Foxground and Berry Bypass

Post-Construction Operational Road Traffic Noise Assessment

S180187RP1 Revision B

Friday, 21 September 2018

Document Information

Project	Foxground and Berry Bypass	
Client	Roads and Maritime Services	
Report title	Post-Construction Operational Road Traffic Noise Assessment	
Project Number	S180187	
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Revision Table

Report revision	Date	Comments
B	17 September 2018	Final

Glossary

AADT	Average Annual Daily Traffic—annual average daily traffic volumes for a given road, including weekends.
A-weighted	A spectrum adaption that is applied to measured noise levels to approximate human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
CoRTN	Calculation of Road Traffic Noise—UK developed algorithm for the prediction of road traffic noise that is widely used in Australia.
CV	Commercial Vehicle—A heavy vehicle such as a truck. Using the AustRoads vehicle classification system, this applies to any vehicle in Classes 3 to 12 inclusive.
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of that sound level.
dB(A)	'A' Weighted sound level in dB.
EPA	NSW Environment Protection Authority.
Feasible and reasonable	Consideration of best practice noise and vibration mitigation measures f taking into account the benefit of proposed measures and their technological and associated operational application in the NSW and Australian context. Feasible relates to engineering considerations and what is practical to build. Reasonable 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 nature and extent of potential improvements.
Frequency	The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone), but slow movements mean the frequency (pitch/tone) is low.
Hz	Hertz—units of frequency.
L_{Aeq}	Equivalent Noise Level— A-weighted energy averaged noise level over the measurement time.
L_{Aeq}	A-weighted energy averaged noise level over a defined measurement period.
$L_{Aeq(1\text{-}hour)}$	A-weighted energy averaged noise level over an hourly period during the usage time of a particular land use. Used in the RNP to assess road traffic noise levels at some non-residential land uses.
$L_{Aeq(15\text{-}hour)}$	A-weighted energy averaged noise level over the 15-hour daytime period from 7 am to 10 pm. Used in the RNP to assess daytime road traffic noise levels.
$L_{Aeq(9\text{-}hour)}$	A-weighted energy averaged noise level over the 9-hour night-time period from 10 pm to 7 am. Used in the RNP to assess night time road traffic noise levels.
L_{AFmax}	Maximum A-weighted sound pressure level within a defined measurement period, using the 'Fast' time weighting on the sound level meter.
RMS	Roads and Maritime Services.
RNP	NSW *Road Noise Policy* administered by the NSW EPA.

Executive summary

Project overview

The Foxground and Berry Bypass (the Project) provided a four-lane highway (two in each direction) with median separation for 12.5 kilometres of the Princes Highway between Toolijooa Road, located to the west of the township of Gerringong, to just south of Andersons Lane, located to the south of the township of Berry. The upgrade of the Princes Highway included a bypass of the existing winding highway at Foxground and a bypass to the north of Berry with interchanges at the north and south of the town.

The Project opened to traffic in mid-2017, with some completion works including final road surfacing undertaken in late 2017.

Purpose of this report

This report presents the results of a post-construction road traffic noise assessment to determine whether road traffic noise levels from the Project comply with the relevant environmental obligations in relation to operational noise. The assessment considers:

- Unattended monitoring results from 18 locations along the Project extent.
- Operator-attended monitoring results at those 18 locations, with operator-attended monitoring also conducted at an additional 11 locations.
- Traffic counting at various locations around the Project.
- The road traffic noise model developed for the Project based on the Fulton Hogan Issued for Construction design that was used to determine road traffic noise mitigation requirements during the Project design and construction phase.

The results of the post-construction noise assessment are documented within this report, with the assessment conducted in general accordance with the Roads and Maritime Services (RMS) Procedure *Preparing a Post Construction Noise Assessment Report* dated June 2014.

Noise model accuracy and appropriateness of noise mitigation measures

A comparison between the measured and predicted noise levels demonstrated that that noise model tended marginally towards over-prediction with an acceptable degree of accuracy. With the exclusion of those samples where other factors were considered to influence the results, there was an excellent agreement in accuracy between the daytime and night-time periods.

Given the apparent acceptable accuracy of the noise model, it is considered that the noise mitigation measures incorporated into the Project were of a suitable extent to address road traffic noise levels in a reasonable and feasible manner.

The apparent accuracy of the noise model demonstrated that the road surface treatment and noise barriers (e.g. mounds) in particular were designed and constructed to achieve a suitable road traffic noise level at noise-sensitive locations based on the assumed traffic volumes adopted during the Environmental Assessment and Design & Construction phases.

Traffic volume discussion

The measured traffic volumes were noted to exceed the stated Project opening volumes that were assumed within the Environmental Assessment and Design & Construction operational noise assessments conducted for the Project. It is noted that this is likely to be the result of an immediate transition of traffic from The Sandtrack to the upgraded highway with a potential contribution from the time of year of the measurements which were conducted, around but not including, the Easter long weekend.

Vehicle speed discussion

The measured average vehicle speeds on the Princes Highway were within 5 km/h of the posted speed limit (100 km/h) for both weeks, with the average speeds remaining relatively constant for both weeks and for the day and night time period. No significant increase in average vehicle speed was observed at night time relative to during the day.

Therefore, an increase in vehicle speeds of this magnitude would not increase predicted noise levels by more than the 1 dB safety factor that was adopted within the road traffic noise level predictions for the Project during the environmental assessment and design and construction phases.

Summary

On the basis of this assessment, it is considered that the operational noise mitigation measures implemented as part of the Project are performing as intended and that the measured road traffic noise levels are consistent with those predicted during the design of the Project.

Because of this, no further consideration of additional noise mitigation measures is required when assessed against the Project's conditions of approval and the NSW EPA's Road Noise Policy.

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1 Introduction

1.1 Project overview

The Foxground and Berry Bypass (the Project) provided a four-lane highway (two in each direction) with median separation for 12.5 kilometres of the Princes Highway between Toolijooa Road, located to the west of the township of Gerringong, to just south of Andersons Lane, located to the south of the township of Berry. The upgrade of the Princes Highway included a bypass of the existing winding highway at Foxground and a bypass to the north of Berry with interchanges at the north and south of the town.

The Project opened to traffic in mid-2017, with some completion works including final road surfacing undertaken in late 2017.

Aerial photographs showing the Project alignment and surrounding area are included in Appendix A.

1.2 Purpose of this report

This report presents the results of a post-construction road traffic noise assessment undertaken in March and April 2018 to assess whether road traffic noise levels from the Project comply with the relevant environmental obligations in relation to operational noise. The assessment considers:

- Unattended monitoring results from 18 locations along the Project extent.
- Operator-attended monitoring results at those 18 locations, with operator-attended monitoring also conducted at an additional 11 locations.
- Traffic counting at various locations around the Project.
- The road traffic noise model developed for the Project based on the Fulton Hogan Issued for Construction design that was used to determine road traffic noise mitigation requirements during the Project design and construction phase.

The results of the post-construction noise assessment are documented within this report, with the assessment conducted in general accordance with the Roads and Maritime Services (RMS) Procedure *Preparing a Post Construction Noise Assessment Report* dated June 2014.

2 Environmental obligations

2.1 Conditions of Approval

The Project Approval for the Project was issued on 22 July 2013 by the Minister for Planning & Infrastructure. The Project Approval included two Conditions relevant to operational road traffic noise.

2.1.1 Operational Noise Mitigation Review

Condition C14 of the Project Approval details a requirement for an Operational Noise Mitigation Review during construction as follows:

> Unless otherwise agreed by the Director General, within 6 months of commencing construction, the Proponent shall, in consultation with the EPA, prepare and submit for the approval of the Director General, a review of the operational noise mitigation measures proposed to be implemented for the project. The review shall:
>
> (a) confirm the operational noise predictions of the project based on detailed design. This operational noise assessment shall be based on an appropriately calibrated noise model (which has incorporated additional noise monitoring, where necessary for calibration purposes);
>
> (b) review the suitability of the operational noise mitigation measures identified in the documents listed under condition A1 to achieve the criteria outlined in the Road Noise Policy (DECCW, 2011), based on the operational noise performance of the project predicted under (a) above; and
>
> (c) where necessary, investigate additional feasible and reasonable noise mitigation measures to achieve the criteria outlined in the Road Noise Policy (DECCW, 2011).

This Operational Noise Mitigation Review was conducted by the appointed design and construction contractor (Fulton Hogan) and is discussed further in Section 2.2.2.

2.1.2 Operational Noise

Condition E1 of the Project Approval details a requirement for operational noise monitoring to be conducted once the road opens as follows:

> Within 12 months of the 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 C14, and prepare an Operational Noise Report to document this monitoring 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 C14 and documents specified under condition A1 of this approval;
>
> (b) a review of the operational noise levels in terms of criteria and noise goals established in the NSW Road Noise Policy (EPA, 2011);
>
> (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 prepared;
>
> (e) any required recalibrations of the noise model taking into consideration factors such as actual traffic numbers and proportions;
>
> (f) an assessment of the performance and effectiveness of applied noise mitigation measures together with a review and if necessary, reassessment of all feasible and reasonable mitigation measures; and
>
> (g) identification of additional feasible and reasonable measures to those identified in the review of noise mitigation measures required by condition C14, that would be implemented with the objective of meeting the criteria outlined in the NSW Road Noise Policy (EPA, 2011), when these measures would be implemented and how their effectiveness would be measured and reported to the Director General and the EPA.

The Proponent shall provide the Director General and the EPA 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.

The monitoring and assessment detailed within this report has been conducted to full Condition E1 above.

2.2 Operational noise assessments

Operational road traffic noise assessments were conducted during both the Environmental Assessment, on the basis of which the Project Approval was issued, and during the Design and Construction phase of the Project.

2.2.1 Environmental Assessment

The Environmental Assessment included an operational road traffic noise assessment that was detailed in a Technical Paper: Noise and Vibration prepared in November 2012 by AECOM Australia Pty Ltd (AECOM). With respect to operational road traffic noise, the AECOM assessment included the following elements:

- An assessment of the noise environment that existed prior to the Project. This was done by monitoring the existing noise environment at 10 locations for a period of one to two weeks. The results were used to validate a noise model of the existing road traffic noise environment, that was then used to predict road traffic noise levels at noise-sensitive locations without the Project at both the Project Opening (2017) and Project Design (2027) years, based on forecast traffic volumes if the Project did not proceed.
- Establishment of road traffic noise criteria at noise-sensitive locations in accordance with the NSW *Road Noise Policy* (RNP) administered by the NSW Environmental Protection Authority (EPA).
- Predictions and assessment of road traffic noise levels at noise-sensitive locations with the Project for both the Project Opening and Project Design years. Noise levels were assessed against the road traffic noise criteria and against principles for the consideration of reasonable and feasible noise mitigation as detailed in the RMS *Environmental Noise Management Manual* (ENMM).
- Description of reasonable and feasible noise mitigation measures that were to be implemented based on the reference design considered during the Environmental Assessment including:
    - The use of a ‘low noise’ stone mastic asphalt (SMA) pavement for the main carriageways of the upgraded Princes Highway including the Berry Bypass.
    - A 4 m high barrier on the south side of the Berry Bypass shielding residences on North Street.
    - A 4 m high barrier on the Berry South Interchange northbound off ramp to shield residences on Huntingdale Park Road.
    - Architectural property treatments for 20 properties where the road surface treatment and barriers did not result in a sufficient reduction in road traffic noise at residences.

2.2.2 Design and Construction

During the Design and Construction phase, the appointed contractor (Fulton Hogan) was required to undertake an operational noise assessment of the as-constructed road design. This operational noise assessment was undertaken by Resonate and the final version of the assessment issued in March 2015.

As part of the Design and Construction contract, Fulton Hogan were required to ensure their design:

- Implemented mitigation measures not less than those included in the Environmental Assessment.
- Where necessary, incorporated additional at-road or barrier treatments such that the predicted operational road traffic noise levels at residences did not increase above the levels presented in the Environmental Assessment.
- Did not result in an increase in architectural property treatments at residences above that specified by RMS.

The operational noise mitigation measures incorporated in the constructed Project, based on the above, are detailed in Section 4.

2.3 Other requirements

2.3.1 Southern Tie-In Extension

The Southern Tie-In Extension refers to an extension of the southern limit of the Project by approximately one kilometre to allow a tie-in with the planned Berry to Bomaderry Princes Highway Upgrade project. While the Southern Tie-In Extension did not result in forecast increased traffic volumes, it required an extension of the area within which operational noise was assessed for the Project.

An assessment of the additional operational noise generated by the Southern Tie-In Extension was carried out by Resonate for Fulton Hogan in March 2015. The assessment concluded that the operational noise impacts from the Southern Tie-In Extension would be in accordance with the Project Approval and RNP as long as:

- The Extension was also surfaced with SMA.
- Architectural property treatments for road traffic noise were provided to two additional receivers.

The operational noise mitigation measures incorporated in the Southern Tie-In Extension are detailed in Section 4.

2.3.2 Receiver 299 noise mound

During construction, an additional earth mound was installed on the northern side of the Berry Bypass to shield the residence identified as Receiver 299 in the Environmental Assessment (Lot 52 DP1188161). This noise mound was constructed as part of an agreement between RMS and the property owner resulting from land acquisition arrangements. This noise mound is included in the noise mitigation measures detailed in Section 4.

3 Noise level objectives

3.1 Operational road traffic noise assessment criteria

The operational road traffic noise criteria for the Project were determined as part of the Environmental Assessment in accordance with the RNP. This is in accordance with the Project Approval issued following the Environmental Assessment.

It is important to note that the Environmental Assessment and the Project Approval were all issued prior to the release of recent RMS documents, specifically the *Noise Criteria Guideline* and *Noise Mitigation Guideline*. Therefore, these documents have not been referenced below.

Table 1 presents the RNP operational road traffic noise assessment relevant to the Project. Unless otherwise stated, the criteria apply at a distance of 1 m from the building facade.

Table 1 RNP road traffic noise assessment criteria relevant to the Project

Road category	Type of project / land use	Assessment criteria	
		Day, 7 am–10 pm	**Night, 10 pm–7 am**
Freeway / arterial / sub-arterial	**New Road** Existing residences affected by noise from new freeway / arterial / sub-arterial road corridors.	55 dB $L_{Aeq(15\text{-}hour)}$	50 dB $L_{Aeq(9\text{-}hour)}$
	Redeveloped Road Existing residences affected by noise from redevelopment of freeways / arterial / sub-arterial road corridors.	60 dB $L_{Aeq(15\text{-}hour)}$	55 dB $L_{Aeq(9\text{-}hour)}$
	Relative Increase Criteria Existing residences near new road corridor / redevelopment of existing road	Existing dB $L_{Aeq(15\text{-}hour)}$ + 12 dB	Existing dB $L_{Aeq(9\text{-}hour)}$ + 12 dB
	Open space – passive use, e.g. Mark Radium Park	55 dB $L_{Aeq(15\text{-}hour)}$ [1]	n/a
	Places of worship – e.g. St Patricks Catholic Church and the Berry Uniting Church.	40 dB $L_{Aeq(1\text{-}hour)}$ [2]	40 dB $L_{Aeq(1\text{-}hour)}$ [2]

(1) Measured and assessed in a free-field location at typical areas where the space may be used for passive uses.

(2) Measured and assessed within a noise-sensitive area of the place of worship.

The Environmental Assessment considered the existing road traffic noise exposure of each noise-sensitive receiver and deemed them to be subject to the ‘New Road’ or ‘Redeveloped Road’ criteria in accordance with Practice Note i of the ENMM. These criteria were maintained through the subject operational noise assessments conducted during the Design and Construction phase of the Project.

The criteria assigned to each noise-sensitive receiver identified adjacent to the Project is identified in Appendix B.

3.2 Sleep disturbance

The RNP includes discussion of current knowledge regarding sleep disturbance due to road traffic noise, and states 'despite intensive research, the triggers for and effects of sleep disturbance have not yet been conclusively determined.' Current research does indicate that the main acoustic characteristic that influences sleep disturbance is the emergence (e.g. magnitude) and number of noisy events heard distinctly above the background level. The RNP suggests that intermittent noisy events, such as truck pass-bys, could be assessed on the basis of emergence events determined as the difference between L_{Amax} levels and the steadier L_{Aeq} or L_{A90} levels.

The RNP makes reference to Practice Note iii of the ENMM which suggests that the $L_{eq,9h}$ road traffic noise guidelines should sufficiently account for sleep disturbance impacts except where both of the following conditions are met:

- the L_{Amax} emergence over the ambient $L_{Aeq,1hour}$ is greater than 15 dB(A) and
- the L_{Amax} level is greater than 65 dB(A).

The Environmental Assessment reviewed the measurement results relating to sleep disturbance and noted that the sleep disturbance emergence criteria were exceeded at locations adjacent to the Princes Highway prior to the Project, indicating that sleep disturbance is likely to be an existing issue for the local area. The Project would reduce these exceedances where the road was not moving closer to receivers but may introduce a concern for receivers where the Project is classified as a New Road.

The Environmental Assessment also noted that the RNP does not provide any requirements for mitigation to be designed to mitigation maximum noise levels to meet sleep disturbance criteria. While the Project design was considered to reduce the gradient of the road in some areas and reduce the potential for high maximum noise levels associated with truck engine braking and the like, the potential for noise mitigation through noise barriers or at-property treatments to address the sleep disturbance criteria was not considered in the Environmental Assessment.

While consideration of sleep disturbance has not informed the selection or design of noise mitigation measures, an assessment of sleep disturbance has been included within this report.

3.3 Reasonable and feasible noise mitigation

Where predicted road traffic noise levels with the Project were identified to exceed the relevant operational road traffic noise assessment criteria at a particular noise-sensitive receiver, it was necessary to consider whether the provision of noise mitigation to that receiver was deemed to be reasonable and feasible. For mitigation to be reasonable and feasible, noise levels at the receiver must exceed the applicable assessment criteria and either be significantly affected by the Project or be considered to be 'acute'.

In accordance with the ENMM, the following process was applied to determine if noise mitigation was reasonable and feasible for receivers where the operational road traffic noise levels exceeded the assessment criteria:

- The Project must contribute to an increase of 2.1 dB L_{Aeq} or greater for day and/or night when compared to the road traffic noise level without the Project at the same year (e.g. Opening or Design Year)
  AND/OR
- The road traffic noise levels at the receiver are greater than or equal to 65 dB $L_{Aeq,15hour}$ or 60 dB $L_{Aeq,9hour}$, in which case the road traffic noise levels are considered 'acute'.

Additionally, the reasonableness and feasibility of the noise barriers at North Street and Huntingdale Park Road was assessed in accordance with Practice Note iv of the ENMM to determine the reasonable height of those barriers, including consideration of community views.

4 Noise mitigation on the Project

This Section details the operational noise mitigation measures incorporated into the design and construction of the Project. The locations of the noise mitigation measures are shown on aerial photographs included in Appendix A.

4.1 Road design

The Project was designed to provide a high-grade four lane highway that replaced the winding sections of the Princes Highway and reduced gradient in many areas. The Project also realigned the Highway to the north of the Berry township to reduce traffic on Queen Street. These measures assisted in reducing noise levels in some areas, particularly in areas where steeper gradients used to exist or where heavy vehicle braking may have previously been more common.

Additionally, the main carriageway was surfaced with SMA, which reduces noise levels at the road-tyre interface in relation to standard asphalt or concrete road surfaces. In accordance with the ENMM, the following reductions in road-tyre noise were assumed for the SMA surface in relation to a standard dense graded asphalt (DGA) surface:

- -2.2 dB for cars
- -4.3 dB for Commercial Vehicle (CV) tyres.

For road design reasons, DGA surfaces were used for the on and off ramps at the interchanges and were used for the bridge crossings over creeks.

4.2 Noise barriers

4.2.1 North Street

The 4 m high noise barrier documented in the Environmental Assessment to shield residences on the southern side of North Street was replaced in the Design and Construction phase with an earth mound that was constructed to a height of at least 4 m above road height. The operational noise assessment conducted during Design and Construction confirmed that the noise mound provided equivalent predicted acoustic performance to the original noise barrier.

A photograph of the mound taken from the southern side is included as Figure 1. The extent of the noise mound is shown on the Figures in Appendix A.

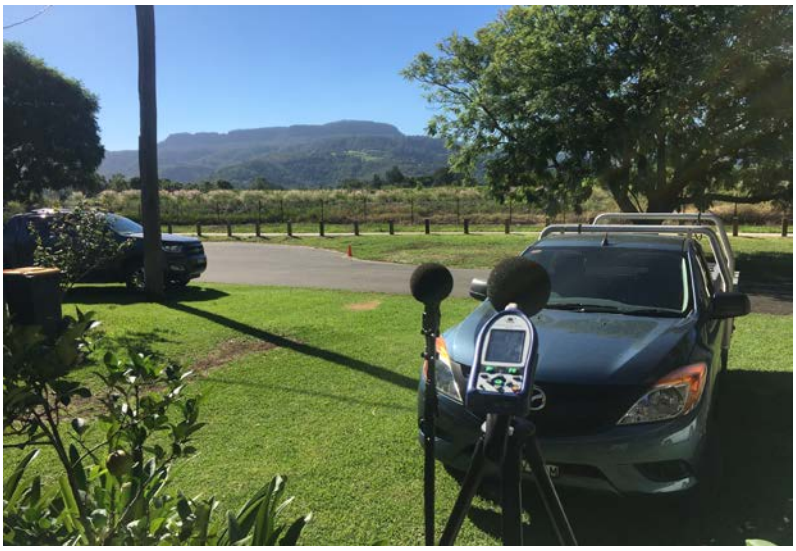

Figure 1 View of North Street noise mound from unattended monitoring location at 90 North Street

4.2.2 Huntingdale Park Road

The 4 m high barrier proposed in the Environmental Assessment to shield residences on the western side of Huntingdale Park Road was also replaced with an earth mound during the Design and Construction phase that

achieved a height of at least four metres above the main carriageway surface. The operational noise assessment predicted that the noise mound would provide equivalent acoustic performance with the inclusion of a short 800 mm barrier on the northern section of the mound.

A photograph of the mound and the short additional barrier taken from Huntingdale Park Road is included as Figure 2. The extent of the Huntingdale Park Road noise mound is shown on the Figures in Appendix A.

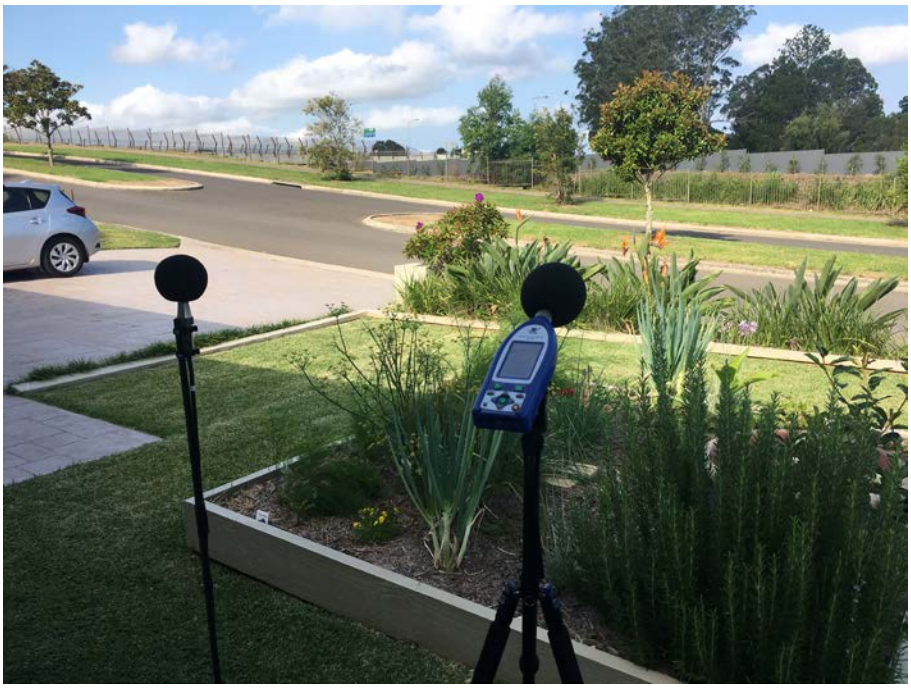

Figure 2 View of noise mound and barrier from unattended monitoring location at 8 Huntingdale Park Road

4.2.3 Receiver 299 noise mound

During construction, an additional earth mound was installed on the northern side of the Berry Bypass to shield the residence identified as Receiver 299 in the Environmental Assessment (Lot 52 DP1188161). This noise mound was constructed as part of an agreement between RMS and the property owner resulting from land acquisition arrangements, and was not included in the Environmental Assessment as a proposed operational noise mitigation measure.

The extent of the Receiver 299 noise mound is shown on the Figures in Appendix A. It was designed to reach a height of 4 m above the road surface of the nearest carriageway of the Princes Highway.

4.3 Architectural property treatments

At a number of noise-sensitive receivers it was deemed that reasonable and feasible road design and barrier treatments were not sufficient for the predicted noise levels to achieve the relevant RNP road traffic noise assessment criteria but that additional mitigation was required. In these cases, RMS administered architectural property treatments to the receivers.

The receivers at which architectural property treatments were provided are summarised in Table 2.

Table 2 Properties at which architectural treatments were provided for operational noise

Receiver	Predicted exceedance of assessment criteria, dB	
	Environmental Assessment	Design and Construction Phase
14a	4	4

Receiver	Predicted exceedance of assessment criteria, dB	
	Environmental Assessment	Design and Construction Phase
17a	3	0
22a	9	8
23	3	2
25	9	7
28	4	4
29	3	4
30	2	3
33a	5	8
73	3	3
110	2	2
299	6	5
355	2	3
374	3	4
384	3	4
386	4	4
439	4	4
445	3	3
451	4	4
603 (Southern Tie-In)	n/a	5
605 (Southern Tie-In)	n/a	7

The properties for which treatments were required were originally identified in the Environmental Assessment (other than two properties identified as part of the Southern Tie-In Extension), with treatments specified on the basis of the predictions in the Environmental Assessment. Predicted noise levels changed to a small degree at some of these receivers during the Design and Construction phase but the nature of the at property treatments at those receivers did not change as any small increase in noise levels was insufficient to necessitate additional treatments to the house.

Additionally, we note that the predicted noise levels at Receiver 17a indicated that acoustic treatment was no longer required with the constructed design but we understand that architectural treatment was still provided.

5 Noise-sensitive land uses

The Project traverses an area that incorporates a mix of land uses including pastureland and agricultural properties, rural residential areas and the town of Berry with its associated urban residential, recreational, commercial and light industrial areas. Residences, businesses and other community facilities (such as churches and open spaces) are located along the Project alignment at varying distances from the existing highway and project alignment.

The rural areas to the north and south of Berry are dominated by pastureland and rural settlement patterns. Generally, the noise level experienced at residences in this area prior to the Project was relatively low except for the sensitive receivers located in close proximity to the existing highway. In particular, residences located next to the existing highway between Toolijooa Road and Tindalls Lane were exposed to high traffic noise levels due to the braking and acceleration of vehicles on the steep grades and sharp bends that characterised this section of the Princes Highway prior to the Project.

Within Berry, the Princes Highway previously ran directly through town along Queen Street, with businesses and residences located along Queen Street experiencing a high level of traffic noise. However, residences and churches located along North Street experienced a lower noise environment and were largely unaffected by noise from the Princes Highway prior to the Project.

5.1 Noise Catchment Areas

To categorise the different noise environments around the Project area, the Environmental Assessment categorised the area into six Noise Catchment Areas (NCAs). The NCAs were primarily used for the assessment of construction noise from the Project but provide a useful summary of the noise environment around the Project alignment.

Table 3 describes the NCAs.

Table 3 Noise Catchment Areas

NCA	Description
NCA 1	Toolijooa Road to Broughton Creek crossing: isolated residences in a rural setting. Noise exposure both prior to and following the Project depends on the proximity to the Princes Highway alignment.
NCA 2	Broughton Creek to Tindalls Lane: isolated residences in a rural setting. Noise exposure both prior to and following the Project depends on the proximity to the Princes Highway alignment.
NCA 3	Tindalls Lane to northern entrance to Berry North interchange: isolated residences in a rural setting. Noise exposure both prior to and following the Project depends on the proximity to the Princes Highway alignment.
NCA 4	Berry North Interchange and bridge across Woodhill Mountain Road and Connollys Creek: mixture of isolate rural residences and more closely spaced residences along Queen Street approaching Berry.
NCA 5	Berry township from Woodhill Mountain Road to the Berry South interchange: detached dwellings in residential area of Berry as well as aged care facilities, Churches and commercial land uses. Noise exposure prior to Project was low for residences on North Street but high for those on Queen Street.
NCA 6	Southern part of Berry township and section of Princes Highway south of Berry. The area includes residential areas along Huntingdale Park Road, with more isolated rural residences to the south of Berry. It also includes Mark Radium Park just south of the Berry South interchange. Generally, noise exposure in this area was relatively high prior to the Project which will did not result in significant realignment of the Highway.

5.2 Noise-sensitive receivers

The Environmental Assessment and Design and Construction operational noise assessments considered the road traffic noise impact of the Project at 591 individual noise-sensitive receivers, including residential uses, aged care uses and two Churches. These receivers are identified in Appendix A and Appendix B of this report alongside the originally predicted ‘No Build’ (without the Project) and ‘Build’ (with the Project) road traffic noise levels.

6 Operational noise monitoring methodology

6.1 Unattended noise monitoring

Unattended road traffic noise monitoring was conducted by Resonate across 18 locations over the project alignment between the dates of Wednesday, 14 March 2018 and Tuesday, 10 April 2018.

6.1.1 Instrumentation

All instrumentation used for the purposes of this assessment are classified as Class 1 and Class 2 measurement devices, as described in Australian Standard AS IEC 61672.1—2004. Acoustic calibration was conducted before and after the logging period and no significant calibration drift was observed. Each sound level meter unit holds current calibration certification.

6.1.2 Weather conditions

It is a requirement of the RNP that noise logging data that correlates with periods of bad weather be excluded from the results prior to the calculation of overall L_{eq} values.

6.1.3 Monitoring locations

The location of and justification for the post-construction noise monitoring and justifications are provided in Table 4 below. These locations are shown in map form in Appendix A.

6.1.4 Results

Table 4 provides a summary of monitoring locations, equipment used, date period for each location and the overall measured $L_{Aeq(period)}$ values. It is noted that the Easter long weekend fell within the unattended noise monitoring period. Data from 12 am on Friday, 30 March 2018 and 12 am on Tuesday, 3 April 2018 has been excluded from the calculation of the overall measured noise levels.

Additionally, the results presented in Table 1 exclude, where possible, measured noise levels during periods where the results were not considered to be controlled by road traffic noise. Generally, noise levels controlled by steady road traffic will have an L_{A10} level 3 dB above the L_{Aeq} level for that period, and periods where this has not occurred have been excluded from the calculation of $L_{Aeq(15\text{-}hour)}$ and $L_{Aeq(9\text{-}hour)}$ where they were considered to be controlled by other sources.

Typically, this includes:

- periods in the early morning or night time period controlled by bird and/or insect noise
- short-term periods where high levels were observed likely to be a result of local activity around the monitoring location such as lawn-mowing or, in the cases of the Churches, car park movements or the like.

Table 4 Noise monitoring results summary

ID	Location	Type/SN (1)	Type/SN (2)	Date period	Measured road traffic (L_{Aeq} period)		Measured road traffic (worst 1-hour period)	
					Day, $L_{Aeq(15\text{-}hour)}$	Night, $L_{Aeq(9\text{-}hour)}$	Day, $L_{Aeq(1\text{-}hour)}$	Night, $L_{Aeq(1\text{-}hour)}$
U1	A371 Princes Hwy, Broughton Village	NL-42 184111		Wednesday, 14 March 2018 Wednesday, 28 March 2018	60	56	64	62
U2	76 Woodhill Mountain Rd, Berry	EL-215 194638	NL-42 873125	Monday, 19 March 2018 Tuesday, 10 April 2018	55	53	64	63
U3	468 Donovan Rd, Broughton Village	NL-42 1060941		Monday, 19 March 2018 Tuesday, 10 April 2018	57	56	64	63
U4	77 Albert St St, Berry (Berry Uniting Church)	NL-42 184109		Wednesday, 14 March 2018 Wednesday, 28 March 2018	52	52	58	57
U5	80 North St, Berry (St Patricks Catholic Church)	NL-42 1173756		Thursday, 15 March 2018 Wednesday, 28 March 2018	53	51	62	56
U6	46 Princes Hwy, Broughton Village	NL-42 521656		Friday, 16 March 2018 Tuesday, 10 April 2018	52	52	66	58
U7	40 Austral Park Rd, Berry	NL-42 184110		Wednesday, 14 March 2018 Wednesday, 28 March 2018	54	51	69	59
U8	185A Princes Hwy, Berry	NL-42 221356		Thursday, 15 March 2018 Tuesday, 10 April 2018	59	57	64	63
U9	140A Princes Hwy, Berry	EL-215 194525	NL-42 184109	Thursday, 15 March 2018 Tuesday, 10 April 2018	52	50	66	58
U10	117 North St, Berry	NL-42 873125		Thursday, 15 March 2018 Wednesday, 28 March 2018	54	53	66	57
U11	130 North St, Berry	EL-215 194535	NL-42 1173759	Friday, 16 March 2018 Tuesday, 10 April 2018	53	49	59	59

ID	Location	Type/SN (1)	Type/SN (2)	Date period	Measured road traffic (L_{Aeq} period)		Measured road traffic (worst 1-hour period)	
					Day, $L_{Aeq(15\text{-}hour)}$	Night, $L_{Aeq(9\text{-}hour)}$	Day, $L_{Aeq(1\text{-}hour)}$	Night, $L_{Aeq(1\text{-}hour)}$
U12	Mark Radium Park	NL-42 1173760		Friday, 16 March 2018 Tuesday, 10 April 2018	61	55	67	59
U13	8 Huntingdale Park Rd, Berry	NL-42 973279		Wednesday, 14 March 2018 Tuesday, 10 April 2018	58	54	64	63
U14a	1 Pepper Farm Dr, Berry	NL-42 1173756		Wednesday, 28 March 2018 Thursday, 29 March 2018	53	51	57	58
U14b	60 Little Corella Ct, Berry	NL-42 1173759		Friday, 16 March 2018 Wednesday, 28 March 2018	54	52	60	56
U15	5 Mullers Ln, Berry	EL-315 15-203-506		Thursday, 15 March 2018 Monday, 26 March 2018	59	57	66	62
U16	43 Queen St, Berry	EL-315 15-203-504		Thursday, 15 March 2018 Tuesday, 27 March 2018	63	59	70	64
U17	90 North St, Berry	NL-42 184110		Wednesday, 28 March 2018 Tuesday, 10 April 2018	53	51	60	58

6.2 Operator-attended noise measurements

Operator -attended noise measurements were conducted simultaneously with unattended noise logging, as well as at various additional locations along the project alignment. The purpose of these noise measurements was to verify road traffic noise contribution captured in the unattended noise logging surveys.

Locations for these attended measurements were selected based on unattended noise logger locations as well as feedback from RMS. Some two-storey measurement were also conducted to investigate differences between ground floor and first storey road traffic noise levels.

A summary of the measured values for each attended measurement is provided in Table 5 below. See Appendix D for aerial-view graphical presentation of measurement locations and Appendix E for a detailed summary and observational notes taken for each attended measurement.

Table 5 Operator-attended noise measurements results summary

ID	Location	Time	Ground floor (1.5 m)			First floor (3.6 m)		
			L_{AFmax}	L_{Aeq}	L_{A90}	L_{AFmax}	L_{Aeq}	L_{A90}
A1	A371 Princes Hwy, Broughton Village	15:53	75	62	56	-	-	-
A2	76 Woodhill Mountain Rd, Berry	10:28	74	55	46	-	-	-
A3	468 Donovan Rd, Broughton Village	16:43	77	62	56	-	-	-
A4(i)	77 Albert St St, Berry (Berry Uniting Church) (external measurement)	14:24	70	45	41	-	-	-
A4(ii)	77 Albert St St, Berry (Berry Uniting Church) (internal measurement)	14:24	47	30	26	-	-	-
A5(i)	80 North St, Berry (St Patricks Catholic Church) (external measurement)	15:34	69	50	46	-	-	-
A5(ii)	80 North St, Berry (St Patricks Catholic Church) (internal measurement)	15:34	49	32	28	-	-	-
A6	46 Princes Hwy, Broughton Village	10:32	70	52	44	-	-	-
A7	40 Austral Park Rd, Berry	16:39	74	53	49	-	-	-
A8	185A Princes Hwy, Berry	09:55	68	57	49	-	-	-
A9	140A Princes Hwy, Berry	11:06	63	47	42	-	-	-
A10	117 North St, Berry	11:04	58	51	41	-	-	-
A11	130 North St, Berry	11:58	67	49	42	-	-	-
A12a	Mark Radium Park	13:30	72	60	53	-	-	-
A12b	9 Windsor Dr, Berry	11:53	68	58	52	-	-	-
A13	8 Huntingdale Park Rd, Berry	16:22	75	59	54	-	-	-
A14a(i)	1 Pepper Farm Dr, Berry	16:20	65	51	47	-	-	-
A14a(ii)	3 Little Corella Ct, Berry	16:20	65	46	41	-	-	-
A14a(iii)	10 Little Corella Ct, Berry	16:20	66	48	40	-	-	-
A14b(i)	60 Little Corella Ct, Berry	17:05	71	52	47	-	-	-
A14b(ii)	48 Little Corella Ct, Berry	17:05	58	46	42	-	-	-

ID	Location	Time	Ground floor (1.5 m)			First floor (3.6 m)		
			L_{AFmax}	L_{Aeq}	L_{A90}	L_{AFmax}	L_{Aeq}	L_{A90}
A14b(iii)	27 Little Corella Ct, Berry	17:05	78	41	36	-	-	-
A15a	5 Mullers Ln, Berry	09:37	64	55	48	-	-	-
A15b	5 Mullers Ln, Berry	09:55	79	58	50	-	-	-
A16	43 Queen St, Berry	09:52	76	63	46	-	-	-
A17	90 North St, Berry	15:30	75	55	49	-	-	-
A18	1 Brangus Cl, Berry	14:08	70	52	45	-	-	-
A19	1 Lincoln Cl, Berry	14:40	79	59	46	-	-	-
A20	1 Host Pl, Berry (two storey measurement)	16:09	62	51	47	63	55	51
A21	14 Ford St, Berry (two storey measurement)	16:36	66	52	47	65	53	49
A22	North St, Berry (near Rawlings Ln)	14:08	71	59	52	-	-	-
A23	1 Queen St, Berry (opposite side adjacent to roundabout)	14:09	78	61	52	-	-	-
A24	17 George St, Berry	16:13	72	56	50	-	-	-
A25	102 North St, Berry	15:43	72	56	51	-	-	-
A26	1 Pulman St, Berry	16:48	82	63	48	-	-	-
A27	9 Schofields Ln, Berry	17:15	76	66	60	-	-	-
A28	10 Windsor Dr, Berry (two storey measurement)	15:34	76	56	45	76	57	48

7 Traffic counting

7.1 Dates and locations

Traffic counting was conducted by Matrix Traffic and Transport Data at the 17 locations summarised in Table 6. The locations are shown on the aerial photographs included in Appendix A. Valid data was gathered at each location for the period from Sunday 25 March to Saturday 7 April 2018.

Table 6 Traffic count locations

Reference	Description of location
T1	Princes Highway, south of Berry – northbound and southbound counters
T2	Berry Bypass – northbound and southbound counters
T3	Princes Highway, north of Berry – northbound and southbound counters
T4	Berry South Interchange – southbound on ramp
T5	Berry South Interchange – southbound off ramp
T6	Berry South Interchange – northbound on ramp
T7	Berry South Interchange – northbound off ramp
T8	Berry North Interchange – northbound on ramp
T9	Berry North Interchange – southbound off ramp
T10	Huntingdale Park Road – northbound and southbound counters
T11	Queen Street – northbound and southbound counters
T12	Tindalls Lane Interchange – southbound ramp
T13	Tindalls Lane Interchange – northbound ramp
T14	Austral Park Road Interchange – southbound on ramp
T15	Austral Park Road Interchange – northbound off ramp
T16	Donovans Road Interchange – northbound on ramp
T17	Toolijooa Road Interchange – southbound off ramp

The traffic counters were pneumatic road tubes that provided separation of the captured movements into the 12 vehicle classes defined by AustRoads as well as a measure of the speed of each vehicle pass-by.

7.2 Measured traffic volumes

Table 7 summarises the measured traffic volumes at each of the locations across the monitoring period, as well as the measured average vehicle speeds.

As the traffic counting occurred over the Easter long weekend (30 March to 2 April), corrected daily averages are presented for each week excluding the Easter public holidays as these days have the potential to result in higher traffic volumes in Berry township than is normal for the remainder of the year. These corrected daily averages are calculated from 25 to 29 March (Week 1) and 3 to 7 April (Week 2).

Table 7 Measured traffic volumes

Road	Direction	Daily average: Week 1, 25 – 29 March						Daily average: Week 2, 3 – 7 April					
		Day, 7 am to 10 pm			Night, 10 pm to 7 am			Day, 7 am to 10 pm			Night, 10 pm to 7 am		
		Cars[1]	CVs[2]	Speed[3]	Cars[1]	CVs[2]	Speed[3]	Cars[1]	CVs[2]	Speed[3]	Cars[1]	CVs[2]	Speed[3]
T1: Princes Highway, south of Berry	NB	8360	979	95	894	213	96	8785	1122	96	609	151	97
	SB	8414	2075	100	992	386	103	7739	2150	103	590	240	104
T2: Berry Bypass	NB	7556	1011	102	829	221	102	7314	1112	102	550	109	103
	SB	7892	1080	101	1004	256	101	6898	1076	101	565	166	101
T3: Princes Highway, north of Berry	NB	7607	1066	102	784	236	102	7970	1225	102	566	167	102
	SB	8707	943	99	1119	223	99	7997	1014	99	652	160	99
T4: Berry Sth I/C On Ramp	SB	2444	156	58	164	20	59	2548	164	58	200	22	59
T5: Berry Sth I/C Off Ramp	SB	286	29	65	29	5	66	302	30	65	120	13	63
T6: Berry Sth I/C On Ramp	NB	381	21	61	39	3	59	382	26	61	15	2	60
T7: Berry Sth I/C Off Ramp	NB	2417	196	74	176	27	73	2530	212	75	20	1	74
T8: Berry Nth I/C On Ramp	NB	1439	105	58	67	16	62	1310	109	58	52	11	61
T9: Berry Nth I/C Off Ramp	SB	1562	129	80	88	20	80	1419	133	81	50	10	81
T10: Huntingdale Park Road	NB	347	54	45	31	1	45	379	50	46	15	0	44
	SB	339	51	48	35	8	48	385	48	48	13	1	47
T11: Queen Street	EB	2645	200	49	163	23	51	2765	220	48	91	11	52
	WB	2486	115	50	131	20	53	2549	121	50	110	11	53
T12: Tindalls I/C SB Ramp	On	29	3	45	2	0	43	37	5	45	2	0	44
	Off	90	13	55	7	1	57	95	15	54	2	1	52

Road	Direction	Daily average: Week 1, 25 – 29 March						Daily average: Week 2, 3 – 7 April					
		Day, 7 am to 10 pm			Night, 10 pm to 7 am			Day, 7 am to 10 pm			Night, 10 pm to 7 am		
		Cars[1]	CVs[2]	Speed[3]	Cars[1]	CVs[2]	Speed[3]	Cars[1]	CVs[2]	Speed[3]	Cars[1]	CVs[2]	Speed[3]
T13: Tindalls I/C NB Ramp	On	0	0	n/a	0	0	n/a	0	0	n/a	0	0	n/a
	Off	97	9	45	5	0	46	101	10	45	3	0	45
T14: Austral Park I/C On Ramp	SB	158	23	84	9	3	78	176	21	84	3	0	89
T15: Austral Park I/C Off Ramp	NB	155	23	81	8	1	82	169	22	81	7	0	83
T16: Donovans Road I/C On Ramp	NB	340	48	75	28	4	75	375	47	76	20	2	71
T17: Toolijooa Road I/C Off Ramp	SB	359	48	82	24	5	78	373	43	82	19	2	81

(1) Cars are considered to be Austroads vehicle classes 1 and 2.

(2) CVs are considered to be Austroads vehicle classes 3 to 12.

(3) Average vehicle speeds in km/h are presented in the table.

7.3 Discussion

7.3.1 Traffic volumes

As part of the operational noise assessment conducted for the Project during the environmental assessment and design and construction phases, forecast traffic volumes were adopted for the following timeframes:

- Project Opening (2017)
- Project Design Year (2027).

As the forecast traffic volumes will have a significant effect on the noise level predictions, it is necessary to compare the forecast volumes with the actual measured volumes during the traffic survey. Table 8 compares the measured average volumes for the Project roads during the traffic counting (averaged across both weeks but excluding Easter) with the Project Opening (2017) traffic volumes that were adopted for the environmental assessment and in later operational noise assessments. Measured volumes that exceeded the forecast volumes are highlighted in **bold** type.

Table 8 Comparison of measured traffic volumes and forecast Project Opening volumes

Road	Direction	Day Traffic Volumes				Night Traffic Volumes			
		Measured[1]		Modelled Project Opening		Measured[1]		Modelled Project Opening	
		Cars	CVs	Cars	CVs	Cars	CVs	Cars	CVs
Princes Highway South of Berry	NB	**8573**	**1051**	7187	718	**752**	**182**	505	160
	SB	**8077**	**2113**	6787	771	**791**	**313**	502	160
Berry Bypass	NB	**7435**	**1062**	5723	572	**690**	**165**	402	127
	SB	**7395**	**1078**	5355	590	**785**	**211**	415	147
Princes Highway North of Berry	NB	**7789**	**1146**	6172	609	**675**	**202**	432	140
	SB	**8352**	**979**	5808	636	**886**	**192**	450	158
Berry Sth I/C On Ramp	SB	**2496**	160	1799	204	**182**	21	133	42
Berry Sth I/C Off Ramp	SB	294	30	383	42	**75**	9	30	10
Berry Sth I/C On Ramp	NB	382	24	361	36	**27**	3	25	8
Berry Sth I/C Off Ramp	NB	**2474**	**204**	1825	182	98	14	128	41
Berry Nth I/C On Ramp	NB	**1375**	**107**	444	44	**60**	**14**	31	10
Berry Nth I/C Off Ramp	SB	**1491**	**131**	449	49	**69**	**15**	35	12

(1) Calculated as an average across the Week 1 and Week 2 data from Table 7.

From Table 8 it can be seen that the measured traffic volumes exceeded the Project Opening forecast volumes for most Project roads.

This increase of traffic relative to the predicted Project Opening volumes is likely to be a result of the traffic switch coming across from the alternative route along the south coast running through Gerringong, Gerroa and Bomaderry, referred to as “The Sandtrack”. Traffic counts from the permanent traffic counter at Gerroa (Counter No. 07.101), showed an AADT of 10,602 vehicles for the 2016 Calendar year. In the 12-months since the opening of the Berry bypass section on 18 July 2017, traffic volumes on The Sandtrack have dropped to an AADT of 5865 vehicles per day. This drop of traffic along The Sandtrack of approximately 4700 vehicles per day is a result of vehicles using the Princes Highway route as the preferred route of travel between Kiama and Bomaderry/Nowra as a result of the highway upgrade.

It appears that there has been an immediate transfer of traffic to the upgraded highway as opposed to a gradual transition to the upgraded highway as was presented in the EIS. As such the future predicted (design year 2027) traffic volumes are considered to remain valid and appropriate in relation to the assessment of noise mitigation measures for the project.

It is also important to note that part of this increase may be a result of the fact that the traffic counting was conducted over the Easter period and, while the Easter public holiday data has been excluded, it is possible that there is a greater number of vehicles using this road at this time of year. The Project Opening forecast volumes are Annual Average Daily Traffic (AADT) volumes and, as such, are averaged over an entire year. Additionally, the average measured volumes have been calculated over eight weekdays, one Saturday and one Sunday, and would therefore be different to volumes averaged over a standard week without any public holidays.

The Environmental Assessment outlined within Section 2.4.3, of Appendix D -Traffic and Transport, that during the Easter period of March/April, a Seasonality Factor of 1.138 was measured for the 2009 traffic surveys when comparing this period to the AADT.

7.3.2 Vehicle speed

Princes Highway

The measured average vehicle speeds on the Princes Highway were within 5 km/h of the posted speed limit (100 km/h) for both weeks, with the average speeds remaining relatively constant for both weeks and for the day and night time period. No significant increase in average vehicle speed was observed at night time relative to during the day.

It can be seen from the measured average vehicle speeds that, for some carriageways of the Princes Highway, the average vehicle speed did exceed the posted speed limit, which was assumed as the road speed in the road traffic noise level predictions. A maximum average vehicle speed of 104 km/h was observed for the southbound carriageway of the Princes Highway during the night time period in the second week of the traffic counting.

While the average speeds for some carriageways of the Princes Highway were above the posted speed limits, which were used as part of the road traffic noise level predictions, the effect of relatively small increases in speed on road traffic noise levels is limited. Under the CoRTN algorithm, an increase in speed of 5% results in an increase in predicted L_{Aeq} noise level of approximately 0.3 to 0.4 dB for roads carrying 10 to 15% CVs. Therefore, an increase in vehicle speeds of this magnitude would not increase predicted noise levels by more than the 1 dB safety factor that was adopted within the road traffic noise level predictions for the Project during the environmental assessment and design and construction phases.

Ramps

The measured vehicle speeds for the interchange ramps reveal relatively constant average speeds for the day and night time periods on the interchange ramps. It is difficult to draw conclusions on the vehicle speeds on the ramps relative to the posted speed limit, as speeds will vary on ramps as vehicles accelerate or decelerate and, therefore, the speed will vary depending on the monitoring position along the ramps. Regardless, it is not considered that higher than expected speeds were measured along the major ramps and it is also noted that generally the traffic on the ramps does not control the overall noise levels at residences adjacent to the Project.

8 Road traffic noise assessment

To assess the accuracy of the road traffic noise predictions that underpinned the noise mitigation measures for the Project detailed in Section 4, the following methodology was implemented:

- The road traffic noise model developed for the Project incorporating the as constructed noise model was used to predict road traffic noise levels at each of the locations at which post-construction noise monitoring was conducted. The predictions were based on the measured traffic volumes for each week as detailed in Table 7.
- The predicted noise levels were compared to the measured noise levels to determine any difference between measured and predicted noise levels.
- If the difference between measured and predicted noise levels fell within standards established for acceptable accuracy for road traffic noise assessments then the model outputs were deemed to be accurate. Generally, a road traffic noise model is deemed to be acceptable if the predicted noise levels are within 2 dB of the measured noise levels for both the day and night time periods.

8.1 Road traffic noise prediction methodology

The road traffic noise prediction methodology employed was consistent with that employed as part of the Environmental Assessment (EA) and Design and Construction (D&C) phases, except where modifications were required.

The road traffic noise prediction parameters are detailed in Table 9. Any deviations from the EA and D&C phases are noted within Table 9.

Table 9 Road traffic noise prediction parameters

Parameter	Description and comment
Software	SoundPlan version 7.4 environmental noise prediction software.
Algorithm	Calculation of Road Traffic Noise (CoRTN) 1988 algorithm as implemented by the SoundPlan software. The CoRTN algorithm is widely used within Australia for the prediction for road traffic noise and is specified for use on NSW RMS projects.
Topography	Existing (pre-Project) topography for the surrounding area was supplied by RMS.
Buildings	Buildings were determined from aerial photography, with heights based on resources such as Google StreetView and site visits. A standard height of 4 m was adopted for most single-storey dwellings.
Road design	Final three-dimensional D&C road design provided by Fulton Hogan on 20 March 2015 including the Southern Tie-In Extension.
Road speeds	Posted speed limits were assumed for all roads within the noise model.
Traffic volumes	Counted traffic volumes as per Table 7.
Road pavement corrections	• -2.2 dB for car tyres on the main carriageway with SMA surface • -4.3 dB for truck tyres on the main carriageway with SMA surface • 0 dB for all other road surfaces (DGA).
Road source heights	• 0.5 m above ground for car exhausts, car engines and car tyres • 0.5 m above ground for truck tyres • 1.5 m above ground for truck engines • 3.6 m above ground for truck exhausts
Truck source corrections	• 0.5 m above ground for car exhausts, car engines and car tyres • -0 dB for • -8.6 dB for truck exhausts.
Ground absorption factor	50% except for road surfaces which were modelled as completely reflective (0%).

Parameter	Description and comment
Search radius	Predicted noise levels considered any road sections within the model within 3 km of the prediction point.
Receiver heights	1.5 m above ground.
Safety factor	No safety factor was applied to the predictions. The EA and D&C phases applied a +1 dB safety factor to all predictions. For the purposes of this comparison between predicted and measured levels has not included the safety factor.
Facade correction factors	+2.5 dB was added to predicted noise levels for locations 1 m from a building facade in accordance with CoRTN procedures. No correction factor was applied to free-field predicted noise levels.
Other correction factors	The following standard NSW correction factors for CoRTN were applied to predicted noise levels: • -1.7 dB for the daytime period • +0.5 dB for the night time period.

8.2 Comparison of measured and predicted noise levels

Table 10 compares the measured noise levels (MNLs) and predicted noise levels (PNLs) for each of the 18 unattended monitoring locations for both the day and night time periods. The comparison is based on the measured noise levels for each of the two weeks for which traffic data was collected (excluding the Easter long weekend), with the PNLs based on the traffic volume counts for that week.

The difference between the PNLs and MNLs is calculated and presented as follows:

- **GREEN** highlight indicates that the PNL is within 2.0 dB of the MNL. This is generally taken to be a reasonable level of accuracy for a road traffic noise model, noting that a difference in noise levels of this magnitude is generally imperceptible or only just perceptible to the human ear in field conditions.
- **BLUE** highlight indicates that the PNL exceeds the MNL by more than 2.0 dB.
- **ORANGE** highlight indicates that the MNL exceeds the PNL by more than 2.0 dB.

From Table 10, it is clear that the majority of measured noise levels fall within 2.0 dB of the predicted noise level, indicating an acceptable degree of noise model accuracy. This occurs for 42 out of 58 comparison periods across the 18 locations.

For 11 comparison periods, the predicted noise levels exceeded the measured noise levels by more than 2.0 dB. Generally, this was in the range of 2.0 to 3.0 dB and is considered most likely that it is a result of additional shielding being present in field than was accounted for in the noise model. For example, this may include New Jersey kerbs not considered in parts of the noise model or shielding features unrelated to the Project that were not fully accounted for. Regardless, it is noted that, at these locations, the model has conservatively over-predicted road traffic noise levels and the actual noise impact of the Project would be lower than considered in the Environmental Assessment or during the Design & Construction phase of the Project.

Table 10 Comparison of measured and predicted noise levels

Location		Week 1, 25 – 29 March						Week 2, 3 – 7 April					
		Day, 7 am to 10 pm			Night, 10 pm to 7 am			Day, 7 am to 10 pm			Night, 10 pm to 7 am		
		MNL[1]	PNL[2]	Diff[3]	MNL[1]	PNL[2]	Diff[3]	MNL[1]	PNL[2]	Diff[3]	MNL[1]	PNL[2]	Diff[3]
U1	A371 Princes Hwy, Broughton Village	58.7	60.9	2.2	57.1	57.8	0.7	–	61.2	–	–	56.2	–
U2	76 Woodhill Mountain Rd, Berry	55.3	55.4	0.1	51.9	52.2	0.3	53.5	55.4	1.9	47.7	49.9	2.2
U3	468 Donovan Rd, Broughton Village	57.7	59.7	2.0	55.3	56.6	1.3	58.3	60.0	1.7	54.6	55.0	0.4
U4	77 Albert St St, Berry (Berry Uniting Church)	52.9	48.9	-4.0	45.8	45.2	-0.6	–	48.9	–	–	43.0	–
U5	80 North St, Berry (St Patricks Catholic Church)	53.5	54.1	0.6	50.2	50.8	0.6	–	54.1	–	–	48.5	–
U6	46 Princes Hwy, Broughton Village	51.8	50.7	-1.1	51.6	47.5	-4.1	50.1	51.0	0.9	51.3	45.9	-5.4
U7	40 Austral Park Rd, Berry	53.4	55.2	1.8	50.4	52.3	1.9	–	55.4	–	–	50.6	–
U8	185A Princes Hwy, Berry	58.2	60.5	2.3	57.0	57.2	0.2	58.9	60.7	1.8	55.0	55.7	0.7
U9	140A Princes Hwy, Berry	55.5	54.7	-0.8	49.8	51.2	1.4	49.9	54.7	4.8	48.6	48.9	0.3
U10	117 North St, Berry	54.2	53.7	-0.5	54.3	50.5	-3.8	–	53.6	–	–	48.2	–
U11	130 North St, Berry	53.7	53.3	-0.4	49.6	50.1	0.5	51.5	53.2	1.7	45.6	47.8	2.2
U12	Mark Radium Park	60.8	59.5	-1.3	54.7	55.9	1.2	59.6	59.5	-0.1	52.8	53.7	0.9
U13	8 Huntingdale Park Rd, Berry	57.1	59.5	2.4	53.4	55.1	1.7	57.7	59.5	1.8	52.5	51.6	-0.9
U14a	1 Pepper Farm Dr, Berry	53.9	56.8	2.9	51.9	53.4	1.5	53.1	56.9	3.8	50.8	51.4	0.6
U14b	60 Little Corella Ct, Berry	54.4	53.8	-0.6	51.4	50.2	-1.2	–	53.9	–	–	48.3	–
U15	5 Mullers Ln, Berry	59.5	61.6	2.1	57.7	57.4	-0.3	60.7	61.7	1.0	57.2	56.2	-1.0
U16	43 Queen St, Berry	63.0	62.8	-0.2	58.5	54.7	-3.8	–	63.0	–	–	53.9	–
U17	90 North St, Berry	53.6	56.8	2.2	52.4	53.7	1.3	53.1	56.8	3.7	51.3	51.3	0.0

(1) Measured Noise Level for relevant time period in dB $L_{Aeq(15\text{-}hour)}$ for day and dB $L_{Aeq(9\text{-}hour)}$ for night.

(2) Predicted Noise Level from noise model based on traffic volumes measured for that period in dB $L_{Aeq(15\text{-}hour)}$ for day and dB $L_{Aeq(9\text{-}hour)}$ for night.

(3) Difference: PNL – MNL. A positive number indicates an over-prediction while a negative number indicates an under-prediction.

For five comparison periods, the measured noise levels exceeded the predicted noise levels by more than 2.0 dB. As this could be an under-prediction of the noise model, each of these cases were closely analysed and are discussed below:

- U4, Berry Uniting Church: The daytime noise levels at Berry Uniting Church exceeded the predicted noise levels by 4 dB but were within acceptable accuracy range at night time. Based on our observations on site and the location of U4, it is clear that other noise controlled the measured daytime noise levels as the measurement location was over 200 m from the Berry Bypass and shielded by intervening buildings. It is considered that the daytime noise levels were influenced by local traffic and activity that could not be reasonably removed by the exclusion of measurement data at this site.
- U6, 46 Princes Hwy, Broughton Village: The measured night time levels at this location exceeded the predicted noise levels by 4 to 5 dB for both Weeks. However, it is apparent from the measurement data that other noise sources controlled the measured night time noise levels at this location, where the monitoring was conducted more than 300 m from the new Princes Highway alignment. In particular, it can be seen that the measured night time noise levels are at or marginally above the measured day time noise levels, which is a clear indication that other noise sources controlled the measurements. For example, insect noise that could not be excluded from the measurement data.
- U10, 117 North Street, Berry: The measured night time levels at this location exceeded the predicted noise levels by 4 dB although the measured daytime noise level was within 0.5 dB of the predicted noise level. It is considered from the measurement data that other noise sources controlled the measured night time noise levels at this location as it can be seen that the measured night time noise levels are equivalent to the measured day time noise levels, which is a clear indication that other noise sources controlled the measurements. For example, insect noise that could not be excluded from the measurement data.
- U16, 43 Queen St, Berry: The measured night time level at this location exceeded the predicted noise level by 4 dB. It is not immediately clear what the cause of the difference at this location is, but it may be a result of local activity noise given the site is positioned on the main street of Berry. Regardless, the noise environment at this location is controlled by non-Project roads (e.g. Queen Street) and no mitigation measures were required for Queen Street as part of the Project, as the Project was expected to significantly reduce traffic volumes on this road.

Considering the above comments, it is noted that the measured noise levels for the five comparison periods where an apparent under-prediction of the road traffic noise level occurred are not considered to be controlled by road traffic noise from the Project roads.

9 Discussion

9.1 Noise model accuracy

Table 11 presents statistical parameters on the difference between measured and predicted noise levels, with a positive value for the mean and median indicating an over-prediction and a negative value indicating an under-prediction. The parameters are presented for both:

- All 18 locations, including those where there were periods where the measured noise levels were not considered to be controlled by road traffic noise levels.
- Excluding those 5 comparison periods where other sources were considered to control the measurements and those 11 comparison periods where an over-prediction of over 2 dB was occurred, as this may have indicated that the noise model did not fully incorporate all shielding features in the environment.

Table 11 Statistical parameters to assess noise model accuracy

Parameter	Day, 7 am to 10 pm	Night, 10 pm to 7 am
All 18 unattended monitoring locations		
Number of samples	29	29
Mean	1.1	0.0
Median	1.7	0.5
Standard deviation	1.8	2.0
Excluding those 5 comparison periods where traffic noise was considered not to suitably control measured noise levels for a suitably accurate comparison to be made, and those 11 comparison periods where the model over-predicted by more than 2 dB		
Number of samples	19	23
Mean	0.5	0.5
Median	0.6	0.6
Standard deviation	1.2	0.9

From Table 11 it can be seen that the noise model tended marginally towards over-prediction with an acceptable degree of accuracy. With the exclusion of those samples where other factors were considered to influence the results, there was an excellent agreement in accuracy between the day and night-time periods.

9.2 Noise mitigation measures

Given the apparent acceptable accuracy of the noise model, it is considered that the noise mitigation measures incorporated into the Project were of a suitable extent to address road traffic noise levels in a reasonable and feasible manner.

The apparent accuracy of the noise model demonstrated that the road surface treatment and noise barriers (e.g. mounds) in particular were designed and constructed to achieve a suitable road traffic noise level at noise-sensitive locations based on the assumed traffic volumes adopted during the Environmental Assessment and Design & Construction phases.

For reference, the noise contours predicted at a height of 1.5 m above ground level are presented in Appendix F for the Year 2027 design year. These predictions include all noise mitigation measures delivered as part of the project (low noise pavement and noise mounds/barriers).

10 Conclusion

This report presents the results of a post-construction road traffic noise assessment undertaken in March and April 2018 to assess whether road traffic noise levels from the Foxground and Berry Bypass comply with the relevant environmental obligations in relation to operational road traffic noise.

The assessment has considered unattended measurements conducted over multiple weeks at 18 locations, supported by attended measurements conducted at those and another 11 locations. It was supported by traffic counting conducted at key locations around the Project.

The final design noise model for the Project was updated to include the measured traffic volumes and used to predict road traffic noise levels at the unattended monitoring locations. The predicted road traffic noise levels compared well with the measured road traffic noise levels, with the predictions being within 2 dB of the measured noise levels for the majority of locations. For the small number (five) instances where an apparent under-prediction was noted, it was determined that this was a result of non-Project related noise sources controlling the measured levels.

The measured traffic volumes were noted to exceed the stated Project opening volumes that were assumed within the Environmental Assessment and Design & Construction operational noise assessments conducted for the Project. It is noted that this is likely to be the result of an immediate transition of traffic from The Sandtrack to the upgraded highway with a potential contribution from the time of year of the measurements which were conducted, around but not including, the Easter long weekend.

On the basis of this assessment, it is considered that the operational noise mitigation measures implemented as part of the Project are performing as intended and that the measured road traffic noise levels are consistent with those predicted during the design of the Project.