

BARANGAROO SOUTH STAGE 1C REMEDIATION AND EARTHWORKS CONSTRUCTION NOISE REPORT

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PREPARED FOR

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TABLE OF CONTENTS

	Page
GLOSSARY OF ACOUSTIC TERMS	
1 INTRODUCTION	1
2 OVERVIEW OF PROPOSED WORKS	2
2.1 Site Location	2
2.2 Scope of the Report	3
2.3 Construction Hours	3
3 AMBIENT NOISE MONITORING	4
3.1 Ambient Noise Levels at South Barangaroo	4
4 CONSTRUCTION NOISE ASSESSMENT	8
4.1 Construction Noise Criteria	8
4.1.1 Construction Noise Management Levels	8
4.1.2 Traffic Noise Criteria	10
5 CONSTRUCTION NOISE ASSESSMENT	11
5.1 Construction Equipment & Noise Source Levels	11
5.2 Construction Noise Predictions	11
5.3 Discussion of Results	14
5.4 Noise Mitigation Measures	14
5.5 Community Liaison & General Approaches to Mitigation	15
5.6 Noise & Vibration Management Plan	15
5.7 Cumulative Noise Impact	16
5.8 Construction Traffic Noise	18
6 CONCLUSION	21

GLOSSARY OF ACOUSTIC TERMS

Most environments are affected by environmental noise which continuously varies, largely as a result of road traffic. To describe the overall noise environment, a number of noise descriptors have been developed and these involve statistical and other analysis of the varying noise over sampling periods, typically taken as 15 minutes. These descriptors, which are demonstrated in the graph below, are here defined.

Maximum Noise Level (L_{Amax}) – The maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.

L_{A1} – The L_{A1} level is the noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the L_{A1} level for 99% of the time.

L_{A10} – The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The L_{A10} is a common noise descriptor for environmental noise and road traffic noise.

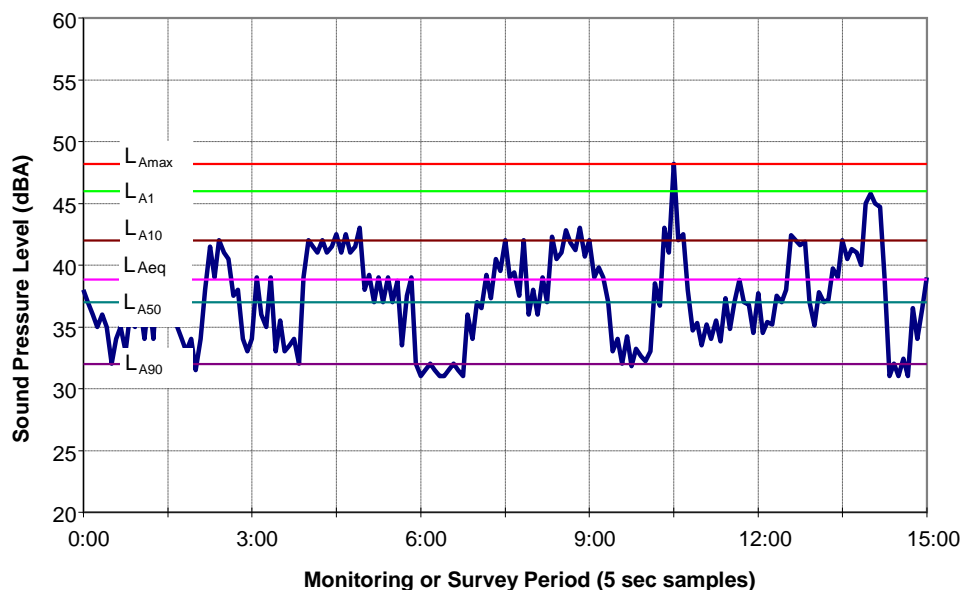
L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) 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.

ABL – 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 (L_{A90}) for each period.

RBL – 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.

Typical Graph of Sound Pressure Level vs Time



1 INTRODUCTION

This report has been prepared by Wilkinson Murray Pty Ltd on behalf of Crown Resorts Ltd ('Crown') to accompany a State Significant Development Application (SSDA) for the Stage 1C Remediation and Earthworks at Barangaroo Sydney. The requirements for noise and vibration are detailed under item 9 as follows:

Noise

'The application must include a Noise and Vibration Impact Assessment of construction, operation, traffic and cumulative noise impacts prepared in accordance with the relevant Environmental Protection Authority guidelines. This assessment must consider any potential impacts on the noise sensitive receivers and outline proposed noise mitigation and monitoring procedures.'

The Stage 1C Remediation and Earthworks is proposed in accordance with the approved Barangaroo Concept Plan (as modified) and is located within Barangaroo South.

The Stage 1C remediation and earthworks are described as follows:

- carrying out of remediation and validation within the Stage 1C remediation and earthworks area to ensure it is suitable for the intended future uses of the land;
- construction of a perimeter retention wall system and internal stabilising walls (called the 'Stage 1C groundwater retention wall system') to the west of Block 4B and Block 4C. The Stage 1C groundwater retention wall system would be fully integrated with the Stage 1B retention wall system (as specified by Lend Lease in the EIS for SSD 5897-2013), with direct connections to create a unified groundwater retention wall system across Stage 1B and Stage 1C; and
- bulk excavation within the perimeter of the Stage 1C groundwater retention wall, and the installation of lateral restraining structures to support the perimeter retention wall system.

These works are collectively known as the Stage 1C Works.

The land which is the subject of the Stage 1C Remediation and Earthworks SSDA is located in the north-western corner of Barangaroo South, immediately to the west of the Stage 1B development area specified by lend Lease in the EIS for SSD 5897-2013.

With reference to the Barangaroo 'development blocks', as identified within the approved Concept Plan Urban Design Controls (MP06_0162 MOD 4), the Stage 1C Works area is located to the west of Blocks 4A, 4B and 4C and incorporates part of Globe Harbour.

2 OVERVIEW OF PROPOSED WORKS

The Stage 1C Remediation and Earthworks SSDA seeks approval for the construction works and operation within the Barangaroo South Site. These works include excavation of the basement and piling works. Construction of the building is the subject of a separate application.

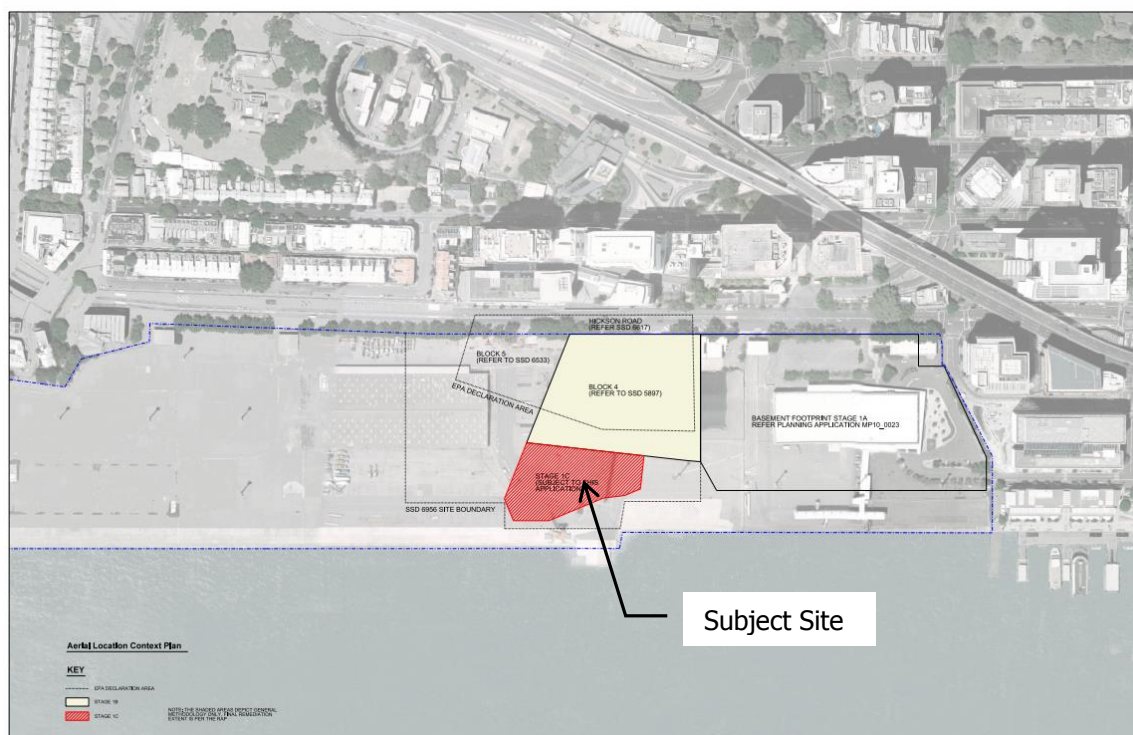
2.1 Site Location

Barangaroo is located on the north western edge of the Sydney Central Business District (CBD), bounded by Sydney Harbour to the west and north; the historic precinct of Millers Point (for the northern half), The Rocks and the Sydney Harbour Bridge approach to the east; and a range of new development dominated by large CBD commercial tenants and the King Street Wharf/Cockle Bay precinct to the south.

The 22ha Barangaroo site is generally rectangular in shape and has a 1.4 kilometre harbour foreshore frontage, with an eastern street frontage to Hickson Road. The site has been divided into three distinct redevelopment areas (from north to south) – the Headland Park, Barangaroo Central and Barangaroo South, and has been subject to multiple investigations that detail the physical and natural characteristics of the site.

The 1C area is located within Barangaroo South as shown in Figure 2-1. The SSDA Site extends over land at the North Western end of the site.

Figure 2-1 South Barangaroo Site Plan



2.2 Scope of the Report

This report assesses potential noise impacts generated during the bulk excavation and piling works of the development of the site and its likely impact on surrounding receivers. The excavation works are planned to occur during over the period September 2015 – April 2017.

In addition it assesses the cumulative noise impacts associated with Stage 1C Remediation and Earthworks and the following surrounding construction works:

Works directly related to Barangaroo South

- Block 4 remediation works
- Block 5 remediation works

All Works external to Barangaroo South will be complete prior to these 1C works

With respect to vibration associated with excavation works and piling activities it is noted that the site is remote from any sensitive receivers and resultant vibration levels will be negligible. Therefore this issue has not been assessed any further in this assessment.

2.3 Construction Hours

The proposed construction hours for the works are between 7.00am and 6.00pm Monday – Friday and between 7.00am and 5.00pm on Saturdays.

It is noted that the proposed hours for Saturdays are outside the EPA's standard hours of construction. However, this extended period of remediation hours will enable the major noise and vibration generating activities to be carried out in a more efficient manner, thereby shortening the overall construction period to which sensitive receptors will be exposed. This represents an approach already approved under South Barangaroo Project Approval MP 10 0023.

No construction / remediation work is proposed to be undertaken outside the proposed Construction/Remediation hours, including on Sundays or Public Holidays, with the exception of the cases identified below.

3 AMBIENT NOISE MONITORING

3.1 Ambient Noise Levels at South Barangaroo

Residential and commercial receivers surrounding the site that may be affected by construction and operational noise from South Barangaroo have been identified in previous relevant applications for the Barangaroo South site. These receivers are also relevant in assessing noise impacts from the broader site. They are detailed in Table 3-1.

Table 3-1 Surrounding Receivers

Receivers	Comments
<i>Commercial Receivers</i>	
A – Napoleon St	Aon Australia Building Symantec Building
B – 30 Hickson Rd	Top Floor Cafe, Lend Lease offices,
C – Lime St, (King Street Wharf)	Commercial office Retail including indoor / outdoor cafes
D – 37 High St, Millers Point	KU Lance Preschool and Children’s Centre
F – Shelley St	Commercial on Cnr of Sussex and Shelley St Commercial on Cnr of Lime and Shelley St
<i>Residential Receivers</i>	
G – 38 Hickson Rd	Multi storey residential building
H – High St, Millers Point	Terrace residences
I – Merriman St, Millers Point	Double storey unit blocks and single storey houses
J – Dalgety Rd, Millers Point	Double storey Community housing
K – Edward St and Little Edward St, Balmain East	Waterfront properties along Balmain peninsula
L – Northern end of Darling Island Rd and Wharf Cr, Darling Island	Multi storey high end apartments
M – Northern end Sydney Wharf Pirrama Rd, Pyrmont	Multi storey high end apartments
N – South Barangaroo Building R8	Multi storey high end apartments
<i>Heritage Receivers</i>	
O – Former Grafton Bond Store, Hickson Rd, Millers Point	Former Grafton Bond Store Building
P – 20-26 Sussex St , Sydney	The Sussex Hotel – Former Moreton’s Hotel
Q – 2-4 Jenkins St	Former MWS stores

In order to quantify the existing noise environment, long-term ambient noise levels were monitored at eight (8) locations surrounding the site, selected to cover the range of environments in the potentially affected areas.

The locations are presented in Table 3-2. The noise logger locations are shown in Figure 3-1.

Table 3-2 Long-Term Noise Monitoring Locations

Logger	Location	Monitoring Period in 2010	Company*
1	Level 4, The Bond 30-38 Hickson Rd	14 April to 29 April	Arup
2	Middle of South Barangaroo Site	14 April to 29 April	Arup
3	South West of site adjacent to Sussex St and Shelley St	14 April to 29 April	Arup
4	South of site adjacent to King Street Wharf Boulevard	14 April to 29 April	Arup
5	3 High St, Miller Point	31 August – 9 September	WM
6	18 Merriman St, Millers Point	31 August – 6 September	WM
7	25 Edward St, Balmain East	31 August – 9 September	WM
8	Adjacent to 3 Darling Island Rd, Darling Island	31 August – 9 September	WM

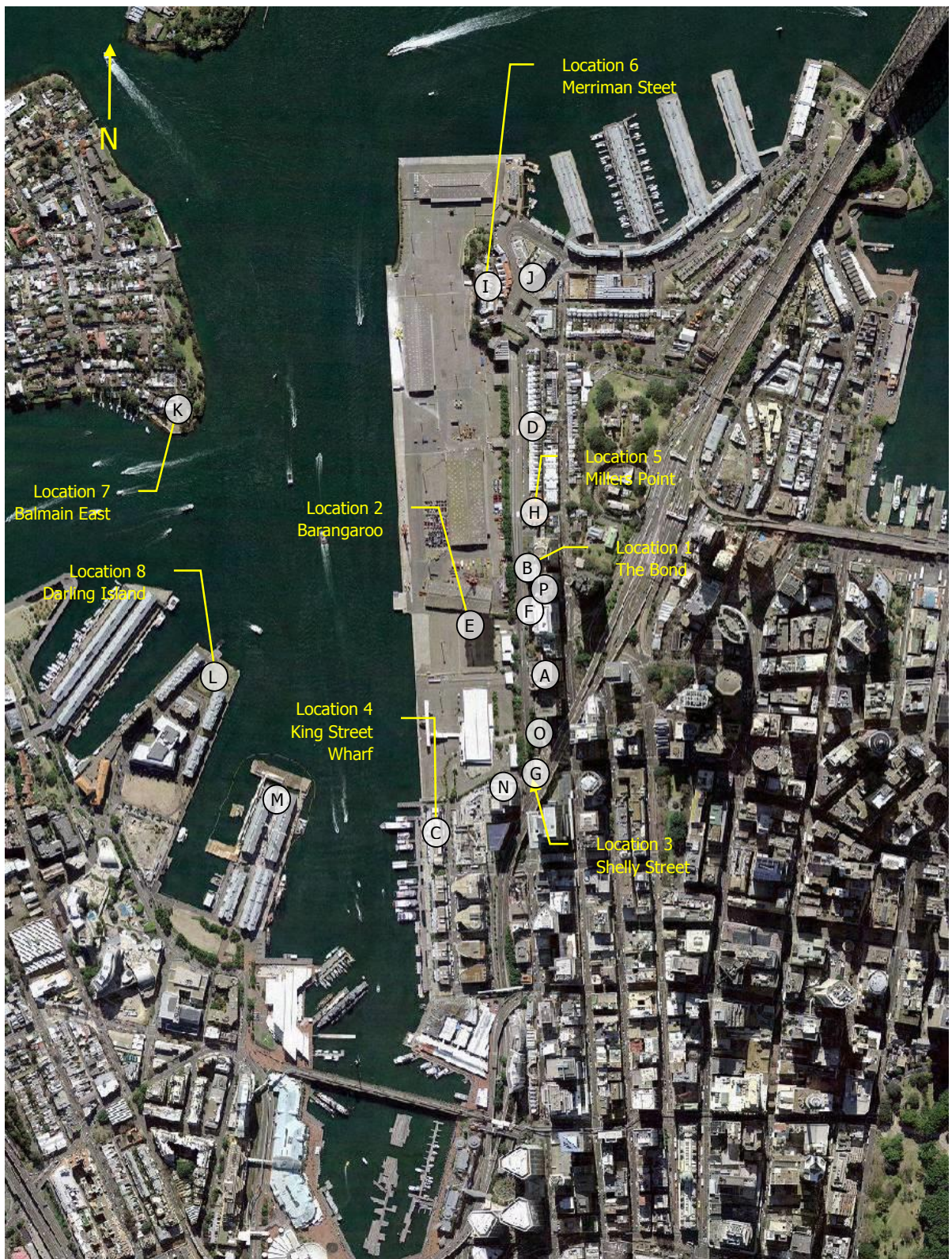
* Monitoring conducted by Arup and Wilkinson Murray.

The noise monitoring equipment used for the Wilkinson Murray noise measurements consisted of ARL Type EL-215 environmental noise loggers set to A-weighted, fast response, continuously monitoring over 15-minute sampling periods. This equipment is capable of remotely monitoring and storing noise level descriptors for later detailed analysis. The equipment calibration was checked before and after the survey and no significant drift was noted.

In the case of noise logging conducted by Arup, the data was reviewed and is considered suitable to use for assessment purposes. The details of the noise measurement equipment and calibration can be referred to within the report.

The logger determines L_{A1} , L_{A10} , L_{A90} and L_{Aeq} levels of the ambient noise. L_{A1} , L_{A10} and L_{A90} are the levels exceeded for 1%, 10% and 90% of the sample time respectively (see Glossary for definitions). The L_{A1} is indicative of maximum noise levels due to individual noise events such as the occasional pass-by of a heavy vehicle. The L_{A90} level is normally taken as the background noise level during the relevant period.

Figure 3-1 Aerial showing Noise Monitoring Locations



*Source Land and Property Management Authority

Table 3-3 summarises the noise results, for daytime, evening and night time periods as defined in the EPA's *Interim Construction Noise Guidelines (CNG)* and the *NSW Industrial Noise Policy (INP)*. Additionally, noise monitoring results for Saturday (7.00am-5.00pm) has been included as Lend Lease proposes to operate outside standard CNG hours during that time.

Table 3-3 Summary of Measured Noise Levels

Noise Logging Site	RBL (dBA)				L _{Aeq,period} (dBA)			
	Daytime 7am-6pm	Evening 6-10pm	Night Time 10pm-7am	Saturday 7am-5pm	Daytime 7am- 6pm	Evening 6-10pm	Night Time 10pm-7am	Saturday 7am-5pm
1	53	53	49	51	62	61	57	60
2	52	50	45	50	56	54	50	56
3	60	59	49	57	67	66	62	66
4	52	60	46	48	60	62	60	60
5	47	44	41	45*	58	55	51	55
6	46	44	40	46*	58	55	50	56
7	49	45	40	46*	67	51	47	56
8	47	44	39	50*	54	49	46	56

* Determined from the afternoon on Saturday 4 September as the morning was affected by rain.

Background noise levels at all locations were free of the influence of extraneous noise sources, such as plant or construction activities. Noise data measured during inclement weather was excluded in accordance with EPA procedures.

4 CONSTRUCTION NOISE ASSESSMENT

4.1 Construction Noise Criteria

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

- *Interim Construction Noise Guideline; and*
- *Road Noise Policy (RNP).*

4.1.1 Construction Noise Management Levels

The EPA released the *CNG* in July 2009. The guideline provides noise goals that assist in assessing the impact of construction noise.

For residences, the basic daytime construction noise goal is that the $L_{Aeq, 15min}$ noise level should not exceed the background noise by more than 10dBA. This is for standard hours: Monday to Friday 7.00am to 6.00pm, and Saturday 8.00am to 1.00pm. Outside the standard hours, the criterion would be background + 5dBA. Table 4-1 details the CNG noise goals.

Table 4-1 Construction Noise Goals at Residences using Quantitative Assessment

Time of Day	Management Level $L_{Aeq, (15min)}$	How to Apply
Recommended		The noise affected level represents the point above which there may be some community reaction to noise.
Standard Hours:		
Monday to Friday		Where the predicted or measured $L_{Aeq, (15min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise.
7am to 6pm	Noise affected	
Saturday	RBL + 10dBA	
8am to 1pm		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.
No work on Sundays or Public Holidays		
	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.

Time of Day	Management Level $L_{Aeq,(15min)}$	How to Apply
Outside recommended standard hours	Noise affected RBL + 5 dB	<p>A strong justification would typically be required for works outside the recommended standard hours.</p> <p>The proponent should apply all feasible and reasonable work practices to meet the noise affected level.</p> <p>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.</p> <p>For guidance on negotiating agreements see section 7.2.2.</p>

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

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

Based on the above, Table 4-2 presents the applicable noise management levels for construction activities at surrounding receivers that have been adopted for all applications.

Table 4-2 Site-Specific Construction Noise Management Levels

Location	Construction Noise Management Level, $L_{Aeq} - dBA$				Highly noise affected Noise Level, $L_{Aeq} - dBA$
	Day	Evening	Night	Saturday (extended)	
1 – Hickson Road Residences	63	58	54	55	75
5 – High Street Residences	57	49	46	50	75
6 – Merriman St Residences	56	49	45	51	75
7 – Balmain East Residences	59	50	45	51	75
8 – Darling Island Residences	57	49	44	55	75
9 – Sydney Wharf Residences	57	49	44	55	75
10- Building R8 Residences	63	58	54	56	75
All Commercial Properties			70		NA
Schools / Preschools			55*		NA
Parks / Outdoor Play Areas			65		NA

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

4.1.2 Traffic Noise Criteria

Noise Criteria for assessment of road traffic noise are set out in the NSW Government's *NSW Road Noise Policy (RNP)*. Table 4-3 sets out the assessment criteria for residences to be applied to particular types of project, road category and land use.

Table 4-3 Traffic Noise Criteria extracted from the NSW RNP

Road category	Type of project/land use	Assessment criteria – dB(A)	
		Day (7 a.m.–10 p.m.)	Night (10 p.m.–7 a.m.)
Freeway/ arterial/ sub-arterial roads	1. Existing residences affected by noise from new freeway/arterial/sub-arterial road corridors	L _{Aeq} , (15 hour) 55 (external)	L _{Aeq} , (9 hour) 50 (external)
	2. Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial roads	L _{Aeq} , (15 hour) 60 (external)	L _{Aeq} , (9 hour) 55 (external)
	3. Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments		
Local roads	4. Existing residences affected by noise from new local road corridors	L _{Aeq} , (1 hour) 55 (external)	L _{Aeq} , (1 hour) 50 (external)
	5. Existing residences affected by noise from redevelopment of existing local roads		
	6. Existing residences affected by additional traffic on existing local roads generated by land use developments		

In summary, the noise level goals at the residential receivers, for this project, based on the *RNP* are:

- L_{Aeq,1hr} day 55dBA; and
- L_{Aeq,1hr} night 50dBA

In addition, where the above criteria are already exceeded as a result of existing traffic the policy notes:

For existing residences and other sensitive land uses affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise level should be limited to 2 dB above that of the corresponding 'no build option'.

5 CONSTRUCTION NOISE ASSESSMENT

5.1 Construction Equipment & Noise Source Levels

Sound Power Levels (SWLs) for typical Stage 1C Remediation and Earthworks construction plant are identified in Table 5- 1. These SWLs have been measured at other similar construction sites. The table gives both Sound Power Level and Sound Pressure Levels (SPL) at 7m for the equipment. Sound Power Level is independent of measurement position.

Table 5-1 Typical Construction Plant Sound Levels – dBA

Plant	Sound Power Level	Sound Pressure Level at 7m
Bulldozer	114	89
Excavator	108	83
Mobile Crane	104	79
Concrete Truck	109	84
Concrete Pump – 120 mm diameter / 50 bar	112	87
Bentonite Plant	104	79
Crawler Cranes	98	73
Ground Water Pump	106	81
Dump Truck	108	83
Front End Loader	112	87
Hammer Hydraulic	122	97
Bored Pile Rig	112	87
Concrete Saw	113	88
Compressor	100	75
Bobcat	103	78

5.2 Construction Noise Predictions

Assessment of likely construction noise at surrounding commercial and residential receivers has been assessed for Stage 1C Remediation and Earthworks excavation and piling works. These works will be conducted when much of the South Barangaroo development is complete or the structure of the buildings is well progressed. Therefore, noise modelling has been conducted with many of the buildings included.

Site-related noise emissions were modeled with the “CadnaA” noise prediction program, using the ISO 9613 noise prediction algorithms. Factors that are addressed in the noise modeling are:

- equipment sound level emissions and location;
- screening effects from buildings;
- receiver locations;
- ground topography;

- noise attenuation due to geometric spreading;
- ground absorption; and
- atmospheric absorption.

Modelling has been conducted for a number of construction scenarios. The two works scenarios considered are summarised in Table 5-2.

Table 5-2 Construction Scenarios for Stage 1C Remediation and Earthworks

Scenario	Description	Works
A	Piling and Perimeter retention System	Removal of ground - using concrete saws and rockhammers for construction of Pile Wall and Diaphragm wall
		Structural Pile Wall - drilling using Auger into earth and socket that will be filled with material - then set - process repeated to create a continuous wall.
		Diaphragm Walls - provide water tight barrier along existing sea wall.
B	Bulk Excavation	Bulk Excavation in rock - excavation using rocksaw, ripping using excavator mounted claws or bulldozers
		Bulk Excavation other than rock(OTR) - mainly using excavators with dozers used to dozers to breakdown large rock elements
		Truck Movements - loaded into trucks sent offsite
		Removal of Groundwater - ground water pumps and treatment plant running 24/7

Noise modelling has been conducted for each of the above scenarios, with plant located across the construction site as follows.

Line Noise Source – Truck routes are modelled as line noise sources with the number of trucks on the haulage route in a 15 minute period applied to these sources.

Point Noise Sources – Fixed plant and equipment are modelled as point sources.

The modelling assumes a “typical worst case” scenario whereby all plant, is running continuously. As such the modelling represents likely noise levels that would occur during intensive periods of construction. Therefore the presented noise levels can be considered in the upper range of noise levels that can be expected at surrounding receivers when the various construction scenarios occur.

Once noise sources have been applied to the model, the resultant noise levels at identified surrounding receivers are predicted. These results are then compared with established site-specific noise criteria.

Table 5-3 and Table 5-4 detail the results of noise modelling for each scenario.

Table 5-3 Predicted Construction Noise Levels at Residence – $L_{Aeq}(15 \text{ min})$ – dBA – Scenario A

Residential Receiver	Predicted Noise Level	Weekday NML*	Exceedance	Sat NML	Exceedance
<i>Scenario A – Perimeter Wall</i>					
1 – Hickson Road Residences	46	63	0	55	0
5 – High Street Residences	44	57	0	50	0
6 – Merriman Street Residences	42	56	0	51	0
7 – Balmain East Residences	48	59	0	51	0
8 – Darling Island Residences	48	57	0	55	0
9 – Sydney Wharf Residences	46	57	0	55	0
10- Building R8 Residences	64	63	0	55	9
<i>Scenario B – Bulk excavation</i>					
1 – Hickson Road Residences	65	63	2	55	10
5 – High Street Residences	55	57	0	50	5
6 – Merriman Street Residences	52	56	0	51	1
7 – Balmain East Residences	50	59	0	51	0
8 – Darling Island Residences	54	57	0	55	0
9 – Sydney Wharf Residences	54	57	0	55	0
10- Building R8 Residences	66	63	3	55	11

A review of results indicates that compliance with noise management levels will be achieved at all surrounding residences for during week day with a small exceedance for Bulk Excavation at residences to the East (Hickson Road) and South (R8 Residences) of the site.

On Saturdays exceedances of between 1 and 11 dBA are predicted. It is noted that as excavation progresses noise sources will be shielded to some degree by the walls of the excavation and therefore the predicted exceedances will reduce.

In all cases predicted noise levels are below the highly affected objective of 75 dBA

Predicted noise levels at commercial receivers are presented in Table 5-4 as follows;

Table 5-4 Predicted Construction Noise Levels at Commercial – $L_{Aeq}(15 \text{ min})$ – dBA

Residential Receiver	Predicted Noise Level	Weekday NML	Exceedance	Sat NML	Exceedance
<i>Scenario A – Structure Construction</i>					
Lime Street, (King Street Wharf)	51	70	0	70	0
30 Hickson Road	55	70	0	70	0
Shelly Street	56	70	0	70	0
The Sussex Hotel	59	70	0	70	0
<i>Scenario B – Facade</i>					
Lime Street, (King Street Wharf)	56	70	0	70	0
30 Hickson Road	66	70	0	70	0
Shelly Street	57	70	0	70	0
The Sussex Hotel	59	70	0	70	0

A review of the results indicates that noise from the proposed construction works associated with the Stage 1C Remediation and Earthworks will comply with all commercial noise management levels.

5.3 Discussion of Results

It is noted that construction noise from the proposed Stage 1C Remediation and Earthworks basement excavation and piling works will not generate excessive levels of construction noise at surrounding receivers. The exceedances reported for works are consistent with other projects on the South Barangaroo Site and other construction projects in the city.

As the site is located away from most residences the potential for significant noise impact is reduced.

5.4 Noise Mitigation Measures

Based on the investigations and findings of this assessment, there are no specific noise and vibration measures that have been identified that need to be adopted for Stage 1C Remediation and Earthworks that are in addition to the management procedures in Lend Lease's current South Barangaroo EMP.

It is noted that a Construction Noise and Vibration Management Sub Plan titled "*Noise & Vibration Management Sub-Plan Barangaroo South Document No: H010106LLC004*" has been prepared by Lend Lease for the Barangaroo South Site in its entirety. It is intended that this plan be a "live document" whereby project-specific noise and vibration control measures are incorporated into the noise and vibration sub plan. The following mitigation measures are recommended:

- *Plant Noise Audit* – Noise emission levels of all critical items of mobile plant and equipment should be checked for compliance with noise limits appropriate to those items prior to the equipment going into regular service. To this end, testing should be established with the

contractor.

- *Operator Instruction* – Operators should be trained in order to raise their awareness of potential noise problems and to increase their use of techniques to minimise noise emission.
- *Equipment Selection* – All fixed plant at the work sites should be appropriately selected, and where necessary, fitted with silencers, acoustical enclosures and other noise attenuation measures in order to ensure that the total noise emission from each work site complies with EPA guidelines.
- *Site Noise Planning* – Where practicable, the layout and positioning of noise-producing plant and activities on each work site should be optimised to minimise noise emission levels.
- Install a 2.4 m plywood noise barrier between the site and street frontages. This should be a minimum 17mm thick structural plywood or equivalent panel. (Included in noise modelling)

The adoption of the above measures and application of the procedures in the Project Noise and Vibration Management Sub Plan are aimed at working towards achieving the noise management levels established at surrounding receivers.

5.5 Community Liaison & General Approaches to Mitigation

An effective community relations programme should be put in place to keep the community that has been identified as being potentially affected apprised of progress of the works, and to forewarn potentially affected groups (e.g. by letterbox drop, meetings with surrounding tenants, etc.) of any anticipated changes in noise and vibration emissions prior to critical stages of the works, and to explain complaint procedures and response mechanisms. This programme will be included in Lend Lease's *Community and Stakeholder Engagement Strategy* that has been specifically developed for the Barangaroo Project.

Close liaison should be maintained between the communities overlooking work sites and the parties associated with the construction works to provide effective feedback in regard to perceived emissions. In this manner, equipment selections and work activities can be coordinated where necessary to minimise disturbance to neighbouring communities, and to ensure prompt response to complaints, should they occur.

5.6 Noise & Vibration Management Plan

Lend Lease have prepared a construction Noise and Vibration Management Sub Plan for the Barangaroo South site in its entirety. The sub plan is revised as needed for additional assessments and planning approvals. Measures required by this assessment and any subsequent planning approval requirements, will be incorporated into a revised version of the sub plan. Areas that have been addressed in plan include:

- noise and vibration monitoring;
- response to complaints;
- responsibilities;
- monitoring of noise emissions from plant items;
- reporting and record keeping;

- non-compliance and corrective action; and
- Community consultation and complaint handling.

Details of monitoring procedures are shown in Table 8.1 extracted from the Sub Plan:

Table 5-5 Sub- Plan Monitoring Procedures

Detail	Frequency	Standards	Reporting	Action if non-complying	Responsibility
Continuous-unattended-noise-monitoring at locations shown in Appendix 1, both L_{Aeq} and $L_{Aeq,100Hz}$ (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
Construction equipment monitoring (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
Attended-noise-monitoring <ul style="list-style-type: none"> → in response to complaints, as per table 1 below, → to refine construction methods to minimise noise, → to differentiate between construction noise sources and other sources (eg. road traffic or Headland Park works), → to assess internal construction noise levels at commercial premises, if needed, or → as needed during site establishment. 	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
Attended-vibration-monitoring 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 BS 6472 DIN 4150 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 5-6 Additional Noise Mitigation Procedures

Scenario	Mitigation measures	
	0 to 10 dBA Noticeable	> 10 dBA Clearly audible – potentially intrusive
Approved hours, no complaints received		→ Review noise data and current work practices.
Approved hours, complaint(s) received	<ul style="list-style-type: none"> → Respond to complainant → CRM entry indicating additional reasonable and feasible measures (see Appendix 5) 	<ul style="list-style-type: none"> → Respond to complainant → CRM entry indicating additional reasonable and feasible measures (see Appendix 5)
Planned out of approved hours, no complaints received	<ul style="list-style-type: none"> → Letter box drops prior to works → Inform relevant authorities prior to works 	<ul style="list-style-type: none"> → Letter box drops prior to works → Inform relevant authorities prior to works → Briefing of residents via CCLG → CRM entry indicating close out actions
Planned out of approved hours, complaint(s) received	<ul style="list-style-type: none"> → Letter box drops prior to works → Inform relevant authorities prior to works → Respond to complainant → CRM entry indicating additional reasonable and feasible measures for next planned out of approved hours work. 	<ul style="list-style-type: none"> → Letter box drops prior to works → Inform relevant authorities prior to works → Respond to complainant → CRM entry indicating additional reasonable and feasible measures for next planned out of approved hours work.

5.7 Cumulative Noise Impact

There are other projects that will be under various stages of works when the Stage 1C Remediation and Earthworks works occur. These include elements of the South Barangaroo project site along with the other major projects at Barangaroo, being:

- Block 5 Remediation
- Block 4 remediation

Other projects such as towers T1 and T3 along with smaller developments on the site will be in the final stages of construction and will not generate significant levels of construction noise that have the potential to contribute to cumulative construction noise when compared to Block 4 and 5 remediation. Therefore an assessment of the cumulative impact these “acoustically significant” works have been included in this assessment.

Construction noise levels associated with the South Barangaroo projects have been predicted based on noise modelling conducted for these projects associated with the project applications.

Based on these assessments, noise levels at residences potentially affected by these sites have been assessed based on noise levels predicted in early 2016. Table 5-5 presents cumulative noise impact from Wilkinson Murray’s predictions of this assessment and the Headland Park, Barangaroo Central and Wynyard Walk Assessments.

Table 5-5 Cumulative Construction Noise Levels– $L_{Aeq}(15 \text{ minutes})$ – dBA

Residences	Block 5 Remediation Works	Block 4 Remediation Works	Stage 1C Works	Cumulative (without 1C Works)	Cumulative (with 1C Works)
Dawes Point	47	48	52	51	54
Balmain East	45	47	50	49	53
37 High Street	57	57	55	60	61
38 Hickson Road	67	73	65	74	75
R8	60	67	66	68	70

A review of the above noise levels in the table reveals that construction noise from the Stage 1C Remediation and Earthworks site in 2016 will be below the cumulative noise levels of other construction works the nearby receivers of High Street, Hickson Road and Building R8 whereby the cumulative effect will result in overall noise levels at these residences increasing by up to 2 dBA.

Given this fact, the predicted Stage 1C Remediation and Earthworks construction noise levels at nearby residences will be similar in magnitude to surrounding remediation works. Therefore it is concluded that the Stage 1C Remediation and Earthworks works will not result in an unacceptable cumulative construction noise increase at surrounding noise sensitive receivers.

The above consideration does not preclude the application of the management procedures contained in the site environmental management plan which of course should be consistently applied to the Stage 1C Remediation and Earthworks excavation and piling works construction works.

5.8 Construction Traffic Noise

Arup, the traffic consultants, in their report titled "*Crown Resorts Limited Stage 1C Remediation and Earthworks Construction Traffic Management Plan Revision A*" advises that the Stage 1C works period could be expected to take place between September 2015 and April 2017.

Given this, from the "*Forecast Vehicle Activity - Vehicle Movements per Hour*" table in the construction traffic report, approximately 68 construction vehicles per hour can be expected on in February 2016. Of these 4 truck movements per hour will be associated with the Stage 1C Remediation and Earthworks.

Based on a review of noise levels at The Bond on Hickson Road it has been determined that existing noise levels in the hours of proposed construction already exceed the daytime objective of 55 dBA. Therefore the already exceeded objective of not increasing existing noise levels by more than 2 dB is applicable for this development.

The point in time where the maximum impact of traffic noise from Stage 1C Remediation and Earthworks around February 2016. At this point, there will be operational traffic from some of the Barangaroo South projects and these have been included in traffic figures.

Data is not available for existing traffic volumes over the 15 hour day and 9 hour night. Morning peak traffic flows are presented in Table 5-6 based on information provided by ARUP, the traffic consultants.

Table 5-6 AM Traffic Flows on Hickson Road South of Site Entrance– Vehicles

Condition	Northbound AM Peak Hour	Southbound AM Peak Hour
Existing 2013 (Existing)	621	254
February 2016 Operational Traffic	707	297
Operational February 2016 with Stage 1C Remediation and Earthworks Construction Traffic	709	299
February 2016 Total Operational and Construction Traffic	742	331

AM peak hour traffic noise levels at the nearest residences on Hickson Road have been predicted using the *Calculation of Road Traffic Noise (CORTN)* traffic noise prediction technique based on a "worst-case" assumption that all construction traffic travels south from the site access.

Table 5-7 details predicted peak hour traffic noise levels with and without the Stage 1B Basement construction traffic.

**Table 5-7 Predicted AM peak Traffic Noise Levels at Hickson Road Residences
– $L_{Aeq,1hr}$ – dBA**

Construction Traffic	Calculated Traffic Noise Level
Base 2013 Traffic (Existing)	67.1
February 2016 Operational Traffic	68.0
February 2016 with Stage 1C Remediation and Earthworks Construction	68.1
February 2016 Total Operational and Construction	69.3

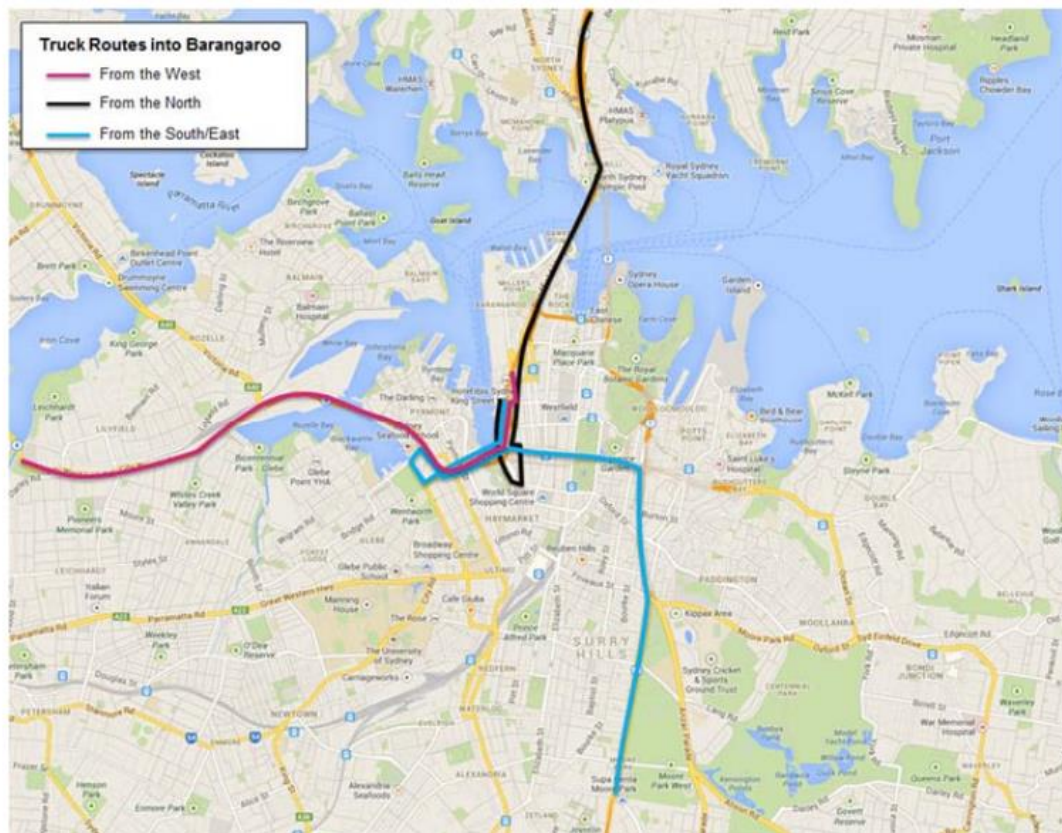
A review of predictions indicates the following;

- Stage 1C Remediation and Earthworks traffic will increase future traffic noise levels at Hickson Road residences by approximately 0.1 dBA;
- When Stage 1C Remediation and Earthworks and all Barangaroo South construction traffic is included an increase of 1 dBA is predicted. Traffic noise levels are therefore not predicted to exceed the 2dBA objective due to construction and operational traffic in October 2017; and
- The predicted changes in hourly peak hour flows are considered representative of the changes over a 15-hour daytime period.

A review of the proposed truck routes (Figure 5.1) to and from the site are through major roads in the CBD. It is not envisaged that traffic from construction will use local streets thereby avoiding any potential traffic noise impact at residences.

A review of the proposed truck routes (Figure 5.1) to and from the site are through major roads in the CBD. It is not envisaged that traffic from construction will use local streets thereby avoiding any potential traffic noise impact at residences.

Figure 5-1 Construction Traffic Routes through the CBD



6 CONCLUSION

A noise review of Stage 1C Remediation and Earthworks has been conducted for Barangaroo South. Site-specific noise criteria that are applicable to this project have been presented.

A noise assessment has been conducted of the proposed construction activities associated with the Stage 1C Remediation and Earthworks to determine the potential for noise and vibration impact at surrounding receivers. No exceedance of noise management levels is expected at surrounding receivers.

Vibration associated with on-site construction activities is considered to be negligible. No specific management and mitigation measures to reduce noise and vibration impact at receivers have been identified beyond the normal measures detailed in the EMP.

Construction traffic noise has been assessed and the increase in noise has determined to be marginal. A Noise and Vibration Management Plan has been prepared by Lend Lease in managing the environmental issues associated with this project.