ACOUSTICS AND AIR

WATERFALL WAY UPGRADE

PACIFIC HIGHWAY TO CONNELLS CREEK
PRELIMINARY ASSESSMENT

REPORT NO. 00541
VERSION E

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PREPARED FOR

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Note

Quality Assurance

We are committed to and have implemented AS/NZS ISO 9001:2008 "Quality Management Systems – Requirements". This management system has been externally certified and Licence No. QEC 13457 has been issued.

AAAC

This firm is a member firm of the Association of Australian Acoustical Consultants and the work here reported has been carried out in accordance with the terms of that membership.

Celebrating 50 Years in 2012

Wilkinson Murray is an independent firm established 50 years ago originally as Carr & Wilkinson. In 1976 Barry Murray joined founding partner Roger Wilkinson and the firm adopted the name which remains today. From a successful operation in Australia, Wilkinson Murray expanded its reach into Asia by opening a Hong Kong office early in 2006. 2010 saw the introduction of our Queensland office and 2011 the introduction of our Orange office to service a growing client base in these regions. From these offices, Wilkinson Murray services the entire Asia-Pacific region.

TABLE OF CONTENTS

GLOSSARY OF ACOUSTIC TERMS

Most environments are affected by environmental noise which continuously varies, largely as a result of road traffic. To describe the overall noise environment, a number of noise descriptors have been developed and these involve statistical and other analysis of the varying noise over sampling periods, typically taken as 15 minutes. These descriptors, which are demonstrated in the graph below, are here defined.

Maximum Noise Level (L_{Amax}) – The maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.

L_{A1} – The L_{A1} level is the noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the L_{A1} level for 99% of the time.

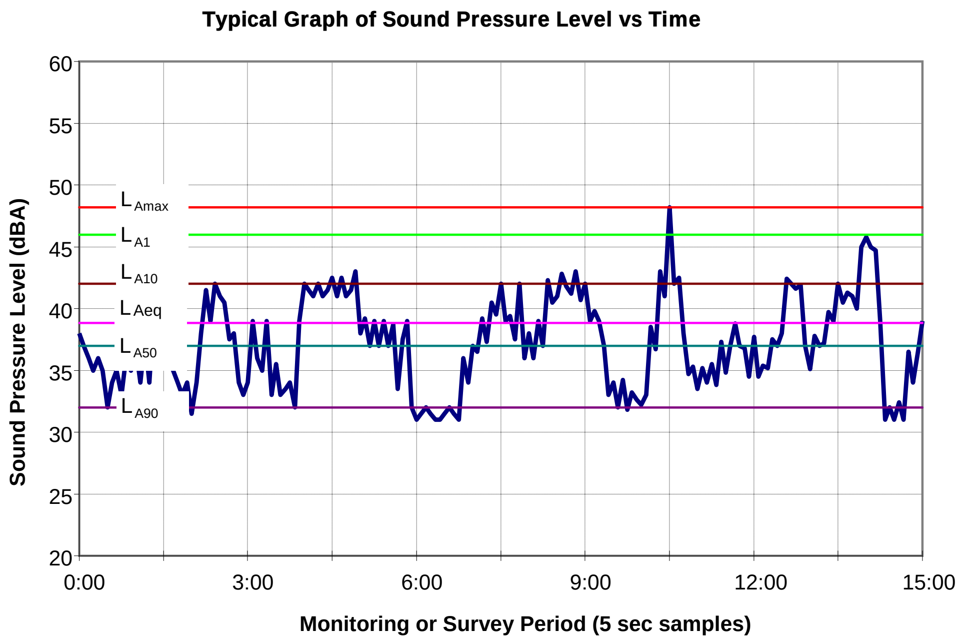
L_{A10} – The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The L_{A10} is a common noise descriptor for environmental noise and road traffic noise.

L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.

ABL – The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10^{th} percentile (lowest 10^{th} percent) background level (L_{A90}) for each period.

RBL – The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period – daytime, evening and night time.



1 INTRODUCTION

The Roads and Maritime Services of New South Wales (RMS) are proposing to realign and widen approximately 3km of Waterfall Way, east of Bellingen from Pacific Highway to Connells Creek (the Project). Two different realignment options have been proposed for the Project.

Wilkinson Murray Pty Limited has been commissioned by GeoLINK to provide a preliminary assessment of the noise and vibration impacts associated with construction and operation of the Project.

2 PROJECT SITE & PROJECT DESCRIPTION

This section of the road is predominantly a single lane dual carriageway with 14mm chip seal road surfaces. Two different alignments for the upgrade have been proposed.

Figure 2-1 presents an aerial showing the entire length of Waterfall Way Upgrade Project and the two proposed alignment options.

Figure 2-1 Proposed Project Alignment Options

The project objectives are to:

- Upgrade the road pavement and improve surface conditions;
- Improve the road alignment;
- Enable a safer 80 kilometers per hour standard and provide a consistent travel speed and level of service;
- Provide traffic lanes 3.5 meters wide;
- Provide road shoulders two metres wide;
- Upgrade the Short Cut Road intersection;
- Minimise impacts on the environment, including avoiding construction through the wetland at Camerons Corner; and
- Reduce the risk of the road being affected by flooding.

3 NOISE SENSITIVE RECEIVERS

All noise sensitive receivers along the upgrade were identified. Figure 3-1 show the location of all noise sensitive receivers.

All noise sensitive receivers were residential receivers. A total of 31 individual residences were identified.

Figure 3-1 Identified Receiver Locations

4 EXISTING NOISE ENVIRONMENT

Ambient noise monitoring was conducted, using unattended noise loggers, in order to characterise the existing noise environment adjacent to the project corridor (in relation to both the construction and operational preliminary noise assessments) and to establish the noise levels upon which to base the noise emission objectives. Environmental noise monitoring was performed at 3 representative locations along the length of Waterfall Way Upgrade Project corridor.

These locations have been selected based on a detailed inspection of potentially affected areas, giving considerations to other noise sources which may adversely influence the measurements, security issues for the noise monitoring devices and gaining permission for access from the residents or landowner.

The monitoring was conducted between Monday, 8 August and Tuesday, 16 August 2011. The measurements were conducted at a height of 1.5m above ground and generally at a distance of 1m from the façade of the subject building, in accordance with the NSW *Road Noise Policy*.

Figure 4-1 presents an aerial outlining the unattended noise monitoring locations and the typical setback distances from the road alignment.

Figure 4-1 Unattended Noise Logging Locations and Typical Setback Distance

All noise measurement instrumentation used in the surveys were designed to comply with the requirements of AS IEC 61672.1 2004 *"Electroacoustics - Sound Level Meters – Specifications"* and carried appropriate and current NATA calibration certificates. The equipment used for the continuous unattended noise surveys comprised Acoustic Research Laboratories Type EL215 and Type EL316 Environmental Noise Loggers.

The calibration of the loggers was checked prior to, and following, each measurement survey and the variation in calibration was found not to exceed 0.5 dB at any location.

All noise loggers were set to record statistical noise descriptors in continuous 15-minute sampling periods for the duration of their deployment.

Weather data recorded during the noise monitoring survey periods by the Bureau of Meteorology was used to assist in identifying potentially adverse weather conditions that could have a detrimental impact on the measured noise levels such as rainy periods, etc.

The project has been broken up into three different Noise Catchments Areas (NCA's) based on factors including geographical location, level of noise exposure and location of the ambient noise monitoring. Figure 4-2 presents an aerial outlining the NCAs and the identified receiver locations.

Figure 4-2 Aerial Outlining NCAs and Identified Receiver Locations

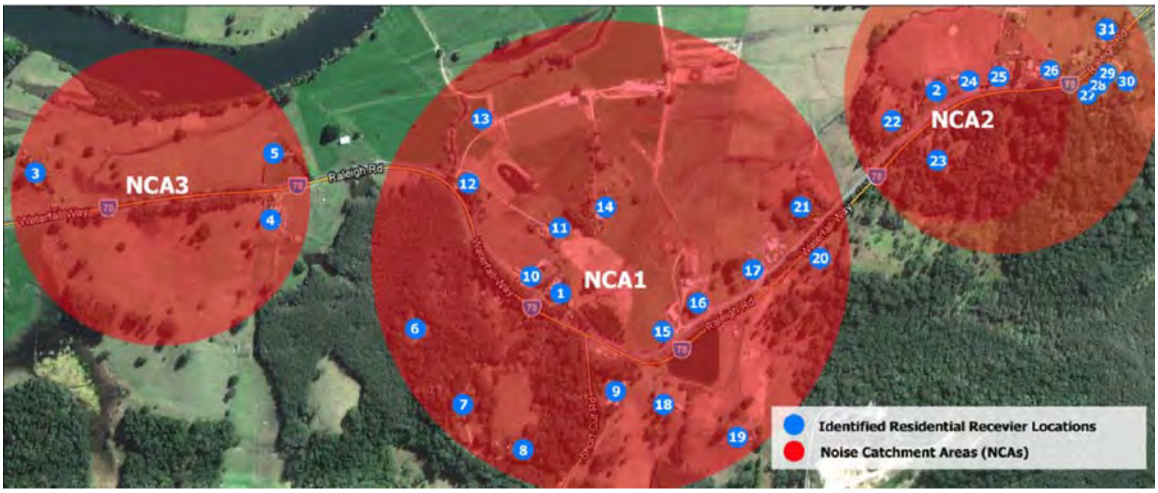


Table 4-1 summarises the measured L_{Aeq} noise levels. These are assumed to represent road traffic noise in all cases. This data is used to verify and calibrate the road traffic noise modelling.

Table 4-1 Measured Road Traffic Noise Levels

Relevant NCA	Identified Receiver Location	Setback Distance to the Road (m)	Measured L_{Aeq} Noise Level (dBA) Daytime $L_{Aeq,15hr}$	Night Time $L_{Aeq,9hr}$
NCA1	1	45	53	46
NCA2	2	28	62	55
NCA3	4	60	54	47

Table 4-2 presents the background noise levels derived from the ambient noise data for the purpose of establishing the construction noise objectives. These are in terms of the Rating Background Level (RBL), which is a measure of background noise defined in the *Industrial Noise Policy* (*INP*), (EPA, 2000).

Table 4-2 Summary of Measured RBL Noise Levels – (dBA)

Relevant NCA	Identified Receiver Location	Measured RBL Noise Level (dBA)		
		Daytime	Evening	Night Time
NCA1	1	41	32	30
NCA2	2	53	41	37
NCA3	4	37	33	30

Note: Background noise levels above are Rating Background Noise Levels based on procedures contained within the *Industrial Noise Policy (INP), (EPA,2000)*; and Daytime (7.00am-6.00pm), Evening (6.00pm-10.00pm) and Night time (10.00pm-7.00am).

5 ROAD TRAFFIC NOISE CRITERIA

5.1 Noise Assessment Criteria

Criteria for assessment of road traffic noise are set out in the NSW Government's *Road Noise Policy (RNP)*. The RMS has also published the *Environmental Noise Management Manual (ENMM),* (RMS, 2001) to assist in implementing the *RNP*.

Under the *RNP*, road developments are classified as either "new road" or "redevelopment of an existing road". Practice note (i) of the *ENMM* describes the circumstances under which each of these applies. For all noise-sensitive locations considered in this project, the proposal would be classified as a *"redevelopment of existing freeway/arterial road"*.

Table 5-1 sets out the noise assessment criteria for residences to be applied to particular types of project, road category and land use.

Table 5-1 Assessment Criteria for Operational Traffic Noise - Residences

Road Category	Type of Project/Land Use	Assessment Criteria	
		Daytime (7.00am-10.00pm)	Night Time (10.00pm-7.00am)
Freeway/arterial/ sub-arterial roads	Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial roads Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq,15hour}$ 60dBA (external)	$L_{Aeq,9hour}$ 55dBA (external)

In applying Table 5-1, the noise level criterion applies to the predicted noise level at the time of opening (future existing) and also at a time 10 years after opening of the project (design year), which in this case are the years 2015 and 2025 respectively. Furthermore the *RNP* requires a comparison of the 'no build option' (i.e. in the absence of the Project) and the 'build option' (i.e. with the proposed Project design) at the time of opening and also 10 years after opening.

The *RNP* also states where existing traffic noise levels are above the noise assessment criteria (or 'base' criteria), the primary objective is to reduce these through feasible and reasonable measures to meet the assessment criteria. A secondary objective is to protect against excessive decreases in amenity as the result of a project by applying the relative increase criteria. In assessing feasible and reasonable mitigation measures, an increase of up to 2dB represents a minor impact that is considered barely perceptible to the average person.

Where the base criteria in Table 5-1 are already exceeded, Practice Note (iv) of the *Environmental Noise Management Manual* provides further discussion of situations where provision of additional controls would be considered "feasible and reasonable". In particular, for redeveloped roads it is generally *not* considered reasonable to take action to reduce noise levels to the target noise levels if the noise levels with the proposal, ten years after project opening, are predicted to be:

- Within 2dBA of 'future existing' noise levels with the 'no build option'; *or*
- No more than 2dBA above the 'base' noise criteria.

The RMS' Environmental Practice Note 24 "Noise assessment for acute levels of noise – redevelopment of existing roads" confirms the following:

"Application of all feasible and reasonable noise mitigation to aim to achieve the ECRTN noise criteria where, following a road redevelopment:

- There is predicted to be a noticeable increase in road traffic noise, or
- Road traffic noise levels are predicted to be acute."

The RMS has a Noise Abatement Program for existing roads where the RMS targets locations or lengths of existing road ways where road traffic noise levels are very high and are considered excessive for noise sensitive land uses. Noise affected sites are not currently given priority for noise treatment unless road traffic noise levels are at least 65dBA $L_{Aeq,15hr}$ or 60dBA $L_{Aeq,9hr}$. These noise levels are termed acute noise levels.

5.2 Relative Increase Criteria

In addition to the assessment criteria outlined in Table 5-1, any increase in the total traffic noise level at a location due to the proposed project or traffic-generating development must be considered. Residences experiencing increases in total traffic noise level above the relative increase criteria in Table 5-2 should also be considered for mitigation.

Table 5-2 Relative Increase Criteria for Residential Land Use

Road Category	Type of Project/Development	Assessment Criteria	
		Daytime (7.00am-10.00pm)	**Night Time (10.00pm-7.00am)**
Freeway/arterial/ sub-arterial roads and transitways	New road corridor/redevelopment of existing road/land use development with the potential to generate additional traffic on existing road	Existing traffic $L_{Aeq,15hour}$ +12dB (external)	Existing traffic $L_{Aeq,9hour}$ +12dB (external)

6 AIRBORNE CONSTRUCTION NOISE OBJECTIVES

The *NSW Interim Construction Noise Guideline (ICNG), (Office of Environment & Heritage (OEH))* presents the process to assess construction in NSW. The *ICNG* was developed by taking into consideration that construction is temporary, noisy and difficult to ameliorate. As such, the *ICNG* was developed to focus on applying a range of work practices most suited to minimising construction noise impacts, rather than focusing only on achieving a numeric noise level.

The *ICNG* recommends that standard construction work hours should typically be as follows:

- Monday to Friday 7.00 am to 6.00 pm.
- Saturday 8.00 am to 1.00 pm.
- No work on Sundays or public holiday.

Additionally, it recommends quantitative management noise goals at residences as presented in Table 6-1.

Table 6-1 Construction Noise at Residences using Quantitative Assessment

Time of Day	Management Level $L_{Aeq\ (15\ min)}$	How to Apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10dBA	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to minimise noise. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking in to account: 1. 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 2. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Time of Day	Management Level $L_{Aeq\ (15\ min)}$	How to Apply
Outside recommended standard hours	Noise affected RBL + 5dBA	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 5dBA above the noise affected level, the proponent should negotiate with the community.

In addition to the above criteria, where any work is conducted during the night time period (10.00pm-7.00 am), the OEH recommends that to protect against sleep disturbance, $L_{A1,1min}$ noise levels should not exceed the background level by more than 15dBA at any residence. In practice, the $L_{A1,1min}$ level can be represented by the maximum noise level.

Based on the background noise levels presented in Table 6-2, the project specific construction noise management levels are as below.

Table 6-2 Project Specific Noise Management Levels, $L_{Aeq,15min}$

Relevant NCA	Identified Receiver Location	Noise Management Levels $L_{Aeq,15min}$		
		Daytime	Evening	Night Time
NCA1	1	51	37	35
NCA2	2	63	46	42
NCA3	4	47	38	35

7 CONSTRUCTION VIBRATION OBJECTIVES

Impacts from vibration can be considered both in terms of effects on building occupants (human comfort) and the effects on the building structure (building damage). Of these considerations, the human comfort limits are the most stringent. Therefore, for occupied buildings, if compliance with human comfort limits is achieved, it will follow that compliance will be achieved with the building damage objectives.

7.1 Human Comfort

Assessing Vibration: A Technical Guideline (OEH, 2006) provides acceptable values for continuous and impulsive vibration in the range 1-80Hz. Both preferred and maximum vibration limits are defined for various locations and are shown in Table 7-1.

Table 7-1 Preferred and Maximum Peak Particle Velocity (PPV) Values for Continuous and Impulsive Vibration

Location	Assessment Period [1]	PPV (mm/s)	
		Preferred Values	Maximum Values
Continuous Vibration			
Residences	Daytime	0.28	0.56
	Night time	0.20	0.40
Impulsive Vibration			
Residences	Daytime	8.6	17.0
	Night time	2.8	5.6

Note: 1. Daytime is 7.00 am to 10.00 pm and night time is 10.00 pm to 7.00 am.

These limits relate to a long-term (15 hours for daytime), continuous exposure to vibration sources. Where vibration is intermittent, a Vibration Dose Value is calculated, and acceptable values are shown in Table 7-2.

Table 7-2 Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime [1]		Night Time [2]	
	Preferred Value	Maximum Values	Preferred Value	Maximum Value
Residences	0.20	0.40	0.13	0.26

Note: 1. Daytime is 7.00 am to 10.00 pm and night time is 10.00 pm to 7.00 am.

7.2 Building Damage

In terms of the most recent relevant vibration damage objectives, Australian Standard AS 2187: Part 2-2006 *"Explosives – Storage and Use – Part 2: Use of Explosives"* recommends the frequency dependent guideline values and assessment methods given in BS 7 385 Part 2-1993 *"Evaluation and measurement for vibration in buil dings Part 2"* as th ey "are applicable to Australian conditions".

The British Standard sets guide values for building vibration based on the lowest vibration levels above which damage h as been cr edibly demonstrated. These levels are judged to give a minimum risk of vibration -induced damage, where minimal risk for a nam ed effect is u sually taken as a 95% probability of no effect.

The recommended limits (guide values) from BS 738 5 for transient vibration to ensure minimal risk of cosm etic damage to residential and in dustrial buildings are presented numerically in Table 7-3 and Figure 7-1.

Table 7-3 Transient Vibration Guide Values - Minimal Risk of Cosmetic Damage

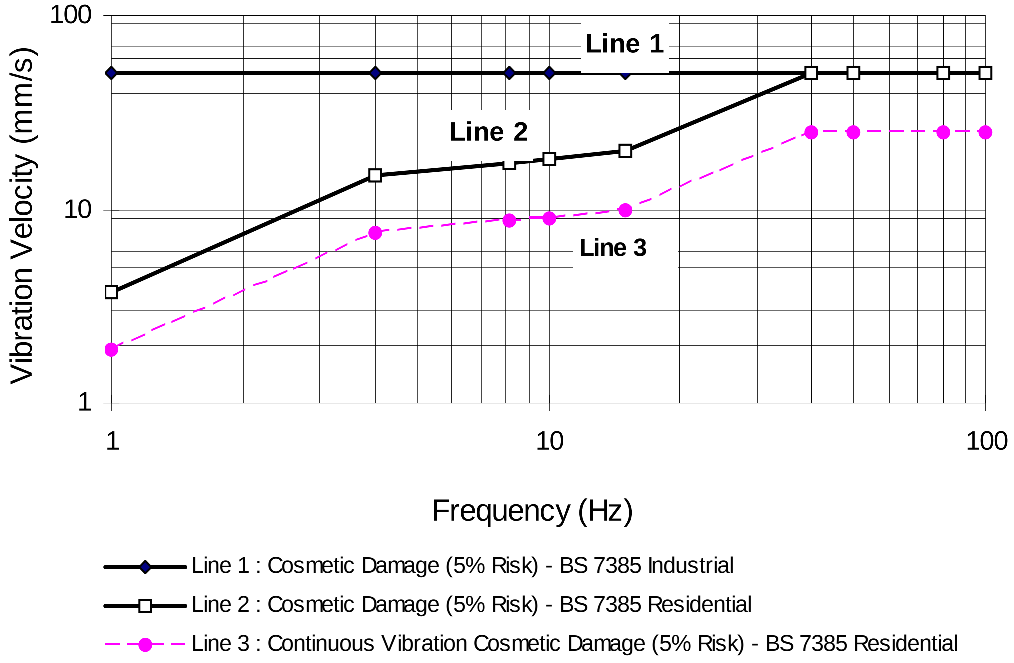
Type of building	Peak component particle velocity in frequency range of predominant pulse	
	4 Hz to 15 Hz	15 Hz and above
Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
Unreinforced or light framed structures Residential or light commercial type buildings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

The standard states that the guide v alues in Table 7-3 relate predominan tly to tr ansient vibration which does not give rise to resonant responses in structures, and to low-rise buildings.

Rockbreaking/hammering, vibratory rolling and sheet piling activities are considered to have the potential to cause dynamic loading in some stru ctures (eg residences) and it may therefore be appropriate to reduce the transient values by 50%.

The British Standard goes on to state th at "Some data suggests that the probability of damage *tends towards zero at 12.5 mm/s peak component particle velocity*

Figure 7-1 Graph of Transient Vibration Guide Values for Cosmetic Damage



8 ROAD TRAFFIC NOISE EMISSION

8.1 Methodology of Assessing Traffic Noise Impact

The assessment of traffic noise impact during the operational phase of the Waterfall Way Upgrade Project is based on guidance contained in the *RNP* (OEH, 2011).

The *RNP* states that noise levels are to be assessed based on traffic volumes projected at a point in time 10 years after the opening of the Project. The 2015 year of opening has only been adopted for preliminary modelling purposes; therefore, the future assessment year applicable for this assessment is 2025. All future calculations and modelling are based on the Annual average daily traffic (AADT) traffic forecasts provided by RMS.

Detailed noise calculations have been carried out for three different scenarios - Existing, Future Existing and Future Design.

- The Existing Scenario (Year 2011) has been modelled to allow for validation of the noise model against noise survey results during a survey conducted in August 2011.
- The Future Existing Scenario (Year 2015) represents noise levels modelled with the traffic forecast for year 2015, but without the proposed upgrades.
- The Future Existing Scenario (Year 2015) represents noise levels modelled with the traffic forecast for year 2015, but with the proposed upgrades.
- The Future Design Scenario (Year 2025) represents noise levels modelled with traffic forecast 10 years post opening, without the proposed upgrades.
- The Future Design Scenario (Year 2025) represents noise levels modelled with traffic forecast 10 years post opening, with the different road upgrade options.

The following factors are considered during the assessment process:

- Traffic volume and likely proportions of heavy vehicles;
- Topographical information along and surrounding the entire project corridor;
- Land use surrounding the project;
- Vehicle speed;
- Different noise emission levels and source heights;
- Location of the noise sources on the motorway;
- Road surface types;
- Road gradient; and
- Attenuation from noise barriers (both natural and purpose built for the project).

8.2 Noise Modelling Procedures

Noise levels from both the existing and proposed road designs were calculated using procedures based on the *CoRTN (Calculation of Road Traffic Noise)* (UK Department of Transport, 1988) prediction algorithms. The standard prediction procedures were modified in the following ways.

- L_{Aeq} values were calculated from the L_{A10} values predicted by the *CoRTN* algorithms using the well-validated approximation $L_{Aeq,1hr} = L_{A10,1hr} - 3$. (NSW RMS, 2001);
- Noise source heights were set at 0.5m for cars, 1.5m for heavy vehicle engines and 3.6m for heavy vehicle exhausts, representing typical values for Australian vehicles. Noise from a heavy vehicle exhaust is 8dBA lower than the noise from the engine; and
- Previous research in Australia has established a negative correction to the *CoRTN* predictions of -1.7 dB for façade-corrected levels. Corrections for Australian conditions have been included in noise modelling for this project. (Samuels and Saunders, 1982).

The model was implemented using CadnaA software (Version 4). Road design information was based on data supplied by the RMS. This has previously been found to give a good correlation with measured noise levels in similar situations. With barriers, hard ground is assumed, as required under the *CoRTN* procedures.

8.2.1 Traffic Data

As the intention of monitoring traffic noise was partly to validate the noise model, simultaneous traffic counts were conducted at three locations along the Project for the duration of the noise monitoring.

The traffic volumes for the Project and calibration are shown in Table 8-1 and Table 8-2 respectively. The 2015 pre-opening volumes have also been assumed to be valid for the 2015 project opening and the 2025 post-opening volumes are valid for 2025 Future Existing scenario.

Table 8-1 2015 Traffic Volumes

Location	2015 AADT (Pre-opening)		15hr Daytime (7.00am to 10.00pm)				9hr Night Time (10.00pm to 7.00am)			
			Eastbound		Westbound		Eastbound		Westbound	
	Eastbound	Westbound	All types of vehicle (light + heavy)	% heavy vehicles	All types of vehicle (light + heavy)	% heavy vehicles	All types of vehicle (light + heavy)	% heavy vehicles	All types of vehicle (light + heavy)	% heavy vehicles
East of Short Cut Road	4248	3922	3951	6	3686	7	298	8	235	19
West of Short Cut Road	4085	4085	3799	5	3799	6	286	8	286	17

Table 8-2 2025 Traffic Volume

Location	2025 AADT (Post-opening)		15hr Daytime (7.00am to 10.00pm)				9hr Night Time (10.00pm to 7.00am)			
			Eastbound		Westbound		Eastbound		Westbound	
	Eastbound	Westbound	All types of vehicle (light + heavy)	% heavy vehicles	All types of vehicle (light + heavy)	% heavy vehicles	All types of vehicle (light + heavy)	% heavy vehicles	All types of vehicle (light + heavy)	% heavy vehicles
East of Short Cut Road	5143	4747	4783	6	4462	7	360	8 285		19
West of Short Cut Road	4945	4945	4599	5	4599	6	346	8 346		17

8.2.2 Posted Traffic Speed

For the purpose of calibration, the modelled speed was taken from traffic counters. The sign posted speed limit is 60km/hr, 80km/hr, 100km/hr east to west with advisory speed signs.

8.2.3 Road Surface Types

The surface corrections for various road surfaces relative to dense graded asphaltic concrete are presented in Table 8-3.

Table 8-3 Road Surface Corrections

Surface type (Regularly Trafficked)	Noise Level Variation, dBA		
	Traffic Noise	Individual Vehicle Pass-by Noise	
		Cars	Trucks
14mm chip seal	+4.0	+4.0	+4.0
14mm chip seal with 7mm scattered	+2.0	+2.0	+2.0
Portland cement concrete: tyned and dragged	0 to +3.0	+1.0 to +3.5	-1.0 to +1.0
Cold overlay	+2.0	+2.0	+2.0
Dense Graded Asphalt	0	0	0
Portland cement concrete: exposed aggregate	-0.5 to -3.0	-0.1	-6.7
Stone mastic asphalt	-2.0 to -3.5	-2.2	-4.3
Open graded asphaltic concrete	0 to -4.5	-0.2 to -4.2	-4.9

The existing Waterfall Way pavement surfacing is mostly surfaced with 14mm chip seal. It is currently proposed that the new alignments may be resurfaced with either 14mm chip seal with 7mm scattered or with Stone Mastic Asphaltic Concrete (SMAC) which is a type of low noise pavement (LNP) as part of the upgrade. Section 10 of this report presents the predicted noise levels based on these two proposed road surface types.

9 NOISE MODEL VALIDATION

The results of traffic noise measurements presented in Section 4 and model calculations for the same period, based on monitored traffic flows are compared in Table 9-1. Noise levels are shown to one decimal place to minimise rounding effects.

Table 9-1 Measured and Calculated Traffic Noise Levels

Location	Measured Day	Predicted Day	Diff. Day	Measured Night	Predicted Night	Diff. Night	Comments
Receiver 1 – Setback 45m	53.1	57.5	-4.4	46.4	50.6	-4.2	Difference between measured and predicted noise levels are approximately 4dB. The difference between predicted and measured levels could be a result of the reduction in speed on the approach of Short Cut Road intersection and attenuation by foliage/topographical shielding.
Receiver 2 – Setback 60m	54.1	52.5	1.6	46.6	45.6	1	Difference between measured and predicted noise levels are within 2dB range.
Receiver 4 – Setback 28m	62.2	61.4	0.8	55.1	53.6	1.5	Difference between measured and predicted noise levels are within 2dB range.

The measurement results represent the $L_{Aeq,period}$ for all valid days of the monitoring period. Data has been excluded during times of rain or wind. Data that most likely do not represent traffic noise were also excluded. This exclusion is based on analysis of the logger charts in Appendix A.

A comparison between the predicted and measured noise levels results in the correction factors for each of the identified receiver locations as shown in Table 9-2 for day and night periods respectively

Table 9-2 Summary of Calibration Factors

Receiver No.	Calibration Factor	
	Daytime (7.00am-6.00pm)	Night time (10.00pm-7.00am)
1, 7, 8, 10, 11, 14	-2.4	-2.2
2, 3, 4, 5, 6, 9, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25	0	0

Accordingly, for the future existing (2015) and 10 years after opening (2025) scenarios, noise modelling was calibrated by adding the calibration factors in Table 9-2 along the length of the alignment. . Calibration factors of -2.4 (daytime) and -2.2 (night time) are applied to receiver locations 1, 7, 8, 10, 11 and 14 to maintain the recommended 2dB difference between measured and predicted noise levels. This is considered to be a conservative approach to prevent under prediction of noise levels at the identified receiver locations.

The locations where calibration factors are applied to are further illustrated in Figure 9-1.

Figure 9-1 Identified Receiver Locations & Calibration Factors

10 PREDICTED NOISE LEVEL AT IDENTIFIED RECEIVERS

For the Future Existing (2015) and Future Design (2025) scenarios, façade noise levels were calculated at each building facade along the route. This section presents the predicted noise levels at each identified receiver locations based on future existing scenario and future scenarios with different road surfaces. The numbers highlighted show exceedances of the noise criteria.

10.1 Future Existing Scenario (2015) and Years (2025) (no upgrade)

The results in Table 10-1 and Table 10-2 identify the Future Existing and Future Existing Plus 10 Years scenarios (with no proposed upgrade) and identify receiver locations along the project route which may be subjected to noise levels exceeding *RNP* base criteria for both daytime ($L_{Aeq,15hr}$ 60dBA) and night time ($L_{Aeq,9hr}$ 55dBA). Receiver locations with predicted noise levels above the base criteria are in bold.

Table 10-1 Predicted L_{Aeq} Noise Levels Future Existing (2015) – dBA

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
1	**62**	55
2	**66**	**57**
3	**61**	54
4	**62**	54
5	**61**	53
6	57	50
7	56	48
8	54	47
9	**64**	**56**
10	54	46
11	50	43
12	59	51
13	58	50
14	51	43
15	**72**	**64**
16	**74**	**65**
17	**70**	**61**
18	60	52
19	54	46
20	**65**	**57**
21	**63**	55
22	**64**	**56**
23	**64**	**56**
24	**66**	**58**

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
25	**65**	**57**
26	**66**	**58**
27	**64**	**56**
28	**65**	**57**
29	**66**	**58**
30	60	52
31	**68**	**60**

Table 10-2 Predicted L_{Aeq} Noise Levels Future Existing plus 10 Years (2025) – dBA

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
1	**63**	**56**
2	**66**	**58**
3	**62**	54
4	**62**	55
5	**62**	54
6	58	51
7	57	49
8	55	47
9	**65**	**57**
10	54	47
11	51	44
12	60	52
13	58	51
14	51	44
15	**73**	**65**
16	**74**	**66**
17	**70**	**62**
18	60	52
19	55	47
20	**66**	**58**
21	**64**	**56**
22	**65**	**57**
23	**65**	**57**
24	**67**	**59**
25	**66**	**58**
26	**67**	**59**

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
27	**65**	**57**
28	**66**	**58**
29	**67**	**59**
30	**61**	53
31	**69**	**61**

10.2 Future Scenario A – 14mm Chip Seal with 7mm Scattered (Yr 2015 & Yr 2025)

Table 10-3 and Table 10-4 present the predicted noise levels for Future Design (Yr2015) and Future Design (Yr 2025) scenarios for proposed Option A. The predicted noise levels in Future Design scenarios are based on road surface of 14mm chip seal with 7mm scattered. Receiver locations with predicted noise levels above the base criteria are in bold.

Table 10-3 Option A: Predicted L_{Aeq} Noise Levels Future Design (2015) – dBA (14mm)

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
1	**61**	53
2	**63**	55
3	59	51
4	60	53
5	60	52
6	55	48
7	54	46
8	53	45
9	**62**	54
10	52	45
11	49	42
12	58	50
13	56	49
14	49	41
15	**62**	54
16	**62**	54
17	**65**	**57**
18	60	52
19	54	46
20	**66**	**58**
21	60	53

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
22	**61**	53
23	**63**	55
24	**63**	55
25	**63**	55
26	**64**	**56**
27	**62**	54
28	**63**	55
29	**64**	**56**
30	58	50
31	**66**	**58**

Table 10-4 Option A: Predicted L_{Aeq} Noise Levels Future Design (2025) – dBA (14mm)

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
1	**62**	54
2	**64**	**56**
3	60	52
4	**61**	54
5	**61**	53
6	56	48
7	55	47
8	53	46
9	**63**	55
10	53	45
11	50	42
12	59	51
13	57	50
14	50	42
15	**63**	55
16	**63**	55
17	**66**	**58**
18	**61**	52
19	54	46
20	**66**	**59**
21	**61**	53
22	**62**	54

23	**64**	**56**
24	**64**	**56**
25	**64**	**56**
26	**65**	**57**
27	**63**	55
28	**64**	**56**
29	**65**	**57**
30	59	51
31	**67**	**59**

10.3 Future Scenario B – 14mm Chip Seal with 7mm Scattered (Yr2015 & Yr 2025)

Table 10-5 and Table 10-6 present the predicted noise levels for Future Design (Yr2015) and Future Design (Yr 2025) scenarios for proposed Option B. The predicted noise levels in Future Design scenarios are based on road surface of 14mm chip seal with 7mm scattered. Receiver locations with predicted noise levels above the base criteria are in bold.

Table 10-5 Option B: Predicted L_{Aeq} Noise Levels Future Design (2015) – dBA (14mm)

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
1	**61**	54
2	**63**	55
3	59	52
4	60	53
5	59	52
6	54	46
7	53	45
8	52	44
9	**62**	54
10	53	46
11	51	43
12	60	53
13	57	49
14	49	42
15	**65**	**57**
16	**63**	55
17	**67**	**59**
18	59	50

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
19	53	45
20	**64**	**56**
21	**61**	53
22	**62**	54
23	**63**	55
24	**64**	**56**
25	**63**	55
26	**64**	**56**
27	**62**	54
28	**63**	55
29	**64**	**56**
30	58	50
31	**66**	**58**

Table 10-6 Option B: Predicted L_{Aeq} Noise Levels Future Design (2025) – dBA (14mm)

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
1	**62**	55
2	**64**	**56**
3	60	52
4	**61**	54
5	60	53
6	55	47
7	54	46
8	53	45
9	**62**	54
10	54	47
11	51	44
12	**61**	54
13	58	50
14	50	42
15	**66**	**58**
16	**64**	**56**
17	**67**	**59**
18	59	51
19	54	46

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
20	**65**	**57**
21	**62**	54
22	**63**	55
23	**63**	55
24	**65**	**57**
25	**64**	**56**
26	**65**	**57**
27	**63**	55
28	**64**	**56**
29	**65**	**57**
30	59	51
31	**67**	**59**

Figure 10-1 to Figure 10-8 graphically identify the receiver locations with predicted noise levels above the base criteria coloured in red.

Figure 10-1 Chip Seal: Option A Future Design (2015) – Daytime

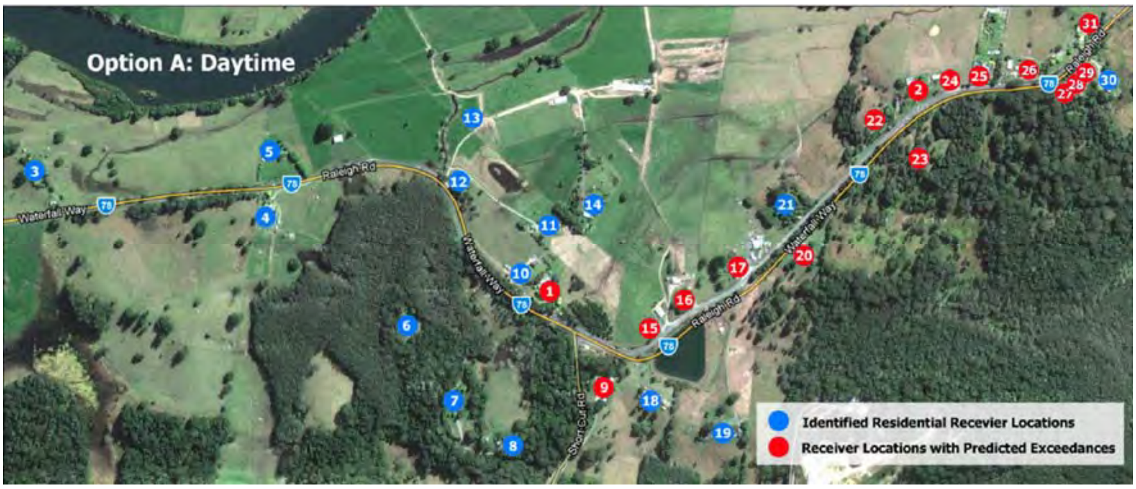


Figure 10-2 Chip Seal: Option A Future Design (2025) – Daytime

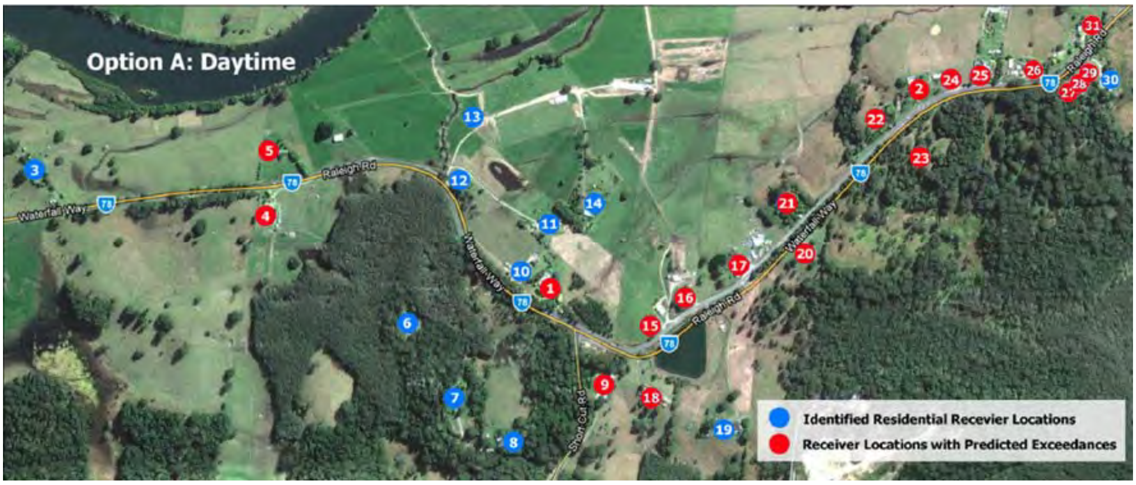


Figure 10-3 Chip Seal: Option A Future Design (2015) – Night Time

Figure 10-4 Chip Seal: Option A Future Design (2025) – Night Time

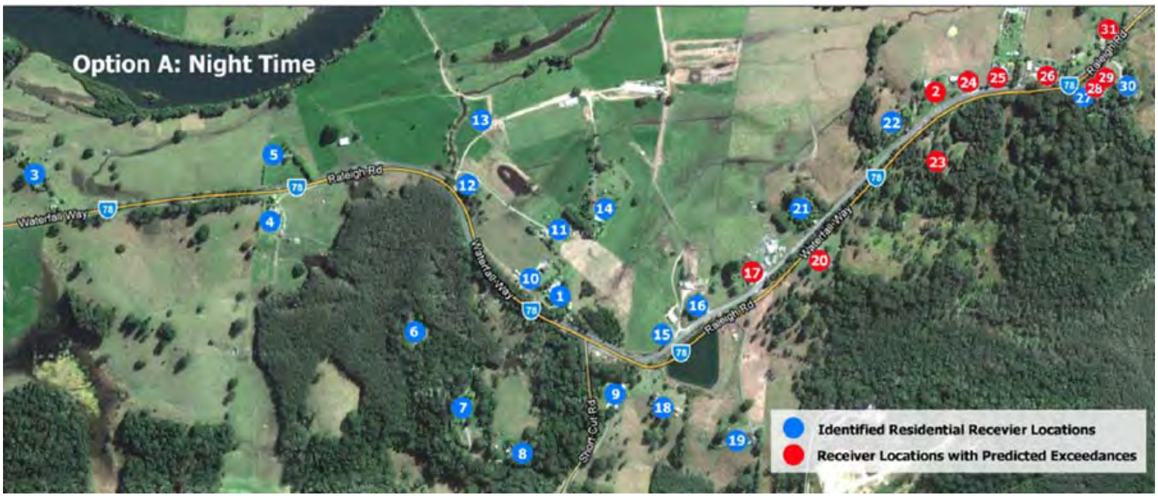


Figure 10-5 Chip Seal: Option B Future Design (2015) – Daytime

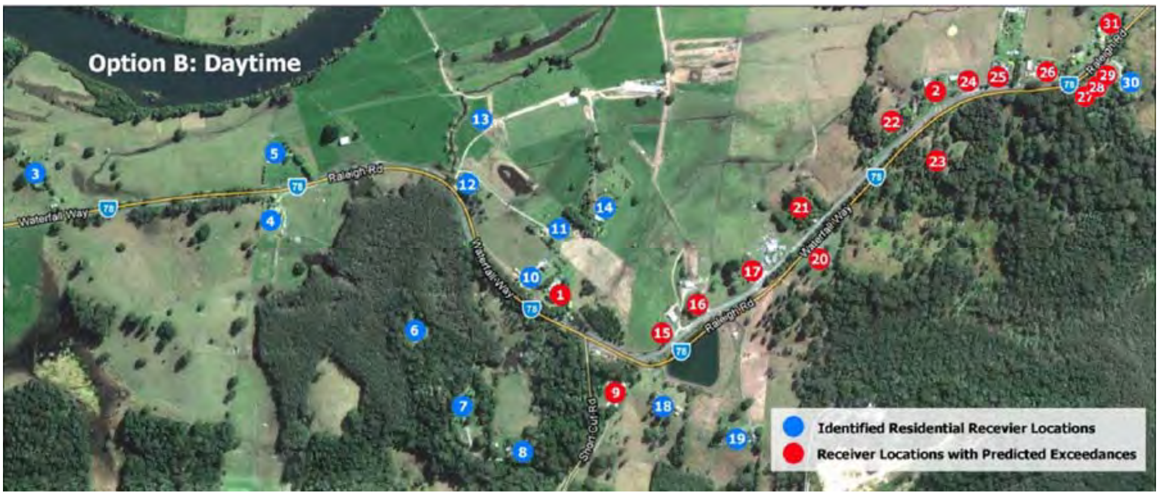


Figure 10-6 Chip Seal: Option B Future Design (2025) – Daytime

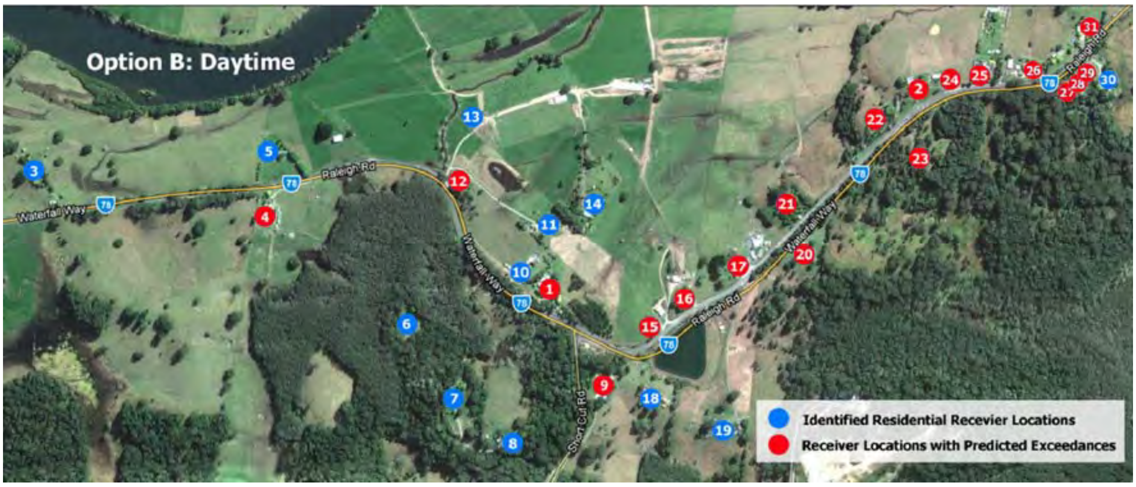
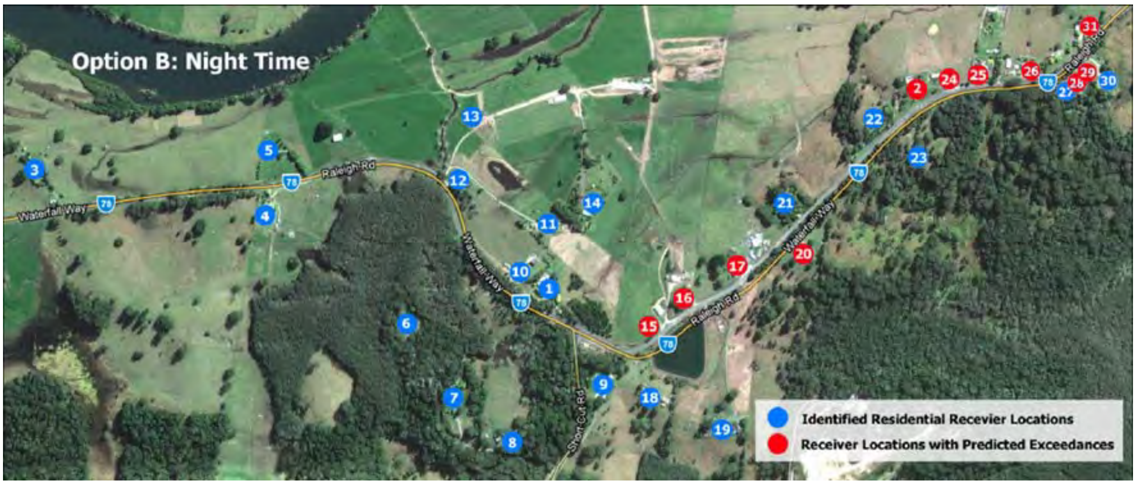


Figure 10-7 Chip Seal: Option B Future Design (2015) – Night Time

Figure 10-8 Chip Seal: Option B Future Design (2025) – Night Time



10.4 Future Design (Yr2015) and (Yr2025) Scenarios for Option A & B – LNP (SMAC)

Table 10-7 to Table 10-8 present the predicted noise levels for Future Design (Yr2015) and Future Design (Yr2025) scenarios for both proposed Option A and Option B, respectively. The predicted noise levels in Future Design scenarios are based on road surface of low noise pavement (SMAC). Receiver locations with predicted noise levels above the base criteria are in bold.

Table 10-7 Option A: Predicted L_{Aeq} Noise Levels Future Design (2015) – dBA

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
1	57	49
2	59	51
3	55	47
4	56	49
5	56	48
6	51	44
7	50	42
8	49	41
9	58	50
10	48	41
11	45	38
12	54	46
13	52	45
14	45	37
15	58	50

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
16	58	50
17	**61**	53
18	56	48
19	50	42
20	**62**	54
21	56	49
22	57	49
23	59	51
24	59	51
25	59	51
26	60	52
27	58	50
28	59	51
29	60	52
30	54	46
31	**62**	54

Table 10-8 Option A: Predicted L_{Aeq} Noise Levels Future Design (2025) – dBA

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
1	58	50
2	60	52
3	56	48
4	57	50
5	57	49
6	52	44
7	51	43
8	49	42
9	59	51
10	49	41
11	46	38
12	55	47
13	53	46
14	46	38
15	59	51
16	59	51
17	**62**	54

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
18	57	48
19	50	42
20	**62**	55
21	57	49
22	58	50
23	60	52
24	60	52
25	60	52
26	**61**	53
27	59	51
28	60	52
29	**61**	53
30	55	47
31	**63**	55

Table 10-9 Option B: Predicted L_{Aeq} Noise Levels Future Design (2015) – dBA

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
1	57	50
2	59	51
3	55	48
4	56	49
5	55	48
6	50	42
7	49	41
8	48	40
9	58	50
10	49	42
11	47	39
12	56	49
13	53	45
14	45	38
15	**61**	53
16	59	51
17	**63**	55
18	55	46
19	49	41

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
20	60	52
21	57	49
22	58	50
23	59	51
24	60	52
25	59	51
26	60	52
27	58	50
28	59	51
29	60	52
30	54	46
31	**62**	54

Table 10-10 Option B: Predicted L_{Aeq} Noise Levels Future Design (2025) – dBA

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
1	58	51
2	60	52
3	56	48
4	57	50
5	56	49
6	51	43
7	50	42
8	49	41
9	58	50
10	50	43
11	47	40
12	57	50
13	54	46
14	46	38
15	**62**	54
16	60	52
17	**63**	55
18	55	47
19	50	42
20	**61**	53
21	58	50

Identified Receiver No.	Predicted $L_{Aeq,period}$ Noise Level	
	Daytime (15hr)	Night time (9hr)
22	59	51
23	59	51
24	**61**	53
25	60	52
26	**61**	53
27	59	51
28	60	52
29	**61**	53
30	55	47
31	**63**	55

Figure 10-9 to Figure 10-16 graphically identify the receiver locations with predicted noise levels above the base criteria are coloured in red for each of the proposed alignment options.

Figure 10-9 SMAC: Option A Future Design (2015) – Daytime

Figure 10-10 SMAC: Option A Future Design (2025) – Daytime

Figure 10-11 SMAC: Option A Future Design (2015) – Night Time

Figure 10-12 SMAC: Option A Future Design (2025) – Night Time

Figure 10-13 SMAC: Option B Future Design (2015) – Daytime

Figure 10-14 SMAC: Option B Future Design (2025) – Daytime

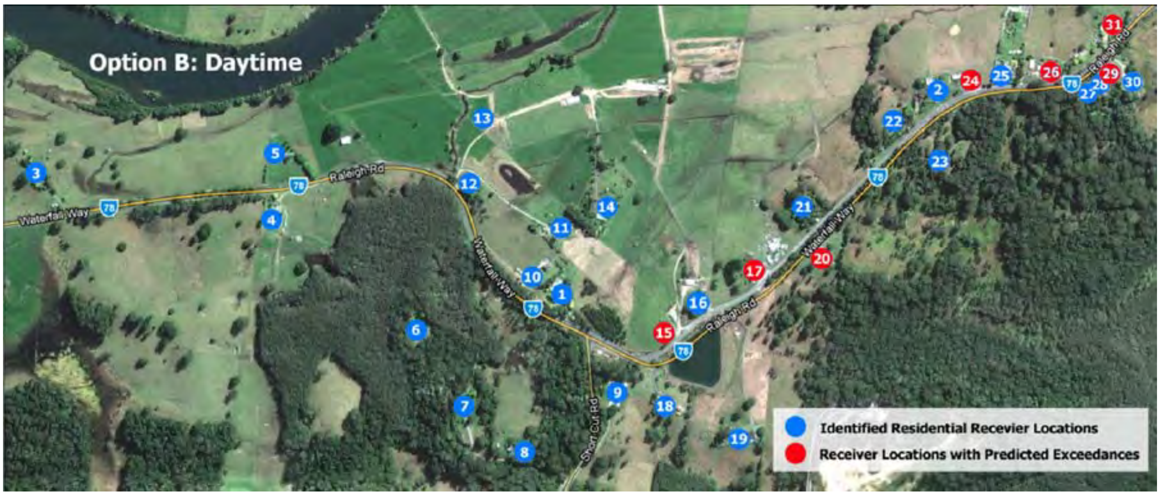


Figure 10-15 SMAC: Option B Future Design (2015) – Night Time

Figure 10-16 SMAC: Option B Future Design (2025) – Night Time

10.5 Discussion of Predicted Results

Review of the results presented in Future Existing and Future Design scenarios; the benefit of resurfacing the new alignments with low noise pavement is evident. The future design scenarios indicate a decrease in the number of receiver locations where noise levels exceed *RNP* base criteria for both daytime ($L_{Aeq,15hr}$ 60dBA) and night time ($L_{Aeq,9hr}$ 55dBA).

Table 10-11 presents a tabulation of the number of receiver locations where exceedances of *RNP* base criteria were predicted.

Table 10-11 Number of Receiver Locations above Base Criteria

Scenario	Road Surface	No. of Receiver Locations Above Base Criteria	
		Daytime ($L_{Aeq,15hr}$ 60dBA)	Night time ($L_{Aeq,9hr}$ 55dBA)
Future Existing (2015)	14mm chip seal	20	15
Future Existing (2025)		21	17
Option A – Future Design (2015)	14mm chip seal with 7mm scattered	16	5
Option A – Future Design (2025)		20	10
Option B – Future Design (2015)	14mm chip seal with 7mm scattered	17	7
Option B – Future Design (2025)		19	11
Option A – Future Design (2015)	SMAC	3	0
Option A – Future Design (2025)		5	0
Option B – Future Design (2015)	SMAC	3	0
Option B – Future Design (2025)		7	0

Comparing the future existing and future design noise levels (10 years in the future) it can be seen that all the receiver locations are within 2dBA. Additionally, there are up to seven houses exceeding acute noise levels for one of the proposed alignment options (reference to Table 10-12).

10.6 Relative Increase Noise Criteria

The increase in noise levels is less than 12dBA therefore they comply with the relative increase criteria.

10.7 Reasonable & Feasible Noise Mitigation

RMS considers through the *ENMM* that noise mitigation would be considered for residential receivers which exceed the base criteria and the 2dBA allowance and/or are exposed to acute noise levels. Overall noise mitigation that could be considered for the project are:

- Roadside noise barriers;
- Low noise road pavement (such as SMAC); and
- Architectural treatment of exposed residences.

10.7.1 Noise Barriers

The *ENMM Practice Note iv* discusses a method for determining the effectiveness of noise barriers with the aim of determining the cost effectiveness of barriers as a noise mitigation option for new roads. The method is intended to assess the "reasonableness" of noise barriers and weighs the benefits, in terms of the noise reductions achieved and the number of people protected, against the total cost of the barrier.

Due to the close proximity of the Waterfall Way to the residential receivers, urban design consideration and driveway access arrangements road side barriers are not considered a feasible option.

10.7.2 Low Noise Pavement

The consideration to resurface the new alignments with low noise pavement may provide an approximate 2-3dBA noise reduction benefit. The stone mastic asphaltic concrete pavement addressed in this assessment qualifies as low noise pavement with a 2dBA noise reduction benefit.

10.7.3 Noise Mitigation to Residences

The consideration of architectural treatment would be in accordance with the guidelines of the *ENMM*. As discussed earlier it is generally *not* considered reasonable to take action to reduce noise levels to the target noise levels if the noise levels with the proposal, ten years after project opening, are predicted to be:

- Within 2dBA of "future existing" noise levels; *and*
- No more than 2dBA above the target noise levels.

The RMS's Environmental Practice Note 24 "Noise assessment for acute levels of noise – redevelopment of existing roads" confirms the following:

"Application of all feasible and reasonable noise mitigation to aim to achieve the ECRTN noise criteria where, following a road redevelopment:

- *There is predicted to be a noticeable increase in road traffic noise, or*
- *Road traffic noise levels are predicted to be acute."*

The noise predictions indicated existing noise levels along the Waterfall Way generally complies with the allowance goal at all receiver locations.

It was also found that traffic noise from the proposed upgrade of the Waterfall Way is predicted to be acute at up to seven residences in 2025. These residences are located in NCA1 and NCA2.

Noise mitigation would be considered for all residential receivers which exceed the allowance goal and/or the acute noise levels. Residences where acute noise levels and/or allowance criteria are exceeded and where architectural noise mitigation is to be considered are shown in Table 10-12.

Table 10-12 Properties to be Considered for Mitigation

Scenario	Road Surface	No. of Acute Receiver Locations Considered for Mitigation		Receiver Locations Considered for Mitigation	
		Daytime	Night Time	Daytime	Night Time
Option A – Future Design (2015)	14mm chip seal with 7mm scattered	3	0	17, 20 and 31	-
Option A – Future Design (2025)		5	0	17, 20, 26, 29 and 31	-
Option B – Future Design (2015)	14mm chip seal with 7mm scattered	3	0	15, 17 and 31	-
Option B – Future Design (2025)		7	0	15, 17, 20, 24, 26, 29 and 31	-
Option A – Future Design (2015)	SMAC	0	0	-	-
Option A – Future Design (2025)		0	0	-	-
Option B – Future Design (2015)	SMAC	0	0	-	-
Option B – Future Design (2025)		0	0	-	-

11 MAXIMUM NOISE LEVEL EVENTS

11.1 Assessment Procedure

According to the *RNP*, there are no universally accepted criteria governing the likelihood of sleep disturbance. In other words, at the current level of understanding, it is not possible to establish absolute noise level goals that would correlate to levels of sleep disturbance (for all or even a majority of people).

The *RNP* states that:

- maximum internal noise levels below 50dBA to 55dBA are unlikely to awaken people from sleep;
- one or two events per night, with maximum internal noise levels of 65dBA to 70dBA, are not likely to affect health and wellbeing significantly;

The issue of sleep disturbance/maximum noise is also addressed within the *ENMM*. It is suggested that the assessment of sleep disturbance should include an examination of "maximum noise events": A "maximum noise event" is defined as any single event where the L_{Amax} noise level exceeds 65dBA and the L_{Amax} noise level exceeds the $L_{Aeq,1hour}$ noise level by more than 15dBA.

"Maximum noise event" characteristics to be assessed at nearest residential receivers include their occurrence throughout the 10.00 pm to 7.00 am night time period and their magnitudes.

A Ngara noise level logger was installed at Receiver 2 (as shown in Figure 4-2) to quantify typical prevailing maximum noise levels. The setback distance of this receiver location to the existing road alignment is approximately 28m.

Table 10-1 presents a summary of the measured noise levels during the night of 15 August 2011 and 16 August 2011 between the hours of 10.00pm to 7.00am.

Table 11-1 Maximum Noise Level Events, Existing Road Alignment

Time	$L_{Aeq,1hr}$	L_{Aeq} + 15dB	No. Of Occurences L_{Aeq} + 15dB and Greater than 65dB	Light Vehicle	Heavy Vehicle	Total
10.00pm to 11.00pm	53	68	7	18	3	21
11.00pm to 12.00am	50	65	6	7	2	9
12.00am to 1.00am	48	63	4	6	0	6
1.00am to 2.00am	48	63	6	3	1	4
2.00am to 3.00am	48	63	7	6	0	6

Time	$L_{Aeq,1hr}$	L_{Aeq} + 15dB	No. Of Occurences L_{Aeq} + 15dB and Greater than 65dB	Light Vehicle	Heavy Vehicle	Total
3.00am to 4.00am	49	64	18	7	1	8
4.00am to 5.00am	53	68	32	17	3	20
5.00am to 6.00am	58	73	17	34	8	42
6.00am to 7.00am	62	77	2	137	22	159

The proposed new alignments are similar to the existing at the eastern and western ends. The main differences in proposed alignment are around Raleigh Dam and between the dam and west of Cameron's Corner. This may result in increased or decreased noise levels at receivers in these areas, depending on their location.

Due to the absence of a definitive qualitative correlation between sleep disturbance and noise level, the *ENMM* suggests that the above nominated noise levels and guidelines should not be taken to as stringent criteria, but should be taken into consideration when determining noise mitigation measures to address general road traffic noise.

12 CONSTRUCTION NOISE & VIBRATION

This section deals with the majority of construction activity which is expected to occur during standard daytime construction hours. This assessment is based on no construction activity outside of standard hours.

12.1 Noise Management Levels

Using the noise criteria presented in Section 6, the noise management levels for residential receivers for each noise catchment, based on the background noise levels measured, are presented in Table 12-1.

Table 12-1 Site Specific Construction Noise Management Levels – dBA

Relevant NCA	Identified Receiver Location	Standard Hours Construction Noise Management Level $L_{Aeq,15min}$	Outside Recommended Standard Hours $L_{Aeq,15min}$	
			Evening	Night
NCA1	1, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 and 21	51	37	35
NCA2	2, 22, 23, 24, 25, 26, 27, 28, 29, 30 and 31	63	46	42
NCA3	3, 4 and 5	47	38	35

12.2 Construction Activities, Equipment Noise Levels & Predictions

Typical construction activities and sound power levels of typical construction equipment are listed in Table 12-2, based on RMS concept design input to the project. The Table gives the sound power level based on the L_{Aeq} (L_{weq}) and L_{Amax} (L_{wmax}) sound power levels emitted by the equipment.

Table 12-2 Typical Construction Events and Plant Sound Levels – (dBA)

Activity	Plant and Equipment	Sound Power Level (SWL)	
		L_{Aeq}	L_{Amax}
Compound establishment	• Light vehicles	93	97
	• Trucks	108	112
	• Crane	105	113
Traffic control	• Traffic control vehicles	93	97
Removal of existing linemarking	• Linemarking trucks	93	97
	• Grinding machine	100	103
Linemarking	• Linemarking trucks	93	97
	• Traffic control vehicles	93	97

Activity	Plant and Equipment	Sound Power Level (SWL)	
		L_{Aeq}	L_{Amax}
Installation or removal of temporary safety barriers	• Traffic control vehicles	93	97
	• Trucks	108	112
	• Crane	105	113
Removal of wire rope barrier	• Trucks	108	112
	• Crane	105	113
	• Generator	100	103
	• Compressor	106	107
Saw cutting	• Saw cutter	114	118
	• Light vehicles	93	97
	• Water cart	109	113
Clearing and grubbing	• Excavator (30t)	109	115
	• Chainsaw	114	118
	• Mulcher	114	118
	• Dump truck	108	112
	• Water cart	109	113
Earthworks	• Excavator	109	115
	• Dump truck	108	112
	• Compactor	109	115
	• Water cart	109	113
	• Grader	109	115
	• Profiler	114	118
	• Dozer	114	118
	Roller	106	114
Pavement construction (rip and re-compact sub-grade, place select material and compact)	• Grader	109	115
	• Excavator	109	115
	• Roller	106	114
	• Dump truck	108	112
	• Water cart	109	113
	• Wacker Packer	106	107
	• Spray sealing equipment	109	113
Concrete works (construction of concrete pavement, kerbs and barriers)	• Agitator truck	109	113
	• Concrete pump	108	112
	• Vibrators	106	107
	• Compaction equipment	106	107
	• Concrete saw	114	118
	• Compressor	106	107
	• Generator	100	103
Paving (delivery of raw materials, placement of surface material, saw cutting)	• Profiler	114	118
	• Paver	114	118
	• Asphalt truck	108	112
	• Sprayer	93	97

Activity	Plant and Equipment	Sound Power Level (SWL)	
		L_{Aeq}	L_{Amax}
	• Roller	106	114
Drainage works	• Agitator truck	109	113
	• Concrete pump	108	112
	• Vibrators	106	107
	• Jackhammer	115	117
	• Welding machine	106	107
	• Under boring equipment	107	110
Mill and re-sheet	• Milling machine	114	118
	• Trucks	108	112
	• Paving machine	114	118
	• Ashpalt trucks	108	112
	• Rollers	106	114
Signs installation	• Piling machine	107	110
	• Agitator truck	109	113
	• Concrete pump	108	112
	• Vibrators	106	107
	• Crane	105	113
	• Trucks	108	112
	• Generators	100	103
Landscaping and vegetation	• Light vehicles	93	97
	• Trucks	108	112
Sedimentation basins works	• Excavator	109	115
	• Concrete pump	108	112
	• Concrete trucks	109	113
	• Vibrators	106	107
	• Trucks	108	112

Using the assumed plant items and their associ ated sound power levels (with considerati on given to the operational changes, intermittent processes and changes in distance of mobi le plant), Table 12-3 presents a combined L_{Aeq} sound power level for each scenario and ranks the construction events with potential noise impacts in descending order.

Table 12-3 Ranking of Construction Events

Ranking	Activity	Equivalent L_{weq} (dBA)
1	Earthworks	119
2	Clearing and grubbing	118
3	Paving (delivery of raw materials, placement of surface material, saw cutting)	117
	Mill and re-sheet	
	Drainage works	
	Concrete works (construction of concrete pavement, kerbs and barriers)	
4	Pavement construction (rip and re-compact sub-grade, place select material and compact)	116
5	Signs installation	114
	Saw cutting	
6	Sedimentation basins works	113
7	Removal of wire rope barrier	109
8	Compound Establishment	105
9	Installation or removal of temporary safety barriers	104
10	Landscaping and vegetation	98
11	Removal of existing linemarking	97
12	Linemarking	94
13	Traffic control	89

12.3 Predicted L_{Aeq} Noise Levels

Table 12-4 to 12-9 present a summary of the typical range of maximum L_{Aeq} noise levels that may be expected at each receiver location (without the implementation of any special noise mitigation) for each of the propose construction activities. The construction activities are presented in ascending ranked order from left to right of the tables.

Table 12-4 Option A: Predicted L_{Aeq} Construction Noise Levels – Daytime

NCA	Receiver No.	Daytime Criterion	Rank 13 L_{weq} 89	Rank 12 L_{weq} 94	Rank 11 L_{weq} 97	Rank 10 L_{weq} 98	Rank 9 L_{weq} 104	Rank 8 L_{weq} 105	Rank 7 L_{weq} 109	Rank 6 L_{weq} 113	Rank 5 L_{weq} 114	Rank 4 L_{weq} 116	Rank 3 L_{weq} 117	Rank 2 L_{weq} 118	Rank 1 L_{weq} 119
1	1	51	43	48	51	52	58	59	63	67	68	70	71	72	73
1	6	51	31	36	39 40		46	47	51	55	56	58	59	60	61
1	7	51	29	34	37 38		44	45	49	53	54	56	57	58	59
1	8	51	28	33	36 37		43	44	48	52	53	55	56	57	58
1	9	51	43	48	51	52	58	59	63	67	68	70	71	72	73
1	10	51	37	42	45 46		52	53	57	61	62	64	65	66	67
1	11	51	32	37	40 41		47	48	52	56	57	59	60	61	62
1	12	51	40	45	48 49		55	56	60	64	65	67	68	69	70
1	13	51	34	39	42 43		49	50	54	58	59	61	62	63	64
1	14	51	27	32	35 36		42	43	47	51	52	54	55	56	57
1	15	51	42	47	50 51		57	58	62	66	67	69	70	71	72
1	16	51	42	47	50 51		57	58	62	66	67	69	70	71	72
1	17	51	49	54	57	58	64	65	69	73	74	76	77	78	79
1	18	51	40	45	48 49		55	56	60	64	65	67	68	69	70
1	19	51	30	35	38 39		45	46	50	54	55	57	58	59	60
1	20	51	51	56	59	60	66	67	71	75	76	78	79	80	81
1	21	51	43	48	51	52	58	59	63	67	68	70	71	72	73
2	22	63	44	49	52 53		59	60	64	68	69	71	72	73	74
2	23	63	44	49	52 53		59	60	64	68	69	71	72	73	74
2	24	63	46	51	54 55		61	62	66	70	71	73	74	75	76

NCA	Receiver No.	Daytime Criterion	Rank 13 L_{weq} 89	Rank 12 L_{weq} 94	Rank 11 L_{weq} 97	Rank 10 L_{weq} 98	Rank 9 L_{weq} 104	Rank 8 L_{weq} 105	Rank 7 L_{weq} 109	Rank 6 L_{weq} 113	Rank 5 L_{weq} 114	Rank 4 L_{weq} 116	Rank 3 L_{weq} 117	Rank 2 L_{weq} 118	Rank 1 L_{weq} 119
2	**25**	63	44	49	52 53		59	60	**64**	**68**	**69**	**71**	**72**	**73**	**74**
2	**2**	63	45	50	53 54		60	61	**65**	**69**	**70**	**72**	**73**	**74**	**75**
2	**26**	63	50	55	58 59		**65**	**66**	**70**	**74**	**75**	**77**	**78**	**79**	**80**
2	**27**	63	50	55	58 59		**65**	**66**	**70**	**74**	**75**	**77**	**78**	**79**	**80**
2	**28**	63	52	57	60 61		**67**	**68**	**72**	**76**	**77**	**79**	**80**	**81**	**82**
2	**29**	63	51	56	59 60		**66**	**67**	**71**	**75**	**76**	**78**	**79**	**80**	**81**
2	**30**	63	42	47	50 51		57	58	62	**66**	**67**	**69**	**70**	**71**	**72**
2	**31**	63	51	56	59 60		**66**	**67**	**71**	**75**	**76**	**78**	**79**	**80**	**81**
3	**3**	47	37	42	45 46		**52**	**53**	**57**	**61**	**62**	**64**	**65**	**66**	**67**
3	**4**	47	43	**48**	**51**	**52**	**58**	**59**	**63**	**67**	**68**	**70**	**71**	**72**	**73**
3	**5**	47	41	46	**49**	**50**	**56**	**57**	**61**	**65**	**66**	**68**	**69**	**70**	**71**

Table 12-5 Option B: Predicted L_{Aeq} Construction Noise Levels – Daytime

NCA	Receiver No.	Daytime Criterion	Rank 13 L_{weq} 89	Rank 12 L_{weq} 94	Rank 11 L_{weq} 97	Rank 10 L_{weq} 98	Rank 9 L_{weq} 104	Rank 8 L_{weq} 105	Rank 7 L_{weq} 109	Rank 6 L_{weq} 113	Rank 5 L_{weq} 114	Rank 4 L_{weq} 116	Rank 3 L_{weq} 117	Rank 2 L_{weq} 118	Rank 1 L_{weq} 119
1	1	51	42	47	50	51	**57**	**58**	**62**	**66**	**67**	**69**	**70**	**71**	**72**
1	6	51	30	35	38	39	45	46	50	**54**	**55**	**57**	**58**	**59**	**60**
1	7	51	28	33	36	37	43	44	48	**52**	**53**	**55**	**56**	**57**	**58**
1	8	51	27	32	35	36	42	43	47	51	**52**	**54**	**55**	**56**	**57**
1	9	51	40	45	48	49	**55**	**56**	**60**	**64**	**65**	**67**	**68**	**69**	**70**
1	10	51	39	44	47	48	**54**	**55**	**59**	**63**	**64**	**66**	**67**	**68**	**69**
1	11	51	34	39	42	43	49	50	**54**	**58**	**59**	**61**	**62**	**63**	**64**
1	12	51	41	46	49	50	**56**	**57**	**61**	**65**	**66**	**68**	**69**	**70**	**71**
1	13	51	34	39	42	43	49	50	**54**	**58**	**59**	**61**	**62**	**63**	**64**
1	14	51	27	32	35	36	42	43	47	51	**52**	**54**	**55**	**56**	**57**
1	15	51	50	**55**	**58**	**59**	**65**	**66**	**70**	**74**	**75**	**77**	**78**	**79**	**80**
1	16	51	44	49	**52**	**53**	**59**	**60**	**64**	**68**	**69**	**71**	**72**	**73**	**74**
1	17	51	**53**	**58**	**61**	**62**	**68**	**69**	**73**	**77**	**78**	**80**	**81**	**82**	**83**
1	18	51	37	42	45	46	**52**	**53**	**57**	**61**	**62**	**64**	**65**	**66**	**67**
1	19	51	29	34	37	38	44	45	49	**53**	**54**	**56**	**57**	**58**	**59**
1	20	51	47	**52**	**55**	**56**	**62**	**63**	**67**	**71**	**72**	**74**	**75**	**76**	**77**
1	21	51	45	50	**53**	**54**	**60**	**61**	**65**	**69**	**70**	**72**	**73**	**74**	**75**
2	22	63	46	51	54	55	61	62	**66**	**70**	**71**	**73**	**74**	**75**	**76**
2	23	63	42	47	50	51	57	58	62	**66**	**67**	**69**	**70**	**71**	**72**

NCA	Receiver No.	Daytime Criterion	Rank 13 L_{weq} 89	Rank 12 L_{weq} 94	Rank 11 L_{weq} 97	Rank 10 L_{weq} 98	Rank 9 L_{weq} 104	Rank 8 L_{weq} 105	Rank 7 L_{weq} 109	Rank 6 L_{weq} 113	Rank 5 L_{weq} 114	Rank 4 L_{weq} 116	Rank 3 L_{weq} 117	Rank 2 L_{weq} 118	Rank 1 L_{weq} 119
2	**24**	63	47	52	55	56	62	63	**67**	**71**	**72**	**74**	**75**	**76**	**77**
2	**25**	63	45	50	53	54	60	61	**65**	**69**	**70**	**72**	**73**	**74**	**75**
2	**2**	63	46	51	54	55	61	62	**66**	**70**	**71**	**73**	**74**	**75**	**76**
2	**26**	63	50	55	58	59	**65**	**66**	**70**	**74**	**75**	**77**	**78**	**79**	**80**
2	**27**	63	50	55	58	59	**65**	**66**	**70**	**74**	**75**	**77**	**78**	**79**	**80**
2	**28**	63	52	57	60	61	**67**	**68**	**72**	**76**	**77**	**79**	**80**	**81**	**82**
2	**29**	63	51	56	59	60	**66**	**67**	**71**	**75**	**76**	**78**	**79**	**80**	**81**
2	**30**	63	42	47	50	51	57	58	62	**66**	**67**	**69**	**70**	**71**	**72**
2	**31**	63	51	56	59	60	**66**	**67**	**71**	**75**	**76**	**78**	**79**	**80**	**81**
3	**3**	47	38	43	46	47	**53**	**54**	**58**	**62**	**63**	**65**	**66**	**67**	**68**
3	**4**	47	43	**48**	**51**	**52**	**58**	**59**	**63**	**67**	**68**	**70**	**71**	**72**	**73**
3	**5**	47	41	46	**49**	**50**	**56**	**57**	**61**	**65**	**66**	**68**	**69**	**70**	**71**

Table 12-6 Option A: Predicted L_{Aeq} Construction Noise Levels - Evening

NCA	Receiver No.	Evening Criterion	Rank 13 L_{weq} 89	Rank 12 L_{weq} 94	Rank 11 L_{weq} 97	Rank 10 L_{weq} 98	Rank 9 L_{weq} 104	Rank 8 L_{weq} 105	Rank 7 L_{weq} 109	Rank 6 L_{weq} 113	Rank 5 L_{weq} 114	Rank 4 L_{weq} 116	Rank 3 L_{weq} 117	Rank 2 L_{weq} 118	Rank 1 L_{weq} 119
1	1	37	43	48	51	52	58	59	63	67	68	70	71	72	73
1	6	37	31	36	39	40	46	47	51	55	56	58	59	60	61
1	7	37	29	34	37	38	44	45	49	53	54	56	57	58	59
1	8	37	28	33	36 37		43	44	48	52	53	55	56	57	58
1	9	37	43	48	51	52	58	59	63	67	68	70	71	72	73
1	10	37	37	42	45	46	52	53	57	61	62	64	65	66	67
1	11	37	32	37	40	41	47	48	52	56	57	59	60	61	62
1	12	37	40	45	48	49	55	56	60	64	65	67	68	69	70
1	13	37	34	39	42	43	49	50	54	58	59	61	62	63	64
1	14	37	27	32	35 36		42	43	47	51	52	54	55	56	57
1	15	37	42	47	50	51	57	58	62	66	67	69	70	71	72
1	16	37	42	47	50	51	57	58	62	66	67	69	70	71	72
1	17	37	49	54	57	58	64	65	69	73	74	76	77	78	79
1	18	37	40	45	48	49	55	56	60	64	65	67	68	69	70
1	19	37	30	35	38	39	45	46	50	54	55	57	58	59	60
1	20	37	51	56	59	60	66	67	71	75	76	78	79	80	81
1	21	37	43	48	51	52	58	59	63	67	68	70	71	72	73
2	22	46	44	49	52	53	59	60	64	68	69	71	72	73	74
2	23	46	44	49	52	53	59	60	64	68	69	71	72	73	74

NCA	Receiver No.	Evening Criterion	Rank 13 L_{weq} 89	Rank 12 L_{weq} 94	Rank 11 L_{weq} 97	Rank 10 L_{weq} 98	Rank 9 L_{weq} 104	Rank 8 L_{weq} 105	Rank 7 L_{weq} 109	Rank 6 L_{weq} 113	Rank 5 L_{weq} 114	Rank 4 L_{weq} 116	Rank 3 L_{weq} 117	Rank 2 L_{weq} 118	Rank 1 L_{weq} 119
2	24	46	46	51	54	55	61	62	66	70	71	73	74	75	76
2	25	46	44	49	52	53	59	60	64	68	69	71	72	73	74
2	2	46	45	50	53	54	60	61	65	69	70	72	73	74	75
2	26	46	50	55	58	59	65	66	70	74	75	77	78	79	80
2	27	46	50	55	58	59	65	66	70	74	75	77	78	79	80
2	28	46	52	57	60	61	67	68	72	76	77	79	80	81	82
2	29	46	51	56	59	60	66	67	71	75	76	78	79	80	81
2	30	46	42	47	50	51	57	58	62	66	67	69	70	71	72
2	31	46	51	56	59	60	66	67	71	75	76	78	79	80	81
3	3	38	37	42	45	46	52	53	57	61	62	64	65	66	67
3	4	38	43	48	51	52	58	59	63	67	68	70	71	72	73
3	5	38	41	46	49	50	56	57	61	65	66	68	69	70	71

Table 12-7 Option B: Predicted L_{Aeq} Construction Noise Levels - Evening

NCA	Receiver No.	Evening Criterion	Rank 13 L_{weq} 89	Rank 12 L_{weq} 94	Rank 11 L_{weq} 97	Rank 10 L_{weq} 98	Rank 9 L_{weq} 104	Rank 8 L_{weq} 105	Rank 7 L_{weq} 109	Rank 6 L_{weq} 113	Rank 5 L_{weq} 114	Rank 4 L_{weq} 116	Rank 3 L_{weq} 117	Rank 2 L_{weq} 118	Rank 1 L_{weq} 119
1	1	37	42	47	50	51	57	58	62	66	67	69	70	71	72
1	6	37	30	35	38	39	45	46	50	54	55	57	58	59	60
1	7	37	28	33	36 37		43	44	48	52	53	55	56	57	58
1	8	37	27	32	35 36		42	43	47	51	52	54	55	56	57
1	9	37	40	45	48	49	55	56	60	64	65	67	68	69	70
1	10	37	39	44	47	48	54	55	59	63	64	66	67	68	69
1	11	37	34	39	42	43	49	50	54	58	59	61	62	63	64
1	12	37	41	46	49	50	56	57	61	65	66	68	69	70	71
1	13	37	34	39	42	43	49	50	54	58	59	61	62	63	64
1	14	37	27	32	35 36		42	43	47	51	52	54	55	56	57
1	15	37	50	55	58	59	65	66	70	74	75	77	78	79	80
1	16	37	44	49	52	53	59	60	64	68	69	71	72	73	74
1	17	37	53	58	61	62	68	69	73	77	78	80	81	82	83
1	18	37	37	42	45	46	52	53	57	61	62	64	65	66	67
1	19	37	29	34	37	38	44	45	49	53	54	56	57	58	59
1	20	37	47	52	55	56	62	63	67	71	72	74	75	76	77
1	21	37	45	50	53	54	60	61	65	69	70	72	73	74	75
2	22	46	46	51	54	55	61	62	66	70	71	73	74	75	76
2	23	46	42	47	50	51	57	58	62	66	67	69	70	71	72

NCA	Receiver No.	Evening Criterion	Rank 13 L_{weq} 89	Rank 12 L_{weq} 94	Rank 11 L_{weq} 97	Rank 10 L_{weq} 98	Rank 9 L_{weq} 104	Rank 8 L_{weq} 105	Rank 7 L_{weq} 109	Rank 6 L_{weq} 113	Rank 5 L_{weq} 114	Rank 4 L_{weq} 116	Rank 3 L_{weq} 117	Rank 2 L_{weq} 118	Rank 1 L_{weq} 119
2	24	46	47	52	55	56	62	63	67	71	72	74	75	76	77
2	25	46	45	50	53	54	60	61	65	69	70	72	73	74	75
2	2	46	46	51	54	55	61	62	66	70	71	73	74	75	76
2	26	46	50	55	58	59	65	66	70	74	75	77	78	79	80
2	27	46	50	55	58	59	65	66	70	74	75	77	78	79	80
2	28	46	52	57	60	61	67	68	72	76	77	79	80	81	82
2	29	46	51	56	59	60	66	67	71	75	76	78	79	80	81
2	30	46	42	47	50	51	57	58	62	66	67	69	70	71	72
2	31	46	51	56	59	60	66	67	71	75	76	78	79	80	81
3	3	38	38	43	46	47	53	54	58	62	63	65	66	67	68
3	4	38	43	48	51	52	58	59	63	67	68	70	71	72	73
3	5	38	41	46	49	50	56	57	61	65	66	68	69	70	71

Table 12-8 Option A: Predicted L_{Aeq} Construction Noise Levels - Night

NCA	Receiver No.	Evening Criterion	Rank 13 L_{weq} 89	Rank 12 L_{weq} 94	Rank 11 L_{weq} 97	Rank 10 L_{weq} 98	Rank 9 L_{weq} 104	Rank 8 L_{weq} 105	Rank 7 L_{weq} 109	Rank 6 L_{weq} 113	Rank 5 L_{weq} 114	Rank 4 L_{weq} 116	Rank 3 L_{weq} 117	Rank 2 L_{weq} 118	Rank 1 L_{weq} 119
1	**1**	35	**43**	**48**	**51**	**52**	**58**	**59**	**63**	**67**	**68**	**70**	**71**	**72**	**73**
1	**6**	35	31	**36**	**39**	**40**	**46**	**47**	**51**	**55**	**56**	**58**	**59**	**60**	**61**
1	**7**	35	29	34	**37**	**38**	**44**	**45**	**49**	**53**	**54**	**56**	**57**	**58**	**59**
1	**8**	35	28	33	**36**	**37**	**43**	**44**	**48**	**52**	**53**	**55**	**56**	**57**	**58**
1	**9**	35	**43**	**48**	**51**	**52**	**58**	**59**	**63**	**67**	**68**	**70**	**71**	**72**	**73**
1	**10**	35	37	**42**	**45**	**46**	**52**	**53**	**57**	**61**	**62**	**64**	**65**	**66**	**67**
1	**11**	35	32	**37**	**40**	**41**	**47**	**48**	**52**	**56**	**57**	**59**	**60**	**61**	**62**
1	**12**	35	**40**	**45**	**48**	**49**	**55**	**56**	**60**	**64**	**65**	**67**	**68**	**69**	**70**
1	**13**	35	34	**39**	**42**	**43**	**49**	**50**	**54**	**58**	**59**	**61**	**62**	**63**	**64**
1	**14**	35	27	32	35	**36**	**42**	**43**	**47**	**51**	**52**	**54**	**55**	**56**	**57**
1	**15**	35	**42**	**47**	**50**	**51**	**57**	**58**	**62**	**66**	**67**	**69**	**70**	**71**	**72**
1	**16**	35	**42**	**47**	**50**	**51**	**57**	**58**	**62**	**66**	**67**	**69**	**70**	**71**	**72**
1	**17**	35	**49**	**54**	**57**	**58**	**64**	**65**	**69**	**73**	**74**	**76**	**77**	**78**	**79**
1	**18**	35	**40**	**45**	**48**	**49**	**55**	**56**	**60**	**64**	**65**	**67**	**68**	**69**	**70**
1	**19**	35	30	35	**38**	**39**	**45**	**46**	**50**	**54**	**55**	**57**	**58**	**59**	**60**
1	**20**	35	**51**	**56**	**59**	**60**	**66**	**67**	**71**	**75**	**76**	**78**	**79**	**80**	**81**
1	**21**	35	**43**	**48**	**51**	**52**	**58**	**59**	**63**	**67**	**68**	**70**	**71**	**72**	**73**
2	**22**	42	**44**	**49**	**52**	**53**	**59**	**60**	**64**	**68**	**69**	**71**	**72**	**73**	**74**
2	**23**	42	**44**	**49**	**52**	**53**	**59**	**60**	**64**	**68**	**69**	**71**	**72**	**73**	**74**

NCA	Receiver No.	Evening Criterion	Rank 13 L_{weq} 89	Rank 12 L_{weq} 94	Rank 11 L_{weq} 97	Rank 10 L_{weq} 98	Rank 9 L_{weq} 104	Rank 8 L_{weq} 105	Rank 7 L_{weq} 109	Rank 6 L_{weq} 113	Rank 5 L_{weq} 114	Rank 4 L_{weq} 116	Rank 3 L_{weq} 117	Rank 2 L_{weq} 118	Rank 1 L_{weq} 119
2	24	42	46	51	54	55	61	62	66	70	71	73	74	75	76
2	25	42	44	49	52	53	59	60	64	68	69	71	72	73	74
2	2	42	45	50	53	54	60	61	65	69	70	72	73	74	75
2	26	42	50	55	58	59	65	66	70	74	75	77	78	79	80
2	27	42	50	55	58	59	65	66	70	74	75	77	78	79	80
2	28	42	52	57	60	61	67	68	72	76	77	79	80	81	82
2	29	42	51	56	59	60	66	67	71	75	76	78	79	80	81
2	30	42	42	47	50	51	57	58	62	66	67	69	70	71	72
2	31	42	51	56	59	60	66	67	71	75	76	78	79	80	81
3	3	35	37	42	45	46	52	53	57	61	62	64	65	66	67
3	4	35	43	48	51	52	58	59	63	67	68	70	71	72	73
3	5	35	41	46	49	50	56	57	61	65	66	68	69	70	71

Table 12-9 Option B: Predicted L_{Aeq} Construction Noise Levels – Night

NCA	Receiver No.	Evening Criterion	Rank 13 L_{weq} 89	Rank 12 L_{weq} 94	Rank 11 L_{weq} 97	Rank 10 L_{weq} 98	Rank 9 L_{weq} 104	Rank 8 L_{weq} 105	Rank 7 L_{weq} 109	Rank 6 L_{weq} 113	Rank 5 L_{weq} 114	Rank 4 L_{weq} 116	Rank 3 L_{weq} 117	Rank 2 L_{weq} 118	Rank 1 L_{weq} 119
1	1	35	42	47	50	51	57	58	62	66	67	69	70	71	72
1	6	35	30	35	38	39	45	46	50	54	55	57	58	59	60
1	7	35	28	33	36	37	43	44	48	52	53	55	56	57	58
1	8	35	27	32	35	36	42	43	47	51	52	54	55	56	57
1	9	35	40	45	48	49	55	56	60	64	65	67	68	69	70
1	10	35	39	44	47	48	54	55	59	63	64	66	67	68	69
1	11	35	34	39	42	43	49	50	54	58	59	61	62	63	64
1	12	35	41	46	49	50	56	57	61	65	66	68	69	70	71
1	13	35	34	39	42	43	49	50	54	58	59	61	62	63	64
1	14	35	27	32	35	36	42	43	47	51	52	54	55	56	57
1	15	35	50	55	58	59	65	66	70	74	75	77	78	79	80
1	16	35	44	49	52	53	59	60	64	68	69	71	72	73	74
1	17	35	53	58	61	62	68	69	73	77	78	80	81	82	83
1	18	35	37	42	45	46	52	53	57	61	62	64	65	66	67
1	19	35	29	34	37	38	44	45	49	53	54	56	57	58	59
1	20	35	47	52	55	56	62	63	67	71	72	74	75	76	77
1	21	35	45	50	53	54	60	61	65	69	70	72	73	74	75
2	22	42	46	51	54	55	61	62	66	70	71	73	74	75	76
2	23	42	42	47	50	51	57	58	62	66	67	69	70	71	72

NCA	Receiver No.	Evening Criterion	Rank 13 L_{weq} 89	Rank 12 L_{weq} 94	Rank 11 L_{weq} 97	Rank 10 L_{weq} 98	Rank 9 L_{weq} 104	Rank 8 L_{weq} 105	Rank 7 L_{weq} 109	Rank 6 L_{weq} 113	Rank 5 L_{weq} 114	Rank 4 L_{weq} 116	Rank 3 L_{weq} 117	Rank 2 L_{weq} 118	Rank 1 L_{weq} 119
2	24	42	47	52	55	56	62	63	67	71	72	74	75	76	77
2	25	42	45	50	53	54	60	61	65	69	70	72	73	74	75
2	2	42	46	51	54	55	61	62	66	70	71	73	74	75	76
2	26	42	50	55	58	59	65	66	70	74	75	77	78	79	80
2	27	42	50	55	58	59	65	66	70	74	75	77	78	79	80
2	28	42	52	57	60	61	67	68	72	76	77	79	80	81	82
2	29	42	51	56	59	60	66	67	71	75	76	78	79	80	81
2	30	42	42	47	50	51	57	58	62	66	67	69	70	71	72
2	31	42	51	56	59	60	66	67	71	75	76	78	79	80	81
3	3	35	38	43	46	47	53	54	58	62	63	65	66	67	68
3	4	35	43	48	51	52	58	59	63	67	68	70	71	72	73
3	5	35	41	46	49	50	56	57	61	65	66	68	69	70	71

12.4 Summary

The predicted noise levels presented in Table 12-4 to Table 12-9 identifies receiver locations where the noise management levels are expected to be exceeded (exceedances predicted are in bold) at least during some stage during project construction. A number of receivers are also predicted to be highly affected (highlighted in red). Noise management and mitigation would therefore need to be considered and implemented where reasonable and feasible, to minimise the acoustic impacts.

This should be reviewed and a Construction Noise Management Plan prepared.

12.5 Mitigation of Construction Noise

12.5.1 General Construction Activities

In accordance with the Interim Construction Noise Guideline, best practice mitigation and management measures will be used to minimise construction noise and vibration at noise sensitive receivers, thereby reducing the potential impacts. This will be described in a Construction Noise Management Plan (CNMP), to be prepared by the contractor for the project.

The CNMP will consider the following issues as a minimum:

a) identify nearby residences and other sensitive land uses;

b) develop noise management levels consistent with the *ICNG*;

c) assess the potential impact from the proposed construction methods;

d) where management levels are exceeded examine feasible and reasonable noise mitigation;

e) develop reactive and proactive strategies for dealing with any noise complaints;

f) identify a site contact person to follow up complaints; and

g) noise monitoring.

In general, management of noise and vibration requires attention to the following:

- Construction hours.
- Noise and vibration monitoring (on site and at sensitive receivers).
- Training and awareness.
- Consultation with potentially affected residents, including regular updates on the nature, timing and duration of anticipated works.
- Incident and emergency response.
- Non-conformance, preventative and corrective action.

Where appropriate the specific noise mitigation measures could include:

- Mitigation of specific noise sources may be possible by using portable temporary screens.
- Respite and/or restricted construction hours may be considered for extended periods of driven piling, rock breaking and other high noise generating activities.
- Maximising the offset distance between noisy plant items and sensitive receivers.
- Avoiding using noisy plant simultaneously and/or close together, adjacent to sensitive receivers.
- Orienting equipment away from sensitive receivers.
- Carrying out loading and unloading away from sensitive receivers.
- Using dampened tips on rock breakers.
- Using noise source controls, such as the use of residential class mufflers, to reduce noise from all plant and equipment including bulldozers, cranes, graders, excavators and trucks.
- Selecting plant and equipment based on noise emission levels.
- Using alternative construction methods to minimise noise levels.
- Providing alternative arrangements with affected residents such as temporary relocation.
- Selecting site access points and roads as far as possible away from sensitive receivers.
- Using spotters, closed circuit television monitors, "smart" reversing alarms, or "squawker" type reversing alarms in place of traditional reversing alarms.
- Design site compounds and site work methods to minimise the need for reversing, therefore minimising reversing alarm noise.

Education and training of site staff is necessary for satisfactory implementation of noise mitigation measures. Education and training strategies should focus on:

- Site awareness training / environmental inductions that include a section on noise mitigation techniques / measures to be implemented throughout the project.
- Ensuring work occurs within approved hours.
- Locating noisy equipment away from sensitive receivers.
- Using noise screens for mobile plant and equipment.
- Ensuring plant and equipment is well maintained and not making excessive noise.
- Turning off machinery when not in use.

For noise mitigation measures that result in a direct reduction in noise level, indicative noise reductions that can potentially be achieved by these measures, subject to the type and number of equipment and intensity of construction activities, are shown in Table 12-10. It is recommended that these be considered in preparation of a construction noise management plan prior to commencing works on site.

Table 12-10 Measures to Reduce Construction Noise

Management Measure	Potential Noise Reduction, dBA
Administrative Controls	
Turning off machinery when not in use	0-5
Engineering Controls	
Portable temporary screens	5-10
Screen or enclosure for stationary equipment	10-15
Maximising the offset distance between noisy plant items and sensitive receivers.	3-6
Avoiding using noisy plant simultaneously and/or close together, adjacent to sensitive receivers.	2-3
Orienting equipment away from sensitive receivers.	3-5
Carrying out loading and unloading away from sensitive receivers.	3-5
Using dampened tips on rock breakers.	3-6
Using noise source controls, such as the use of residential class mufflers, to reduce noise from all plant and equipment including bulldozers, cranes, graders, excavators and trucks	5-10
Selecting site access points and roads as far as possible away from sensitive receivers	3-6
Employ non noise-generating structures such as site offices, storage sheds, stockpiles and tanks as noise barriers	5-10

12.6 Assessment of Construction Vibration

Impacts from vibration can be consi dered both in terms of effects on building occupants (human comfort) and the effects on the building structur e (building damage). Of these considerations, the human comf ort limits are the most stringent. Therefore, for occupied buildings, if compliance with human comfort limits is achieved, it will follow that compliance will be achieved with the building damage objectives.

12.6.1 Vibration Impacts

Ground vibration may potentially be c aused by piling, rock h ammering, drilling and ground compaction operations associated with construction of the road. Most of the proposed works will be in soft ground and rock hammeri ng and drilling is not likely to be carried out. Vibration levels generated during piling and ground compac tion operations (including vibratory rolling) will depend on the exac t equipment to be used and the type of ground. Table 12-11 provides estimated vibration levels at a r ange of distanc es from piling, rock hammerin g, drilling and ground compaction operations. These vibration levels have been taken from Wilkinson Murray's database and are based on previous m easurements on similar pr ojects. The vibratory roller, impact piling and bored piling were measured in soft ground whilst the other equipment listed operates in rock.

Table 12-11 Typical Vibration Levels from Construction Plant for Typical Worst-case Ground Conditions

Source	Peak Particle Vibration Levels, mm/s					
	5m	10m	20m	30m	40m	50m
Vibratory roller	-	4.1	2.6	2.4	2.2	1.9
Heavy Rock Breaker	4.5	1.3	0.4	0.2	0.12	0.085
Rock drill (estimate)	-	0.5	0.2	0.1	0.05	0.04
Light Rock Hammer (e.g. 600kg)	0.2	0.06	0.02	0.01	-	-
Impact Piling	11	3.5	1.0	0.5	0.2	0.05
Bored Piling	-	0.2	<0.1	-	-	-

Note: Theoretically, there can be an increase in vibration levels from two pieces of plant operating at the same location and in phase for energy average levels; however, this is unlikely to affect the peak particle velocity as they are rando m incoherent vibration sources. Given t his, vibration assessments are c onducted based on individual sources.

The vibration criterion associated with building damage to residences (15mm/s) is easily complied with, considering the typical distances that any construction activities will be occurring from residential buildings. The criterion based on BS7385 depends on the frequency, but for normal construction activity the frequency would suggest even a higher criterion. Compliance with the criterion indicates that there is a low risk of building damage from the pr oposed construction works.

In respect of human comfort, the only activities with potential for affecting nearby residents are vibratory roller and impact piling. In relation to impact piling, this is not expected to be carried out near resi dences, so this secti on addresses primarily vibratory rolling. A vibratory roller generates continuous vibration and it has been assumed that one may operate almost continuously for a full day during daytime hours. On this basis, depending upon the response of the particular ground type at the loc ation, the daytime human comfort criterion would only be met at distances signifi cantly greater than 50m. This means that there is potential that the human comfort criterion may be exceeded in some areas, mainly in those limited areas where a vibratory roller is used in the con struction of pavement outside the existing lanes and possibly also in some cases where the vibratory roller is used on the median strip.

12.6.2 Vibration Mitigation Measures

When vibratory rollers or impact piling rigs are brought to the site, ground-borne vibration levels will be measured to establish the minimum working separation between the equipment and nearby vibration sensitive receivers.

Continuous vibration monitoring may be carried out when a vibratory roller is operated within 30 m of a building, or as required. Where the measured vibration levels exceed the appropriate limit applying to the measurement, construction activities or equipment will be modified (eg using a lighter or smaller vibratory roller) to ensure ongoing compliance with the limits. Otherwise, arrangements will be made with the affected residents to allow the operations to continue without affecting the residents' comfort.

Vibration monitoring will be carried out as may be necessary if there is any concern.

The above mitigation measures, and any other measures deemed feasible and reasonable, should be addressed by the contractor in the Construction Noise Management Plan for the project.

13 CONCLUSION

Noise from the proposed Waterfall Way Upgrade Project has been assessed. The following aspects have been considered:

- Operational noise; and
- Construction noise and vibration.

13.1 Noise Monitoring

Noise monitoring was undertaken at three locations, for use on the project. The noise monitoring was used to establish background noise levels for setting construction noise objectives, and to provide existing traffic noise levels for the purpose of verification/ calibration of the noise model.

13.2 Traffic Noise Modelling and Validation

The noise model used for the noise predictions was calibrated using three different road segments and based on the measured existing noise levels provided for the project.

The noise predictions for various modelling scenarios, without noise mitigation being considered, are as below:

- Future Existing Year 2015 noise levels (no upgrade);
- Future Existing Year 2025 noise levels (no upgrade);
- Future Design Year 2015 Option A noise levels – year of opening;
- Future Design Year 2025 Option A noise levels – 10 years after opening;
- Future Design Year 2015 Option B noise levels – year of opening; and
- Future Design Year 2025 Option B noise levels – 10 years after opening.

The consideration of architectural treatment would be in accordance with the guidelines of the *ENMM*. As discussed earlier it is generally *not* considered reasonable to take action to reduce noise levels to the target noise levels if the noise levels with the proposal, ten years after project opening, are predicted to be:

- Within 2dBA of "future existing" noise levels; *and*
- No more than 2dBA above the target noise levels.

The RMS's Environmental Practice Note 24 "Noise assessment for acute levels of noise – redevelopment of existing roads" confirms the following:

"Application of all feasible and reasonable noise mitigation to aim to achieve the ECRTN noise

criteria where, following a road redevelopment:

- *There is predicted to be a noticeable increase in road traffic noise, or*
- *Road traffic noise levels are predicted to be acute."*

The noise predictions indicated existing noise levels along the Waterfall Way generally complies with the allowance goal at all receiver locations.

It was also found that traffic noise from the proposed upgrade of the Waterfall Way with chip seal option is predicted to be acute at up to seven residences in 2025. These residences are located in NCA1 and NCA2.

Noise mitigation would be considered for all residential receivers which exceed the allowance goal and/or the acute noise levels. Residences where acute noise levels and/or allowance criteria are exceeded and where architectural noise mitigation is to be considered are shown in Table 13-1.

Table 13-1 Properties to be Considered for Mitigation

Scenario	Road Surface	No. of Acute Receiver Locations Considered for Mitigation		Receiver Locations Considered for Mitigation	
		Daytime	Night Time	Daytime	Night Time
Option A – Future Design (2015)	14mm chip seal with 7mm scattered	3	0	17, 20 and 31	-
Option A – Future Design (2025)		5	0	17, 20, 26, 29 and 31	-
Option B – Future Design (2015)	14mm chip seal with 7mm scattered	3	0	15, 17 and 31	-
Option B – Future Design (2025)		7	0	15, 17, 20, 24, 26, 29 and 31	-
Option A – Future Design (2015)	SMAC	0	0	-	-
Option A – Future Design (2025)		0	0	-	-
Option B – Future Design (2015)	SMAC	0	0	-	-
Option B – Future Design (2025)		0	0	-	-

Without the proposed Waterfall Way upgrade, there would be 21 receiver locations over the daytime ($L_{Aeq,15hr}$ 60dBA) base criterion and 17 receiver locations over the night time ($L_{Aeq,9hr}$ 55dBA) base criterion.

After the proposed upgrade in 2025 with 14mm chip seal with 7mm scattered, 20 receiver locations would remain over the daytime base noise criterion and up to 10 receiver locations would be over the night time base criterion in proposed Option A. Option B would result in 19 receiver locations over the daytime base noise criterion and up to 11 receiver locations over the night time base criterion.

In addition, acute noise levels are predicted during day time period for both proposed alignment options. A total of five receiver locations would be acute for proposed Option A and seven receiver locations for proposed Option B.

However, with the proposed upgrade with SMAC road surface type, a total of seven receiver locations would be over the daytime base noise criterion and the night time base criterion would be complied with at all receiver locations. The reduced number of receiver locations is predicted for both proposed alignment options. No acute noise levels are predicted with SMAC road surface type.

Scenario	**Road Surface**	**No. of Receiver Locations Above Base Criteria**	
		Daytime ($L_{Aeq,15hr}$ 60dBA)	**Night time ($L_{Aeq,9hr}$ 55dBA)**
Future Existing (2015)	14mm chip seal	20	15
Future Existing (2025)		21	17
Option A – Future Design (2015)	14mm chip seal with 7mm scattered	16	5
Option A – Future Design (2025)		20	10
Option B – Future Design (2015)	14mm chip seal with 7mm scattered	17	7
Option B – Future Design (2025)		19	11
Option A – Future Design (2015)	SMAC	3	0
Option A – Future Design (2025)		5	0
Option B – Future Design (2015)	SMAC	3	0
Option B – Future Design (2025)		7	0

13.3 Recommendations for Operational Noise Mitigation

For the receiver locations requiring mitigation, the following are proposed to mitigate noise is as follows:

- Provision of architectural treatment to acute receiver locations identified in Table 13-1; or
- The consideration to resurface the new alignments with low noise pavement such as SMAC and the provision of architectural treatment to the remaining acute receiver locations.

Consideration of feasible and reasonable noise mitigation measures would be re-assessed again during the detailed design phase of the project when the final alignment has been confirmed and more detailed ground surveys have been completed.

13.4 Construction Noise and Vibration Assessment

Noise from construction is expected to result in impact at some receiver locations, for at least some of the time. It is likely that the noise management levels would be exceeded during project construction.

Vibration will generally be within comfort levels, and well within damage thresholds, although perceptible at times. The most significant vibration is expected to occur during the use of vibratory rollers, particularly in limited areas where some widening outside the existing lanes is carried out. In order to minimise the impacts, it is recommended that a Construction Noise Management Plan be prepared by the contractor prior to undertaking works on site. This will be based on the proposed construction methodology, activities and details of plant and equipment available at the time, to review the impacts and identify management and mitigation measures that can be implemented where feasible and reasonable.

APPENDIX A

NOISE MEASUREMENT RESULTS