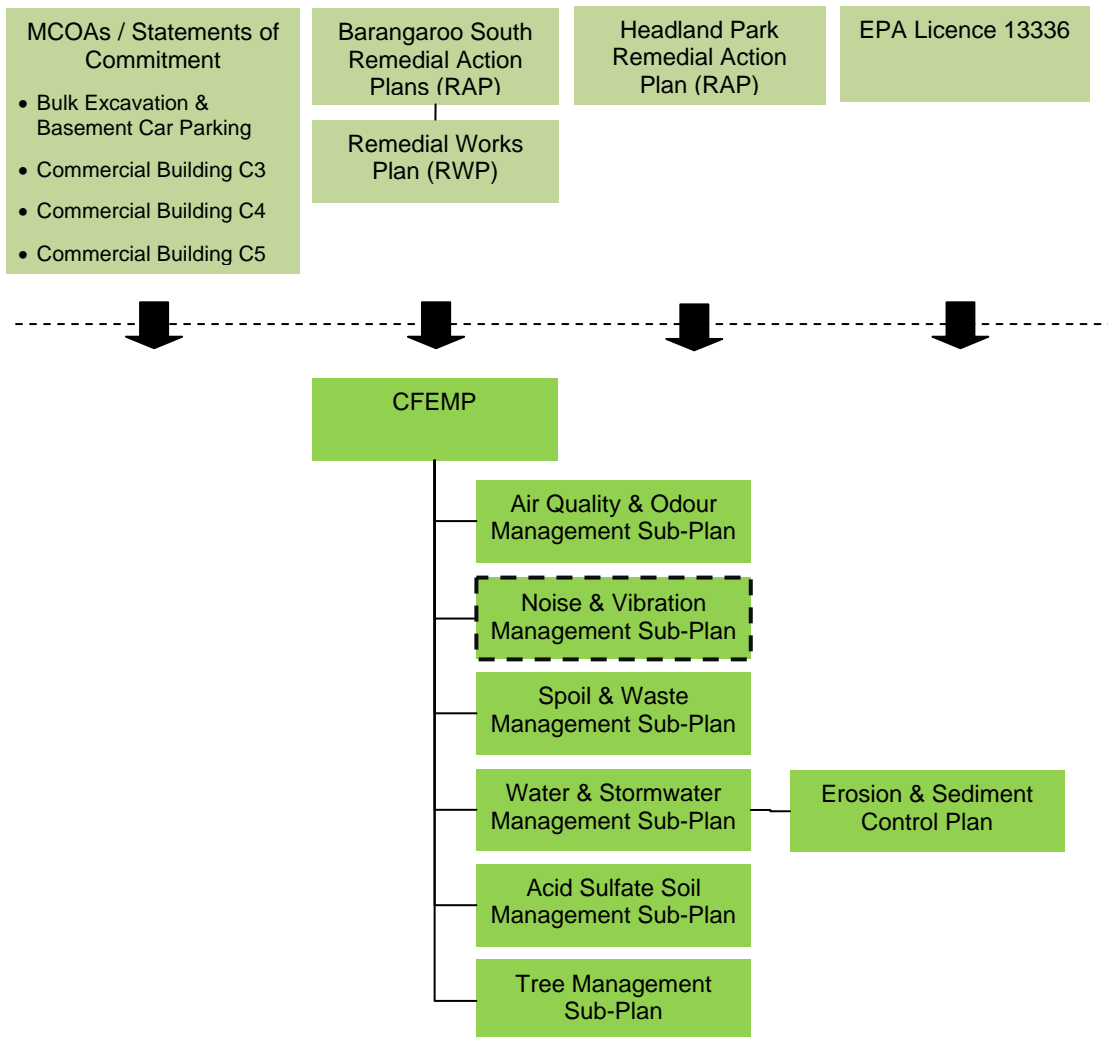
Where there is a requirement for out of hours activities other than those listed above, authorised by MCOA or the Environmental Protection Licence, and would be audible, Lend Lease will submit relevant information to DP&I for consideration under Condition C3.2d of the 'Basement' MCOA, or Condition D1 of the C3, C4 and C5 MCOAs. This process is described in Appendix 2 of this sub-plan.

This would include justification of the varied construction hours, appropriate notification to sensitive receivers, and noise reduction measures to be put in place. Appropriate community notification would be required, as defined in the *Community and Stakeholder Engagement Strategy*.

For all out of hours trade-related works, a report will be prepared as per Condition C3.2n of MCOA MP10\_0023 as described in Section 5 (NV23).

<b>Statutory Requirements</b>	<p><i>Protection of the Environment Operations Act 1997 (NSW) (POEO Act)</i></p> <p>The POEO Act is the key piece of environment protection legislation, and regulates activities via:</p> <ul style="list-style-type: none"> <li>• environment protection licencing, as per Schedule 1;</li> <li>• regulation of scheduled and non-scheduled activities;</li> <li>• environmental protection offences and penalties; and</li> <li>• establishment of a general duty to notify of environmental harm.</li> </ul> <p><i>Protection of the Environment Operations (Noise Control) Regulation 2008 (NSW)</i></p> <p>This regulation controls noise emissions from vehicles and vessels, and provides for inspection and testing of noise emissions.</p> <p><i>Interim Construction Noise Guidelines, DECCW 2009</i></p> <p>Deals with the assessment of noise from construction activities and advises on best practice approaches to minimise noise impacts. It is aimed at managing noise from construction works regulated by EPA, and is used to set statutory conditions in licences or other regulatory instruments.</p> <p><i>Assessing vibration: A Technical Guideline, DECC 2006</i></p> <p>This document 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.</p>
<b>Other Relevant Plans</b>	<ul style="list-style-type: none"> <li>• Project EHS Plan</li> <li>• Community and Stakeholder Engagement Strategy</li> <li>• Lend Lease Project Management &amp; Construction Global Minimum Requirements.</li> </ul> <p>All environment-related plans are shown in Figure 2 below.</p>
<b>Environmental Aspects &amp; Impacts</b>	<p>Refer to the Project EHS Risk Assessment, which forms part of the Project EHS Plan.</p>
<b>Licence &amp; Permit Requirements</b>	<p>The requirements of EPA Licence 13336 that relate to Barangaroo Stage 1 are included in Section 4 of this sub-plan. These requirements will be updated with each relevant licence variation issued by EPA.</p>

**Figure 2: Environment Document Structure**



## 1 MCOA REQUIREMENTS

### Bulk Excavation and Basement Carparking (MP10\_0023)

No.	Original Ref.	Relevant Requirement	Reference
1.	A12	Prior to the commencement of barging/shipping of materials from the site, the proponent shall update the Environmental Construction Management Plan, as outlined in the Statement of Commitments. All barging/shipping details must be reviewed by the EPA prior to the commencement of barging/shipping activities. Environment Protection Licence No 13336 must also be varied, where relevant, prior to the commencement of barging/shipping activities to ensure environmental impacts of this activity are appropriately regulated.	Not applicable at this stage
2.	A13(d)	Prior to the issue of a construction certificate for the installation and operation of the concrete batching plant, the proponent shall update the following Plans in accordance with the terms of the respective conditions and provide a copy to the department and the City of Sydney Council:... c. C3 Construction Noise & Vibration Management Plan. All management, monitoring and mitigation measures incorporated into the endorsed plans, as relevant to the operation of the concrete batching plant, are to be fully implemented for the term of operation of the concrete batching plant.	This sub-plan
3.	C3.1	The proponent must prepare and implement a detailed <i>Construction Noise and Vibration Management Plan (CNVMP)</i> , to be approved by the Director General before commencement of works, which includes but is not necessarily limited to:	This sub-plan
4.	C3.1 (a)	Identification of the specific activities that will be carried out and associated noise sources at the premises;	Appendix 1
5.	C3.1 (b)	Identification of all potentially affected sensitive receiver premises;	Appendix 1
6.	C3.1 (c)	Quantification of the rating background noise level (RBL) for sensitive receivers, as part of the CNVMP, or as undertaken in the EA;	Appendix 1
7.	C3.1 (d)	The construction noise, ground-borne noise and vibration objectives derived from an application of the DECCW Interim Construction Noise Guidelines (ICNG), as reflected in conditions of approval;	Appendix 1
8.	C3.1 (e)	Prediction and assessment of potential noise, ground-borne noise (as relevant) and vibration levels from the proposed construction methods expected at sensitive receiver premises against the objective identified in the ICNG and conditions of approval;	Appendix 1
9.	C3.1 (f)	Where the objectives are predicted to be exceeded, an analysis of feasible and reasonable noise mitigation measures that can be implemented to reduce construction noise impacts;	Appendix 5 Section 5
10.	C3.1 (g)	Description of management methods and procedures, and specific noise mitigation treatments that will be implemented to control noise and vibration during construction;	Section 5
11.	C3.1 (h)	Where the NML's cannot be met, additional measures including, but not necessarily limited to, the following should be considered and implemented where practicable; reduced hours of construction, the provision of respite from noisy / vibration intensive activities, acoustic barriers / enclosures, alternative excavation methods or other negotiated outcomes with the affected community;	Section 5, Section 6
12.	C3.1 (i)	Where night time management levels cannot be satisfied, a report shall be submitted to the Director General outlining the mitigation measures applied, the noise levels achieved and justification that the outcome is consistent with best practice.	Section 5 - NV27 Section 10

No.	Original Ref.	Relevant Requirement	Reference
13.	C3.1 (j)	Measures to identify non-conformances with the requirements of the CNVMP, and procedures to implement corrective and preventative action;	Section 6
14.	C3.1 (k)	Procedures for notifying residents of construction activities that are likely to effect their noise and vibration amenity;	<i>Community &amp; Stakeholder Engagement Strategy</i>
15.	C3.1 (l)	Measures to monitor noise performance and respond to complaints;	Section 6
16.	C3.1 (m)	Measures to reduce noise related impacts associated with offsite vehicle movements on nearby access and egress routes from the site;	Section 5 - NV15
17.	C3.1 (n)	Reporting procedures for occasions of out of hours trade related works, including; hours worked, activities undertaken, justification that the works were essential, results of noise monitoring where undertaken, complaint and response data, corrective and preventative action to potentially avoid out of hour work occurrences and mitigate noise emissions above relevant noise management levels;	Section 5 - NV28
18.	C3.1 (o)	Procedures to allow for regular professional acoustic input to construction activities and planning; and	Section 6
19.	C3.1 (p)	Effective site induction and ongoing training and awareness measures for personnel (eg. toolbox talks, meetings).	Section 7
20.	C3.2	All construction work at the premises must be conducted between the hours of 7am and 6pm Mondays to Friday and between 7am and 5pm Saturdays and at no time on Sundays and public holidays, unless inaudible at any residential premises. Works outside these hours are not permitted except as explicitly specified below or in other conditions and include: <ul style="list-style-type: none"> <li>• The delivery of materials which is required outside these hours as requested by Police or other authorities for safety reasons;</li> <li>• Emergency work to avoid the loss of lives, damage to property and/or to prevent environmental harm;</li> <li>• Other works expressly approved by the Director General;</li> <li>• Out of standard hours works identified in a CNVMP approved by the Director General.</li> </ul>	Goals, outcomes, key issues Appendix 2
21.	C3.3	Construction noise management levels (NML) derived in accordance with the DECCW Interim Construction Noise Guidelines apply to this project, and are required to be identified in a CNVMP. Any activities that have the potential for noise emissions that exceed the NML's must be identified and managed in accordance with the Construction Noise and Vibration Management Plan. The Proponent must implement all Reasonable and Feasible noise mitigation and management measures with the aim of achieving the NML's.	Appendix 1
22.	C3.4	Vibration caused by Construction and received at any sensitive receiver outside the proposal must be assessed against the guidelines contained in the DECCW publication "Environmental Noise Management – Assessing Vibration: a technical guideline" and in accordance with the CNVMP.	Section 6 Section 9

## Commercial Building C4 (MP10\_0025)

No.	Original Ref.	Relevant Requirement	Reference
23.	B20	<p>Construction Noise and Vibration Management Plan</p> <p>Prior to the issue of a relevant Construction Certificate, a Construction Noise and Vibration Management Plan prepared in accordance with the Statement of Commitments in Schedule 3 shall be submitted to DECCW for review and comment and submitted to the Certifying Authority.</p>	This sub-plan
24.	D1	<p>Hours of Work</p> <p>The hours of construction, including the delivery of materials to and from the site, shall be restricted as follows:</p> <ol style="list-style-type: none"> <li>(1) between 7:00 am and 7:00 pm, Mondays to Fridays inclusive;</li> <li>(2) between 7:00 am and 5:00 pm, Saturdays;</li> <li>(3) no work on Sundays and public holidays.</li> </ol> <p>Works outside these hours are not permitted except as explicitly specified below or in other conditions and include:</p> <ol style="list-style-type: none"> <li>(a) the delivery of materials which is required outside these hours as requested by Police or other authorities for safety reasons;</li> <li>(b) emergency work to avoid the loss of lives, damage to property and/or to prevent environmental harm;</li> <li>(c) other works expressly approved by the Director General;</li> <li>(d) out of standard hours works identified in a CNVMP approved by the Director General.</li> </ol>	Goals, Outcomes, Key Issues Section 5 - NV17
25.	D11	<p>Vibration Criteria</p> <p>Vibration caused by construction at any residence or structure outside the subject site must be limited to:</p> <ol style="list-style-type: none"> <li>(1) for structural damage vibration, German Standard DIN 4150 Part 3 Structural Vibration in Buildings. Effects on Structures;</li> <li>(2) 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. These limits apply unless otherwise approved in the Construction Noise and Vibration Management Plan.</li> </ol>	Section 6 Appendix 1
26.	D12	<p>Vibration Management</p> <p>Vibratory compactors must not be used closer than 30 metres from residential buildings unless vibration monitoring confirms compliance with the vibration criteria specified above.</p>	Section 5 - NV19
27.	D13	<p>Noise Management</p> <p>For the duration of the works noise must be managed in accordance with the approved Construction Noise and Vibration Management Plan.</p>	This sub-plan.
28.	AN10	<p>Noise Generation</p> <p>Any noise generated during the construction of the development shall not exceed limits specified in any relevant noise management policy prepared pursuant to the Protection of the Environment Operations Act, 1997 or exceed approved noise limits for the site.</p>	Section 6 Appendix 1

## Commercial Building C3 (MP10\_0227)

No.	Original Ref.	Relevant Requirement	Reference
29.	B19	<p>Construction Noise and Vibration Management Plan</p> <p>Prior to the issue of a relevant Construction Certificate, a Construction Noise and Vibration Management Plan prepared in accordance with Statement of Commitments in Schedule 3 shall be submitted to the EPA for review and comment and submitted to the Certifying Authority. This Plan must be consistent with all of the relevant requirements of the Environment Protection Licence no 13336.</p>	This sub-plan
30.	D1	<p>Hours of Work</p> <p>The hours of construction, including the delivery of materials to and from the site, shall be restricted as follows:</p> <p>(1) between 7:00 am and 7:00 pm, Mondays to Fridays inclusive;</p> <p>(2) between 7:00 am and 5:00 pm, Saturdays;</p> <p>(3) no work on Sundays and public holidays.</p> <p>Works outside these hours are not permitted except as explicitly specified below or in other conditions and include:</p> <p>(a) the delivery of materials which is required outside these hours as requested by Police or other authorities for safety reasons;</p> <p>(b) emergency work to avoid the loss of lives, damage to property and/or to prevent environmental harm;</p> <p>(c) other works expressly approved by the Director General;</p> <p>(d) out of standard hours works identified in a CNVMP approved by the Director General.</p>	Goals, Outcomes, Key Issues Section 5 - NV17
31.	D13	<p>Vibration Criteria</p> <p>Vibration caused by construction at any residence or structure outside the subject site must be limited to:</p> <p>a. for structural damage vibration, German Standard DIN 4150 Part 3 Structural Vibration in Buildings. Effects on Structures;</p> <p>b. 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.</p> <p>These limits apply unless otherwise approved in the Construction Noise and Vibration Management Plan.</p>	Section 6 Appendix 1
32.	D14	<p>Vibration Management</p> <p>Vibratory compactors must not be used closer than 30 metres from residential buildings unless vibration monitoring confirms compliance with the vibration criteria specified above.</p>	Section 5 - NV19
33.	D15	<p>Noise Management</p> <p>For the duration of the works noise must be managed in accordance with the approved Construction Noise and Vibration Management Plan.</p>	This sub-plan.
34.	AN10	<p>Noise Generation</p> <p>Any noise generated during the construction of the development shall not exceed limits specified in any relevant noise management policy prepared pursuant to the Protection of the Environment Operations Act, 1997 or exceed approved noise limits for the site.</p>	Section 6 Appendix 1

## Commercial Building C5 (MP11\_0044)

No.	Original Ref.	Relevant Requirement	Reference
35.	B19	<p>Construction Noise and Vibration Management Plan</p> <p>Prior to the issue of a relevant Construction Certificate, a Construction Noise and Vibration Management Plan prepared in accordance with Statement of Commitments in Schedule 3 shall be submitted to the EPA for review and comment and submitted to the Certifying Authority. This Plan must be consistent with all of the relevant requirements of the Environment Protection Licence no 13336.</p>	This sub-plan
36.	D1	<p>Hours of Work</p> <p>The hours of construction, including the delivery of materials to and from the site, shall be restricted as follows:</p> <p>(1) between 7:00 am and 7:00 pm, Mondays to Fridays inclusive;</p> <p>(2) between 7:00 am and 5:00 pm, Saturdays;</p> <p>(3) no work on Sundays and public holidays.</p> <p>Works outside these hours are not permitted except as explicitly specified below or in other conditions and include:</p> <p>(a) the delivery of materials which is required outside these hours as requested by Police or other authorities for safety reasons;</p> <p>(b) emergency work to avoid the loss of lives, damage to property and/or to prevent environmental harm;</p> <p>(c) other works expressly approved by the Director General;</p> <p>(d) out of standard hours works identified in a CNVMP approved by the Director General.</p>	Goals, Outcomes, Key Issues Section 5 - NV17
37.	D13	<p>Vibration Criteria</p> <p>Vibration caused by construction at any residence or structure outside the subject site must be limited to:</p> <p>a. for structural damage vibration, German Standard DIN 4150 Part 3 Structural Vibration in Buildings. Effects on Structures;</p> <p>b. 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.</p> <p>These limits apply unless otherwise approved in the Construction Noise and Vibration Management Plan..</p>	Section 6 Appendix 1
38.	D14	<p>Vibration Management</p> <p>Vibratory compactors must not be used closer than 30 metres from residential buildings unless vibration monitoring confirms compliance with the vibration criteria specified above.</p>	Section 5 - NV19
39.	D15	<p>Noise Management</p> <p>For the duration of the works noise must be managed in accordance with the approved Construction Noise and Vibration Management Plan.</p>	This sub-plan.
40.	AN10	<p>Noise Generation</p> <p>Any noise generated during the construction of the development shall not exceed limits specified in any relevant noise management policy prepared pursuant to the Protection of the Environment Operations Act, 1997 or exceed approved noise limits for the site.</p>	Section 6 Appendix 1

## 2 STATEMENT OF COMMITMENT REQUIREMENTS

### Bulk Excavation and Basement Carparking (MP10\_0023)

No.	Original Ref.	Relevant Requirement	Reference
41.	1.8	Lend Lease commits to undertaking the bulk excavation and basement car park construction works generally in accordance with the findings, recommendations and mitigative strategies of the <i>Supplementary Excavation and Construction Noise and Vibration Assessment</i> prepared by Wilkinson Murray (September 2010) and the <i>Bulk Excavation and Basement Carparking PA1 – S75W1 (MP10_0023) Excavation and Construction Noise and Vibration Assessment Report No.10232</i> Version C prepared by Wilkinson Murray dated November 2010, including the installation of a 2.4m noise barrier between the truck haulage route and the temporary Cruise Passenger Terminal.	This sub-plan.
42.	1.8	The supplementary Construction Noise Impact Assessment states: "Housing NSW's assets are at a distance from the construction site that predicted vibration levels associated with rockbreakers will be well below both structural damage and Human Comfort vibration criteria."  Notwithstanding this, prior to commencement of works, Lend Lease will undertake a dilapidation survey of a selected number of dwellings within the Millers Point area that Lend Lease believes are representative of the overall building stock and offer an appropriate benchmark of the condition of all properties.	Section 5, NV1

### Commercial Building C4 (MP10\_0025)

No.	Original Ref.	Relevant Requirement	Reference
43.	SOC 35	Construction and site management relating to the construction of Building C4 will be in generally accordance with the Environmental, Construction and Site Management Plan prepared by Cardno & Bovis Lend Lease included at Appendix EE of the Environmental Assessment Report prepared by JBA Urban Planning Consultants dated November 2010 including the following as updated by this Statement of Commitments (refer to Commitments 37, 38 and 40):  - Construction Noise and Vibration Assessment and Construction Noise and Vibration Assessment - Supplementary prepared by Wilkinson Murray, which addresses the noise and vibration impacts on and off site (refer to Appendix FF of the Exhibited EAR);	This sub-plan
44.	SOC 36	The Environmental Construction & Site Management Plan prepared by Cardno & Lend Lease will be updated to include:  - A requirement for preparation of a site wide strategy relating to the preparation of post construction dilapidation reports that includes a requirement for the Proponent to engage a suitably qualified person to prepare a post-construction dilapidation report: (a) At the completion of all excavation and piling works associated with the construction of the basement, Commercial Building C3, Commercial Building C4 and Commercial Building C5 works; and (b) At the completion of all construction works associated with the construction of the basement, Commercial Building C3, Commercial Building C4 and Commercial Building C5 works.	Section 5, NV1
45.	SOC 37	Lend Lease will prepare a Construction Noise and Vibration Management Plan with reference to Section 8 of the Wilkinson Murray Construction Noise and Vibration Assessment included at Attachment T of the PPR prepared by JBA Urban Planning Consultants dated February 2010 that includes the following:	

		<ul style="list-style-type: none"> <li>- The appropriate noise and vibration objectives for each identified noise sensitive receiver;</li> <li>- Identification of activities that have the potential to generate noise and/or vibration levels greater than the identified objectives at surrounding sensitive receivers;</li> <li>- Noise and vibration from ancillary activities such as site yards, plan compounds, batch plants and crushing plants;</li> <li>- Approved hours of construction;</li> <li>- Plant &amp; equipment that will operate (e.g pumps) and activities (if any) that will take place outside standard hours of construction;</li> <li>- Respite times to be implemented for particularly noise activities such as percussive piling);</li> <li>- Works timetabling in particular works outside standard hours, if any, to minimise noise impacts;</li> <li>- Justification for any activities outside standard construction hours;</li>   <li>- All feasible and reasonable noise mitigation measures, including the use of alternative methods to be implemented where potential noise impacts exceeds the relevant objectives;</li> <li>- A detailed description of what actions and mitigation measures will be implemented to ensure that these works would comply with the relevant noise and vibration criteria/guidelines;</li> <li>- A description of how the effectiveness of these actions and measures would be monitored during the proposed works, clearly indicating how often monitoring would be conducted, how the results of the monitoring would be recorded and if any non compliance is detected;</li> <li>- Procedures to notify residents of activities that are likely to affect their noise and vibration amenity, as well as procedures for dealing with and responding to noise complaints;</li>   <li>- Site contact person and appropriate telephone number;</li>   <li>- Description and commitment to work practices which minimise noise; and management and mitigation measures which minimise impact; and</li> <li>- Consideration of the cumulative noise and vibration impacts resulting from other activities taking place on Barangaroo at the same time, and all feasible and practicable measures that will be implemented to minimise the cumulative noise and vibration impacts.</li> </ul>	<p>Appendix 1</p> <p>Appendix 1</p> <p>Appendix 1</p> <p>Section 5 - NV17</p> <p>Appendix 1</p> <p>Section 5 - NV7, 11, 18</p> <p>Section 5 – NV17</p> <p>Goals, Outcomes, Key Issues, Appendix 2</p> <p>Section 5</p> <p>Appendix 5</p> <p>Section 5</p> <p>Section 6</p> <p>Section 5 – NV26</p> <p><i>Community &amp; Stakeholder Engagement Strategy</i></p> <p>1300 phone number in <i>Community &amp; Stakeholder Engagement Strategy</i></p> <p>Section 5</p> <p>Appendix 5</p> <p>Noise &amp; Vibration Assessment, Section 6.4</p>
46.	SOC 38	<p>If required following monitoring of noise levels at the Billabond Childcare Centre in accordance with the Construction Noise Management Plan, suitable noise amelioration measures will be implemented in accordance with the recommendations of the Construction Noise and Vibration Assessment prepared by Wilkinson Murray included at Attachment AA of the PPR prepared by JBA Urban Planning Consultants dated February 2011.</p>	<p>Section 5 – NV18</p> <p>[Note no Attachment AA to the PPR]</p>

### Commercial Building C3 (MP10\_0227)

No.	Original Ref.	Relevant Requirement	Reference
47.	SOC 34	<p>Construction and site management relating to the construction of Commercial Building C3 will be in generally accordance with the Environmental, Construction and Site Management Plan prepared by Cardno &amp; Lend Lease included at Appendix CC of the Environmental Assessment Report prepared by JBA Planning dated November 2011 including the following:</p> <ul style="list-style-type: none"> <li>• Construction Noise and Vibration Assessment prepared by Wilkinson Murray, which addresses the noise and vibration impacts on and off site (refer to Appendix EE of the EAR);</li> <li>• A requirement for preparation of a site wide strategy relating to the preparation of post construction dilapidation reports that includes a requirement for the Proponent to engage a suitably qualified person to prepare a post-construction dilapidation report: <ul style="list-style-type: none"> <li>- At the completion of all excavation and piling works associated with the construction of the basement, Commercial Building C3, Commercial Building C4 and Commercial Building C5 works; and</li> <li>- At the completion of all construction works associated with the construction of the basement, Commercial Building C3, Commercial Building C4 and Commercial Building C5 works.</li> </ul> </li> </ul>	<p>This sub-plan</p> <p>Section 5, NV1</p>

### Commercial Building C5 (MP11\_0044)

No.	Original Ref.	Relevant Requirement	Reference
48.	SOC 33	<p>Construction and site management relating to the construction of Commercial Building C5 will be in generally accordance with the Environmental, Construction and Site Management Plan prepared by Cardno &amp; Lend Lease included at Appendix CC of the Environmental Assessment Report prepared by JBA Planning dated November 2011 including the following:</p> <ul style="list-style-type: none"> <li>• Construction Noise and Vibration Assessment prepared by Wilkinson Murray, which addresses the noise and vibration impacts on and off site (refer to Appendix EE of the EAR);</li> <li>• A requirement for preparation of a site wide strategy relating to the preparation of post construction dilapidation reports that includes a requirement for the Proponent to engage a suitably qualified person to prepare a post-construction dilapidation report: <ul style="list-style-type: none"> <li>- At the completion of all excavation and piling works associated with the construction of the basement, Commercial Building C3, Commercial Building C4 and Commercial Building C5 works; and</li> <li>- At the completion of all construction works associated with the construction of the basement, Commercial Building C3, Commercial Building C4 and Commercial Building C5 works.</li> </ul> </li> </ul>	<p>This sub-plan</p> <p>Section 5, NV1</p>

### 3 OTHER COMMITMENTS

No.	Original Ref.	Relevant Requirement	Reference
1.	Supplementary Updated Noise and Vibration Impact Assessment - Bulk Excavation removal by Ship	<ul style="list-style-type: none"> <li>Establish a 4m high noise berm from spoil on the eastern side of the ship loading area.</li> <li>Undertake loading at night on the western side of the noise berm.</li> <li>Check Front End Loaders at commencement of works to ensure noise emissions do not exceed a sound power level of 112 dBA (i.e. 87 dBA at 7 m). Where feasible investigations into quieter machines should be considered. Alternatively the installation of silencing kits on these machines should be considered.</li> <li>Fit Front End Loaders with low noise broadband reversing alarms to ensure that potential for sleep disturbance is eliminated.</li> <li>Check the noise levels of equipment to be used at night prior to installation on site.</li> <li>Manage ship operations to minimise noise generation particularly in the night period, by: <ul style="list-style-type: none"> <li>Limiting operating equipment on the ship to one auxiliary generator;</li> <li>No maintenance, bunkering or operation of ship based equipment while loading;</li> <li>No PA or alarm systems to be used;</li> <li>Retain minimal levels of spoil in each compartment to minimise loading noise.</li> </ul> </li> </ul>	Not applicable at this stage

### 4 LICENCE AND PERMIT REQUIREMENTS

#### EPA Licence 13336

No.	Original Ref.	Relevant Requirement	Reference
1.	EPL 13336, M4.1	All noise and vibration monitoring must be done in accordance with the <i>Construction Noise and Vibration Management Plan</i> unless otherwise required in writing by the EPA.	Section 6
49.	EPL 13336, L5.1	<p><i>Bulk Excavation and Basement Car Park</i></p> <p>For the purposes of construction permitted by project Approval MP10_0023, work at the premises must be conducted between 7am and 6pm Monday to Friday and between 7am and 5pm Saturdays and at no time on Sundays and public holidays, unless inaudible at any residential premises.</p> <p><i>Building C3, C4 and C5</i></p> <p>For the purposes of construction permitted by project Approvals MP11_0044, MP10_0025, and MP10_0227, work at the premises must be conducted between 7am and 7pm Monday to Friday and between 7am and 5pm Saturdays and at no time on Sundays and public holidays, unless inaudible at any residential premises.</p>	Goals, outcomes, key issues Appendix 2

No.	Original Ref.	Relevant Requirement	Reference
		Works outside these hours are not permitted except as explicitly specified below or in other conditions and include: (a) the delivery of materials which is required outside these hours as requested by Police or other authorities for safety reasons; (b) emergency work to avoid the loss of lives, damage to property and/or to prevent environmental harm; or (c) Approved out of standard hours works identified in a CNVMP.	

## 5 MITIGATION MEASURES

Ref.	Mitigation Measure	Design	Site Establishment	Construction	Relevant Location / Activity	Relevant Approval Conditions	Accountability	Timing
<b>PLANNING / GENERAL</b>								
NV1.	Prior to commencement of works, undertake dilapidation surveys at representative dwellings in Millers Point that are an appropriate benchmark of the condition of all properties. Undertake post construction dilapidation surveys at the completion of excavation and piling, and construction, of the C3, C4 and C4 buildings.	■		■	Millers Point	Basement SOC 1.8 C4 SOC 36 C3 SOC 34 C5 SOC 33	Construction Manager	Prior to construction
NV2.	Install a 2.4m noise barrier/hoarding along the eastern, northern and western boundaries, and a 3.0m noise barrier/hoarding along the southern boundary, with minimum 17mm thick structural plywood.	■	■	■	Perimeter of construction site	Noise assessments Basement MCOA C3.1 (f)	Construction Manager	Prior to construction
NV3.	Ensure all fixed plant at the work sites are appropriately selected, and where necessary, fitted with silencers, acoustical enclosures and other noise attenuation measures.	■	■	■	Entire project	Noise assessments Basement MCOA C3.1 (f)	EHS Manager (Environment)	Throughout construction
NV4.	Arrange work sites to avoid or minimise truck movements, and ensure vehicles enter and exit work sites in a forward direction.	■	■	■	Entire project	Basement MCOA C3.1 (f)	Project Engineers	Throughout construction
NV5.	Position noisy plant and equipment as far apart as is practicable from each other and consider whether orientation and location of the plant can reduce noise impacts at sensitive receivers.	■	■	■	Entire project	Basement MCOA C3.1 (f)	Project Engineers	Throughout construction
NV6.	Ensure that public address systems are not used, except in emergencies. Orientate speakers away from sensitive receivers.	■	■	■	Entire project	Best practice	Safety Manager	Throughout construction
NV7.	Use non-percussive piling techniques for all piles where practicable. If impact piling is required, limit the impact of noise emissions using measures such as limiting hours of operation, lowering the height of hammers, shielding by positioning of construction equipment or use of acoustic shrouding and resilient dollies.	■	■	■	Entire project	Basement MCOA C3.1 (f) C4 SOC 37	Project Engineers	Throughout construction
<b>CONSTRUCTION</b>								
NV8.	Install all noise controls identified in this plan as early as is practical		■	■	Entire project	Basement MCOA	EHS Manager	Throughout

Ref.	Mitigation Measure	Design	Site Establishment	Construction	Relevant Location / Activity	Relevant Approval Conditions	Accountability	Timing
	prior to the relevant stage of construction.					C3.1 (f)	(Environment)	construction
NV9.	Reduce the use of rock-hammering where feasible and use alternative measures such as rock-saws and rippers where possible.	■	■	■	Entire project	Noise assessments Basement MCOA C3.1 (f)	Construction Manager	Throughout construction
NV10.	If the use of rock-hammers are unavoidable, use smaller rockbreakers with quiet 'cityhammers'.	■	■	■	Entire project	Noise assessments Basement MCOA C3.1 (f)	Project Engineers	Throughout construction
NV11.	Provide periods of relief when practical during noise intensive activities such as rock breaking.	■	■	■	Entire project	Basement MCOA C3.1 (f) C4 SOC 37	Construction Manager	Throughout construction
NV12.	Install non-tonal and / or automatically adjusting reversing alarms on site equipment (see Appendix 3 for further information).	■	■	■	Entire project	Basement MCOA C3.1 (f)	Project Engineers	Throughout construction
NV13.	Use only silenced generators and compressors.	■	■	■	Entire project	Basement MCOA C3.1 (f)	Project Engineers	Throughout construction
NV14.	Minimise vehicles and plant idling when not in use.		■	■	Entire project	Basement MCOA C3.1 (f)	Project Engineers	Throughout construction
NV15.	Prevent vehicles and plant queuing and idling outside the site, particularly prior to the construction start time.		■	■	Outside site entrances	Basement MCOA C3.1 (f)	Project Engineers	Throughout construction
NV16.	Ensure that equipment is operated in the correct manner including repair of defective mufflers, tightening/correction of rattling parts and components and repair of leakages in compressed airlines.		■	■	Entire project	Basement MCOA C3.1 (f)	Project Engineers	Throughout construction
NV17.	Ensure that audible construction activities are only undertaken between 7am and 6pm Monday - Friday, and 7am to 5pm Saturday. Works on building C3, C4 and C5 can continue to 7pm Monday to Friday.  Where out-of-hours works are predicted to be undertaken that are not subject to prior approval (by this sub-plan, MCOA or EPL), obtain approval from the Director General prior to commencing works as per the procedure identified in Appendix 2.	■	■	■	Entire project	Basement MCOA C3.1 (f) C4 MCOA D1	EHS Manager (Environment) Construction Manager Project Engineers	Throughout construction

Ref.	Mitigation Measure	Design	Site Establishment	Construction	Relevant Location / Activity	Relevant Approval Conditions	Accountability	Timing
NV18.	When undertaking noisy activities near outdoor eating areas south of the site, or Billabond Childcare Centre, if practicable: <ul style="list-style-type: none"> <li>Schedule rock breaking outside periods when cafés or restaurants are busiest.</li> <li>Liaise with proprietors to provide respite where feasible.</li> <li>Remove hardstand by ripping rather than rock-breaking.</li> <li>Utilise smaller rockbreakers which generate lower noise levels.</li> <li>Install low noise silencer and kits to the piling rig engine.</li> </ul>			■	Southern boundary	Noise assessments C4 SOC 37	EHS Manager (Environment)	According to construction schedule
NV19.	Ensure that vibratory compactors must not be used closer than 30 metres from residential buildings unless vibration monitoring confirms compliance with the vibration criteria specified above.			■	Eastern and southern boundary	C4 MCOA D12	EHS Manager (Environment)	As required
NV20.	Locate a 3 metre moveable noise barrier between the works site and receivers, particularly when rock breaking or sawing occurs.			■	Permanent stormwater works	Noise assessment report	Project Manager	During permanent stormwater works
NV21.	Where feasible, schedule sawing and rock breaking during periods when lower occurrence occurs, such as in the early mornings or after lunch periods.			■	Permanent stormwater works	Noise assessment report	Project Manager	During permanent stormwater works
VERIFICATION								
NV22.	Undertake verification of the noise model using near-field noise measurements of equipment.		■	■	Entire project	Best Practice	EHS Manager (Environment)	According to scenario timing
NOTIFICATION								
NV23.	Notify residents and potentially affected stakeholders of out-of-hour works and deliveries, and activities with high noise impact, two days in advance. Procedures for notification are detailed in the <i>Community &amp; Stakeholder Engagement Strategy</i> .	■	■	■	Entire project	Best Practice	Community Relations Manager	As required

Ref.	Mitigation Measure	Design	Site Establishment	Construction	Relevant Location / Activity	Relevant Approval Conditions	Accountability	Timing
NV24.	Where night time management levels cannot be satisfied, submit a report to the Director General outlining the mitigation measures applied, the noise levels achieved and justification that the outcome is consistent with best practice.		■	■	Entire project	Best Practice	EHS Manager (Environment)	As required
NV25.	Prepare a report after all instances of out of hours trade related works, including: <ul style="list-style-type: none"> <li>• hours worked and activities undertaken,</li> <li>• justification that the works were essential,</li> <li>• results of noise monitoring where undertaken,</li> <li>• complaint and response data,</li> <li>• corrective and preventative action to potentially avoid out of hour work occurrences and mitigate noise emissions above relevant noise management levels.</li> </ul>		■	■	Entire project	Basement MCOA C3.1 (n)	EHS Manager (Environment) Construction Supervisor	As required

## 6 MONITORING

Detail	Frequency	Standards	Reporting	Action if non-complying	Responsibility
<b>Continuous unattended noise monitoring</b> at locations shown in Appendix 1, both $L_{Aeq}$ and $L_{Aeq(>1000Hz)}$ (the web-based monitoring system used for Barangaroo South is shown in Appendix 4).	Real-time monitoring using a web-based system.	NMLs in Appendix 1, Table 4.	Monthly	Follow noise response table below. Seek professional acoustic input if required.	EHS Manager (Environment) Noise Specialist
<b>Construction equipment monitoring</b> (noise audit) to assess compliance with expected noise levels, and to allow any increase in noise levels to be detected and addressed.	If equipment is perceived as being noisy or noisier than other similar equipment, or in response to complaints.	Levels in Appendix 1, Table 2 – Typical Plant & Equipment Noise Levels. AS 2012	N/A	Assess equipment and undertake remedial action such as repair, noise-proofing, redeployment or removal.	EHS Co-ordinator Noise Specialist
<b>Attended noise monitoring:</b> <ul style="list-style-type: none"> <li>in response to complaints, as per table 1 below,</li> <li>to refine construction methods to minimise noise,</li> <li>to differentiate between construction noise sources and other sources (eg. road traffic or Headland Park works),</li> <li>to assess internal construction noise levels at commercial premises, if needed, or</li> <li>as needed during site establishment.</li> </ul>	As required.	NMLs in Appendix 1, Table 4. AS 1055	As required Monthly	Follow noise response table below. Seek professional acoustic input if required.	EHS Manager (Environment) Noise Specialist
<b>Attended vibration monitoring</b> at locations shown in Appendix 1.	Initial two weeks of significant vibratory activity. Frequency to be reassessed following data interpretation. As required for changes in works or complaints.	EPA guidelines BS6472 DIN4150 Part 3	Monthly	Cease relevant activities, and/or implement additional measures. Seek professional vibration input if required.	EHS Manager (Environment) Vibration Specialist
Integrity of site hoarding.	Weekly.	Hoarding intact.	Weekly Site Checklist	Construction Manager to repair or replace	Foreman

**Table 1: Additional noise mitigation measures**

Scenario	Mitigation measures LAeq(15 minute) noise level above NML	
	<b>0 to 10 dBA</b> Noticeable	<b>&gt; 10 dBA</b> Clearly audible – potentially intrusive
Approved hours, no complaints received		<ul style="list-style-type: none"> <li>• Env. Response Form indicating reasonable and feasible measures</li> </ul>
Approved hours, complaint(s) received	<ul style="list-style-type: none"> <li>• Respond to complainant</li> <li>• Env. Response Form indicating additional reasonable and feasible measures (see Appendix 5)</li> </ul>	<ul style="list-style-type: none"> <li>• Respond to complainant</li> <li>• Env. Response Form indicating additional reasonable and feasible measures (see Appendix 5)</li> </ul>
Planned out of approved hours, no complaints received	<ul style="list-style-type: none"> <li>• Letter box drops prior to works</li> <li>• Inform relevant authorities prior to works</li> </ul>	<ul style="list-style-type: none"> <li>• Letter box drops prior to works</li> <li>• Inform relevant authorities prior to works</li> <li>• Briefing of residents via CCLG</li> <li>• Env. Response Form indicating additional reasonable and feasible measures (see Appendix 5)</li> </ul>
Planned out of approved hours, complaint(s) received	<ul style="list-style-type: none"> <li>• Letter box drops prior to works</li> <li>• Inform relevant authorities prior to works</li> <li>• Respond to complainant</li> <li>• Env. Response Form indicating additional reasonable and feasible measures for next planned out of approved hours work.</li> </ul>	<ul style="list-style-type: none"> <li>• Letter box drops prior to works</li> <li>• Inform relevant authorities prior to works</li> <li>• Respond to complainant</li> <li>• Env. Response Form indicating additional reasonable and feasible measures for next planned out of approved hours work.</li> </ul>

## 7 TRAINING AND RESOURCES

Training
<p>In addition to other Lend Lease training requirements discussed in the CFEMP, inductions are required and are to address:</p> <ul style="list-style-type: none"><li>• Site and neighbouring properties are sensitive to noise and vibration.</li><li>• Need to ensure plant and equipment brought to site operates efficiently and quietly.</li><li>• Strict adherence to the approved hours of operation.</li><li>• All plant to have non-tonal reversing beepers.</li><li>• All generators are to be silenced.</li><li>• Notification of the EHS Manager (Environment) of any works likely to cause significantly high vibration / noise emissions.</li></ul> <p>Toolbox talks to be conducted on:</p> <ul style="list-style-type: none"><li>• Working hours allowed, and required procedure for approval of any out of hours works.</li><li>• Results of noise and vibration monitoring.</li></ul>
Resources
<ul style="list-style-type: none"><li>• Calibrated sound level meters</li><li>• Calibrated vibration meter (to be supplied and operated by a vibration specialist)</li><li>• Calibrated noise loggers – web activated monitoring system allowing instantaneous records and live audio streaming (to be supplied and operated by noise specialist)</li><li>• On-site weather station</li><li>• Bureau of Meteorology (BOM) weather information.</li><li>• Noise and vibration specialists, EHS Co-ordinator, EHS Manager (Environment).</li></ul>

## 8 CONTACTS

Contacts
For contact names, numbers and positions, see the <i>Project Contacts List</i> .

## 9 REFERENCES AND REVISIONS

Related Documents
Bulk Excavation & Basement Car Parking, Supplementary Excavation & Construction Noise & Vibration Assessment, Wilkinson Murray Sept 2010 (Report No. 10232 Version B).
Preferred Project Report, Bulk Excavation and Basement Car Parking, Barangaroo Stage 1, JBA Planning Sept 2010
Construction Of Commercial Building C4, MP10_0025, Construction Noise And Vibration Assessment, Wilkinson Murray November 2010, Rev B
Construction of Commercial Building C3, Planning Application, Construction Noise and Vibration Assessment, Wilkinson Murray, November 2011, Rev D.
Construction of Commercial Building C5, Planning Application, Construction Noise and Vibration Assessment, Wilkinson Murray, November 2011, Rev D.
Section 75W Application: Concrete Batch Plant Noise & Vibration Assessment, Wilkinson Murray, September 2012.
Stormwater Diversion Works, Construction Noise and Vibration Assessment, Wilkinson Murray, December 2012.
Community and Stakeholder Engagement Strategy
Attended Noise Monitoring Procedure
Weekly EHS Checklist
Construction Noise Monitoring Sheet
References
Interim Construction Noise Guidelines, EPA 2009
AS 2436: Guide to noise control on construction, maintenance and demolition sites.
AS 1055: Acoustics – Description and measurement of environmental noise.
AS 2012: Acoustics – Measurement of airborne noise emitted by earth moving machinery: Stationary test condition – Determination of compliance with limits for exterior noise.
AS2107: Acoustics – Recommended design sound levels and reverberation times for building interiors.
Assessing vibration: A Technical Guideline, DECCW 2006
British Standard 6472: Guide to evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)
British Standard 7385: Part 2 – Evaluation and measurement of vibration in buildings
Revision, Control & Amendment
Revisions to this plan are to be made in accordance with Lend Lease Blue Book document control procedures.

## 10 COMPLAINTS HANDLING AND SITUATION PLANNING

Complaints Handling Procedures			
<p>The <i>Community &amp; Stakeholder Engagement Strategy</i> identifies policies and procedures for managing community specific issues arising from construction activities. If an environmental complaint is received, the complaints management process outlined in the Strategy will be followed. This will involve the complaint being referred directly to the EHS Manager (Environment) and/or Construction Manager. If they are on site at the time an entry in 'Consultation Manager', the project consultation database, will be made to ensure appropriate action and monitoring. A response would be required to 'close out' the complaint, and the resolution would be recorded in Consultation Manager.</p> <p>The <i>Community &amp; Stakeholder Engagement Strategy</i> also outlines a number of proactive strategies for dealing with community and stakeholder issues.</p>			
Situation Planning & Response			
<p>Potential situations that could arise during the works include the following:</p>			
No.	Situation	Response	Responsibility
1.	Noise and / or vibration monitoring equipment damaged or not operational.	EHS Co-ordinator to record the event, then replace or adjust equipment. If the integrity of the recorded data is compromised, and replacement monitoring equipment cannot be sourced, the data would be recorded with a note acknowledging a potential error in the data as a result of malfunctioning equipment.	EHS Co-ordinator
2.	Vibration causing structural damage	Cease activities causing vibration under direction of the EHS Manager (Environment) or Construction Manager. Notify relevant staff according to the Incident and Emergency Management Plan. If appropriate, evacuate any occupants of buildings with due consideration to safety, and secure the area to prevent unauthorised access.  Undertake a structural assessment and compare results with any previous condition survey. If any damage is associated with construction, implement rectification works or agree compensation.	Construction Manager

**APPENDIX 1: NOISE ASSESSMENT AND MONITORING LOCATIONS**

## **Barangaroo South – Noise Assessments**

The following material provides relevant information required by the various MCOAs, and is based on information in the following noise assessment documents:

### **Basement**

- *Bulk Excavation and Basement Car Parking PA1 (MP10\_0023), Supplementary Excavation and Construction Noise and Vibration Assessment*, Wilkinson Murray, September 2010, Rev B.
- *Section 75W Application - Bulk Excavation and Basement Car Parking PA1 - S75W3 (MP10\_0023), Excavation and Construction Noise and Vibration Assessment*, Wilkinson Murray, September 2011, Rev E.
- *Section 75W Application: Concrete Batch Plant Noise & Vibration Assessment*. Wilkinson Murray, September 2012.

### **C4**

- *Barangaroo South, Construction of Commercial Building C4, MP10\_0025, Construction Noise and Vibration Assessment*, Wilkinson Murray, November 2010, Rev B.

### **C3**

- *Barangaroo South, Construction of Commercial Building C3, Planning Application, Construction Noise and Vibration Assessment*, Wilkinson Murray, November 2011, Rev D.

### **C5**

- *Barangaroo South, Construction of Commercial Building C5, Planning Application, Construction Noise and Vibration Assessment*, Wilkinson Murray, November 2011, Rev D.

## 1. Noise Sensitive Locations

Residential and commercial receivers that surround the site and may be affected by construction noise and vibration are listed below, and illustrated in the diagram below.

### Commercial Receivers

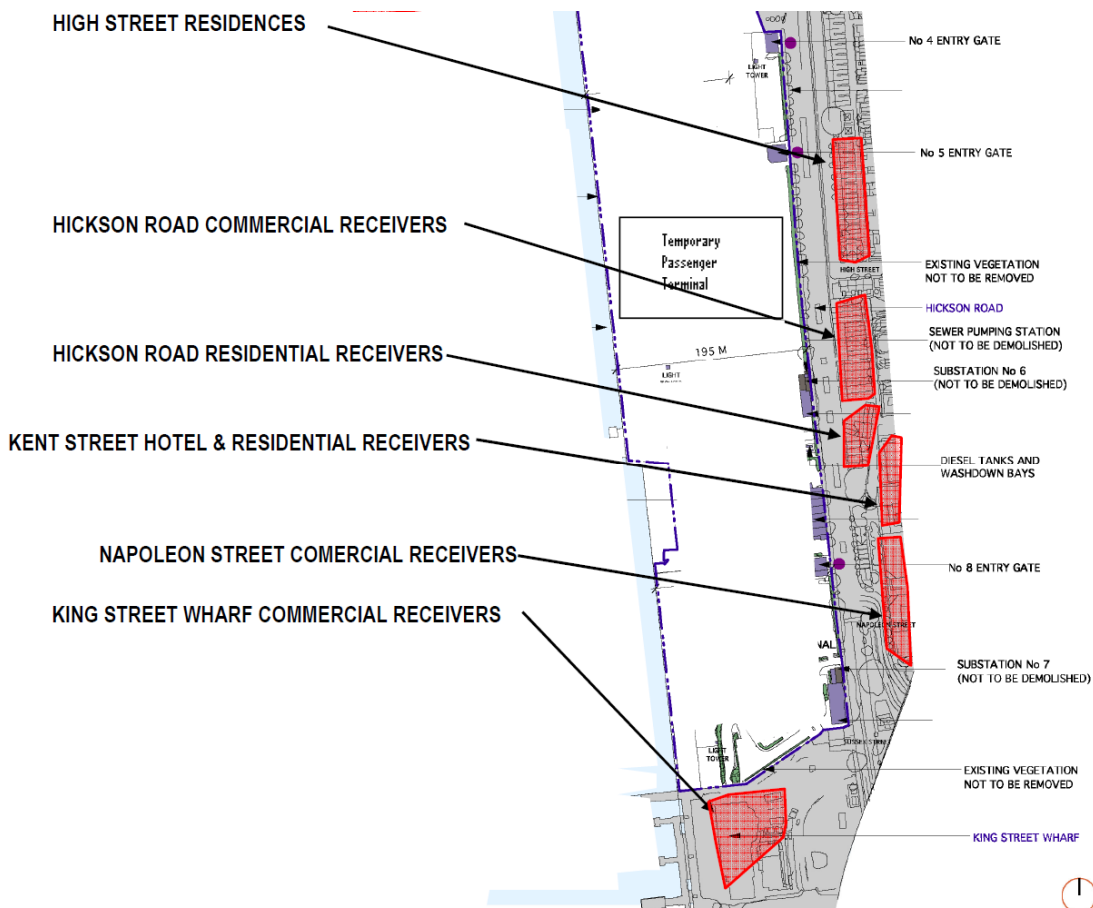
- Napoleon St – Aon Australia Building & Symantec Building.
- 30 Hickson Rd – Billabond Child Care Centre, Top Floor Café and Lend Lease offices.
- Lime Street, (King Street Wharf) – Commercial office and retail including indoor / outdoor cafes.
- 37 High St – KU Lance Preschool and Children's Centre.
- Millers Point – Barangaroo Temporary Cruise Passenger Terminal.
- Shelley St – Commercial on the corner of Sussex and Shelley Street.

### Residential Receivers

- 38 Hickson Rd – multi storey residential building.
- High St, Millers Point – terrace residences.
- Kent St – hotel and residential.
- Merriman St, Dawes Point – double storey unit blocks and single storey houses.
- Dalgety Road, Dawes Point – double storey community housing.
- Edward St & Little Edward St, Balmain East – waterfront properties along Balmain peninsula.
- Northern end of Darling Island Road and Wharf Cr, Darling Island – multi storey apartments.
- Northern end Sydney Wharf Pirrama Road, Pyrmont – multi storey apartments.

### Heritage Receivers

- Former Grafton Bond Store, Hickson Road, Millers Point – Former Grafton Bond Store Building.
- 20-26 Sussex St, Sydney-The Sussex Hotel – Former Moreton's Hotel.
- 2-4 Jenkins St – Former MWS stores.



## 2. Rating Background Levels

Table 1 below summarises background noise monitoring results (as Rating Background Level – RBL) for daytime, evening and night time periods at selected noise sensitive locations. Results for Saturday (7am-5pm) have been included as construction will take place outside standard working hours at that time.

**Table 1: Rating Background Levels**

No.	Background Monitoring Location	RBL (dBA)			
		Daytime 7-6pm	Evening 6-10pm	Night Time 10pm-7am	Saturday 7am-5pm
1	Level 4, The Bond 30-38 Hickson road	53	53	49	51
2	Middle of Barangaroo Stage 1, representative of Temporary Cruise Passenger Terminal	52	50	45	50
3	South west of site adjacent to Sussex St & Shelley St	60	59	49	57
4	South of site adjacent to King Street Wharf Boulevard	52	60	46	48
5	3 High St, Miller Point	47	44	41	45
6	18 Merriman St, Dawes Point	46	44	40	46
7	25 Edward St, Balmain East	49	45	40	46
8	Adjacent to 3 Darling Island Road, Darling Island	47	44	39	50

### 3. Construction Activities

Noise modelling has been conducted for several construction scenarios that have been established based on the construction program which are summarised in Tables 2a, 2b, 2c and 2d below.

**Table 2a: Basement construction activities**

Scenario	Description	Works
A	Piling and Perimeter retention System	<ul style="list-style-type: none"> <li>Removal of ground – using concrete saws and rock hammers for construction of diaphragm wall.</li> <li>Perimeter Retention Wall – removing earth and socket that will be filled with material – then set – process repeated to create a continuous wall.</li> <li>Temporary dewatering plant during archaeological testing.</li> </ul>
B	Removal of Ground Slab / Hardstand	<ul style="list-style-type: none"> <li>Diaphragm walls – provide water tight barrier along existing sea wall.</li> <li>Removal of ground slab – cutting slab, lift and break up using excavators or sent to mobile crushing and screening plant.</li> <li>Removal of topsoil and loose rock – using dozers and excavators; then trucked to Headland Park or offsite.</li> <li>Establishment of permanent dewatering plant north of stockpile (24/7).</li> </ul>
C	Earlier Bulk Rock Excavation	<ul style="list-style-type: none"> <li>Bulk excavation in rock – excavation using rocksaw, ripping using excavator mounted claws or bulldozers, rock hammer.</li> <li>Bulk excavation other than rock (OTR) – mainly using excavators with dozers.</li> <li>Demolition of former caisson structures, former timber piles and structures associated with historical wharves, and former seawall structures and foundations.</li> <li>Demolition of concrete foundation piles and footings of Wharf 8 structures and maritime apron slabs.</li> <li>Ground anchors – installed to stabilise walls (if required).</li> <li>Groundwater treatment – ground water pumps and treatment plant running 24/7.</li> </ul>
D	Later Bulk Rock Excavation	<ul style="list-style-type: none"> <li>Bulk excavation in rock – excavation using rocksaw, ripping using excavator mounted claws or bulldozers, rock hammer.</li> <li>Bulk excavation other than rock (OTR) – mainly using excavators with dozers.</li> <li>Truck movements – loaded into trucks sent to stockpiles, Headland Park or offsite.</li> <li>Remediation plant operating, groundwater treatment – ground water pumps and treatment plant running 24/7.</li> </ul>
E	Piling and Retaining Walls	<ul style="list-style-type: none"> <li>Bulk excavation in rock – excavation using rocksaw, ripping using excavator mounted claws or bulldozers, rock hammer.</li> <li>Bulk excavation other than rock (OTR) – mainly using excavators with dozers.</li> <li>Demolition of former caisson structures, former timber piles and structures associated with historical wharves, and former seawall structures and foundations.</li> <li>Demolition of concrete foundation piles and footings of Wharf 8 structures and maritime apron slabs.</li> <li>Truck movements – loaded into trucks sent to stockpiles, Headland Park or offsite.</li> <li>Groundwater treatment – ground water pumps and treatment plant running 24/7.</li> </ul>
F	Bulk Excavation	<ul style="list-style-type: none"> <li>Bulk excavation in rock – excavation using rocksaw, ripping using excavator mounted claws or bulldozers, rock hammer</li> <li>Bulk excavation other than rock (OTR) – mainly using excavators with dozers.</li> <li>Demolition of former timber piles and structures associated with historical wharves, seawall structures and foundations.</li> <li>Demolition of concrete foundation piles and footings of Wharf 8 structures and maritime apron slabs.</li> <li>Truck movements – loaded into trucks sent to stockpiles, Headland Park or offsite.</li> <li>Groundwater treatment – ground water pumps and treatment plant running 24/7.</li> </ul>
F1	Bulk Excavation – night works with shipping	<ul style="list-style-type: none"> <li>Operation of front end loaders within the excavation to load stockpiled material into conveyor hoppers</li> <li>Operation of ship loading conveyors between the excavation and the ship</li> <li>Personal access to and from the ship</li> <li>Basic conveyor maintenance in the event of breakdowns.</li> </ul>

G	Construction	<ul style="list-style-type: none"> <li>Construction of basement (Stage1A), tower building footings, concrete pumping and floating, installation of services, blockwork laying, materials handling.</li> <li>Remediation plant operating, groundwater treatment – ground water pumps and treatment plant running 24/7.</li> </ul>
---	--------------	--

**Table 2b: Commercial Building C4 construction activities**

Scenario	Description	Works
A	C4 Piling	<ul style="list-style-type: none"> <li>In the event that piling for C4 occurs in isolation. 4 piling rigs and 2 truck movements are assumed to operate in 15 minutes.</li> </ul>
B	C4 Building Construction	<ul style="list-style-type: none"> <li>2 concrete pumps, 2 forklifts, 4 compressors, 2 cranes, a boom truck and lift are assumed to operate in 15 minutes.</li> <li>Concrete trucks and delivery trucks assumed to be 12 movements in 15 minutes.</li> </ul>
C	C4 Facade	<ul style="list-style-type: none"> <li>In the event that the construction of the façade occurs in isolation.</li> <li>Forklift and power tools assumed.</li> <li>4 truck movements in 15 minutes assumed.</li> </ul>
D	Scenarios B + C	<ul style="list-style-type: none"> <li>Represents periods where both Scenarios B and C occur concurrently.</li> </ul>
E	Scenario A + Basement earthworks + piling	<ul style="list-style-type: none"> <li>Represents periods where the piling for C4 and earthwork and piling for basement occur concurrently.</li> </ul>

**Table 2c: Commercial Building C3 construction activities**

Scenario	Description	Works
A	C3 Piling	<ul style="list-style-type: none"> <li>In the event that piling for C3 occurs in isolation – 4 piling rigs and 2 truck movements are assumed to operate in 15 minutes.</li> </ul>
B	C3 Building Construction	<ul style="list-style-type: none"> <li>2 concrete pumps, 2 forklifts, 4 compressors, 2 cranes, a boom truck and lift are assumed to operate in 15 minutes.</li> <li>Concrete trucks and delivery trucks assumed to be 12 movements in 15 minutes.</li> </ul>
C	C3 Facade	<ul style="list-style-type: none"> <li>In the event that the construction of the façade occurs in isolation.</li> <li>Forklift and power tools assumed.</li> <li>4 truck movements in 15 minutes assumed.</li> </ul>
D	Scenarios B + C	<ul style="list-style-type: none"> <li>Represents periods where both Scenarios B and C occur concurrently.</li> </ul>
E	Scenario A + Basement earthworks + piling	<ul style="list-style-type: none"> <li>Represents periods where the piling for C3 and earthwork and piling for basement occur concurrently.</li> </ul>

**Table 2d: Commercial Building C5 construction activities**

Scenario	Description	Works
A	C5 Piling	<ul style="list-style-type: none"> <li>In the event that piling for C5 occurs in isolation – 4 piling rigs and 2 truck movements are assumed to operate in 15 minutes.</li> </ul>
B	C5 Building Construction	<ul style="list-style-type: none"> <li>2 concrete pumps, 2 forklifts, 4 compressors, 2 cranes, a boom truck and lift are assumed to operate in 15 minutes.</li> <li>Concrete trucks and delivery trucks assumed to be 12 movements in 15 minutes.</li> </ul>
C	C5 Facade	<ul style="list-style-type: none"> <li>In the event that the construction of the façade occurs in isolation.</li> <li>Forklift and power tools assumed.</li> <li>4 truck movements in 15 minutes assumed.</li> </ul>
D	Scenarios B + C	<ul style="list-style-type: none"> <li>Represents periods where both Scenarios B and C occur concurrently.</li> </ul>
E	Scenario A + Basement earthworks + piling	<ul style="list-style-type: none"> <li>Represents periods where the piling for C5 and earthwork and piling for basement occur concurrently.</li> </ul>

#### 4. Construction Equipment Noise Levels

Typical plant likely to be used during demolition, excavation (including shipping) and construction are identified in Tables 3a and 3b below. The table gives Sound Power Level (SWL) which are independent of measurement position. These SWLs have recently been measured at other similar construction sites.

**Table 3a: Typical Construction Plant Sound Levels – dBA**

Plant	Typical Use Period	Sound Power Level
Bulldozer	Day	114
Pug Mill – Remediation Plant	Day	100
Excavator	Day	108
Rotary Hoe	Day	109
Mobile Crane	Day	104
Concrete Truck	Day	109
Angle Grinder	Day	109
Concrete Pump – 120 mm diameter / 50 bar	Day	112
Bentonite Plant (or components)	Day, evening, night	104
Sheet metal forming (grinding, hammering)	Day	105
Concrete Crushing and Screening Plant	Day	116
Concrete Saw	Day	116
Crawler Cranes	Day	98
Ground Water Pump / Treatment Plant	Day, evening, night	106
Mobile Crane	Day	98
Rotary Boring Drill Rig	Day	107
Site Cranes	Day	104
Dump Truck	Day	108
Front End Loader	Day	112
Excavator	Day	107
Hammer Hydraulic	Day	122
Auger Vibro Pile	Day	110
Bored Pile Rig	Day	112
Piling – Vibrating	Day	108
Concrete Saw	Day	113
Compressor	Day	100
Bobcat	Day	103
Hand Tools	Day	90
Jackhammer	Day	105

**Table 3b: Typical Shipping Construction Plant Sound Levels – dBA**

Plant	Typical Use Period	Sound Power Level
Ship Auxiliary Power Units	Day, evening, night	91
Mobile Crushers	Day	110
Front End Loader	Day, evening, night	112
Hopper	Day, evening, night	105
Conveyor Generators	Day, evening, night	103
Conveyor (50 metre length)	Day, evening, night	90
Conveyor Drive	Day, evening, night	101
Screens	Day	111

## 5. Noise & Vibration Criteria

The following sections detail the applicable site specific construction noise and vibration criteria based on the guidelines from EPA, being:

- *Interim Construction Noise Guideline*; and,
- *Assessing Vibration: A Technical Guideline*.

### 5.1 Noise Criteria

The *Interim Construction Noise Guideline* provides noise goals that assist in assessing the impact of construction noise. Table 4 below details these noise goals.

**Table 4: Interim Construction Noise Guideline goals**

Time of Day	Management Level LAeq,(15min)	Application
Recommended standard hours: Monday to Friday - 7am to 6pm Saturday - 8am to 1pm No work on Sundays or Public Holidays	Noise affected RBL + 10dBA	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured Leq,(15min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. 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 75dBA	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 proponent should consider very carefully if there is any other feasible and reasonable way to reduce noise to below this level. If no quieter work method is feasible and reasonable, and the works proceed, the proponent should communicate with the impacted residents by clearly explaining the duration and noise level of the works, and by describing any respite periods that will be provided.
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 5dB(A) above the noise affected level, the proponent should negotiate with the community.

In addition, the following construction noise management levels  $L_{Aeq,15min}$  are recommended for other receivers and areas.

- Active recreation areas (such as parks): external  $L_{Aeq,15min}$  65dBA
- Industrial premises: external  $L_{Aeq,15min}$  75dBA
- Offices, retail outlets: external  $L_{Aeq,15min}$  70dBA
- Classrooms at schools and other educational institutions internal  $L_{Aeq,15min}$  45dBA.

The internal construction noise objective for commercial buildings is based on the maximum recommended internal noise level 45 dBA from AS2107.

### 5.2 Vibration Criteria

Vibration criteria for human comfort specified in the EPA guideline document *Assessing Vibration: A Technical Guideline* (2006). This document is based on criteria for assessment of the effects of vibration on human comfort set out in British Standard 6472-1992.

Acceptable values of human exposure to continuous vibration, such as that associated with underground drilling, are dependent on the time of day and the activity taking place at the receiver (eg workshop, office, residence or a vibration-critical area). Guidance on preferred values for continuous vibration is set out in Table 5.

**Table 5: EPA Criteria for Exposure to Continuous Vibration**

Place	Time	Peak Particle Velocity (mm/s)	
		Preferred	Maximum
Critical working areas (e.g. hospitals, precision laboratories)	Day or night time	0.14	0.28
Residences	Daytime	0.28	0.56
	Night time	0.20	0.40
Offices	Day or night time	0.56	1.1
Workshops	Day or night time	1.1	2.2

For intermittent vibration which is caused by equipment such as rockbreakers, a vibration dose approach is recommended which is presented in Table 6.

**Table 6: Acceptable Vibration Dose Values for Intermittent Vibration (m/s<sup>1.75</sup>)**

Location	Daytime		Night Time	
	Preferred Value	Maximum Value	Preferred Value	Maximum Value
Critical areas	0.10	0.20	0.10	0.20
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

British Standard *BS7385: Evaluation and measurement of vibration in buildings* is used to assess the possibility of building damage from vibration from construction activities. BS 7385 uses peak particle velocity to assess vibration, and specifies damage criteria for frequencies from 4Hz to 250Hz, in the range of significance for construction related damage. The levels from the standard are shown in Table 7 below.

**Table 7: BS 7385 structural vibration criteria**

Type of Structure	Peak Component Particle Velocity, mm/s		
	4Hz to 15Hz	15Hz to 40Hz	40Hz & above
Reinforced or framed structures, industrial and heavy commercial buildings	50	50	50
Un-reinforced or light framed structures, residential or light commercial type buildings	15 to 20	20 to 50	50

German Standard *DIN 4150: Structural Vibration in Buildings - Effects on Structures* provides recommended maximum vibration levels that reduce the likelihood of building damage caused by vibration.

These levels are 'safe limits', up to which no damage due to vibration effects have been observed. 'Damage' is defined by DIN 4150 to include even minor non-structural effects such as superficial cracking in cement render, the enlargement of cracks already present, and the separation of partitions or intermediate walls from load bearing walls. DIN 4150 also states that when vibrations higher than the 'safe limits' are present, it does not necessarily follow that damage will occur. DIN 4150 values are shown in Table 8 below.

**Table 8: DIN4150 structural vibration criteria**

Type of Structure	Peak Component Particle Velocity, mm/s		
	< 10Hz	10Hz to 50Hz	50Hz & above
Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20 to 40	40 to 50
Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20
Structures that because of their particular sensitivity to vibration, do not correspond to those listed above, and have intrinsic value (eg. heritage buildings)	3	3 to 8	8 to 10

## 6. Noise management levels

Based on the above, Table 9 below presents the applicable noise management levels for construction activities measured as  $L_{Aeq(15 \text{ min})}$  at surrounding receivers.

The following table identifies representative noise sensitive locations with the potentially most affected noise sensitive areas. These locations are illustrated in Figure 4 below.

**Table 9: Noise monitoring locations and corresponding Noise Management Levels**

Location			Noise Management Levels, $L_{Aeq}$ – dBA				Maximum Noise Level, $L_{Aeq}$ – dBA
Ref	Sensitive Receiver	Associated Construction Monitoring Location	Day	Evening	Night	Saturday (extended)	
1	Hickson Road Residences	South of 38 Hickson Rd	63	58	54	55	75
2	High Street Residences	Northern end of The Bond	57	49	46	50	75
3	Balmain East Residences	Illoura Reserve, Balmain East	59	50	45	51	75
4	Darling Island & Sydney Wharf Residences	Ballarat Park, Darling Island	57	49	44	55	75
-	All Commercial Properties		70	70	70	70	75
-	Schools / Preschools		55*	-	-	-	75
-	Parks / Outdoor Play Areas		65	-	-	65	75

\*The external noise goal of 55dBA is based on a 10dB reduction through an open window.



- Permanent noise monitoring locations
- Temporary vibration monitoring locations

Figure 4: Noise and vibration monitoring locations

## 7. Predicted Construction Noise

Assessment of likely noise at surrounding commercial and residential receivers was assessed as part of the environmental assessments listed in Section 1 of this Appendix 1, for the Barangaroo South works. Noise modelling was undertaken based on the construction activities defined in Tables 2a, 2b, 2c and 2d above.

Noise modelling assumes a typical worst case scenario whereby all construction equipment is running continuously. As such the modelling represents likely noise levels that would occur during intensive periods of construction. Therefore the predicted noise levels can be considered in the upper range of noise levels that can be expected at surrounding receivers when the various construction activities occur.

Once noise sources have been modelled, the resultant noise levels at identified surrounding receivers are predicted. These results are then compared with established site specific noise criteria. Further information on noise levels at surrounding receivers is provided below.

### 7.1 Residential Receivers

#### Impacts from construction works at the basement, C3, C4 and C5

The greatest potential exceedance at residential receivers during construction, up to 15 dBA at Hickson Road residences, is likely to occur during extended hours on Saturdays when construction noise objectives are the most stringent for daytime.

During normal operating hours, there are predicted exceedance of up to 10 dBA at the Hickson Road residences.

The predicted noise levels are from cumulative noise from the construction of the basement, C3, C4 and C5. These noise levels are consistent with the Basement construction noise assessment, whereby noise from C3, C4 and C5 construction works are not as significant as basement construction works.

All predicted construction noise levels are well below the maximum construction noise level of 75 dBA.

It is likely that as the basement depth increases during excavation, that the shielding effect of the excavation depth and perimeter excavation faces will act to diminish potential noise exceedances.

The most potentially affected residences are:

- Hickson Road and other residences overlooking residences immediately to the East of the Site particularly on Saturday afternoons.
- High Street and Dawes Street residences during periods when haulage to Headland Park occurs.
- Residences west of the site, such as Sydney Wharf and Darling Island, where noise from stationary plant such as the bentonite plant will result in an exceedance of night criteria.

Measures to reduce noise emissions as detailed in Section 5 of this sub-plan are required to ensure the acoustic amenity of these properties is protected.

#### Impacts from concrete batch plant and stormwater works

##### Concrete batch plant

A review of the potential noise impact associated with the use of a concrete batch plant at the South Barangaroo site determined that noise from the plant and associated activities will comply with established weekday daytime noise management goals.

On Saturdays, general compliance is indicated at most surrounding receivers. Small exceedances are indicated at High Street and Hickson Road residences. These exceedances, which are up to 4 dBA, are well below the maximum management level of 75 dBA and are considered small and manageable. It is noted that the predicted batch plant noise levels at High Street and Hickson Road residences are below measured existing ambient LAeq noise levels at these locations.

In addition, a review of the cumulative noise impact at residences determined that the addition of the concrete batching plant will not result in an unacceptable increase in construction noise levels at surrounding receivers during the daytime.

##### Permanent stormwater works

Noise levels from most construction activities associated with the stormwater diversion have been predicted to comply at most receivers with regard to established noise management levels, when localised noise barriers are deployed between the site and receivers. Commercial receivers on Hickson Road and to a lesser extent Lime Street will be subject to the highest construction levels. Recommended measures to mitigate and manage noise have been incorporated in Section 5 of the Noise & Vibration Management Sub-Plan.

## 7.2 Commercial Receivers

### **Commercial buildings**

General compliance with the 70 dBA noise objective is indicated at surrounding commercial premises. The exceptions are properties at Lime Street and Shelley Street where exceedances up to 4 and 7 dBA respectively are predicted during rock breaking of the hardstand.

As surrounding commercial premises are generally of modern construction and do not have operable windows, a facade noise reduction of 30 dBA is expected. As a result, maximum internal noise levels in the order of 47 dBA are predicted. Noise levels of this magnitude are not uncommon for office areas. Therefore, whilst audible, noise from construction at these premises is not expected to result in disruption to most office type activities, and general compliance with the objective of 45 dBA can be expected. This is consistent with the maximum noise levels recommended in Australian Standard 2107 for general office areas.

It is noted that commercial receivers which have operable windows, such as in heritage buildings, would be subjected to construction noise levels approximately 10 dBA louder if windows were open. Therefore windows may need to be closed during intensive periods of construction to meet the 45dBA noise objective.

Monitoring of internal noise levels is specified in Section 6 of this sub-plan.

### **Retail outlets**

At restaurants and cafes at the northern end of Lime Street and the Shelley Street precinct, construction noise levels up to 74 and 77 dBA respectively are predicted when rockbreakers are used nearby to remove the ground slab and hardstand.

During auger piling along the southern boundary, noise levels of around 65dBA are predicted at outdoor eating areas in Shelley and Lime Streets. A review of ambient noise levels indicated that impact will be greatest at Shelley Street outdoor areas when daytime background noise levels are lowest (RBL 52dBA).

Measures to reduce noise emissions as detailed in Section 5 (NV18) of this sub-plan are required to ensure the acoustic amenity of these areas is protected.

Following these works it is likely that, as the basement depth increases during excavation, that the shielding effect of the excavation depth and perimeter excavation faces will act to diminish potential noise exceedances at the restaurants and cafes of Lime and Shelley Streets

## 7.3 Preschools

Construction noise levels in play areas of identified preschools are predicted to comply with the external 65 dBA noise objective for active recreation areas. In the case of internal areas an exceedance of internal noise objectives by up to 9 dBA when windows are open is expected. Therefore windows may need to be closed during intensive periods of construction.

Again, it is likely that as the basement depth increases during excavation, the shielding effect of the excavation depth and perimeter excavation faces will act to diminish potential noise exceedances.

## 7.4 Temporary Cruise Passenger Terminal

Maximum noise levels of up to 65 dBA are predicted during some construction activities if fill is transported to Headland Park. At these noise levels effective communication will be achieved in the terminal at distance of up to one metre between persons in the terminal using a normal voice effort.

The installation of a 2.4m high plywood barrier between the terminal and the haul route reduced predicted noise levels in the terminal to around 57dBA, which increases the effective communication distance to around three metres within the terminal.

Cumulative noise levels are predicted to be up 59 dBA. These noise levels are not considered excessive.

## **8. Predicted Construction Vibration**

### **Basement construction**

The primary sources of vibration will be rocksaws operating at the perimeter of the site, and rockbreakers at the remainder of the site. The highest vibration levels will be those generated by heavy rockbreakers. Vibration levels associated with rock saws and auger piling are significantly lower than that of rockbreakers. Other vibration sources during building construction include vibratory piling and bored piling.

A review of the site plan and surrounding receivers indicate that the minimum distance between potential rockbreaking activities and surrounding buildings, including heritage buildings, will be:

- Residences and Heritage Buildings - 30m.
- Shelley Street and Lime Street Commercial Buildings - 20m.

At these distances peak particle velocity levels in the order of 0.2 and 0.4 mm/s can be expected for heavy rockbreakers for residences and commercial buildings respectively.

At these levels of vibration, the preferred vibration dose (VDV) for human comfort criteria of  $0.2 \text{ mm/s}^{1.75}$  and  $0.4 \text{ mm/s}^{1.75}$  will not be exceeded for heavy rockbreakers.

As structural damage vibration criteria in commercial, heritage and residential buildings are much higher than human comfort criteria, compliance with the latter ensures that damage requirements will be satisfied.

### **Commercial Buildings C3, C4, C5 construction**

The vibratory level of construction activities at C3, C4 and C5 would be less than 0.1mm/s at 50m. Hence no vibration impact is predicted.

**APPENDIX 2: OUT OF HOURS WORKS APPROVAL PROCEDURE**

### Out of Hours Works Procedure

Where there is a requirement for out of hours activities that are not previously authorised by an MCOA, listed in this Noise and Vibration Management Sub-Plan or the Environmental Protection Licence, and would be audible, Lend Lease is required to submit relevant information to DP&I for consideration under Condition C3(2)(d) of the Basement MCOA (MP10\_0023), or Condition D2 of the 'C4' MCOA (MP10\_0025). This will be undertaken as per Figure 5 below.

This will include justification of the varied construction hours, appropriate notification to sensitive receivers, and noise reduction measures to be put in place.

Appropriate community notification will be required, as defined in the *Community and Stakeholder Engagement Strategy*.

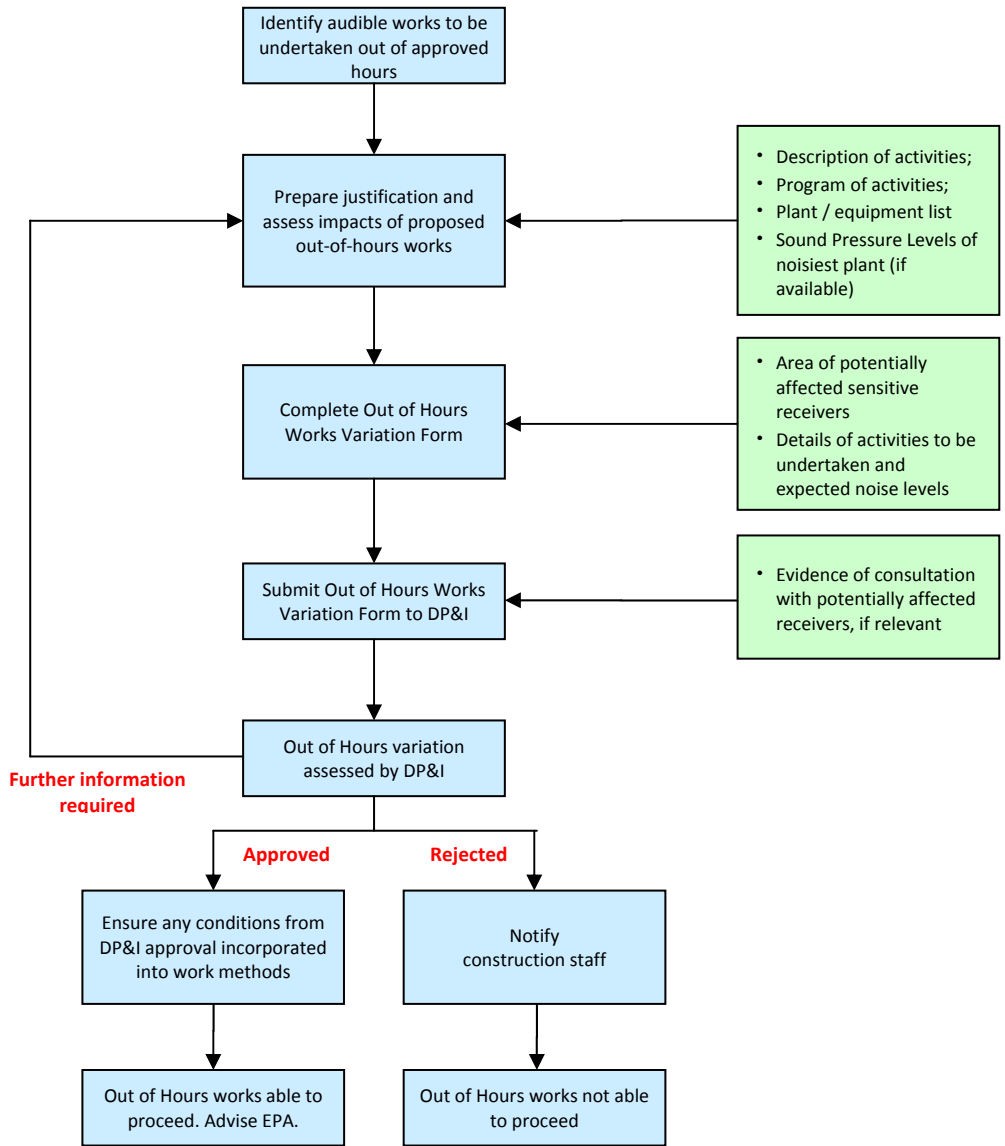


Figure 5: Out of Hours Works approval procedure

**APPENDIX 3: REVIEW OF ALTERNATIVES TO 'BEEPER' ALARMS FOR  
CONSTRUCTION EQUIPMENT, OEH – MAY 2009**

**EXTRACT – RECOMMENDATIONS AND CONCLUSION**

## RECOMMENDATIONS

This review has identified that when there is a requirement for an audible movement alarm as a safety feature for construction equipment there is currently no requirement that specifically prescribes the use of a 'beeper' type alarm. If an item of plant has a 'beeper' alarm supplied as standard then this alarm can be replaced by an alternative audible signal as long as a risk assessment has been undertaken.

There is a range of alternatives to 'beeper' alarms that are feasible - ie are available and can be used with appropriate worker training. These alternatives are also reasonable – ie do not impose a significant cost per item of plant on industry and, subject to appropriate selection, do not reduce on-site worker safety.

The main alternatives for movement alarms on construction sites are;

- Spotters which may be appropriate on particular sites and for particular hazards
- Visual alarms which may be appropriate on particular sites but are rarely used as the sole warning of moving plant
- Audible alarms which are generally preferred as a warning of moving plant on construction sites

There are two main risks for moving plant: on construction sites which require different approaches to provision of warnings

- Risk of damage to objects that are in the pathway of the moving plant when the person in charge of the moving plant must take action
  - Suitable warning comprises proximity alarm coupled with an in-cabin audible alarm and optional rear view camera
- Risk of injury to people who may be in the vicinity of the moving plant when those in the area of potential danger must take action as the person in charge of the plant may not be able to take action
  - Preferred warning is an external audible warning alarm

Once an external audible warning alarm is required there is the potential for noise impacts on the community. Work site layout and practices can minimise the need for the movement that activates the alarm; most commonly this is reduction of reversing. This can assist to minimise the noise impact but is not usually sufficient alone to overcome the problem. Options for audible alarms to reduce the noise impact include:

- Broadband alarms which have been demonstrated cause less annoyance in the surrounding communities. Broadband alarms have lower sound levels away from the area of potential danger and hence the additional benefits of the focussed alarms.
- Self adjusting broadband alarms that vary in level depending on the surrounding noise further reduce any noise impact.
- Self adjusting 'beeper' alarms that vary in level depending on the surrounding noise thus reducing the loudness of noise impact.
- Proximity sensors coupled with audible alarms thus reducing the duration of the noise impact.
- Proximity sensors coupled with broadband alarms would further reduce the duration of any noise impact.
- 'Beeper' alarms that focus the sound mainly in the area of potential danger thus reducing the spread of sound around the site.

Implementation of alternatives to the conventionally accepted "beeper' type audible external alarm requires a risk assessment. Where a risk assessment identifies an alternative is suitable, some factors that may relate to applying the alternative are:

A. If one company is responsible for all work on site and there is little variation in workers and plant then:

- Use of the same type of alarm sound on all plant used regularly on site to ensure association of the sound as the warning.
- Conduct a trial to check appropriate placement on each item of plant and adequate sound level and for each item.
- Provide training on the type of alarm during site induction.
- Install appropriate site signage.

B. If there is one site manager but a number of subcontractors hence varying workforce and different items of plant on site then:

- Consult with all plant operator/owner/renters on the options.
- Require the same type of alarm sound on all plant used regularly on site to ensure association of the sound as the warning.
- Require a demonstration of appropriate placement on each item of plant and of adequate sound level and for each item.
- Ensure training provided on the type of alarm during site induction
- Install appropriate site signage.

Note that the above are only some of the considerations necessary for a risk assessment and the person responsible may use a variety of means to support their decision making. Further work may be required to assist with guidance material for those undertaking such risk assessment.

## CONCLUSION

A warning of a reversing vehicle is essential for those who need to take action to avoid an accident. The options for movement alarms include spotters, visual alarms, audible alarms and proximity sensors plus alarms. The most common form of alarm is an audible alarm.

Pulsed tonal alarms (normally referred to as 'beeper' alarms) are widely accepted as hazard alerts. Advances in audible alarms include those which adjust the level to be above the background, those which focus the sound in the area where persons may be potentially at risk and those with a pulsed broadband signal.

While there is no independent verification of all of the features of broadband alarms as promoted by the suppliers, the alarms have been used on many construction sites following assessment that they provide an effective warning. The alarm signal is more focussed on the area where a person is potentially at risk and there is less risk of confusion from multiple alarm signals on the site.

Note that the study highlights that where a risk assessment is required as part of the project approval, the person responsible for undertaking this assessment may use a variety of means to support their decision making. Further work may be required to assist with guidance material for those undertaking such risk assessment. However some key features for effective implementation of the alternative alarms on a construction site include:

- Use of the same type of alarm sound for all vehicles on site - to ensure association of the sound with the warning and to avoid confusion caused by a mix of warning signals
- Selection of appropriate sound level – this is not necessarily obvious and trials of different models may be necessary
- Correct location of the alarm on the item of plant – so that the sound is heard clearly in the area where a person is potentially at risk
- Appropriate training for all site personnel and signage - to ensure association of the sound with a hazard.

'Beeper' alarms frequently cause annoyance for the community surrounding construction sites. Broadband alarms have been demonstrated to reduce noise complaints from the community due to the character and nature of the sound.

This review has shown that there is a range of alternatives to 'beeper' alarms that are feasible - ie are available and can be used with appropriate worker training. These alternatives are also reasonable – ie do not impose a significant cost per item of plant on industry and, subject to appropriate selection, do not reduce on-site worker safety. It is up to industry to consider these alternatives, along with any other relevant factors, when designing their system of work to minimise noise impact on the community surrounding the site – particularly when planning to work at night.

**APPENDIX 4: WEB-BASED NOISE MONITORING**

## Web-Based Noise Monitoring

The Barangaroo noise monitoring system consists of multiple field units all connected to a central server via wireless 3G internet. In cases where mains power is not available, an appropriate solar system and modem cycling is used. The noise monitoring system at East Balmain is shown in the figure below.

All data is uploaded to a central server that automatically performs the necessary acoustic processing and adds the results to a database. A customised website is used to interrogate the data and present the results in a graphical form for easy interpretation by the user. Email and SMS alerts are generated from the server, immediately alerting appropriate personnel of any exceedances of the construction noise criteria.

The system is capable of recording audio files, enabling the monitors to record a continuous, compressed audio signal that is uploaded to the server when required. This enables users to audibly review the recorded audio signal in response to complaints to provide further diagnosis of the noise sources measured.

All data is stored continuously in the same online repository and is always available.

Summary of capabilities:

- All data is uploaded in near real time, providing key personnel with the information they need to quickly respond to complaints;
- A compressed audio file of the audio signal is recorded at all monitors allowing diagnosis of noise sources;
- Housing all data in an online repository generally negates the need for traditional reporting techniques; and
- Up to date information can be viewed by multiple people from multiple organisations simultaneously.



## **APPENDIX 5: ANALYSIS OF POSSIBLE NOISE REDUCTION MEASURES**

## Analysis of reasonable and feasible noise reduction measures

The following table provides an evaluation of whether measures are reasonable and feasible to implement.

Noise Reduction Measure	Measure type	Source	Day or Night	Reasonable and feasible?
<b>In previous documents</b>				
Encapsulate engine chambers and fit silencers to equipment. This typically provides 5dBattenuation, but can achieve attenuation up to 10dB(A) .	Quiet equipment		Day & night	Yes – install on equipment operating long term on-site.
Minimise equipment use especially during off peak hours.	Procedure		Night	Yes – reduce equipment used whenever practical.
Use temporary barriers or berms to shield construction equipment. Examples include: <ul style="list-style-type: none"> <li>- Stacking containers around noisy equipment;</li> <li>- Constructing a shield around operation equipment such as dewatering pumps.</li> </ul>	Shielding		Day & night	Yes – provide hoardings around the site, and barriers for pumps and static plant if needed. Provide barriers during permanent stormwater works.
Restricting times when noisy work is carried out (respite periods).	Procedure		Day	Yes – provide periods of relief when practical during noise intensive activities such as rock breaking.
Placement of work compounds, parking areas, equipment and material stockpile sites away from noise-sensitive locations.	Design		Day & night	Yes – current location of these facilities is away from noise-sensitive receivers.
Where noise barriers/walls are to be constructed, program this as early as possible to reduce noise impacts on neighbouring residents.	Procedure		Day & night	Yes – hoardings will be built at the commencement of construction.
Ensure that least noisy construction methods, vehicles, plant and equipment are used, and adopting alternative construction measures.	Quiet equipment		Day & night	Yes – bored piling preferred. Otherwise generally not feasible due to specialised construction equipment required.
Consider alternatives to, or curtailing of reversing alarms.	Quiet equipment		Day & night	Yes – non-tonal alarms for on-site equipment.
Prevent vehicles and plant queuing and idling outside construction hours.	Procedure		Day & night	Yes – procedural.
Identify measures to be implemented to ensure that where movement alarms are fitted to vehicles, plant or equipment entering or operating on the site, such alarms are of a type that minimised noise at noise sensitive receivers.	Quiet equipment		Day & night	Yes – non-tonal alarms.
Minimise use of impact piling techniques.	Quiet equipment / design		Day	Yes, bored piling preferred. Dependant on piling equipment used.
<b>Based on current construction methods</b>				
Silenced generators.	Quiet equipment		Day & night	Yes
Quiet compressors & pumps.	Quiet equipment		Day & night	Yes
Notify community two days in advance of noisy activities.	Procedure		Day & night	Yes
Verification of noise model by monitoring equipment.	Procedure		Day & night	Yes