WOOD & GRIEVE ENGINEERS

URBNSURF, Sydney

Acoustic Report for Development Application

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Project No. 29130-SYD-N
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Revision

REVISION	DATE	COMMENT	APPROVED BY
4	25/10/2017	Construction Noise & Vibration	**ORFG**
3	27/03/2017	WavePark Comments	**ORFG**
2	08/03/2017	Traffic Update	**ORFG**
1	23/01/2017	For review	**ORFG**

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1. Introduction

As part of the DA documentation process, Wood & Grieve Engineers have been engaged by Wave Park Group to provide a noise and vibration assessment for the surf-park development located in Hills Road, Sydney Olympic Park, NSW.

The proposed development will consist of a sports and recreation venue with approximately 1,950 m^2 of built form amenities over a 1,350m^2 footprint. The location of the proposed development is located within the Sydney Olympic Park sports and recreation zoning.

This assessment discusses the likely noise impact from the development on the potentially nearest most-affected receivers of the development.

This assessment has been prepared considering the following documents:

- Sydney Olympic Park Master Plan 2030.
- NSW Government – State Environmental Planning Policy (State and Regional Development, 2011).
- AS/NZS 2107:2000 – Acoustics – Recommended Design Sound Levels and Reverberation Times for Building Interiors.

This report provides:

- A statement of compliance with the relevant statutory criteria for the proposed surf-park development within the vicinity of the nearest potentially affected receivers.
- Recommendations for noise mitigation measures for the proposed development in order to meet the relevant criteria when compliance is not achieved.

This noise assessment is based on noise data collected by a combination of unattended and attended noise measurements at representative locations around the site over 8 days during December 2016.

This report is based on our understanding of the proposed project, application of the relevant state guidelines and professional experience within the acoustic field.

2. Background

2.1 Information Sources

The following documentation has been used for the preparation of this report:

- Site drawings presenting the location of the proposed development in relation to the nearest receivers;
- Noise data collected on site through the use of noise loggers and a hand held spectrum analyser;
- AECOM Environmental Noise Assessment – Melbourne Wave Park, Tullamarine, dated 14/01/2016;
- Architectural drawings provided by MJA Studio;
- Traffic information provided by The Transport Planning Partnership

3. Project Overview

3.1 Site Description

The URBNSurf surf-park site is located on the south-eastern end of the corner of Hill Road and Holker Busway. The proposed development site is bound by existing carparks to the South/West and North/East, the Hill Road and bushlands to the North, Sydney BMX Track to the East, and bushland to the North.

The most sensitive receivers are the residential area which located approximately 350m to the North/West of the proposed development site.

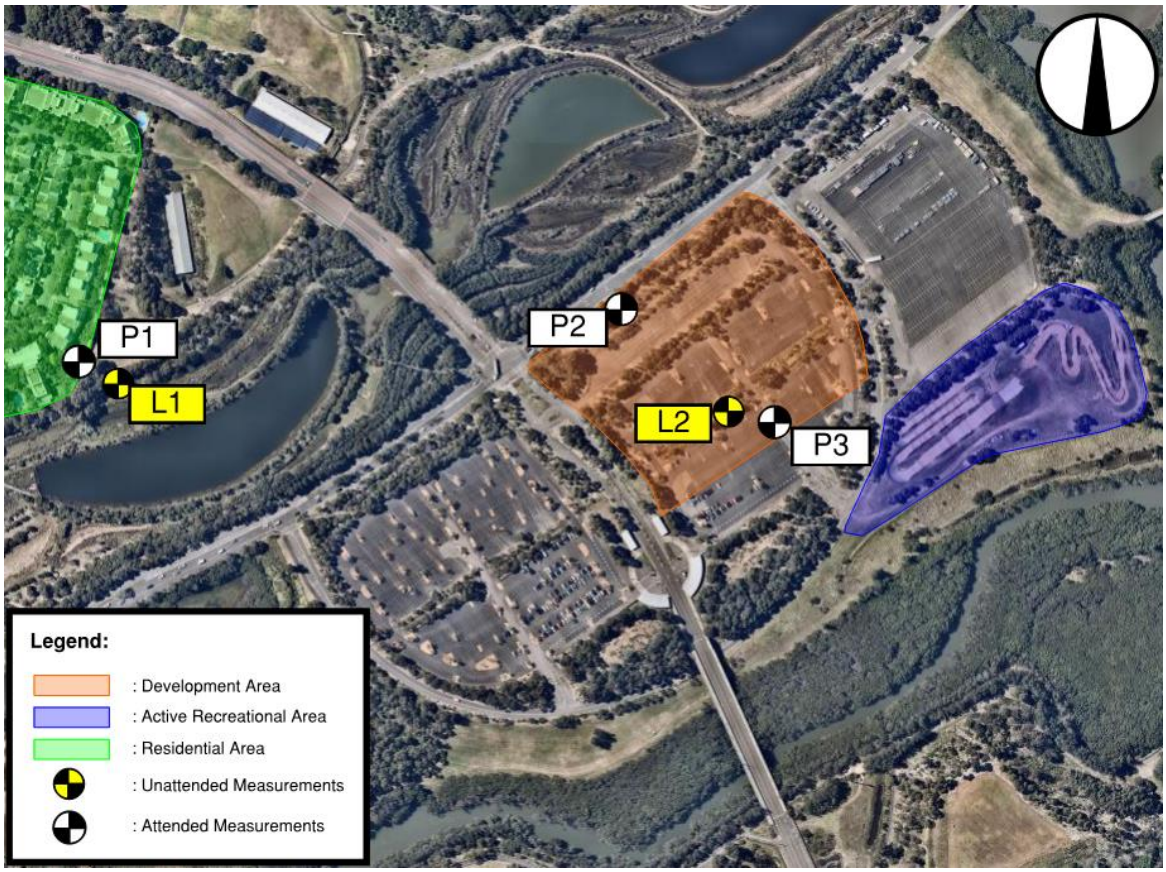
The site location, measurement positions and surrounding residential and commercial receivers are shown in Figure 1.

3.1.1 Acoustic Issues

The acoustic issues relating to the development are as follows:

- Noise intrusion from vehicle movements along the Hills Road;
- Noise intrusion from active recreational area (Sydney BMX Track) which located approximately 50m to the South/East of the development site;
- Noise emissions from patron and mechanical plant from the development to the surrounding receivers.

Figure 1: Overview of the site and measurement locations



Source: nearmap.com

4. Noise Survey

4.1 Instrumentation

The following equipment was used for the noise surveys:

- ARL Environmental Noise Logger ARL EL-215 S/N 194677;
- ARL Environmental Noise Logger ARL EL-215 S/N 194444;
- Hand-held sound spectrum analyzer B&K 2250, S/N 2709742;
- Sound Calibrator B&K Type 4231, S/N 2709826;
- Hand-held sound spectrum analyzer NTi – XL 2, S/N A2A-11555-E0.

All equipment was calibrated before and after the measurements and no significant drift was found. All equipment carries current traceable calibration certificates that can be provided upon request.

4.2 Attended Noise Survey Results

Several 15 minute attended noise measurements were conducted using a Brüel & Kjær 2250 Hand-held Analyser which is fully compliant with AS IEC standard 61672-1 "Electro acoustics—Sound level meters Part 1: Specifications". These measurements were conducted in order to characterise the acoustic environment for noise intrusion into the development and to determine any noise impact on the surrounding receivers.

This instrument was calibrated before and after measurements using a 94 dB(A), 1 KHz calibration tone, with no significant drift occurring.

A summary of the attended noise measurements taken at site are shown in Table 1. Refer to Figure 1 for measurement locations.

Table 1: Attended noise measurements

Measurement Location	Measurement Time	$L_{Aeq, 15mins}$ dB(A)	L_{A90} dB(A)	L_{Amax} dB(A)	Comments
P1	5/12/2016 12:09	51.8	41.1	70.2	Ambience and aircraft noise
P2	5/12/2016 11:22	65.3	55.6	83.9	Traffic background noise
P3	5/12/2016 11:02	54.4	45.2	72.1	Ambience and aircraft noise
P3	13/12/2016 14:00	51.3	48.8	84.7	Ambience, heavy machinery, and aircraft noise

4.3 Unattended Noise Survey Results

This assessment will consider the method for determining the RBL background for each period of the day in accordance with the NSW EPA Industrial Noise Policy (INP). The INP defines background and ambient noise for the daytime, evening and night time periods as follows:

Day: is defined as 7:00am to 6:00pm, Monday to Saturday and 8:00am to 6:00pm Sundays & Public Holidays.

Evening: is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays.

Night: is defined as 10:00pm to 7:00am, Monday to Saturday and 10:00pm to 8:00am Sundays & Public Holidays**.**

4.3.1 Background and Ambient Noise Monitoring

A noise logger was placed at position L1 as shown in Figure 1 to measure the background and ambient noise that is representative of the surrounding residential receivers. Logger L1 was installed from the 5th to the 12th of December 2016. The results for the unattended background noise surveys are shown in Table 2 below (for the day, evening and night periods).

A noise logger has also been placed at position L2 as shown in Figure 1 to measure the background and ambient noise that is representative of the development site. Logger L2 was installed from the 5th to the 12th of December.2016 The results for the unattended background noise surveys are shown in Table 2 below (for the day, evening and night periods).

Note: that any rain affected data during the period of logging has been excluded from the calculations.

Table 2: Unattended noise measurements L1

Location	Equivalent Continuous Noise Level $L_{Aeq,period}$ - dB(A)			Background Noise Level RBL - dB(A)		
	Day	Evening	Night	Day	Evening	Night
L1	55	54	54	44	45	39
L2	60	60	50	45	45	37

The local ambient noise environment is dominated by traffic noise throughout the majority of the day, evening and night periods. Refer to Figure 2 and Figure 3for the noise data.

Figure 2: Unattended noise monitor data L1

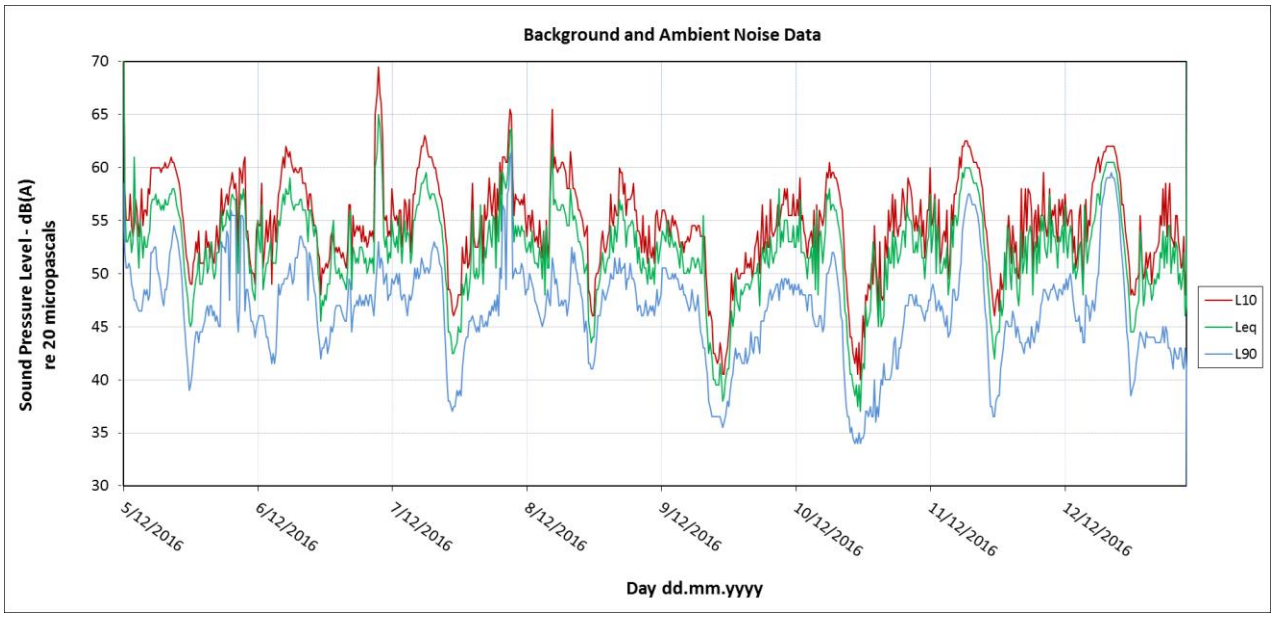
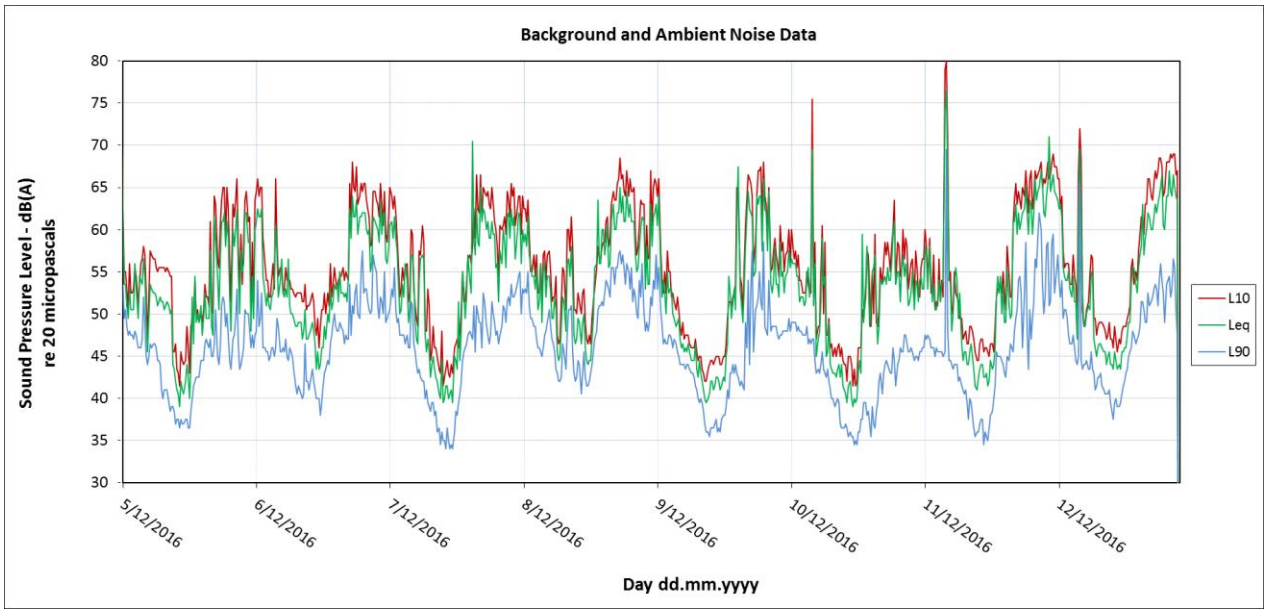


Figure 3: Unattended noise monitor data L2



5. Noise and Vibration Criteria

5.1 Internal Noise Levels (Airborne Noise Intrusion)

This section details the criteria used to define the internal noise goals for spaces in the development in regards to external noise intrusion from traffic and other airborne noise factors affecting the development.

5.1.1 Sydney Olympic Park Master Plan 2030 (SOPA-MP 2030)

The General Controls and Guidelines Section of the Sydney Olympic Park Master Plan 2030 is applicable to this development. Section 4.6.15 of the SOPA-MP 2030 states the following in regards to internal noise levels:

1. *New development is to acknowledge that it will be located within a major sport and entertainment events precinct that may be subject to high noise events from time to time. This will be achieved by creating a 'Section 88D' instrument (on Sydney Olympic Park land) or a 'Section 88E' instrument (on non – Sydney Olympic Park land) on title advising of likely noise levels in the precinct*
2. *Applicants for a new development must prepare a report by a suitably qualified acoustic consultant assessing the possibility of land use conflicts as a result of the development. The land use conflict could be, for example, from an entertainment venue on the closest residential receiver or it could be the result of a new residential development possibly restricting the use of an existing entertainment venue. The suitability of the development for the site is the responsibility of the applicant who is required to assess the noise impact and to incorporate appropriate measures into the development.*
6. Design commercial development to comply with the maximum internal noise criteria set out in Table 3 below:

Table 3: Maximum Noise Criteria - Office Development

Internal Space	Noise Criteria	Time Period	Parameter
Office	45 dB(A)	Day & Evening	LA,eq 15min

5.1.2 Australia Standard (AS) 2107:2000

Australian Standard (AS) 2107:2000 – *'Acoustics- Recommended design sound levels and reverberation times for building interiors'* specifies target noise levels for internal spaces to the development. Refer to Table 4 for the values corresponding to the non-residential spaces that are expected to be within the development.

Table 4: Recommended noise levels according to AS/NZS 2107:2000

Type of occupancy / activity	Recommended Design Sound Level, L_{Aeq}, dB(A)	
	Satisfactory	Maximum
Small retail stores (general)	45	50
Restaurant/Coffee bars	45	50
Cafeterias/food court	45	55

5.2 Site Noise Emission

The following section presents the criteria applicable for noise emissions from the development.

5.2.1 Sydney Olympic Park Master Plan 2030 (SOPA-MP 2030)

Section 4.6.15 of the SOPA-MP 2030 states the following in regards to external noise emissions:

3. *All noise impact assessments require ambient noise levels measured at the noise sensitive premises during representative periods to ensure all major intermittent noises are measured and quantified. This particularly applies to outdoor concerts, sporting events and late night parties. The results of the noise measurements should be used to design noise mitigation measures relevant to the proposed development.*
4. *All plant rooms shall be designed to meet the requirements of the NSW Industrial Noise Policy.*

5.2.2 NSW EPA Industrial Noise Policy

The NSW Environmental Protection Authority (EPA) Industrial Noise Policy (INP) sets out noise criteria to control the noise emission from industrial noise sources. Mechanical and operational noise from the development shall be addressed following the guideline in the NSW INP.

The calculation is based on the results of the ambient and background noise unattended monitoring, addressing two components:

- Controlling intrusive noise into nearby residences (Intrusiveness Criteria)
- Maintaining noise level amenity for particular land uses (Amenity Criteria)

Once both criteria are established the most stringent for each considered assessment period (day, evening, night) is adopted as the project-specific noise level (PSNL).

Intrusiveness Criteria

The NSW EPA INP states the following:

> *"The intrusiveness of an industrial noise source may generally be considered acceptable if the equivalent continuous (energy-average) A-weighted level of noise from the source (represented by the Laeq descriptor), measured over a 15-minute period, does not exceed the background noise level measured in the absence of the source by more than 5 dB(A)."*

The intrusiveness criterion can be summarised as L_{Aeq}, 15 minute $\leq$ RBL background noise level plus 5 dB(A).

Table 5: EPA INP intrusiveness criteria

Period	Noise Descriptor – dB(A)	Noise Criteria – dB(A)
Daytime 7am – 6pm	$L_{Aeq,15min} \leq$ RBL + 5	49
Evening 6pm – 10pm	$L_{Aeq,15min} \leq$ RBL + 5	50
Night 10pm – 7am	$L_{Aeq,15min} \leq$ RBL + 5	44

Noise and Vibration Criteria

Amenity Criteria

The NSW INP states the following:

> *"To limit continuing increases in noise levels, the maximum ambient noise level within an area from industrial noise sources should not normally exceed the acceptable noise levels specified in Table 2.1 of the INP. Meeting the acceptable noise levels in table 2.1 will protect against noise impacts such as speech interference, community annoyance and to some extent sleep disturbance. These levels represent best practice for assessing industrial noise sources, based on research and a review of assessment practices used overseas and within Australia."*

The applicable parts of Table 2.1: Recommended L_{Aeq} Noise Levels from Industrial Noise Sources – dB(A) which are relevant to the project are reproduced below:

Table 6: Amenity criteria for external noise levels

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level, dB(A)	
			Acceptable	Recommended Maximum
Residential	All	Day	60	65
	All	Evening	50	55
	All	Night	45	50
Active recreation area	All	When in use	55	60

*Urban area as defined in EPA INP 2. 2.1.6.

Modifying Factor' Adjustments

The NSW INP also states:

> *"Where a noise source contains certain characteristics, such as tonality, impulsiveness, intermittency, irregularity or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same noise level."*

In order to take into account, the potential annoying character of the noise an adjustment of 5 dB(A) for each annoying character aspect and cumulative of up to a total of 10 dB(A), is to be added to the measured value to penalise the noise for its potentially greater annoyance aspect.

Table 4.1 of Chapter 4 of the NSW DECCW INP (see Table 7 below) provides procedures for determining whether an adjustment should be applied for greater annoyance aspect.

Table 7: Table 4.1 NSW DECCW INP – Modifying factor corrections

Factor	Assessment / Measurement	When to Apply	Correction[1]	Comments
Tonal Noise	One-third octave or narrow band analysis	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: - **5 dB** or more if the centre frequency of the band containing the tone is above 400 Hz - **8 dB** or more if the centre frequency band containing the tone is 160 to 400 Hz inclusive - **15 dB** or more if the centre frequency of the band containing the tone is below 160 Hz	5 dB[2]	Narrow-band frequency analysis may be required to precisely detect occurrence.
Low Frequency Noise	Measurement of C-weighted and A-weighted level	Measure / assesses C- and A-weighted levels over same time period. Correction to be applied if the difference between the two levels is 15 dB or more	5 dB[2]	C-weighting is designed to be more responsive to low-frequency noise, especially at higher overall levels
Impulsive Noise	A-weighted fast response and impulsive response	If difference in A-weighted maximum noise levels between fast response and impulse response is greater than 2 dB	Apply difference in measured levels as the correction, up to a maximum of 5 dB.	Characterised by a short rise time of 35 milliseconds (ms) and decay time of 1.5 s.
Intermittent Noise	Subjectively assessed	Level varies by more than 5 dB	5 dB	Adjustment to be applied for **night-time only.**
Duration	Single-event noise duration may range from 1.5 min to 2.5 h	On event in any 24-hour period	0 to – 20 dB(A)	The acceptable noise level may be increased by an adjustment depending on duration of noise.
Maximum Adjustment	Refer to individual modifying factors	Where two or more modifying factors are indicated	Maximum correction of 10dB(A)[2] (excluding duration correction)	

Notes:

1. Corrections to be added to the measured or predicted levels.
2. Where a source emits tonal and low-frequency noise, only one 5 dB correction should be applied if the tone is in the low-frequency range.

5.2.3 Project-specific noise levels (PSNL)

The following criteria is applicable for the external noise emissions from the development, as detailed below in Table 8. These project specific noise levels are in accordance with the requirements of the NSW INP, and shall be assess to the most affected point on or within the residential boundary.

Table 8: Project specific noise levels

Period	Descriptor	PSNL dB(A)
Residential receivers		
Day (7:00am to 6:00pm)	$L_{Aeq,15min}$	49
Evening (6:00pm to 10:00pm)	$L_{Aeq,Evening}$	45
Night (10:00pm to 7:00am)	$L_{Aeq,15min}$	40
Active recreation receivers (BMX Track)		
When in use	$L_{Aeq,duration}$	55

Where necessary, noise mitigation measures will be incorporated in the design to ensure that noise levels comply with the recommended noise emission criteria noted above.

5.3 Traffic Noise Generation Criteria

The L_{Aeq} noise level or the "equivalent continuous noise level" correlates best with the human perception of annoyance associated with traffic noise.

Road traffic noise impact is assessed in accordance with the introduced NSW Road Noise Policy (Office of Environment and Heritage July 2011) which supersedes the *NSW Environmental Criteria for Road Traffic Noise* (ECRTN, Department of Environment Climate Change and Water 1999). The criterion (Table 3 – Road Traffic Noise Assessment Criteria for Residential Land Uses) divides land use developments into different categories and lists the respective criteria for each case. The category that is relevant to the proposed use of the site is shown below:

Table 9: NSW Road Noise Policy – Traffic noise assessment criteria

Road Category	Type of project/land use	Assessment Criteria – dB(A)	
		Day (7am – 10pm)	Night (10pm – 7am)
Sub-arterial roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq,1\ hour}$ 60 (external)	$L_{Aeq,1\ hour}$ 50 (external)

In the event that the traffic noise at the site is already in excess of the criteria noted above, the NSW RNP states that the primary objective is to reduce the existing level through feasible and reasonable measures to meet the criteria above.

If this is not achievable, Section 3.4.1 Process for applying the criteria – Step 4 states that for existing residences affected by additional traffic on existing roads generated by land use developments, any increase in the total traffic noise should be limited to 2 dB above that of the corresponding 'no build option'.

5.4 Construction Noise Criteria

The noise criteria for construction sites are established in accordance with the Interim Construction Noise Guideline (ICNG July 2009) by the Office of Environment and Heritage (OEH). This document is referred to as OEH's standard policy for assessing construction noise on new projects.

The key components of the ICNG 2009 incorporated into this assessment include:

1. **Use of LAeq as the noise metric for measuring and assessing construction noise**
   In recent years, NSW noise policies including OEH INP and the NSW Environmental Criteria for Road Traffic Noise (ECRTN) have selected the LAeq to be the primary noise metric when measuring and assessing construction noise. Consistent with ICNG 2009, the use of the LAeq as a key descriptor for measuring and assessing construction noise may follow a 'best practice' approach.

2. **Application of feasible and reasonable noise mitigation measures**
   As stated in the ICNG 2009, a noise mitigation measure is feasible if it is capable of being put into practice, and is practical to build given the project constraints. Selecting reasonable mitigation measures from those that are feasible requires one to determine whether the overall noise benefit of applying the measure outweighs the overall social, economic and environmental effects, including the cost of the measure.

3. **Quantitative and qualitative assessment**
   The ICNG 2009 provides two methods for assessment of construction noise, being either a quantitative or a qualitative assessment.

   A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement and prediction of noise levels, and assessment against set criteria.

   A qualitative assessment is recommended for small projects with a short-term duration where works are not likely to affect an individual or sensitive land use for more than three weeks in total. It focuses on minimising noise disturbance through the implementation of feasible and reasonable work practice, and community notification.

   Given the significant scale of the construction works proposed for this Project, a quantitative assessment is carried out herein, consistent with the ICNG 2009 requirements.

4. **Management levels**
   Table 1 below (based on the ICNG criteria and the Conditions of Consent construction hours) sets out the noise management levels and how they should be applied. The guidelines intend to provide respite for residents exposed to excessive construction noise outside the recommended standard hours whilst allowing construction during the recommended standard hours without undue constraints.

   The rating background level (RBL) is used when determining the management level. The RBL is the overall single-figure background noise level measured in each relevant assessment period (during or outside the recommended standard hours).

Noise and Vibration Criteria

Table 10: NSW DECCW ICNG Construction noise criteria

Time of Day	Management Level $L_{Aeq,15min}$ *	How to Apply
Recommended Standard Hours: Mon – Fri (7am – 6pm) Sat (8am – 1pm) No work on Sunday & Public Holidays	Noise Affected 54 dB(A)	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq,15min}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residences 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(A)	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 in, taking into account: • 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) • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside Recommended Standard Hours	Noise Affected Evening - 50 dB(A) Night - 44 dB(A)	• 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.

* NOTE: Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Source: Chapter 4 (Table 2 Sec 4.1.1) of NSW OE&H ICNG

Table 11 (reproduced from Table 2 Sec 4.1.1 (Chapter 4) of the ICNG 2009) sets out the noise management levels for various sensitive land use developments.

Table 11: OEH ICNG Construction Noise Criteria at Other Sensitive Land Uses

Land Use	Management Level, $L_{Aeq,15min}$ – applies when land use is being utilized
Classrooms at schools and other educational institutions	Internal noise level 45 dB(A)
Hospital wards and operating theatres	Internal noise level 45 dB(A)
Places of worship	Internal noise level 45 dB(A)
Active recreation areas	External noise level 65 dB(A)
Passive recreation areas	External noise level 60 dB(A)
Community centres	Depending on the intended use of the centre. Refer to the 'maximum' internal levels in AS/NZS 2107:2000 for specific uses.

Table 12 below (reproduced from Sec 4.1.3 (Chapter 4) of the ICNG 2009) sets out the noise management levels for commercial and industrial use developments. The external noise levels should be assessed at the most-affected occupied point.

Table 12: OEH ICNG Construction Noise Criteria at Commercial and Industrial Premises

Land Use	Management Level, $L_{Aeq,15min}$ – applies when land use is being utilized
Industrial premises	External noise level 75 dB(A)
Offices, retail outlets	External noise level 70 dB(A)

5.5 Construction Vibration Criteria

NSW Department of Environmental and Conservation now EPA developed a document, "Assessing vibration: A technical Guideline" in February 2006 to assist in preventing people from exposure to excessive vibration levels within buildings. The guideline does not however address vibration induced damage to structures or structure-borne noise effects. Vibration and its associated effects are usually classified as continuous, impulsive or intermittent.

5.5.1 Human Comfort – Continuous and Impulsive Vibration Criteria

Structural vibration in buildings can be detected by occupants and can affect them in many ways including reducing their quality of life and also their working efficiency. Complaint levels from occupants of buildings subject to vibration depend upon their use of the building and the time of the day.

Maximum allowable magnitudes of building vibration with respect to human response are shown in Table 13. It should be noted that the human comfort for vibration are more stringent than the building damage criteria.

Table 13: Preferred and maximum weighted RMS values for continuous and impulsive vibration acceleration (m/s^2) 1-80Hz

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration					
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and place of worship	Day or night time	0.020	0.014	0.040	0.028
Impulsive vibration					
Residences	Daytime	0.30	0.21	0.60	0.42
	Night time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and place of worship	Day or night time	0.64	0.46	1.28	0.92

Human Comfort – Intermittent Vibration Criteria

Disturbance caused by vibration will depend on its duration and its magnitude. This methodology of assessing intermittent vibration levels involves the calculation of a parameter called the Vibration Dose Value (VDV) which is used to evaluate the cumulative effects of intermittent vibration. Various studies support the fact that VDV assessment methods are far more accurate in assessing the level of disturbance than methods which is only based on the vibration magnitude.

Table 14: Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime (7:00am to 10:00pm)		Night-time (10:00pm to 7:00am)	
	Preferred value	Maximum value	Preferred value	Maximum value
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and place of worship	0.40	0.80	0.40	0.80

5.5.2 Structural Damage – Vibration Criteria

Ground vibration criteria are defined in terms of levels of vibration emission from infrastructures or from the construction activities which will avoid the risk of damaging surrounding buildings or structures. It should be noted that human comfort criteria are normally expressed in terms of acceleration whereas structural damage criteria are normally expressed in terms of velocity.

Most commonly specified structural vibration levels are defined to minimize the risk of cosmetic surface cracks and are set below the levels that have the potential to cause damage to the main structure. Structural damage criteria are presented in German Standard DIN4150-Part 3 "Structural vibration in buildings – Effects on structures" and British Standard BS7385-Part 2: 1993 "Evaluation and Measurement for Vibration in Buildings". Table 15 indicates the vibration limits presented in DIN4150-Part 3 to ensure structural damage doesn't occur.

Table 15: Guideline value of vibration velocity, vi, for evaluating the effects of short-term vibration

Line	Type of Structure	Vibration velocity, vi, in mm/s			
		Foundation			Plane of floor of uppermost full storey
		At a frequency of			
		Less than 10Hz	10 to 50Hz	50 to 100*Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8
*For frequencies above 100Hz, at least the values specified in this column shall be applied					

Table 16 presents guide values for building vibration, based on the lowest vibration levels above which cosmetic damage has been demonstrated as per BS7385-Part 2:1993.

Table 16: Transient vibration guide values for cosmetic damage

Type of Building	Peak Particle Velocity in frequency range of predominant pulse (PPV)	
Residential or light commercial type buildings	4 Hz to 15 Hz	15 Hz and above
	15mm/s at 4Hz increasing to 20mm/s at 15Hz	20mm/s at 15Hz increasing to 50mm/s at 40Hz and above

5.5.3 Vibration Objectives

Table 17 indicates the vibration criteria for the nearest residential and commercial properties to the development.

Table 17: Construction vibration criteria summary

Location	Period	Human Comfort Vibration Objectives			Building damage Objectives – Velocity (mm/s)
		Continuous mm/s² (RMS)		Intermittent m/s$^{1.75}$ (VDV)	
		z-axis	x- and y-axis		
Residential	Daytime	10 - 20	7 - 14	0.20 - 0.40	5
	Night time	7 - 14	5 - 10	0.13 - 0.26	5
Commercial	Any time	20 - 40	14 - 28	0.40 – 0.80	20

6. Noise Impact Assessment

A 3D acoustic modelling for external noise intrusion from the surrounding roads was conducted using the software SoundPlan (Version 7.4). Noise levels from the road were calculated in accordance with the Calculation of Road Traffic Noise (CRTN) methodology, and calibrated to measurements and logger data from around the site. This model is recognised by regulatory authorities around Australia and is endorsed by the NSW EPA for the use in projects of this scale. The acoustic modelling was undertaken considering no specific meteorological characteristics such as dominant wind direction and speed or temperature therefore it was considered under neutral conditions.

6.1 Noise Emissions

A 3D acoustic modelling for noise emissions was conducted using the software SoundPlan (Version 7.4). Noise emissions from the operational noise sources were calculated for the nearest and potentially most affected residential and commercial receiver locations with consideration of the adjacent natural environmental values. The noise emissions from the development were determined by modeling the noise sources, receiver locations, and topographical features.

The following noise sources are associated with the site operation, and details about expected noise levels from these sources are given in the ensuing sub-sections. Noise sources from general operations at the site typically include mechanical services noise from air-conditioning equipment and exhaust fans etc. servicing the residential units, retail and car parks. These noise sources have been used to predict the worst case scenario noise impact of the proposed use of the site to the surrounding residential receivers.

The main sources associated with the development will include:

- **Waves:** waves were modelled based on the noise levels provided by WaveGarden of the WaveGarden Demo facility in Aizarnazabal. It is assumed that there will be 2 waves breaking at one time on each sides of the pier.
- **Wave generating plants:** Plant and equipment located at the wave-driving and wave-receiving stations.
- **General building services (eg. A/C Units):** Rooftop plant associated with the facility will be selected so that the total Sound Power Level of no more than 75 dB(A) per facility building is achieved.
- **Patron noise:** The patron area was assumed to be located at the southern side of the facility buildings. With assumption of maximum patron capacity (500 patrons) were present at the same time, and 50% of the patron were speaking loudly.
- **Ambient music noise:** It is assumed that 80dB(A) background music were used inside the function centre, which would be a typical of loud music played in the function centre.

In order to assess the worst case scenario, the night time criterion was used as the noise target at the boundary of the nearest residential receivers for the project as it is the most stringent period for the noise generated by the operation of wave park.

Table 18 presented the proposed sound power levels associated with the proposed development. Note that in order to meet these sound power levels, acoustic mitigation measures such as acoustic barriers, attenuators, acoustic louvres and internal acoustic lining may be required.

Table 18: Sound Power Levels used in the acoustic modelling of the Wavepark

Noise Source	Sound Power Level[1], in dB(A)	Comments
Waves	83 (per linear metre)	Modelled as a line noise source
Wave Generating Plant	75 (per linear metre)[2]	Modelled as a line noise source as an approximation of multiple point source along the wave generation plant line. Independent point sources are to be encapsulated so noise levels are generally inaudible below the wave noise.
General Building Service Plant (A/C Units)	75	Individual point noise sources modelled 1m above roof height of the facility buildings
Patron Noise	104	Modelled as an area source spread over the entire patron area south and east of the lagoon
Music from Function Centre	80 (per square metre)	Modelled as an area source spread over the function area to the south and east of the lagoon

Notes:

1. Based on the noise data presented on AECOM's Environmental Noise Assessment Report for Melbourne Wave Park.
2. Based on WGE Melbourne's conversation with Wavepark Group on July 2016 and the latest wave generating plant technology proposed for the development.

6.1.1 Predicted Noise Levels

Based on the 3D acoustic modelling for noise emissions the noise levels due to the proposed Wave Park towards the nearest residential receiver can be predicted.

Operation Noise

In accordance with the 3D models as shown on Appendix 2, it is shown that with all of the noise sources operating simultaneously, the effective noise level of less than **44 dB(A)** is expected at the nearest residence. This includes the noise generated from the following sources:

- Waves
- Wave-generating plant
- General building plant
- Crowds
- Music

A noise level of **44 dB(A)** is compliant with evening period (i.e. between 6pm to 10pm) noise limit which the Wave Park will be operated. It is expected that when the Wave Park operate during the night period, the crowd attendance would be significantly lower, which would result in lower noise levels. Therefore, this is assessment demonstrates a very conservative approach in which the worst-case scenario of maximum expected patronage occurring during evening period.

6.2 Road Traffic Noise Assessment

This assessment has considered the generation of traffic noise from the proposed development, as detailed by The Transport Planning Partnership, onto the local road. This data has been used to calculate the expected noise increase due to traffic associated with the development. As presented in the traffic report, the existing land use generates significantly more traffic than the proposed development.

The noise assessment has been conducted and the relevant information regarding peak hour vehicle movements on Hill Road has been summarized in Table 19.

Table 19: Existing and predicted traffic flow volumes (peak hour)

Traffic Volume	Existing vehicles			Predicted Increase			Noise Level Increase (dB)		
	AM	PM	Weekends	AM	PM	Weekends	AM	PM	Weekends
Hill Road, between Site Access (W) and Holker Street	1,232	1,428	948	1,256	1,444	1,008	0.1	0.0	0.3
Hill Road, between Holker Street and Site Access (E)	1,696	1,936	1,246	1,714	1,955	1,295	0.0	0.0	0.2

As shown in Table 19 the relative increase in noise is at most 0.3dB during the peak hours, which is less than the 2dB increase criteria, therefore the proposed development is expected comply with the requirements of the NSW RNP.

7. Preliminary Construction Noise & Vibration Assessment

7.1 Construction Noise Assessment

7.1.1 Proposed Works & Equipment

The works will comprise two parts which are the early works and construction works. Table 20 below summarises the equipment that could possibly be used for the works as well as their indicative sound power levels.

Table 21: Indicative sound power levels for construction and demolition equipment

Scenario	Equipment	Number of operating equipment	Indicative Sound Power Levels dB(A) re 1 pW
Early works	23t Excavator (rockbreaker)	2	112
	22t Excavator	2	105
	29t Tip truck	4	107
	31t Wheeled Loader	1	112
Construction works	Concrete mix truck	1	103
	Concrete pumps	3	105
	29t Tip truck	4	107
	Piling rig	4	95

7.1.2 Acoustic Modelling

The noise emissions generated by both the early works and construction works has been modelled using SoundPLAN version 7.4 with the equipment that could possibly be used provided in Table 21. The results of noise emission modelling show that the predicted noise level at the façade of the nearest residential receivers will range between 48-52 dB(A) and 52-56dB(A) at the nearest active recreational boundaries. Please refer to Appendix 2, Figure 5 and Figure 6 for the predicted noise emission contour maps for both the early works stage and construction stage.

The noise emissions generated during the early works stage and construction stage are predicted to comply with the criteria provided in Table 10 and Table 11 based on the preliminary assumptions provided in Section 7.1.1.

7.2 Construction Vibration Assessment

The vibration associated with construction is dependent on a number of variables including the types of machinery, the proximity to the nearby receivers as well as the ground type. Due to the lack of information regarding this at the early stages of the development, an accurate calculation of the vibration impacts cannot be predicted.

It is required that a Construction Noise and Vibration Management Plan (CNVMP) is conducted prior to construction in order to manage construction noise/vibration as well as to perform high level predictions to avoid non-compliances with the vibration criteria. In addition, the use of noise and vibration monitoring during construction will be essential in order to ascertain the extent of vibration and noise generated in and around the site.

Further to the above, generic safe working distances for vibration impacts associated with various types of machinery at given distances are presented within the *"Construction Noise Strategy "*document (issued by the Transport Infrastructure Development Corporation, dated November 2007). This document presents the safe construction working limits for Cosmetic Damage to adjacent structures and Human Comfort. It is recommended that the indicative safe working distances should be maintained from vibrating equipment which could be used during demolition and construction tasks.

Table 22: Recommended indicative safe working distances

Plant Item	Rating / Description	Safe Working Distance (m)	
		Structural Cosmetic Damage	Human Comfort
Vibratory Roller	< 50 kN (Typically 1 – 2 tonnes)	5	15 - 20
	< 100 kN (Typically 2 – 4 tonnes)	6	20
	< 200 kN (Typically 4 – 6 tonnes)	12	40
	< 300 kN (Typically 7 – 13 tonnes)	15	100
	> 300 kN (Typically more than 13 tonnes)	20	100
Small hydraulic hammer	300 kg, typically 5 – 12 tonnes excavator	2	7
Medium hydraulic hammer	900 kg, typically 12 – 18 tonnes excavator	7	23
Large hydraulic hammer	1600 kg, typically 18 – 34 tonnes excavator	22	73
Vibratory pile driver	Sheet piles	2 – 20	20
Pile boring	≤ 800 mm	2	N/A
Jackhammer	Hand held	1	Avoid contact with structure (including slab reinforcements)

Please note these safe distances should be confirmed and updated in a Construction Noise and Vibration Management Plan based on the following information:

- Details of the demolition and construction tasks (including scope and duration).
- List of equipment to be used in each demolition and construction task.

Finally, the following amelioration measures shall be taken into account in order to minimise the transmitted vibration around the site:

- Monitor vibration levels using attended/un-attended methods during construction in order to manage potential excessive vibration.
- Manage construction program so as to minimise heavy machinery operating concurrently.
- Prepare dilapidation reports on adjacent structures and monitor the effects.
- As far as practical, locate heavy machinery away from nearby sensitive receivers

8. Conclusion

An acoustic assessment for the proposed mixed-use development at the proposed development site, URBNSurf, Olympic Park has been conducted. This document forms part of the documentation package to be submitted to local authorities as part of the DA process.

This report has provided criteria, in-principle treatment and design requirements which aim to achieve the statutory criteria discussed in Section 5. In terms of noise criteria, we have provided the following:

- Internal noise levels in accordance AS2107 for the retail/office spaces, provided in Section 5.1;
- Noise criteria for emissions from the development to residential receivers in accordance with Sydney Olympic Park Master Plan 2030 and the NSW INP, provided in Section 5.2;
- Construction noise criteria provided in Section 5.4 in accordance with the ICNG;

The location of the proposed development is consistent with the Sydney Olympic Park sports and recreation zoning.

In accordance with the model, the predicted noise emission from the operation of the Wave Park shows the compliances with the evening noise limit (i.e. between 6pm – 10pm). Therefore, it is in our opinion that the operation of the Wave Park will not cause a significant impact on the surrounding community and sensitive faunas located within the Narrawang Wetlands (located north of Hill Road).

The predicted noise level from peak hour vehicle movement from the proposed development is not expected to exceed the requirements in regards to the NSW Road Noise Policy.

The predicted noise emissions generated during the early works stage and construction stage are expected to comply with the criteria provided in Table 10 and Table 11.

Even though no assessment can be considered as being thorough enough to preclude all potential environmental impacts, having given regard to the above listed conclusions, it is the finding of this assessment that the development application should not be refused on the grounds of excessive noise generation.

The information presented in this report shall be reviewed if any modifications to the features of the development specified in this report occur, including and not restricted to selection of air-conditioning units, layout of equipment, modifications to the building and introduction of any additional noise sources.

Appendix 1 – Glossary of Acoustic Terms

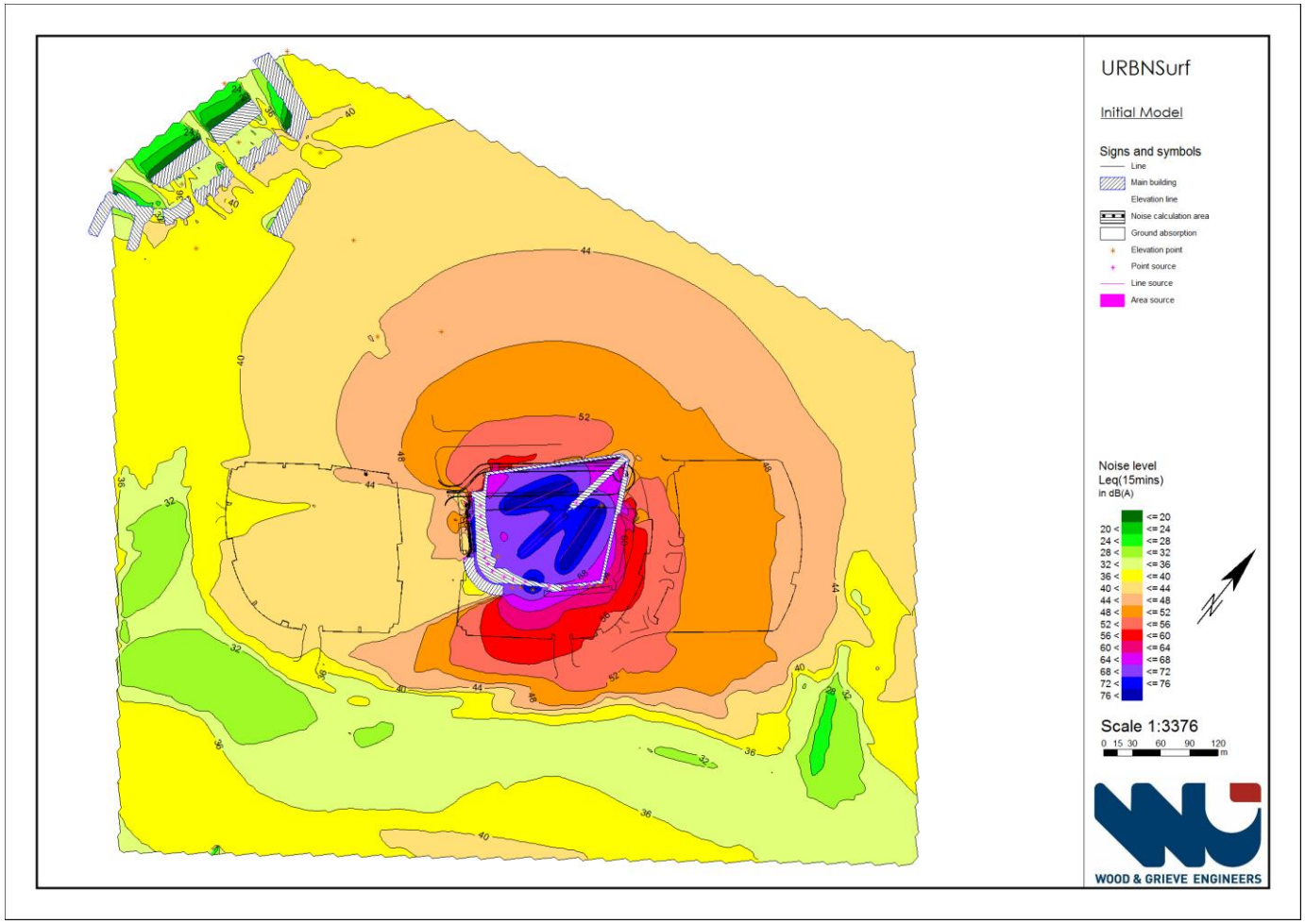
NOISE	
Acceptable Noise Level:	The acceptable LAeq noise level from industrial sources, recommended by the EPA (Table 2.1, INP). Note that this noise level refers to all industrial sources at the receiver location, and not only noise due to a specific project under consideration.
Adverse Weather:	Weather conditions that affect noise (wind and temperature inversions) that occur at a particular site for a significant period of time. The previous conditions are for wind occurring more than 30% of the time in any assessment period in any season and/or for temperature inversions occurring more than 30% of the nights in winter).
Acoustic Barrier:	Solid walls or partitions, solid fences, earth mounds, earth berms, buildings, etc. used to reduce noise.
Ambient Noise:	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment Period:	The period in a day over which assessments are made.
Assessment Location	The position at which noise measurements are undertaken or estimated.
Background Noise:	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level.
Decibel [dB]:	The units of sound pressure level.
dB(A):	A-weighted decibels. Noise measured using the A filter.
Extraneous Noise:	Noise resulting from activities that are not typical of the area. Atypical activities include construction, and traffic generated by holidays period and by special events such as concert or sporting events. Normal daily traffic is not considered to be extraneous.
Free Field:	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground
Frequency:	Frequency is synonymous to pitch. Frequency or pitch can be measured on a scale in units of Hertz (Hz).
Impulsive Noise:	Noise having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent Noise:	Level that drops to the background noise level several times during the period of

Appendix 1 – Glossary of Acoustic Terms

	observation.
LAmax	The maximum A-weighted sound pressure level measured over a period.
LAmin	The minimum A-weighted sound pressure level measured over a period.
LA1	The A-weighted sound pressure level that is exceeded for 1% of the time for which the sound is measured.
LA10	The A-weighted sound pressure level that is exceeded for 10% of the time for which the sound is measured.
LA90	The A-weighted level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
LAeq	The A-weighted "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
LAeqT	The constant A-weighted sound which has the same energy as the fluctuating sound of the traffic, averaged over time T.
Reflection:	Sound wave changed in direction of propagation due to a solid object met on its path.
R-w:	The Sound Insulation Rating R-w is a measure of the noise reduction performance of the partition.
SEL:	Sound Exposure Level is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound Absorption:	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound Level Meter:	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound Pressure Level:	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound Power Level:	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise:	Containing a prominent frequency and characterised by a definite pitch.

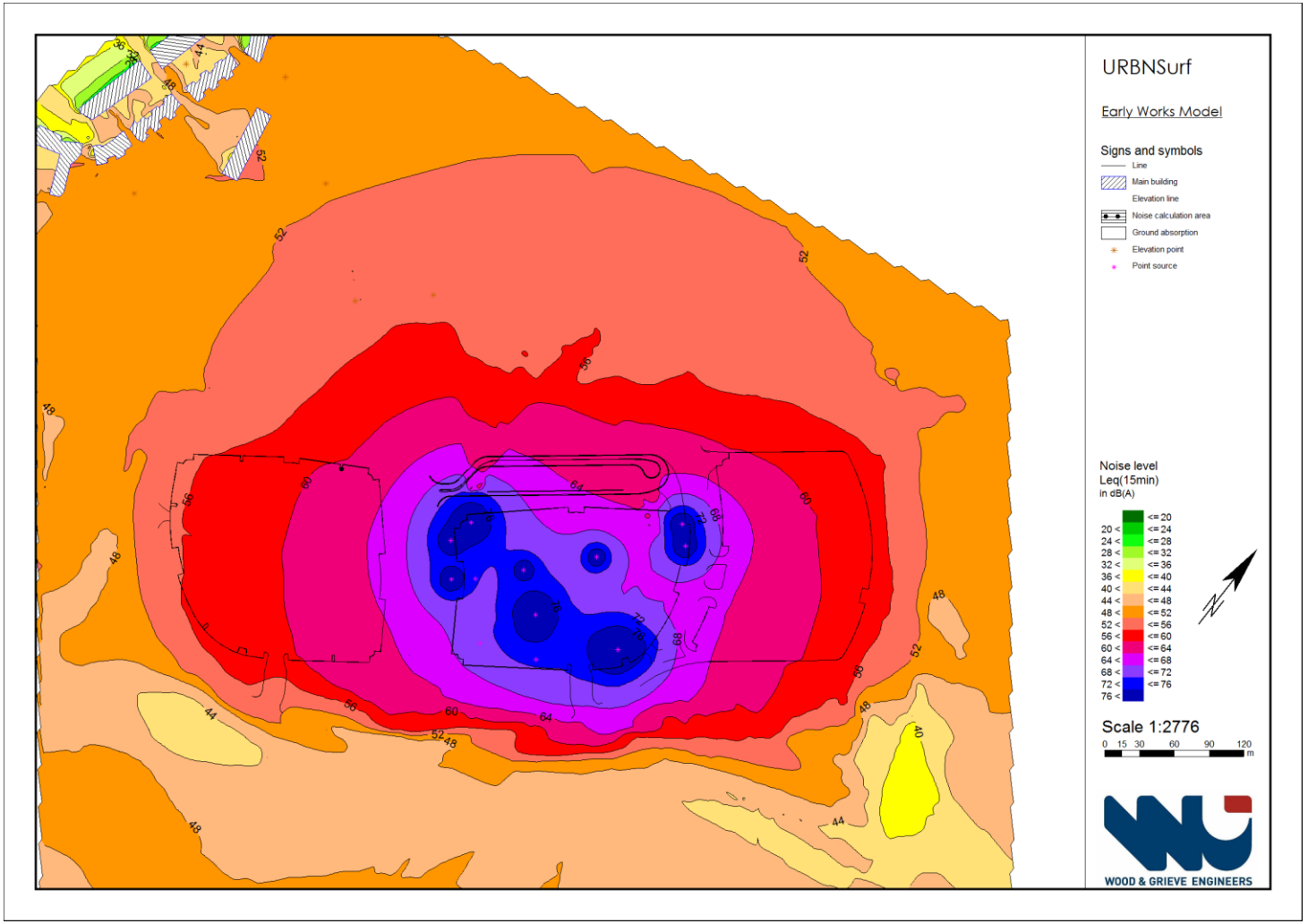
Appendix 2 – SoundPLAN Models

Figure 4: Noise Contour Map – Predicted Operational Noise (Crowd, Music, Mechanical and Waves Noise)



Appendix 2 – SoundPLAN Models

Figure 5: Noise Contour Map – Early Works



Appendix 2 – SoundPLAN Models

Figure 6: Noise Contour Map – Construction Works