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Tintenbar to Ewingsdale Pacific Highway upgrade

Post-construction operational noise report

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Glossary

Term	Description
CoRTN	United Kingdom Department of Environment entitled "Calculation of Road Traffic Noise (1998)"
dB(A)	Decibel (A weighted)
DEC	Department of Environment and Conservation (NSW)
DECC	Department of Environment and Climate Change (NSW)
DECCW	Department of Environment, Climate Change and Water (NSW)
Design year	10 years after project opening
DGEAR	Director-General's Environmental Assessment Report (DoP)
DPI	Department of Planning and Infrastructure (NSW)
EA	Tintenbar to Ewingsdale Environmental Assessment (RTA 2008)
ECRTN	Environmental Criteria for Road Traffic Noise (EPA 1999)
ENMM	Environmental Noise Management Manual (RTA 2001)
EPA	Environment Protection Authority (NSW)
Feasible and Reasonable	Consideration of best practice taking into account the benefit of proposed measures and their technological and associated operational application in the NSW and Australian context. **Feasible** relates to the engineering considerations and what is practical to build. **Resonable** relates to the application of judgement in arriving at a decision, taking into account mitigation benefits and cost of mitigation versus benefits provided, community views and naure and extent of potential improvements.
Free-field	Location where noise measurments are conducted outdoors at least 3.5 m from any acoustic reflecting structures other than the ground.
Future-Existing	Pre-construction scenario at project opening year
HV	Heavy vehicle
$L_{Aeq(period)}$	Equivalent sound pressure level over a specified period of time, that would produce the same energy equivalence as the fluctuating sound level actually occurring
$L_{A90(period)}$	The sound pressure level exceeded for 90% of the measurement period
$L_{A1(period)}$	The sound pressure level exceeded for 1% of the measurement period
L_{Amax}	The maximum sound level recorded during the measurement period
$L_{Aeq(15hr)}$	The L_{Aeq} noise level for the period 7.00 am to 10.00 pm
$L_{Aeq(9hr)}$	The L_{Aeq} noise level for the period 10.00 pm to 7.00 am

Term	Description
$L_{Aeq(1hr)}$	The highest hourly L_{Aeq} noise level during the day and night periods
MCoA	Minister's Conditions of Approval
OEH	Office of Environment and Heritage (NSW)
ONMR	Operational Noise Management Report
PCNA	Post Construction Noise Assessment
PCNA Procedure	Preparing a Post Construction Noise Assessment Report (Roads and Maritime, June 2014)
RBL	The rating background level which is the overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period.
RMS	Roads and Maritime Services (NSW)
RTA	Roads and Traffic Authority (NSW)
Sensitive receiver	Residence, education institution (e.g. school), health care facility (e.g. hospital) and religious facility (e.g. church)
T2E	Tintenbar to Ewingsdale

1. Introduction

1.1 Overview

GHD Pty Ltd (GHD) has been commissioned by the NSW Roads and Maritime Services (Roads and Maritime) to undertake a post construction noise assessment (PCNA) for the upgrade of 16.3 km of the Pacific Highway between Tintenbar and Ewingsdale.

The PCNA has been undertaken based on the Post Construction Noise Assessment Report Procedure (Roads and Maritime, June 2014, v1.2) to address the objectives of the Minister's Conditions of Approval (MCoA). The MCoA refers to the The Environmental Criteria for Road Traffic Noise (EPA, May 1999) (ECRTN) which is applicable for the operation of the Project.

1.2 Background

The upgrade of the Pacific Highway between Tintenbar and Ewingsdale (the Project) is part of the Pacific Highway Upgrade Program, being implemented by Roads and Maritime.

Key components of the Project includes:

- Four-lane divided carriageways (two lanes each way with three lanes near Ewingsdale, Bangalow and Ross Lane Interchanges), with a wide median allowing for the future addition of a third lane in each direction.
- Connection to the northern end of the completed Ballina bypass at the Ross Lane interchange. Provision of new northbound on-ramp and a new southbound off-ramp. The remainder of this interchange has been constructed as part of the Ballina bypass project.
- Upgrading the existing Ewingsdale interchange to provide full access between the modified local and regional road network and the highway.
- A half interchange at Bangalow. South-facing ramps to provide access between the local road network, including to Bangalow and Lismore and the proposed upgrade to the south.
- A number of twin bridges, two local road underpasses and two overbridges. This includes twin bridges above Byron, Emigrant and Skinners creeks and the existing Casino-Murwillumbah railway on the northern side of Byron Creek.
- Twin parallel tunnels under St Helena ridge (one tunnel for each carriageway). The tunnels are about 434 m long and about 45 m below St Helena Road.
- Retention of the existing highway as a continuous road for local and regional traffic.
- Installation of signage providing clear directions for traffic on approach to and at the Ross Lane, Bangalow and Ewingsdale interchanges.
- Relocation of a number of public utilities and services.

An Operational Noise Management Report was prepared for the Project in 2014 ('ONMR', Pacific Highway Upgrade Tintenbar to Ewingsdale *Final Design Operational Noise Management Report GHD* 6 March 2014), with the objective being to manage operational road traffic noise from the Project and ensure appropriate operational noise mitigation measures are designed and installed to minimise noise impacts on the community.

1.3 Objectives

The purpose and objective of this PCNA is as follows:

- Monitor post construction traffic noise levels and traffic volumes.
- Use measured traffic noise and volume data to prepare a validated noise model.
- Account for the delayed project opening from 2014 to 2016.
- Use the PCNA Procedure to assess if the predicted noise levels have been met or exceeded and determine whether additional mitigation measures should be considered.
- Review of the operational noise levels in terms of criteria and noise goals established in the Environmental Criteria for Road Traffic Noise (EPA, 1999) to identify if any additional feasible and reasonable measures are required.

1.4 Scope

The following tasks were undertaken as part of this assessment:

- Property owners at the proposed monitoring locations were contacted to obtain permission for noise logger placement.
- Unattended long term road traffic noise monitoring was undertaken at 26 receiver locations for a minimum of seven days. The noise monitoring data was used for the post construction operational noise model verification process. Additionally, 15 minute attended measurements were undertaken at the logger locations to enable the identification of local noise sources and the nature of traffic noise in the area.
- Traffic counts were undertaken simultaneously with the noise measurements utilising 42 MetroCount 5600 loggers at 29 sites.
- Noise modelling has been undertaken based on the PCNA Procedure. The year of opening was delayed by two years from forecast 2014 to actual 2016. To address the requirements of the MCoA and account for the delay in project opening, traffic volumes have been re-forecast from forecast 2014 to the actual opening year of 2016 and from 2024 to 2026.
- Noise assessment was also undertaken with respect to the ECRTN criteria for the design year 2026 and Practice Note iv of the ENMM.
- Receivers would be identified for possible additional noise mitigation treatments where considered reasonable and feasible according to the ENMM.

1.5 Limitations

This report has been prepared by GHD for Roads and Maritime Services and may only be used and relied on by Roads and Maritime Services for the purpose agreed between GHD and Roads and Maritime Services as set out in Section 1.4 of this report. GHD otherwise disclaims responsibility to any person other than Roads and Maritime Services arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report. The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

GHD accepts no responsibility for the integrity of the software coding of the approved acoustic model (SoundPLAN) used.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report (Section 1.4). GHD disclaims liability arising from any of the assumptions being incorrect. GHD has prepared this report on the basis of information provided by Roads and Maritime Services and others who provided information to GHD, which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

It is not the intention of the assessment to cover every element of the acoustical environment, but rather to conduct the assessment with consideration to the prescribed work scope. The findings of the acoustic assessment represent the findings apparent at the date and time of the monitoring and the conditions of the area at that time. It is the nature of environmental monitoring that not all variations in environmental conditions can be accessed and all uncertainty concerning the conditions of the ambient noise environment cannot be eliminated. Professional judgement must be exercised in the investigation and interpretation of observations.

2. Requirements and policy

2.1 Minister's conditions of approval

As part of the Minister's Conditions of Approval (MCoA) relating to the operation of the Project, post-construction operational noise monitoring is required to be undertaken. Table 2-1 summarises the MCoAs relevant to the operational noise of the Project.

Table 2-1 **Minister's Conditions of Approval**

No.	Original reference	Relevant requirement	PCNA reference
1	Schedule 2 – 2.19	Operational noise Unless otherwise agreed to by the Director General, the Proponent shall submit for the approval of the Director General a review of proposed operational noise mitigation measures identified in the documents listed under Condition 1.1 within six months of commencing construction. The review shall take into account the detailed design of the project and where feasible and reasonable, refine the proposed measures with the objective of meeting the criteria outlined in the Environmental Criteria for Road Traffic Noise (EPA, 1999). The review shall be undertaken in consultation with the DECCW.	Completed – Tintenbar to Ewingsdale 100% Design Noise Report (ONMR) (GHD, 6 March 2014)
2	Schedule 2 – 3.3	Noise auditing No later than one year after commencement of operation of the project, or as otherwise agreed by the Director General, the Proponent shall undertake operational noise monitoring to compare actual noise performance of the project against noise performance predicted in the review of noise mitigation measures required by Condition 2.19 and prepare an Operational Noise Report. The Report shall include, but not necessarily be limited to: a) Noise monitoring to assess compliance with the operational noise levels predicted in the review of operational noise mitigation measures required under Condition 2.19 and documents specified under Condition 1.1 of this approval. b) A review of the operational noise levels in terms of criteria and noise goals established in the Environmental Criteria for Road Traffic Noise (EPA, 1999). c) Methodology, location and frequency of noise monitoring undertaken, including monitoring sites at which project noise levels are ascertained, with specific reference to locations indicative of impacts on sensitive receivers. d) Details of any complaints and enquiries received in relation to operational noise generated by the project between the date of commencement of operation and the date the report was prepare.	This report Section 5 Section 0 Section 5 Appendix G

No.	Original reference	Relevant requirement	PCNA reference
		e) Any required recalibrations of the noise model taking into consideration factors such as noise monitoring undertaken and actual traffic numbers and proportions.	Section 5
		f) An assessment of the performance and effectiveness of applied noise mitigation measures together with a review and if necessary, reassessment of all reasonable and feasible mitigation measures.	Section 0
		g) Any additional feasible and reasonable measures to those identified in the review of noise mitigation measures required by Condition 2.19, that would be implemented with the objective of meeting the criteria outlined in the Environmental Criteria for Road Traffic Noise (EPA, 1999), when these measures would be implemented and how their effectiveness would be measured and reported to the Director General and the DECCW. The Proponent shall provide the Director General and the DECCW with a copy of the Operational Noise Report within 60 days of completing the operational noise monitoring referred to in (a) above, or as otherwise agreed by the Director General.	Section 0

2.2 Environmental Criteria for Road Traffic Noise

The ECRTN criteria are reproduced in Table 2-2. Noise criteria applicable to the Project were derived as part of the 2014 ONMR assessment and adjusted to account for the actual year opening of 2016 and 2026.

The ECRTN provides non-mandatory traffic noise target levels for residential receivers near new roads and redevelopment of existing roads. The target levels should aim to be achieved 10 years after project opening.

The Project is classed as a freeway or arterial road as it is a road handling through-traffic, with characteristically heavy and continuous traffic flows during peak periods. With consideration to the ECRTN, the entire Project is classed as a 'new' road for each receiver location, with the exception of a small section south of the Clover Hill area, which is classed as a road 'redevelopment'.

Table 2-2 provides the ECRTN road traffic noise target levels for residential receivers and other sensitive land uses near new and redeveloped roads. The target noise levels are applicable at one metre from the most affected building façade.

Table 2-2 ECRTN Operational traffic noise target levels, $L_{Aeq(period)}$ dB(A)

Situation	Day (7.00 am – 10.00 pm)	Night (10.00 pm – 7.00 am)	Where criteria are already exceeded
New freeway or arterial road corridor	55 $L_{Aeq(15hr)}$	50 $L_{Aeq(9hr)}$	The new road should be designed so as not to increase existing noise levels by more than 0.5 dB. Where feasible and reasonable, noise levels from existing roads should be reduced to meet the noise criteria. In some instances this may be achievable only through long-term strategies such as improved planning, design and construction of adjoining land use developments, reduced vehicle emission levels through new vehicle standards and regulation of in-service vehicles, greater use of public transport and alternative methods of freight haulage.
Redevelopment of existing freeway or arterial road.	60 $L_{Aeq(15hr)}$	55 $L_{Aeq(9hr)}$	In all cases, the redevelopment should be designed so as not to increase existing noise levels by more than 2 dB. Where feasible and reasonable, noise levels from existing roads should be reduced to meet the noise criteria. In some instances this may be achievable only through long-term strategies such as improved planning, design and construction of adjoining land use developments, reduced vehicle emission levels through new vehicle standards and regulation of in-service vehicles, greater use of public transport and alternative methods of freight haulage.
Proposed school classrooms	40 $L_{Aeq(1hr)}$ internal		To achieve the internal noise criteria in the short term the most practical mitigation measures are often related to building or façade treatments. Where existing levels of traffic noise exceed the criteria, all feasible and reasonable noise control measures should be evaluated and applied. Where this has been done and the internal or external criteria (as appropriate) cannot be achieved, the proposed road or land use development should be designed so as not to increase existing traffic noise levels by more than 0.5 dB(A) for new roads and 2 dB(A) for redeveloped roads.
Existing school classroom	45 $L_{Aeq(1hr)}$ internal	-	
Hospital wards	35 $L_{Aeq(1hr)}$ internal	35 $L_{Aeq(1hr)}$ internal	
Places of worship	40 $L_{Aeq(1hr)}$ internal	40 $L_{Aeq(1hr)}$ internal	
Active recreation areas	60 $L_{Aeq(15hr)}$	-	
Passive recreation and school playgrounds	55 $L_{Aeq(15hr)}$ (when in use)	-	

2.3 PCNA Procedure

The PCNA procedure is used to assess the predicted noise levels have been met or exceeded and determine whether additional mitigation measures should be considered. Section 2 of the procedure states, *"The procedure applies to the preparation of a PCNA report and should be completed when a PCNA has been required through Minister's Conditions of Approval or where noise compliants have been received following project opening".*

The PCNA Procedure requires that a comparison of the predicted noise from the validated PCNA model using forecast opening volumes is to be made with the predicted noise from the detailed design noise report. The PCNA procedure flow chart is provided in Figure 2-1.

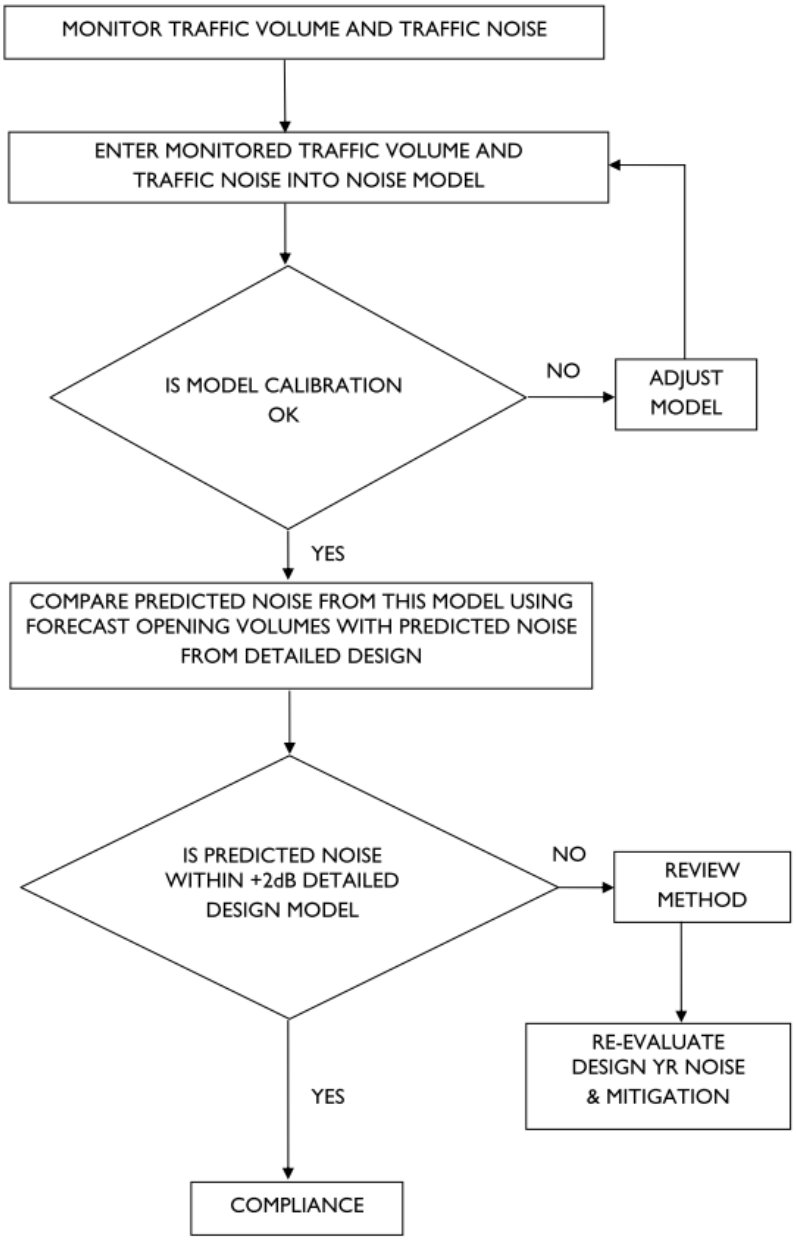


Figure 2-1 Post construction noise assessment flow chart (Source: Roads and Maritime[1])

[1] Procedure – Preparing a Post Construction Noise Assessment Report, Roads and Maritime Services, June 2014

2.4 Environmental Noise Management Manual

Practice note (iv) of the ENMM provides guidance for selecting 'Feasible and Reasonable' noise mitigation measures for reducing road traffic noise impacts at residences.

The approach adopted during the design stage of the Project was consistent with the ENMM which states:

"It is generally not 'reasonable' to take action to reduce predicted noise levels through the adoption of measures (such as noise barriers/mounds, architectural treatments and quieter pavement surfaces) beyond the adoption of all feasible and reasonable traffic management and other road measures:

[1] For proposed *"new" roads and road "redevelopments" the RTA believes it is generally not "reasonable" to take action to reduce predicted noise levels to the target noise levels if the noise levels with the proposal, ten years after project opening, are predicted to be:*

- *Within 2 dB(A) of "future existing" noise levels (the noise levels from existing sources of road traffic noise predicted for the time of project opening), and*
- *No more than 2 dB(A) above the target noise levels set out in columns 2 and 3 of Table 1 in ECRTN.*

This approach is based on the insignificance of the changes in noise levels involved and the insignificant exceedances of the target noise levels."

[2] For proposed "redevelopments" of roads where existing noise levels already exceed the ECRTN target noise levels and all "feasible and reasonable" traffic management and noise-reducing design opportunities have been incorporated into the road design, the RTA believes it is generally not "reasonable" to apply additional treatments such as noise barriers/mounds, quieter pavement surfaces and architectural treatment of private dwellings if the predicted design year noise levels:

- *Do not exceed the ECRTN allowances (in column 4 of Table 1 in the ECRTN) over the "future existing" noise levels (the noise levels from existing sources of road traffic noise predicted for the time of project opening), and*
- *Will not be acute (i.e. the noise levels are predicted to be less than 65 dB(A) $L_{eq(15hr)\ (day)}$ and 60 dB(A) $L_{eq(9hr)\ (night)}$).*

Therefore, the ENMM considers it reasonable to consider noise mitigation options when:

- There is no existing road traffic noise exposure and the year 2026 Design noise levels are greater than 0.5 dB(A) above the ECRTN traffic target noise levels.
- There is existing road traffic noise exposure above the noise target levels and the year 2026 Design noise levels are:
  - 2 dB(A) above the year 2016 Future Existing noise levels for the redeveloped road criteria.
  - 0.5 dB(A) above the year 2016 Future Existing noise levels for the new road criteria.
- When there is existing road traffic noise exposure and the year 2026 Design noise levels are at or above the acute 65 $L_{Aeq(15hr)}$ Day and 60 $L_{Aeq(9hr)}$ night noise levels.

2.5 Maximum noise levels

The MCoA does not specifically require an assessment of maximum noise levels to be considered during the development of noise mitigation for assessed sensitive receivers. However, maximum noise levels were previously assessed as part of the detailed design with consideration to the ECRTN.

The ECRTN does not provide specific criteria relating to sleep disturbance events, however does recommend that an assessment of maximum noise levels during each hour of the night time period (10:00 pm to 7:00 am) from road traffic be undertaken where impacts may occur during the night.

The ENMM states:

> *'The maximum noise assessment should be used as a tool to help priortise and rank mitigation strategies, but should not be applied as a decisive criterion in itself'*

The ECRTN provides a literature review of international sleep disturbance research, which indicates that:

- Maximum internal noise levels below 50-55 dB(A) are unlikely to cause awakening reactions.
- One or two noise events per night with maximum internal noise levels of 65-70 dB(A) are not likely to significantly affect health and well-being.

Practice Note (iii) of the ENMM states:

At locations where road traffic is continuous rather than intermittent, the $L_{Aeq(9hr)}$ (night) target noise levels should sufficiently account for sleep disturbance impacts.

However, where the emergences of L_{Amax} over the ambient L_{Aeq} is equal to or greater than 15 dB(A), the $L_{Aeq(9hr)}$ criteria may not sufficiently account for sleep disturbance impacts.

A "maximum noise event" can therefore be defined as any pass-by for which:

- L_{Amax} noise level > 65 dB(A) where $L_{Amax} - L_{Aeq(1hr)} \geq 15$ dB(A).

Sleep disturbance impacts are likely to be dependent on the following:

- Maximum noise level of an event
- Number of occurrences
- Duration of the event
- Level above background or ambient noise levels.

3. Review of mitigation measures

Roads and Maritime carried out extensive investigations into noise impacts of the Project as part of the Environmental Assessment and during progressive design stages. These mitigation measures included location, length and heights of noise mounds and noise walls, as well as the use of low noise pavement along specific sections of the Project. Roads and Maritime has also carried out at residence acoustic treatment at nominated receivers along the Project alignment. These noise mitigation measures were incorporated into the detailed design and were included in the ONMR and this PCNA. The following sections summarise the noise mitigation measures implemented on this Project to reduce noise impacts at receivers.

3.1 Stakeholder consultation

Community consultation was undertaken throughout the design stage of the Project with regards to operational noise mitigation:

- Roads and Maritime conducted extensive consultation with affected residents throughout the design stage to determine at residence acoustic treatments, having regards to the predicted impacts, the specifics of each dwelling and the landowners' preferences.
- Roads and Maritime and Baulderstone (Lendlease) jointly presented a review of operational noise management on the Project. The presentation was given to both separate landowner groups and the broader community between 19 March and 26 March 2013 to gather the community's views and opinions. The presentation included a review of operational noise mitigation measures, including the improvement in road gradients, low pavement sections, noise walls and mounds.

The ONMR was forwarded to the NSW Environment Protection Authority (EPA) for comments on 11 March 2013, which was within six months of construction commencement with consideration to MCoA 2.19. EPA advised on 2 May 2013 that, from its point of view, this ONMR appropriately addressed operational noise issues.

Further discussion of noise mitigation options, as detailed in the ENMM, is provided in the following sections.

3.2 Low noise pavements

In areas with posted traffic speeds of 70 km/h or more, for all vehicles in a reasonable state of maintenance, the dominant source of road traffic noise is in the interaction between the road pavement and tyres. Therefore, reduction of road tyre noise can be a useful noise reduction treatment.

The type of road surface can have a significant impact on the level of traffic noise generated by the pavement and tyre interaction, as indicated in Table 3-1 of the ENMM, detailed below.

Table 3-1 Road surface noise corrections, relative to dense graded asphaltic concrete (Source: ENMM)

Surface type	Noise level variation, dB(A)		
	Traffic Noise	Individual vehicle pass-by noise	
		Cars	Trucks
14 mm chip seal	+ 4.0	+ 4.0	+ 4.0
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
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

Stone mastic asphalt (SMA) pavement was used throughout a significant portion of the Project as follows:

- Chainage 18450 (southern approach slab of twin bridges over Minor Creek) to Chainage 21600 (northern approach slab of twin bridges over Skinners Creek).
- Chainage 23000 (dual carriageway overpass south of Bangalow) to Chainage 25700 (northern approach slab of bridge over Tinderbox Road) (through Bangalow area).
- Front face of the northern portal of St Helena Tunnel to the northern extent of the Project (Ewingsdale area).
- Bangalow northbound off-ramp from the carriageway to approximately 10 m from the Bangalow Road roundabout.
- Service road from the Bangalow roundabout to Chainage 24050.
- Ewingsdale northbound off-ramp from Chainage 29800 to Chainage 29650.
- Service road from the Ewingsdale Interchange Western Connection to Chainage 29600.

Other areas of the main carriageway use concrete with transverse tyning and longitudinal hessian drag. The service roads other than mentioned above and other local roads have remained as dense graded asphaltic concrete.

3.3 Minimising road gradients

Reducing the road gradient can minimise road traffic noise levels through creating smoother traffic flows and reducing acceleration noise and engine/exhaust brake noise. The ENMM states that a "*5% reduction in road gradient will reduce L_{eq} traffic noise levels by about 1.5 dB(A)*".

The Project design has minimised road gradients as much as possible, particularly in areas such as St Helena hill and significantly reduces the road gradients when compared to the existing Pacific Highway.

3.4 Low noise bridge joints

The Project has six twin bridges and two overbridges. Bridge joints have been designed and selected to reduce vehicle noise impacts.

Standard bridge joints were designed in accordance with Roads and Maritime Bridge Technical Direction BTD 2008/10, which considers the noise impacts of joints. The joints were designed to be flat and provide a smooth transition from the bridge deck to the approach slabs.

Further details are provided below:

- Finger plate expansion joints are provided at the abutments to accommodate the movement of the twin bridges. A fingerplate joint type is selected due to the skew angle, as this joint type can be easily manufactured to suit the skew, without gaps occurring between the fingers. The rigid fixing of the joint to the deck and abutment, combined with the single steel contact surface means that the vibrations due to vehicular use are minimal and the noise emitted is limited.
- Strip seal joints are used where justified by the movement range and skew of the bridge. The effect of racking of the gland due to the skew has been discussed with the joint manufacturer and is not detrimental to the performance of the joint. The rigid fixing of the joint to the deck and abutment, combined with the single steel contact surface means that the vibrations due to vehicular use are minimal and the noise emitted is limited.

3.5 Roadside noise mounds and noise walls

Acoustic barriers and noise mounds provide immediate reductions in road traffic at the shielded properties. To gain maximum effectiveness the noise wall or noise mound must intersect the line-of-sight between the traffic noise sources and sensitive receiver. The closer its location to the noise source or receiver, the greater the attenuation provided.

With consideration to Practice Note (iv) of the ENMM and previous experience, earth mounds and noise walls are generally only considered as reasonable and feasible when the sensitive receivers are clustered, i.e. a group of three or more affected sensitive receivers exist within 50 m of each other. In addition, earth mounds and noise walls are most effective when the receiver is close (e.g. within 100 m) to the traffic noise source and are subject to adequate space within the corridor and access to fill material. As part of the PCNA, the as-built survey was compared to the design detailed in the ONMR. A number of additional noise mounds were built, as well as the finalisation of wall locations. The as-built locations of these mounds and barriers have been included in this noise assessment.

For an individual receiver, architectural treatment would generally be the recommended option. The design of the noise walls and mounds as implemented in the Project are as follows:

Noise barrier, Ewingsdale:

- North of the tunnel on the east side of the southbound carriageway and merges in with the noise mound (described below).
- 4.5 m high and 580 m in length.
- Transparent to retain landscape views of Cape Byron with trees, shrubs and grasses planted on the lower slopes.

Noise mound, Ewingsdale:

- Merges in with the noise wall on the edge of the southbound carriageway.
- 8 m high and 945 m in length.
- Designed to be integrated with the natural landscape, densely vegetated on both sides to provide a visual buffer to Ewingsdale and to retain the dominance of the scenic landscape.

Noise mound, Clover Hill (Bangalow):

- 5.5 m high increasing to 11 m high then dropping down to 2.5 m high.
- 515 m in length running parallel to the existing Pacific Highway.
- Designed to be concealed by landscape planting on both sides.

Noise mound, Newrybar:

- 4.5 m high and 405 m in length running along the northbound carriageway.
- Designed to integrate with the natural landform and vegetation pattern.

Additional noise protection is provided from glare barriers, ramp walls and fences present along the alignment. These include:

- A 2.8 m light glare barrier south of Bangalow, 200 m in length.
- Local fences around properties north of Bangalow intersection.

These barriers and fences have been included as part of the post construction noise assessment.

3.6 At residence treatment

Individual house treatments can be provided where the external road traffic noise criteria (as prescribed in the ECRTN) will be exceeded and other mitigation measures are impractical or not cost-effective. Architectural treatments may also be required in conjunction with other mitigation measures such as low noise pavements or noise barriers if reasonable and feasible.

With consideration to the ENMM, “mitigation measures should be designed to achieve the internal noise levels that would have prevailed had the external traffic noise criteria been able to be achieved. Most buildings will achieve an internal noise level 10 dB(A) below the external noise level with the windows open, without providing additional treatment.”

Approaches to the acoustic treatment of buildings include:

- Improved window glazing and door construction in the facades exposed to the road.
- The installation of fresh air ventilation systems, which allows windows and doors to be closed.
- The installation of courtyard walls.

Roads and Maritime has identified a number of residences as requiring architectural treatment and has carried out negotiations with the community. Theses residences are generally isolated and have not benefited substantially from at-road noise mitigation.

4. Locality

4.1 Study area/catchment areas

The project is located in a primarily rural area, featuring scattered dwellings, pockets of built-up residential areas and a number of plantation farms. The following sections outline and describe the types of sensitive receivers identified in the vicinity of the project, with these receivers shown in Appendix A.

4.1.1 Residential receivers

Residential receivers form the vast majority of sensitive receivers along the Project route. These are identified in Appendix A.

4.1.2 Educational facilities

Newrybar Public School is located at the corner of the old Pacific Highway and Broken Head Road in Newrybar and is identified in Appendix A. The school's sportsgrounds and buildings are approximately 50 and 100 m from the edge of T2E respectively.

There are no other educational facilities in the vicinity of the Project.

4.1.3 Health care facilities

Feros Village, Bangalow is located at the corner of Ballina Road and Bangalow Road in Bangalow and is identified in Appendix A. The facility provides long-term and short-term care to seniors needing 24-hour nursing, personal and dementia support. The facility is capable of supporting 64 residents. The facility is located approximately 300 m west from the edge of T2E (Bangalow Interchange northbound off-ramp).

There are no other health care facilities in the vicinity of the Project.

4.1.4 Places of worship

Ewingsdale Church (St Columba's) is located off Old Pacific Highway in Ewingsdale and is shown in Appendix A. The site is approximately 160 m from the edge of T2E (Ewingsdale Interchange on-ramp).

There are no other places of worship in the vicinity of the Project.

4.1.5 Active recreation areas

Active recreation areas are characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion. Along the Project route, only Bangalow Oval and Sports field (off Bangalow Road) has been identified as an active recreation area.

4.1.6 Passive recreation areas and school playgrounds

Passive recreation areas are characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, for example, reading and meditation.

Newrybar Public School grounds and the recreation area of Macadamia Castle have been identified as fitting into this receiver category.

4.1.7 Community centres

Ewingsdale Community Hall is located off Old Pacific Highway in Ewingsdale. The site is approximately 160 m from the edge of T2E (Ewingsdale Interchange on-ramp) and is situated next to Ewingsdale Church (St Columba's).

Newrybar Community Hall is located off Old Pacific Highway in the village of Newrybar.

These community centres are shown in Appendix A.

5. Monitoring

5.1 Overview

Schedule 2 – 3.3 of the Minister's Conditions of Approval states that the post-construction noise monitoring is required no later than one year after the commencement of the operation of the Project.

Practice Note viii of the ENMM provides a post-construction monitoring protocol for post-construction noise monitoring and the evaluation of noise control performance for "new" and "redeveloped" roads. This PCNA has been performed with guidance from this document.

The ENMM recommends the following:

- The monitoring is generally conducted to give a minimum of seven consecutive days of data.
- Classified traffic monitoring needs to be conducted simultaneously with the noise monitoring to identify traffic flows and mixes.

Practice Note viii of the ENMM gives further guidance for post construction noise monitoring and states:

> *"Post-construction monitoring is undertaken to determine whether the mitigation measures have been adequate for the predicted design noise levels to be met.*
>
> *The "Design Noise Level for Year 1" is the noise level for the road development at project opening, after all feasible and reasonable mitigation strategies have been applied.*
>
> *Provided traffic flows and mixes following the road's opening are in line with those used for the predictions, it can be expected that if the predicted noise levels for Year 1 are achieved the predicted Year 10 noise levels will also be achieved.*
>
> *It should be recognised that noise prediction modeling has some accuracy limitations and will commonly produce acceptable errors of around 2 dB(A). In addition, when noise levels for a new road are being monitored short-term and uncharacteristic variations in traffic flow need to be taken into account when comparing the measured and predicted noise levels."*

The post construction noise assessment has been undertaken within one year following the completion of the Roads and Maritime Pacific Highway Tintenbar to Ewingsdale upgrade project.

RMS recognise that it is generally not practicable to measure noise levels at all receivers included in an assessment. Given the extensive number of receivers involved in this assessment, noise logging was conducted during August 2016 at 26 residential receiver locations to obtain road traffic noise levels in accordance with the Roads and Maritime PCNA Procedure. Simultaneous traffic counts were undertaken at 29 locations using 42 MetroCount loggers during the monitoring period. The noise measurement and traffic count results are then used to validate the noise model. The validated noise model was used to determine the 2016 and design year 2026 noise levels at all sensitive receivers.

5.2 Unattended (long-term) noise logging

Noise logging was undertaken using a combination of SVAN 955, SVAN 977 and Larson Davis 831 noise loggers, which were all within current NATA accredited calibration. These instruments conform to the requirements of Type 1 or Type 2 as set out in AS 1259.2 (1990) *Acoustics – Sound Level Meters – Integrating – Averaging* or AS IEC 61672.1 (2013) *Electro Acoustics - Sound Level Meters Specifications*.

The noise loggers were deployed over two days from 15 August to 16 August and were retrieved between 23 August and 26 August 2016. This provided sufficient time to enable a full seven days of data to be captured, allowing for any periods of adverse weather during the survey to be excluded. The loggers were programmed to accumulate A-weighted, fast time response environmental noise data continuously over sampling periods of 15 minutes for the entire logging duration.

Pre-measurement calibration checks were performed on the noise monitoring equipment using a sound level calibrator with a sound pressure level of 94 dB(A) at 1 kHz. At completion of the measurements, the meter's calibration was re-checked to ensure that the sensitivity of the noise monitoring equipment had not varied. The noise loggers were found to be within the acceptable tolerance of ± 0.5 dB(A).

Logged data was reviewed to exclude any anomalous data and data potentially affected by adverse weather conditions. Meteorological data for the monitoring period in 30-minute intervals was sourced from two Roads and Maritime weather stations near Talofa and Newrybar.

It should be noted that on the afternoon of Tuesday 16 August, traffic was diverted on to the old Pacific Highway (Hinterland Way) due to a traffic incident which resulted in the closure of new Pacific Highway. Traffic diversions were in place from approximately 4.00 pm to 10.00 pm on 16 August. This data was excluded from the assessment due to atypical traffic flows. Although not specifically required for this PCNA, this information is useful as it provides an indication of traffic noise levels experienced on the Old Pacific Highway (Hinterland Way) i.e. representative of no-build future existing 2016 scenario. This is discussed further in Section 6.5.

5.2.1 Noise monitoring locations

Long term unattended, short-term attended and maximum (L_{Amax}) noise monitoring was undertaken at locations selected in consultation with Roads and Maritime and relevant land holders. The locations were selected based on the following:

- Locations previously used for monitoring as outlined in the ONMR (GHD 2014).
- Areas where previous noise modelling has indicated future design noise levels will be marginally within 2 dB(A) of the adopted criteria.
- Areas where complaints relating to operational traffic noise have been received.

Noise logging equipment was placed at each location at a position considered to be safe and secure to minimise the risk of vandalism or tampering. Locations were also selected based on other factors such as proximity to extraneous non-traffic noise sources (e.g. air conditioners, pool pumps, inverters etc). Where possible, loggers for single storey residences were placed at one metre from the building façade most exposed to traffic noise, with microphones at a height of 1.2 m to 1.5 m above floor level. In some instances, the most affected façade was located on the first floor level, therefore loggers were positioned accordingly depending on the applicable building.

It should be noted that where possible, noise monitoring was conducted at the locations previously used for monitoring as outlined in the ONMR. However, in some instances the previous monitoring locations may not necessarily represent the most exposed façade of a building due to the old Pacific Highway and the project being on opposite sides of a particular property. Therefore, monitoring locations for this PCNA may be at different locations to previously monitored in the ONMR.

Table 5-1 provides details of the noise loggers. Noise monitoring locations are shown in Appendix A.

Table 5-1 Unattended noise monitoring locations

Logger ID	Receiver ID	Address	Equipment type and serial no.	Date deployed	Date retrieved	
L01	1307-HO1	61 Myocum Road, Ewingsdale	LD831 SN 3338	15/08/2016 11:43:34	25/08/2016 14:10:35	
L02	1214-HO1	66 Plantation Drive, Ewingsdale	LD831 SN 1639	15/08/2016 13:33:28	25/08/2016 14:25:09	
L03	1162-HO1	26 Plantation Drive, Ewingsdale	LD831 SN 2377	15/08/2016 14:07:44	25/08/2016 14:47:04	

Logger ID	Receiver ID	Address	Equipment type and serial no.	Date deployed	Date retrieved	
L04	2018-H01	18 St Helena Road, McLeods Shoot	SVAN955 SN 27612 SVAN955 SN 27622	16/08/2016 11:45:03	26/08/2016 14:47:43	
L05	896-HO9	17 Blackwood Crescent, Bangalow	LD831 SN 1620	15/08/2016 16:48:55	25/08/2016 13:41:41	
L06	701-HO1	Pacific Highway, Bangalow	LD831 SN 1621	15/08/2016 17:29:44	23/08/2016 05:55:39	

Logger ID	Receiver ID	Address	Equipment type and serial no.	Date deployed	Date retrieved	
L07	501-HO2	2095 Pacific Highway, Newrybar	SVAN979 SN 35873	16/08/2016 14:00:00	26/08/2016 10:45:00	
L08	485-HO1	13 Broken Head Road, Newrybar	LD831 SN 3300	16/08/2016 13:36:33	26/08/2016 11:55:33	
L09	424-HO1	16 Old Pacific Highway, Newrybar	LD831 SN 3340 SVAN977 SN45748	16/08/2016 12:59:41	25/08/2016 12:43:27	
L10	344-HO1	18 Hambly Lane, Newrybar	SVAN977 SN 36819	15/08/2016 12:45:00	25/08/2016 12:37:33	

Logger ID	Receiver ID	Address	Equipment type and serial no.	Date deployed	Date retrieved	
L11	249-HO1	1711 Pacific Highway, Knockrow	SVAN977 SN 36825	15/08/2016 15:00:00	25/08/2016 12:20:13	
L12	266-HO1	19 Ivy Lane, Knockrow	SVAN977 SN 45751	15/08/2016 14:15:00	25/08/2016 11:02:24	
L13	190-HO1	44 Martins Lane West, Knockrow	SVAN 977 SN 27614	15/08/2016 15:30:00	25/08/2016 12:02:13	

Logger ID	Receiver ID	Address	Equipment type and serial no.	Date deployed	Date retrieved	
L14	146-HO1	1404 Hinterland Way, Knockrow	SVAN955 SN27613	15/08/2016 16:00:02	25/08/2016 11:21:44	
L15	1120-HO2	St Helena Road, McLeods Shoot	SVAN955 SN 27621	15/08/2016 14:15:04	25/08/2016 15:12:06	
L16	1101-HO1	58 St Helena Rd, McLeods Shoot	SVAN977 SN 36820	15/08/2016 14:45:00	25/08/2016 14:53:43	

Logger ID	Receiver ID	Address	Equipment type and serial no.	Date deployed	Date retrieved	
L17	1122-HO1	80 St Helena Road, McLeods Shoot	SVAN955 SN 27615	16/08/2016 12:00:03	26/08/2016 15:06:53	
L18	322-HO2	14 Hambly Lane, Newrybar	SVAN977 SN 36820	15/08/2016 13:15:00	25/08/2016 12:48:48	
L19	2000-HO1	19 Ballina Road, Bangalow	LD831 SN 3339	15/08/2016 15:18:41	26/08/2016 14:26:48	

Logger ID	Receiver ID	Address	Equipment type and serial no.	Date deployed	Date retrieved	
L20	1039-HO1	7 Tinderbox Road, Talofa	SVAN977 SN36821	15/08/206 12:30:00	25/08/2016 14:15:00	
L21	132-HO1	84 Hinterland Way, Knockrow	SVAN977 SN 36826	18/08/2016 15:15:01	26/08/2016 12:17:28	
L23	137-HO1	88 Hinterland Way, Knockrow	SVAN977 SN 36823	15/08/2016 17:30:00	25/08/2016 11:41:05	

Logger ID	Receiver ID	Address	Equipment type and serial no.	Date deployed	Date retrieved	
L24	1257-HO1	85 Parkway Drive, Ewingsdale	LD831 SN 3337	15/08/2016 12:45:00	25/08/2016 09:45:00	
L25	168-HO2	38 Killen Falls Road, Tintenbar	SVAN977 SN 45748	15/08/2016 18:30:00	25/08/2016 11:39:42	
L26	T9	277 Friday Hut Road, Tintenbar	SVAN977 SN 45746	15/08/2016 19:00:00	25/08/2016 11:45:00	

Logger ID	Receiver ID	Address	Equipment type and serial no.	Date deployed	Date retrieved	
Add01	897-HO6	3 Marblewood Place, Bangalow	LD831 SN 2846 SVAN955 SN 27625	15/08/2016 16:30:00 22/08/2016 16:30:00	21/08/2016 06:45:00 26/08/2016 14:00:00	

5.2.2 Unattended noise monitoring results

Relevant road traffic noise descriptors to the post construction noise assessment are summarised in Table 5-2 for each monitoring location over the respective time periods. Noise level charts are presented in Appendix C. A detailed description of the acoustic terms can be found in the Glossary at the start of this report.

The road traffic noise monitoring results are typical of areas influenced by consistent traffic volumes and increased noise levels during the peak traffic periods. Road traffic noise is reduced at the majority of assessed locations during the night time period corresponding with lower traffic volumes.

Table 5-2 Summary of unattended noise monitoring results, dB(A)

Noise logging location	Road traffic noise descriptors (weekday)	
	$L_{Aeq(15hr)}$ (7.00 am to 10.00 pm weekdays)	$L_{Aeq(9hr)}$ (10.00 pm to 7.00 am weekdays)
L1: 61 Myocum Road, Ewingsdale	54.5	51.8
L2: 66 Plantation Drive, Ewingsdale	47.7	46.8
L3: 26 Plantation Drive, Ewingsdale	51.1	50.1
L4: 18 St Helena Road, McLeods Shoot	56.2	52.1
L5: 17 Blackwood Crescent, Bangalow	51.7	48.5
L6: 230 Pacific Highway, Bangalow	61.2	59.7
L7: 2095 Pacific Highway, Newrybar	54.8	48.2
L8: 13 Broken Head Road, Newrybar	52.7	51.5
L9: 16 Old Pacific Highway, Newrybar	54.9	51.4
L10: 18 Hambly Lane, Newrybar	53.7	53.4
L11: 1711 Pacific Highway, Knockrow	51.1	49.3
L12: 19 Ivy Lane, Knockrow	55.2	54.3
L13: 44 Martins Lane West, Knockrow	68.7	66.1
L14: 1404 Hinterland Way, Knockrow	54.3	52.4
L15: St Helena Road, McLeods Shoot	49.3	49.0
L16: 58 St Helena Road, McLeods Shoot	57.1	56.2
L17: 80 St Helena Road, McLeods Shoot	53.4	53.1
L18: 14 Hambly Lane, Newrybar	52.5	52.3
L19: 19 Ballina Road, Bangalow	57.8	56.1
L20: 7 Tinderbox Road, Bangalow	52.7	52.6
L21: 84 Hinterland Way, Knockrow	58.9	55.1
L23: 88 Hinterland Way, Knockrow	54.9	50.5
L24: 85 Parkway Drive, Ewingsdale	46.1	44.3
L25: 38 Killen Falls Road, Tintenbar	51.8	49.7
L26: 277 Friday Hut Road, Tintenbar	47.3	45.3
Add01: 3 Marblewood Place, Bangalow	52.0	51.6

5.3 Attended (short-term) noise monitoring

Attended monitoring assists with validating the noise model and is used to provide a better understanding of the ambient noise environment, extraneous prevailing noise at the subject site (e.g. dogs, birds, intermittent industrial noise, etc.) and any specific issues associated with each location.

Attended noise measurements of 15-minute duration were taken during logger deployment and during subsequent visits between 16 and 19 August 2016 during the daytime and night time periods in order to identify local noise sources and the relative contribution of traffic noise at each of the monitoring locations. Attended monitoring was also conducted at additional locations (denoted in Table 5-3 with suffix 'A') based on comments and complaints received from the community.

The attended measurements were conducted using SVAN 979 sound level meters (SLM) calibrated using either a Larson Davis CAL200 sound level calibrator (9193), a Rion NC-73 sound level calibrator (10334238) or one of two Svantek SV30A sound level calibrators (44650, 29074) at 94 dB, 1kHz. At completion of the measurements, the meter's calibration was re-checked to ensure the sensitivity of the noise monitoring equipment had not varied. The SLMs were found to be within the acceptable tolerance of ± 0.5 dB(A).

Attended noise monitoring results and observations are provided in Table 5-3.

Table 5-3 Attended noise monitoring results

Location	Period	Date/time	L_{Aeq} (15min)	L_{A90} (15min)	Observations / dominant noise sources
L1: 61 Myocum Road, Ewingsdale	Day	17/08/2016 14:15	55.3	52.3	– Constant traffic noise – Frequent car and truck passbys: 53-63 dB(A) – Bird and insect noise throughout measurement – Occasional slight wind
	Night	16/08/2016 23:38	52.8	37.9	– Occasional car and truck passbys – Occasional lulls in traffic noise – Insect noise throughout measurement
L2: 66 Plantation Drive, Ewingsdale	Day	17/08/2016 14:55	44.5	38.1	– Distant road noise audible throughout measurement – Occasional car and truck passbys: 41-50 dB(A) – Occasional lulls in traffic – Dominant bird and insect noise throughout measurement – Occasional slight wind
	Night	17/08/2016 03:10	48.1	35.3	– Distant road noise audible throughout measurement – Occasional car and truck passbys: 36-61 dB(A) – Occasional slight wind
L3: 26 Plantation Drive, Ewingsdale Mundun	Day	17/08/2016 15:21	43.2	39.4	– Constant traffic noise, distant road noise audible throughout measurement – Occasional car and truck passbys: 42-47 dB(A) – Bird and insect noise throughout measurement – Occasional slight wind

Location	Period	Date/time	L_{Aeq} (15min)	L_{A90} (15min)	Observations / dominant noise sources
	Night	17/08/2016 03:35	50.4	45.8	– Constant traffic noise – Occasional car and truck passbys: 46-66 dB(A) – Insect noise throughout measurement – Constant wind through trees
L4: 18 St Helena Road, McLeods Shoot	Day	17/08/2016 14:30	51.0	44.4	– Constant traffic noise; Old Pacific Highway dominant – Bird noise throughout measurement – Frequent car and truck passbys: 46-61 dB(A) – Residential noise
	Night	18/08/2016 00:39	45.1	35.5	– Intermittent traffic noise with occasional lulls – Occasional car and truck passbys: 42-60 dB(A) – Occasional slight wind
L5: 17 Blackwood Crescent, Bangalow	Day	17/08/2016 16:25	49.7	43.6	– Constant and controlling traffic noise – Bird and insect noise throughout measurement – Occasional noise from dog barking – Frequent car and truck passbys: 44-63 dB(A) – Residential noise
	Night	19/08/2016 00:18	45.4	36.1	– Intermittent traffic noise with occasional lulls – Insect noise throughout measurement – Occasional car and truck passbys: 41-61 dB(A)
L6: 230 Pacific Highway, Bangalow	Day	18/08/2016 14:03	60.3	55.5	– Constant and controlling traffic noise – Bird noise throughout measurement – Frequent car and truck passbys: 54-69 dB(A)
	Night	19/08/2016 01:58	56.9	35.8	– Intermittent traffic noise – Occasional car and truck passbys: 54-72 dB(A) – Intermittent insect noise – Birds audible during lulls in traffic
L7: 2095 Pacific Highway, Newrybar	Day	18/08/2016 14:31	54.7	44.8	– Constant traffic noise from T2E and Old Pacific Highway – Intermittent noise from birds – Distant road noise audible throughout – Frequent car and truck passbys: 50-64 dB(A) – Occasional slight wind
	Night	18/08/2016 23:39	43.8	32.3	– Intermittent traffic noise – Insect and bird noise audible during lulls in traffic – Occasional car and truck passbys: 44-58 dB(A)
L8: 13 Broken Head Road, Newrybar	Day	18/08/2016 14:55	50.8	44.9	– Constant traffic noise from T2E and Old Pacific Highway: 45-69 dB(A) – Insect and bird noise audible during lulls in traffic
	Night	19/08/2016 00:07	48.2	37.7	– Constant traffic noise from T2E and Old Pacific Highway: 43-59 dB(A) – Other noise sources not audible

Location	Period	Date/time	L_{Aeq} (15min)	L_{A90} (15min)	Observations / dominant noise sources
L9: 16 Old Pacific Highway, Newrybar	Day	18/08/2016 15:28	55.9	48.9	– Constant traffic noise, distant road noise audible – Bird noise throughout measurement – Pump/compressor running intermittently throughout measurement
	Night	19/08/2016 00:36	49.4	39.4	– Constant traffic noise, distant road noise audible: 38-60 dB(A) – Pump/compressor running constantly throughout measurement – Residential noise
L10: 18 Hambly Lane, Newrybar	Day	17/08/2016 17:20	52.7	48.2	– Constant and controlling traffic noise – Insect and bird noise throughout measurement – Frequent car and truck passbys: 48-61 dB(A)
	Night	19/08/2016 03:00	49.9	37.7	– Constant traffic noise – Constant noise from insects and frogs in background – Frequent car and truck passbys: 42-58 dB(A)
L11: 1711 Pacific Highway, Knockrow	Day	18/08/2016 18:04	46.8	43.0	– Constant traffic noise: 42-48 dB(A) – Truck passbys at 50 dB(A) – Intermittent noise from insects and frogs
	Night	19/08/2016 01:04	47.0	36.0	– Constant traffic noise with occasional lulls – Frequent truck passbys: 48-57 dB(A)
L12: 19 Ivy Lane, Knockrow	Day	18/08/2016 17:36	52.9	47.5	– Intermittent traffic noise – Occasional noise from insects, frogs, and birds – Occasional car and truck passbys: 52-62 dB(A) – Constant noise from machinery in background throughout back half of measurement – Residential noise
	Night	19/08/2016 02:15	55.6	32.5	– Intermittent traffic noise – Occasional noise from insects, frogs, and birds – Occasional car and truck passbys: 52-62 dB(A) – Constant noise from machinery in background throughout back half of measurement
L13: 44 Martins Lane West, Knockrow	Day	18/08/2016 16:18	67.7	57.9	– Constant and controlling traffic noise – Barely audible noise from insects – Frequent and highly audible car and truck passbys: 55-84 dB(A)
	Night	18/08/2016 01:17	64.7	43.9	– Constant traffic noise – Frequent and highly audible car and truck passbys: 60-82 dB(A) – Occasional slight wind

Location	Period	Date/time	L_{Aeq} (15min)	L_{A90} (15min)	Observations / dominant noise sources
L14: 1404 Hinterland Way, Knockrow	Day	18/08/2016 16:40	52.0	46.1	– Constant traffic noise – Intermittent noise from birds – Distant road noise audible throughout – Frequent car and truck passbys: 50-64 dB(A)
	Night	18/08/2016 01:42	49.1	39.3	– Intermittent traffic noise – Distant road noise audible throughout – Occasional car and truck passbys: 47-60 dB(A)
L15: St Helena Road, McLeods Shoot	Day	17/08/2016 14:58	51.6	46.5	– Constant traffic noise – Occasional bird calls – Frequent car and truck passbys: 49-59 dB(A) – Intermittent wind noise
	Night	17/08/2016 04:15	56.2	39.5	– Intermittent traffic noise – Frequent truck passbys: 52-68 dB(A) – Occasional noise from insects
L16: 58 St Helena Road, McLeods Shoot	Day	17/08/2016 15:51	53.0	47.5	– Constant and controlling traffic noise – Rural noise from roosters, birds, insects, horses, and dogs – Frequent car and truck passbys: 42-62 dB(A)
	Night	18/08/2016 01:56	52.3	41	– Constant traffic noise – Insect noise throughout measurement – Frequent car and truck passbys: 49-62 dB(A)
L17: 80 St Helena Road, McLeods Shoot	Day	17/08/2016 15:20	49.2	44.2	– Constant traffic noise – Occasional noise from birds – Frequent car and truck passbys entering and exiting tunnel: 43-55 dB(A)
	Night	18/08/2016 01:30	53.7	36.4	– Intermittent traffic noise – Insects audible throughout measurement – Frequent car and truck passbys entering and exiting tunnel: 40-66 dB(A)
L18: 14 Hambly Lane, Newrybar	Day	17/08/2016 17:50	47.8	42.3	– Constant traffic noise – Occasional noise from insects and birds – Frequent car and truck passbys: 44-58 dB(A) – Residential noise – Frequent noise from reversing beeper
	Night	19/08/2016 04:00	52.8	42.6	– Constant traffic noise – Occasional noise from insects and birds – Frequent car and truck passbys: 38-62 dB(A)
L19: 19 Ballina Road, Bangalow	Day	17/08/2016 17:21	56.5	52.0	– Constant traffic noise – Constant noise from insects and birds – Frequent car and truck passbys: 52-64 dB(A)
	Night	18/08/2016 22:30	57.1	47.0	– Constant traffic noise – Frequent car and truck passbys: 50-69 dB(A) – Constant noise from flowing stream nearby

Location	Period	Date/time	L_{Aeq} (15min)	L_{A90} (15min)	Observations / dominant noise sources
L20: 7 Tinderbox Road, Bangalow	Day	17/08/2016 16:38	43.0	37.9	– Constant low traffic noise hum – Constant rustling grass noise – Frequent noise from insects and birds – Frequent car and truck passbys: 43-52 dB(A)
	Night	17/08/2016 00:46	50.6	38.8	– Frequent distant traffic noise with intermittent lulls – Frequent car and truck passbys: 51-60 dB(A) – Frequent noise from insects and frogs
L21: 84 Hinterland Way	Day	18/08/2016 15:15:02	55.0	48.3	– Constant and controlling traffic noise – Frequent car and truck passbys: 47-69 dB(A) – Occasional slight wind
	Night	17/08/2016 22:53:04	57.5	46	– Constant and controlling traffic noise – Frequent car and truck passbys: 47-61 dB(A) – Residential noise
L23: 88 Hinterland Way	Day	18/08/2016 15:34	53.2	44.3	– Constant traffic noise – Frequent car and truck passbys: 48-59 dB(A) – Residential noise – Dogs barking – Occasional bird calls
	Night	18/08/2016 02:04	50.6	38.1	– Constant traffic noise – Wind through nearby trees – Frequent truck passbys: 50-57 dB(A) – Dogs barking
L24: 85 Parkway Drive, Ewingsdale	Day	17/08/2016 15:45	60.7	37.1	– Intermittent distant traffic noise with frequent lulls – Constant dominant noise from birds throughout measurement – Residential noise – Occasional wind gusts – Occasional car and truck passbys on local road: 42-85 dB(A)
	Night	17/08/2016 1:23	38.8	30.9	– Intermittent distant traffic noise with frequent lulls – Constant insect noise throughout measurement – Occasional slight wind – Occasional car and truck passbys on local road: 33-52 dB(A)
L25: 38 Killen Falls Road, Tintenbar	Day	18/08/2016 16:14	44.6	42	– Intermittent distant traffic noise – Constant bird calls throughout measurement – Constant noise from nearby waterfall throughout measurement – Occasional car and truck passbys: 43-52 dB(A)
	Night	18/08/2016 2:48	43.4	41.2	– Intermittent distant traffic noise with frequent lulls – Constant noise from nearby waterfall throughout measurement – Occasional car and truck passbys: 45-49 dB(A)

Location	Period	Date/time	L_{Aeq} (15min)	L_{A90} (15min)	Observations / dominant noise sources
L26: 277 Friday Hut Road, Tintenbar	Day	18/08/2016 16:41	46.3	40.8	– Intermittent traffic noise with frequent lulls – Constant insect, frog, and bird noise throughout measurement – Local machinery operating – Occasional car and truck passbys on local road: 45 dB(A)
	Night	18/08/2016 3:18	42.1	37	– Intermittent distant traffic noise – Constant insect and frog noise throughout measurement – Occasional car and truck passbys: 38-51 dB(A)
Add01: 3 Marblewood Place, Bangalow	Day	17/08/2016 16:49	53.8	49.6	– Constant traffic noise with occasional lulls – Intermittent noise from birds – Frequent car and truck passbys: 40-60 dB(A)
	Night	19/08/2016 02:22	49.0	35.9	– Intermittent traffic noise with occasional lulls – Occasional car and truck passbys: 49-63 dB(A)
A1 40 St Helena Road, McLeods Shoot	Night	16/08/2016 23:43	51.2	38.5	– Constant traffic noise – Constant frog noise in background and dogs barking throughout measurement – Frequent car and truck passbys entering and exiting tunnel: 43-55 dB(A)
	Night	17/08/2016 00:02	50.8	41.8	– Constant traffic noise – Constant insect noise in background throughout measurement – Frequent car and truck passbys entering and exiting tunnel
A2 8 Gumtree Place, Bangalow	Night	19/08/2016 01:34	42.2	34.2	– Intermittent traffic noise with frequent lulls – Constant insect noise throughout measurement – Occasional car and truck passbys: 38-54 dB(A)
	Night	19/08/2016 01:16	41.3	34.1	– Intermittent traffic noise with frequent lulls – Constant insect and frog noise throughout measurement – Occasional car and truck passbys: 40-50 dB(A)
A3 26 Palm Lilly Crescent	Night	18/08/2016 23:00	34.8	28.9	– Intermittent traffic noise with frequent lulls – Constant insect and bird noise throughout measurement – Occasional car and truck passbys: 36-51 dB(A) – Residential noise
	Night	18/08/2016 23:39	43.8	32.3	– No audible traffic noise – Dominant rural noise from birds, dogs, ducks, and cows. – Residential noise – Frequent wind gusts through foliage

Location	Period	Date/time	L_{Aeq} (15min)	L_{A90} (15min)	Observations / dominant noise sources
A4 8 Ballina Road, Bangalow	Night	18/08/2016 23:32	42.5	36.1	– Intermittent traffic noise with frequent lulls – Constant insect noise throughout measurement – Occasional car and truck passbys: 38-54 dB(A)
	Night	18/08/2016 23:55	40.7	35.7	– Intermittent traffic noise with frequent lulls – Constant insect noise throughout measurement – Intermittent noise from birds and cows nearby – Occasional car and truck passbys: 40-53 dB(A) – Residential noise
A5 7 Marblewood Place, Bangalow	Night	20/08/2016 02:27	39.4	34	– Intermittent traffic noise – Noise from cowl creaking on house – Occasional car and truck passbys: 40-52 dB(A) – Occasional slight wind through trees and bird calls
	Night	20/08/2016 02:45	40.8	35.2	– Intermittent traffic noise – Noise from cowl creaking on house – Occasional car and truck passbys: 40-50 dB(A) – Occasional slight wind through trees

Location	Period	Date/time	L_{Aeq} (15min)	L_{A90} (15min)	Observations / dominant noise sources
A6 11 Marblewood Place, Bangalow	Night	19/08/2016 02:42	39.8	31.1	– Intermittent traffic noise – Occasional bird calls – Occasional car and truck passbys: 40-51 dB(A)
	Night	19/08/2016 02:58	38.8	31.1	– Intermittent traffic noise with frequent lulls – Intermittent insect noise – Occasional car and truck passbys: 36-46 dB(A)
A7 15 Hinterland Way, Ewingsdale	Night	17/08/2016 00:10	46.3	37.9	– Intermittent traffic noise – Constant insect noise throughout measurement – Occasional car and truck passbys: 42-55 dB(A) – Occasional slight wind – Topography shielding noise to east of property
	Night	17/08/2016 00:27	44.2	36.9	– Intermittent traffic noise – Constant insect noise throughout measurement – Occasional car and truck passbys: 44-56 dB(A) – Occasional slight wind through trees – Topography shielding noise to east of property
A8 10 Ballina Road, Bangalow	Night	18/08/2016 22:51	47.1	37.2	– Constant traffic noise – Frog and bird noise audible in background – Occasional lulls in traffic – Frequent car and truck passbys: 48-61 dB(A)
	Night	18/08/2016 23:09	45.8	40.5	– Constant traffic noise – Constant insect noise throughout measurement – Frequent car and truck passbys: 44-57 dB(A)
A9 13 Ballina Road, Bangalow	Night	18/08/2016 02:36	45.4	36.5	– Intermittent traffic noise – No noise sources audible during lulls in traffic – Occasional car and truck passbys: 42-58 dB(A)
	Night	18/08/2016 02:58	43.8	33.4	– Intermittent traffic noise – Frog and insect noise audible in background – Occasional car and truck passbys: 34-51 dB(A)
A10 660 Bangalow Road, Talofa	Night	17/08/2016 03:34	47.6	36.5	– Constant background traffic noise – Constant insect and frog noise throughout measurement – Occasional lulls in traffic – Frequent car and truck passbys: 42-59 dB(A)
	Night	17/08/2016 03:50	49.1	41.0	– Constant background traffic noise – Constant insect and frog noise throughout measurement – Occasional lulls in traffic – Frequent car and truck passbys: 41-62 dB(A)

Location	Period	Date/time	L_{Aeq} (15min)	L_{A90} (15min)	Observations / dominant noise sources
A11 13 Blackwood Crescent, Bangalow	Night	19/08/2016 00:38	41.0	33.7	– Constant traffic noise – Occasional noise from birds – Minimal lulls in traffic – Frequent car and truck passbys: 36-51 dB(A)
	Night	19/08/2016 00:56	43.5	36.1	– Constant traffic noise – Minimal lulls in traffic – Frequent car and truck passbys: 39-54 dB(A)
A12 323 Alcorn Road, Knockrow	Night	19/08/2016 01:29	58.2	31.7	– Occasional traffic noise and car and truck passbys: 42-71 dB(A) – Occasional noise from bats in nearby trees – Frequent lulls in traffic
	Night	19/08/2016 01:45	61.3	30.6	– Occasional traffic noise and car and truck passbys: 45-75 dB(A) – Residential air conditioner audible during lulls in traffic
A13 20 Tinderbox Road, Talofa	Night	17/08/2016 02:00	42.8	29.9	– Constant traffic noise – Occasional noise from animals, dogs, and birds nearby – Occasional lulls in traffic – Frequent very audible car and truck passbys
	Night	17/08/2016 02:30	48.2	37.3	– Constant traffic noise – Dominant contributions from a cow nearby – Occasional lulls in traffic – Frequent very audible car and truck passbys
A13A 20 Tinderbox Road, Talofa	Night	17/08/2016 01:32	41.3	32.5	– Constant traffic noise – Occasional noise from animals in nearby trees and dogs barking in distance – Occasional lulls in traffic – Frequent car and truck passbys: 47-72 dB(A)
	Night	17/08/2016 02:48	51	37.7	– Constant traffic noise – Constant noise from frogs in background – Occasional lulls in traffic – Frequent car and truck passbys: 51-62 dB(A)
A14 900 Bangalow Road, Bangalow	Night	17/08/2016 04:30	56.3	41.7	– Constant traffic noise – Occasional noise from insects – Minimal lulls in traffic – Frequent car and truck passbys: 47-72 dB(A)
	Night	17/08/2016 04:48	55.8	42.8	– Constant traffic noise – Minimal lulls in traffic – Frequent car and truck passbys: 44-69 dB(A)
A15 16 Hambly Lane, Newrybar	Night	19/08/2016 04:00	52.8	42.6	– Constant traffic noise – Occasional noise from insects and birds – Frequent car and truck passbys: 38-62 dB(A)

Location	Period	Date/time	L_{Aeq} (15min)	L_{A90} (15min)	Observations / dominant noise sources
	Night	19/08/2016 04:30	49.4	38.6	– Constant traffic noise – Occasional noise from tree nuts falling from trees – Occasional lulls in traffic – Frequent car and truck passbys: 48-58 dB(A)
A17 10 Valley Court, Ewingsdale	Night	17/08/2016 02:33	40.6	31.7	– Occasional traffic noise – Occasional car and truck passbys: 35-59 dB(A) – Frequent lulls in traffic with quiet background – Occasional bird calls – Intermittent wind and insect noise barely audible
	Night	17/08/2016 02:49	44.3	33.6	– Occasional traffic noise T2E dominant – Occasional car and truck passbys: 39-56 dB(A) – Frequent lulls in traffic with quiet background – Occasional bird and insect noise – Dogs barking
A18 17 Avocado Crescent, Ewingsdale	Night	17/08/2016 01:46	41.2	33	– Occasional traffic noise T2E dominant – Occasional car and truck passbys: 40-56 dB(A) – Frequent lulls in traffic with quiet background – Intermittent wind noise barely audible
	Night	17/08/2016 02:03	38.8	32.4	– Occasional traffic noise T2E dominant – Occasional car and truck passbys: 35-56 dB(A) – Frequent lulls in traffic with quiet background – Intermittent wind noise barely audible
A19 10 Hambly Lane, Newrybar	Night	19/08/2016 03:00	49.9	37.7	– Constant traffic noise – Constant noise from insects and frogs in background – Frequent car and truck passbys: 42-58 dB(A)
	Night	19/08/2016 03:16	49.7	33.1	– Constant traffic noise – Constant noise from insects and frogs in background – Frequent car and truck passbys: 43-61 dB(A)

5.4 Traffic monitoring

Traffic volumes, classification of vehicles and vehicle speeds were monitored concurrently with the noise monitoring for 14 days.

Traffic monitoring locations are shown in Table 5-4 and also shown on maps in Appendix A.

Table 5-5 presents the counted daytime (15hr) and night time (9hr) traffic volumes and 85th percentile vehicle speeds at the assessed locations.

Table 5-4 Traffic monitoring locations

Site ID	Direction	Location details	Date deployed	Date retrieved
Site 1	NB	Kinvara Ridge Road, Tintenbar – 750 m north of Ross Lane	15/08/2016	28/08/2016

Site ID	Direction	Location details	Date deployed	Date retrieved
	SB	Kinvara Ridge Road, Tintenbar – 750 m north of Ross Lane Overpass	15/08/2016	28/08/2016
Site 2	NB	Pacific Highway, Tintenbar – 750 m north of Ross Lane overpass	15/08/2016	28/08/2016
Site 3	SB	Pacific Highway, Tintenbar – 750 m north of Ross Lane Overpass	15/08/2016	28/08/2016
Site 4	NB	Saddle Road, Tintenbar – 750 m north of Tamarind Drive	15/08/2016	28/08/2016
	SB	Saddle Road, Tintenbar – 750 m north of Tamarind Drive	15/08/2016	28/08/2016
Site 5	SB	Pacific Highway, Knockrow - 1.8 km north of Ross Lane Overpass	15/08/2016	28/08/2016
Site 6	NB	Old Pacific Highway, Knockrow – 110 m north of Caney Place	15/08/2016	28/08/2016
	SB	Old Pacific Highway 110 m north of Caney Place	15/08/2016	28/08/2016
Site 7	NB	Old Pacific Highway, Knockrow – 110 m south of Hamby Lane	15/08/2016	28/08/2016
	SB	Old Pacific Highway, Newrybar -110 m south of Hamby Lane	15/08/2016	28/08/2016
Site 8	NB	Pacific Highway, Newrybar - 1.5 km south of Broken Head Road Overpass	15/08/2016	28/08/2016
Site 9	SB	Pacific Highway, Newrybar - 1.5 km south of Broken Head Road Overpass	15/08/2016	28/08/2016
Site 10	EB	Broken Head Road, Newrybar – 550 m east of Old Pacific Highway	15/08/2016	28/08/2016
	WB	Broken Head Road, Newrybar – 550 m east of Old Pacific Highway	15/08/2016	28/08/2016
Site 11	NB	Old Pacific Highway, Newrybar – 100 m north of Broken Head Road	15/08/2016	28/08/2016
	SB	Old Pacific Highway, Newrybar – 100 m north of Broken Head Road	15/08/2016	28/08/2016
Site 12	NB	Old Pacific Highway, Bangalow – 400 m south of Bangalow Road	15/08/2016	28/08/2016
	SB	Old Pacific Highway, Bangalow – 400 m south of Bangalow Road	15/08/2016	28/08/2016
Site 13	SB	Pacific Highway, Bangalow – 400 m south of Bangalow Road	15/08/2016	28/08/2016
Site 14	SB	Pacific Highway Onramp, Bangalow – 400 m south of Bangalow Road	15/08/2016	28/08/2016
Site 15	NB	Pacific Highway Off-ramp, Bangalow – 220 m south of Bangalow Road	15/08/2016	28/08/2016
Site 16	NB	Pacific Highway, Bangalow – 220 m south of Bangalow Road	15/08/2016	28/08/2016
Site 17	NB	Pacific Highway, McLeods Shoot - 1.6 km north of Bangalow Road underpass	15/08/2016	28/08/2016
Site 18	SB	Pacific Highway, McLeods Shoot - 1.6 km north of Bangalow Road underpass	15/08/2016	28/08/2016

Site ID	Direction	Location details	Date deployed	Date retrieved
Site 19	NB	Old Pacific Highway, Ewingsdale - 1.4 km south of Myocum Road Roundabout	15/08/2016	28/08/2016
	SB	Old Pacific Highway, Ewingsdale - 1.4 km south of Myocum Road Roundabout	15/08/2016	28/08/2016
Site 20	NB	Pacific Highway, Ewingsdale – 450 m south of Myocum Road Overpass	15/08/2016	28/08/2016
Site 21	SB	Pacific Highway, Ewingsdale – 450 m south of Myocum Road Overpass	15/08/2016	28/08/2016
Site 22	EB	Myocum Road, Ewingsdale - on Overpass	15/08/2016	28/08/2016
	WB	Myocum Road, Ewingsdale - on Overpass	15/08/2016	28/08/2016
Site 23	SB	Pacific Highway Off-ramp, Ewingsdale – 240 m north of Myocum Road	15/08/2016	28/08/2016
Site 24	NB	Woodford Lane, Ewingsdale – 450 m north of Ewingsdale Road	15/08/2016	28/08/2016
	SB	Woodford Lane, Ewingsdale – 450 m north of Ewingsdale Road	15/08/2016	28/08/2016
Site 25	NB	Pacific Highway, Ewingsdale – 650 m north of Myocum Road	15/08/2016	28/08/2016
Site 26	SB	Pacific Highway, Ewingsdale – 650 m north of Myocum Road	15/08/2016	28/08/2016
Site 27	NB	Friday Hut Road, Tintenbar – 280 m south of Kitten Falls Drive	15/08/2016	28/08/2016
	SB	Friday Hut Road, Tintenbar – 280 m south of Kitten Falls Drive	15/08/2016	28/08/2016
Site 28	EB	Bangalow Road, Bangalow - west of Pacific Highway Overpass	15/08/2016	28/08/2016
	WB	Bangalow Road, Bangalow - west of Pacific Highway Overpass	15/08/2016	28/08/2016
Site 29	EB	Myocum Road, Ewingsdale – 270 m west of Roundabout	15/08/2016	28/08/2016
	WB	Myocum Road, Ewingsdale – 270 m west of Roundabout	15/08/2016	28/08/2016

Table 5-5 Weekday traffic counts, 15 hr / 9 hr (14 days)

Location details	Day (15 hr)			Night (9 hr)		
	LV	HV	85th percentile speed	LV	HV	85th percentile speed
Kinvara Ridge Road, Tintenbar – 750 m north of Ross Lane (NB)	535	70	89	34	6	94
Kinvara Ridge Road, Tintenbar – 750 m north of Ross Lane Overpass (SB)	2057	219	90	113	16	33

Location details	Day (15 hr)			Night (9 hr)		
	LV	HV	85th percentile speed	LV	HV	85th percentile speed
Pacific Highway, Tintenbar – 750 m north of Ross Lane overpass (NB)	6610	1153	110	786	533	107
Pacific Highway, Tintenbar – 750 m north of Ross Lane Overpass (SB)	5476	1544	111	677	293	110
Saddle Road, Tintenbar – 750 m north of Tamarind Drive (NB)	85	10	81	10	3	82
Saddle Road, Tintenbar – 750 m north of Tamarind Drive (SB)	37	5	83	2	1	0
Pacific Highway, Knockrow - 1.8 km north of Ross Lane Overpass (SB)	7103	1714	112	799	319	111
Old Pacific Highway, Knockrow – 110 m north of Caney Place (NB)	674	69	89	42	6	94
Old Pacific Highway 110 m north of Caney Place (SB)	650	81	93	30	6	94
Old Pacific Highway, Knockrow – 110 m south of Hamby Lane (NB)	550	46	88	40	4	91
Old Pacific Highway, Newrybar -110 m south of Hamby Lane (SB)	488	47	86	28	2	88
Pacific Highway, Newrybar - 1.5 km south of Broken Head Road Overpass (NB)	6067	1712	117	843	586	113
Pacific Highway, Newrybar - 1.5 km south of Broken Head Road Overpass (SB)	7142	1626	115	730	316	113
Broken Head Road, Newrybar – 550 m east of Old Pacific Highway (EB)	507	60	75	47	6	78
Broken Head Road, Newrybar – 550 m east of Old Pacific Highway (WB)	547	68	73	22	5	78
Old Pacific Highway, Newrybar – 100 m north of Broken Head Road (NB)	822	94	85	48	9	88
Old Pacific Highway, Newrybar – 100 m north of Broken Head Road (SB)	686	124	94	38	10	92
Old Pacific Highway, Bangalow – 400 m south of Bangalow Road (NB)	890	69	79	55	7	82

Location details	Day (15 hr)			Night (9 hr)		
	LV	HV	85th percentile speed	LV	HV	85th percentile speed
Old Pacific Highway, Bangalow – 400 m south of Bangalow Road (SB)	872	143	81	47	8	82
Pacific Highway, Bangalow – 400 m south of Bangalow Road (SB)	6571	1365	113	838	277	113
Pacific Highway Onramp, Bangalow – 400 m south of Bangalow Road (SB)	908	111	89	64	13	89
Pacific Highway Off-ramp, Bangalow – 220 m south of Bangalow Road (NB)	1019	148	77	76	21	78
Pacific Highway, Bangalow – 220 m south of Bangalow Road (NB)	6538	1239	110	800	525	107
Pacific Highway, McLeods Shoot - 1.6 km north of Bangalow Road underpass (NB)	5370	1204	113	958	472	111
Pacific Highway, McLeods Shoot - 1.6 km north of Bangalow Road underpass (SB)	6110	1577	114	739	309	113
Old Pacific Highway, Ewingsdale - 1.4 km south of Myocum Road Roundabout (NB)	4023	324	66	393	70	69
Old Pacific Highway, Ewingsdale - 1.4 km south of Myocum Road Roundabout (SB)	3781	267	62	353	43	63
Pacific Highway, Ewingsdale – 450 m south of Myocum Road Overpass (NB)	5363	1276	114	683	546	114
Pacific Highway, Ewingsdale – 450 m south of Myocum Road Overpass (SB)	5354	1233	109	643	286	107
Myocum Road, Ewingsdale - on Overpass (EB)	3130	241	61	348	37	62
Myocum Road, Ewingsdale - on Overpass (WB)	9767	925	58	680	98	59
Pacific Highway Off-ramp, Ewingsdale – 240 m north of Myocum Road (SB)	7881	671	82	828	120	82
Woodford Lane, Ewingsdale – 450 m north of Ewingsdale Road (NB)	123	14	79	8	2	78

Location details	Day (15 hr)			Night (9 hr)		
	LV	HV	85th percentile speed	LV	HV	85th percentile speed
Woodford Lane, Ewingsdale – 450 m north of Ewingsdale Road (SB)	116	16	74	10	2	0
Pacific Highway, Ewingsdale – 650 m north of Myocum Road (NB)	12926	1559	107	957	595	105
Pacific Highway, Ewingsdale – 650 m north of Myocum Road (SB)	12399	2814	111	1199	672	116
Friday Hut Road, Tintenbar – 280 m south of Kitten Falls Drive (NB)	134	15	67	16	2	71
Friday Hut Road, Tintenbar – 280 m south of Kitten Falls Drive (SB)	143	19	77	6	1	71[1]
Bangalow Road, Bangalow - west of Pacific Highway Overpass (EB)	2615	135	60	169	18	61
Bangalow Road, Bangalow - west of Pacific Highway Overpass (WB)	1506	119	62	94	10	65
Myocum Road, Ewingsdale – 270 m west of Roundabout (EB)	914	71	67	92	6	71
Myocum Road, Ewingsdale – 270 m west of Roundabout WB)	930	85	64	52	4	68

Note 1: Data not available for south-bound speed on this road, therefore assumed to be the same as north-bound.

5.5 Meteorology during monitoring

Meteorological data for the monitoring period in 30-minute intervals was sourced from two Roads and Maritime weather stations near Talofa and Newrybar. Noise measurements were reviewed and any affected by rain or wind at speeds greater than 5 m/s at the microphone were excluded from analysis.

The consideration for noise propagating meteorological conditions such as temperature inversions and wind have not been assessed as part of this PCNA as they do not form part of the requirements of the ECRTN. The ENMM also states:

"…in most cases the distances involved in traffic noise impact assessments are less than 300 m from the road and meteorological conditions have little impact on traffic noise problems over these short distances".

The traffic noise monitoring was predominantly undertaken at distances within 300 m from the Project and therefore noise propagating meteorological conditions would have little impact on the measured traffic noise levels.

6. Noise assessment

6.1 Noise modelling overview

Noise modelling has been undertaken based on the PCNA Procedure and comparison to the ECRTN criteria for the 2026 design year. The year opening has delayed 2 years from 2014 to 2016. To address the requirements of the MCoA and account for the delay in project opening the traffic volumes for the 2016 year opening assessment and 2026 have been reforecast and supplied by RMS. The assessment process includes:

- As part of the PCNA, the detailed design model was updated to incorporate any changes to as-built components that may have changed from the original design features to reflect the as-built configuration.
- Using the measured traffic noise, volumes, classifications and vehicle speed data to validate the noise model at the noise modelling locations and determine calibration adjustments.
- Using the validated noise model to predict the year opening 2016 noise levels at all receivers using the re-forecasted traffic volumes and design traffic speeds. Compare the year opening 2016 noise levels to the detailed design year opening 2014 noise levels.
- Using the validated noise model to predict the design year 2026 noise levels at all receivers using the re-forecasted traffic volumes and design traffic speeds. Compare the design year 2026 noise levels to the ECRTN criteria.

A graphical summary of the detailed design and post construction models is provided in Table 6-1.

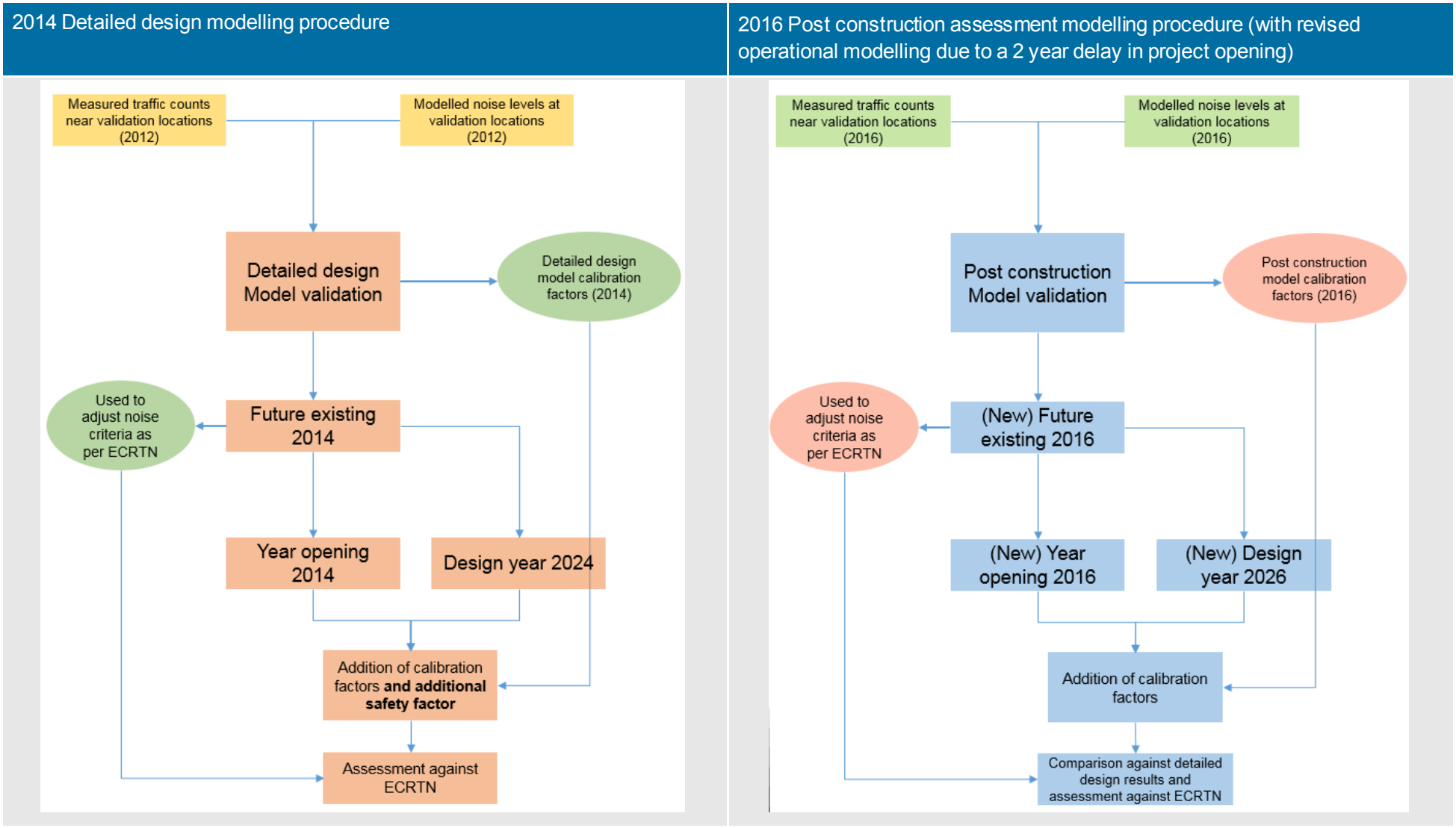
Noise predictions were undertaken using the SoundPLAN noise modelling software implementing the Calculation of Road Traffic Noise (CoRTN) algorithm, developed by the United Kingdom Department of Environment. The CoRTN algorithm is a mathematical model that has been specifically validated under Australian conditions and is accepted as the industry standard by the NSW Government. The CoRTN algorithm models road traffic noise as a broadband noise source, which is considered most appropriate for road traffic noise. Results are calculated using the A-weighted noise scale. The A-weighting scale is used to best simulate the response of the human ear. The application of the A-weighting scale is recognised in the ECRTN and has been applied for this noise assessment. For continuous high volume traffic, the L_{Aeq} descriptor has been assessed.

Noise modelling is based on the following key parameters:

- Three-dimensional road design that reflects the final height of the road, surrounding terrain, buildings and sensitive receiver locations.
- Design traffic speeds and volumes.
- Proportion of light and heavy vehicles.
- Type of road surface.
- Height and location of vehicle noise sources (tyre, engine and truck exhaust noise).
- Model calibration adjustments from noise monitoring data.

Noise modelling inputs and assumptions are discussed further in the following section.

Table 6-1 Detailed design and post construction assessment methodology summary



6.2 Modelling inputs

6.2.1 Noise modelling inputs and assumptions

The noise modelling inputs and assumptions used for the validation model, year opening 2016 and design year 2026 predictions are summarised in Table 6-2.

All modelling assumptions are consistent with the detailed design assessment except for the concrete pavement correction. The ENMM provides a pavement correction factor of between 0 to 3 dBA for tyned and dragged concrete surfaces.

The detailed design assessment used the maximum correction value of + 3 dB. However, site investigations revealed that the as-built concrete surface was a high quality ride surface, with traverse tyning and longitudinal hessian drag. Additionally, the Project design has minimised road gradients. Both of these factors have led this assessment to adopt a median concrete correction of +1.5 dB.

The use of this average value improved model validation (refer to Section 6.2).

Table 6-2 Noise model inputs and assumptions

Inputs and assumptions	Data incorporated into noise model
Verification model traffic speeds	Obtained from traffic count data, refer to Table 5-5 for traffic speeds for each section of road
Noise model	SoundPlan Version 7.2
Prediction algorithm	CoRTN
Angle increment	1.0 degree
Reflection depth	0
Number of reflections	0
Maximum search radius	2500
Contour grid spacing	20
Contour height above ground	1.5 m
Grid interpolation field size	9 x 9
Grid interpolation min / max	2 dB(A)
Grid interpolation difference	0.1 dB(A)
Calibration adjustments[1]	-1.3 day and +1.9 night
Road surface	• Concrete pavement correction: +1.5 dB(A) (main carriageway except where stone mastic asphalt (SMA)). • Dense grade asphalt pavement correction: +0 dB(A) (service roads and local roads) • Stone mastic asphalt pavement correction: – 2 dB(A)

Inputs and assumptions	Data incorporated into noise model
Australian Road Research Board correction	• -1.7 dB(A) for 'façade' • -0.7 dB(A) for 'free-field'
Road gradient	Taken into account based on the design model
Façade correction	+2.5 dB(A) to account for noise reflected from the façade of a dwelling
Source height	• Cars: 0.5 m • Truck engines: 1.5 m • Truck exhausts: 3.6 m (Exhaust modelled as 8 dB(A) quieter than the truck engine source)
Receiver heights	• Ground floor – 1.5 m above building ground level • First floor – 4.5 m above building ground level
Ground absorption	• G = 0.6 (all areas except over water) • G = 0.0 (over water)
CoRTN conversion factors	CoRTN predicts $L_{A10(1hr)}$ noise levels which is converted to the $L_{Aeq(1hr)}$ descriptor with a -3 dB(A) correction factor. Since hourly average traffic data was input for the day (15hr) and night (9hr) in the model, the $L_{Aeq(1hr)}$ is then equal to the $L_{Aeq(15hr)}$ or $L_{Aeq(9hr)}$, respectively.
As built alignment terrain	Road design as constructed
Surrounding terrain outside of design alignment	As per surveys
Buildings	Obtained from aerial photography and field observations

Note 1 – Calibration adjustments have been derived from the model validation procedure as detailed in Section 6.2.2.

6.2.2 Model validation

The purpose of model validation is to demonstrate that the noise model produced for the existing situation is an accurate representation of the real world within the limitations of the prediction algorithm and to identify potential errors associated with the geospatial data and modelling approach.

The post construction model validation process compares the modelled 2016 road traffic noise levels (using measured traffic volumes) with measured traffic noise levels to determine any variation between the measured and modelled values at each monitoring location. The average difference between the modelled and measured values are then applied as correction factors to the post construction noise models. These correction factors differ to those calculated for the detailed design assessment as the new measured data is more representative of the post-construction noise environment.

A comparison of the modelled and monitored results at the long term monitoring locations for the day and night time periods are shown in Table 6-3. The following locations have been excluded from the noise model validation process:

- L20: Located 730 m from the road alignment.
- L24: Located 770 m from the road alignment.
- L25: Located 825 m from the road alignment.
- L26: Located 1.4 km from the road alignment.

All of these locations are at a significant distance away from the source of road traffic noise and are affected by local, non-traffic noise sources. Additionally, the CoRTN noise algorithm is not considered accurate for road traffic noise predictions at these distances.

A statistical analysis of the results was then undertaken to determine the mean difference and standard deviation between the modelled and measured noise levels. The noise model typically overpredicts during the day time period and under predicts during the night time period. The mean difference and standard deviation is within 2 dB(A) during both the day and night time periods.

Where individual site differences were greater than 2 dB(A), further investigation of the monitoring data and model inputs was undertaken to identify potential reasons for these differences. Based on the investigation, it was concluded that the following factors contributed to the difference between the monitored and modelled results.

- Complex terrain including tunnel portals (and the use of geotextiles at the portal, which is not captured in the noise model).
- Ground absorption including areas of dense foliage.
- Variations in concrete and SMA road surface corrections depending on temperature and humidity.
- Extraneous noise including fauna noise (insects, frogs, dogs barking, etc.).
- Wind blowing from source to receiver locations increasing measured levels or receiver to source decreasing measured levels.
- The possibility of temperature inversions at night for noise monitors placed at distances greater than 100 m from the road.

The calibration factors derived from the model validation process are applied to the forecast 2016 and 2026 noise predictions. Overall, the validation results are considered to provide a reasonable level of confidence in the accuracy of the model.

Table 6-3 Long term monitoring location noise model verification, dB(A)

Location[1]	Day $L_{Aeq(15hr)}$			Night $L_{Aeq(9hr)}$		
	Measured	Modelled	Variation	Measured	Modelled	Variation
L1: 61 Myocum Road, Ewingsdale	54.5	54.2	-0.3	51.8	49.3	-2.5
L2: 66 Plantation Drive, Ewingsdale	47.7	47.8	0.1	46.8	43.2	-3.6
L3: 26 Plantation Drive, Ewingsdale	51.1	52.4	1.3	50.1	48.2	-1.9
L4: 18 St Helena Road, McLeods Shoot	56.2	53.8	-2.4	52.1	47.9	-4.2

Location[1]	Day $L_{Aeq(15hr)}$			Night $L_{Aeq(9hr)}$		
	Measured	Modelled	Variation	Measured	Modelled	Variation
L5: 17 Blackwood Crescent, Bangalow	51.7	50.9	-0.8	48.5	46.3	-2.2
L6: 230 Pacific Highway, Bangalow	61.2	62.2	1.0	59.7	57.5	-2.2
L7: 2095 Pacific Highway, Newrybar	54.8	55.8	1.0	48.2	47.3	-0.9
L8: 13 Broken Head Road, Newrybar	52.7	53.2	0.5	51.5	46.6	-4.9
L9: 16 Old Pacific Highway, Newrybar	54.9	56.7	1.8	51.4	50.9	-0.5
L10: 18 Hambly Lane, Newrybar	53.7	55.9	2.2	53.4	51.2	-2.2
L11: 1711 Pacific Highway, Knockrow	51.1	53.2	2.1	49.3	48.5	-0.8
L12: 19 Ivy Lane, Knockrow	55.2	58.4	3.2	54.3	53.7	-0.6
L13: 44 Martins Lane West, Knockrow	68.7	69.3	0.6	66.1	64.3	-1.8
L14: 1404 Hinterland Way, Knockrow	54.3	58.4	4.1	52.4	51.8	-0.6
L15: St Helena Road, McLeods Shoot	49.3	50.6	1.3	49.0	46.2	-2.8
L16: 58 St Helena Road, McLeods Shoot	57.1	60.7	3.6	56.2	56.3	0.1
L17: 80 St Helena Road, McLeods Shoot	53.4	52.9	-0.5	53.1	48.5	-4.6
L18: 14 Hambly Lane, Newrybar	52.5	53.3	0.8	52.3	48.6	-3.7
L19: 19 Ballina Road, Bangalow	57.8	58.3	0.5	56.1	53.7	-2.4
L21: 84 Hinterland Way	58.9	61.9	3.0	55.1	56.8	1.7
L23: 88 Hinterland Way	54.9	57.2	2.3	50.5	51.3	0.8
Add01: 3 Marblewood Place, Bangalow	52.0	53.7	1.7	51.6	49.0	-2.6
Mean difference			**+1.2**			**-1.9**
Standard Deviation			**1.5**			**1.7**

Note 1: The following logger locations have been excluded from the noise model validation process due to the distance from the alignment and associated inaccuracy in the CoRTN model at these distances: L20, L24, L25 and L26. Refer to the discussion in Section 6.2.2.

6.3 Post construction reforecast traffic volumes

The traffic data was reforecast by RMS to provide traffic volumes for the later opening year of 2016 and the new design year of 2026. The traffic data was used in the post construction noise models and is summarised in Table 6-4.

Table 6-4 Post construction reforecast AADT traffic volumes

Road section	Traffic speed (km/h)	Project opening year 2016				Design year 2026			
		Day 15hr		Night 9hr		Day 15hr		Night 9hr	
		Hourly av	% HV	Hourly av	% HV	Hourly av	% HV	Hourly av	% HV
Main Carriageway-Ewingsdale between Ramps Northbound	115 (day) 120 (night)	632	16	142	54	792	15	177	53
Main Carriageway-Ewingsdale between RampsSouthbound		1164	12	252	34	1434	12	312	34
Main Carriageway – North of Bangalow Interchange (2way)		858	14	188	44	1048	13	228	42
Main Carriageway – South of Bangalow Interchange (2way)		952	13	211	41	1212	13	266	40
Bangalow interchange Off Ramp – Northbound	80	63	8	10	13	78	7	10	10
Bangalow interchange On Ramp – Southbound	80	63	8	10	13	78	7	10	10
Ewingsdale – On Ramp – Northbound	80	533	8	110	8	648	8	135	8
Ewingsdale – Off Ramp – Northbound	80	109	8	22	11	129	8	32	9
Ewingsdale – On Ramp – Southbound	80	110	8	22	11	135	8	32	9
Ewingsdale – Off Ramp – Southbound	80	524	8	116	8	594	8	169	7
Ewingsdale – Pacific Highway Overpass	80	892	8	183	8	1077	8	223	8
Service Road – North of Bangalow	80	655	7	83	19	805	7	98	19
Service Road – South of Bangalow	80	132	6	16	17	167	6	21	18
Broken Head Road	80	57	4	10	0	67	4	10	0

6.4 Post construction noise assessment

Noise results for the future existing 2016, project opening 2016 and design 2026 scenarios are provided in Appendix D. Noise contours for project opening 2016 and 2026 design year are also provided in Appendix E and Appendix F for the day and night time periods respectively.

The later project opening 2016 noise levels were compared with the detailed design 2014 predictions to assess whether noise levels increase by more than 2 dB, in accordance with the PCNA flowchart (Figure 2-1). The comparison showed that the project opening 2016 noise levels were within 2 dB of the 2014 detailed design noise levels at all receivers during the day time period.

During the night time period, the project opening 2016 noise levels were more than 2 dB greater than the 2014 detailed design levels at the following sensitive receivers:

- Along Ross Lane: 99-HO1 and 102-HO1.
- Clover Hill area: 878-HO1, 895-HO6, 896-HO5 and HO6, 898-HO4, 898-HO7, HO8 and HO9, 899-HO2, 899-HO4, 899-HO5 and 899-HO6.

The 2014 detailed design models were investigated to check the cause of the increase at these locations. It was found that in the detailed design models:

- The modelled traffic volumes on Ross Lane during the night time period were significantly lower than cited. Hence, the Ross Lane night time traffic volumes were corrected as part of this assessment.The noise level increase is not caused as a result of the project.
- Modelled building heights in the Clover Hill area were adjusted to the as-built terrain as part of this assessment.

Additionally, differences between the detailed design and post construction models are due to differences in local shielding, traffic differences and the as-built road to terrain interface changes.

Requirements for additional mitigation are based on a re-evaluation of design 2026 post construction noise levels with respect to ECRTN noise goals. Noise levels for the development year 2026 are predicted to comply with the ECRTN criteria for all assessed sensitive receivers except at one sensitive receiver 99-H01 as shown in Table 6-5. The night time noise levels for the 2016 revised opening year are predicted to increase by 4 dB when compared to the detailed design 2014 noise levels at 99-HO1. As discussed above, this is due to the revision in heavy vehicle volumes during the night time period along Ross Lane.

Furthermore, it is noted that the predicted development year 2026 noise levels are within 2 dB of future existing year 2016 noise levels and less than or within 2 dB of the ECRTN target noise levels. It is not considered reasonable and feasible to take action in such instances on the basis of an insignificant change in noise level and an insignificant exceedance of the ECRTN target noise levels (ENMM page 98).

Noise levels at other sensitive land uses (other than residential) for design year 2026 are all predicted to be less than the predicted 2024 detailed design noise levels.

Table 6-5 Summary of receivers predicted to exceed detailed design levels

Receiver ID	Floor	Future-existing 2016 noise level		New project opening 2016 noise level		ECRTN target criteria		DD 2014 noise level		Project opening 2016 noise level		New design year 2016-DD 2014		Project opening 2016 - DD 2014 Variance <= 2 dB?		Design 2026		ECRTN base target levels Complies?	
		Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night
99-HO1 52 Ross Lane, Tintenbar Lot 1 DP240840	1	64	57	60.5	57	64.5	57.5	60	53	60.5	57	0.5	4	Yes	No	61.5	58	Yes	No

6.5 Traffic noise levels on Old Pacific Highway

On the afternoon of 16 August 2016 traffic was diverted on to the Old Pacific Highway (Hinterland Way) due to a traffic incident which resulted in the closure of the new Pacific Highway. Traffic diversions were in place from approximately 4.00 pm to 10.00 pm on 16 August.

Although not specifically required for this PCNA, this information is useful as it provides an indication of traffic noise levels experienced on the Old Pacific Highway (Hinterland Way) i.e. representatve of no-build future existing 2016 scenario.

Analysis of unattended noise logging data indicates road traffic noise levels increase substantially by approximately 8 to 10 dB at assessed receivers during this diverted traffic period as shown in Table 6-1 to Table 6-4. The measured noise levels then generally fall by a similar margin following the re-opening of the new Pacific Highway after 10.00 pm.

Therefore, based on the measured noise levels at the identified receivers during this diverted traffic scenario, it is reasonable to conclude that traffic noise levels on the new Pacific Highway are quieter when compared to traffic on the Old Pacific Highway (Hinterland Way).

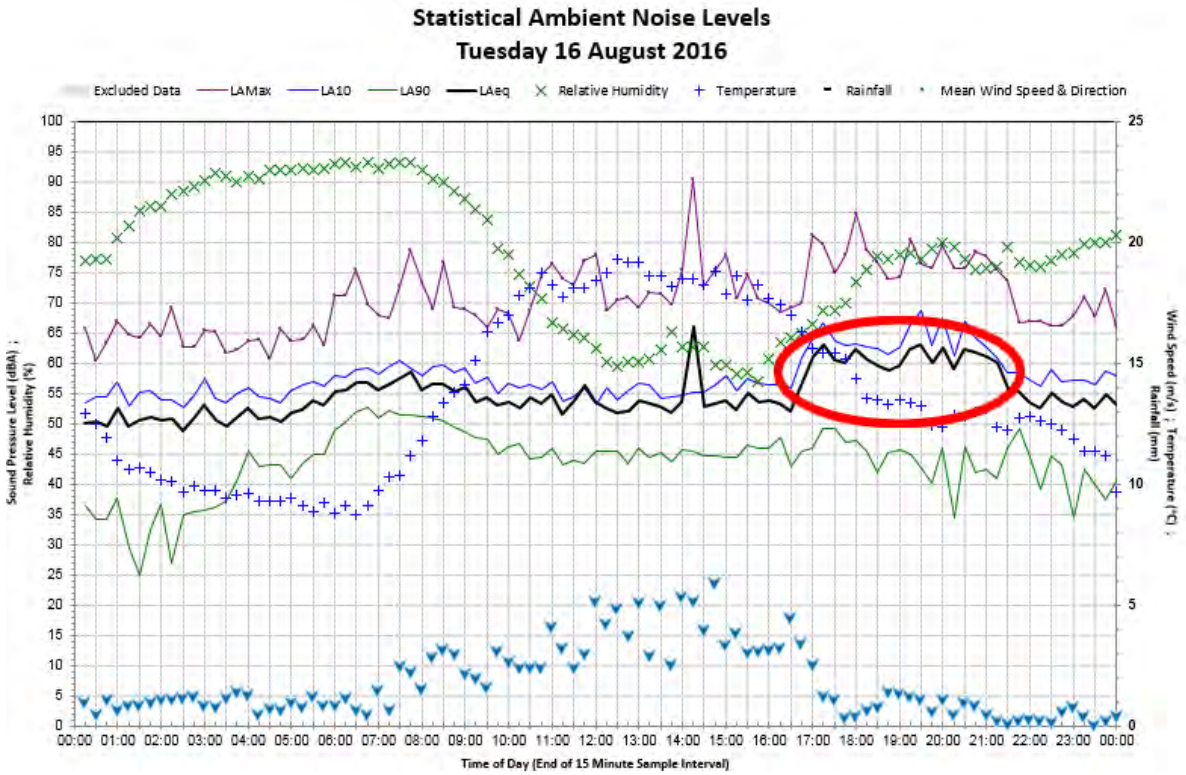


Figure 6-1Logged noise levels showing diverted traffic period on 16 August 2016 (Receiver 146-HO1A,1404 Hinterland Way, Knockrow)

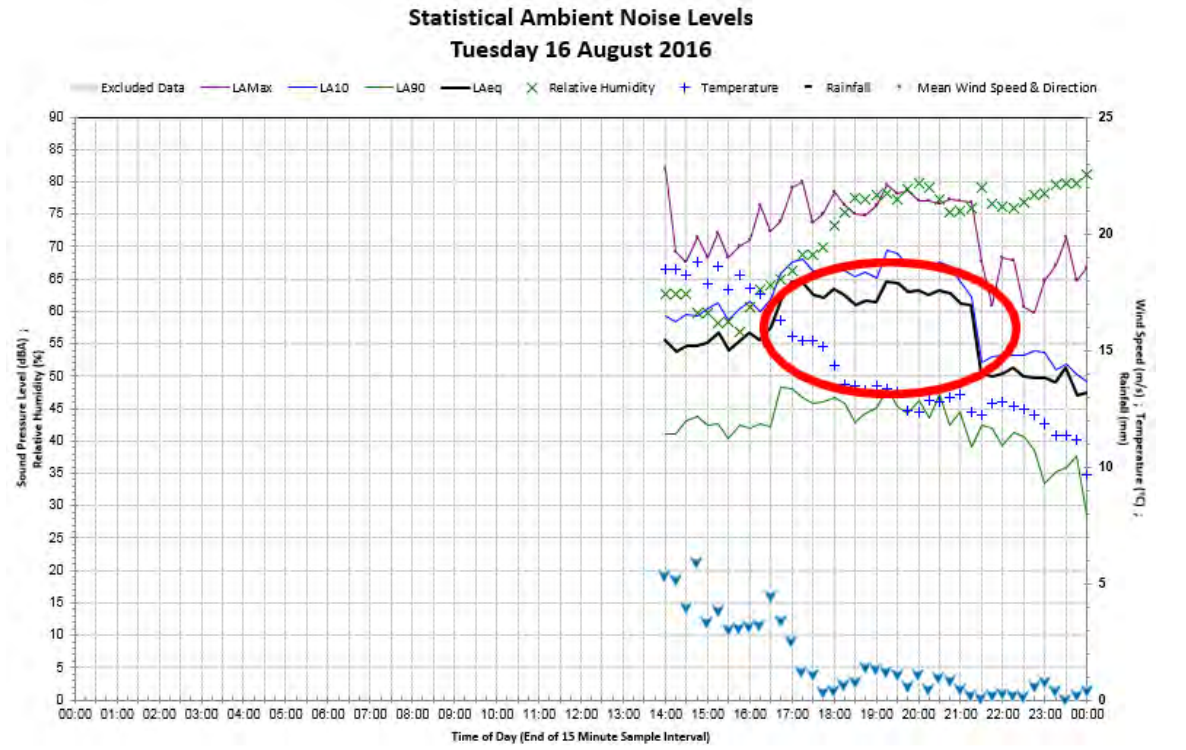


Figure 6-2Logged noise levels showing diverted traffic period on 16 August 2016 (Receiver 501-HO2, 2095 Old Pacific Highway, Newrybar)

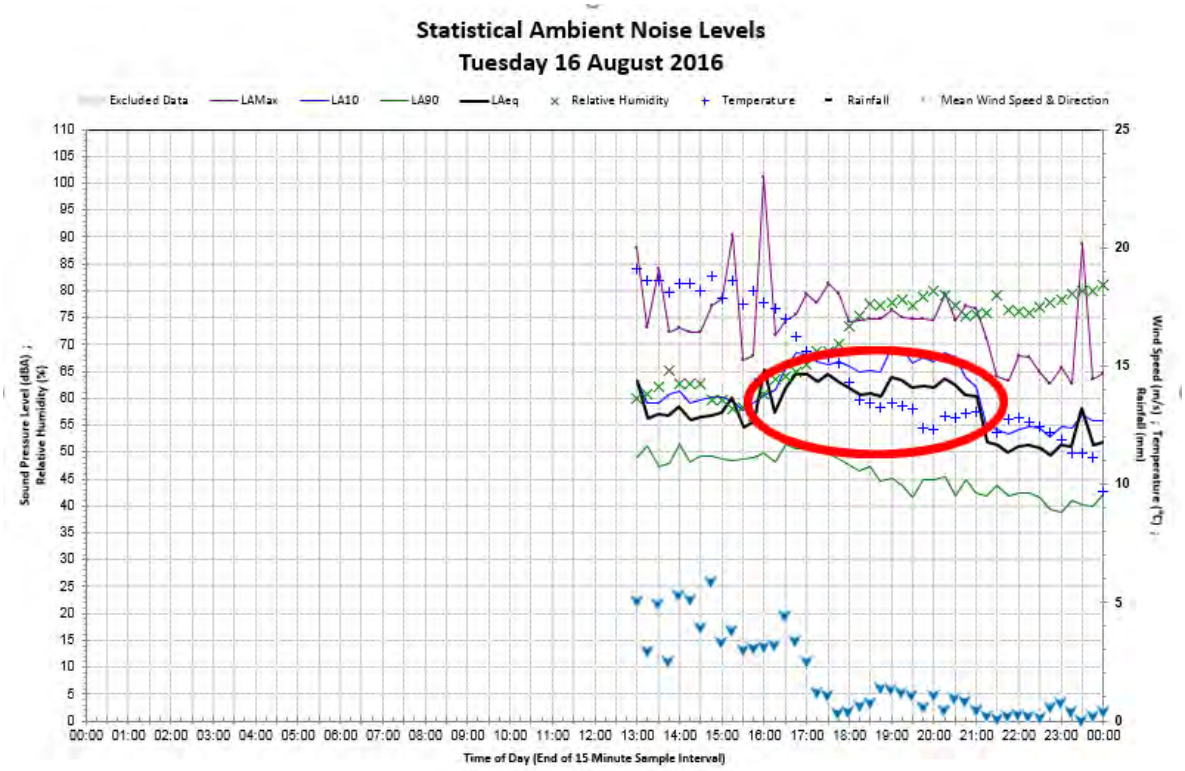


Figure 6-3Logged noise levels showing diverted traffic period on 16 August 2016 (Receiver 424-HO1, 16 Old Pacific Highway, Newrybar)

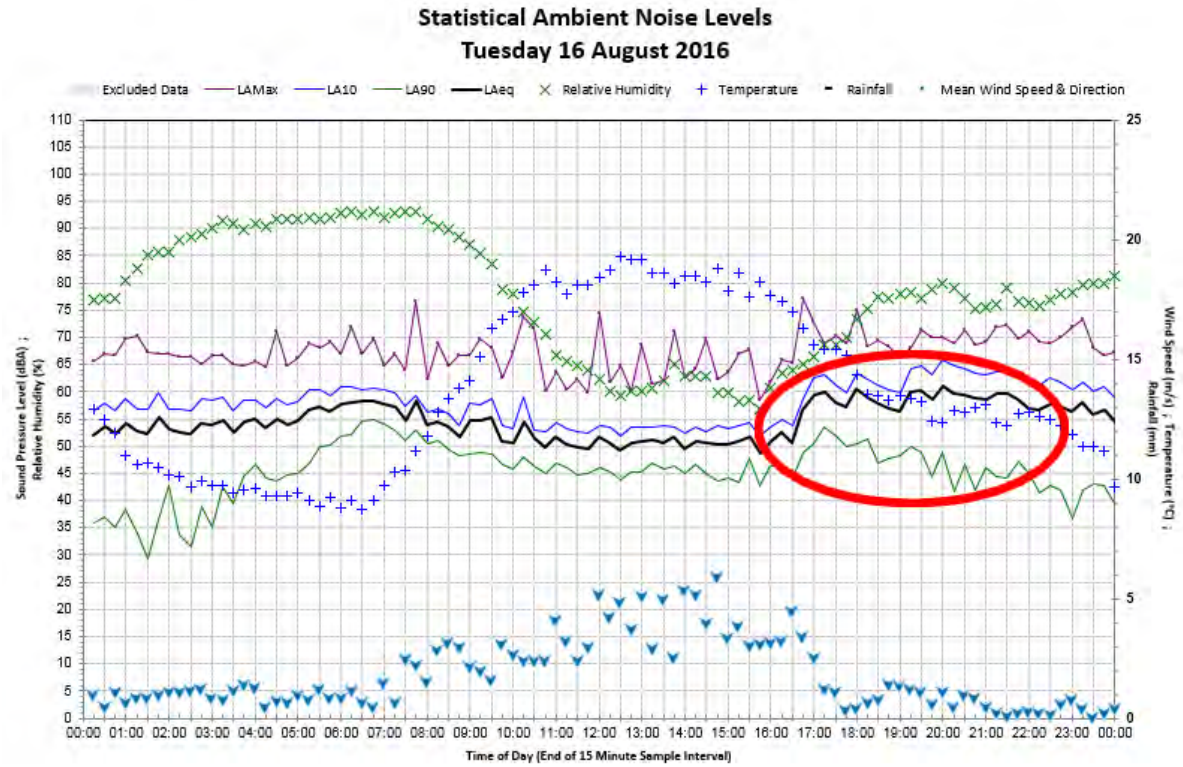


Figure 6-4Logged noise levels showing diverted traffic period on 16 August 2016 (Receiver 266-HO1, 19 Ivy Lane, Knockrow)

6.6 Maximum noise level assessment

A maximum noise level assessment has been undertaken to assess the potential for night time sleep disturbance events from road traffic noise.

The Project has been designed to minimise gradients along the Project length, allowing vehicles to maintain a constant speed. As a consequence, the use of engine braking on heavy vehicles and frequency of gear changing is likely to be significantly reduced compared to the previous highway. In addition, the Project should reduce the maximum noise levels due to the following:

- An improved road surface which is likely to reduce road irregularities and associated maximum noise level events.
- The use of low noise pavements along sections of the alignment (Section 3.2).
- Minimised road gradients and large radii curves allowing vehicles to maintain more constant speeds (Section 3.3).
- The use of low noise bridge joints (Section 3.4).
- Proposed mitigation design such as earth mounds and noise walls (Section 3.5).
- A number of residences in close proximity to the design alignment have received acoustic treatment (Section 3.6).

6.6.1 L_{Amax} noise monitoring

Maximum (L_{Amax}) noise levels were measured continuously at key locations as part of the noise monitoring program associated with this PCNA with the number of sleep disturbance events identified for each night time hour period. The key locations were selected to provide an indication of measured maximum noise levels along the alignment and at various distances from the Project. It is recognised that the further away a location is from the project, the more likely the maximum noise events will be dominated by local extraneous events rather than traffic on the highway.

The noise monitoring equipment at these locations were configured to log maximum noise levels every 0.5 seconds with audio WAV files recorded to assist with source identification.

The measured noise data was analysed using Matlab software to identify maximum noise events that satisfy the criteria as follows:

- L_{Amax} noise level > 65 dB(A) where $L_{Amax} - L_{Aeq(1hr)} \geq 15$ dB(A)

Once maximum noise events were identified, where possible the audio recordings were interrogated to determine the likely noise source responsible for generating the triggered event. Note that the L_{AMax} analysis includes all weather affected data. Maximum noise events caused by adverse weather conditions, such as rain and wind gusts, are noted in Appendix H.

Results can be found in Appendix H.

6.6.2 Maximum noise level modelling

Maximum noise levels from the Project were predicted using the SoundPLAN v7.2 noise modelling software. Based on monitoring data and the ONMR (GHD, 2014), a noise source with a sound power of 122 dB(A) was modelled as a moving point source along the Project alignment as well as the service road (existing Pacific Highway) to represent a maximum noise level event.

A comparison of the design and year opening 2016 results was conducted to determine any differences in vehicle passby maximum noise levels at assessed receiver locations.

Additionally, the predicted maximum noise levels were compared to measured 95th percentile maximum noise levels at four locations previously assessed in the ONMR.

A 95th percentile maximum noise level was derived from monitoring data at these locations and was used to represent a typical maximum noise level event.

6.6.3 Discussion

A comparison of the design and year opening 2016 results was conducted to determine any dfferences in vehicle passby maximum noise levels at assessed receiver locations.

The ONMR for detailed design stage presented modelled L_{Amax} noise levels at specific receiver locations based on a noise source with a sound power of 122 dB(A). The source was modelled as a moving point source along the Project alignment as well as the service road (existing Pacific Highway) to represent a maximum noise level event.

The results of modelling indicate a mean difference of - 0.4 dB between ONMR detailed design and post construction noise levels and a 1.2% reduction in the number of receivers predicted to experience maximum noise levels of more than 65 dB(A). A comparison of the ONMR detailed design and post construction maximum noise levels indicate a significant reduction in typical L_{max} noise levels for some residences, whilst similar levels were found for remaining residences. That is, approximately 99% of assessed sensitive receivers show L_{Amax} noise levels either do not increase significantly or reduce as a result of the Project. For the remaining assessed receivers above 65 dB(A) and where significant increases were predicted, these receivers were previously identified at detailed design stage and acoustic treatment provided.

The maximum noise levels were also predicted at the four monitoring locations assessed in the ONMR and compared to the previously predicted values to identify any differences as shown in Table 6-6. The results indicate the project opening year 2016 predicted noise levels are equal to or less than the development 2014 noise levels previously assessed in the ONMR.

Table 6-6 Comparison of ONMR and PCNA L_{Amax} noise levels

Receiver ID	Address	Modelled	
		Development year 2014 L_{Amax}	Project opening 2016 L_{Amax}
501-HO2	2095 Pacific Highway, Newrybar	79	78
485-HO1	13 Broken Head Road, Newrybar	75	63[1]
424-HO1	16 Old Pacific Highway, Newrybar	79	79
146-HO1	Pacific Highway, Knockrow	86	82

Note: [1] The predicted noise level due to the Project is sginifcantly less than the previous Old Pacific Highway due to the additional distance to the potentially most affected façade located on the eastern side of the property relative to the Project.

As stated in section 6.6.1, maximum noise events were identified during the night time period (10.00 pm to 7.00 am) at additional locations along the alignment to supplement the previous locatons shown in Appendix A. The identified events for assessed receivers with respect to the ENMM trigger values are shown Figure 6-5 to Figure 6-10. Additionally, triggered events are provided on the time trace data results shown in Appendix H.

The results indicate that locations closer to road corridors (including local roads and the highway) experience a higher number of maximum noise events during the night time period, typically ranging from zero to less than five events in a one hour period. However, it should be noted that the number of events was not necessarily attributed to vehicles travelling on the T2E project, but also due to extraneous noise events or vehicles travelling along local roads that may be closer to the relevant receiver e.g. higher maximum noise levels were recorded at some locations which are closer to the service road than the Project (new Pacific Highway). Therefore, recorded audio files were used to assist with identification of potential sources associated with the triggered maximum noise events.

Results indicate that locations at greater distances from the alignment typically experience less triggered maximum noise events. In particular, location L25, 38 Killen Falls Road had few maximum noise events during the night time survey periods, except for the 6.00 am to 7.00 am period when bird activity dominated triggered events.

The peak number of maximum noise events typically occurred during the 6.00 am to 7.00 am period which was found to be largely attributed to bird activity. There were also a contribution to the elevated number of events, on certain nights due to extraneous events such as wind gusts and rainfall. These events are noted in Appendix D.

The ONMR for detailed design stage provided a conservative estimate of approximately 30 maximum noise events in a typical night time period at locations in the vicinity of the Project. Comparison to the results in Figure 6-5 to Figure 6-10 indicate the measured number of potential maximum noise events due to the Project is generally under the ONMR predicted values.

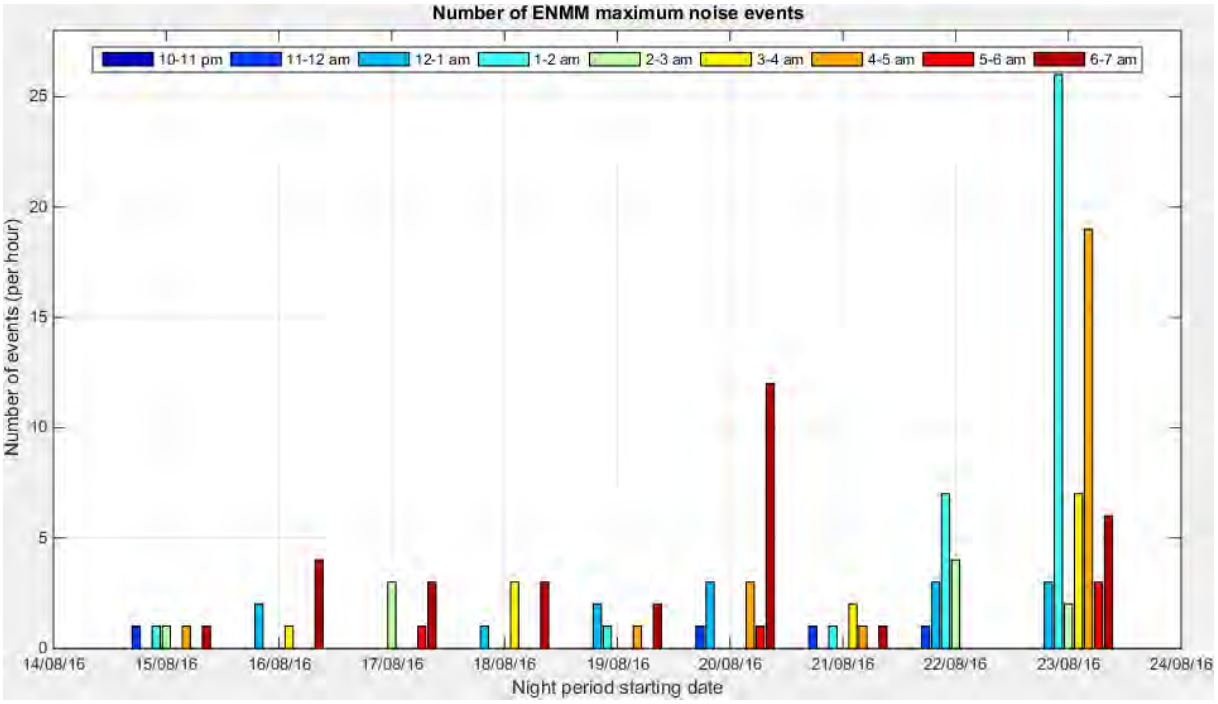


Figure 6-5Maximum noise events – L10, 18 Hambly Lane Newrybar

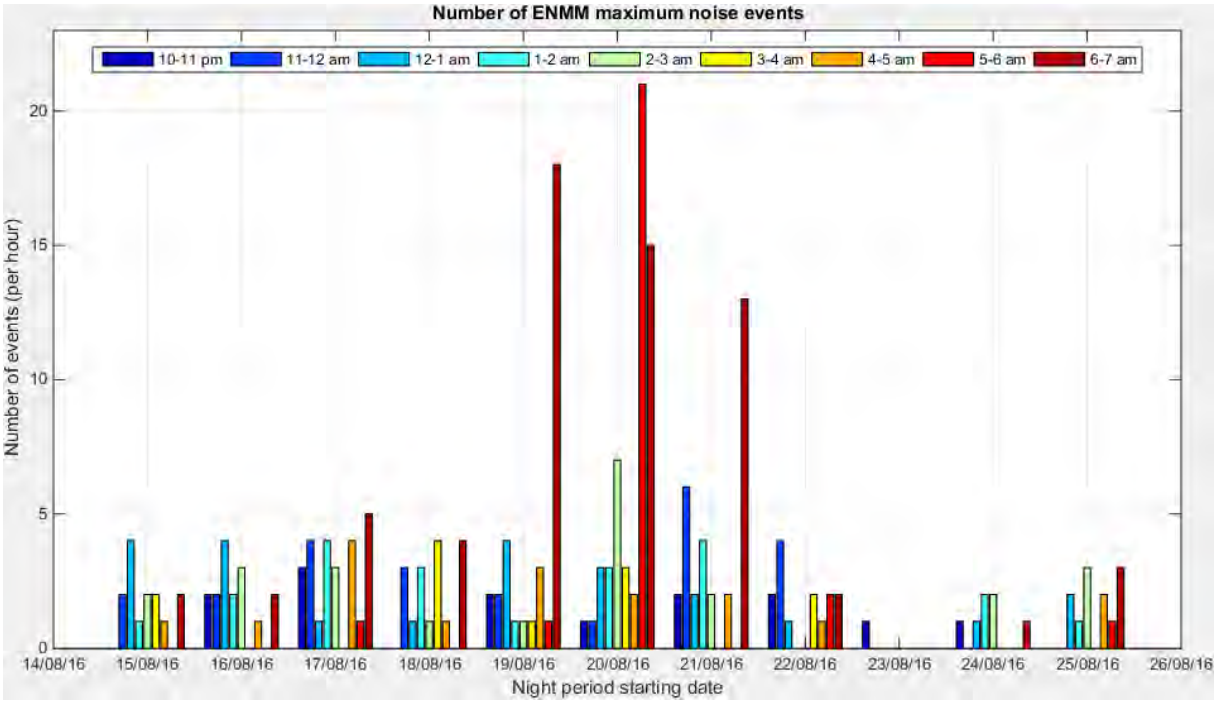


Figure 6-6Maximum noise events – L19, 19 Ballina Road Bangalow

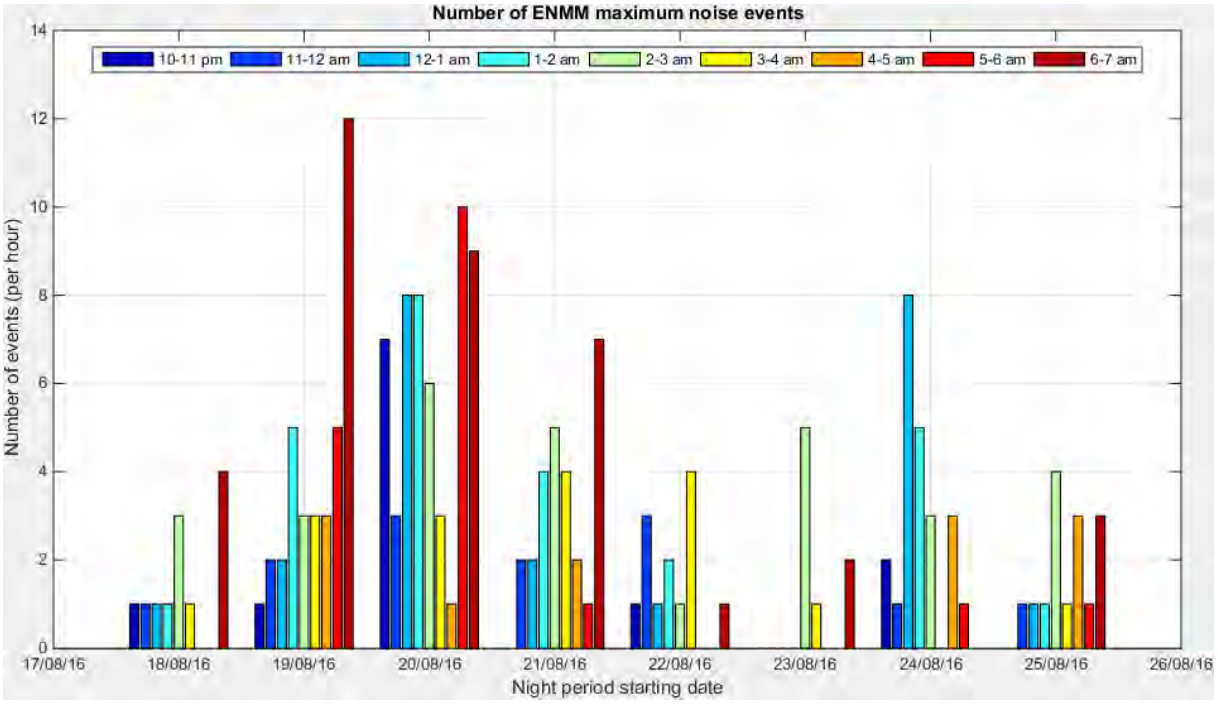


Figure 6-7Maximum noise events – L21, 84 Hinterland Way Tintenbar

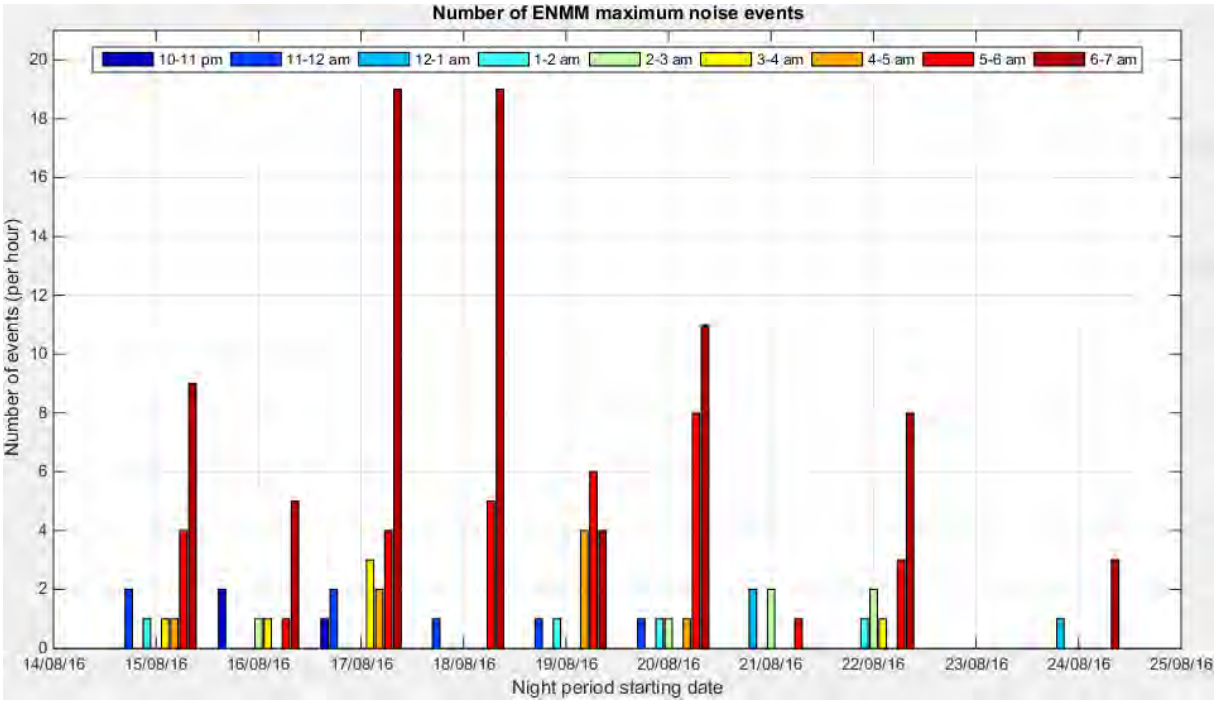


Figure 6-8Maximum noise events – 85 Parkway Drive Ewingsdale

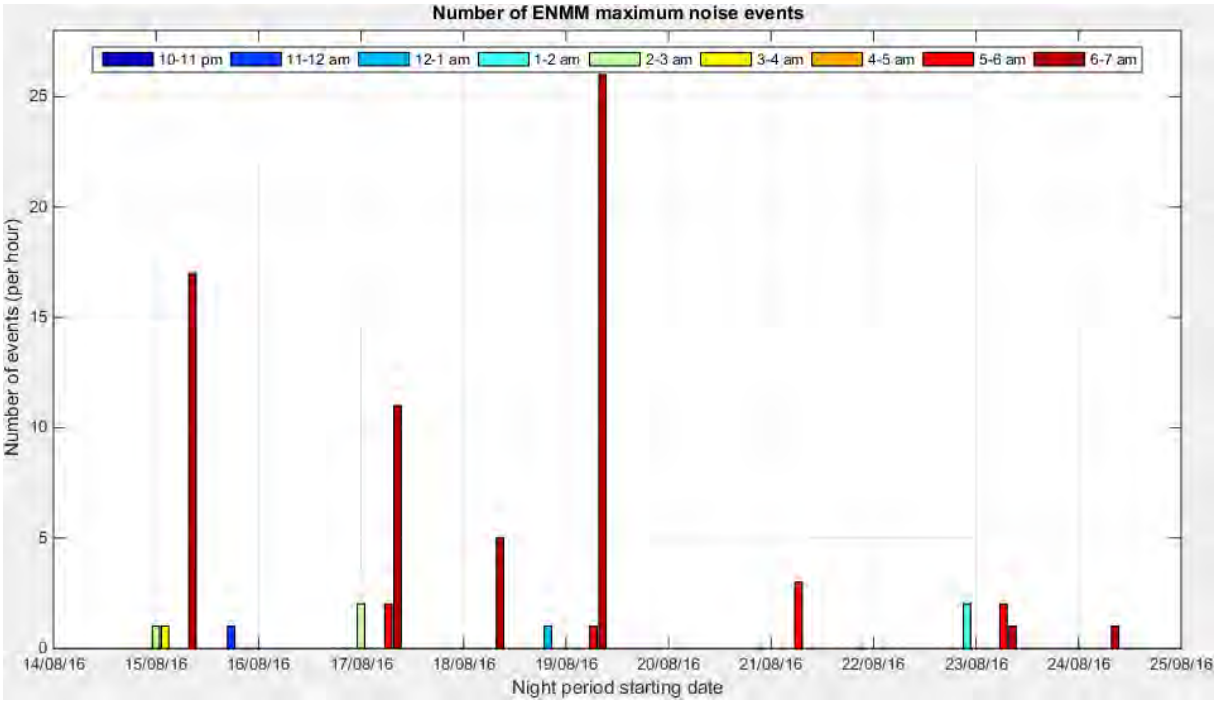


Figure 6-9Maximum noise events – 38 Killen Falls Road, Tintenbar

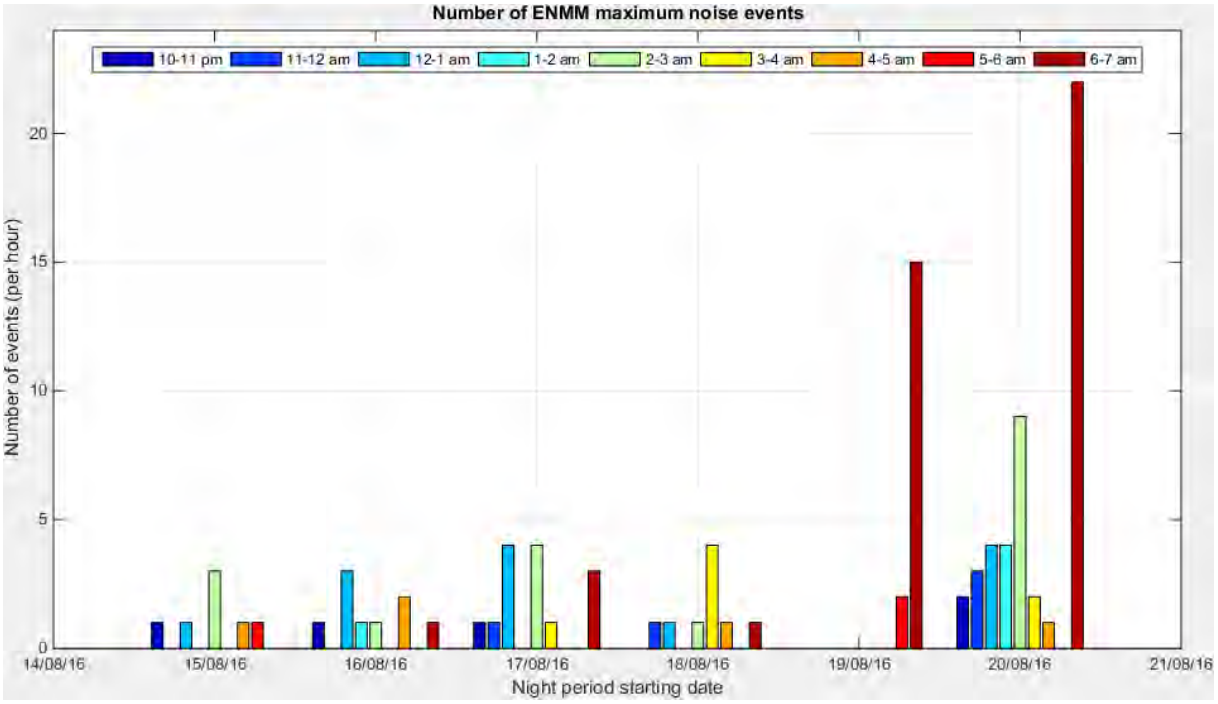


Figure 6-10 Maximum noise events – 3 Marblewood Place, Bangalow

7. Conclusion

The post construction noise assessment (PCNA) was undertaken for the upgrade of 16.3 km of the Pacific Highway between Tintenbar and Ewingsdale. The assessment was undertaken to address the objectives of the Minister's Condititions of Approval. Based on the PCNA results and findings, the following conclusions are made with consideration to the assumptions and limitations outlined in this report:

The ECRTN assessment method requires comparison of scenarios for the existing road at opening year 'future existing' and the project in 10 years' from opening. Where project noise levels are predicted to exceed the ECRTN criteria and show an increase of +2 dB over existing levels at year opening, then reasonable and feasible noise mitigation measures are required to be explored. This PCNA has compared modelled noise levels from 2016 'project opening' with 2014 'future existing' noise levels. The PCNA has assessed 2026 design year levels against the ECRTN criteria.

The post construction noise model was calibrated using the results from long-term unattended noise monitoring within the study area with simultaneous measured traffic volumes. The validation process found that overall, the results are considered to provide a reasonable level of confidence in the accuracy of the detailed design model. The model indicated good validation with a mean difference of +1.2 dB for day and -1.9 dB for night along with a standard deviation of 1.5 and 1.7 dB for day and night respectively.

The post construction noise levels at 2016 opening year are predicted to be less than or within 2 dB of the predicted 2014 detailed design noise levels at all assessed sensitive receivers except at one sensitive receiver 99-H01 (42 Ross Lane, Tintenbar). However, the predicted development year 2026 noise levels at this receiver are within 2 dB of future existing year 2016 noise levels and less than or within 2 dB of the ECRTN target noise levels. It is not considered reasonable and feasible to take action in such instances on the basis of an insignificant change in noise level and an insignificant exceedance of the ECRTN target noise levels (ENMM page 98).

The results of L_{Amax} maximum noise modelling indicate a mean difference of - 0.4 dB between ONMR detailed design and post construction noise levels and a 1.2% reduction in the number of receivers predicted to experience maximum noise levels of more than 65 dB(A). A comparison of the ONMR detailed design and post construction maximum noise levels indicate a significant reduction in typical L_{max} noise levels for some residences, whilst similar levels were found for remaining residences. That is, approximately 99% of assessed sensitive receivers show L_{Amax} noise levels either do not increase significantly or reduce as a result of the Project. For the remaining assessed receivers above 65 dB(A) and where significant increases were predicted, these receivers were previously identified at detailed design stage and acoustic treatment provided.

The maximum noise levels were also predicted at the four monitoring locations assessed in the ONMR and compared to the previously predicted values to identify any differences. The results indicate the project opening year 2016 predicted and measured noise levels are equal to or less than the development 2014 noise levels previously assessed at these receivers in the ONMR.

Maximum noise events were identified during the night time period (10.00 pm to 7.00 am) at additional locations along the alignment to supplement the previous ONMR assessed locatons. Maximum noise events were assessed for receivers with respect the ENMM trigger values. Additional analysis of measured maximum noise events at assessed locations typically indicated the number of events increased or decreased relative to the distance from the road corridors. However, the results indicated that receivers located closer to the road corridors typically triggered nil to five events in a one hour period. Assessed locations at greater distances from the alignment typically experienced less triggered maximum noise events. In particular, location L25, 38 Killen Falls Road predominantly triggered no maximum noise events during the night time survey periods, except for the 6.00 am to 7.00 am period when bird activity dominated triggered events.

Comparison of detailed design and post construction noise assessment results indicate the measured number of potential maximum noise events due to the Project is generally under the ONMR predicted values.

Analysis of unattended noise logging data during the traffic diversion along the Old Pacific Highway indicated road road traffic noise levels reduced substantially by approximately 8 to 10 dB at assessed receivers during this diverted traffic period. Therefore, based on the measured noise levels at the identified receivers during this diverted traffic scenario, traffic noise levels on the new Pacific Highway were quieter when compared to traffic on the Old Pacific Highway (Hinterland Way).

Noise model results indicate that no further mitigation measures are required to meet the project criteria. Except as otherwise agreed with the individual property owner, all mitigation measures have been identified in the detailed design stage of the project and have been implemented. The model was then updated to incorporate any changes to as-built components that may have changed from the original design features to reflect the as-built configuration. The noise model results confirm the adequacy of the traffic noise mitigation measures implemented on this Project.

8. References

Environmental Noise Criteria for Road Traffic Noise. DECCW, 1999.

Environmental Noise Management Manual. RTA 2001.

Preparing a Post Construction Noise Assessment Report Procedure Version 1.2. Roads and Maritime, 2014.

Tintenbar to Ewingsdale 100% Design Noise Report. GHD, 6 March 2014.

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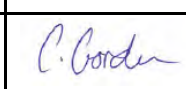
1	C Evenden P Pandey J Vallis	C Gordon	On file	E Milton	On file	12/04/2017
2	C Evenden P Pandey J Vallis	C Gordon		E Milton		19/04/2017