Lend Lease (Millers Point) Pty Limited

Barangaroo - South Concept Plan Amendment - (MP06_0162 MOD 4)

Acoustic Report

ARUP

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1 Introduction

1.1 Background

On the 20 December 2009, Lend Lease (Millers Point) Pty Limited (Lend Lease) was appointed as the preferred proponent to develop Barangaroo South: comprising of Blocks 1 to 4 and associated public recreation areas.

The area of land that is subject to the Concept Plan Amendment is indicatively shown in Figure 1, and is herein referred to as “Barangaroo South” or the “Site”. It comprises an open apron which is largely reclaimed over water and is identified in the existing approved Concept Plan as Blocks 1 – 4 and the immediately adjacent public recreation area. Barangaroo South also extends beyond the western edge of the existing apron and includes a north-west oriented intrusion into the existing waters of Darling Harbour (see Figure 1).

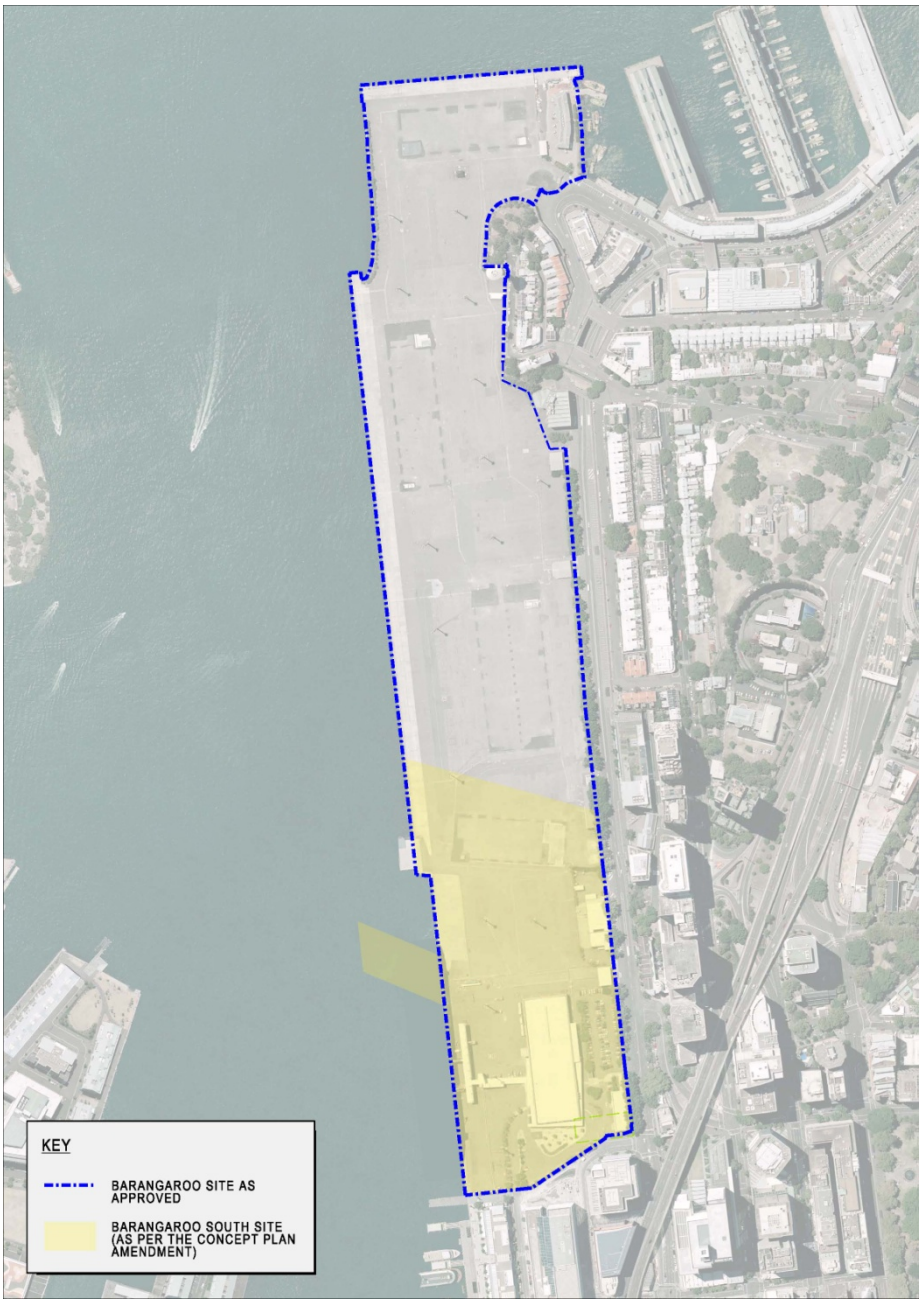

Figure 1: Indicative Site Boundary for Barangaroo South

1.2 Planning History

On 9 February 2007 the Minister approved a Concept Plan for the site and on 12 October 2007 the land was rezoned to facilitate its redevelopment. The Approved Concept Plan allowed for:

- a mixed use development involving a maximum of 388,300m^2 of gross floor area (GFA) contained within 8 blocks on a total site area of 22 hectares;
- approximately 11 hectares of new public open space/public domain, with a range of formal and informal open spaces serving separate recreational functions and including a 1.4km public foreshore promenade;
- maximum building heights and maximum GFA for each development block within the mixed use zone; and
- public domain landscape concept, including parks, streets and pedestrian connections.

A condition of consent also required two enlarged water intrusions into the Barangaroo site, one at the northern end and one at the southern end and the creation of a natural northern headland.

Modification No. 1 was approved in September 2007 which corrected a number of minor typographical errors.

On 25 February 2009 the Minister approved Modification No. 2 to the Concept Plan. The Approved Concept Plan as modified allowed for a mixed use development involving a maximum of 508,300m^2 of gross floor area (GFA) contained within 8 blocks on a total site area of 22 hectares.

On 11 November 2009 the Minister approved Modification No. 3 to the Concept Plan to allow for a modified design for the Headland Park and Northern Cove. The Approved Concept Plan as modified allowed for a mixed use development involving a maximum of 489,500m^2 of gross floor area (GFA) contained within 7 blocks on a total site area of 22 hectares.

The proposed Concept Plan Amendment (MP 06_0162 MOD 4) seeks the Minister's consent for:

- additional GFA within Barangaroo South, predominantly related to an increase in residential GFA;
- redistribution of the land use mix;
- an increase in height of a number of the proposed towers within Barangaroo South;
- the establishment of the new pier and landmark building extending into the Harbour; and
- reconfiguration and activation of the public waterfront area through the introduction of uses including retail and residential to the west of Globe Street.

1.3 Purpose

This report has been prepared in support of the Concept Plan Amendment (MP06_0162 MOD 4) for Barangaroo and addresses the Director General Requirements.

The Concept Plan Amendment contains various types of development including:

- Residential buildings;
- Commercial office buildings;
- Retail spaces;
- Outdoor recreational areas;
- Entertainment areas;
- Cultural Centre;
- A hotel;
- Car parking areas;
- Loading dock;
- Public open space; and
- Associated infrastructure.

The report covers the following aspects as part of a high level initial acoustic assessment for the developments proposed for the Barangaroo South:

- Guidance for operational noise criteria for all parts of the proposed development under Concept Plan Amendment Application (MP 06_0162 MOD 4).
- A survey of the existing noise environment on and around the vacant subject site.
- Potential noise impact of the development on the surrounding environment, and
- Potential noise impact of the surrounding environment on the development.

It is recommended that an Acoustic Benchmarking Study be undertaken during the design development phase to establish definitive project specific environmental noise criteria in the context of the sites both former and proposed land uses. This is in addition to the recent noise survey undertaken by ARUP and contained in this report, which is not representative of either the future, or most recent noise environment on and around the site because currently, the site is vacant and unused with the exception of the existing Passenger Terminal. This report references applicable planning guidance and standards. These guidelines have been noted and suggested as initial noise targets in lieu of a future proposed Acoustic Benchmarking Study to help define definitive environmental noise targets.

The developments will produce noise from traffic movements and plant associated with the developments that are likely to increase noise levels on and in the vicinity of the Barangaroo South site. This has the potential to impact future noise sensitive receivers (NSR's) on the Barangaroo South site and exiting NSR's in areas close by. Practical noise mitigation measures will be undertaken to meet relevant project criteria once they are established.

1.4 Site Noise Environment

The wider Barangaroo site has been subject to multiple uses over the years. Historical maps and photography indicate that the majority of the site has been produced by land reclamation since the late 19th Century, and that it has predominantly been used for the berthing of ships and storage of materials from shipping.

A gas works was located in the middle of the site from 1820 to 1921.

The most recent (and current) use of part of the site is as a Passenger Terminal with the terminal building being built in 2000. A temporary passenger terminal is located to the north of the Basement Car Parking site until a more permanent location can be found and is expected to remain for a period of 2 years.

The surrounding area adjacent to the site has contained a mix of residential and commercial communities throughout this history and been characterised as a bustling and important area of the City.

With the previous industrial and shipping operations occurring on the site up to 24 hours per day, coupled with associated construction and land reclamation activities, industrial noise has been a feature of the noise environment of this part of the City for over 150 years. It is this type of prior land use that most of the existing receptors surrounding the wider Barangaroo site have been exposed and have become accustomed. In 2008/09 some buildings on the site were demolished under a Project Application entitled Barangaroo Demolition Works, East Darling Harbour, Major Project Approval Ref 07_0077 in preparation for the developments at Barangaroo.

The current period represents an unusual chapter in the history of the site as there are currently no significant daily noise generating activities on the site, with the exception of the Passenger Terminal which operates intermittently in both shipping and functional venue modes. The proposed commercial, retail, residential, tourism and entertainment developments on the Barangaroo South site will introduce noise sources to the site once again.

1.5 Strategy for Setting Environmental Noise Criteria

Noise impact to Noise Sensitive Receivers (NSR's) around development sites are generally derived from noise surveys taken in the existing noise environment of a proposed development. However, as the Barangaroo site is largely vacant (with current activities largely limited to the Temporary Passenger Terminal) and the proposed mixed use is for; commercial, retail, tourism, residential and entertainment based developments, the future noise environment is expected to be vastly different to the current environment.

For this reason a noise survey on and around the site, although interesting and useful as a 'snapshot' of the noise environment in time, is not considered appropriate for setting planning noise criteria alone.

It is acknowledged that the there is guidance for amenity noise levels from a planning perspective given in AS 1055.2[1] and the NSW Industrial Noise Policy[2] . Nevertheless for a development of the scale of and cultural significance of Barangaroo, in terms of the socio-economic aspects to the local and wider community, and to be recognised as an example of, 'world's best practice' for many years to come, there is an opportunity to rethink the suitable amenity criteria for the noise sensitive receivers on and around the site.

1 AS 1055.2 – 1997: Acoustics – Description and measurement of environmental noise. Part 2: Application to specific situations

2 NSW Industrial Noise Policy, Environmental Protection Authority (EPA INP), January 2000

It is therefore recommended that in addition to the recent noise survey undertaken on and around the site and reference to applicable planning guidance, that an Acoustic Benchmarking Study is carried out at other similar sites in Sydney, such as Circular Quay, King Street Wharf and Darling Harbour, to establish appropriate project specific environmental noise criteria in the context of both the sites most recent prior and proposed future land uses. This would include carrying out noise surveys at these and other sites where applicable and obtaining previous noise survey data where available. A review of this data would feed into the process of establishing definitive and appropriate criteria that relate to all developments proposed for Barangaroo South.

It recommended that the Acoustic Benchmarking Study be undertaken as a post planning exercise during the design development phase.

2 Operational Criteria

2.1 Introduction

This section discusses noise criteria applicable to the external noise environment from noise emitted from operational activities related to the Barangaroo South developments.

Internal design sound levels for spaces in developments are also recommended.

Construction noise and vibration is considered in a separate report provided by Acoustic Logic Consultancy.

All noise criteria discussed below will be subject to further review following completion of the Acoustic Benchmarking Study.

2.2 Sustainable Design Criteria

The Barangaroo South development is aiming to create a new benchmark for sustainable design. Creating an appropriate noise environment is an important aspect of creating a sustainable environment and will therefore be part of a 'holistic' approach to sustainable design.

2.3 Environmental Noise Guidelines for Residential Areas (AS 1055)

2.3.1 Environmental Noise Guidelines for Residential Areas (AS 1055)

AS 1055.2[3] provides guidelines for setting noise limits for all sources of environmental noise for different areas containing residences in Australia. Although the standard clearly states that whenever possible, values of $L_{A90,t}$ (background noise) shall be measured. When this does not occur, or existing noise levels are not representative of the new land use or development the following suggested $L_{A90,t}$ limits are a useful reference when considering appropriate environmental noise limits for areas containing residences.

The developments on the Barangaroo South site fall into this category as many new noise sources are proposed to be introduced over a relatively short space of time, whereas the site is currently largely vacant with current activities generally limited to the Temporary Passenger Terminal.

The noise environment at the Barangaroo South site (once all of it is completed) is considered to fall into noise area category R5. This is described as,

> *'Areas with very dense transportation or in commercial districts or bordering industrial districts'.*

These noise levels are suggested as an initial starting point for residential areas on Barangaroo South and to be revised if necessary following a recommended post planning benchmarking study of current noise environments at similar sites in Sydney and historical data where available.

3 AS 1055.2 – 1997: Acoustics – Description and measurement of environmental noise. Part 2: Application to specific situations

Table 1 Reproduced from Appendix A of AS 1055:2. Noise area category (Notes 1 and 2)

	Description of neighbourhood	Average background A-weighted sound pressure level, dB L_{A90} ,T					
		Monday to Saturday			Sundays and public holidays		
		0700–1800	1800–2200	2200–0700	0900–1800	1800–2200	2200–0900
R1	Areas with negligible transportation	40	35	30	40	35	30
R2	Areas with low density transportation	45	40	35	45	40	35
R3	Areas with medium density transportation or some commerce or industry	50	45	40	50	45	40
R4	Areas with dense transportation or some commerce or industry	55	50	45	55	50	45
R5 (See Note 3)	Areas with very dense transportation or in commercial districts or bordering industrial districts	60	55	50	60	55	50
R6 (See note 3)	Areas with extremely dense transportation or within predominantly industrial districts	65	60	55	65	60	55

NOTES:

1 The division into noise area categories is necessary in order to accommodate existing sound levels encountered at residential sites in predominantly commercial or industrial districts, or in areas located close to main land transport routes, i.e. road and rail.

2 The noise area category most appropriate should be selected irrespective of metropolitan or rural zoning and will vary from location to location.

3 Some industrial and commercial sites are not predominant sources of high background sound levels

2.3.2 Noise Break-out from Plant and Industrial Noise Sources (INP)

2.3.2.1 Intrusiveness and Amenity criteria

The NSW Industrial Noise Policy[4] (INP) defines two criteria for environmental noise limits from plant and other industrial noise sources.

First, the *intrusiveness criterion* is summarised as:

- $L_{Aeq,\ 15minute}$ Rating Background Level (RBL, $dBL_{A90,15}$) + 5 dB

Secondly the *amenity criterion* depends on the receiver type (commercial or residential), and the existing background noise levels where traffic is the dominant noise source. The policy suggests that for cases where the existing ambient level is greater than the Acceptable Noise Level (ANL), and existing noise levels are unlikely to decrease in the future, the amenity criterion should be assumed to be 10 dB below the existing noise level. This is to avoid creeping noise levels overtime.

Table 2 below shows relevant Acceptable Noise Levels from Table 2.1 of the INP.

4 NSW Industrial Noise Policy, Environmental Protection Authority (EPA INP), January 2000

Table 2 Acceptable Noise Levels as per Table 2.1 Amenity Criteria of the INP

Type of Development	Time of the Day	Acceptable	Recommended maximum
Residences (urban)	Day	60	65
	Evening	50	55
	Night	45	50
Active recreation areas	when in use	55	60
Passive recreation areas	when in use	50	55
Commercial premises	when in use	65	70

The most stringent of the *intrusiveness* and *amenity criterion* will typically apply to the closest noise sensitive receivers.

Appropriate noise limits are determined based on attended and unattended 24-hour noise logging conducted around the site. However, the noise survey recently undertaken at various locations on and around the subject site is not considered appropriate to derive limiting noise criteria. This is because the Barangaroo South site, as it currently exists, is not representative of its intended future use. A proposed bench marking study of similar areas around Sydney such as, Circular Quay, King Street Wharf and Darling Harbour will be undertaken as a post planning study to determine suitable target noise levels for the site and the surrounding noise sensitive receivers.

2.3.3 Assessment in developing areas

Section 2.2.4 of the INP discusses the 'assessment of developing areas'.

For sites like Barangaroo that are undergoing a change of use and several developments within an otherwise empty site are proposed, the Intrusiveness criteria may be more stringent than the amenity criteria. This is because the site is quieter than it will be in the future as the noise sources that determine the change of use are not yet present.

In this case several developments may be assessed as a group. This holistic approach allows project-specific noise levels to be set for a proposed development, so that the total impact from all proposed and potential developments does not cause amenity to deteriorate. This approach also provides an equitable spread of the burden for individual developments in meeting the noise criteria.

Operational noise sources from the Barangaroo South developments are recommended to be assessed in this holistic manner when targeting the amenity noise levels derived from the proposed benchmarking study.

2.3.4 Protection of the Environment Operations Act 1997 – Offensive Noise

The definition of offensive noise appearing in the Protection of the Environment Operations (POEO) Act is:

> *'That by reason of its level, nature, character or quality, or the time at which it is made, or any other circumstances:*
>
> *Is harmful to (or is likely to be harmful to) a person who is outside the premises from which it is emitted, or*
>
> *Interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted, or*

that is of a level, nature, character or quality prescribed by the regulations or that is made at a time, or in other circumstances, prescribed by the regulations.'

2.3.5 Recommendations

AS 1055.2[5] suggests general amenity noise levels for all noise sources for developments containing residents in Australia and the NSW Industrial Noise Policy[6] suggests amenity noise levels for residential, commercial and other land use subjected to industrial noise sources. Both of the documents recommend that definitive noise criteria are derived from noise survey results at sensitive receivers around the site.

The amenity noise levels for Category R5 for residences suggested by AS 1055 and the amenity noise levels suggested by the Industrial Noise Policy are recommended as interim noise targets for noise sensitive receivers on and around the Barangaroo South site. This is until a noise bench marking study is undertaken to establish more definitive and appropriate project noise targets.

2.4 Internal design sound levels as per the AS2107-2000

AS2107[7] provides recommendations for design sound levels for various types of buildings. The limits apply to "steady-state or quasi-steady-state sounds, such as noise from air conditioning systems." The design sound levels that relate to the proposed uses in the development are presented in Table 3.

Background noise levels and reverberation times within all developments will be controlled with reference to the applicable criteria from AS 2107.

Table 3 Summary of recommended design sound levels, AS2107.

Type of occupancy	Recommended design sound level, dB(A) (From Table 1, AS2107)	
	Satisfactory	Maximum
Residential buildings		
Living areas	35	45
Sleeping areas	30	40
Office buildings		
General office areas	40	45
Private offices	35	40
Conference and convention centres	30	45
Public spaces		
Railway, ferry and bus terminals	45	55
Public spaces	40	50
Car Park (enclosed)	55	65
Common areas – Lift lobbies, foyers, coffee bars and restaurants, cafeterias and food courts, railway and bus terminals ticket sales areas, and waiting areas	45	50-55

5 AS 1055.2 – 1997: Acoustics – Description and measurement of environmental noise. Part 2: Application to specific situations

6 NSW Industrial Noise Policy, Environmental Protection Authority (EPA INP), January 2000

7 AS 2107:2000 Acoustics – Recommended design sound levels and reverberation times for building interiors

Type of occupancy	Recommended design sound level, dB(A) (From Table 1, AS2107)	
	Satisfactory	Maximum
Shop buildings – show rooms, small retail stores (general)	45	50
Shop buildings – speciality shops (where detailed discussion is necessary in transactions)	40	45
Shopping malls – e.g. concourse and retail area	45	55

Note: The recommended design sound levels given in Table 1 are used 'traditionally' for sealed, air-conditioned buildings, and apply only to the steady-state noise – predominantly from mechanical plant.

These noise levels correspond to the combined measured level of external sources of noise break-in and the ventilation/air-conditioning systems operating normally.

2.5 Vibration Design Criteria - DECCW *Assessing Vibration*: A technical guideline, 2006

The '*Assessing Vibration'* guideline provides operational vibration criteria for maintaining human comfort at any place of different occupancy with different space uses.

Both 'preferred' and 'maximum' vibration criteria are presented which give a target range of vibration levels not to be exceeded.

The '*Assessing Vibration'* guideline recommends maximum weighted vibration levels for continuous vibration sources, such as mechanical services plant, and for impulsive vibration sources, such as vibration caused by impacts. The weighting curves are obtained from BS 6472:1992[8]: *Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)*.

For intermittent sources (e.g. trains, heavy vehicles and intermittent construction), the *Assessing Vibration* guideline uses the Vibration Dose Value (VDV) metric to assess human comfort effects of vibration. VDV takes into account both the magnitude of vibration events and the number of instances of the vibration event over the relevant assessment period.

Intermittent events that occur less than 3 times in an assessment period (either, daytime 7 am to 10 pm, or night-time 10 pm to 7 am) are counted as "impulsive" sources for the purposes of the *Assessing Vibration* guideline.

The vibration limits recommended for maintaining human comfort in residences and offices are shown in Table 4 below.

Table 4 Vibration limits in the DECCW 'Assessing Vibration' guideline for different types of occupancy

Location	Preferred and Maximum z-axis weighted rms vibration acceleration (m/s^2)		Vibration Dose Value ($m/s^{1.75}$)
	Continuous	Impulsive	Intermittent
Residential areas (night)	0.007 – 0.014	0.1 – 0.2	0.13 – 0.26
Residential areas (day)	0.01 – 0.02	0.3 – 0.6	0.2 – 0.4
Office areas	0.02 – 0.04	0.64 – 1.28	0.4 – 0.8
Workshops	0.04 – 0.08	0.64 – 1.28	0.8 – 1.6

8 BS 6472 was revised in 2008 and now focuses on Vibration Dose Values (VDV) as an assessment parameter, rather than individual measurements results. However, the VDV recommendations for a low probability of adverse comment are broadly similar to the 1992 version.

The Assessing Vibration technical guideline does not provide a specific criterion for retail spaces, but it would appear reasonable to apply the same limit as for workshop environments. This is because occupants of retail spaces are less likely to be seated and working quietly than office occupants and therefore less likely to be adversely affected by lower levels of vibration.

2.6 Entertainment Noise

2.6.1 NSW Office of Liquor, Gaming and Racing

Events and entertainment venues at the Barangaroo South development have the potential to cause a noise impact at nearby residential receivers, in particular the receivers at Darling Island, Pyrmont Bay Wharf, Balmain East, Hickson Road and the future residential receivers located on the Barangaroo South site.

The Office of Liquor, Gaming and Racing (OLGR) specifies noise criteria for noise emission from licensed premises. It is anticipated that there may be licensed premises at the site, and therefore any event noise generated from these venues can be controlled to meet the OLGR criteria.

The OLGR criteria for noise from licensed premises require that:

- The L_{A10} noise level emitted from the licensed premises shall not exceed the background noise level in any octave band centre frequency (31.5 Hz – 8kHz inclusive) by more than 5 dB between 0700hrs (7:00am) and Midnight (12.00am) at the boundary of any affected residence.
- The L_{A10} noise level emitted from the licensed premises shall not exceed the background noise level in any octave band centre frequency (31.5 Hz – 8 kHz inclusive) between Midnight (12.00am) and 0700hrs (7:00am) at the boundary of any affected residence.
- Notwithstanding compliance with the above, the noise from the licensed premises shall not be audible within any habitable room in any residential premises between the hours of Midnight (12:00am) and 0700hrs (7:00am).

2.6.2 Notice of Preventative Action (DECCW)

The Department of the Environment, Climate Change and Water (DECCW) can draw up site specific licences in the form of 'Notice's of Preventative Action'. These documents provide noise criteria and monitoring locations for certain types of events according to the audience size and whether amplified sound is being used for example.

The requirement for this type of licence for entertainment activities will most likely be determined once any entertainment developments have been completed (if applicable).

2.7 Road Traffic

Noise from vehicles movements generated by the Barangaroo South development operating on public roads is subject to the ECRTN[9] noise criteria. The ECRTN provides several categories for type of development and appropriate noise planning targets are given for each type of development.

The ECRTN noise criteria are planning goals for new development and as such are not legislative requirements which must be met by new developments, as the ECRTN recognises that achieving these criteria may not be considered 'feasible and reasonable' for all developments.

9 Environment Criteria for Road Traffic Noise, Environment Protection Authority (now known as Department of Environment, Climate Change and Water), May 1999

Barangaroo South is best characterised as a development of Type 8 – *Land use developments with potential to create additional traffic on collector roads*. However, Table 5 presents an extract from Table 1 of the ECRTN outlining the appropriate noise criteria.

Table 5 Recommended traffic criteria

Development	Day 7am to 10pm	Night time 10pm to 7am
7. Land use developments with potential to create additional traffic on existing freeway/arterial roads	60 dB $L_{Aeq(15\ hour)}$	55 dB $L_{Aeq(9\ hour)}$
8. Land use developments with potential to create additional traffic on collector roads	60 dB $L_{Aeq(1\ hour)}$	55 dB $L_{Aeq(1\ hour)}$
13. Land use developments with potential to create additional traffic on local roads	55 dB $L_{Aeq(1\ hour)}$	50 dB $L_{Aeq(1\ hour)}$

2.8 Light Rail

A Light Rail connection may be constructed in proximity of the Barangaroo South site along Hickson Road. The applicable criteria for noise and vibration from this source are discussed below.

2.8.1 Groundborne Noise

The groundborne noise criteria for rolling stock activities relevant to any future light rail are contained in the *Interim Guideline for the Assessment of Noise from Infrastructure Rail Projects: 2007* (IGANRIP). The criteria in Table 6 except for commercial and retail are extracted from this guideline.

Table 6 Recommended groundborne noise criteria

Receiver Types	Time of Day	Noise Criteria $dBL_{Amax\ (slow)}$
Residential	Daytime (7am – 10pm)	40 $dBL_{Amax\ (slow)}$
	Night-time (10pm – 7am)	35 $dBL_{Amax\ (slow)}$
Commercial		45 $dBL_{Amax\ (slow)}$
Retail		50-55 $dBL_{Amax\ (slow)}$

2.8.2 Airborne Noise

The airborne noise criteria for rolling stock activities relevant to light rail are contained in the *Interim Guideline for the Assessment of Noise from Infrastructure Rail Projects* (IGANRIP). The criteria in the Table 7 below are extracted from this guideline. There are no criteria that relate to commercial or retail property and suitable criteria will be developed during the design development stage and detailed in future Project Applications as relevant.

Table 7 Recommended airborne noise criteria

Residential Land Uses	Noise trigger Levels dBL_{Amax}	Comment
Daytime (7am – 10pm)	60 $dBL_{Aeq,15hr}$, 80 dBL_{Amax}	These numbers represent external noise levels that trigger the requirement for an assessment of the potential noise impacts from a rail infrastructure project
Night-time (10pm – 7am)	55 $dBL_{Aeq,9hr}$, 80 dBL_{Amax}	

2.8.3 Vibration

The DECCW '*Assessing Vibration'* guideline 2006 provides operational vibration criteria for maintaining human comfort at any place of different occupancy with different space uses.

Both "preferred" and "maximum" vibration criteria are given which gives a target range of vibration levels not to be exceeded.

For intermittent sources such as trains, heavy vehicles and intermittent construction activities, the *Assessing Vibration* guideline uses the Vibration Dose Value (VDV) metric to assess human comfort effects of vibration. VDV takes into account both the magnitude of vibration events and the number of instances of the vibration event over the assessment period.

Intermittent events that occur less than 3 times in an assessment period (either, daytime 7am to 10pm, or night-time 10pm to 7am) are counted as "impulsive" sources for the purposes of the *Assessing Vibration* guideline.

The vibration limits recommended for maintaining human comfort in residences and offices are shown in Table 8.

Table 8 Vibration limits in the DECCW 'Assessing Vibration' guideline for different types of occupancy

Location	Preferred and Maximum z-axis weighted rms vibration acceleration (m/s^2)		Vibration Dose Value ($m/s^{1.75}$)
	Continuous	Impulsive	Intermittent
Residential areas (night)	0.007 – 0.014	0.1 – 0.2	0.13 – 0.26
Residential areas (day)	0.01 – 0.02	0.3 – 0.6	0.2 – 0.4
Office areas	0.02 – 0.04	0.64 – 1.28	0.4 – 0.8
Workshops	0.04 – 0.08	0.64 – 1.28	0.8 – 1.6

The Assessing Vibration technical guideline does not provide a specific criterion for retail spaces, but it would appear reasonable to apply the same limit as for workshop environments. This is because occupants of retail spaces are less likely to be seated and working quietly than office occupants and therefore less likely to be adversely affected by lower levels of vibration.

2.9 Sydney Metro

Whilst the NSW Government has deferred the Sydney Metro (on 21 February 2010) its corridor and station box may be protected for future development. The same criteria that apply to the light rail given in 2.8 above could also apply to the Sydney Metro.

2.10 Boats and Ferries

Whilst on the Barangaroo site, that is, at the ferry terminal or inside "Southern Cove", boats and ferries are considered as industrial noise and therefore assessed by the procedures and criteria of the Industrial noise Policy (INP).

2.11 Air traffic

2.11.1 Helicopters

Noise criteria relating to helicopter operations apply for noise resulting from the arrival and departure of helicopters from a landing site and do not apply to helicopters in normal flight. As Barangaroo South is not proposing a helicopter landing or take-off site, a helicopter noise criterion is not applicable to the development.

2.11.2 Aircraft

AS 2021 defines indoor design sound levels for aircraft noise affecting a variety of premises including residential and commercial buildings. The intent of the standard is to ensure that buildings affected by aircraft noise are constructed so that these indoor design sound levels are achieved during the typical noisiest aircraft events (defined as the average maximum noise level, $dBL_{Amax,Slow}$).

Recommended internal noise levels for residential and commercial buildings are given in Table 9.

Table 9 Recommended internal design noise levels from AS2021 - 2000

Building type and activity	Indoor design sound level, dB(A)
Houses, home units, flats	
Sleeping areas, dedicated lounges	50
Other habitable spaces	55
Bathrooms, toilets, laundries	60
Commercial buildings, offices, shops	
Private offices, conference rooms	55
Drafting , open plan offices	65
Typing, data processing	70
Shops, supermarkets, showrooms	75

3 Noise Survey

3.1 General

A noise survey was carried out from 14 April to 29 April 2010 to establish the current ambient noise levels around the proposed development site and to identify noise sensitive receivers. This included both attended and unattended monitoring.

An Acoustic Benchmarking Study is recommended to supplement this data as the operational noise sources are not yet present on the Barangaroo South site, meaning that the survey results are not necessarily appropriate to develop environmental noise targets on their own. This is because the results of the noise survey data do not address the context of either the most recent land use (to which existing receptors are accustomed) or the proposed future land use scenarios.

The closest noise sensitive receivers that could be identified are shown in Figure 2 in Section 3.3.

The results of the noise survey are included in Appendix B.

3.2 Relevance to Environmental Noise Criteria

Although a comprehensive noise survey has been undertaken in and around the Barangaroo South site, it must be recognised that there are currently no significant noise sources on the site.

Given the scale of development proposed, it is unreasonable and impractical to assume that there will be no increase in noise on the site and areas immediately adjacent to the site when the Barangaroo South developments become operational. Therefore, the noise data from the recent survey and presented in Appendix B is important as a ‘snapshot’ in time when there are limited significant noise generating developments on the wider Barangaroo site and can be useful in understanding the noise sources existing outside of the site. However, this data will not be used on its own to determine planning noise design targets for the developments proposed at Barangaroo South.

It is acknowledged that the there is guidance for amenity noise levels from a planning perspective given in AS1055 and the Industrial Noise Policy. Nevertheless for a development of the scale and cultural significance of Barangaroo to Sydney, there is an opportunity to rethink the suitable amenity criteria for the noise sensitive receivers on and around the site.

To this end it is recommended that an Acoustic Benchmarking Study is carried out at other appropriate benchmarking sites in Sydney, such as Circular Quay, King Street Wharf and Darling Harbour (or other relevant sites). This would include carrying out noise surveys at these and other sites where applicable and obtaining previous noise survey data where available. This can be reviewed as a post planning exercise during design development to make recommendations for site specific noise criteria relating to the Barangaroo South development.

A separate noise survey has been carried by Acoustic Logic Consultancy that relates to the construction stage of the project. Both surveys cannot be directly compared as they were undertaken in different circumstances and at different locations.

3.3 Noise sensitive receivers

The following noise sensitive receivers (NSR's) have been identified on and around the wider Barangaroo development site.

Closest noise sensitive receivers in proximity of the site:

1. Residents of the apartments along Hickson Road, located east of the subject site.
2. Residents of the apartments at Darling Island on the west of the subject site
3. Residents of the apartments at Pyrmont Bay Wharf on the west of the subject site
4. Residents of the premises at Balmain East, north west of the subject site
5. Occupants of the commercial premises located along Shelley St, south of the subject site.
6. The Bond commercial offices and child care centre located at ground level of 30 The Bond, Hickson Road.
7. Temporary Passenger Terminal

Future closest noise sensitive receivers on the subject site:

- Residents of apartments.
- Office occupants of commercial premises.
- Occupants and users of the retail areas and cafes
- Users of the Cultural facilities
- Hotel

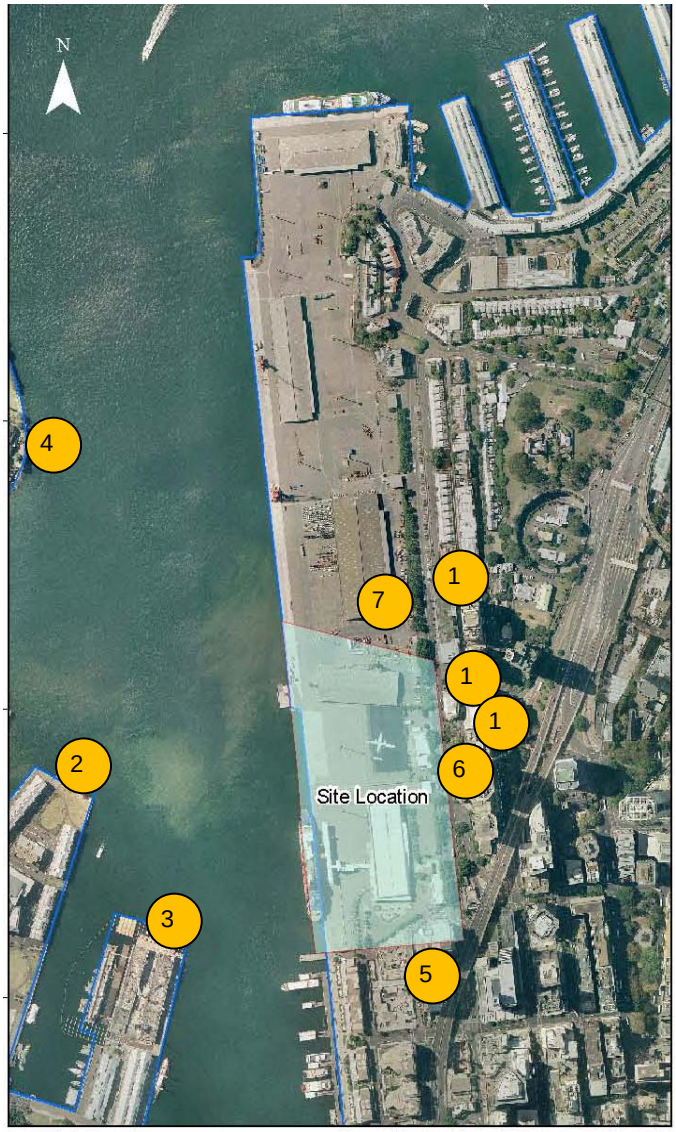

Figure 2: Site and Location of Noise Sensitive Receivers

3.4 Summary of Noise Environments

Measured noise levels at locations representative of these locations can be found in Appendix B.

3.4.1 Off-site noise sensitive receivers

- **NSR's 1, 6 and 7 (residents and commercial properties along Hickson Road, including child care centre and temporary Passenger Terminal)**: The dominant noise source is traffic on Hickson Road, during the weekday day time hours. This reduces by a few decibels during the weekends, highlighting the commercial nature of the site even in absence of the Barangaroo development. Noise levels are expected to increase slightly as a result of traffic associated with the development.
- **NSR's 2, 3 and 4 (residents east of the site on Balmain East, Darling Island and Pyrmont Bay Wharf)**: The existing noise environments at these locations are relatively quiet with the noise level generally dominated by distant road and air traffic in addition to boat traffic in the harbour. Noise associated with the Barangaroo development is not expected to adversely impact these NSR's.
- **NSR's 5 (commercial receivers along Shelley St)**: Noise levels at these NSR's are dominated by road traffic from Sussex and Shelly Streets and activities on King Street Wharf, due to the entertainment aspect of this harbour foreshore area. Although there may be some additional road traffic in this area associated with the Barangaroo development, the additional noise generated is not expected to result in an adverse impact to these NSR's.

3.4.2 On-site receivers

The dominant noise sources currently affecting the site are largely determined by the location. Areas close to Hickson Road to the east and Sussex and Shelly Street to the south are dominated by traffic noise during the day. Noise from entertainment establishments on King Street Wharf dominates the south western corner of the site. In the middle of the site and at the water's edge the hum of distant traffic and mechanical plant from commercial buildings is audible. Noise sources from harbour traffic are also more audible than at locations where traffic noise masks this noise. Noise from cruise ships, when in port also adds to the noise environment.

4 Noise Impacts from the Development on the Community

4.1 General

There will be various noise sources associated with the development that could potentially impact the surrounding community. The following sections represent a high level preliminary assessment. A detailed assessment of these sources will be undertaken during the design phase when more detailed information is available and an Acoustic Benchmarking Study has been undertaken and suitable design criteria established. Practical noise control measures will be applied to address compliance with the relevant criteria at the NSR's surrounding the site as well as the NSR's on the site.

4.2 Mechanical Services Plant

A large part of the mechanical services plant (chillers, air handling plant etc) associated with the offices and retail areas is proposed to be centralised and located in the car park basement development of the site.

These could potentially include:

- Blackwater treatment plant;
- Central Energy Plant;
- Harbour Heat Rejection Plant;
- Chiller Plant; and
- Gas Plant.

In addition, other plant such car park exhaust fans will form part of the development.

All items of mechanical services plant will be assessed against the adopted operational criteria and practical remediation measures such as plant selection, attenuators, enclosures and suitable orientation of exhaust and inlet louvres etc. will be applied both internally and external to the building.

4.3 Retail Units and Future Retail Outlets

Retail areas including high street fashion, a supermarket, cafés and restaurants are proposed in the Barangaroo South development zone.

Breakout noise from these areas is not expected to affect places of different occupancy within and outside of the development. This is based on experience of other similar retail precincts in Sydney such as Pitt Street Mall.

4.4 Car Parking and Loading Docks

Car parking for Barangaroo South will be located in the Basement with some on street parking also proposed. Parking will be split between commercial and residential buildings. Loading docks for service vehicles will also be located in the Basement.

Traffic entering and leaving the car park on the site has the potential to cause noise disturbance to neighbouring areas. Noise levels will be controlled to meet the appropriate criteria by controlling the speed of the traffic, the location of the access roads and informing residents, workers and visitors to enter and leave the development quietly.

As the loading docks are below ground level, impact and other noise from loading and unloading is not expected to cause adverse noise impacts to occupants of Barangaroo South and outside of the site.

The closest noise sensitive receivers are expected to be the residential areas on and adjacent to the site and the existing child care facility on Hickson Road.

4.5 Road Traffic

The Barangaroo South development is likely to increase road traffic in the surrounding areas as well as on the subject site, where the new streets, run through the site from southwest to northeast, and along the northern boundary respectively. A traffic noise assessment will be undertaken during the design to ensure that the relevant criteria are met, once established.

4.6 Ferries and other Harbour Traffic

The Barangaroo South development is likely to have a ferry terminal and this will potentially increase the noise levels on the Barangaroo foreshore and to the residents of Pyrmont. The new development will also have a new harbour known as ”Southern Cove”. No vessels are proposed to navigate “Southern Cove” with the exception of maintenance craft.

Whilst adjacent the Barangaroo South site, ferry and other craft related noise will be considered as industrial noise and subject to the criteria in the INP or noise criteria derived from the proposed benchmarking noise study. However, once they leave the site there are no noise restrictions, as ferries and pleasure craft are subject to individual noise restrictions governed by the POEO Act and outside the jurisdiction of Barangaroo South.

A noise assessment will be undertaken during the design phase to ensure any increased boat activity will be managed as far as practical, by introducing appropriate management systems to encourage responsible boat use.

4.7 Entertainment

Expected entertainment activities on the site are:

- Entertainment activities on the promenades and public spaces
- Outdoor performances at the Cultural Centre
- Street Performances
- Music break-out from entertainment venues along the Walkway and the Cultural Centre

Noise from entertainment activities on the site will be controlled to minimise the impact on surrounding areas and ensure compliance with the relevant noise criteria.

4.8 Construction Noise

With the many proposed developments on the Barangaroo South site being staged over a number of years, construction noise will be a regular feature of the local noise environment. This is similar to the continuous industrial related noise emanating from the site's most recent land use as the former Patricks Stevedore and P & O Passenger Ship Terminal which operated up to 7 days, 24 hours per day.

With careful management the adverse effects of construction noise and vibration on the community can be minimised, although the inherent noisy nature of construction works means that some impact will be inevitable. However, construction activities are also transient and noise sources will not be located in the same place for extended periods of time and will not be operational on a consistent basis giving respite periods to noise sensitive receivers.

Reasonable and practicable noise and vibration mitigation measures are proposed to be implemented to minimise impacts to the community.

Management of construction noise and vibration is addressed in a separate report produced by Acoustic Logic Consultancy. A separate noise survey has been carried out for this purpose using different locations and measured at different times from those results contained in this study. The results and therefore direct comparison between those results and the survey results given in Appendix B of this report is not appropriate.

5 Noise Impacts from the Community on the Development

5.1 General

The area surrounding Barangaroo South is varied. To the west across the harbour there are residential areas in Pyrmont and Balmain that experience low background noise levels during the evening and night-time. To the north across the harbour is the residential suburb McMahons Point. To the east is the CBD including a mix of commercial and residential buildings and to the south are the commercial buildings and entertainment precinct of Sussex Street and King Street Wharf respectively.

The Barangaroo South Concept Plan proposes that commercial developments will occupy the centre and the eastern boundary of the Barangaroo South site bordering Hickson Road (Hungry Mile). Residential developments are proposed in proximity to the southern boundary adjacent to Lime Street and King Street Wharf. Further residential developments are proposed to be set back from the western harbour foreshore and others set back from the proposed ”Southern Cove”.

Noise sources form the west, north and east of the Barangaroo South site are not expected to cause significant adverse impact on the proposed commercial, retail and residential developments.

Noise sources to the south of the site pose the greatest risk of adverse noise impacts to the developments at Barangaroo South, particularly the residential buildings that may be located close to the southern end of the site.

Below is a high-level noise assessment of the likely noise sources that could impact on the developments on the Barangaroo South site.

5.2 Mechanical Services Plant

Mechanical services plant associated with surrounding buildings may affect residential NSR’s at the site. This is most likely from the commercial buildings to the south and east of the site. However, by locating commercial buildings along the eastern boundary the more sensitive residential NSR’s are located further away from these existing noise sources.

No significant noise sources were singled out during the attended noise survey. Developments will be designed to protect the occupants of the proposed buildings from an adverse noise impact from mechanical plant outside of the site.

5.3 Traffic

Noise from traffic on Hickson Road, Sussex St, Shelley St and other as large roads surrounding the site such as the Western Distributor and traffic on the Anzac Bridge dominates current noise levels on the Barangaroo South site. Noise mitigation measures will be implemented where required to protect NSR’s from traffic noise as far as practical.

5.4 Ferries and other harbour traffic

Noise levels west of the site are influenced by noise from ferries and other harbour traffic. Measured noise levels from harbour traffic are relatively low compared to the traffic noise levels on the eastern side of the site and not expected to cause a significant impact on the Barangaroo South developments. However, the Hotel jutting out into the harbour will be most susceptible to any noise from passing water traffic. Nevertheless, a more detailed assessment of these noise sources will be carried out during the design stage. Practical mitigation measures will be implemented to developments where required.

5.5 Light Rail

An above ground light rail system along Hickson Road may be a possibility. Should this arise then a full noise and vibration assessment will be undertaken to ensure that all the relevant criteria are met.

5.6 Entertainment

King Street Wharf to the south of the site is a bustling entertainment area incorporating bars, clubs, restaurants and a bowling alley. Many of these establishments have outside areas and the resulting noise levels dominate the noise environment in the evenings, particularly at weekends (see Section B1.3.6).

Residential buildings are at the greatest risk of an adverse noise impact as these buildings will be occupied at night and residents will be trying to sleep.

Mitigation measures will be implemented where required to protect NSR's on site from entertainment noise from this area.

This area of the City will also be subject to noise from fireworks displays from Darling Harbour and Circular Quay.

5.7 Air Traffic

Although not dominating the noise environment, noise from occasional air traffic such as helicopters and aircraft are clearly audible and influence the existing ambient noise environment on site. However, measured noise levels from air traffic are relatively low, compared to the road traffic noise levels on the eastern side of the site. Nevertheless, a more detailed assessment of these noise sources will be carried out during the design stage.

It may not be practical to mitigate against helicopter noise, but practical mitigation measures will be implemented where required.

6 Conclusion

This report identifies and discusses acoustic issues relating to the Concept Plan Amendment for Barangaroo. The purpose of the assessment is to inform and accompany the Concept Plan Amendment (MP 06_0162 MOD 4)

ARUP has undertaken a noise survey on and around the site. Although informative and useful as a 'snapshot' of the noise environment in time, is not considered appropriate for setting planning noise criteria.

It is recommended that an Acoustic Benchmarking Study be undertaken during the design development phase to establish definitive project specific environmental noise criteria in the context of the sites both former and proposed land uses. This is in addition to the abovementioned noise survey undertaken by ARUP and contained in this report, which is not representative of either the future, or most recent noise environment on and around the Barangaroo South site because currently, the site is vacant and un-used.

The Acoustic Benchmarking Study should be carried out at other similar sites in Sydney, such as Circular Quay, King Street Wharf and Darling Harbour, to establish appropriate project specific environmental noise criteria in the context of both the sites most recent prior and proposed future land uses. This would include carrying out noise surveys at these and other sites where applicable and obtaining previous noise survey data where available. A review of this data from would feed into the process of establishing definitive and appropriate criteria that relate to the Basement Car Park and all other proposed developments on Barangaroo South.

It is recommended that the Acoustic Benchmarking Study be undertaken as a post planning exercise during the design development phase.

Noise sources from the surrounding community affecting the Barangaroo South developments and from Barangaroo South developments affecting the community have been identified. Practical mitigation measures will be taken to meet all relevant noise and vibration criteria.

Arup conclude that the development scheme presented in the proposed Concept Plan Amendment (Modification 4) will not result in any significant additional impacts beyond those reasonably understood and expected to have been contemplated in the Approved Concept Plan (as modified).

Appendix A

Acoustic Standard Glossary

A1 Acoustic Standard Glossary

ACOUSTIC BENCHMARKING STUDY (ABS)

A study to be undertaken during the design development phase to establish definitive Barangaroo South project specific environmental noise criteria. These will be in the context of the sites both former and proposed land uses and in addition to the noise survey undertaken by ARUP and contained in this report, which is not representative of either the future, or most recent noise environment on and around the site because currently, the site is vacant and un used.

The Acoustic Benchmarking Study will be carried out at other similar sites in Sydney, such as Circular Quay, King Street Wharf and Darling Harbour, to establish appropriate project specific environmental noise criteria in the context of both the sites most recent prior and proposed future land uses and would include carrying out of noise surveys at these and other sites where applicable and obtaining previous noise survey data where available. A review of this data from would feed into the process of establishing definitive and appropriate criteria that relate to the Basement Car Park and all other proposed developments on Barangaroo South.

ASSESSMENT BACKGROUND LEVEL (ABL)

A single-number figure used to characterise the background noise levels from a single day of a noise survey. ABL is derived from the measured noise levels for the day, evening or night time period of a single day of background measurements. The ABL is calculated to be the tenth percentile of the background L_{A90} noise levels – i.e. the measured background noise is above the ABL 90% of the time.

'A'-WEIGHTED SOUND LEVEL dB(A)

The unit generally used for measuring environmental, traffic or industrial noise is the A-weighted sound pressure level in decibels, denoted dB(A). An A-weighting network can be built into a sound level measuring instrument such that sound levels in dB(A) can be read directly from a meter. The weighting is based on the frequency response of the human ear and has been found to correlate well with human subjective reactions to various sounds. An increase or decrease of approximately 10 dB corresponds to a subjective doubling or halving of the loudness of a noise. A change of 2 to 3 dB is subjectively barely perceptible.

DECIBEL

The ratio of sound pressures which we can hear is a ratio of 10^6:1 (one million : one). For convenience, therefore, a logarithmic measurement scale is used. The resulting parameter is called the 'sound level' (L) and the associated measurement unit is the decibel (dB). As the decibel is a logarithmic ratio, the laws of logarithmic addition and subtraction apply.

Some typical noise levels are given below:

Noise Level dB(A)	Example
130	Threshold of pain
120	Jet aircraft take-off at 100 m
110	Chain saw at 1 m
100	Inside disco
90	Heavy lorries at 5 m
80	Kerbside of busy street
70	Loud radio (in typical domestic room)
60	Office or restaurant
50	Domestic fan heater at 1m
40	Living room
30	Theatre
20	Remote countryside on still night
10	Sound insulated test chamber
0	Threshold of hearing

EQUIVALENT CONTINUOUS SOUND LEVEL (L_{Aeq})

Another index for assessment for overall noise exposure is the equivalent continuous sound level, L_{eq}. This is a notional steady level, which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating levels can be described in terms of a single figure level.

FREQUENCY

The rate of repetition of a sound wave. The subjective equivalent in music is pitch. The unit of frequency is the Hertz (Hz), which is identical to cycles per second. A thousand hertz is often denoted kilohertz (kHz), e.g. 2 kHz = 2000 Hz. Human hearing ranges from approximately 20 Hz to 20 kHz. The most commonly used frequency bands are octave bands, in which the mid frequency of each band is twice that of the band below it. For design purposes, the octave bands between 63 Hz to 8 kHz are generally used. For more detailed analysis, each octave band may be split into three one-third octave bands or, in some cases, narrow frequency bands.

MAXIMUM SOUND LEVEL, L_{max}

The maximum sound level is the maximum weighted sound pressure level experienced during the measurement period.

RATING BACKGROUND LEVEL (RBL)

A single-number figure used to characterise the background noise levels from a complete noise survey. The RBL for a day, evening or night time period for the overall survey is calculated from the individual Assessment Background Levels (ABL) for each day of the measurement period, and is numerically equal to the median (middle value) of the ABL values for the days in the noise survey.

SOUND POWER AND SOUND PRESSURE

The sound power level (L_w) of a source is a measure of the total acoustic power radiated by a source. The sound pressure level (L_p) varies as a function of distance from a source. However, the sound power level is an intrinsic characteristic of a source (analogous to its mass), which is not affected by the environment within which the source is located.

STATISTICAL NOISE LEVELS

For levels of noise that vary widely with time, for example road traffic noise, it is necessary to employ an index that allows for this variation. 'A'-weighted statistical noise levels are denoted L_{A10}, dBL_{A90} etc. The reference time period (T) is normally included, e.g. $dBL_{A10, 5min}$ or $dBL_{A90, 8hr}$.

L_{A90} (T)

Refers to the sound pressure level measured in dB(A), exceeded for 90% of the time interval (T) –i.e. measured noise levels were greater than this value for 90% of the time interval. This is also often referred to the background noise level.

L_{A10} (T)

Refers to the sound pressure level measured in dB(A), exceeded for 10% of the time interval (T). This is often referred to as the average maximum noise level and is frequently used to describe traffic noise.

L_{A1}(T)

Refers to the sound pressure level measured in dB(A), exceeded for 1% of the time interval (T). This is often used to represent the maximum noise level from a period of measurement.

VIBRATION

Vibration may be expressed in terms of displacement, velocity and acceleration. Velocity and acceleration are most commonly used when assessing structure borne noise or human comfort issues respectively. Vibration amplitude may be quantified as a peak value, or as a root mean squared (rms) value.

Vibration amplitude can be expressed as an engineering unit value e.g. $1mms^{-1}$ or as a ratio on a logarithmic scale in decibels:

Vibration velocity level, L_V (dB) = 20 log (V/V_{ref}),

(where the preferred reference level, V_{ref}, for vibration velocity = 10^{-9} m/s).

The decibel approach has advantages for manipulation and comparison of data.

Appendix B

Noise Survey

B1 Noise Survey

B1.1 Methodology

A noise survey was carried out to establish the current ambient noise levels around the proposed development site and to identify noise sensitive receivers. This included both attended and unattended monitoring.

The closest noise sensitive receivers that could be identified are shown in **Error! Reference source not found.**Figure 2 in Section 3.3.

From Tuesday 14 April 2010 to Thursday 29 April 2010 six noise loggers were set up on and around the site.

Figure B.1 in Section **Error! Reference source not found.**B1.2 shows the logger locations. These positions were chosen as they represented secure places to leave the noise loggers unattended whilst obtaining typical representative noise levels of that area of the City.

The loggers recorded L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} noise parameters at 15-minute intervals continuously for the week long measurement period (See Appendix A1 for a glossary of acoustic terminology). Weather patterns were noted during this period and where noise levels were affected the data was not used. The loggers were checked for calibration before and after the monitoring period and no deviation had occurred.

The average hourly noise levels throughout the day have been determined from the total measurement period for all logger locations and split into weekdays and the weekend. These are presented graphically in to Figure B.2 to Figure B.13. The raw data from the loggers is available upon request.

The results of Monday 26 April 2010 have been disregarded as this day was a public holiday. (These results have not been used to calculate the weekly or weekend average.)

To supplement and verify the unattended measurements some attended measurements were undertaken at the logger locations. Again the L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} noise parameters were measured for 15-minute periods. A Brüel and Kjær 2250 sound level meter (serial no. 2449851) was used to take the measurements. This was checked for calibration before and after the measurements. No deviation occurred.

It is recommended that an Acoustic Benchmarking Study be undertaken during the design development phase to establish definitive project specific environmental noise criteria in the context of the sites both former and proposed land uses. This is in addition to the abovementioned noise survey undertaken by ARUP and contained in this report, which is not representative of either the future, or most recent noise environment on and around the site because currently, the site is vacant and un used.

The Acoustic Benchmarking Study should be carried out at other similar sites in Sydney, such as Circular Quay, King Street Wharf and Darling Harbour, to establish appropriate project specific environmental noise criteria in the context of both the sites most recent prior and proposed future land uses. This would include carrying out noise surveys at these and other sites where applicable and obtaining previous noise survey data where available. A review of this data would feed into the process of establishing definitive and appropriate criteria that relate to the Basement Car Park and all other proposed developments on Barangaroo South.

B1.2 Measurement Locations

Figure B.1 below shows the attended and unattended noise measurement locations

Figure B.1 Site and Noise Measurement Locations

Attended measurement location

Unattended measurement location (noise logger location)

Measurement locations include:

1. On Level 4 of the Bond building at 30-38 Hickson Road, balcony adjacent to Hickson Road.
2. In front of the eastern façade of the Barangaroo Exhibition Building.
3. In the middle of the subject site.
4. West of the subject site, approximately 3 m from the water edge.
5. South-west of the subject site adjacent to the Sussex Street and Shelley St crossing.
6. South of the site adjacent to the King Street Wharf Boulevard.
7. In front of the apartments on the eastern side of Darling Island

B1.3 Results

Figure B.2 to Figure B.13 show the measured average noise levels for weekdays and weekends. Table B 1 shows the results of the attended noise measurements undertaken at the various locations. The measurement results are discussed in Section B1.4.

B1.3.1 Location 1: The Bond building, 30 Hickson Road

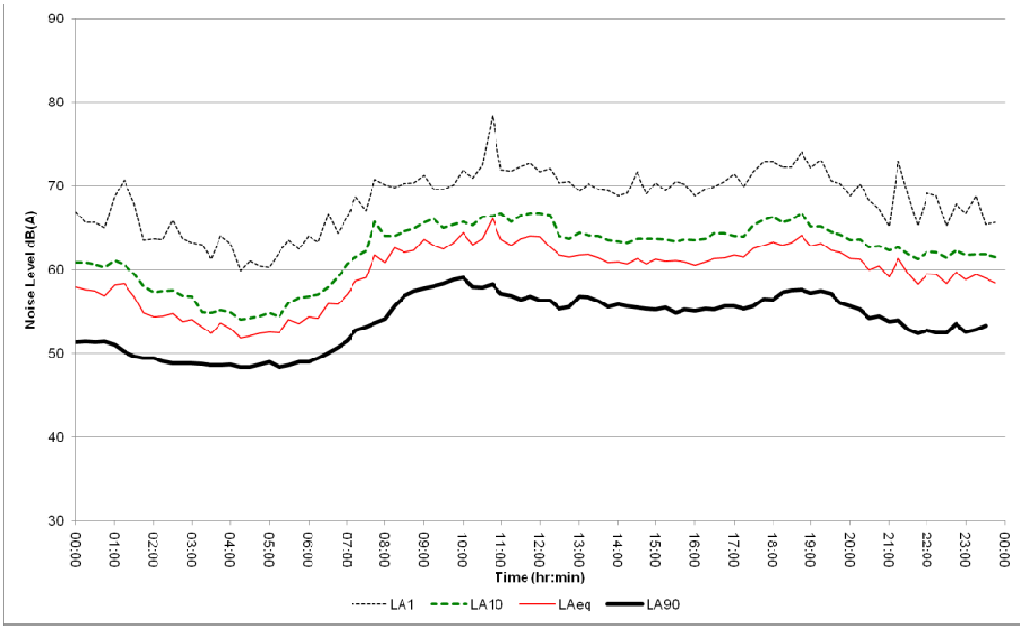

Figure B.2 Average Weekday Noise Levels for Location 1

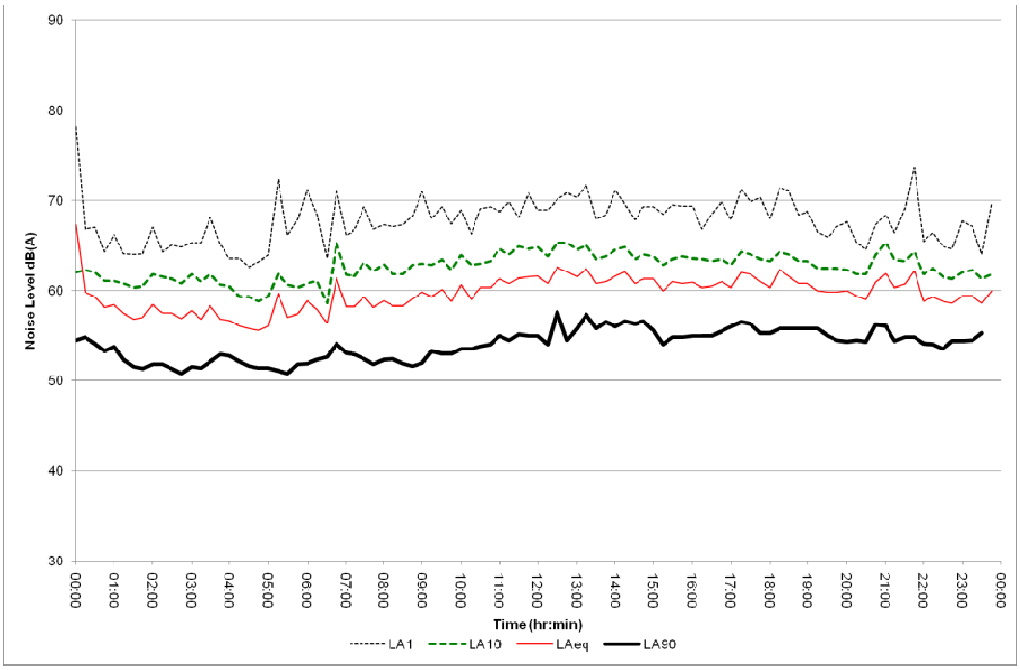

Figure B.3 Average Weekend Noise Levels for Location 1

B1.3.2 Location 2: East façade of Barangaroo Exhibition Building, Hickson Road

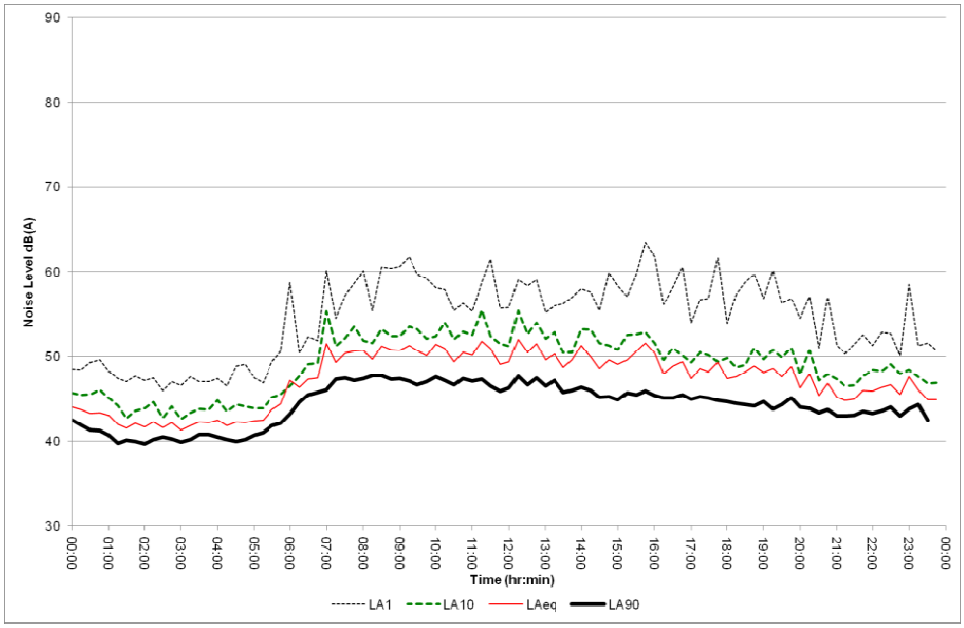

Figure B.4 Average Weekday Noise Levels for Location 2

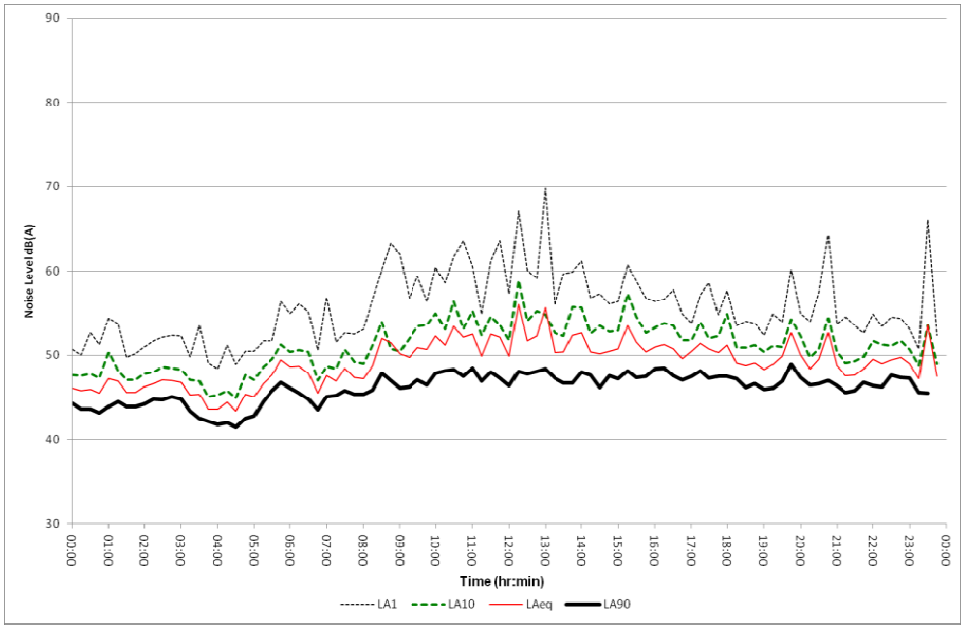

Figure B.5 Average Weekend Noise Levels for Location 2

B1.3.3 Location 3: Middle of the site

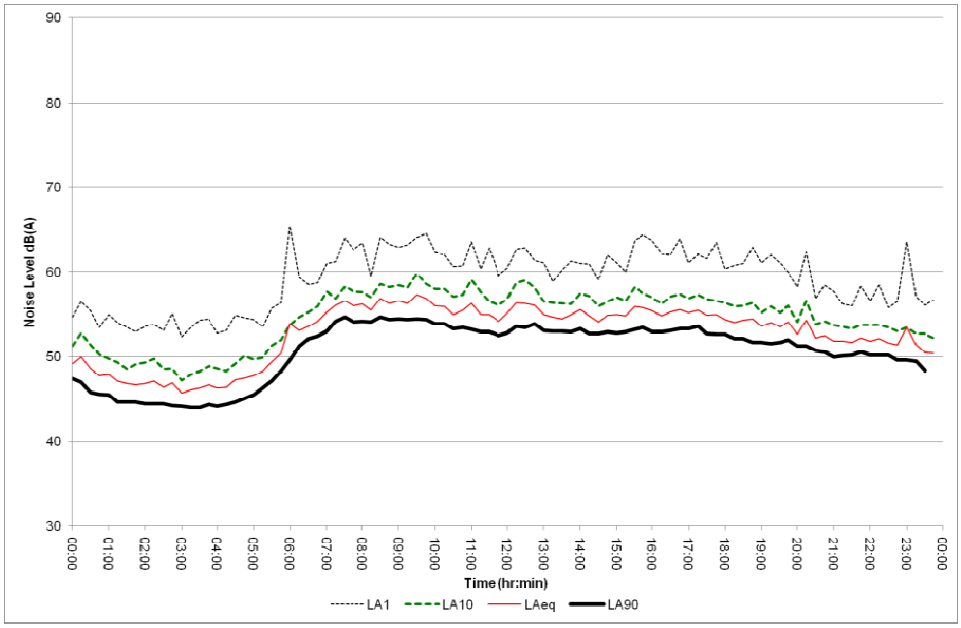

Figure B.6 Average Weekday Noise Levels for Location 3

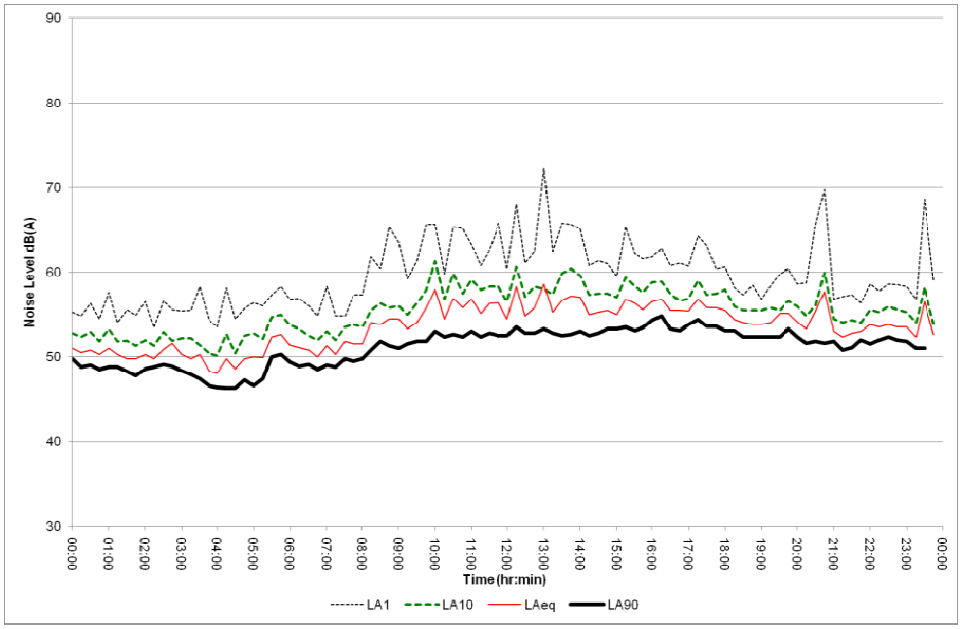

Figure B.7 Average Weekend Noise Levels for Location 3

B1.3.4 Location 4: East of the site near the water edge

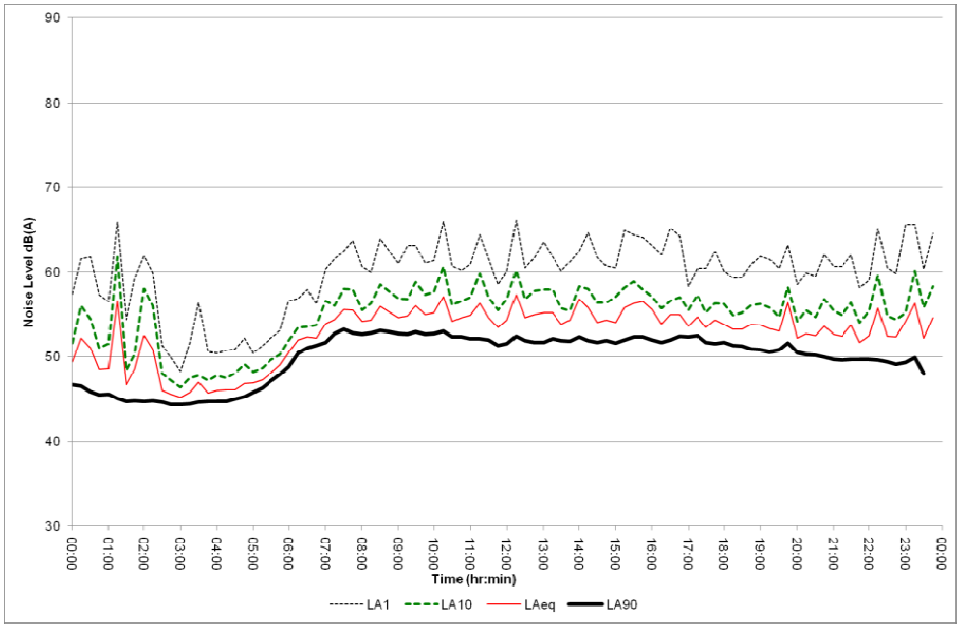

Figure B.8 Average Weekday Noise Levels for Location 4

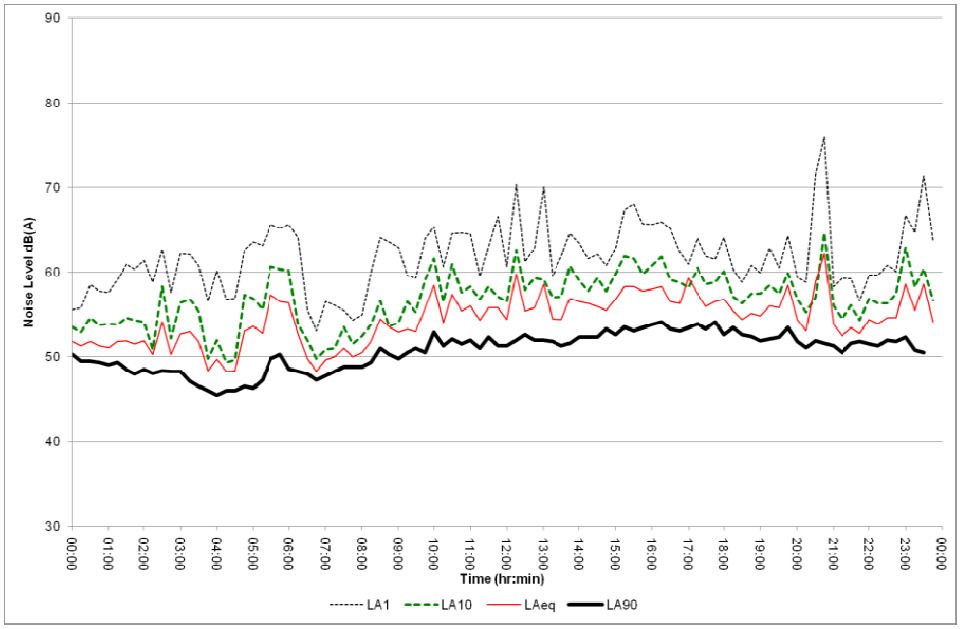

Figure B.9 Average Weekend Noise Levels for Location 4

B1.3.5 Location 5: South-west of the site near corner Sussex St and Shelley St

Figure B.10 Average Weekday Noise Levels for Location 5

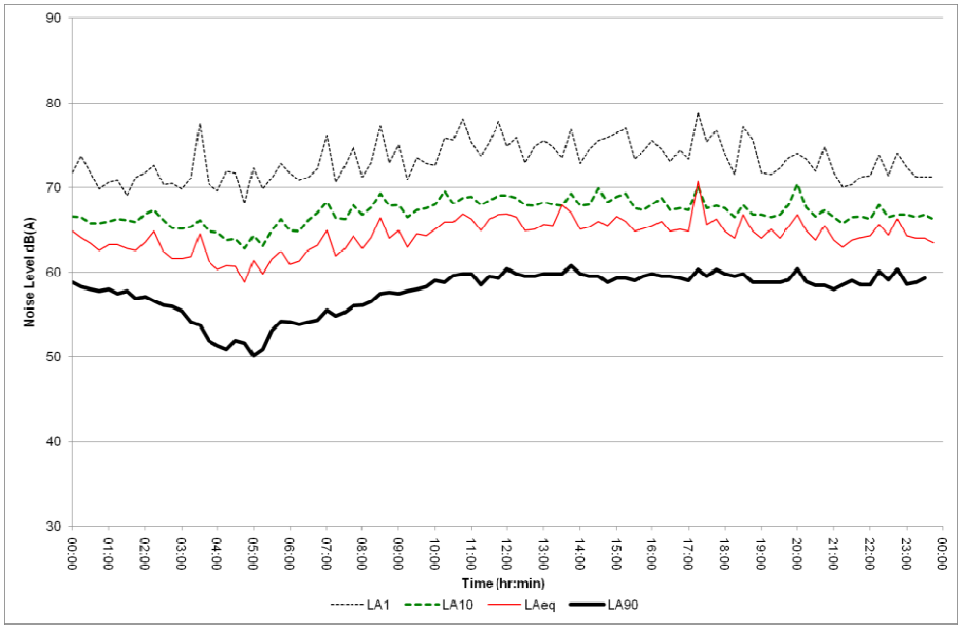

Figure B.11 Average Weekend Noise Levels for Location 5

B1.3.6 Location 6: South-of the site near King Street Wharf Boulevard

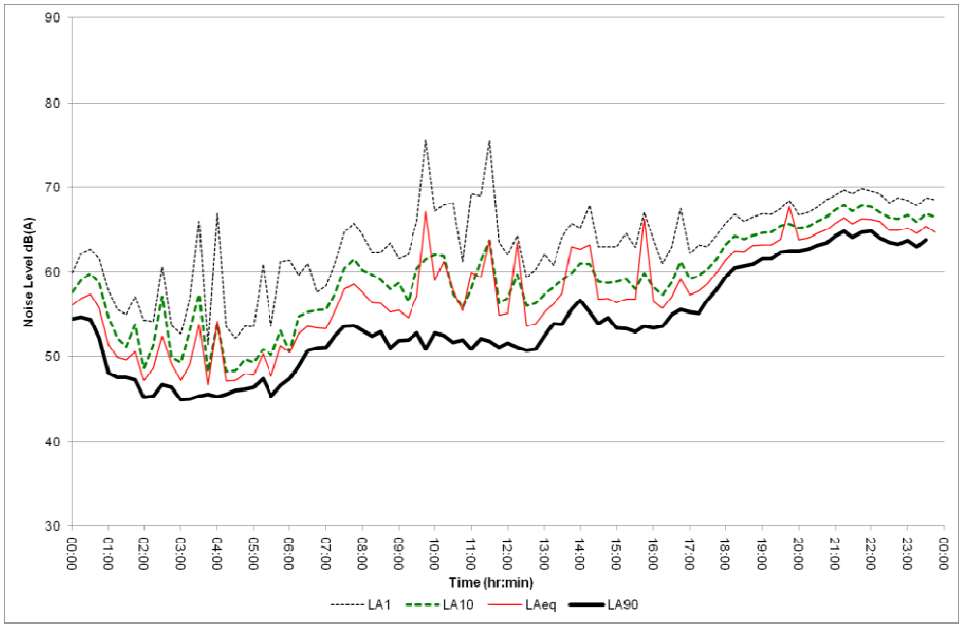

Figure B.12 Average Weekday Noise Levels for Location 6

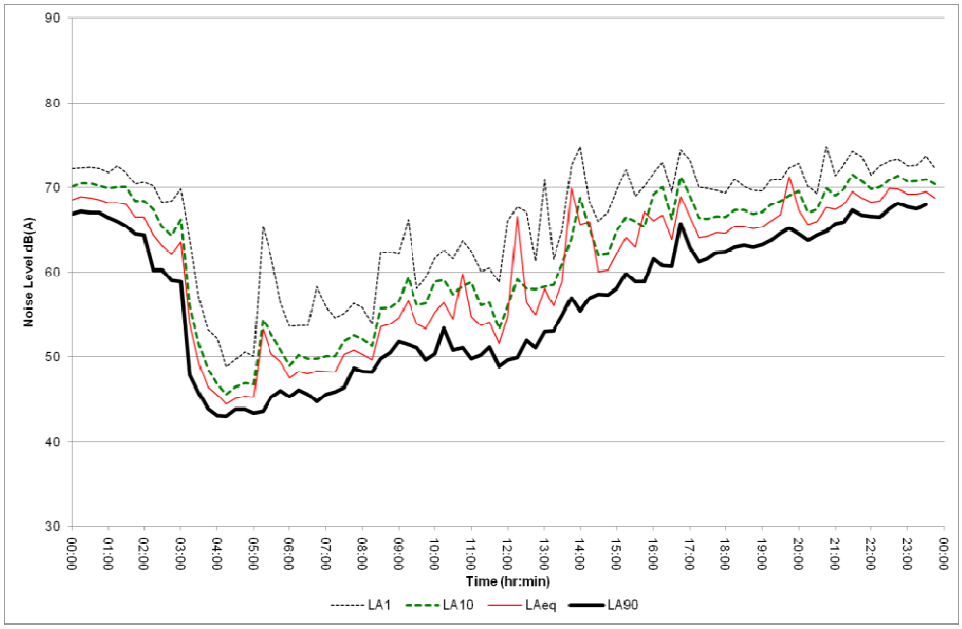

Figure B.13 Average Weekend Noise Levels for Location 6

Table B 1 gives details of the measured noise levels and activities during the attended measurement periods.

Table B 1 Results of attended measurements

Location	Date	Time	Noise Level dB(A) L_{A1}	L_{A10}	L_{Aeq}	L_{A90}	Comments
Location 1 The Bond Building at Hickson Road Level 4 balcony	19/04/10	13:25 – 13:40	-	63	61	50	Traffic noise on Hickson Road dominant. Also noise from surrounding roads and air traffic audible. Occasionally the sound of birds.
	29/04/10	09:00-09:15	71	65	63	58	Traffic noise on Hickson Road dominant. Car alarm going off. Very windy conditions. Noise from shading devices rattling in the wind.
Location 2 at site south of the exhibition building	20/04/10	13:40-13:55	-	52	52	47	Despite the shielding effect of the exhibition building noise levels of traffic on Hickson Road and the Western Distributor dominate the measured noise level, as well as air traffic and boat noise.
	29/04/10	10:05-10:20	59	56	55	50	
Location 3 centre of site	20/04/10	14:25-14:40	-	56	55	53	Noise from traffic on Hickson road and the Western distributor as well as boat and air traffic dominant.
	29/04/10	10:30-10:45	62	57	55	52	Noise from traffic on Hickson road and the Western distributor as well as boat and air traffic dominant. Strong breeze at the time.
Location 4 eastern edge site adjacent to water	20/04/10	15:45-16:00	-	55	54	52	Traffic noise, air traffic (helicopters and planes) as well boat traffic dominant. Slap back from water against shore also audible.
	29/04/10	09:45-10:00	62	57	55	52	
Location 5 south-west edge of the site near the crossing of Sussex and Shelley St	20/04/10	15:05-15:20	-	71	69	63	Traffic noise on Sussex St and Shelley St dominant. Cars idling and pulling up at traffic lights.
	29/04/10	10:55-11:10	79	69	68	62	
Location 6 South of the site adjacent to King St Wharf Boulevard	23/04/10	17:15-17:30		66	64	62	Music from Bungalow 8 pub and pedestrian noise dominant. Traffic and boat noise also audible.
	29/04/10	09:25-09:40	73	70	70	69	Gas truck idling next to site. (Measurement not considered representative)
Location 7 east of Darling Island	22/04/10	23:10-23:25	-	49	46	44	Plant and faint music noise from King St Wharf (Bungalow 8). Occasional boat and helicopter noise audible. Local insect and bird noise
	22/04/10	23:30-23:45		49	48	46	
	23/04/10	15:55-16:10		58	55	52	Boat noise and distant car traffic dominant (Western Distributor). Also audible, light car traffic close by, pedestrians and birds.

B1.4 Summary of Noise Environments Around Noise Sensitive Receivers

B1.4.1 Off-site noise sensitive receivers

- **NSR's 1 (residents and commercial tenants along Hickson Road, including child care centre and temporary Passenger Terminal):** Figures B1 and B4 best represent the typical noise levels experienced by NSR's along Hickson Road. The dominant noise source is traffic on Hickson Road, during the weekday day time hours. This reduces by a few decibels during the weekends, highlighting the commercial nature of the site even in absence of the Barangaroo South development. Noise levels are expected to increase marginally as a result of traffic associated with the development.
- **NSR's 2, 3 and 4 (residents east of the site on Balmain East, Darling Island and Pyrmont Bay Wharf):** These receivers are best represented by Figures B7 and B8. The existing noise level in these areas is generally dominated by distant road and air traffic as well as boat traffic in the harbour. Noise from the Barangaroo South development activities is not expected to adversely impact these NSR's.
- **NSR's 5 (commercial receivers along Shelly St):** The typical noise environments for these NSR's are represented best by Figures B11 and B12. Noise levels are dominated by road traffic on Sussex and Shelly Streets in addition to activities on King Street Wharf, which comes alive at night due to the entertainment aspect of this harbour foreshore area. Although there may be some additional road traffic in this area associated with the Barangaroo South development. The noise generated is not expected to result in an adverse impact to these NSR's.

B1.4.2 On-site receivers (Residential, Commercial, Retail and Cultural Centre)

The dominant noise sources currently affecting the site are largely determined by the location of the NSR. Areas close to Hickson Road to the east and Sussex and Shelly Street to the south are dominated by traffic noise during the day.

Noise from entertainment establishments on King Street Wharf in the evening and night dominates the south western corner of the site.

In the middle of the site and at the water's edge the hum of distant traffic and mechanical plant from commercial buildings is audible. Noise sources from harbour traffic are also more audible than at locations where traffic noise masks this noise. Noise from cruise ships, when in port also adds to the noise environment.

All NSR's on and off the Barangaroo South site are affected by helicopter flyovers that occur on a semi-regular basis.