Woolgoolga to Ballina Pacific Highway upgrade

Operational Noise Review

Roads and Maritime Services | April 2018

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Roads and Maritime Services

Pacific Highway Upgrade Glenugie to Pimlico

April 2018

Prepared by Pacific Complete

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Approval and authorisation

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Glossary

Term	Description
Acute noise level	A level of road traffic noise of 65 dBA or more for the day period of 7am to 10pm or 60 dBA or more for the night period of 10pm to 7am and measured as an equivalent continuous noise level (LAeq) 1 metre from the building facade.
Ambient noise	The all-encompassing noise associated within a given environment. It is the composite of sounds from many sources, both near and far.
Background noise	The underlying level of noise present an environment. Typically described using the L_{90} descriptor.
Build scenario	The scenario that represents conditions where the road project proceeds
Chainage	The chainage represents the distance in metres from the start of the project along the road control line.
CONCAWE	Conservation of Clean Air and Water in Europe
Controlling criterion	The most stringent criteria applicable to a receiver under the *Noise Criteria Guideline*.
CoRTN	*Calculation of Road Traffic Noise* (United Kingdom Department of Transport, 1988)
Cumulative limit	A noise level that is 5 dBA or more above the Noise Criteria Guideline controlling criterion in the build year.
dB	Decibel (dB) is the unit used to describe the level of sound. The decibel is defined as 20 times the logarithmic ratio of a given sound pressure to a reference pressure.
dBA	Decibels with the A-weighting filter applied. The A-weighting filter is a correction applied to sound levels of different frequencies that approximates the human ear's response to different frequencies.
DGA	Dense graded asphalt. A type of road pavement surface made from a blend of aggregate and bitumen. Also known as asphaltic concrete.
DECC	Department of Environment and Climate Change
DECCW	Department of Environment, Climate Change and Water
EIS	Environmental Impact Statement
ENMM	Environmental Noise Management Manual (Roads and Maritime, 2001)

Term	Description
Feasibility	'Feasibility' as defined in the Noise Mitigation Guideline relates to engineering considerations (what can be practically built). These engineering considerations may include: • The inherent limitations of different techniques to reduce noise emissions from road traffic noise sources • Safety issues, such as restrictions on road vision • Road corridor site constraints such as space limitations • Floodway and stormwater flow obstruction • Access requirements • Maintenance requirements • The suitability of building conditions for architectural treatments.
INP	*Industrial Noise Policy* (EPA, 2000)
$L_{eq(period)}$	Equivalent continuous sound pressure level: the single number sound level that is equivalent in energy to the actual fluctuating sound level of a specific period.
$L_{10(period)}$	The sound pressure level exceeded for 10% of the measurement period.
$L_{90(period)}$	The sound pressure level exceeded for 90% of the measurement period.
L_{max}	The maximum sound level recorded during the measurement period.
$L_{eq(15\ hour)}$	The L_{eq} noise level for the period Day period, 7 am to 10 pm.
$L_{eq(9\ hour)}$	The L_{eq} noise level for the period Night period, 10 pm to 7 am.
$L_{eq(1\ hour)}$	The highest hourly L_{eq} noise level during the day and night periods.
Maximum noise level	The highest measured noise level within the measurement period, described as L_{max}
NCG	*Noise Criteria Guideline* (Roads and Maritime, 2015)
NMG	*Noise Mitigation Guideline* (Roads and Maritime, 2015)
No Build scenario	The scenario that represents the conditions that would have occurred had the road project not proceeded.
Noise sensitive receiver	An area or place potentially affected by noise as defined in the *Noise Criteria Guideline* including residential dwellings, schools, child care centres, places of worship, health care institutions and active or passive recreational areas.
Rating background level (RBL)	The single figure background level representing each assessment period (day/evening/night) over the whole monitoring period as defined in the *Industrial Noise Policy*.

Term	Description
Reasonable	Selecting 'reasonable' measures as defined in the Noise Mitigation Guideline from those that are feasible involves judging whether the overall noise benefits provide significant social, economic or environmental benefits. The factors to be considered are: • The noise reduction provided and the overall number of people that benefit from the mitigation • Existing and future noise levels, including changes in noise levels in the build and design year and the extent of any exceedance of the noise criteria • Potential for a mitigation measure to reduce noise during construction as well from road traffic after the proposal is complete • The cost of mitigation, including the cost of noise mitigation measures as a percentage of the total proposal cost and the ongoing maintenance and operational costs • Community views and wishes • Visual impacts for the community surrounding the road proposal and for road users • The wider community benefits arising from noise mitigation of the proposed road and road redevelopment • Relative weighting of treatments with respect to protection of outdoor areas or only internal living spaces.
RNP	*Road Noise Policy* (DECCW, 2011)
SMA	Stone mastic asphalt pavement. A type of road pavement made from a blend of aggregate and bitumen with a different ratio and aggregate size than DGA.
Transition zone	The area either side of the physical transition point between road development types (e.g. New versus Redeveloped road proposal).

Executive Summary

The Pacific Highway upgrade is one of the largest road infrastructure projects in NSW. The upgrade between Woolgoolga to Ballina comprises about 155 kilometres of dual carriageways extending from about six kilometres north of Woolgoolga to about six kilometres south of Ballina.

The Woolgoolga to Ballina section of the Pacific Highway upgrade is being delivered in several portions as follows:

- Woolgoolga to Glenugie Link
- Glenugie Link
- Glenugie Link to Maclean
- Maclean to Devils Pulpit
- Devils Pulpit Upgrade
- Devils Pulpit to Richmond River
- Richmond River to Pimlico
- Pimlico to Teven.

This report provides an operational noise review of the sections of the Woolgoolga to Ballina Pacific Highway upgrade from the Glenugie Link to Pimlico (EIS sections 3 to 11). This report does not address operational noise impacts from the following portions as they have been assessed elsewhere:

- Woolgoolga to Glenugie (EIS sections 1 and 2)
- Glenugie Link
- Devils Pulpit Upgrade (EIS section 6A)
- Pimlico to Teven to tie in the Ballina Bypass and the Bruxner Highway.

This report does not provide assessment of construction noise or vibration associated with building the project.

This report provides a summary of the noise assessments carried out for each of the four portions between Glenugie and Pimlico, referred to hereafter as “the project”. The noise assessments for each portion were delivered by the design contractors.

The Woolgoolga to Ballina upgrade was approved by the Department of Planning and Environment in 2014 based on the Environmental Impact Statement (EIS) carried out in 2012. The Ministers Conditions of Approval required an operational noise review to be carried out to review the impact of the project and identify mitigation measures.

Noise impacts associated with the project were assessed in line with the NSW Environmental Protection Authority’s Road Noise Policy (RNP) and Road and Maritime Services (Roads and Maritime) guideline for the implementation of the RNP, the Noise Criteria Guideline (NCG). Mitigation was identified for the project in line with Roads and Maritime’s Noise Mitigation Guideline (NMG).

Noise models of each of the four portions between Glenugie and Pimlico were prepared to predict the noise level from the project. The noise models were prepared using the detailed design of the project and parameters in line with the Pacific Highway design brief and design parameters. The models included more detailed information relating to ground topography, buildings and updated forecast traffic volumes.

As part of the operational noise review, receivers were ground truthed using on site observations to confirm the location of sensitive receivers and distinguish between noise sensitive and non-noise sensitive structures.

The noise models were validated using simultaneous noise monitoring and traffic counting data collected for the EIS. Where additional monitoring and traffic counting data were required, they were carried out in 2016 to supplement the existing data set.

Noise levels were predicted for two scenarios; where the project is built (the Build scenario) and a do nothing scenario where the project is not built (No build scenario). The two scenarios were evaluated at two points in time; when the project opens in 2019 and ten years after opening in 2029.

Impacts at receivers up to 600 metres from the project were considered in line with the RNP. Impacts were also assessed at distances between 601 and 900 metres from the project in consideration of the Noise Criteria Guideline.

There were two assessment areas for consideration of mitigation. Receivers within 600 metres identified as eligible for consideration of mitigation are to be investigated for treatment at the earliest opportunity. Receivers eligible for consideration of mitigation between 601 and 900 metres from the road will be investigated as part of the operational noise compliance report on a case by case basis when actual noise levels from the project can be determined at those properties.

The predicted noise impacts were assessed and noise mitigation measures identified in the EIS were reviewed.

There were 792 residential receivers assessed within 600 metres of the project which is 85 more than the EIS. This is a result of ground truthing, property register searches and a review of sensitive receivers from high resolution aerial photography. A further 416 residential receivers were assessed between 601 and 900 metres from the project.

Mitigation including quieter pavement (additional to areas identified in the EIS) and a noise barrier have been identified as reasonable and feasible as follows:

- A noise barrier at Tyndale
- Additional low noise pavement for about two kilometres at Gulmarrad, south of Maclean
- Additional low noise pavement for about three kilometres at Broadwater.

After the application of the reasonable and feasible additional mitigation, there were 307 residential receivers and three non-residential receivers eligible for consideration of at-property treatment within 600 metres of the project. The application of the additional mitigation reduced the number of receivers eligible for the consideration of mitigation by 57.

In addition, there were 47 receivers between 601 and 900 metres from the project identified as eligible for consideration at the operational compliance stage.

Assessment of the maximum noise levels indicated impacts would increase in the New road corridors. This would be more apparent where there is no current existing road traffic including areas between Glenugie and Tyndale and those next to the Woodburn, Broadwater and Wardell bypasses. In existing corridors, maximum noise level impacts are expected to be similar. For receivers within bypassed villages such as Woodburn, Broadwater and Wardell, maximum noise level impacts would be substantially reduced.

The primary reasons for the increase in the number of eligible receivers are:

- Changing in the assessment criteria to use the most up to date approach. The assessment criteria used are more stringent in some cases compared with the EIS approach
- Increasing the level of detail used in the noise modelling including buildings, structures and refined ground topography, other significant road noise sources and more detailed assessment of receivers which included assessment at each façade and storey
- Differences in traffic volumes and vehicle mix, considering 2029 as the design year instead of 2026
- Increase in the number of receivers identified through detailed ground surveys and investigation. Change in the classification of receivers previously assessed as non-sensitive receivers, subsequently identified as a sensitive receiver
- Increasing the modelled design speed and inclusion of a +0.8 dB safety factor. This means the noise model predicts higher noise levels to provide a conservative assessment
- Change in road design including road geometry and pavement design.

A summary of the outcomes from each of the portions follows:

Glenugie to Maclean

Ninety two (92) receivers within 600 metres of the project are eligible for consideration of mitigation. A further 31 receivers were identified between 601 and 900 metres from the project as eligible for consideration at the operational compliance stage.

An additional extent of quieter pavement at Gulmarrad was found to be reasonable for inclusion. Noise barriers were investigated at three locations. A barrier at Tyndale was found to be reasonable and feasible for implementation. Barriers at other locations were not found to be a reasonable and feasible mitigation measure.

There were 61 more residential receivers identified for consideration of mitigation in the operational noise review than in the EIS, 30 of which were within 600 metres of the project. An additional 31 receivers between 601 and 900 metres from the project were identified as eligible for consideration at the operational compliance stage.

Maclean to Devils Pulpit

Ninety seven (97) residential receivers and two non-residential receivers within 600 metres of the project are eligible for consideration of mitigation. There were no residential receivers between 601 and 900 metres from the project identified as eligible for consideration of mitigation at the operational compliance stage.

An assessment of reasonable and feasible additional mitigation measures was carried out including a review of barriers in Harwood. The design already includes low noise pavement for the new bridge over the Clarence River at Harwood. The assessment concluded that barriers and additional at-road mitigation was not reasonable or feasible and at-property mitigation would be considered for eligible receivers.

There were 83 additional residential receivers eligible for consideration of mitigation than identified in the EIS, within 600 metres of the project. The operational noise review also found one additional non-residential receiver eligible for consideration of mitigation.

Devils Pulpit to Richmond River

Seventy five (75) residential receivers and one non-residential receiver within 600 metres of the project are eligible for consideration of mitigation. A further eight receivers were identified between 601 and 900 metres from the project as eligible for consideration of mitigation at the operational compliance stage.

An assessment of reasonable and feasible additional mitigation measures was carried which included consideration of additional quieter pavement. About three kilometres of additional quieter pavement to the east of Broadwater was found to be reasonable and feasible for implementation.

There were 32 more residential receivers identified for consideration of mitigation in the operational noise review than in the EIS, 24 of which were within 600 metres of the project. An additional eight receivers between 601 and 900 metres from the project were identified eligible for consideration at the operational compliance stage.

Richmond River to Pimlico

Forty three (43) receivers within 600 metres of the project are eligible for consideration of mitigation. A further eight receivers were identified between 601 and 900 metres from the project as eligible for consideration at the operational compliance stage.

An assessment of reasonable and feasible mitigation was carried out. The reasonable and feasible mitigation for these receivers was determined to be at-property treatment.

There were 19 more residential receivers identified for consideration of mitigation in the operational noise review than in the EIS, 11 of which were within 600 metres of the project. An additional eight receivers between 601 and 900 metres from the project were identified as eligible for consideration at the operational compliance stage.

1 Introduction

1.1 Background

The Pacific Highway upgrade is one of the largest road infrastructure projects in NSW. It connects Sydney and Brisbane, and is a major contributor to Australia's economic activity. The road is a vital piece of the nation's infrastructure and is a key link in the National Land Transport Network. The Australian and NSW governments have been jointly upgrading the Pacific Highway since 1996.

An upgraded Pacific Highway must continue to service the needs of the travelling public and achieve transport efficiencies, while also ensuring ecological sustainability and meeting the needs of the coastal communities located along the highway. Upgrading new sections and carrying out safety improvements to the existing highway have brought major improvements to road conditions. These improvements support regional development and provide:

- Safer travel
- Reduced travel times with improved transport efficiency
- More consistent and reliable travel
- Improved amenity for local communities.

Figure 1-1 presents an overview of the current status of the Pacific Highway upgrade.

Figure 1-1 Status of Pacific Highway upgrade – April 2018

1.2 Overview of the Woolgoolga to Ballina upgrade

The Woolgoolga to Ballina Pacific Highway upgrade (the project) is a joint commitment by the Australian and NSW governments comprising about 155 kilometres of dual carriageways extending from about six kilometres north of Woolgoolga to about six kilometres south of Ballina.

The project does not include the completed Glenugie and Devils Pulpit upgrades. When complete, the 155 kilometre Woolgoolga and Ballina project will:

- Reduce overall length from 180 kilometres to 167 kilometres, saving about 13 kilometres in travel distance
- Allow for a higher posted speed limit of up to 110 km/h
- Reduce travel time from 130 minutes to about 105 minutes, saving 25 minutes
- Reduce crash rates by an expected 27 percent due to divided carriageways
- Improve travel reliability through better flood immunity, fewer incidents and more readily available alternative routes.

Key features of the project include:

- Duplication of 155 kilometres of the Pacific Highway to a motorway standard (Class M) or arterial road (Class A), with two lanes in each direction and room to add a third lane if required in the future
- Split-level (grade-separated) interchanges at Range Road, Glenugie, Tyndale, Maclean, Yamba / Harwood, Woombah (Iluka Road), Woodburn, Broadwater and Wardell
- Bypasses of South Grafton, Ulmarra, Woodburn, Broadwater and Wardell
- More than 100 bridges over rivers, creeks and floodplains, including major bridges crossing the Clarence River and Richmond River
- Bridges over and under the highway to maintain access to local roads
- Access roads to maintain connections to existing local roads and properties
- Structures designed to encourage animals over and under the upgraded highway where it crosses key animal habitat or wildlife corridors
- Rest areas located at about 50 kilometre intervals at Pine Brush (Tucabia) and north of Mororo Road
- A heavy vehicle checking station near Halfway Creek.

An overview of the project is provided in Figure 1-2.


Ballina
Casino
Bruxner Highway
Alstonville
Uralba Nature Reserve
Pimlico
Richmond River
LISMORE LGA
BALLINA LGA
Tuckean Nature Reserve
Wardell
Coraki
Broadwater
RICHMOND VALLEY LGA
Broadwater National Park
Woodburn
Evans Head
New Italy
The Summerland Way
Jackywalbin State Conservation Area
Tabbimoble Swamp Nature Reserve
Bundjalung State Conservation Area
Bundjalung National Park
Mororo
Mororo Creek Nature Reserve
Iluka
Yamba
Harwood
Maclean
Woodford Island Nature Reserve
Yaegl Nature Reserve
Angourie
Lawrence
Clarence River
Tyndale
Shark Creek
Pacific Highway
Brooms Head
Yuraygir National Park
Gwydir Highway
Ulmarra
Grafton
Tucabia
South Grafton
Clarenza
CLARENCE VALLEY LGA
Glenugie
Pillar Valley
Minnie Water
Wooli
Yuraygir State Conservation Area
Wells Crossing
Red Rock
Sherwood Nature Reserve
Corindi Beach
Glenreagh
Garby Nature Reserve
Mullaway
Woolgoolga
COFFS HARBOUR LGA
St 164.0
St 158.6
St 145.1
St 137.6
St 126.4
St 111.1
St 105.4
St 96.4
St 82.0
St 68.8
St 33.8
St 28.7
St 17.0
St 00.0
Coolgardie Road to Ballina Bypass
11
Richmond River to Coolgardie Road
10
Broadwater National Park to Richmond River
9
Trustums Hill to Broadwater National Park
8
Devils Pulpit upgrade to Trustums Hill
7
Devils Pulpit upgrade
Iluka Road to Devils Pulpit upgrade
6
Maclean to Iluka Road
5
Tyndale to Maclean
4
Glenugie upgrade to Tyndale
3
Glenugie upgrade
Halfway Creek to Glenugie upgrade
2
Woolgoolga to Halfway Creek
1

Figure 1-2 Overview of Woolgoolga to Ballina Pacific Highway Upgrade

1.3 Purpose of this report

This report provides an operational noise review of the sections of the Woolgoolga to Ballina Pacific Highway upgrade between Glenugie and Pimlico (EIS sections 3 to 11). This report does not address operational noise impacts from the following portions as they have been previously assessed:

- Woolgoolga to Glenugie (EIS sections 1 and 2)
- Devils Pulpit Upgrade (EIS section 6A)
- Pimlico to Teven to tie in the Ballina Bypass and the Bruxner Highway

This report does not provide assessment of construction noise or vibration associated with building the project.

In line with the Ministers Conditions of Approval Condition D11, NSW state policy and Roads and Maritime guidelines, this report is to provide a summary of the methodology and consolidated outcomes of the noise assessments from the detailed design process. This report forms a key item in the progress of the project.

The report also provides a comparison with the previous assessment carried out during the Environmental Impact Statement (EIS).

1.4 Agency consultation

In line with the Ministers Condition of Approval D11, this report has been provided to the NSW Environmental Protection Authority and NSW Department of Planning and Environment for review and feedback.

The full comments and responses are provided in Appendix F and a summary is provided below:

EPA

EPA Noise Assessment Unit considers the report to be acceptable and has no further comments

DPE

- Seeking clarification on extent of low noise pavement throughout project
- Clarification on numbers of receivers identified for consideration of at house noise mitigation
- Query regarding additional traffic and noise monitoring undertaken for ONR.
- Request for update on status of provision of operational noise mitigation measures

Following these reviews all agency comments have been addressed and included in the report.

1.5 Operational noise policy and guidance

Operational noise assessment for the project is guided by the following key documents:

- *Road Noise Policy* (RNP) (NSW Environmental Protection Authority previously Department of Environment, Climate Change and Water, 2011)
- *Noise Criteria Guideline* (NCG), (Roads and Maritime, 2015)

- *Noise Mitigation Guideline* (NMG), (Roads and Maritime, 2015)
- Project Approval dated 24 June 2014
- Woolgoolga to Ballina – Pacific Highway Upgrade – Environmental Impact Assessment (EIS), Roads and Maritime 2012.

Figure 1-3 Operational road traffic noise policy and guidance

1.6 Document structure

The structure and content of this operational noise review (ONR) is presented in Table 1-1 below.

Table 1-1 Structure and content of the ONR

Chapter	Title	Description
	Executive Summary	Provides an overview of the report and its conclusions
Chapter 1	Introduction	Provides a broad overview of the project and purpose and structure of the report
Chapter 2	Project Description	Provides a broad overview of the project
Chapter 3	Project requirements	Provides an overview of the project approval requirements relating to operational noise and where conditions are addressed in the report
Chapter 4	Operational Noise Assessment	Provides an overview of the operational noise review process, policy, guidelines and assessment process.
Chapter 5	Existing environment	Provides details of the noise sensitive receivers and monitoring undertaken
Chapter 6	Noise assessment	Provides outcome of the operational noise assessment for the project
Chapter 7	Summary of key findings	Provides summary of the key findings from the noise assessment and details operational noise mitigation measures to be implemented
Chapter 8	Conclusion	Summarises the operational noise review process and identifies the next steps in the noise process
Appendix A	Project layout and receiver maps	Provides maps that show the location of the project, sensitive receivers and noise monitoring locations
Appendix B	Measured noise levels	Shows the available noise monitoring graphs for the monitoring carried out for the project
Appendix C	Noise criteria maps	Shows the assessment criteria transition zone maps for each portion
Appendix D	Predicted noise levels	Tables of the predicted noise levels for each portion for each assessed scenario, showing the noise levels with and without the project and the criteria
Appendix E	Noise contour maps	Provides noise contour maps for each portion for each assessed scenario
Appendix F	Agency consultation	Provides summary of comments raised during agency consultation.

2 Project description

2.1 Project staging and delivery

Roads and Maritime has engaged Pacific Complete (comprising of Laing O'Rourke and WSP) to partner with the Pacific Highway Project Office to deliver the 155 kilometre Woolgoolga to Ballina, Pacific Highway upgrade. The project is being progressively delivered in the following portions:

- Glenugie upgrade to Maclean (Sections 3 and 4)
- Maclean to Devils Pulpit (Sections 5 and 6)
- Devils Pulpit to Richmond River (Sections 7 to 9)
- Richmond River to Pimlico (Sections 10 and 11).

Design teams were appointed to each of the portions between Glenugie and Pimlico to deliver the detailed design of the road, including a noise assessment of the detailed design. Figure 1-2 presents the locations of the portions and sections.

2.2 Glenugie to Maclean

The Glenugie to Maclean portion of the upgrade is about 48 kilometres. The majority of the project is being built in new areas and meets the existing Pacific Highway at Glenugie, Tyndale and Maclean. Key features include:

- Interchanges at Glenugie, Tyndale and Maclean
- Bypasses of south Grafton and Ulmarra
- A rest area between Bostock and Somervale roads.

An overview of the Glenugie to Maclean area is presented in Figure 2-2

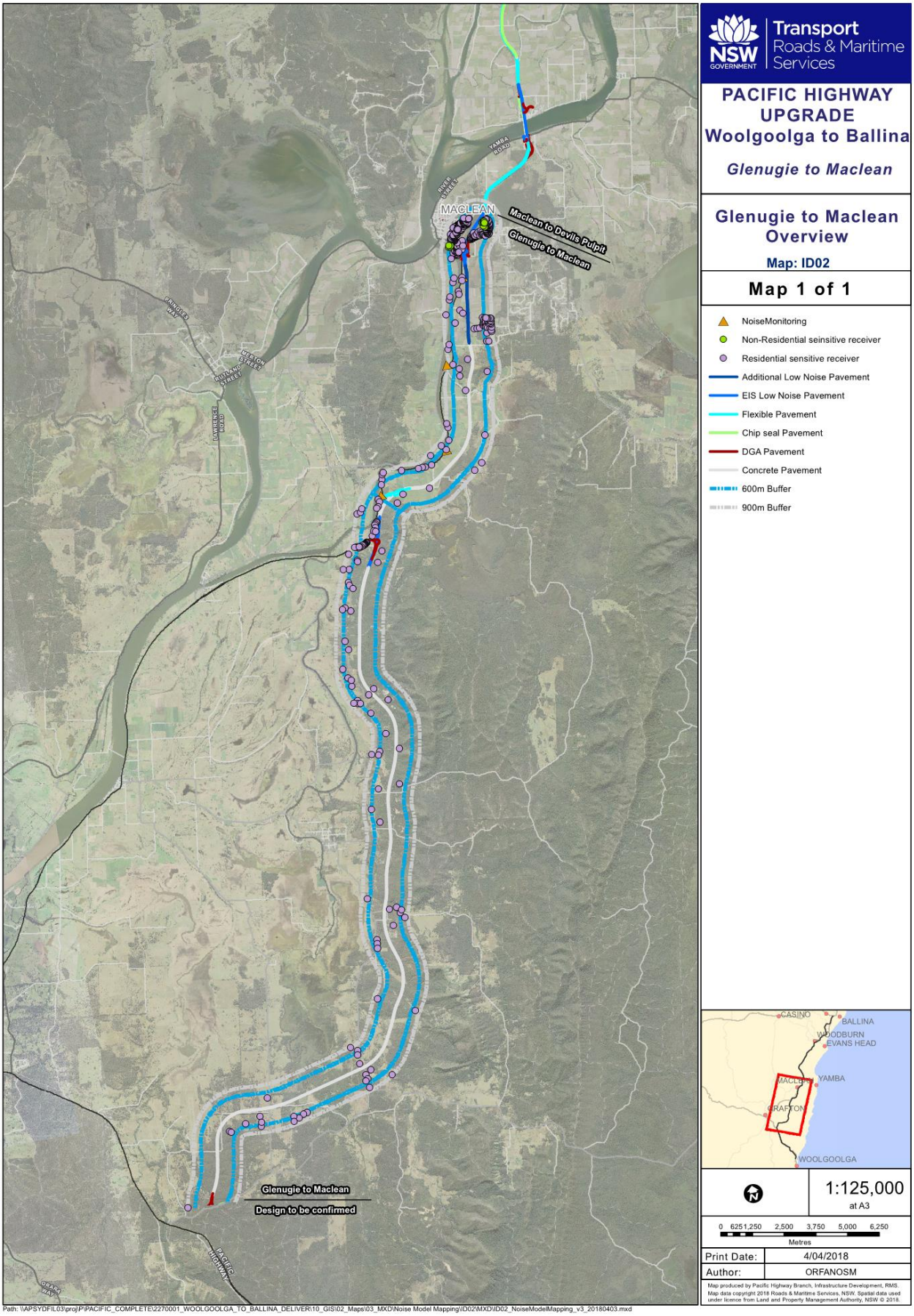


Figure 2-1 Overview of Glenugie to Maclean

2.3 Maclean to Devils Pulpit

The Maclean to Devils Pulpit portion of the upgrade is about 30 kilometres. It starts north of Jubilee Street, Maclean and travels north along the existing Pacific Highway through to the Devils Pulpit upgrade. The majority of the road is being built within the existing Pacific Highway corridor. Key features include:

- Interchanges at Yamba Road, Harwood, and Woombah (Iluka Road)
- A new bridge over the Clarence River next to the existing Harwood Bridge
- A new rest area at Mororo.

An overview of the Maclean to Devils Pulpit is presented in Figure 2-2.

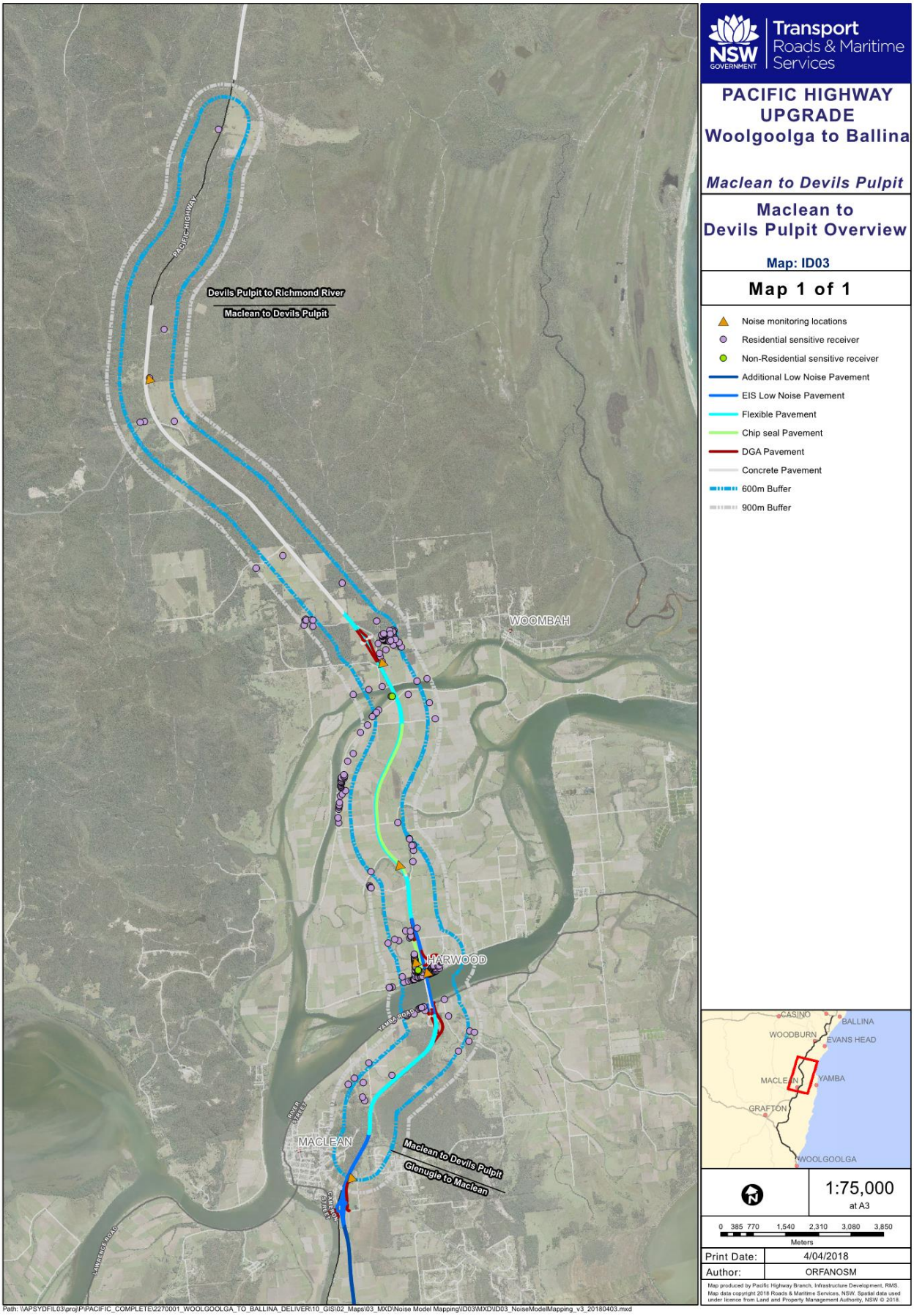


Figure 2-2 Overview of Maclean to Devils Pulpit

2.4 Devils Pulpit to Richmond River

The Devils Pulpit to Richmond River portion of the upgrade is about 34 kilometres from the Devils Pulpit upgrade to the northern bank of the Richmond River at Broadwater. The upgrade is being built within the existing highway corridor and sections of new corridor, where it deviates to bypass Woodburn and Broadwater.

The key features of the portion include:

- Interchanges at Woodburn and Broadwater
- Bypasses of Woodburn and Broadwater
- A new bridge over the Richmond River at Broadwater.

An overview of the Devils Pulpit to Richmond River is presented in Figure 2-3.

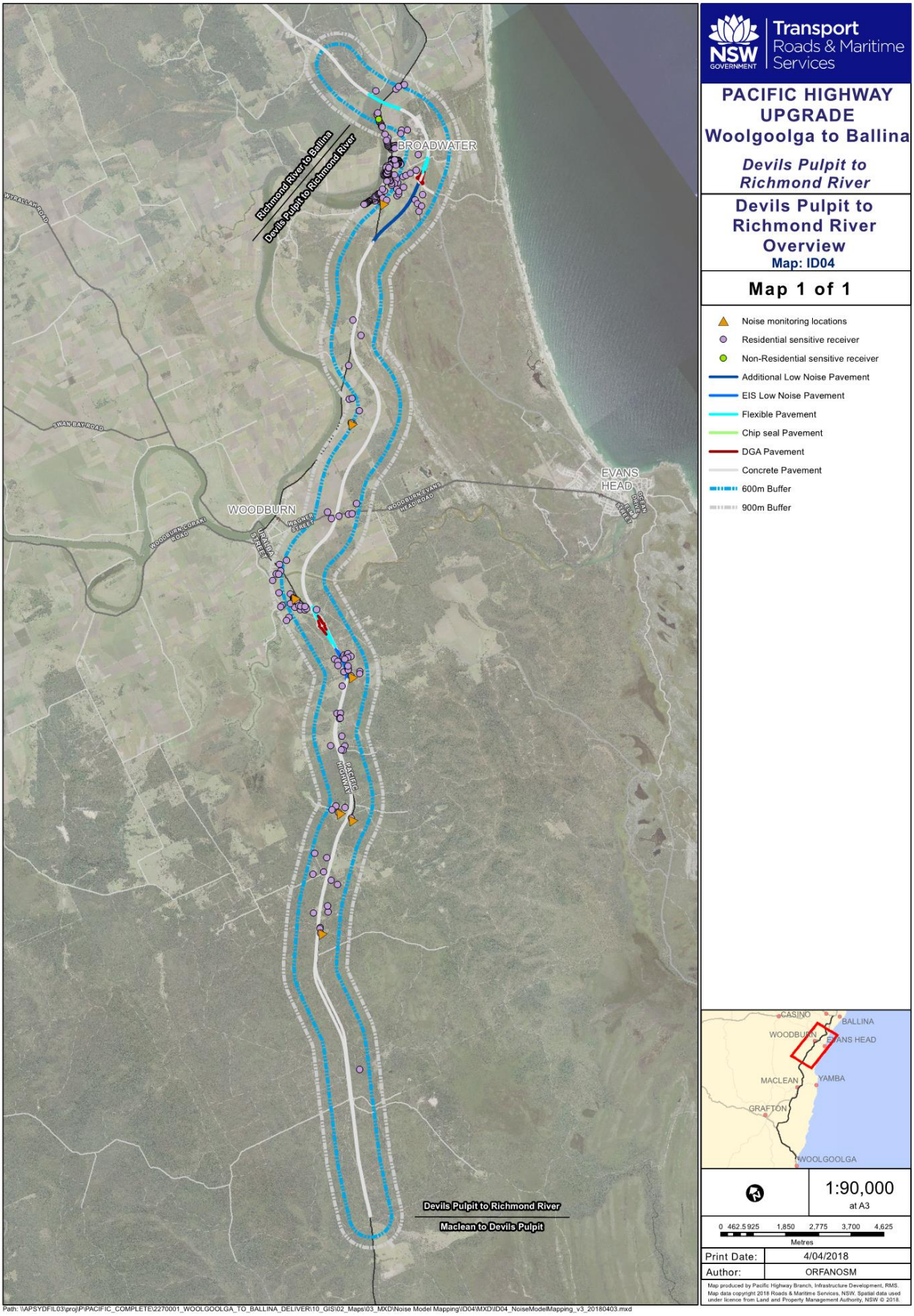


Figure 2-3 Overview of Devils Pulpit to Richmond River

2.5 Richmond River to Pimlico

The Richmond River to Pimlico portion of the upgrade is about 18 kilometres. Starting north of the Richmond River continuing to the Pimlico to Teven upgrade. The project is being built within the existing highway corridor and sections of new corridor. Key features include:

- An interchange at Coolgardie Road
- A bypass of Wardell.

An overview of the Richmond River to Pimlico is presented in Figure 2-4.

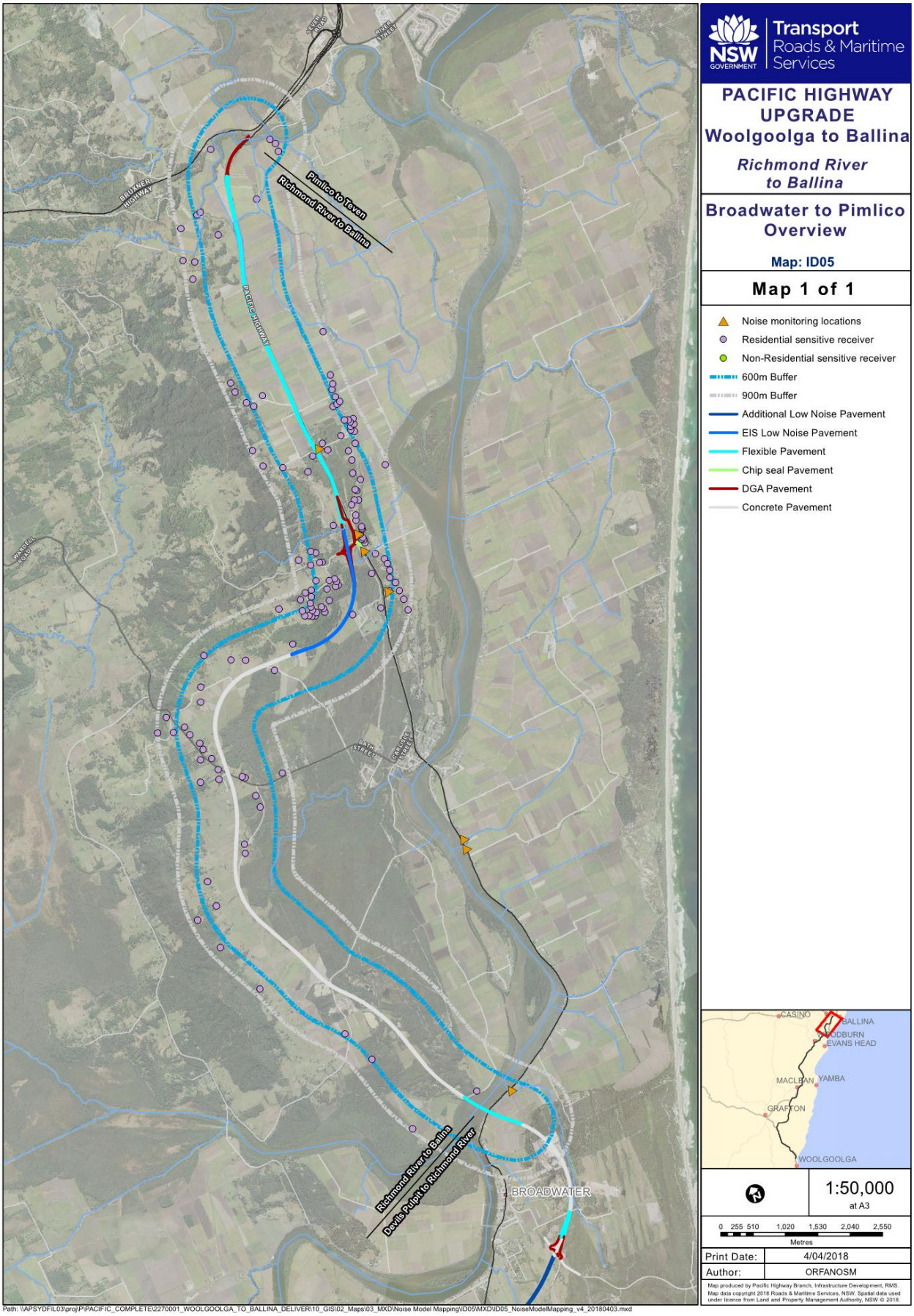


Figure 2-4 Overview of Richmond River to Pimlico

3 Project requirements

The Woolgoolga to Ballina, Pacific Highway upgrade is subject to the requirements of the MCoA, NSW state policy and Roads and Maritime guidelines that specifically refer to the operational noise generated by the upgrade, including:

- *Ministers Conditions of Approval* (MCoA) SSI-4963 (Department of Planning and Environment, 2014)
- *Road Noise Policy* (RNP) (Department of Environment, Climate Change and Water DECCW, 2011)
- *Noise Criteria Guideline* (NCG) (Roads and Maritime, 2015)
- *Noise Mitigation Guideline* (NMG) (Roads and Maritime, 2015)
- *Upgrading the Pacific Highway, Design Guidelines* (Roads and Maritime, 2015)
- *Environmental Noise Management Manual* (ENMM) (Roads and Maritime, 2001).

3.1 Minister's Conditions of Approval

The MCoA of the State Significant Infrastructure (SSI) application contains the following condition relevant to operational noise:

Operational Noise Review	Where addressed
D11. The Applicant shall prepare a review of the operational noise mitigation measures proposed to be implemented for the SSI, within six months of commencing construction, unless otherwise agreed by the Secretary. The review shall be prepared in consultation with the EPA, to the satisfaction of the Secretary. The review may be submitted in stages to suit the staged construction of the SSI and shall:	This report
(a) confirm the operational noise predictions of the SSI 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);	Chapters 5 and 6
(b) review the suitability of the operational noise mitigation measures identified in the documents listed in condition A2 [The EIS]. The review shall take into account the detailed design of the SSI and, where feasible and reasonable, and where necessary, refine the proposed measures with the objective of meeting the criteria outlined in the NSW Road Noise Policy (Department of Environment, Climate Change and Water, 2011), based on the operational noise performance of the SSI predicted under (a) above; and	Chapters 4 and 6
(c) where necessary, investigate additional feasible and reasonable noise mitigation measures to achieve the criteria outlined in the NSW Road Noise Policy (DECCW, 2011).	Chapter 6

Operational Noise Review	Where addressed
D28. The Applicant shall undertake operational noise monitoring, to compare actual noise performance of the SSI against noise performance predicted in the review of noise mitigation measures required by condition D11, within 12 months of the commencement of operation of the SSI, or as otherwise agreed by the Secretary. The Applicant shall subsequently prepare an Operational Noise Compliance Report to document this monitoring. The Report shall include, but not necessarily be limited to:	On project completion
(a) noise monitoring to assess compliance with the operational noise levels predicted in the review of operational noise mitigation measures required under condition D11 and documents listed in condition A2;	On project completion
(b) a review of the operational noise levels in terms of criteria and noise goals established in the NSW Road Noise Policy 2011;	On project completion
(c) methodology, location and frequency of noise monitoring undertaken, including monitoring sites at which SSI noise levels are ascertained, with specific reference to locations indicative of impacts on sensitive receivers;	On project completion
(d) details of any complaints and enquiries received in relation to operational noise generated by the SSI between the date of commencement of operation and the date the report was prepared;	On project completion
(e) any required recalibrations of the noise model taking into consideration factors such as noise monitoring and actual traffic numbers and proportions;	On project completion
(f) an assessment of the performance and effectiveness of applied noise mitigation measures together with a review and if necessary, reassessment of feasible and reasonable mitigation measures; and	On project completion
(g) identification of additional feasible and reasonable measures to those identified in the review of noise mitigation measures required by condition D11, that would be implemented with the objective of meeting the criteria outlined in the NSW Road Noise Policy 2011, when these measures would be implemented and how their effectiveness would be measured and reported to the Secretary and the EPA.	On project completion
The Applicant shall provide the Secretary 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 Secretary. Note: • The audit may be staged to suit the staged operation of the SSI.	On project completion

3.2 EIS and SPIR mitigation measures

In the EIS a range of environmental outcomes and management measures were identified to avoid or reduce the impact the project has on the environment. These measures were further refined during the SPIR. Table 3-1 provides a summary of these commitments, related to operational noise, and where they are addressed in this report.

Table 3-1 EIS and SPIR mitigation measures

ID	Aspect	Issue	Management measure	Where addressed in this report
HH26	Non-Aboriginal (Historical) heritage	Impacts on item 34 Townsend Residence, Townsend	Architectural noise treatment to the house will be investigated and provided where reasonable and feasible and in consultation with a qualified heritage consultant. Consideration will be given for the need to revise the SOHI for this item when the specific architectural noise treatment options are identified.	Chapter 6
HH39	Non-Aboriginal (Historical) heritage	Impacts on item 26, Broadwater	Architectural noise treatment to the house will be investigated and provided where reasonable and feasible and in consultation with a qualified heritage consultant. Consideration will be given for the need to revise the SOHI for this item when the specific architectural noise treatment options are identified.	Chapter 6
HH49	Non-Aboriginal (Historical) heritage	Impacts on item 29: 'Stoneheng e' Property, Wardell	Architectural noise treatment to the house will be investigated and provided where reasonable and feasible and in consultation with a qualified heritage consultant. Consideration will be given for the need to revise the SOHI for this item when the specific architectural noise treatment options are identified.	Chapter 6
ONV1	Operation Noise and Vibration	Road traffic noise	Architectural treatments will be considered for noise-affected receivers identified in the EIS and Submissions / Preferred Infrastructure Report (Appendix F), subject to confirmation at the detailed design stage.	Chapter 6
ONV2	Operation Noise and Vibration	Road traffic noise	Low noise wearing surface will be implemented in areas identified in section 5.3.21 of the EIS.	Chapter 6

ID	Aspect	Issue	Management measure	Where addressed in this report
ONV3	Operation Noise and Vibration	Road traffic noise	No later than one year after commencement of operation of the project stages as they are constructed, Roads and Maritime will undertake operational noise monitoring to compare the actual noise performance of the project against predicted noise performance. The report will include, but not necessarily be limited to: • Noise monitoring to assess compliance with the operational noise levels predicted. • A review of the operational noise levels in terms of criteria and noise goals. • Methodology, location and frequency of noise monitoring undertaken. • Details of any complaints and enquiries received in relation to operational noise. • Any required recalibrations of the noise model. • An assessment of the performance and effectiveness of applied noise mitigation measures. • Any additional feasible and reasonable measures required.	Chapter 7

3.3 Road Noise Policy

The *Road Noise Policy* (RNP) (DECCW, 2011) is used to assess road traffic noise on public roads in NSW. It contains noise criteria guidelines for their assessment. The RNP has been applied to the project.

The criteria take into account noise from:

- Existing roads
- Redeveloped roads
- New roads
- Large changes in exposure to road traffic noise
- Land use developments that generate additional traffic.

The policy was developed by the former DECCW in 2011. The implementation and regulation of the policy is now with the Environment Protection Authority (EPA).

3.4 Roads and Maritime guidelines

Roads and Maritime have developed guidelines on how to implement the criteria, defined in the RNP and allocate mitigation in a consistent and equitable manner.

The EIS was prepared under old guidelines that have been superseded. The operational noise review uses the latest guidelines:

- *Noise Criteria Guideline* (NCG) (Roads and Maritime, 2015)
- *Noise Mitigation Guideline* (NMG) (Roads and Maritime, 2015).

These guidelines are explained in more detail in Chapter 4.

The *Upgrading the Pacific Highway Design Guidelines* (Roads and Maritime, 2015) were developed to provide a consistent set of guidelines and design principles to apply to the whole of the Pacific Highway upgrade from Hexham to Tweed Heads. The guidelines contain requirements for operational noise and include inputs for the consideration of operational noise assessment and mitigation. These are outlined in Chapter 5 and 6 of this report.

4 Operational noise assessment process

The assessment of operational noise impacts occurs a number of times throughout the project lifecycle. These broad stages are outlined in Figure 4-1 and include:

- Concept Design – predicted noise impacts modelled as part of environmental impact statement based on concept design
- Detailed Design – predicted noise impacts modelled on detailed design
- Operation – actual noise impacts based on actual traffic and noise levels from operational traffic.

4.1 Overview of operational noise process

The new and upgraded sections of highway will be a source of traffic noise to surrounding areas. The level of noise experienced because of the highway improvements will vary across the project. In cases where new highway sections go through new areas or move closer to existing noise sensitive receivers, there may be significant increases in the level of road traffic noise. In other cases, where the work moves the highway further away from noise sensitive receivers or the project is within the existing Pacific Highway corridor, there would be less of a change in the level of noise or the noise level may decrease.

The operational noise review provides the predicted change in noise level, noise impacts and identifies appropriate mitigation to either reduce noise levels at the road or consider providing treatment at properties.

Noise levels were predicted for two scenarios; where the project is built (the build scenario) and a do nothing scenario where the project is not built (no build scenario). The two scenarios were evaluated at two points in time; when the project opens in 2019 and ten years after opening in 2029.

The noise assessments have been carried out in line with NSW state policy and Roads and Maritime guidelines. The mitigation strategy applied to the project is consistent with these policies and guidelines.

The upgrade has completed the detailed design stage and is in the process of being built. The operational review is an assessment of the finalised design and the mitigation measures such as quieter road pavement, noise barriers and at-property mitigation that are being considered. Figure 4-1 shows the overall design, assessment and approvals process and the current status of the project in this process.

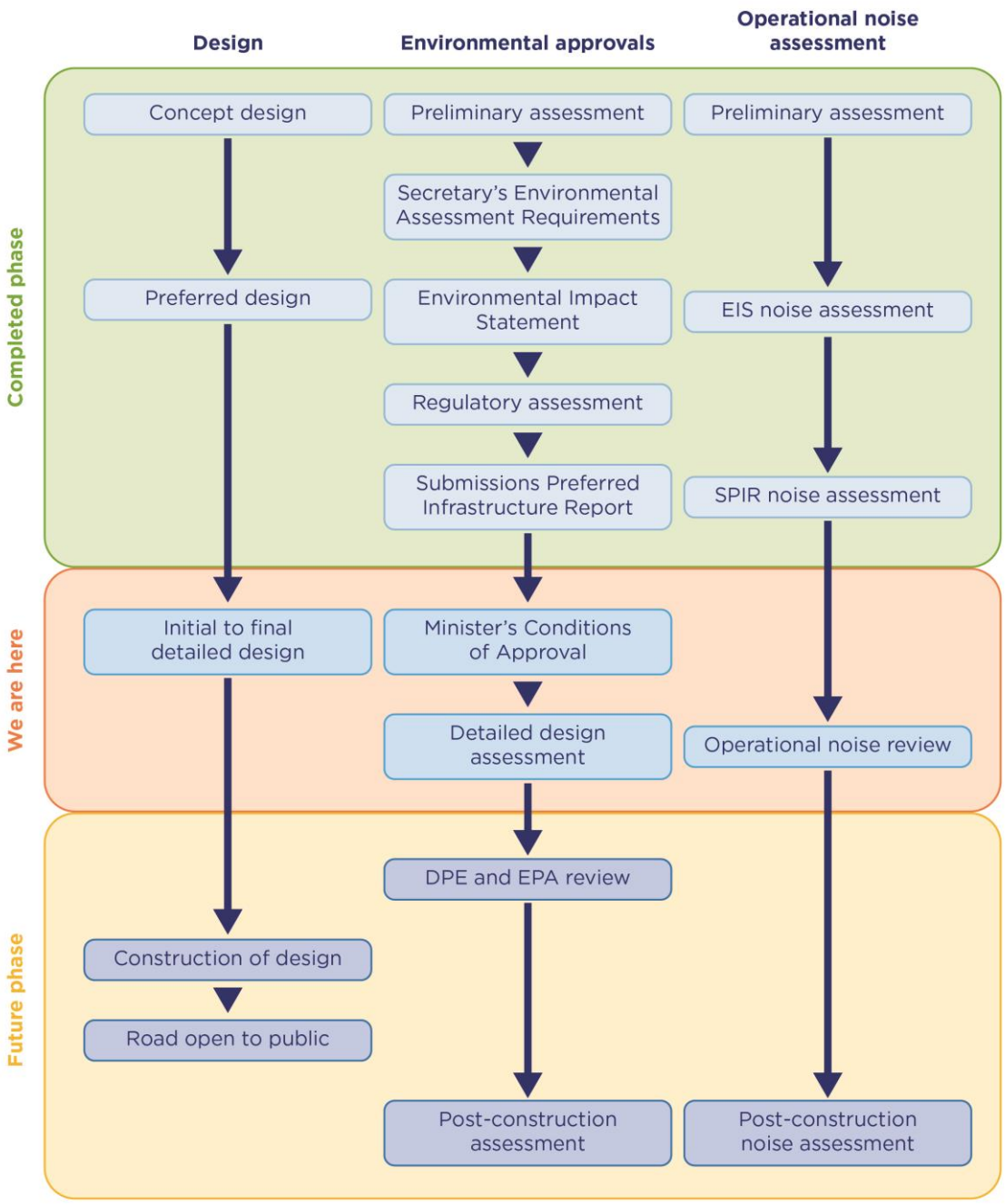


Figure 4-1 Design, approvals and noise assessment pathway

The upgrade was classified as SSI and the application to build and operate the project was approved by the Minister for Planning in June 2014. The application was based on the EIS prepared in 2012 which assessed the concept design for the project.

A noise assessment of the operation of the project was prepared for the EIS. The assessment predicted noise levels from the project and the situation where the project was not built. State policy and Roads and Maritime procedures were used to identify noise mitigation options to be further assessed during the detailed design process.

The MCoA (reference SSI-4963) contains condition D11 which requires the preparation of an operational noise review. This is an assessment of the design that is refined during the detailed design process and a comparison with the EIS results, including the proposed mitigation measures.

Submissions were received during the EIS stage and the SPIR was prepared to respond to the feedback received. The SPIR provided a comparison of the EIS and SPIR design and identified only minor changes in the noise impacts between the EIS design and the SPIR updated design.

The noise impacts from the detailed design of the project are assessed in line with the state's Road Noise Policy (RNP) and Roads and Maritime's Noise Criteria Guideline and Noise Mitigation Guideline that provide processes for assessment and identification of mitigation. These policies and guidelines are applied across NSW and are intended to provide the most effective and equitable outcomes where reasonable and feasible to address noise impacts from road projects in NSW.

Design requirements for the entire Pacific Highway upgrade were defined in the *Upgrading the Pacific Highway Design Guidelines* (UPHDG). This has allowed a consistent approach to be taken across all of the sections between Woolgoolga to Ballina. The noise mitigation nominated in the EIS has been considered in this operational noise review.

The design of the project was divided into four portions, with the designer of each portion carrying out the detailed design and noise assessment of the design.

The noise assessments carried out in the detailed design stage form the basis for the noise mitigation strategy applied to the project.

4.2 An introduction to noise

Noise is unwanted sound. Unlike other types of noise such as industrial noise, road traffic noise is rarely loud enough to cause hearing loss. Instead the main effects of noise from road traffic are generally annoyance and masking of wanted sounds such as bird calls and rustling leaves.

Annoyance due to a noise source is perceived differently by each person and depends on acoustic factors such as volume, tone and frequency, as well as non-acoustic factors such as the listener's opinion of the noise source. Noise criteria aim to stop 90 percent of the community from becoming highly annoyed.

The measurement unit for sound and noise is decibels (dB). A sound level in dB represents the sound pressure level, which is the amount of sound a listener receives. The sound power level is distinctly different from a sound pressure level. The sound power level is a measure of the acoustic energy of the sound source and is not equivalent to the sound pressure level.

The difference between sound power and pressure is similar to a lightbulb producing light. The power rating of a light bulb is like the sound power level and the brightness of light in a part of the room is like the sound pressure level.

Adding noise levels is not done arithmetically, for example Figure 4-2 shows two small generators with a noise level of 75 dB each have a combined noise level of 78 dB.

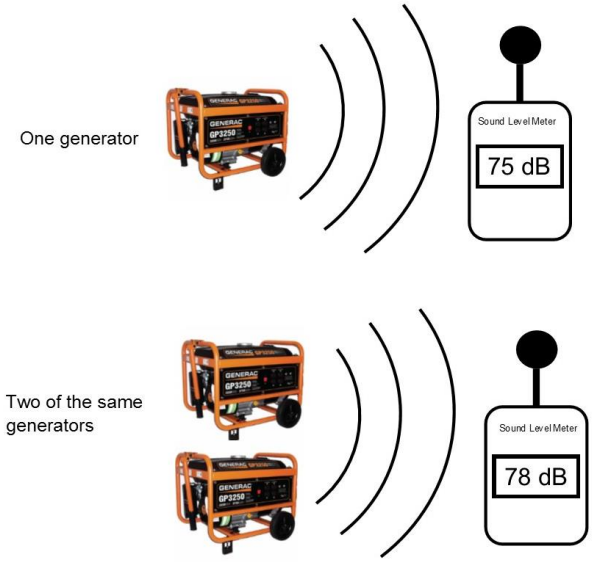


Figure 4-2 Example of decibel addition

Two noise sources of the same noise level equals a total noise level 3 dB higher than the single noise source

The A-weighting scale was developed to approximate the ear's sensitivity to different frequencies. Noise levels associated with environmental noise, such as road traffic noise and industrial noise are usually expressed as A-weighted decibels (dBA).

Sound levels of 0 to 10 dB represents the typical lower limit of hearing in a young healthy adult. A change in noise level of 2 dB represents a change that is considered barely perceptible to the average person. A change in noise level of 5 dB is considered to be definitely noticeable and a change of 10 dB is considered to be equivalent to a doubling of loudness.

Figure 4-3 shows examples of A-weighted noise levels produced by some typical activities.

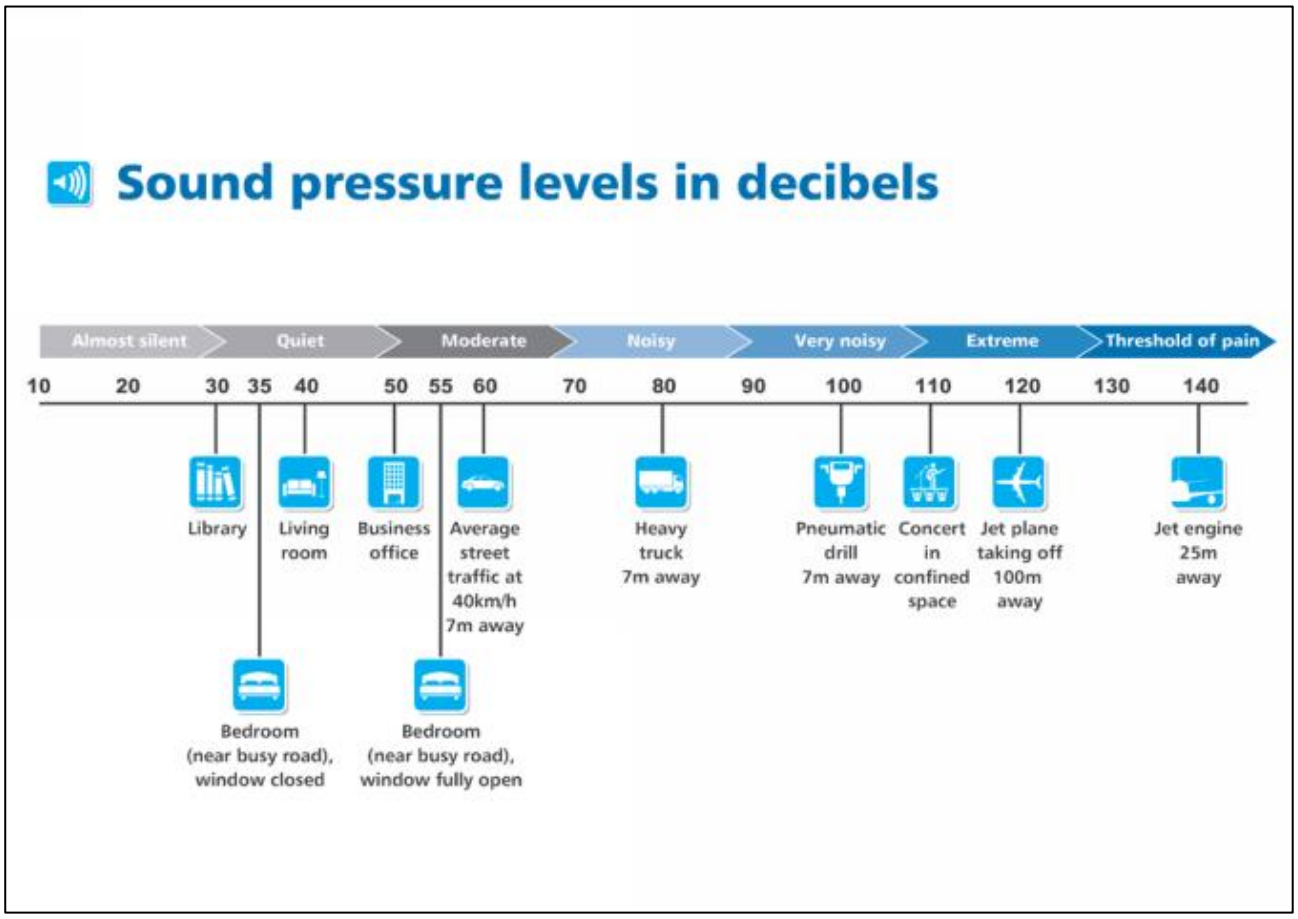


Figure 4-3 Examples of common noise sources

4.3 Road traffic noise

Noise from road traffic is caused by a number of different sources including the interaction between vehicle tyres and the road surface, engines, exhaust and braking systems of vehicles and to a lesser extent the noise created by the wind and air interacting with the body of the vehicle. The noise prediction model takes into account all of these sources.

The amount of noise generated and experienced in the community from road traffic changes depending on a number of factors such as:

- The mix of light and heavy vehicles, the ages and type of vehicles and vehicle speed
- The gradient of the road
- Traffic flow
- Road pavement
- The surrounding ground topography including mounds, hills, cuttings as well as the presence of noise barriers, fences, walls, buildings and other shielding structures
- The type of ground in between the road and receivers. Soft ground such as grassed or vegetated areas reflect less sound than concrete or water surfaces.

4.4 Noise descriptors

Road traffic noise is the total of the noise produced by vehicles in a traffic stream on a road. The noise level typically varies over a short period of time such as minutes, and also over longer time periods such as a few hours or periods of the day.

The noise level from road traffic noise is measured and assessed using the equivalent continuous energy average noise level ($L_{eq\ (Day\ or\ Night)}$) descriptor. The Leq is a measure of the sound energy over a period of time. It is the single level that has the same amount of sound energy as the actual varying sound level during that period of time.

Freeways, arterial and sub-arterial roads handle high volumes of through-traffic over extended periods of time, therefore the noise descriptor that measures noise exposure for the full day and night is needed.

Road traffic noise is assessed using the L_{eq} descriptor over a longer period of time such as the day (7am to 10pm) and night (10pm to 7am) periods for collector, sub-arterial, arterial, highways and motorways.

For local roads, noise is assessed over a shorter period of time using the L_{eq} descriptor over a one hour period.

Other commonly used noise descriptors associated with environmental noise are:

- L_{max} is the maximum noise level over the specific period. The maximum noise level can be used to describe short, peak noise events
- L_{10} is the noise level exceeded for 10 percent of the specific time period
- L_{90} is the noise level exceeded for 90 percent of the specific time period. The L_{90} is commonly referred to as the background noise level.

Figure 4-4 shows an example noise level varying over time and how each of the descriptors relate to the time varying noise.

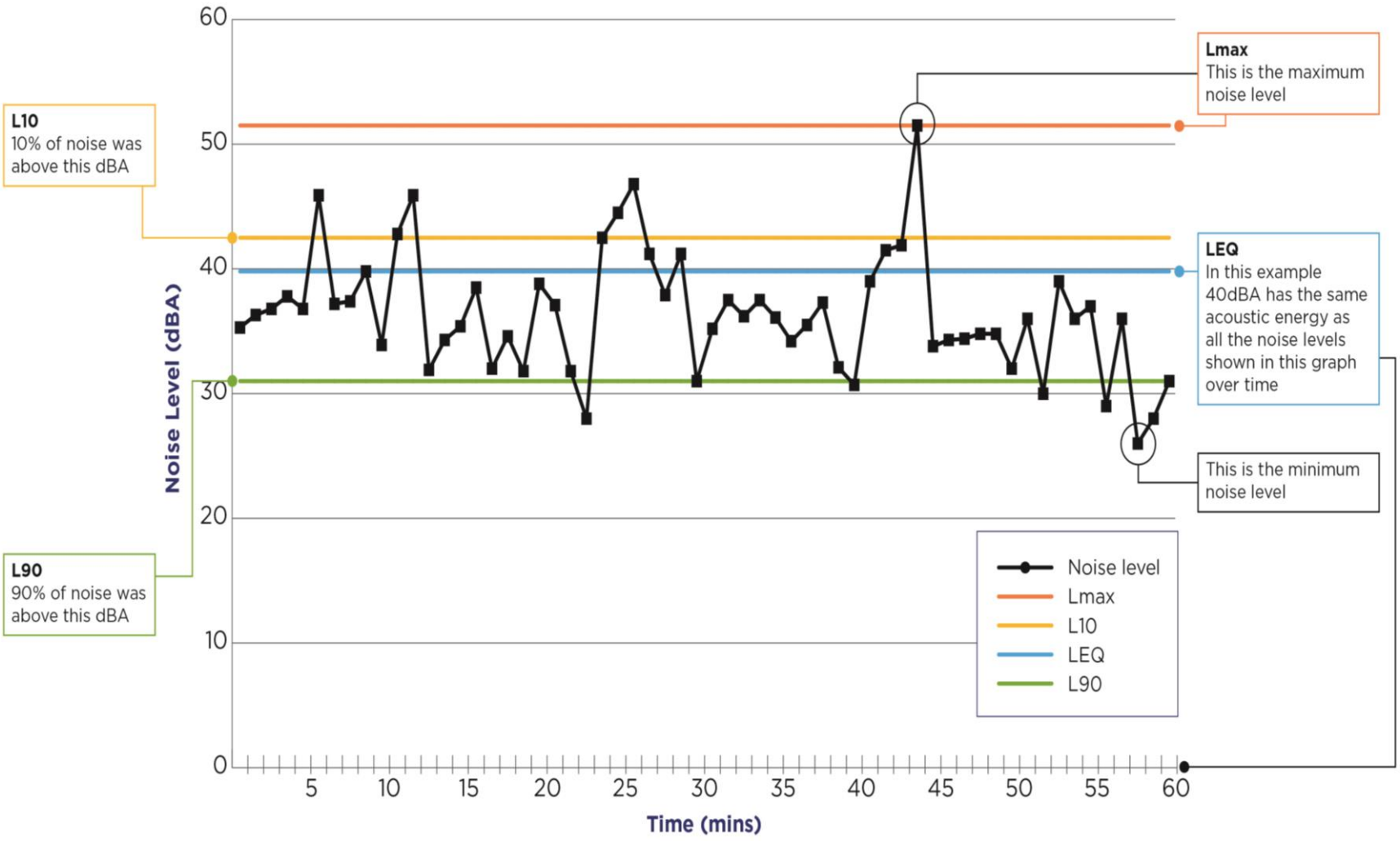


Figure 4-4 Example of noise descriptors

4.5 Road traffic noise assessment

This segment provides an overview of the noise assessment process, the applicable criteria and triggers for mitigation of road traffic noise in NSW.

Sensitive receivers are identified within an assessment area and noise criteria are assigned to each of the receivers. As required by the MCoA the RNP is the state policy applied to the project.

The EIS was completed in 2012 and project approval received in 2014. In 2015, Roads and Maritime published updated noise guidelines to apply to all NSW road projects. The updated guidelines reflect the latest assessment and mitigation processes. These guidelines were used for the detailed design process so the assessment and mitigation selected for the project represents the most recent processes applied throughout NSW.

The No build represents conditions as if there was no upgrade, existing roads continued to operate and traffic grew at the normal rate for the area.

The Build scenario represents conditions where the project is built. It includes all the roads associated with the project and existing roads not affected by the project.

Only noise from traffic on roads is considered in the assessment, as required by the RNP. Non-road traffic and other sources of ambient noise (such as insects, wind or industrial and commercial noise) are not included as do not relate to the operation of the road and cannot be managed by a road project.

The level of noise from road traffic is predicted at receivers for two scenarios; ‘Build’ and ‘No build’.

The noise level is predicted at receivers using a validated three-dimensional mathematical computer model. The model is validated by comparing the predicted noise level with a measured noise level. If the prediction is within the acceptable level of accuracy of the measured level, the model is considered valid.

The inputs to the validation are noise measurements and traffic counts, carried out at the same time at sample locations. Measurements do not need to be carried out at every property to confirm the model is valid.

Once the model is demonstrated to be valid, it is used to predict noise levels for the Build and No build scenarios at two periods in time:

- The year the project is due to open (2019)
- Ten (10) years after the project is due to open (2029).

The predictions use forecast traffic volumes for each road that either influences the level of traffic noise in the area or is affected by the project.

Local roads that do not carry much traffic are not included in the noise model as they do not have a significant influence on the total road traffic noise level.

The predicted noise level at a receiver is then compared with the criteria noise level.

Where the noise level is predicted to exceed the criteria, noise mitigation is then investigated in order of:

- Road design
- Quieter pavement surfaces
- In corridor noise mound
- In corridor noise walls
- At-property treatment.

It is more effective and provides greater overall benefits to reduce noise at the road than at the receiver. Mitigation measures determined to be reasonable and feasible are then implemented for the project.

As this is a Roads and Maritime project, the NMG has been used to define how mitigation is identified and assigned to the project.

An overview of the process for assessing road traffic noise is shown in Figure 4-5.

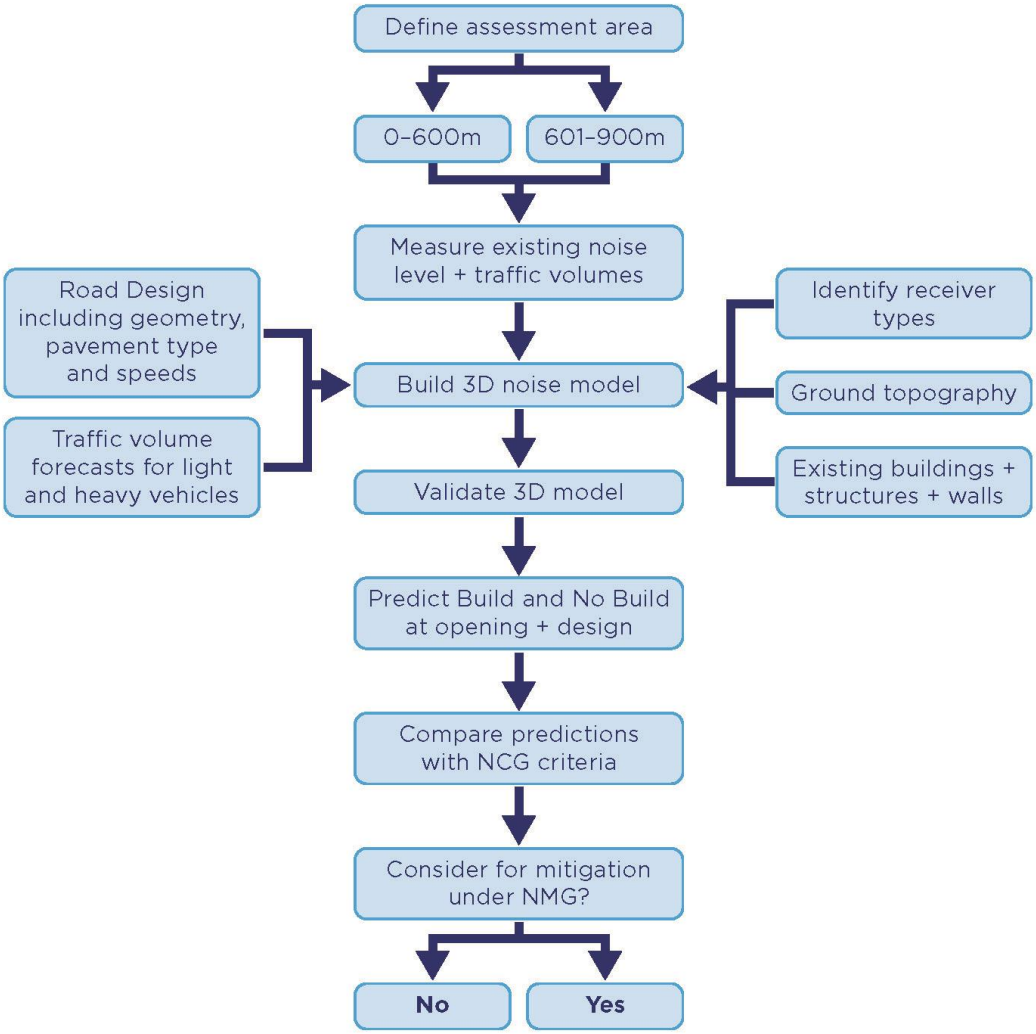


Figure 4-5 Road traffic noise assessment process overview

4.5.1 Road Noise Policy

The RNP defines the **road categories**, **project types** and assessment **criteria** in NSW. This ensures a consistent set of rules, assessment process and criteria are applied to all relevant road projects in NSW.

The **road categories** outlined in the RNP are summarised in Table 4-1.

Table 4-1 Road function types for noise assessment

Road type	Definition
Arterial/Freeway/Motorway	Supports major regional and inter-regional traffic movement and carry traffic directly from one region to another. For noise assessment this term also includes freeways and motorways.
Sub-arterial road	Connects arterials to regions of development and carry traffic from one part of a region to another. Provide connection between arterial roads and local roads. May support arterial roads during peak periods. A road that collects local traffic leaving a locality and connects to another local road, sub-arterial or arterial. * Note not all networks are large enough to have both sub-arterial and collector roads.
Collector road	Connects the sub-arterial roads to the local road system in developed areas. May support sub-arterial roads during peak periods. May have been designed as local streets but can serve major traffic-generating developments or support non-local traffic. *Note not all networks are large enough to have both collector and sub-arterial roads. The RNP does not provide separate noise criteria for collector roads. Roads and Maritime applies sub-arterial noise criteria to collector roads and still considers collector roads and sub-arterial roads to be different functional classes.
Local road	Provide vehicle access to abutting property and surrounding streets. They are the subdivisional roads within a particular developed area.

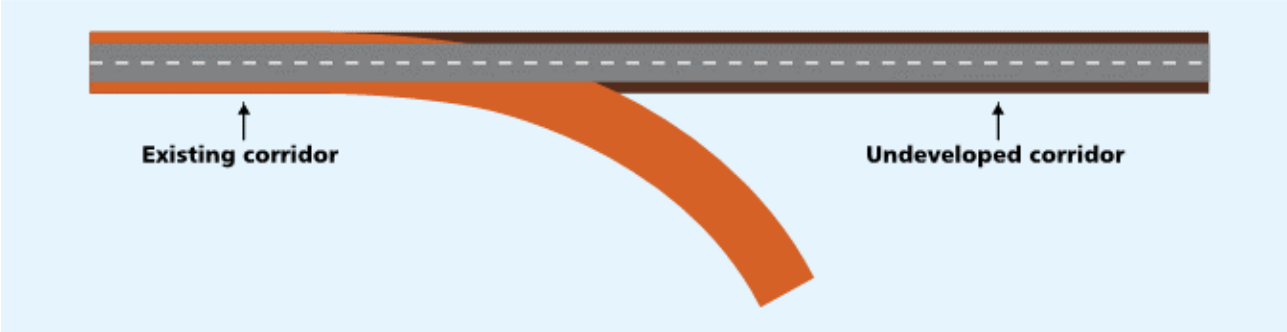
Source: NCG

The three different types of **road projects** considered in the RNP are:

- New roads
- Redeveloped road
- Land use development generating additional traffic on existing roads.

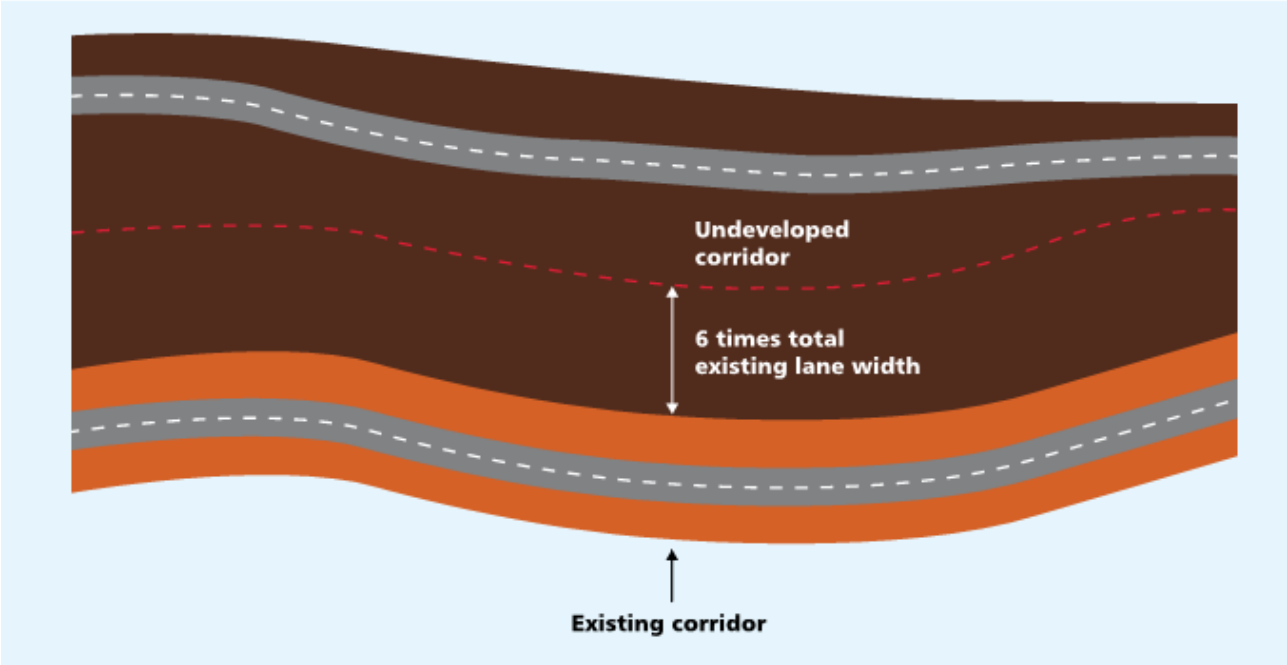
Source: NCG

Figure 4-6 and Figure 4-7 from the NCG present examples of projects that fit the description of a ‘New road’.



Source: NCG

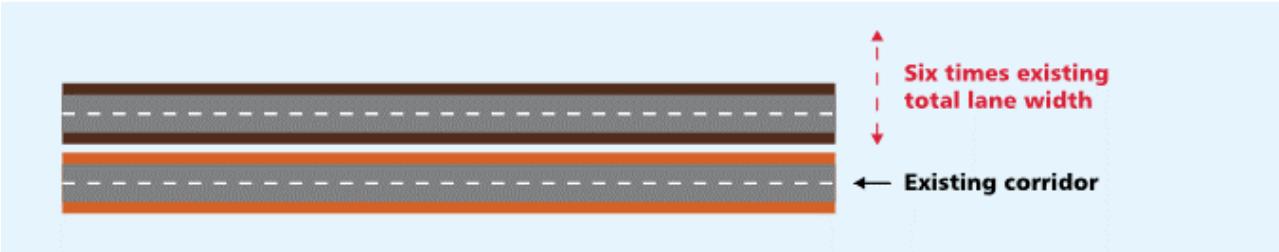
Figure 4-6 ‘New road’ example – bypass with road construction through a new area.



Source: NCG

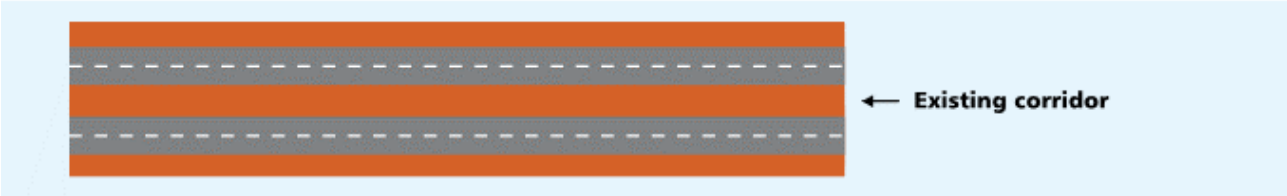
Figure 4-7 ’New road’ example – substantially realigned duplication or upgraded road.

Figure 4-8 and Figure 4-9 present examples of projects that fit the description of a ‘Redeveloped road’.



Source: NCG

Figure 4-8 ‘Redeveloped road’ example – duplicated carriageway, road widening or curve straightening without substantial realignment of existing road.



Source: NCG

Figure 4-9 'Redeveloped road' example – upgraded road alignment or carriageway duplicated within existing road corridor.

Table 4-2 sets out the **criteria** assigned to each of the **road categories** and **project types** in the RNP for residential land uses. Although it is not required to achieve the noise assessment criteria in the RNP, proponents need to demonstrate if it is not considered feasible or reasonable to achieve them. The RNP states the criteria for road traffic noise should be assessed over an area 600 metres either side of the centreline of the outermost traffic lane.

Table 4-2 Road traffic noise assessment criteria for residential land uses

Road Category	Type of project/land use	Assessment criteria dBA	
		Day (7am to 10pm)	Night (10pm to 7am)
Freeway/ arterial/ sub-arterial roads	1. Existing residences affected by noise from **New** freeway/arterial/sub-arterial road corridors	$L_{eq\ (15\ hour)}$ 55 (external)	$L_{eq\ (9\ hour)}$ 50 (external)
	2. Existing residences affected by noise from **Redevelopment** of existing freeway/arterial/sub-arterial roads 3. Existing residences affected by **additional traffic** on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{eq\ (15\ hour)}$ 60 (external)	$L_{eq\ (9\ hour)}$ 55 (external)
Local roads	4. Existing residences affected by noise from **New** local road corridors 5. Existing residences affected by noise from **Redevelopment** of existing local roads 6. Existing residences affected by **additional traffic** on existing local roads generated by land use developments	$L_{eq\ (1\ hour)}$ 55 (external)	$L_{eq\ (1\ hour)}$ 50 (external)

Source: RNP

The RNP also considers non-residential land uses considered to be sensitive to noise from road traffic noise. The non-residential noise sensitive land uses considered in the RNP and their assessment criteria are presented in Table 4-3.

Table 4-3 Road traffic noise assessment criteria for non-residential sensitive land uses

Existing sensitive land use	Assessment criteria dBA Day (7am to 10pm)	Assessment criteria dBA Night (10pm to 7am)	Additional considerations
School classrooms	$L_{eq\ (1\ hour)}$ 40 (internal)	-	In the case of buildings used for education or health care, noise level criteria for spaces other than classrooms and wards may be obtained by interpolation

Existing sensitive land use	Assessment criteria dBA Day (7am to 10pm)	Assessment criteria dBA Night (10pm to 7am)	Additional considerations
Hospital wards	$L_{eq\ (1\ hour)}$ 35 (internal)	$L_{eq\ (1\ hour)}$ 40 (internal)	from the 'maximum' levels shown in Australian Standard 2107:2000 (Standards Australia 2000).
Places of worship	$L_{eq\ (1\ hour)}$ 40 (internal)	$L_{eq\ (1\ hour)}$ 40 (internal)	The criteria are internal, i.e. the inside of a church. Areas outside the place of worship, such as a churchyard or cemetery, may also be a place of worship. Therefore, in determining appropriate criteria for such external areas, it should be established what is in these areas that may be affected by road traffic noise. For example, if there is a church car park between a church and the road, compliance with the internal criteria inside the church may be sufficient. If, however, between the church and the road are areas where outdoor services may take place such as weddings and funerals, external criteria for these areas are appropriate. As issues such as speech intelligibility may be a consideration in these cases, the passive recreation criteria may be applied.
Open space (active use)	$L_{eq\ (1\ hour)}$ 60 (external) when in use	-	Active recreation is characterised by sporting activities and activities which generate their own noise or focus for participants, making them less sensitive to external noise intrusion.
Open space (passive use)	$L_{eq\ (1\ hour)}$ 55 (external) when in use	-	Passive recreation is characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, e.g. playing chess, reading. In determining whether areas are used for active or passive recreation, the type of activity that occurs in that area and its sensitivity to noise intrusion should be established. For areas where there may be a mix of passive and active recreation, e.g. school playgrounds, the more stringent criteria apply. Open space may also be used as a buffer zone for more sensitive land uses.
Isolated residences in commercial or industrial zones	-	-	For isolated residences in industrial or commercial zones, the external ambient noise levels can be higher than those in residential areas. Internal noise levels in such residences are likely to be more appropriate in assessing any road traffic noise impacts, and the proponent should determine suitable internal noise level targets, taking guidance from Australian Standard 2107:2000 (Standards Australia 2000).
Mixed use developments	-	-	Each component of use in a mixed use development should be considered separately. For example, in a mixed use development containing residences and a child care facility, the residential component should be assessed against the appropriate criteria for residences and the child care component should be assessed against the appropriate criteria for child care facilities.

Existing sensitive land use	Assessment criteria dBA Day (7am to 10pm)	Assessment criteria dBA Night (10pm to 7am)	Additional considerations
Child care facilities	Sleeping rooms $L_{eq\ (1\ hour)}$ 35 (internal) Indoor play areas $L_{eq\ (1\ hour)}$ 40 (internal) Outdoor play areas $L_{eq\ (1\ hour)}$ 55 (external)	-	Multipurpose spaces, e.g. Shared indoor play/sleeping rooms should meet the lower of the respective criteria. Measurements for sleeping rooms should be taken during designated sleeping times for the facility, or if these are not known, during the highest hourly traffic noise level during the opening hours of the facility.
Aged care facilities	-	-	Residential land use noise assessment criteria should be applied to these facilities.

Source: RNP

The RNP also provides assessment criteria for residential receivers where there is a large increase in noise level as a result of a road project. This is to protect against excessive increases in noise from a road project in quiet areas.

These criteria are of particular relevance to rural receivers affected by new roads where there is little existing road traffic noise. The relative increase criteria (RIC) are outlined in Table 4-4.

Table 4-4 Relative Increase Criteria for residential land uses

Road category	Type of project/development	Total traffic noise level increase dBA Day (7am to 10pm)	Total traffic noise level increase dBA Night (10pm to 7am)
Freeway/arterial/sub-arterial roads and transit ways	New road corridor/Redevelopment of existing road/land use development with the potential to generate existing traffic on existing road	Existing traffic $L_{eq\ (15\ hour)}$ + 12 dB (external)	Existing traffic $L_{eq\ (9\ hour)}$ + 12 dB (external)

Source: RNP

4.5.2 Noise Criteria Guideline

The noise criteria guideline (NCG) is the Roads and Maritime guideline to implementing the RNP on Roads and Maritime projects. It establishes a consistent approach to identifying road noise criteria for new, redeveloped and minor work projects. It also provides a practical approach for specific situations relevant to Roads and Maritime projects, such as defining:

- What is considered a New and Redeveloped road
- Transition zones between different road types: New, Redeveloped and existing

- The assessment area.

A road project is considered a New road, for the purposes of assessment if:

- The project is through a new corridor
- The project changes the functional class of a road
- There is a substantial vertical or horizontal realignment
- The duplication is a substantial realignment
- There is a bypass where the road extends beyond the existing corridor.

Roads where the upgrade is not a substantial realignment would be considered a redevelopment. The road would also be considered a redevelopment where the traffic carrying capacity is increased due to a project.

For new and redeveloped sections of road, the RNP criteria for residential receivers apply (Table 4-2). Where two types of road projects join, such as a New and Redeveloped road or a New and existing road the NCG defines a transition zone.

New and Redeveloped roads have different criteria. Where the two types of roads meet, a transition zone is used to provide a smooth change between the New and Redeveloped criteria. The transition zone criteria are based on the difference of the contribution from each of the road types at each receiver. The transition zone criteria are defined in Table 4-5.

Table 4-5 Transition zone contributions

Contribution difference New minus Redeveloped sections dBA	Total noise level criteria	
	Day $L_{eq,15hr}$ dBA	Night $L_{eq,15hr}$ dBA
Contribution difference ≥ +3.0	55	50
+3.0 > Contribution difference ≥ +1.5	56	51
+1.5 > Contribution difference ≥ +0	57	52
0 > Contribution difference ≥ -1.5	58	53
-1.5 > Contribution difference ≥ -3.0	59	54
-3.0 > Contribution difference	60	55

Source: NCG

A transition zone between an existing road and the project road applies if the noise level, as a result of the project, increases by more than 2 dBA and the noise level from the existing road is higher than the project road. In this case the existing road criteria are set at the affected building façade.

The NCG also provides guidance on the definition of the assessment area. While the RNP defines the assessment area as 600 metres either side of the centreline of the outermost traffic lane. The NCG recognises in some rural areas, the criteria may still be exceeded outside of the 600 metres area.

For this project, the assessment area was extended beyond 600 metres as described in 4.5.4.

4.5.3 Noise Mitigation Guideline

The noise mitigation guideline (NMG) provides guidance in managing and controlling road traffic noise and describes the principles to be applied when reviewing noise mitigation. The NMG recognises the criteria in the NCG are not always practicable and it is not always feasible or reasonable to expect they should be achieved.

The NMG defines the preference for road traffic noise to be controlled at the source. Where at-source measures are not reasonable or feasible, additional methods are required to reduce noise to within acceptable levels. Additional methods may include the use of noise barriers (noise walls or noise mounds) and/or consideration for at-property treatment of residences.

The NMG defines triggers where receivers may qualify for consideration of mitigation options. These triggers are:

1) The predicted total Build noise level exceeds the NCG criteria and the increase in noise level due to the project (build minus no build scenario) is greater than 2 dB
2) The predicted total Build noise level increases by 12 dB or more compared with the No build scenario – this is the relative increase criteria
3) The predicted noise level is 5 dB or more above the NCG controlling criteria where the road project is the most significant source, regardless of the increase between the Build and No build scenario.
4) The noise level contribution from the road project at a residential receiver is acute. Acute noise levels are defined as equal to or above a day time noise level $L_{eq\ (15\ hour)}$ 65 dBA or night $L_{eq\ (9\ hour)}$ 60 dBA.

Once eligible receivers have been identified, an investigation of mitigation options is carried out. Mitigation is investigated in the following order of preference in line with the RNP:

- Road design
- Quieter pavement surfaces
- In corridor noise mound
- In corridor noise walls
- At-property treatment.

If the NCG criteria cannot reasonably and feasibly be satisfied with quieter pavement and noise mounds or wall, only then is the receiver is eligible of consideration of at-property treatment.

When considering additional quieter pavements or noise barriers as a mitigation measures, the NMG provides guidance on when they are considered reasonable and feasible. Where there are four or more closely spaced receivers that qualify for consideration of mitigation, quieter pavements and noise barriers should be investigated where the measure is feasible. Following the investigation, further considerations apply to determine if the measure reasonable for implementation in context of the broader considerations of the project including:

- The noise reduction provided and the overall number of people that benefit from the mitigation
- Existing and future noise levels, including changes in noise levels in the build and design year and the extent of any exceedance of the noise criteria
- Potential for a mitigation measure to reduce noise during construction as well as from road traffic after the project is complete
- The cost of mitigation, including the cost of noise mitigation measures as a percentage of the total project cost and the ongoing maintenance and operational costs
- Community views and preferences
- Visual impacts

- The wider community benefits arising from noise mitigation of the proposed road or road redevelopment
- Relative weighting of treatments with respect to protection of outdoor areas or only internal living spaces.

Where at-property treatment is identified as a reasonable and feasible measure for a property, the installation of any treatment is subject to further consideration by Roads and Maritime on a case by case basis. The further consideration includes, but is not limited to:

- Property inspection
- Structural condition
- Façade construction
- Heritage considerations
- Planning approval for the dwelling
- Supporting infrastructure.

4.5.4 Assessment area

The assessment area has been defined in two areas; 0 to 600 metres, and 601 to 900 metres as measured from the centreline of the outermost traffic lane of the upgrade.

The RNP sets the assessment area for a road project to be 600 metres either side of the road from centreline the outermost traffic lane. The NCG allows for this area to be extended where appropriately justified on a case by case basis.

For this upgrade, it was recognised there may be areas where the criteria may be exceeded at distances beyond 600 metres as there are not any existing major roads nearby. It was determined receivers up to 900 metres from the road may experience noise levels above the criteria. This distance is based on the noise level from a concrete road in a rural setting with a similar number of vehicles on it as the upgrade.

As the assessment area has been extended beyond the required RNP distance, there are other considerations to take into account.

The computer model used to predict traffic noise levels is called the Calculation of Road Traffic Noise (CoRTN). It has an acceptable level of accuracy at distances up to 600 metres from a road. At distances beyond this, the predicted noise level is generally greater than the actual noise level. This is because the traffic noise model does not apply as much reduction for the absorption of sound in the air or by soft ground coverings at large distances.

At distances beyond 600 metres these parameters start to affect the predicted total noise level of the road traffic. When compared with other prediction methods such as the CONCAWE method, commonly used for industrial noise sources, the noise level predicted by CoRTN can be 3 to 4 dB above the actual noise level. Therefore at distances beyond 600 metres, the over prediction by CoRTN is a safety factor that provides a conservative approach to the assessment.

Roads and Maritime guidelines allow mitigation to be investigated at distances beyond 600 metres on a case by case basis. For mitigation measures in the road corridor such as quieter pavement surfaces and noise barriers or mounds, the mitigation has been applied in line with Roads and Maritime's guidelines.

For at-property treatments, receivers have been addressed in the two assessment areas:

- Receivers within 600 metres, identified as eligible for consideration of mitigation, are to be investigated for treatment at the earliest opportunity
- Receivers between 601 and 900 metres identified as eligible for consideration will be investigated as part of the operational noise compliance report.

4.5.5 Identification of affected properties

The assessments carried out for the operational noise review identify:

- Each property eligible for the consideration of mitigation
- Steps taken to determine the reasonable and feasible mitigation applied to the project
- Properties considered for at-property mitigation.

The assessments are based on predicted noise levels at each receiver façade on each storey. Each receiver is assigned an ID number. The predicted impact is shown in two formats; a table of predicted noise levels and noise contour maps. The location and ID number of a property can be found on the maps and the corresponding predicted noise levels are displayed in the tables.

The predicted noise level in the tables is what is used to determine the noise impact and eligibility for consideration of mitigation as it is a direct prediction at the assessment location. Noise contour maps are indicative only as the calculation is done at 20 metre intervals and so does not represent the exact prediction at each receiver.

Figure 4-10 presents an example of how to interpret the predicted noise levels.

Receiver ID
Identification number assigned to each receiver. Each ID number can be found on the noise contour maps.

Façade
The facade is the side of the building that was assessed. The floor level is the storey which was assessed and the direction is the side of the house the facade is located on.

Predicted noise level Design Year 2029
The predicted noise levels in the design year are 10 years after the project opens. These noise levels are used to define the eligibility for mitigation.

Study area
States if the receiver is within 0 to 600m or between 600 and 900m from the upgrade.

No Build/Build
The no build scenario is the situation where the upgrade is not built. The build scenario is where the upgrade is built.

Change in noise level (Build–No Build)
The change in noise level between the build scenario and the no build scenario. Positive numbers means the noise level will increase with the upgrade.

NCG Project road noise criteria
The NCG criteria are defined for new roads, redeveloped roads, relative increase and existing roads.

Was property considered for treatment in EIS?
Properties identified for consideration of treatment in the EIS, prior to changes and assessment at detailed design.

Is property considered for further treatment?
Property is considered for further treatment based on the four triggers.

Day/Night
Day is 7am to 10pm.
Night is 10pm to 7am.

Receiver ID	Address	Lot/DP	Study area	Façade		Predicted noise level Opening Year 2019				Predicted noise level Design Year 2029				Change in noise level (Build – No Build)				NCG Project road noise criteria		NCG project road criteria exceedance (dB)		Do noise levels exceed NCG relative increase criteria?		Do noise levels equal or exceed the cumulative limit with project roads adding ≥2dB to the total noise levels?		NMC Cumulative criteria exceedance (db)		Is the contribution from the road project Acute?		Is property considered for further treatment?	Triggering criteria	Was property considered for treatment in EIS?
						No Build		Build		No Build		Build		Opening Year 2019		Design Year 2029																
				Floor level	Direction	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	Day Laeq, 15hr ≥65dB	Night Laeq, 9hr ≥60dB			
123	1 Long Street, Grafton	Lot 2/ DP114425	600–900mm	Ground	SW	30	30	49	49	30	30	50	50	18.7	18.9	19.5	19.9	42	42	8	8	Yes	Yes	Yes	Yes	3	3	No	No	Yes	RIC	Yes
123	1 Long Street, Grafton	Lot 2/ DP114425	600–900mm	Ground	SE	30	30	48	48	30	30	49	49	18.0	18.1	18.8	19.2	42	42	7	7	Yes	Yes	Yes	Yes	2	2	No	No	Yes	RIC	Yes
123	1 Long Street, Grafton	Lot 2/ DP114425	600–900mm	Ground	NW	30	30	50	50	30	30	51	51	19.8	20.0	20.7	21.1	42	42	9	9	Yes	Yes	Yes	Yes	4	4	No	No	Yes	RIC	Yes
123	1 Long Street, Grafton	Lot 2/ DP114425	600–900mm	Ground	NE	30	30	52	52	30	30	53	53	21.7	21.8	22.5	22.9	42	42	11	11	Yes	Yes	Yes	Yes	6	6	No	No	Yes	RIC	Yes
456	15 Kays Road, Wardell	Lot 11/ DP11535	≥600mm	Ground	N	50	46	60	60	50	48	61	61	10.5	13.8	10.7	13.8	55	50	6	11	No	Yes	Yes	Yes	1	6	No	Yes	Yes	RIC	No
456	15 Kays Road, Wardell	Lot 11/ DP11535	≥600mm	Ground	W	44	41	59	60	45	42	60	60	15.0	18.1	15.1	18.2	55	50	5	11	Yes	Yes	Yes	Yes	0	6	No	Yes	Yes	NR	No
456	15 Kays Road, Wardell	Lot 11/ DP11535	≥600mm	Ground	S	51	48	55	55	52	49	55	56	3.4	6.5	3.5	6.4	55	50	0	6	No	No	No	Yes	–	1	No	No	Yes	NR	No
456	15 Kays Road, Wardell	Lot 11/ DP11535	≥600mm	Ground	E	52	49	55	55	53	50	56	56	2.5	5.5	2.6	5.4	55	50	1	6	No	No	No	Yes	–	1	No	No	Yes	NR	No

Figure 4-10 Example predicted noise level table and explanation of terms

4.6 Maximum noise levels

Noise from the project has been assessed for its potential to disturb sleep. The effect of traffic noise on sleep is discussed in Chapter 5.4 of the RNP. The RNP does not include criteria for maximum noise levels and they do not trigger eligibility for consideration of mitigation, however they may be used to prioritise treatment packages.

The disruption of a person's normal sleep patterns or sleep disturbance, due to road traffic noise, has been the subject of numerous research studies conducted over the last 30 years. Despite intensive research, sleep disturbance triggers and effects have not yet been conclusively determined.

Sleep disturbance occurs through changes in sleep state and awakenings. Awakenings are better correlated to subjective assessments of sleep quality than are changes in sleep state, which generally require objective measurement.

A summary of the current literature concerning sleep disturbance due to noise indicates the main noise characteristics influencing sleep disturbance are the number of noisy events heard distinctly above the ambient noise level, the occurrence of these events and the maximum noise level.

When vehicles are continuously passing, peaks in the noise levels are less likely to happen. On steep grades or during periods of occasional vehicles passing, individual vehicles can create peaks in noise above the general traffic noise.

As outlined in the RNP, sleep disturbance triggers and effects caused by exposure to intermittent noise (such as road traffic noise) are still being studied, and there appears to be insufficient evidence to set new indicators for potential sleep disturbance due to road traffic noise.

Further guidance is provided in the Roads and Maritime ENMM practice note (iv) that defines a maximum noise level event during the night as when:

- The L_{max} is more than 15 dB above the $L_{eq,1hr}$
- The L_{max} noise level is greater than 65 dBA.

The assessment of maximum noise levels considers the number and noise level of the events and how often they occur in the No build scenario. The assessment compares the existing situation with the proposed Build situation to assess changes in the magnitude of the events and how often the events would occur.

When reviewing maximum traffic noise levels, typical sound power levels associated with trucks maximum noise levels were considered. Typical sound power levels (SWL) from truck activities are SWL L_{max} 114 dBA for a truck passby on the motorway and up to SWL L_{max} 130 dBA for truck compression braking. The maximum noise level is a measure of the peak instantaneous noise level and does not represent the time varying noise level.

Importantly, the sound power level is not the same as the sound pressure level. The sound power level is a measure of the acoustic energy of a sound source. The sound pressure level is the sound pressure that is measured at a specific point from the source and is influenced by the environment which the sound moves through. Sound pressure level at a point is calculated from the sound power level and applying attenuation due to its location relative to the source and characteristics of environment the sound travels through.

4.7 Rest areas

Rest areas are fixed facilities and are not assessed in the same way road traffic noise, generated on public roads, is assessed. The assessment of rest areas has been carried out in line with the NSW *Industrial Noise Policy* (INP) (EPA, 2000).

The INP defines two assessment methods - the Amenity criteria and the Intrusive criteria. The Intrusive criteria are assessed over 15 minutes and are intended to control short term intrusive impacts of noise over the existing background noise level. The Amenity criteria are assessed over the day, evening and night period and are intended to limit the total noise level of industrial noise in an area.

The two criteria are derived for each noise sensitive receiver and the most stringent criterion is selected as the Project Specific Noise Level (PSNL).

The criteria are non-mandatory, however where an exceedance of the criteria is predicted, reasonable and feasible mitigation needs to be considered to reduce noise levels towards the PSNL.

There is only one rest area within 900 metres of a receiver. It is located between Bostock and Somervale Road, Tucabia.

The other rest area is located at Mororo near Devils Pulpit which is at least 900 metres from any sensitive receivers. Due to the distance involved, noise impacts are not expected and an assessment has not been carried out. This is consistent with the findings of the EIS.

Maximum noise levels associated with operational traffic behaviour that is changed as a result of the rest areas have been considered as part of the maximum noise level assessment in Chapter 4.6.

4.8 Pavement types

The Woolgoolga to Ballina project design incorporates a number of different pavement types across the project. These include:

- Concrete pavement
- Flexible pavement
- Quieter/low noise pavement

The selection of type of pavement during detailed design considered total life costs (which include construction and ongoing maintenance costs), environmental impacts, material sourcing and constructability. The RNP outlines that the quality of the pavement surface finish can affect the amount of road traffic noise generated. However, the choice of road pavement surfaces and textures must meet a number of criteria including skid resistance, water shedding and design life as well as potential noise generating characteristics. The road pavement surface's noise performance throughout its duration and the need to maintain that performance when the pavement is replaced are also important considerations.

Generally the new dual carriageways sections consist of a heavy-duty concrete pavement. In some areas, a flexible / granular pavement is nominated as an alternative to a rigid concrete pavement due to the potential for ongoing settlement due to soft soils or damage from flood inundation. This pavement would allow for periodic (or rapid) pavement restoration.

The individual pavement designs for intersections, local access roads and interchanges differ depending on traffic loads, however typically include an asphalt pavement with concrete pavement for intersection roundabouts.

Where the existing Pacific Highway is included within the new dual carriageway or would become a service road, various treatments have been considered including chip seal pavement.

In addition to engineering requirements of the pavement outlined above, quieter pavements have been considered during the concept design and Environmental Impact Statement, as well as being considered during the operational noise investigations as outlined in the RNP and NMG. The NMG defines a low noise pavement as pavement that has an emission level 2dBA lower or more than dense graded asphalt.

The Woolgoolga to Ballina Environmental Impact Statement (EIS Chapter 5 Section 5.2.31) identified specific areas where low noise pavement was proposed based on the project concept design. These are outlined Table 4-6.

Table 4-6 Location of Low Noise Pavements from Woolgoolga to Ballina EIS

Location	Chainage start	Chainage finish	Length (m)
Section 3, Tyndale	66,400	68,300	1900
Section 4, Maclean	80,500	82,500	2000
Section 5, Harwood	85,900	88,000	2100
Section 8, Trustums Hill: (The Gap Rd)	127,000	128,100	1100
Section 10, 2km south of Coolgardie interchange to Coolgardie Road	155,400	157,800	2400

These extents of low noise pavement have been incorporated into the final detailed design. Additional assessment was undertaken for each portion of the project as outlined in Section 6 of this report. This assessment identified whether any additional quieter pavements were considered reasonable or feasible in accordance with the relevant guidelines. Where applicable the extent of additional areas of quieter pavements that have been incorporated following the operational noise assessment are outlined in Section 6.

The location of different pavement types are shown on the figures included in Appendix A, C and E of this report. They are captured as either:

- *Concrete pavement* – a rigid concrete pavement type
- *Flexible pavement* – where engineering requirements have driven the need for a flexible pavement (stone mastic asphalt) e.g. flood prone or soft soil areas.
- *EIS Low Noise Pavement* – areas that Low Noise Pavement was outlined in the EIS (stone mastic asphalt).
- *Additional Low Noise Pavement* – areas that have been identified during the operational noise review and included in the final design (stone mastic asphalt).

Note that there are a number of bridges throughout the project length. In general these bridges contain concrete with a flexible surface to manage the engineering requirements of these bridge to earthworks interfaces. These minor bridges have not been captured in the mapping in the Appendices.

5 Existing environment

5.1 Noise sensitive receivers

Residential and non-residential receivers potentially sensitive to noise have been identified using cadastral information, aerial photography and on site observations. The locations of receivers were confirmed by on site survey in August 2017 which identified, as far as possible, noise sensitive and non-noise sensitive structures. Sensitive receivers as defined by the NCG include:

- Residential dwellings
- Schools
- Hospitals
- Places of worship
- Child care centres.

Sensitive receivers were identified within the assessment areas defined as up to 900 metres from the project. The receivers were separated into two areas; within 600 metres of the project and between 601 and 900 metres of the project.

Sensitive receivers identified during the EIS were used when assessing the detailed design. In addition, a review of the sensitive receivers was carried out and receivers were added or removed, based on additional properties identified using desktop surveys and on site observations identifying noise sensitive receivers.

Assessments have considered properties with Development Approval (DA) to construct a noise sensitive receiver before the EIS was approved on 24 June 2014. Where a noise sensitive receiver was approved after the approval date, it is not the responsibility of Roads and Maritime to provide mitigation.

Where a property has been acquired by Roads and Maritime as part of the project and the dwelling has been retained, it has been assessed as a sensitive receiver.

There was a total of 792 residential receivers and six non-residential assessed within 600 metres of the project. A further 416 residential receivers were assessed between 601 and 900 metres from the project.

5.1.1 Glenugie to Maclean

Noise sensitive receivers in the assessment area between Glenugie and Maclean are primarily sparsely distributed residential receivers. Tyndale, Maclean and Townsend are low to medium density suburban type areas consisting mainly of free standing houses.

The total residential receivers assessed was 520, of these 407 residential receivers are between 0 and 600 metres from the project and 113 receivers are between 601 and 900 metres. The EIS identified 302 residential receivers within 600 metres of the project.

The assessment does not include those receivers in the vicinity of the Glenugie Link between the Glenugie interchange and Six Mile Lane as this section of the project is still under design.

The Glenugie to Maclean and the Maclean to Devils Pulpit portions meet north of Maclean interchange at Townsend and both areas were assessed in each of the detailed design noise assessments. For the purposes of this operational noise review, the receivers in Maclean and Townsend have been included in the assessment for Glenugie to Maclean.

The assessment area was not extended beyond 600 metres in the populated areas of Maclean and Townsend. Due to the higher density of receivers in this area and because the road noise from the project is coming from the same direction as the existing highway, where the first few rows of houses are not affected, the houses behind them will also not be affected.

There are three non-residential noise sensitive receivers within 900 metres of the project:

- Maclean High School/TAFE NSW, Maclean
- Pacific Valley Christian School, Townsend
- Lower Clarence Baptist Church, Townsend.

Detailed figures of the location of noise sensitive receivers between Glenugie and Maclean are presented in Appendix A.

5.1.2 Maclean to Devils Pulpit

Noise sensitive receivers in the assessment area between Maclean and Devils Pulpit are primarily sparsely distributed rural residential receivers with more populated areas around Harwood and Woombah. Harwood is the main population centre and is a low density town, located at the Clarence River crossing.

The assessment area for this portion overlapped with the assessment of Glenugie to Maclean. As described in Chapter 5.1.1 the receivers in Townsend and Maclean were included as part of the Glenugie to Maclean assessment.

The total residential receivers assessed was 246, of these 176 residential receivers are between 0 and 600 metres from the project and 70 receivers are between 601 and 900 metres. The EIS identified 222 residential receivers within 600 metres of the project.

Two non-residential noise sensitive receivers were identified within 900 metres of the project; Harwood Island Public School, Harwood and Crematorium at Riverview Funerals, Harwood

Detailed figures of the location of noise sensitive receivers between Maclean and Devils Pulpit are presented in Appendix A.

5.1.3 Devils Pulpit to Richmond River

Noise sensitive receivers in the assessment area between Devils Pulpit and Richmond River are primarily sparsely distributed rural residential receivers as the road bypasses Woodburn and Broadwater. These towns are located about 1.2 kilometres and 800 metres west of the project respectively. Residential dwellings in these towns are characterised by low to medium density suburban type housing.

The total residential receivers assessed was 300, of these 110 residential receivers are between 0 and 600 metres from the project and 190 receivers are between 601 and 900 metres. The EIS identified 90 residential receivers within 600 metres of the project.

One non-residential receiver was identified within 900 metres of the project which was Broadwater Public School.

The assessment area included Broadwater as there are a number of receivers up to 900 metres from the project that are potentially affected from a new direction, on a different house façade as the new bypass significantly deviates from the existing highway route.

Detailed figures of the location of noise sensitive receivers between Devils Pulpit and Richmond River are presented in Appendix A.

5.1.4 Richmond River to Pimlico

Noise sensitive receivers in the assessment area between Richmond River and Pimlico are primarily sparsely distributed rural residential receivers for the sections of the road in new corridors. Coolgardie is located to the west and the project bypasses Wardell. Residential dwellings in these areas are characterised by low density type housing.

The total residential receivers assessed was 142, of these 99 receivers are between 0 and 600 metres from the project and 43 receivers are between 601 and 900 metres. The EIS identified 93 residential receivers within 600 metres of the project.

Detailed figures of the location of sensitive receivers between Richmond River and Pimlico are presented in Appendix A.

5.2 Noise monitoring

5.2.1 Methodology

Noise monitoring of existing traffic noise levels was carried out to measure a representative sample of the existing traffic noise conditions to validate the noise model.

Noise levels were measured using unattended noise monitors. Noise monitoring took place at the same time as vehicle counts so that measured noise levels could be correlated with traffic numbers.

Monitoring was carried out for the EIS between February and March 2012. As part of the detailed design noise assessments, EIS data was reviewed by each design team to determine the suitability to validate the noise models. The review showed that the EIS data did not have enough locations for the Richmond River to Pimlico portion and therefore supplementary monitoring was carried out between Richmond River and Pimlico to ensure sufficient data to validate the noise model. For the other portions, the data from the EIS was deemed sufficient by the detailed designers to validate the noise models.

Noise monitoring was completed in line with Australian Standard AS 2702 Methods for the Measurement of Road Traffic Noise, AS 1055:1997 Description and Measurement of Environmental Noise and the requirements of the RNP.

Periods in the noise monitoring adversely affected by inclement weather, such as high winds or rain, were removed from the noise monitoring. As during these periods, the noise level measured does not represent the noise level from only road traffic and therefore it is not included.

Monitoring locations were chosen to validate the noise model and provide a representative sample of the existing road traffic noise conditions before the project is built.

Noise monitoring is not carried out at every house, instead a representative sample is used to validate the predicted noise levels.

Where there is no existing road and the project goes through new areas, noise monitoring for the purposes of validating the model cannot carried out as there is no existing road noise. Instead, the minimum road traffic noise level as defined in the RNP has been applied, which is 30 dBA during the day and night. Noise monitoring for road traffic noise levels uses the following descriptors:

- $L_{eq\ (15\ hour)}$ dBA representing the L_{eq} noise level for the daytime period 7am–10pm
- $L_{eq\ (9\ hour)}$ dBA representing the L_{eq} noise level for the night time period 10pm–7am.

5.2.2 Measured road traffic noise levels

Table 5-1 presents a summary of the road traffic noise levels measured in each section used to validate the updated noise models of the project and the existing conditions. Monitoring locations are shown in the figures in Appendix A and the available noise monitoring graphs presented in Appendix B.

Table 5-1 Measured traffic noise levels

Portion	EIS Section	ID	Distance to existing Pacific Highway (metres)	Measured traffic noise level dBA[2]	
				Leq,15hr	Leq,9hr
Glenugie to Maclean	3	678	210	49	47
		S3_1[1]	>1km	42	32
		703[1]	>1km	52	43
		729[1]	>1km	51	39
		S3_2[1]	>1km	52	43
		748[1]	>1km	54	48
	4	842	58	66	65
		849	47	66	65
		S4_1	106	60	59
		892	34	67	66
		1026	51	62	60
		1080	411	58	50
Maclean to Devils Pulpit	5	1331	69	59	59
		1396	141	57	55
		1438	16	72	71
		1471	460	58	58
	6	1542	75	63	61
		1546	47	60	58
Devils Pulpit to Richmond River	7	1557	168	66	64
		1591	214	61	59
		1592	373	54	53
	8	1631	139	61	54
		1698	124	60	58
	9	1756	29	65	64
Richmond River to Pimlico	10	L1	18	74	71
		L2	15	73	70
		L3	65	65	62
		L4	30	68	65
	11	L5	25	70	67

Note 1: Noise levels not dominated by road traffic.

Note 2: Traffic noise levels presented are façade reflected noise levels.

5.3 Traffic volume counting

Traffic volume counting was carried out at the same time as the noise monitoring carried out for the EIS in 2012 and during the supplementary noise monitoring carried out in 2016 between Richmond River and Pimlico.

The traffic counting involved vehicle counts, vehicle classification and vehicle speed. The traffic volume counting is used in conjunction with noise measurements to validate the noise model at locations which provide a representative sample of the traffic volumes passing the noise monitors at their various locations for each sections of the existing Pacific Highway.

Table 5-2 presents a summary of the traffic counting (both directions of travel combined) for sections of the project.

Table 5-2 Traffic volume counting and speed

EIS Section	Location	Day (7am to 10pm)			Night (10pm to 7am)		
		Total vehicles	% heavy vehicles	Speed (km/h)	Total vehicles	% heavy vehicles	Speed (km/h)
3 & 4	Pacific Highway, north of Farlows Lane, Maclean	6983	19%	100	1346	45%	100
5	Pacific Highway, 500 metres south of Lewis Lane, Woombah	7863	29%	110	1306	56%	111
6 & 7	Pacific Highway, 100 metres south of Turners Road, New Italy	6871	20%	105	1278	44%	106
8	Pacific Highway, 100 metres south of Turners Road, New Italy	6871	20%	105	1278	44%	106
	Pacific Highway, North Woodburn[1]	8735	18%	107	1596	42%	108
9	Pacific Highway, South Broadwater[1]	8735	18%	107	1596	42%	108
	Pacific Highway, North Broadwater[1]	8728	17%	107	1642	38%	108
10	Pacific Highway, between Meaneys Lane and Owen Lane, Wardell	9922	20%	104	1475	38%	105
11	Pacific Highway, between Salt Water Creek and Coolgardie Road, Pimlico	9196	20%	102	1385	46%	103

Note 1: Speed profiles for section based on data from section 8.

6 Noise assessment

6.1 Methodology

The noise assessment was carried out by creating a noise model for each portion to predict the noise levels with and without the project.

The noise models were developed using the SoundPLAN noise modelling software implementing the Calculation of Road Traffic Noise (CoRTN) method.

The settings and inputs for the noise model were consistent for each portion. The noise models were validated using the noise measurements and traffic volumes described in Chapter 5. The noise modelling used the following inputs:

- Three dimensional ground topography and ground attenuation
- Three dimensional road layouts of the detailed design for the Build scenario and the existing road layout for the No build scenario
- Noise sensitive receiver locations
- Forecast road traffic volumes for light and heavy vehicles, speeds and pavement types.

The modelling inputs were refined compared with the EIS noise model in the following ways:

- Final detailed design of the project
- Increased level of detail for ground contours, utilising the 0.5 to one metre LIDAR survey data
- Inclusion of building structures for noise sensitive and non-noise sensitive receivers
- Prediction of noise levels at each façade and storey
- Inclusion of significant non-project roads
- Analysis of contribution from non-project and project roads as part of mitigation analysis
- Expansion of the assessment area to take into consideration potential noise impacts up to 900 metres from the project
- Updated traffic volumes for the modelled years 2019 and 2029.

The noise modelling inputs used across the project are summarised in Table 6-1.

The noise model does not specifically take into account the presence of trees and vegetation, except to define the ground attenuation. Trees and vegetation are not effective noise barriers and are not permanent due to bush fires, changes in foliage and growth year to year and so have not been included.

Table 6-1 Noise modelling inputs

<table>
<tr><th>Item</th><th>Description</th></tr>
<tr><td>Calculation method</td><td>Calculation of Road Traffic Noise (1988) with NSW adjustments</td></tr>
<tr><td>Calculation search radius</td><td>2500 metres</td></tr>
<tr><td>Assessment Area</td><td>900 metres</td></tr>
<tr><td>Source heights and corrections</td><td>Three noise source height were used in the model as follows:
<table>
<tr><td>Source</td><td>Height (m)</td><td>Correction (dB)</td></tr>
<tr><td>Light vehicles</td><td>0.5</td><td>0.0</td></tr>
<tr><td>Heavy vehicles engine</td><td>1.5</td><td>-0.6</td></tr>
<tr><td>Heavy vehicles exhaust</td><td>3.6</td><td>-8.6</td></tr>
</table></td></tr>
</table>

Item	Description
Road design	The existing road was modelled using existing ground survey data. The proposed road design for the project was the final detailed design.
Road gradient	The road gradient was calculated based on the road design.
Pavement design	The road pavement modelled was the final detailed pavement design.
Pavement corrections	Dense graded asphalt (DGA) = 0 dB Stone Mastic Asphalt (SMA) = -2 dB Concrete = +3 dB Design pavement chip seal = + 2 dB Existing pavement chip seal = +2.5 dB Existing pavement worn DGA = +1 dB
Australian conditions correction	In line with the ARRB corrections: Day: -1.7 dB for façade reflected noise levels Night: +0.5 dB for façade reflected noise levels applied as a specific Pacific Highway upgrade correction.
Safety factor	+0.8 dB correction added to all scenarios.
Façade reflection	+2.5 dB correction for façade reflected receivers.
L_{10} to L_{eq}	-3 dB correction
Receiver heights	1.5 metres for single storey and 4.5 metres for double storey.
Receiver locations	1 metre from the façade for receivers defined by buildings.
Receiver naming	Receivers are the same as the EIS. Where additional receivers were identified, additional labelling has been used.
Receiver types	Residential and other sensitive receivers named in the NCG were included. Commercial (including hotels/motels) and industrial receivers are not included.
Planning approvals	An approved Development Application (DA) is only eligible to be included where approval was granted to construct a sensitive receiver prior to the approval of the EIS.
Buildings, structures and walls	Each façade and storey for a sensitive receiver has been modelled. Other buildings and structures included where acoustically relevant.
Ground absorption	Where 0.9 was used in the EIS for validation, assumption was also used to be consistent with the noise model validation assumptions. For Build and No build predictions ground absorption factors of 0.75 for soft ground areas and 0 for water were used.
Topography	0.5 metre to 1 metre interval data up to 1 kilometre either side of the project and existing roads.

<table>
<tr><th>Item</th><th>Description</th></tr>
<tr><td>Vehicle speeds</td><td>Speeds for the upgraded main carriage way were modelled at the 85th percentile design speed (not posted speed) as follows:
<table>
<tr><th>Section</th><th>Speed (km/h)</th></tr>
<tr><td>Main carriageway Day (7am - 10pm)</td><td>115</td></tr>
<tr><td>Main carriageway Night (10pm - 7am)</td><td>120</td></tr>
<tr><td>All other roads including ramps access roads and service roads.</td><td>Posted speed</td></tr>
</table>
Where the existing Pacific Highway is not being changed as part of the project, the existing posted speed was used. The 85th percentile speeds from traffic counting data collected concurrently with noise monitoring were used for the validation of the model.</td></tr>
<tr><td>Traffic volumes</td><td>For model validation, the traffic counting carried out at the time of the noise monitoring was used.
For the Build and No build models at opening and ten years after opening, traffic forecasts for 2019 and 2029 were used.</td></tr>
</table>

6.2 Glenugie to Maclean

The detailed design and noise assessment for the Glenugie to Maclean portion was carried out by GHD. This section summarises the noise assessment carried out between Glenugie and Maclean.

6.2.1 Site description

Table 6-2 provides a description of the project and existing environment in each EIS section between Glenugie to Maclean.

Table 6-2 Glenugie to Maclean site description

EIS section number	EIS section name	Length (km)	Chainage	Description
3	Glenugie upgrade to Tyndale	35	33,800 to 68,800	Upgrade leaves the existing alignment and travels north through new road corridor to Tyndale where it meets the existing alignment. The area surrounding the new corridor is sparsely populated with isolated dwellings. A new interchange is located at both Glenugie and Tyndale with separated south and north bound on and off ramps. A rest area is located between Bostock and Somervale Road, Tucabia.
4	Tyndale to Maclean	13.2	68,800 to 82,000	North of Tyndale the road travels through new road corridor and meets the existing Pacific Highway south of Maclean. A grade separated interchange is located at Maclean at Jubilee Street and Cameron Street.

The assessment area was extended one kilometre north, to include the residential and school areas of Maclean and Townsend.

The proposed Grafton Correctional Centre is to be located at 313 Avenue Road, Lavadia and would connect to the public road network via Avenue Road. The correctional centre was approved by the Department of Planning and Environment in 2017 and has the potential to generate additional vehicle movements on Avenue Road and connecting roads a result of the nature of the land use development. In line with the RNP, the responsibility for identifying and mitigating any potential road traffic noise impacts from the correctional centre's land use development is with the proponents of the centre and not Roads and Maritime.

6.2.2 Existing environment

Sensitive receivers

The description of the sensitive receivers is provided in Chapter 5. The number of sensitive receivers assessed are summarised in Table 6-3.

Table 6-3 Number of receivers assessed in the Glenugie to Maclean portion

Description	Distance from road (metres)	Number of receivers (EIS)	Number of receivers (ONR)[1]	Notes
Residential receivers	0-600	302	407	Sparsely populated receivers located in rural area without existing traffic noise. Small town located at Tyndale with low density residential adjacent to existing highway. Large town at Maclean and Townsend with low to medium density receivers located either side of the project.
	601-900	N/A[2]	113	Generally sparsely populated isolated receivers and low density residential receivers in Townsend and Maclean.
Non-residential receivers	0-600	1 (Maclean High School)	3	Pacific Valley Christian School, Townsend Maclean High School and TAFE Lower Clarence Baptist Church, Townsend
	601-900	N/A[2]	0	-

Note 1: Receivers in Townsend and Maclean have been included in the Glenugie and Maclean portion assessment.

Note 2: Receivers were only assessed up to 600 metres from the project in the EIS.

Existing noise environment

Noise monitoring as described in Chapter 5 was carried out for the EIS at locations shown in Appendix A. A summary of the noise monitoring used for the model validation between Glenugie and Maclean is provided in Table 6-4.

Table 6-4 Noise measurement results, dBA

Location ID	Address	Distance to Existing Highway (metres)	Measured traffic noise level	
			$L_{eq,15hr}$ Day	$L_{eq,9hr}$ Night
842	Pacific Highway, Tyndale	58	66	65
849	Pacific Highway, Tyndale	47	66	65
S4_1	O'Maras Lane, Gulmarrad	106	60	59
892	Pacific Highway, Gulmarrad	34	67	66
1026	Jubilee Street, Townsend	51	62	60
1080	Scullin Street, Townsend	411	58	50

6.2.3 Specific criteria – transition zones

The portion has both New roads and Redeveloped roads. Where the two road types meet, transition zone criteria are applicable.

The assessment identified transition zones where the project deviates substantially from the existing road corridor at Glenugie and where it rejoins the existing road corridor at Maclean. In these areas there is a transition zone between New road and Redeveloped road types.

At Tyndale, the new road corridor is located further than six times the width of the existing corridor away from the existing Pacific Highway and has been considered as a New road project.

There are a number of interactions with existing roads including the existing Pacific Highway. A transition zone with an existing road is only applicable where the noise level increases by more than 2 dBA and the existing road noise is dominant at the receiver. The assessment did not identify any transition zones for existing roads. The following road types were identified:

- New road between Glenugie and Maclean
- Redeveloped road north of the Maclean interchange.

The individual criteria for each receiver were calculated and are presented in the predicted noise level tables in Appendix D-1. Appendix C presents the transition zone criteria for day and night at Maclean respectively.

6.2.4 Technical parameters for noise modelling

Pavement type

The pavement type for the design includes:

- Concrete pavement
- SMA pavements (Flexible and EIS specified)
- DGA pavement.

The location of each of the pavements is shown on maps in Appendix E-2.

Forecast traffic volumes

The forecast traffic volumes for the roads between Glenugie to Maclean for the day and night periods are shown in Table 6-5 for the No build scenario and Table 6-6 for the Build scenario. Table 6-7 and Table 6-8 present the forecast traffic numbers on roads other than the Pacific Highway.

Table 6-5 No build forecast traffic volumes Pacific Highway

Road	Direction	Day (7am to 10pm)			Night (10pm to 7am)		
		Total vehicles	% heavy vehicles	Speed (km/h)	Total vehicles	% heavy vehicles	Speed (km/h)
No build 2019							
Pacific Highway (to Grafton)	North bound	3821	17%	100	736	63%	100
	South bound	4317	21%	100	647	50%	100
Pacific Highway (Grafton to Tyndale)	North bound	4436	17%	100	854	63%	100
	South bound	4749	21%	100	712	50%	100
Pacific Highway (Tyndale to Maclean)	North bound	4429	17%	80/100	861	61%	80/100
	South bound	4732	21%	80/100	729	50%	80/100
Pacific Highway (North of Maclean)	North bound	4911	17%	100	954	61%	100
	South bound	4041	21%	100	623	50%	100
No build 2029							
Pacific Highway (to Grafton)	North bound	4308	20%	100	908	67%	100
	South bound	4892	24%	100	774	54%	100
Pacific Highway (Grafton to Tyndale)	North bound	4896	20%	100	1032	67%	100
	South bound	5299	24%	100	839	54%	100
Pacific Highway (Tyndale to Maclean)	North bound	4893	20%	80/100	1035	65%	80/100
	South bound	5278	24%	80/100	860	54%	80/100
Pacific Highway (North of Maclean)	North bound	5399	20%	100	1141	65%	100
	South bound	4556	24%	100	742	54%	100

Table 6-6 Build forecast traffic volumes main carriageway Pacific Highway

Road	Direction	Day (7am to 10pm)			Night (10pm to 7am)		
		Total vehicles	% heavy vehicles	Speed (km/h)	Total vehicles	% heavy vehicles	Speed (km/h)
Build 2019							
Pacific Highway S2 (south of Glenugie)	North bound	3535	26%	115	1022	36%	120
	South bound	4208	32%	115	756	64%	120
Pacific Highway (Glenugie to Eight Mile Lane)	North bound	2147	26%	115	620	36%	120
	South bound	2617	32%	115	471	64%	120
Pacific Highway (Eight Mile Lane to Tyndale)	North bound	2175	26%	115	629	36%	120
	South bound	2617	32%	115	471	64%	120
Pacific Highway (existing to Grafton)	North bound	1389	12%	100	401	39%	100
	South bound	1590	7%	100	286	48%	100
Pacific Highway S3 (South of Tyndale)	North bound	2175	26%	115	629	36%	120
	South bound	2617	32%	115	471	64%	120
Pacific Highway (Tyndale to Maclean)	North bound	4429	17%	115	861	61%	120
	South bound	4732	21%	115	729	50%	120
Pacific Highway (Maclean interchange)	North bound	3497	17%	115	680	61%	120
	South bound	3875	21%	115	597	50%	120
Pacific Highway (North of Maclean)	North bound	4911	17%	115	954	61%	120
	South bound	5637	21%	115	869	50%	120
Build 2029							
Pacific Highway S2 (south of Glenugie)	North bound	4103	30%	115	1113	78%	120
	South bound	4759	36%	115	907	68%	120
Pacific Highway (Glenugie to Eight Mile Lane)	North bound	2547	30%	115	690	78%	120
	South bound	3026	36%	115	577	68%	120
Pacific Highway (Eight Mile Lane to Tyndale)	North bound	2580	30%	115	699	78%	120
	South bound	3026	36%	115	577	68%	120
Pacific Highway (existing to Grafton)	North bound	1557	13%	100	422	41%	100
	South bound	1733	8%	100	330	51%	100
Pacific Highway S3 (South of Tyndale)	North bound	2580	30%	115	699	78%	120
	South bound	3026	36%	115	577	68%	120
Pacific Highway (Tyndale to Maclean)	North bound	4893	20%	115	1035	65%	120
	South bound	5278	24%	115	860	54%	120
Pacific Highway (Maclean interchange)	North bound	3913	20%	115	827	65%	120
	South bound	4367	24%	115	712	54%	120
Pacific Highway (North of Maclean)	North bound	5399	20%	115	1141	65%	120
	South bound	6225	24%	115	1015	54%	120

Table 6-7 Forecast traffic on interchanges in the opening year 2019

Road	Direction	Day (7am to 10pm)			Night (10pm to 7am)		
		Total vehicles	% heavy vehicles	Speed (km/h)	Total vehicles	% heavy vehicles	Speed (km/h)
Old Pacific Highway (south facing ramps)	North bound off-ramp	1389	12%	100/80	401	39%	100/80
	South bound on-ramp	1590	7%	100/80	286	48%	100/80
Eight Mile Lane (north facing ramps)	North bound on-ramp	31	46%	80	7	75%	80
	South bound off-ramp	86	46%	80	14	75%	80
Eight Mile Lane (east)	East bound	475	3%	80	89	17%	80
	West bound	440	3%	80	110	29%	80
Eight Mile Lane (west)	East bound	489	3%	80	92	17%	80
	West bound	422	3%	80	106	29%	80
Tyndale (south facing ramps)[1]	North bound off-ramp	78	14%	80	22	40%	80
	South bound on-ramp	85	14%	80	15	40%	80
Tyndale (north facing ramps)	North bound on-ramp	1929	7%	80	557	30%	80
	South bound off-ramp	2011	6%	80	362	21%	80
Maclean (south facing ramps)	North bound off-ramp	874	13%	80	239	52%	80
	South bound on-ramp	776	13%	80	213	52%	80
Maclean (north facing ramps)	North bound on-ramp	1325	13%	80	363	52%	80
	South bound off-ramp	1597	13%	80	438	52%	80
Maclean (interchange link)	East bound	1946	9%	60	433	37%	60
	West bound	2331	9%	60	488	30%	60
Maclean - Cameron Street	East bound	490	14%	60	132	53%	60
	West bound	482	14%	60	130	53%	60
Maclean - Jubilee Street	East bound	243	46%	50	89	75%	50
	West bound	221	46%	50	81	75%	50

Note 1: The ramps have a very low traffic volume and the contribution from the south facing ramps to the total noise level is expected to be negligible and therefore they have not been included in the model.

Table 6-8 Forecast traffic on interchanges in the design year 2029

Road	Direction	Day (7am to 10pm)			Night (10pm to 7am)		
		Total vehicles	% heavy vehicles	Speed (km/h)	Total vehicles	% heavy vehicles	Speed (km/h)
Old Pacific Highway (south facing ramps)	North bound off-ramp	1557	13%	100/80	422	41%	100/80
	South bound on-ramp	1733	8%	100/80	330	51%	100/80
Eight Mile Lane (north facing ramps)	North bound on-ramp	31	46%	80	11	75%	80
	South bound off-ramp	73	46%	80	27	75%	80
Eight Mile Lane (east)	East bound	518	6%	80	87	17%	80
	West bound	484	5%	80	102	38%	80
Eight Mile Lane (west)	East bound	535	6%	80	89	17%	80
	West bound	465	5%	80	98	38%	80
Tyndale (south facing ramps)[1]	North bound off-ramp	79	14%	80	21	40%	80
	South bound on-ramp	84	14%	80	16	40%	80
Tyndale (north facing ramps)	North bound on-ramp	2084	8%	80	565	33%	80
	South bound off-ramp	2129	7%	80	406	25%	80
Maclean (south facing ramps)	North bound off-ramp	921	15%	80	267	56%	80
	South bound on-ramp	821	15%	80	238	56%	80
Maclean (north facing ramps)	North bound on-ramp	1394	15%	80	405	56%	80
	South bound off-ramp	1671	15%	80	485	56%	80
Maclean (interchange link)	East bound	2005	7%	60	524	45%	60
	West bound	2450	9%	60	534	32%	60
Maclean - Cameron Street	East bound	510	16%	60	145	55%	60
	West bound	503	16%	60	143	55%	60
Maclean - Jubilee Street	East bound	266	46%	50	97	75%	50
	West bound	240	46%	50	88	75%	50

Note 1: The ramps have a very low traffic volume and the contribution from the south facing ramps to the total noise level is expected to be negligible and therefore they have not been included in the model.

Model validation

To confirm the noise model is performing within acceptable tolerances, a model of the existing road between Glenugie and Maclean was prepared using traffic volume and 85th percentile speed data from February and March 2012, presented in Chapter 5. The predicted noise levels were then compared to the measured traffic noise levels at six noise monitoring locations.

Table 6-9 compares the noise modelling results of the existing road to the measured traffic noise levels.

Based on the expected accuracy of standard noise modelling procedures, a tolerance of ±2 dB between predicted and measured traffic noise levels is considered generally acceptable for validation purposes. No sections had a variation of more than ±1 dB meaning calibration factors are not required.

Table 6-9 Glenugie to Maclean noise model validation

Location	Daytime $L_{eq,15hr}$ dBA			Night Time $L_{eq,9hr}$ dBA		
	Measured	Predicted	Difference	Measured	Predicted	Difference
842	65.6	66.2	0.6	65	63.8	-1.2
849	65.9	67.8	1.9	64.9	65.2	0.3
S_1	60	60.6	0.6	58.9	58.1	-0.8
892	67.1	68.8	1.7	66.4	66.3	-0.1
1026	61.7	62.4	0.7	59.8	60	0.2
1080[1]	57.6	54.2	-3.4	50.1	51.7	1.6
Median			0.7			-0.1

Note 1: The noise measured at location 1080 was not included in the validation as the noise level was affected by non road traffic noise sources and was not suitable to be included in the validation.

Coordination with adjacent portions

Maclean is an interface area that has been considered for consistency between two portions. This is to ensure that the predicted noise levels were similar.

The designers compared the predicted noise levels at representative receivers at the interface of the portions and the results were within ±1 dB and are considered a good correlation.

6.2.5 Results

Residential receivers

Traffic noise levels for 2019 and 2029 have been predicted at the identified noise sensitive receivers. The results are shown in full in the tables in Appendix D-1 for receivers 0 to 600 metres and receivers between 601 and 900 metres from the project.

Noise contour maps showing a graphical representation of noise levels for each modelled scenario are presented in Appendix E-1.

An assessment of the predictions against the relevant criteria as described in Chapter 4.5 indicated:

- A total of 147 residential receivers were identified as eligible for consideration of further mitigation
- One hundred and seven (107) of the receivers within 600 metres of the project are eligible for consideration of mitigation
- Forty (40) of the receivers within 601 to 900 metres of the project are eligible for consideration at the operational compliance stage

- Seven (7) receivers (IDs 786, 798, 800, 801, 802, 812 and 854) were identified as eligible for consideration of mitigation in the EIS but not the operational noise review. These receivers will be considered at the operational compliance stage.

The predicted night time traffic noise levels exceed the NCG criteria by higher margins than the daytime levels and also exhibit the largest increase when compared to the No build noise levels. Mitigation measures designed to achieve the night time criteria would therefore meet the daytime criteria.

Non-residential receivers

Predicted internal noise levels ($L_{eq,1hr}$ dBA) at the Maclean High School, Pacific Valley Christian School and Lower Clarence Baptist Church are provided in Table 6-10.

Maclean High School does not qualify for additional mitigation because noise levels are predicted to decrease from existing levels and noise levels are below the cumulative limit.

Some of the buildings at Pacific Valley Christian School are not yet constructed so the transmission loss of the building facades is not known. A 20 dBA reduction has been applied based on visual inspection that the school has a closed façade on existing buildings. Noise levels are not predicted to exceed the $L_{eq,1hr}$ 40 dBA internal level assuming a 20 dBA reduction in noise through the closed building facades.

External areas at the school used for passive recreation have not been identified. Noise levels are not predicted to exceed the $L_{eq,15hr}$ 55 dBA noise criteria for passive recreation at most of the school with the exception of areas directly adjacent to building receiver ID C01.

It is predicted noise levels in this area will decrease in the Build scenario due to installation of a quieter road surface and change in road geometry.

The Lower Clarence Baptist Church does not qualify for additional mitigation because noise levels are predicted to decrease from existing levels and noise levels are below the cumulative limit.

Table 6-10 Predicted noise levels at non-residential receivers

Name	Receiver ID	Internal noise level criteria $L_{eq,1hr}$ dBA	Design year predicted external noise level $L_{eq,1hr}$ dBA	Design year predicted internal noise level $L_{eq,1hr}$ dBA	Change in noise level (Build-No build) more than 2 dB	Consider for mitigation?
Maclean High School	M01	40	47	37[1]	No	No
Maclean High School	M02	40	48	38[1]	No	No
Maclean High School	M03	40	47	37[1]	No	No
Maclean High School	M04	40	48	38[1]	No	No
TAFE NSW Maclean	G387	40	48	38[1]	No	No
TAFE NSW Maclean	G388	40	48	38[1]	No	No
Pacific Valley Christian School	C01	40	58	38[2]	No	No
Pacific Valley Christian School	C02	40	55	35[2]	No	No
Pacific Valley Christian School	C03	40	56	36[2]	No	No
Pacific Valley Christian School	C04	40	57	37[2]	No	No
Pacific Valley Christian School	C05	40	54	34[2]	No	No
Pacific Valley Christian School	C06	40	53	33[2]	No	No
Pacific Valley Christian School	C07	40	55	35[2]	No	No
Pacific Valley Christian School	C08	40	55	35[2]	No	No
Pacific Valley Christian School	C09	40	53	33[2]	No	No
Pacific Valley Christian School	C10	40	53	33[2]	No	No
Lower Clarence Baptist Church	1096	40	52	42[1]	No	No

Note 1: Internal noise levels based on the 2029 build scenario with a 10 dB correction for external to internal noise levels.

Note 2: Internal noise levels based on the 2029 build scenario with a 20 dB correction for external to internal noise levels.

6.2.6 Mitigation

The assessment identified 107 receivers between Glenugie and Maclean as eligible for consideration of additional mitigation within 600 metres of the project. Mitigation to reduce noise impacts has been considered in line with the NMG, outlined in Chapter 4.5.3.

The NMG states quieter pavement and noise barriers should be considered where there are four or more closely spaced receivers. A closely spaced receiver is generally defined as when the façades of buildings are up to 20 metres apart and an isolated receiver is when the facades are more than 100 metres apart. Where there are receivers which have facades regularly spaced between 20 and 100 metres, the context of the residential area should be considered to determine if the receivers are considered isolated.

Four groups of four or more receivers eligible for consideration of mitigation spaced between 20 and 100 metres were identified. These were in Tyndale in between the project and the existing highway, at Gulmarrad, at Maclean on the western side of the project and on Jubilee Street, Maclean. In line with the NMG, additional mitigation was investigated for these receivers.

In line with the NMG, the benefit of the mitigation must be evaluated to determine if it is reasonable in context of the broader considerations of the project as described in Chapter 4.5.3.

Quieter pavements

Quieter pavement surfaces were considered for eligible groups of receivers. Between Glenugie and Tyndale, the receivers are not closely spaced and are considered isolated and therefore it was not considered reasonable to use additional quieter pavement surface in this area.

A group of 15 closely space residences was identified north of Clyde Essex Drive, Gulmarrad on the eastern side of the highway.

More than two kilometres of additional SMA pavement surface was identified as an option for additional noise mitigation at this location. The additional SMA pavement reduces noise levels at the nearest receivers and there were 20 receivers which had noise levels reduced to within the criteria who would no longer be eligible for at-property treatment.

The additional extents of the low noise pavement were found to be feasible for implementation. In line with the NMG the measure needs to be considered further to identify if it is reasonable.

The noise reduction provided by the low noise pavement is up to 5 dB compared with concrete pavement. This is considered a substantial reduction, as it represents a noticeable change in noise levels to the affected receivers and many adjacent receivers in the residential development.

The number of receivers that experience reduced noise levels and are no longer eligible for consideration of mitigation is 20. The pavement also provides substantial noise reduction benefits at many other properties in Gulmarrad and those adjacent to the additional SMA pavement. The cost of the additional pavement is greater than individual at-house treatment, however given the noise reduction benefits it is considered reasonable to implement.

Quieter pavement is already included in the design for the receivers located west of the highway in Maclean and receivers at Tyndale. In these areas the flexible pavement has been provided to cater for technical earthworks requirements.

The predicted noise contours with the additional mitigation are shown in Appendix E-1 and predicted noise levels with mitigation in Appendix D-1.

Noise barriers

Noise barriers were considered at three locations, one location at Tyndale and two locations near Maclean, in line with the NMG, to determine if barriers were a reasonable and feasible mitigation measure.

Maximum barrier height – The barrier height where there are no receivers behind the barrier that need at-property noise treatment other than those influenced by barrier end effects or noise from other non-project roads.

Design barrier height – Barrier where two-thirds of receivers (that qualify for consideration of noise mitigation) receive benefit from the noise barrier and no longer need at-property treatments.

Tyndale

A noise barrier was considered as a mitigation option at Tyndale as there were five receivers (Receiver IDs 813, 816, 817, 818 and 819) eligible for consideration of mitigation in a group with a spacing of between 20 and 100 metres apart.

The assessment was based on night time noise levels as they have higher exceedances of the criteria than during the day. The barrier assessment considered two barrier options outlined in Table 6-11 and shown in Figure 6-1.

Table 6-11 Assessed barrier options at Tyndale

Barrier Option	Location	Barrier length (metres)	Initial design height (metres)	Optimal design height (metres)
A	Western side of new road chainage 67,850 to 68,110	260	4.0	4.0
B	Western side of new road chainage 67,850 to 68,175	325	3.5 (Ch. 67.850 to 68110) 3.0 (Ch. 68,110 to 68,175	3.5 (Ch. 67.850 to 68110) 3.0 (Ch. 68,110 to 68,175

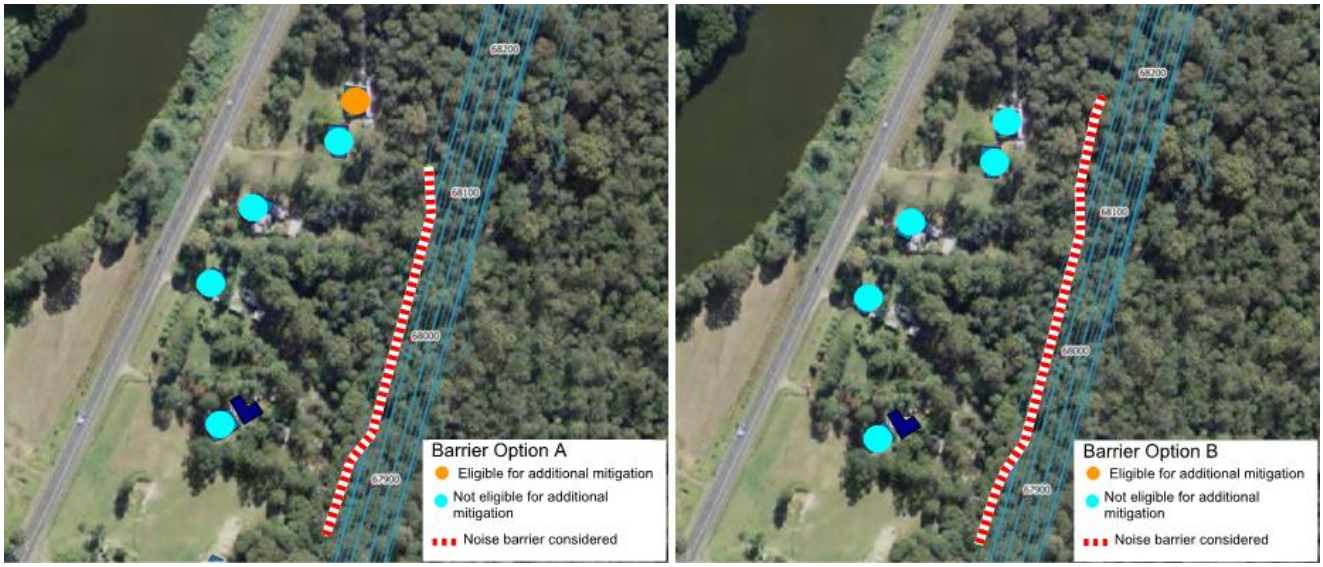


Figure 6-1 Barrier options at Tyndale

Barrier option A would benefit all receivers behind the barrier and no receivers would qualify for consideration of mitigation at the maximum barrier height of 4.5 metres.

Following the barrier analysis, in line with the NMG, the optimum barrier height was 4.0 metres which would result in receivers 813, 816, 817 and 818 no longer qualifying for additional mitigation.

The barrier analysis for option A is shown in Figure 6-2. The maximum reduction in noise level at the barrier height of 4.0 metres was 5 dBA. A noise barrier can be considered as the barrier reduces the number of qualifying receivers by two thirds in the group of receivers that would benefit from the barrier. In this instance four out of five receivers (813, 816, 817 and 818) no longer qualify for consideration for additional mitigation. Receiver 819 would be eligible for consideration for additional mitigation with option A.

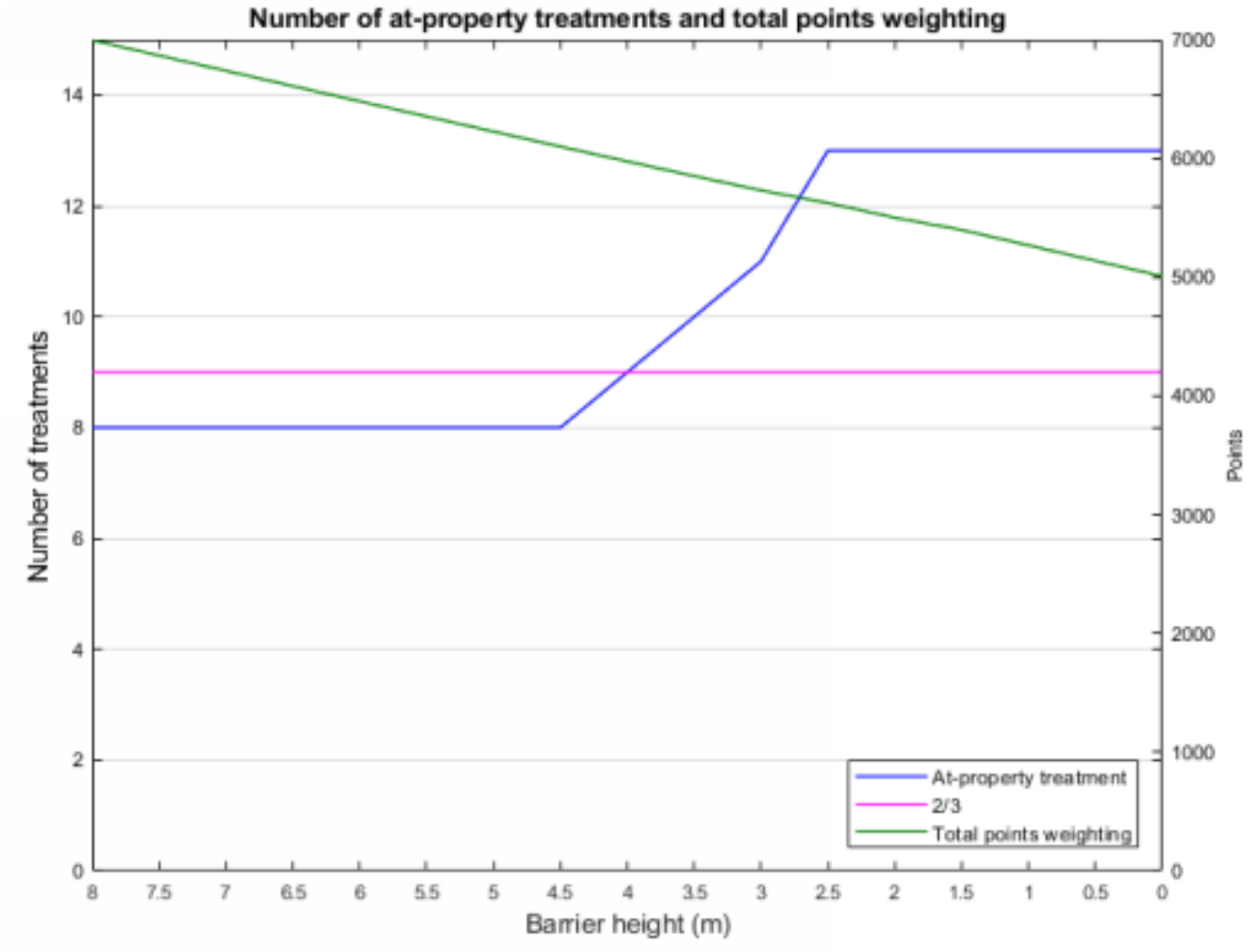


Figure 6-2 Noise barrier analysis Tyndale option A (night time noise levels)

To determine if another barrier configuration would provide better outcomes and the target insertion loss of 5 dBA, barrier option B was investigated.

Barrier option B extended the barrier north of receivers 818 and 819 to consider an extent that would further benefit these receivers. The barrier assessment indicated all receivers located behind option B would have the potential to benefit from the barrier. The maximum barrier height was identified to be 3.5 metres where no receivers would qualify for additional mitigation. At this barrier height, the highest reduction from the barrier was 5 dBA.

The barrier assessment indicated the optimum barrier height would be 3.5 metres which would result in five receivers (IDs 813, 816, 817, 818 and 819) no longer qualifying for additional mitigation. The barrier analysis for option B is shown in Figure 6-3.

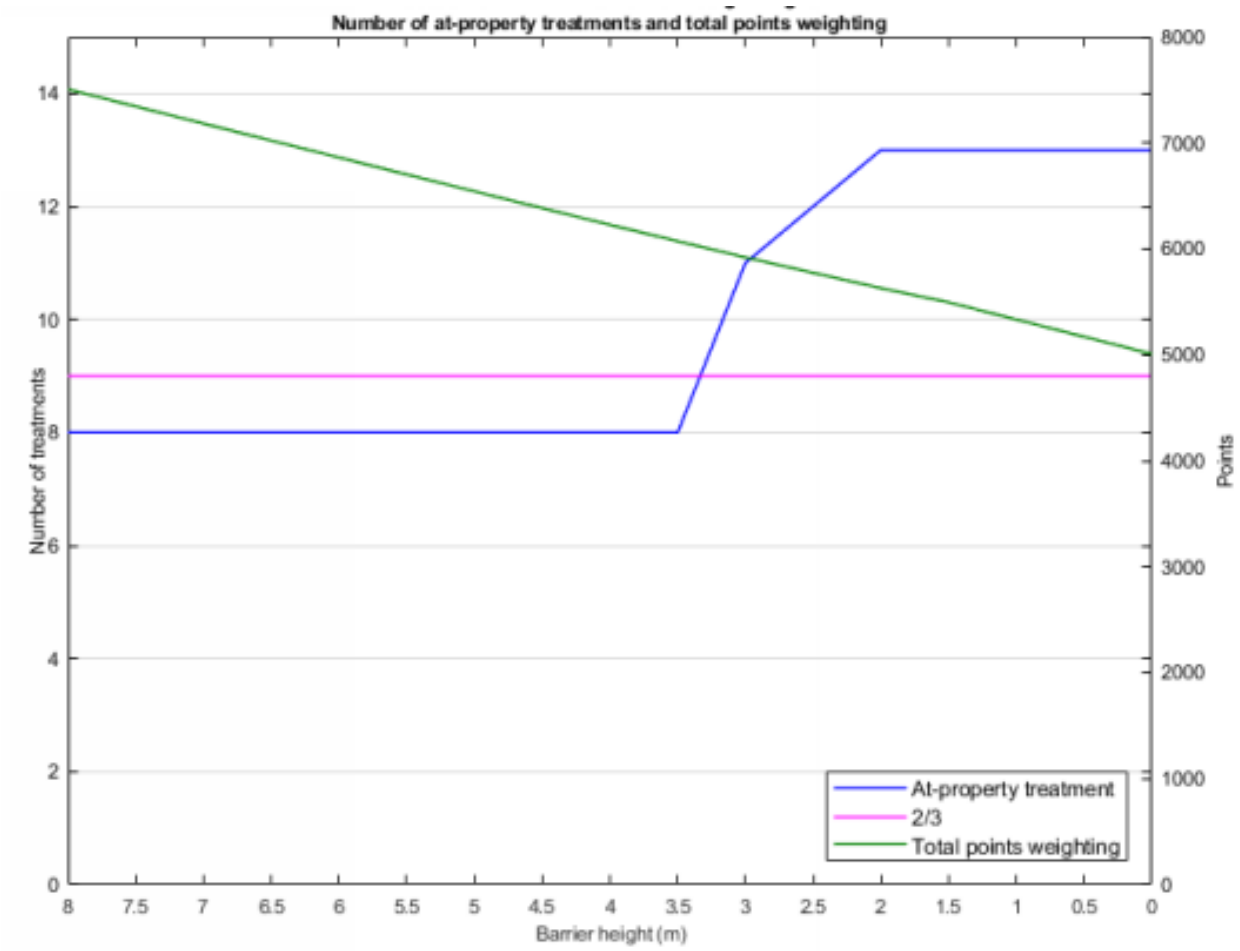


Figure 6-3 Noise barrier analysis Tyndale Option B (night time noise levels)

The design height noise barrier reduced the number of receivers that qualified for consideration of additional mitigation by more than two thirds and provided a reduction of up to 5 dBA.

The investigated noise barriers provide noise control benefits and in line with the NMG are investigated further to determine if they are reasonable and feasible in context of the broader considerations of the project.

The inclusion of a noise barrier in this location is feasible in an engineering sense however, would require significant civil engineering additions including drainage, structural foundations and embankment verge widening.

The predicted noise levels are increasing on the eastern façades of all receivers which is a newly exposed façade due to the new road corridor, however in some cases, they are already above the criteria due to noise from the existing highway. Eastern facing facade noise levels are increasing typically by 7 dB at the affected receivers and by up to 9 dB at the most affected façade. The inclusion of a barrier reduces the noise level increase and four out of five receivers no longer qualify for at-property treatment with option A and no receivers for option B.

The cost of including a noise barrier at this location is greater than the cost of providing at-property treatments, however a barrier cannot be discounted based solely on cost.

The noise barrier would provide up to 5 dB reduction and typically between 3 to 4 dB at the other receivers for external noise levels which is considered a noticeable change. One out of five receivers would still require at property treatment. The no build noise level is above the criteria at some of the receivers due to existing exposure from the existing Pacific Highway and the barrier would not reduce noise levels from this road as it comes from a different direction, however the

total noise levels reduce and would no longer be acute. The caravan park would also benefit from reduced noise levels, however the park itself is not a sensitive receiver for assessment purposes.

Consideration of combinations of quieter pavement surfaces and noise barriers was not required as the location already has a quieter pavement surface included as part of the design.

Barrier option A was selected as preferable to option B as the difference in acoustic performance was not significant for the additional surface area required for option B.

In consideration of the increase in noise due to the project, the predicted noise levels at the receivers and the performance of the noise barrier, a noise barrier at Tyndale is considered reasonable for inclusion in the design. The location of the barrier is shown in Appendix A.

Maclean Interchange

A noise barrier was considered on the western side of the highway near the Maclean interchange between chainage 80,400 and 81,800, which can be identified on the maps in Appendix A. Consideration of a noise barrier was triggered by receivers 953, 959, 965, 972, 982 being eligible for consideration of mitigation and being closely spaced.

The barrier length was determined based on the principles of the NMG where receivers should receive equitable outcomes and therefore incorporated receivers adjacent to these receivers to benefit from the barrier.

The barrier analysis indicated the optimum barrier height would be 6 metres. This height would reduce the number of residences qualifying for additional noise mitigation by three out of 17. The highest reduction in noise level was found to be 4 dBA for the houses that qualify for additional mitigation. In line with the NMG, a noise barrier is not considered to be a reasonable mitigation option as it is greater than 5 metres in height and does not provide at least 10 dBA of noise reduction.

The NMG also states where the location exceeds the noise criteria by less than 5 dBA this can lead to the design of a noise barrier to achieve a reduction in noise levels of less than 5 dBA. Under these circumstances where two-thirds of the residences no longer require at-property treatment, a noise barrier would not be discounted because it did not provide a 5 dBA reduction in noise levels. As the optimal barrier height did not reduce the number of receivers qualifying for mitigation by two-thirds, a noise barrier is not considered reasonable.

Combinations of quieter pavement surfaces and noise barriers were not required as the locations where quieter pavements and noise barriers were applicable already has a quieter pavement surface.

Noise barriers and at-property treatment are not considered a reasonable option as the barrier analysis indicates the noise barrier would not be capable of providing the insertion loss required. As a result, at-property treatment is considered the reasonable mitigation strategy in this area.

Jubilee Street

A noise barrier was considered as a mitigation option on the eastern side of the highway near the Maclean interchange and Jubilee Street between chainage 80,950 and 81,600.

Investigation of a barrier was triggered by nine receivers (IDs 977, 979, 980, 981, 999, 1002, 1026, 1051 and 1065) spaced between 20 and 100 metres which are identified as eligible for consideration of mitigation.

The barrier analysis indicated the optimum barrier height would be 1.5 metres. This barrier height would reduce the number of residences qualifying for additional noise mitigation by six, which represents two thirds of the number of eligible receivers. The maximum reduction in noise level was found to be 2 dBA for residences qualifying for consideration of additional mitigation.

The NMG states noise barriers should provide at least 5 dB reduction for up to 5 metres in height. However, a barrier may be considered further where there is a reduction of two thirds in the number of receivers that qualify for additional mitigation.

A barrier may be considered further in this location as seven out of nine residences no longer qualify for additional mitigation. Increasing this barrier height to two metres would result in all nine receivers no longer qualifying for additional mitigation from the new road. Figure 6-4 presents the noise barrier analysis and Table 6-5 shows the location of the barrier.

The inclusion of a barrier would reduce the project road contribution to the total noise level, however four receivers (IDs 977, 979, 980 and 981) would still be expected to experience noise levels significantly above the noise criteria as Jubilee Street is the dominant noise source at these receivers.

The four receivers (IDs 977, 979, 980 and 981) would still have high noise levels even with the barrier in place. The remaining receivers are in one group of three receivers spaced about 45 metres apart and 115 metres away is a group of two receivers spaced about 48 metres apart. At the design barrier height, the highest reduction is 3 dB at the most affected receiver and other adjacent receivers have less than a 2 dB benefit.

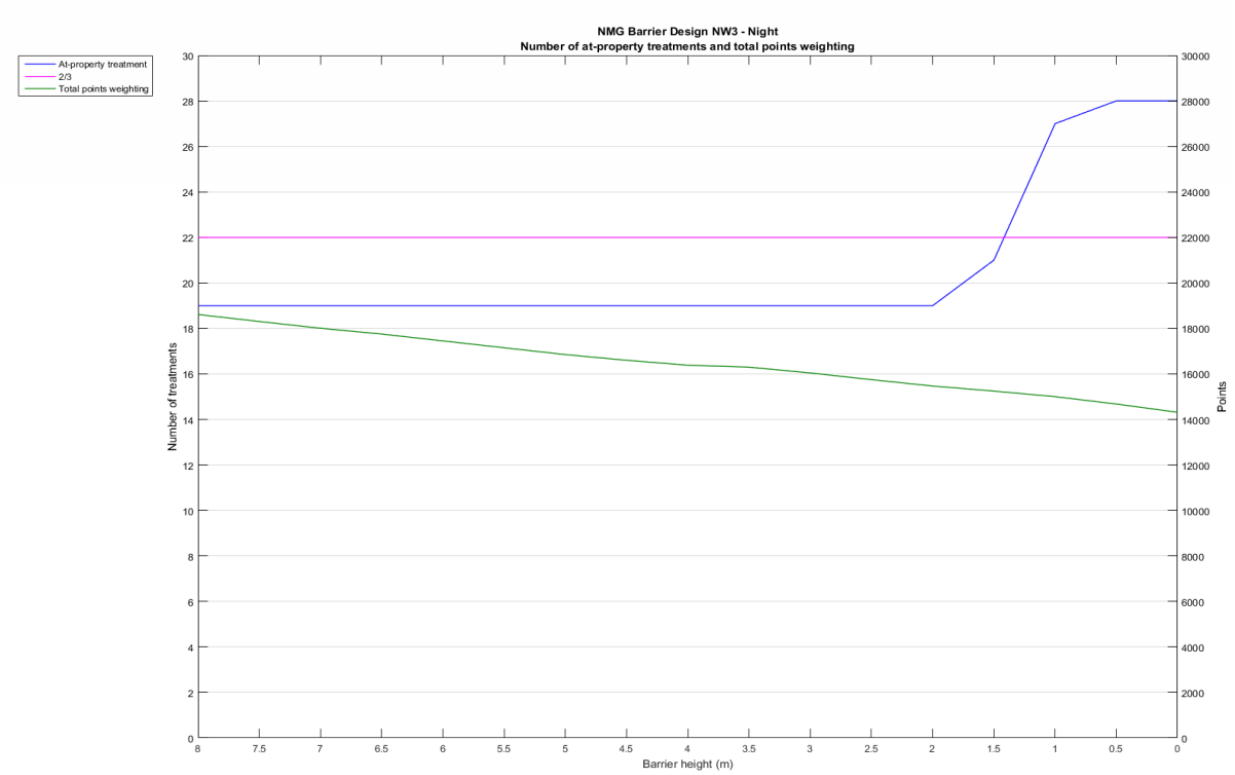


Figure 6-4 Noise barrier analysis Jubilee Street

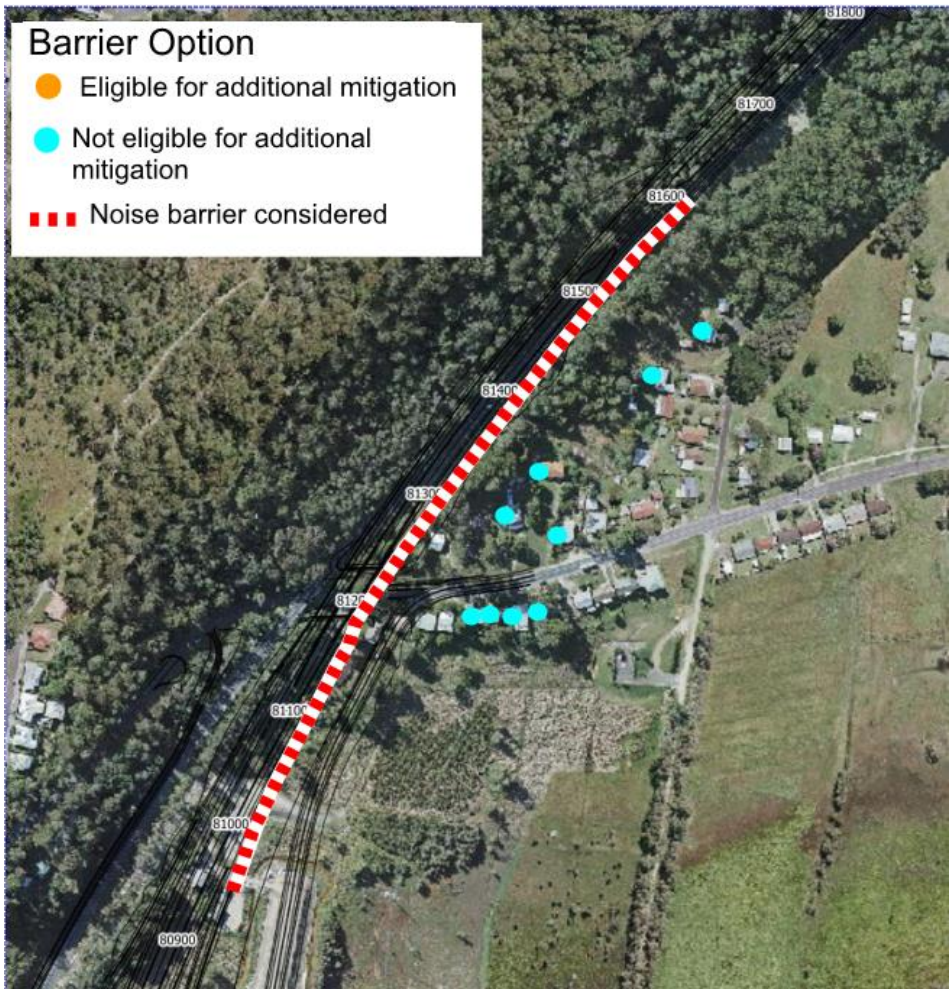


Figure 6-5 Barrier option at Jubilee Street, Maclean

While analysis indicates barriers provides a noise control benefit, it is recognised this benefit must be evaluated in context with the broader considerations of the project as defined above.

Further reasonable and feasible consideration of the noise barrier at Jubilee Street, Maclean was carried out. The cost of including the 650 metre noise barrier at Maclean was more than the costs of providing at house treatment for the affected properties. The noise reduction benefit of the proposed noise barrier is not substantial and does not provide the target insertion loss at the design height at the receivers. Noise levels as a result of the project are reducing without the barrier and the addition of the barrier would not provide significant additional protection of internal or external spaces at receivers exposed to existing traffic noise.

The adjacent receivers also do not receive a substantial benefit (average 1 dB reduction) from the design barrier as other existing roads in the area also contribute to the total noise level. This means there would not be a significant benefit to external noise levels or internal noise levels. Given the extents of the barrier required and the marginal noise level reduction, the barrier does not represent an efficient noise reduction measure and is not considered reasonable for inclusion in the design. At-property treatments would be selected for the eligible receivers instead.

At-property treatment

At-property treatment would only be considered for residences where other noise mitigation measures are either exhausted or are not feasible or reasonable. At-property treatment is the most appropriate mitigation measure for consideration for receivers still eligible for consideration of mitigation after the assessment the implementation of reasonable feasible quieter pavement and noise barriers.

There are 92 residential receivers within 600 metres identified as eligible for consideration of at-property mitigation. There are 31 residential receivers between 601 and 900 metres from the project that will be considered at the operational compliance stage.

After the implementation of additional mitigation, there were 11 receivers (IDs 786, 798, 800, 801, 802, 812, 813, 816, 817, 818 and 854) that were identified as eligible for consideration of additional mitigation in the EIS that no longer require mitigation.

Appendix D-1 and E-1 present the predicted noise levels and noise contour maps with the adopted mitigation.

Non-residential receivers

There were no non-residential receivers identified for consideration of additional mitigation.

6.2.7 Maximum noise level assessment

The cause of most maximum noise emissions between Glenugie and Maclean would be from heavy vehicles during engine compression braking, gear changes and pass-by events travelling along the highway during the night.

The highest maximum noise levels would typically be during compression braking events where heavy vehicles would reduce speeds to negotiate bends in the road, intersections, descending down road gradients or for changes in posted speed limits.

The existing Pacific Highway consists of numerous tight bends in the road through Ulmarra and Tyndale. In addition, other vehicles turning off or on to the highway may trigger trucks to slow down.

The existing Pacific Highway has a posted speed limit of 100 km/h which reduces to 80 km/h when approaching towns. With the reduction in the posted speed limit, heavy vehicles may use compression braking to reduce their speeds.

The posted speed limit has been increased from 80 km/h and is constant on the majority of the alignment. Therefore, heavy vehicles would not be required to change speed due to the change in speed limit and a reason to use compression braking is removed.

At Maclean interchange the off ramps are closer to receivers than the existing highway and there are locations with gradient of five percent or greater. Slowing down to access the ramps or to compensate for the gradient may trigger the use of compressions brakes for trucks.

At the Tyndale interchanges, the introduction of new on and off ramps in the north and south may trigger trucks to use their compression braking in order to access the ramps.

The assessment indicated the predicted L_{max} noise levels would be above the maximum noise level event screening criteria at three receivers in Maclean. Maximum noise levels events are not a trigger for providing mitigation. However, these receivers are already identified for at-property treatment to control noise from operational traffic noise.

In the south of the project, where the road goes through a new corridor, there was no previous exposure to significant road traffic noise. In this location there was no previous significant exposure to maximum noise levels from road traffic on an arterial road. Receivers are likely to experience:

- An increase in maximum noise levels
- Increased frequency of maximum noise levels.

The majority of the residential receivers within 600 metres of the new alignment south of Tyndale have been identified as eligible for consideration for at-house mitigation as part of the operational noise review. As such, the maximum noise level impacts from the project would be addressed by at-property treatment.

Receivers in Tyndale may experience similar or reduced maximum noise levels as the speed limit is constant on the new road and is much straighter than the existing highway, reducing the potential for compression breaking. However, the southern Tyndale interchange ramps may induce trucks to use their compression brakes. The nearest receivers to the Tyndale southern interchange ramps have been identified for at-property treatment as part of the operational noise review.

Between Tyndale and Maclean, the new road is straighter and has a constant speed which removes triggers for compression breaking. The alignment is also moving away from receivers and therefore a reduction in maximum noise levels could be expected.

For receivers in Maclean, the road is in an existing corridor and the magnitude and frequency of maximum noise levels would likely be similar to those currently experienced. The Maclean interchange may trigger trucks to use their compressions brakes which may affect receivers previously not affected by trucks using their compression brakes on the existing interchange. Maximum noise levels potentially impact receivers nearest the Maclean interchange have been identified for at-property treatment as part of the operational noise review.

6.2.8 Rest area

A rest area will be located between Bostock Road and Somervale Road. There is a northbound and southbound rest area with provision for light vehicles and up to 20 heavy vehicle parking spaces in each rest area.

The closest receiver (G233) located to the rest area is about 580 metres from the northbound and about 780 metres from the southbound area.

As described in Chapter 4.7, the noise emission criteria for the rest area has been derived from the Industrial Noise Policy. The closest representative monitoring location is at receiver 748. Noise levels were measured as part of the EIS and are considered representative of the potentially affected receiver. A summary of the measured ambient and background noise levels is presented in Table 6-12.

Table 6-12 Representative background noise levels at nearest receiver to rest area

Location	Ambient noise level $L_{eq,15min}$ dBA			Rating background level dBA		
	Day	Evening	Night	Day	Evening	Night
Receiver 748	54	52	48	34	39	42

Analysis of data indicates increased night time noise levels, measured during the monitoring period, were due to the activity of wildlife in the area. As such, a daytime RBL of 34 dBA has been adopted for assessment purposes. The day time background level of 34 dBA means:

- The $L_{eq,15min}$ criteria is 39 dBA
- The L_{max} screening criteria (for the assessment for rest stop activities) was based on the INP screening criteria of 15 dB above the background noise level.

Based on the measured noise level, the adopted screening criterion was L_{max} 49 dBA.

Heavy vehicles using the rest area are likely to be the most dominant noise source. The assessment has conservatively assumed there would be up to 10 heavy vehicles stopped at the rest area and 10 heavy vehicles moving in and out of the rest area in a 15 minute period. Trucks were assumed to move at 20 km/h.

The noise source levels used for the truck sources were consistent with the Sapphire to Woolgoolga upgrade assessment. The sound pressure levels in dBA at seven metres were:

- Truck idle 66
- Tuck door slam L_{max} 75
- Truck refrigeration unit 73
- Truck moving at 20 km/h 80
- Truck start 85
- Bleed air brake L_{max} 88

The predicted noise level from the use of both rest areas at receiver G233 is $L_{eq,15min}$ 40 dBA. This is 1 dBA above the criteria and represents a minor exceedance.

The predicted $L_{eq,9hr}$ traffic noise level at G233 is 49 to 51 dBA in the opening year 2019. This means the ambient noise level would be dominated by the traffic on the new Pacific Highway and not by noise from the rest area.

The predicted maximum noise level, caused by heavy vehicle bleed air brakes being used at the rest area, is L_{max} 45 dBA at receiver G233. This level is below the sleep disturbance screening criteria.

The operational noise review identified receiver G233 as eligible for consideration of at-property mitigation. The mitigation assigned for the operational traffic noise level will be sufficient to address a 1 dBA exceedance. In consideration of this, no further mitigation measures are required for the rest area.

The rest area may induce heavy vehicles to use their engine brakes. Maximum noise levels of up to L_{max} 59 dBA are predicted at G233 from trucks compression braking to access the rest area.

The rest area may introduce a trigger for truck compression braking to occur. At-property mitigation identified for the potentially impacted receivers as part of the operational noise review would be sufficient to control the potential noise impact from engine braking near the rest area.

6.2.9 Comparison of outcomes with EIS

The operational noise review assessed a total of 520 receivers between Glenugie to Maclean located up to 900 metres from the project. Of these receivers, 407 were located within 600 metres of the project and a further 113 were located between 601 and 900 metres. The EIS assessed 302 receivers in the area up to 600 metres from the project.

The operational noise review also included assessment of Townsend, which the EIS considered under a different assessment area.

The EIS identified 62 receivers as eligible for consideration of mitigation. The operational noise review identified 85 more residential receivers for consideration of mitigation before the implementation of additional mitigation. There were 45 more receivers within 600 metres of the project with an additional 40 receivers between 601 and 900 metres from the project identified as eligible for consideration of mitigation.

The mitigation considered reasonable and feasible for these additional receivers is an additional length of low noise pavement near Gulmarrad, a noise barrier at Tyndale and at-property treatments for all other eligible receivers. Noise barriers for other locations were not considered reasonable or feasible for implementation.

With the additional mitigation identified in the operational noise review, there were 61 more residential receivers identified for consideration of mitigation in the operational noise review than in the EIS. There were 30 more receivers within 600 metres of the project with an additional 31 receivers between 601 and 900 metres from the road identified as eligible for consideration of mitigation.

The key reasons for the increase in the number of properties eligible for consideration of mitigation are:

- Differences in traffic volumes and vehicle mix
- Increase in modelled design speed
- Changes in the road design
- Inclusion of a safety factor
- Change in the assessment criteria to use the most up to date approach. The assessment criteria used are more onerous in some cases compared with the EIS approach
- Assessment of the total noise level at receivers. The EIS only considered the noise level from the project alone
- More detailed assessment of receivers which included assessment at each façade and storey
- Increased number of receivers identified through ground surveys and investigation

- Change in the category of some of the receivers assessed, such as those previously identified non-residential buildings
- Inclusion of receivers outside of the 600 metres area assessed in the EIS.

6.2.10 Summary of key findings

Additional noise sensitive receivers were identified and assessed due to:

- Increasing the assessment area to 900 metres
- Changes in receiver identification through on site observations and property searches.

The operational noise review found additional quieter pavement was reasonable for implementation at Gulmarrad. Barriers were investigated at three locations and a barrier at Tyndale was found to be reasonable for implementation. Barriers at other locations were not found to be reasonable and feasible mitigation measures. As a result, at-property treatment was determined to be the reasonable measure to be considered at the remaining eligible receivers.

Ninety two (92) residential receivers within 600 metres of the project were identified as eligible for consideration of at-property mitigation.

Thirty one (31) residential receivers between 601 and 900 metres will be considered at the operational compliance stage.

After the implementation of additional mitigation, there were 11 receivers (IDs 786, 798, 800, 801, 802, 812, 813, 816, 817, 818 and 854) that were identified as eligible for consideration of additional mitigation in the EIS that no longer require mitigation. These receivers will be considered at the operational compliance stage.

The maximum noise level assessment indicates impacts would likely increase in the new road corridors of the portion. In existing corridors, maximum noise level impacts are expected to be similar to current conditions. The proposed at-property mitigation was found to be sufficient to control maximum noise level impacts.

The assessment of the rest area did not identify the requirement for any additional mitigation measures.

6.3 Maclean to Devils Pulpit

The detailed design and noise assessment for the portion was carried out by Arcadis Beca Joint Venture and Wilkinson Murray Pty Ltd. This section summaries the noise assessment carried out between Maclean to Devils Pulpit.

6.3.1 Site description

Table 6-13 summarises the Maclean to Devils Pulpit Portion B sections.

Table 6-13 Maclean to Devils Pulpit site description

EIS Section number	Section name	Length (km)	Chainage	Description
5	Maclean to Iluka Road (including new bridge over the Clarence River)	14.5	81,983 to 96,400	Follows the existing Pacific Highway, crossing the Clarence River to the south and north of Chatsworth Island. There are existing northbound and southbound on and off ramps on the southern side of the existing bridge at Harwood and two interchanges located at Harwood and Iluka Road, Mororo. A further high level bridge crossing would be constructed to the east of the existing bridge crossing of the Clarence River at Harwood. The existing bridge at Harwood would remain in its current location, continuing to open and close for water traffic, as necessary. The project deviates substantially from the existing corridor to the north of the Clarence River.
6	Iluka Road to Devils Pulpit Upgrade	9	96,400 to 105,400	Follows the existing Pacific Highway, passing through the community of Mororo, as well as the Mororo State Forest and the Devils Pulpit State Forest. Noise-sensitive receivers are very sparsely distributed through this section.

6.3.2 Existing environment

Sensitive receivers

The number of receivers included within the noise model are summarised in Table 6-14, categorised by distance from the road.

The assessment areas of the Glenugie to Maclean and Maclean to Devils Pulpit overlapped north of Maclean interchange. As the majority of the receivers in Maclean and Townsend were located in the Glenugie to Maclean section they have been addressed in the Glenugie to Maclean assessment.

Table 6-14 Number of assessed receivers in the Maclean to Devils Pulpit portion

Description	Distance from road (metres)	Number of receivers (EIS)[1]	Number of receivers (ONR)	Notes
Residential receivers	0-600	222	176	Operational noise review of Maclean and Townsend was assessed in the Glenugie to Maclean portion in Chapter 6.2.
	601-900	N/A[1]	70	Receivers generally sparsely populated
Non-residential receivers	0-600	1 (Harwood Island Public School)	2	Harwood Island Public School at 11 Morpeth Street, Harwood Riverview Funerals at 441 Chatsworth Road, Chatsworth. Pacific Valley Christian School was assessed in the Glenugie to Maclean portion in Chapter 6.2
	601-900	N/A[1]	0	-

Note 1: Receivers were only assessed up to 600 metres from the project in the EIS.

Existing noise environment

Noise monitoring as described in Chapter 5 was carried out in this section for the EIS at six locations used for the validation of the noise model. A summary of the noise monitoring is provided in Table 6-15.

Table 6-15 Results from the EIS traffic noise survey at receivers between Maclean and Devils Pulpit

Receiver ID	Address	Distance to Existing Highway (metres)	Measured traffic noise level	
			$L_{eq,15hr}$ Day	$L_{eq,9hr}$ Night
1026	Jubilee Street, Townsend	51	62	60
1331	Petticoat Lane, Harwood	69	59	59
1396	Morpeth Street, Harwood	141	57	55
1438	Pacific Highway, Chatsworth	16	72	71
1471	Old Pacific Highway, Woombah	109	58	58
1542	Pacific Highway Jackybulbin	75	63	61

6.3.3 Specific criteria – transition zones

The portion consists of predominately Redeveloped roads with one area of New road at Harwood Bridge. Where the two road types meet, transition zone criteria are applicable.

A transition zone was identified at Harwood including the new bridge over the Clarence River at Harwood. The project is substantially realigned north of the new bridge over the Clarence River. In addition the new bridge is considered substantially vertically realigned compared with the existing bridge with heights between 15 to 20 metres above the existing bridge height including a new viaduct north of the Clarence River. As a result, the bridge was considered a New road where the bridge is in viaduct.

The transition zones between Maclean and Devils Pulpit are shown in Appendix C.

6.3.4 Technical parameters for noise modelling

The noise modelling between Maclean and Devils Pulpit was carried out based on the technical parameters listed in the following sections.

Pavement type

The adopted pavement for the assessment, incorporate the extents of low noise pavement as set out in the EIS and other design pavements as follows:

- Concrete pavements
- SMA pavements (Flexible and EIS specified)
- Chip Seal pavement
- DGA pavement

The pavement types are shown on the figures in Appendix E-2.

Forecast traffic volumes

Traffic volumes for the various road sections and time of day are shown in Table 6-16 and Table 6 17 for the existing and upgraded Pacific Highway and Table 6 18 and Table 6 19 for the surrounding road network for the Build and No build scenarios in the year of opening (2019) and the design year (2029).

Table 6-16 No build forecast traffic volumes for the Pacific Highway

Road	Direction	Day 7am to 10pm			Night 10pm to 7am		
		Total vehicles	% heavy vehicles	Speed (km/h)	Total vehicles	% heavy vehicles	Speed (km/h)
No build 2019							
South point of model to Yamba	North bound	4984	17%	100	880	61%	100
	South bound	4046	26%	100	618	57%	100
Existing Clarence River Bridge	North bound	5530	17%	80	953	60%	80
	South bound	5875	20%	80	817	50%	80
Watts Lane to Iluka Road	North bound	4058	20%	80/100	769	65%	80/100
	South bound	4332	24%	80/100	643	55%	80/100
Iluka Road to north point of model	North bound	3356	23%	100	695	69%	100
	South bound	3633	28%	100	572	60%	100

Road	Direction	Day 7am to 10pm			Night 10pm to 7am		
		Total vehicles	% heavy vehicles	Speed (km/h)	Total vehicles	% heavy vehicles	Speed (km/h)
No build 2029							
South point of model to Yamba	North bound	5498	20%	100	1042	65%	100
	South bound	4561	30%	100	739	62%	100
Existing Clarence River Bridge	North bound	6064	20%	80	1149	65%	80
	South bound	6510	24%	80	965	55%	80
Watts Lane to Iluka Road	North bound	4511	22%	80/100	915	68%	80/100
	South bound	4859	28%	80/100	764	60%	80/100
Iluka Road to north point of model	North bound	3776	26%	100	833	72%	100
	South bound	4119	31%	100	687	64%	100

Table 6-17 Build forecast traffic volumes for the Pacific Highway

Road	Direction	Day 7am to 10pm			Night 10pm to 7am		
		Total vehicles	% heavy vehicles	Speed (km/h)	Total vehicles	% heavy vehicles	Speed (km/h)
Build 2019							
South point of model to Yamba	North bound	5057	14%	115	808	56%	120
	South bound	5788	18%	115	769	45%	120
New Clarence River Bridge to Watts Lane	North bound	3042	23%	115	630	69%	120
	South bound	3941	25%	115	593	56%	120
Watts Lane to Iluka Road Interchange	North bound	4059	20%	115	768	65%	120
	South bound	4332	24%	115	643	55%	120
Iluka	North bound	3107	20%	115	588	65%	120
	South bound	3452	28%	115	544	60%	120
Iluka Interchange to north point of model	North bound	3356	23%	115	695	69%	120
	South bound	3632	28%	115	573	60%	120
Build 2029							
South point of model to Yamba	North bound	5498	20%	115	1042	65%	120
	South bound	6330	22%	115	910	52%	120
New Clarence River Bridge to Watts Lane	North bound	3424	26%	115	755	72%	120
	South bound	4440	28%	115	699	60%	120
Watts Lane to Iluka Road Interchange	North bound	4511	22%	115	914	68%	120
	South bound	4858	28%	115	765	59%	120
Iluka	North bound	3502	22%	115	710	68%	120
	South bound	3922	31%	115	654	64%	120
Iluka Interchange to north point of model	North bound	3776	26%	115	833	72%	120
	South bound	4119	31%	115	687	64%	120

Table 6-18 No build forecast traffic volumes for the surrounding road network

Road	Direction	Day 7am to 10pm			Speed (km/h)		
		Total vehicles	% heavy vehicles	Speed (km/h)	Total vehicles	% heavy vehicles	Speed (km/h)
No build 2019							
Yamba SB On Ramp	South bound	668	3%	80	73	19%	80
Yamba SB Off Ramp	North bound	2505	7%	80	265	24%	80
Yamba NB On Ramp	South bound	1210	8%	80	160	36%	80
Yamba NB Off Ramp	North bound	684	5%	80	68	16%	80
Yamba Road (East)	East bound	3080	5%	80	362	26%	80
	West bound	3144	5%	80	313	17%	80
Yamba Road (Mid)	East bound	1832	3%	80	194	16%	80
	West bound	3693	6%	80	374	19%	80
Yamba Road (West)	East bound	1156	2%	80	119	13%	80
	West bound	2459	4%	80	240	14%	80
Watts Lane	East bound	2371	11%	80	361	47%	80
	West bound	2491	13%	80	300	37%	80
Iluka Road	East bound	1182	8%	80	161	39%	80
	West bound	1200	11%	80	137	32%	80
No build 2029							
Yamba SB On Ramp	South bound	705	5%	80	83	25%	80
Yamba SB Off Ramp	North bound	2670	9%	80	293	28%	80
Yamba NB On Ramp	South bound	1291	9%	80	182	41%	80
Yamba NB Off Ramp	North bound	726	6%	80	74	19%	80
Yamba Road (East)	East bound	3267	6%	80	396	29%	80
	West bound	3330	7%	80	345	21%	80
Yamba Road (Mid)	East bound	1927	3%	80	212	19%	80
	West bound	3921	7%	80	406	21%	80
Yamba Road (West)	East bound	1215	2%	80	124	12%	80
	West bound	2597	5%	80	258	17%	80
Watts Lane	East bound	2544	14%	80	418	52%	80
	West bound	2686	16%	80	341	42%	80
Iluka Road	East bound	1257	11%	80	186	45%	80
	West bound	1291	13%	80	152	36%	80

Table 6-19 Build forecast traffic volumes for the surrounding road network

Road	Direction	Day 7am to 10pm			Night 10pm to 7am		
		Total vehicles	% heavy vehicles	Speed (km/h)	Total vehicles	% heavy vehicles	Speed (km/h)
Build 2019							
Existing Clarence River Bridge	North bound	2485	9%	80	326	43%	80
	South bound	1927	13%	80	231	35%	80
Yamba SB On Ramp	South bound	2337	7%	80	242	21%	80
Yamba SB Off Ramp	South bound	508	5%	80	50	16%	80
Yamba NB On Ramp	North bound	582	8%	80	77	36%	80
Yamba NB Off Ramp	North bound	1903	9%	80	290	40%	80
Yamba Road (East)	East bound	2898	5%	80	544	18%	80
	West bound	2919	4%	80	538	15%	80
Yamba Road (Mid)	East bound	1222	5%	80	230	18%	80
	West bound	569	8%	80	115	26%	80
Yamba Road (West)	East bound	1086	2%	80	188	8%	80
	West bound	669	6%	80	131	22%	80
Mill Road	East bound	2281	11%	80	450	39%	80
	West bound	2331	11%	80	460	39%	80
Watts Lane NB On Ramp	North bound	1036	11%	80	119	32%	80
Watts Lane SB Off Ramp	South bound	391	18%	80	51	45%	80
Iluka Road	East bound	1182	8%	80	161	39%	80
	West bound	1200	11%	80	137	32%	80
Iluka Road Overbridge	East bound	301	18%	80	57	60%	80
	West bound	1020	9%	80	113	27%	80
Iluka Road NB Off Ramp	North bound	1000	8%	80	133	36%	80
Iluka Road NB On Ramp	North bound	301	18%	80	57	60%	80
Iluka Road SB Off Ramp	South bound	186	16%	80	24	42%	80
Iluka Road SB On Ramp	South bound	889	7%	80	92	22%	80
Build 2029							
Existing Clarence River Bridge	North bound	2653	11%	80	380	49%	80
	South bound	2074	15%	80	262	41%	80
Yamba SB On Ramp	South bound	2433	7%	80	257	24%	80
Yamba SB Off Ramp	South bound	534	7%	80	55	22%	80
Yamba NB On Ramp	North bound	645	9%	80	91	41%	80

Road	Direction	Day 7am to 10pm			Night 10pm to 7am		
		Total vehicles	% heavy vehicles	Speed (km/h)	Total vehicles	% heavy vehicles	Speed (km/h)
Yamba NB Off Ramp	North bound	1990	10%	80	371	43%	80
Yamba Road (East)	East bound	3074	6%	80	589	20%	80
	West bound	3084	6%	80	591	20%	80
Yamba Road (Mid)	East bound	1307	6%	80	251	20%	80
	West bound	608	9%	80	128	30%	80
Yamba Road (West)	East bound	1120	6%	80	219	22%	80
	West bound	758	9%	80	157	28%	80
Mill Road	East bound	2449	14%	80	513	44%	80
	West bound	2502	14%	80	524	44%	80
Watts Lane NB On Ramp	North bound	1114	13%	80	132	36%	80
Watts Lane SB Off Ramp	South bound	425	21%	80	59	51%	80
Iluka Road	East bound	1257	11%	80	186	45%	80
	West bound	1290	13%	80	153	35%	80
Iluka Road Overbridge	East bound	1063	9%	80	150	41%	80
	West bound	346	25%	80	52	56%	80
Iluka Road NB Off Ramp	North bound	1063	9%	80	150	41%	80
Iluka Road NB On Ramp	North bound	330	22%	80	68	65%	80
Iluka Road SB Off Ramp	South bound	203	20%	80	27	48%	80
Iluka Road SB On Ramp	South bound	944	8%	80	102	25%	80

Model validation

To check that the noise model is performing within acceptable tolerances, a model of the existing road between Maclean and Devils Pulpit was prepared using traffic volume and speed data from the EIS, presented in Chapter 5. The predicted noise levels were then compared to the measured traffic noise levels at six noise monitoring locations.

Based on the expected accuracy of standard noise modelling procedures, a tolerance of ±2 dB between predicted and measured traffic noise levels is considered generally acceptable for validation purposes.

Table 6-20 compares the noise modelling results of the existing road to the measured traffic noise levels.

Table 6-20 Maclean to Devils Pulpit noise model validation, dBA

Location	Daytime $L_{eq,15hr}$			Night Time $L_{eq,9hr}$		
1026	61.7	61.6	-0.1	59.8	59.7	-0.1

Location	Daytime $L_{eq,15hr}$			Night Time $L_{eq,9hr}$		
1331	59.3	61.9	2.6	58.6	60.1	1.5
1396	57.4	59.4	2.0	55.1	57.7	2.6
1438	72.3	70.6	-1.7	71.4	69.7	-1.7
1471	57.7	60.9	3.2	58.1	59.0	0.9
1542	62.5	62.0	-0.5	61.3	61.0	-0.3
Median			-0.1			0.4

The difference in measured and predicted noise levels in Table 6-20 generally fall within the acceptable tolerance. The greatest deviation is seen in the results for Receiver 1471, where the predicted daytime traffic noise level is more than 3 dB higher than the measured noise level.

The consultant's assessment of the reason for this significant deviation is that an intervening stand of trees in the line of sight between receiver 1471 and the road has created uncertainty in the output, meaning this is not a suitable location for model validation purposes. The results from this site have not been included for this reason.

There are two other outliers in the results, being a daytime result at Receiver 1331 and a night time result at Receiver 1396. The EIS identified that marginal over-predictions may occur because of restricted traffic flows during the monitoring, which could cause variations in traffic speeds. The remaining nine predictions for the other locations and time periods are within a tolerance of ±2 dB.

The median difference between the measured and modelled noise levels being within ±1 dB and in consideration of the above the designer considered the model valid and calibration adjustments were not applied for any sections.

Coordination with adjacent portions

The Maclean to Devils Pulpit portion meets the Glenugie to Maclean portion at Maclean. The predictions at the interface were compared for consistency to ensure that the predicted noise levels were similar.

The predicted noise levels from the two noise assessments at representative receivers at the interface of the Portions were within ±1 dB and were considered a good correlation.

6.3.5 Results

Residential receivers

Traffic noise levels for 2019 and 2029 have been predicted at the identified residential receivers. The results are shown in full in the tables Appendix D-2 for receivers 0 to 600 metres and receivers between 601 and 900 metres from the project.

Noise contour maps showing a graphical representation of noise levels for each modelled scenario are presented in Appendix E-2.

An assessment of the predictions against the relevant criteria as described in Chapter 4.5 indicated the following:

- A total of 97 residential receivers were identified as eligible for consideration of mitigation within 600 metres of the project are eligible for consideration of mitigation.
- There were no receivers between 601 and 900 metres of the project identified as eligible for consideration at the operational compliance stage.
- Two (2) receivers (IDs 1246 and 1475) were identified as eligible for consideration of mitigation in the EIS but not the operational noise review. These receivers will be considered at the operational compliance stage.

The predicted night time traffic noise levels exceed the NCG criteria by higher margins than the daytime levels and also exhibit the largest increase when compared to the No build noise levels. Mitigation measures that have been designed to achieve the night time criteria would therefore also meet the daytime criteria.

Non-residential receivers

At the two non-residential receivers, the project is predicted to exceed the internal noise criteria and cumulative limit at the majority of the non-residential receiver buildings. Table 6-21 presents a summary of the predicted noise levels for the non-residential receivers.

The results show that Harwood Island Public School and Riverview Funerals should be considered for additional mitigation.

Table 6-21 Predicted noise levels at non-residential receivers Maclean to Devils Pulpit

Name	Receiver ID	Internal noise level criteria $L_{eq,1hr}$ dBA	Design year predicted external noise level $L_{eq,1hr}$ dBA	Design year predicted internal noise level $L_{eq,1hr}$ dBA	Change in noise level (Build-No build) more than 2 dB	Consider for mitigation?
Harwood Island Public School	SCHOOL02-1-1	40	47	37	No	No
Harwood Island Public School	SCHOOL02-1-2	40	51	41	No	No
Harwood Island Public School	SCHOOL02-1-3	40	54	44	No	Yes
Harwood Island Public School	SCHOOL02-1-4	40	54	44	No	Yes
Harwood Island Public School	SCHOOL02-1-5	40	59	49	No	Yes
Harwood Island Public School	SCHOOL02-1-6	40	57	47	No	Yes
Harwood Island Public School	SCHOOL02-2-1	40	47	37	No	No
Harwood Island Public School	SCHOOL02-2-2	40	53	43	No	No
Harwood Island Public School	SCHOOL02-2-3	40	58	48	No	Yes

Name	Receiver ID	Internal noise level criteria $L_{eq,1hr}$ dBA	Design year predicted external noise level $L_{eq,1hr}$ dBA	Design year predicted internal noise level $L_{eq,1hr}$ dBA	Change in noise level (Build-No build) more than 2 dB	Consider for mitigation?
Harwood Island Public School	SCHOOL02-2-4	40	56	46	No	Yes
Harwood Island Public School	SCHOOL02-3-1	40	60	50	No	Yes
Harwood Island Public School	SCHOOL02-3-2	40	60	50	No	Yes
Harwood Island Public School	SCHOOL02-3-3	40	61	51	No	Yes
Harwood Island Public School	SCHOOL02-3-4	40	62	52	No	No
Harwood Island Public School	SCHOOL02-3-4	40	62	52	No	Yes
Harwood Island Public School	SCHOOL02-3-5	40	59	49	No	Yes
Harwood Island Public School	SCHOOL02-3-6	40	53	43	No	Yes
Harwood Island Public School	SCHOOL02-3-7	40	56	46	No	Yes
Harwood Island Public School	SCHOOL02-3-8	40	49	39	No	No
Harwood Island Public School	SCHOOL02-4-1	40	56	46	No	Yes
Harwood Island Public School	SCHOOL02-4-2	40	55	45	No	Yes
Harwood Island Public School	SCHOOL02-4-3	40	53	43	No	No
Harwood Island Public School	SCHOOL02-4-5	40	54	44	No	No
Harwood Island Public School	SCHOOL02-4-6	40	52	42	No	No
Harwood Island Public School	SCHOOL02-5-1	40	50	40	No	No
Harwood Island Public School	SCHOOL02-5-2	40	53	43	No	No
Harwood Island Public School	SCHOOL02-5-3	40	60	50	No	Yes

Name	Receiver ID	Internal noise level criteria $L_{eq,1hr}$ dBA	Design year predicted external noise level $L_{eq,1hr}$ dBA	Design year predicted internal noise level $L_{eq,1hr}$ dBA	Change in noise level (Build-No build) more than 2 dB	Consider for mitigation?
Harwood Island Public School	SCHOOL02-5-4	40	54	44	No	Yes
Harwood Island Public School	SCHOOL02-6-1	40	59	49	No	Yes
Harwood Island Public School	SCHOOL02-6-2	40	61	51	No	Yes
Harwood Island Public School	SCHOOL02-6-3	40	54	44	No	Yes
Harwood Island Public School	SCHOOL02-6-4	40	51	41	No	No
Riverview Funerals	CREM-1-1	40	63	53	No	Yes
Riverview Funerals	CREM-1-2	40	66	56	No	Yes
Riverview Funerals	CREM-1-3	40	64	54	No	Yes
Riverview Funerals	CREM-1-4	40	65	55	No	Yes
Riverview Funerals	CREM-1-5	40	62	52	No	Yes
Riverview Funerals	CREM-1-6	40	52	42	No	No
Riverview Funerals	CREM-2-1	40	64	54	No	Yes
Riverview Funerals	CREM-2-2	40	67	57	No	Yes
Riverview Funerals	CREM-2-3	40	65	55	No	Yes
Riverview Funerals	CREM-2-4	40	65	55	No	Yes
Riverview Funerals	CREM-2-5	40	63	53	No	Yes

Note: A correction of -10 dB has been used to convert external noise levels to internal noise levels.

6.3.6 Mitigation

Quieter pavement

SMA pavement was included in the design at various locations as detailed in Chapters 4.8 and 6.3.4. Further low noise pavement was not considered reasonable for implementation.

Noise barriers

Noise barriers were assessed as a mitigation option for the residential receivers where mitigation is to be considered. The outcome of the barrier study showed noise barriers were not feasible or reasonable in line with the NMG and therefore were not adopted as a mitigation option.

The locations of the receivers identified for consideration of mitigation have been reviewed to determine whether barriers may provide a noise reduction benefit. This review has determined that at road mitigation measures, quieter pavements or noise barriers would not generally provide practicable solutions due to the large mutual separations between the affected receivers.

However, in one locality where grouped exceedances have been predicted, principally for receivers 1396-1407 located on Morpeth Street, Harwood, barriers have been considered in line with the NMG. The identified receiver group and other closely grouped receivers identified for mitigation consideration are shown in

Figure 6-6

Figure 6-6 Harwood receivers adjacent to the new alignment eligible for consideration of mitigation. Main cluster located on Morpeth Street.

When considering the placement of barriers it is necessary to consider the relative heights of the roads with respect to the receivers. To be fully effective, the barrier must be substantially high and long enough to break the acoustic line of sight between the source and receiver. Figure 6-7 shows an artist's impression of the existing and new Clarence River Bridges, looking south. This illustrates the relative height differences between the two bridges and the surrounding receivers.

Figure 6-7 Existing and New bridges over the Clarence River - Artist's Impression, looking South

For the purpose of this assessment it has been assumed that, by design, the new bridge would not be provided with walls that would provide acoustic shielding. Once operating, the new bridge would carry the majority of the traffic crossing the Clarence River. The new bridge would be constructed with SMA low noise pavement, which is relatively quieter than the existing highway. With respect to receivers located to the west of the roads, the principal noise source also moves further away, thus reducing the noise exposure to these receivers.

Comparing the Build and No build results, traffic noise levels were predicted to typically reduce by 4-5 dB at Receivers 1396-1407 located on Morpeth Street, once the new bridge becomes operational, which is regarded as a substantial improvement.

The principal noise source moves closer to the receivers to the east, with respect to the horizontal alignment of the new bridge. Increases in traffic noise exposure to the receivers to the east are, generally offset due to the application of SMA low noise pavement on the new bridge surface in addition to the new bridge's relative height increase with respect to the existing bridge. At the closest receivers to the east, the far-side lanes of the new bridge are also more effectively shielded by the bridge itself, due to its elevation.

Due to traffic noise coming from three different roads (new highway and bridge, existing highway and bridge and Mill Road) the consultant reviewed the performance of barriers in the various locations and also considered what combination of barrier locations, lengths and heights would be required to achieve the NCG criteria at all receivers in the groupings to the north of the river that require mitigation. Barriers will also reduce noise levels for receivers not requiring mitigation.

Barrier to the west of the existing Pacific Highway

To reduce traffic noise levels at the Morpeth Street receivers, the inclusion of a barrier to the west of the existing Pacific Highway, as shown in Figure 6-8, has been considered.

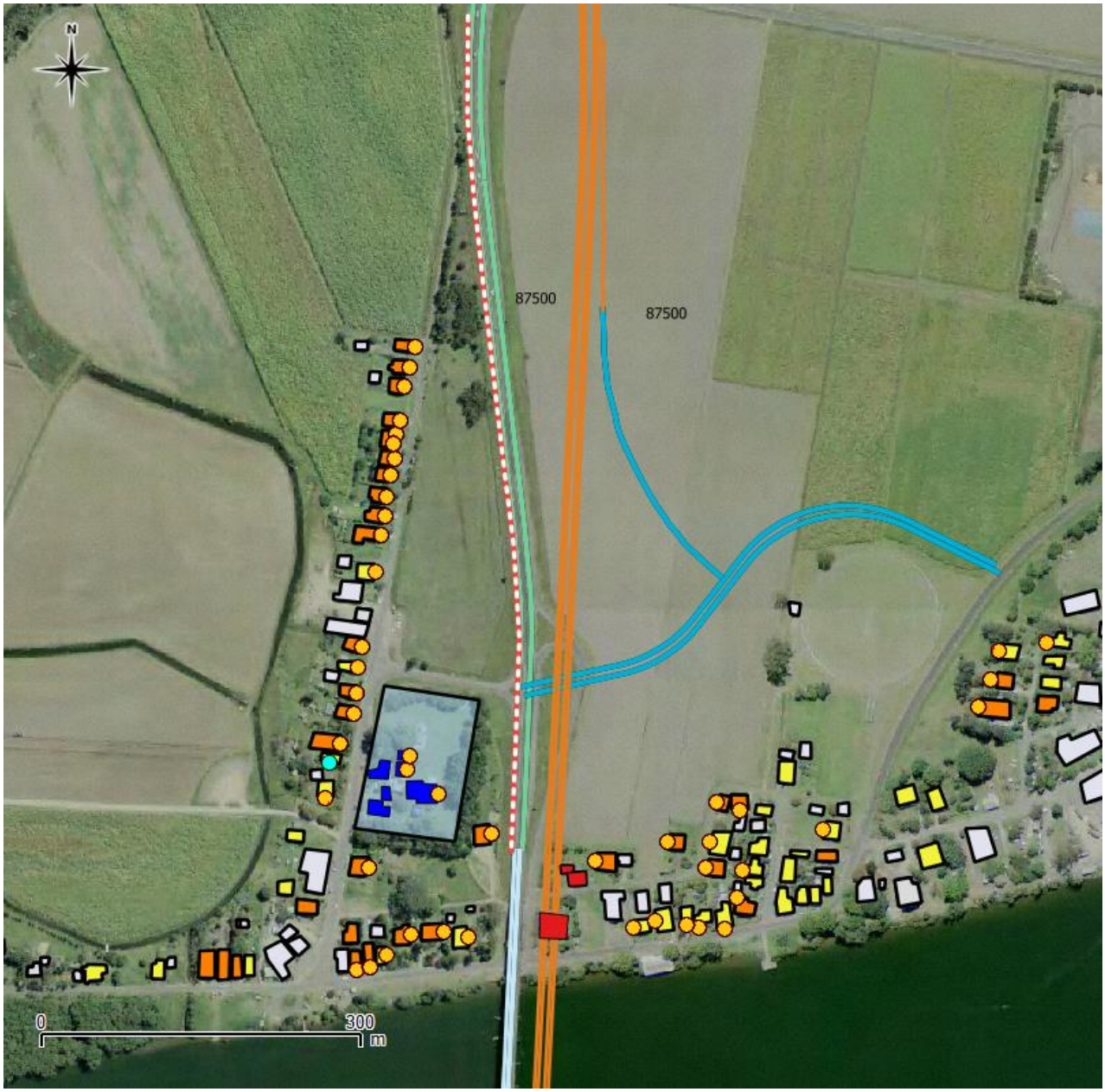


Figure 6-8 Barrier location considered to west of existing Pacific Highway (shown by dotted red line) – receiver identified for mitigation consideration with predicted noise levels within NCG criteria shown by blue dot. Those with predicted noise levels adjacent to the new alignment remaining above NCG criteria shown by orange dots.

Noise modelling indicated that a barrier of up to eight metres in height (the maximum permissible height recognised by the NMG) in the location shown in Figure 6-8 (extending a length of approximately 800 metres), would be effective in reducing traffic noise to within NCG criteria at only one ground floor receiver (as indicated by blue dots in Figure 6-8).

The maximum height barrier is predicted to provide an attenuation of approximately 4 dB at the identified receiver's most exposed facade. With consideration to the achievable attenuation, the construction of a barrier in this location alone would not be considered reasonable. In this regard, the NMG notes noise barriers are considered to be a reasonable noise mitigation option where they are capable of providing an insertion loss of:

- 5 dB at representative receivers for heights up to 5 metres high
- 10 dB at representative receivers for heights above 5 metres and up to 8 metres high.

Review of the relative heights of the new and existing bridges and approaches identifies a barrier located to the west of the existing Pacific Highway in the location shown in Figure 6-8 would not be effective in shielding the new road. Further analysis shows that a combination of barriers on the existing and new roads would be required to effectively reduce total traffic noise exposure to the affected receivers.

While any barriers on the new or existing bridges would need to consider views of the local community, constructability and cost implications and a review of noise barrier efficacy in various configurations is provided in the following sections.

New bridge over the Clarence River

Analysis showed in order to reduce traffic noise levels to within NCG criteria at the identified Morpeth Street receivers, a combination of barriers would be required. Figure 6-9 shows the receivers with predicted traffic noise levels reduced to within the NCG criteria (indicated by blue dots) and those remaining above criteria (orange dots) with consideration of a barrier combination comprising:

- 5 metres high barriers on both sides of the new bridge, extending the full length of the bridge (approximately 1,700 metres)
- 6 metres high, 800 metres long barrier to the west of the existing Pacific Highway.

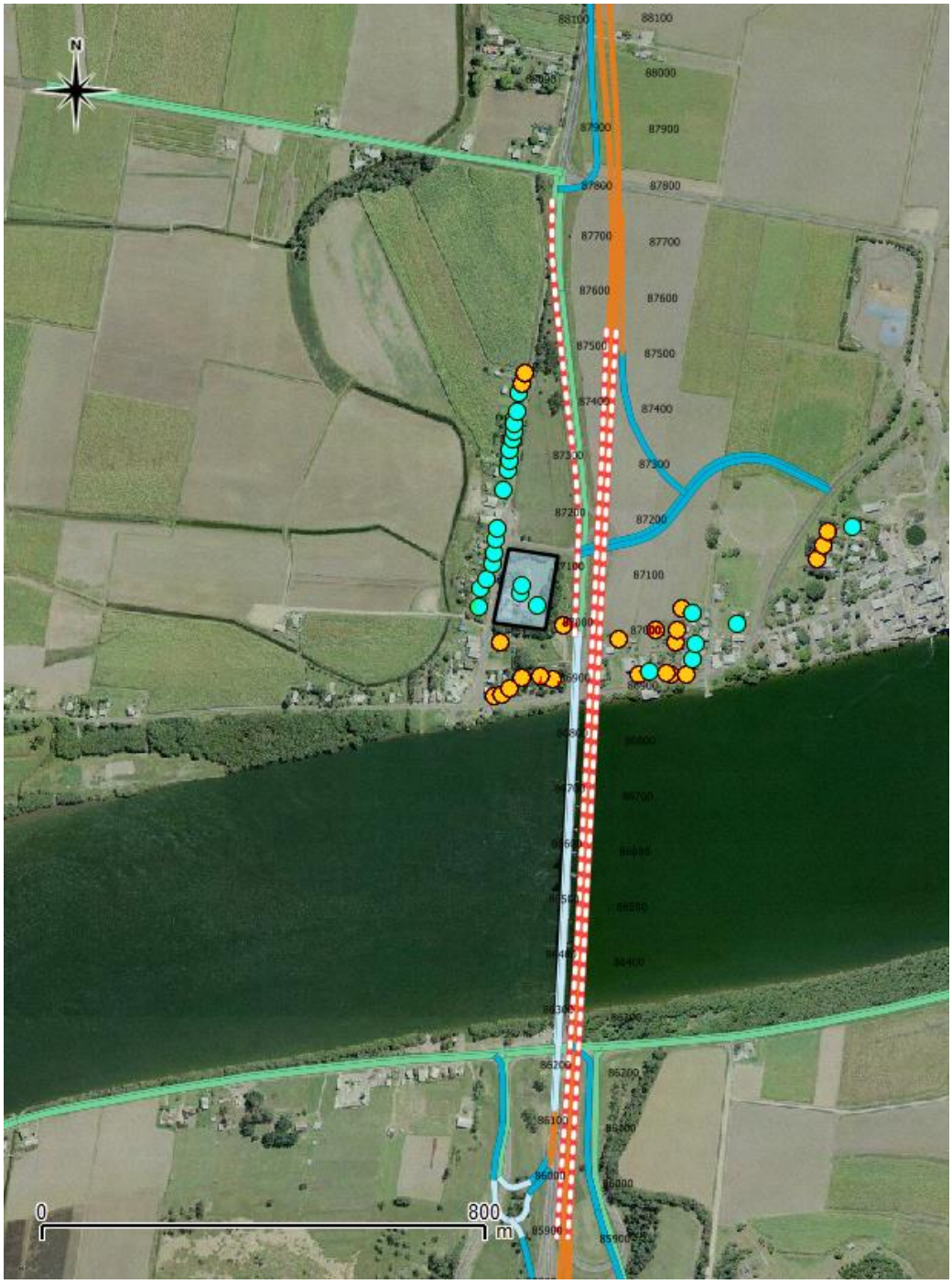


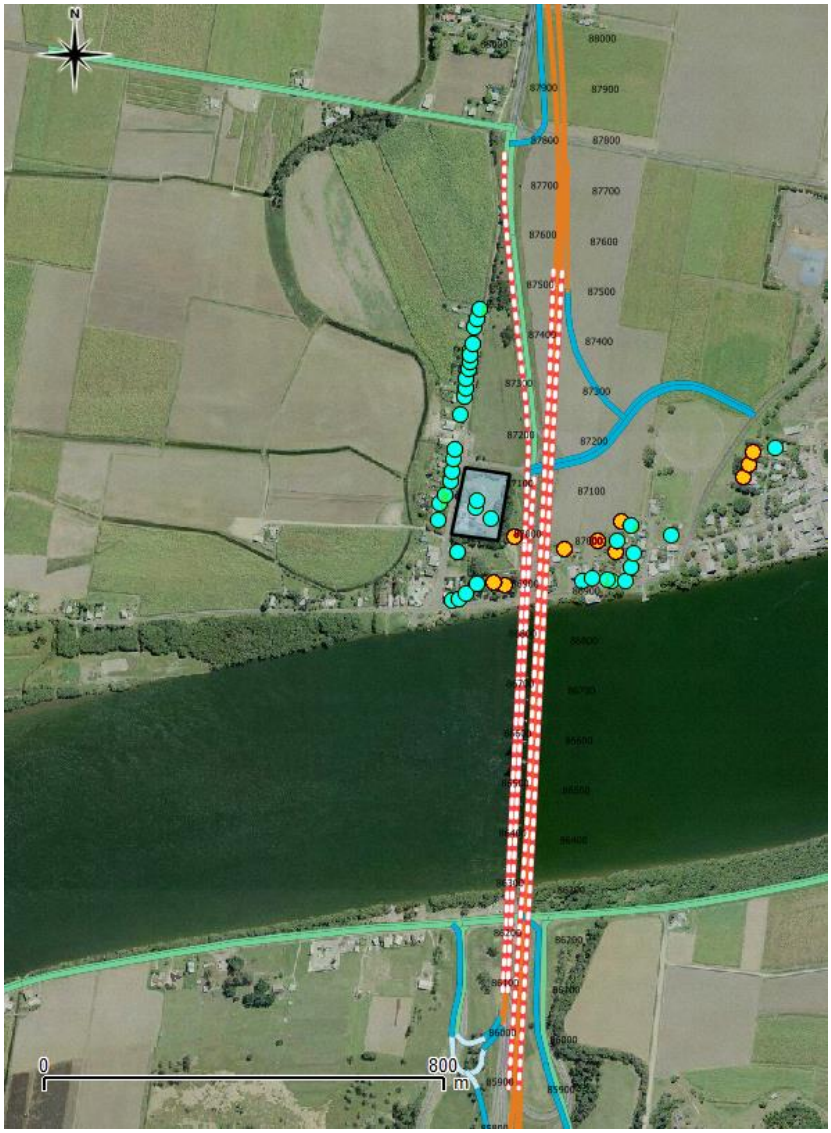
Figure 6-9 Considered Barriers – 5 metres high barriers on new Pacific Highway bridge and 6 metres high barrier to west of existing Pacific Highway (shown by dotted red lines). Receivers identified for mitigation consideration with predicted noise levels within NCG criteria shown by blue dots. Those with predicted noise levels remaining above NCG criteria shown by orange dots.

Assessment of barriers on existing Harwood bridge

Figure 6-10 Additional barriers considered on existing Pacific Highway Bridge (shown by dotted red lines). Receivers identified for mitigation consideration with predicted noise levels within NCG criteria shown by blue dots. Those with predicted noise levels remaining above NCG criteria shown by orange dots.

Due to the relative height difference between the existing and new bridges, noise from the existing road would remain a significant source, albeit at a reduced level, for the receivers located closer to the water on the northern side of Clarence River (Receivers 1290-1352). Given the contribution from the existing bridge, barriers on the new bridge would not be expected to be fully effective in reducing total traffic noise to within criteria for these receivers. Figure 6-10 shows the predicted effect a barrier combination comprising:

- 2 metres high edge barriers retrofitted to the full span of the existing Harwood bridge (approximately 660 metres on each side)
- 5 metres high edge barriers on both sides of the new bridge, extending the full length of the bridge (approximately 1,700 metres on each side)
- 6 metres high barrier to the west of the Pacific Highway (extending approximately 800 metres).



As shown in Figure 6-10, even with barriers extending the full span of both bridges, a number of receivers located to the north of the Clarence River remain above criteria which is due to the influence of Mill Road.

Optimal barrier configuration including Mill Road barrier

Modelling indicated that in order to reduce the total traffic noise exposure to all receivers on the northern side of Clarence River to within criteria, the barrier combinations shown in Figure 6-11 would be required, including an additional barrier to the south of Mill Road. Table 6-22 details these barrier extents.

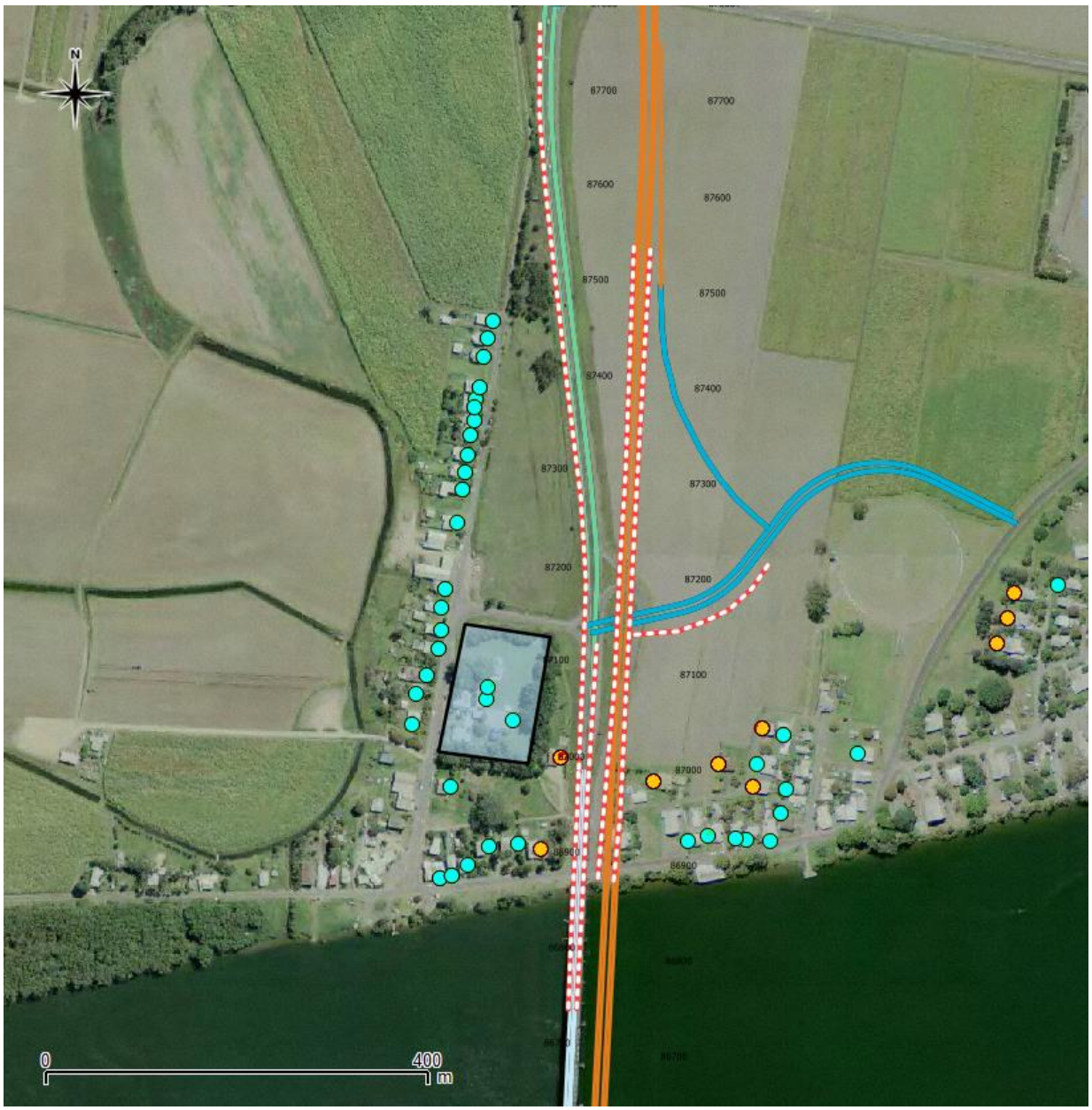


Figure 6-11 Barrier extents required for full compliance at all receivers in the grouping to the north of the Clarence River (shown by dotted red lines). Receivers identified for mitigation consideration with predicted noise levels within NCG criteria shown by blue dots. Those with predicted noise levels remaining above NCG criteria shown by orange dots

Table 6-22 Bridges over Clarence River identified barrier extents

Barrier location	Chainage	Barrier length (metres)	Barrier height (metres)
West of existing Pacific Highway	87,000-87,780	800	7
East and west of New Clarence River Bridge	86,900-87,520	800 east 800 west	4.5
East and west of existing Harwood Bridge	86,750-87,000	350 east 465 west	4.5
South of Mill Road	-	144	4

Due to traffic noise from Yamba Road, barriers will not provide any significant benefit to the receivers located to the south of the river. These receivers are therefore not considered when designing the barrier height.

Assessment of design barrier height

Using the optimal barrier configuration shown in Figure 6-11 and Table 6-22 as the maximum design height, an analysis has been conducted to establish a design barrier height in line with the NMG. The maximum design height was taken as the optimal configuration set out in Table 6-22 as this reduces all receivers below criteria. Each of the barriers were then systematically reduced in half metre increments at the same rate.

Following the NMG process, Figure 6-12 shows an initial design barrier height of approximately 2.3 metres less than the heights specified in Table 6-22, corresponding to the barrier configuration that would be expected to result in compliant noise levels at two thirds of the assessed receivers. As there is no minimum in the total points weighting between the initial design barrier height and the maximum barrier height, the initial design configuration may be considered the design barrier height. Due to the low housing density of the area there are relatively few receivers that benefit per metre length of wall.

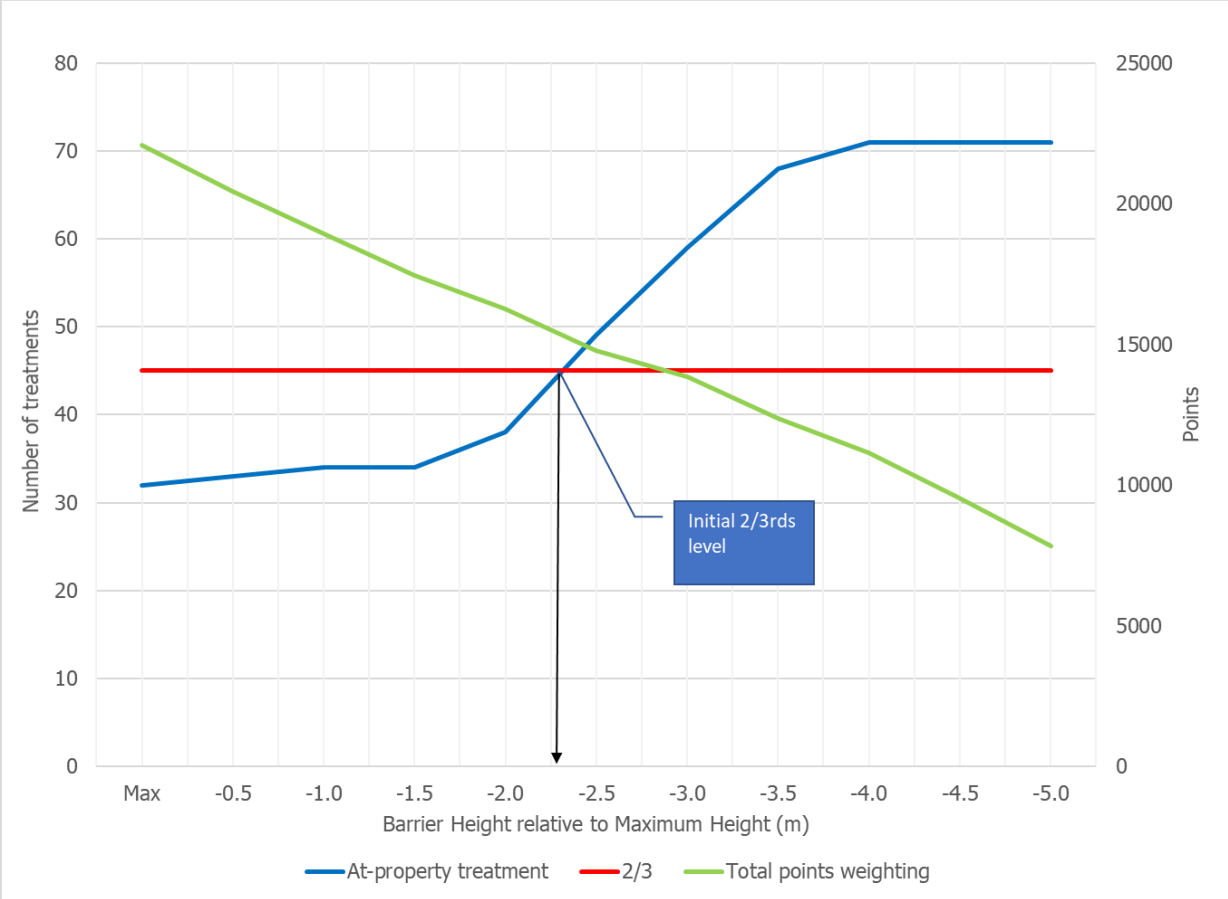


Figure 6-12 Noise barrier analysis for barriers at Harwood and on bridges over the Clarence River.

Whilst the use of barriers has been analysed and found that a combination of barriers on the new and existing roads and bridges provide noise control benefit, it is recognised that this benefit must be evaluated in context with the broader considerations of the project, including:

- Engineering feasibility including and wind loading constraints
- Practicability in retrofitting the existing bridge infrastructure
- Cost of mitigation measure
- Safety issues
- Visual impact and urban design
- Community views and preferences.

Urban design considerations

The ABJV urban design specialist Spackman Mossop Michaels carried out a review of the noise barrier configuration options discussed above and has provided the following comments:

ABJV urban design specialist notes the Pacific Highway around Maclean passes through a particularly scenic landscape. The area to the south of the Clarence River is well vegetated, and glimpses of the broad floodplain are provided from the highway. Spectacular views in both directions along the Clarence River are available from the existing Harwood bridge. To the north, expansive views are afforded over the sugar cane plantations on the floodplain to the mountain ranges in the west and north. These qualities establish a unique identity to the area. In addition, the existing Harwood bridge has been identified as having potential local heritage significance in the Woolgoolga to Ballina EIS Historical (non-Aboriginal) Heritage Assessment (W2BPA 2012a).

The new Clarence River Bridge at Hardwood was assessed to have a high visual impact due to its scale and height, its location next to the existing Harwood bridge and proximity to the Harwood Heritage Conservation Area. The addition of a five metres high noise barrier on the new bridge

and/or a two metres high noise barrier on the existing bridge would add another element to the structure of the bridges and would add to the sense of enclosure when on the bridges and visual bulk when viewing the bridges from the land or the water. It would also be challenging to visually integrate the noise barrier with the truss structure of the existing bridge.

The selection of transparent acrylic panels could help to reduce visual bulk of the noise barrier structures. On the new bridge, these could be angled to reduce the sense of enclosure, however, on the existing bridge, the panels would most likely need to be vertical to align with the truss structure. Despite the use of transparent acrylic panels, the significant views from the highway would be greatly reduced due to the solid vertical posts required for the new bridge, the requirement for anti-bird strike treatment to the acrylic panels, possible sun glare and deterioration of the panels transparency over time. Therefore, from an urban design and visual perspective, ABJV urban design specialist does not recommend noise walls on either the existing Harwood bridge or new Clarence River Bridge.

Consideration of noise barriers – summary

Based on the extent of barriers required to reduce traffic noise levels to within criteria, urban design specialist comments, it not reasonable to implement these barriers. At-property treatment would provide the most effective form of noise mitigation for the affected receivers. Mitigation in the form of at-property treatment can be designed to achieve the internal noise levels.

At-property treatment

At-property treatment would only be considered for residences where other noise mitigation measures are either exhausted or are not feasible or reasonable. At-property treatment is the most appropriate mitigation measure for consideration as the assessment showed additional quieter pavements and noise barriers are not reasonable or feasible for implementation.

Ninety seven (97) residential receivers within 600 metres of the project are eligible for consideration of mitigation. There are no receivers between 601 and 900 metres from the project identified as eligible.

Non-residential receivers

Based on the outcomes of the assessment and the reasonable and feasible consideration of additional quieter pavements and barriers, the following non-residential receivers should be considered for at-property mitigation measures:

- Harwood Island Public School
- Riverview Funerals.

6.3.7 Maximum noise level assessment

The cause of most maximum noise emissions between Maclean and Devils Pulpit would be from heavy vehicles during engine compression braking, gear changes and passby events travelling along the highway during the night.

The highest maximum noise levels would typically be during compression braking events where heavy vehicles would reduce speeds to negotiate bends in the road, intersections, descending down road gradients or for changes in posted speed limits.

The existing Pacific Highway consists of a speed change in Harwood for the existing Harwood bridge and heavy vehicles may use compression braking to reduce their speeds. The new road is generally within the existing road corridor and has a constant speed and therefore removes a potential trigger for the use of engine brakes.

The provision of dual carriageways was also predicted to reduce the occurrence of truck engine braking and therefore also reduce the number of maximum noise events.

The maximum noise levels assessment indicated that maximum noise levels up to L_{max} 77 dBA were predicted at the external façade of receivers closest and most exposed to the road.

The predicted L_{max} levels were in all cases no more than 15 dB above the predicted L_{eq} levels that would occur due to free-flowing traffic, and therefore would not be regarded as particularly intrusive, in line with the guidance contained in ENMM.

The locations predicted to be impacted by maximum noise events such as those caused by truck compression braking on ramps, connecting road intersections and the rest area, have already been nominated for mitigation measures to control noise from free-flowing traffic to meet the $L_{eq,9hr}$ night time target. It is predicted these mitigation measures would also control maximum noise events from typical truck operations.

6.3.8 Comparison of outcomes with EIS

The operational noise review assessed a total of 246 residential receivers between Maclean to Devils Pulpit located up to 900 metres from the project. Of these receivers, 176 were located within 600 metres of the project and a further 70 were located between 601 and 900 metres from the project. The EIS assessed 222 receivers in the area up to 600 metres from the project, however the EIS included some receivers in Maclean and Townsend which have been assessed in the Glenugie to Maclean portion of this report.

The EIS identified 14 receivers for consideration for mitigation in the form of architectural treatment. The operational noise review predicted 83 more residential receivers eligible for consideration of mitigation than the EIS study, with 97 residential and two non-residential receivers identified as eligible for the consideration of mitigation within 600 metres of the project.

The reasonable and feasible mitigation identified for the 97 residential receivers and two non-residential receivers was consideration of at-property treatment. The majority of these receivers are within Harwood where the new bridge is located and there was a change in the assessment criteria from Redeveloped criteria used in the EIS to New road used in the ONR due to the substantial vertical and horizontal realignment of the new bridge and highway compared with the existing alignment.

The main differences in the modelling scenarios that have resulted in the changes in outputs and number of receivers affected are:

- Differences in traffic volumes, notably higher traffic volumes have generally been applied in the detailed design, particularly in the southernmost part of the corridor, where a substantial increase in traffic volume of approximately 40 percent has been modelled.
- Increase in modelled speed
- Inclusion of a safety factor
- Changes in the road design including the new Harwood Bridge
- Change in the assessment criteria to use the most up to date approach. The assessment criteria used are more onerous in some cases compared with the EIS approach.
    - This is particularly relevant to Harwood Bridge where the new bridge and approach viaduct was considered substantially vertically and horizontally realigned and therefore the more onerous New road criteria was applied to receivers in this location.
- More detailed assessment for receivers which included assessment at each façade and storey.
- Increased number of receivers identified through detailed ground surveys and investigation.
- Change in the category of some of the receivers assessed, such as those previously identified non-residential buildings.
- Inclusion of receivers outside of the 600 metres area assessed in the EIS.
- Assessment of the total noise level at receivers. The EIS only considered the noise level from the project alone.
- The EIS did not state the volumes that were used for the no build scenarios for the existing Clarence River Bridge, with differences expected to result in differing model predictions for the nearby receivers.
- The design included a significantly greater stretch of flexible SMA pavement than the EIS in the southern part of the alignment, which extends from the southernmost point of the portion to chainage 96,250. This additional SMA pavement was required as part of the engineering design and not an additional noise mitigation measure.

6.3.9 Summary of key findings

Additional noise sensitive receivers were identified and assessed due to:

- Increasing the assessment area to 900 metres
- Changes in receiver identification through on site observations and property searches.

The operational noise review found additional low noise pavement or barriers were not reasonable and feasible mitigation measures. As a result, at-property treatment was determined to be the reasonable measure to be considered at eligible receivers.

Ninety seven (97) residential receivers and two non-residential receivers within 600 metres of the project were identified as eligible for consideration of at-property mitigation.

Two (2) receivers (IDs 1246 and 1475) were identified as eligible for consideration of mitigation in the EIS but not the operational noise review. These receivers will be considered at the operational compliance stage.

The maximum noise level assessment indicated that impacts would likely be similar to the existing maximum noise levels. The proposed at-property mitigation was found to be sufficient to control maximum noise level impacts.

6.4 Devils Pulpit to Richmond River

The detailed design and noise assessment for the portion was carried out by Arup Cardno Join Venture. This section summarises the noise assessment carried out between Devils Pulpit to Richmond River.

6.4.1 Site description

Table 6-23 summarises the Devils Pulpit to Richmond River portion.

Table 6-23 Devils Pulpit to Richmond River site description

EIS section number	Section name	Length (km)	Chainage	Description
7	Devils Pulpit Upgrade to Trustrums Hill	15.3	111,100 to 126,400	Upgrade of existing road corridor passing New Italy with sparsely distributed dwellings
8	Trustrums Hill to Broadwater National Park	11.2	126,400 to 137,600	Bypass of town of Woodburn through new road corridor with sparsely distributed dwellings with some areas of isolated dwellings to the north and south along the existing road corridor.
9	Broadwater National Park to Richmond River	7.5	137,600 to 145,100	Bypass of town of Broadwater through new road corridor with sparsely distributed dwellings with some areas of isolated dwellings to the north and south along the existing road corridor.

6.4.2 Existing environment

Sensitive receivers

The description of the sensitive receivers and the existing environment is provided in Chapter 5. The number of sensitive receivers assessed in this portion are summarised in Table 6-24.

Table 6-24 Number of receivers assessed in the Devils Pulpit to Richmond River portion

Description	Distance from road (metres)	Number of receivers (EIS)	Number of receivers (ONR)	Notes
Residential receivers	0-600	90	110	Sparsely distributed isolated dwellings throughout assessment area.
Residential receivers	601-900	N/A[1]	190	Sparsely distributed isolated dwellings throughout assessment area. Some small pockets of low density residential near to Broadwater.
Non-residential receivers	0-600	0	1	Broadwater Public School is located about 500 metres from the project.
	601-900	N/A[1]	0	-

Note 1: Receivers were only assessed up to 600 metres from the project in the EIS.

Existing noise environment

Noise monitoring as described in Chapter 5 was carried out in this section for the EIS at six locations used for the validation of the noise model. A summary of the noise monitoring is provided in Table 6-25.

Table 6-25 Noise measurements results, dBA

Location ID	Address	Distance to Existing Highway (metres)	Measured traffic noise level	
			$L_{eq,15hr}$ Day	$L_{eq,9hr}$ Night
1557	8120 Pacific Highway Tabbimobile	168	66	64
1591	Pacific Highway, The Gap	214	61	59
1592	65 Whites Road New Italy	373	54	53
1631	20 The Gap Road Trustums Hill	139	61	54
1698	82 Trustums Hill Road Woodburn	124	60	58
1756	4 Pacific Highway Broadwater	29	65	64

6.4.3 Specific criteria – transition zones

The portion has both New roads and Redeveloped roads. Where the two road types meet, transition zone criteria are applicable.

The project is a Redeveloped road in the southern section of the portion. The project becomes a New road for the bypass of Woodburn and is substantially realigned from the existing road corridor for the majority of the distance between Woodburn and Broadwater, with some areas of redeveloped road. The bypass of Broadwater is considered a New road. There are several transition zones between the New and Redeveloped sections of the main alignment.

There are also redevelopments to significant existing roads which meet the new bypasses. In these areas there is a transition zone between the New road and the Redevelopment road project types.

The individual criteria for each receiver were calculated and are presented in the predicted noise level tables in Appendix D-3. Appendix C presents the transition zone criteria for day and night respectively.

6.4.4 Technical parameters for noise modelling

The noise modelling between Devils Pulpit to Richmond River was carried out based on the technical parameters listed in the following sections.

Pavement type

The adopted pavement for the assessment, incorporate the extents of low noise pavement as set out in the EIS and other design pavements as follows:

- Concrete pavement
- SMA pavements (Flexible and EIS specified)
- DGA and SMA pavements on ramps

The pavement types are shown in Appendix E-3.

Forecast traffic volumes

The forecast traffic volumes for the roads between Devils Pulpit and Richmond River for the day and night periods are shown in Table 6-26 and Table 6-27 for the Pacific Highway and Table 6-28 and

Table 6-29 for other roads. The existing Pacific Highway and new Pacific Highway are classified as arterial roads.

Table 6-26 No build forecast traffic volumes Pacific Highway

Road	Direction	Day (7am to 10pm)			Night (10pm to 7am)		
		Total	% heavy	Speed (km/h)	Total	% heavy	Speed (km/h)
No build 2019							
Section 7	North bound	2982	21%	100	560	70%	100
	South bound	3240	26%	100	508	58%	100
South of Woodburn interchange	North bound	2955	19%	100	587	62%	100
	South bound	3246	26%	100	502	52%	100
North of Woodburn interchange	North bound	4024	19%	50/100	800	62%	50/100
	South bound	4380	26%	50/100	678	52%	50/100
South of Broadwater interchange	North bound	4033	18%	100	791	60%	100
	South bound	4372	24%	100	686	51%	100
North of Broadwater interchange[1]	North bound	4189	18%	50/80/100	821	60%	80/100
	South bound	4613	24%	50/80/100	724	51%	80/100
No build 2029							
Section 7	North bound	3370	25%	100	693	74%	100
	South bound	3704	30%	100	614	62%	100
South of Woodburn interchange	North bound	3344	22%	100	719	66%	100
	South bound	3715	29%	100	603	57%	100
North of Woodburn interchange	North bound	4494	22%	50/100	966	66%	50/100
	South bound	4958	29%	50/100	805	57%	50/100
South of Broadwater interchange	North bound	4508	21%	100	952	64%	100
	South bound	4949	28%	100	814	55%	100
North of Broadwater interchange[1]	North bound	4676	21%	50/80/100	987	64%	80/100
	South bound	5214	28%	50/80/100	858	55%	80/100

Note 1: The locations referenced in relate to indicative or equivalent geographical positions to the Build scenarios, however it is acknowledged that there are no interchanges in the No build scenario.

Table 6-27 Build forecast traffic volumes main carriageway Pacific Highway

Road	Direction	Day (7am to 10pm)			Night (10pm to 7am)		
		Total	% heavy	Speed (km/h)	Total	% heavy	Speed (km/h)
Build 2019							
Section 7	North bound	3410	21%	115	641	70%	120
	South bound	3635	26%	115	570	58%	120
South of Woodburn interchange	North bound	3316	23%	115	735	68%	120
	South bound	3614	30%	115	591	57%	120

Road	Direction	Day (7am to 10pm)			Night (10pm to 7am)		
		Total	% heavy	Speed (km/h)	Total	% heavy	Speed (km/h)
Build 2019							
North of Woodburn interchange	North bound	2491	23%	115	552	68%	120
	South bound	2879	30%	115	471	57%	120
South of Broadwater interchange	North bound	2475	24%	115	568	68%	120
	South bound	2870	29%	115	480	56%	120
North of Broadwater interchange	North bound	2682	24%	115	615	68%	120
	South bound	3249	29%	115	544	56%	120
Build 2029							
Section 7	North bound	3823	25%	115	786	74%	120
	South bound	4124	30%	115	683	62%	120
South of Woodburn interchange	North bound	3718	26%	115	930	71%	120
	South bound	4104	33%	115	514	61%	120
North of Woodburn interchange	North bound	2831	26%	115	679	71%	120
	South bound	3313	33%	115	568	61%	120
South of Broadwater interchange	North bound	2816	28%	115	694	72%	120
	South bound	3303	32%	115	578	60%	120
North of Broadwater interchange	North bound	3051	28%	115	753	72%	120
	South bound	3708	32%	115	649	60%	120

Table 6-28 Forecast traffic volumes other roads 2019

Road	Speed (km/h)	Direction	Day (7am to 10pm)		Night (10pm to 7am)	
			Total	% heavy	Total	% heavy
Woodburn interchange Western Roundabout off-ramp	50	North bound	763	21%	246	68%
Woodburn interchange Western Roundabout on-ramp	110	North bound	404	15%	96	42%
Woodburn interchange	50	South bound	367	45%	133	75%
Woodburn interchange Eastern Roundabout on-ramp	110	South bound	703	13%	152	56%
Woodburn interchange Link Road	50	North bound	367	45%	133	75%
		South bound	703	13%	152	56%
Woodburn interchange Western Roundabout Service Road - North	50	North bound	794	17%	215	63%
		South bound	672	17%	183	63%
Existing Pacific Highway –	100	North bound	794	17%	215	63%

Road	Speed (km/h)	Direction	Day (7am to 10pm)		Night (10pm to 7am)	
			Total	% heavy	Total	% heavy
South of Woodburn		South bound	672	17%	183	63%
Existing Pacific Highway – North of Woodburn	100	North bound	1401	17%	380	63%
		South bound	1343	17%	365	63%
Evans Head Road	80	West bound	1128	17%	302	53%
		East bound	1098	17%	302	53%
Existing Pacific Highway between Woodburn and Broadwater	100	North bound	1401	17%	380	63%
		South bound	1343	17%	365	63%
Broadwater interchange Eastern Roundabout Off-ramp	50	West bound	364	16%	79	38%
Broadwater interchange Western Roundabout On-ramp	110	East bound	207	24%	47	68%
Broadwater interchange Link Road	50	North bound	655	23%	169	56%
		South bound	356	11%	71	37%
Evans Head Broadwater Road (south)	70	North bound	655	23%	169	56%
		South bound	690	2%	179	38%
Evans Head Broadwater Road (north)	70	North bound	552	23%	145	54%
		South bound	562	16%	119	49%

Table 6-29 Forecast traffic volumes other roads 2029

Road	Speed (km/h)	Direction.	Day (7am to 10pm)		Night (10pm to 7am)	
			Total	% heavy	Total	% heavy
Woodburn interchange Western Roundabout off-ramp	50	North bound	887	24%	213	70%
Woodburn interchange Western Roundabout on-ramp	110	North bound	404	15%	96	42%
Woodburn interchange	50	South bound	367	45%	133	75%
Woodburn interchange Eastern Roundabout on-ramp	110	South bound	715	19%	211	65%
Woodburn interchange Link Road	50	North bound	367	45%	133	75%
		South bound	715	19%	211	65%
Woodburn interchange Western Roundabout Service Road - North	50	North bound	850	19%	250	65%
		South bound	715	19%	211	65%
Existing Pacific Highway – South of Woodburn	100	North bound	850	19%	250	65%
		South bound	715	19%	211	65%
Existing Pacific Highway – North of Woodburn	100	North bound	1506	19%	444	65%
		South bound	1453	19%	429	65%
Evans Head Road	80	West bound	1197	18%	348	56%
		East bound	1171	50%	340	88%
Existing Pacific Highway between Woodburn and Broadwater	100	North bound	1506	19%	444	65%
		South bound	1453	19%	429	65%
Broadwater interchange Eastern Roundabout Off-ramp	50	West bound	391	15%	86	33%
Broadwater interchange Western Roundabout On-ramp	110	East bound	236	28%	58	72%
Broadwater interchange Link Road	50	North bound	699	27%	191	52%
		South bound	365	27%	100	52%
Evans Head Broadwater Road (south)	70	North bound	699	27%	191	52%
		South bound	739	27%	202	52%
Evans Head Broadwater Road (north)	70	North bound	581	27%	161	49%
		South bound	601	27%	158	59%

Model validation

In order to check the noise model is performing within acceptable tolerances, a model of the existing road between Devils Pulpit and Richmond River was prepared using traffic volumes and speed data from the EIS. The predicted noise levels were then compared to the measured traffic noise levels at seven noise monitoring locations, shown in Table 6-30.

Based on the expected accuracy of standard noise modelling procedures, a tolerance of ±2 dB between predicted and measured traffic noise levels is considered generally acceptable for validation purposes.

The median difference for EIS Sections 7 (locations 1557, 1591 and 1592) and EIS Section 9 (location 1756) were +1.4 dB and +1.3 dB respectively during the daytime. As a result, a calibration factor of -1.4 dB and -1.3 dB were applied to these sections during the day only. No calibration factors were applied to the night time scenarios. The night time period is the critical period as the exceedance of the noise criteria is higher during the night than the day.

Table 6-30 Devils Pulpit to Richmond River to noise model validation

Location	Daytime $L_{eq,15hr}$ dBA			Night Time $L_{eq,9hr}$ dBA		
	Measured	Predicted	Difference	Measured	Predicted	Difference
1557	65.9	67.2	1.3	63.8	64.8	1
1591	60.9	62.3	1.4	59.4	59.9	0.5
1592	53.7	55.2	1.5	53.3	52.6	-0.7
1631	60.8	57	-[1]	53.7	54.6	0.9
1698	59.7	59.9	0.2	57.9	57.5	-0.4
S8_2	54.1	53.7	-0.4	49.7	51.3	1.6
1756	64.6	65.9	1.3	63.7	64	0.3
Median			1.3			0.5

Note 1: It was reported in the EIS noise report notes that during the daytime period, measured noise levels were significantly affected by insect noise. This noise monitoring location has therefore been excluded from the validation process during the daytime period.

Coordination with adjacent portions

The new bridge over the Richmond River is an interface between the Devils Pulpit to Richmond River and Richmond River to Pimlico portions.

The designers of each portion compared the predicted noise levels at representative receivers at the interface of the portions. The results were generally within ±1 dB and are considered a good correlation.

6.4.5 Results

Residential receivers

Traffic noise levels for 2019 and 2029 have been predicted at all of the identified residential and locations. The results are shown in full in the tables Appendix D-3 for receivers 0 to 600 metres and receivers between 601 and 900 metres from the project.

Noise contour maps showing a graphical representation of noise levels for each modelled scenario are presented in Appendix E-3.

An assessment of the predictions against the relevant criteria as described in Chapter 4.5 indicated the following:

- A total of 112 receivers were identified as eligible for consideration of mitigation.
- Eighty three (83) of the receivers within 600 metres of the project are eligible for consideration of mitigation.
- Twenty nine (29) of the receivers between 601 and 900 metres of the project are eligible for consideration at the operational compliance stage.
- One (1) receiver (ID 1606) was identified as eligible for consideration of mitigation in the EIS but not the operational noise review. This receiver will be considered at the operational compliance stage.

The predicted night time traffic noise levels exceed the NCG criteria by higher margins than the daytime levels. Mitigation measures designed to achieve the night time criteria would therefore also meet the daytime criteria.

Non-residential receivers

External noise levels predicted at outdoor areas of Broadwater Public School are predicted to comply with relevant $L_{eq,15hr}$ criteria for both active and passive recreation. Table 6-31 presents predicted $L_{eq,1hr}$ road traffic noise levels at each façade of Broadwater Public School.

Table 6-31 Predicted noise levels at Broadwater Public School

Name	Receiver façade ID	Internal noise level criteria $L_{eq,1hr}$ dBA	Design year predicted external noise level $L_{eq,1hr}$ dBA	Design year predicted internal noise level $L_{eq,1hr}$ dBA	Change in noise level (Build-No build) more than 2 dB	Consider for mitigation?
Broadwater Public School	BPS-1	40	64	54	No	Yes
Broadwater Public School	BPS-2	40	62	52	No	Yes
Broadwater Public School	BPS-3	40	62	52	No	Yes
Broadwater Public School	BPS-4	40	64	54	No	Yes

Note: A correction of -10 dB has been used to convert external noise levels to internal noise levels.

The predicted noise levels from the Build scenario are lower than the No build scenario meaning noise levels will decrease when the project is built. However, cumulative noise levels are predicted to be 7-9 dB above the cumulative limit screening criterion of $L_{eq,1hr}$ 45 dBA (internal) for schools at all facades. The north, south and east facades have a dominant contribution from the project. The school therefore qualifies for consideration of additional mitigation.

6.4.6 Mitigation

Quieter pavements

Additional quieter pavements were considered in line with the NMG. The majority of the study area between Devils Pulpit and Richmond River is comprised of receivers that are not closely spaced.

Residences are located closer to each other through the Woodburn and Broadwater town centres. In these locations, the contribution to noise levels from the existing road network becomes significant, most notably from the existing Pacific Highway. This has been taken into account when assessing the potential benefit of mitigation measures by modelling analysing the relative contribution from the project road to overall noise levels.

There were several groups of receivers spaced between 20 to 10 metres apart, where the bypass is east of Broadwater between chainages 140,800 and 142,700 which were identified as eligible for consideration of additional mitigation. This triggered the consideration of quieter pavements in the area.

As a result of the analysis, additional low noise pavement was adopted at the chainages presented in Table 6-32.

Table 6-32 Devils Pulpit to Richmond River additional low noise pavement extents

Mitigation Option	Description
Low noise SMA pavement	About 3 kilometres in length on the new highway to the east of Broadwater

Note: These sections were included as part of the design

The additional SMA pavement reduces the number of receivers eligible for consideration of mitigation by 29, meaning that the total number of receivers eligible for consideration of at-property treatment is 83.

The additional extent of the low noise pavement has been analysed and found to provide a noise control benefit to be evaluated in context with the broader considerations of the project as previously described in Chapter 6.2.6.

The use of the low noise pavement in this section will result in a significant reduction in the number of properties eligible for consideration of at-property treatment. The cost of the additional low noise pavement is more than the at-property treatments.

The measure is an at-road measure and would reduce external noise levels by up to 5 dBA compared with the concrete design pavement which is considered a substantial reduction. It also would provide a noticeable reduction in noise level at many adjacent receivers in Broadwater.

In consideration of the above, the additional low noise pavement is reasonable for implementation.

The predicted noise levels with the additional SMA pavement extents are presented in Appendix D-3 and noise contour maps are presented in Appendix E-3.

Noise barriers

In areas where quieter pavement has been considered, the receivers are located at distance more than 200 metres from the road. The location of the road relative to the receiver locations indicates that noise barriers would need to be prohibitively long in order to provide a benefit. As a result barriers are not considered reasonable as a mitigation measure.

At-property treatment

At-property treatment would only be considered for residences where other noise mitigation measures are either exhausted or are not feasible or reasonable. At-property treatment is the most appropriate mitigation measure for consideration for receivers that are still eligible for consideration of mitigation after the implementation of the identified quieter pavements.

There were 75 residential receivers and one non-residential receivers identified as eligible for consideration of at-property treatment within 600 metres of the upgrade.

There were eight residential receivers identified between 601 and 900 metres that will be considered at the operational compliance stage.

Non-residential receivers

Based on the outcomes of the assessment and the reasonable and feasible consideration of additional quieter pavements and barriers, the following non-residential receivers should be considered for at-property mitigation measures:

- Broadwater Public School.

6.4.7 Maximum noise level assessment

Based on the noise monitoring, the maximum noise levels assessment indicated maximum noise levels up to L_{max} 65-84 dBA for receivers up to 20 metres from the road and L_{max} of 65-73 up to 100 metres from the road at the external façade of receivers based on the measured noise levels in the EIS.

The noise levels from the road in the new corridor were indicated to be up to 66 dBA for a truck passby and up to 79 dBA for truck compression braking at a distance of 100 metres from the road, based on typical truck passby and compression braking noise levels.

Where the road is within the existing road corridor in the south of the portion on sections with a constant speed limit, the magnitude and frequency of maximum noise level events is expected to be similar compared with the existing situation. The closest receivers, which are most likely to be impacted have already been identified for at-property treatment as part of the operational noise review.

The new road will have a constant speed limit of 110 km/h compared with the multiple speed limit zones that currently exist on sections of the existing Pacific Highway in this portion. This would represent a reduction in the triggers for truck compression braking and therefore potentially reduce the number of compression braking events that would occur.

For receivers in Woodburn and Broadwater the number of maximum noise levels would reduce due to the new bypasses diverting heavy vehicle traffic from the towns.

Where the new road goes through a new corridor, the receivers that were not previously exposed to road traffic noise would experience an increase in the number and magnitude of maximum noise level events. Generally receivers within 600 metres of the new corridor have been identified for at-property treatment.

6.4.8 Comparison of outcomes with EIS

The ONR assessed a total of 300 receivers between Devils Pulpit to Richmond River located up to 900 metres from the project, of which 110 were within 600 metres of the project. The EIS assessed 90 receivers in the area up to 600 metres from the project.

In total, there were 61 more residential receivers identified for consideration of mitigation in the ONR, without additional mitigation, than in the EIS. There were 32 more receivers within 600 metres of the project with an additional 29 receivers more than 600 metres from the road identified as eligible for consideration of mitigation.

There was also one non-residential receiver, Broadwater Public School, included in the assessment that was not identified in the EIS.

Receivers in Broadwater between the project and the existing road were also identified for mitigation at distances beyond 600 metres from the road. The assessment of noise levels at individual facades a more realistic representation of the acoustic shielding provided by the building. Therefore when the noise is coming from a different direction, in some cases it leads to different outcomes compared with the EIS.

With the additional mitigation identified in the ONR, there were 32 more residential receivers identified for consideration of mitigation in the operational noise review than in the EIS. There were 24 more receivers within 600 metres of the project with an additional eight receivers between 601 and 900 metres from the project identified as eligible for consideration of mitigation.

The key reasons for the increase in the number of properties eligible for consideration of mitigation in this section are:

- Differences in traffic volumes and vehicle mix
- Increase in modelled speed
- Inclusion of a safety factor
- Changes in the road design
- Change in the assessment criteria to use the most up to date approach. The assessment criteria used are more onerous compared with the EIS approach.
- Assessment of the total noise level at receivers. The EIS only considered the noise level from the project alone.
- More detailed assessment for receivers which included assessment at each façade and storey.
- Increased number of receivers identified through detailed ground surveys and investigation.
- Change in the category of some of the receivers assessed, such as those previously identified non-residential buildings.
- Inclusion of receivers outside of the 600 metres area assessed in the EIS.

6.4.9 Summary of key findings

Additional noise sensitive receivers were identified and assessed due to:

- Increasing the assessment area to 900 metres
- Changes in receiver identification through on site observations and property searches.

The reasonable and feasible mitigation for these receivers was determined to be a combination of about three kilometres of additional quieter pavement and at-property treatment. The additional quieter pavement reduced the number of receivers eligible for consideration of at-property treatment by 29 receivers.

Seventy five (75) residential receivers and one non-residential receiver within 600 metres of the project were identified as eligible for consideration of at-property mitigation.

Eight (8) residential receivers between 601 and 900 metres were identified as eligible for considered at the operational compliance stage.

One (1) receiver (ID 1606) was identified as eligible for consideration of mitigation in the EIS but not the operational noise review. This receiver will be considered at the operational compliance stage.

The maximum noise level assessment indicated that impacts would likely increase in the new road corridors of the portion, especially those to the east of Broadwater and Woodburn. In existing corridors, maximum noise level impacts are expected to be similar. Maximum noise level impacts

in Broadwater and Woodburn along the existing Pacific Highway would substantially reduce as vehicles are diverted onto the bypass.

6.5 Richmond River to Pimlico

The detailed design and noise assessment for the portion was carried out by SMEC and Renzo Tonin and Associates. The following section provides a summary of the noise assessment analysis and outcomes.

6.5.1 Site description

Table 6-33 summarises the Richmond River to Pimlico portion.

Table 6-33 Richmond River to Pimlico site description

EIS section number	Section name	Length (km)	Chainage	Description
10	Richmond River to Coolgardie Road	13.5	145100-158600	Upgrade goes through new road corridor in the west of Wardell north of the Richmond River.
11	Coolgardie Road to Pimlico to Teven	5.4	158600-164000	Alignment joins the existing Pacific Highway alignment north of Wardell in Pimlico at Coolgardie Road and joins the Pimlico to Teven upgrade at the Pimlico Road intersection.

6.5.2 Existing environment

Sensitive receivers

The description of the sensitive receivers and the existing environment is provided in Chapter 5. The number of sensitive receivers assessed in this portion are summarised in Table 6-34.

Table 6-34 Number of receivers assessed in the Richmond River to Pimlico portion

Description	Distance from road (metres)	Number of receivers (EIS)	Number of receivers (ONR)	Notes
Residential receivers	0-600	93	99	Sparsely distributed isolated dwellings throughout assessment area.
	601-900	N/A[1]	43	Sparsely distributed isolated dwellings throughout assessment area.
Non-residential receivers	0-900	0	0	There are no non-residential sensitive receivers within the assessment area
	601-900	N/A	0	-

Note 1: Receivers were only assessed up to 600 metres from the project in the EIS.

Existing noise environment

Noise monitoring as described in Chapter 5 was carried out in this section in 2016 at five locations shown in Appendix A. A summary of the noise monitoring is provided in Table 6-35.

Table 6-35 Noise measurements results, dBA

Location	Address	Distance to Existing Highway (metres)	Measured traffic noise level	
			$L_{eq,15hr}$ Day	$L_{eq,9hr}$ Night
L1	10770 Pacific Hwy Wardell	18	74	71
L2	11184 Pacific Hwy Wardell	15	73	70
L3	848 Pimlico Rd Wardell	65	65	62
L4	746 Pimlico Rd Wardell	30	68	65
L5	52-58 Pimlico Rd Wardell	25	70	67

6.5.3 Portion specific criteria – transition zones

The portion has both New roads and Redeveloped roads. Where the two road types meet, transition zone criteria are applicable.

New road is located between the southern extent and the Coolgardie Road intersection as it travels through a new road corridor. It becomes a Redeveloped road when the project re-joins the existing corridor.

The transition zone between the New and Redeveloped road is just to the north of the Coolgardie intersection. There are no transition zones applicable for existing roads in the portion.

The individual criteria for each receiver were calculated and are presented in the predicted noise level tables in Appendix D-4. Appendix C presents the transition zone criteria for day and night respectively.

6.5.4 Technical parameters for noise modelling

The noise modelling between Richmond River and Pimlico was carried out based on the technical parameters listed in the following sections.

Pavement type

The adopted pavement for the assessment, incorporate the extents of low noise pavement as set out in the EIS and other design pavements as follows:

- Concrete pavement
- SMA pavements (Flexible and EIS specified)

The pavement types are shown on the maps in Appendix E-4.

Forecast traffic volumes

The forecast traffic volumes for the roads between Richmond River and Pimlico for the day and night periods are shown in Table 6-36 and Table 6-37. The existing Pacific Highway and new Pacific Highway are classified as arterial roads.

Table 6-36 No Build forecast traffic volumes

Road	Direction	Day (7am to 10pm)			Night (10pm to 7am)		
		Total vehicles	% heavy vehicles	Speed (km/h)	Total vehicles	% heavy vehicles	Speed (km/h)
No Build Year 2019							
Existing Pacific Hwy - MacDonald St to River Dr	North bound	4,214	17%	100	796	55%	100
	South bound	4,607	22%	100	730	48%	100
Existing Pacific Hwy - River Dr to Bath St	North bound	4,315	17%	80	815	55%	80
	South bound	4,729	22%	80	750	48%	80
Existing Pacific Hwy - Bath St to Bruxner Hwy	North bound	4,774	10%	80/100	601	35%	80/100
	South bound	5,197	13%	80/100	480	27%	80/100
No Build Year 2029							
Existing Pacific Hwy - MacDonald St to River Dr	North bound	4,712	19%	100	951	59%	100
	South bound	5,209	26%	100	863	52%	100
Existing Pacific Hwy - River Dr to Bath St	North bound	4,820	19%	80	973	59%	80
	South bound	5,343	26%	80	885	52%	80
Existing Pacific Hwy - Bath St to Bruxner Hwy	North bound	5,363	12%	80/100	703	38%	80/100
	South bound	5,889	15%	80/100	556	30%	80/100

Table 6-37 Build forecast traffic volumes

Road	Direction	Day (7am to 10pm)			Night (10pm to 7am)		
		Light Vehicles	Heavy Vehicles	Speed (km/h)	Light Vehicles	Heavy Vehicles	Speed (km/h)
Build Year 2019							
Upgraded Pacific Hwy – Richmond River to Coolgardie interchange	North bound	2,663	26%	115	634	69%	120
	South bound	3,238	28%	115	555	55%	120
Upgraded Pacific Hwy – Coolgardie interchange to Ballina Deviation	North bound	4,774	10%	115	601	35%	120
	South bound	5,197	13%	115	480	27%	120
Coolgardie Rd interchange On-Ramps	North bound	1,828	8%	80	251	28%	80
	South bound	1,657	8%	80	227	28%	80
Coolgardie Rd interchange Off-Ramps	North bound	250	7%	80	50	24%	80
	South bound	250	7%	80	50	24%	80
Existing Pacific Hwy – MacDonald St to River Dr	North bound	1,506	8%	80	207	28%	80
	South bound	1,358	8%	80	186	28%	80
Existing Pacific Hwy – River Dr to Bath St	North bound	1,613	8%	80	221	28%	80
	South bound	1,483	8%	80	203	28%	80
Existing Pacific Hwy – Bath St to Coolgardie interchange	North bound	1,828	8%	80	251	28%	80
	South bound	1,657	8%	80	227	28%	80
Build Year 2029							

Road	Direction	Day (7am to 10pm)			Night (10pm to 7am)		
		Light Vehicles	Heavy Vehicles	Speed (km/h)	Light Vehicles	Heavy Vehicles	Speed (km/h)
Upgraded Pacific Hwy – Richmond River to Coolgardie interchange	North bound	3,029	29%	115	775	72%	120
	South bound	3,695	31%	115	662	59%	120
Upgraded Pacific Hwy – Coolgardie interchange to Ballina Deviation	North bound	5,363	12%	115	703	38%	120
	South bound	5,889	15%	115	556	30%	120
Coolgardie Rd interchange On-Ramps	North bound	1,991	7%	80	271	27%	80
	South bound	1,838	7%	80	250	27%	80
Coolgardie Rd interchange Off-Ramps	North bound	250	7%	80	50	24%	80
	South bound	250	7%	80	50	24%	80
Existing Pacific Hwy – MacDonald St to River Dr	North bound	1,635	7%	80	223	27%	80
	South bound	1,509	7%	80	205	27%	80
Existing Pacific Hwy – River Dr to Bath St	North bound	1,751	7%	80	238	27%	80
	South bound	1,647	7%	80	224	27%	80
Existing Pacific Hwy – Bath St to Coolgardie interchange	North bound	1,991	7%	80	271	27%	80
	South bound	1,838	7%	80	250	27%	80

Model validation

For validation purposes, a noise model of the existing road was prepared using traffic volume and speed data from the noise measurements and traffic counting carried out between Richmond River and Pimlico as described in Chapter 5. Table 6-38 presents a comparison of the noise modelling results of the existing road with the actual measured traffic noise levels.

Based on the expected accuracy of standard noise modelling procedures and the variability in traffic speeds, a tolerance of ±2 dB between predicted and measured traffic noise levels is considered generally acceptable for validation purposes. The median variation was within ±1 dB and no calibration factors were included.

Table 6-38 Richmond River to Pimlico to noise model validation

Location	Noise level Day $L_{eq,15hr}$ dBA			Noise level Night $L_{eq,9hr}$ dBA		
	Measured	Predicted	Difference	Measured	Predicted	Difference
L1	71.5	70.7	-0.8	68.7	68.4	-0.3
L2	70.7	69.8	-0.9	67.9	67.8	-0.1
L3	62.0	63.0	1.0	59.7	60.9	1.2
L4	65.1	67	1.9	62.9	64.8	1.9
L5	67.9	68	0.1	64.9	65.8	0.9
Median			0.1			0.9

6.5.5 Results

Traffic noise levels for 2019 and 2029 have been predicted at all of the identified residential locations. The results are shown in full in Appendix D-4 for receivers between 0 to 600 metres and 601 and 900 metres from the project.

Noise contours maps showing a graphical representation of noise levels for each modelled scenario are presented in Appendix E-4.

An assessment of the predictions against the relevant criteria as described in Chapter 4.5 indicated the following:

- A total of 51 receivers were identified as eligible for consideration of mitigation.
- Forty three (43) of the receivers within 600 metres of the project are eligible for consideration of mitigation.
- Eight (8) of the receivers between 601 and 900 metres of the project are eligible for consideration at the operational compliance stage.
- Two (2) receivers (IDs 2034 and 2046) were identified as eligible for consideration of mitigation in the EIS but not the operational noise review. These receivers will be considered at the operational compliance stage.

The predicted night time traffic noise levels exceed the NCG criteria by higher margins than the daytime levels. Mitigation measures designed to achieve the night time criteria would therefore also meet the daytime criteria.

6.5.6 Mitigation

Quieter pavements

Additional quieter pavements were considered in line with the NMG. The majority of the study area between Richmond River and Pimlico is comprised of receivers that are not closely spaced as defined by the NMG. Therefore in line with the NMG, quieter pavement is not considered to be reasonable for implementation.

Furthermore, it was determined that the noise reduction benefits of SMA pavement compared to concrete (up to 5 dBA reduction) would not reduce traffic noise levels to below the criteria at affected receivers. On average the traffic noise levels for the Build scenario in the design year exceed the applicable relative increase or New road criteria in some cases by 10 dBA or more at the receivers impacted by the new deviation.

These receivers in this section are impacted by the New road alignment, have the new road criteria and the more stringent relative increase criteria for both day and night time periods, which triggers the consideration for mitigation at these receivers.

As the receivers are not closely spaced as defined in the NMG replacing the proposed concrete pavement in the south of the project with quieter pavements is not a reasonable and feasible option.

Noise barriers

Between Richmond River and Pimlico, residences that qualify for consideration of mitigation are of the rural type and are not closely grouped as defined by the NMG. Therefore, noise barriers are not considered to be a reasonable and feasible option in providing noise treatment to the affected receivers.

At-property treatment

At-property treatment would only be considered for residences where other noise mitigation measures are either exhausted or are not feasible or reasonable. Other measures have been shown not be reasonable or feasible and therefore at-property treatment is the most appropriate mitigation measure for consideration.

There were 43 residential receivers within 600 metres of the project identified as eligible for consideration of at-property treatment.

There were eight residential receivers between 601 and 900 metres of the project that will be considered at the operational compliance stage.

Non-residential receivers

There were no non-residential receivers identified for consideration of additional mitigation.

6.5.7 Maximum noise level assessment

The existing Pacific Highway consists of numerous tight bends in the road, in particular south of the township of Wardell and the existing bridge over the Richmond River, where heavy vehicles would need to reduce their speeds in order to negotiate bends resulting in compression braking events.

In addition, the existing Pacific Highway has a posted speed limit of 100 km/h which reduces to 80 km/h when approaching Wardell from both the south and north, with an existing speed camera located at the northern end. With the reduction in the posted speed limit, heavy vehicles tend to use compression braking to reduce their speeds.

Based on the noise monitoring, maximum noise level assessment indicated maximum noise levels between L_{max} 78 to 86 dBA within 25 metres of the road and up to L_{max} 78 dBA at distances up to 65 metres from the road.

The noise levels from the road in the new corridor were indicated to be up to 66 dBA at for a truck passby and up to 79 dBA for truck compression braking at a distance of 100 metres from the road, based on typical truck passby and compression braking noise levels.

For the receivers located along the road in the existing corridor, the addition of an extra lane in each direction allowing for free-flowing traffic, an increase in the speed limit from 100 km/h to 110 km/h and the reduction in the road gradient at some locations would equate to less slowing down of heavy vehicles and a decrease in the use of engine compression brakes.

The design of the project generally reduces the road gradient at various locations, compared with the existing Pacific Highway, and reduces the amount of tight bends in the road. There are some sweeping bends south of the Coolgardie Interchange which may result in occasional compression braking.

The posted speed limit has been increased to 110 km/h along this portion of the project. Therefore, heavy vehicles would not be required to change speed due to the change in speed limit one of the reasons for compression braking is removed.

These road design improvements will assist to provide a substantial reduction to existing L_{max} noise levels experienced by adjacent receivers in the north of the portion.

In the south of the portion, where there was no previous exposure to significant road traffic noise, receivers are likely to experience an increase in maximum noise levels and the frequency they

occur because there was no previous significant exposure to maximum noise levels from road traffic on an arterial road in this location.

The majority of the residential receivers within 600 metres of the new corridor have been identified as eligible for consideration for mitigation as part of the noise assessment. Therefore the additional maximum noise level impacts from the project would be addressed by this treatment.

For receivers in the north of the portion where the road is in an existing corridor, the majority of receivers were not identified as eligible for consideration of at-property mitigation. However, in this section the impacts are predicted to be reduced as receivers are already exposed to maximum noise levels and the causes that trigger maximum noise level events are being reduced.

6.5.8 Comparison of outcomes with EIS

The ONR assessed a total of 142 receivers between Richmond River and Pimlico located up to 900 metres from the project which included 99 receivers within 600 metres. The EIS assessed 93 receivers in the area up to 600 metres from the project.

In total, there were 19 more receivers identified for consideration of mitigation in the operational noise review within 900 metres of the project than in the EIS. There were 11 more receivers within 600 metres of the project with an additional eight receivers between 601 and 900 metres from the project identified as eligible for consideration of mitigation.

The mitigation considered reasonable and feasible for these additional receivers is at-property treatments. Additional quieter pavement or noise barriers are not considered reasonable or feasible for implementation.

The key reasons for the increase in the number of properties eligible for consideration of mitigation in this section are:

- Differences in traffic volumes and vehicle mix
- Increase in modelled speed
- Changes in the road design
- Change in the assessment criteria to use the most up to date approach. The assessment criteria used are in some cases more onerous compared with the EIS approach.
- Assessment of the total noise level at receivers. The EIS only considered the noise level from the project alone.
- More detailed assessment for receivers which included assessment at each façade and storey.
- Change in the category of some of the receivers assessed, such as those previously identified non-residential buildings.
- Increased number of receivers identified through detailed ground surveys and investigation.
- Inclusion of receivers up to 900 metres from the project, which is more than the 600 metres assessed in the EIS.

6.5.9 Summary of key findings

Additional noise sensitive receivers were identified and assessed due to:

- Increasing the assessment area to 900 metres
- Changes in receiver identification through on site observations and property searches.

The reasonable and feasible mitigation for these receivers was determined to be at-property treatment.

Noise sensitive receivers eligible for consideration of at-property mitigation include:

- Forty three (43) residential receivers within 600 metres of the project were identified as eligible for consideration of at-property treatment.
- Eight (8) residential receivers between 601 and 900 metres were identified as eligible for considered at the operational compliance stage.
- Two (2) receivers (IDs 2034 and 2046) were identified as eligible for consideration of mitigation in the EIS but not the operational noise review. These receivers will be considered at the operational compliance stage.

Additional quieter pavements were considered in line with the NMG. The majority of the study area between Richmond River and Pimlico is comprised of receivers that are not closely spaced. Therefore in line with the NMG, quieter pavement is not considered to be reasonable for implementation.

The maximum noise level assessment indicated that impacts would likely increase in the new road corridor in the south of the portion and reduce in the northern section where the road is in an existing corridor. Maximum noise level impacts in the town of Wardell along the existing Pacific Highway would substantially reduce.

7 Summary of key findings for all portions

The key findings of the ONR for each portion are summarised in this section. Table 7-1 presents a summary of the mitigation outcomes from the operational noise reviews.

Table 7-1 Summary of operational noise review outcomes

Portion	Number of receivers assessed		Additional mitigation measures	Eligible for consideration of at-property mitigation (≤600 metres)	Eligible for consideration at operational compliance stage (601-900 metres)
	Within 600 metres	601-900 metres			
Glenugie to Maclean	407	113	Additional low noise pavement, barrier at Tyndale and at-property treatment	92	31
Maclean to Devils Pulpit	176	70	At-property treatment	97	0
Devils Pulpit to Richmond River	110	190	At-property treatment and additional low noise pavement	75	8
Richmond River to Pimlico	99	43	At-property treatment	43	8
Total	792	416		307	47

Note 1: Receivers between 601 and 900 metres will be considered at the operational noise compliance stage.

Note 2: The totals do not include the receivers identified in the EIS as eligible for mitigation that were not identified in the ONR. These receivers will be considered at the operational compliance stage.

As a result of the refinements to the modelling and assessment process, changes to the design and assessed year, the operational noise review identified more receivers than the EIS as eligible for consideration of mitigation and additional mitigation measures in the form of additional low noise pavement and at-property treatment.

As the EIS considered residential receivers up to 600 metres from the road, the outcomes of the EIS have been compared with the ONR up to 600 metres from the road, as summarised in Table 7-2.

The ONR identified three non-residential receivers as eligible for consideration of mitigation:

- Harwood Island Public School
- Riverview Funerals
- Broadwater Public School

The EIS did not specifically identify any non-residential receivers as eligible for consideration of mitigation. The EIS did not identify the Riverview Funerals, Lower Clarence Baptist Church or Pacific Valley Christian School as sensitive non-residential receivers.

Table 7-2 Comparison of EIS and ONR outcomes for residential receivers within 600 metres of the project

Portion	EIS			Operational noise review (within 600 metres of the project)			Difference between EIS and ONR in No. of additional receivers identified as eligible for consideration of at-property mitigation
	No. of receivers assessed	No. of residential receivers eligible for consideration of mitigation	Recommended mitigation measures	No. of receivers assessed	No. of residential receivers eligible for consideration of mitigation	Mitigation measures[2]	
Glenugie to Maclean	302	62	At-property treatment for eligible receivers. Low noise pavement Ch. 66,400 to 68,300 and 80,500 to 82,500	407[1]	92[3]	Additional low noise pavement, barrier at Tyndale and at-property treatment	30
Maclean to Devils Pulpit	222	14	At-property treatments and low noise pavement Ch. 85,900 to 88,000	176[1]	97	At-property treatment	83
Devils Pulpit to Richmond River	90	51	At-property treatments and low noise pavement Ch. 127,000 to 128,000	110	75	At-property treatment and additional low noise pavement	24
Richmond River to Pimlico	93	32	At-property treatments and low noise pavement Ch. 155,400 to 157,700	99	43	At-property treatment	11
Totals	707	159		792	307		148

Note 1: In the ONR, receivers in Maclean and Townsend were included in the Glenugie to Maclean section and therefore the number assessed between Maclean to Devils Pulpit is reduced compared with those in the EIS sections 5 and 6. Receivers adjacent to Glenugie interchange not included as this section is under design review.

Note 2: The detailed design included low noise pavement recommended in the EIS as part of the design and are not considered additional extents.

Note 3: This does not include the receivers adjacent to the Glenugie interchange as this section is under design review.

The detailed design assessments identified the following mitigation measures in addition to those already included as part of the design:

- Noise barrier at Tyndale
- Additional two kilometres of low noise pavement at Gulmarrad
- Additional three kilometres of low noise pavement at Broadwater
- At-property treatments to be considered for 307 residential receivers and three non-residential receivers.

The implementation of the additional noise mitigation measures reduced the total number of receivers eligible for consideration by 53. The number of receivers eligible for consideration of mitigation was reduced by each measure as follows:

- Four (4) receivers for the Tyndale noise barrier
- Twenty (20) receivers for the low noise pavement at Gulmarrad
- Twenty nine (29) receivers for the low noise pavement at Broadwater.

Table 7-3 provides a summary table of the effect of the additional mitigation measures applied to the project.

Table 7-3 Summary of residential receivers eligible for consideration of mitigation for each additional mitigation option assessed

Portion	Number of residential receivers			Number of receivers eligible for consideration of mitigation											
	≤600m	601-900m	Total	No additional mitigation			Quieter pavement surfaces only			Noise barriers only			Eligible for at-property treatment after implementation of quieter pavement and noise barriers		
				≤600m	601-900m	Total	≤600m	601-900m	Total	≤600m	601-900m	Total	≤600m	601-900m	Total
Glenugie to Maclean	407	113	520	107	40	147	96	31	127	103	40	143	92	31	123
Maclean to Devils Pulpit	176	70	246	97	0	97	97	0	97	97	0	97	97	0	97
Devils Pulpit to Richmond River	110	190	300	83	29	112	75	8	83	83	29	112	75	8	83
Richmond River to Pimlico	99	43	142	43	8	51	43	8	51	43	8	51	43	8	51
Total	792	416	1208	330	77	407	311	47	358	326	77	403	307	47	354

The change in the mitigation identified for the project are due to the update in the road design, traffic volumes, noise modelling refinements, safety factors and assessment process. The modelling and assessment carried out by each portion for the ONR was refined and has resulted in different outcomes compared with the EIS. The key differences are as follows:

- Updated road and pavement, considering the 100 percent detailed design
- Updated traffic forecasting, considering 2019 as the opening year and 2029 as the design year
- Conservative parameters used in the future noise modelling including:
  - 85th percentile design posted speeds for the new highway
  - Safety factor of +0.8 dB
- Increased resolution of topography from 2 metres resolution to 0.5 metres
- Additional receivers identified through ground truthing to correlate modelled receivers with on-site observations including refinement and differentiation between sensitive receivers and sheds and other non-sensitive receivers from previously assessed receivers
- Receivers classified as non-sensitive in the EIS, reclassified as sensitive receivers after further investigation
- Assessment at the height of single and double storey houses, on each façade and storey
- Inclusion of building structures in the model which provides a more accurate calculation of acoustic shielding
- Inclusion of non-project roads for calculation of total noise level. The EIS only included the project road
- The EIS was assessed using the ENMM implementation of the RNP and the ENMM to define reasonable and feasible mitigation measures. The ONR used the NCG implementation of the RNP with the NMG used to define reasonable and feasible mitigation measures
- The NCG defines criteria transition zones between New and Redeveloped roads. Transition zones were not used under the previous guidance
- Change of criteria from Redeveloped road to New road for the new Harwood Bridge and section north of the river due to the substantial horizontal and vertical realignment compared with the existing bridge and new viaduct through Harwood
- The NMG is more stringent than the previous approach in some situations such as consideration of the total noise level, not just noise from the project, definition of New and Redeveloped roads and the cumulative limit which applies whether noise levels increase or decrease.

Between Glenugie and Maclean, major factors in combination with the above that lead to the increase in mitigation was the identification of additional sensitive receivers adjacent to the alignment, including the identification of existing receivers not included in the EIS and reclassification of some receivers identified as non-sensitive in the EIS as sensitive receivers in the ONR.

Between Maclean and Devils Pulpit, major factors in combination to the above that lead to the increase in mitigation was the change of criteria for the new Harwood Bridge, the change in traffic volumes that were substantially different in some sections to those in the EIS and the change in the modelled speed.

Between Devils Pulpit and Richmond River, major factors in combination to the above that lead to the increase in mitigation included refinement of criteria from Redeveloped to New road in some locations, assessment of each receiver façade, inclusion of non-project traffic noise in the assessment and a change in the traffic forecasting.

Between Richmond River and Pimlico, major factors in combination with the above that lead to the increase in mitigation included the increased modelled speed, change in traffic forecasting and assessment of each receiver façade.

There were 85 more receivers assessed within 600 metres of the project compared with the EIS. As a result of the review of receivers, there were 65 receivers assessed in the EIS that were not assessed in the ONR. There were also 150 receivers that were not assessed in the EIS that were assessed in the ONR. The reasons for these receivers either been included or excluded is generally due to the fact that subsequent inspections or reviews have identified them differently to the EIS by identifying them as a non-sensitive receivers like a shed or structures which have been demolished.

There was a total of 148 more receivers identified in the ONR as eligible for consideration of mitigation compared with the EIS for receivers located within 600 metres of the project.

As a result of design changes and the application of additional mitigation, there were 16 receivers identified as eligible for consideration of mitigation in the EIS and not in the ONR. These receivers (IDs 786, 798, 800, 801, 802, 812, 813, 816, 817, 818, 854, 1246, 1475, 1606, 2034 and 2046) were not found to be eligible in the ONR as the predicted noise levels at these receivers were such that they are no longer eligible under the NMG.

In accordance with the MCoA, within one year of the project opening, an operational noise compliance report will be prepared. This will measure the noise from the completed upgrade and compare the noise levels with those predicted in the ONR and review the suitability of the noise mitigation identified in the ONR.

8 Conclusion

The four assessments carried out for this operational noise reviews for the Pacific Highway upgrade between Glenugie and Pimlico indicated additional mitigation is to be applied to the project compared with the EIS. This is a result of updates to the design, assessment and refinement of modelling inputs since the EIS was carried out.

The operational noise reviews identified a noise barrier, two additional extents of low noise pavement and at-property treatments were reasonable and feasible mitigation measures to be considered for the project.

In line with condition D28 of the MCoA, within 12 months of the project being completed and traffic travelling at the posted speed, an operational noise compliance report will be prepared. This will measure the noise from the completed project and compare the noise levels with those predicted in the operational noise reviews and assess the suitability of the noise mitigation.

Appendix A

Project layout and receiver location maps

Appendix B

Noise measurement graphs

Appendix C

Criteria maps

Appendix D

Predicted noise levels

Appendix D-1 Predicted noise levels Glenugie to Maclean

Appendix D-2 Predicted noise levels Maclean to Devils Pulpit

Appendix D-3 Predicted noise levels Devils Pulpit to Richmond River

Appendix D-4 Predicted noise levels Richmond River to Pimlico

Appendix E

Noise Contour Maps

Appendix E-1 Noise contour maps Glenugie to Maclean

Appendix E-2 Noise contour maps Maclean to Devils Pulpit

Appendix E-3 Noise contour maps Devils Pulpit to Richmond River

Appendix E-4 Noise contour maps Richmond River to Pimlico

Appendix F

Agency Consultation

Woolgoolga to Ballina Pacific Highway Upgrade (SSI 4963) – Operational Noise Review Condition D11

Report name	**Operational Noise Review**		
Agency	**NSW Environmental Protection Authority - Noise Assessment Unit**		
Date	**31 October 2017**		
Comment number	**Document section**	**EPA Comment**	**RMS Response**
1.		The EPA appreciated the opportunity to review and provide comment on the Woolgoolga to Ballina Operational Noise Management Report.	Noted.
2.		The EPA Noise Assessment Unit (NAU) has completed its review and has provided the following comments. • NAU has reviewed the Woolgoolga to Ballina Pacific Highway Upgrade – Glenugie to Pimlico Operational Noise Review (ONR) prepared by Roads and Maritime Services dated 10/10/2017. • Given that this project covers a large section of the Pacific Highway and includes many residences and other sensitive receivers, its outside the scope of our review to carry out an exhaustive check of all calculations at all locations. NAU have instead focused on the ONR methodology and a sample of the ONR outcomes to see that a comprehensive assessment has been done and the results look sensible. In summary, NAU considers the report to be acceptable and has no further additional comments.	Noted.

Report name	**Operational Noise Review October 2017**			
Agency	**Department of Planning and Environment (DPE)**			
Date	**15 December 2017**			
Comment number	**DPE Comment**	**Initial RMS Response**	**Additional information required**	**Updated RMS response**
1.	Clarify whether low noise pavement is proposed for the new Harwood bridge. The executive summary indicates that low noise pavement will be provided, but section 6.3.6 indicates it won't be provided.	Low noise pavement is included as part of the design for Harwood Bridge as indicated in the chainages in Section 6.3.4 and on the project layout maps in Appendix A. It was not included in Section 6.3.6 as it is not considered an additional noise mitigation measure, as it was included as part of the design.	Noted	N/A
2.	Chapter 7 should also include a summary of the proposed locations for low noise pavement and noise barriers. In addition to this request, of the 1222 receivers clarify how many may benefit from at-house treatment, low noise pavement or noise barriers.	Noted, the updated report will include a summary in Chapter 7 of the mitigation measures and the number of receivers that benefit from the proposed additional mitigation measures.	Noted. Clarification is sought on how many receivers would benefit from low noise pavement or noise barriers. The final figure wasn't provided in the October 2017 report. It is understood that this information will be provided in the final update report to be submitted to DPE shortly. A table showing the following information would clearly summarise the outcomes of the Operational Noise Review: • Number of receivers within 600 /900 metres • Number of receivers eligible for consideration of mitigation • Number of receivers following low noise pavement • Number of receivers following noise barriers	Additional information on quieter pavement and noise barriers is included in updated report. The report outlines the process of investigation into operational noise impacts and mitigation measures. Given the quieter pavement is a design feature separate figures on how many residents will 'benefit' from the low noise has not been specifically included. The report does outline however that as a result of the noise assessment following detailed design that noise mitigation measures to be implemented in order to meet the relevant NSW government guidelines includes an additional two kilometres of low noise pavement near Gulmarrad, and an additional three kilometres of low noise pavement near Broadwater. Details of locations of low noise pavement are included in the maps in Appendix A.

Report name	Operational Noise Review October 2017			
Agency	Department of Planning and Environment (DPE)			
Date	15 December 2017			
Comment number	**DPE Comment**	**Initial RMS Response**	**Additional information required**	**Updated RMS response**
			• Number of receivers requiring at house treatment	Table outlining the summary of receivers and operational noise outcomes is included in Table 7-1 of the report and the effect of the additional mitigation measures on the number of receivers affected is included in Table 7-3.
3.	Why was additional traffic monitoring undertaken between Broadwater and Pimlico and not for the remainder of the project alignment?	Each of the designers and noise consultants reviewed the data supplied by the EIS authors for the purposes of validating the refined noise model used for the ONR. The designers for the portion between Broadwater and Pimlico required additional noise and traffic data that was not available from the EIS in order to validate the model and therefore supplementary monitoring was carried out. The remaining design and noise consultants reviewed the available data and confirmed that it was sufficient information from the EIS to validate their noise models.	Noted	N/A
4.	Clarify the final number of eligible receivers for at house treatment, is it 321 or 370 receivers?	Section 4.5.4 of the report details the assessment area for the noise review. The total number of receivers identified for consideration of at-property treatment was 370 receivers identified within 900 metres of the project. For the purposes of providing prioritised treatment to the most affected receivers and given the limitations of the noise modelling beyond 600 metres, the 49 receivers identified between 601-900 metres will be considered during the post construction operational stage.	DPE considers that of the 49 receivers located 601-900m of the project, those predicted to have acute noise levels (65dBA day and 60 dBA night must be prioritised for at house treatment. This would ensure that treatment is in place prior to operation of the project.	Section 4.5.4 of the ONR outlines the assessment area for the operational noise assessment. This section outlines the modelling approach and guideline requirements e.g. 600 metres that need to be considered by Proponents. As outlined in this section, Roads and Maritime guidelines allow mitigation to be investigated at distances beyond 600 metres on a case by case basis. For at-property treatments, receivers have been addressed in the two assessment areas: • Receivers within 600 metres, identified as eligible for consideration of mitigation, are to be investigated for treatment at the earliest opportunity • Receivers between 601 and 900 metres, identified as eligible for consideration of mitigation, will be investigated as part of the operational noise compliance report. The receivers between 601 and 900 will not be assessment further until the operational noise compliance report, prepared in accordance with MCoA D28, within 12 months of the commencement of operation of the SSI. Notwithstanding this, should any additional receivers be identified or confirmed during this process, those with the highest noise impact can be prioritised for at house treatments.
5.	Provide a status update on the provision of operational noise mitigation measures in accordance with Condition B29.	RMS will provide the Department with a status update in relation to MCoA B29 separately to the provision of the final report.	The letter dated 31 October 2017 advised that RMS will commence notification to sensitive receivers in November 2017. Priority is being given to receivers: • within 0 – 200m from alignment • located near batch plants, borrow sites and site compounds • who have raised queries with the Project regarding construction or operational noise. DPE considers that in addition to the above, receivers predicted to exceed the construction noise management level by 10 dBA or more must be prioritised for noise	The Departments comments are noted. In principle the at house noise treatments have been targeted based on predicted operational noise levels at sensitive receivers. The process that has previously been discussed with agencies captures the sensitive receivers that are potentially highly affected by either construction or operational noise e.g. 0-200m from alignment. These are not based on a specific noise level or Noise Management Level but rather proximity to the alignment. Consultation with sensitive receivers has commenced as part of the at house treatment program with the intent of achieving installation of operational noise mitigation

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			treatment. This would ensure that high noise affected receivers benefit from noise mitigation during construction of the project. Notwithstanding the above, DPE considers that compliance with Condition B29 should be achieved early in the construction of the project.	measures as soon as possible during the construction program.
6.	Clarify why supplementary monitoring was carried out between Broadwater and Pimlico in 2016 and not for the reminder of the project? Why was the EIS data deemed sufficient, by the detailed designers, to validate the noise models for the remaining sections?	As part of the validation of the noise model for the operational noise review, each of the designers and noise consultants were provided with EIS data. The EIS authors supplied the noise model and data that was used to validate the EIS noise model, however, the data supplied was not complete between Broadwater to Pimlico and therefore additional data was required. This was not the case for the other portions of the project where there was the simultaneously collected noise and traffic data available. The validation scenario used the EIS model, with the refinements in Section 6.1 the ONR report, and simultaneously collected noise and traffic data in order to demonstrate the models, refined since the EIS, are still capable of predicting noise within acceptable accuracy in each portion for the existing situation. The refined version of the EIS model is used so that the ONR can confirm mitigation measures or identify additional mitigation above those in the EIS. In this case, the refinements to the existing situation consisted of more accurate ground topography and the inclusion of building structures. The outcomes of the validation exercise showed that the refined model predicted noise levels within the acceptable level of accuracy when compared to the measured noise levels in each portion.	Noted	N/A
7.			Clarify how much additional low noise pavement and noise barriers will be provided under the ONR? In addition, clarify how many additional receivers will benefit from these mitigation measures.	Details of low noise pavement and noise barriers are included in the updated report. These mitigation has been developed throughout the detailed design in accordance with RMS and relevant government guidelines. Inclusion of low noise pavement and noise barriers has been incorporated in addition to other mitigation such as at house noise treatments. The ONR identified an additional 5km of quieter pavement to be installed between Tyndale and Maclean and adjacent to Broadwater compared with the EIS. The additional quieter pavement is expected to reduce the number of receivers eligible for at-property mitigation by up to 45. The noise barrier at Tyndale is a localised noise barrier and is expected to reduce noise levels at 5 residential receivers removing the requirement for at-property treatment at 4 receivers.

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				A summary of the number of receivers eligible for at-property treatment by each treatment type is provided in the report in Table 7-3.
8.			Section 4.6 Maximum noise levels. The last sentence of the last paragraph is incomplete.	Noted, updated in final report.

rms.nsw.gov.au

contactus@rms.nsw.gov.au

Customer feedback
Roads and Maritime
Locked Bag 928,
North Sydney NSW 2059