Georges Cove Marina

Noise and vibration impact assessment

Prepared for Benedict Industries Pty Ltd
April 2019

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Georges Cove Marina

Noise and vibration impact assessment

Report Number

J180179 RP4

Client

Benedict Industries Pty Ltd

Date

4 April 2019

Version

v1 Final

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4 April 2019

This report has been prepared in accordance with the brief provided by the client and has relied upon the information collected at the time and under the conditions specified in the report. All findings, conclusions or recommendations contained in the report are based on the aforementioned circumstances. The report is for the use of the client and no responsibility will be taken for its use by other parties. The client may, at its discretion, use the report to inform regulators and the public.

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1 Introduction

Benedict Industries Pty Ltd (Benedict) proposes to construct and operate a marina and related facilities on part of Lot 7 DP 1065574 (also known as 146 Newbridge Road, Moorebank) in the Liverpool City Council Local Government Area (LGA). The marina development will utilise approximately 13 ha of the 22 ha site adjoining the Georges River. The portion that will be used to develop the marina is referred to as the 'subject site'. The overall site has been used for sand extraction, dredging and recycling operations.

The development will utilise an existing sand extraction dredge pond (approximately 6 ha) as the basis for forming the final marina basin. This will largely remove the need to import fill to restore the landform following the closure of the quarry as is permitted by the existing quarry planning approval.

The architect-designed marina redevelopment will provide an alternative means to implement the final restoration of the extractive industry activity on the site. It is an innovative proposal which is sensitive to the high value riverine locality and will provide valuable community recreational infrastructure which will reconnect the community with the river foreshore.

The proposed development is classified as local development and Liverpool City Council is the consent authority. Development consent is required under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) and pursuant to the provisions of the Liverpool Local Environmental Plan (LEP) 2008 and Development Control Plan (DCP) 2008. The proposal is designated and integrated local development and the Sydney Western City Joint Regional Planning Panel (JRPP) will be the determining authority.

EMM Consulting Pty Limited (EMM) has been commissioned by Benedict to prepare a noise and vibration impact assessment (NVIA) for the proposed marina development.

1.1 Glossary of acoustic terms

A number of technical terms are required for the discussion of noise. These are explained in Table 1.1.

Table 1.1 Glossary of acoustic terms

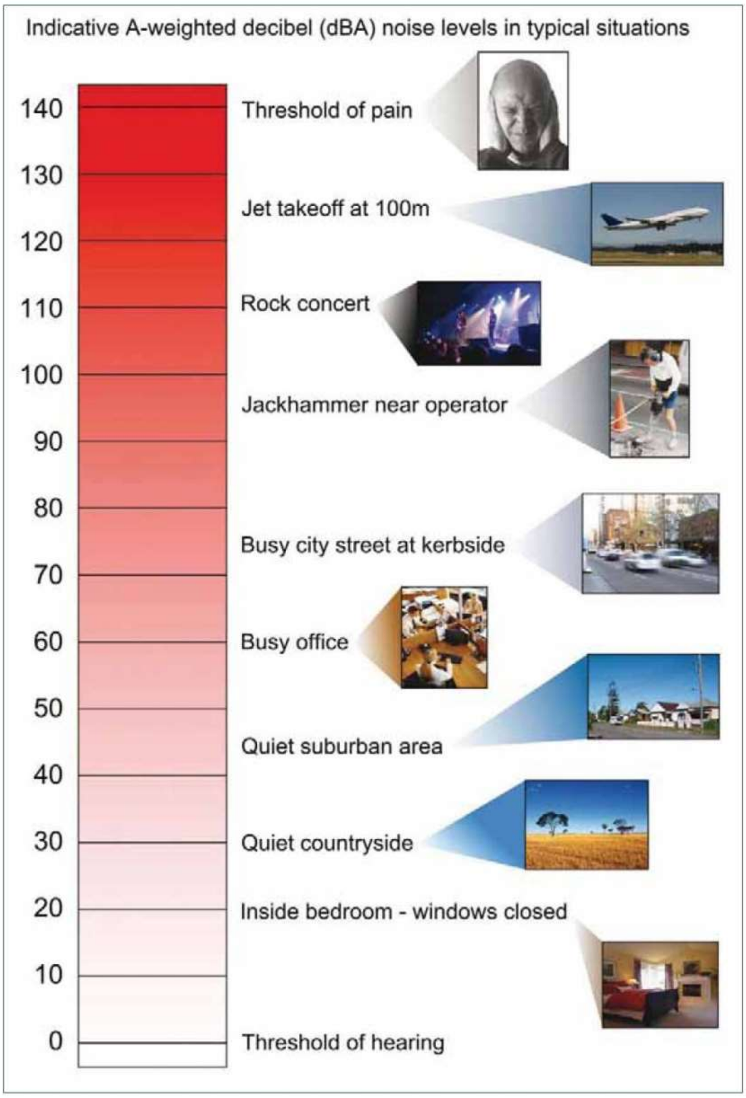
Term	Description
dB(A)	Noise is measured in units called decibels (dB). There are several scales for describing noise, the most common being the 'A-weighted' scale. This attempts to closely approximate the frequency response of the human ear.
L_{A1}	The noise level exceeded for 1% of a measurement period.
L_{A10}	A noise level which is exceeded 10% of the time. It is approximately equivalent to the average of maximum noise levels.
L_{A90}	Commonly referred to as the background noise, this is the level exceeded 90% of the time.
L_{Aeq}	It is the energy average noise from a source and is the equivalent continuous sound pressure level over a given period. The $L_{eq,15min}$ descriptor refers to a L_{Aeq} noise level measured over a 15-minute period.
L_{Amax}	The maximum root mean squared sound pressure level received at the microphone during a measuring interval.
RBL	The Rating Background Level (RBL) is an overall single value background level representing each assessment period over the whole monitoring period.
Sound power level	This is a measure of the total power radiated by a source. The sound power of a source is a fundamental property of the source and is independent of the surrounding environment.
Temperature inversion	A positive temperature gradient. A meteorological condition where atmospheric temperature increases with altitude.

It is useful to have an appreciation of decibel, the unit of noise measurement. Table 1.2 gives an indication as to what an average person perceives about changes in noise levels in the environment.

Table 1.2 Perceived change in noise

Change in sound pressure level (dB)	Perceived change in noise
Up to 2	Not perceptible
3	Just perceptible
5	Noticeable difference
10	Twice (or half) as loud
15	Large change
20	Four times (or quarter) as loud

Examples of common noise levels are provided in Figure 1.1.



Source: Road Noise Policy (Department of Environment, Climate Change and Water 2011).

Figure 1.1 Common noise levels

2 Project description

2.1 Overview

The proposed marina development includes the construction and operation of the following main elements:

- the Maritime Building located near the western boundary of the subject site. This structure will house:
  - a dry berth facility providing 250 berths for small craft;
  - a function centre; and
  - associated kiosks, tourist, entertainment and recreational and club facilities.
- a wet berth facility for 186 small craft (including casual berths) which will consist of:
  - a marina basin;
  - rock protection of the basin and foreshore including embellishment and revegetation of river foreshore;
  - construction of public recreational facilities on the foreshore including bike paths, barbeque facilities and shelters;
  - floating berths and walkways;
  - a petrol tank (about 60,000 L) and a diesel tank (about 60,000 L) and fuel pumping facilities;
  - sewage pump out facilities; and
  - emergency berth access for Marine Area Command (Water Police), NSW Maritime (RMS), medical evacuation and other emergency services.
- three external carparking areas and basement carparking providing a total of 637 car spaces;
- a private Marina Clubhouse on the northern portion of the RE2 (private recreation) zoned land; and
- support infrastructure - power, water and sewerage services.

The proposed site layout is provided in Figure 2.1.

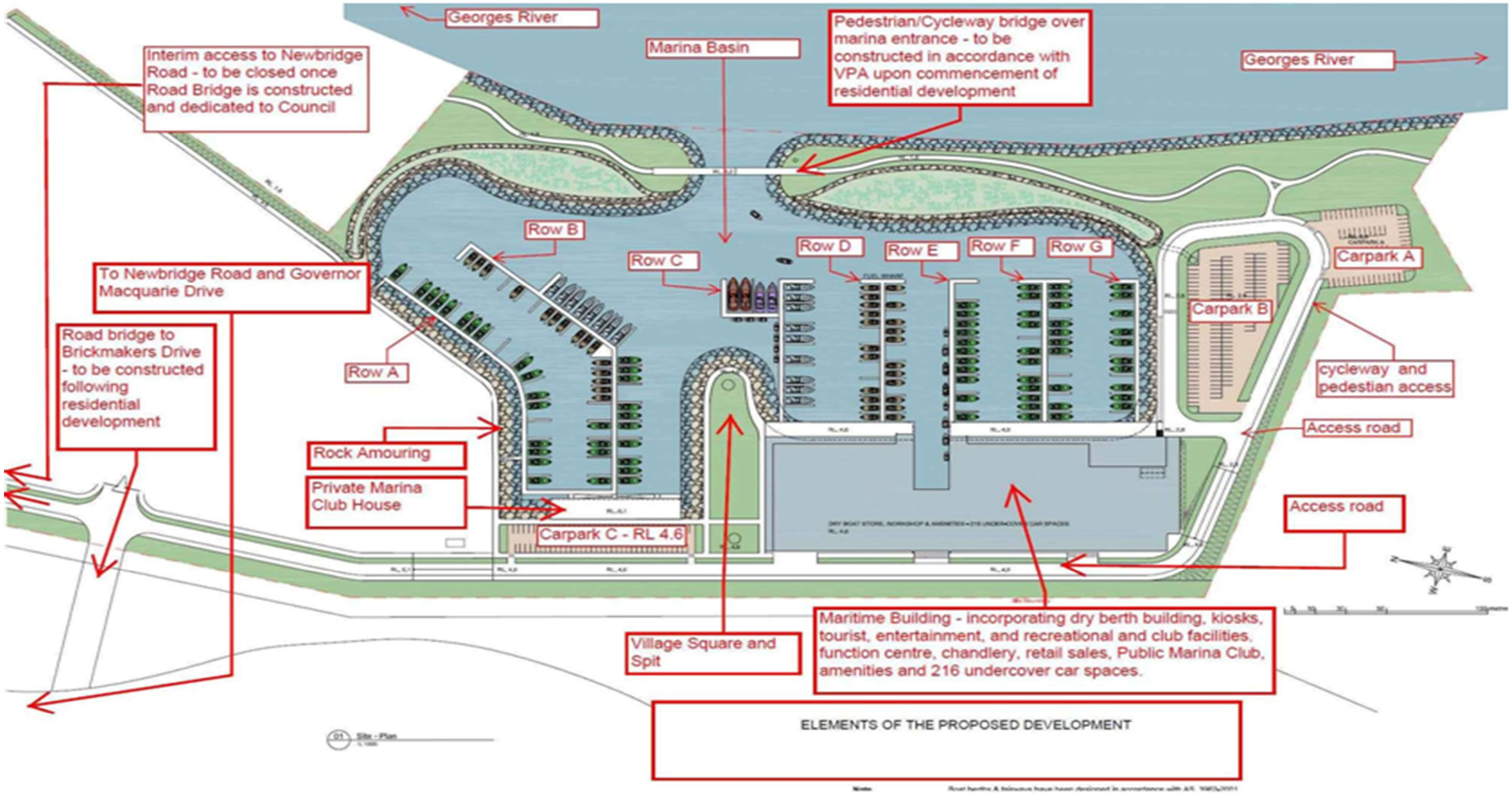


Figure 2.1 Georges Cove Marina layout

2.2 Access and parking

Access to the wet berths will be controlled by access control gates.

Public access to the marina (by car, bicycle and on foot) will be provided during normal operating hours. Equipment and products to the marina will be delivered by road during normal working hours, Monday to Friday.

Vehicular access from Brickmakers Drive to the proposed marina will be provided. The development will incorporate about 637 car spaces. These will be provided in a series of three external parking areas and in basement carparks.

2.3 Hours of operation

The proposed hours of the marina berthing operations are as follows:

- Summer (daylight saving): 7 am to 10 pm seven days a week; and
- Winter (non-daylight saving): 7 am to 10 pm seven days a week.

It is proposed that the private marina clubhouse, marina function centre and associated venues be permitted to operate to 12 am (midnight) as previously approved by the JRPP.

2.4 Site preparation and construction

Construction activities will involve different types of construction methods and equipment. The main activities will be the construction of the hardstands, installation of piling, installation of the pontoon units, and installation of services and access gangways.

The construction phase is expected to take approximately 48 weeks.

Construction will be restricted to standard construction hours including Monday to Friday between 7 am to 5 pm, Saturday between 7 am to 1 pm. No construction will take place on Sundays or public holidays.

There are no existing structures on the site to be removed.

2.5 Key noise and vibration issues

The broad potential noise and vibration issues for the subject site are:

- noise and vibration associated with construction activities;
- noise associated with the marina operations including boat movements and refuelling;
- music and patron noise from the restaurant and function centre precinct; and
- noise associated with the increased traffic to/from the site during construction and operation.

The NVIA has focussed on these potential issues and includes the review of previous background noise monitoring data collected by EMM and other parties in the area surrounding the project, determination of suitable criteria in accordance with government policies and guidelines, and assessment of predicted noise levels and vibration from the project against the relevant criteria.

3 Existing environment

3.1 Assessment locations

The subject site is surrounded by noise sensitive land uses such as existing residential properties and recreational land areas. There is residential development west of Brickmakers Drive and proposed residential development, the Moorebank East residential development, directly north of the subject site.

Noise and vibration have been assessed at nearest representative noise sensitive properties (referred to herein as assessment locations) to quantify potential noise and vibration levels from the site during construction and operation. The representative assessment locations are shown in Figure 3.1 and listed in Table 3.1.

Table 3.1 Assessment locations

ID	Receiver type	Approximate distance from site boundary (m)
R1	Residential	310
R2	Residential	170
R3	Residential	60
R4	Residential	120
R5	Residential	210
R6	Residential	330
R7	Residential	410
R8	Active recreation	270
R9	Residential	370
R10[1]	Residential (future Moorebank East residential development)	1[2]

Notes: 1. Northern site boundary neighbour.
2. At the site boundary.

3.2 Existing noise environment

A key element in assessing environmental noise impact is to quantify the existing ambient and background noise levels at representative assessment locations.

Existing ambient noise levels for the project area have previously been reported in the following reports:

- *Georges Cove Marina – Noise impact Assessment* prepared by EMM dated 17 June 2015;
- *Liverpool City Council v Moorebank Recyclers Pty Ltd & Ors and Benedict Industries Pty Ltd & Ors v Minister for Planning & Ors – L&EC Proceedings No 2016/159652 and 2016/157848 - Expert Evidence of Renzo Tonin – Acoustics* prepared by Renzo Tonin & Associates (Renzo Tonin) for the NSW Land and Environment Court dated 17 August 2016; and
- *Statement of Evidence: Najah Ishac – Benedict industries Pty Limited and Tanlane Pty Ltd v Minister for Planning and Moorebank Recyclers Pty Ltd – Land & Environment Court Proceedings No. 16/*157848 (formerly 2015/10951) prepared by EMM for the NSW Land and Environment Court dated 21 July 2016.

A review of the noise monitoring data presented in these reports showed that the area surrounding the subject site is generally dominated by distant and local traffic, typical suburban or urban noise, occasional aircraft noise and natural noise sources (eg birds and wind in foliage). Background (L_{A90}) noise levels were typically controlled by traffic on Newbridge Road in areas north of the subject site and/or by traffic on Brickmakers Drive.

3.2.1 Unattended noise monitoring

The noise monitoring data, including the rating background noise levels (RBLs), has been used for the purpose of this assessment. A summary of RBLs and ambient (L_{Aeq}) noise levels from previous unattended noise monitoring is shown in Table 3.2. A modified night-time period (10 pm to 12 am) was also adopted for the Office of Liquor, Gaming and Racing (OLGR) music and patron noise assessment purposes.

Table 3.2 Summary of background and ambient noise levels

ID	Monitoring location	Monitoring period	RBL, dB(A)				Ambient (L_{Aeq}) noise level, dB		
			Day	Evening	Night	OLGR night	Day	Evening	Night
L2[1]	41 Martin Cr, Milperra	20/6/15 to 4/6/15	39	40	34	38[2]	53	48	47
L3[1]	28 Elouera Cr, Moorebank	1/5/13 to 9/5/13	42	40	35	38[2]	53	48	45
L4[3]	14 Cotter Ln, Georges Fair	23/3/16 to 7/4/16	41	43	37	40[4]	59	58	54
M8A[5]	71 Horizon Cct, Georges Fair	June 2016 (Weekday and Saturday)	50	-	-	n/a	61	-	-
M8B[5]	99 Travers St, Georges Fair	June 2016 (Weekday and Saturday)	51	-	-	n/a	61	-	-
M11[5]	149 Maddecks Av, Georges Fair	July 2016 (Weekday)	51	-	-	n/a	64	-	-
M12[5]	12 Silverleaf Ln, Georges Fair	July 2016 (Weekday)	44	-	-	n/a	58	-	-
M13[5]	43 Conlon Av, Georges Fair	July 2016 (Weekday)	45	-	-	n/a	63	-	-

Notes:
1. Obtained from EMM's report dated 17 June 2015. Reference ID is consistent with this report.
2. RBL calculated using measured noise data from 10 pm to 12 am for the OLGR assessment.
3. Obtained from the report 'Statement of Evidence: Najah Ishac' dated 21 July 2016, although referenced therein as 'L2'.
4. Mid-point between the evening period RBL and night period RBL as per NSW EPA's NPfI.
5. Obtained from Renzo Tonin's report dated 17 August 2016. Reference ID is consistent with this report.
6. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; evening: 6 pm to 10 pm; night is the remaining periods.
7. Noise levels shown exclude weather affected data.

3.2.2 Attended noise monitoring

Attended noise monitoring data to quantify ambient noise levels at four locations surrounding the site were also referenced from the EMM's noise impact assessment report (2015). Attended noise monitoring results are presented in Table 3.3. Ambient noise data showed that the area surrounding the project was generally dominated by distant and local traffic, typical suburban noise, occasional aircraft noise and natural noise sources (eg birds and wind in foliage). Background noise levels were typically controlled by traffic on Newbridge Road in areas north of the site and/or by traffic on Brickmakers Drive.

Table 3.3 Attended noise monitoring results

ID	Monitoring location	Date	Period[1]	Start time (hours)	Attended measurement 15-minute noise level, dB	
					L_{Aeq}	L_{A90}
A1	Elouera Cr	27/5/15	Day	15:15	54	47
		1/6/15	Night	22:30	44	40
A2	Speare St	27/5/15	Day	16:45	51	41
		1/6/15	Night	22:00	52	42
A3	Martin Cr	1/6/15	Night	23:00	43	38
A4	Moorebank Cove residential	27/5/15	Day	16:00	53	46

Notes: 1. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; evening: 6 pm to 10 pm; night is the remaining periods.

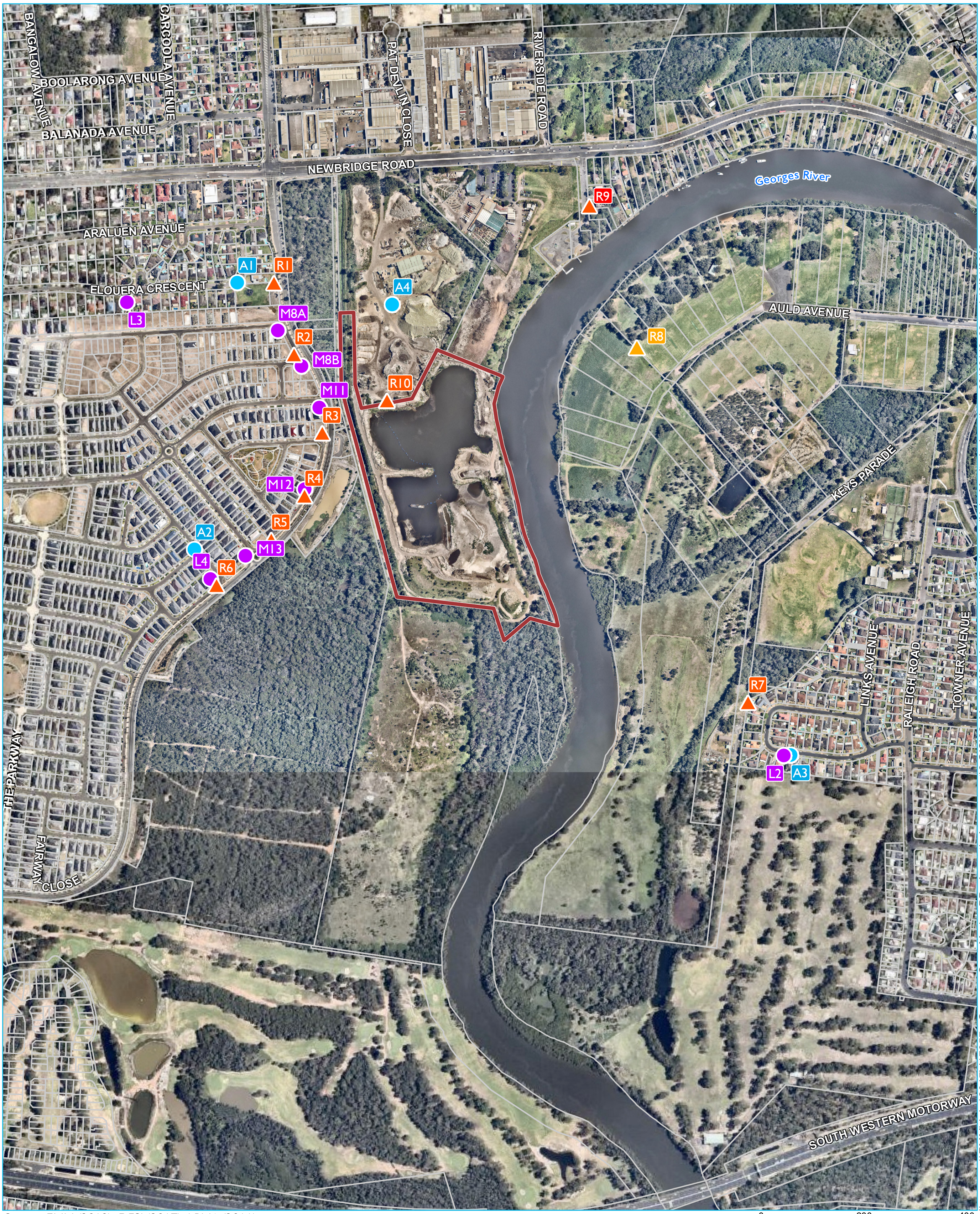
The night-time background noise level spectra (L_{A90}) recorded at locations A1, A2 and A3 as presented in the 2015 EMM report are presented in Table 3.4. These spectra are used as the basis of noise criteria for music and patron noise as required by OLGR (discussed further in Section 4.3).

Table 3.4 Octave band background noise measurement results (EMM 2015)

ID	Location	Date & start time (hours)	Octave band centre frequency (Hz) background noise level ($L_{A90,15min}$), dB									Overall dB(A)
			31.5	63	125	250	500	1k	2k	4k	8k	
A1	Eloura Cr (near R1)	1/6/15 22:30	5	24	30	30	34	37	28	15	12	40
A2	Speare St (near R6)	1/6/15 22:00	8	23	31	32	37	38	30	21	19	42
A3	Martin Cr (near R10)	1/6/15 23:00	5	21	28	31	32	33	23	14	13	38

The noise monitoring was conducted in general accordance with the procedures described in Australian Standard AS 1055-1997, Acoustics - Description and Measurement of Environmental Noise.

Noise monitoring and assessment locations are presented in Figure 3.1.



Source: *EMM (2018); DFSI (2017); LPMA (2011)*

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GDA 1994 MGA Zone 56

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KEY

Assessment location
- Residential
- Active recreation

Noise monitoring location
- Attended
- Long-term
- Site boundary
- Cadastre

Noise monitoring and assessment locations

Georges Cove Marina
Acoustic assessment
Figure 3.1

EMM

3.3 Noise-enhancing meteorological conditions

Noise propagation over distance can be significantly affected by meteorological conditions. Of most interest are source-to-receiver wind, the presence of a temperature inversion or the combination of both, as these conditions can enhance received noise levels. To account for these phenomena, the NSW Environment Protection Authority (EPA) Noise Policy for Industry (NPfI) (2017) specifies the following two options:

1. adopt the noise-enhancing meteorological conditions for all assessment periods for noise impact assessment purposes without an assessment of how often these conditions occur (conservative approach); and

2. determine the significance of noise-enhancing conditions, which is based on a threshold of occurrence of 30%.

3.3.1 Wind

Source-to-receiver wind (as being the directional component of wind) can enhance noise levels from a development at receivers.

The NPfI states that where wind is identified to be a significant feature of the area then assessment of noise impacts should consider the highest wind speed up to 3 m/s, which is considered to prevail for at least 30% of the time. The NPfI defines significant wind as the presence of source-to-receiver wind speed (measured at 10 m above ground level) of 3 m/s or less, occurring for 30% of the time or more in any assessment period and season.

3.3.2 Temperature inversion

The NPfI states that the assessment of the impact of temperature inversion be confined to the night-time noise assessment period where temperature inversions generally occur. Sigma-theta data is required to determine the significance of temperature inversions, that is if they occur for 30% of the time or more during the night period.

3.3.3 Adopted meteorological conditions

The use of both 'standard' and/or 'noise-enhancing' meteorological conditions (NPfI option 2) was adopted for this assessment. Standard and noise-enhancing conditions as presented in Table D1 of the NPfI (EPA 2017) are reproduced in Table 3.5.

Table 3.5 Standard and noise-enhancing meteorological conditions

Meteorological conditions	Meteorological parameters
Standard	Day/evening/night: stability categories A-D with wind speed up to 0.5 m/s at 10 m AGL
Noise-enhancing	Day/evening: stability categories A-D with light winds (up to 3 m/s at 10 m AGL)
	Night: stability categories A-D with light winds (up to 3 m/s at 10 m AGL) and/or stability category F with winds up to 2 m/s at 10 m AGL

Notes: 1. m = metres; m/s - metres per second; AGL = above ground level; stability categories are based on the Pasquill-Gifford stability classification scheme.
2. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; evening: 6 pm to 10 pm; night is the remaining periods.

Noise levels from the marina during construction and operation have been modelled based on the meteorological parameters shown in Table 3.6.

Table 3.6 Meteorological conditions adopted for noise modelling

Assessment period	Meteorological condition	Meteorological parameter	Air temperature	Relative humidity	Wind speed	Wind direction	Stability category
Day	Standard	Calm	15°C	70%	0 m/s	N/A	D class
	Noise-enhancing	Wind	15°C	70%	3 m/s	W, WNW	D class
Evening and night	Standard	Calm	10°C	70%	0 m/s	N/A	D class
	Noise-enhancing	Wind	10°C	70%	3 m/s	Source-to-receiver	D class
		Temperature inversion	10°C	70%	0 m/s	N/A	F class

4 Assessment criteria

4.1 Operational noise

Noise from industrial sites or processes in NSW are regulated by the local council, the Department of Planning and Environment (DPE) and/or the EPA. A licence will be required stipulating noise limits if the development is considered to be a scheduled activity under the *Protection of the Environment Operations Act 1997* (POEO Act). These limits are generally derived from operational noise trigger levels applied at assessment locations. They are based on NPfI guidelines (EPA 2017) or noise levels that can be achieved at a specific site following the application of all reasonable and feasible noise mitigation.

The NPfI guidelines for assessing industrial facilities have been used for this assessment. With respect to the noise trigger levels, the NPfI states:

> The project noise trigger level provides a benchmark or objective for assessing a proposal or site. It is not intended for use as a mandatory requirement. The project noise trigger level is a level that, if exceeded, would indicate a potential noise impact on the community.

Regarding decisions on developments, The NPfI also states:

> Planning decisions for proposed developments take into account social, economic and environmental factors. Noise impact is one factor taken into account and decisions can be made that result in residual noise impacts.

The objectives of noise assessment noise trigger levels for industrial facilities are to protect the community from excessive intrusive noise and preserve amenity for specific land uses.

To ensure these objectives are met, the EPA provides two separate noise trigger levels: intrusiveness noise level and amenity noise level. These are discussed further in the following sections.

4.1.1 Intrusiveness

The intrusiveness noise trigger levels require that $L_{Aeq,15min}$ noise levels from the subject site during the relevant operational periods (ie day, evening and night) do not exceed the RBL by more than 5 dB at any residence.

The RBLs adopted for residences are based on the review of unattended noise data provided in Table 3.2 presents the intrusiveness noise levels determined for the project based on the RBLs adopted for all residences surrounding the site.

Table 4.1 Intrusiveness noise levels

Residence and relevant noise logger location[1]	Adopted RBL, dB(A)			Intrusiveness $L_{Aeq,15\,min}$ noise level, dB		
	Day	Evening	Night	Day	Evening	Night
R1 (Day RBL from M8A and evening/night RBLs from L3)	50	40	35	55	45	40
R2 (Day RBL from M8B and evening/night RBLs from L3)	51	40	35	56	45	40
R3 (Day RBL from M11 and evening/night RBLs from L4)	51	43	37	56	48	42
R4 (Day RBL from M12 and evening/night RBLs from L4)	44	43	37	49	48	42
R5 (Day RBL from M13 and evening/night RBLs from L4)	45	43	37	50	48	42

Table 4.1 Intrusiveness noise levels

Residence and relevant noise logger location[1]	Adopted RBL, dB(A)			Intrusiveness $L_{Aeq,15\ min}$ noise level, dB		
	Day	Evening	Night	Day	Evening	Night
R6 (RBLs from L4)	41	41[2]	37	46	46	42
R7 (RBLs from L2)	39	39[2]	34	44	44	39
R9 (RBLs from L3)	42	40	35	47	45	40
R10 (Day RBL from M8B and evening/night RBLs from L3)	51	40	35	56	45	40

Notes: 1. Refer to Figure 3.1.
2. In accordance with the NPfI, the RBL for day has been adopted for the evening period since the measured RBL during the evening was higher than that for daytime.
3. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; Evening: 6 pm to 10 pm; Night: all remaining periods.
4. R8 is not a residential assessment location and hence not listed above.

4.1.2 Amenity

The assessment of amenity is based on noise trigger levels specific to the land use. The noise trigger levels relate only to industrial noise and exclude road or rail noise.

Residential assessment locations potentially affected by the subject site have been categorised in the NPfI 'suburban' amenity category, in accordance with the definitions provided in Table 2.3 of the NPfI (EPA 2017). The NPfI states:

> Suburban – an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry. This area often has the following characteristic: evening ambient noise levels defined by the natural environment and human activity.

The corresponding recommended amenity noise trigger levels for the subject site are given in Table 4.2. It is noted that no adjustment to the recommended amenity L_{Aeq} noise level was necessary during all periods since there are no existing or future industrial sites in the area surrounding the subject development that could generate additional industrial noise at the assessment locations. It is noted that the Moorebank Recycling consent applicable to the property immediately to the south of the subject site has lapsed and any future development on this land cannot be industrial. This land remains vacant at the present time and we understand there is no current DA with Council for development of any kind.

Table 4.2 Amenity noise trigger levels

Assessment location	Indicative area	Time period	Recommended noise level, $L_{Aeq,period}$, dB
Residential (R1 to R7, R9 to R10)	Suburban	Day	55
		Evening	45
		Night	40
Active recreation (R8)	All	When in use	55

Notes: 1. In accordance with Table 2.2 of the NPfI (EPA 2017).

4.1.3 Project noise trigger levels

The project noise trigger levels (PNTLs) are the lower of the calculated intrusive or amenity noise trigger levels and is provided in Table 4.3 for all assessment locations.

Table 4.3 Project noise trigger levels

Assessment location	Intrusiveness $L_{Aeq,15min}$ noise level, dB			Amenity $L_{Aeq,15min}$ noise level[1], dB			PNTL $L_{Aeq,15min}$, dB		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
R1 - Residence	**55**	**45**	**40**	58	48	43	55	45	40
R2 - Residence	**56**	**45**	**40**	58	48	43	56	45	40
R3 - Residence	**56**	**48**	**42**	58	**48**	43	56	48	42
R4 - Residence	**49**	**48**	**42**	58	**48**	43	49	48	42
R5 - Residence	**50**	**48**	**42**	58	**48**	43	50	48	42
R6 - Residence	**46**	**46**	**42**	58	48	43	46	46	42
R7- Residence	**44**	**44**	**39**	58	48	43	44	44	39
R8 - Milperra sports fields	N/A	N/A	N/A	58 (when in use)			58 (when in use)		
R9 - Residence	**47**	**45**	**40**	58	48	43	47	45	40
R10 - Future residences	**56**	**45**	**40**	58	48	43	56	45	40

Notes: 1. Project amenity $L_{Aeq,15min}$ noise level is the recommended amenity noise level $L_{Aeq,period}$ + 3 dB as per the NPfI (EPA 2017).
2. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; evening: 6 pm to 10 pm; night is the remaining periods.
3. Value in bold font and underlined is the lower of the intrusiveness and amenity noise levels.

4.2 Sleep disturbance

It has been assumed that the subject site will operate during the night-time period from 10 pm to 12 am and therefore the assessment of potential sleep disturbance from night-time operational noise and maximum noise level events (eg from car movements) at residences is required in accordance with the NPfI. Sleep disturbance is defined in the NPfI as both awakenings and disturbance to sleep stages.

The NPfI provides the following sleep disturbance noise trigger levels for residences:

- $L_{Aeq,15min}$ 40 dB or the prevailing RBL plus 5 dB, whichever is the greater; and/or
- L_{Amax} 52 dB or the prevailing RBL plus 15 dB, whichever is the greater.

A detailed maximum noise level event assessment is required if at least one of these trigger levels is exceeded. The detailed assessment should cover the maximum noise level, the extent to which the maximum noise level exceeds the RBL, and the number of times this happens during the night-time period. Some further guidance in regard to potential impact on sleep is provided in the NSW Department of Environment, Climate Change and Water (DECCW) *Road Noise Policy* (RNP) (2011).

The RNP calls upon a number of studies that have been conducted into the effect of maximum noise levels on sleep, and provides the following factors that are key in assessing the extent of impacts on sleep:

- how often high noise events would occur;
- the distribution of likely events across the night-time period and the exiting ambient maximum events in the absence of the project;
- whether there are times of day when there is a clear change in the noise environment (such as during early-morning shoulder periods); and

- current scientific literature available at the time of the assessment regarding the impact of maximum noise level events at night.

The sleep disturbance noise trigger levels for the residential assessment locations are shown in Table 4.4.

Table 4.4 Sleep disturbance noise trigger levels - residential assessment locations

Assessment location	Adopted RBL, dB(A)[1]	Recommended sleep disturbance noise trigger levels	
		$L_{Aeq,15min}$, dB Standard or RBL +5	L_{Amax}, dB Standard or RBL +15
R1 - Residence	35	40	52
R2 - Residence	35	40	52
R3 - Residence	37	42	52
R4 - Residence	37	42	52
R5 - Residence	37	42	52
R6 - Residence	37	42	52
R7- Residence	34	40	52
R9 - Residence	35	40	52
R10 - Future residences[1]	35	40	52

Notes: 1. Night-time RBLs adopted.

4.3 Music and patron noise

Noise from licensed venues is governed by the OLGR. The noise criteria for music and patron noise that would apply to the member and function centre precinct are as per the OLGR standard noise condition, which states:

> The LA10 noise level emitted from the licensed premises shall not exceed the background noise level in any Octave Band Centre Frequency (31.5Hz–8kHz inclusive) by more than 5dB between 7 am and midnight at the boundary of any affected residence.
>
> The LA10 noise level emitted from the licensed premises shall not exceed the background noise level in any Octave Band Centre Frequency (31.5Hz–8kHz inclusive) between midnight and 7 am 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 and 7 am.
>
> For the purpose of this condition, the LA10 can be taken as the average maximum deflection of the noise emission from the licensed premises.

Music and patron noise have been assessed at all assessment locations for the day, evening and night (between 10 pm and 12 am only) periods. The OLGR noise criteria for each period has been set by offsetting the measured short-term $L_{A90,15min}$ spectrum (refer to Table 3.4) with the respective adopted RBL derived using the long-term noise monitoring results and are shown in Table 4.5.

Table 4.5 OLGR music and patron noise criteria

ID	Period	Octave band centre frequency (Hz) noise criteria ($L_{10,15min}$)									Overall dB(A)
		31.5	63	125	250	500	1k	2k	4k	8k	
R1 (A2 Spectra)	Day	12	31	37	37	41	44	35	22	19	55
	Evening	10	5	5	5	5	5	5	5	5	45
	Night	8	3	3	3	3	3	3	3	3	43
R2 (A3 Spectra)	Day	23	33	39	39	43	46	37	24	21	56
	Evening	12	33	39	39	43	46	37	24	21	45
	Night	10	32	38	38	42	45	36	23	20	43
R3 (A3 Spectra)	Day	23	39	46	49	50	51	41	32	31	56
	Evening	15	31	38	41	42	43	33	24	23	48
	Night	12	28	35	38	39	40	30	21	20	45
R4 (A3 Spectra)	Day	16	32	39	42	43	44	34	25	24	49
	Evening	15	31	38	41	42	43	33	24	23	48
	Night	12	28	35	38	39	40	30	21	20	45
R5 (A3 Spectra)	Day	17	33	40	43	44	45	35	26	25	50
	Evening	15	31	38	41	42	43	33	24	23	48
	Night	12	28	35	38	39	40	30	21	20	45
R6 (A3 Spectra)	Day	13	29	36	39	40	41	31	22	21	46
	Evening	15	31	38	41	42	43	33	24	23	48
	Night	12	28	35	38	39	40	30	21	20	45
R7 (A3 Spectra)	Day	11	27	34	37	38	39	29	20	19	44
	Evening	11	27	34	37	38	39	29	20	19	44
	Night	10	26	33	36	37	38	28	19	18	42
R9 (A1 Spectra)	Day	10	26	33	36	37	38	28	19	18	47
	Evening	8	24	31	34	35	36	26	17	16	45
	Night	6	22	29	32	33	34	24	15	14	43
R10 (A3 Spectra)	Day	23	42	48	48	52	55	46	33	30	56
	Evening	12	31	37	37	41	44	35	22	19	45
	Night	10	29	35	35	39	42	33	20	17	43

Notes: 1. For the OLGR assessment, the day period of 7 am to 6 pm, evening period of 6 pm to 10 pm and night period of 10 pm to 12 am (midnight) have been adopted.
2. Night-time L_{A90} octave band noise spectra have been adopted for all periods and offset to the respective day, evening and night RBL from Table 3.4. For the night period, the RBL from 10 pm to 12 am (midnight) has been adopted to align with the proposed operating hours and the OLGR assessment periods.

4.4 Construction noise

The NSW Department of Environment and Climate Change (DECC) *Interim Construction Noise Guidelines* (ICNG) (2009) provides guidelines for the assessment and management of noise from construction works. This assessment has adopted the ICNG quantitative approach.

4.4.1 Noise management level

The ICNG suggests the following time restrictions for construction activities where noise is audible at residential premises:

- Monday to Friday: 7 am−6 pm;
- Saturday: 8 am−1 pm; and
- no construction work is to take place on Sundays or public holidays.

Table 4.6 is an extract from the ICNG (DECC 2009) and provides noise management levels (NMLs) for residential receivers for day and out-of-hours periods. These time restrictions are the primary management tool of the ICNG.

Table 4.6 ICNG residential NMLs

Time of day	Noise management level $L_{Aeq,15min}$	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm, Saturday 8 am to 1 pm, No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq,15\text{-}min}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75 dB	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: i) times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences; and ii) if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours (out-of-hours)	Noise affected RBL +5 dB	• A strong justification would typically be required for works outside the recommended standard hours. • The proponent should apply all feasible and reasonable work practices to meet the noise affected level. • Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community. • For guidance on negotiating agreements see Section 7.2.2.

In summary, the ICNG NMLs for activities during the standard hours are 10 dB above the RBLs. For activities outside of the recommended standard hours (out-of-hours), construction noise levels should be no more than 5 dB above the RBLs. It is expected that construction will occur during standard hours only.

The construction NMLs for residential and other land uses for the proposal are provided in Table 4.7.

Table 4.7 Construction NMLs (standard hours)

Assessment location (land use)	Day RBL, dB(A)	NML, $L_{Aeq,15min}$, dB
R1 (residential)	50	60
R2 (residential)	51	61
R3 (residential)	51	61
R4 (residential)	44	54
R5 (residential)	45	55
R6 (residential)	41	51
R7 (residential)	39	49
R8 (active recreation)	n/a	65
R9 (residential)	42	52
R10 (future residential)	51	61

4.5 Construction vibration

4.5.1 Human Comfort

i General discussion on human perception of vibration

Vibration levels which are well below those causing any risk of damage to a building or its contents can be felt by humans. 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 4.8.

Table 4.8 Peak vibration levels and human perception of motion

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
1.0 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6.0 mm/s	Strongly noticeable
14.0 mm/s	Very strongly noticeable

Notes: 1. These approximate vibration levels (in floors of building) are for vibration having a frequency content in the range of 8 Hz to 80 Hz.

Table 4.8 suggests that people can barely start to feel floor vibration at levels as low as 0.15 mm/s and that the motion becomes "noticeable" at a level of approximately 1.0 mm/s.

ii Assessing vibration: a technical guideline

The NSW Department of Environment and Conservation (DEC) guideline *Environmental Noise Management – Assessing Vibration: A Technical Guideline* (2006) is based on guidelines contained in British Standards BS 6472-2008 Evaluation of human exposure to vibration in buildings (1-80Hz).

The guideline presents preferred and maximum vibration values for use in assessing human responses to vibration and provides recommendations for measurement and evaluation techniques. At vibration values below the preferred values, there is a low probability of adverse comment or disturbance to building occupants. Where all feasible and reasonable mitigation measures have been applied and vibration values are still beyond the maximum value, it is recommended the operator negotiate directly with the affected community.

The guideline defines three vibration types and provides direction for assessing and evaluating the applicable criteria. Table 2.1 of the guideline provides examples of the three vibration types and has been reproduced in Table 4.9.

Table 4.9 Types of vibration

Continuous vibration	Impulsive vibration	Intermittent vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period (eg occasional dropping of heavy equipment, occasional loading and unloading). Blasting is assessed using ANZECC (1990).	Trains, intermittent nearby construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer these would be assessed against impulsive vibration criteria.

The type of vibration of relevance to the proposed development is intermittent vibration hence, continuous and impulsive vibration have not been discussed further.

iii Intermittent vibration

Intermittent vibration (as defined in Section 2.1 of the guideline) is assessed using the vibration dose concept which relates to vibration magnitude and exposure time. Intermittent vibration is representative of activities such as impact hammering, rolling or general excavation work (eg excavator tracking).

Section 2.4 of the guideline provides acceptable values for intermittent vibration in terms of vibration dose values (VDV) which requires the measurement of the overall weighted root mean square (rms) acceleration levels over the frequency range 1 Hz to 80 Hz. To calculate the VDV, the following formula is used (refer Section 2.4.1 of the guideline):

$$VDV = \left[\int_0^T a^4(t)dt \right]^{0.25}$$

Where VDV is the vibration dose value in $m/s^{1.75}$, *a (t)* is the frequency-weighted rms of acceleration in m/s^2 and *T* is the total period of the day (in seconds) during which vibration may occur.

The acceptable VDV for intermittent vibration are reproduced in Table 4.10. There is a low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values. Adverse comment or complaints may be expected if vibration values approach the maximum values. The guideline states that activities should be designed to meet the preferred values where an area is not already exposed to vibration.

Table 4.10 Acceptable vibration dose values for intermittent vibration

Location	Daytime		Night-time	
	Preferred value, $m/s^{1.75}$	Maximum value, $m/s^{1.75}$	Preferred value, $m/s^{1.75}$	Maximum value, $m/s^{1.75}$
Critical Areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes: 1. Daytime is 7 am to 10 pm and night-time is 10 pm to 7 am.
2. These criteria are indicative only, and there may be a need to assess intermittent values against continuous or impulsive criteria for critical areas.

4.5.2 Structural vibration criteria

Most commonly specified 'safe' structural vibration limits are designed to minimise the risk of threshold or cosmetic surface cracks, and are set well below the levels that have potential to cause damage to the main structure.

In terms of the most recent relevant vibration damage criteria, Australian Standard AS 2187.2-2006 – Explosives - Storage and Use - Use of Explosives (the standard) recommends the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 Evaluation and Measurement for Vibration in Buildings Part 2 be used as they are "applicable to Australian conditions".

The standard sets guide values for building vibration based on the lowest vibration levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (eg compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

The recommended limits (guide values) for transient vibration to ensure minimal risk of cosmetic damage to residential and commercial/industrial buildings are presented numerically in Table 4.11 and graphically in Figure 4.1.

Table 4.11 Transient vibration guide values - minimal risk of cosmetic damage

Line	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s	50 mm/s
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

The standard states that the guide values in Table 4.11 relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

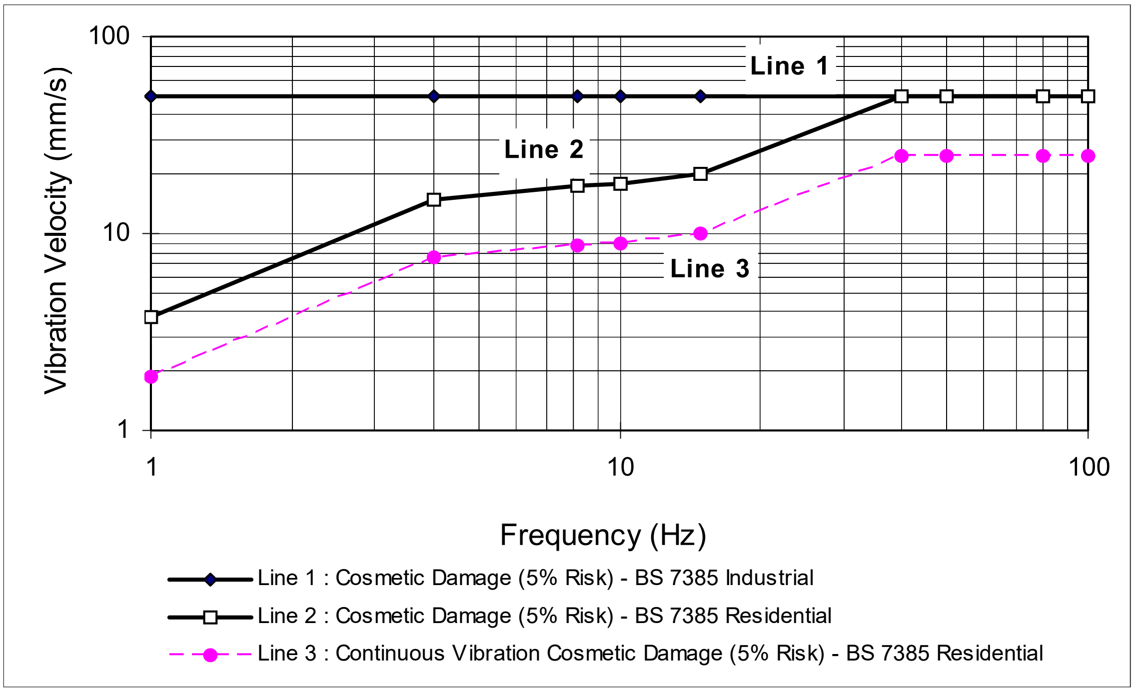


Figure 4.1 Graph of transient vibration guide values for cosmetic damage

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

The standard goes on to state that minor damage is possible at vibration magnitudes which are greater than twice those given in Table 4.11, and major damage to a building structure may occur at values greater than four times the tabulated values.

Fatigue considerations are also addressed in the standard and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in Table 4.11 should not be reduced for fatigue considerations.

In order to assess the likelihood of cosmetic damage due to vibration, the standard specifies that vibration should be measured at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) should be compared with the criteria curves presented in Table 4.11.

It is noteworthy that extra to the guide values nominated in Table 4.11, the standard states that:

> Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK.

The standard also states that:

> A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive.

4.6 Road traffic noise

The potential impacts of traffic noise resulting from both construction and operational related traffic on public roads are assessed against criteria defined in the RNP (DECCW 2011). The application of appropriate criteria for the subject site has followed the two-step process identifying the assessment and relative increase criteria as outlined in Section 3.4.1 of the RNP.

Table 4.12 presents the road traffic noise assessment criteria for residential land uses, reproduced from Table 3 of the RNP (DECCW 2011).

Table 4.12 Road traffic noise assessment criteria for residential land uses

Road category	Type of project/development	Assessment criteria dB	
		Day (7 am–10 pm)	Night (10 pm–7 am)
Freeway/arterial/ sub-arterial roads	Existing residences affected by noise from new freeway/arterial/sub-arterial road corridors. Existing residences affected by noise from new freeway/arterial/sub-arterial road corridors. Existing residences affected by additional traffic on existing freeway/arterial/sub-arterial roads generated by land use developments.	$L_{Aeq,15hr}$ 60 (external)	$L_{Aeq,9hr}$ 55 (external)
Local roads	Existing residences affected by noise from new local road corridors. Existing residences affected by noise from redevelopment of existing local roads. Existing residences affected by additional traffic on existing local roads generated by land use developments.	$L_{Aeq,1hr}$ 55 (external)	$L_{Aeq,1hr}$ 50 (external)

Additionally, the RNP states where existing road traffic noise criteria are already exceeded, any additional increase in total traffic noise level should be limited to 2 dB.

The $L_{Aeq,1hr}$ is the road traffic noise level associated with the peak one-hour traffic period of interest, day or night. The 'local roads' category for Brickmakers Drive has been conservatively adopted, although this road joins sub-arterial roads at both ends and takes traffic from one locality to another.

5 Noise modelling and assessment

5.1 Operations

This section presents the methods and assumptions used to model noise levels from the operation of the subject site.

Noise levels from the site's operation was modelled using Brüel & Kjær Predictor software. 'Predictor' can calculate total noise levels at assessment locations from the concurrent operation of multiple noise sources. The model considers factors such as:

- the lateral and vertical location of noise sources;
- source to assessment location distances;
- ground effects;
- atmospheric absorption;
- topography of the subject site and surrounding area; and
- applicable meteorological conditions (refer to Section 3.3).

Operational noise sources and activities included in the Georges Cove Marina model included on-site car and delivery truck movements, boat movements, refuelling and general boat storage and marina operation. Noise levels over a typical worst case 15-minute scenario were modelled and assessed against NPfI and OLGR noise criteria (where relevant).

5.1.1 Noise sources and operating assumptions

i NPfI assessment

Noise sources, and their quantities over day, evening and night periods (10 pm to 12 am only), and associated sound power levels are presented in Table 5.1. The list of sources is based on advice from the proponent and benchmarked against similar facilities. Sound power levels have been sourced from an EMM database which has been developed from measurements taken at similar facilities. Where measurement data was not available, data was sourced from published sound power level data.

Table 5.1 Operational noise source quantities and sound power levels

Modelled noise source	Quantity over worst-case 15-minute period			Individual sound power level, dB re 10^{-12} watts	
	Day	Evening	Night[1]	$L_{Aeq,15min}$	L_{Amax}[2]
Boat idling/slow moving	10	10	-	95	n/a[3]
Refuelling pump	1	1	-	94	n/a[3]
Chiller	2	2	2	89	n/a[4]
Car	5	5	5	89	97[5]
Delivery truck	1	-	-	102	n/a[3]
Workshop activity	1	-	-	98	n/a[3]
Forklift	1	1	-	104	n/a[3]

Notes: 1. Between 10 pm to 12 am only.
2. L_{Amax} sound power level is used for the sleep disturbance assessment during the night period only.
3. Steady state noise source unlikely to generate sleep disturbance impacts.
4. Day and evening operation only – sleep disturbance assessment is not applicable.
5. L_{Amax} sound power level of a car starting which is representative of the loudest noise event from this noise source.

In addition to the above, the following assumptions have been considered in the operational noise model:

- boats will be spread evenly at worst-case operating locations relative to surrounding assessment locations and are assumed to operate for 5 minutes in any 15-minute period;
- workshop activity and the forklift use are assumed in the marina buildings continuously for 15 minutes with all windows and doors (as applicable) closed;
- all other noise sources are assumed to operate continuously for 15 minutes at typical worst-case operating locations relative to assessment locations; and
- a 2 m high acoustic barrier is proposed to be constructed to the west of the carpark as indicated in Figure 5.1. This is to mitigate carpark activity during the night-time period (10 pm to 12 am only).

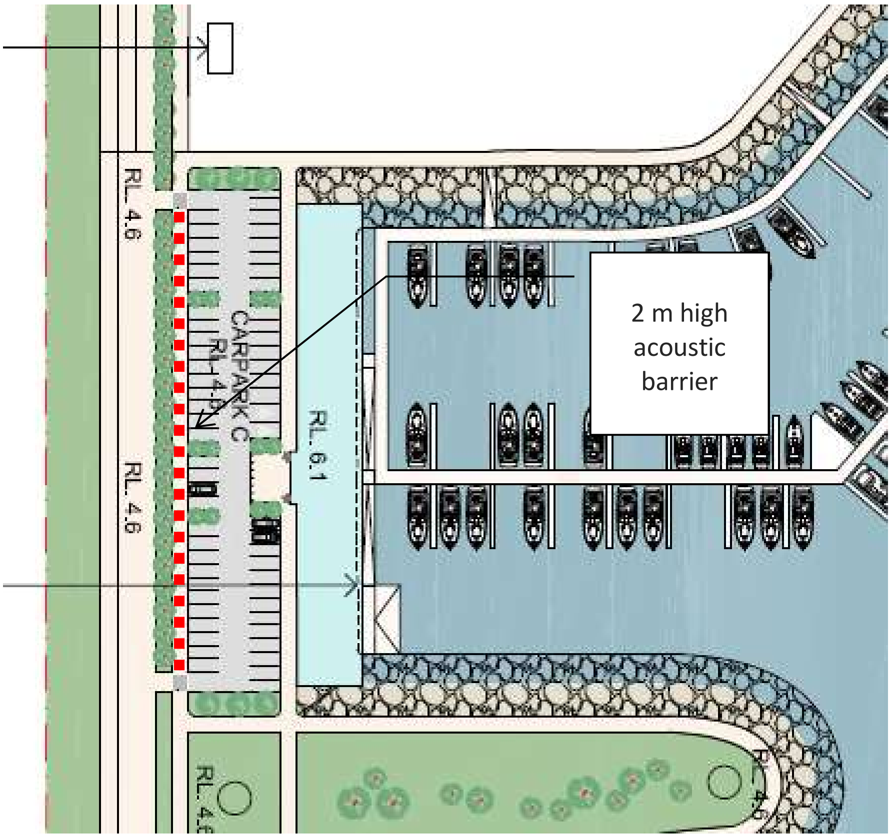


Figure 5.1 Indicative acoustic barrier location

ii OLGR assessment

Source levels adopted for the music and patron noise assessment are presented in Table 5.2. The music source level is based on an internal reverberant sound pressure level measurement of a live band at a private function. The patron noise sound power level has been adopted based on data available in published documents and EMM measurement database.

It is worth noting that there are many factors that can influence the magnitude of patron noise, including number and mix of people, behaviour, age group, demographic, level of alcohol consumption and the level of background noise, to name a few. Therefore, it is difficult to apply a typical sound power level based on the number of people alone. Conservative sound power levels have been adopted to account for potential high patron noise levels which are appropriate given the capacity of the marina function and public spaces.

Table 5.2 Music and patron octave band centre frequency noise levels

Description	Assessed music and patron noise levels ($L_{A10,15min}$), Hz									Overall dB(A)
	31.5	63	125	250	500	1k	2k	4k	8k	
Music noise, Lp,rev[1]	58	69	76	81	83	86	83	79	75	90
Patron noise sound power level (large crowd >20 patrons)	-	70	81	81	87	89	83	75	-	93
Patron noise sound power level (small crowd <20 patrons)	-	66	77	77	83	86	80	71	-	89

Notes: 1. Internal reverberant sound pressure level.

5.1.2 Noise modelling results and discussion

i NPfI assessment

Predicted operational $L_{Aeq,15min}$ and maximum (night-time) L_{Amax} noise levels from the site at all assessment locations are provided in Table 5.3. Noise levels have been predicted based on the meteorological conditions provided in Table 3.6.

Table 5.3 NPfI operational and sleep disturbance noise level predictions

Assessment location	Period	Predicted $L_{Aeq,15min}$ noise level, dB		Predicted L_{Amax} noise level, dB		Criteria		
		Calm	Adverse	Calm	Adverse	PNTL, $L_{Aeq,15min}$	Sleep disturbance	
							$L_{Aeq,15min}$	L_{Amax}
R1	Day	38	n/a	n/a	n/a	55	n/a	n/a
	Evening	37	39	n/a	n/a	45	n/a	n/a
	Night	33	35	41	43	40	40	52
R2	Day	41	n/a	n/a	n/a	56	n/a	n/a
	Evening	41	42	n/a	n/a	45	n/a	n/a
	Night	38	39	46	47	40	40	52
R3	Day	43	n/a	n/a	n/a	56	n/a	n/a
	Evening	41	42	n/a	n/a	48	n/a	n/a
	Night	38	39	45	47	42	42	52
R4	Day	42	41	n/a	n/a	49	n/a	n/a
	Evening	39	41	n/a	n/a	48	n/a	n/a
	Night	37	38	44	46	42	42	52
R5	Day	34	n/a	n/a	n/a	50	n/a	n/a
	Evening	32	34	n/a	n/a	48	n/a	n/a
	Night	31	33	37	39	42	42	52
R6	Day	34	32	n/a	n/a	46	n/a	n/a
	Evening	31	34	n/a	n/a	46	n/a	n/a
	Night	30	33	38	40	42	42	52
R7	Day	34	37	n/a	n/a	44	n/a	n/a
	Evening	34	37	n/a	n/a	44	n/a	n/a
	Night	<30	<30	33	36	39	40	52

Table 5.3 NPfI operational and sleep disturbance noise level predictions

Assessment location	Period	Predicted $L_{Aeq,15min}$ noise level, dB		Predicted L_{Amax} noise level, dB		Criteria		
		Calm	Adverse	Calm	Adverse	PNTL, $L_{Aeq,15min}$	Sleep disturbance	
							$L_{Aeq,15min}$	L_{Amax}
R8	When in use	39	41	n/a	n/a	58	n/a	n/a
R9	Day	36	38	n/a	n/a	47	n/a	n/a
	Evening	36	38	n/a	n/a	45	n/a	n/a
	Night	<30	<30	31	34	40	40	52
R10	Day	54	54	n/a	n/a	56	n/a	n/a
	Evening	**54**	**54**	n/a	n/a	45	n/a	n/a
	Night	37	38	45	46	40	40	52

Notes: 1. Predicted noise level shown in bold with grey shading indicated exceedance of the PSNL.

Predicted noise levels satisfy the PNTLs at all assessment locations during all periods, with the exception of R10 during the evening period for calm and adverse weather conditions.

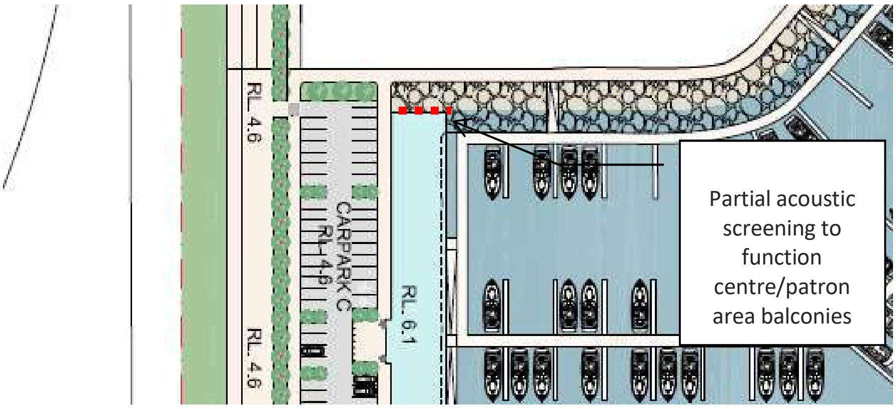
The predicted noise level above the PNTL at R10 is caused by boat movements directly south of this assessment location. It is anticipated however that noise controls (eg buffers, architectural noise screening etc) would be incorporated in the future Moorebank East residential development (represented by R10) which would mitigate marina noise activity. We understand that development of the marina and the Moorebank East residential area will likely be completed by the same or related entity. Hence there is good opportunity to work collaboratively to achieve a practical outcome for noise.

Predicted noise levels satisfy the sleep disturbance criteria at all assessment locations.

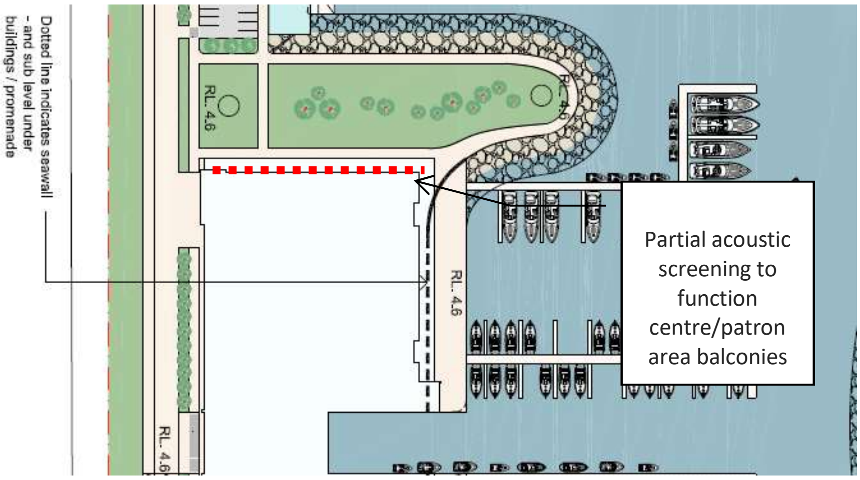
ii Music and patron noise assessment

Music and patron noise levels from the site were predicted at the nearest boundary of all assessment locations. The predictions are based on the following main assumptions:

- a live band (or similar) is located inside each function room generating the sound power level presented in Table 5.2;
- function room windows are assumed closed with standard 4 mm glazing;
- patrons are located externally on outdoor areas and are at capacity. Outdoor area capacity has been assumed as the total external seating as indicated in the DA drawings for each respective outdoor area; and
- the north outdoor areas indicated in Figure 5.2 have the option for partial screening (eg louvres) providing at least 7 dB of patron noise reduction.



Clubhouse



Marina Building

Figure 5.2 Acoustic screening

A comparison of modelled noise levels at each assessment location to OLGR criteria (refer to Table 4.5) is presented in Table 5.4. The results provided in Table 5.4 represent the level of noise above the OLGR criteria. Compliance with the OLGR criteria is therefore indicated by a zero. Noise levels presented are based on the highest predicted noise level from all assessed meteorological conditions provided in Table 3.6.

Table 5.4 Predicted music and patron octave band centre frequency noise levels

Description	Period	Predicted noise level above OLGR criteria ($L_{A10,15min}$), Hz, dB									Overall, dB(A)
		31.5	63	125	250	500	1k	2k	4k	8k	
R1	Day	-6	0	0	0	0	0	0	0	0	0
	Evening	6	0	0	0	0	0	0	0	0	0
	Night	8	0	0	0	0	0	0	0	0	0
R2	Day	-6	0	0	0	0	0	0	0	0	0
	Evening	7	0	0	0	0	0	0	0	0	0
	Night	9	0	0	0	0	0	0	0	0	0

Table 5.4 Predicted music and patron octave band centre frequency noise levels

Description	Period	Predicted noise level above OLGR criteria ($L_{A10,15min}$), Hz, dB									Overall, dB(A)
		31.5	63	125	250	500	1k	2k	4k	8k	
R3	Day	-2	0	0	0	0	0	0	0	0	0
	Evening	7	-2	0	0	0	0	0	0	0	0
	Night	12	3	0	0	0	0	0	0	0	0
R4	Day	5	0	0	0	0	0	0	0	0	0
	Evening	7	-3	0	0	0	0	0	0	0	0
	Night	12	2	0	0	0	0	0	0	0	0
R5	Day	-4	0	0	0	0	0	0	0	0	0
	Evening	-1	0	0	0	0	0	0	0	0	0
	Night	4	0	0	0	0	0	0	0	0	0
R6	Day	0	0	0	0	0	0	0	0	0	0
	Evening	-3	0	0	0	0	0	0	0	0	0
	Night	2	0	0	0	0	0	0	0	0	0
R7	Day	8	0	0	0	0	0	0	0	0	0
	Evening	8	0	0	0	0	0	0	0	0	0
	Night	9	0	0	0	0	0	0	0	0	0
R9	Day	8	0	0	0	0	0	0	0	0	0
	Evening	10	0	0	0	0	0	0	0	0	0
	Night	12	0	0	0	0	0	0	0	0	0
R10	Day	1	-4	-4	-8	-2	0	3	3	0	0
	Evening	12	7	7	3	9	11	14	14	0	9
	Night	14	9	9	5	11	13	16	16	0	11

Notes: 1. Blue shading indicates exceedance predominantly generated by music noise; orange shading indicates exceedance predominately generated by patron noise; grey shading indicates exceedance of the overall $L_{A10,15min}$ criterion.

Noise level predictions indicate that energy in 31.5 Hz octave band centre frequency have the potential to exceed the OLGR criteria at all assessment locations for the majority of periods. Some exceedances of up to 3 dB were also predicted for energy in 63 Hz octave band centre frequency at two assessment locations during the night period. These exceedances were generally due to music noise in function areas. These can be mitigated/managed by limiting the low frequency noise output of the public address system or increasing the glazing thickness, or a combination of both. Such measures should be designed and specified at the project detailed design stage (discussed further in Section 6).

The predicted noise levels above the OLGR criteria at R10 are predominantly related to patron noise on external balconies at the Marina Clubhouse. It is noted that the assessment assumed all function centre balconies are at capacity and adopted a conservative patron noise sound power level. There is scope to reduce patron noise levels (discussed further in Section 6) with appropriate management. This includes limiting the use or number of patrons at the north balconies, especially during the evening and night periods, to reduce noise levels at R10.

It is also anticipated that a distance buffer, acoustic screening, or similar would be incorporated in the Moorebank East residential development design to mitigate against noise from this area of the marina. Purchasers of dwellings adjacent to the marina will be made aware of the marina development (it will be a selling point) and the associated noise generation. This development of dwellings near entertainment areas is common, and being 'close to the action' is valued by many purchasers, for example in Darling Harbour.

5.2 Construction

5.2.1 Construction noise

Construction noise levels have been assessed for earthworks, road construction and building construction stages of the project. Noise from construction activity has been predicted at assessment locations using the Bruel & Kjaer Predictor noise modelling software.

The plant and equipment quantities and sound power levels considered in each scenario are presented in Table 5.5. All plant and equipment items have been conservatively assumed to operate continuously throughout a 15-minute ICNG assessment period.

Table 5.5 Representative equipment sound power levels and quantities

Equipment	$L_{Aeq,15min}$ sound power level, dB re 10^{-12} watts	Quantity per scenario		
		Earthworks	Road construction	Building construction
Front end loader	112	1	-	-
Excavator	104	1	-	-
Backhoe	102	-	1	1
Dump truck	103	3	1	1
Concrete truck	106	-	1	1
Crane	105	-	-	1
Generator	101	2	1	1
Bored piling rig	108	1	-	-
Roller	109	1	1	-
Asphalt plant	104	-	1	-
Scraper	103	1	-	-
Hand tools (grinder)	98	-	-	1

Predicted $L_{Aeq,15min}$ noise levels from the site construction at all assessment locations are provided in Table 5.6. Noise levels have been predicted based on the meteorological conditions provided in Table 3.6.

Table 5.6 Predicted construction noise levels

Assessment location	Predicted $L_{Aeq,15min}$ noise level, dB						NML, dB(A)	Highly affected NML, dB(A)
	Excavation		Road works		Building construction			
	Calm	Adverse	Calm	Adverse	Calm	Adverse		
R1	**55**	n/a	**55**	n/a	43	n/a	52	75
R2	**58**	n/a	**60**	n/a	46	n/a	49	75
R3	**62**	n/a	**61**	n/a	**50**	n/a	49	75
R4	**61**	n/a	**57**	n/a	**51**	n/a	49	75
R5	**57**	n/a	**51**	n/a	46	n/a	49	75
R6	**54**	n/a	48	n/a	46	n/a	49	75
R7	**51**	**54**	48	**50**	40	43	49	75
R8	56	58	50	52	43	45	65	n/a
R9	**53**	**68**	48	51	40	43	52	75

Table 5.6 Predicted construction noise levels

Assessment location	Predicted $L_{Aeq,15min}$ noise level, dB						NML, dB(A)	Highly affected NML, dB(A)
	Excavation		Road works		Building construction			
	Calm	Adverse	Calm	Adverse	Calm	Adverse		
R10	**65**	**65**	**64**	**64**	**51**	**51**	49	75

Notes: 1. Predicted noise level shown in bold with grey shading indicated exceedance of the NML.
2. n/a indicates that the calm condition represents the worst case, or adverse, weather condition.

Results are summarised as follows:

- Predicted construction noise levels are below the ICNG highly noise affected 75 dB NML at all residential assessment locations for all construction activities.
- Predicted construction noise levels during excavation/earthworks stage are above the ICNG noise affected NMLs at all residential assessment locations for calm and adverse weather conditions.
- Predicted construction noise levels during road works are above the ICNG NMLs at most residential assessment locations for calm and adverse weather conditions, the exception being locations R6 and R9.
- Predicted construction noise levels during building construction are below the ICNG NMLs at most residential assessment locations for calm and adverse weather conditions, the exception being locations R3, R4 and R10 where marginal noise levels above the NMLs are predicted.
- Predicted construction noise levels are below the ICNG NML for non-residential assessment location R8.

Given the above, construction noise will have to be appropriately managed by adopting feasible and reasonable measures. The primary method of managing noise is to limit construction to standard hours which is proposed. Additional noise management and mitigation measures are provided in Section 6.

5.2.2 Construction vibration

As a guide, safe working distances for typical items of vibration intensive plant are listed in Table 5.7. The safe working distances are quoted for both "Cosmetic Damage" (refer British Standard BS 7385) and "Human Comfort" (refer British Standard BS 6472-1).

Table 5.7 Recommended safe working distances for vibration intensive plant

Plant item	Rating/description	Safe working distance	
		Cosmetic damage (BS 7385)	Human response (BS 6472)
Vibratory Roller	<50 kN (typically 1–2 tonnes)	5 m	15 to 20 m
	<100 kN (typically 2–4 tonnes)	6 m	20 m
	<200 kN (typically 4–6 tonnes)	12 m	40 m
	<300 kN (typically 7–13 tonnes)	15 m	100 m
	>300 kN (typically 13–18 tonnes)	20 m	100 m
	>300 kN (>18 tonnes)	25 m	100 m

Table 5.7 Recommended safe working distances for vibration intensive plant

Plant item	Rating/description	Safe working distance	
		Cosmetic damage (BS 7385)	Human response (BS 6472)
Small hydraulic hammer	(300 kg, 5–12 tonnes excavator)	2 m	7 m
Medium hydraulic hammer	(900 kg, 12–18 tonnes excavator)	7 m	23 m
Large hydraulic hammer	(1600 kg – 18–34 tonnes excavator)	22 m	73 m
Vibratory pile driver	Sheet piles	2 m to 20 m	20 m
Pile boring	≤800 mm	2 m (nominal)	N/A
Jackhammer	Hand held	1 m (nominal)	Avoid contact with structure

Source: Transport Infrastructure Development Corporation Construction's Construction Noise Strategy (Rail Projects) (November 2007).

The safe working distances presented in Table 5.7 are indicative and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions. In relation to human comfort (response), the safe working distances in Table 5.7 relate to continuous vibration and apply to residential receivers. For most construction activities, vibration emissions are intermittent in nature and hence higher vibration levels occurring over shorter periods are allowed, as specified in British Standard BS 6472-2008.

The nearest building to the site (Georges Fair residences) is approximately 65 m from the eastern property boundary. It is therefore envisaged that cosmetic damage to nearby structures is unlikely. At such distance however, human response can be expected for construction activities that include the use of a large vibratory roller (ie >6 tonnes). The safe working distances provided in Table 5.7 should be followed in the first instance and management of vibration levels may be required when the vibratory roller is proposed to be used.

There is potential for vibration impact at future Moorebank East residences (immediately to the north of the subject site) if the residential development is constructed and occupied before the start of the marina construction. It is unclear at this stage if this will be the case. Notwithstanding, the safe working distances provided in Table 5.7 should be followed in the first instance and management of vibration levels may be required if a small (ie <6 tonnes) or a large vibratory roller (ie >6 tonnes) is proposed to be used within 40 m or 100 m respectively, from the nearest future Moorebank East residence. As noted earlier, we understand that the development of the Moorebank East residential area and the marina will be done cooperatively and by the same or related entity, and hence opportunities to address such issues will be available.

Management and mitigation measures should be implemented to minimise vibration impact during the construction phase of the development, as recommended in Section 6.

5.3 Road traffic noise

The Predictor software was used to predict noise levels from the proposed road and determine the effectiveness of mitigation measures. The model uses the accepted Calculation of Road Traffic Noise (CoRTN) algorithm and adds refinements including variable source heights and atmospheric effects and has advantages over the traditional CoRTN methods in the simple handling of complex and extensive road traffic noise modelling. EMM have used this algorithm on a number of projects and it has shown strong correlation with measured data on a number of occasions.

The representative assessment locations used for future dwellings were modelled as single storey (ie 1.5 m above ground level) but the results are also relevant to two-storey homes as there is no ground level acoustic screening.

5.3.1 Traffic volume data

i Marina access road

The key information used for the road model is as follows:

- 197 vehicles accessing the site per hour weekday peaks; and
- 220 vehicles accessing the site per hour for Friday and Saturday evenings.

The results of traffic noise modelling are presented for both weekday and weekend situations. The modelling considered that Friday and Saturday evenings traffic volumes will be higher, and that traffic will preferentially use the undercover carpark and carpark C which are closest to the private marina clubhouse and function centre. For weekdays, vehicles could use any of the carparks and therefore it has been conservatively assumed that 197 vehicles per hour will use carparks A and B (ie the southern carparks).

ii Brickmakers Drive

Noise levels on Brickmakers Drive were assessed to determine the traffic noise changes from the marina access road, which is particularly relevant for Georges Fair residences. Table 5.8 presents the existing traffic volume data for Brickmakers Drive.

Table 5.8 Brickmakers Drive traffic count data – January 2015

Time	Northbound movements	Southbound movements	Two-way movements
Weekday morning	685	170	855
Weekday afternoon	165	715	880
Friday evening	120	300	420
Saturday evening	105	175	280

Notes: Traffic counts taken from EMM Hourly Site Traffic Generation Calculations, January 2015.

5.3.2 Predicted road traffic noise levels

The noise modelling results are summarised in Table 5.9 and Table 5.10 for weekday and weekend traffic volumes respectively. Both daytime and night-time traffic noise criteria are shown in the event that peak movements occur from the proposed marina outside of 7 am to 10 pm (ie outside daytime hours). The results are displayed as noise contours in Figure 5.3 and Figure 5.4. As discussed earlier, the assessment conservatively adopted the local road category for Brickmakers Drive. The predicted $L_{Aeq,1hr}$ noise levels from future road traffic on Brickmakers Drive is representative of peak movements (worst-case) for the marina

The results show the following:

- The proposed marina's weekday peak hour traffic noise contributions are relatively minor in comparison to existing noise levels from Brickmakers Drive for all nominated assessment locations. Total future road traffic noise levels for Georges Fair residences are shown to be similar to existing levels. Predicted traffic noise levels from vehicles accessing the marina will satisfy the RNP allowance criterion of no more than 2 dB increase where existing traffic noise is above acceptable levels.

- The proposed marina's weekend peak hour traffic noise contributions are relatively minor in comparison to existing levels from Brickmakers Drive for all nominated assessment locations. Total future road traffic noise levels for Georges Fair residences are shown to be similar to existing levels. Predicted traffic noise levels from vehicles accessing the marina will satisfy the RNP allowance criterion of no more than 2 dB increase where existing traffic noise is above acceptable levels.

The results of noise modelling are summarised in Table 5.9 for weekday volumes.

Table 5.9 Predicted traffic noise modelling results – weekday

Receiver		Criteria, dB(A)		Predicted $L_{Aeq,1hr}$, peak traffic noise level dB		
Name	**Receiver number[1]**	**Daytime**	**Night-time**	**Existing[2] (Brickmakers Dr)**	**Marina local road[3]**	**Total (future)**
Georges Fair residences west of Brickmakers Drive (existing and future)	1	55	50	64	51	64
	2	55	50	51	47	52
	3	55	50	64	48	64
	4	55	50	68	51	68

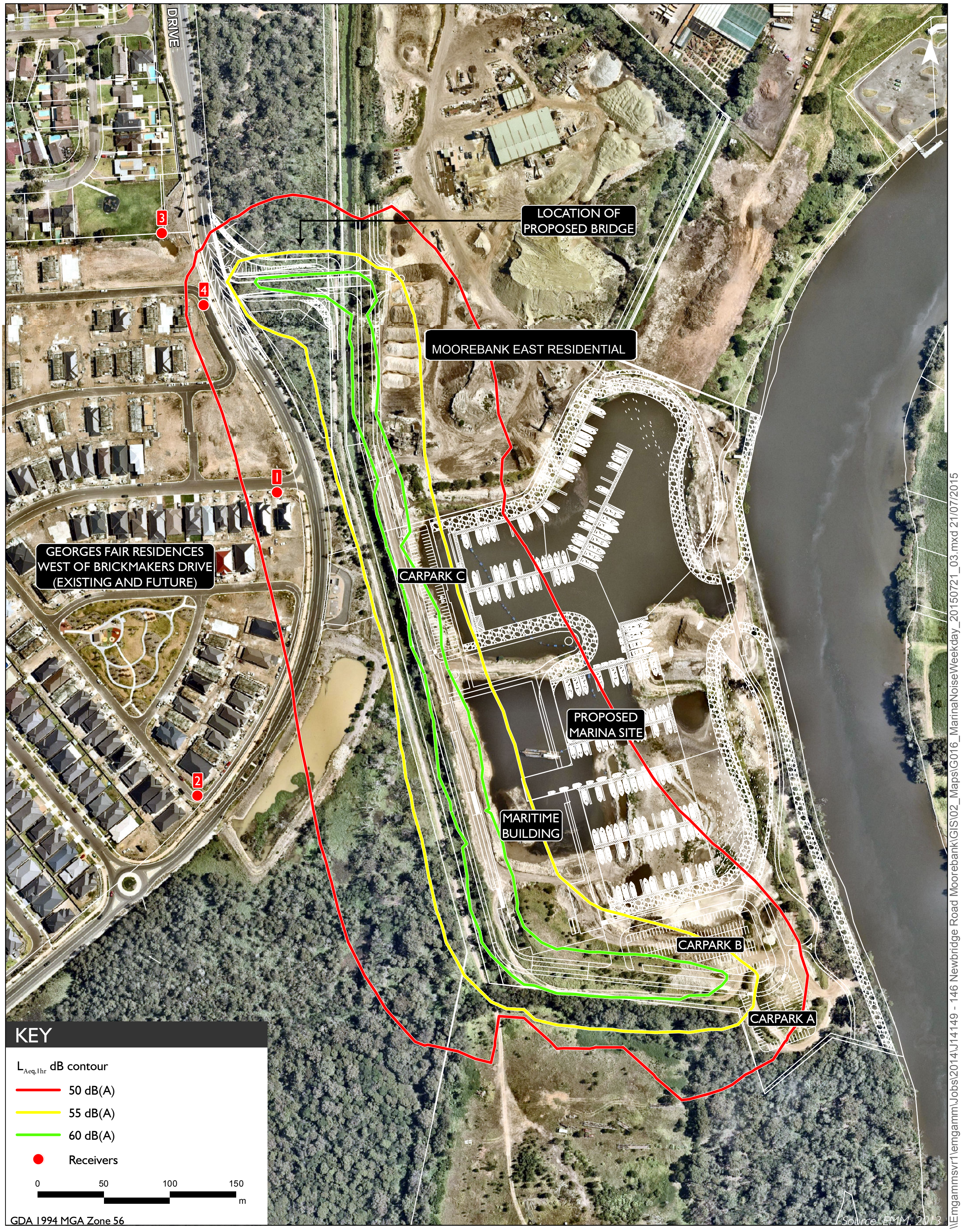
Notes: 1. Refer to Figure 5.3.
2. Brickmakers Drive existing weekday traffic noise shown.
3. Noise levels shown are for 197 vehicle per hour for marina to southern carparks.

The results of noise modelling are summarised in Table 5.10 for weekend volumes.

Table 5.10 Predicted traffic noise modelling results – weekend

Receiver		Criteria, dB(A)		Predicted $L_{Aeq,1hr}$, peak traffic noise level dB		
Name	**Receiver number[1]**	**Daytime**	**Night-time**	**Existing[2] (Brickmakers Dr)**	**Marina local road[3]**	**Total (future)**
Georges Fair residences west of Brickmakers Drive (existing and future)	1	55	50	61/60	51	61/60
	2	55	50	48/46	44	49/48
	3	55	50	62/60	47	62/61
	4	55	50	65/64	51	65/64

Notes: 1. Refer to Figure 5.4.
2. Noise levels shown are for existing Friday and Saturday evening traffic on Brickmakers Drive.
3. Noise levels shown are for 220 vehicle per hour for marina to northern carparks.



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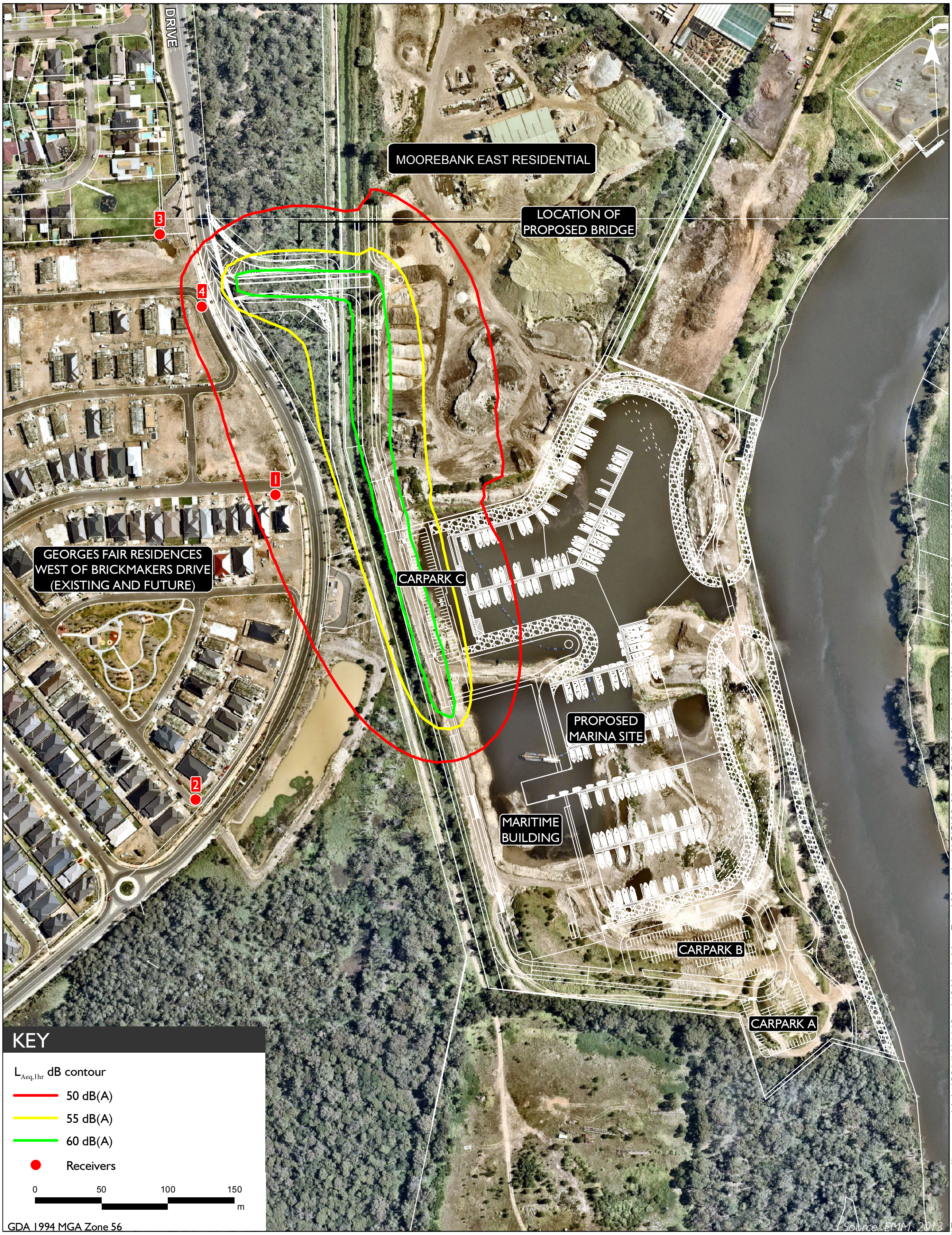
EMGA Mitchell McLennan

Predicted marina traffic noise levels - weekday

Georges Cove Marina

Noise and Vibration Impact Assessment

Figure 5.3



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Predicted marina traffic noise levels - weekend

Georges Cove Marina

Noise and Vibration Impact Assessment

Figure 5.4

6 Noise management and mitigation

6.1 Operations

The following operational noise management and mitigation will be adopted:

- a 2 m high acoustic barrier will be constructed to the west of the Marina Clubhouse carpark as indicated in Figure 5.1.

- partial acoustic screening (eg louvres) will be installed on the north balconies of the marina clubhouse and marina building. The screening will be operable to allow additional acoustic screening during large functions when the respective function centres are in use.

- music noise from the function centres will be managed and/or mitigated to limit low frequency noise in 31.5 and 63 Hz octave band centre frequencies to the criteria presented in Table 4.5. This can be achieved by fitting the public address system with a noise limiter or increasing the glazing thickness at function centres, or a combination of both measures. This and other alternate measures will be detailed further in the project design stage.

- a noise management plan will be implemented, outlining procedures for patron management, paying attention to more sensitive evening and night-time periods.

6.2 Construction

6.2.1 Noise management plan

Given predicted noise levels are above the NMLs at several assessment locations (especially during the excavation/earthworks stage), it is recommended that a noise management plan be prepared and include:

- identification of nearby residences and sensitive land uses;

- description of approved hours of work and what work will be undertaken;

- description of what work practices will be applied to minimise noise;

- description of the complaints handling process;

- description of monitoring that is required; and

- notification process for nearby properties.

6.2.2 Community consultation

In addition to the above, a programme to engage in active community consultation about the project generally should be implemented to maintain positive relations with local residents.

6.2.3 Adoption of general noise management practices (AS 2436-2010)

Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites (AS 2436-2010) sets out numerous practical recommendations to assist in mitigating construction noise emissions. Examples of strategies that could be implemented on the subject site are listed below.

i Universal work practices

Universal work practices that will be adopted during construction will include:

- regular reinforcement (such as at toolbox talks) of the need to minimise noise and vibration;
- regular identification of noisy activities and adoption of improvement techniques;
- avoiding the use of portable radios, public address systems or other methods of site communication that may unnecessarily impact upon nearby residents;
- developing routes for the delivery of materials and parking of vehicles to minimise noise;
- minimising the use of equipment that generates impulsive noise;
- minimising the need for vehicle reversing for example, by arranging for one-way site traffic routes;
- use of broadband audible reverse alarms ("growlers") on vehicles and elevating work platforms used on site;
- minimising the movement of materials and plant and unnecessary metal-on-metal contact;
- minimising truck movements; and
- scheduling respite periods for intensive works.

ii Plant and equipment

Additional noise management measures for plant and equipment will include:

- employing techniques for all high noise activities such as rock breaking, concrete sawing, and using power and pneumatic tools that minimise noise emissions;
- where possible choosing quieter plant and equipment based on the optimal power and size to most efficiently perform the required tasks;
- operating plant and equipment in the quietest and most efficient manner; and
- regularly inspecting and maintaining plant and equipment to minimise noise and vibration level increases, to ensure that all noise and vibration reduction devices are operating effectively.

iii On-site noise mitigation

Onsite noise mitigation measures will include:

- where possible maximising the distance between noise activities and noise sensitive land uses; and
- where possible using temporary site building and material stockpiles as noise barriers. These can often be created using site earthworks and may be included as a part of final landscape design.

iv Work scheduling

Work scheduling will consider the following:

- scheduling work to coincide with non-sensitive periods;
- scheduling noisy activities to coincide with high levels of neighbourhood noise so that noise from the activities is partially masked and not as intrusive;
- planning deliveries and access to the site to occur quietly and efficiently and organising parking only within designated areas located away from the sensitive receivers;
- optimising the number of deliveries to the site by amalgamating loads where possible and scheduling arrivals within designated hours;
- designating, designing and maintaining access routes to the site to minimise impacts; and
- including contract conditions that include penalties for non-compliance with reasonable instructions by the principal to minimise noise or arrange suitable scheduling.

7 Conclusion

EMM has completed a noise impact assessment for the Georges Cove Marina proposed at Moorebank, NSW.

Operational noise levels are predicted to satisfy the NPfI PNTLs at all assessment locations during calm and worst-case meteorological conditions. For the closest residences in the future Moorebank East residential development, it is anticipated that appropriate noise controls, such as distance buffers and acoustic screening, will be incorporated in the design of the development to provide appropriate noise amenity for occupants. This will be facilitated through opportunities expected due to the cooperative approach to the two developments being undertaken by the same or related entities. People looking to buy the dwellings adjacent to the marina will be informed of the Georges Cove Marina development (and associated noise). Those who go on to buy one of these dwellings are expected to see being 'close to the action' as a positive attribute of the location. Notwithstanding, existing noise levels at Georges Cove generally include boat movements. Given the riverside locality and position near the subject site, and that boat movements will be generally short-term in nature, it is anticipated that such noise activity would be largely accepted to a degree by residents.

Operational noise and maximum noise level events during the night-time period are predicted to satisfy the EPA sleep disturbance noise trigger levels at all assessment locations during calm and worst-case meteorological conditions.

Music and patron noise are predicted to satisfy the OLGR criteria in most octave band centre frequencies at all assessment locations during calm and worst-case meteorological conditions. Music noise from function centres has been predicted to generate exceedances at 31.5 and 63 Hz octave band centre frequencies. This can be mitigated by fitting a noise limiter on public address systems or increasing the glazing thickness to function rooms, or a combination of both. Such noise control strategies will be finalised in the project design phase. Patron noise levels at the closest Moorebank East residential development are predicted to exceed the OLGR criteria in the 63 Hz octave band centre frequency and above. This can be mitigated by the installation of partial acoustic screens at some outdoor patron areas (refer Figure 5.2) to reduce worst-case patron noise levels.

Construction noise levels are predicted to satisfy ICNG highly noise affected NML at all residential assessment locations. Construction noise levels above the noise affected NMLs have been predicted at most assessment locations, predominantly during site preparation earthworks and road construction. The proponent will actively manage construction noise, especially when construction equipment is operating relatively close to surrounding receivers. This will primarily be achieved by limiting construction to ICNG standard construction hours.

Construction vibration impact is not expected from the proposed construction works at this stage, nonetheless the safe working distances provided in Table 5.7 should be followed in the first instance, and management and mitigation recommendations provided in Section 6 should be implemented, where required.

Further, a noise management plan will be prepared and implemented that will detail strategies to control patron noise (especially during the night-time period) and measures to manage and mitigate noise during the construction phase.

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