COCKLE BAY MARINE STRUCTURES RENEWAL PROJECT NOISE & VIBRATION ASSESSMENT

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PREPARED FOR

SYDNEY HARBOUR FORESHORE AUTHORITY LEVEL 6, 66 HARRINGTON STREET THE ROCKS NSW 2000



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Version	Status	Date	Prepared By	Reviewed By
А	DRAFT	9 December 2014	Jeffrey Peng	Barry Murray
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Wilkinson Murray Pty Limited · ABN 39 139 833 060

Level 4, 272 Pacific Highway, Crows Nest NSW 2065, Australia • Offices in Orange, Qld & Hong Kong t +61 2 9437 4611 • f +61 2 9437 4393 • e acoustics@wilkinsonmurray.com.au • w www.wilkinsonmurray.com.au

ACOUSTICS AND AIR



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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 10^{th} percentile (lowest 10^{th} 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

The Sydney Harbour Foreshore Authority (the Authority) is planning to renew the waterside structures surrounding Cockle Bay at Darling Harbour. This is required because many of the existing structures are at the end of their working life and there is also a need to improve their functionality within the waterway. The intention of the works is to provide for more usable and more appropriately designed structures, which allow for better access for both pedestrians and users of the bay.

Wilkinson Murray Pty Limited (WM) has been engaged by the Authority to undertake a construction noise and vibration assessment for the proposed works, based on staging of the construction works provided by the Authority.

This resulting construction and noise vibration impact statement (CNVIS) for the concept design has been prepared in accordance with the following documents:

- NSW Interim Construction Noise Guideline 2009 (DECC);
- NSW Industrial Noise Policy 2000 (EPA);
- Assessing Vibration: A Technical Guideline (DECCW); and
- German Standard DIN 4150, Part 3: Structural Vibration in Buildings: Effects on Structures

This approach satisfies the Secretary's Environmental Assessment Requirements (Reference *SSD 661-2014*) for this Project.

2 SITE DESCRIPTION & CONSTRUCTION STAGING

The site consists of part of the bed of Sydney Harbour known as Cockle Bay and immediate adjoining foreshore land. The site extends from Pyrmont Bridge in the north to Darling Harbour in the South as is shown in Figure 2-1.

The area surrounding the site is predominantly commercial (including retail stores, restaurants, cafes and hotels). To the north-east and north-west of the site are museum/exhibition spaces.

The waterway and the surrounding foreshore land is owned and managed by the Authority.

Cockle Bay is currently developed with various waterway structures for which the uses have changed and evolved over time. A basic break-up of these structures is shown on the plan below in Figure 2-1. The current uses of the existing marine structures include a mix of public and private uses ranging from berthing of private yachts and vessels to drop-off and pick up by marine leisure vessels. In addition, the bay is used for many Darling Harbour events that are hosted or managed by the Authority.

Many of the existing structures are inappropriately located or designed. The intention of the renewal Project is to allow the waterway to work more effectively and efficiently, as well as to create a more open and usable space for the Authority water based events.

The key components of the proposed works are:

- Demolition of existing Harbourside Steps, Harbourside Jetty, Harbourside Promenade, Convention Wharf and Cockle Bay Marina;
- New east-side commercial marina which is publicly accessible for short stay berthing of vessels; and
- New west-side floating public landing facilities which can also be used as event spaces and for foreshore public access (including the Heritage Foreshore Boardwalk).

2.1 Construction Stages

In order to evaluate the noise and vibration impact for this project, the construction processes and equipment below has been assumed since full details will only be available after award of the contract:

- (1) Site Establishment Includes installation of fencing & hoarding on the land immediately adjacent to the site compound which will be over water. All amenities and equipment will be delivered via the waterway;
- (2) Dismantling and removal of the existing structures The existing timber structures and concrete pontoon will be dismantled and removed. All piles will be removed, where possible.
 Piles will be cut off at seabed level if they cannot be removed or if removal may disturb a heritage relic. Material will be recycled where possible;
- (3) Removal of the existing Harbourside steps The existing concrete steps will be sawn and removed using water based crane. Material will be recycled where possible;
- (4) Installation of piles The timber and steel piles supporting the new wharf structures will be installed using water-based crane and piling rig. This will be the noisiest part of the construction process;

- (5) Installation of the structures All pontoon systems will be proprietary concrete floats manufactured off-site and will be timber decked. These fixed structures will be delivered to the site by a service barge. The deck planks will be lifted onto the piles by water based crane; and
- (6) Fit out of the wharf Installation of lights and services will occur in stages through the project. Final fit out of the wharf will be done from the shore, towards the end of the project.

All access and works will be from water except site hoardings. Only stages (2), (3), (4) and (5) are considered in this assessment as these stages would sufficiently cover the likely acoustic impact from the works.

Note that construction will take place over a 10 week period from March to May in 2016 and two 15 week windows from August to November in 2015 and 2016. Noise generating work will be restricted to the following periods:

- 8.00am to 1.00pm (Monday to Saturday);
- 2.00pm to 5.00pm (Monday to Friday);
- No works on Sundays and public holidays; and
- No noise generating work during lunchtimes (12.00pm-2.00pm).

2.2 Sensitive Receivers

There are a number of commercial receivers sensitive to noise and vibration located in the vicinity of the work sites. The potentially most affected receivers, which have been considered for the purpose of this assessment, are presented in Table 2-1 below and their locations indicated in Figure 2-1.

Figure 2-1 Locality Map



Table 2-1 Receiver List

ID	Location	Floor	Function
ANMM1	HMAS Vampire	-	Museum
ANMM2	Australian National Maritime Museum	GF	Museum
CBW1	Home Nightclub	GF	Night Club
CBW2	Tokio Hotel	GF	Bar
CBW3	Nick's Seafood	GF	Restaurant
CBW4	Nick's 103	GF	Cafe
CBW5	Lindt Cafe	GF	Cafe
CBW6	Adria Rybar & Grill	GF	Bar Restaurant
CBW7	I'm Angus Steakhouse	GF	Restaurant
CBW8	Baia The Italian	GF	Restaurant
CBW9	Pontoon Bar	GF	Bar
CBW10	Home Nightclub	1st	Night Club
CBW11	Tokio Hotel	1st	Bar
CBW12	Blackbird Cafe	1st	Bar Restaurant
CBW13	Dockside	1st	Function Venue
CBW14	Pontoon Bar	1st	Bar
Helm Bar	Helm Bar	GF	Bar
HSSC1	Margaritaville	GF	Restaurant
HSSC2	Blue Fish	GF	Restaurant
HSSC3	Waterfront Grill	GF	Restaurant
HSSC4	Olivio	GF	Restaurant
HSSC5	Passello	GF	Restaurant
HSSC6	Watershed	GF	Bar
HSSC7	Cyren	GF	Restaurant
HSSC8	Hurricanes	1st	Resaurant
HSSC9	Festival Cafe	1st	Café Bar
HSSC10	Dragon Boat	1st	Bar Restaurant
HSSC11	Criniti's	1st	Restaurant
HSSC12	Thai Foon	1st	Restaurant
HSSC13	Zaaffran	1st	Restaurant
HSSC14	Kamikaze	1st	Restaurant
HSSC15	Cohibar	1st	Bar
HSSC16	Hard Rock Cafe	1st	Bar Restaurant
IMAX	IMAX	GF	Movie Theatre
Madame Tussauds	Madame Tussauds Sydney	GF	Museum
Sydney Aquarium	Sydney Aquarium and Wildlife Centre	GF	Aquarium

There are no residential receivers within 200m of the proposed works.

3 EXISTING ACOUSTIC ENVIRONMENT

In order to establish appropriate noise management levels for the project, it is necessary to establish the existing ambient noise environment in the study area. With the agreement of Lend Lease, the results of recent background noise measurement at Darling Harbour Live during RDO were used. It is considered that the background noise levels measured outside Harbourside Shopping Centre on Monday, 1 December 2014 and Tuesday, 2 December 2014 (during construction RDOs) are broadly representative of the background noise levels occurring throughout the respective localities of the study area. The rating background level (RBL) for the relevant assessment periods, namely between 8.00am and 12.00pm (Monday to Saturday) and 2.00pm and 5.00pm (Monday to Friday), is 59dBA.

The RBL represents the background noise in the area, and is determined from measurement of L_{A90} noise levels. Importantly, noise from the source(s) subject to assessment must be absent to determine the RBL. The full methodology for calculating RBL values from measured L_{A90} levels is set out in the NSW *Industrial Noise Policy (INP)*. The RBL of 59dBA forms the basis of the construction noise management levels for the project, as detailed in Section 4.

4 CONSTRUCTION NOISE & VIBRATION CRITERIA

4.1 Quantitative Assessment Method for Airborne Construction Noise

The quantitative assessment method set out in the *ICNG* has been used to assess the potential impacts from construction noise. This document guides EPA in setting statutory conditions in licences or other regulatory instruments for construction noise.

The *ICNG* recommends noise management levels of $L_{Aeq,15min}$ 60dBA (externally) for external passive recreational areas, such as outdoor dining areas. For indoor sensitive land use such as restaurants/coffee bars, museum foyer and exhibition spaces, the recommended 'maximum' internal management levels of $L_{Aeq,15min}$ 50dBA, 50dBA and 45dBA, respectively, as taken from AS2107 *Acoustics – Recommended design sound levels and reverberation times for building interior* should be used.

However, people's reaction to noise from construction will depend on the time of day that works are undertaken as background noise levels change. For example, people in residences are usually most annoyed by work at night time as it has the potential to disturb sleep (during times of low background noise level). As such, it is necessary to take into account the ambient noise environment.

Darling Harbour is a large recreational and pedestrian precinct where the background noise level is already high. It is therefore considered necessary to examine the rating background levels in conjunction with the recommended outdoor noise management levels mentioned above to determine appropriate project-specific construction noise management levels. Where the recommended NML for outdoor sensitive land use is lower than rating background level plus 10dB (NML for residential use), the latter has been adopted.

4.1.1 Project-Specific Construction Noise Management Levels

For the purpose of this assessment, the daytime RBL determined by monitoring has been used to establish the construction noise management level for outdoor sensitive land uses surrounding the site. For indoor sensitive land use, the *ICNG* recommended noise management levels have been adopted. A conservative estimate of the difference between internal and external noise level of 25dB has been assumed for fixed windows and 15dB has been assumed for open windows / doors. In accordance with the above process, the following construction noise management levels (assessed externally) are applicable during the nominated construction hours:

•	Australian National Maritime Museum (HMAS Vampire)	69dBA (based on RBL + 10dB)
•	Australian National Maritime Museum (internal)	70dBA (indoor 45dBA)
•	Harbourside Shopping Centre (Outdoor Restaurants)	69dBA (based on RBL + 10dB)
•	IMAX Foyer	65dBA (indoor 50dBA)
•	Cockle Bay Wharf (Outdoor Restaurants)	69dBA (based on RBL + 10dB)
•	Helm Bar (Outdoor Restaurants)	69dBA (based on RBL + 10dB)
•	Sydney Aquarium	70dBA (indoor 45dBA)
•	Madame Tussauds	70dBA (indoor 45dBA)

The *ICNG* does not include any criteria to assess off-site maritime traffic noise associated with the construction. Noise from maritime traffic associated with the proposed construction would be minimised as much as practicable by limitations on construction hours and maritime vessel noise limits.

Regardless, given the existing volume of traffic on the water-way within the study area, it would be expected that additional maritime traffic movements associated with the construction would not generate a material rise in traffic noise during the construction phase. Additionally, construction maritime traffic noise would provide a relatively minor contribution with respect to the actual construction activities.

4.2 Assessment Method for Construction Vibration

Construction work is generally considered an intermittent source of vibration. When assessing vibration, there are two components that require consideration:

- human exposure to vibration; and
- the potential for building damage from vibration.

Furthermore, whilst not discussed in guidelines, the vibration from construction has the potential to impact on the marine environment housed in the Sydney Aquarium so this aspect also needs to be considered.

4.2.1 Human Exposure to Vibration

The DECCW's *Assessing Vibration: A Technical Guideline* provides guidance for assessing human exposure to vibration. The publication is based on British Standard BS 6472:1992. Intermittent vibration is best assessed by the Vibration Dose Value (VDV) which is based on the *weighted* root mean quartic (rmq) acceleration. However, for simplicity of assessment and monitoring, a peak component particle velocity (PCPV) goal (in the vertical direction) is preferred.

Table 4-1 sets out PCPV values for continuous and impulsive vibration as specified by *Assessing Vibration: A Technical Guideline.* The impulsive vibration goals are shown in brackets.

Place	Day (7.00a	m-10.00pm)	Night (10.00pm-7.00am)		
	Preferred	Maximum	Preferred	Maximum	
Residences	0.28 (8.6)	0.56 (17.0)	0.20 (2.8)	0.40 (5.6)	
Offices,					
Places of	0.56 (18.0)	1.1 (36.0)	0.56 (18.0)	1.1 (36.0)	
Worship					
Workshops	1.1 (18.0)	2.2 (36.0)	1.1 (18.0)	2.2 (36.0)	

Table 4-1 Human Comfort Vibration Goals – PCPV (mm/s)

Note: Impulsive goals are shown in brackets – These are most relevant to activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading. The commercial/church criteria only apply when the premises' are occupied.

As seen in Table 4-1, the Guideline does explicitly state the vibration goals for public areas, such as café, restaurant, bar and museum. For the purpose of this assessment, the maximum vibration goal for residences has been adopted to assess these sensitive public areas, which is also in line with the preferred goal for offices and places of worship.

For Sydney Aquarium and IMAX Theatre, the vibration impacts are assessed using a different approach as described below.

4.2.2 Effects of Vibration

Humans are far more sensitive to vibration than is commonly realised. They can detect and possibly even be annoyed by vibration levels which are well below those causing any risk of damage to a building or its contents.

The actual perception of motion or vibration may not, in itself, be disturbing or annoying. An individual's response to that perception, and whether the vibration is "normal" or "abnormal", depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as "normal" in a car, bus or train is considerably higher than what is perceived as "normal" in a shop, office or dwelling.

Human tactile perception of random motion, as distinct from human comfort considerations, was investigated by Diekmann and subsequently updated in German Standard DIN 4150 Part 2-1975. On this basis, the resulting degrees of perception for humans are suggested by the vibration level categories given in Table 4-2.

Approximate Vibration Level	Degree of Perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable
1 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

Table 4-2Vibration Levels and Human Perception of Motion – PPV

Note: These approximate vibration levels (in floors of building) are for vibration having a frequency content in the range of 8 Hz to 80 Hz.

A review of the information in Table 4-2 suggests that people will just be able to feel floor vibration at levels of about 0.15 mm/s, and that the motion becomes "noticeable" at a level of approximately 1 mm/s.

It is considered that the human perception of motion as described above would be a good starting point to screen the vibration impacts upon the marine environment housed in the Sydney Aquarium.

4.2.3 Ground-borne noise at IMAX Theatre

Ground-borne noise is noise generated by vibration transmitted through the ground into a structure. Ground-borne noise caused by, for example, piling or underground works can be more noticeable than airborne noise. For this project, the IMAX Theatre is considered to be highly sensitive to external noise, and is likely to be impacted by ground-borne noise. It is considered that exceedance of a ground-borne noise level of 35dBA inside the IMAX Theatre indicates when management actions should be implemented. This level recognises the temporary nature of construction and is based on the recommended maximum internal design sound level for 'cinema' type space as specified in AS 2107.

4.2.1 Building Damage from Vibration

There are currently no Australian Standards or guidelines for assessing the potential for building damage from vibration. It is common practice to derive goals from international standards. British Standard BS 7385:1993 and German Standard DIN 4150:1999 both provide goals, below which vibration is considered insufficient to cause building damage. Of these, DIN 4150 is the more stringent. Table 4-3 summarises the goals specified in DIN 4150.

Table 4-3Guideline Values for Vibration Velocity to be used when Evaluating the
Effects of Short-Term Vibration on Structures (DIN4150-3:1999)

-	Guideline Values for Velocity – PCPV (mm/s)				
Type of Structure	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz		
Buildings used for commercial purposes, industrial buildings, and buildings of similar design	20	20 to 40	40 to 50		
Dwellings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20		
Structures that, because of their particular sensitivity to vibration, cannot be classified under either of the other classifications and of great intrinsic value	3	3 to 8	8 to 10		

With regard to these levels DIN 4150 states, "experience has shown that if these values are complied with, damage that reduces the serviceability of the building will not occur. If damage nevertheless occurs, it is to be assumed that other causes are responsible. Exceeding [these] values does not necessarily lead to damage; should they be significantly exceeded, however, further investigations are necessary."

For general construction vibration, the dominant frequency of vibration is typically in the range 31.5 - 100 Hz. Because the dominant frequency of vibration cannot be determined with certainty, this assessment has adopted a conservative goal of 20mm/s for commercial and industrial buildings. This goal would apply on the foundations of the building.

5 CONSTRUCTION NOISE ASSESSMENT

5.1 Noise Modelling Methodology & Assumptions

Construction noise emissions from the site have been modelled using the ISO9613-2 noise prediction algorithm in SoundPLAN (ver 7.1) acoustic noise prediction software. Factors that are addressed in the noise modelling are:

- Equipment noise emission levels and location;
- Screening from structures (1.8m high site hoarding);
- Receiver locations;
- Ground topography;
- Noise attenuation due to geometric spreading;
- Ground absorption;
- Atmospheric absorption; and
- Meteorological conditions that may influence noise levels.

5.2 Construction Stages & Noise Sources

Noise impacts for each construction stage have been calculated based on the assumed equipment schedules and sound power levels provided in Table 5-1 below.

Table 5-1 Assumed Equipment Schedules

Activity	Significant Noise Source	Sound Power Level L _{Aeq} (dBA)
Domoval of Evideina	Crane Barge	106
Superstructure / Piles	Electric Saw / Angle Grinder / Electric Drill	108
Demonstration Change	Crane Barge	106
Removal of Concrete Steps	Concrete Saw	114
Installation of Dilos	Crane Barge	106
	Bored/Screw Piling	106
	Crane Barge	106
Installation of New Structures	Electric Saw / Angle Grinder / Electric Drill	108
	Miscellaneous Hand Tools	100

These sound power levels have been applied in the predictions of worst-case noise that may arise during construction stages. Note that in Table 2-1, 'Activity' describes the stage of construction and 'Significant Noise Source' describes the noisier plant/equipment that are likely to be used during the construction stage. For the purpose of this assessment, it has been assumed that one of each of the identified plant items would operate and all plant would operate concurrently during the 15-minute assessment period during each stage.

The predicted $L_{Aeq,15min}$ construction noise levels are provided for each construction activity in the following sections.

5.3 Noise Prediction – Harbourside Jetty

The worst-case predicted noise levels at all identified sensitive receivers during various stages of works at Harbourside Jetty are presented in Table 5-2. Exceedance of the project-specific noise management levels are identified and shown in **bold font.** A review of the results in Table 5-2 indicates the following:

- Removal of Timber Structures Predicted noise levels are below the NML at most locations with the exception of Hurricanes (HSSC8) and Festival Café (HSSC9);
- Piling The predicted noise levels will comply with the NML at all locations except Margaritaville; and
- Installation of New Structures Predicted noise levels are below the NML at most locations with the exception of Hurricanes (HSSC8) and Festival Café (HSSC9).

5.4 Noise Prediction – Harbourside Promenade

The worst-case predicted noise levels at all identified sensitive receivers during various stages of works at Harbourside Promenade are presented in Table 5-3. Exceedance of the project-specific noise management levels are identified and shown in bold font. A review of the results in Table 5-3 indicates the following:

- Removal of Timber Structures Predicted noise levels are below the NML at most locations with the exception of Hurricanes (HSSC8), Festival Café (HSSC9) and Dragon Boat (HSSC10);
- Piling The predicted levels will generally comply with the NML except for small exceedances at Blue Fish, Hurricanes, Festival Café and Dragon Boat; and
- Installation of New Structures Predicted noise levels are below the NML at most locations with the exception of Hurricanes (HSSC8), Festival Café (HSSC9) and Dragon Boat (HSSC10).

5.5 Noise Prediction – Harbourside Steps

The worst-case predicted noise levels at all identified sensitive receivers during various stages of works at Harbourside Steps are presented in Table 5-4. Exceedance of the project-specific noise management levels are identified and shown in **bold font.** A review of the results in Table 5-4 indicates the following:

- Removal of Timber Structures Predicted noise levels are below the NML at most locations with the exception of Kamikaze (HSSC14) and Cohibar (HSSC15);
- Piling The NML will not be exceeded by the predicted levels at any location; and
- Installation of New Structures Predicted noise levels are below the NML at most locations with the exception of Kamikaze (HSSC14) and Cohibar (HSSC15).

5.6 Noise Prediction – Heritage Foreshore Boardwalk

The worst-case predicted noise levels at all identified sensitive receivers during various stages of works to construct Heritage Foreshore Boardwalk are presented in Table 5-5. Exceedance of the project-specific noise management levels are identified and shown in **bold font.** A review of the results in Table 5-5 indicates the following:

- Piling The predicted levels will generally comply with the NML except for small exceedances at Margaritaville, Blue Fish, Hurricanes, Festival Café and Dragon Boat; and
- Installation of New Structures Predicted noise levels are below the NML at most locations with the exception of Margaritaville (HSSC1), Hurricanes (HSSC8), Festival Café (HSSC9) and Dragon Boat (HSSC10).

5.7 Noise Prediction – Convention Wharf

The worst-case predicted noise levels at all identified sensitive receivers during various stages of works at Harbourside Steps are presented in Table 5-6. Exceedance of the project-specific noise management levels are identified and shown in **bold font.** A review of the results in Table 5-6 indicates the following:

- Removal of Timber Structures Predicted noise levels are below the NML at most locations with the exception of Zaaffran (HSSC13), Kamikaze (HSSC14), Cohibar (HSSC15) and Hard Rock Café (HSSC16);
- Piling The predicted levels will comply with the NML except at Zaaffran, Kamikaze, Cohibar and Hard Rock Café; and
- Installation of New Structures Predicted noise levels are below the NML at most locations with the exception of Zaaffran (HSSC13), Kamikaze (HSSC14), Cohibar (HSSC15) and Hard Rock Café (HSSC16).

5.8 Noise Prediction – Cockle Bay Marina

The worst-case predicted noise levels at all identified sensitive receivers during various stages of works at Harbourside Steps are presented in Table 5-7. Exceedance of the project-specific noise management levels are identified and shown in **bold font.** A review of the results in Table 5-7 indicates the following:

- Removal of Timber Structures Predicted noise levels are below the NML at most locations with the exception of Home Nightclub (CBW1), Tokio Hotel (CBW2), Blackbird Cafe (CBW12), Dockside (CBW13) and Pontoon Bar (CBW14);
- Piling The predicted levels will exceed the NML at only a few locations: Home Nightclub, Tokio Hotel, Blackbird Café and Pontoon Bar; and
- Installation of New Structures Predicted noise levels are below the NML at most locations with the exception of Home Nightclub (CBW1) and Tokio Hotel (CBW2).

5.9 Sources of Noise Exceedances

Where exceedances of the NML have been identified in this section, the likely causes of such exceedances will be:

- Removal of Structures combination of equipment, except during concrete removal the concrete saw will dominate;
- Piling the bored or screw piling rig; and
- Installation of New Structures Hand tools and barge.

		NMI	Predicted Noise Levels L _{Aeq,15min} dB(A)			
ID	Location	dB(A)	Removal of Timber Structures	Piling	Installation of New Structures	
ANMM1	HMAS Vampire	69	57	56	57	
ANMM2	Australian National Maritime Museum	70	66	65	66	
CBW1	Home Nightclub	69	50	52	49	
CBW2	Tokio Hotel	69	50	52	50	
CBW3	Nick's Seafood	69	48	49	47	
CBW4	Nick's 103	69	48	49	47	
CBW5	Lindt Cafe	69	49	50	48	
CBW6	Adria Rybar & Grill	69	49	50	48	
CBW7	I'm Angus Steakhouse	69	49	50	48	
CBW8	Baia The Italian	69	49	50	49	
CBW9	Pontoon Bar	69	50	51	50	
CBW10	Home Nightclub	69	47	48	47	
CBW11	Tokio Hotel	69	47	48	47	
CBW12	Blackbird Cafe	69	51	52	50	
CBW13	Dockside	69	52	53	52	
CBW14	Pontoon Bar	69	53	55	53	
Helm Bar	Helm Bar	69	50	51	50	
HSSC1	Margaritaville	69	68	71	67	
HSSC2	Blue Fish	69	64	64	64	
HSSC3	Waterfront Grill	69	59	59	59	
HSSC4	Olivio	69	56	56	55	
HSSC5	Passello	69	55	56	55	
HSSC6	Watershed	69	55	54	55	
HSSC7	Cyren	69	48	48	47	
HSSC8	Hurricanes	69	79	77	79	
HSSC9	Festival Cafe	69	70	69	71	
HSSC10	Dragon Boat	69	68	67	68	
HSSC11	Criniti's	69	63	61	63	
HSSC12	Thai Foon	69	56	56	56	
HSSC13	Zaaffran	69	55	55	55	
HSSC14	Kamikaze	69	56	56	57	
HSSC15	Cohibar	69	56	56	55	
HSSC16	Hard Rock Cafe	69	51	52	51	
IMAX	IMAX	65	49	51	49	
Madame Tussauds	Madame Tussauds Sydney	70	55	56	55	
Sydney Aguarium	Sydney Aquarium and Wildlife Centre	70	52	53	52	

Table 5-2 Predicted Construction Noise Levels – Harbourside Jetty

Note1: Bolded denotes - exceedance of the project-specific noise management level.

		NMI	Predicted Noise Levels L _{Aeq,15min} dB(A)			
ID	Location	dB(A)	Removal of Timber Structures	Piling	Installation of New Structures	
ANMM1	HMAS Vampire	69	54	55	54	
ANMM2	Australian National Maritime Museum	70	59	58	59	
CBW1	Home Nightclub	69	50	52	50	
CBW2	Tokio Hotel	69	51	52	50	
CBW3	Nick's Seafood	69	48	49	48	
CBW4	Nick's 103	69	48	49	48	
CBW5	Lindt Cafe	69	49	49	48	
CBW6	Adria Rybar & Grill	69	51	51	51	
CBW7	I'm Angus Steakhouse	69	50	50	50	
CBW8	Baia The Italian	69	51	51	51	
CBW9	Pontoon Bar	69	51	52	51	
CBW10	Home Nightclub	69	48	49	48	
CBW11	Tokio Hotel	69	48	48	48	
CBW12	Blackbird Cafe	69	52	53	51	
CBW13	Dockside	69	53	54	54	
CBW14	Pontoon Bar	69	55	56	55	
Helm Bar	Helm Bar	69	51	52	51	
HSSC1	Margaritaville	69	65	65	65	
HSSC2	Blue Fish	69	68	70	66	
HSSC3	Waterfront Grill	69	60	62	59	
HSSC4	Olivio	69	56	58	55	
HSSC5	Passello	69	54	56	53	
HSSC6	Watershed	69	51	54	50	
HSSC7	Cyren	69	42	46	38	
HSSC8	Hurricanes	69	72	70	72	
HSSC9	Festival Cafe	69	78	77	79	
HSSC10	Dragon Boat	69	74	72	75	
HSSC11	Criniti's	69	61	62	60	
HSSC12	Thai Foon	69	55	58	53	
HSSC13	Zaaffran	69	54	56	52	
HSSC14	Kamikaze	69	52	55	51	
HSSC15	Cohibar	69	51	54	49	
HSSC16	Hard Rock Cafe	69	34	35	32	
IMAX	IMAX	65	49	50	48	
Madame Tussauds	Madame Tussauds Sydney	70	55	56	56	
Sydney Aquarium	Sydney Aquarium and Wildlife Centre	70	53	54	53	

Table 5-3 Predicted Construction Noise Levels – Harbourside Promenade

Note 1: Bolded denotes - exceedance of the project-specific noise management level.

	-	NMI	Predicted Noise Levels L _{Aeq,15min} dB(A)			
ID	Location	dB(A)	Removal of Concrete Structures	Piling	Installation of New Structures	
ANMM1	HMAS Vampire	69	55	50	49	
ANMM2	Australian National Maritime Museum	70	52	54	54	
CBW1	Home Nightclub	69	59	54	54	
CBW2	Tokio Hotel	69	59	54	54	
CBW3	Nick's Seafood	69	56	51	51	
CBW4	Nick's 103	69	56	51	51	
CBW5	Lindt Cafe	69	56	51	50	
CBW6	Adria Rybar & Grill	69	57	52	51	
CBW7	I'm Angus Steakhouse	69	57	52	52	
CBW8	Baia The Italian	69	57	53	52	
CBW9	Pontoon Bar	69	56	51	50	
CBW10	Home Nightclub	69	56	51	50	
CBW11	Tokio Hotel	69	56	51	52	
CBW12	Blackbird Cafe	69	59	55	54	
CBW13	Dockside	69	60	56	55	
CBW14	Pontoon Bar	69	60	55	54	
Helm Bar	Helm Bar	69	56	51	50	
HSSC1	Margaritaville	69	54	54	50	
HSSC2	Blue Fish	69	60	57	57	
HSSC3	Waterfront Grill	69	64	62	59	
HSSC4	Olivio	69	63	62	59	
HSSC5	Passello	69	66	64	61	
HSSC6	Watershed	69	67	62	63	
HSSC7	Cyren	69	61	56	56	
HSSC8	Hurricanes	69	56	57	56	
HSSC9	Festival Cafe	69	60	59	58	
HSSC10	Dragon Boat	69	64	63	63	
HSSC11	Criniti's	69	66	65	65	
HSSC12	Thai Foon	69	67	66	66	
HSSC13	Zaaffran	69	69	68	69	
HSSC14	Kamikaze	69	72	68	74	
HSSC15	Cohibar	69	72	65	70	
HSSC16	Hard Rock Cafe	69	61	60	64	
IMAX	IMAX	65	59	54	55	
Madame Tussauds	Madame Tussauds Sydney	70	59	54	54	
Sydney Aguarium	Sydney Aquarium and Wildlife Centre	70	57	53	52	

Table 5-4 Predicted Construction Noise Levels – Harbourside Steps

Note 1: Bolded denotes - exceedance of the project-specific noise management level.

ID	Location	NML	Predicted Noise Levels L _{Aeq,15min} dB(A)		
	Location	dB(A)	Piling	Installation of New Structures	
ANMM1	HMAS Vampire	69	57	56	
ANMM2	Australian National Maritime Museum	70	67	67	
CBW1	Home Nightclub	69	52	52	
CBW2	Tokio Hotel	69	52	52	
CBW3	Nick's Seafood	69	50	49	
CBW4	Nick's 103	69	50	50	
CBW5	Lindt Cafe	69	50	49	
CBW6	Adria Rybar & Grill	69	51	51	
CBW7	I'm Angus Steakhouse	69	50	50	
CBW8	Baia The Italian	69	51	51	
CBW9	Pontoon Bar	69	51	51	
CBW10	Home Nightclub	69	49	48	
CBW11	Tokio Hotel	69	48	48	
CBW12	Blackbird Cafe	69	53	52	
CBW13	Dockside	69	55	54	
CBW14	Pontoon Bar	69	55	54	
Helm Bar	Helm Bar	69	52	51	
HSSC1	Margaritaville	69	71	70	
HSSC2	Blue Fish	69	70	69	
HSSC3	Waterfront Grill	69	62	62	
HSSC4	Olivio	69	61	60	
HSSC5	Passello	69	59	58	
HSSC6	Watershed	69	55	55	
HSSC7	Cyren	69	50	50	
HSSC8	Hurricanes	69	75	75	
HSSC9	Festival Cafe	69	77	79	
HSSC10	Dragon Boat	69	72	72	
HSSC11	Criniti's	69	64	63	
HSSC12	Thai Foon	69	59	59	
HSSC13	Zaaffran	69	58	57	
HSSC14	Kamikaze	69	59	59	
HSSC15	Cohibar	69	59	58	
HSSC16	Hard Rock Cafe	69	55	55	
IMAX	IMAX	65	51	51	
Madame Tussauds	Madame Tussauds Sydney	70	56	56	
Sydney Aquarium	Sydney Aquarium and Wildlife Centre	70	54	54	

Table 5-5 Predicted Construction Noise Levels – Heritage Foreshore Boardwalk

Note 1: **Bolded** denotes – exceedance of the project-specific noise management level.

	Location	NML dB(A)	Predicted Noise Levels L _{Aeq,15min} dB(A)			
ID			Removal of Timber Structures	Piling	Installation of New Structures	
ANMM1	HMAS Vampire	69	48	50	48	
ANMM2	Australian National Maritime Museum	70	47	48	46	
CBW1	Home Nightclub	69	56	56	56	
CBW2	Tokio Hotel	69	55	56	55	
CBW3	Nick's Seafood	69	52	51	52	
CBW4	Nick's 103	69	51	51	52	
CBW5	Lindt Cafe	69	51	50	50	
CBW6	Adria Rybar & Grill	69	51	51	50	
CBW7	I'm Angus Steakhouse	69	51	51	51	
CBW8	Baia The Italian	69	51	51	51	
CBW9	Pontoon Bar	69	50	50	50	
CBW10	Home Nightclub	69	53	53	52	
CBW11	Tokio Hotel	69	53	52	53	
CBW12	Blackbird Cafe	69	55	55	55	
CBW13	Dockside	69	55	55	55	
CBW14	Pontoon Bar	69	53	54	54	
Helm Bar	Helm Bar	69	49	50	48	
HSSC1	Margaritaville	69	50	51	49	
HSSC2	Blue Fish	69	52	50	52	
HSSC3	Waterfront Grill	69	57	57	56	
HSSC4	Olivio	69	58	60	58	
HSSC5	Passello	69	61	63	60	
HSSC6	Watershed	69	66	68	65	
HSSC7	Cyren	69	62	64	61	
HSSC8	Hurricanes	69	51	51	50	
HSSC9	Festival Cafe	69	39	41	35	
HSSC10	Dragon Boat	69	56	57	56	
HSSC11	Criniti's	69	59	59	59	
HSSC12	Thai Foon	69	67	65	67	
HSSC13	Zaaffran	69	71	69	72	
HSSC14	Kamikaze	69	76	74	76	
HSSC15	Cohibar	69	75	73	76	
HSSC16	Hard Rock Cafe	69	71	70	72	
IMAX	IMAX	65	57	56	57	
Madame Tussauds	Madame Tussauds Sydney	70	51	53	51	
Svdnev Aquarium	Sydney Aquarium and Wildlife Centre	70	52	53	51	

Table 5-6 Predicted Construction Noise Levels – Convention Wharf

Note 1: Bolded denotes - exceedance of the project-specific noise management level.

	Location	NML dB(A)	Predicted Noise Levels L _{Aeq,15min} dB(A)			
ID			Removal of Timber Structures	Piling	Installation of New Structures	
ANMM1	HMAS Vampire	69	48	49	49	
ANMM2	Australian National Maritime Museum	70	50	51	50	
CBW1	Home Nightclub	69	74	73	74	
CBW2	Tokio Hotel	69	75	73	72	
CBW3	Nick's Seafood	69	66	68	62	
CBW4	Nick's 103	69	64	66	60	
CBW5	Lindt Cafe	69	63	64	59	
CBW6	Adria Rybar & Grill	69	64	64	60	
CBW7	I'm Angus Steakhouse	69	64	64	60	
CBW8	Baia The Italian	69	64	65	60	
CBW9	Pontoon Bar	69	65	64	63	
CBW10	Home Nightclub	69	66	67	68	
CBW11	Tokio Hotel	69	66	68	67	
CBW12	Blackbird Cafe	69	75	73	67	
CBW13	Dockside	69	71	69	65	
CBW14	Pontoon Bar	69	72	70	69	
Helm Bar	Helm Bar	69	60	60	60	
HSSC1	Margaritaville	69	49	50	49	
HSSC2	Blue Fish	69	49	50	49	
HSSC3	Waterfront Grill	69	49	50	49	
HSSC4	Olivio	69	50	51	50	
HSSC5	Passello	69	51	51	50	
HSSC6	Watershed	69	52	67	51	
HSSC7	Cyren	69	51	52	52	
HSSC8	Hurricanes	69	52	53	53	
HSSC9	Festival Cafe	69	54	55	54	
HSSC10	Dragon Boat	69	53	53	53	
HSSC11	Criniti's	69	53	53	53	
HSSC12	Thai Foon	69	54	54	54	
HSSC13	Zaaffran	69	54	55	54	
HSSC14	Kamikaze	69	55	55	55	
HSSC15	Cohibar	69	55	55	56	
HSSC16	Hard Rock Cafe	69	55	56	56	
IMAX	IMAX	65	61	60	60	
Madame Tussauds	Madame Tussauds Sydney	70	58	58	58	
Sydney Aguarium	Sydney Aquarium and Wildlife Centre	70	61	60	60	

Table 5-7 Predicted Construction Noise Levels – Cockle Bay Marina

Note 1: Bolded denotes - exceedance of the project-specific noise management level.

6 CONSTRUCTION VIBRATION ASSESSMENT

Activities undertaken during construction may generate ground vibration. With respect to the construction plant identified in Section 5.2, the highest levels of vibration would be expected to occur during construction phases using a piling rig.

Results from vibration monitoring trials of bored piling rigs operating, as previously undertaken by WM, are set out in Table 6-1. These levels were measured at other sites throughout NSW and provide a guide to the levels that may occur due to similar activities undertaken on the subject site. It should be noted however, that actual levels would depend on the specific site geological conditions. The PPV levels in the table are almost the same as the vertical PCPV levels.

Table 6-1 Measured Vibration Levels from Various Construction Plant

6	PPV Vibration Level (mms⁻¹) at Distance					
Source	5m	10m	20m	30m	40m	50m
Bored Piling*	-	0.2	<0.1	-	-	-
Natas y The silvertian level from severy villes is extinized to be similar to be welded.						

Note: * The vibration level from screw piling is anticipated to be similar to bored piling.

As shown in Table 6-1, vibration levels reduce substantially with distance. Based on the vibration levels generated from bored piling, the following can be concluded:

- The separation distances between the closest identified receiver and the Cockle Bay Marine Structures Renewal works sites are sufficient to ensure that these activities would not generate any material vibration impacts;
- There is some potential for exceedance of the human comfort criteria at receivers with less than 10m setback distance from the works, depending on the response of the ground;
- The Sydney Aquarium and the IMAX Theatre are both more than 90m away from the works and the vibration levels are predicted to be in the magnitude of or less than 0.01mm/s. On this basis, the vibration impacts at the Sydney Aquarium and the IMAX Theatre would be minimal and the effect of vibration is unlikely to be felt by humans (refer to Table 4-2); and
- The predicted vibration level of 0.01mm/s at the base of the IMAX Theatre equates to ground-borne noise of well below 35dBA inside the theatre (refer to Section 4.2.3).

For the above reasons, it is recommended that during the early stage of piling vibration measurements are undertaken on site to confirm that piling can comply with the maximum level of 0.56 mm/s at the closest sensitive receiver. This testing should consider the recommendations of *Assessing Vibration: A Technical Guideline*, giving due consideration to the vibration dose method described by the guideline.

7 MITIGATION MEASURES

The analysis reported in this report indicates that vibration levels are likely to comply with reasonable criteria to protect buildings from damage and humans from disturbance. However, some predicted noise levels will exceed the noise management levels identified in the *Interim Construction Noise Guideline* published by the EPA. The exceedances are expected to be small.

During construction works, it is recommended that best practice management strategies are implemented to minimise any potential noise and vibration impacts.

Detailed mitigation measures should be set out in a construction noise and vibration management plan (CNVMP) prepared by the contractor, after the construction process is planned in detail.

WM recommends that the following matters are addressed within the CNVMP:

- Construction hours;
- Noise and vibration monitoring on site and at sensitive receivers;
- Training and awareness of contractors;
- Communication with potentially affected parties;
- Incident and emergency response;
- Non-conformance, preventative and corrective action;
- Notification and negotiation procedures for receivers where noise impact cannot be mitigated to meet the noise management levels;
- A procedure for dealing with and responding to complaints; and
- Development of noise monitoring and auditing procedures to verify compliance with the predicted noise impacts.

WM recommends that the following noise management strategies are considered during the preparation of the CNVMP, which would reduce the potential for noise and vibration issues during construction:

- Respite periods from noise from impact piling;
- Avoiding using noisy plant items simultaneously and/or close together, adjacent to sensitive receivers;
- Using noise source controls, such as the use of residential class mufflers, to reduce noise from all plant and equipment;
- Selecting plant and equipment based on noise emission levels;
- Using alternative construction methods, where this is practicable;
- Consult with potentially affected business owners in the nearby area;
- Provide details of noisy works to businesses prior to commencement;

- Maintaining a suitable complaints register. Should noise complaints be received, they should be immediately investigated and where appropriate, noise monitoring should be undertaken at the locations concerned to determine compliance with the determined construction noise limits. Reasonable and feasible measures would then need to be implemented to reduce any noise impacts; and
- Vibration monitoring of early piling, as discussed in Section 6.

Education and training of site staff is necessary for satisfactory implementation of noise mitigation measures. Education and training strategies should focus on:

- Site awareness training / environmental inductions that include a section on noise mitigation techniques / measures to be implemented throughout the proposal;
- Ensuring work occurs within approved hours;
- Ensuring plant and equipment is well maintained and not making excessive noise; and
- Turning off machinery when not in use.

8 CONCLUSION

Sydney Harbour Foreshore Authority is planning to upgrade the water structures surrounding the Cockle Bay at Darling Harbour in order to allow for better access for the pedestrian and for the waterway to work more effectively and efficiently and create a more open and usable space.

Wilkinson Murray has undertaken a construction noise and vibration assessment for the Project based on likely works staging.

There are four stages of construction that are considered in this assessment, namely:

- Dismantling and removal of the existing structures;
- Removal of the existing Harbourside steps;
- Installation of piles; and
- Installation of new structures.

Noise predictions have been undertaken to determine the potential exceedance of the construction noise management levels, established in-line with the provisions of the NSW *Interim Construction Noise Guideline*. Results have been reported for the sensitive receivers generally deemed representative of the potentially most impacted receivers surrounding the proposed works. The results should be regarded as indicative only and may be updated once comprehensive details of the construction methodology and plant are available.

This construction noise and vibration impact statement has identified that there is potential for exceedances of the established construction noise management levels throughout the stages, particularly during piling.

Provided the works are undertaken with the expected care and diligence it is considered that there would be no material risk of structural damage to properties surrounding the works due to vibration. Furthermore, vibration impact on the marine environment housed in Sydney Aquarium and ground-borne noise impact inside the IMAX Theatre would be minimal. Potential for exceedance of the human comfort vibration criteria has, however, been noted at receivers with a setback distance of less than 30m from the works.

A number of mitigation measures have been identified that, if employed, would be expected to effectively reduce the level of impacts to the most practicable extent. It is recommended that these measures are incorporated within a Construction Noise and Vibration Management Plan (CNVMP) prepared by the contractor, once more certainty surrounding the construction methods and programme exists. In particular, screw piling should be adopted instead of driven piling if practicable.