WOOD & GRIEVE ENGINEERS

26 Shepherd Street

Acoustic Report
Development Application

Prepared for:

Katrina Lim
Coronation Pty Ltd

Prepared by:

Sean Matthews
Project No. 29650-SYD-N
\\WGE-SYD-FS-01\PROJECTS\29650\PROJECT DOCUMENTATION\ACOUSTICS\DESIGN\REPORTS\N_RE_001_SM.DOCX

Date:
21/12/2016

Level 6, Building B, 207 Pacific Highway, St Leonards NSW 2065
T: (02) 8484 7000 **F:** (02) 8484 7100 **E:** sydney@wge.com.au **W:** www.wge.com.au

Revision

REVISION	DATE	COMMENT	APPROVED BY
1	21/12/16	Initial issue	**Mathew McGrory**

WGE is a proud member of the Association of Australian Acoustical Consultants (AAAC).

AAAC members are competent and capable in the acoustic field. Members of the AAAC provide professional unbiased advices and recommendations in order to deliver practical innovative and cost effective solutions to their clients.
AAAC members are bind to a specific code of professional conduct which can be consulted on the AAAC website: http://www.aaac.org.au/au/aaac/ethics.aspx

Contents

1. Introduction

As part of the DA documentation process, Wood & Grieve Engineers have been engaged by Coronation Property Pty Ltd to provide an acoustic assessment for the proposed multi-level residential development located at 26 Shepherd Street, Liverpool.

The proposed development will consist of:

- 14 Level residential development
- Two levels of basement car parking
- Communal spaces and swimming pool on roof top

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

This assessment has been prepared considering the following documents:

- Liverpool Development Control Plan (DCP) 2008
- Infrastructure State Environmental Planning Policy 2007
- Department of Planning (DoP) – Development Near Rail Corridors and Buys Roads – Interim Guideline
- NSW EPA Industrial Noise Policy (INP)

This report provides:

- A statement of compliance with the Liverpool council requirements for the proposed residential development within the vicinity of the nearest potentially affected residential 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 9 days during March/April 2015.

This report is based on our understanding of the proposed project, application of the relevant state guidelines and professional experience within the acoustic field. Therefore this report shall not be relied upon as providing any warranties or guarantees.

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
- Architectural drawings provided by Woods Bagot:
  - 26/28 Shepherd Street Combined DA/Stage 2 DA dated 20-12-16

- Noise data collected on site through the use of noise loggers and a hand held spectrum analyser

3. Project Overview

3.1 Site description

The site is located at 26 Shepherd Street, Liverpool and is bound by Shepherd Street to the west, a future residential development and a retail facility to the north at 20 Shepherd Street, future proposed residential apartments to the south at 28 Shepherd Street, and industrial facilities approximately 120 metres to the east across the Georges River. Across Shepherd Street are mainly industrial facilities with some commercial buildings amongst them.

The nearest existing noise sensitive receivers are the future residential apartments located at the 20 and 28 Shepherd Street developments. The train line is approximately 60 metres from the development and as such, consideration will be given to train noise and vibration in accordance with the Department of Planning Interim Guideline.

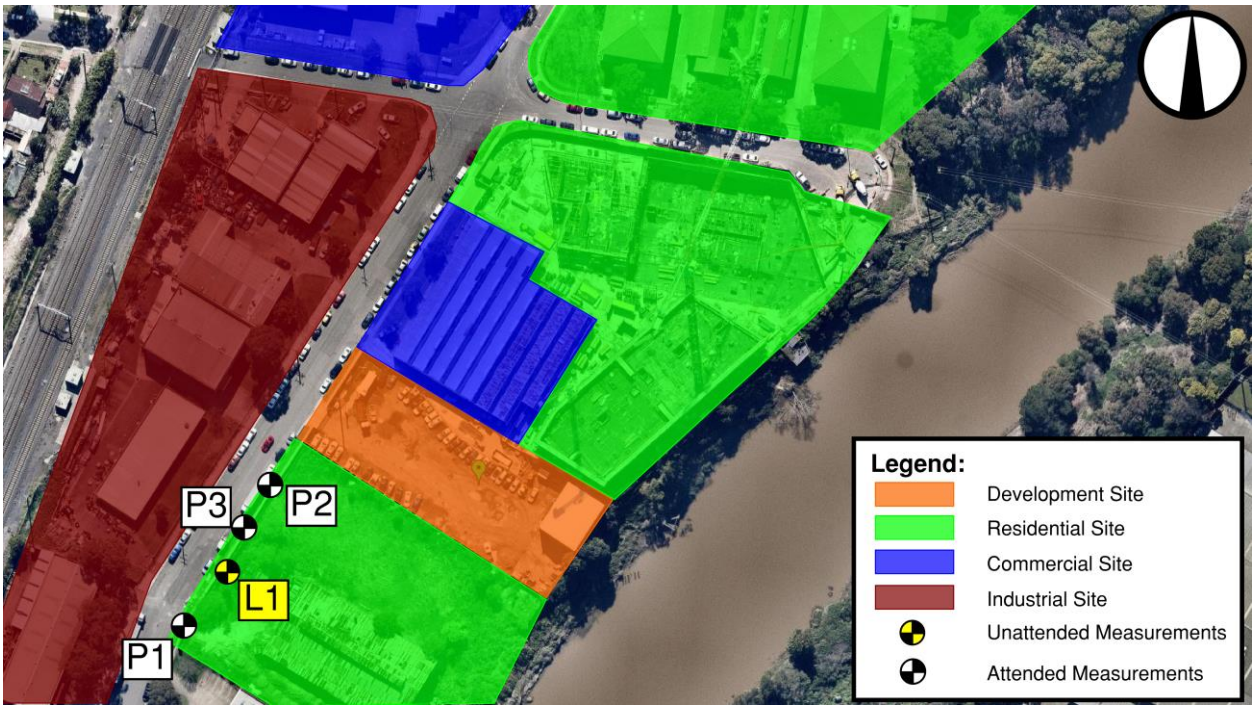
The site location, measurement positions and surrounding commercial, residential and industrial receivers are shown in Figure 1.

3.1.1 Acoustic and Vibration Issues

The acoustic and vibration issues relating to the development are as follows:

- Noise intrusion from vehicle movements on Shepherd Street
- Noise intrusion from train pass-by's
- Noise intrusion from activities at the industrial facilities surrounding the site
- Noise emissions from mechanical services from the development to the surrounding receivers
- Traffic noise generation on Shepherd Street
- Train vibration for human perception and structural damage

Figure 1: Overview of the site and measurement locations



Source: nearmap.com

4. Noise Survey

4.1 Instrumentation

The equipment used for the noise survey was the following:

- ARL Environmental Noise Logger ARL EL-215 S/N 194525
- Hand-held sound spectrum analyzer B&K 2250, S/N 2709742
- Sound Calibrator B&K Type 4231, S/N 2709826
- SVAN 958 Sound and Vibration Analyser Type 1 S/N 15153
- SVANTEK SV207A Building Vibration Accelerometer S/N 22824

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

Attended noise measurements of 15-minute duration were conducted on site to characterise the acoustic environment for noise intrusion into the development, and to determine any noise impact on the surrounding receivers. The measurement positions are shown in Figure 1, and a summary of the attended noise measurements taken at site are shown in Table 1. Included in the table are train pass-by measurements of short duration.

Table 1: Noise measurements

Measurement Location	Measurement Time	$L_{Aeq,\ 15mins}$ dB(A)	L_{A90} dB(A)	Comments
P1	25/03/15 2:20pm	63	48	Noise from vehicle and train pass-by, and some surrounding industrial noises
P2	25/03/15 2:35pm	58	51	Noise from vehicle and train pass-by, and some surrounding industrial noises
P3	02/04/15 12:17pm	49	-	Train pass-by – $L_{Aeq,\ duration}$ *Measurement influenced by car passby
	02/04/15 12:19pm	54	-	
	02/04/15 12:21pm	65*	-	
	02/04/15 12:23pm	51	-	
	02/04/15 12:25pm	50	-	
	02/04/15 12:29pm	59	-	

4.3 Unattended Noise Survey Results

The NSW EPA Industrial Noise Policy 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.

Noise Survey

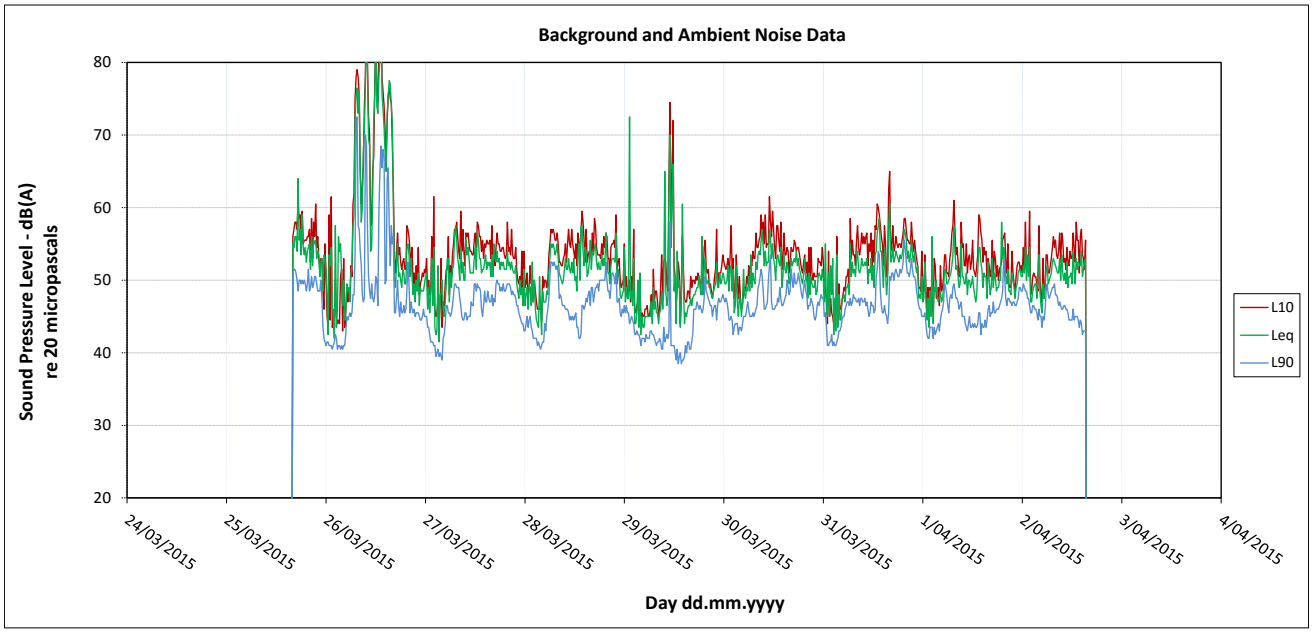
A noise logger was placed at position L1 as shown in Figure 1 to measure the ambient and background noise that is representative of the site and surrounding residential receivers. The logger was installed from the 25th of March to the 2nd of April 2015. The results of the unattended noise survey are shown in Table 2 below.

Table 2: Unattended noise measurements

Location	Equivalent Continuous Noise Level $L_{Aeq,period}$ - dB(A)			Background Noise Level RBL- dB(A)		
	Day	Evening	Night	Day	Evening	Night
L1	54	52	52	44	47	42

The local ambient noise environment consists of general ambient noise from an urban and industrial area. There is a low amount of vehicle activity on the local roads, as it is generally movement to and from the commercial and industrial facilities. Refer to Figure 2 for the noise data. Note that where there was rainfall during the measurement period and/or extraneous noise during the 26th of March; the affected data has been excluded from the calculations.

Figure 2: Unattended noise monitor data



5. Criteria

5.1 Site noise emission

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

5.1.1 NSW EPA Industrial Noise Policy

In the absence of any specific acoustic requirements in the Liverpool DCP, the NSW Office of Environment and Heritage (EPA) Industrial Noise Policy will be used. The INP sets out noise criteria to control the noise emission from industrial noise sources. The external noise due to mechanical services from the proposed development is also addressed following the guideline in the NSW EPA's 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 3: 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	52
Night 10pm – 7am	$L_{Aeq,15min} \leq$ RBL + 5	47

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:

Criteria

Table 4: Amenity criteria for external noise levels

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level, dB(A)		Adjusted Acceptable L_{Aeq} Levels
			Acceptable	Recommended Maximum	
Residential	All	Day	60	65	49
	All	Evening	50	55	42
	All	Night	45	50	42
Commercial	All	When in use	65	70	64
Industrial	All	When in use	70	75	69

*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 5 below) provides procedures for determining whether an adjustment should be applied for greater annoyance aspect.

Table 5: 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 Project-Specific Noise Levels (PSNL)

Table 6 below displays the project-specific noise levels PSNL for the project. Any operational or mechanical noise emissions from the development must comply with the PSNL provided at the surrounding receivers. In the case of the EPA INP intrusiveness and amenity criteria, the lowest of the two has to be chosen as the PSNL.

Table 6: Project specific noise levels

Period	Descriptor	PSNL dB(A)
Residential Areas		
Day (7:00am to 6:00pm)	$L_{Aeq,15min}$	**49**
Evening (6:00pm to 10:00pm)	$L_{Aeq,15min}$	**42**
Night (10:00pm to 7:00am)	$L_{Aeq,15min}$	**42**
Commercial Areas	$L_{Aeq,when\ in\ use}$	**64**
Industrial Areas	$L_{Aeq,when\ in\ use}$	**69**

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 Internal Noise Levels

This section details the criteria used to define the internal noise goals for spaces in the development.

5.3.1 Department of Planning – Development near Rail Corridors and Busy Roads – Interim Guideline

The DoP Interim Guideline has been considered for this development due to the proximity to the rail line. The guideline is in accordance with clause 87 of the Infrastructure State Environmental Planning Policy (SEPP) which states the following for residential developments adjacent to rail corridors:

If the development is for the purpose of a building for residential use, the consent authority must be satisfied that appropriate measures will be taken to ensure that the following LAeq levels are not exceeded:

- *in any bedroom in the building : 35dB(A) at any time 10pm–7am*
- *anywhere else in the building (other than a garage, kitchen, bathroom or hallway): 40dB(A) at any time.*

The external façade of the development will be designed such that it complies with the requirements of the Infrastructure SEPP for rail noise. In the case of this development, other noise sources such as vehicle movements and industrial noise may place the greatest demand on the façade and will be considered in the design whilst achieving the specified internal noise levels.

5.4 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 7: 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)
Local roads	Existing Residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq,1\ hour}$ 55 (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'.

5.5 Construction Noise Criteria

Noise criteria for construction sites are established in accordance with the Interim Construction Noise Guideline (*ICNG July 2009*) by the NSW Office of Environment &Heritage (NSW EPA). It is important to note that the recommended criteria are for planning purposes only. Numerous other factors need to be considered when assessing potential noise impacts from construction works.

However, in undertaking the assessment of potential noise intrusion associated with the proposed construction activities, Chapter 4 of the NSW EPA ICNG (July 2009) were specifically referenced. The noise limits are presented in Table 8, and are applicable to the development.

Criteria

Table 8: 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 RBL + 10dB	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 RBL + 5dB	• 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 EPA ICNG

5.6 Train and Construction Vibration Criteria

The Office of Environment and Heritage (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.

5.6.1 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 9. It should be noted that the human comfort for vibration are more stringent than the building damage criteria.

Table 9: Preferred and maximum weighted RMS values for continuous and impulsive vibration acceleration (m/s2) 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 10: Acceptable Vibration Dose Values for Intermittent Vibration (m/s1.75)

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

5.6.2 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 11 indicates the vibration limits presented in DIN4150-Part 3 to ensure structural damage doesn't occur.

Table 11: 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 12 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 12: Transient vibration guide values for cosmetic damage

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

5.6.3 Vibration Objectives

Table 13 indicates the train vibration criteria applicable to the residential development as well as the construction vibration criteria for the adjacent residential properties to the development.

Table 13: Construction vibration criteria summary

Location	Period	Human Comfort Vibration Objectives			Building damage Objectives – Velocity (mm/s)
		Continuous mm/s^2 (RMS)		Intermittent $mm/s^{1.75}$ (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

6. Noise Impact Assessment

6.1 Train Noise Levels

Based on the noise measurements conducted from train pass bys as shown in Table 1, and using the number of train movements as estimated from the Transport Sydney Trains for T2, T3, T5 lines, the results of the train noise measurements at the façade of the development have been calculated. The levels have been calculated in accordance with the DoP Interim Guideline and are shown in Table 14.

Table 14: Train noise levels, $L_{Aeq,\ period}$ dB(A)

Location	Day time $L_{Aeq,\ 15hours}$ dB(A)	Night time $L_{Aeq,\ 9hours}$ dB(A)
North façade	49.7	43.4

The noise levels as shown above are purely from train movements for the glazing design in accordance with the requirements of the DoP Interim Guideline. Noise levels from the attended and unattended measurements have been used in conjunction with these levels to design the glazing as they are higher than those from the pure train noise.

6.2 External Glazing

The general limiting factor of the performance of a building façade in term of noise attenuation is the glazing. In this particular case of the proposed development, the combination of general surrounding traffic noise, industrial noise, and train pass-by's provide the most acoustic demand on the development.

In order to achieve the internal noise levels specified in the DoP Interim Guideline, the minimum recommended glazing selection for the façades of the proposed development is presented in the following Table 15. The data presented in this table is based on the worst case scenario of external noise obtained from the attended noise measurement and noise data from the unattended logger. The glazing thicknesses presented below should be considered as the minimum thicknesses to achieve acoustical ratings. Greater glazing thicknesses may be required for structural loading, wind loading, ESD, etc.

Table 15: Recommended acoustic performance of glazing system

Façade	Level	Occupancy	Glass System	Required Acoustic Rating of Glazing Assembly, Rw[1]
All	All	Bedrooms	8.38mm laminated	34
		Living rooms	6.38mm laminated	33
The Required Acoustic Rating of Glazing Assembly, refers to the acoustic performance of the glazing once installed on site (including the frame)				

During the detailed design stage of the project the acoustic performance of the glazing facade should be reviewed as the combined noise from external sources and mechanical services could result in the internal noise level exceeding the design sound level ($L_{Aeq,T}$ dBA).

[1] See Appendix 1 for Rw definition

6.3 Noise Emissions

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 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 nearby residential receivers.

The proposed residential development will be provided with air-conditioning systems throughout all apartment blocks. The main mechanical sources associated with the development will include:

- Condenser units located on the balconies of each apartment
- Car park exhaust fan (CPEF) and car park supply fan (CPSF) located on the roof top
- 1 x level 1 roof mounted supply fan
- 6 x level 1 roof mounted toilet extract fans
- Level 13 plant room

In order to assess the worst case scenario, it was assumed that the mechanical services associated with the residential apartments are running at any time throughout a 24hr period.

The units have been calculated from the closest building façade to the residential receivers. With all, the night time is the most stringent period for the noise generated by the operation of mechanical plant; therefore this criterion was used as the noise target at the boundary of the nearest sensitive receivers for the project.

6.3.1 Proposed Noise Levels

Table 16 presents the proposed maximum sound power levels for mechanical plant in order to achieve the noise criteria shown in Table 6 at the boundary of the nearest receivers.

Table 16: Proposed acoustic power for individual CU

Item	SWL re 1pW (dB)								
	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	Overall dB(A)
Single Condenser Unit	64	69	63	55	54	52	50	45	61
CPEF	80	77	78	79	78	77	73	66	83
CPSF	80	77	78	79	78	77	73	66	83
Level 1 supply fan	57	63	55	54	56	54	47	40	60
Level 1 toilet extract fan	57	63	55	54	56	54	47	40	60

During detailed design, where the roof mounted supply and toilet exhaust fans cannot meet the maximum sound power level requirement, acoustic mitigation measures such as detailed below should be considered, or alternatively using in-line axial fans with acoustic treatment to the duct work.

It is our opinion that the project specific noise levels at the boundaries of the surrounding receivers should be met if the requirements of Table 16 are satisfied. Note that this is a preliminary solution as the design is yet to be finalised, it is recommended that an updated acoustic report is conducted at a later juncture when more information becomes available about the specific units to be used.

6.3.2 Level 13 Plant Room

Acoustic mitigation measures will be required to the level 13 plant room such as acoustic louvres, attenuators to the duct work in order to mitigate the noise emissions to the 28 Shepherd Street development, in accordance with the criteria.

6.3.3 Mechanical Services Mitigation Measures

Mitigation measures for the mechanical plant should be considered during the Design Development stage so as to comply with the outlined criteria at the nearest sensitive receivers. These amelioration measures could include but not limited to the following:

- Positioning mechanical plant away from nearby receivers
- Acoustic attenuators fitted to duct work
- Screening around mechanical plant
- Acoustic insulation within duct work

6.4 Road Traffic Noise Impact Assessment

For the road traffic noise assessment, traffic numbers and generated vehicles was based on the information provided InRoads Group. This data has been used to calculate the expected noise increase due to traffic associated with the development. It was predicted that 80 percent of the vehicles entering or exiting the roundabout from the north/south Shepherd Street are from the Shepherd Street industrial cul-de-sac. The results are summarized in Table 17 and Table 18.

Table 17: Existing and predicted traffic flow volumes (peak hour)

Traffic Volume	Existing vehicles		Predicted Increase		Post-Development	
	AM	PM	AM	PM	AM	PM
Shepherd Street	192	232	24	24	216	256

Based on the noise measurements from the existing traffic, Table 18 presents the predicted noise levels due to traffic noise increase.

Table 18: Predicted increase in traffic noise levels

Location	Existing Noise Levels	Predicted Noise Levels	Proposed maximum Noise Levels	Complies (Yes/No)
	$L_{Aeq-1hour}$, dB(A)	$L_{Aeq-1hour}$, dB(A)	$L_{Aeq-1hour}$, dB(A)	
Shepherd Street (AM)	53.4	53.9	55.0	Yes
Shepherd Street (PM)	54.2	54.7	55.0	Yes

As shown in Table 18 there is not predicted to be any increase above the maximum noise level of 55dB(A) along Shepherd Street. Based on this assessment, the proposed development is expected comply with the requirements of the NSW RNP.

7. Vibration Assessment

A vibration assessment has been conducted in accordance with the DoP Interm Guideline and referenced documents due to the proximity to the train line. The vibration levels of trains pass bys have been measured at the nearest point on the façade of the proposed development for all three axes. The measured values were processed and assessed in accordance with the criteria as detailed in section 5.6 to determine whether there will be any adverse effect on occupants of the development from human perception, or potential structural damage to the building. Refer to Table 19 for the Vibration Dose Value results based on the Z axis of the measurements for human comfort.

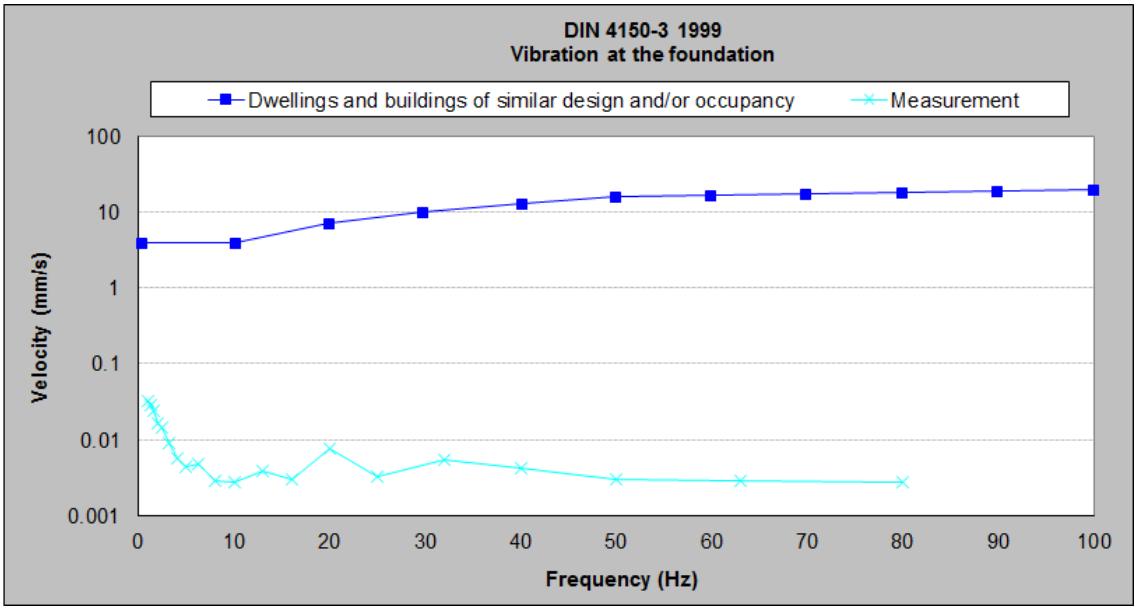
Table 19: Vibration Dose Values for Z-axis from train vibration

Period	eVDV ($m/s^{1.75}$)	Criteria	Complies
Day (7am – 10pm)	0.0092	0.20	Yes
Night (10pm – 7am)	0.0057	0.13	Yes

Based on the vibration measurements, there is not predicted to be any human annoyance or disturbance to the occupants of the proposed development as determined in accordance with the "Assessing Vibration: A technical Guideline" document.

Refer to Figure 3 for the results of the vibration velocity levels (mm/s) for comparison with the structural damage criteria for residential buildings from DIN4150 – 3 for building damage.

Figure 3: Vibration velocity (mm/s) for Z-axis



Based on the measurements, there is not predicted to be any exceedance of the criteria for structural damage to the development in accordance with the limits set by the DIN 4150-3 standard.

8. Swimming Pool

During detailed design the proposed rooftop swimming pool should be assessed and treated with vibration isolation to avoid regenerated noise from the pool to the apartments beneath which may have the potential to cause disturbance to the occupants.

9. Conclusion

An acoustic assessment for the proposed multi-level residential development at 26 Shepherd Street, Liverpool 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:

- Noise intrusion from train passbys in accordance with the DoP Guidelines in section 5.5
- Train vibration criteria for human perception and structural damage in section 5.6 in accordance with the Assessing Vibration Guideline and the DoP Interim Guideline
- Noise criteria for emissions from the development to receivers in accordance with the INP provided in section 5.1
- Traffic generated noise criteria in accordance with the RNP provided in section 5.4
- Construction noise criteria provided in section 5.5 in accordance with the ICNG

Glazing for the building has been designed to achieve internal noise levels in accordance with the requirements of DoP Interim Guideline and the Infrastructure SEPP. The glazing is presented in section 6.2.

The predicted noise levels presented in this report show that the day, evening and night criteria is expected to be met with the implementation of the proposed sound power levels for the mechanical services.

Based on the vibration measurements, there is not predicted to be any exceedance of the human comfort or structural damage criteria.

The road traffic noise assessment, based on information provided by InRoads Group regarding generated vehicles and measurements conducted by WGE has shown that there is not expected to be any exceedance of the RNP criteria.

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.

Appendix 1 - Glossary of Acoustic Terms

Intermittent Noise:	Level that drops to the background noise level several times during the period of 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.

WOOD & GRIEVE ENGINEERS

28 Shepherd Street - Stage 2

Acoustic Report for Development Application

Prepared for:

Danielle Eloss
Coronation Pty Ltd

Date:
21/12/2016

Prepared by:

Sean Matthews
Project No. 27826-SYD-N-2
\\WGE-SYD-FS-01\PROJECTS\27826-2\PROJECT DOCUMENTATION\ACOUSTICS\REPORTS\N_RE_001_SM.DOCX

Level 6, Building B, 207 Pacific Highway, St Leonards NSW 2065
T: (02) 8484 7000 **F:** (02) 8484 7100 **E:** sydney@wge.com.au **W:** www.wge.com.au

Revision

REVISION	DATE	COMMENT	APPROVED BY
01	20/12/16	Initial issue	**Mathew McGrory**
02	21/12/16	Following comments	**Mathew McGrory**

WGE is a proud member of the Association of Australian Acoustical Consultants (AAAC).

AAAC members are competent and capable in the acoustic field. Members of the AAAC provide professional unbiased advices and recommendations in order to deliver practical innovative and cost effective solutions to their clients.
AAAC members are bind to a specific code of professional conduct which can be consulted on the AAAC website: http://www.aaac.org.au/au/aaac/ethics.aspx

Contents

1. Introduction

As part of the DA documentation process, Wood & Grieve Engineers have been engaged by Coronation Property Pty Ltd to provide an acoustic assessment for Stage 2 of the proposed multi-level residential development located at 28 Shepherd Street, Liverpool composed of buildings C2 and C1.

The proposed development for Stage 2 will consist of:

- Additional 150 units resulting in 11 and 14 additional levels in Building C1
- Communal spaces on roof top

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

This assessment has been prepared considering the following documents:

- Liverpool Development Control Plan (DCP) 2008
- Infrastructure State Environmental Planning Policy 2007
- Department of Planning (DoP) – Development Near Rail Corridors and Buys Roads – Interim Guideline
- NSW OEH Industrial Noise Policy (INP)

This report provides:

- A statement of compliance with the Liverpool council requirements for the proposed residential development within the vicinity of the nearest potentially affected residential 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 9 days during March/April 2015.

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
- Architectural drawings provided by Woods Bagot:
  - 26/28 Shepherd Street Combined DA/Stage 2 DA dated 20-12-16
- Noise data collected on site through the use of noise loggers and a hand held spectrum analyser

3. Project Overview

3.1 Site description

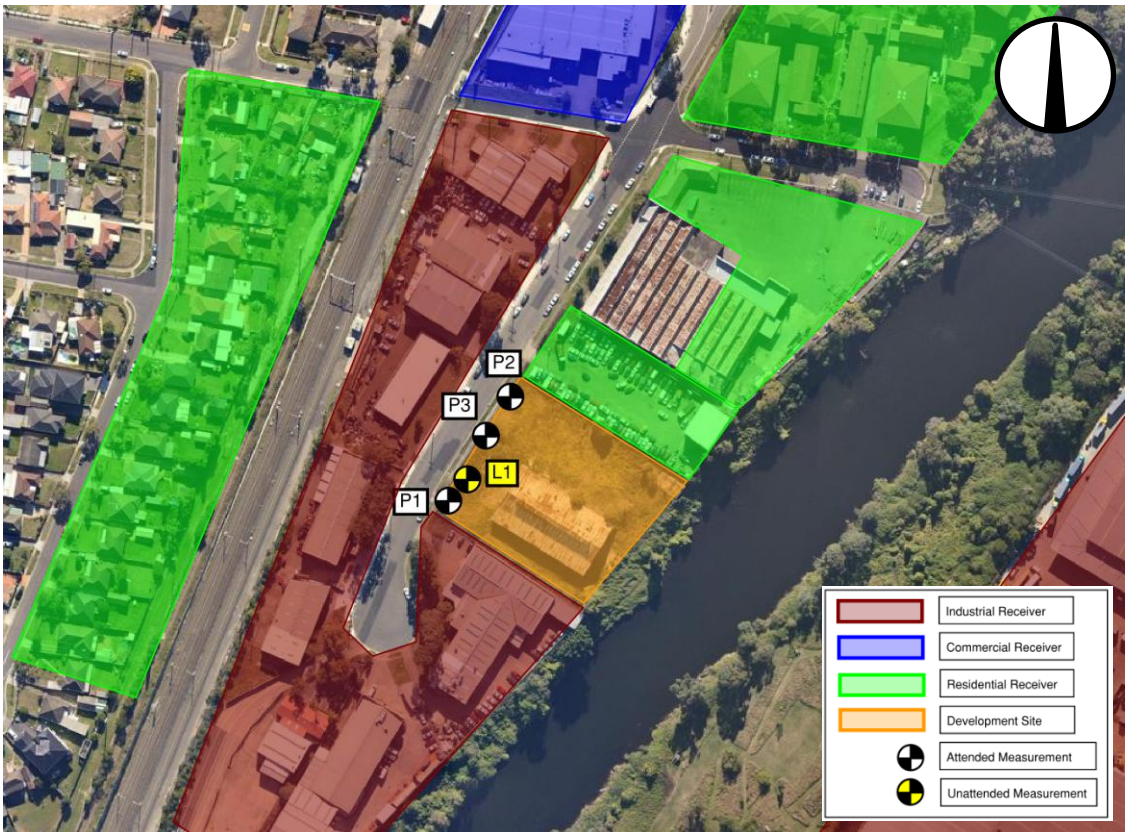
The site is located at 28 Shepherd St, Liverpool and is bound by Shepherd Street to the west, a car yard to the north with potential for future development, industrial facility to the south on the adjacent property, and industrial facilities approximately 120 metres to the east across the Georges River. Across Shepherd St are mainly industrial facilities with some commercial buildings amongst them. The nearest existing noise sensitive receivers are the multi-storey residential buildings across the train line to the west at approximately 120 metres. The potential future residential receivers adjacent to the north will also be considers as noise sensitive receivers for this assessment. The train line is approximately 60 metres from the development and as such, consideration will be given to train noise and vibration in accordance with the Department of Planning Interim Guideline.
The site location, measurement positions and surrounding commercial, residential and industrial receivers are shown in Figure 1.

3.1.1 Acoustic and Vibration Issues

The acoustic and vibration issues relating to the development are as follows:

- Noise intrusion from vehicle movements on Shepherd Street
- Noise intrusion from train pass-by's
- Noise intrusion from activities at the industrial facilities surrounding the site
- Noise emissions from typical mechanical plant from the development to the surrounding receivers
- Traffic noise generation on Shepherd Street
- Train vibration for human perception and structural damage

Figure 1: Overview of the site and measurement locations



Source: nearmap.com

4. Noise Survey

4.1 Instrumentation

The equipment used for the noise survey was the following:

- ARL Environmental Noise Logger ARL EL-215 S/N 194525
- Hand-held sound spectrum analyzer B&K 2250, S/N 2709742
- Sound Calibrator B&K Type 4231, S/N 2709826
- SVAN 958 Sound and Vibration Analyser Type 1 S/N 15153
- SVANTEK SV207A Building Vibration Accelerometer S/N 22824

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

Attended noise measurements of 15-minute duration were conducted on site to characterise the acoustic environment for noise intrusion into the development, and to determine any noise impact on the surrounding receivers. The measurement positions are shown in Figure 1, and a summary of the attended noise measurements taken at site are shown in Table 1. Included in the table are train pass-by measurements of short duration.

Table 1: Noise measurements

Measurement Location	Measurement Time	$L_{Aeq, 15mins}$ dB(A)	L_{A90} dB(A)	Comments
P1	25/03/15 2:20pm	63	48	Noise from vehicle and train pass-by, and some surrounding industrial noises
P2	25/03/15 2:35pm	58	51	Noise from vehicle and train pass-by, and some surrounding industrial noises
P3	02/04/15 12:17pm	49	-	Train pass-by – $L_{Aeq, duration}$ *Measurement influenced by car passby
	02/04/15 12:19pm	54	-	
	02/04/15 12:21pm	65*	-	
	02/04/15 12:23pm	51	-	
	02/04/15 12:25pm	50	-	
	02/04/15 12:29pm	59	-	

4.3 Unattended Noise Survey Results

The NSW OE&H Industrial Noise Policy 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.

Noise Survey

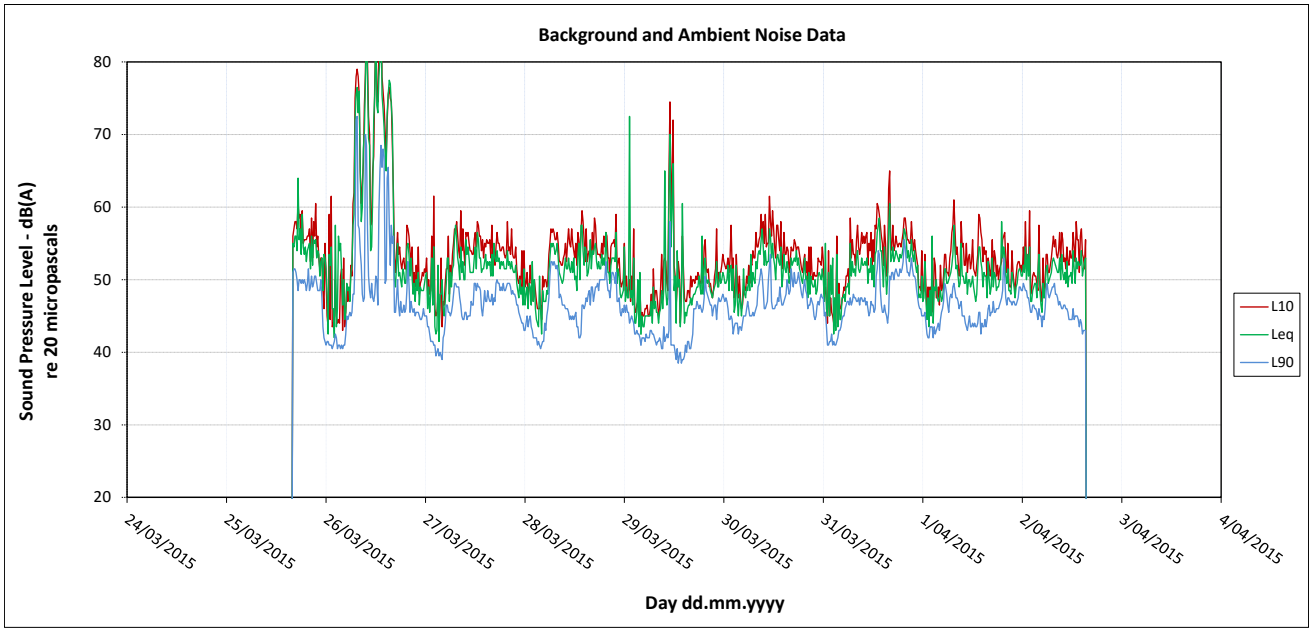
A noise logger was placed at position L1 as shown in Figure 1 to measure the ambient and background noise that is representative of the site and surrounding residential receivers. The logger was installed from the 25th of March to the 2nd of April 2015. The results of the unattended noise survey are shown in Table 2 below.

Table 2: Unattended noise measurements

Location	Equivalent Continuous Noise Level $L_{Aeq,period}$ - dB(A)			Background Noise Level RBL- dB(A)		
	Day	Evening	Night	Day	Evening	Night
L1	54	52	52	44	47	42

The local ambient noise environment consists of general ambient noise from an urban and industrial area. There is a low amount of vehicle activity on the local roads, as it is generally movement to and from the commercial and industrial facilities. Refer to Figure 2 for the noise data. Note that where there was rainfall during the measurement period and/or extraneous noise during the 26th of March, the affected data has been excluded from the calculations.

Figure 2: Unattended noise monitor data



5. Criteria

5.1 Site noise emission

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

5.1.1 NSW OEH Industrial Noise Policy

In the absence of any specific acoustic requirements in the Liverpool DCP, the NSW Office of Environment and Heritage (OEH) Industrial Noise Policy will be used. The INP sets out noise criteria to control the noise emission from industrial noise sources. The external noise due to mechanical services from the proposed development is also addressed following the guideline in the NSW OEH's 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 OEH 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 3: OEH 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	52
Night 10pm – 7am	$L_{Aeq,15min} \leq$ RBL + 5	47

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:

Criteria

Table 4: Amenity criteria for external noise levels

Type of Receiver	Indicative Noise Amenity Area	Time of Day	Recommended L_{Aeq} Noise Level, dB(A)		Adjusted Acceptable L_{Aeq} Levels
			Acceptable	Recommended Maximum	
Residential	All	Day	60	65	49
	All	Evening	50	55	42
	All	Night	45	50	42
Commercial	All	When in use	65	70	64
Industrial	All	When in use	70	75	69

*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 5 below) provides procedures for determining whether an adjustment should be applied for greater annoyance aspect.

Table 5: 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 Project-Specific Noise Levels (PSNL)

Table 6 below displays the project-specific noise levels PSNL for the project. Any operational or mechanical noise emissions from the development must comply with the PSNL provided at the surrounding receivers. In the case of the EPA INP intrusiveness and amenity criteria, the lowest of the two has to be chosen as the PSNL.

Table 6: Project specific noise levels

Period	Descriptor	PSNL dB(A)
Residential Areas		
Day (7:00am to 6:00pm)	$L_{Aeq,15min}$	**49**
Evening (6:00pm to 10:00pm)	$L_{Aeq,15min}$	**42**
Night (10:00pm to 7:00am)	$L_{Aeq,15min}$	**42**
Commercial Areas	$L_{Aeq,when\ in\ use}$	**64**
Industrial Areas	$L_{Aeq,when\ in\ use}$	**69**

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 Internal Noise Levels

This section details the criteria used to define the internal noise goals for spaces in the development.

5.3.1 Department of Planning – Development Near Rail Corridors And Busy Roads – Interim Guideline

The DoP Interim Guideline has been considered for this development due to the proximity to the rail line. The guideline is in accordance with clause 87 of the Infrastructure State Environmental Planning Policy (SEPP) which states the following for residential developments adjacent to rail corridors:
If the development is for the purpose of a building for residential use, the consent authority must be satisfied that appropriate measures will be taken to ensure that the following LAeq levels are not exceeded:

- *in any bedroom in the building : 35dB(A) at any time 10pm–7am*
- *anywhere else in the building (other than a garage, kitchen, bathroom or hallway): 40dB(A) at any time.*

The external façade of the development will be designed such that it complies with the requirements of the Infrastructure SEPP for rail noise. In the case of this development, other noise sources such as vehicle movements and industrial noise may place the greatest demand on the façade and will be considered in the design whilst achieving the specified internal noise levels.

5.4 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 7: 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)
Local roads	Existing Residences affected by additional traffic on existing local roads generated by land use developments	$L_{Aeq,1\ hour}$ 55 (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'.

5.5 Construction Noise Criteria

Noise criteria for construction sites are established in accordance with the Interim Construction Noise Guideline (*ICNG July 2009*) by the NSW Office of Environment &Heritage (NSW OE&H). It is important to note that the recommended criteria are for planning purposes only. Numerous other factors need to be considered when assessing potential noise impacts from construction works.
However, in undertaking the assessment of potential noise intrusion associated with the proposed construction activities, Chapter 4 of the NSW OE&H ICNG (July 2009) were specifically referenced. The noise limits are presented in Table 8, and are applicable to the development.

Criteria

Table 8: 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 RBL + 10dB	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 RBL + 5dB	• 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

5.6 Train and Construction Vibration Criteria

The Office of Environment and Heritage (OEH) 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.

5.6.1 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 9. It should be noted that the human comfort for vibration are more stringent than the building damage criteria.

Table 9: Preferred and maximum weighted RMS values for continuous and impulsive vibration acceleration (m/s2) 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 10: Acceptable Vibration Dose Values for Intermittent Vibration (m/s1.75)

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

5.6.2 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 11 indicates the vibration limits presented in DIN4150-Part 3 to ensure structural damage doesn't occur.

Table 11: 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 12 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 12: Transient vibration guide values for cosmetic damage

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

6. Noise Impact Assessment

6.1 Train Noise Levels

Based on the noise measurements conducted from train pass bys as shown in Table 1, and using the number of train movements as estimated from the Transport Sydney Trains for T2, T3, T5 lines, the results of the train noise measurements at the façade of the development have been calculated. The levels have been calculated in accordance with the DoP Interim Guideline and are shown in Table 13.

Table 13: Train noise levels, $L_{Aeq,\ period}$ dB(A)

Location	Day time $L_{Aeq,\ 15hours}$ dB(A)	Night time $L_{Aeq,\ 9hours}$ dB(A)
North façade (C2)	49.7	43.4

The noise levels as shown above are purely from train movements for the glazing design in accordance with the requirements of the DoP Interim Guideline. Noise levels from the attended and unattended measurements have been used in conjunction with these levels to design the glazing as they are higher than those from the pure train noise.

6.2 External Glazing

The general limiting factor of the performance of a building façade in term of noise attenuation is the glazing. In this particular case of the proposed development, the combination of general surrounding traffic noise, industrial noise, and train pass-by's provide the most acoustic demand on the development.
In order to achieve the internal noise levels specified in the DoP Interim Guideline, the minimum recommended glazing selection for the façades of the proposed development is presented in the following Table 14. The data presented in this table is based on the worst case scenario of external noise obtained from the attended noise measurement and noise data from the unattended logger. The glazing thicknesses presented below should be considered as the minimum thicknesses to achieve acoustical ratings. Greater glazing thicknesses may be required for structural loading, wind loading, ESD, etc.

Table 14: Recommended acoustic performance of glazing system

Building	Façade	Level	Occupancy	Glass System	Required Acoustic Rating of Glazing Assembly, Rw[1]
C2	South-East	All	Bedrooms	6.38mm laminated	33
			Living rooms	6mm float	31
	North-West		Bedrooms	8.38mm laminated	34
			Living rooms	6.38mm laminated	33
C1	North-West		Bedrooms	6.38mm laminated	33
			Living rooms	6mm float	31
	South-East		Bedrooms	8.38mm laminated	34
			Living rooms	6.38mm laminated	33
C1, C2	South-West North-East	All	Bedrooms	8.38mm laminated	34
			Living rooms	6.38mm laminated	33
The Required Acoustic Rating of Glazing Assembly, refers to the acoustic performance of the glazing once installed on site (including the frame)					

During the detailed design stage of the project the acoustic performance of the glazing facade should be reviewed as the combined noise from external sources and mechanical services could result in the internal noise level exceeding the design sound level ($L_{Aeq,T}$ dBA)

[1] See Appendix 1 for Rw definition

6.3 Noise Emissions

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 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 nearby residential receivers.
The proposed residential development will be provided with air-conditioning systems throughout all apartment blocks. The main mechanical sources associated with the development will include:

- External air conditioner units (ACU) distributed on the roof top area, the basement and balconies.
- Car park exhaust fan (CPEF) and car park supply fan (CPSF) located in the basement plant rooms and exhausting on the roof

In order to assess the worst case scenario, it was assumed that the air conditioning units associated with the residential apartments are running at any time throughout a 24hr period.
The units have been calculated from the closest building façade to the residential receivers. With all, the night time is the most stringent period for the noise generated by the operation of mechanical plant; therefore this criterion was used as the noise target at the boundary of the nearest sensitive receivers for the project.

6.3.1 Proposed Noise Levels

Table 15 presents the proposed maximum sound power levels for individual outdoor air conditioning condenser units to achieve the noise criteria shown in Table 6 at the boundary of the nearest receivers.

Table 15: Proposed acoustic power for individual CU

Item	SWL re 1pW								
	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	Overall dB(A)
External CU	64	69	63	55	54	52	50	45	61

Table 16 below presents the proposed sound power level for the car park exhaust fan (CPEF) in the basement, such that compliance is achieved with the surrounding residential receivers due to noise emission from the roof top exhaust. Note that internal duct lining to the discharge or an attenuator may be required in order to comply with the noise emissions limits.

Table 16: Proposed acoustic power for CPEF in basement plant room

Item	SWL re 1pW								
	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	Overall dB(A)
CPEF	80	77	78	79	78	77	73	66	83

Table 17 below presents the proposed sound power level for the car park supply fan (CPSF) in the basement, such that compliance is achieved with the surrounding residential receivers due to noise emission from the roof top intake. Note that internal duct lining to the intake or an attenuator may be required in order to comply with the noise emissions limits.

Table 17: Proposed acoustic power for CPSF in basement plant room

Item	SWL re 1pW								
	63 Hz	125 Hz	250 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	Overall dB(A)
CPSF	80	77	78	79	78	77	73	66	83

It is our opinion that the project specific noise levels at the boundaries of the surrounding receivers should be met if the requirements of Table 15, Table 16 and Table 17 are satisfied. Note that this is a preliminary solution as the design is yet to be finalised, it is recommended that an updated acoustic report is conducted at a later juncture when more information becomes available about the specific units to be used.

6.3.2 Mechanical Services Mitigation Measures

Mitigation measures for the mechanical plant should be considered during the Design Development stage so as to comply with the outlined criteria at the nearest sensitive receivers. These amelioration measures could include but not limited to the following:

- Positioning mechanical plant away from nearby receivers
- Acoustic attenuators fitted to duct work
- Screening around mechanical plant
- Acoustic insulation within duct work

6.4 Road Traffic Noise Impact Assessment

For the road traffic noise assessment, traffic numbers and generated vehicles was based on the information provided by InRoads Group. This data has been used to calculate the expected noise increase due to traffic associated with the development. It was predicted that 80 percent of the vehicles entering or exiting the roundabout from the north/south Shepherd Street are from the Shepherd Street industrial cul-de-sac. The results are summarized in Table 18 and Table 19.

Table 18: Existing and predicted traffic flow volumes (peak hour)

Traffic Volume	Existing vehicles		Predicted Increase		Post-Development	
	AM	PM	AM	PM	AM	PM
Shepherd Street	192	232	84	84	276	316

Based on the noise measurements from the existing traffic, Table 19 presents the predicted noise levels due to traffic noise increase.

Table 19: Predicted increase in traffic noise levels

Location	Existing Noise Levels	Predicted Noise Levels	Proposed maximum Noise Levels	Complies?
	$L_{Aeq-1hour}$, dB(A)	$L_{Aeq-1hour}$, dB(A)	$L_{Aeq-1hour}$, dB(A)	
Shepherd Street (AM)	53.4	55.0	55.0	Yes
Shepherd Street (PM)	54.2	55.6	55.0	Yes

As shown in Table 19 there is not predicted to be any increase above the maximum noise level of 55dB(A) along Shepherd Street. Note that there is a marginal exceedance of 0.6dB for the PM period, which is considered negligible. Based on this assessment, the proposed development is expected comply with the requirements of the NSW RNP.

7. Vibration Assessment

A vibration assessment has been conducted in accordance with the DoP Interm Guideline and referenced documents due to the proximity to the train line. The vibration levels of trains pass bys have been measured at the nearest point on the façade of the proposed development for all three axes. The measured values were processed and assessed in accordance with the criteria as detailed in section 5.6 to determine whether there will be any adverse effect on occupants of the development from human perception, or potential structural damage to the building. Refer to Table 20 for the Vibration Dose Value results based on the Z axis of the measurements for human comfort.

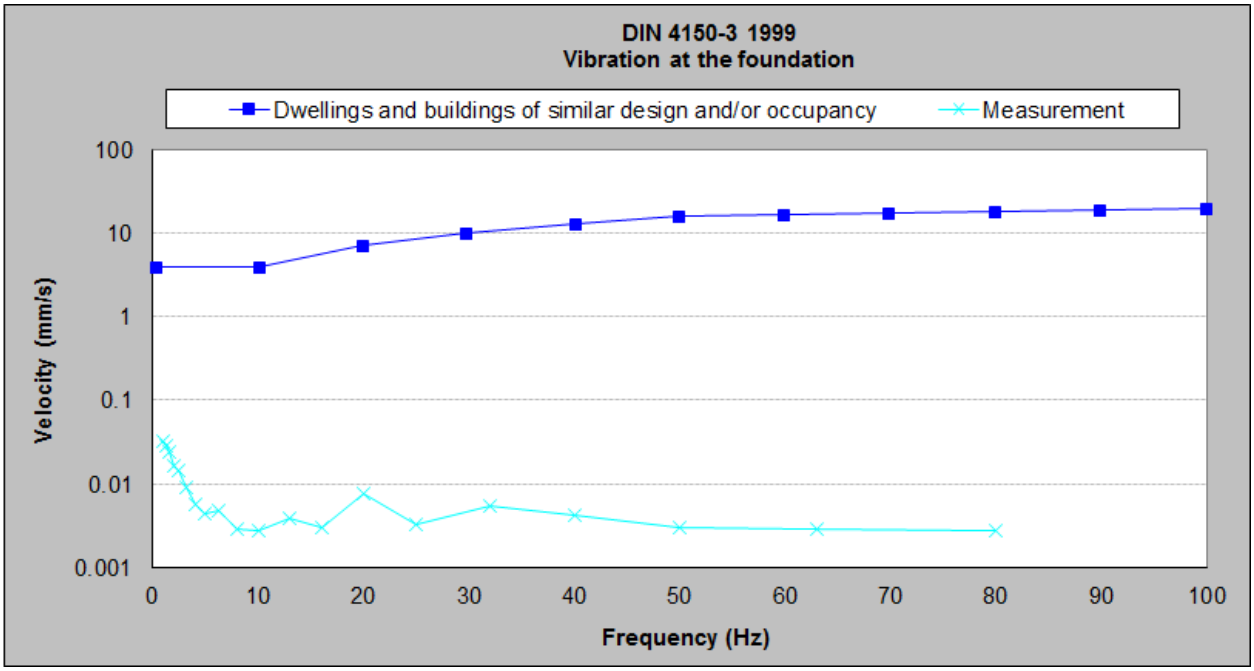
Table 20: Vibration Dose Values for Z-axis from train vibration

Period	eVDV ($m/s^{1.75}$)	Criteria	Complies
Day (7am – 10pm)	0.0092	0.20	Yes
Night (10pm – 7am)	0.0057	0.13	Yes

Based on the vibration measurements, there is not predicted to be any human annoyance or disturbance to the occupants of the proposed development as determined in accordance with the "Assessing Vibration: A technical Guideline" document.

Refer to Figure 3 for the results of the vibration velocity levels (mm/s) for comparison with the structural damage criteria for residential buildings from DIN4150 – 3 for building damage.

Figure 3: Vibration velocity (mm/s) for Z-axis



Based on the measurements, there is not predicted to be any exceedance of the criteria for structural damage to the development in accordance with the limits set by the DIN 4150-3 standard.

8. Conclusion

An acoustic assessment for the proposed multi-level residential development at 28 Shepherd Street, Liverpool 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:

- Noise intrusion from train passbys in accordance with the DoP Guidelines in section 5.5
- Train vibration criteria for human perception and structural damage in section 5.6 in accordance with the Assessing Vibration Guideline and the DoP Interim Guideline
- Noise criteria for emissions from the development to receivers in accordance with the INP provided in section 5.1
- Traffic generated noise criteria in accordance with the RNP provided in section 5.4
- Construction noise criteria provided in section 5.5 in accordance with the ICNG

Glazing for the building has been designed to achieve internal noise levels in accordance with the requirements of DoP Interim Guideline and the Infrastructure SEPP.

The predicted noise levels presented in this report show that the day, evening and night criteria is expected to be met with the implementation of the proposed sound power levels for the external air conditioning units and for the car park exhaust and supply fans.

Based on the vibration measurements, there is not predicted to be any exceedance of the human comfort or structural damage criteria, as shown in section 7.

The road traffic noise assessment, based on information provided by InRoads Group in regards to generated vehicles, and measurements conducted by WGE has shown that there is not expected to be any exceedance of the RNP criteria.

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.

Appendix 1 - Glossary of Acoustic Terms

Intermittent Noise:	Level that drops to the background noise level several times during the period of 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.