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Jervis Bay Road Intersection Detailed Design

Operational Road Traffic Noise Assessment

S210580RP3 Revision C

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Glossary

'A' Weighted	A spectrum adaption that is applied to measured noise levels to approximate human hearing. A-weighted levels are used as human hearing does not respond equally at all frequencies.
dB	Decibel—a unit of measurement used to express sound level. It is based on a logarithmic scale which means a sound that is 3 dB higher has twice as much energy. We typically perceive a 10 dB increase in sound as a doubling of that sound level.
dB(A)	'A' Weighted sound level in dB.
Feasible and reasonable	Consideration of best practice noise and vibration mitigation measures taking into account the benefit of proposed measures and their technological and associated operational application in the NSW and Australian context. Feasible relates to engineering considerations and what is practical to build. Reasonable relates to the application of judgement in arriving at a decision, taking into account mitigation benefits and cost of mitigation versus benefits provided, community views and nature and extent of potential improvements.
Frequency	The number of times a vibrating object oscillates (moves back and forth) in one second. Fast movements produce high frequency sound (high pitch/tone), but slow movements mean the frequency (pitch/tone) is low.
Hz	Hertz—units of frequency.
L_{A10}	A-weighted energy noise level present for 10% of the 15 minute interval. Commonly referred to the average maximum noise level.
L_{A90}	A-weighted energy noise level exceeded for 90% of time (background level). The average minimum background sound level (in the absence of the source under consideration)
L_{Aeq}	Equivalent Noise Level— A-weighted energy averaged noise level over the measurement time.
$L_{Aeq, (15 min)}$	A-weighted energy averaged noise level over a 15-minute period. Used in the EPA Interim Construction Noise Guideline (ICNG).
$L_{Aeq, (15 hour)}$	A-weighted energy averaged noise level over the 15-hour daytime period from 7 am to 10 pm. Used in the EPA Road Noise Policy (RNP).
$L_{Aeq, (9 hour)}$	A-weighted energy averaged noise level over the 9-hour night-time period from 10 pm to 7 am. Used in the EPA Road Noise Policy (RNP).
L_{Amax}	A-weighted maximum recorded noise level.
Noise Catchment Area (NCA)	Noise Catchment Areas are groupings of receivers within the study area that are associated for the purposes of assessment and reporting. Receivers are grouped based on common noise exposure to construction works.
PSNL	Project Specific Noise Level
Rating Background Level (RBL)	The Rating Background Level for each period is the median value of the average background values for the period over all of the days measured. There is an RBL value for each period (day, evening and night).
SWL	Sound Power Level. A measure of acoustic energy radiated from a noise source.
SPL	Sound Pressure Level. A measure of atmospheric pressure caused by a sound wave.

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1 Introduction

This section introduces the proposal and provides the context of the detailed design operational road traffic noise assessment and the detailed design multi-modal transport facility operational noise impact assessment.

1.1 Intersection proposal description

Transport for NSW proposes to upgrade the intersection of Jervis Bay Road and the Princes Highway in the vicinity of Falls Creek, NSW, located about 12 kilometres south of Nowra within the City of Shoalhaven local government area. The proposal would provide a grade separated through alignment for the Princes Highway with network access to Jervis Bay Road and Princes Highway provided via dual at grade roundabouts serviced by on and off ramps.

Key features of the proposal are shown in Figure 1 and would include:

- A new intersection between Jervis Bay Road and the Princes Highway, incorporating:
  - Realignment of the existing Princes Highway, including widening from two lanes to a four-lane divided highway (two lanes in each direction), with median separation using flexible safety barriers, providing an uninterrupted through alignment for the Princes Highway
  - An overpass bridge over Jervis Bay Road
  - An unsignalised single-lane at-grade double roundabout interchange providing:
    - Direct access from Jervis Bay Road and Princes Highway to the Princes Highway
    - Direct access from the Princes Highway to Jervis Bay Road and Princes Highway
  - Direct connection to existing properties and businesses at the Princes Highway
  - A connection from Willowgreen Road to Princes Highway
  - Tie-ins with the Princes Highway and with Jervis Bay Road
- Access road to service Princes Highway properties south-east of the intersection
- Shared user paths along Jervis Bay Road, connecting to the new bus bay and Jervis Bay Road and Old Princes Highway road shoulders
- Adjustments of drainage infrastructure and provision of new drainage infrastructure such as pit and pipe networks, culverts, open channels and retention basins
- Permanent water quality measures such as vegetated swales, bioretention swales and bioretention basins
- Adjustment, protection and relocation of existing utilities
- Other roadside furniture including safety barriers, signage, line marking, lighting and fencing
- A bus bay adjacent to the interchange, including kiss and ride car spots
- Establishment and use of temporary ancillary facilities during construction
- Property works including acquisition, demolition and adjustments to accesses, and at-property noise treatments.
- Rehabilitation of disturbed areas and landscaping.
- A multi-modal transport facility adjacent to the interchange, including bus bays, kiss and ride car spots and car parking, subject to funding availability.

A detailed description of the proposal is provided in Chapter 3 of the Review of Environmental Factors (REF) and Chapter 1 of the Response to Submissions Report.

1.2 Multi-modal transport facility description

Following further investigation, and as documented in the Submissions Report, Transport for NSW has considered inclusion of a multi-modal transport facility as part of the proposal. The multi-modal transport facility would be located southeast of the intersection adjacent to the eastern roundabout, wholly within the Proposal construction footprint. The facility would be accessed from the southbound on ramp via a one way road that would connect it to a new local road and then Jervis Bay Road. The design and layout of the facility is planned to include:

- Bus bay along local road, for around four buses
- Kiss and ride spots, for around five vehicles

- Car parking, for around 50 vehicles
- Overflow parking, for around 20 vehicles
- Bicycle racks, for around 30 bicycles
- Bus shelters, including seating for around 20 people
- Lighting.

The multi-modal transport facility features listed above have been used to inform this assessment.

Figure 1 Key proposal features

1.3 Purpose of this document

The purpose of this Operational Traffic Noise Report is to:

- Review the Noise and Vibration assessment undertaken for the environmental assessment to provide relevant data for input into the detailed design for noise mitigation
- Identify design changes since the completion of the operational noise assessment included within the environmental assessment for the project and any changes to parameters used for calculations or computer modelling for the operational noise assessment within the environmental assessment for the project
- Specify all the noise attenuation measures required for the project.

This report has been prepared in accordance with operational traffic noise assessment requirements of the TfNSW *Procedure for Preparing an* Operational Traffic and Construction Noise and Vibration Assessment Report, inclusive of an assessment of barrier height in accordance with the TfNSW Road Noise Policy.

A detailed construction and operational noise and vibration impact assessment (report S200327RP2F, dated 3 June 2021) was prepared for the proposal as part of the Princes Highway Upgrade Program Jervis Bay Road Intersection Upgrade Review of Environmental Factors (REF).

Since public display of the REF, the proposal has been subject to further review and refinement which has resulted in the consideration of two design changes that required further consideration to what was presented in the REF noise and vibration impact assessment report. This resulted in the provision of the addendum noise and vibration report which is appended to the Submissions Report (report S200327RP3C, dated 23 November 2021).

1.4 Summary of changes since the completion of the environmental assessment

Since the completion of the environmental assessment (and the release of the Submissions Report), a detailed design of the project has been completed. The detailed design process has resulted in some minor design changes that affect the output of the noise model as follows:

- The Submissions Report detailed the need for an interim two lane, two way connection to the existing Princes Highway at the southern end of the project. The design of this connection has now been completed and as such is now included in the noise model. The change results in traffic flows moving further to the east (and more in line with existing conditions), when compared to the Submissions Report.
- As part of ongoing design refinement, adjustments to road alignments, ramps and gradients have been undertaken to improve safety and constructability. Some changes were required to comply with the Austroads' Guide to Road Design. These adjustments have now been completed and included in the noise model.
- At the time of preparing the Submissions Report, the final location and layout of the multimodal transport facility were not yet detailed. The final layout and design of the facility has now been finalised and has been updated in the noise model

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2 Existing ambient noise environment

The area surrounding the proposal contains various noise and vibration sensitive receivers, including residential and non-residential buildings. The ambient acoustic environment was characterised as part of the environmental assessment. This information has been used to inform the detailed design as described below.

The existing ambient environment that surrounds the proposal intersection is typically dominated by the road traffic noise generated from Princes Highway and Jervis Bay Road. Noted noise generating sources during installation and collection of noise monitors included:

- Engine noise and tyre noise from vehicle passbys at highway speeds.
- Acceleration and deceleration at the existing intersection.

2.1 Noise monitoring

Noise monitoring was conducted in August, September and October 2020 to formulate noise criteria for construction noise management and operational road traffic noise validation. The locations of these monitoring sites are shown in Figure 2.

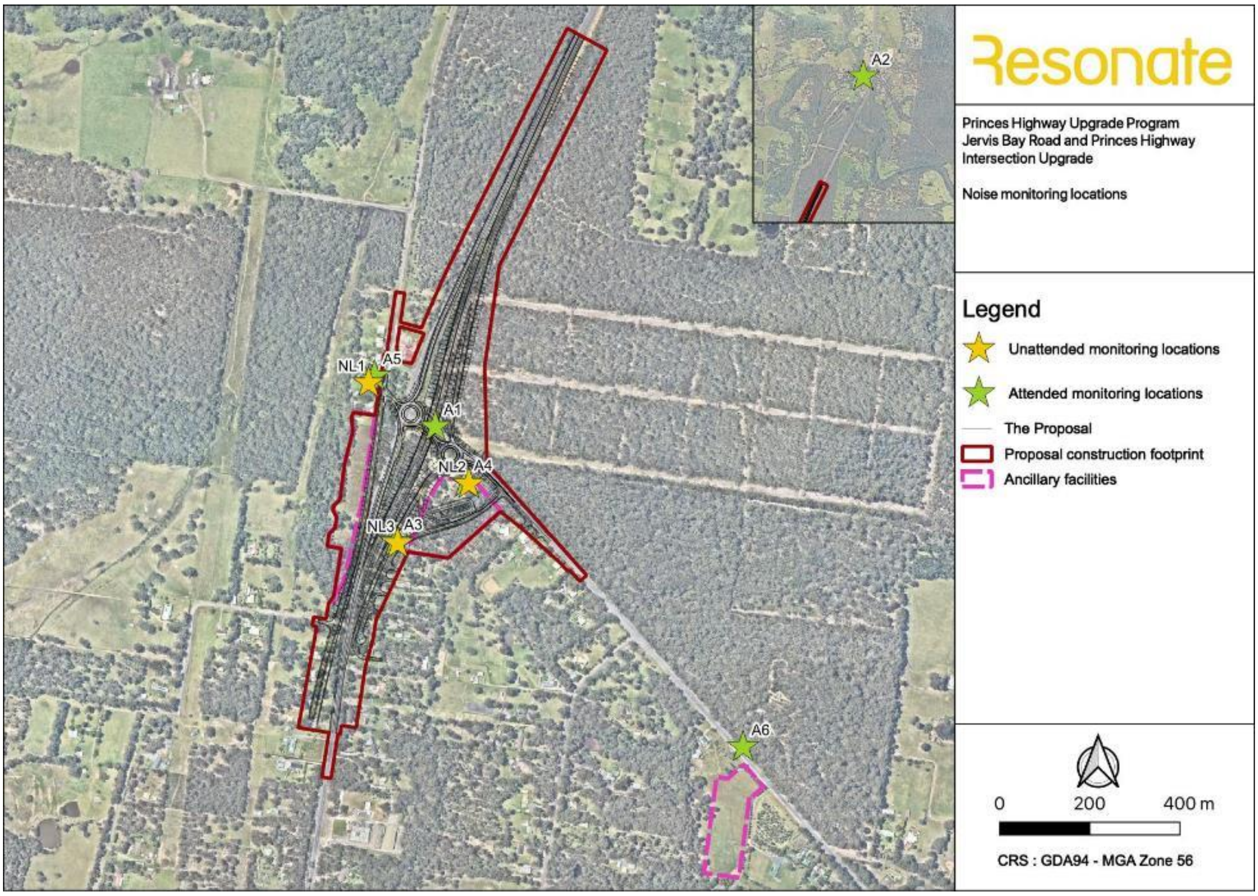

Figure 2 Noise monitoring locations

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2.1.1 Unattended noise monitoring

The purpose of unattended noise measurements was to obtain the local average noise level (the A-weighted average noise level measured the monitoring period, L_{Aeq}) and the background noise level (the A-weighted noise level which is exceeded for 90% of the time, L_{A90}) for sensitive receivers located in close proximity to the proposal. These measurements were undertaken for approximately three weeks.

Unattended noise monitoring was conducted at three locations adjacent to the proposed road alignment. Details of these locations are provided in Table 1 and an aerial view shown in Figure 2.

Table 1 Unattended noise monitoring locations

ID	Address	Measurement period	Position	Approx. setback distance to edge of nearest road, (metres)	Ambient Acoustic Environment
NL1[1]	136 Old Princes Highway	21/08/20 to 11/09/20 and 14/10/20 to 15/10/20	Fence located on the front yard (Free-field) 	24	• Princes Highway is the dominant noise source at this site. • Amplified Announcement system from nearby truck yard clearly audible. • Traffic flow from Princes Highway is consistent.
NL2[1]	24 Jervis Bay Road	21/08/20 to 11/09/20 and 14/10/20 to 15/10/20	Fence located on the front yard (Free-field) 	48	• Engine noise very audible at logger. • Cars and trucks stopping and starting on Jervis Bay Road. • During peak traffic periods a high volume of cars becomes congested at the intersection of Jervis Bay Road and Princes Highway.

ID	Address	Measurement period	Position	Approx. setback distance to edge of nearest road, (metres)	Ambient Acoustic Environment
NL3	D921 Princes Highway	21/08/20 to 11/09/20	Fence located on the front yard (Free-field) 	42	• Dominant noise source is road noise from Princes Highway. • Tyre on road noise more pronounced than engine noise. • Traffic flow constant and constant. • Semi frequent heavy vehicle passbys.

(1) Two loggers were set up at these sites. One logger to take $L_{Aeq\text{-}15\ minute}$ measurements to assess background noise levels and one logger to take $L_{Aeq\text{-}1\ second}$ measurements to assess maximum noise level events.

These locations were selected on the basis of their proximity to the proposal to best represent the existing background noise levels in the surrounding area.

The equipment used in the monitoring process were Rion NL-42 (serial numbers: 946977 and 946983), NL-32 (serial number: 451254), NL-22 (serial number: 862918) and NL-21 (serial number: 888235) sound level meters. All instruments carry current calibration certification. Calibration was checked before and after logging and the level of drift was less than 0.5 decibels (dB) in all cases.

2.1.2 Weather conditions

It is a requirement that noise data is captured during periods of favourable weather conditions avoiding adverse impacts of wind and rain on background noise levels. In order to assess weather conditions for the measurement period, half-hourly weather data was obtained from the Bureau of Meteorology weather observation station Nowra Ran Air Station AWS (Station number: 068072) approximately five kilometres from the proposal.

Noise data has been excluded from the processed results if:

- Rain was observed during a measurement period, and/or
- Wind speed exceeded 5 metres per second (18 kilometres per hour) at the measurement height of 1.5 metres above ground. Wind data obtained from the BOM is presented as the value at 10 metres above ground.

The BOM wind speed data obtained for this report was measured at a height of 10 metres above ground level. It is therefore necessary to apply a correction factor in order to estimate the wind speed at the height of the logger (1.5 metres).

The methodology to formulate a correction factor has been derived (Gowen et al 2004)[1]. The correction multiplier for the measured wind speed at 10 metres is derived by the following formula:

$$W_{1.5}=W_{10}\times\left(\frac{M_{1.5,cat}}{M_{10,cat}}\right)$$

where:

- $W_{1.5}$ = Wind speed at height of 1.5 metres
- W_{10} = Wind speed at height of 10 metres
- $M_{1.5,cat}$ = AS 1170 multiplier for receiver height of 1.5 metres and terrain category
- $W_{10,cat}$ = AS 1170 multiplier for receiver height of 10 metres and terrain category

Noise logging data that has been excluded due to adverse weather conditions is identified in the overall summary and daily noise logging graphs presented in Appendix B.

2.2 Unattended noise monitoring results

A summary of results from unattended noise surveys are presented in Table 2. The Rating Background Level (RBL) and overall average noise level (L_{Aeq}) are provided for each assessment period.

The RBL for each period is the median value of the average background values for the period over all the days measured. There is an RBL value for each period (day, evening and night).

The L_{Aeq} or equivalent noise level is the energy averaged noise level over the measurement period. Detailed daily noise logging graphs are provided in Appendix B.

Table 2 Unattended noise survey results summary

ID	Address	Noise Level, dB(A)							
		Day (7 am to 6 pm)		Evening (6 pm to 10 pm)		Night (10 pm to 7 am)		Day 15 hour (7am to 10pm)	Night 9 hour (10pm to 7am)
		RBL	L_{eq}	RBL	L_{eq}	RBL	L_{eq}	$L_{Aeq-15 hour}$	$L_{Aeq-9 hour}$
NL1	136 Old Princes Highway	51	58	44	54	30	53	57	53
NL2	24 Jervis Bay Road	50	59	40	56	30	53	59	54
NL3	D921 Princes Highway	51	63	39	58	30	57	62	57

[1] Gowen, T., Karantonis, P. & Rofail, T. (2004), *Converting Bureau of Meteorology wind speed data to local wind speeds at 1.5m above ground level*, Proceedings of ACOUSTICS 2004

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2.3 Attended noise monitoring

Attended noise monitoring was conducted during collection of the noise loggers. These measurements were conducted offset from the main alignment of Jervis Bay Road and Princes Highway intersection to understand the acoustic environment at these receivers.

The equipment used in the monitoring process was a Rion NL-52 (serial number: 820995) and a Bruel and Kjaer 2250 (serial number: 2506777) sound level meter. Calibration was conducted before and after the measurements and no calibrated drift was observed.

Table 3 provides a summary of operator attended noise measurement locations and measured levels. Note that multiple measurements were conducted at some locations during different periods of the day. Locations of attended measurements are shown in Figure 2 above.

Table 3 Operator-attended short-term noise measurement results

ID	Start time	Length (min:sec)	L_{eq}	L_{max}	L_{10}	L_{90}	Observations	Location description
			dB(A)					
A1	16:09	15:00	72	95	75	61	• 10 heavy passbys during measurement period. • L_{Amax} was controlled by heavy passbys. • Traffic turning onto the Princes Highway is constant and very slow moving.	• On the corner of Jervis Bay road and Princes Highway approximately two metres from the side of Jervis Bay Road and approximately 30 metres from the edge of the Princes Highway.
A2	12:00	15:00	62	77	64	57	• 26 Heavy passbys during measurement period. • L_{Amax} was controlled by heavy passbys. • Traffic was free flowing and consistent. • Helicopter passed out overhead was approximately 74 dB(A).	• Approximately 20 metres north of Parma road and 80 metres from the Princes Highway.
A3	14:05	15:00	61	70	64	54	• 19 heavy passbys during measurement period. • L_{Amax} was controlled by heavy passbys. • Road noise consistent, most noise originated from tyre on road noise.	• Approximately one metre from the westmost façade of the property located at D921 Princes Highway.
A3	19:17	15:00	58	71	62	44	• Five heavy passbys during measurement period. • L_{Amax} was controlled by heavy passbys. • Road noise consistent, most noise originated from Tyre on road noise.	• Approximately one metre from the westmost façade of the property located at D921 Princes Highway

ID	Start time	Length (min:sec)	L_{eq}	L_{max}	L_{10}	L_{90}	Observations	Location description
			dB(A)					
A4	14:46	15:00	59	70	63	53	• 10 heavy passbys during measurement period. • L_{Amax} was controlled by heavy passbys. • Engine noise audible as trucks stop and start as they turn onto Princes Highway. Traffic stopping and starting continuously.	• Located at 26 Jervis Bay Road approximately 50 metres south west of Jervis Bay Road and 180 metres south east of Princes Highway.
A4	18:53	15:00	57	76	61	46	• Two heavy passbys during measurement period.	• Located at 26 Jervis Bay Road approximately 50 metres south west of Jervis Bay Road and 180 metres south east of Princes Highway.
A5	15:15	15:00	59	74	62	55	• 22 heavy passbys during measurement period. • L_{Amax} was controlled by heavy passbys. • PA system from nearby truck yard clearly audible. .	• Measurement taken at front gate of 136 Old Princes Highway.
A5	15:49	15:00	59	73	61	55	• 21 heavy passbys during measurement period. • L_{Amax} was controlled by heavy passbys.	• Measurement taken at front gate of 136 Old Princes Highway.
A6	12:38	15:00	72	101	76	67	• 13 heavy passbys during measurement period. • L_{Amax} was controlled by heavy passbys. • Traffic sporadic but consistently flowing.	• Measurement taken on road side opposite 98 Jervis Bay Road approximately six metres from the road.
A6	18:46	15:00	72	102	77	61	• Two heavy passbys during measurement period. • L_{Amax} was controlled by heavy passbys. • Lower volume of trucks relative to daytime measurements.	• Measurement taken on road side opposite 98 Jervis Bay Road approximately six metres from the road.

ID	Start time	Length (min:sec)	L_{eq}	L_{max}	L_{10}	L_{90}	Observations	Location description
			dB(A)					
A6	22:00	15:00	65	95	67	48	• One heavy passbys during measurement period. • L_{Amax} was controlled by heavy passby. • Very quiet, faint cicada noise audible from across the road. Crackling and animal movements audible from forest. • Traffic passbys are very rare.	• Measurement taken on road side opposite 98 Jervis Bay Road approximately six metres from the road side.

2.4 Noise catchment areas and sensitive receivers

As it is not feasible to determine background noise levels for each receiver individually, noise monitoring is undertaken for groups of receivers based on them having a common exposure to the same construction works. To facilitate the assessment of noise impacts from the proposal, noise sensitive receivers within the study area have been allocated within a Noise Catchment Area (NCA). The NCA extends as far back from the proposal as is required to ensure all areas of lower background noise are included. This ensures that the determined mitigation measures would address impacts at all receivers.

The NCA and noise sensitive receiver locations are shown in Appendix A.

One NCA has been identified for the noise sensitive areas surrounding the proposal due to the similarity in ambient noise environment measured as detailed in Section 4.1. The summary and location of the NCA for the proposal is detailed in Table 4.

Table 4 Noise catchments areas

ID	Receiver types	Minimum distance from the nearest road to the worst affected receiver
NCA1	Low density residential / rural area. Scattered commercial and child care receivers. Princes Highway and Jervis Bay Road are within this NCA. Covers entire proposal construction footprint and surroundings.	20 metres

3 Operational road traffic noise assessment

3.1 Operational road traffic noise criteria

Noise criteria are assigned to sensitive receivers using Transport for NSW's Noise Criteria Guideline (NCG, NSW Government 2006). The NCG provides guidance on how to implement the NSW Environmental Protection Authority's (EPA) *NSW Road Noise Policy* (RNP, Department of Environment, Climate Change and Water NSW 2011). The assessment timeframes for the criteria are in the year of opening and 10 years after opening.

3.1.1 Residential receivers

Residences may be assigned new, redeveloped, transition zone or relative increase criteria depending on how the proposal influences noise levels. For each facade of the residence the most stringent applicable criteria have been used in the assessment. Applicable criteria for residential land uses are presented in Table 5.

It is noted that the area surrounding the proposal is currently sparsely developed and has a soundscape associated with a low level of urban development. The receivers assessed within this assessment have been based upon the receivers that have been noted using high-resolution aerial images from September 2020. The receivers should be reviewed at the detailed design stage.

Criteria are based on the road development type a residence may be affected by due to the proposal. In some instances, residences may be exposed to noise from both new and redeveloped roads.

The criteria for noise sensitive receivers are presented per facade for each building in Appendix E.

Table 5 NCG criteria for residential land uses

Road category	**Type of proposal/land use**	**Assessment criteria – dB**	
		Day (7am–10pm)	**Night (10pm–7am)**
Freeway/ arterial/ sub-arterial roads	1. Existing residences affected by noise from new freeway/arterial/sub-arterial road corridors	$L_{Aeq(15hour)}$ 55 (external)	$L_{Aeq(9hour)}$ 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	$L_{Aeq(15hour)}$ 60 (external)	$L_{Aeq(9hour)}$ 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	$L_{Aeq(1hour)}$ 55 (external)	$L_{Aeq(1hour)}$ 50 (external)

3.1.2 Relative increase criterion

The relative increase criterion is designed to account for large increases in traffic noise levels that may impact residential receivers that currently experience low levels of traffic noise. This is achieved by having a criterion that is set 12 dB above the existing traffic noise levels during the daytime or night-time periods. The minimum noise level for existing road traffic noise is 30 dB(A) as per NSW Environmental Protection Authority's (EPA) *NSW Road Noise Policy* (RNP, Department of Environment, Climate Change and Water NSW 2011) and is used as the minimum level for the relative increase criterion. The relative increase criteria are as shown in Table 6.

Table 6 Relative increase criteria for residential land uses

Road category	Type of proposal/development	Total traffic noise level increase	
		Day (7am–10pm)	Night (10pm–7am)
Freeway/arterial/ sub-arterial roads and transitways	New road corridor/ redevelopment of existing road/land use development with the potential to generate additional traffic on existing road.	Existing traffic $L_{Aeq(15hour)}$ + 12 dB (external)	Existing traffic $L_{Aeq(9hour)}$ + 12 dB (external)

The relative increase criterion has not been implemented in this report.

3.1.3 Cumulative limit

The cumulative limit applies when the total noise level in the design build year is 5 dB(A) or more above the NCG criterion. The cumulative limit does not apply where the proposal roads (new road or redeveloped section of road) add less than 2 dB(A) to the total noise level at a given facade for the design build year.

3.1.4 Acute

Where predicted noise levels at residential receivers exceed 65 dB(A) $L_{eq,15h}$ (daytime) or 60 dB(A) $L_{eq,9h}$ (night-time), then road traffic noise levels are considered to be 'acute'. Residential receivers exposed to 'acute' noise levels as part of a road proposal are considered for mitigation regardless of the increase associated with the proposal, as long as the dominant noise at the receiver is due to the proposal.

3.1.5 Non-residential land uses

The criteria for other non-residential sensitive receivers relevant to the proposal are summarised in Table 7.

Table 7 Proposal specific NCG criteria for non-residential sensitive land uses

Existing sensitive land use	Assessment criteria – dB(A)		Additional considerations
	Day (7am–10pm)	Night (10pm–7am)	
School classrooms	$L_{Aeq(1hour)}$ 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 from the 'maximum' levels shown in Australian Standard 2107:2016 (Standards Australia 2016).
Child care facilities	Sleeping rooms $L_{Aeq(1hour)}$, 35 (internal) Indoor play areas $L_{Aeq(1hour)}$, 40 (internal) Outdoor play areas $L_{Aeq(1hour)}$ 55 (external)	–	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. 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.

(2) Land use developers must meet internal noise goals set for sensitive developments alongside busy roads as identified in the Infrastructure SEPP.

3.1.6 Assessing eligibility for consideration of noise mitigation measures

The Transport for NSW's Noise Mitigation Guideline (NMG) (Roads and Maritime 2015) provides guidance in managing and controlling road traffic generated noise and describes the principles to be applied when reviewing noise mitigation. The NMG recognises that the criteria recommended by the NCG are not always practicable and that it is not always feasible or reasonable to expect that they should be achieved.

The NMG notes that the most effective way of minimising noise from vehicles and traffic is to control vehicle noise at the source. Where source measures are not practical, or do not provide sufficient noise reduction, additional methods are required to reduce levels to within acceptable margins. Such additional methods may include the use of quieter pavement surfaces, noise barriers and/or consideration of at-property treatment.

The NMG provides three triggers where a receiver may qualify for consideration of noise mitigation (beyond the adoption of road design and traffic management measures). These are:

- The predicted Build (with the proposal) noise level exceeds the NCG controlling criterion and the noise level increase due to the proposal (i.e. the noise predictions for the Build minus the No Build) is greater than two dB(A),or
- The predicted Build noise level is five dB(A) or more above the criteria (exceeds the cumulative limit) and the receiver is significantly influenced by proposal road noise, regardless of the incremental impact of the proposal, or

- The noise level contribution from the proposal is acute (daytime $L_{Aeq(15hour)}$ 65 dB(A) or higher, or night-time $L_{Aeq(9hour)}$ 60 dB(A) or higher) then it qualifies for consideration of noise mitigation even if noise levels are dominated by another road.

The eligibility of receivers for consideration of additional noise mitigation is determined before the benefit of additional noise mitigation (quieter pavement and noise barriers) is included. The requirement for the proposal is to provide reasonable and feasible additional mitigation for these eligible receivers to meet the NCG controlling criterion. If the NCG criterion cannot be satisfied with quieter pavement and noise barriers, then the receiver may be eligible for consideration of at-property treatment.

The RNP (Department of Environment, Climate Change and Water NSW 2011) includes a review of internal sleep arousal research but does not provide noise goals. The RNP concludes that there appears to be insufficient evidence to set new indicators for potential sleep disturbance due to road traffic noise. Guidance for considering sleep disturbance due to maximum noise levels is provided in Practice Note iii of the Environmental Noise Management Manual (RTA 2001). The sleep disturbance assessment (guided by Practice Note iii of the Environmental Noise Management Manual (RTA 2001)) does not influence the degree of mitigation required but is used to rank and prioritise design options and noise mitigation strategies.

3.2 Operational Noise Assessment

3.2.1 Road traffic noise modelling methodology

A computer noise model of the existing scenario and the proposed upgraded road was developed using SoundPLAN V8.2 noise prediction software. SoundPLAN implements the UK Calculation of Road Traffic Noise (CoRTN) algorithms for the prediction of road traffic noise. The CoRTN methodology is an accepted road traffic noise prediction method in NSW.

The NCG requires the following operational road traffic noise scenarios to be modelled in order to assess the potential noise impact from the proposal:

- Existing Scenario based on current (measured) road traffic flows, current (measured) noise levels and road alignments. The purpose of this scenario is to validate the noise model to ensure that the model is predicting sufficiently accurate noise levels within the proposal area
- Future Year of Proposal Opening Scenario (2025) – Build (with the proposal) Scenario incorporating traffic flow predictions for the year of proposal opening and the proposed road design
- Future Year of Proposal Opening Scenario (2025) – No Build (without the proposal) Scenario incorporating traffic flow predictions for the year of proposal opening assuming that the road proposal did not proceed
- Future 10 Years after Proposal Opening Scenario (2035) – Build (with the proposal) Scenario incorporating traffic flow predictions for a time horizon ten years after proposal opening and the proposed road design
- Future 10 Years after Proposal Opening Scenario (2035) – No Build (without the proposal) Scenario incorporating traffic flow predictions for a time horizon ten years after proposal opening assuming that the road proposal did not proceed
- Properties that would be acquired as part of the proposal have been assumed to be demolished and therefore not included in the Build scenarios.

The proposal is not expected to generate additional traffic at this intersection, rather increase capacity to reduce current congestion and delays. Hence, the traffic volumes between the No Build (without the proposal) and Build (with the proposal) scenarios remains similar with the exception of a portion of the traffic being relocated onto the on and off ramps.

3.2.2 Road traffic noise modelling parameters

The road traffic noise modelling parameters assumed for each scenario are presented in Table 8.

Table 8 Road traffic noise modelling parameters

Parameter	Detailed design noise model
Vehicle speeds	• Existing posted speeds have been applied to the No-Build (without the proposal scenarios) • Build (with the proposal) speeds as follows: – Ramps – 80 kilometres per hour – Roundabouts – 50 kilometres per hour – Mainline – 100 kilometres per hour – Jervis Bay Road – 80 kilometres per hour • Existing non-project roads as per existing posted speeds.
Traffic volumes	• Refer to Appendix C
Proposal study area	• Roads that influence the noise environment surround the proposal have been included for a minimum distance of 600 metres from the proposal alignment
Vegetation	• Large amount of closely spaced vegetation was noted throughout the site during the noise monitoring. Vegetation has been incorporated in the validation noise model for the purposes of calibrating the noise model. Vegetation has not been applied to the assessment scenarios.
Road traffic noise prediction algorithm	• Calculation of Road Traffic Noise (CoRTN) 1988, using the CoRTN NSW prediction method.
'Appropriate adjustments for NSW noise descriptors'	• The 15 hour and 9 hour traffic flows have been divided by 15 and 9 respectively • The CoRTN $L_{10,1hr}$ predictions have been converted to $L_{eq,15h}$ and $L_{eq,9h}$ by subtracting 3 dB from the result for each period • A 3 dB difference between L_{10} and L_{eq} levels is widely accepted.
Three source heights	• 0.5 metres above ground for car exhausts, car engines, car tyres (single source string) • 0.5 metres above ground for truck tyres • 1.5 metres above ground for truck engines • 3.6 metres above ground truck exhausts
Source corrections	• 25 per cent for tyre noise • 60 per cent for engine noise • 15 per cent for exhaust noise
Pavement corrections	• 0 dB(A) for Densely Graded Asphalt (DGA) applied to the car and truck tyre string for the new and upgraded sections of road. • +4 dB(A) for chip seal applied to new local road for private residents (cul-de-sac).
Receiver heights	• 1.5 metres above ground for ground floor receiver • 4.5 metres above ground for first floor receiver • or as adjusted for elevated ground floor situations based on site observations.
Ground absorption factor	• 75 per cent for grassed land and • 50 per cent over built up areas • 0 per cent for water surface or other highly reflective surfaces.
Search radius	• 1.5 kilometres for predicted levels • 3 kilometres for grid noise maps.
Grid spacing and height above ground	• 20 metre grid • 1.5 metres above ground.
Model validation	• Refer to validation against measured data in Section 3.2.3.
Safety factor	• N/A

Parameter	Detailed design noise model
Facade reflection correction	• + 2.5 dB(A) at 1 metre from facade (single point receiver calculations) • Noise contour plots (grid noise maps) are presented as free field noise levels (i.e. with no + 2.5 dB(A) facade reflection correction).
Standard Australian condition correction based on ARRB	• -1.7 dB(A) for standard correction at 1 metre from facade • -0.7 dB(A) for free field measurements.

3.2.3 Road traffic noise model validation

A noise model of the proposal area was developed and was based on the existing road alignments and the existing traffic volumes and speeds that were measured as part of the traffic counting survey. The parameters used for the validation model are presented in Table 9.

Table 9 Validation model parameters

Correction	Comment	Correction
Existing Roads	Dense graded asphalt or equivalent	+ 0 dB
Proposed Roads	Dense graded asphalt or equivalent	+ 0 dB
Truck Corrections	As per Table 8	-
ARRB Correction	1 metre from facade	-1.7 dB
ARRB Correction	Free Field	-0.7 dB
Facade Correction	For predictions at 1 metre from building facade	+ 2.5 dB
Vehicle speeds	Refer to Appendix C.	-
Traffic volumes	Refer to Appendix C.	-

The predicted noise levels were compared to measured noise levels at unattended noise monitoring locations as presented in Table 10.

Table 10 Road traffic noise model validation

Ref	Location	Daytime road noise level, dB(A)			Night-time road noise level, dB(A)		
		Measured	Predicted	Difference	Measured	Predicted	Difference
NL1[1]	136 Old Princes Highway	56.6	58.5	1.9	53	51.8	-1.2
NL2[1]	24 Jervis Bay Road	58.8	60.5	1.7	53.6	53.5	-0.1
NL3[2]	D921 Princes Highway	61.6	61.8	0.2	56.9	55.2	-1.7
Median difference				1.7			-1.2

(1) Levels shown for this monitoring location are free-field.

(2) Levels shown for this monitoring location are facade corrected.

A comparison of the modelled versus measured noise levels showed the following:

- A median prediction of +1.7 dB during the daytime period
- A median prediction of -1.2 dB during the night-time period.

The predicted and measured road traffic noise levels agree within a median tolerance of ±2 dB, which is considered a suitable level of accuracy for road traffic noise proposals.

Due to the good correlation between the measured and predicted noise levels, no additional calibration factors were required. Densely packed vegetation is a feature in the area surrounding the proposal as noted during the installation and collection of the noise monitoring. Research has found the vegetation does have an effect on road traffic noise of an approximate reduction between two dB - three dB through 10 metres – 20 metres as noted in “The effects of vegetation on road traffic noise” (J. Peng, S. Kean, and R. Bullen, 2014). For the purposes of validation, the effects of the noise attenuation through the vegetation noted in the proposal environment has been incorporated into the noise model.

3.2.4 Predicted noise levels without mitigation

Operational road traffic noise levels have been predicted in the form of noise contours assessed at 1.5 metres above the ground level for the proposal opening scenario (2025) and 10 years after (2035) for both daytime (7 am–10 pm) and night-time (10 pm–7 am) time periods.

Operational road traffic noise contours are presented in Appendix D.

Noise levels have also been predicted at every facade of every floor for each potentially affected noise sensitive receiver. The predicted noise levels for each location are tabulated in Appendix E. Appendix E presents the following:

- Build (with the proposal) and No-Build (without the proposal)
- Noise levels for each scenario
- An assessment of noise sensitive receiver locations at which noise mitigation should be considered.

The predicted noise levels shown in Appendix E indicate the proposal would not substantially change traffic noise levels in most locations with almost all (99%) sensitive receivers predicted to experience changes in operational road traffic noise levels of less than 2 dB(A). Four sensitive receivers; two residential buildings and two buildings associated with one child care facility along the proposal alignment have triggered for consideration of noise mitigation. The location of the receivers for consideration of noise mitigation is shown in Figure 3.

Figure 3 Buildings considered for noise mitigation as a result of the detailed design

3.2.5 Changes in buildings considered for noise mitigation since Submissions Report

Table 11 describes changes in buildings considered for noise mitigation since the Submissions Report. Figure 4 shows buildings considered for noise mitigation during the Submissions Report design for comparison.

Table 11 Changes in buildings considered for noise mitigation since Submissions Report

Address (Receiver ID)		Discussion
Detailed Design	Submissions Report	
D925 Princes Highway (216)	D925 Princes Highway (196)	This receiver is no longer considered for mitigation due to minor changes in the road alignment resulting in a slight drop in design year noise levels which means that the receiver does not increase by more than 2 dB over existing.

Address (Receiver ID)		Discussion
Detailed Design	**Submissions Report**	
D970B Princes Highway (222)	D970B Princes Highway (123)	This receiver is no longer considered for mitigation due to the development of the design of an interim two lane/two way design connection to the existing Princes Highway. This has resulted in the road alignment moving approximately 30 metres away from the property when compared with the Submissions Report, therefore slightly dropping the design year noise levels.
D965 Princes Highway (408)	D965 Princes Highway (95)	This receiver now triggers for consideration of mitigation due to the development of the design of an interim two lane/two way design connection to the existing Princes Highway. This has resulted in the road alignment moved approximately 30 metres closer to the property when compared to the Submissions Report, therefore slightly increasing design year noise levels. In addition, the southern extent of the southern tie-in extends marginally further to the south compared to the Submissions Report concept design. This results in receiver 408 triggering for consideration of mitigation when compared to the Submissions Report.

Figure 4 Submissions Report design and buildings considered for mitigation for comparison

3.2.6 Operational road traffic noise mitigation

The Noise Mitigation Guideline (NMG, Roads and Maritime 2015) provides guidance on how to determine whether a noise sensitive receiver qualifies for the consideration of mitigation and the type of mitigation that would be suitable.

The NMG requires that mitigation measures be investigated in order of preference as follows:

- Road design and traffic management
- Quieter pavement surfaces
- Noise mounds and walls
- At-property treatments

Low noise pavement

The proposal has been modelled assuming DGA would be used as the wearing surface for the new or upgraded roads of the proposal. Although DGA is not a low noise pavement, DGA is a quieter pavement when compared to standard spray seal variants. Low Noise Pavement by definition in Transport for NSW's *Noise Model Validation Guideline* is a pavement that has a surface correction of minus 2 dB(A).
Quieter pavement surfaces may be considered where groups of four or more receivers are predicted to exceed the criteria and the posted speeds are to be greater than 70 kilometres per hour to be considered reasonable to implement.
Exceedances were predicted at only two residential buildings and two buildings associated with one child care facility. Therefore, the application of low noise pavement has been determined to not be reasonable for the Proposal.

Noise barriers

Noise barriers such as noise walls or mounds are considered where there are four or more closely spaced receivers that are identified to be impacted by the road proposal.

Of the four buildings that have triggered for the consideration of mitigation, there are no groupings of closely spaced receivers that would benefit from the consideration of a noise barrier as a form of noise mitigation. Further, receivers along the Proposal have property access via Princes Highway and therefore the implementation of noise barriers is restricted.

Noise barriers have been determined to not be reasonable or feasible options for noise mitigation for this proposal based on the location of the exceeding receivers.

At-property treatments

At-property treatments are considered where dwellings remain above the NCG criteria after all other noise mitigation measures have been explored. The NCG's noise criteria are external noise goals, and building treatment only reduces noise levels inside a dwelling. Therefore, any architectural treatments would be designed to achieve internal noise levels had the proposal complied with the NCG criteria externally.

At-property treatments are generally limited to acoustic treatment of the building elements and the installation of acoustic screen walls close to the receiver where they also protect outdoor living spaces. Architectural treatments have been recommended at residual criteria exceedance locations behind noise barriers or at locations where source or path mitigation measures did not allow for the compliance with the relevant criteria to be achieved.

The Transport for NSW At-Receiver Noise Treatment Guideline recommends treatments that may comprise of the following:

- Ventilation systems that meet Building Code of Australia fresh air requirements with the windows and doors shut
- Upgraded windows, glazing and solid core doors on the exposed facades of substantial structures (e.g. masonry or insulated board cladding each with sealed underfloor)

- Upgraded window or door seals
- The sealing of wall vents
- The sealing of the underfloor below the bearers and appropriately treating sub-floors ventilation
- Roof insulation
- The sealing of eaves.

Typically, these architectural treatments could be applied based upon the residual exceedance of the NCG criteria.

The applicable architectural treatments per package type would be as per Appendix B – "*Deemed to comply mitigation packages (Based on R_w +C_{tr})"* of the At-Property Noise Treatment Guideline.

The table describing the predicted noise levels and potential treatment packages is attached as Appendix E to this report for reference. Of the four buildings requiring at property treatments, one building is eligible for a Package 1 at-property treatment option (5 dB(A) exceedance) and three buildings are eligible for a Package 2 at-property treatment option (6-8 dB(A) exceedance).

The final scope of the at-property architectural treatments should be finalised after a property inspection, to determine the suitability of the proposed treatments. It should be noted that some architectural treatments may already exist at some receivers.

3.3 Summary of mitigation measures

Results of the noise modelling revealed that two residential receivers and one child care facility would experience operational road traffic noise exceedances due to their proximity to the proposal alignment.

To manage these exceedances, multiple noise mitigation options were assessed including, low noise pavement, noise barriers and at-property treatments. The following was determined:

- The use of low noise pavement is not considered reasonable due to the low number and spread-out locations of exceedances.
- Noise barriers are not considered feasible in this location due to the existing access routes for the exceeding properties and the low number of exceedances.
- At-property treatments have been determined to be the only reasonable and feasible option for noise mitigation for this proposal due to the limitations of other forms mitigations.

At-property treatments may be considered for treatment at the four sensitive receiver locations under the Transport for NSW Noise Mitigation Policy principles that communities should receive reasonable and equitable outcomes, whereby noise mitigation shall be evaluated and installed where feasible and reasonable.

3.4 Assessment of maximum noise levels

3.4.1 Assessment basis

The RNP (Department of Environment, Climate Change and Water NSW 2011) includes discussion of current knowledge regarding sleep disturbance due to road traffic noise, and states 'despite intensive research, the triggers for and effects of sleep disturbance have not yet been conclusively determined.' Current research does indicate that the main acoustic characteristic that influences sleep disturbance is the emergence (eg magnitude) and number of noisy events heard distinctly above the background level. The RNP suggests that intermittent noisy events, such as truck passbys, could be assessed on the basis of emergence events determined as the difference between L_{Amax} levels and the steadier L_{Aeq} or L_{A90} levels.

The RNP makes reference to Practice Note iii of the ENMM[2] which suggests that the $L_{eq,9h}$ road traffic noise guidelines should sufficiently account for sleep disturbance impacts except where both of the following conditions are met:

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

Section 5.4 of the RNP further states that:

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

3.4.2 Assessment methodology

The results of the one second noise monitoring that was conducted for the proposal have been used for the purposes for this maximum noise level assessment. This monitoring was conducted on both Princes Highway (NL1) and Jervis Bay Road (NL2).

Figure 5 presents the number of maximum noise level events during the night-time period, measured at the unattended one second noise monitoring locations NL1 and NL2, over the course of the monitoring period.
The highest measured maximum noise level event, unaffected by weather, was 73 dB(A) along Princes Highway and 79 dB(A) along Jervis Bay Road. This demonstrates the existing receivers along Princes Highway have exceedances of the L_{Aeq}+15 dB criteria of up to 5 dB, whereas receivers along Jervis Bay Road have exceedances of up to 10 dB.

Average maximum noise levels events during logging were 67 dB(A) at NL1 (136 Old Princes Highway) which is offset by approximately 80 metres from Princes Highway and 67 dB(A) at NL2 (24 Jervis Bay Road) at a distance of approximately 60 metres from Jervis Bay Road and approximately 160 metres from the Princes Highway. The typical offset distance for receivers adjacent to the proposal roads is approximately 75 metres.

The noise monitoring for the purposes of the maximum noise level assessment was conducted over the course of a 24-hour period to fully encompass an entire night-time period. Over the course of the 9-hour night-time monitoring period, 21 maximum noise levels events were recorded at 24 Jervis Bay Road and 11 events were recorded at 136 Old Princes Highway.

[2] RTA Environmental Noise Management Manual

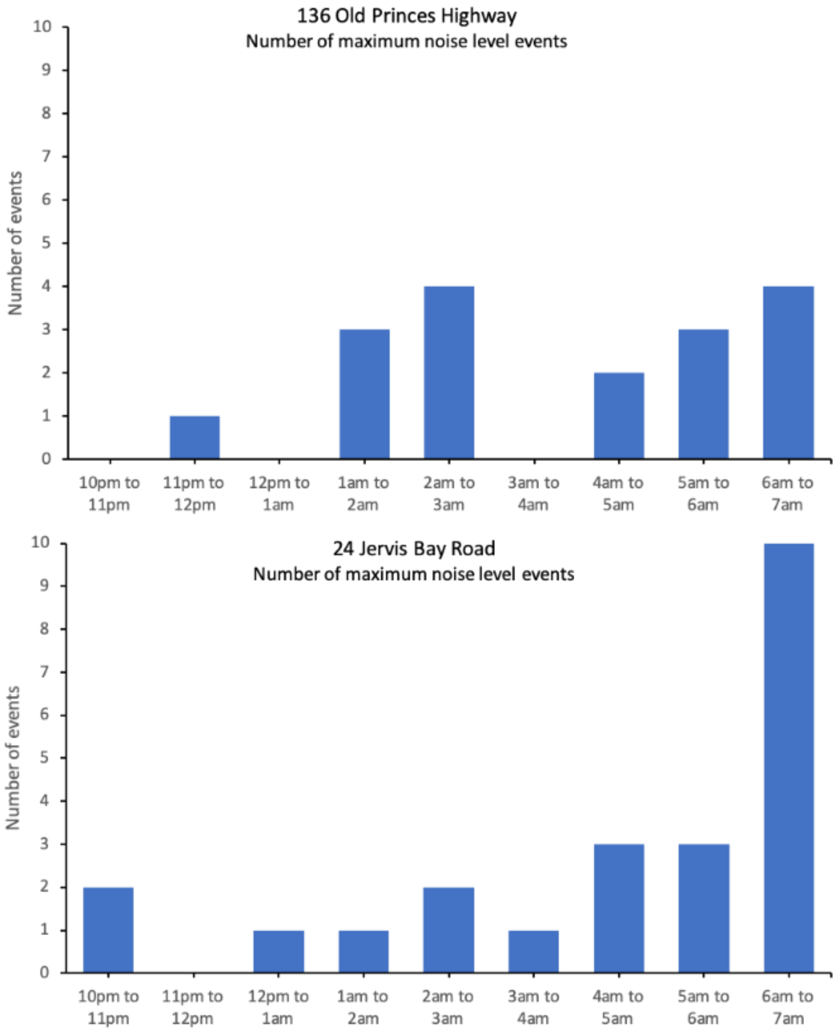


Figure 5 Maximum noise level exceedances based upon the unattended monitoring at 136 Old Princes Highway and 24 Jervis Bay Road.

A summary of exceedance events detected during the logging can be seen in Table 12 below.

Table 12 Number of maximum noise level events

Time Period	24 Jervis Bay Road (Number of Maximum noise level events)		136 Old Princes Highway (Number of maximum noise level events)	
	L_{Aeq1hr} + 15 dB & > 65 dB(A)	Maximum Recorded SPL - dB(A)	L_{Aeq1hr} + 15 dB & > 65 dB(A)	Maximum Recorded SPL - dB(A)
10pm to 11pm	2	71	0	65
11pm to 12pm	0	67	1	68
12pm to 1am	1	71	0	65
1am to 2am	1	72	3	73
2am to 3am	2	72	4	73
3am to 4am	1	74	0	66
4am to 5am	3	73	2	69
5am to 6am	3	75	3	69
6am to 7am	10	79	4	73
9-hour period	21	79	13	73

Given that this proposal is, in effect, relocating the traffic to be in closer proximity to the nearby receivers, it is expected that the order of the maximum noise level exceedance would increase. The proposal alignment would bring traffic noise from the Princes Highway from approximately 80 metres distance from the receiver located at 136 Old Princes Highway (NL1) to approximately 40 metres. The proposal alignment would increase the exposure of the receivers along Old Princes Highway to traffic travelling along the on and off ramps.

The daytime and night-time L_{Aeq} noise level predictions presented in Appendix D and Appendix E do not consider the transient acceleration and deceleration as a constant posted speed has been assumed to predict the worst-case daytime and night-time noise levels. The maximum noise levels do consider the transient noise level events generated by the acceleration and deceleration of vehicles and the most notable location where this may occur, compared to the existing alignment, is at the new roundabouts located adjacent to the overpass of Princes Highway.

The inclusion of the unsignalised single lane roundabouts would mean that passing vehicles would slow or potentially stop and then accelerate into and out of the roundabout. The deceleration and acceleration of vehicles is a contributing factor to maximum noise level events. While acceleration and deceleration are noted acoustic properties of the site due to the existing intersection, the proposal incorporates two roundabouts of which the south-east roundabout is located closer to sensitive receivers. This may cause an increase in magnitude of maximum noise level events to nearby sensitive receivers.

A study conducted by the UK Noise Association titled ‘Speed and Road Traffic Noise’ (Mitchell, P., 2009) found that acceleration has a more significant impact on noise levels than braking during deceleration. It found that on average, for moderate acceleration, maximum noise levels may increase by approximately 2 dB and by approximately 4.5 dB for heavy acceleration.

Using the maximum measured night-time event of 79 dB(A), an approximate increase of 11 dB would be expected when the proposal is operating 40 metres from receivers along Old Princes Highway with maximum events expected to reach 90 dB(A).

The receivers located along Jervis Bay Road are also predicted to experience increased maximum noise levels by the relocation of the proposal alignment and the inclusion of the roundabouts. Using the maximum measured sound pressure level of 79 dB(A) at 40 metres distance from Jervis Bay Road, an approximate increase of 8 dB(A) with an estimated sound pressure level of 87 dB(A) is predicted at these receivers.

Therefore, noise levels are expected to increase for receivers located adjacent to the proposal along Jervis Bay Road and Princes Highway. The number of maximum noise level events is unlikely to increase between the Build and No-Build scenarios as the proposal would not increase the volumes of traffic.

The *Environmental Noise Management Manual* (RTA, 2001) states that maximum noise assessment should be used as a tool to help prioritise and rank mitigation strategies, but should not be applied as a decisive criterion in itself. Hence, Transport for NSW may consider the maximum noise levels in prioritising options of the applicable architectural treatment packages for receivers that qualify for consideration of mitigation.

4 Multi-modal transport facility

4.1 Existing ambient acoustic environment

The existing ambient acoustic environment for the proposal including background noise monitoring and identification of noise and vibration sensitive receivers is described in detail in Section 1.3 and Appendix D.

Unattended background noise monitoring was conducted at three locations as part of the operational road traffic noise assessment. The measured background noise levels at each location were found to be very similar and was controlled by road traffic noise from Jervis Bay Road and Princes Highway. The noise monitoring location (NL3) in closest proximity to the multi-modal transport facility was used as the basis for setting the operational noise assessment criteria. The background noise levels at NL3 were slightly lower than NL2 during the evening period resulting in a more stringent assessment criterion. Therefore, noise monitoring location NL3 was used as the basis for this assessment.

The nearest potentially affected noise sensitive receivers to the proposed multi-modal transport facility together with the noise monitoring location are shown on Figure 6. The nearest noise sensitive receivers are located within approximately 40 metres of the proposed multi-modal transport facility and are classified as residential.

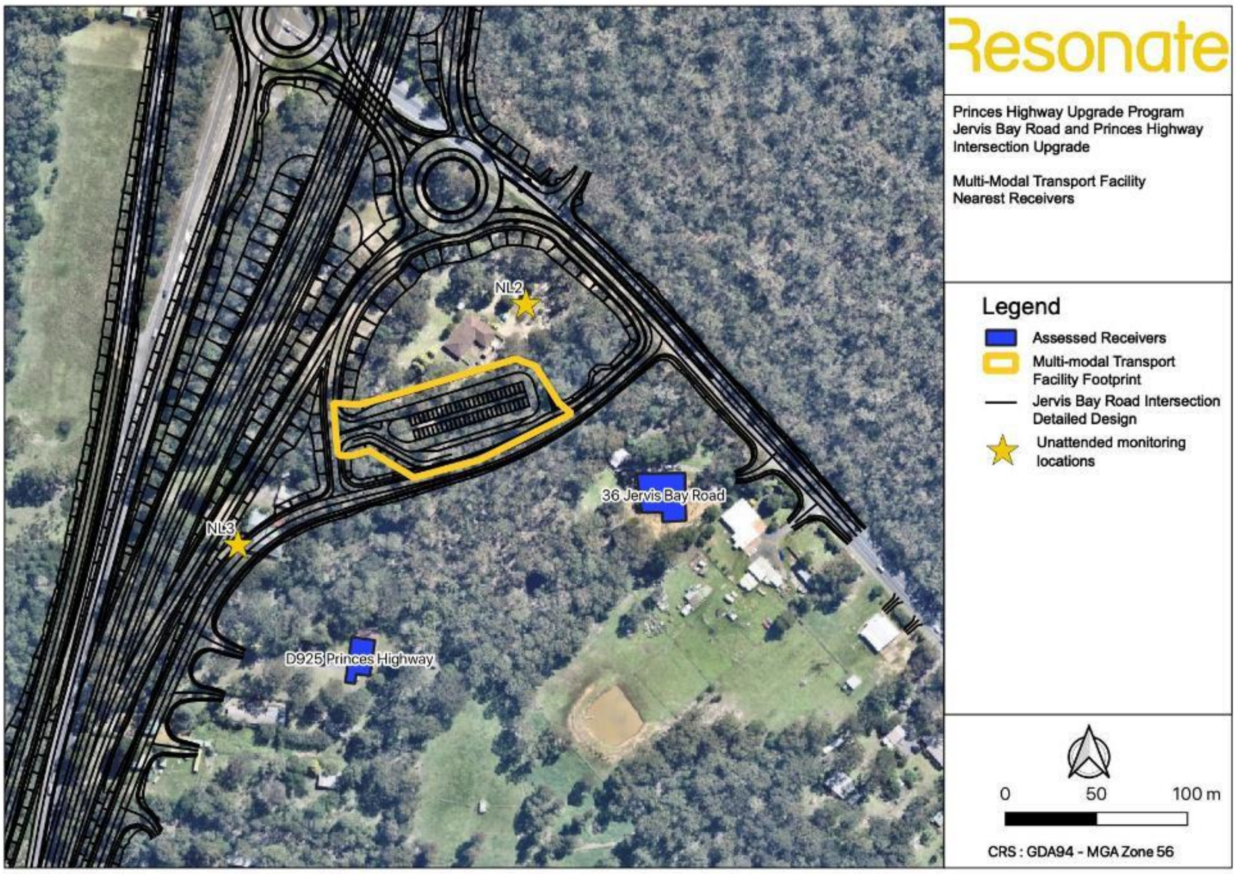


Figure 6 Noise sensitive receivers and noise monitoring location

4.2 Operational noise assessment criteria

Noise emissions from the operation of the proposed multi-modal transport facility should comply with the requirements of the NSW EPA's Noise Policy for Industry (NPI). The NPI is applicable to the multi-modal transport facility because it is considered a fixed facility as distinct from public roads which are subject to the requirements of the NSW Road Noise Policy.

4.2.1 Noise Policy for Industry

The NPI sets two separate noise criteria to meet desirable environmental outcomes:

- **Intrusiveness** – steady-state noise from the site should be controlled to no more than 5 dB(A) above the background noise level in the area. In this case, the steady-state L_{eq} noise level should not exceed the RBL measured for different time periods in the environment. The intrusiveness criterion is measured over a 15-minute period.
- **Amenity** – amenity criteria are set based on the land use of an area. It requires noise levels from new industrial noise sources to consider the existing industrial noise level such that the cumulative effect of multiple sources does not produce noise levels that would significantly exceed the amenity criteria. As the amenity criteria is provided in the NPI document as a period level i.e. between 7am and 6pm for daytime activities, 3 dB is added to the amenity noise level to approximately represent a 15-minute period for direct comparison to the intrusiveness criterion. For new noise sources 5 dB must be subtracted from the amenity criterion to minimise noise creep over time as more noise sources are introduced to an area.

Both intrusiveness and amenity criteria are derived from the unattended noise survey and the NPI. They are then compared with each other and the lowest and most stringent noise level is adopted to represent the project specific noise criterion for the relevant time period; daytime, evening and night-time.

Table 13 presents the Project Specific Noise Level (PSNL) for the assessment of operational noise from the multi-modal transport facility for residential land uses for the daytime, evening and night-time periods.

Table 13 NPI noise emission criteria for residential land uses

Description	Derivation of NPI Project Specific Noise Levels		
	Daytime (7am – 6pm)	Evening (6pm – 10pm)	Night-time (10pm – 7am)
Rating background level (RBL)	51	39	30
Intrusive criterion (RBL + 5 dB(A))	56	44	**35**
Acceptable Noise Level (ANL) Suburban[1]	55	45	40
Amenity Criterion (ANL – 5dBA + 3dBA)	**53**	**43**	38
NPI PSNL for residential land uses[2]	**53**	**43**	**35**

(1) A suburban classification has been adopted for the site, described as an area that has local traffic with characteristically intermittent traffic flows or with some limited commerce or industry. This area often has the following characteristic: evening ambient noise levels defined by the natural environment and human activity.

(2) The PSNL are the lowest of the Intrusive criterion and the Amenity criterion for new sources for each time period and are shown as bold text in the table.

4.2.2 Sleep disturbance

As stated in the NPI the potential for sleep disturbance from maximum noise level events generated by premises during the night-time period needs to be considered. The term "sleep disturbance" is considered to be both awakenings and disturbance to sleep stages.

To evaluate potential sleep disturbance or awakening issues associated with the construction of the Project the NPI screening method has been adapted as follows. There is limited potential for sleep disturbance or awakening issues to occur, where:

- The predicted project night-time noise level ($L_{eq,\ 15\ minute}$ in dB(A)) at any residential receptor remains below 40 dB(A) (or the prevailing night-time background noise level plus 5 dB(A)), whichever is the greater.
- The predicted project night-time noise level (L_{max} in dB(A)) at any residential receptor remains below 52 dB(A) (or the prevailing night-time background noise level plus 15 dB(A)), whichever is the greater.

4.3 Multi-modal transport facility operational noise assessment

4.3.1 Noise modelling methodology

A 3D (computer simulated) noise model of the proposed multi-modal transport facility was developed using SoundPLAN V8.2 noise prediction software.

The CONCAWE environmental noise prediction algorithm was implemented within SoundPLAN to predict $L_{Aeq(15\text{-}minute)}$ noise levels at the nearest most potentially affected noise sensitive receivers (refer to Figure 6) in accordance with the requirements of the NPI. CONCAWE is an industrial noise prediction algorithm commonly accepted by government regulatory bodies in NSW.

The noise model was developed to consider the following key noise prediction parameters:

- The noise source sound power levels relating to the operation of light vehicles and buses within the multi-modal transport facility (refer to Table 14 for a list of sound power levels assumed for each noise source).
- The location of nearby sensitive receivers.
- The location, quantity and indicative operational pattern of each noise source.
- The distance between the noise sources and sensitive receivers captured by the 3D representation of the multi-modal transport facility, surrounding terrain and sensitive receivers within the noise model.
- Worst case source to receiver wind direction was assumed with a wind speed of 2 metres per second with a Category F temperature inversion representative of noise enhancing weather conditions as per the requirements of the NPI.
- The bus source noise levels were modelled at an average height of 1.5 metres above ground. This takes into account the height of the engine noise component and the average height of the exhaust outlets noting that buses that may operate within the multi-modal transport facility are likely to have exhaust outlet heights ranging between 1 metre and 2.2 metres above ground level.

Table 14 Sound power levels

Noise source	$L_{eq,SWL}$ dB(A)
Car door closure	83
Car Idling	80
Car pass-by	84
Bus Passby	101
Bus Idling	91

Noise modelling scenarios

The NPI requires predicted noise levels from the proposed multi-modal transport facility to be assessed against the daytime, evening and night-time criteria as described in Section 4.2. The noise assessment scenarios described below have been developed on the basis of the features described in Section 1.2.

The scenarios represent the indicative operational scenario during each of the daytime, evening and night-time periods. For context, it should be noted that during the evening and night-time period, the primary use of the facility would be between 6 pm and 7 pm and 6 am and 7 am. It should be noted that the NPI requires assessment relative to a 15-minute time horizon. It is for this reason that the number of cars and buses are described on a per 15-minute basis and are relative to the indicative capacity of the multi-modal transport facility. At present, no services are expected between 7pm and 6am.This is summarised again below:

- Bus bays, for around four buses
- Kiss and ride spots, for around five vehicles
- Car parking, for around 50 vehicles
- Overflow parking, for around 20 vehicles

In order to develop the operational scenarios for noise modelling purposes, the following assumptions were made:

- The key noise sources are:
  - Bus movements into and out of the site and buses idling at the bus bays.
  - Vehicle movements into and out of the site split between the car park and kiss and ride spots.
  - Other noise sources relating to car park activities (doors closing, engine starts).
- For the daytime period:
  - Car park: Approximately 50% of the car park capacity would be operational in a 15-minute period (approximately 12 cars would be in operation on the internal site roads and approximately 12 cars would be in operation in the parking bays). Cars would idle for up to 30 seconds each when in the car parking area.
  - Kiss and ride: five bays would be turned over twice within the 15-minute timeframe. Cars would idle in the kiss and ride bays for up to 60 seconds each per 15-minute period. Two door or boot slams per drop off is assumed.
  - Buses: Four buses would be operational on the site during the 15-minute timeframe. When stopped at the bus bays, each bus would idle for up to one minute before the engine is switched off or the bus departs.
- For the evening period:
  - Car park: Approximately 25% of the car park capacity would be operational in a 15-minute period (approximately six cars would be in operation on the internal site roads and approximately six cars would be in operation in the parking bays). Cars would idle for up to 30 seconds each when in the car parking area.
  - Kiss and ride: three bays would be turned over twice within the 15-minute timeframe. Cars would idle in the kiss and ride bays for up to 60 seconds each per 15-minute period. Two door or boot slams per drop off is assumed.
  - Buses: Two buses would be operational on the site during the 15-minute timeframe. When stopped at the bus bays, each bus would idle for up to one minute before the engine is switched off or the bus departs.
- For the night-time period:
  - Car park: Approximately 25% of the car park capacity would be operational in a 15-minute period (approximately six cars would be in operation on the internal site roads and approximately six cars would be in operation in the parking bays). Cars would idle for up to 30 seconds each when in the car parking area.
  - Kiss and ride: three bays would be turned over twice within the 15-minute timeframe. Cars would idle in the kiss and ride bays for up to 60 seconds each per 15-minute period. Two door or boot slams per drop off is assumed.
  - Buses: Two buses would be operational on the site during the 15-minute timeframe. When stopped at the bus bays, each bus would idle for up to one minute before the engine is switched off or the bus departs.

At the time of preparing the Submissions Report, the final location and layout of the multimodal transport facility were not yet detailed. The final layout and design of the facility has now been finalised and has been updated in the noise model. The final design has been used to develop the predicted noise levels as detailed in Section 4.3.2

4.3.2 Predicted noise levels

$L_{Aeq(15\text{-}minute)}$ noise levels have been predicted at the nearest most potentially affected noise sensitive receivers as described in Section 4.1. Compliance with the NPI criteria at these sensitive receivers would allow for compliance to be achieved at all other sensitive receivers that are located further from multi-modal transport facility. A sensitivity analysis of the impact of the proposed overflow car park was conducted and did not have an influence on the overall noise levels at the sensitive receiver locations due to the higher noise levels and closer proximity of the bus bays and main car park.

Noise level predictions for the nearest noise sensitive receivers are presented in Table 15. Operational $L_{Aeq15minute}$ noise contours for the daytime, evening and night-time scenarios are presented in Appendix F.

The NPI recommends to assess the noise impact at the reasonable most-affected point on or within the residential property boundary. For this assessment, it is suggested that the property boundary would be the preferred assessment location for when residents are likely outside for activities. This would be during the daytime and evening period. During night-time it is likely that residents would be inside the residence for most of the time. Therefore, the building façade may be considered a reasonable assessment location during the night-time period.

Table 15 Predicted noise levels without mitigation

Sensitive Receiver (ID)	Criteria (Daytime / Evening / Night-time) $L_{eq(15\text{-}minute)}$ dB(A)	Predicted Noise Level (Daytime / Evening / Night-time) $L_{eq(15\text{-}minute)}$ dB(A)	Compliance (Daytime / Evening / Night-time)
		Without Mitigation	
D925 Princes Highway (216)	53 / 43 / 35	35 / 31 / (30) [1]	Yes / Yes / (Yes) [1]
36 Jervis Bay Road (404)	53 / 43 / 35	42 / 39 / (33)[1]	Yes / Yes / (Yes) [1]

(1) Noise levels and compliance status shown in brackets reflects noise levels at the facade for the night-time noise assessment.

A review of Table 15 shows the following:

- Compliance with the established NPI criteria is predicted at the nearest most potentially affected receivers during the daytime, evening and night-time periods where noise levels are assessed at the façade during the night-time period.
- The NPI states that "the project noise trigger level and maximum noise levels are to be assessed at the reasonably most-affected point on or within the residential property boundary or, if that is more than 30 metres from the residence, at the reasonably most-affected point within 30 metres of the residence". The façade of the dwelling is considered to be the reasonably most-affected location during the night-time period when people would typically be inside sleeping.
- On this basis, further consideration of mitigation is not required.

Sleep disturbance

The highest L_{Amax} noise level was predicted to be 55 dB(A) at 36 Jervis Bay Road. This relates to bus movements into and out of the bus bays. This exceeds the sleep disturbance screening criterion of 52 dB(A). A review of the background noise logger data shows that the existing maximum noise levels during the night-time period in this area range between 65 dB(A) and more than 75 dB(A) and noting the relatively low number of bus movements during the night-time period, further noise mitigation may not be reasonable given existing noise levels.

5 Conclusion

Resonate Consultants Pty Ltd has been engaged by Arcadis Pty Ltd to prepare a detailed operational road traffic noise assessment for the Princes Highway Upgrade Program, Jervis Bay Road Intersection Upgrade.

Due to the location of the redeveloped road alignment, several potentially affected noise sensitive receivers have been identified. Unattended noise surveys and operator-attended noise measurements were undertaken to properly characterise the prevailing ambient and road traffic noise within the investigation area. The operational road traffic noise impact has been assessed based upon criteria derived from the existing noise environment, the proposed road design.

Operational road traffic noise assessment

Operational road traffic noise levels have been assessed in accordance with the requirements of the NCG. Results of the operational road traffic noise modelling determined that four sensitive receivers; two residential buildings and two buildings associated with one child care facility, along the proposal alignment would experience operational road traffic noise criteria exceedances due to their proximity to the revised proposal alignment.

At-property architectural treatments have been determined as the preferred form of noise mitigation for this proposal. Low noise pavement has not been determined as reasonable due to the spread-out locations and low number of buildings exceeding the criteria. Noise barriers have not been determined as reasonable or feasible due to private access requirements along Princes Highway.

Multi-modal transport facility

Operational noise levels were predicted at the nearest noise sensitive receivers to the proposed site. Compliance with the NPI criteria at these locations would allow for compliance to be achieved at all locations.

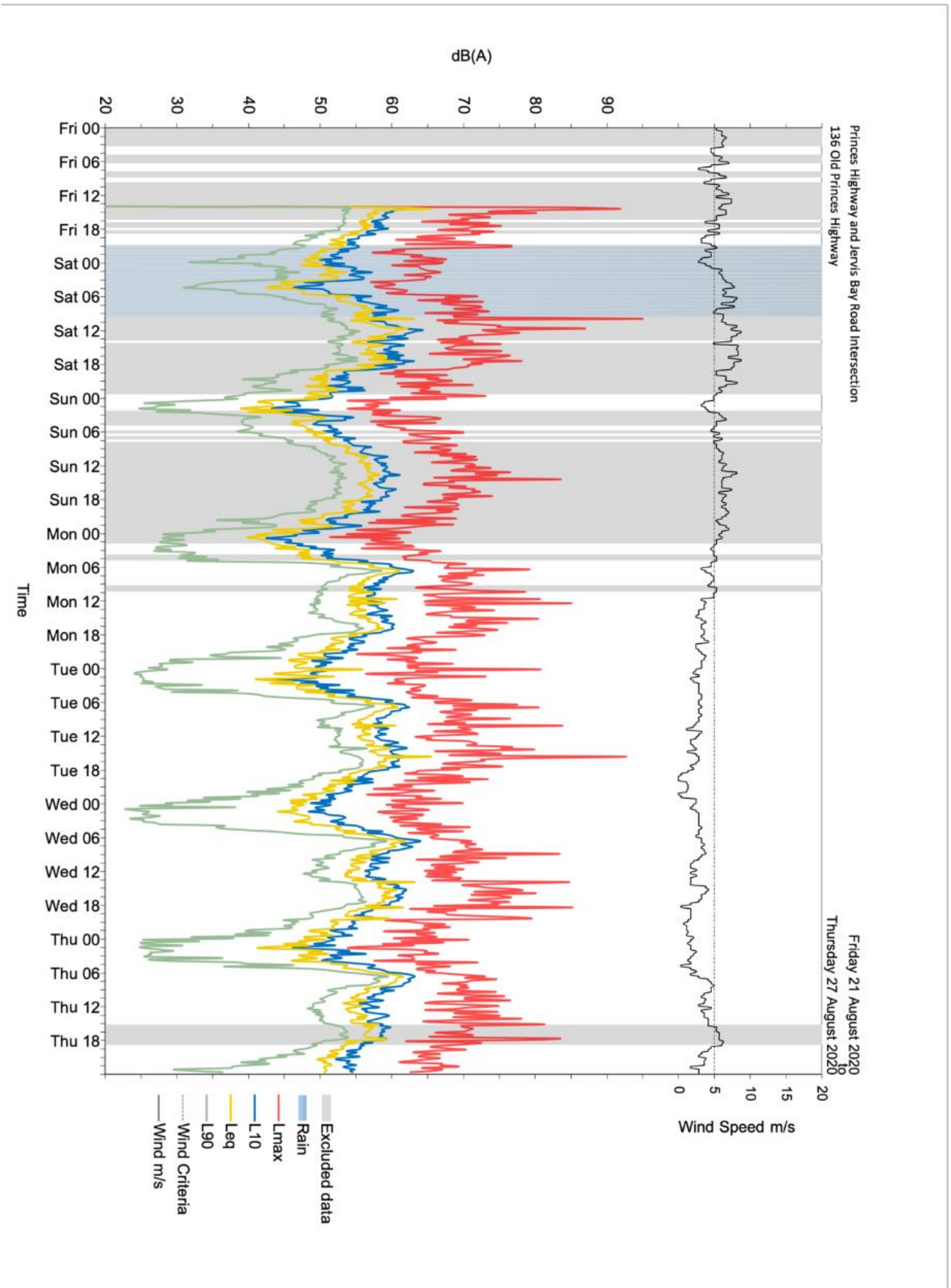
Compliance with the established NPI criteria is predicted at the nearest most potentially affected receivers during the daytime, evening and night-time periods when assessed at the property boundary during the daytime and evening periods and at the façade during the night-time period.

The highest L_{Amax} noise level was predicted to be 55 dB(A) at 36 Jervis Bay Road. This relates to bus movements into and out of the bus stops. This exceeds the sleep disturbance screening criterion of 52 dB(A). A review of the background noise logger data shows that the existing maximum noise levels during the night-time period in this area range between 65 dB(A) and more than 75 dB(A) and noting the relatively low number of bus movements during the night-time period, further noise mitigation would not be reasonable given existing noise levels.

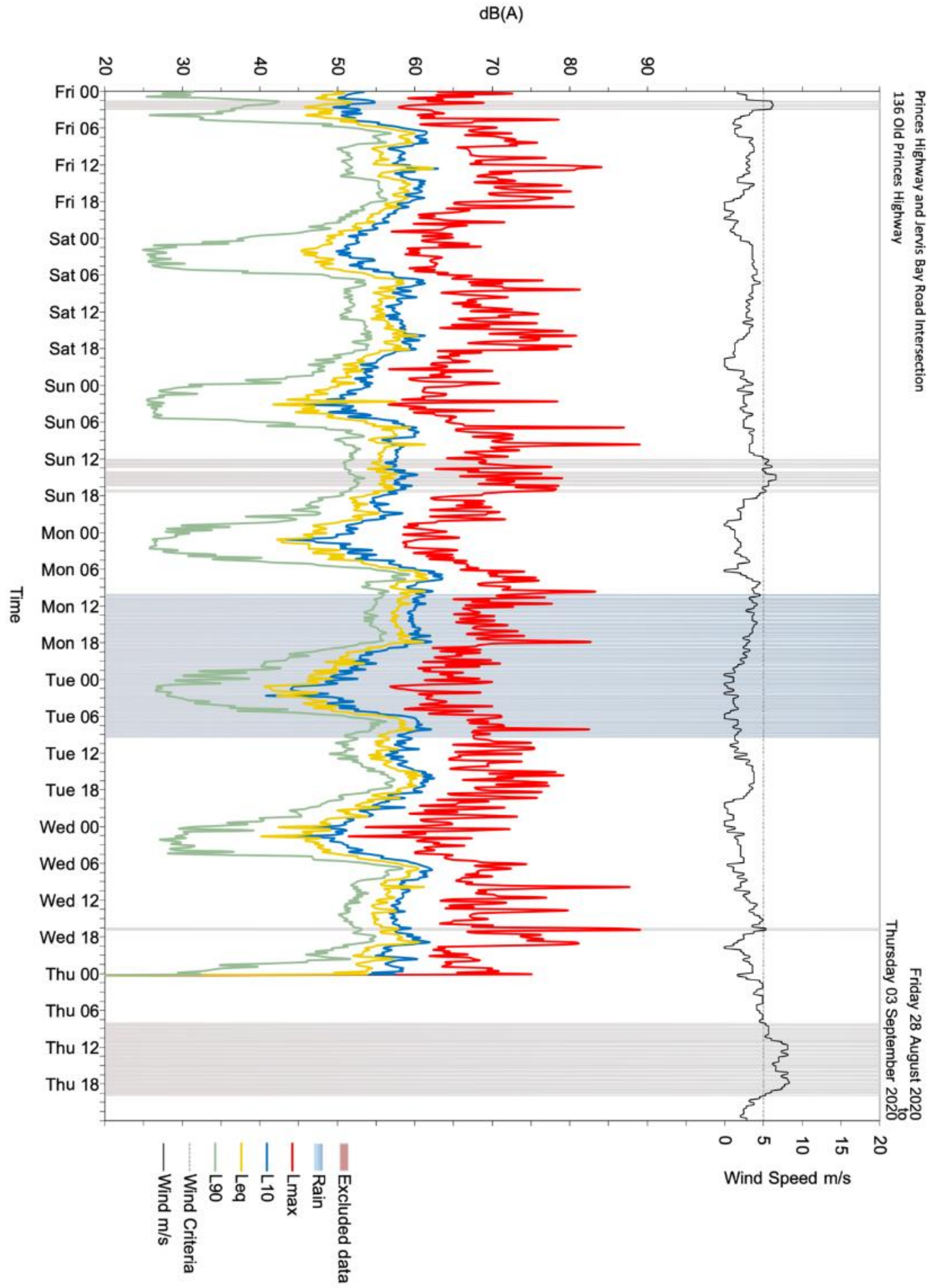
Appendix A – Noise catchment area and noise sensitive receiver locations

Appendix B – Noise monitoring results

Address/location	136 Old Princes Highway
Logger ID	NL1
Measurement location	Next to drive way located in front yard
Measurement details	L_{Aeq} 15 minute measurements and L_{Aeq} 1 second unattended measurements including; L_{A90}, L_{Aeq}, L_{A10} and L_{Amax},
Logging period	L_{Aeq} 15 minute logging: Friday 21st August 2020 to Friday 11th September 2020 L_{Aeq} 1 second logging: Thursday 10th September to Friday 11th September.
General Description	Measured noise levels were controlled by adjacent traffic on Jervis Bay Road. Periods of wind (exceeding 5 metres per second) and rain have been noted and excluded from the determination of measured noise levels. High noise levels were experienced, specifically speaker announcements due to the commercial premises located to the north.


Princes Highway and Jervis Bay Road Intersection
136 Old Princes Highway
Friday 21 August 2020
to
Thursday 27 August 2020
dB(A)
Time
Wind Speed m/s
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

Resonate


Princes Highway and Jervis Bay Road Intersection
136 Old Princes Highway
Friday 28 August 2020
to
Thursday 03 September 2020
dB(A)
20
30
40
50
60
70
80
90
Time
Fri 00
Fri 06
Fri 12
Fri 18
Sat 00
Sat 06
Sat 12
Sat 18
Sun 00
Sun 06
Sun 12
Sun 18
Mon 00
Mon 06
Mon 12
Mon 18
Tue 00
Tue 06
Tue 12
Tue 18
Wed 00
Wed 06
Wed 12
Wed 18
Thu 00
Thu 06
Thu 12
Thu 18
0
5
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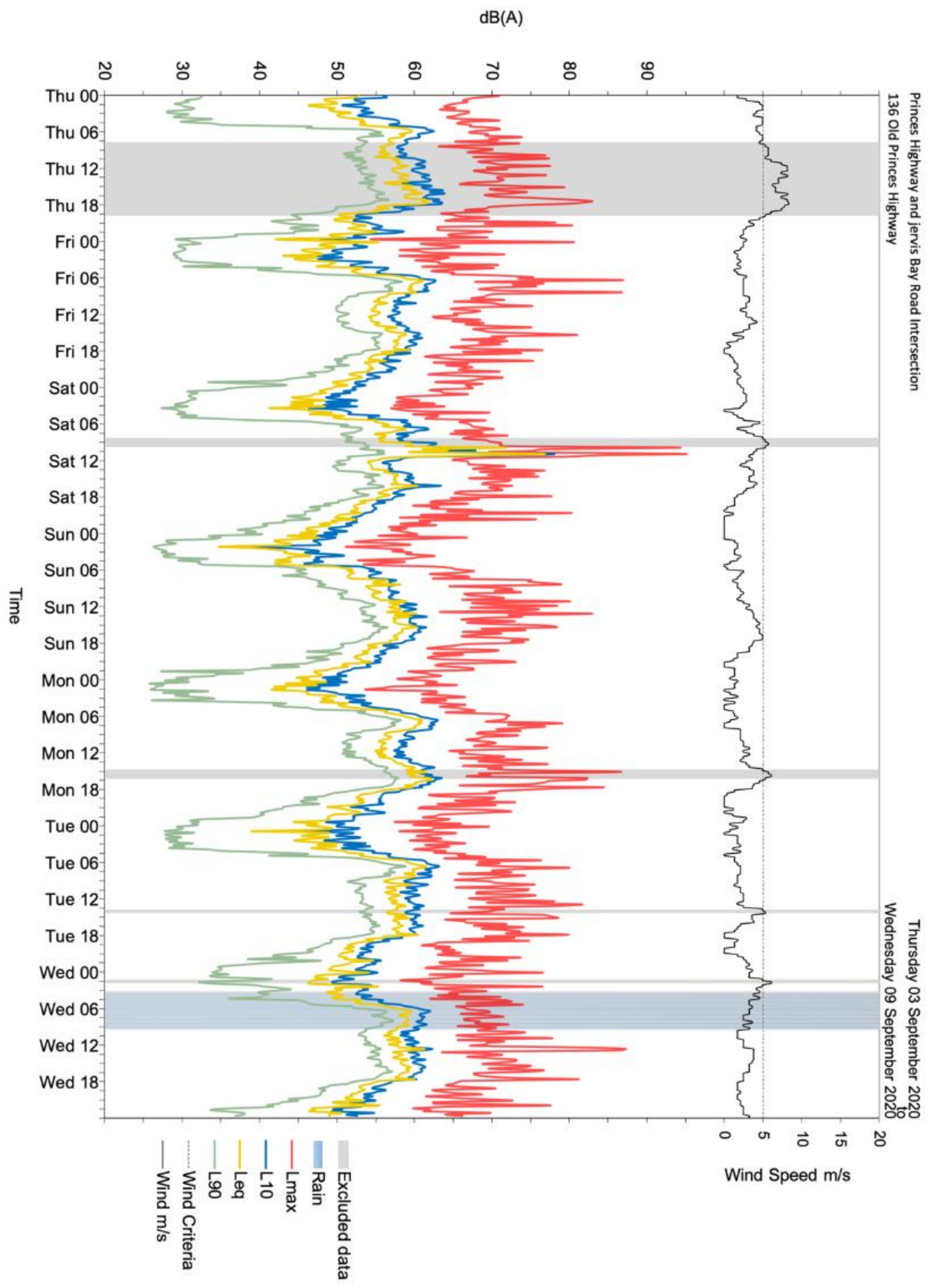
15
20
Wind Speed m/s
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s


Princes Highway and Jervis Bay Road Intersection
136 Old Princes Highway
Thursday 03 September 2020
to
Wednesday 09 September 2020
dB(A)
Time
Wind Speed m/s
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

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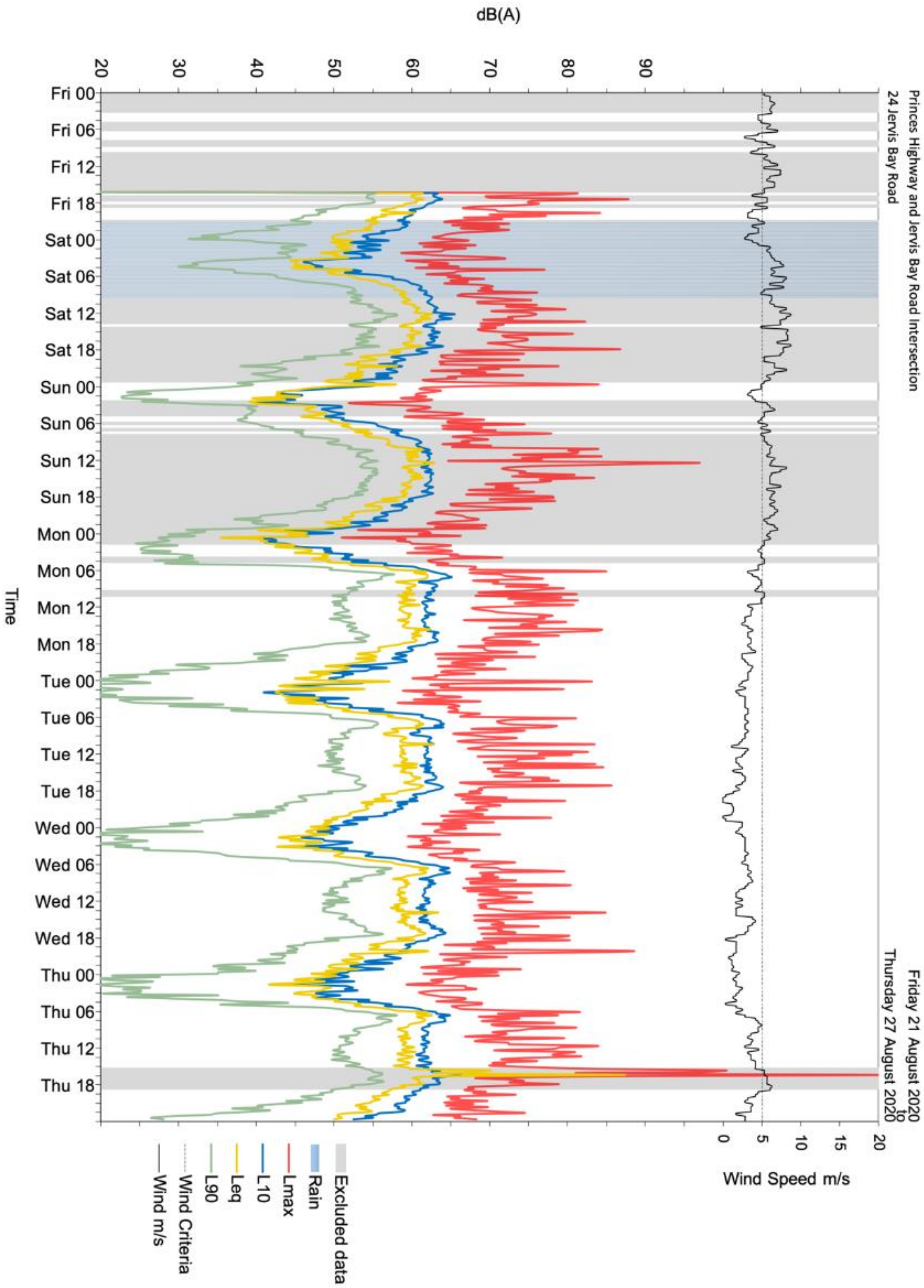
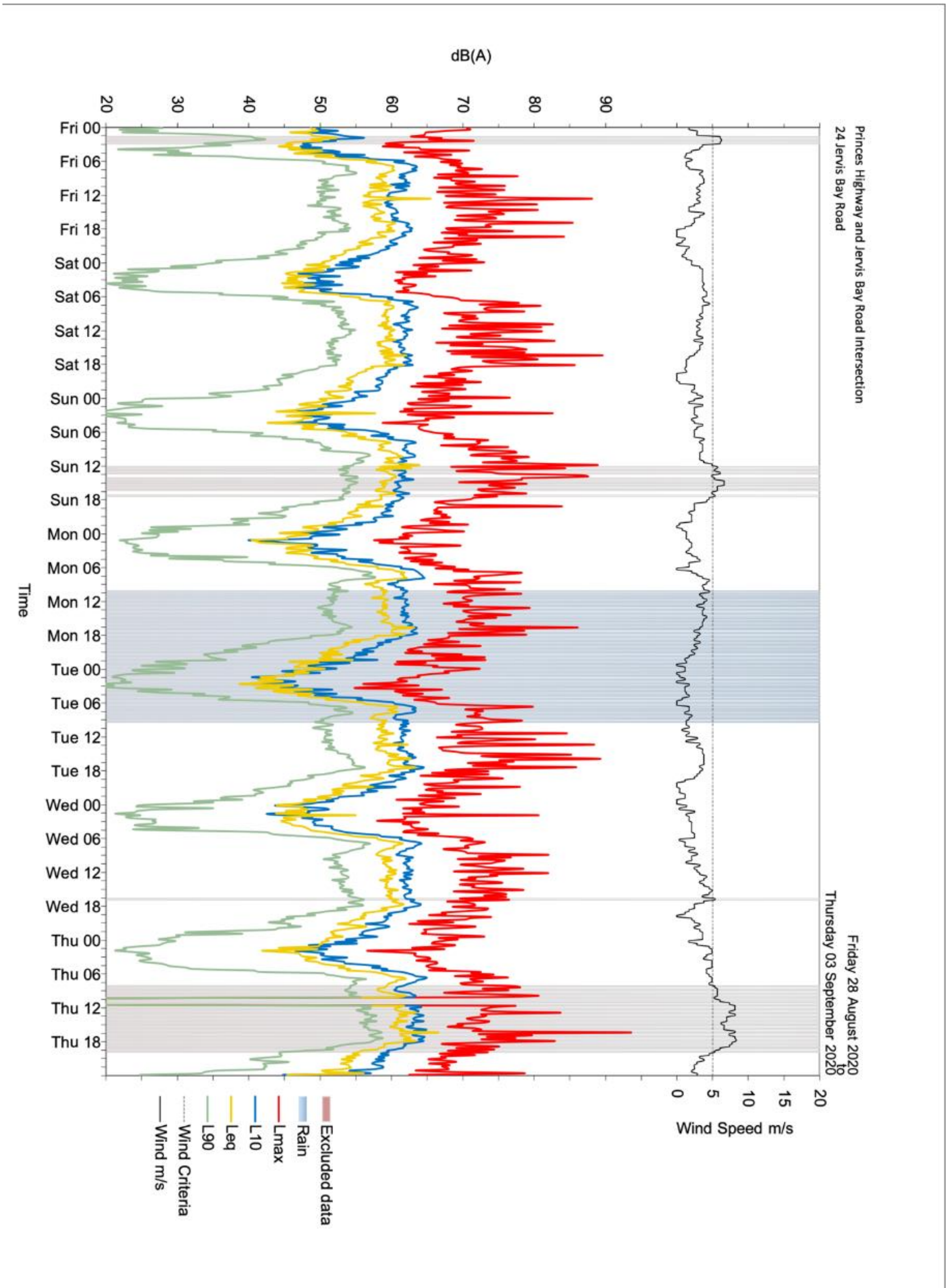
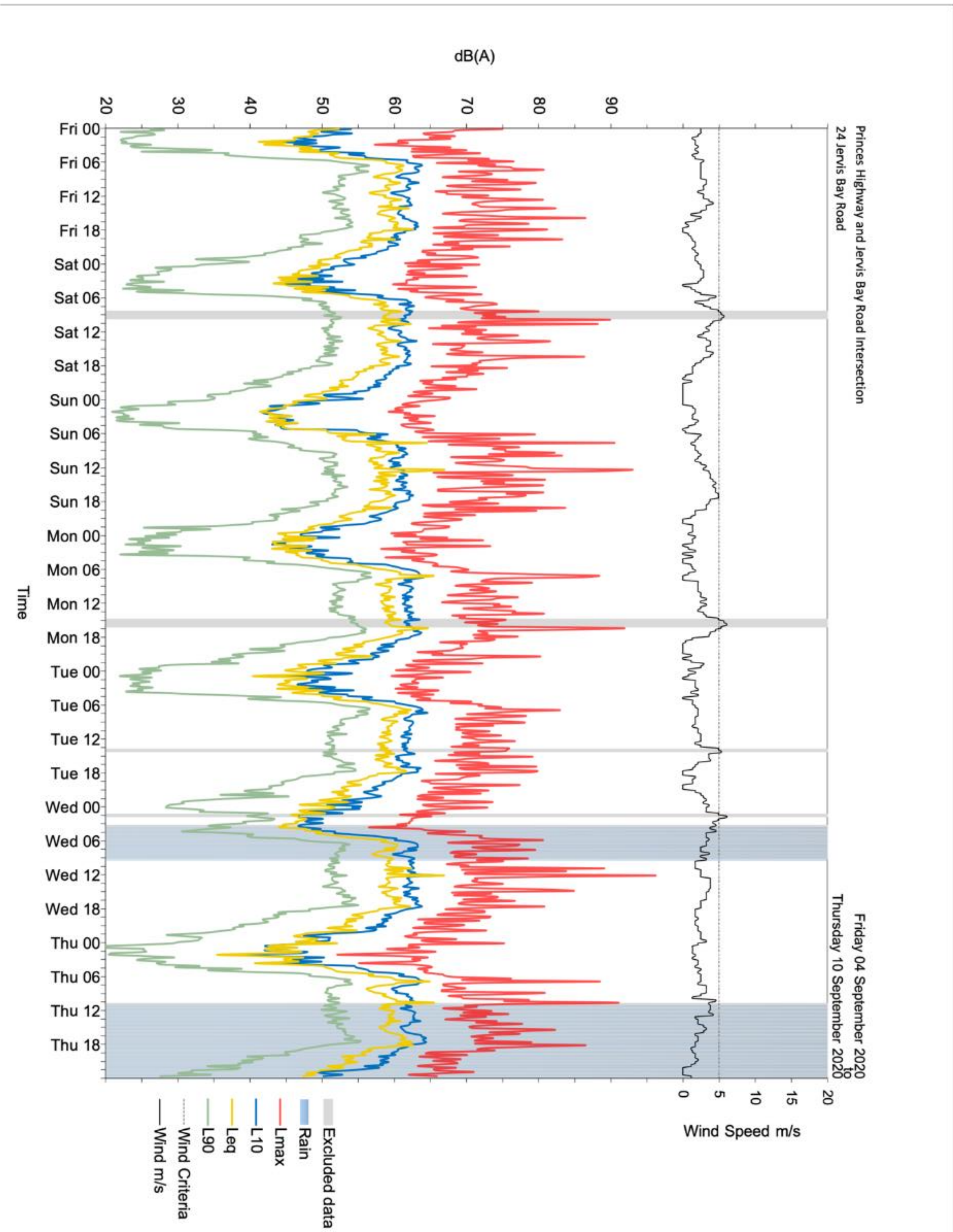
Address/location	24 Jervis Bay Road
Logger ID	NL2
Measurement location	Next to drive way located in front yard
Measurement details	L_{Aeq} 15 minute measurements and L_{Aeq} 1 second unattended measurements including; L_{A90}, L_{Aeq}, L_{A10} and L_{Amax},
Logging period	L_{Aeq} 15 minute logging: Friday 21st August 2020 to Friday 11th September 2020 L_{Aeq} 1 second logging: Thursday 10th September to Friday 11th September.
General Description	Measured noise levels were controlled by adjacent traffic on Jervis Bay Road. Periods of wind (exceeding 5 metres per second) and rain have been noted and excluded from the determination of measured noise levels. There was one noted extraneous event during the measurement period. This event occurred during a period of high wind (>= 5 metres per second) and is not included in the assessment process. This event may likely be due to an impact of a foreign object on the windshield during the high winds but did not affect the ongoing operation of the noise logger.



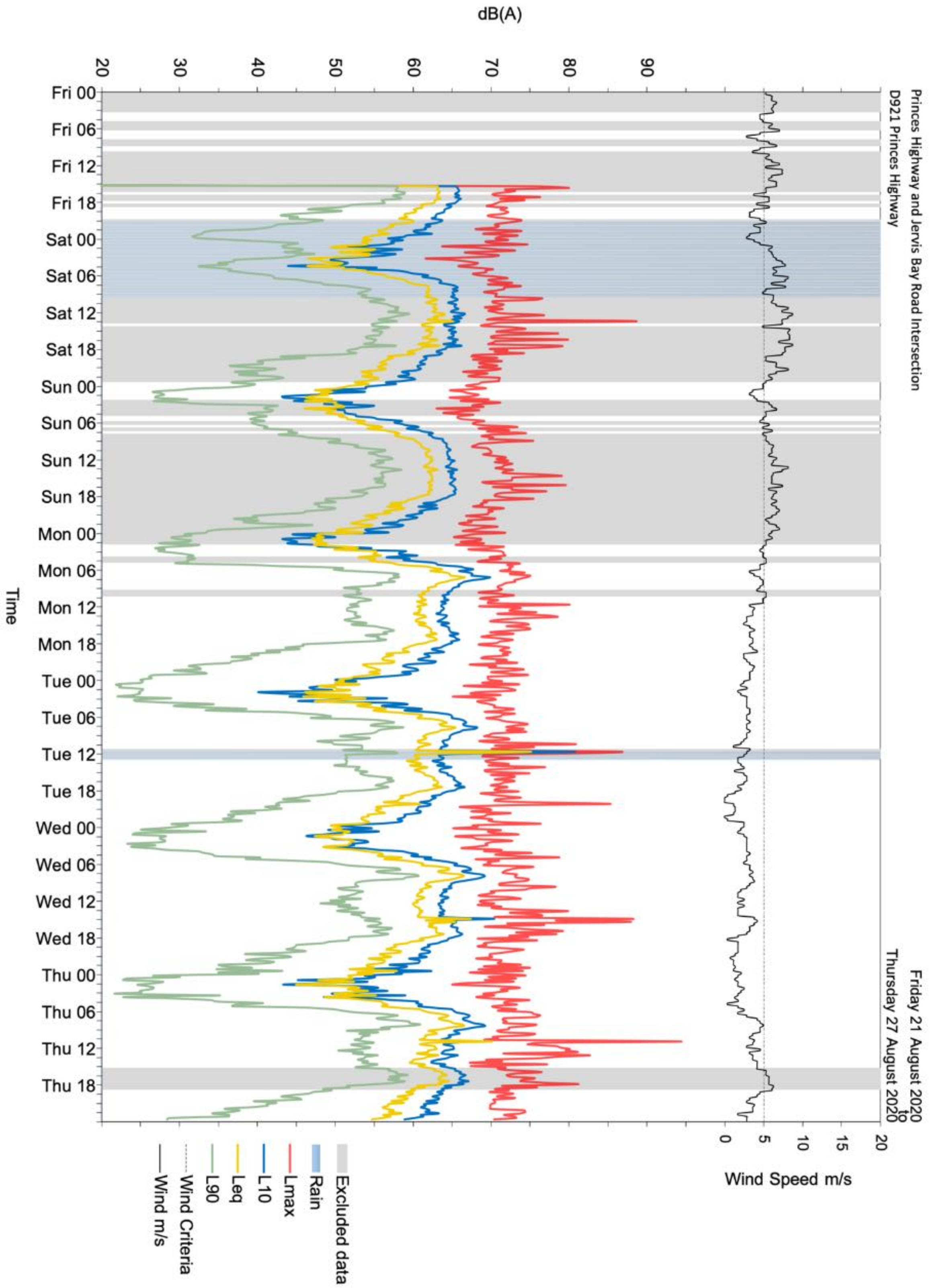
Princes Highway and Jervis Bay Road Intersection
24 Jervis Bay Road
Friday 21 August 2020 to Thursday 27 August 2020
dB(A)
20
30
40
50
60
70
80
90
Time
Fri 00
Fri 06
Fri 12
Fri 18
Sat 00
Sat 06
Sat 12
Sat 18
Sun 00
Sun 06
Sun 12
Sun 18
Mon 00
Mon 06
Mon 12
Mon 18
Tue 00
Tue 06
Tue 12
Tue 18
Wed 00
Wed 06
Wed 12
Wed 18
Thu 00
Thu 06
Thu 12
Thu 18
Wind Speed m/s
0
5
10
15
20
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s


Princes Highway and Jervis Bay Road Intersection
24 Jervis Bay Road
Friday 28 August 2020
to
Thursday 03 September 2020
dB(A)
Time
Wind Speed m/s
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

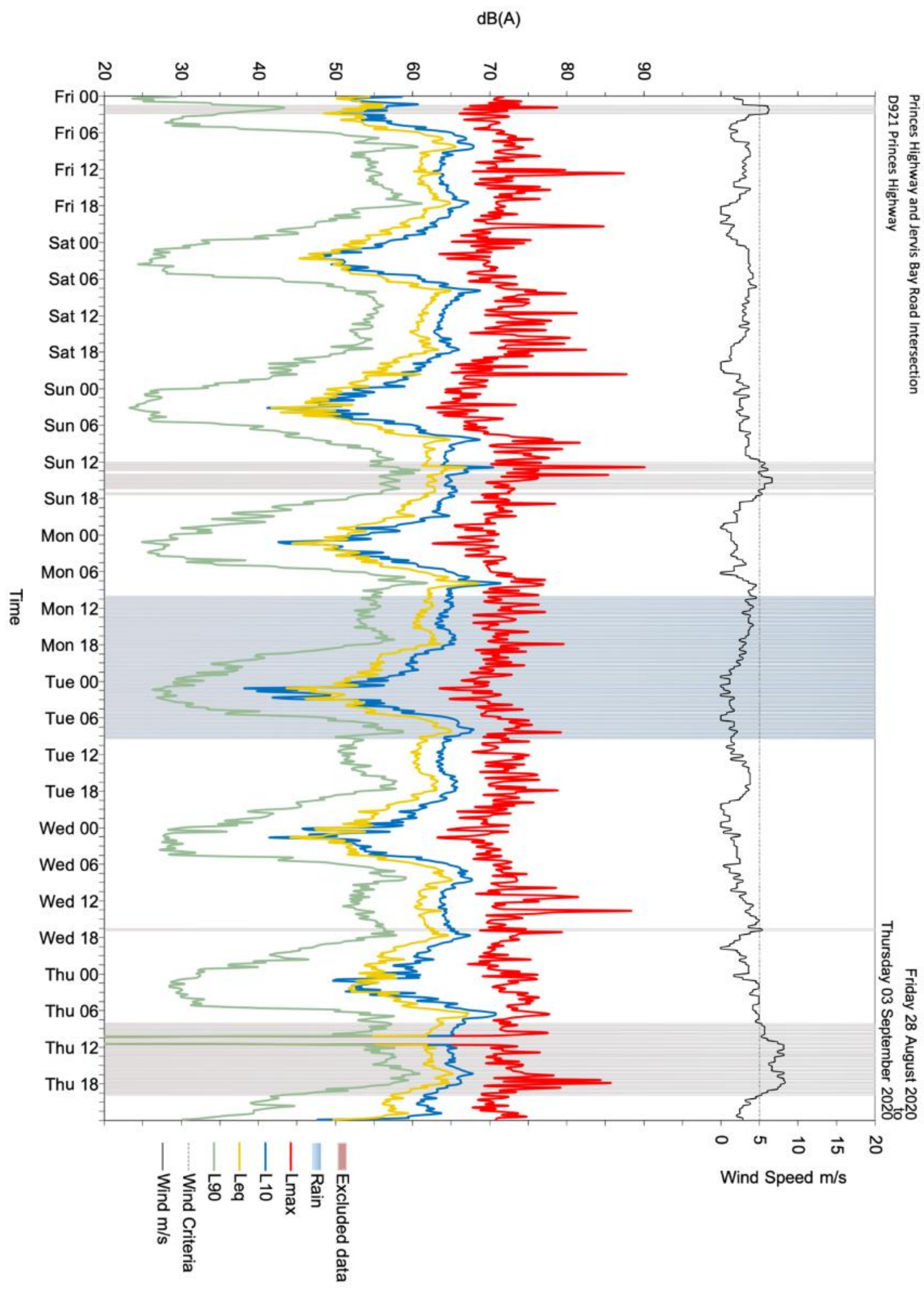

Princes Highway and Jervis Bay Road Intersection
24 Jervis Bay Road
Friday 04 September 2020
to
Thursday 10 September 2020
dB(A)
20
30
40
50
60
70
80
90
Time
Fri 00
Fri 06
Fri 12
Fri 18
Sat 00
Sat 06
Sat 12
Sat 18
Sun 00
Sun 06
Sun 12
Sun 18
Mon 00
Mon 06
Mon 12
Mon 18
Tue 00
Tue 06
Tue 12
Tue 18
Wed 00
Wed 06
Wed 12
Wed 18
Thu 00
Thu 06
Thu 12
Thu 18
Wind Speed m/s
0
5
10
15
20
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

Address/location	D921 Princes Highway
Logger ID	NL3
Measurement location	Next to driveway located in front yard
Measurement details	L_{Aeq} 15 minute measurements unattended measurements including; L_{A90}, L_{Aeq}, L_{A10} and L_{Amax},
Logging period	L_{Aeq} 15 minute logging: Friday 21st August 2020 to Friday 11th September 202.
General Description	Measured noise levels were controlled by adjacent traffic on Jervis Bay Road. Periods of wind (exceeding 5 metres per second) and rain have been noted and excluded from the determination of measured noise levels.

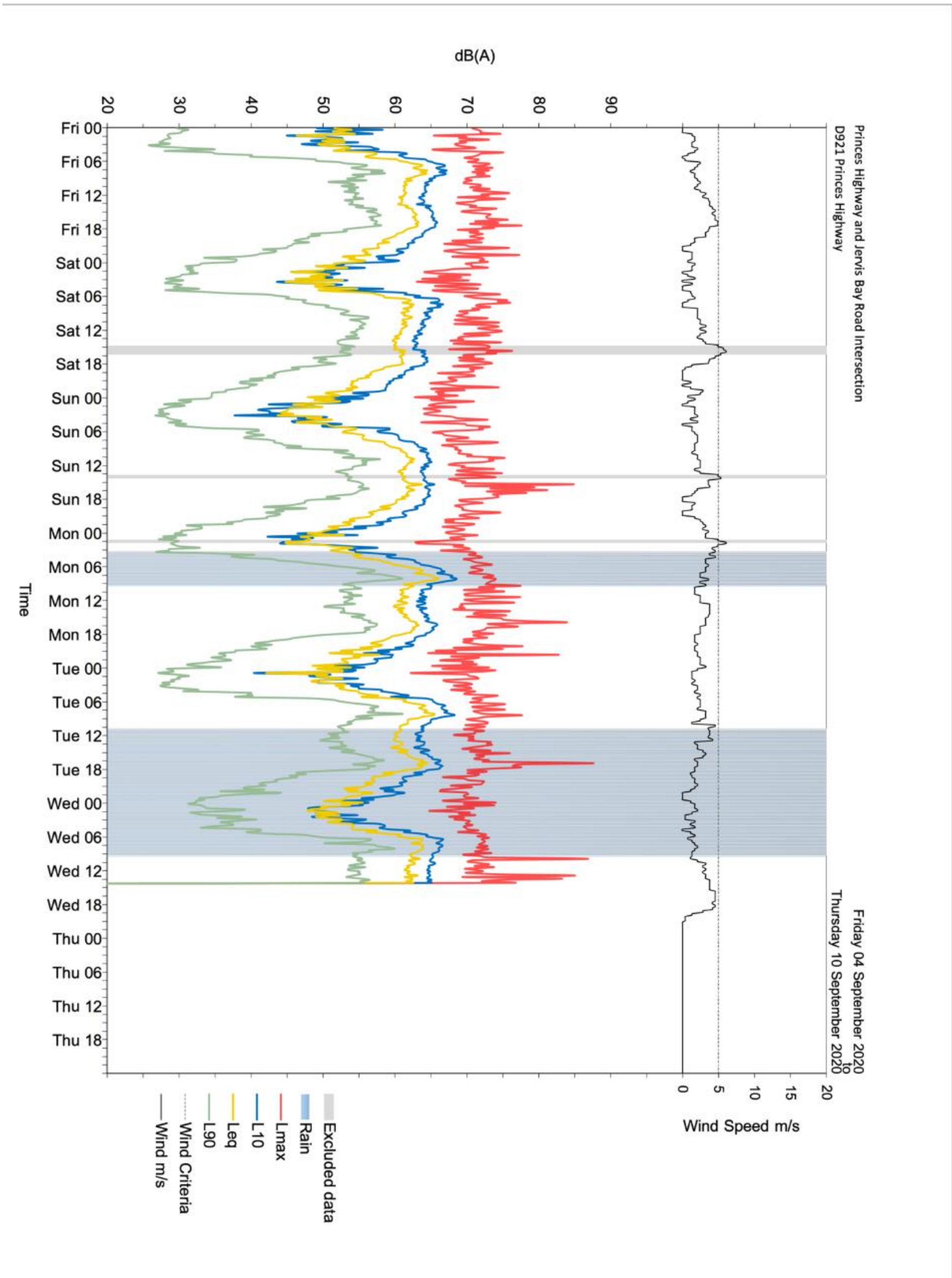
Resonate



Princes Highway and Jervis Bay Road Intersection
D921 Princes Highway
Friday 21 August 2020 to Thursday 27 August 2020
dB(A)
20
30
40
50
60
70
80
90
Time
Fri 00
Fri 06
Fri 12
Fri 18
Sat 00
Sat 06
Sat 12
Sat 18
Sun 00
Sun 06
Sun 12
Sun 18
Mon 00
Mon 06
Mon 12
Mon 18
Tue 00
Tue 06
Tue 12
Tue 18
Wed 00
Wed 06
Wed 12
Wed 18
Thu 00
Thu 06
Thu 12
Thu 18
0
5
10
15
20
Wind Speed m/s
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s



Princes Highway and Jervis Bay Road Intersection
D921 Princes Highway
Friday 28 August 2020
to
Thursday 03 September 2020
dB(A)
Time
Wind Speed m/s
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s


Princes Highway and Jervis Bay Road Intersection
D921 Princes Highway
Friday 04 September 2020
to
Thursday 10 September 2020
dB(A)
Time
Wind Speed m/s
Excluded data
Rain
Lmax
L10
Leq
L90
Wind Criteria
Wind m/s

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Appendix C – Traffic volumes

2020 measured traffic volumes for model validation

Road Name	2020 measured traffic volumes					
	Traffic direction	Total vehicles (Day)	Total vehicles (Night)	%HV (Day)	%HV (Night)	Speed (km/h)
Princes Highway (North of intersection)	NB	710	154	7.8	9.2	97.3
	SB	771	88	10.4	26.3	99.2
Princes Highway (South of intersection)	NB	445	104	14.6	19.9	93.6
	SB	450	52.6	22.2	43.3	98.1
Jervis Bay Road	EB	303	28.7	22.9	37.8	86.5
	WB	261	49.5	22.5	34.3	85.4

Resonate

No-Build (without the proposal) - Year of Opening & Design Year (10 year after opening) traffic volumes

Road / Location		No Build - Forecast year of opening (2025)			No Build - Forecast 10 years after opening (2035)		
		Total	HV	%HV	Total	HV	%HV
Princes Highway North of intersection NB	Day 15 Hr (07:00 - 22:00)	11,092	1,063	9.6%	13,129	1,258	9.6%
	Night 9Hr (22:00 - 07:00)	1,681	197	11.9%	1,990	234	11.9%
Princes Highway North of intersection SB	Day 15 Hr (07:00 - 22:00)	11,997	1,945	16.5%	14,199	2,302	16.5%
	Night 9Hr (22:00 - 07:00)	667	271	41.2%	790	320	41.2%
Princes Highway South of intersection NB	Day 15 Hr (07:00 - 22:00)	6,482	833	12.8%	7,673	985	12.8%
	Night 9Hr (22:00 - 07:00)	1,114	169	15.4%	1,318	200	15.4%
Princes Highway South of intersection SB	Day 15 Hr (07:00 - 22:00)	7,634	1,727	23.0%	9,036	2,044	23.0%
	Night 9Hr (22:00 - 07:00)	371	256	70.2%	439	303	70.2%
Jervis Bay Road EB	Day 15 Hr (07:00 - 22:00)	4,301	215	5.0%	4,870	243	5.0%
	Night 9Hr (22:00 - 07:00)	292	15	5.1%	331	17	5.1%
Jervis Bay Road WB	Day 15 Hr (07:00 - 22:00)	4,622	227	5.1%	5,324	257	5.1%
	Night 9Hr (22:00 - 07:00)	606	28	5.1%	740	32	5.1%

Build (with the proposal) - Year of Opening & Design Year (10 year after opening) traffic volumes

Road / Location		Build (With the proposal) - Forecast year of opening (2025)			Build (With the proposal) - Forecast 10 years after opening (2035)		
		Total	HV	%HV	Total	HV	%HV
Princes Highway North of intersection NB	Day 15 Hr (07:00 - 22:00)	11,092	1,063	9.6%	13,129	1,258	9.6%
	Night 9Hr (22:00 - 07:00)	1,681	197	11.9%	1,990	234	11.9%
Princes Highway North of intersection SB	Day 15 Hr (07:00 - 22:00)	11,997	1,945	16.5%	14,199	2,302	16.5%
	Night 9Hr (22:00 - 07:00)	667	271	41.2%	790	320	41.2%
Princes Highway South of intersection NB	Day 15 Hr (07:00 - 22:00)	6,482	833	12.8%	7,673	985	12.8%
	Night 9Hr (22:00 - 07:00)	1,114	169	15.4%	1,318	200	15.4%
Princes Highway South of intersection SB	Day 15 Hr (07:00 - 22:00)	7,634	1,727	23.0%	9,036	2,044	23.0%
	Night 9Hr (22:00 - 07:00)	371	256	70.2%	439	303	70.2%
Jervis Bay Road EB	Day 15 Hr (07:00 - 22:00)	4,301	215	5.0%	4,870	243	5.0%
	Night 9Hr (22:00 - 07:00)	292	15	5.1%	331	17	5.1%
Jervis Bay Road WB	Day 15 Hr (07:00 - 22:00)	4,622	227	5.1%	5,324	257	5.1%
	Night 9Hr (22:00 - 07:00)	606	28	5.1%	740	32	5.1%
Princes Highway Northbound Offramp	Day 15 Hr (07:00 - 22:00)	191	10	5.0%	227	11	5.0%
	Night 9Hr (22:00 - 07:00)	33	2	5.0%	39	2	5.0%
Princes Highway Southbound Offramp	Day 15 Hr (07:00 - 22:00)	4,459	223	5.0%	5,278	264	5.0%

Road / Location		Build (With the proposal) - Forecast year of opening (2025)			Build (With the proposal) - Forecast 10 years after opening (2035)		
		Total	HV	%HV	Total	HV	%HV
	Night 9Hr (22:00 - 07:00)	248	12	5.0%	294	15	5.0%
Princes Highway Northbound Onramp	Day 15 Hr (07:00 - 22:00)	4,498	225	5.0%	5,168	258	5.0%
	Night 9Hr (22:00 - 07:00)	630	31	5.0%	758	38	5.0%
Princes Highway Southbound Onramp	Day 15 Hr (07:00 - 22:00)	169	8	5.0%	197	10	5.0%
	Night 9Hr (22:00 - 07:00)	56	3	5.0%	67	3	5.0%
New Local road for private residents (cul-de-sac)	Day 15 Hr (07:00 - 22:00)	77	0	0.0%	91	0	0.0%
	Night 9Hr (22:00 - 07:00)	46	0	0.0%	55	0	0.0%

Appendix D – Operational noise contours

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Appendix E – Operational noise detailed results tables

Appendix F – Operational noise contours (multi-modal transport facility)