WOOD & GRIEVE ENGINEERS

41 Broadarrow Road, Narwee

Acoustic Report

Development Application

Prepared for:

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c/- Caltex Narwee

Prepared by:

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Project No. 39973
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REVISION	DATE	COMMENT	APPROVED BY
01	15/10/18	Initial issue	**Brandon Notaras**
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1. Introduction

As part of the Development Application (DA) documentation process, Wood & Grieve Engineers has been engaged by Mr. and Mrs. Costas c/- Caltex Narwee to provide an acoustic assessment for the proposed mixed-use development located at 41 Broadarrow Road, Narwee.

The proposed work is to include:

- Four (4) levels of basement car parking
- Commercial and retail on ground floor
- Seven (7) levels of residential apartments

This assessment has been prepared considering the following documents:

- Australian Standard AS/NZS 2107:2016 – 'Acoustics- Recommended design sound levels and reverberation times for building interiors'
- AS1668.2
- Department of Planning: Development near Rail Corridors and Busy Roads – Interim Guideline
- Apartment Design Guide (ADG) Objective 4B-1
- NSW Environment Protection Authority (EPA) Interim Construction Noise Guideline (ICNG July 2009).
- NSW EPA Noise Policy for Industry (NPI)
- NSW Road Noise Policy (Office of Environment and Heritage July 2011)
- Department of Environment and Conservation NSW Assessing Vibration – A Technical Guideline (NSW AV-TG) (2006), now part of the NSW EPA.
- British Standard BS5228: Part 1:1997 "Noise and Vibration Control on Construction and Open Sites."
- British Standard BS7358:1993 "Evaluation and Measurement for Vibration in Buildings" – Part 2: "Guide to Damage Levels from Groundborne Vibration"
- German Standard DIN4150-Part 3 "Structural vibration in buildings – Effects on structures
- Bureau of Meteorology, Daily rainfall report.

This assessment discusses the likely noise impact of the proposed development upon the nearest and most-affected receivers, as well as outlining mitigation measures for noise intruding into the development.

This report provides:

- A statement of compliance with the Canterbury Development Control Plan 2012 acoustic requirements for the reference design, including residential within the vicinity of the nearest potentially affected receivers
- Indicative recommendations for noise mitigation measures for the proposed development in order to meet the relevant criteria

The work documented in this report was carried out in accordance with the Wood & Grieve Engineers Quality Assurance system, which is based on Australian Standard / NZS ISO 9001.

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

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

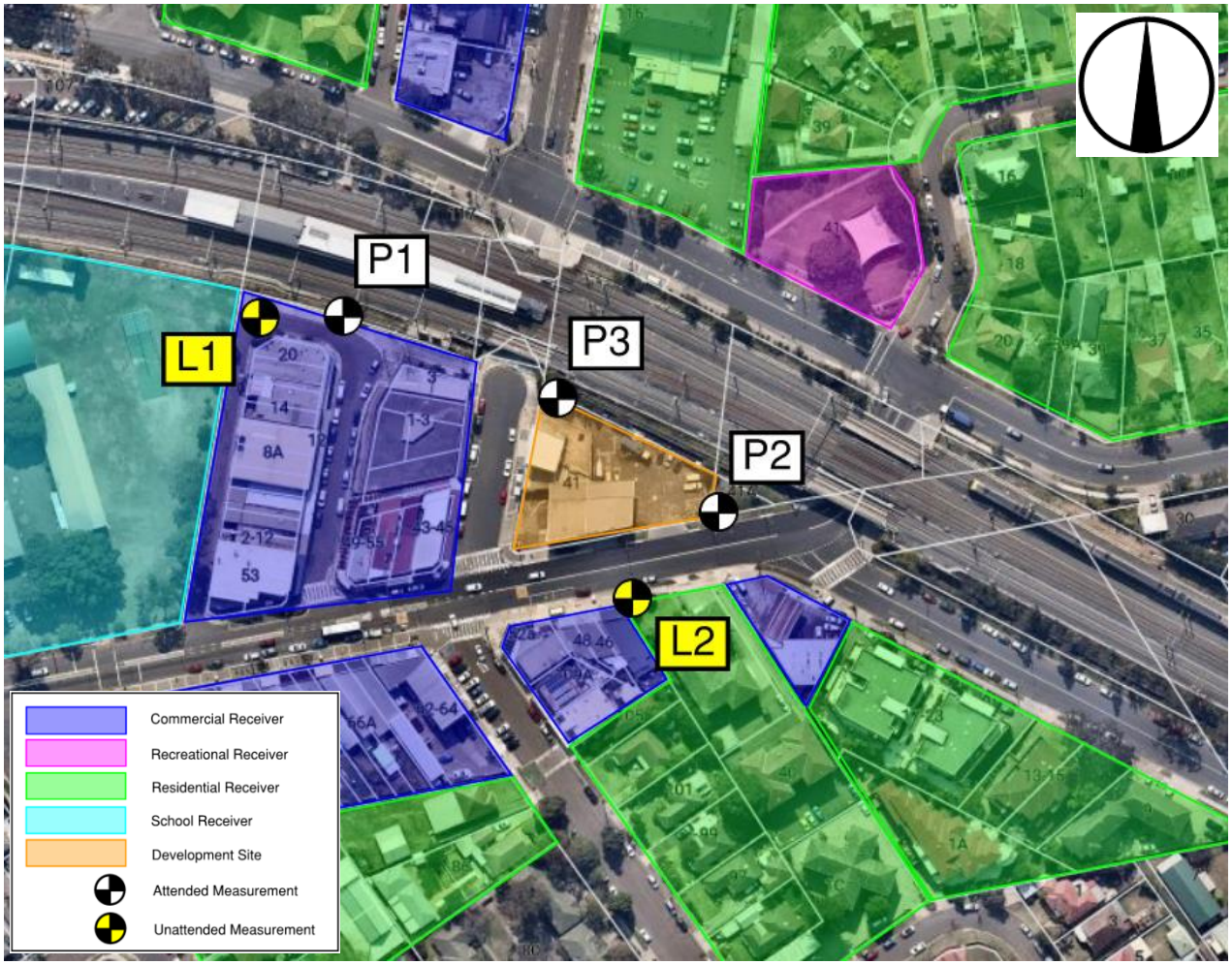
- Site drawings presenting the location of the proposed development in relation to the nearest receivers.
- Noise data collected on site through the use of a noise logger and a hand held spectrum analyser.
- Traffic & Parking Report – Traffic Impact Assessment, dated October 2018
- Architectural DA issue drawings issued by Jackson Teece Architects dated 05/11/18

3. Project Overview

3.1 Site description

The proposed residential development is located at 41 Broadarrow Road, Narwee. The proposed development is bound by a train line to the North, Broadarrow Road to the South and Penshurst Road to the West. There are residential and commercial properties located across Broadarrow Road and to the West. The proposed development site, the unattended noise monitoring locations, the attended noise monitoring locations, and the nearest sensitive receivers are shown in in Figure 1 below.

Figure 1: Overview of the site and measurement locations



Source: nearmap.com

3.1.1 Acoustic Issues

The acoustic issues relating to the development are as follows:

- Noise intrusion from train movements within the rail corridor into the habitable spaces within the proposed development
- Noise intrusion from vehicle movements on Broadbarrow Road into the habitable spaces within the proposed development
- Vibration impacts of train-pass-bys to the structure of the proposed development
- Noise emissions from mechanical plant servicing the proposed development to the surrounding residential receivers
- Increased traffic noise associated with the proposed development affecting the surrounding residential receivers

4. Noise Survey

4.1 Instrumentation

The equipment used for the noise survey was the following:

- Hand-held sound spectrum analyser Brüel & Kjær Type 2250, S/N 2709742
- Brüel & Kjær Sound Calibrator, S/N 2709826
- SVAN 958 Sound and Vibration Analyser Type 1 S/N 15153
- SVANTEK SV207A Building Vibration Accelerometer S/N 22824
- ARL Environmental Noise Logger, NL-42X, S/N 184109
- ARL Environmental Noise Logger, NL-42X, S/N 117376

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 intruding into the development and to determine any noise impacts on the surrounding receivers. A summary of the attended noise measurements taken in the vicinity of the proposed development site are shown in Table 1. Refer to Figure 1 for measurement locations.

Table 1: Summary of attended noise measurements

Measurement Location	Measurement Time	$L_{Aeq,\ 15mins}$, dB(A)	L_{Amax}, dB(A)	Comments
P1	14/08/2018 12:58	57	76	General surrounding traffic and train noise
P2	14/08/2018 13:39	64	71	General surrounding traffic and train noise

Additional attended noise measurements were conducted to characterise and assist in quantifying the noise intrusion into the proposed development as a consequence of trains passing by. The results of the noise measurements are shown in Table 2.

Table 2: Summary of attended noise measurements for train pass-bys

Measurement Location	Measurement Time	$L_{Aeq\ duration}$, dB(A)	L_{Amax}, dB(A)	Comments
P1	14/08/2018 13:19	70	78	Train movements
P1	14/08/2018 13:20	61	70	Train movements
P1	14/08/2018 13:21	62	70	Train movements
P1	14/08/2018 13:22	57	62	Train movements
P1	14/08/2018 13:23	53	67	Train movements
P1	14/08/2018 13:24	57	66	Train movements
P2	14/08/2018 13:35	66	70	Train movements
P2	14/08/2018 13:36	58	64	Train movements
P2	14/08/2018 13:37	60	62	Train movements
P2	14/08/2018 13:38	62	71	Train movements

4.3 Unattended Noise Survey Results

4.3.1 Background and Train Noise Monitoring

A noise logger was placed at position L1 as shown in Figure 1 to measure the background, ambient and train noise generated by train pass-bys during the 15 hour and 9 hour periods established in the DOP Development near Rail Corridors and Busy Roads – Interim Guideline. Logger L1 was installed from the 14th to the 22nd of August 2018. The results for the unattended background noise surveys are shown in Table 3 below (for the day, evening and night periods), and time periods as per the DoP shown in Table 4.

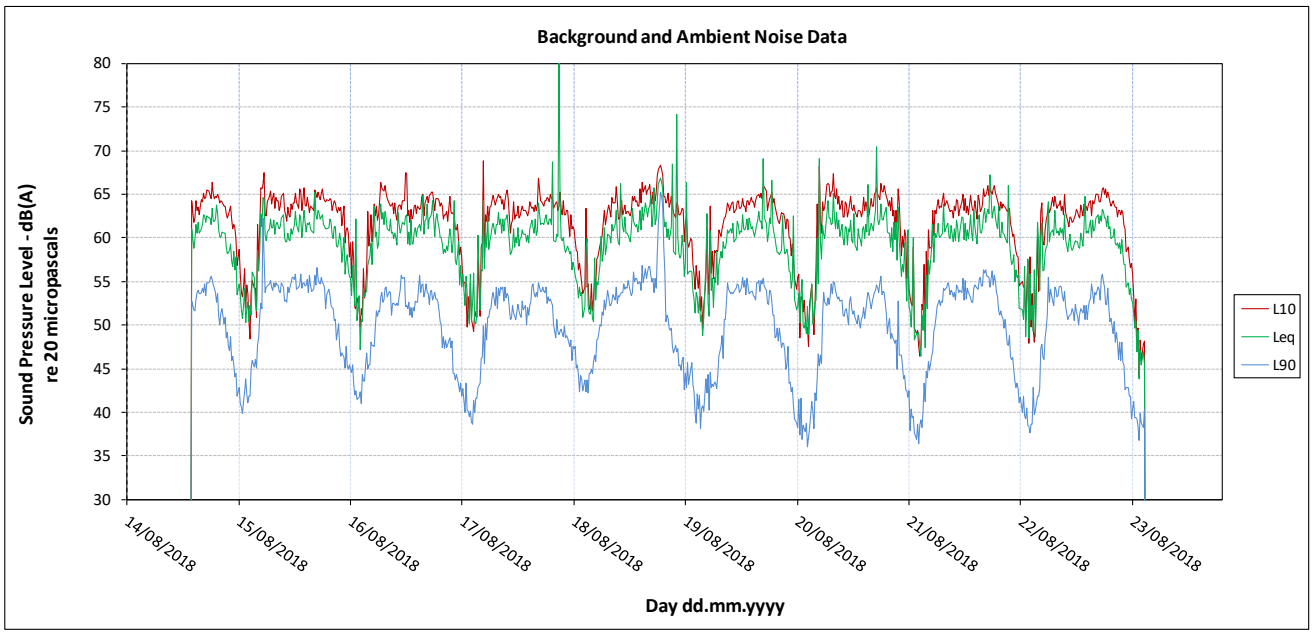
Table 3: Unattended noise measurements of L1

Location	Equivalent Continuous Noise Level $L_{Aeq,period}$ - dB(A)			Background Noise Level RBL - dB(A)		
	Day	Evening	Night	Day	Evening	Night
L1	62	64	58	51	48	40

Table 4: Unattended noise measurements of L1

Location	Equivalent Continuous Noise Level $L_{Aeq,period}$ - dB(A)		Noisiest 1 Hour $L_{Aeq,1hour}$ - dB(A)	
	Day (15hr)	Night (9hr)	Day	Night
L1	62	58	66	63

Figure 2: Unattended background, ambient and train noise monitoring data – L1



The local ambient noise environment is dominated by traffic noise throughout the majority of the day, evening and night periods. Refer to Figure 2 for the noise data. Note that any rain affected data during the period of logging has been excluded from the calculations.

4.3.2 Background and Ambient Noise Monitoring

A noise logger was placed at position L2 as shown in Figure 2 to measure the background and ambient noise representative of the surrounding receivers. Logger L2 was installed from the 14th to the 20th of August 2018. The results for the unattended background noise surveys are shown in Table 5. Refer to Table 6 for the results as per the DoP time periods (for the day and night periods). Note that any rain affected data during the period of logging has been excluded from the calculations.

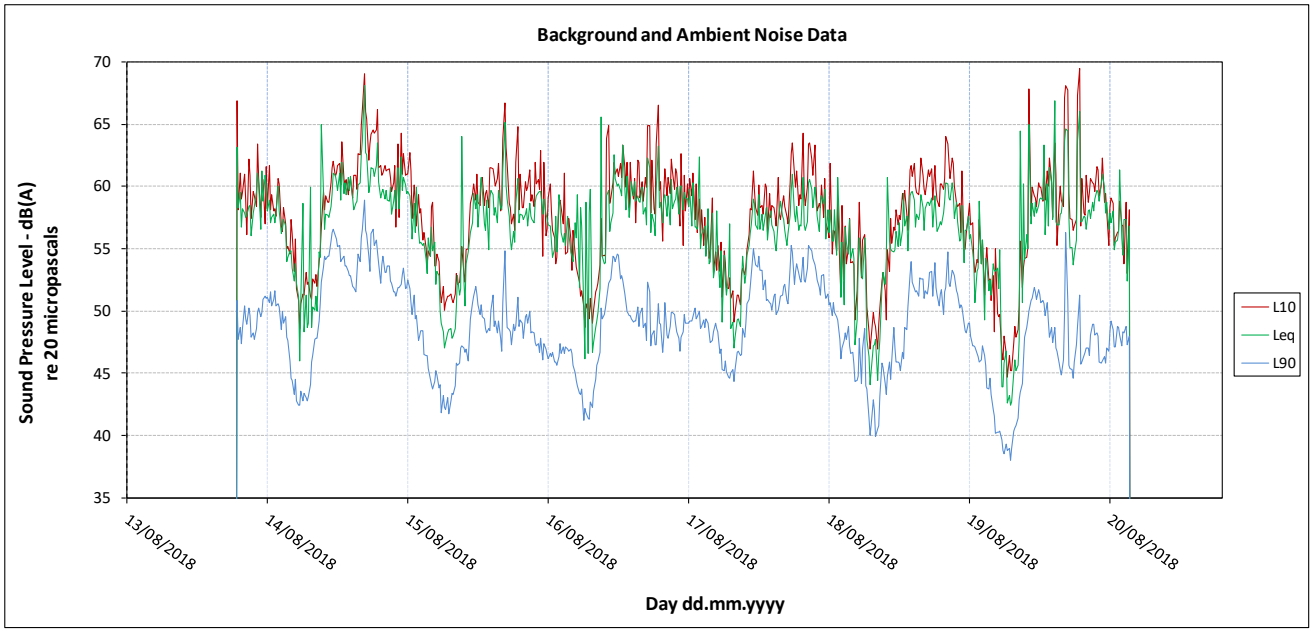
Table 5: Unattended noise measurements of L2

Location	Equivalent Continuous Noise Level $L_{Aeq,period}$ - dB(A)			Background Noise Level RBL - dB(A)		
	Day	Evening	Night	Day	Evening	Night
L2	59	58	56	47	47	42

Table 6: Unattended noise measurements of L2

Location	Equivalent Continuous Noise Level $L_{Aeq,period}$ - dB(A)		Noisiest 1 Hour $L_{Aeq,1hour}$ - dB(A)	
	Day (15hr)	Night (9hr)	Day	Night
L2	59	56	50	46

Figure 3: Unattended noise monitoring data – L2



5. Noise Criteria

5.1 Internal Noise Level Criteria

5.1.1 Canterbury DCP 2012

The Canterbury DCP specifies that all requirements in the Department of Planning *Development Near Rail Corridors and Busy Roads - Interim Guideline (2008)* must be met.

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

The DoP's Development near Rail Corridors and Busy Roads – Interim Guideline governs the required maximum internal noise levels averaged over certain periods within bedrooms and living areas of apartments in the development. The guideline details the application of clause 87 of the State Environmental Planning Policy (SEPP) Infrastructure which states the following for residential developments:

"If the development is for the purposes of residential accommodation, the consent authority must not grant consent to the development unless it is satisfied that appropriate measures will be taken to ensure that the following LAeq levels are not exceeded:

(a) In any bedroom in the residential accommodation – 35 dB(A) at any time between 10.00 pm and 7.00 am,

(b) Anywhere else in the residential accommodation (other than a garage, kitchen, bathroom or hallway) – 40 dB(A) at any time."

The DoP's Development near Rail Corridors and Busy Roads – Interim Guideline also states the following in regards to an open windows assessment:

"If internal noise levels with windows or doors open exceed the criteria by more than 10dBA, the design of the ventilation for these rooms should be such that occupants can leave windows closed, if they so desire, and also to meet the ventilation requirements of the Building Code of Australia."

The ventilation requirements referred to in the requirements are in-line with the requirements established in the ADG Objective 4B-1 and AS1668.2.

Table 7 provides a summary of the criteria established in the DoP's Interim Guideline below.

Table 7: Summary of DoP's Interim Guideline criteria for residential developments adjacent to rail corridors

Type of habitable space	Applicable Time Period	Assessment Noise Metric	Windows/Doors Closed Criteria – dB(A)	Windows/Doors Open Criteria – dB(A)
Sleeping areas (bedrooms)	10:00pm – 7:00am	$L_{Aeq,9h(night)}$	35	45
Living rooms	At any time	$L_{Aeq,15h(day)}$	40	50

5.1.3 AS/NZS 2107:2016

For other areas that are not specified on DoP's Development near Rail Corridors and Busy Roads – Interim Guideline, Australian Standard AS/NZS 2107:2016 – *'Acoustics- Recommended design sound levels and reverberation times for building interiors'* will be used to specifies target noise levels for internal spaces to the development. Traffic noise intrusion AS 3671 refers to internal noise compliance with AS/NZS2107:2016. Refer to Table 8 for the values corresponding to residential spaces near major roads.

Table 8: Recommended noise levels extracted from AS/NZS 2107:2016

Type of occupancy / activity	Design sound level L_{Aeq}, dB(A) range
Residential Buildings	
Apartment common areas (e.g. foyer, lift lobby)	45 to 50
Restaurant	40 to 50
General offices	40 to 45

5.2 External Noise Emissions

5.2.1 NSW EPA Noise Policy for Industry (NPI)

In the absence of noise emission criteria in the Canterbury DCP 2012 the NPI sets out noise criteria to control the noise emission from industrial noise. The external noise due to mechanical services from the proposed development is also addressed following the guideline in the NSW EPA's NPI.

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

APPENDIX A The NSW EPA NPI states the following:

> *APPENDIX B "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 L_{Aeq} 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 follows:

$L_{Aeq,\ 15\ minute} \leq$ RBL background noise level + 5 dB(A)

The intrusiveness criterion for the closest residential receivers is presented in Table 9. Note the values from L2 have been used in this assessment as they are the most relevant to define the background and ambient noise level of the residential receivers.

Table 9: EPA INP Intrusiveness Criteria

Period	Noise Descriptor – dB(A)	Noise Criteria – All residential receivers $L_{Aeq,15mins}$
Daytime 7am – 6pm	$L_{Aeq,15min} \leq$ RBL + 5	52
Evening 6pm – 10pm	$L_{Aeq,15min} \leq$ RBL + 5	52
Night 10pm – 7am	$L_{Aeq,15min} \leq$ RBL + 5	47

Amenity Criteria

The NSW NPI states the following:

> *"To limit continuing increases in noise levels from application of the intrusiveness level alone, the ambient noise level within an area from all industrial noise sources combined should remain below the recommended amenity noise levels specified in Table 2.2 where feasible and reasonable. The recommended amenity noise levels will protect against noise impacts such as speech interference, community annoyance and some sleep disturbance. The recommended amenity noise levels have been selected on the basis of studies that relate industrial noise to annoyance in communities (Miedema and Voss, 2004).*
>
> To ensure that industrial noise levels (existing plus new) remain within the recommended amenity noise levels for an area, a project amenity noise level applies for each new source of industrial noise as follows "Project amenity noise level for industrial developments = recommended amenity noise level (Table 2.2) minus 5 dB(A)"

The applicable parts of Table 2.2: Amenity noise levels which are relevant to the project are reproduced below:

Table 10: NSW NPI Table 2.2 amenity criteria for external noise levels

Type of Receiver	Noise Amenity Area	Time of Day	L_{Aeq} , dB(A)	$L_{Aeq, period}$ dB(A)
			Recommended amenity noise level	Project amenity noise level
Residential	Urban*	Day	60	55
		Evening	50	45
		Night	45	40
Commercial	Urban*	When in use	60	55

*Urban area as defined in EPA NSW NPI Table 2.3

'Modifying Factor' Adjustments

The NSW NPI also states:

> *"Where a noise source contains certain characteristics, such as tonality, 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 C1 of Fact Sheet C of the NSW NPI (see Table 11 below) provides procedures for determining whether an adjustment should be applied for greater annoyance aspect.

Table 11: Table C1 from the NSW NPI – Modifying factor corrections

Factor	Assessment / Measurement	When to Apply	Correction[1]	Comments
Tonal Noise	One-third octave band analysis using the objective method for assessing the audibility of tones in noise – simplified method *(ISO1996.2-2007 – Annex D)*.	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 in the range 500–10,000 Hz • 8 dB or more if the centre frequency of the band containing the tone is in the range 160–400 Hz • 15 dB or more if the centre frequency of the band containing the tone is in the range 25–125 Hz.	5 dB[2,3]	Third octave measurements should be undertaken using unweighted or Z-weighted measurements. **Note**: Narrow-band analysis using the reference method in *ISO1996-2:2007, Annex C* may be required by the consent/regulatory authority where it appears that a tone is not being adequately identified, e.g. where it appears that the tonal energy is at or close to the third octave band limits of contiguous bands.
Low Frequency Noise	Measurement of source contribution C-weighted and A-weighted level and one-third octave measurements in the range 10–160 Hz	Measure/assess source contribution C- and A-weighted $L_{eq,T}$ levels over same time period. Correction to be applied where the C minus A level is 15dB or more and: • where any of the one-third octave noise levels in Table C2 are exceeded by up to and including 5 dB and cannot be mitigated, a 2dB(A) positive adjustment to measured/predicted A-weighted levels applies for the evening/night period • where any of the one-third octave noise levels in Table C2 are exceeded by more than 5 dB and cannot be mitigated, a 5-dB(A) positive adjustment to measured/predicted A-weighted levels applies for the evening/night period and a 2dB(A) positive adjustment applies for the daytime period.	2 or 5 dB[2]	A difference of 15 dB or more between C- and A-weighted measurements identifies the potential for an unbalance spectrum and potential increased annoyance. The values in Table C2 are derived from Moorhouse (2011) for DEFRA fluctuating low-frequency noise criteria with corrections to reflect external assessment locations.
Intermittent Noise	Subjectively assessed but should be assisted with measurement to gauge the extent of change in noise level.	The source noise heard at the receiver varies by more than 5 dB(A) and the intermittent nature of the noise is clearly audible.\	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	One event in any assessment period.	0 to 20 dB(A)	The project noise trigger level may be increased by an adjustment depending on duration of noise (see Table C3).
Maximum Adjustment	Refer to individual modifying factors	Where two or more modifying factors are indicated	Maximum correction of 10dB(A)[2] (excluding duration correction)	

1. Corrections to be added to the measured or predicted levels, except in the case of duration where the adjustment is to be made to the criterion.

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, that is, at or below 160 Hz.

3. Where narrow-band analysis using the reference method is required, as outlined in column 5, the correction will be determined by the ISO1996-2:2007 standard.

Sleep Disturbance

The NPI establishes sleep disturbance criteria for residential receivers in close proximity to industrial noise sources during the night-time period, such as vehicle movements and car door slams on private roads. The criteria for protecting the amenity of surrounding residential receivers in regards to sleep disturbance is:

- $L_{Aeq,15min}$ 40 dB(A) or prevailing RBL plus 5dB, whichever is greater, and/or
- L_{AFmax} 52 dB(A) or prevailing RBL plus 15dB, whichever is greater

Table 12 summarises the sleep disturbance criteria for the proposed development.

Table 12: Sleep Disturbance Criteria

Period	Sleep Disturbance Criteria	
	L_{AFmax} – dB(A)	$L_{Aeq,15min}$ – dB(A)
Night (10:00pm to 7:00am)	55	45

5.2.2 Project Noise Trigger Levels

In summary, there are two criteria specific to this project. The overall criteria from all industrial plant noise sources were established using the lowest values from the amenity and intrusiveness NPI noise levels mentioned above. These are shown in Table 13 below.

Table 13: Project noise trigger levels for industrial noise emissions

Period	Descriptor	Project Specific Noise Emission Levels dB(A)
Residential Receivers		
Day (7:00am to 6:00pm)	$L_{Aeq,15min}$	52
Evening (6:00pm to 10:00pm)	$L_{Aeq,15min}$	48
Night (10:00pm to 7:00am)	$L_{Aeq,15min}$	43
Commercial		
When in use	$L_{Aeq,15min}$	58

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 categories which are relevant to the proposed use of the site are shown below in Table 14.

Table 14: 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)
Sub-arterial	Existing residences affected by additional traffic on existing sub-arterial roads generated by land use developments	$L_{Aeq,1\ hour}$ 60 (external)	$L_{Aeq,1\ hour}$ 55 (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

Noise criteria for construction sites are established in accordance with the Interim Construction Noise Guideline (ICNG July 2009) by the NSW Environment Protection Authority (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 limits presented in Table 15 apply.

Table 15: NSW EPA ICNG Construction Noise Criteria

Time of Day	Management Level $L_{Aeq,15min}$ *	How to Apply
Recommended Standard Hours: Mon – Fri (7am – 6pm)	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.
Sat (8am – 1pm) No work on Sunday & Public Holidays	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 Mon – Fri	• 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 DECCW ICNG

5.5 Construction & Train Vibration Criteria

The NSW Environment Protection Authority (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 16. It should be noted that the human comfort for vibration are more stringent than the building damage criteria.

Table 16: 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

Source: Table 2.2 Sec 2.3 of NSW EPA "Assessing Vibration: A Technical Guideline"

5.5.2 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 17: 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

Source: Table 2.4 Sec 2.4 of NSW EPA "Assessing Vibration: A Technical Guideline"

5.5.3 Structural Damage – Vibration Criteria

Ground vibration criteria are defined in terms of levels of vibration emission 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 18 indicates the vibration limits presented in DIN4150-Part 3 to ensure structural damage doesn't occur.

Table 18: 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					

Source: Table 1 Sec 3.1 of DIN4150-Part 3 "Structural vibration in buildings – Effects on structures"

Table 19 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 19: 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

5.5.4 Construction & Train Vibration Objectives

Table 20 indicates the construction vibration criteria applicable to the residential properties located adjacent to the development site and the train vibration criteria applicable to the habitable spaces within the proposed development.

Table 20: Construction and train 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	Day time	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

The following sections detail the acoustic requirements for the proposed building glazing, and the noise impact assessment from external noise emissions to internal receivers.

6.1 External Glazing Assessment

In order to comply with the project specific internal noise levels, the acoustic performance of the building facades was assessed. 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 train movements on the nearby rail corridor (to the North of the development site) will place the greatest acoustic demand on the North—West facades of the proposed development.

6.1.1 Glazing Recommendations

The general limiting factor of the performance of a building façade in terms of noise attenuation is the glazing. In this particular case of the proposed development, the noise generated by train movements within the rail corridor adjacent to the proposed development provides the greatest acoustic demand on all facades of the proposed development, except for the South facade for which the vehicle movements along Broadarrow Street tend to dominate noise intrusion into the proposed development.

In order to achieve the maximum internal noise levels established in DoP's Interim Guideline and AS2107:2016 for the non-residential spaces, the minimum recommended glazing thicknesses for the facades of the proposed development are presented in Table 21 below. The glazing thicknesses presented below should be considered as the minimum thicknesses to achieve the required maximum internal noise levels. Greater glazing thicknesses may be required for structural loading, wind loading, thermal requirements etc.

Table 21: Required acoustic performance of glazing systems

Type of Space	Façades	Fixed Single Glazed System	Required Acoustic Rating of Glazing Assesmbly, R_w
Bedrooms	North and West facing (Refer to Figure 1)	12.38mm laminated glass	37
Living areas		8.38mm laminated glass	34
Bedrooms	South and East facing (Refer to Figure 1)	10.38mm laminated glass	35
Living areas		8.38mm laminated glass	34
Commercial/Restaurant/Retail	All	10.38mm laminated glass	35
Note: The required acoustic rating of glazing assembly, refers to the acoustic performance of the glazing once installed on site (including the frame)			

The glazing system proposed above has been provided as a high level analysis only. The acoustic performance of the glazing facade may be reduced at certain locations within the development during the Detailed Design phase of the project.

Figure 4: Glazing mark up Level 1 (typical levels 1-2)

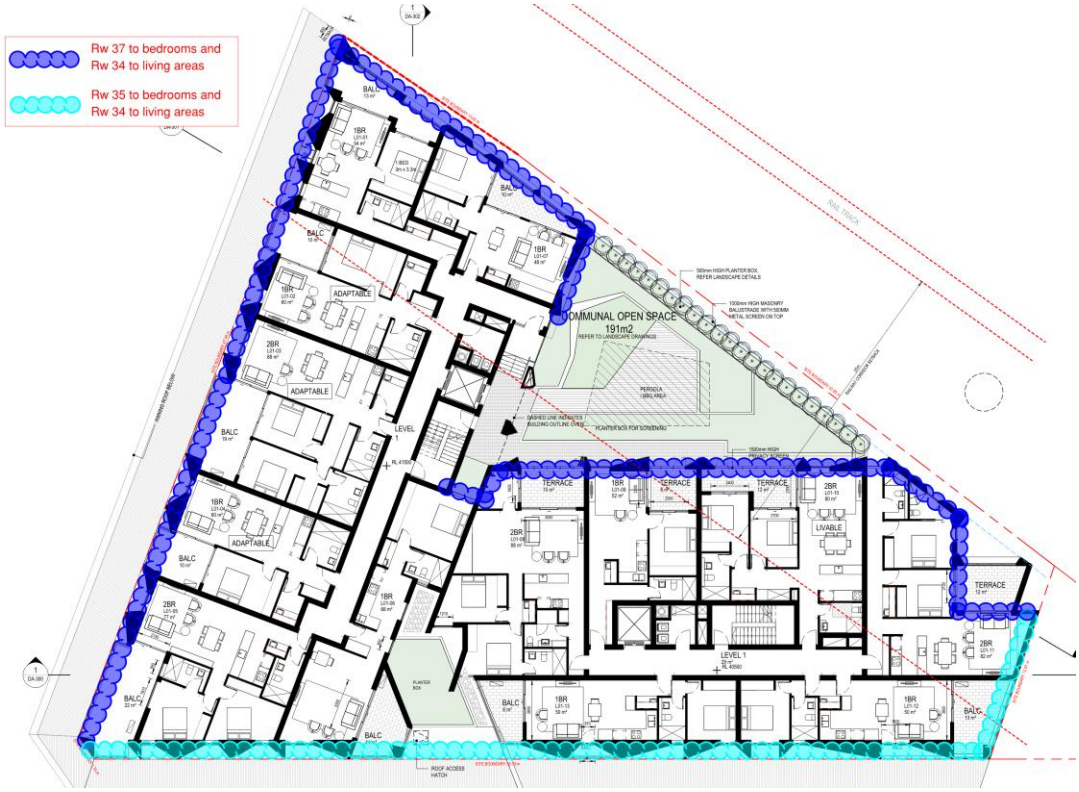


Figure 5: Glazing mark up Level 3-6

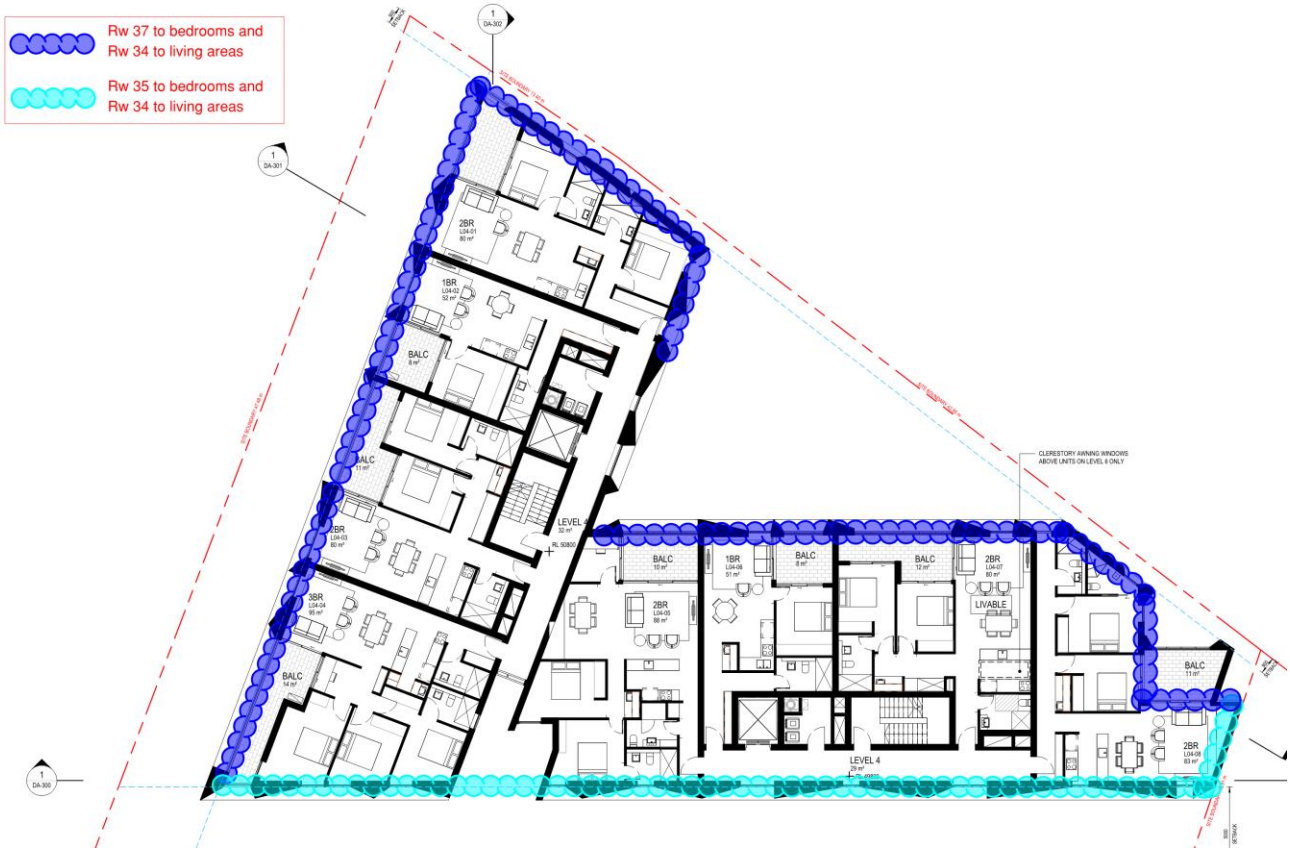
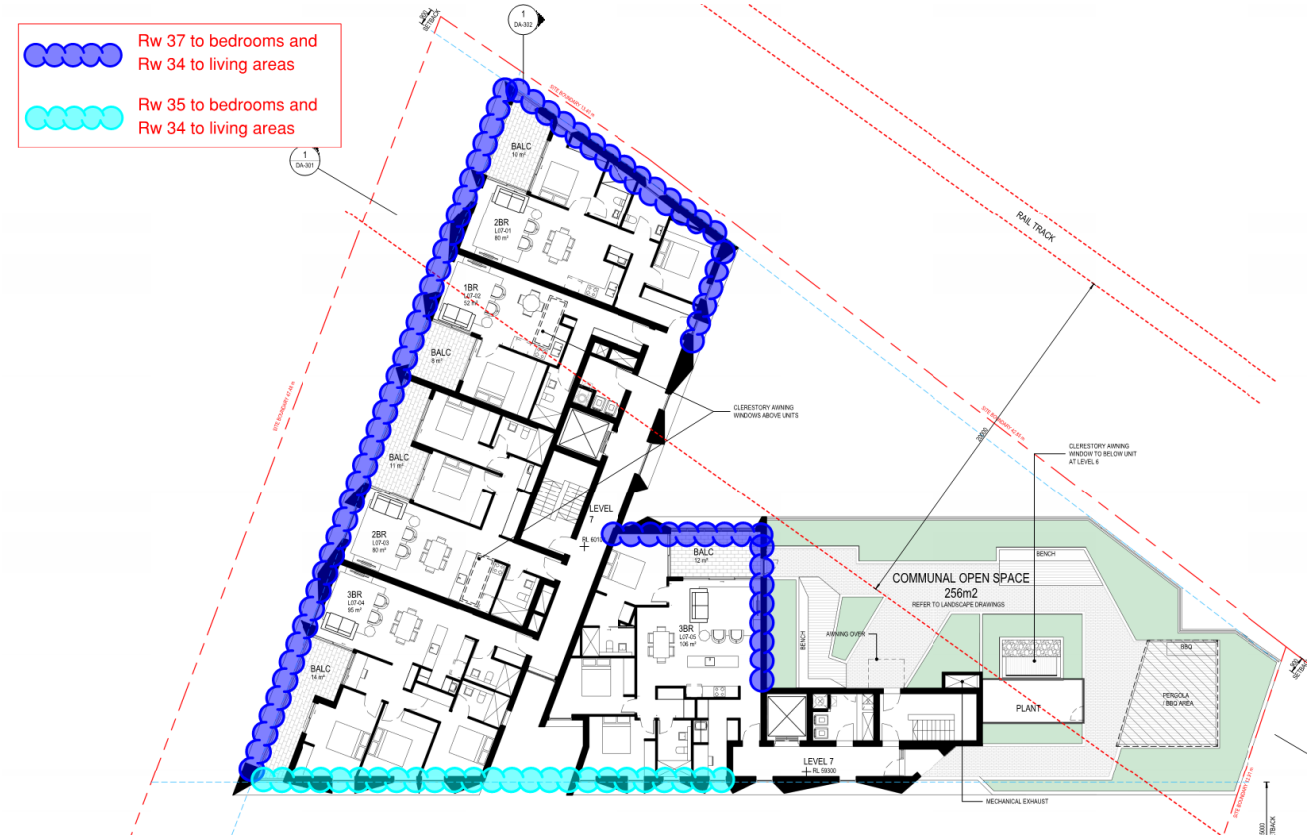


Figure 6: Glazing mark up Level 7



6.2 Alternative Means of Ventilation

An open windows assessment has been conducted in order to assess whether the habitable spaces can meet the internal noise level requirements of the DoP Interim Guideline with windows open for natural ventilation (where open windows means in accordance with the natural ventilation requirements of the NCC). If there is an exceedance of the internal noise level criteria with the windows open, alternative means of ventilation is required in accordance with the requirements of the NCC (i.e. mechanical ventilation or air conditioning system complying with AS 1668.2 and AS/NZS 3666.1).

Refer to Appendix B for a markup of the locations on the façade where bedrooms and living rooms would require an alternative means of ventilation due to train line noise.

6.3 Mechanical 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 following sub-sections. Noise sources from general operations at the site typically include mechanical services noise from air-conditioning equipment and exhaust and supply fans servicing the carpark. There is currently no mechanical services documentation, as such this assessment has only considered the condenser units that would be associated with each apartment. 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. During detailed design other mechanical plant such as carpark supply and exhaust fans must be addressed such as to comply with the external noise emission requirements, with all mechanical operating.

In order to assess the worst case scenario, it was assumed that the air conditioning units associated with the proposed residential development are running at any time throughout a 24hr period. With all, night time is the most stringent period for the noise generated by the operation of the 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 Maximum Noise Levels

Table 22 presents the proposed maximum sound power levels for individual condenser units.

Table 22: Proposed acoustic power for individual condenser units

Item	SWL re 10^{-12} W, dB(A)								
	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	Overall dB(A)
Balcony Condenser Unit	67	69	65	63	58	56	48	38	65

6.3.2 Noise 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 mitigation measures could include but are 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

Note that this is a preliminary solution as the design is yet to be finalized. A detailed acoustic assessment will be conducted during the design stage as more information becomes available regarding performance data of specific mechanical equipment or any further mechanical design information. Acoustic treatment will be proposed to ensure compliance with the project noise trigger levels established in Section 5.2.2.

6.4 Train Vibration Assessment

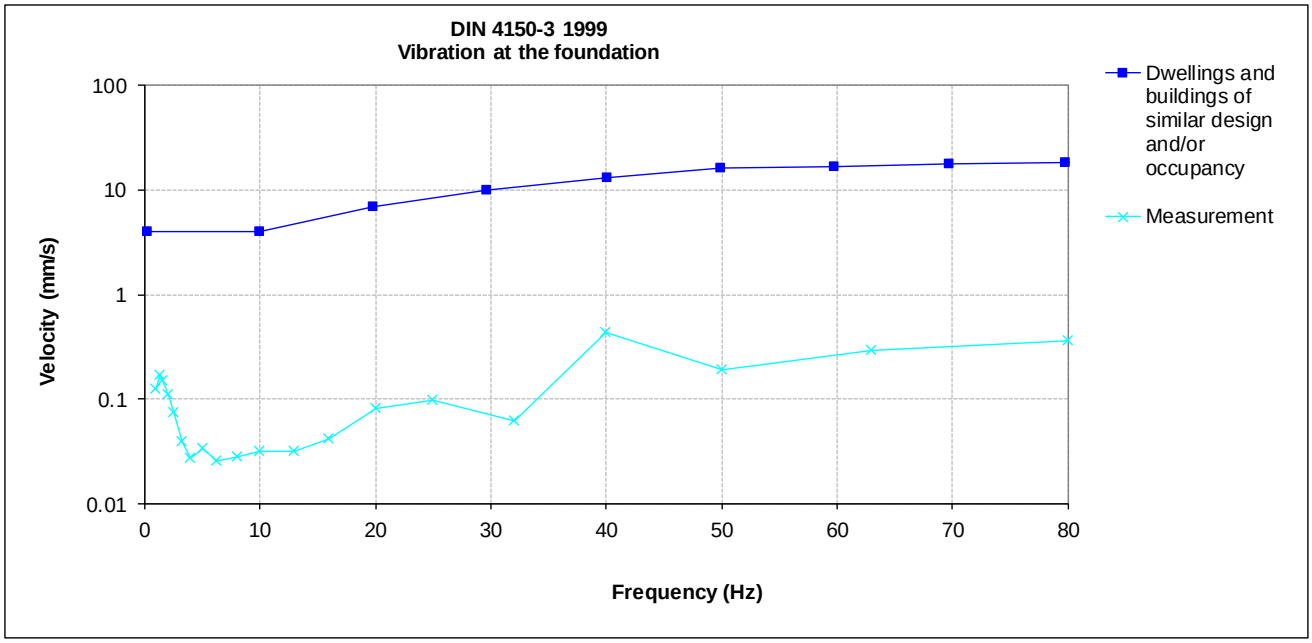
A vibration assessment has been conducted in accordance with the DoP's Interim Guideline and referenced documents due to the proximity of the proposed development to the rail corridor. The vibration levels of train pass-bys have been measured at the nearest point on the façade of the proposed development for all three axes. The measured values were processed and assessed in accordance with the criteria 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 23 for the results of the Vibration Dose Values (VDV) for day and night.

Table 23: Vibration Dose Values from train vibration

Period	eVDV ($m/s^{1.75}$)	Criteria	Complies (Yes/No)
Day (7am – 10pm)	0.068	0.40	Yes
Night (10pm – 7am)	0.045	0.26	Yes

Refer to Figure 7 for the results of the vibration velocity levels for comparison with the structural damage criteria from DIN4150 – 3.

Figure 7: Train vibration for structural damage (DIN 4150)



Based on the measured vibration levels at the façade of the proposed development, it is not expected that there will be any exceedance of the criteria established with regards to structural damage. There is also no exceedance of the VDV criteria for human comfort during the day or night time.

6.5 Traffic Noise Generation Assessment

For the road traffic noise assessment, existing peak hour traffic count and traffic generation for the site was based on the Traffic Impact Assessment prepared by Stantec. This data has been used to calculate the expected noise increase due to traffic associated with the development onto Broadarrow Road. The results are summarized in Table 24.

Table 24: Existing and predicted traffic flow volumes (peak hour)

Location	Existing vehicles	Existing vehicles	Predicted Increase	Predicted Increase	Noise Level Increase dB	Noise Level Increase dB
	AM	PM	AM	PM	AM	PM
Broadarrow Road	880	730	37	51	-0.2	-0.3

Based on the results of the assessment, there is predicted to be less than a 1dB increase in traffic noise levels, therefore proposed development is expected comply with the requirements of the NSW RNP in regards to the maximum 2dB increase.

6.6 Commercial Loading Zone

The commercial loading/unloading zone is located between the train line and the development, on the North side. As there is significant shielding and no line of sight from where the activities occur to the surrounding residential receivers, there is not expected to be any noise impact. The following measures should be implemented to reduce the potential for any noise impact however:

- All service trucks including waste collection will be restricted to entering and exiting and operating during the day time period (7:00am – 6:00pm)
- Works are carried out in the quietist reasonable and practicable manner
- The equipment used to carry out the work is the quietest reasonably available
- Vehicles must turn engines off while loading and unloading activities are occurring
- Broadband reverse alarms are to be used and not tonal beepers

6.7 Train-Induced Ground Borne Noise

An assessment for the ground borne noise, or regenerated noise, into the habitable spaces of the development due to a train pass-bys from the train line been conducted. Vibration levels were based on the measurements conducted on site. Department of Planning recommends a maximum internal noise level of 35dB(A) from 95% of train pass bys.

Based on this assessment the maximum noise levels inside the most affected habitable rooms has been predicted to be between 30 and 35dB(A) due to the pass by of a train, and is not expected to exceed the DoP criteria for ground borne noise.

7. Conclusion

An acoustic assessment for the proposed residential development located at 41 Broadarrow Rd, Narwee NSW 2209 has been conducted. This document forms part of the documentation package to be submitted to local authorities as part of the Development Application 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 criteria for internal noise levels according to DoP's Development near Rail Corridors and Busy Roads – Interim Guideline and AS/NZS 2107:2016
- Noise criteria for emissions from the development to receivers in accordance with the NPI
- Traffic noise criteria for additional vehicle movements on public roads generated by the proposed development
- Construction noise and vibration criteria
- Train vibration criteria for human comfort and structural damage

Glazing for the residential spaces within the proposed development has been designed to achieve internal noise levels in accordance with the requirements of the DoP Interim Guideline, and AS 2107:2016 for the non-residential spaces.

An open windows assessment has been conducted in accordance with the requirements of the DoP Interim Guideline. Alternative means of ventilation will be required as per the requirements of the DoP Interim Guideline. The habitable spaces which require an alternative means of ventilation to meet the DoP natural ventilation requirements are presented in Appendix B.

The maximum sound power levels for balcony condenser units has been presented in order to achieve the criteria for noise emissions. No assessment has been conducted for mechanical plant such as carpark supply or exhaust fans as there is currently no mechanical documentation. During detailed design other mechanical plant such as carpark fans must be selected and acoustically treated such as to achieve the external noise criteria from all plant operating.

The traffic noise generation assessment has shown that there would be less than 2dB increase in noise levels on Broadarrow Road, and as such the development is expected to meet the acoustic requirements of the NSW RNP.

Based on the vibration measurements conducted on site, there is not expected to be any exceedance in the vibration criteria with regards to human comfort and structural damage due to train movements.

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, as it can comply with all applicable regulations.

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 A 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

	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 B – Alternative Means of Ventilation Zones

Figure 8: Alternative ventilation mark-up (typical for levels 1 -2)

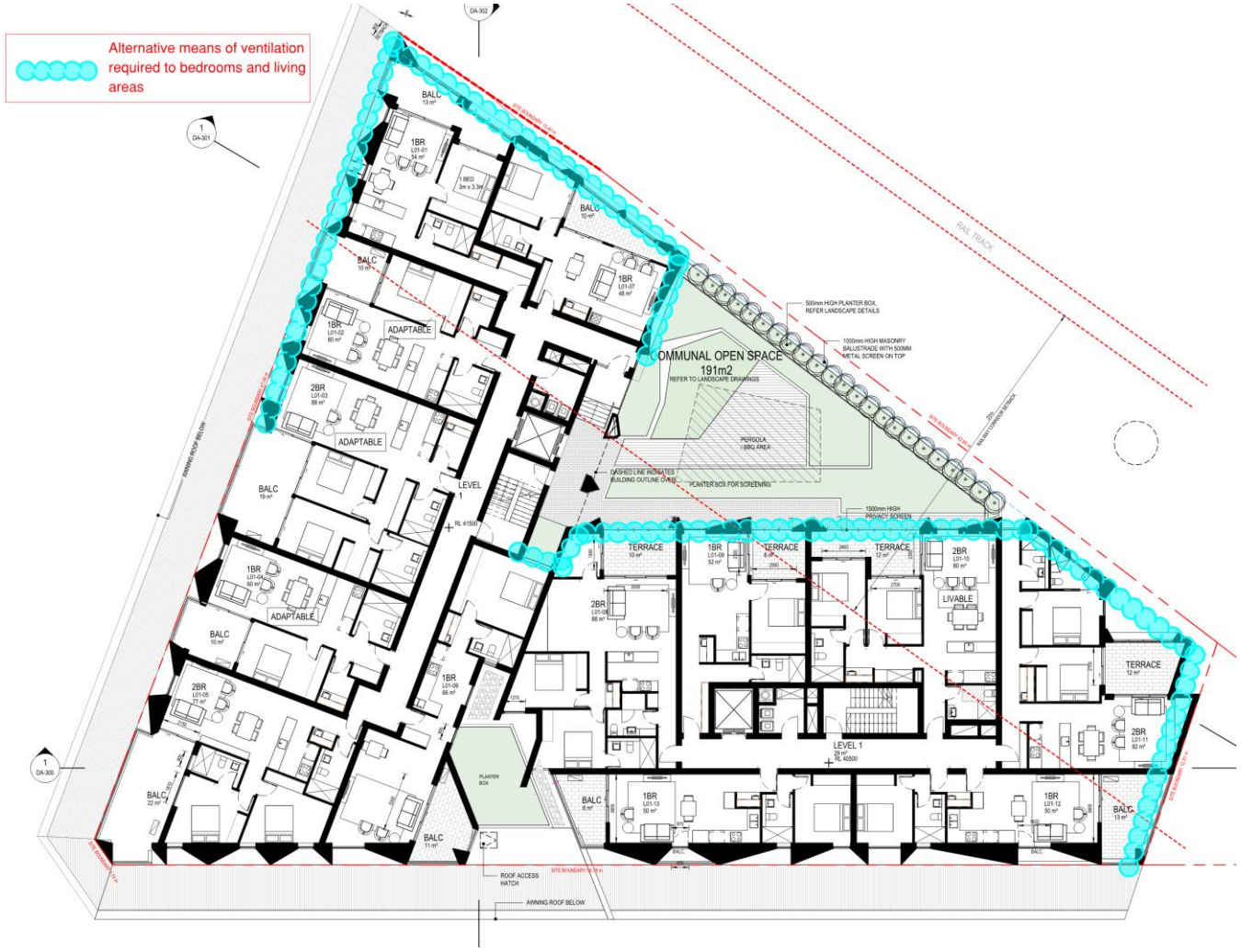
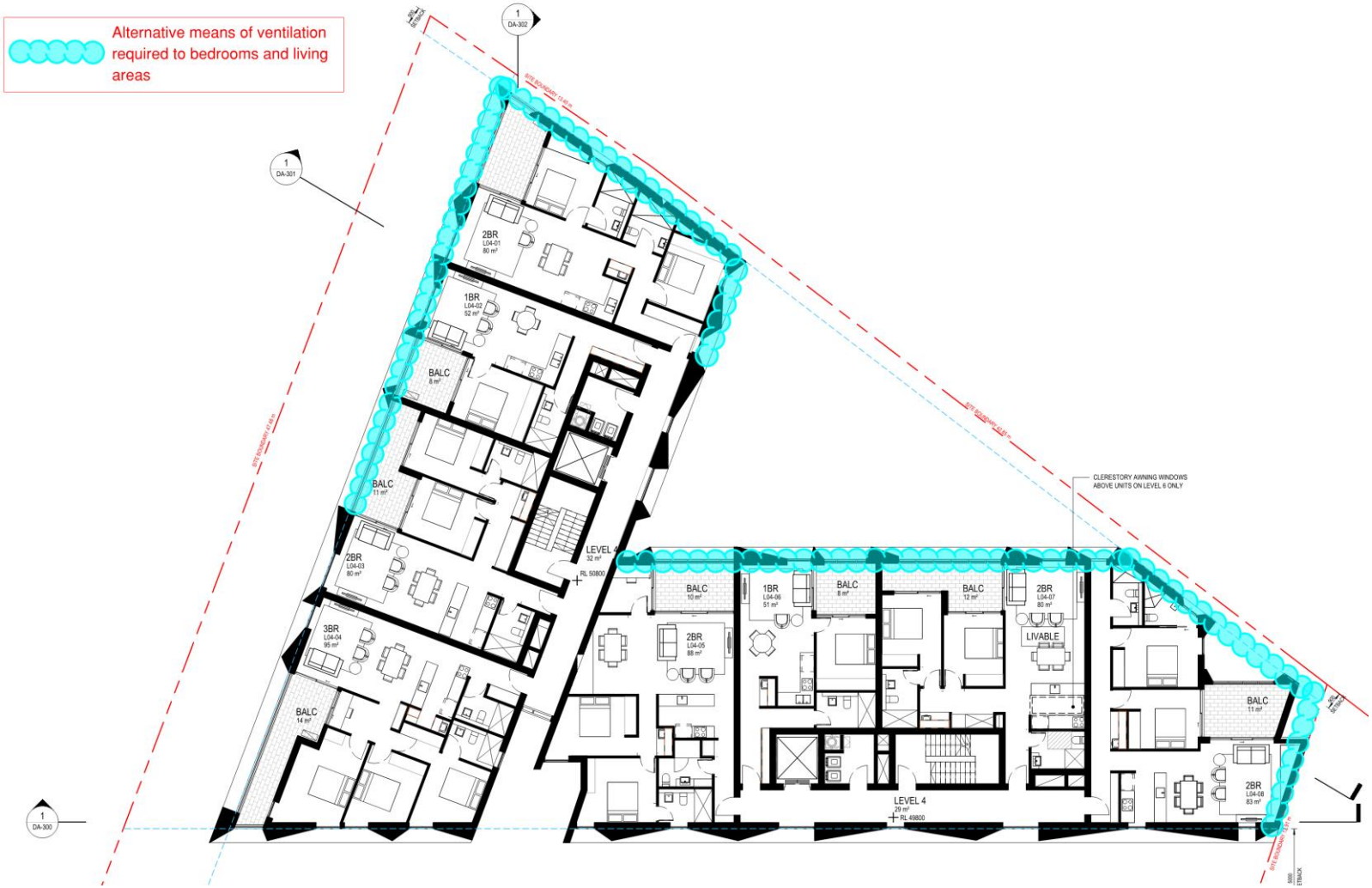
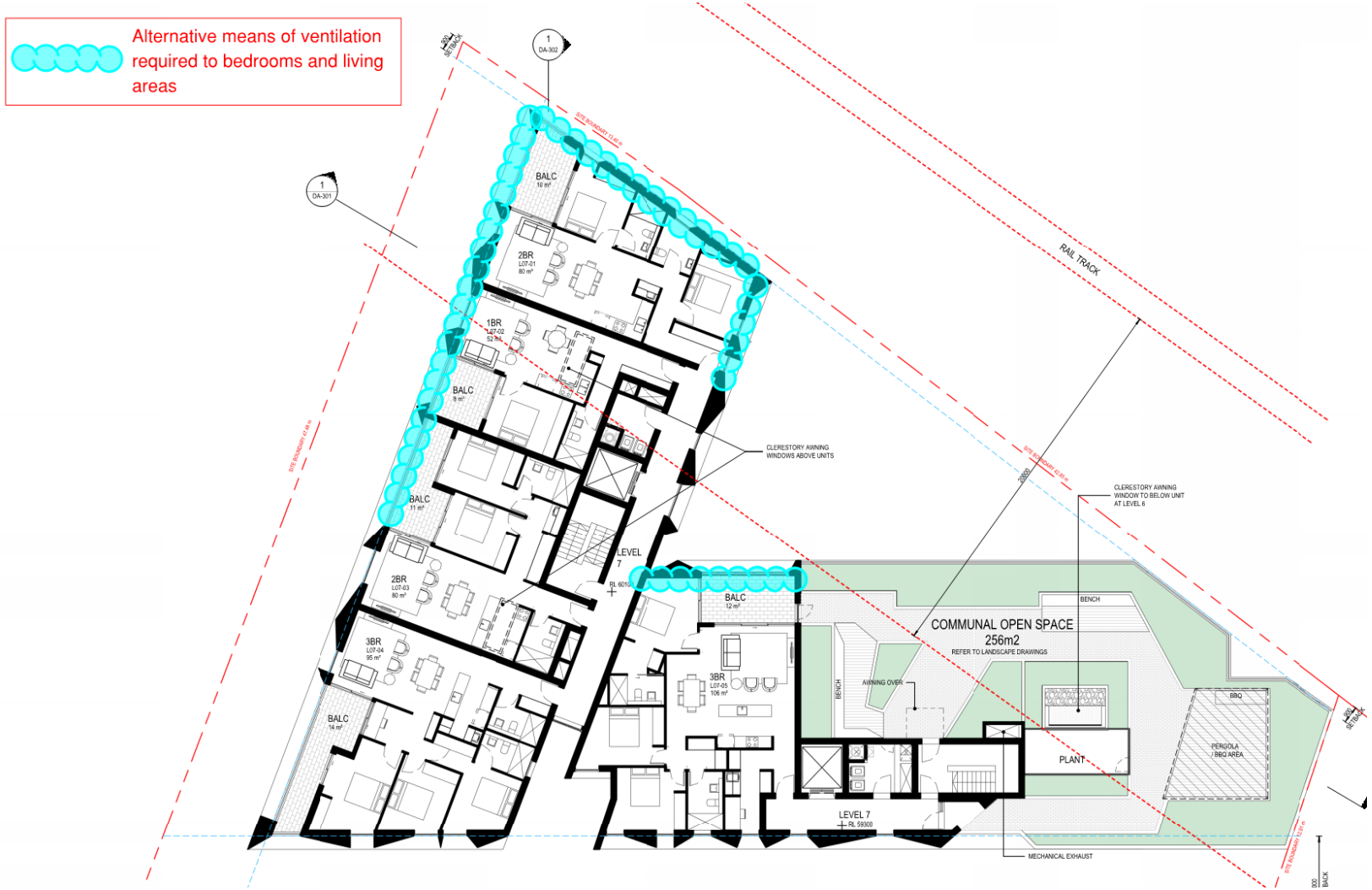


Figure 9: Alternative ventilation mark-up (typical for levels 3 - 6)



– Alternative Means of Ventilation Zones

Figure 10: Alternative ventilation mark-up (Level 7)



– Alternative Means of Ventilation Zones

APPENDIX C – Noise Maps

Figure 11: Grid noise map (day time) 6m high

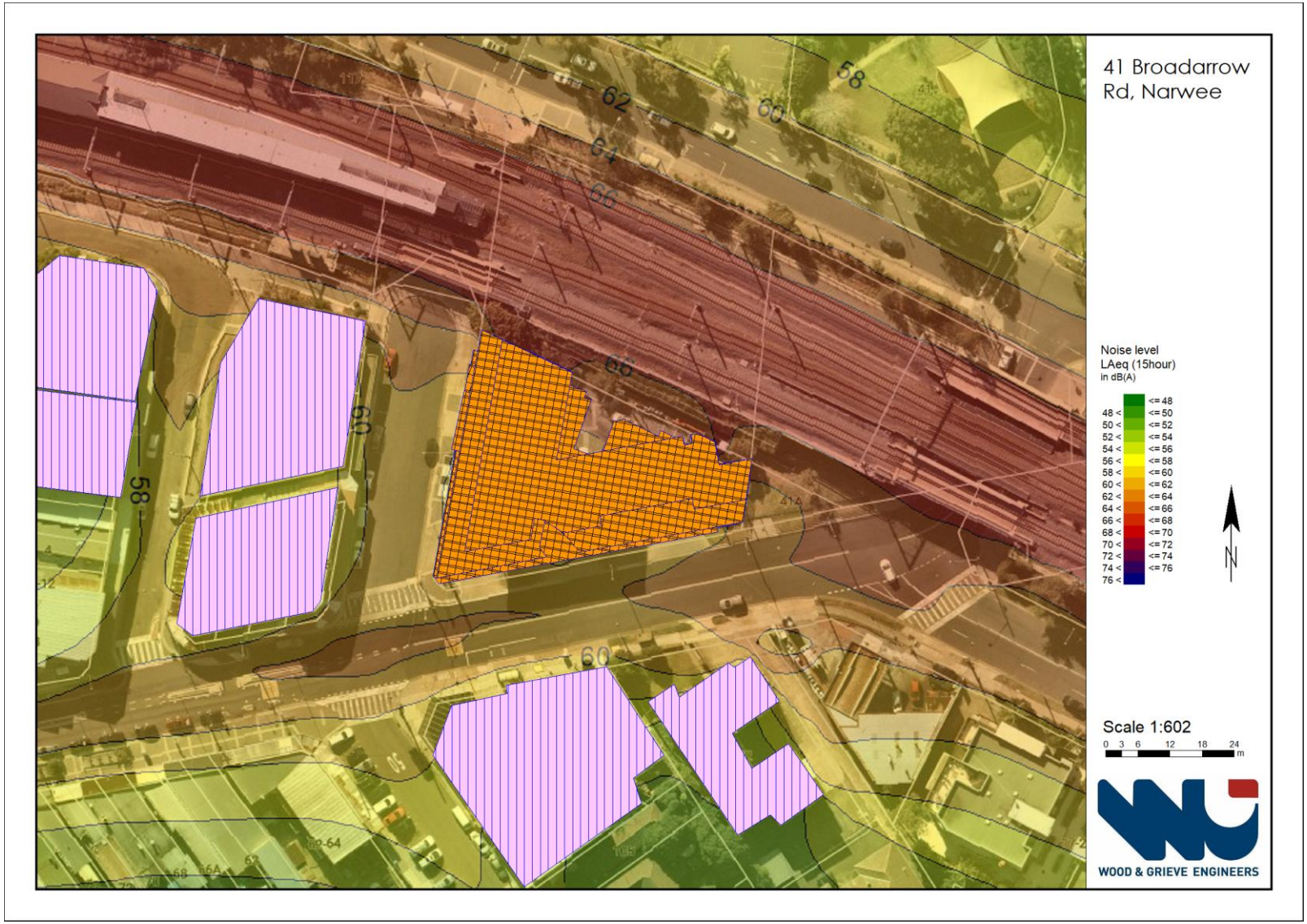


Figure 12: Grid noise map (day time) 12m high

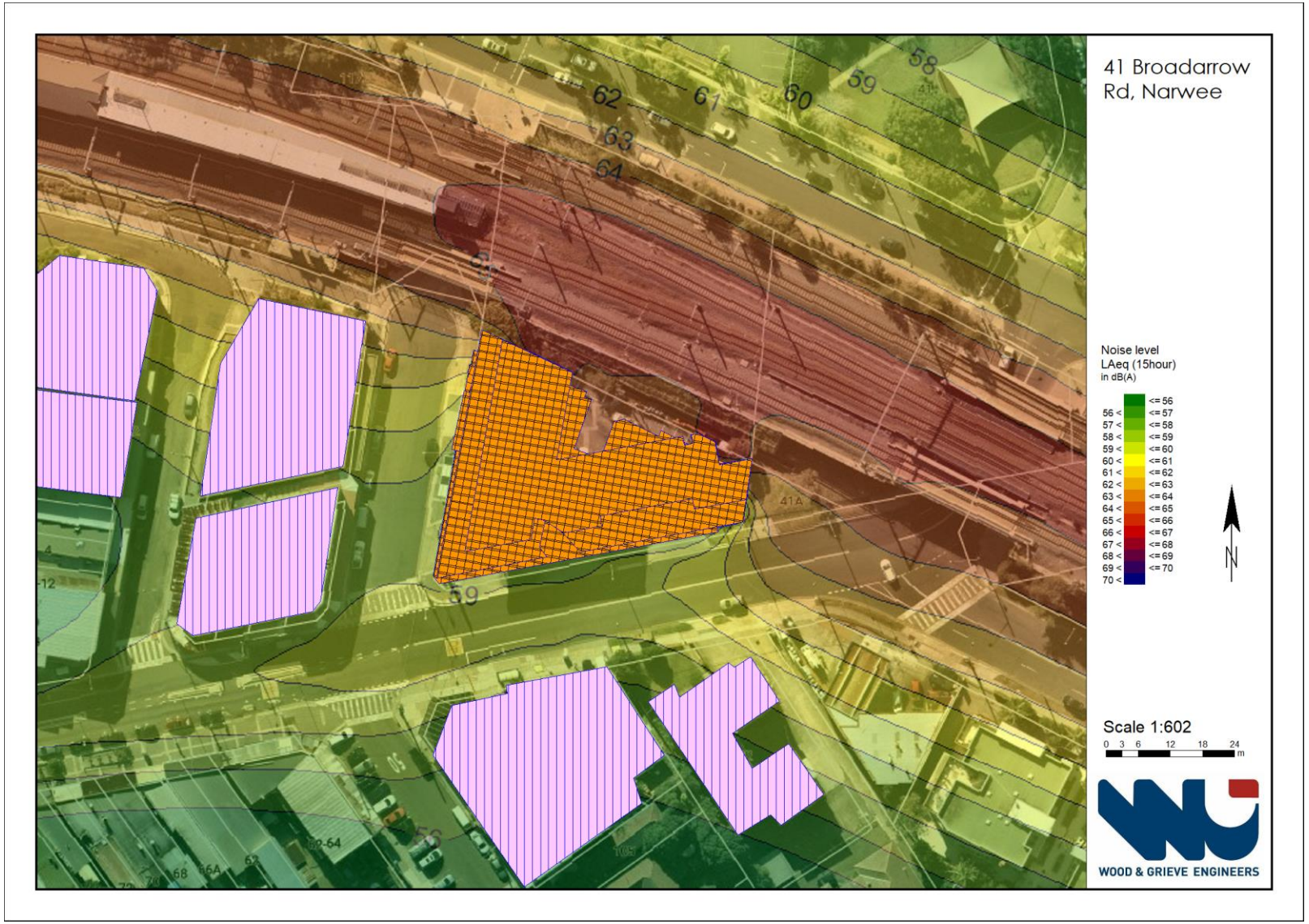


Figure 13: Façade Noise Map (day time)