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Transportation Noise Assessment

Vista Structure Plan, Karnup

Reference: 11041828-01i

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1 INTRODUCTION

This report has been prepared to assess transportation noise to the proposed Karnup Structure Plan, Lots 3, 805 and 806 Mandurah Road, Karnup. As this proposed subdivision is located adjacent to Mandurah Road and the South West Metropolitan Railway, an assessment of future transportation noise levels is required to determine the expected noise impact and the extent of noise control that would be required to achieve compliance with relevant criteria.

While several revisions have occurred over the years for the combined areas, this report details updates to the Lot 805 Local Structure Plan area only (northern most area). This area is shown highlighted in *Figure 1-2*.

The locality of the site is shown below on *Figure 1-1* with the proposed local structure plan shown in *Figure 1-2*.

Figure 1-1 Site Locality

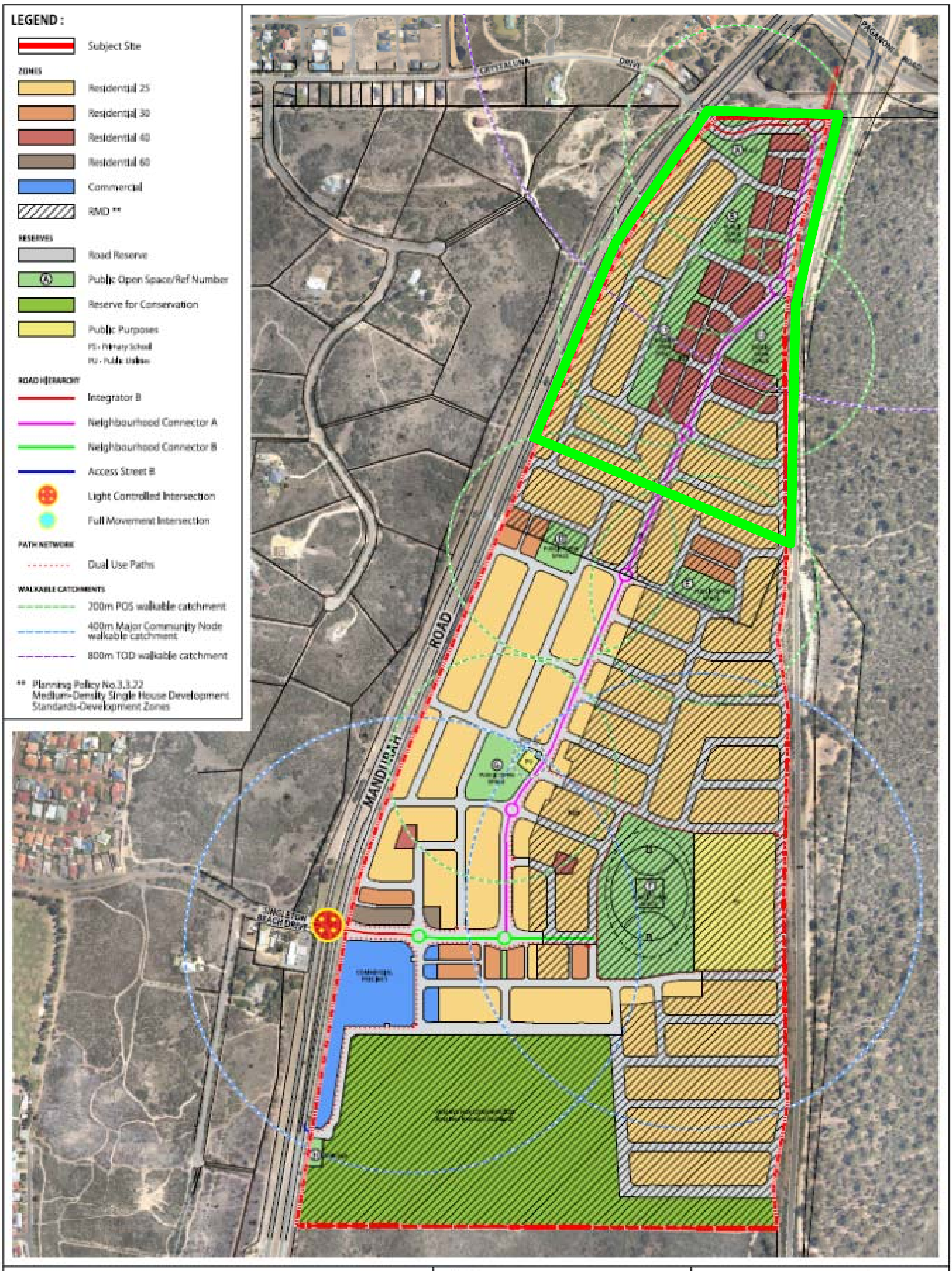


Figure 1-2 Proposed Local Structure Plan (Revised 16/06/2017)

Appendix B contains a description of some of the terminology used throughout this report.

2 CRITERIA

The criteria relevant to this assessment is the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (hereafter referred to as the Policy) produced by the Western Australian Planning Commission (WAPC). The objectives in the Policy are to:

- Protect people from unreasonable levels of transport noise by establishing a standardised set of criteria to be used in the assessment of proposals;
- Protect major transport corridors and freight operations from incompatible urban encroachment;
- Encourage best practice design and construction standards for new development proposals and new or redevelopment transport infrastructure proposals;
- Facilitate the development and operation of an efficient freight network; and
- Facilitate the strategic co-location of freight handling facilities.

The Policy's outdoor noise criteria are shown below in *Table 2-1*. These criteria applying at any point 1-metre from a habitable façade of a noise sensitive premises and in one outdoor living area.

Table 2-1 Outdoor Noise Criteria

Period	Target	Limit
Day (6am to 10pm)	55 dB $L_{Aeq(Day)}$	60 dB $L_{Aeq(Day)}$
Night (10pm to 6am)	50 dB $L_{Aeq(Night)}$	55 dB $L_{Aeq(Night)}$

Note: The 5 dB difference between the target and limit is referred to as the margin.

In the application of these outdoor noise criteria to new noise sensitive developments, the objectives of this Policy is to achieve -

- acceptable indoor noise levels in noise-sensitive areas being 35 dB $L_{Aeq(Night)}$ in bedrooms and 40 dB $L_{Aeq(Day)}$ in other habitable spaces; and
- a 'reasonable' degree of acoustic amenity in at least one outdoor living area on each residential lot.

If a noise sensitive development takes place in an area where outdoor noise levels will meet the *target*, no further measures are required under this policy.

In areas where the *target* is exceeded, but noise levels are likely to be within the 5 dB margin (i.e. less than the *limit*), mitigation measures should be implemented by the developer with a view to achieving the *target* levels in at least one outdoor living area on each residential lot. Where indoor spaces are planned to be facing any outdoor area in the *margin*, mitigation measures should be implemented to achieve acceptable indoor noise levels in those spaces.

In areas where the *limit* is exceeded (i.e. above $L_{Aeq(Day)}$ of 60dB(A) or $L_{Aeq(Night)}$ of 55dB(A)), a detailed noise assessment is to be undertaken. Customised noise mitigation measures should be implemented with a view to achieving the *target* in at least one outdoor living area on each residential lot, or if this is not practicable, within the *margin*. Where indoor spaces are planned to be facing outdoor areas that are above the *target*, mitigation measures should be implemented to achieve acceptable indoor noise levels in those spaces.

3 METHODOLOGY

Noise measurements and modelling have been undertaken in accordance with the requirements of the Policy as described below in *Sections 3.1 and 3.2*. Where rail noise is concerned, site measurements were not taken, however on file rail data from the Public Transport Authority was used in the modelling.

3.1 Site Measurements

Traffic noise monitoring was undertaken alongside Mandurah Road at one location in order to:

- Quantify the existing noise levels;
- Determine the differences between different acoustic parameters ($L_{A10,18hour}$, $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$); and
- Calibrate the noise model for existing conditions.

The instrument used was an ARL Type 316 noise data logger (pictured below in *Figure 3.1*). The logger was programmed to record hourly L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} levels. This instrument complies with the instrumentation requirements of *Australian Standard 2702-1984 Acoustics – Methods for the Measurement of Road Traffic Noise*. The logger was field calibrated before and after the measurement session and found to be accurate to within +/- 1 dB. Lloyd George Acoustics also holds current laboratory calibration certificate for the loggers.

Figure 3-1 Automatic Noise Data Logger

The measurement location is shown in *Figure 3.2*.

The noise logger was set-up to obtain 3 full weekdays, between 4th July and 8th July 2011 and located approximately 15 metres from the road. This data was used in the original noise assessments to calibrate the noise model, which is still applicable in follow up assessments provided there are no significant alignment changes.

Sound pressure levels were measured in accordance with Australian Standard 2702-1984: *Acoustics - Method For Measurement of Road Traffic Noise*, with the logger positioned in free field conditions with the microphone height at 1.4 metres above ground floor level.

From the hourly measurements, the $L_{A10,18\ hour}$, $L_{Aeq,24\ hour}$, $L_{Aeq\ (Day)}$ and $L_{Aeq\ (Night)}$ values were determined for each complete measurement day. These results were averaged and the mean level reported.

Figure 3-2 Noise Data Logger Location

The noise data collected was verified by inspection and professional judgement. Where hourly data was considered atypical, an estimated value was inserted and highlighted by bold italic lettering.

The weather conditions during the measurement period were obtained from the Bureau of Meteorology's, Perth Metro (Mount Lawley). This data was compared against the Main Roads Western Australia (MRWA) specifications for measurement conditions and any unacceptable conditions commented on.

3.2 Noise Modelling

The computer programme *SoundPLAN 7.3* was utilised incorporating the *Nordic Rail Prediction Method* (Kilde Rep. 130) algorithm for rail transport and the *Calculation of Road Traffic Noise* (CoRTN) algorithms for road transport. Both the rail and road algorithms have been modified to reflect local conditions.

The rail noise modifications include:

- The Nordic Rail Prediction Method (Kilde Rep. 130) algorithm is for generic train types in Europe and requires modification to align with measured noise levels of passenger trains operating in the Perth region. Measured noise levels used are shown in *Table 3-1.*

Table 3-1 – Sound Pressure Levels Used in the Noise Model

Description	dB(A) at One-Third Octave Frequencies (Hz)									Overall dB(A)
	31.5	63	125	250	500	1K	2K	4K	8K	
Train speed of 130 km/hr at a distance of 15m	30	51	59	62	73	79	79	77	69	87
	35	54	61	65	73	79	80	74	64	
	42	53	61	69	78	80	78	72	58	

The road noise modifications include:

- Vehicles were separated into heavy (Austroads Class 3 upwards) and non-heavy (Austroads Classes 1 & 2) with non-heavy vehicles having a source height of 0.5 metres above road level and heavy vehicles having two sources, at heights of 1.5 metres and 3.6 metres above road level, to represent the engine and exhaust respectively. By splitting the noise source into three, allows for less barrier attenuation for high level sources where barriers are to be considered. Note that corrections are applied to the exhaust of –8.0 dB (based on Transportation Noise Reference Book, Paul Nelson, 1987) and to the engine source of –0.8 dB, so as to provide consistent results with the CoRTN algorithms for the no barrier scenario;

- An adjustment of –1.7 dB has been applied to the predicted levels based on the findings of An Evaluation of the U.K. DoE Traffic Noise Prediction; Australian Road Research Board, Report 122 ARRB – NAASRA Planning Group 1982.

Predictions are made at heights of 1.4 metres above ground floor level and at 1.0 metre from an assumed building façade (resulting in a + 2.5 dB correction due to reflected noise).

Various input data are included in the modelling such as ground topography, road design, traffic volumes etc. These model inputs are discussed below.

3.2.1 Ground Topography, Road Design & Cadastral Data

The overall topographical data was based on that provided by Emerge Associates, which is from the Department of Land Information (DLI). The contours are in 5 metre intervals and cover the noise sensitive premises of concern. The contours for the future site were provided by JSDI Consulting Engineers. An existing noise wall of varying height up to 2.5m bordering Lot 806 was also included in the modelling.

The elevation for the railway was based on our previous involvement with the Public Transport Authority.

Buildings have also been included as these can provide barrier attenuation when located between a source and receiver, in much the same way as a hill or wall provides noise shielding. All single storey buildings are assumed to have a height of 4 metres.

3.2.2 Train Movements

The train configuration and numbers of movements used in the noise prediction modelling are presented below in *Tables 3-2 and 3-3.*

Table 3-2 – Variables Used in the Noise Prediction Model

Description of Variable		Value
Type of noise source		Line source
Train length	3 Car Set	75 metres
	4 Car Set	100 metres
	6 Car Set	150 metres
Height of noise source above railhead		0.8 metres
Train Speeds		Up to 130 km/h

Table 3-3 – Rail Movements Per Hour Assumed in Noise Model

Train Description	Train Movements per Hour	
	Day	Night
Northbound		
3 Car Sets	5.37	1.0
6 Car Sets	0.37	0
Southbound		
3 Car Sets	5.00	1.0
6 Car Sets	0.37	0

3.2.3 Traffic Data

Traffic data includes:

- Road Surface – The noise relationship between different road surface types is shown below in *Table 3-4*.

Table 3-4 Noise Relationship Between Different Road Surfaces

Road Surfaces						
Chip Seal			Asphalt			
14mm	10mm	5mm	Dense Graded	Novachip	Stone Mastic	Open Graded
+3.5 dB	+2.5 dB	+1.5 dB	0.0 dB	-0.2 dB	-1.0 dB	-2.5 dB

  The existing road surface is worn 14mm chip seal and the future road surface will be dense graded asphalt.

- Vehicle Speed – The existing speed is 100 km/hr, whilst future posted speeds are 80km/hr.

- Traffic Volumes – Information used in the modelling is provided in *Table 3-5*. This information has been provided by Main Roads using calibrated ROM24 modelling (Request #40581: Yu, Clare – 19 June 2017).

Table 3-5 Traffic Information Used in the Modelling

Parameter	Scenario	
	Existing - 2005	Future - 2037
	South of Pagnoni Road	South of Pagnoni Road
24 Hour Volume	27,100	40,400
% Heavy	5-6%	4-5%

3.2.4 Ground Attenuation

The ground attenuation has been assumed to be 0.25 (25%) within the road reserve, 0.6 (60%) throughout the subdivision, except for the public open space, which was set to 1.00 (100%) and 0.9 (90%) outside of the subdivision. Note 0.0 represents hard reflective surfaces such as water and 1.00 represents absorptive surfaces such as grass.

3.2.5 Parameter Conversion

The CoRTN algorithms used in the *SoundPlan* modelling package were originally developed to calculate the $L_{A10,18hour}$ noise level. The WAPC Policy however uses $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$. The relationship between the parameters varies depending on the composition of traffic on the road (volumes in each period and percentage heavy vehicles).

As noise monitoring was undertaken, the relationship between the parameters is based on the results of the monitoring – refer *Section 4.1*. Guidance on the relationship between these parameters has been taken from *Converting the UK Traffic Noise Index $L_{A10,18h}$ to EU Noise Indices for Noise Mapping*; TRL Limited.

4 RESULTS

4.1 Noise Monitoring

The results of the noise monitoring are summarised below in *Table 4-1* and shown graphically in *Figure 4-1*.

Table 4-1 Measured Average Noise Levels – Mandurah Road

Date	Average Weekday Noise Level, dB			
	$L_{A10,18hour}$	$L_{Aeq,24hour}$	$L_{Aeq\ (Day)}$	$L_{Aeq\ (Night)}$
Weekday Average	70	65	66	59

The average differences between the $L_{Aeq\ (Day)}$ and $L_{Aeq\ (Night)}$ are 7 dB. This same difference has been assumed to exist in future years. As such, it is the daytime noise levels that will dictate compliance since these are at least 5 dB more than night-time levels.

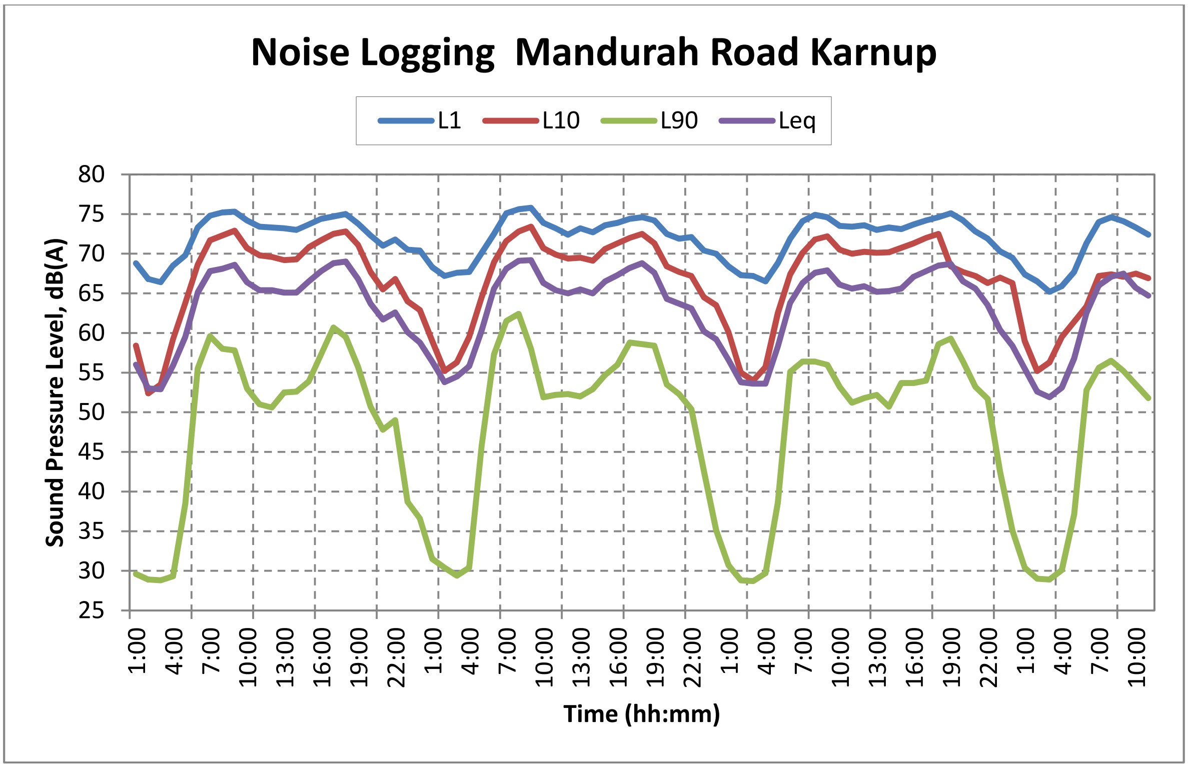


Figure 4-1 Noise Monitoring Results

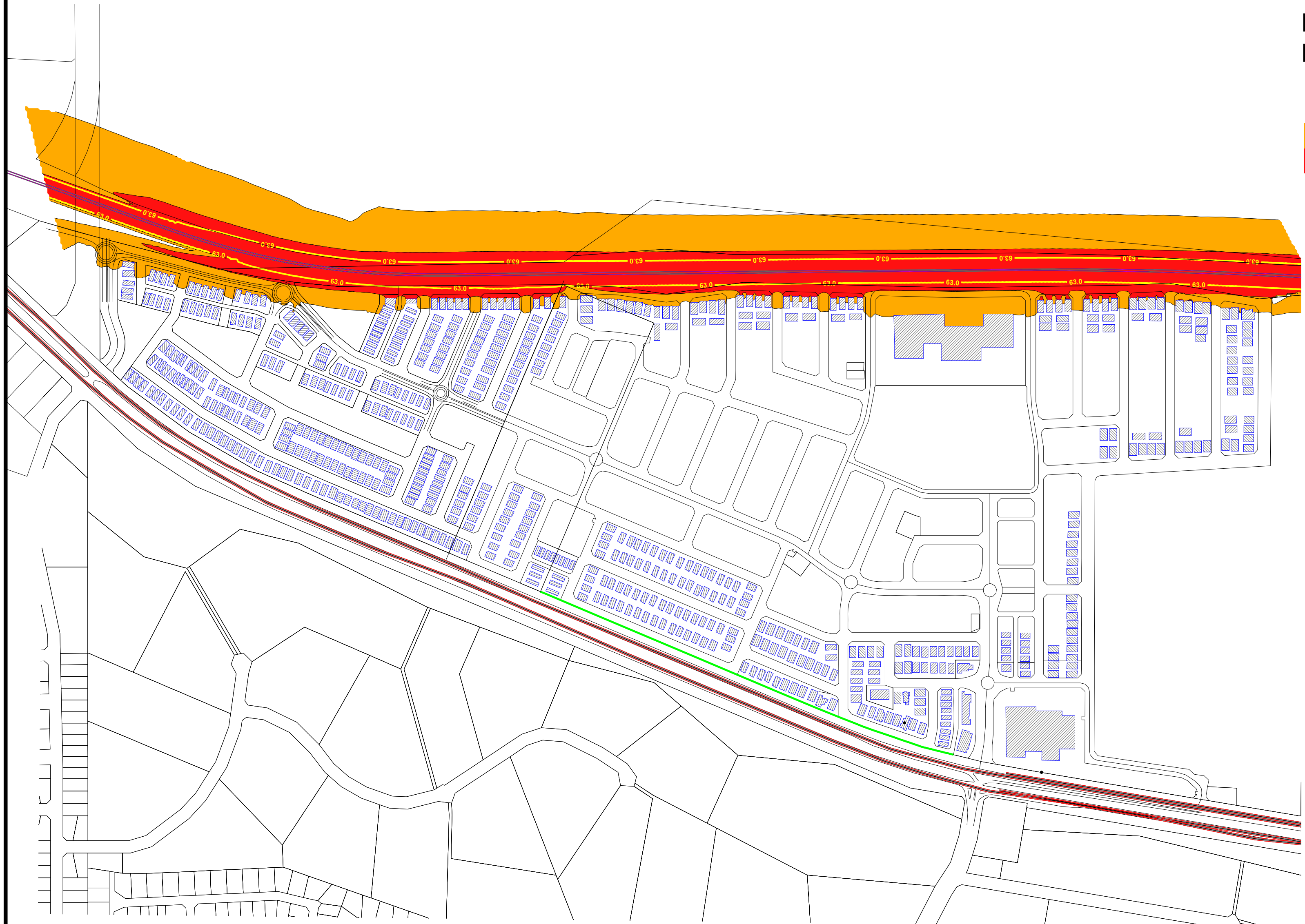
4.2 Noise Modelling

The road traffic noise modelling is provided as $L_{Aeq\ (Day)}$ noise level contour plots on *Figure 4-2* being for the future conditions.

Rail noise modelling results are presented as noise level contour plots on *Figure 4-3*. Again only the $L_{Aeq(Day)}$ levels are presented as these are most critical.

Mandurah Road, Karnup - Rail Noise Model
Predicted Noise Level, Leq Day

Figure 4.3



Noise levels
L_{Aeqday} dB(A)

<= 55 Noise Target
<= 60 Above Target, below Limit
> 60 Above Limit

Signs and symbols
Road axis
Emission line
Main building
Existing Wall

4 July 2017

Length Scale 1:10000
0 50 100 200 300 400 m

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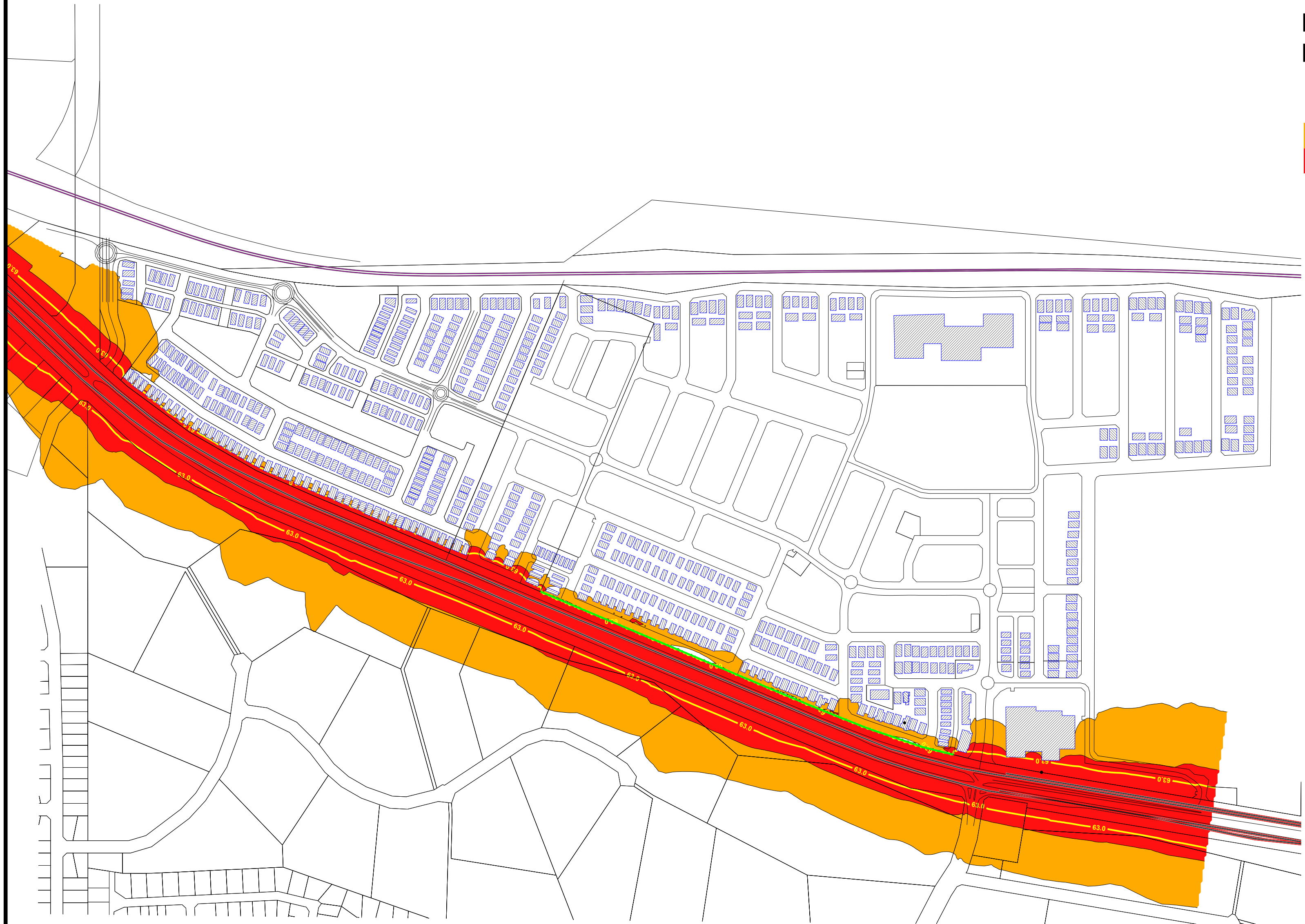
Mandurah Road, Karnup - Road Traffic Noise Model

Predicted Noise Level, Leq Day, based on 2037 Traffic Projections, Dense Graded Asphalt

Figure 4.2



Noise levels

L_{Aeqday} dB(A)

<= 55 Noise Target

<= 60 Above Target, below Limit

> 60 Above Limit

Signs and symbols

Road axis

Emission line

Main building

Existing Wall

4 July 2017

Length Scale 1:10000

0 50 100 200 300 400 m

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5 ASSESSMENT

The objectives of the criteria are for noise at all houses to be no more than the *limit* and preferably no more than the *target*. Where the *target* is achieved, no further controls are required. Where the *limit* is achieved or noise levels are within the *margin* (between the *limit* and *target*), further controls are necessary.

With no noise control, road traffic and railway noise levels for future dwellings will be above the *target*. As such, consideration has been given to the construction of noise walls. It is considered impracticable to achieve the *target* with the construction of noise walls alone with the height of the wall needing to be above 4 metres, which is a commonly adopted maximum acceptable wall height in Western Australia.

5.1 Road Noise

From *Figure 4.2* the following can be summarised:

- The future road noise levels would exceed the *Target* criteria at all lots adjacent to Mandurah Road;
- The future road noise levels would exceed the *Limit* criteria at the majority of the lots adjacent to Mandurah Road; and

As the noise levels exceed the SPP 5.4 *Target* criteria, noise mitigation needs to be considered. The mitigation options that are appropriate for this assessment include a noise wall along the development boundary adjacent to the road reserve, and treatments to the facade of properties exceeding the *Target* criteria.

5.2 Rail Noise

From *Figure 4.3*, the following can be summarised:

- The future rail noise levels would exceed the *Target* criteria at a number of lots adjacent to the South West Metropolitan Railway;
- The future rail noise levels would exceed the *Limit* criteria at a number of lots adjacent to the South West Metropolitan Railway; and
- The *Target* will be achieved at a distance of approximately 80m from the centre of the railway.

As the noise levels exceed the SPP 5.4 *Target* criteria, noise mitigation needs to be considered. The mitigation options that are appropriate for this assessment include a noise wall along the development boundary adjacent to the South West Metropolitan Railway, and/or treatments to the facade of properties exceeding the *Target* criteria.

6 RECOMMENDATIONS

From *Figure 4.2,* it can be seen that the majority of the proposed lots fronting Mandurah Road are predicted to exceed the SPP 5.4 *Limit* criteria at the facades facing the road. It is understood that the upgrade to Mandurah Road will include a dense graded asphalt pavement, however the use of a quieter road surface beyond that, such as open graded asphalt, would not generally be considered by Main Roads Western Australia.

Based on the predicted noise levels, it is proposed that a combination of a minimum 2.2 metre high wall and architectural treatments be considered. It is noted that the existing wall along Lot 806 (As shown in *Figure 4-3* is 2.5 metres high). Where a noise wall is constructed, it is to be solid, free of gaps and of a material having a minimum surface mass of $12kg/m^2$.

Generally homes directly adjacent to the Mandurah Rd boundary will require Package B. This may be reduced at time of individual building application via a detailed noise assessment once floor plans are known.

From *Figure 4.3,* it can be seen that a number of the proposed lots are predicted to exceed the SPP 5.4 *Limit* criteria at the facades facing the South West Metropolitan Railway. Based on the predicted noise levels, it is proposed that a combination of a 2.0 metre high wall and architectural treatments be considered. Generally homes in the first row facing the rail boundary will require Package A.

The results of the noise modelling with the inclusion of the recommended barriers are shown in *Figure 6.1* and *Figure 6.2* for road and rail noise sources. In addition to the noise wall design, the associated affected lots will require architectural treatments as follows:

- Where residences are predicted to experience future noise levels between, and including, 61 dB and 63 dB $L_{Aeq(Day)}$, Package B is to be incorporated (refer *Appendix A*). Alternative constructions may be acceptable if supported by a report undertaken by a suitably qualified acoustical consultant once the lots specific building plans are available.

- Where residences are predicted to experience future noise levels between, and including, 56 dB and 60 dB $L_{Aeq(Day)}$, Package A is to be incorporated (refer *Appendix A*). Alternative constructions may be acceptable if supported by a report undertaken by a suitably qualified acoustical consultant once the lots specific building plans are available.

- All affected lots are to have notifications on lot titles as per the Policy requirements – refer *Appendix A*.

- All affected lots are to provide one outdoor entertaining area where noise levels are below the *limit*. For those dwellings within Package B, one outdoor entertaining area is to be located on the side of the house opposite the transport corridor or within an alcove of the house so that the house itself shields it from the transport corridor.

- Where an affected lot is to be of double storey construction, specialist advice must be sort since the upper level will not receive the same level of attenuation provided by walls or other dwellings.

7 CONCLUSION

The analysis has shown that to comply with the criteria of the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* a combination of noise mitigating features, walls and architectural treatments will be required.

Multiple storey dwellings within the yellow or red zones of *Figures 6.1 & 6.2* should be discouraged. If these are permitted, specialist advice should be obtained from a qualified acoustic consultant (member of the Australian Acoustical Society or Association of Australian Acoustical Consultants). The reason for this is that the proposed barrier will provide negligible noise attenuation to upper floors and the façade treatments will need to be increased.

Figure 6.1

Mandurah Road, Karnup - Road Traffic Noise Model

Predicted Noise Level, Leq Day, based on 2037 Traffic Projections, Dense Graded Asphalt and with 2.2m High Barrier Along Mandurah Road

Noise levels

L_{Aeqday} dB(A)

- <= 55 Noise Target
- <= 60 Above Target, below Limit
- > 60 Above Limit

Signs and symbols

- Road axis
- Emission line
- Main building
- Existing Wall
- 2.2m High Barrier

4 July 2017

Length Scale 1:10000

0 50 100 200 300 400 m

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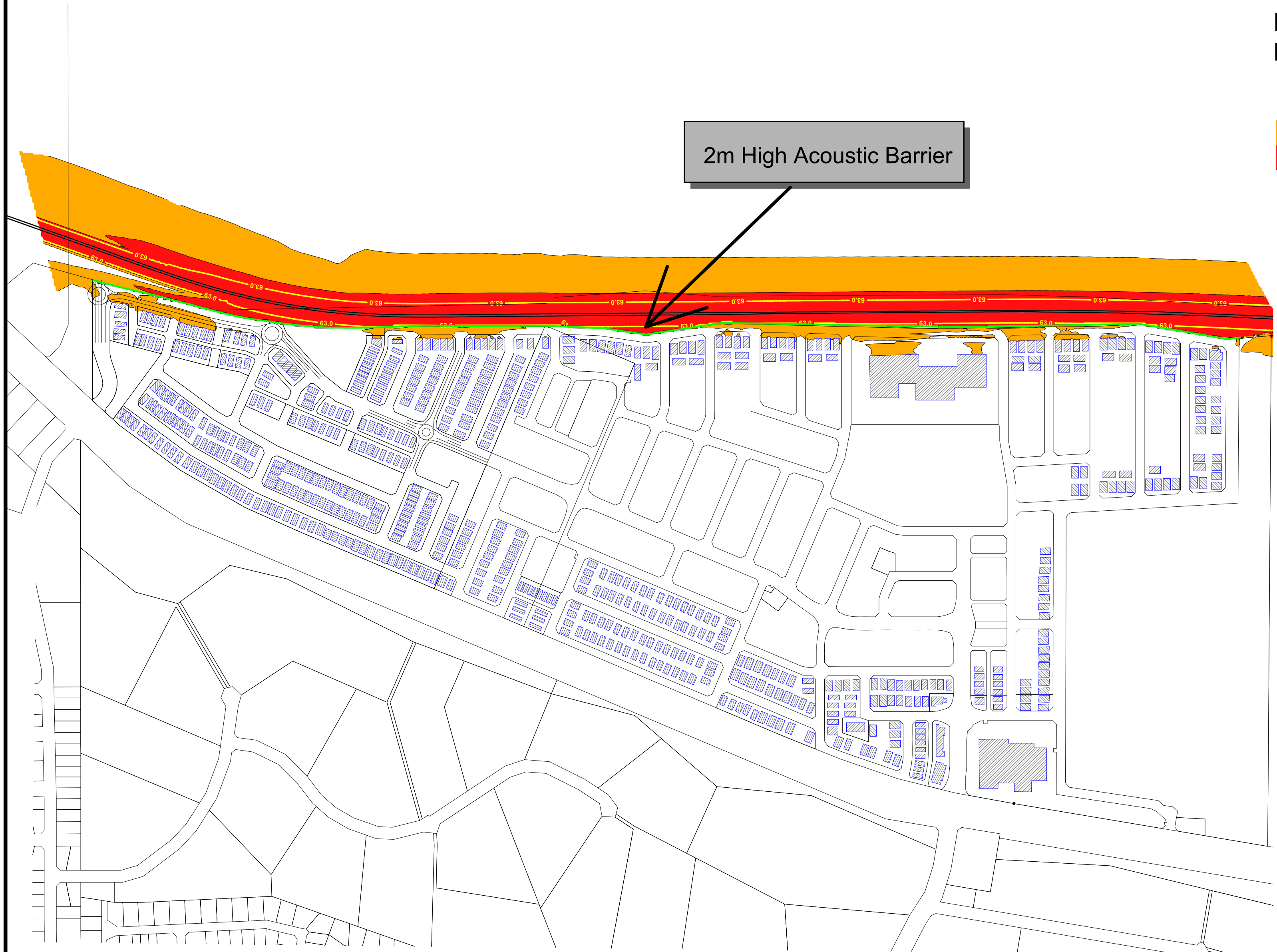
Mandurah Road, Karnup - Rail Noise Model

Predicted Noise Level at Building Facade with 2m High Barrier along Lot Boundary

Figure 6.2



Noise levels

L_{Aeqday} dB(A)

<= 55 Noise Target

<= 60 Above Target, below Limit

> 60 Above Limit

Signs and symbols

Rail Line

Main building

2m High Barrier

4 June 2017

Length Scale 1:10000

0 50 100 200 300 400 m

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Appendix A

ACCEPTABLE TREATMENT PACKAGES

Appendix B

Terminology

The following is an explanation of the terminology used throughout this report.

Decibel (dB)
The decibel is the unit that describes the sound pressure and sound power levels of a noise source. It is a logarithmic scale referenced to the threshold of hearing.

A-Weighting
An A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. An A-weighted sound level is described as L_A dB.

L_1
An L_1 level is the noise level which is exceeded for 1 per cent of the measurement period and is considered to represent the average of the maximum noise levels measured.

L_{10}
An L_{10} level is the noise level which is exceeded for 10 per cent of the measurement period and is considered to represent the "*intrusive*" noise level.

L_{90}
An L_{90} level is the noise level which is exceeded for 90 per cent of the measurement period and is considered to represent the "*background*" noise level.

L_{eq}
The L_{eq} level represents the average noise energy during a measurement period.

$L_{A10,18hour}$
The $L_{A10,18\ hour}$ level is the arithmetic average of the hourly L_{A10} levels between 6.00 am and midnight. The *CoRTN* algorithms were developed to calculate this parameter.

$L_{Aeq,24hour}$
The $L_{Aeq,24\ hour}$ level is the logarithmic average of the hourly L_{Aeq} levels for a full day (from midnight to midnight).

$L_{Aeq,8hour}$ / $L_{Aeq\ (Night)}$
The $L_{Aeq\ (Night)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 10.00 pm to 6.00 am on the same day.

$L_{Aeq,16hour}$ / $L_{Aeq\ (Day)}$
The $L_{Aeq\ (Day)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 6.00 am to 10.00 pm on the same day. This value is typically 1-3 dB less than the $L_{A10,18hour}$.

R_w
This is the weighted sound reduction index and is similar to the previously used STC (Sound Transmission Class) value. It is a single number rating determined by moving a grading curve in integral steps against the laboratory measured transmission loss until the sum of the deficiencies at each one-third-octave band, between 100 Hz and 3.15 kHz, does not exceed 32 dB. The higher the R_w value, the better the acoustic performance.

C_{tr}
This is a spectrum adaptation term for airborne noise and provides a correction to the R_w value to suit source sounds with significant low frequency content such as road traffic or home theatre systems. A wall that provides a relatively high level of low frequency attenuation (i.e. masonry) may have a value in the order of –4 dB, whilst a wall with relatively poor attenuation at low frequencies (i.e. stud wall) may have a value in the order of -14 dB.

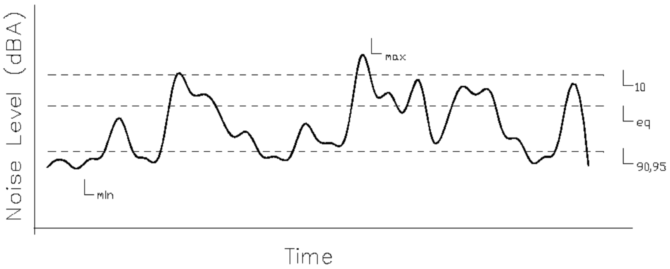
Satisfactory Design Sound Level

The level of noise that has been found to be acceptable by most people for the environment in question and also to be not intrusive.

Maximum Design Sound Level

The level of noise above which most people occupying the space start to become dissatisfied with the level of noise.

Chart of Noise Level Descriptors



Austroads Vehicle Class

AUSTROADS Vehicle Classification System

Level 1 Length (indicative)	Level 2 Axles and Axle Groups		Level 3 Vehicle Type	AUSTROADS Classification		
Type	Axles	Groups	Typical Description	Class	Parameters	Typical Configuration
LIGHT VEHICLES						
Short up to 5.5m		1 or 2	Short Sedan, Wagon, 4WD, Utility, Light Van, Bicycle, Motorcycle, etc	1	d(1) ≤ 3.2m and axles = 2	
Medium 5.5m to 14.5m	3, 4 or 5	3	Short - Towing Trailer, Caravan, Boat, etc	2	groups = 3 d(1) ≥ 2.1m, d(1) ≤ 3.2m, d(2) ≥ 2.1m and axles = 3, 4 or 5	
HEAVY VEHICLES						
	2	2	Two Axle Truck or Bus	3	d(1) > 3.2m and axles = 2	
	3	2	Three Axle Truck or Bus	4	axles = 3 and groups = 2	
	> 3	2	Four Axle Truck	5	axles > 3 and groups = 2	
Long 11.5m to 19.0m	3	3	Three Axle Articulated Three axle articulated vehicle, or Rigid vehicle and trailer	6	d(1) > 3.2m, axles = 3 and groups = 3	
	4	> 2	Four Axle Articulated Four axle articulated vehicle, or Rigid vehicle and trailer	7	d(2) < 2.1m or d(1) < 2.1m or d(1) > 3.2m axles = 4 and groups > 2	
	5	> 2	Five Axle Articulated Five axle articulated vehicle, or Rigid vehicle and trailer	8	d(2) < 2.1m or d(1) < 2.1m or d(1) > 3.2m axles = 5 and groups > 2	
	≥ 6	> 2	Six Axle Articulated Six axle articulated vehicle, or Rigid vehicle and trailer	9	axles = 6 and groups > 2 or axles > 6 and groups = 3	
Medium Combination 17.5m to 36.5m	> 6	4	B Double B Double, or Heavy truck and trailer	10	groups = 4 and axles > 6	
	> 6	5 or 6	Double Road Train Double road train, or Medium articulated vehicle and one dog trailer (M.A.D.)	11	groups = 5 or 6 and axles > 6	
Large Combination Over 33.0m	> 6	> 6	Triple Road Train Triple road train, or Heavy truck and three trailers	12	groups > 6 and axles > 6	

Definitions: Group: Axle group, where adjacent axles are less than 2.1m apart
Groups: Number of axle groups
Axles: Number of axles (maximum axle spacing of 10.0m)
d(1): Distance between first and second axle
d(2): Distance between second and third axle

Typical Noise Levels