Appendix G

Noise and vibration assessment

GREAT WESTERN HIGHWAY - RAGLAN DUPLICATION

Review of Environmental Factors
Noise and Vibration Assessment

Prepared for:

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1 Introduction

Transport for NSW (TfNSW) proposes to widen the existing two-lane section of Great Western Highway at Raglan, east of Bathurst, NSW (the proposal) to improve traffic efficiency and safety. About 3.7 kilometres of the Great Western Highway is proposed to be upgraded between about 385 metres east of Ceramic Avenue, Raglan and Ashworth Drive, Kelso.

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Jacobs Group (Australia) Pty Ltd to undertake a noise and vibration assessment for the proposal as part of the Review of Environmental Factors (REF).

Key features of the proposal include:

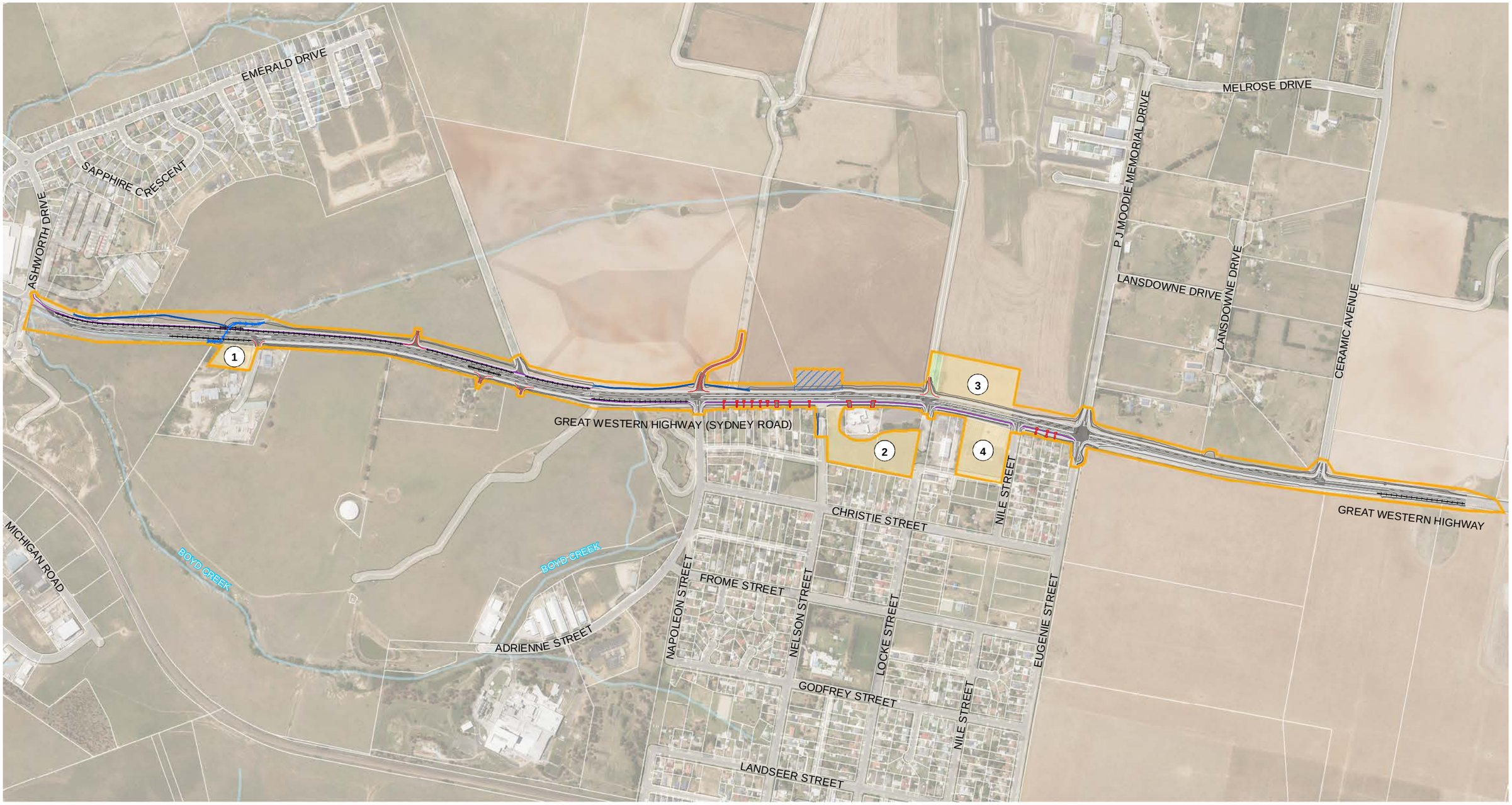
- Realigning the highway up to 16 metres to the north of the existing highway
- Road widening up to 13 metres to provide:
  - Two eastbound lanes for the length of the proposal
  - Two westbound lanes west of Napoleon Street
  - One westbound lane east of Napoleon Street
  - Shoulders on both sides of the highway.
  - A variable-width central median for the length of the proposal with occasional traffic barriers
- A 2.5 metre wide shared path along the southern side of the highway between Eugenie Street and just west of Napoleon Street, where it crosses to the northern side of the highway and continues to Ashworth Drive
- Provision of a 5.5 metre wide verge between the shared path and the southern edge of the highway to allow for a second westbound lane east of Napoleon Street
- Removing redundant highway pavement
- Raising the highway by up to one metre, with batters generally sloping at four to one
- Upgrading four junctions by providing or extending dedicated turn lanes at Napoleon, Locke and Nile Streets and Ceramic Avenue
- Upgrading the Eugenie Street and PJ Moodie Memorial Drive intersection with traffic signals and a light vehicle U-turn facility along Eugenie Street
- A widened median is provided at the Napoleon Street intersection to allow for future traffic signals
- Street lighting provided at:
  - PJ Moodie Memorial Drive / Eugenie intersection and Napoleon, Locke and Nile Street junctions
  - Pedestrian crossings
  - Bathurst Sheds access.
- Realignment of an unnamed tributary of Boyd Creek
- Tie-in works with existing pavements and highway levels at the eastern and western extents
- Driveway adjustment and upgrade where required for properties with direct access to the Great Western Highway

- Upgrading the at-grade access to Bathurst Sheds with a dedicated right-turn lane
- Relocation and/or adjustments of public utilities and street lighting
- Property acquisitions and adjustments
- Minor relocation and provision of widened shoulders at three bus stops
- Drainage infrastructure including:
  - Replacement and augmentation of existing pipe drainage systems
  - Extension of the existing five cell pipe culvert through which the unnamed tributary of Boyd Creek runs
  - Installation of new drainage (including kerb and guttering and table drains) in various locations
  - A flood detention basin on the northern side of the Great Western Highway opposite Nelson Street.
- Ancillary works including safety barriers, signage, line marking and environmental protection work
- Landscaping and rehabilitation work
- Temporary ancillary facilities including site compounds and stockpile sites.

The proposal is shown in Figure 1.

1.1 Terminology

The assessment uses specific acoustic terminology and an explanation of common terms is included in Appendix A.



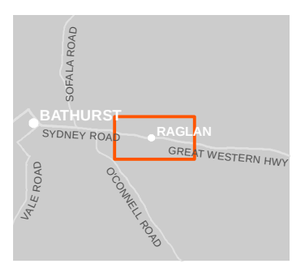
Proposal area
Existing Roads and Maritime stockpile site
Potential ancillary site/site number
Proposed flood storage
Waterway
Alignment pavement

Design
Batter slope
Table drain
Creek realignment

Kerb and gutter
Safety barrier
Driveway
Shared path

0 250 500 m

1:10,000 at A3



Data sources

Roads and Maritime Services 2019
Jacobs 2019
Aerometrex Dec 2018

GDA94 MGA56

Figure 1 Overview of the proposal

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2 Existing Environment

The proposal is located in the suburbs of Raglan and Kelso. Existing noise levels in the study area are influenced by road traffic noise from the Great Western Highway, aircraft noise from Bathurst Airport to the north of the proposal and rail noise from Main Western railway line to the south.

The nearest receivers to the proposal are residential properties to the south of the Great Western Highway, between Napoleon Street and Eugenie Street in Raglan. More distant receivers are also to in the north-west of the study area near Emerald Drive in Kelso and in the north-east near PJ Moodie Memorial Drive in Raglan.

The assessment uses several Noise Catchment Areas (NCAs) that reflect the land uses in the study area and the existing background noise levels. These are shown in Figure 2 and described in Table 1.

Table 1 Noise Catchment Areas and Surrounding Land Uses

NCA	Minimum Distance[1]	Description
NCA01	60 m	This catchment covers the north-west portion of the study area. It is to the north of the Great Western Highway, near the intersection with Ashworth Drive and is mainly residential except for the Gold Panner Motor Inn and NRMA Bathurst Panorama Holiday Park which face the highway. The eastern section of the catchment is rural land.
NCA02	20 m	This catchment covers the south-west portion of the study area. It is to the south of the Great Western Highway and is mainly rural land with small areas of commercial/industrial receivers.
NCA03	50 m	This catchment covers the north-east portion of the study area. It is to the north of the Great Western Highway and includes Bathurst Airport. Sparsely distributed residential receivers are near to the intersection of the Great Western Highway and PJ Moodie Memorial Drive.
NCA04	5 m	This catchment covers the south-east portion of the study area, to the south of the Great Western Highway. It is mostly residential with the nearest receivers being adjacent to the Great Western Highway.

Note 1: Approximate minimum horizontal distance from the proposal to the nearest receiver building in each NCA.

2.1 Noise and Vibration Sensitive Receivers

Receivers potentially sensitive to noise and vibration have been categorised as residential dwellings, commercial/industrial buildings, or 'other sensitive' land uses which include hotels, an educational facility, child care centre, place of worship and various outdoor recreation areas. Receiver types and locations are shown in Figure 2.

The 'other sensitive' non-residential receivers identified in the study area are shown in Table 2.

Figure 2 Site Plan, Receivers and Noise Monitoring Locations

Note: The NCAs extend to a minimum distance of 600 m from the project.

Table 2 'Other Sensitive' Receivers (Non-Residential)

NCA	Description	Address	Type
NCA01	Gold Panner Motor Inn	260 Sydney Road, Kelso	Hotel
	NRMA Bathurst Panorama Holiday Park	250 Sydney Road, Kelso	Hotel
NCA02	Elmo Lavin Park	Off Napoleon Street, Raglan	Outdoor passive
NCA03	Child Care Centre	PJ Moodie Memorial Drive	Child care
NCA04	Kingdom Hall of Jehovah's Witnesses	Great Western Hwy & Napoleon Street, Raglan	Place of worship
	Raglan Public School	Nelson Street, Raglan	Educational
	Outdoor recreation area off Nile Street	Nile Street, Raglan	Outdoor active
	Ralph Cameron Park	Eugenie Street, Raglan	Outdoor active

2.2 Existing Noise Surveys and Monitoring Locations

Unattended noise monitoring was completed in the study area during November and December 2019. The measured noise levels have been used to determine the existing noise environment and to set the criteria used to assess the potential impacts from the proposal.

The measured existing noise levels are representative of receivers that would likely be most affected by the construction and operation of the proposal in each NCA. For NCAs that have receivers which are close to the proposal, the monitoring equipment was located at front row receivers which would have line-of-sight to the proposal, within constraints such as accessibility, security and land owner permission.

The noise monitoring equipment continuously measured existing noise levels in 15-minute periods during the daytime, evening and night-time. All equipment carried current National Association of Testing Authorities (NATA) calibration certificates and calibration was checked before and after each measurement.

The results of the noise monitoring have been analysed to exclude noise from extraneous events and data affected by adverse weather conditions, such as strong wind or rain (wind was measured at a locally deployed weather station and rain at Bathurst Airport), to establish representative existing noise levels for each NCA.

The noise monitoring locations are shown in Figure 2 and the results are summarised in Table 3. Details of each monitoring location together with graphs of the measured daily noise levels are provided in Appendix B.

Table 3 Summary of Unattended Noise Logging Results

ID	Address	Measured Noise Level (dBA)							
		Construction[1]						Operational[2]	
		Background Noise (RBL)			Average Noise (LAeq)			Average Noise (LAeq)	
		Day	Evening	Night	Day	Evening	Night	Day	Night
L01	29 Sapphire Crescent	35 (31 actual)[3]	35	30 (26 actual)[3]	46	45	41	-[4]	-[4]
L02	5415 Great Western Highway[5]	45	42	30 (28 actual)[3]	56	55	55	56	55
L03	77 Sydney Road	45	40	30 (24 actual)[3]	64	63	62	64	62
L04	2 PJ Moodie Memorial Drive	43	40	30 (28 actual)[3]	56	57	55	57	55

Note 1: Construction noise is assessed during the daytime which is 7 am to 6 pm, the evening which is 6 pm to 10 pm and the night-time which is 10 pm to 7 am. See the NSW EPA Interim Construction Noise Guideline.

Note 2: Operational road traffic noise is assessed during the daytime which is 7 am to 10 pm and the night-time which is 10 pm to 7 am. See the NSW EPA Road Noise Policy.

Note 3: The monitored level was less than the minimum assumed Rating Background Levels (RBLs) specified in the NSW EPA Noise Policy for Industry.

Note 4: Noise monitoring location used to measure background noise levels for the construction assessment only. This location is distant from Great Western Highway and noise levels are not dominated by road traffic noise alone.

Note 5: The wind station was positioned at this location.

2.3 Attended Noise Measurements

Short-term attended noise monitoring was also completed at each monitoring location. The attended measurements allow the contributions of the various noise sources at each location to be determined. Detailed observations from the attended measurements are provided in Appendix B.

The attended measurements were generally found to be consistent with the results of the unattended noise monitoring and show that existing noise levels are typically dominated by road traffic noise from the surrounding road network.

3 Policy Context

3.1 Construction Noise and Vibration Guidelines

3.1.1 Construction Noise and Vibration Guidelines

The guidelines used to assess construction impacts from the proposal are listed in Table 4. The guidelines aim to protect the community and environment from excessive adverse noise and vibration impacts as projects are constructed.

Table 4 Construction Noise and Vibration Guidelines

Guideline/Policy Name	Where Guideline Used
Interim Construction Noise Guideline (ICNG) (DECC, 2009)	Assessment of airborne noise impacts on sensitive receivers
AS2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors	Provides recommended design sound levels for internal areas of occupied spaces
Road Noise Policy (RNP) (DECCW, 2011)	Assessment of construction traffic impacts
BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2, BSI, 1993	Assessment of vibration impacts (structural damage) to non-heritage sensitive structures
DIN 4150:Part 3-2016 Structural vibration – Effects of vibration on structures, Deutsches Institute fur Normung, 1999	Screening assessment of vibration impacts (structural damage) to heritage sensitive structures, where the structure is found to be unsound
Assessing Vibration: a technical guideline (DEC, 2006)	Assessment of vibration impacts on sensitive receivers
Construction Noise and Vibration Guideline (CNVG) (Roads and Maritime Services, 2016)	Assessment and management protocols for airborne noise and vibration impacts for road infrastructure projects

3.1.2 Interim Construction Noise Guideline

The NSW Interim Construction Noise Guideline (ICNG) is used to assess and manage impacts from construction noise on residences and other sensitive land uses in NSW.

The ICNG contains procedures for determining project specific Noise Management Levels (NMLs) for sensitive receivers based on the existing background noise in the area. The 'worst-case' noise levels from construction of a project are predicted and then compared to the NMLs in a 15-minute assessment period to determine the likely impact of the project.

The NMLs are not mandatory limits, however, where construction noise levels are predicted or measured to be above the NMLs, feasible and reasonable work practices to minimise noise emissions are to be investigated.

Residential Receivers

The ICNG approach for determining NMLs at residential receivers is shown in Table 5.

Table 5 ICNG NMLs for Residential Receivers

Time of Day	NML $L_{Aeq(15minute)}$	How to Apply
Standard Construction Hours Monday to Friday 7:00 am to 6:00 pm Saturday 8:00 am to 1:00 pm No work on Sundays or public holidays	RBL[1] + 10 dB	• The noise affected level represents the point above which there may be some community reaction to noise • Where the predicted or measured $L_{Aeq(15minute)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practises to meet the noise affected level • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

	Highly Noise Affected 75 dBA	• The Highly Noise Affected (HNA) level represents the point above which there may be strong community reaction to noise
		• Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restructuring the hours that the very noisy activities can occur, taking into account:
		  • Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools or mid-morning or mid-afternoon for works near residences
		  • If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

Outside Standard Construction Hours	RBL + 5 dB	• A strong justification would typically be required for works outside the recommended standard hours • The proponent should apply all feasible and reasonable work practices to meet the noise affected level • Where all feasible and reasonable practises have been applied and noise is more than 5 dB above the noise affected level, the proponent should negotiate with the community.

Note 1: The RBL is the Rating Background Level and the ICNG refers to the calculation procedures in the NSW Industrial Noise Policy (INP). The INP has been superseded by the NSW EPA Noise Policy for Industry (NPfI).

Works are recommended to be completed during Standard Construction Hours where possible. More stringent requirements are placed on works that are required to be completed outside Standard Construction Hours (ie during the evening or night-time) which reflects the greater sensitivity of communities to noise impacts during these periods.

Sleep Disturbance

Infrastructure projects often require certain works to be completed during the night-time. Where night works are located close to residential receivers there is potential for sleep disturbance impacts.

The ICNG lists five categories of works that might need to be undertaken outside of Standard Construction Hours:

- The delivery of oversized equipment or structures that require special arrangements to transport on public roads
- Emergency work to avoid the loss of life or damage to property, or to prevent environmental harm
- Maintenance and repair of public infrastructure where disruption to essential services or considerations of worker safety do not allow work within standard hours

- Public infrastructure works that shorten the length of the project and are supported by the affected community
- Works where a proponent demonstrates and justifies a need to operate outside the recommended standard hours.

Where construction works are planned to extend over more than two consecutive nights, the ICNG recommends that an assessment of sleep disturbance impacts should be completed. The ICNG refers to the NSW Environmental Criteria for Road Traffic Noise for assessing the potential impacts, which notes that to limit the level of sleep disturbance the L_1 level (or L_{Amax}) should not exceed the existing L_{90} background noise level by more than 15 dB.

Summary of Residential NMLs

The residential NMLs for the proposal have been determined using the results from the unattended existing noise monitoring (see Section 2) and are shown in Table 6.

Table 6 Residential Receiver Construction Noise Management Levels

NCA	Representative Background Monitoring Location	Noise Management Level ($L_{Aeq(15minute)}$ – dBA)				Sleep Disturbance Screening Criteria (RBL +15 dB)
		Standard Construction (RBL +10 dB)	Out of Hours (RBL +5 dB)			
		Daytime	Daytime[1]	Evening	Night-time	
NCA01	L01	45	40	40	35	45
NCA02	L02	55	50	47	35	45
NCA03	L04	53	48	45	35	45
NCA04	L03	55	50	45	35	45

Note 1: Daytime out of hours is 7 am to 8 am and 1 pm to 6 pm on Saturday, and 8 am to 6 pm on Sunday and public holidays.

'Other Sensitive' Land Uses and Commercial Receivers

Several non-residential land uses have been identified in the study area. These include 'other sensitive' land uses such as educational institutes, places of worship, outdoor recreational areas and commercial properties. The ICNG NMLs for 'other sensitive' receivers are shown in Table 7.

Table 7 ICNG NMLs for 'Other Sensitive' Receivers

Land Use	Noise Management Level $L_{Aeq(15minute)}$ (Applied when the property is in use)
Classrooms at schools and other education institutions	Internal noise level 45 dBA[1]
Hospital wards and operating theatres	Internal noise level 45 dBA[1]
Places of Worship	Internal noise level 45 dBA[1]
Active recreation areas (characterised by sporting activities and activities which generate their own noise or focus for participants)	External noise level 65 dBA
Passive recreation areas (characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion)	External noise level 60 dBA
Community centres	Refer to the recommended 'maximum' internal levels in AS 2107 for specific uses
Commercial	External noise level 70 dBA

Note 1: The criteria is specified as an internal noise level for this receiver category. As the noise model predicts external noise levels, it has been conservatively assumed that all schools and places of worship have openable windows and external noise levels are 10 dB higher than the corresponding internal level, which is representative of windows being partially open to provide ventilation.

The ICNG references AS2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors for criteria for 'other sensitive' receivers which are not listed in the guideline. The AS2107 NMLs for other sensitive receivers are shown in Table 8.

Table 8 AS2107 NMLs for 'Other Sensitive' Receivers

Use	Period	AS2107 Classification	Noise Management Level $L_{Aeq(15minute)}$
Hotel	Daytime and evening	Bars and lounges	Internal noise level 50 dBA[1]
	Night-time	Sleeping Areas: - Hotels near major road	Internal noise level 40 dBA[1]

Note 1: These receivers are assumed to have fixed windows with a conservative 20 dB reduction for external to internal noise levels.

3.1.3 Construction Traffic Noise Guidelines

The potential impacts from construction traffic associated with the proposal when travelling on public roads are assessed under the NSW EPA Road Noise Policy (RNP) and Roads and Maritime Construction Noise and Vibration Guideline (CNVG).

An initial screening test is first applied to evaluate if existing road traffic noise levels are expected to increase by more than 2.0 dB as a result of construction traffic. Where this is considered likely, further assessment is required using the RNP and Roads and Maritime Noise Criteria Guideline (NCG) base criteria shown in Table 9.

Table 9 RNP/NCG Criteria for Assessing Construction Traffic on Public Roads

Road Category	Type of Project/Land Use	Assessment Criteria (dBA)	
		Daytime (7 am – 10 pm)	Night-time (10 pm – 7 am)
Freeway/ arterial/ sub-arterial roads	Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial roads generated by land use developments	$L_{Aeq(15hour)}$ 60 (external)	$L_{Aeq(9hour)}$ 55 (external)
Local roads	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)

3.1.4 Construction Vibration Guidelines

The effects of vibration from construction works can be divided into three categories:

- Those in which the occupants of buildings are disturbed (human comfort)
- Those where building contents may be affected (building contents)
- Those where the integrity of the building may be compromised (structural or cosmetic damage).

Human Comfort Vibration

People can sometimes perceive vibration impacts when vibration generating construction works are located close to occupied buildings.

Vibration from construction works tends to be intermittent in nature and the EPA's Assessing Vibration: a technical guideline (2006) provides criteria for intermittent vibration based on the Vibration Dose Value (VDV). The 'preferred' and 'maximum' VDVs for human comfort impacts are shown in Table 10.

Table 10 Vibration Dose Values for Intermittent Vibration

Building Type	Assessment Period	Vibration Dose Value[1] ($m/s^{1.75}$)	
		Preferred	Maximum
Critical Working Areas (eg operating theatres or laboratories)	Day or night-time	0.10	0.20
Residential	Daytime	0.20	0.40
	Night-time	0.13	0.26
Offices, schools, educational institutions and places of worship	Day or night-time	0.40	0.80
Workshops	Day or night-time	0.80	1.60

Note 1: The VDV accumulates vibration energy over the daytime and night-time assessment periods, and is dependent on the level of vibration as well as the duration.

While the construction activities for the proposal are generally not expected to result in continuous or impulsive vibration impacts, the appropriate criteria are provided in Table 11.

Table 11 Preferred and Maximum Weighted Root Mean Square Values for Continuous and Impulsive Vibration Acceleration (m/s^2) 1–80 Hz

Location	Assessment period	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration					
Critical working areas[1] (eg operating theatres or precision laboratories where sensitive operations are occurring)	Day or night-time	0.0050	0.0036	0.010	0.0072
Residential	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or night-time	0.020	0.014	0.040	0.028
Workshops	Day or night-time	0.04	0.029	0.080	0.058
Impulsive vibration					
Critical working areas[1] (eg operating theatres or precision laboratories where sensitive operations are occurring)	Day or night-time	0.0050	0.0036	0.010	0.0072
Residential	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day or night-time	0.64	0.46	1.28	0.92
Workshops	Day or night-time	0.64	0.46	1.28	0.92

Note 1: No critical working areas have been identified in the study area.

Effects on Building Contents

People perceive vibration at levels well below those likely to cause damage to building contents. For most receivers, the human comfort vibration criteria are the most stringent and it is generally not necessary to set separate criteria for vibration effects on typical building contents.

Exceptions to this can occur when vibration sensitive equipment, such as electron microscopes, are in buildings near to construction works. No such equipment has been identified in the study area from a desktop based review.

Structural and Cosmetic Damage Vibration

If vibration from construction works is sufficiently high it can cause damage to structural elements of affected buildings. The levels of vibration required to cause cosmetic damage tend to be at least an order of magnitude (10 times) higher than those at which people can perceive vibration.

Examples of damage that can occur includes cracks or loosening of drywall surfaces, cracks in supporting columns and loosening of joints. Structural damage vibration limits are contained in British Standard BS 7385 and German Standard DIN 4150.

BS 7385

British Standard BS 7385 recommends vibration limits for transient vibration judged to give a minimal risk of vibration induced damage to affected buildings. The limits for residential and industrial buildings are shown in Table 12.

Table 12 BS 7385 Transient Vibration Values for Minimal Risk of Damage

Group	Type of Building	Peak Component Particle Velocity in Frequency Range of Predominant Pulse	
		4 Hz to 15 Hz	15 Hz and Above
1	Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures. Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Note 1: Where the dynamic loading caused by continuous vibration may give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values may need to be reduced by up to 50%.

For heritage buildings, the standard states that "a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive".

DIN 4150

German Standard DIN 4150 also provides guideline vibration limits for different buildings. Damage is not expected to occur where the values are complied with and the values are generally recognised to be conservative. The DIN 4150 values for buildings and structures are shown in Table 13.

Table 13 DIN 4150 Guideline Values for Short-term Vibration on Structures

Group	Type of Structure	Guideline Values Vibration Velocity (mm/s)				
		Foundation, All Directions at a Frequency of			Topmost Floor, Horizontal	Floor Slabs, Vertical
		1 to 10 Hz	10 to 50 Hz	50 to 100 Hz	All frequencies	All frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40	20
2	Residential buildings and buildings of similar design and/or occupancy	5	5 to 15	15 to 20	15	20
3	Structures that, because of their particular sensitivity to vibration, cannot be classified as Group 1 or 2 and are of great intrinsic value (eg heritage listed buildings)	3	3 to 8	8 to 10	8	20[1]

Note 1: It may be necessary to lower the relevant guideline value markedly to prevent minor damage.

3.1.5 Heritage Buildings or Structures

Heritage buildings and structures should be considered on a case-by-case basis but as noted in BS 7385 should not be assumed to be more sensitive to vibration, unless structurally unsound. Where a heritage building is deemed to be sensitive, the more stringent DIN 4150 Group 3 guideline values in Table 13 can be applied.

The only heritage building or structure is the Violet Hill homestead at 5350 Great Western Highway, Raglan. This building is, however, over 700 m to the north of the proposal, as shown in Figure 2.

3.1.6 Minimum Working Distances for Vibration Intensive Works

Minimum working distances for typical vibration intensive construction equipment are provided in the CNVG and are shown in Table 14. The minimum working distances are for both cosmetic damage (from BS 7385 and DIN 4150) and human comfort (from the NSW EPA Vibration Guideline). They are calculated from empirical data which suggests that where works are further from receivers than the quoted minimum distances then impacts are not considered likely.

Table 14 Recommended Minimum Working Distances from Vibration Intensive Equipment

Plant Item	Rating/Description	Minimum Distance		
		Cosmetic Damage		Human Response (NSW EPA Guideline)
		Residential and Light Commercial (BS 7385)	Heritage Items (DIN 4150, Group 3)	
Vibratory Roller	<50 kN (1–2 tonne)	5 m	11 m	15 m to 20 m
	<100 kN (2–4 tonne)	6 m	13 m	20 m
	<200 kN (4–6 tonne)	12 m	15 m	40 m
	<300 kN (7–13 tonne)	15 m	31 m	100 m
	>300 kN (13–18 tonne)	20 m	40 m	100 m
	>300 kN (>18 tonne)	25 m	50 m	100 m
Small Hydraulic Hammer	300 kg (5 to 12 t excavator)	2 m	5 m	7 m
Medium Hydraulic Hammer	900 kg (12 to 18 t excavator)	7 m	15 m	23 m
Large Hydraulic Hammer	1,600 kg (18 to 34 t excavator)	22 m	44 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	5 m to 40 m	20 m
Piling Rig – Bored	≤ 800 mm	2 m (nominal)	5 m	4 m
Jackhammer	Hand held	1 m (nominal)	3 m	2 m

The minimum working distances are indicative and will vary depending on the particular item of equipment and local geotechnical conditions. The distances apply to cosmetic damage of typical buildings under typical geotechnical conditions.

3.2 Operational Noise and Vibration Guidelines

The guidelines used to assess the potential operational road traffic noise impacts from the proposal are listed in Table 15. The guidelines aim to protect the community and environment from excessive noise and vibration impacts from the long-term operation of projects.

Table 15 Operational Road Traffic Noise and Vibration Guidelines

Guideline/Policy Name	When Guideline is Used
Road Noise Policy (RNP) (DECCW, 2011)	Operational road traffic noise assessment
Noise Criteria Guideline (NCG) (Roads and Maritime, 2015)	Defines Roads and Maritime's interpretation of the RNP and details how criteria is applied to sensitive receivers
Noise Mitigation Guideline (NMG) (Roads and Maritime, 2015)	Details how additional mitigation measures are to be applied to road infrastructure projects
Model Validation Guideline (Roads and Maritime, 2018)	Contains procedures for validating operational road traffic noise models
Environmental Noise Management Manual (ENMM) (Roads and Traffic Authority, 2001)	Additional information for operational road traffic noise assessment, including maximum noise assessments
Preparing an Operational and Construction Noise and Vibration Assessment Report (Roads and Maritime, 2016)	Defines how to complete operational road traffic noise and vibration assessments
AS2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors	Provides recommended design sound levels for internal areas of occupied spaces.
At-Receiver Noise Treatment Guideline (Roads and Maritime, 2017)	Provides an overview and discussion of feasible and reasonable at-receiver noise mitigation measures

3.2.1 Airborne Noise – Road Noise Policy and Noise Criteria Guideline

The NSW Road Noise Policy (RNP) is used to assess and manage potential airborne noise impact from new and redeveloped road projects.

This assessment is undertaken with guidance from the Noise Criteria Guideline (NCG) which is Roads and Maritime's interpretation of the RNP and provides a consistent approach to identifying road noise criteria for infrastructure projects.

The RNP and NCG provide non-mandatory criteria for residential and 'other sensitive' land uses. Where a project results in road traffic noise levels which are predicted to be above the criteria, the project should investigate feasible and reasonable noise mitigation measures to minimise the impacts.

The RNP and NCG use the following terms to describe and assess the impacts from road projects:

- 'No Build' – the assessment scenario used to predict noise levels if the project were not to go ahead
- 'Build' – the assessment scenario used to predict noise levels with the project.

The difference between the 'Build' and the 'No Build' noise levels is used to determine the impact of the project.

Residential Receivers

The proposal would 'redevelop' the Great Western Highway. A road is 'redeveloped' where works are in an existing road corridor and the existing road is not substantially realigned. The relevant noise criteria for residential receivers are shown in Table 16.

Table 16 NCG Criteria for Residential Receivers

Road Category	Type of Project/Land Use	Assessment Criteria (dBA)	
		Daytime (7 am – 10 pm)	Night-time (10 pm – 7 am)
Freeway/ arterial/ sub-arterial roads	2. Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial roads	$L_{Aeq(15\ hour)}$ 60 (external)	$L_{Aeq(9\ hour)}$ 55 (external)
	6. Existing residences affected by increases in traffic noise of 12 dB or more from redevelopment of existing freeway/arterial/sub-arterial roads[1]	Between $L_{Aeq(15hour)}$ 42-60 (external)	Between $L_{Aeq(9hour)}$ 42-55 (external)
Local roads	8. Existing residences affected by noise from redevelopment of existing local roads	$L_{Aeq(1\ hour)}$ 55 (external)	$L_{Aeq(1\ hour)}$ 50 (external)

Note 1: The relative increase criterion at each facade is determined from the existing traffic noise level plus 12 dB.

The criteria are lower for the night-time due to the greater sensitivity of communities to noise impacts during this period.

The RNP and NCG require noise to be assessed at project opening and for a future design year, which is typically ten years after opening. For this proposal, the at-opening year is 2022 and the future design year is 2032.

'Other Sensitive' Land Uses

Several 'other sensitive' non-residential land uses have been identified in the study area. The noise criteria for these receivers are shown in Table 17. The NCG does not consider commercial and industrial receivers as being sensitive to operational airborne road traffic noise impacts.

Table 17 NCG Criteria for Other Sensitive Receivers

Existing Sensitive Land Use	Assessment Criteria (dB)		Additional Considerations
	Daytime (7 am – 10 pm)	Night-time (10 pm – 7 am)	
1. School classrooms	$L_{Aeq(1\ hour)}$ 40 (internal)[1]	-	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 2107:2000 (Standards Australia 2000).
2. Hospital wards	$L_{Aeq(1\ hour)}$ 35 (internal)	$L_{Aeq(1\ hour)}$ 35 (internal)	
3. Places of worship	$L_{Aeq(1\ hour)}$ 40 (internal)[1]	$L_{Aeq(1\ hour)}$ 40 (internal)[1]	The criteria are internal, ie 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.

Existing Sensitive Land Use	Assessment Criteria (dB)		Additional Considerations
	Daytime (7 am – 10 pm)	Night-time (10 pm – 7 am)	
4. Open space (active use	$L_{Aeq(15\ hour)}$ 60 (external)	-	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.
5. Open space (passive use)	$L_{Aeq(15\ hour)}$ 55 (external)	-	Passive recreation is characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion (eg playing chess, reading).
6. Child care facilities	Sleeping rooms $L_{Aeq(1\ hour)}$ 35 (internal)[1] Indoor play areas $L_{Aeq(1\ hour)}$ 40 (internal)[1] Outdoor play areas $L_{Aeq(1\ hour)}$ 55 (internal)	-	Multipurpose spaces (eg 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.
7. Aged care facilities	-	-	The criteria for residential land uses should be applied to these facilities.

Note 1: The criteria are specified as an internal noise level for this receiver category. As the noise model predicts external noise levels, it has been conservatively assumed that all schools and places of worship have openable windows and external noise levels are 10 dB higher than the corresponding internal level, which is representative of windows being partially open to provide ventilation.

The Gold Panner Motor Inn and NRMA Bathurst Panorama Holiday Park are located close to the proposal. Certain hotels and holiday parks have staff who reside permanently on site and the NCG residential criteria have, therefore, been applied to these receivers, noting that only areas of permanent residence require assessment.

3.2.2 Potential Road Traffic Noise Impacts on the Surrounding Road Network

Where a project results in traffic redistribution, noise impacts can occur on the surrounding road network due to vehicles using different routes after the project is complete. The NCG criteria (see Table 16) are therefore to be applied to the surrounding road network where a road project generates an increase in road traffic noise of more than 2.0 dB.

4 Methodology

4.1 Construction Airborne Noise Assessment Methodology

A noise model of the study area has been used to predict noise levels from the proposed construction works to all surrounding receivers. The model uses ISO 9613 algorithms in SoundPLAN V8 software.

Local terrain, receiver buildings and structures were digitised in the noise model to develop a three-dimensional representation of the construction sites and surrounding areas.

4.1.1 Works Description

Representative scenarios have been developed to assess the likely impacts from the various construction phases of the proposal. These scenarios are shown in Table 18 together with a high-level description of each works activity. The locations of the various work scenarios are shown in Figure 3.

The assessment uses 'realistic worst-case' scenarios to determine the impacts from the noisiest 15-minute period that are likely to occur for each work scenario, as required by the ICNG. The impacts represent construction noise levels without mitigation applied.

The assessment is generally considered conservative as the calculations assume several items of construction equipment are in use at the same time within individual scenarios.

Table 18 Construction Scenario Descriptions

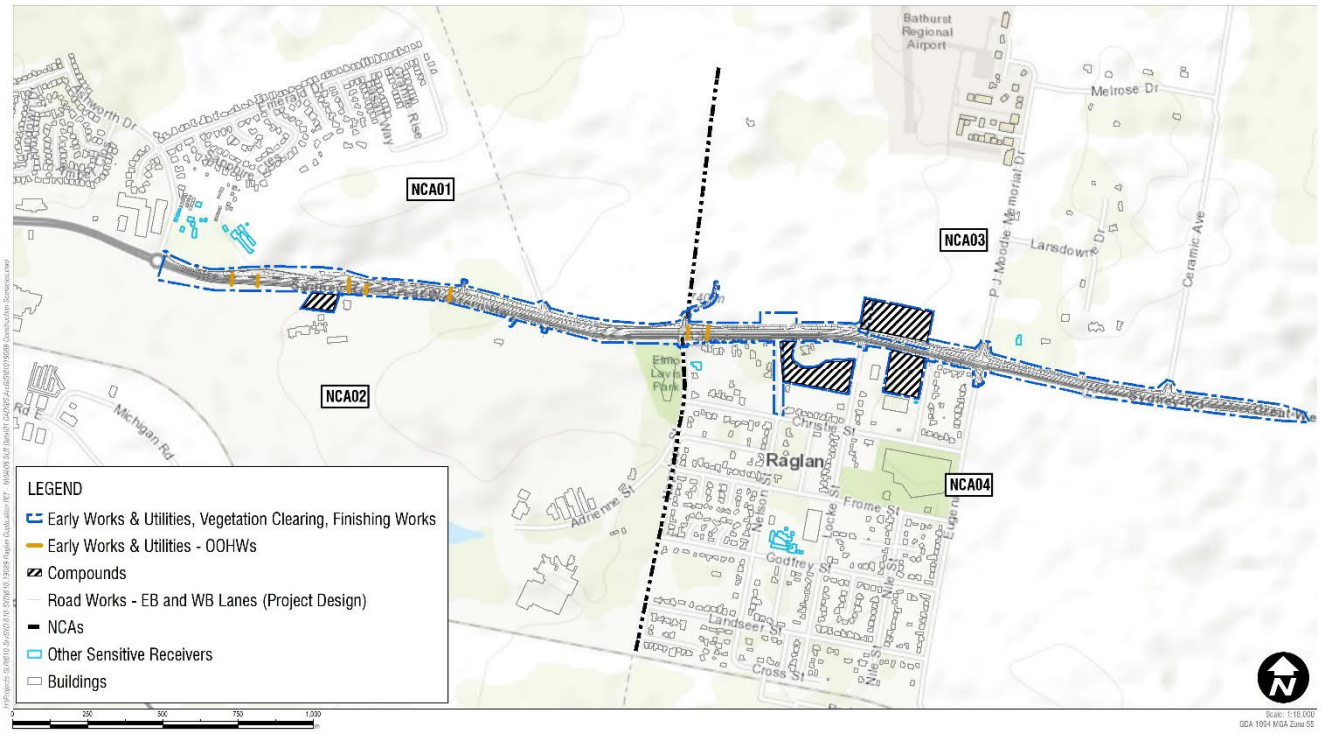
ID	Scenario[1,2]	Description
W.01	Early Works and Utilities - Noise Intensive Works	Early works would include: • Property adjustment works (including adjustments to property accesses) • Erection of fencing and safe work barriers • Construction of access roads (as necessary) • Establishment of traffic and environmental controls • Install temporary drainage diversions to maintain clean water through the site • Dewater dams where they are being adjusted or filled. Several utilities are also present along the alignment which require re-location. Noise intensive equipment such as concrete saws and rockbreakers would be required at times during the works to remove existing concrete structures. Certain utility works along the alignment would require temporary lane closures and would be required to completed outside Standard Construction Hours to minimise potential traffic disruption.
W.02	Early Works and Utilities - Typical Works	
W.03	Early Works and Utilities - OOHWs	

ID	Scenario[1,2]	Description
W.04	Compounds - Establishment	Establishment of site compounds including storage areas and parking areas including: • Clearing and grubbing site compound areas • Minor earthworks to grade flat work areas • Erection of fencing and safe work barriers • Delivery and placement of site sheds • Installation of temporary amenities and services • Delivery of machinery, equipment and materials • Stockpiling of essential construction materials. Noise intensive equipment would not be expected to be required during these works.
W.05	Vegetation Clearing	Vegetation that would be affected by construction of the proposal would be required to be removed including the root ball. Trees and other large vegetation would be removed using chainsaws and mulchers and then removed from site.
W.06	Road Works - Eastbound	Road works would be required along the entire road alignment. The works would be split into constructing the eastbound lanes first and then constructing the westbound lanes. Road construction would include: • Ground works to excavate, backfill and compact formation layer • Excavation and placement of drainage infrastructure • Compaction of road pavement layers and surfacing • Tie-ins to existing intersections and pavement. Vibratory rollers would be required during the works to compact the new road surface pavement layers. Pavement resurfacing works along the full alignment would require temporary lane closures and would be required to occur outside Standard Construction Hours to minimise potential traffic disruption.
W.07	Road Works - Westbound	
W.08	Road Works - Pavement Works	
W.09	Finishing Works	After the main construction works are complete, finishing works would be required which would include: • Installation of street furniture (ie lighting, safety barriers, etc) • Line marking • Installation of landscaping works. Finishing works generally have no requirement for noise intensive equipment.
W.10	Compound - Operation	The compounds would include site offices, laydown areas, worker amenities and workforce parking, as needed. Evening and night-time operation of some compounds would be required at times to support out of hours works.

Note 1: Equipment lists for each scenario and Sound Power Level data are provided in Appendix C.

Note 2: OOHWs = Out of Hours Works

Figure 3 Construction Works Locations



4.1.1.1 Working Hours

Construction of the proposal would be carried out during 'Standard Construction Hours' where possible. Standard Construction Hours are defined in the ICNG as:

- Monday to Friday 7 am to 6 pm
- Saturdays from 8 am to 1 pm
- No work on Sundays or public holidays.

However, the proposal specific constraints mean evening and night-time works would be required at certain times to minimise impacts on road traffic and for safety reasons, including:

- Construction and utility adjustment works requiring road occupancy
- Placement of asphalt wearing course.

The expected periods in which the works would be completed are shown in Table 18. The expected durations of each scenario are also provided.

Table 19 Construction Scenarios – Working Hours

ID	Scenario	Estimated Duration (weeks)	Hours of Works			
			Std. Day	Day OOH[1]	Evening	Night-time
W.01	Early Works and Utilities - Noise Intensive Works	16	✓	-	-	-
W.02	Early Works and Utilities - Typical Works		✓	-	-	-
W.03	Early Works and Utilities		-	✓	✓	✓
W.04	Compounds - Establishment	4	✓	-	-	-
W.05	Vegetation Clearing	4	✓	-	-	-
W.06	Road Works - Eastbound	32	✓	-	-	-
W.07	Road Works - Westbound	32	✓	-	-	-
W.08	Road Works - Pavement Works	8	✓	✓	✓	✓
W.09	Finishing Works	12	✓	-	-	-
W.10	Compound - Operation[2]	23 months	✓	✓	✓	✓

Note 1: OOH = out of hours. Daytime out of hours is Saturday between 7 am to 8 am and 1 pm to 6 pm, on Sunday and public holidays between 8 am to 6 pm.

Note 2: Operation of the compounds would likely be required at times to support the evening and night-time works listed in this table.

4.2 Construction Vibration Assessment

The potential impacts during vibration intensive works have been assessed using the CNVG minimum working distances for cosmetic damage and human response shown in Table 14. The assessment identifies structures which are within the minimum working distances assuming a 13-18 tonne vibratory roller or a large rockbreaker are used during construction in the appropriate scenarios (see Figure 3 and Appendix C).

4.3 Construction Traffic

The potential impacts from construction traffic on public roads have been predicted using the Calculation of Road Traffic Noise (CoRTN) algorithm.

Where the criteria are found to be exceeded, feasible and reasonable mitigation and management measures should be considered.

4.4 Construction Mitigation

The ICNG acknowledges that due to the nature of construction works it is inevitable that there will be impacts where construction is near to sensitive receivers. Several approaches are used on major infrastructure projects to minimise the potential noise and vibration impacts as far as practicable.

Standard Mitigation Measures

The Construction Noise and Vibration Guideline (CNVG) contains a number of 'standard mitigation measures' for mitigating and managing noise and vibration impacts during construction of road infrastructure projects.

These standard measures include items such as requiring construction contractors to complete site inductions to make workers aware of any noise and vibration specifics, completing regular monitoring to check noise and vibration levels are as expected, and checking noise emission levels from construction equipment to ensure they remain within manufacturers' specifications. The 'standard mitigation measures' are shown in full in Appendix C.

Additional Mitigation Measures

Where noise impacts remain after the use of 'standard mitigation measures', the CNVG requires 'additional mitigation measures' to be applied, where feasible and reasonable. The 'additional mitigation measures' include items such as notification of upcoming works, using respite where there are high impacts and verification of construction noise and vibration levels. The measures are determined based on the exceedance of the management levels and are shown in Appendix C.

4.5 Operational Noise Modelling Methodology

4.5.1 Key Operational Features of the Proposal

The key features of the proposal that have the potential to change operational noise impacts in the study area include:

- Widening and realignment of the Great Western Highway to the north. This would move traffic on the highway closer to receivers to the north, however, it is noted that the nearest receivers are generally to the south and the highway would be further away from these receivers.
- Introduction of a signalised intersection at the intersection of the Great Western Highway and Eugenie Street, which has the potential to alter the noise environment near the intersection due to stopping and starting traffic.

4.5.2 Noise Model

A noise model of the study area has been used to predict noise levels from the operation of the proposal to the surrounding receivers. The model uses Calculation of Road Traffic Noise (CoRTN) (UK Department of Transport, 1988) algorithms in SoundPLAN software.

Local terrain, receiver buildings and structures were digitised in the noise model to develop a three-dimensional representation of the proposal and surrounding areas.

The 'No Build' scenarios use the existing road alignment geometry, with all existing structures and features within the road corridor included.

The 'Build' scenarios use the proposed design of the proposal, which includes all widening works and changes to existing ground levels such as cuttings and embankments.

4.5.3 Project and Non-Project Roads

Roads where design or engineering changes are proposed as part of the project are considered as 'project' roads. Existing roads with no works are considered 'non-project'.

All major roads in the study area have been modelled together with major roads on the surrounding road network to determine the contributions from 'project' and 'non-project' roads at individual receivers, as required by the NCG.

4.5.4 Noise Modelling Parameters

Further details on the noise modelling parameters used in the assessment are shown in Table 20.

Table 20 Summary of Noise Model Inputs and Parameters

Input Parameter	Source of Data
Ground topography	The noise model includes a 'digital ground model' which is an accurate 3D representation of the terrain in the study area. The ground model was constructed from a combination of surveyed road corridor data, LIDAR point cloud data and 1 m contours.
Buildings, receiver locations and floors	Buildings can provide screening to more distant locations of the study area. The buildings in the noise model were generated from a combination of aerial photography and site inspections, with heights derived from LIDAR data. The model predicts noise to every facade of every identified receiver in the assessment area using the following heights: • Ground floor – 1.5m[1] • First floor – 4.5m[1].
Study area	The assessment area extends a minimum of 600 m from the project roads as required by the NCG.
Assessment timeframes	The proposal is assessed 'at-opening' in 2022 and in the 'future design' year in 2032.
Traffic volumes	Existing traffic volumes were measured at the same time as the noise monitoring survey. This data was used to model the existing situation and validate the operational model. The predicted traffic volumes for the 2022 and 2032 assessment years were determined by a Traffic and Transport Assessment (Jacobs, December 2019) prepared for the REF and are shown in Appendix D. Constructing an additional lane increases the capacity of the road, however, it would not necessarily increase traffic volumes. Given that there are no suitable direct, alternative routes to travel east-west to and from Bathurst besides using the Great Western Highway, the project would not increase traffic volumes.
Vehicle speed	Existing vehicle speeds were measured during the noise monitoring survey and used to validate the noise model. Existing and future posted vehicle speeds used in the model for Great Western Highway are 100 km/h at the eastern end of the study area, 80 km/h west of Ceramic Avenue and 60 km/h at the western end of the study area.
Source heights and source correction	Vehicles generally emit road traffic noise at four source heights. These are represented in the noise model by the following: • Cars (at 0.5 m height with a source correction of 0.0 dB) • Truck tyres (at 0.5 m height with a source correction of -5.4 dB) • Truck engines (at 1.5 m height with a source correction of -2.4 dB) • Truck exhausts (at 3.6 m height with a source correction of -8.5 dB).
Road surface corrections	The existing road surface is chip seal. The proposed future road surface is Dense Grade Asphalt (DGA) which has a 0 dB surface correction factor or 14/7 chip seal which has a correction of +2.5 dB for cars and 0 dB for trucks[2]. Both proposed surfaces have been assessed separately.
Ground absorption	Noise levels at receivers can be influenced by the type of ground between the source of noise and the receiver. A ground absorption factor of 75% has been used in the noise model.

Input Parameter	Source of Data
General corrections	The model also includes the following corrections to convert the noise model outputs to the appropriate assessment noise levels: • Facade reflections +2.5 dB • L_{A10} to L_{Aeq} -3 dB[3] • $L_{Aeq(15hour)}$ to $L_{Aeq(1hour)}$ +1.5 dB[3] • $L_{Aeq(9hour)}$ to $L_{Aeq(1hour)}$ +3.0 dB[3].

Note 1: These are typical heights above ground level, the height of some receivers were adjusted according to site survey information.

Note 2: Chip seal corrections are based on a literature review which indicates noise from cars is louder than DGA pavements, whereas noise from trucks is approximately the same.

Note 3: Derived from the existing noise monitoring data which is summarised in Section 2. Corrections are based on the median difference between the peak 1-hour results and the corresponding daytime/night-time results.

4.5.5 Noise Model Validation

To validate the operational road traffic noise model, the 2019 existing scenario was modelled and compared to existing noise measurements in the study area (see Section 2). The validation measurement sites are shown in Figure 2 and a summary of the model validation is provided in Table 21. Only noise monitoring locations which were used for model validation purposes are shown.

Table 21 Comparison of Measured and Predicted Road Traffic Noise Levels

Location	Noise Level (dBA)[1]					
	Daytime $L_{Aeq(15hour)}$			Night-time $L_{Aeq(9hour)}$		
	Measured	Predicted	Difference[2]	Measured	Predicted	Difference[2]
L02 – 5415 GWH	56.0	57.7	1.7	55.5	55.9	0.4
L03 – 77 Sydney Road	64.4	65.8	1.4	62.3	65.2	2.9
L04 – 2 PJ Moodie	56.5	57.8	1.3	55.0	56.9	1.9
		Median	1.4		Median	1.9

Note 1: Validation of the noise model was completed using data from 9 to 13 December 2019. This period excluded weekends which tend to have lower and intermittent traffic volumes.

Note 2: Difference is Predicted minus Measured. A negative difference indicates the predicted level of road traffic noise is lower than the measured data, a positive difference indicates the predicted level is higher.

The Roads and Maritime Environmental Noise Management Manual (ENMM) notes that "it should be recognised that noise prediction modelling has some accuracy limitations and will commonly produce acceptable errors of around 2 dBA".

The above predictions show that the noise model is generally slightly conservative at the validation sites and within the anticipated modelling accuracy at most locations. The only exception is during the night-time at L03 where the model is overpredicting by 2.9 dB. This monitoring location is next to the intersection of Great Western Highway and Eugenie Street/PJ Moodie Memorial Drive and was selected to determine existing noise levels adjacent to the proposed signalised intersection (ie not specifically chosen for model validation).

Road traffic noise levels near to intersections can be difficult to predict as many vehicles slow on approach to the intersection to make turns which results in noise levels being variable. The underprediction during the night-time is likely due to this.

On this basis of the above, the model is considered to perform as expected and is valid for predicting road traffic noise levels for the proposal.

4.5.6 Noise Mitigation

The Roads and Maritime 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 that the NCG criteria are not always practicable and that it is not always feasible or reasonable to expect that they are achieved.

As projects progress through the early design stages, various road design features are evaluated to assist with minimising road traffic noise. The NMG defines these 'integrated noise reduction measures' as including:

- Adjustments to vertical and horizontal alignments
- Road gradient modifications
- Traffic management
- Cost effective use of won project spoil to provide landscape mounds where there is suitable site footprint.

Following use of the above measures, site specific 'additional noise mitigation measures' are then required to be investigated for receivers which have residual exceedances of the criteria. When evaluating if a receiver qualifies for consideration of 'additional noise mitigation measures' the NMG considers how far above the criterion the noise level is and also how much a project increases noise levels. These considerations provide a feasible and reasonable approach to identifying qualifying receivers.

The NMG provides three triggers where a receiver may qualify for consideration of 'additional noise mitigation' (beyond the use of 'integrated noise reduction measures'). These are:

- Trigger 1 – the predicted 'Build' noise level exceeds the NCG controlling criterion and the noise level increase due to the project (ie the noise predictions for the 'Build' minus the 'No Build') is greater than 2.0 dB
- Trigger 2 – the predicted 'Build' noise level is 5 dB or more above the NCG controlling criterion (ie exceeds the cumulative limit) and the receiver is significantly influenced by project road noise, regardless of the incremental impact of the project
- Trigger 3 – the noise level contribution from the road project is acute (daytime $L_{Aeq(15hour)}$ 65 dBA or higher, or night-time $L_{Aeq(9hour)}$ 60 dBA or higher) even if noise levels are controlled by a non-project road.

The eligibility of receivers for consideration of 'additional noise mitigation' is determined before the benefit of low noise pavement and noise barriers is included. The requirement for the project is to provide feasible and reasonable additional mitigation to eligible receivers with the aim of meeting the NCG controlling criterion.

For receivers that qualify for consideration of 'additional noise mitigation', potential noise mitigation measures are to be considered in the following order of preference:

- At-source mitigation:
  - Quieter road pavement surfaces

- In-corridor mitigation:
  - Noise mounds
  - Noise barriers
- At-receiver mitigation:
  - At-property treatments.

4.5.7 Maximum Noise Levels

Maximum noise levels near roads are generally controlled by noise from trucks. Where roads are located close to residential receivers there is potential for sleep disturbance impacts from maximum noise level events.

The RNP and ENMM both state that while a maximum noise level assessment is required to be undertaken for new and redeveloped road infrastructure projects, it should only be used as a tool to help prioritise and rank mitigation strategies and should not be applied as a decisive criterion.

The purpose of a maximum noise level assessment is to determine where maximum noise levels are likely to change as a result of a project.

The maximum noise level assessment includes an evaluation of the number and distribution of night-time events in accordance with the ENMM. A maximum noise level event is defined as being any passby where:

- The maximum noise level of the event is greater than 65 dBA L_{AFmax}

  and

- The $L_{AFmax} - L_{Aeq(1hour)}$ is greater than or equal to 15 dB.

Existing maximum noise levels were monitored in the study area during the unattended noise monitoring survey (see Section 2). The potential for changes in maximum noise levels to nearby sensitive receivers are then evaluated where the proposal redevelops roads.

5 Assessment of Construction Impacts

5.1 Overview of Construction Impacts at Residential Receivers

The following overview is based on the predicted noise impacts at the most affected receivers in each NCA and is representative of the worst-case situation where construction equipment is at the closest point to each receiver. For most works, the construction noise impacts would frequently be lower than predicted as the worst-case situation is typically only apparent for a relatively short period when noisy equipment is in use nearby.

The following assessment shows the predicted noise impacts based on the exceedance of the NML, as per the categories in Table 22. The likely subjective response of people affected by the impacts is also shown in the table, noting that the subjective response would vary and depends on the period in which the impacts occur (ie people are generally less sensitive to impacts during the daytime and more sensitive in the evening and night-time).

Table 22 NML Exceedance Bands and Corresponding Subjective Response to Impacts

Exceedance of NML	Symbol	Likely Subjective Response
Compliance	·	Potentially Noticeable
1 to 10 dB	●	Marginal to Minor
11 dB to 20 dB	◆	Moderate
>20 dB	■	High

The predicted construction noise impacts are presented for the most affected receivers. Receivers which are further away from the works and/or shielded from view would have lower impacts. The assessment is generally considered conservative as the calculations assume several items of construction equipment are in use at the same time within individual scenarios.

A summary of the predicted construction noise impacts in each NCA for residential receivers is shown in Table 23. Detailed noise level predictions and summaries of the number of receivers predicted to have 'minor', 'moderate' and 'high' impacts in each NCA are provided in Appendix C.

Table 23 Predicted Worst-case Construction Noise Exceedances – Residential Receivers

Period	ID	Scenario	NCA01	NCA02	NCA03	NCA04
Daytime	W.01	Early Works and Utilities - Noise Intensive Works	◆	◆	◆	■
	W.02	Early Works and Utilities - Typical Works	●	●	●	◆
	W.04	Compounds - Establishment	·	·	·	■
	W.05	Vegetation Clearing	●	●	●	■
	W.06	Road Works - Eastbound	●	●	●	◆
	W.07	Road Works - Westbound	●	●	●	■
	W.08	Road Works - Pavement Works	●	●	●	■
	W.09	Finishing Works	·	●	●	◆
	W.10	Compound - Operation	·	·	·	◆
Evening	W.03	Early Works and Utilities	●	●	·	■
	W.08	Road Works - Pavement Works	◆	◆	◆	■
	W.10	Compound - Operation	·	·	·	■
Night	W.03	Early Works and Utilities	●	◆	●	■
	W.08	Road Works - Pavement Works	◆	■	■	■
	W.10	Compound - Operation	●	●	●	■
Key to Impacts		● Minor (1 to 10 dB)	◆ Moderate (11 dB to 20 dB)		■ High (>20 dB)	

The above assessment for residential receivers shows that:

- The worst-case impacts are generally limited to NCA04 which is due to residential receivers along Great Western Highway being close to the works. Receivers in the other catchments are generally further from the proposal and the worst-case impacts are correspondingly lower.
- 'High' impacts are seen in scenarios which use noise intensive equipment, such as rockbreakers, concrete saws or chainsaws. This includes W.01 – Early Works and Utilities – Noise Intensive Works, which requires rockbreakers and concrete saws, and W.05 – Vegetation Clearing, which requires chainsaws.
- 'High' daytime impacts are also seen during noisy works that are required to be completed near to sensitive receivers, including W.04 – Compounds – Establishment, W.07 – Road Works – Westbound, and W.08 – Road Works – Pavement Works.
- 'High' impacts are also seen when noisy works are required to be completed outside of Standard Construction Hours near to receivers, including W.03 – Early Works and Utilities, W08 – Road Works – Pavement Works, and W.10 – Compound – Operation.
- For most scenarios the noisiest works would, however, only be required for a relatively short period of the total proposal duration. Noise levels and impacts at other times works would be much lower.
- The worst-case predicted noise levels at the nearest receivers in NCA04 are around 75 to 85 dBA (see Appendix C) meaning some residential receivers in this catchment are predicted to be Highly Noise Affected when noisy works are being completed nearby.

- The worst-case noise levels in NCAs with more distant receivers are around 50 to 60 dBA.
- The worst-case night-time impacts are predicted to be 'high' at the nearest receivers in NCA04 during all three scenarios when noisy equipment is in use.
- The worst-case night-time impacts at the nearest receivers in NCA01 to NCA03 are predicted to be 'high' or 'moderate' during W08 – Road Works – Pavement Works.
- It is noted that the worst-case impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would frequently be periods when construction noise levels are much lower than the worst-case levels predicted and there would also be times when no equipment is in use and no impacts occur.

5.2 Detailed Construction Noise Impacts at All Receiver Types

The predicted construction noise impacts from each works scenario are provided in assessment tables in Appendix C for each NCA. The following sections provide a detailed discussion of the key construction impacts.

5.2.1 Worst-case Daytime Scenarios

The worst-case daytime construction impacts are predicted during Early Works and Utilities when noise intensive equipment is in use and during Road Works – Westbound when works are close to receivers. The predicted daytime impacts during these works are shown in:

- Figure 4 – W.01 – Early Works and Utilities – Noise Intensive Works, when equipment such as concrete saws or rockbreakers are being used. Noise levels during typical activities completed as part of Enabling Works and Utilities that do not require noise intensive equipment are shown Figure 5 as a comparison.
- Figure 6 – W.07 – Road Works – Westbound, which do not require noise intensive equipment but are required to be completed relatively close to the adjacent receivers in NCA04.

Early Works and Utilities are anticipated to last around 16 weeks. Road Works are anticipated to last around 32 weeks.

Figure 4 Predicted Impacts 'W.01 – Early Works and Utilities – Noise Intensive Works' (Daytime)

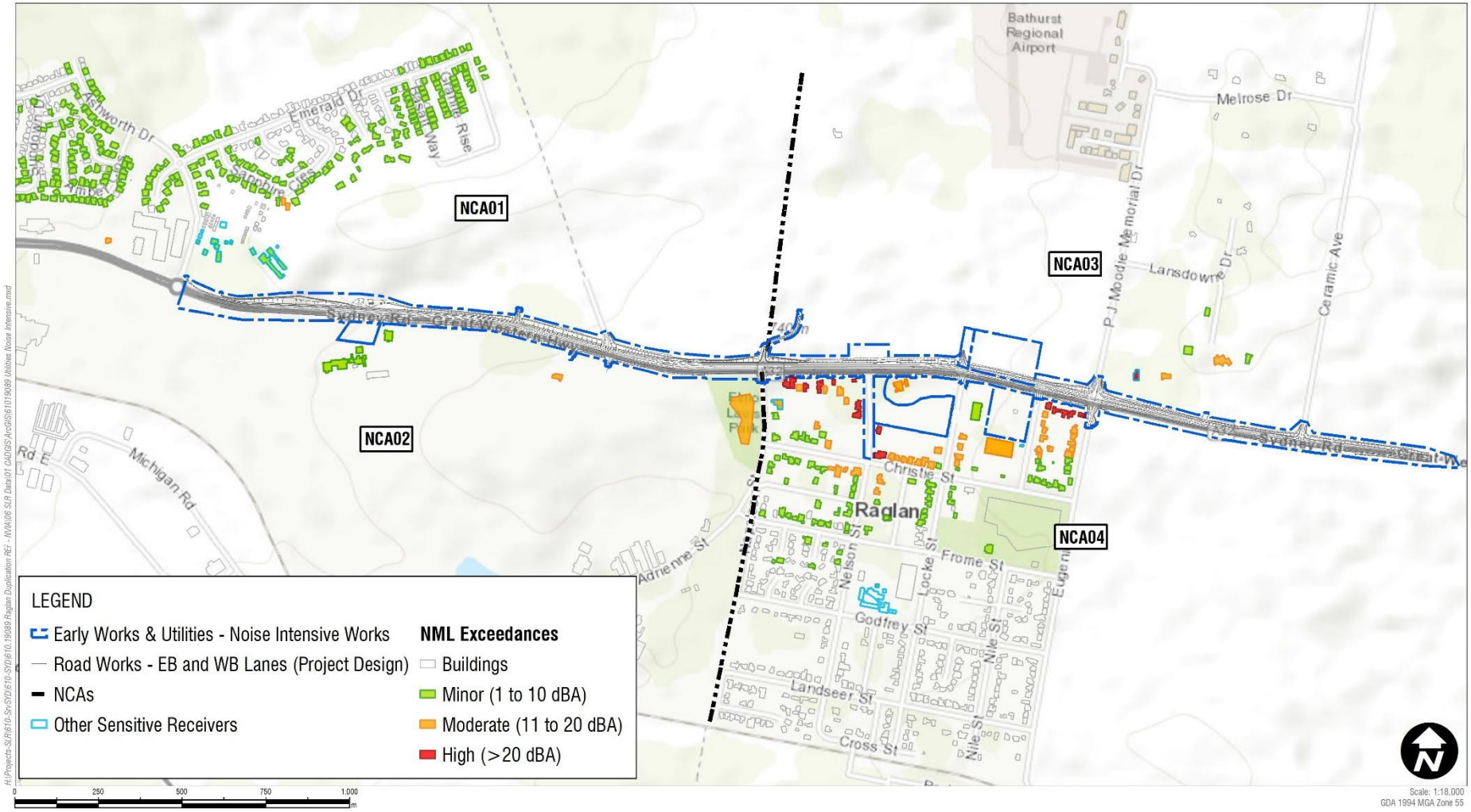


Figure 5 Predicted Impacts 'W.02 – Early Works and Utilities – Typical Works' (Daytime)

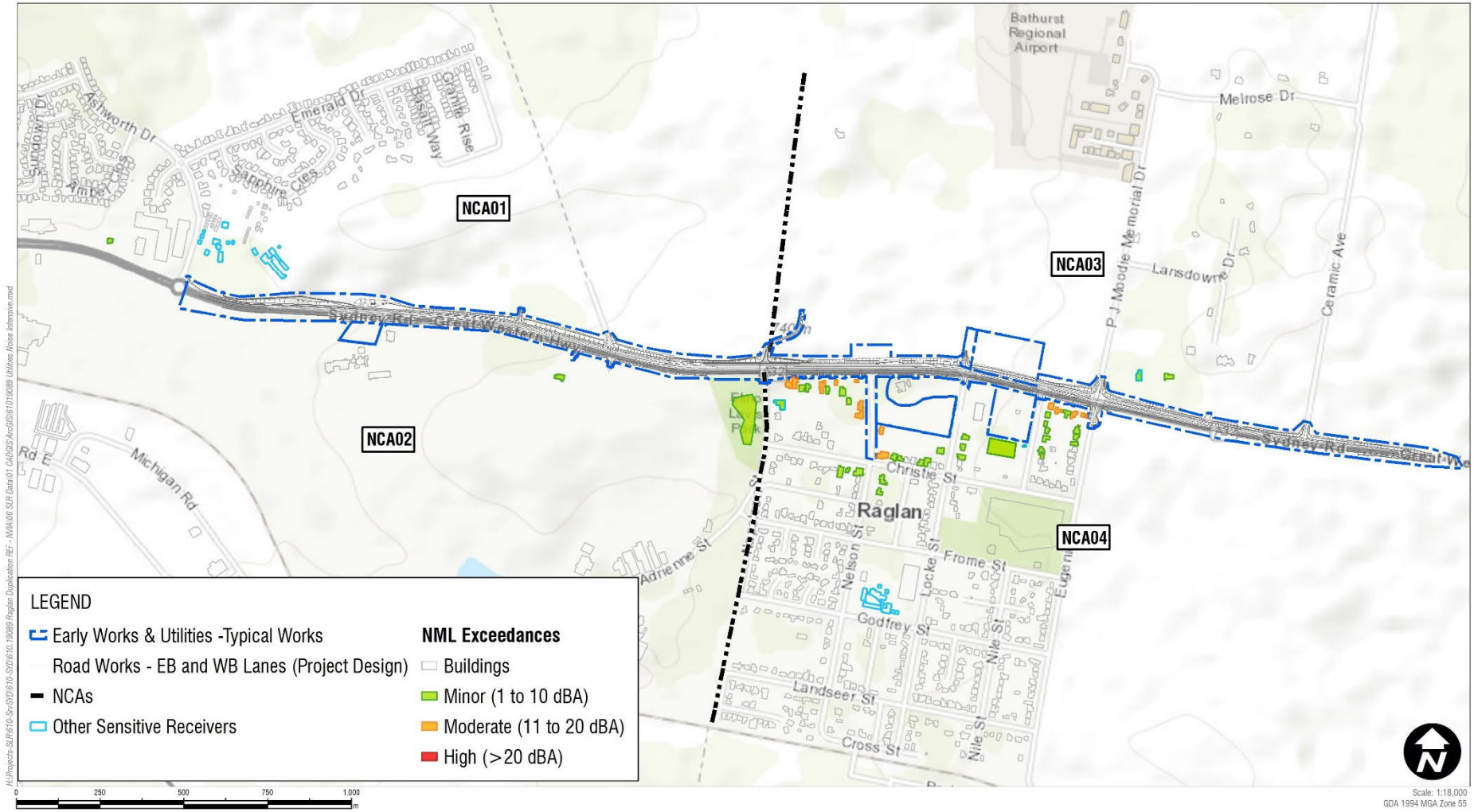
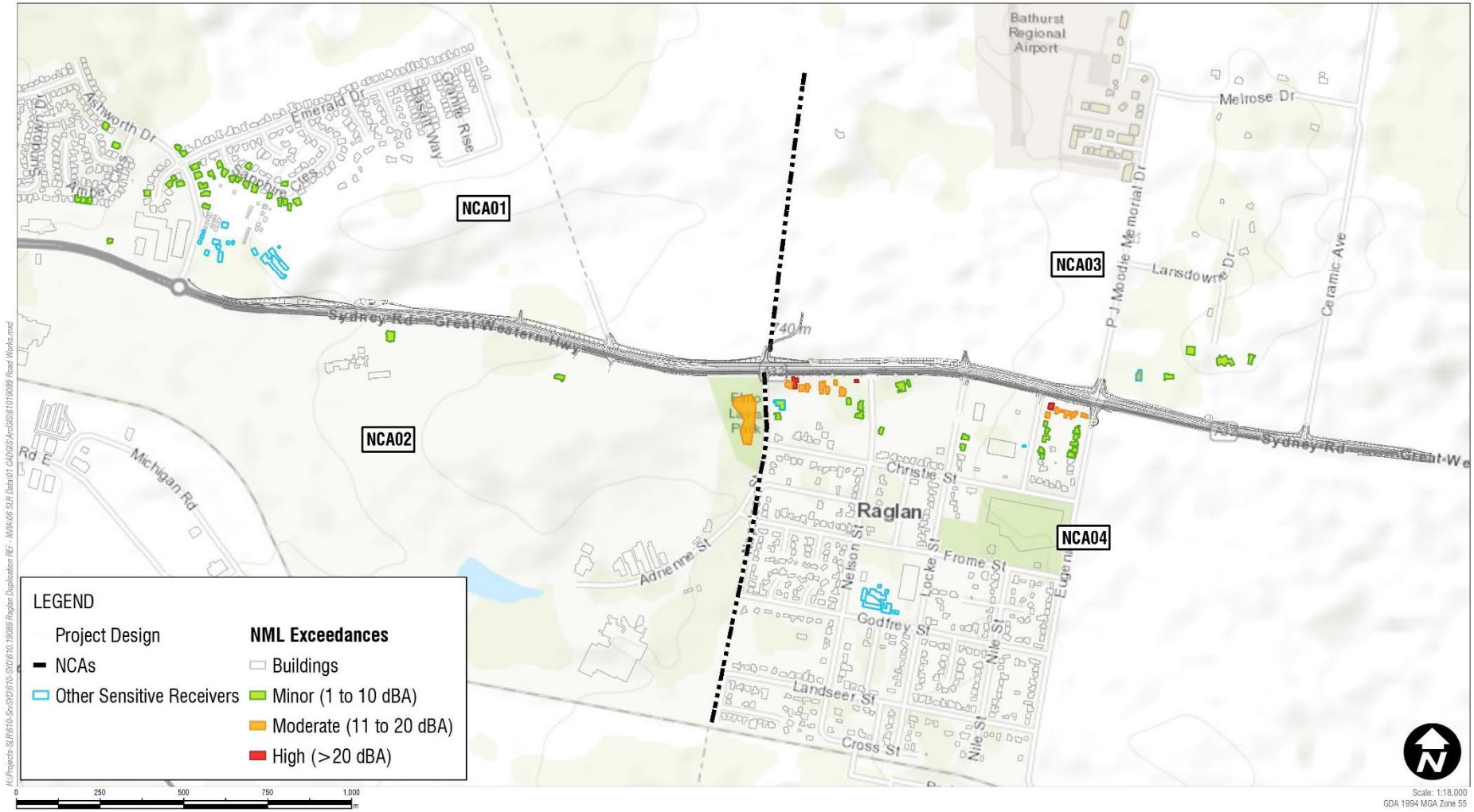


Figure 6 Predicted Impacts 'W.07 – Road Works – Westbound' (Daytime)



The above figures show that several receivers near to the works are predicted to have 'high' worst-case daytime impacts when noise intensive equipment such as rockbreakers or concrete saws are used during Early Works and Utilities. The 'high' impacts are limited to the south of the Great Western Highway in NCA04. Receivers in the other catchments are further away and the worst-case impacts are 'moderate' or 'minor'.

When noise intensive equipment is not being used during Early Works and Utilities, the daytime noise levels would be substantially lower with much fewer receivers affected. The nearest receivers in NCA04 are predicted to have worst-case impacts that are 'moderate' or 'minor', with compliant noise levels generally seen in the rest of the study area.

'High' worst-case impacts are also predicted during Road Works – Westbound, which is due to the proximity of the works to the nearest receivers in NCA04. Receivers which are more setback are predicted to have 'moderate' or 'minor' impacts, with compliant noise levels in distant areas.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would frequently be periods when construction noise levels are much lower than the worst-case levels predicted and there would be times when no equipment is in use and no impacts occur.

5.2.2 Night-time Scenarios

The predicted impacts during the three construction scenarios required to be completed during the night-time shown in:

- Figure 7 – W.03 – Early Works and Utilities
- Figure 8 – W.08 – Road Works – Pavement Works
- Figure 9 – W.10 – Compound – Operation.

Early Works and Utilities are required at certain locations along the alignment where temporary road closures are necessary meaning works would be required to be completed outside Standard Construction Hours to minimise potential traffic disruption.

Road Works – Pavement Works are required along the entire road alignment and would also require temporary lane closures.

Evening and night-time works would be required as part of Compound – Operation at times to support out of hours works.

Figure 7 Predicted Impacts 'W.03 – Early Works and Utilities' (Night-time)

Figure 8 Predicted Impacts 'W.08 – Road Works – Pavement Works' (Night-time)

Figure 9 Predicted Impacts 'W.10 – Compound – Operation' (Night-time)

The above figures show that the impacts during night-time works are more widespread, which is due to lower NMLs during this period. Receivers near to the works are predicted to have 'high' worst-case night-time impacts when noisy equipment is being used, with more distant receivers generally having 'moderate' or 'minor' worst-case impacts.

The impacts presented above are based on all equipment working simultaneously in each assessed scenario. There would frequently be periods when construction noise levels are much lower than the worst-case levels predicted and there would be times when no equipment is in use and no impacts occur.

The requirements for night-time works would be confirmed as the proposal progresses. Construction mitigation and management measures are discussed further in Section 7.1.

5.3 Commercial/Industrial and Other Sensitive Receivers

A summary of the predicted construction noise impacts in each NCA for commercial/industrial and 'other sensitive' receivers is presented in Table 24 and shown in Figure 10. Noise level predictions are provided in Appendix C.

The assessment of commercial/industrial and 'other sensitive' receivers shows the following:

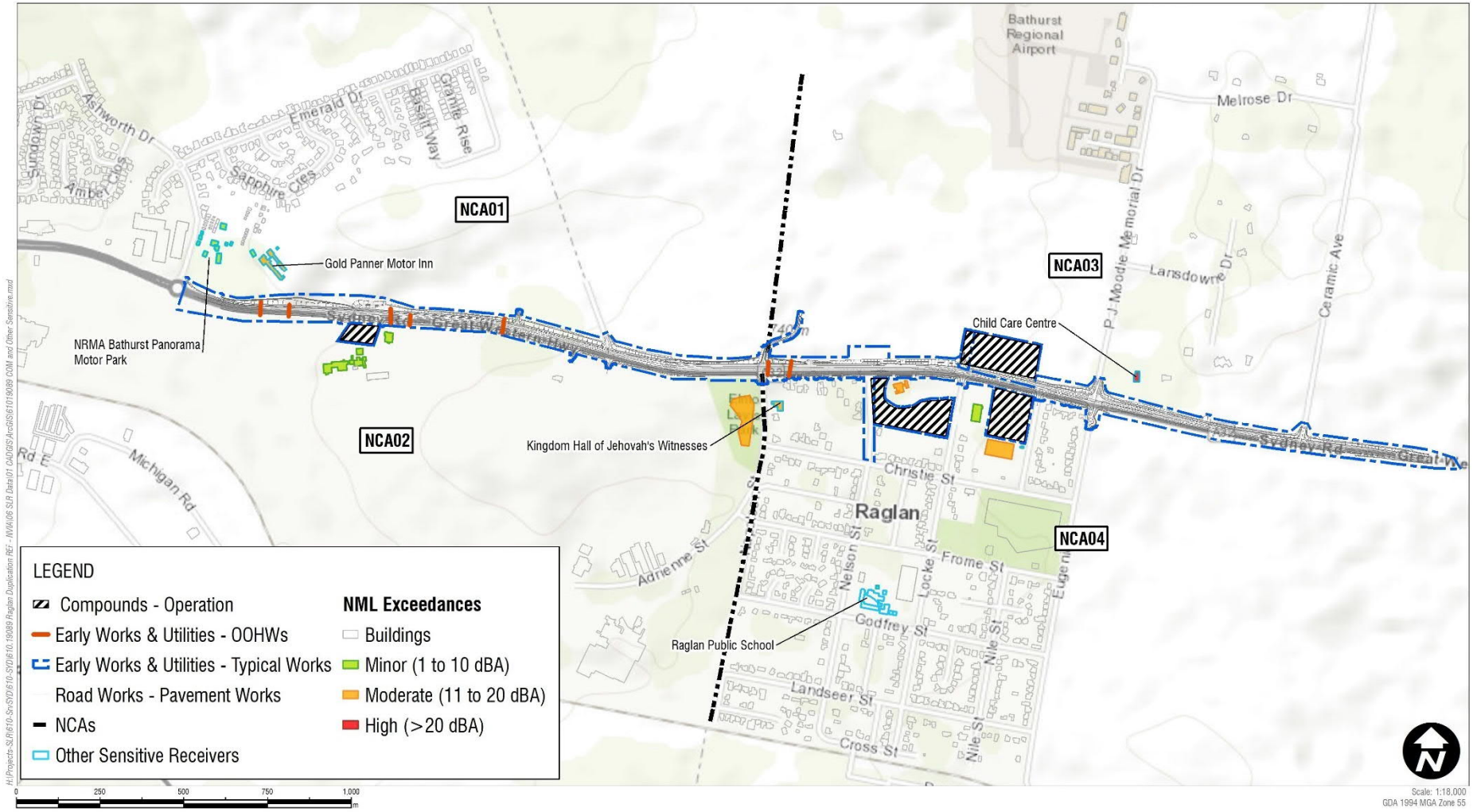
- 'High' worst-case impacts are predicted at the child care centre off PJ Moodie Memorial Drive.
- 'Moderate' worst-case impacts are predicted at Gold Panner Motor Inn, Kingdom Hall of Jehovah's Witnesses place of worship, the outdoor area off Nile Street, Elmo Lavin Park and one commercial building during the noisiest works.
- 'Minor' worst-case impacts are predicted at the NRMA Bathurst Panorama Holiday Park and the above identified receivers during less noisy works.

Table 24 Overview of Commercial/Industrial and 'Other Sensitive' Receiver NML Exceedances

ID	Scenario	Number of Receiver Buildings Affected																							
		Child Care[1]			Educational[2]			Place of Worship[3]			Public Building[4]			Outdoor Areas[5]			Hotels[6]						Commercial /Industrial		
		Daytime			Daytime			Daytime			Daytime			Daytime			Daytime			Night-time			Daytime		
		1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	1-10 dB	11-20 dB	>20 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
W.01	Early Works & Utilities - Noise Intensive Works	-	-	1	1	-	-	-	1	-	-	1	-	-	2	-	10	-	-	n/a	n/a	n/a	7	1	-
W.02	Early Works & Utilities - Typical Works	1	-	-	-	-	-	1	-	-	1	-	-	2	-	-	-	-	-	n/a	n/a	n/a	-	-	-
W.03	Early Works & Utilities	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-
W.04	Compounds - Establishment	1	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	-	-	n/a	n/a	n/a	-	-	-
W.05	Vegetation Clearing	-	1	-	-	-	-	1	-	-	1	-	-	2	-	-	1	-	-	n/a	n/a	n/a	1	-	-
W.06	Road Works - Eastbound	-	1	-	-	-	-	1	-	-	-	-	-	1	-	-	2	-	-	n/a	n/a	n/a	-	-	-
W.07	Road Works - Westbound	-	1	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	n/a	n/a	n/a	2	-	-
W.08	Road Works - Pavement Works	-	1	-	-	-	-	1	-	-	-	-	-	-	1	-	2	-	-	12	2	-	2	-	-
W.09	Finishing Works	1	-	-	-	-	-	-	-	-	1	-	-	2	-	-	-	-	-	n/a	n/a	n/a	-	-	-
W.10	Compound - Operation	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-

Note 1: Child care centre at the intersection of Great Western Highway and PJ Moodie Memorial Drive.
Note 2: Raglan Public School.
Note 3: Kingdom Hall of Jehovah's Witnesses Church.
Note 4: Associated with Ralph Cameron Park.
Note 5: Outdoor area off Nile Street and Elmo Lavin Park.
Note 6: Gold Panner Motor Inn and NRMA Bathurst Panorama Holiday Park.

Figure 10 Predicted Worst-case Impacts – Commercial/Industrial and Other Sensitive Receivers



5.4 Sleep Disturbance

A sleep disturbance screening assessment has been undertaken for the construction works and a summary is provided in the assessment tables in Appendix C.

Review of the predictions shows that the sleep disturbance screening criterion is likely to be exceeded when night works occur near residential receivers. The receivers which would potentially be affected by sleep disturbance impacts are generally the same receivers where 'high' night-time impacts have been predicted (see Section 5.1 to 5.2).

The requirements for night-time works would be confirmed as the proposal progresses. Construction mitigation and management measures are discussed further in Section 7.1.

5.5 Construction Vibration Assessment

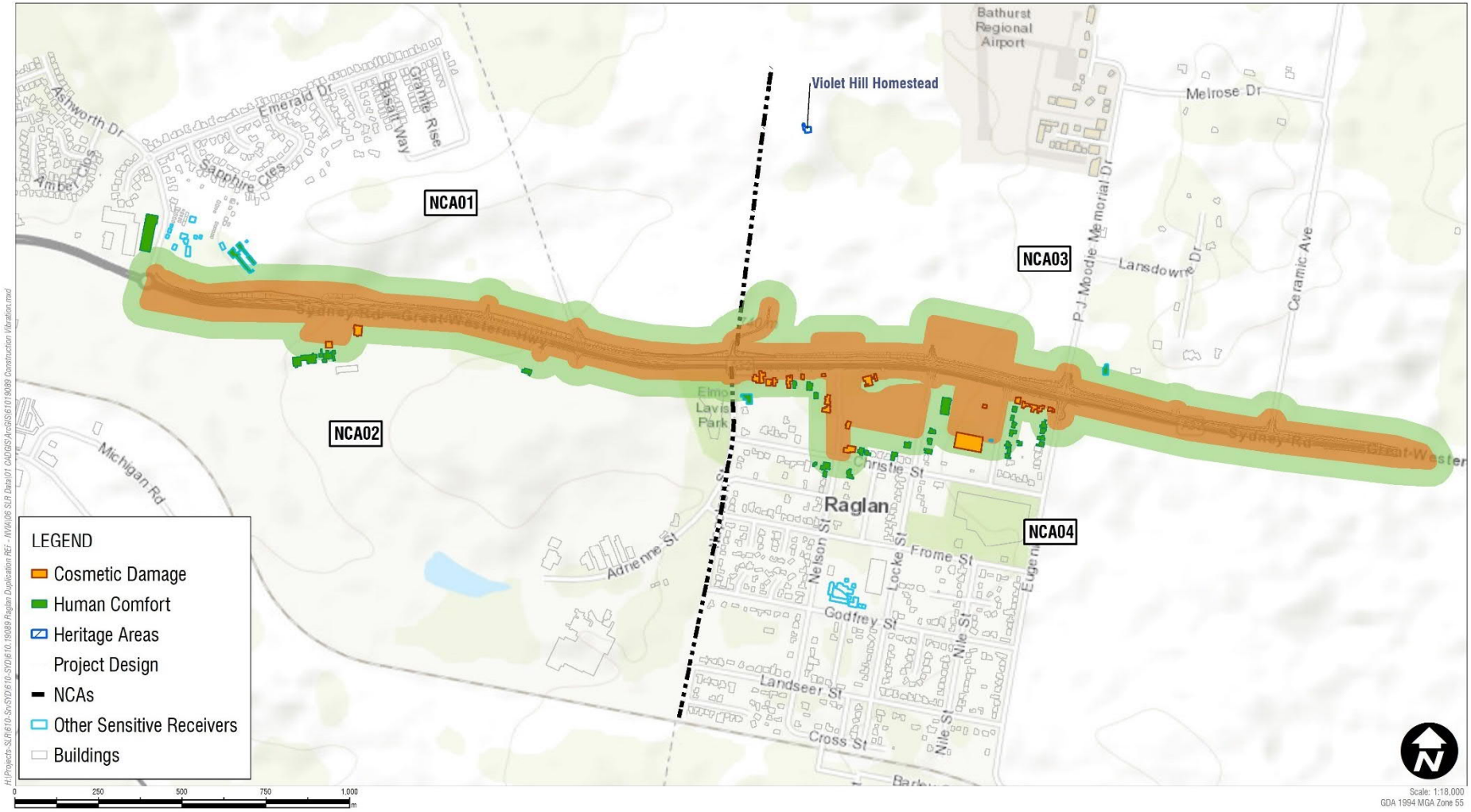
The main potential sources of vibration during construction would be from vibratory rollers and rockbreakers. The construction scenarios which require vibration intensive equipment are shown in Table 25.

Table 25 Requirement for Vibration Intensive Equipment

ID	Scenario	Vibration Intensive Equipment
W.01	Early Works / Utilities - Noise Intensive Works	Excavator – Breaker, Underboring Rig
W.06	Road Works - Eastbound	Roller – Vibratory
W.07	Road Works - Westbound	Roller – Vibratory
W.08	Road Works – Pavement Works (OOHWs)	Roller – Vibratory

Vibration offset distances have been determined from the CNVG minimum working distances for cosmetic damage and human response in Table 14 and the assessment is summarised in Figure 11. Buildings within the minimum working distances are shown on the figure.

Figure 11 Construction Vibration Assessment – Large Rockbreaker used as part of W.01 - Early Works and Utilities



Cosmetic Damage Assessment

The above figure shows that the distance between the construction works and the nearest receivers is generally sufficient for most buildings in the study area to be unlikely to suffer cosmetic damage from the proposed works.

Some buildings and structures are, however, within the recommended minimum working distances, particularly in the eastern section of the study area, where receivers in NCA04 are located close to the works.

Human Comfort Vibration Assessment

Certain receivers in the study area are also within the human comfort minimum working distance and occupants of affected buildings may be able to perceive vibration impacts at times when vibration intensive equipment is in use. Where impacts are perceptible, they would likely only be apparent for relatively short durations when equipment such as rockbreakers or vibratory rollers are nearby.

Heritage Structures

No heritage buildings or structures that have been identified in the study area as being within the cosmetic damage minimum working distances.

Construction mitigation and management measures are discussed further in Section 7.1.

5.6 Cumulative Impacts

Cumulative construction noise impacts can occur where multiple works are being completed near to a particular receiver at the same time.

Since the construction scenarios generally require similar items of equipment, concurrent construction works being completed in an area of the proposal could theoretically increase the worst-case noise levels in this report by around 3 dB (ie a logarithmic adding of two sources of noise at the same level).

The likelihood of worst-case noise levels being generated by two different works at the same time is, however, considered low and rather than increase construction noise levels, the impact of concurrent works would generally be a potential increase in the duration, and annoyance, of noise impacts on the affected receivers.

In practice, construction noise levels in any one location would vary and would be frequently much lower than worst-case due to construction phasing moving works around and, in many cases, only a few items of equipment being used at any one time.

5.7 Construction Traffic Noise Assessment

Construction related traffic has the potential to temporarily increase road traffic noise levels at receivers which are adjacent to construction haulage routes. The likely construction traffic routes are detailed in Table 26.

Table 26 Construction Traffic Routes

Construction Stage	Indicative Volume	Route
Construction traffic	20 to 30 truck 40 to 50 light vehicles	Great Western Highway and potentially Littlebourne Street depending on the location of the asphalting plant.
Construction spoil haulage to four sites: • 234 Gilmour, St Kelso • Works at Mount Panorama • Works at Perthville (levee construction) • Works on the Great Western Highway at Glanmire	50 trucks per day	Construction spoil haulage routes: • Great Western Highway and Gilmour Street. • Great Western Highway, Havannah Street, and potentially Lloyds Road, Pit Straight, and Mountain Straight depending on the location of the spoil storage site. • Great Western Highway, Havannah Street, Russell Street, Alpha Street, Vale Road, and potentially Bridge Street, Bathurst Street, Perth Street, and North Street depending on the location of the spoil storage site. • Great Western Highway.

Where construction traffic uses existing major roads such as the Great Western Highway, the relatively low numbers of construction traffic compared to the high existing volumes on major roads (ie around 10,000 vehicles daily on the Great Western Highway) are not expected to result in any noticeable impacts.

Some of the routes, however, potentially use local roads, including Lloyds Road, Perth Street, and North Street. Existing traffic volumes on these roads are likely to be low meaning noticeable increases in noise may be apparent for receivers adjacent to these roads.

6 Assessment of Operational Impacts

Operational road traffic noise impacts 'without mitigation' have been predicted for all sensitive receivers in the study area. The operational impacts are discussed in the following sections.

The following assessment assumes Dense Grade Asphalt as the future pavement surface in the study area. The impacts from the proposed alternative chip seal pavement are discussed in Section 6.2.

6.1 DGA Pavement

6.1.1 Residential Receivers

The predicted operational road noise levels at residential receivers are summarised in Table 27 for the 2022 at-opening and 2032 future design scenarios. The table shows the worst-case impacts in each NCA, which are typically for receivers nearest to the proposal.

Receivers are generally most affected by the proposal in the night-time period in 2032 with respect to the NCG criteria and NMG triggers, and this scenario is considered to control the assessment in terms of determining the worst-case impacts and requirements for mitigation.

The predicted noise levels for the controlling 2032 night-time scenario are shown in Figure 12 and the predicted change in noise levels (Build (with project) minus No Build (without project)) for the same scenario is in Figure 13.

Detailed noise predictions at triggered receivers are in Appendix D together with operational road traffic noise contours.

Table 27 Predicted Road Traffic Noise Levels at Most Affected Residential Receivers in each NCA

NCA	Predicted Noise Level (dBA)[1]								Number of Triggered Buildings[2]			
	At Opening (2022)				Future Design (2032)							
	No Build (without project)		Build (with project)		No Build (without project)		Build (with project)					
	Day	Night	Day	Night	Day	Night	Day	Night	Trigger 1 >2.0 dB	Trigger 2 Cumulative	Trigger 3 Acute	Total
NCA01	64	60	64	60	65	61	65	61	-	-	-	-
NCA02	63	58	61	57	63	58	62	58	-	-	-	-
NCA03	59	54	59	54	59	55	59	55	-	-	-	-
NCA04	75	69	68	63	75	70	68	64	-	11	11	11
											Total	11

Note 1: Daytime and night-time are $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ noise levels, respectively.

Note 2: The NMG triggers are discussed in Section 4.5.6.

Figure 12 Worst-case Predicted Operational Noise Levels (2032 Night-time, Build)

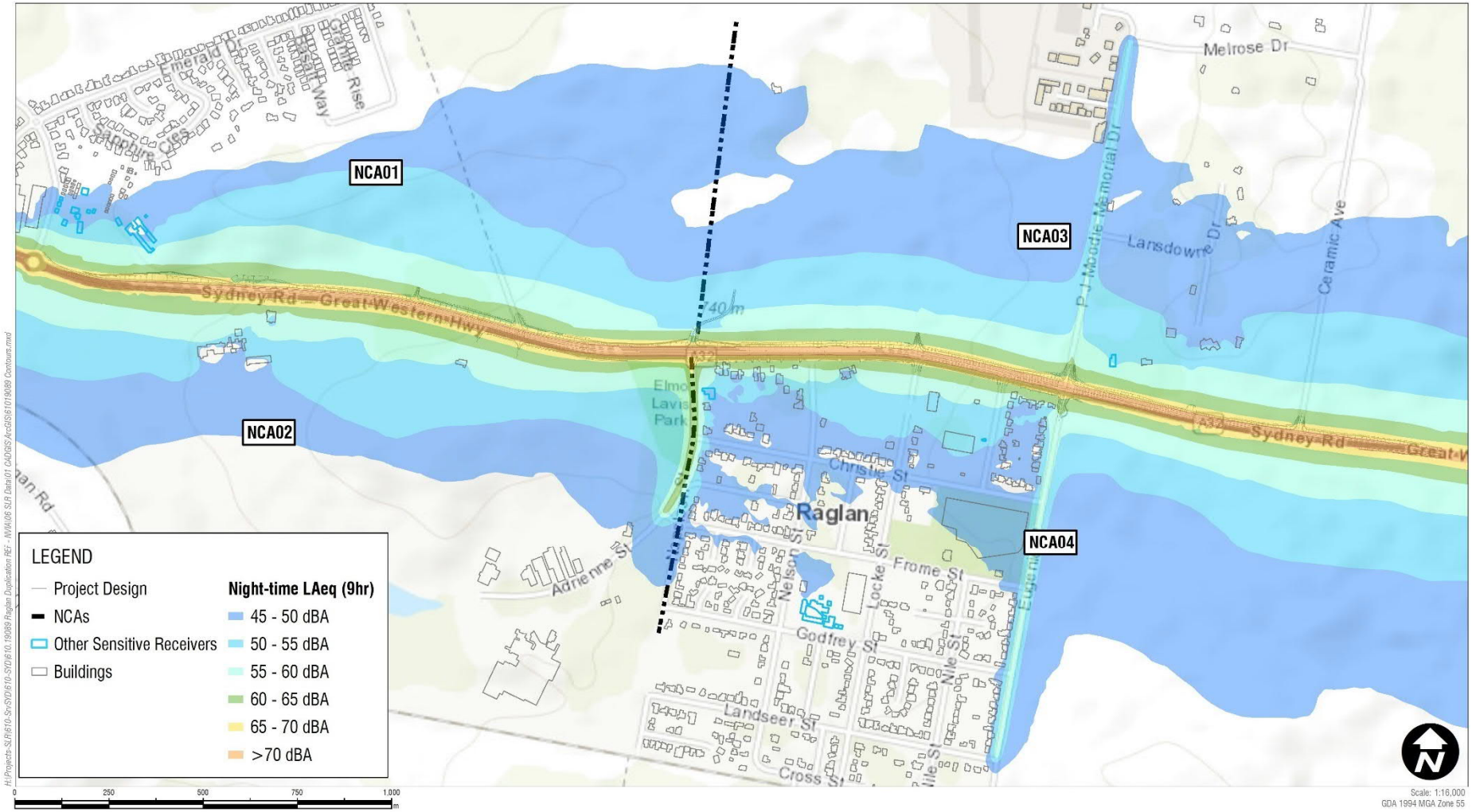
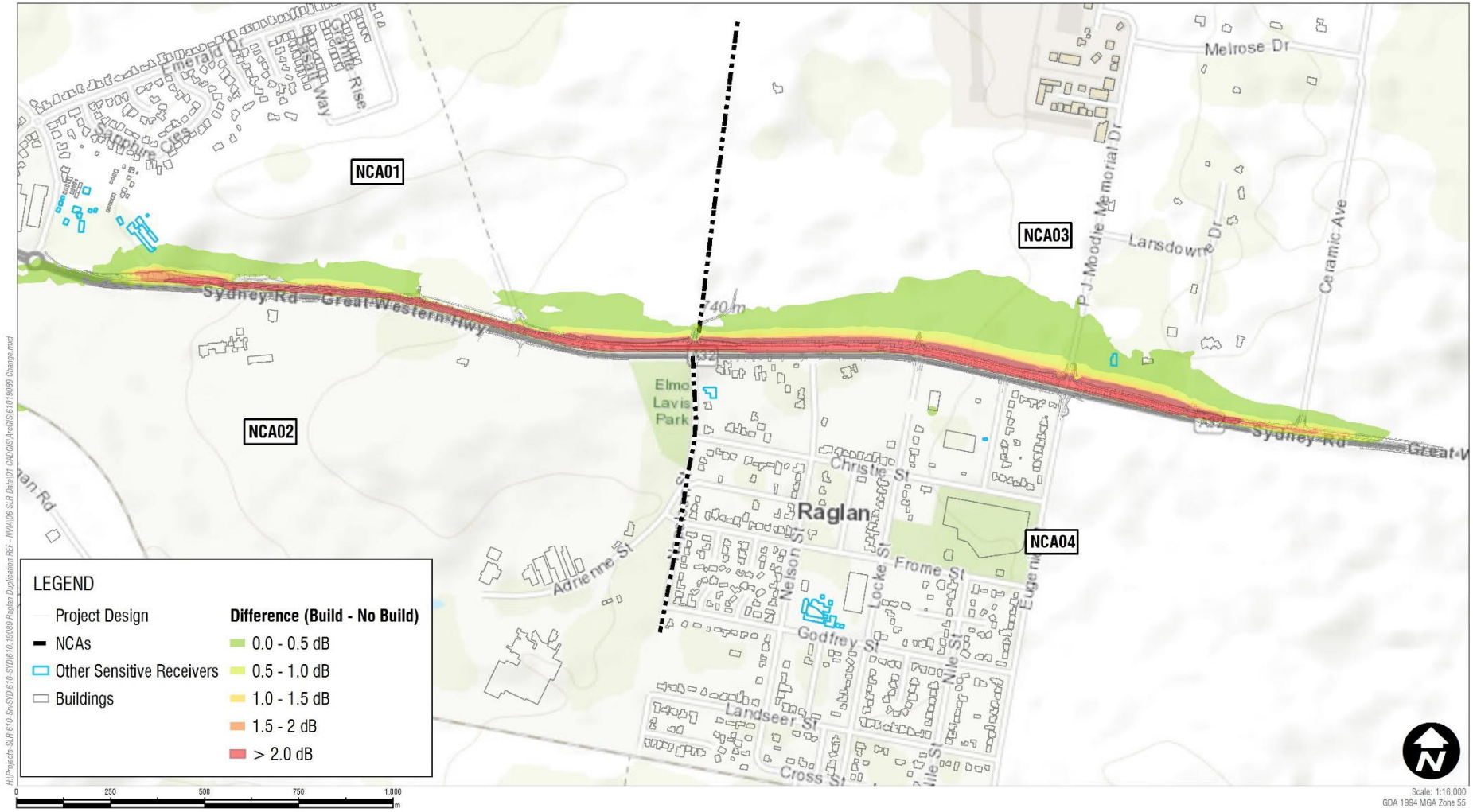


Figure 13 Worst-case Predicted Change in Operational Noise (2032 Night-time, Build minus No Build)



The above results show the following:

- The nearest residential receivers to the proposal are subject to relatively high existing road traffic noise impacts which already exceed the NCG criterion in many cases.
- The proposal would widen and realign the Great Western Highway to the north which increases road traffic noise levels in this direction. The increase is, however, predicted to be less than 2.0 dB for all receivers to the north.
- Receivers to the south are predicted to have decreases in road traffic noise due to the realignment of Great Western Highway. The proposed DGA pavement also results in lower noise levels than compared to the existing chip seal surface.
  - Receivers adjacent to the Great Western Highway in NCA04 are predicted to have decreases of up to 6 dB.
  - More distant receivers in NCA04 and receivers in NCA02 are predicted to have decreases of around 1 to 2 dB.
- Exceedances of the NCG cumulative limit criteria (ie 5 dB or more above the NCG controlling criterion) are predicted at residential receivers in NCA04 which are adjacent to the Great Western Highway. It is noted that road traffic noise levels at these receivers are predicted to reduce as a result of the proposal.
- The same receivers are also predicted to be subject to acute noise levels (ie daytime noise levels are 65 dBA or higher, or night-time noise levels are 60 dBA or higher).
- In summary, the proposal results in:
  - No residential receivers having increases of greater than 2.0 dB
  - 11 residential receivers being above the cumulative limit criteria
  - 11 residential receivers having acute noise levels
  - In total, 11 residential receivers (all in NCA04 to the south of the proposal) are predicted to have exceedances of the NCG operational road traffic noise criteria. All triggered residential receivers are, however, predicted to have decreases in road traffic noise.

6.1.2 'Other Sensitive' Receivers

'Other sensitive' receivers that are predicted to have exceedances of the trigger levels are shown in Table 28 for the controlling 2032 scenario. The location of the triggered 'other sensitive' receivers are shown Figure 14.

Table 28 'Other Sensitive' Receivers Triggers

NCA	Receiver	Type	NMG Triggers[1]		
			Trigger 1 >2.0 dB	Trigger 2 Cumulative	Trigger 3 Acute
NCA03	PJ Moodie Memorial Drive	Child Care Centre	-	Y	-
NCA04	Kingdom Hall of Jehovah's Witnesses	Place of Worship	-	Y	-

Note 1: The NMG triggers are discussed in Section 4.5.6.

In summary, the above assessment shows a total of two 'other sensitive' receiver buildings are predicted to have exceedances of the NCG operational road traffic noise criteria.

6.1.3 Receivers Eligible for Consideration of 'Additional Noise Mitigation'

The receivers which have been identified as eligible for consideration of 'additional noise mitigation' (ie triggered receivers) are summarised in Table 29 and shown in Figure 14.

Table 29 Receivers Eligible for Consideration for 'Additional Noise Mitigation'

NCA	Number of Triggered Buildings (Floors)		Comments
	Residential	Other Sensitive	
NCA01	- (-)	- (-)	-
NCA02	- (-)	- (-)	-
NCA03	- (-)	1 (1)	The triggered 'other sensitive' receiver in this catchment is the child care centre on PJ Moodie Memorial Drive. The receiver is triggered due to cumulative limit exceedances.
NCA04	11 (11)	1 (1)	Residential receivers are triggered to the south of the proposal in this catchment due to cumulative limit exceedances and acute noise levels from the proposal. The triggered 'other sensitive' receiver is the Kingdom Hall of Jehovah's Witnesses place of worship. It is noted that road traffic noise levels at these receivers are predicted to reduce as a result of the proposal.
Sub Total	11 (11)	2 (2)	-
TOTAL	13 (13)		

Note 1: The count of 'floors' represents separate floors within each building.

In summary, the above assessment shows a total of 13 sensitive receiver buildings are predicted to have exceedances of the NCG operational road traffic noise criteria with a DGA pavement and are therefore eligible for consideration of 'additional noise mitigation'. Operational noise mitigation measures for the proposal are discussed further in Section 7.2.

Figure 14 Receivers Eligible for Consideration of Additional Mitigation

6.2 Chip Seal Alternative Pavement

6.2.1 Residential Receivers

The predicted operational road noise levels at residential receivers are summarised in Table 30 for the 2022 at-opening and 2032 future design scenarios. The table shows the worst-case impacts in each NCA, which are typically for receivers nearest to the proposal.

Receivers are generally most affected by the proposal in the night-time period in 2032 and this scenario is considered to control the assessment in terms of determining the worst-case impacts and requirements for mitigation.

The predicted noise levels for the controlling 2032 night-time scenario are shown in Figure 15 and the predicted change in noise levels (Build (with project) minus No Build (without project)) for the same scenario is in Figure 16.

Detailed noise predictions at triggered receivers are in Appendix D together with operational road traffic noise contours.

Table 30 Predicted Road Traffic Noise Levels at Most Affected Residential Receivers in each NCA

NCA	Predicted Noise Level (dBA)[1]								Number of Triggered Buildings[2]			
	At Opening (2022)				Future Design (2032)							
	No Build (without project)		Build (with project)		No Build (without project)		Build (with project)					
	Day	Night	Day	Night	Day	Night	Day	Night	Trigger 1 >2.0 dB	Trigger 2 Cumulative	Trigger 3 Acute	Total
NCA01	64	60	64	60	65	61	65	61	-	-	-	-
NCA02	63	58	63	58	63	58	63	58	-	-	-	-
NCA03	59	54	60	55	59	55	61	56	-	-	-	-
NCA04[3]	75	69	69	64	75	70	70	65	-	11	11	11
											Total	11

Note 1: Daytime and night-time are $L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$ noise levels, respectively.

Note 2: The NMG triggers are discussed in Section 4.5.6.

Figure 15 Worst-case Predicted Operational Noise Levels (2032 Night-time, Build)

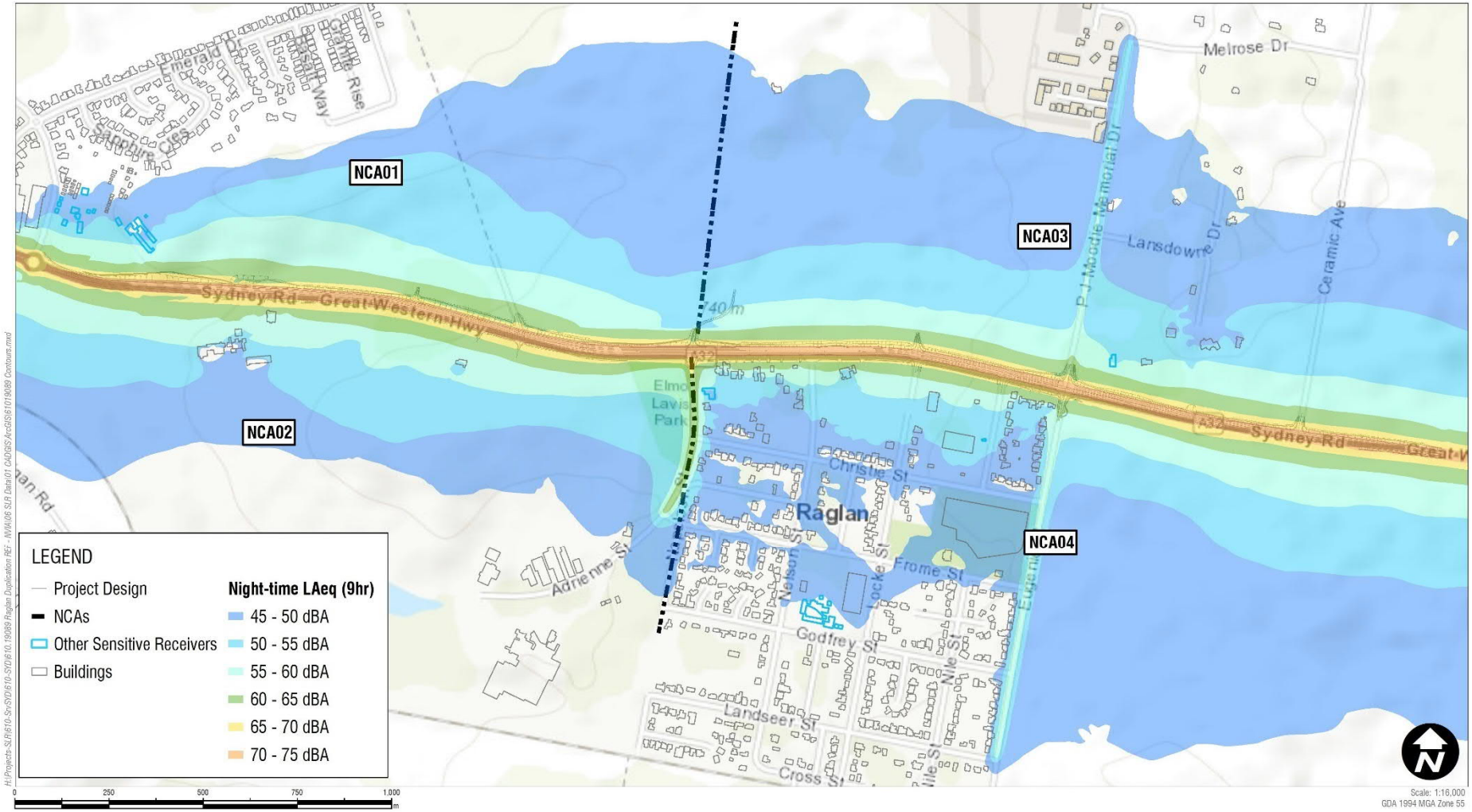
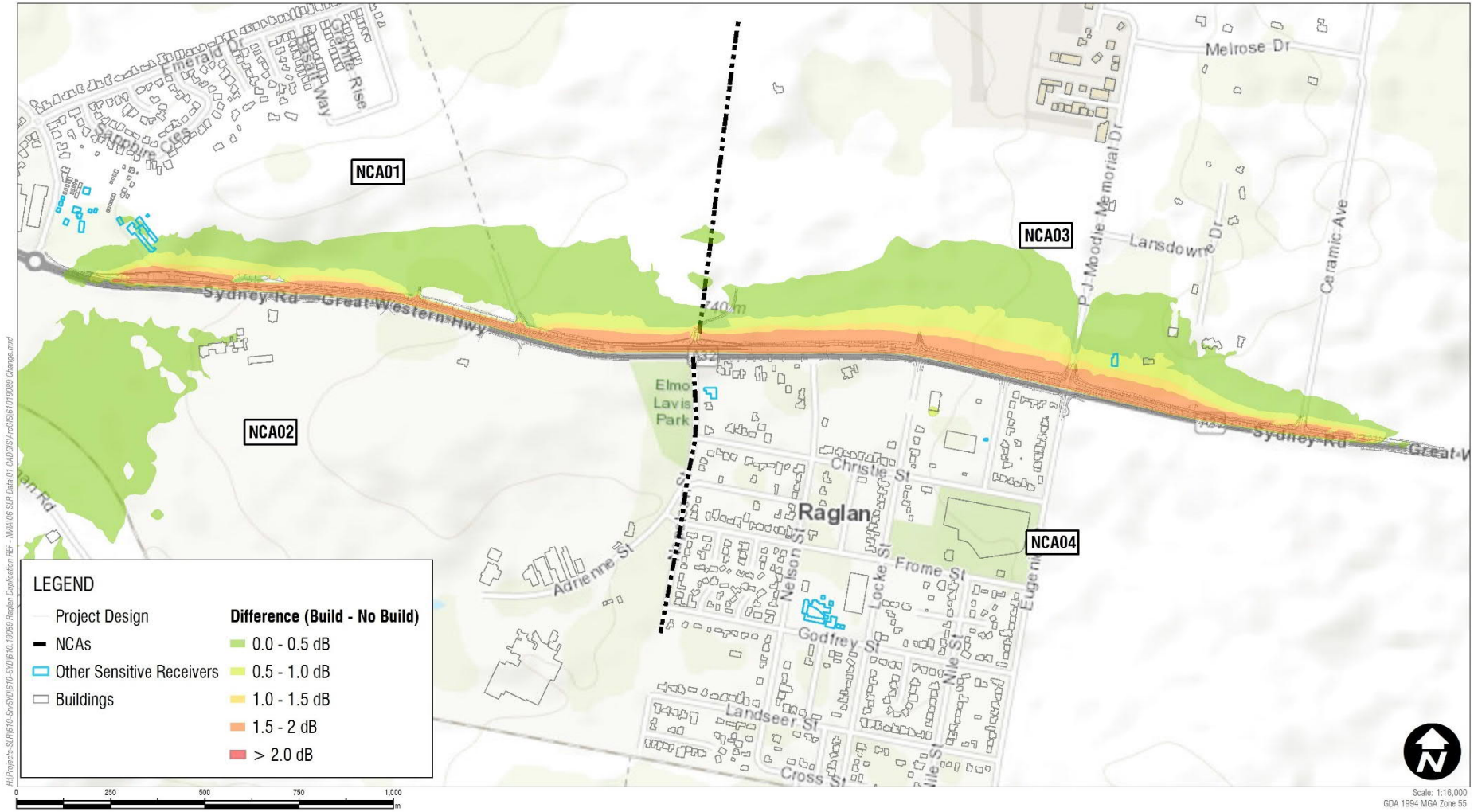


Figure 16 Worst-case Predicted Change in Operational Noise (2032 Night-time, Build minus No Build)



The above results show the following:

- The nearest residential receivers to the proposal are subject to relatively high existing road traffic noise impacts which already exceed the NCG criterion in many cases.
- The proposal would widen and realign the Great Western Highway to the north which increases road traffic noise levels in this direction. The increase is, however, predicted to be less than 2.0 dB for all receivers to the north.
- Receivers to the south are predicted to have decreases in road traffic noise due to the realignment of Great Western Highway.
  - Receivers adjacent to the Great Western Highway in NCA04 are predicted to have decreases of up to 5 dB.
  - More distant receivers in NCA04 and receivers in NCA02 are predicted to have decreases of around 1 to 2 dB.
- Exceedances of the NCG cumulative limit criteria (ie 5 dB or more above the NCG controlling criterion) are predicted at residential receivers in NCA04 which are adjacent to the Great Western Highway. It is noted that road traffic noise levels at these receivers are predicted to reduce as a result of the proposal.
- The same receivers are also predicted to be subject to acute noise levels (ie daytime noise levels are 65 dBA or higher, or night-time noise levels are 60 dBA or higher).
- In summary, the proposal results in:
  - No residential receivers having increases of greater than 2.0 dB
  - 11 residential receivers being above the cumulative limit criteria
  - 11 residential receivers having acute noise levels
  - In total, 11 residential receivers (all in NCA04 to the south of the proposal) are predicted to have exceedances of the NCG operational road traffic noise criteria. All triggered residential receivers are, however, predicted to have decreases in road traffic noise.

6.2.2 'Other Sensitive' Receivers

'Other sensitive' receivers that are predicted to have exceedances of the trigger levels are shown in Table 31 for the controlling 2032 scenario. The location of the triggered 'other sensitive' receivers are shown Figure 17.

Table 31 'Other Sensitive' Receivers Triggers

NCA	Receiver	Type	NMG Triggers[1]		
			Trigger 1 >2.0 dB	Trigger 2 Cumulative	Trigger 3 Acute
NCA03	PJ Moodie Memorial Drive	Child Care Centre	-	Y	-
NCA04	Kingdom Hall of Jehovah's Witnesses	Place of Worship	-	Y	-

Note 1: The NMG triggers are discussed in Section 4.5.6.

In summary, the above assessment shows a total of two 'other sensitive' receiver buildings are predicted to have exceedances of the NCG operational road traffic noise criteria.

6.2.3 Receivers Eligible for Consideration of 'Additional Noise Mitigation'

The receivers which have been identified as eligible for consideration of 'additional noise mitigation' (ie triggered receivers) are summarised in Table 32 and shown in Figure 17.

Table 32 Receivers Eligible for Consideration for 'Additional Noise Mitigation'

NCA	Number of Triggered Buildings (Floors)		Comments
	Residential	Other Sensitive	
NCA01	- (-)	- (-)	-
NCA02	- (-)	- (-)	-
NCA03	- (-)	1 (1)	The triggered 'other sensitive' receiver in this catchment is the child care centre on PJ Moodie Memorial Drive. The receiver is triggered due to cumulative limit exceedances.
NCA04	11 (11)	1 (1)	Residential receivers are triggered to the south of the proposal in this catchment due to cumulative limit exceedances and acute noise levels from the proposal. The triggered 'other sensitive' receiver is the Kingdom Hall of Jehovah's Witnesses place of worship. It is noted that road traffic noise levels at these receivers are predicted to reduce as a result of the proposal.
Sub Total	11 (11)	2 (2)	-
TOTAL	13 (13)		

Note 1: The count of 'floors' represents separate floors within each building.

In summary, the above assessment shows a total of 13 sensitive receiver buildings are predicted to have exceedances of the NCG operational road traffic noise criteria with a chip seal pavement and are therefore eligible for consideration of 'additional noise mitigation'. Operational noise mitigation measures for the proposal are discussed further in Section 7.2.

Figure 17 Receivers Eligible for Consideration of Additional Mitigation

6.2.4 Maximum Road Traffic Noise Levels

Existing Maximum Noise Levels

Existing maximum noise levels were measured in the study area during the noise monitoring survey and a summary of the data is shown in Table 33. Detailed results are provided in Appendix D.

Table 33 Existing Maximum Noise Level Events

Monitoring Location	Total Night-time Events	Measured Maximum Noise Levels (dBA L_{Amax})	
		Range	Median
L02 – 5815 Great Western Highway	107	65-78	70
L03 – 77 Sydney Road	662	70-86	77
L04 – 2 PJ Moodie Memorial Drive	163	65-79	70

The above table shows that existing maximum noise level events are a regular feature at the monitoring locations and typically range from 65 to 85 dBA. Higher levels were measured at L03 due to the proximity of this location to the Great Western Highway and the intersection with PJ Moodie Memorial Drive.

Maximum noise level events towards the upper end of the range are likely to be from heavy vehicle passbys, with light vehicles tending to be in the lower end of the range.

Future Maximum Noise Levels

As the proposal would widen and realign certain roads there is potential for changes to maximum noise level events in the study area. A summary of the predicted changes is provided in Table 34.

Table 34 Predicted Change in Maximum Noise Levels

NCA	Worst-case Change (dB)	Discussion
NCA01	1	Maximum noise levels are predicted to increase by up to 1 dB from the proposal in this NCA. This is due to the Great Western Highway being realigned to the north, closer to the Gold Panner Motor Inn. A negligible change in maximum noise levels is predicted for the majority of receivers in this NCA, which are further to the north.
NCA02	0	This catchment only has one residential receiver. Maximum noise levels at 5415 Great Western Highway are predicted to decrease by 0.5 dB which is due to the Great Western Highway being realigned to the north, further away from the receiver
NCA03	2	Maximum noise levels are predicted to increase by up to 2 dB in this NCA. This is due to the Great Western Highway moving to the north, closer to receivers off P J Moodie Memorial Drive. The 2 dB increase is predicted for receivers near to the Great Western Highway. Receivers which are further away have a predicted increase of 0 to 1 dB.
NCA04	0	Maximum noise levels are predicted to decrease in this NCA due to the Great Western Highway being realigned to the north, away from receivers in this catchment. The front row residential receivers which face the Great Western Highway are predicted to have a 4 to 6 dB decrease in maximum noise levels, with lower decreases predicted at receivers further back.

While receivers are not triggered for consideration of 'additional noise mitigation' by maximum noise levels alone, the selection of feasible and reasonable mitigation measures should consider the potential change in maximum noise levels and the effect the potential mitigation would have on those levels.

It is noted that a signalised intersection would be introduced at the intersection of the Great Western Highway and PJ Moodie Memorial Drive which may affect receivers to the north in NCA03 and receivers to the south in NCA04. The final approach to mitigating operational road traffic noise impacts in this area should consider the potential effect the intersection would have on maximum noise levels, including noise from stop-start traffic.

The recommend operational mitigation measures are discussed in Section 7.2.

7 Mitigation

7.1 Construction Impacts

The ICNG acknowledges that due to the nature of construction works it is inevitable that there will be impacts where construction is near to sensitive receivers. Examples of potential mitigation and management measures which could be applied to the proposal to minimise the impacts are provided below.

7.1.1 Standard Mitigation Measures

The Roads and Maritime Construction Noise and Vibration Guideline (CNVG) contains a number of 'standard mitigation measures' for mitigating and managing construction impacts. The measures are shown in Appendix C and should be applied to the works where feasible and reasonable.

7.1.2 Additional Mitigation Measures

Where noise impacts remain after the use of 'standard mitigation measures', the CNVG requires the use of 'additional mitigation measures' where feasible and reasonable. The 'additional mitigation measures' are determined on the basis of the exceedance of the appropriate management levels. Descriptions of the various measures are in Appendix C. The CNVG defines how 'additional mitigation measures' are applied to airborne noise impacts and the approach is shown in Table 35.

Table 35 CNVG Triggers for Additional Mitigation Measures – Airborne Noise

Predicted $L_{Aeq(15minute)}$ Airborne Noise Level at Receiver			Additional Mitigation Measures	
Perception	dBA above RBL	dBA above NML	Type[1]	Mitigation Levels[2]
All hours				
75 dBA or greater			N, V, PC, RO	HNA
Standard Hours: Mon – Fri (7am – 6pm), Sat (8am – 1pm), Sun/Public Holiday (Nil)				
Noticeable	5 to 10	0	-	NML
Clearly Audible	10 to 20	<10	-	NML
Moderately Intrusive	20 to 30	10 to 20	N, V	NML+10
Highly Intrusive	>30	>20	N, V	NML+20
OOHW Period 1: Mon – Fri (6pm – 10pm), Sat (7am – 8am & 1pm – 10pm), Sun/Public Holiday (8am – 6pm)				
Noticeable	5 to 10	<5	-	NML
Clearly Audible	10 to 20	5 to 15	N, R1, DR	NML+5
Moderately Intrusive	20 to 30	15 to 25	V, N, R1, DR	NML+15
Highly Intrusive	>30	>25	V, IB, N, R1, DR, PC, SN	NML+25

Predicted $L_{Aeq(15minute)}$ Airborne Noise Level at Receiver			Additional Mitigation Measures	
OOHW Period 2: Mon – Fri (10pm – 7am), Sat (10pm – 8am), Sun/Public Holiday (6pm – 7am)				
Noticeable	5 to 10	<5	N	NML
Clearly Audible	10 to 20	5 to 15	V, N, R2, DR	NML+5
Moderately Intrusive	20 to 30	15 to 25	V, IB, N, PC, SN, R2, DR	NML+15
Highly Intrusive	>30	>25	AA, V, IB, N, PC, SN, R2, DR	NML+25

Note 1: N = Notification, SN = Specific Notification, PC = Phone Calls, IB = Individual Briefings, R1 = Respite Period 1, R2 = Respite Period 2, RO = Project Specific Respite Offer, DR = Duration Respite, AA = Alternative Accommodation, V = Verification.

Note 2: NML = Noise Management Level, HNA = Highly Noise Affected (ie 75 dBA or greater for residential receivers).

The requirement for 'additional mitigation measures' would be further evaluated as the proposal progresses and detailed construction scheduling information becomes available. A Construction Noise and Vibration Management Plan would be prepared prior to works commencing which would detail the approach to providing mitigation during construction. Site specific Construction Noise and Vibration Impact Statements would also be completed for works that are required to be completed outside of Standard Construction Hours which have the potential to impact receivers.

Indicative Additional Mitigation Measures

Using the airborne noise construction predictions in Section 5, indicative worst-case 'additional mitigation measures' for all construction works on the project have been determined as per the requirements of the CNVG (see Table 35). The required 'additional mitigation measures' are shown for:

- Daytime construction noise – Figure 18
- Evening construction noise – Figure 19
- Night-time construction noise – Figure 20.

The figures show the required 'additional mitigation measures' based on the CNVG 'perception' categories in Table 35.

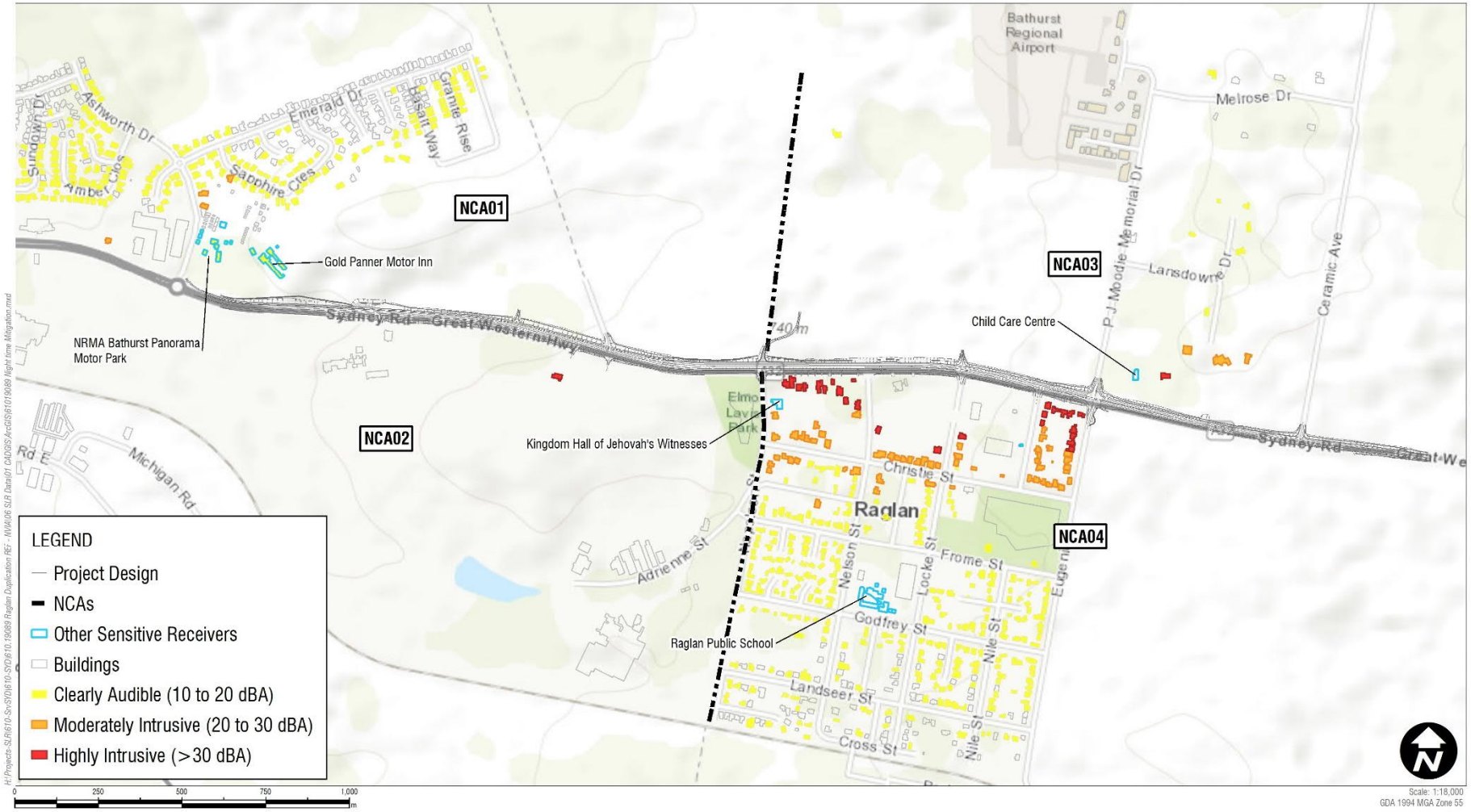
Figure 18 Indicative Worst-case Additional Mitigation Measures for All Construction Activities during the Daytime

Note: The daytime 'Additional Mitigation Measures' are: Clearly Audible = nil, Moderately Intrusive = N, V, Highly Intrusive = N, V (see Table 35 for requirement definitions).

Figure 19 Indicative Worst-case Additional Mitigation Measures for All Construction Activities during the Evening

Note: The evening 'Additional Mitigation Measures' are: Clearly Audible = N, R1, DR, Moderately Intrusive = V, N, R1, DR, Highly Intrusive = V, IB, N, R1, DR, PC, SN (see Table 35 for requirement definitions).

Figure 20 Indicative Worst-case Additional Mitigation Measures for All Construction Activities during the Night-time



Note: The night-time 'Additional Mitigation Measures' are: Clearly Audible = V, N, R2, DR, Moderately Intrusive = V, IB, N, PC, SN, R2, DR, Highly Intrusive = AA, V, IB, N, PC, SN, R2, DR (see Table 35 for requirement definitions).

7.1.3 Proposal Specific Construction Mitigation Measures

On the basis of the predictions, Table 36 lists the proposal specific mitigation measures which are recommended to be used to minimise the impacts.

Table 36 Recommended Proposal Specific Noise Mitigation Measures

Item	Discussion and Recommendations
Construction Noise and Vibration Management Plan	A Construction Noise and Vibration Management Plan should be prepared before any works begin which would include: • Identification of nearby sensitive receivers • Description of works, construction equipment and hours works would be completed in • Criteria for the proposal and relevant licence and approval conditions • Requirements for noise and vibration monitoring • Details of how community consultation would be completed • Procedures for handling complaints • Details on how respite would be applied where ongoing high impacts are seen at certain receivers.
Construction noise and vibration assessments	Location and activity specific noise and vibration impact assessments should be carried out prior to (as a minimum) activities: • With the potential to result in noise levels above 75 dBA at any receiver • Required outside Standard Construction Hours likely to result in noise levels in greater than the relevant Noise Management Levels • With the potential to exceed relevant criteria for vibration. The assessments should confirm the predicted impacts at the relevant receivers in the vicinity of the activities to aid the selection of appropriate management measures, consistent with the requirements of the CNVG.
Construction noise exceedances	The assessment has identified that high impacts are likely when noise intensive equipment such as rockbreakers or concrete saws are in use, especially during evening and night-time periods. The nearest residential receivers are predicted to have 'high' impacts during the evening and night-time when the noisiest construction works are nearby (particularly in NCA04). Where noise intensive equipment is to be used near sensitive receivers, the works should be scheduled for Standard Construction Hours, where possible. If it is not possible to restrict the works to the daytime then they should be completed as early as possible in each work shift. Appropriate respite should also be provided to affected receivers in accordance with the CNVG and/or the proposal's conditions of approval.
Compounds with long term works	Hoarding, or other shielding structures, should be used where receivers are impacted near compounds or fixed works areas with long durations. To provide effective noise mitigation, the barriers should break line of sight from the nearest receivers to the works and be of solid construction with minimal gaps.
Monitoring	Monitoring should be carried out at the start of new noise and vibration intensive activities to confirm that actual levels are consistent with the predictions and that appropriate mitigation measures from the CNVG have been implemented.

Item	Discussion and Recommendations
Vibration works within minimum working distance	Where works are within the cosmetic damage minimum working distances and considered likely to exceed the criteria: • Different construction methods with lower source vibration levels should be investigated and implemented, where feasible • Attended vibration measurements should be undertaken at the start of the works to determine actual vibration levels at the item. Works should be ceased if the monitoring indicates vibration levels are likely to, or do, exceed the relevant criteria.
	Certain receivers in the study area are within the human comfort minimum working distance and occupants of affected buildings may be able to perceive vibration impacts when vibration intensive equipment is in use. The potential human comfort impacts and requirement for vibration intensive works should be reviewed as the proposal progresses.
Building condition surveys	Building condition surveys should be completed before and after the works where buildings or structures are within the minimum working distances and considered likely to exceed the cosmetic damage criteria during the use of vibration intensive equipment.
Construction traffic	Further consideration of the potential impacts from construction traffic should be completed when the final haulage routes are known.

7.2 Recommended Operational Road Traffic Noise Mitigation Measures

Road traffic noise levels from infrastructure projects should be reduced to meet the NCG noise criteria using feasible and reasonable mitigation. The assessment in Section 6 predicts road traffic noise levels to the surrounding receivers without any mitigation applied to the project.

For receivers that qualify for consideration of 'additional noise mitigation', potential noise mitigation measures are to be considered in the following order of preference:

- At-source mitigation:
  - Quieter road pavement surfaces
- In-corridor mitigation:
  - Noise mounds
  - Noise barriers
- At-receiver mitigation:
  - At-property treatments.

7.2.1 At-Source Mitigation – Low Noise Pavements

The type of road surface can significantly affect road traffic noise levels at affected receivers. Jointed concrete pavements tend to be the noisiest with low noise pavements such as open grade asphalt (OGA) being the quietest.

Low noise pavements are the preferred form of noise mitigation as they reduce source noise levels which benefits both outside areas and internal spaces. Low noise pavements have no associated visual impact and are also likely to provide noise benefits to receivers at greater distances than noise barriers. They are generally considered feasible to use where there are four or more closely spaced receivers that exceed the NCG criteria.

Road pavement surfaces and textures must meet a number of criteria besides noise performance including structural integrity, skid resistance, water shedding, maintenance requirements and design life.

Low noise pavements are generally most effective where vehicle speeds are high, such as on motorways, and less effective where traffic speeds are slower or where traffic is required to slow down or stop. It is noted that the proposal would introduce a new signalised intersection at the intersection of Great Western Highway and Eugenie Street/PJ Moodie Memorial Drive which would reduce the effectiveness of low noise pavements due to stop/start traffic.

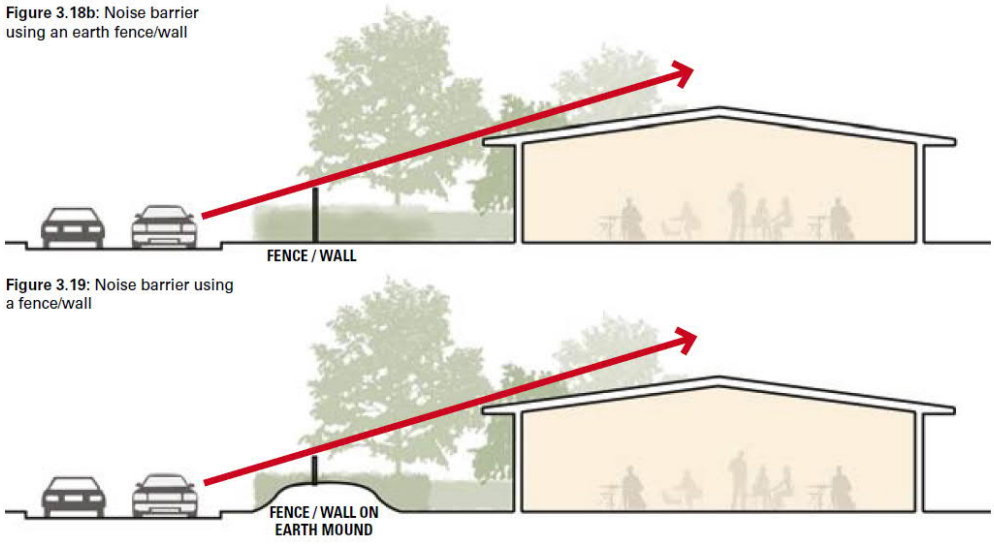
The noise assessment includes consideration of the use of quieter noise pavement in the form of dense graded asphalt (DGA) across the extent of the proposal. The use of low noise pavements, such as DGA, are not currently considered a suitable mitigation approach for the proposal, however, they remain an option to be investigated further taking into account whole-of-life engineering considerations and the overall social, economic and environmental effects.

7.2.2 In-Corridor Mitigation – Noise Barriers

After at-source mitigation has been investigated, the next approach is to consider in-corridor mitigation which aims to block line of sight from the source of noise to nearby receivers.

Noise barriers (in the form of walls or mounds) can provide significant noise reductions and also reduce both external and internal noise levels. Where space allows, raised earth mounds can be used as noise barriers and can be enhanced by placing a low wall on top. Noise walls are often more feasible than a mound as the footprint is much smaller. These methods are shown in Figure 21.

Figure 21 Noise Barriers



Note: Taken from DP&I Development near Rail Corridors and Busy Roads – Interim Guideline.

Noise barriers can, however, introduce a number of negative aspects, including access to property, aesthetic impacts, daylight access, overshadowing, drainage, graffiti, restriction of line of sight, maintenance access and safety concerns.

Noise barriers are typically most efficient when receivers are located at ground floor level. As the height of a receiver increases, the noise reduction from barriers reduces due to line of sight over the top of the barrier. Because of this, noise barriers are assessed using noise predictions at ground and first floor only, with architectural treatment of individual dwellings being used for higher floors if necessary.

Assessment of Noise Barriers

A group of clustered residential receivers are triggered to the south of the Great Western Highway in NCA04. These receivers are, however, all accessed from the Great Western Highway meaning construction of a noise barrier in the location is not possible as gaps in the barrier would be required for access which would make the barrier ineffective.

The triggered child care centre to the north of the proposal in NCA03 is an isolated receiver and noise barriers are only considered as a potential option where they are used to mitigate clustered exceeding receivers.

Based on the above, the use of noise barriers as a mitigation option for the proposal is unlikely to be feasible.

7.2.3 At-Property Mitigation – Architectural Treatment

Where residual impacts remain after the investigation of at-source and in-corridor mitigation, the final approach is to use at-property mitigation. This typically involves using architectural treatments such as thicker glazing and doors, or upgraded facade constructions to achieve appropriate internal noise levels.

At-property mitigation can potentially be used in place of at-source and in-corridor mitigation, such as where receivers are not grouped together or where there is community preference. These treatments are generally limited to architectural upgrades to building elements and the installation of acoustic screen walls close to the receiver where they also protect outdoor living spaces.

Architectural treatments are more effective when they are applied to masonry buildings compared to lightly clad timber framed structures, and caution should be taken before providing treatments to buildings in a poor state as they may not be effective.

The architectural treatments provided are typically limited to:

- Fresh air ventilation systems that meet the National Construction Code of Australia requirements with the windows and doors shut
- Upgraded windows and glazing and solid core doors on the exposed facades of the substantial structures only (eg masonry or insulated weather board cladding with sealed underfloor). These techniques would be unlikely to produce any noticeable benefit for light frame structures with no acoustic insulation in the walls
- Upgrading window or door seals and appropriately treating sub-floor ventilation
- The sealing of wall vents
- The sealing of the underfloor below the bearers
- The sealing of eaves.

The final operational noise mitigation strategy would be determined by TfNSW prior to construction. Low noise pavements and noise barriers have been found to be unfeasible meaning at-receiver treatment is likely to be preferred option for mitigation the predicted exceedances.

All triggered residential receivers are adjacent to the Great Western Highway in NCA04. It is noted that a small number of residential receivers in this area which are slightly more setback from the highway are predicted to be compliant with the criteria by a relatively small margin. The project should therefore consider offering at-property treatments to all properties fronting the Great Western Highway between Nelson and Napoleon Street.

Any treatments offered to receivers near to the proposed new signalised intersection at the Great Western Highway and PJ Moodie Memorial Drive should also considered the potentially changed noise environment near to the intersection (ie stop-start traffic).

8 Conclusion

Transport for NSW are proposing the Raglan Duplication. The proposal comprises realigning the highway up to 16 m to the north of the existing highway, along with road widening to provide additional lanes.

This report describes the existing noise environment in the study area, outlines the method used in the assessment and identifies the likely impacts from construction and operation of the proposal on the nearby sensitive receivers. Where impacts are predicted, appropriate measures have been recommended to mitigate and manage the impacts

Construction Noise and Vibration

The nearest receivers to the proposal are predicted to be subject to 'high' worst-case noise impacts, particularly when noise intensive equipment such as rockbreakers or concrete saws are in use near to receivers. The 'high' impacts are, however, generally limited to the south of the proposal in NCA04 where receivers are adjacent to the Great Western Highway. Receivers in other parts of the study area are generally more distant and the worst-case impacts are substantially lower.

Certain works would require lane closures and would be required to occur outside Standard Construction Hours to minimise potential traffic disruption. The impacts during these evening and night-time works are predicted to be increased due to more stringent criteria.

The main potential sources of construction vibration are from vibratory rollers and rockbreakers. The distance between the construction works and the nearest sensitive receivers is generally sufficient for most structures to be unlikely to suffer cosmetic damage. A small number of structures which are close to the proposal are, however, within the minimum working distances.

Construction vehicles associated with the proposal would generally use major roads such as the Great Western Highway. As these roads have high existing traffic volumes no impacts from construction traffic are predicted for the adjacent receivers. Certain routes associated with spoil removal may, however, require vehicles to use smaller local roads. Where this is necessary, noticeable increases noise may occur if existing volumes on these roads are low.

The proposal should apply all feasible and reasonable work practices to reduce the potential impacts. The exact strategies would be determined during development of a Construction Noise and Vibration Management Plan prior to construction works commencing.

Operational Road Traffic Noise

The nearest affected receivers are already close to the Great Western Highway and subject to relatively high existing road traffic noise levels.

The proposal would widen and realign the Great Western Highway which increases road traffic noise levels to the north of the road and decreases noise to the south. Notwithstanding, no receivers in the study area are predicted to have increases in road traffic noise of greater than 2.0 dB.

Exceedances of the criteria are, however, predicted at receivers in NCA04 which are adjacent to the Great Western Highway due to cumulative limit exceedances and acute noise levels from the proposal. It is noted that road traffic noise levels at these receivers are predicted to reduce as a result of the proposal. One child care centre to the north of the proposal near PJ Moodie Memorial Drive is also predicted to exceed the criteria.

A total of 13 receiver buildings are predicted to have exceedances of the operational road traffic noise criteria and have been identified as being eligible for consideration of additional noise mitigation. At-receiver treatment is likely to be preferred option for mitigation the predicted exceedances.

APPENDIX A

Acoustic Terminology

1. Sound Level or Noise Level

The terms 'sound' and 'noise' are almost interchangeable, except that 'noise' often refers to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure. The human ear responds to changes in sound pressure over a very wide range with the loudest sound pressure to which the human ear can respond being ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or LP are commonly used to represent Sound Pressure Level. The symbol LA represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2 x 10^{-5} Pa.

2. 'A' Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an 'A-weighting' filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People's hearing is most sensitive to sounds at mid frequencies (500 Hz to 4,000 Hz), and less sensitive at lower and higher frequencies. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dB or 2 dB in the level of a sound is difficult for most people to detect, whilst a 3 dB to 5 dB change corresponds to a small but noticeable change in loudness. A 10 dB change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels.

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as 'linear', and the units are expressed as dB(lin) or dB.

3. Sound Power Level

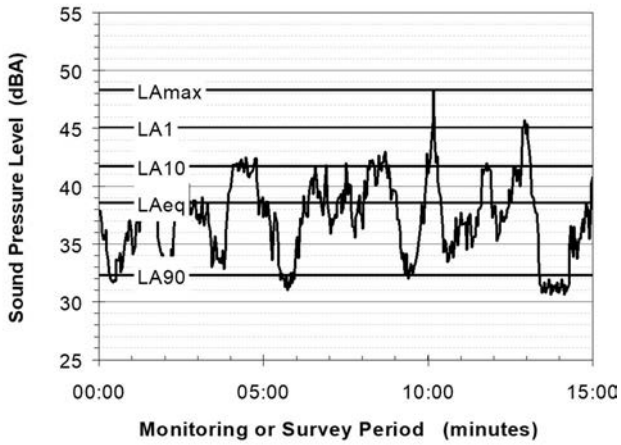
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure is similar to the effect of an electric radiator, which is characterised by a power rating but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4. Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels LAN, where LAN is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the LA1 is the noise level exceeded for 1% of the time, LA10 the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

LA1 The noise level exceeded for 1% of the 15 minute interval.

LA10 The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

LA90 The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

LAeq The A-weighted equivalent noise level (basically, the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

5. Frequency Analysis

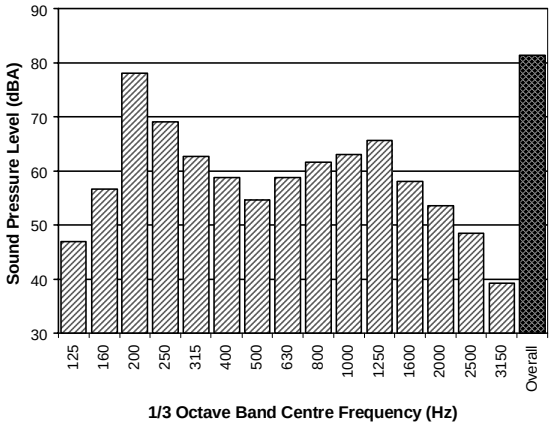
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (three bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



6. Annoying Noise (Special Audible Characteristics)

A louder noise will generally be more annoying to nearby receivers than a quieter one. However, noise is often also found to be more annoying and result in larger impacts where the following characteristics are apparent:

- Tonality - tonal noise contains one or more prominent tones (ie differences in distinct frequency components between adjoining octave or 1/3 octave bands), and is normally regarded as more annoying than 'broad band' noise.
- Impulsiveness - an impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.
- Intermittency - intermittent noise varies in level with the change in level being clearly audible. An example would include mechanical plant cycling on and off.
- Low Frequency Noise - low frequency noise contains significant energy in the lower frequency bands, which are typically taken to be in the 10 to 160 Hz region.

7. Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of 'peak' velocity or 'rms' velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements (ie vertical, longitudinal and transverse).

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/Vo), where Vo is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used.

8. Human Perception of Vibration

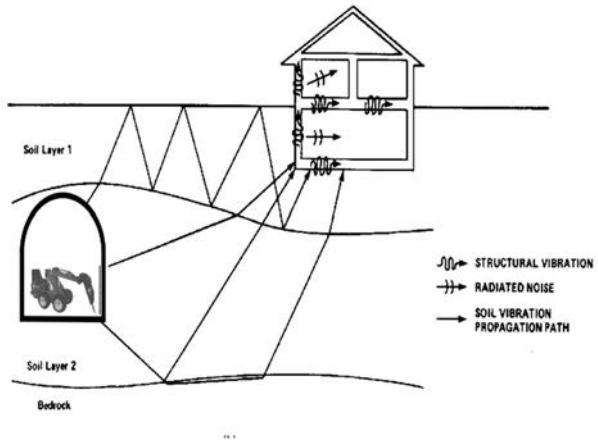
People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as 'normal' in a car, bus or train is considerably higher than what is perceived as 'normal' in a shop, office or dwelling.

9. Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents an example of the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise.

APPENDIX B

Existing Noise Monitoring Data

Noise Monitoring Location	L.01
Noise Monitoring Address	**29 Sapphire Street, Kelso**

Logger Device Type: Svantek 957, Logger Serial No: 20664
Sound Level Meter Device Type: Brüel and Kjær 2260, Sound Level Meter Serial No: 2487418

Ambient noise logger deployed at residential address 29 Sapphire Street, Kelso. Logger located at rear of property yard, elevated above the fence line. Logger view of the Great Western Highway, to the south, obstructed by ground elevation.

Attended noise measurements indicate the ambient noise environment at this location is dominated by distant road traffic noise from the Great Western Highway. Frequent light-vehicle passbys from local traffic, as well as noise from birds and dogs also contribute to the L_{Aeq} at this location.

Recorded Noise Levels (L_{Amax}):
18/11/2019: Road traffic Great Western Highway: 42-53 dBA, Local road traffic: 49 dBA,
Birds: 49-55 (intermittent) dBA, Dogs: 44-56 dBA (intermittent)

Map of Noise Monitoring Location

Ambient Noise Logging Results – ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	31	46	44	52
Evening	35	45	45	51
Night-time	26	41	42	47

Ambient Noise Logging Results – RNP Defined Time Periods

Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	46	49
Night-time (10pm-7am)	41	44

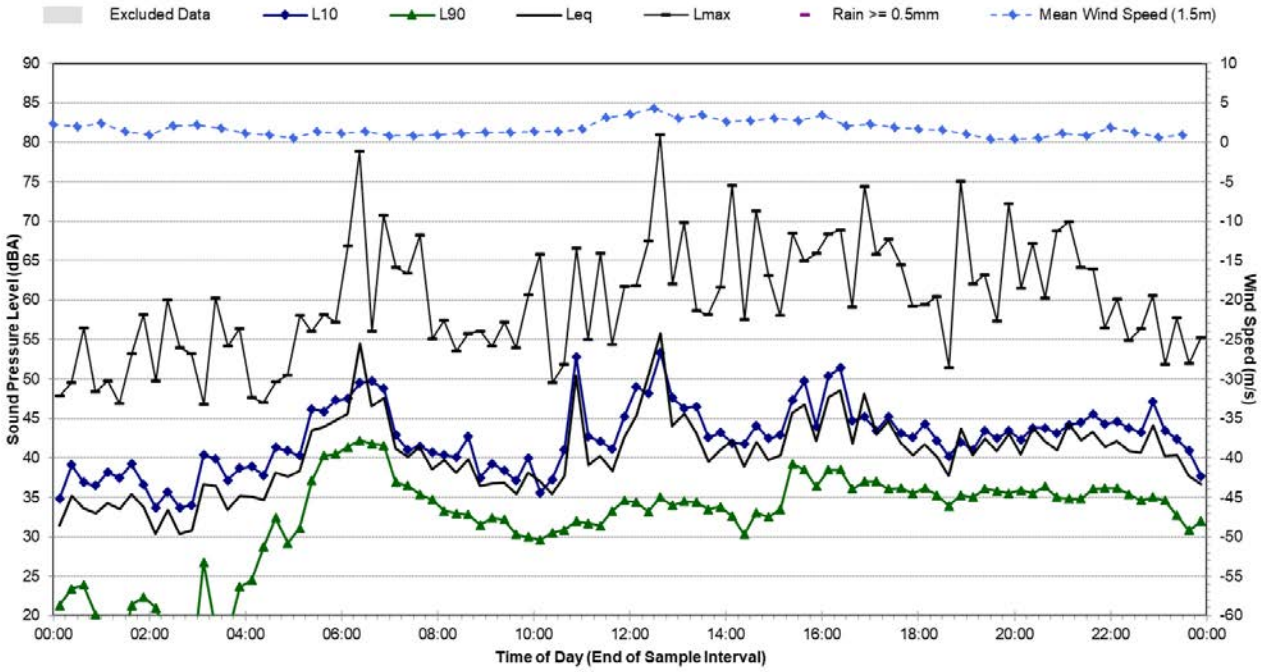
Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
18/11/2019	17:29	39	44	73

Photo of Noise Monitoring Location

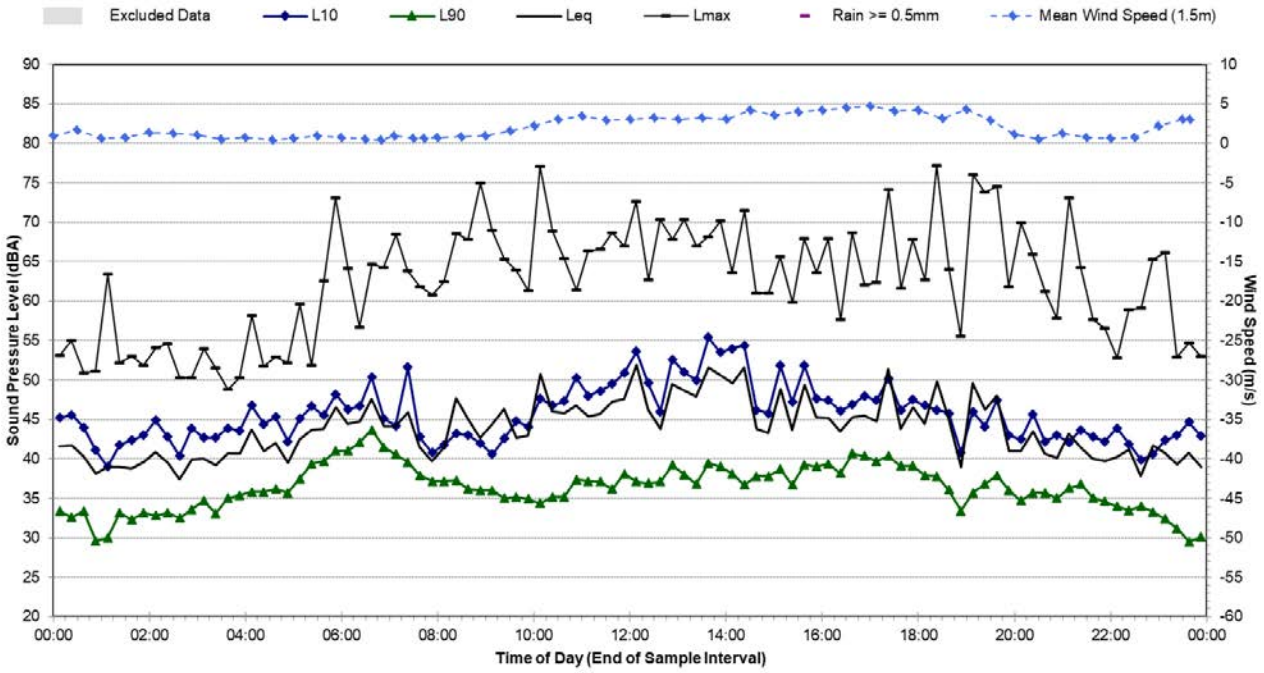
Statistical Ambient Noise Levels

L.01 - 29 Sapphire Cresent, Kelso - Monday, 9 December 2019



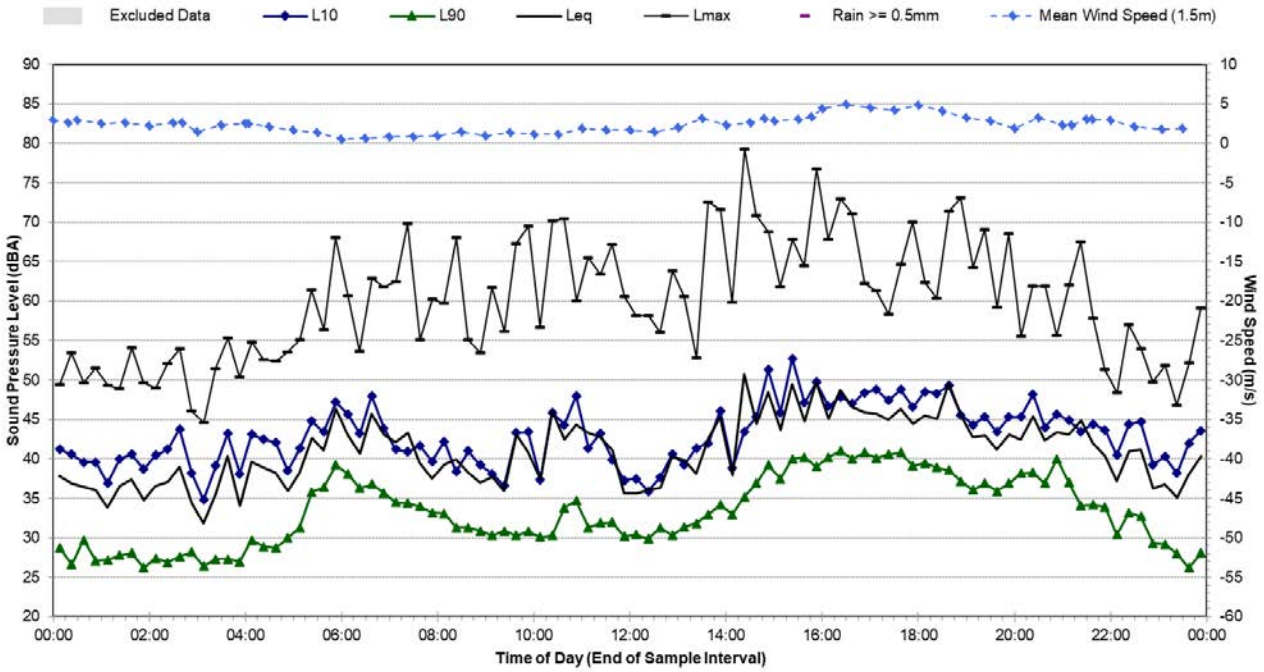
Statistical Ambient Noise Levels

L.01 - 29 Sapphire Cresent, Kelso - Tuesday, 10 December 2019



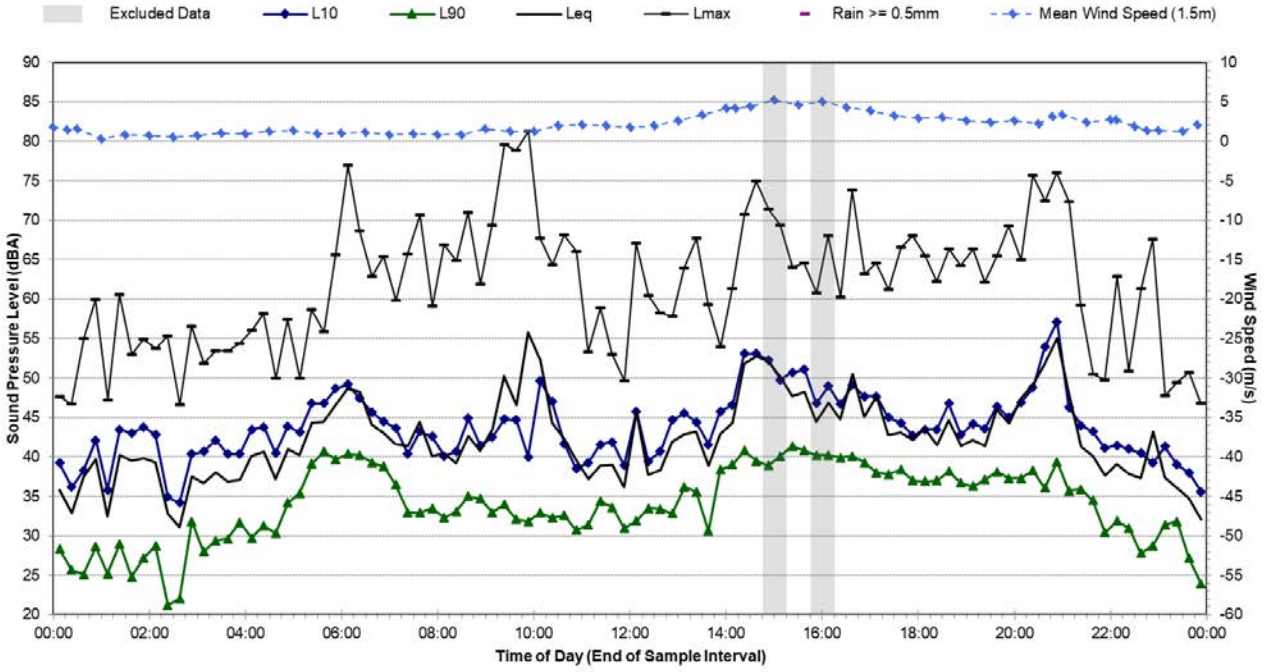
Statistical Ambient Noise Levels

L.01 - 29 Sapphire Cresent, Kelso - Wednesday, 11 December 2019



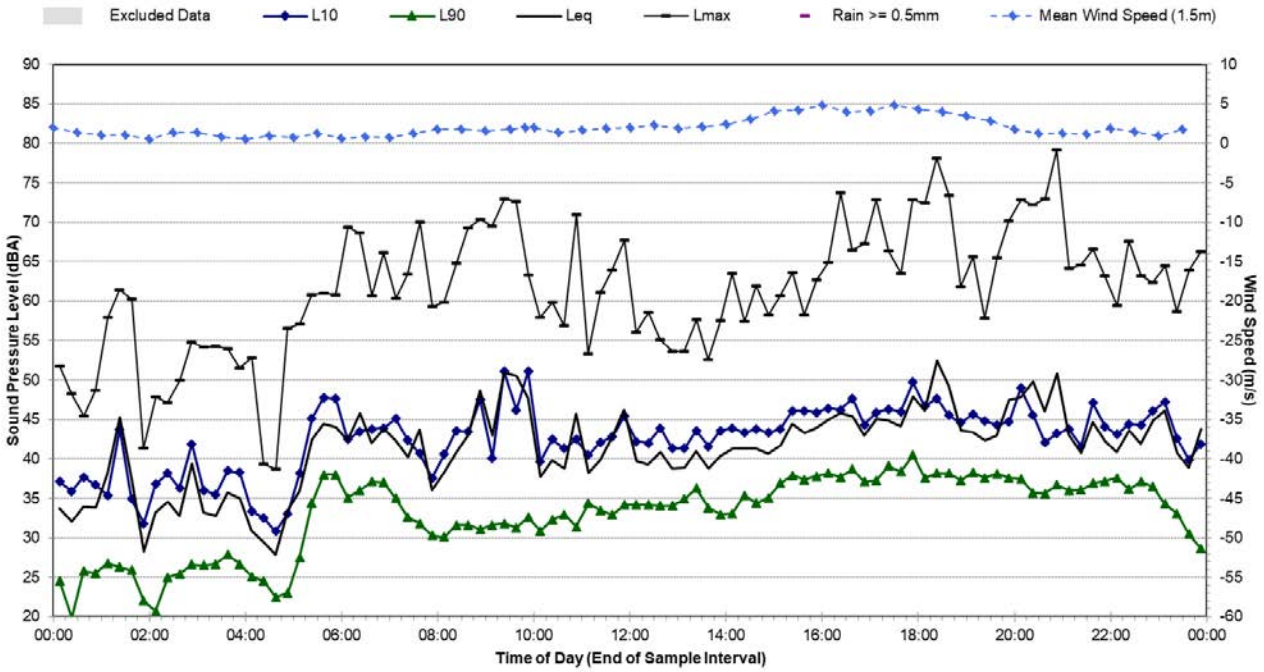
Statistical Ambient Noise Levels

L.01 - 29 Sapphire Cresent, Kelso - Thursday, 12 December 2019



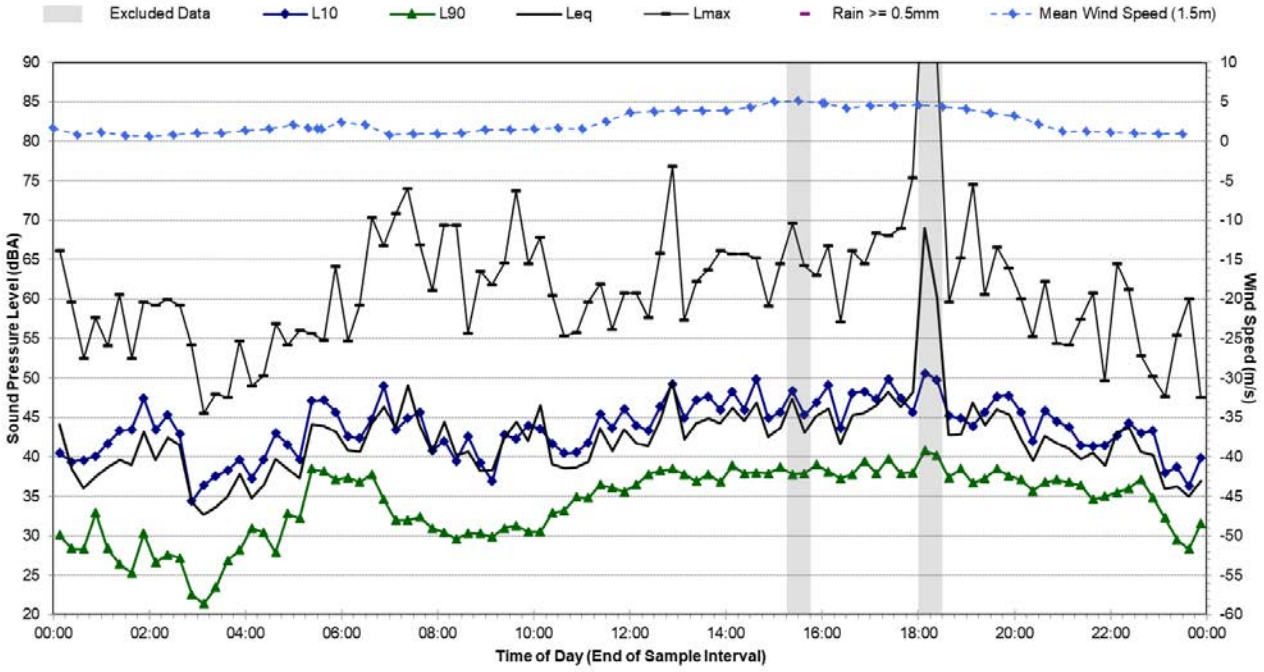
Statistical Ambient Noise Levels

L.01 - 29 Sapphire Cresent, Kelso - Friday, 13 December 2019



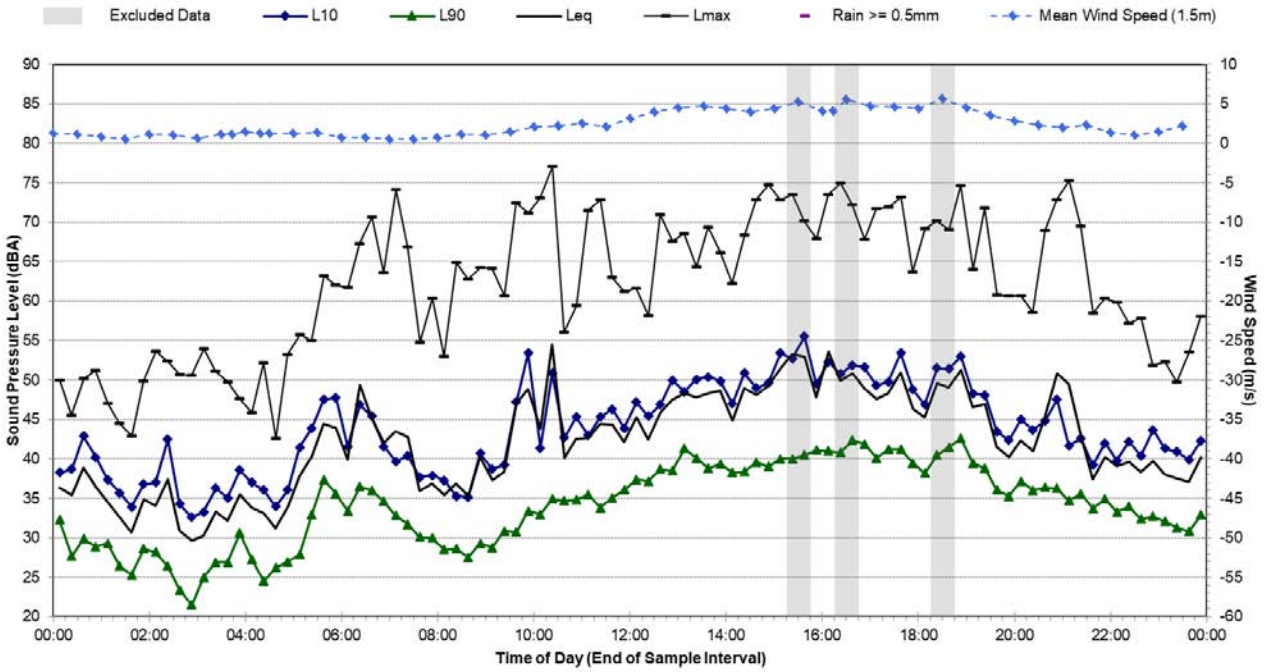
Statistical Ambient Noise Levels

L.01 - 29 Sapphire Cresent, Kelso - Saturday, 14 December 2019



Statistical Ambient Noise Levels

L.01 - 29 Sapphire Cresent, Kelso - Sunday, 15 December 2019



Noise Monitoring Location	L.02
Noise Monitoring Address	**5415 Great Western Highway, Kelso**

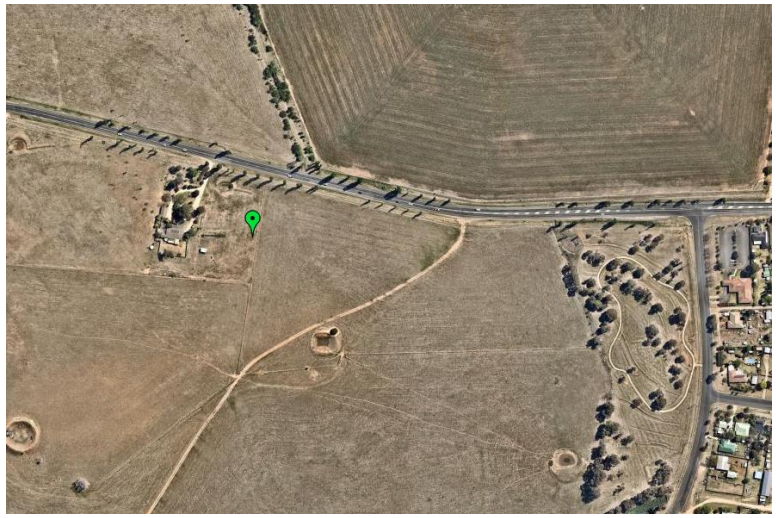
Logger Device Type: Svantek 957, Logger Serial No: 20675
Sound Level Meter Device Type: Brüel and Kjær 2260, Sound Level Meter Serial No: 2487418

Ambient noise logger deployed at residential address 5415 Great Western Highway, Kelso. Logger located at eastern fence line of property, with direct view of the Great Western Highway to the north.

Attended noise measurements indicate the ambient noise environment at this location is dominated by road traffic noise from the Great Western Highway.

Recorded Noise Levels (LAmax):
18/11/2019: Light-vehicle traffic Great Western Highway: 48-59 dBA,
Heavy-vehicle traffic Great Western Highway: 56-69 dBA, Birds: 44-72 dBA (intermittent)

Map of Noise Monitoring Location



Ambient Noise Logging Results – ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	45	56	59	64
Evening	42	55	59	64
Night-time	28	55	58	65

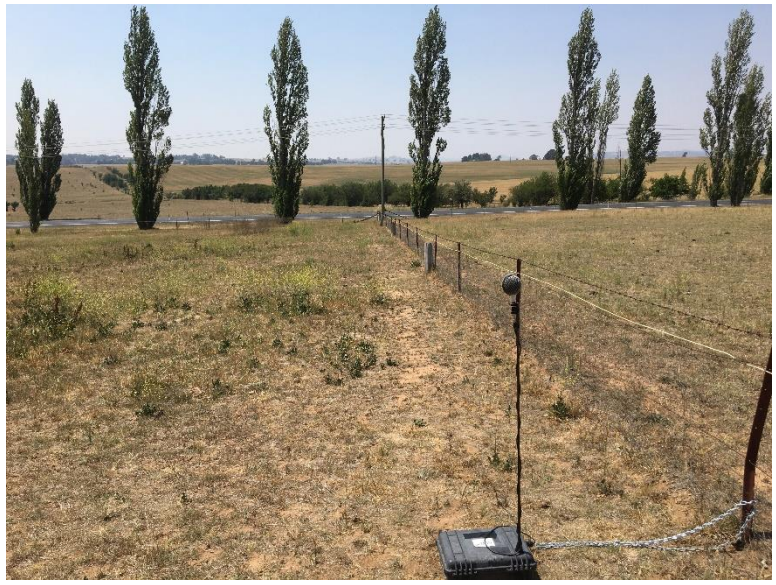
Ambient Noise Logging Results – RNP Defined Time Periods

Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	56	57
Night-time (10pm-7am)	55	58

Attended Noise Measurement Results

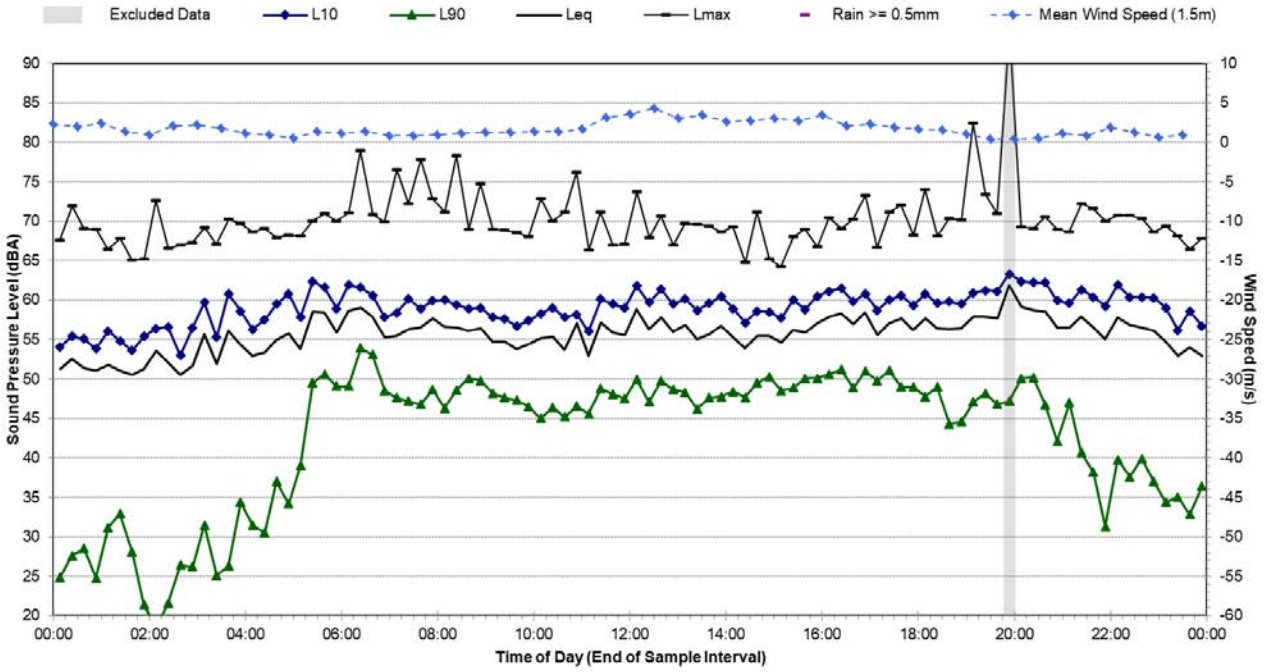
Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
18/11/2019	13:39	44	55	72

Photo of Noise Monitoring Location



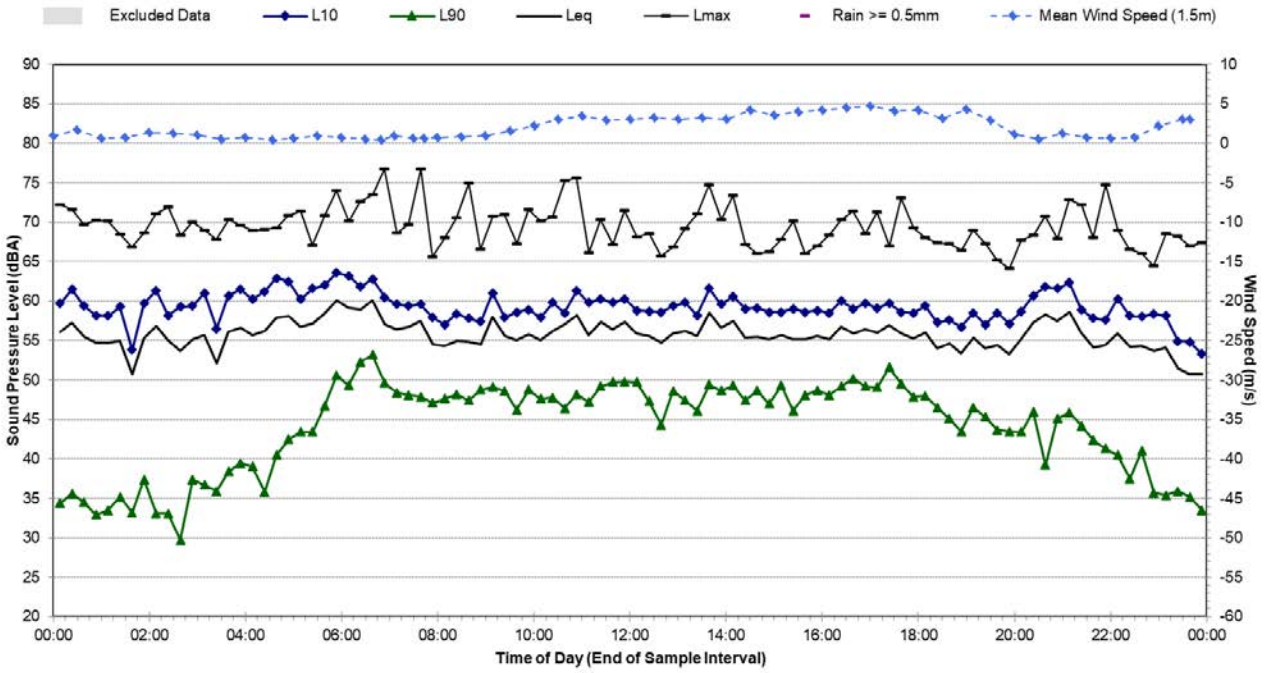
Statistical Ambient Noise Levels

L.02 5415 Great Western Highway, Kelso - Monday, 9 December 2019



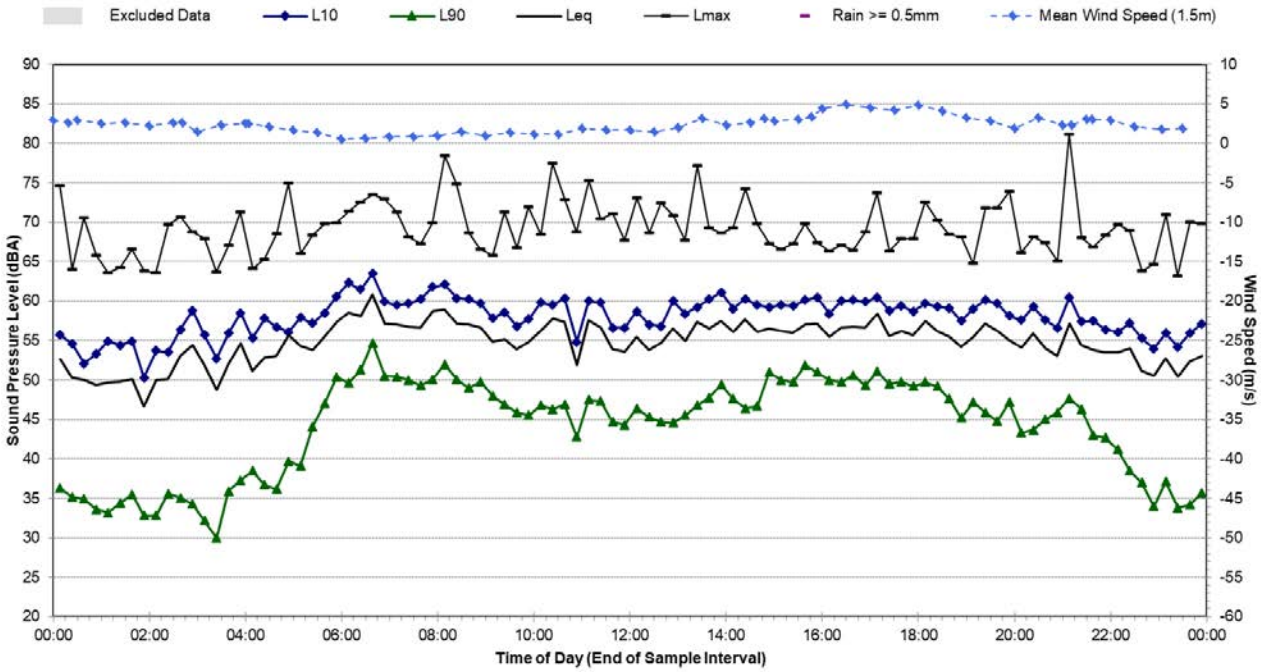
Statistical Ambient Noise Levels

L.02 5415 Great Western Highway, Kelso - Tuesday, 10 December 2019



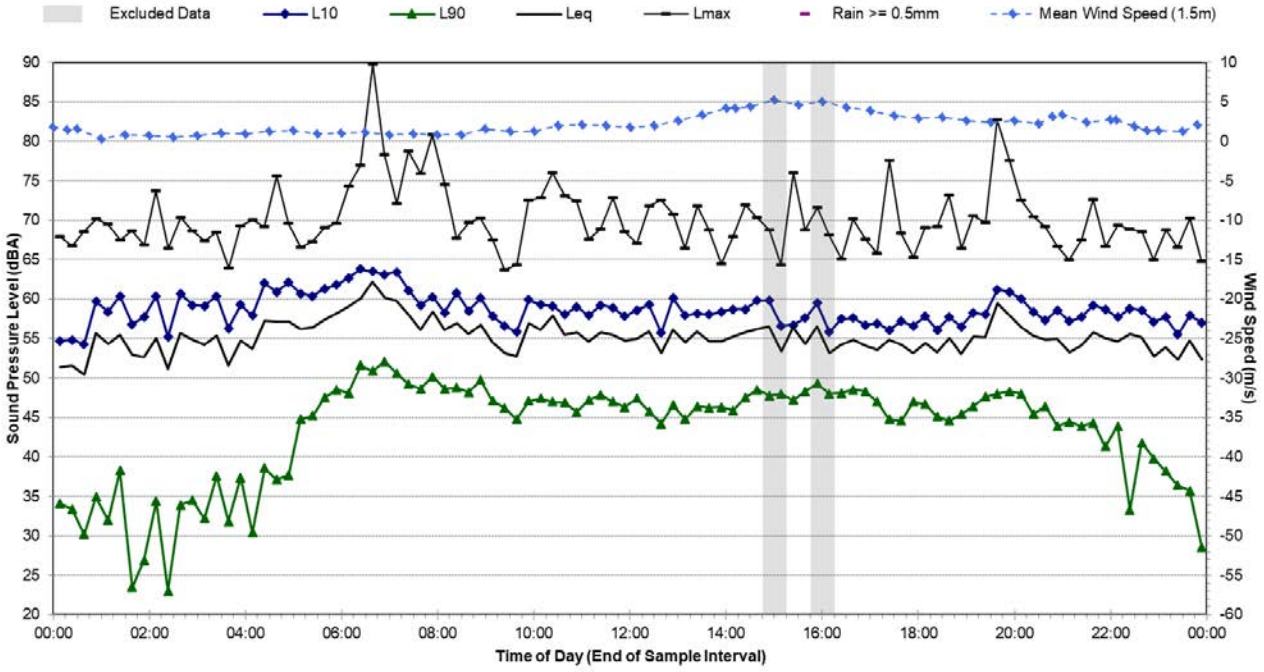
Statistical Ambient Noise Levels

L.02 5415 Great Western Highway, Kelso - Wednesday, 11 December 2019



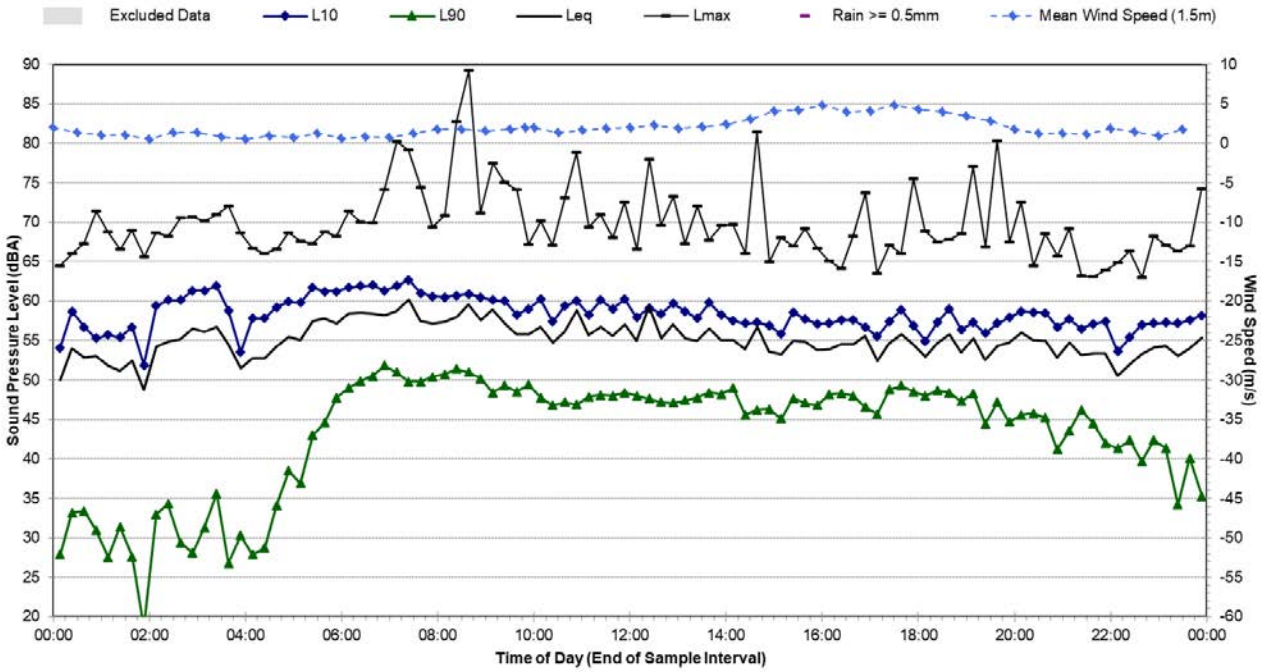
Statistical Ambient Noise Levels

L.02 5415 Great Western Highway, Kelso - Thursday, 12 December 2019



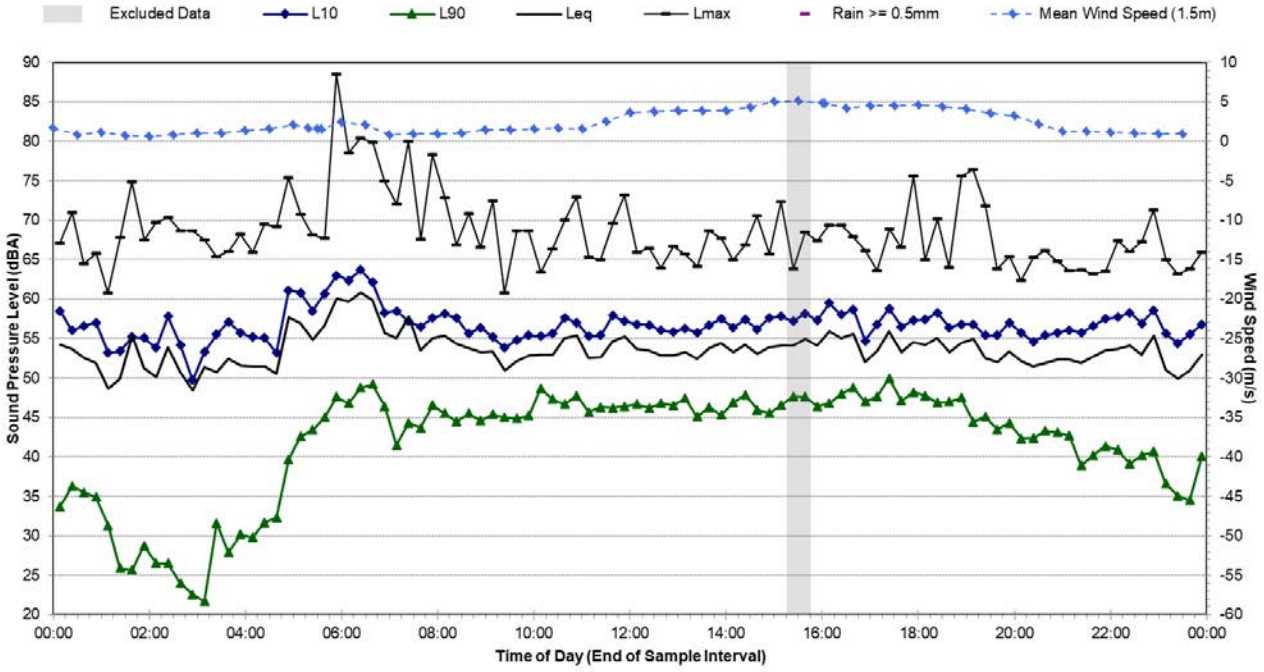
Statistical Ambient Noise Levels

L.02 5415 Great Western Highway, Kelso - Friday, 13 December 2019



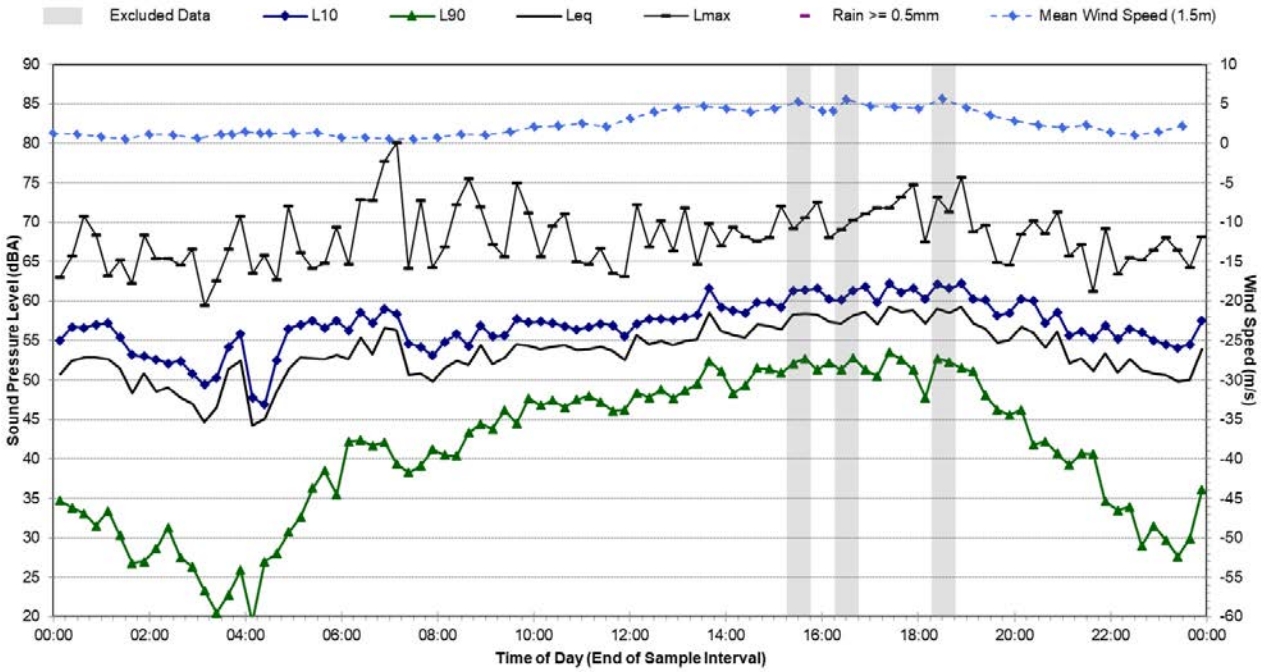
Statistical Ambient Noise Levels

L.02 5415 Great Western Highway, Kelso - Saturday, 14 December 2019



Statistical Ambient Noise Levels

L.02 5415 Great Western Highway, Kelso - Sunday, 15 December 2019



Noise Monitoring Location	L.03
Noise Monitoring Address	**77 Sydney Road, Raglan**

Logger Device Type: Svantek 957, Logger Serial No: 23247
Sound Level Meter Device Type: Brüel and Kjær 2260, Sound Level Meter Serial No: 2487418

Ambient noise logger deployed at residential address 77 Sydney Road, Raglan. Logger located at the front facade of the residence, with direct view of the Great Western Highway intersection with P J Moodie Memorial Drive and Eugenie Street, to the north.

Attended noise measurements indicate the ambient noise environment at this location is dominated by road traffic noise from the Great Western Highway. Road traffic noise from P J Moodie Memorial Drive and Eugenie Street also contribute to the LAeq at this location. At the time of the attended measurement some construction works were being undertaken to install a nearby sewer line. This activity was not present for the duration of the noise logging.

Recorded Noise Levels (LAmax):
18/11/2019: Light-vehicle traffic Great Western Highway: 61-71 dBA,
Heavy-vehicle traffic Great Western Highway: 67-80 dBA, Road traffic Eugenie Street: 60-67 dBA
Construction works: 50-55 dBA

Map of Noise Monitoring Location

Ambient Noise Logging Results – ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	45	64	68	74
Evening	40	63	67	73
Night-time	24	62	63	75

Ambient Noise Logging Results – RNP Defined Time Periods

Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	64	65
Night-time (10pm-7am)	62	65

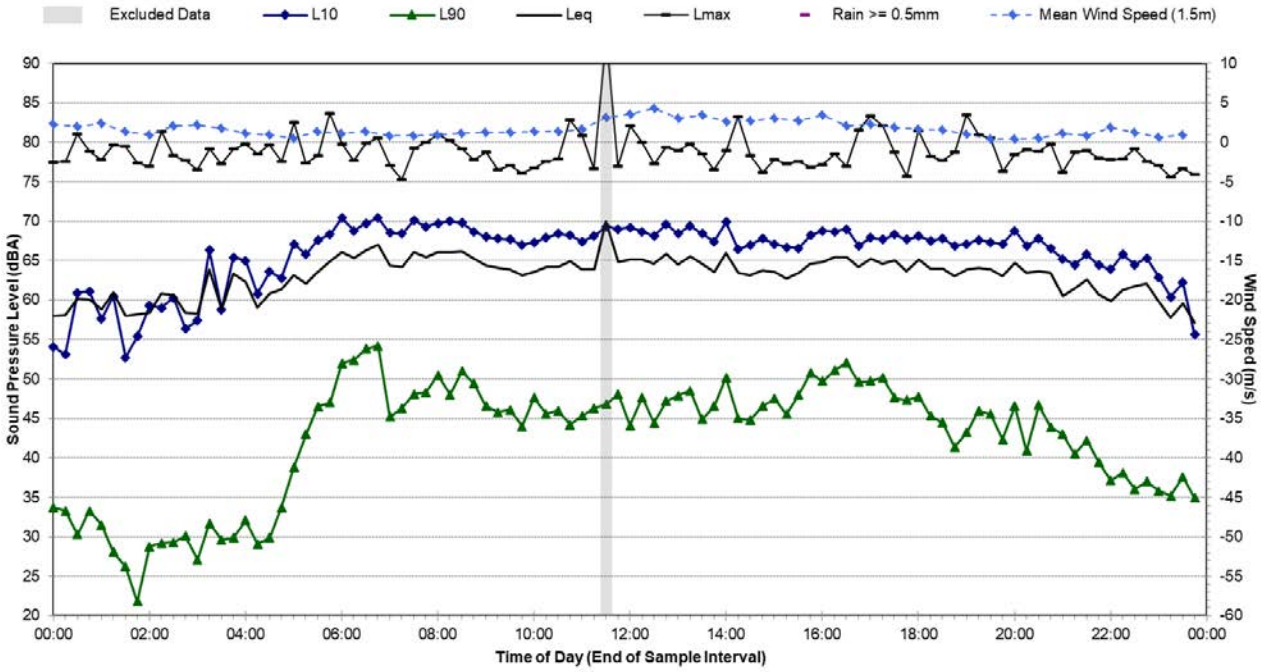
Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
18/11/2019	15:30	53	64	80

Photo of Noise Monitoring Location

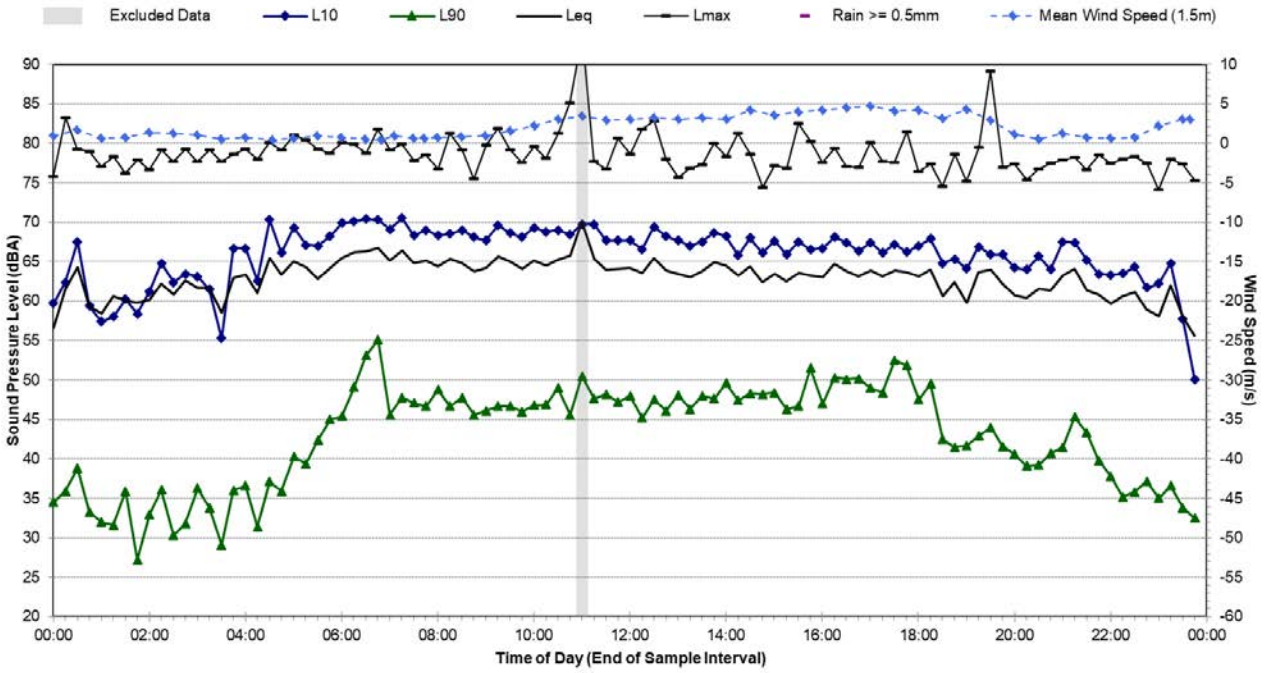
Statistical Ambient Noise Levels

L.03 77 Sydney Road, Raglan - Monday, 9 December 2019



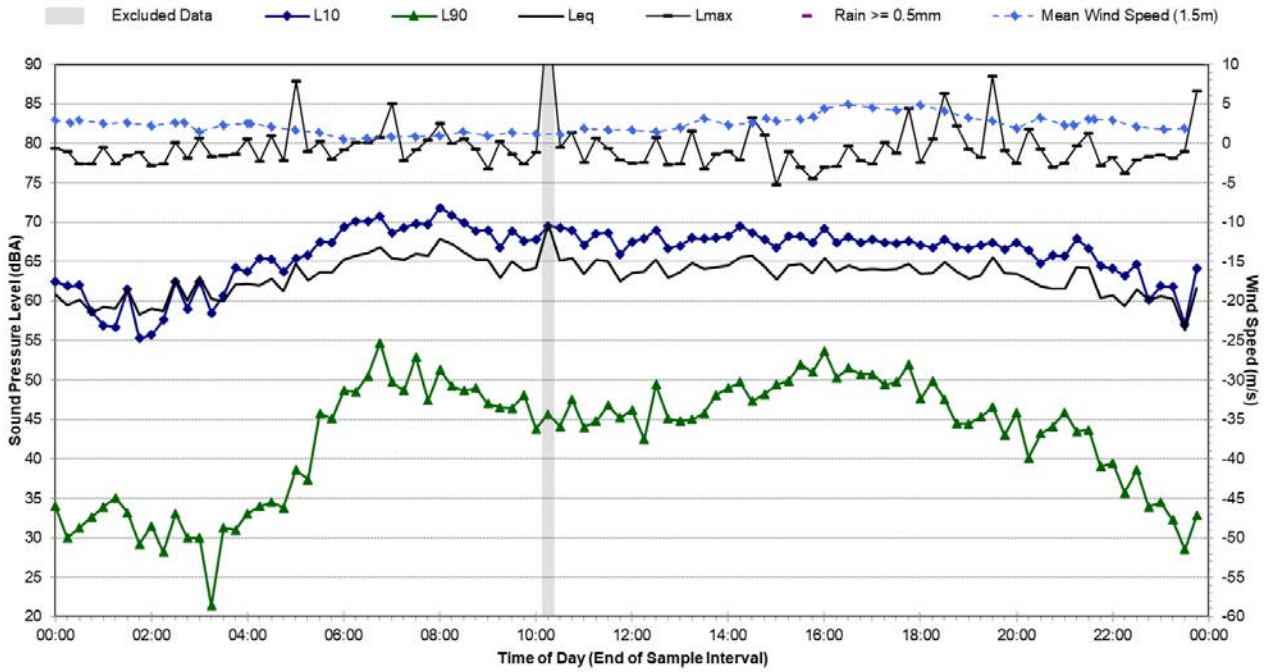
Statistical Ambient Noise Levels

L.03 77 Sydney Road, Raglan - Tuesday, 10 December 2019



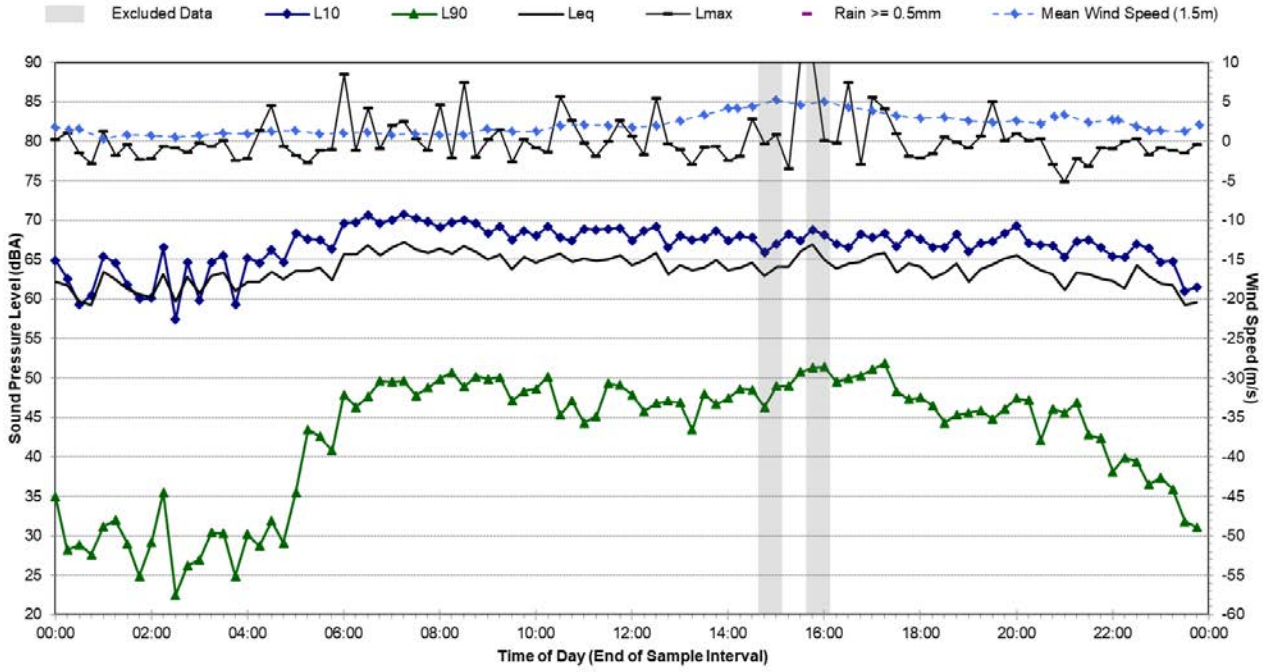
Statistical Ambient Noise Levels

L.03 77 Sydney Road, Raglan - Wednesday, 11 December 2019



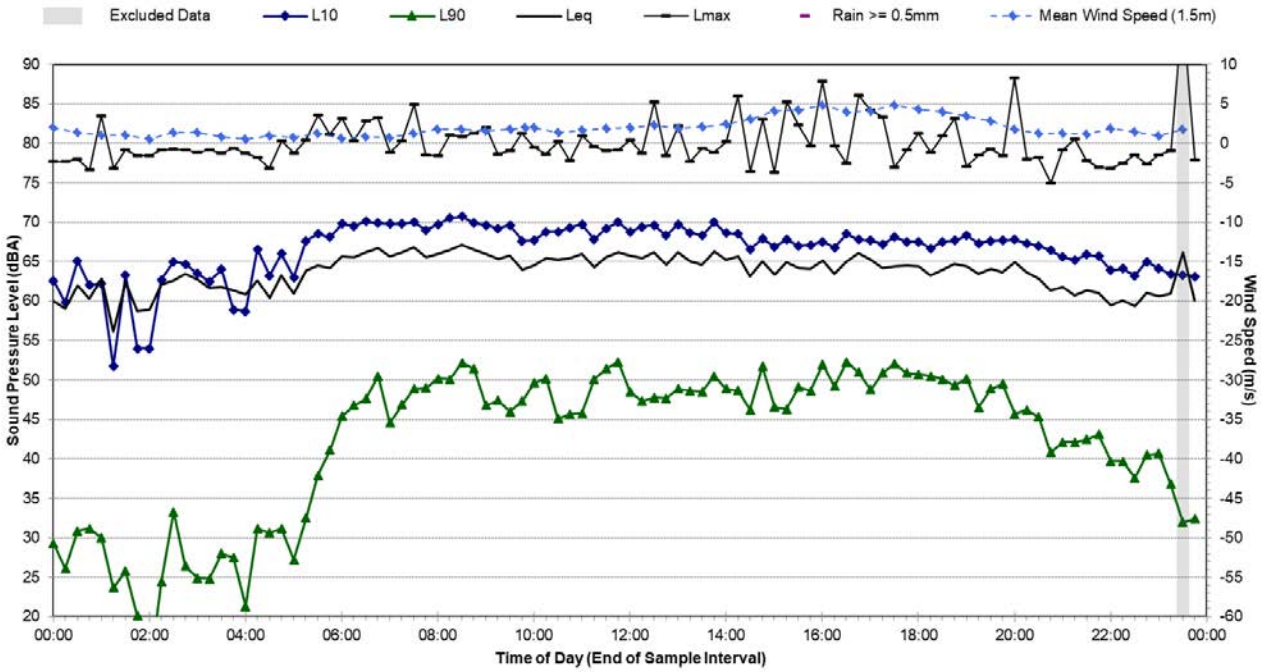
Statistical Ambient Noise Levels

L.03 77 Sydney Road, Raglan - Thursday, 12 December 2019



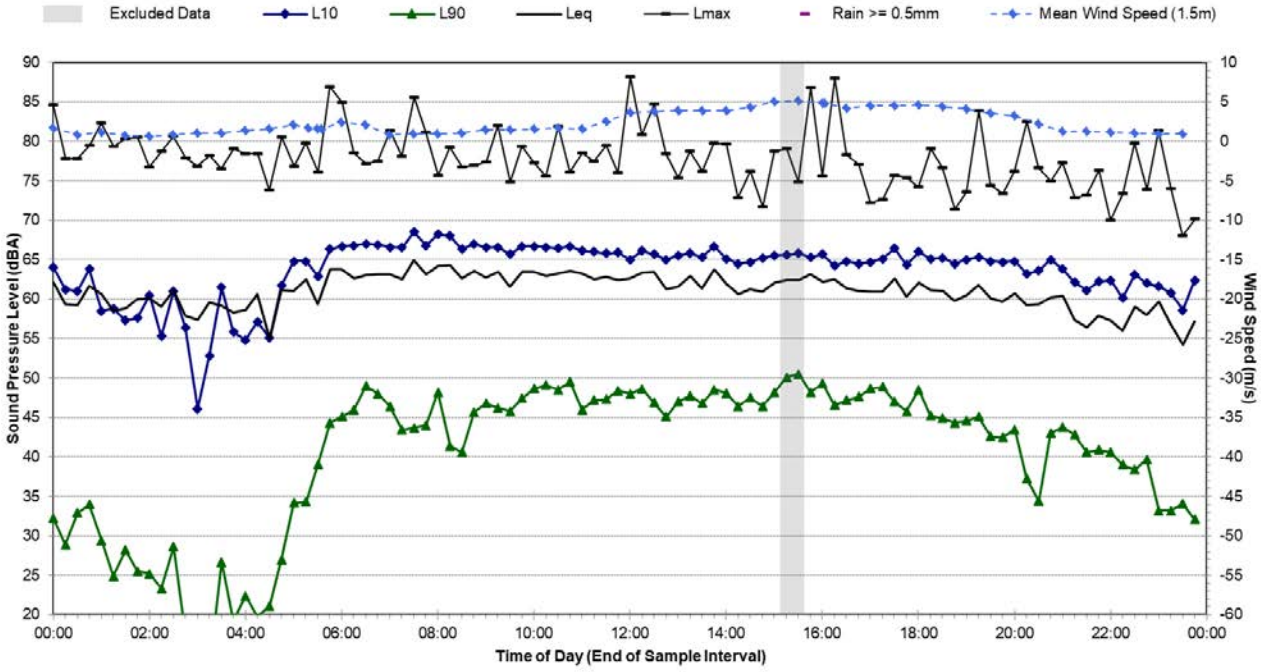
Statistical Ambient Noise Levels

L.03 77 Sydney Road, Raglan - Friday, 13 December 2019



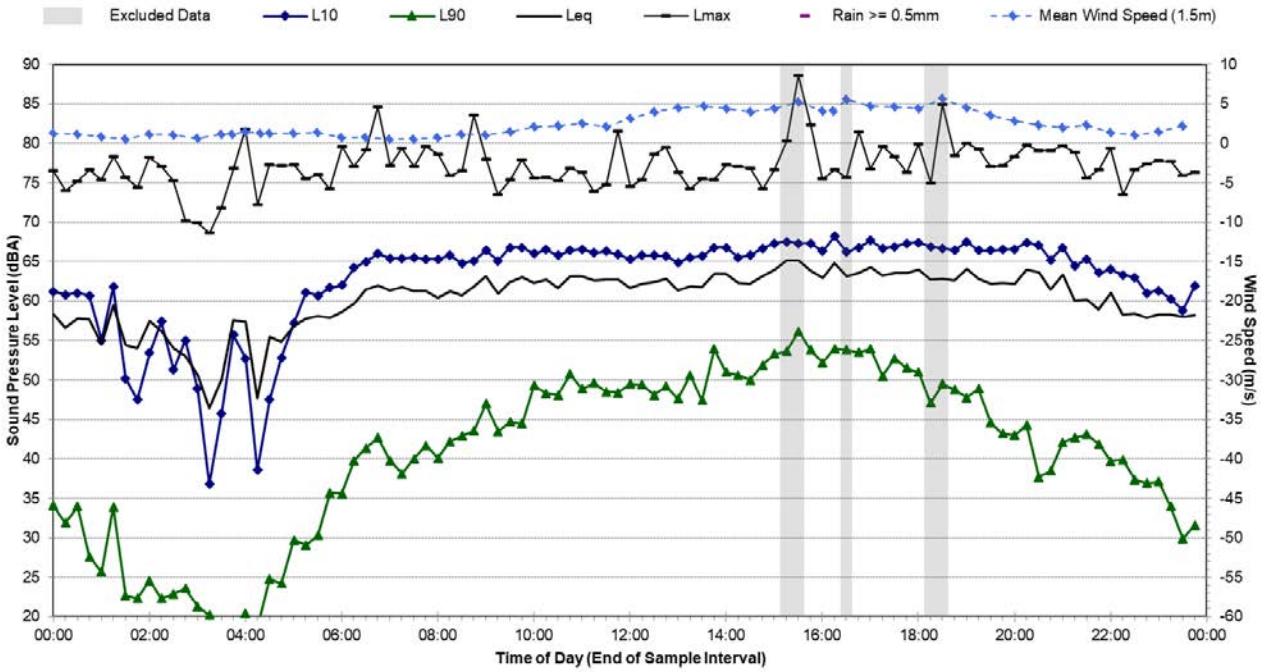
Statistical Ambient Noise Levels

L.03 77 Sydney Road, Raglan - Saturday, 14 December 2019



Statistical Ambient Noise Levels

L.03 77 Sydney Road, Raglan - Sunday, 15 December 2019



Noise Monitoring Location	L.04
Noise Monitoring Address	**2 P J Moodie Memorial Drive, Raglan**

Logger Device Type: Svantek 957, Logger Serial No: 23244
Sound Level Meter Device Type: Brüel and Kjær 2260, Sound Level Meter Serial No: 2487418

Ambient noise logger deployed at residential address 2 P J Moodie Memorial Drive, Raglan. Logger located in southern yard of the property, with direct view of the Great Western Highway to the south.

Attended noise measurements indicate the ambient noise environment at this location is dominated by road traffic noise from the Great Western Highway.

Recorded Noise Levels (L_{Amax}):
18/11/2019: Light-vehicle traffic Great Western Highway: 55-66 dBA,
Heavy-vehicle traffic Great Western Highway: 61-72 dBA, Birds: 55-61 dBA (intermittent), Helicopter: 60-65 dBA

Map of Noise Monitoring Location

Ambient Noise Logging Results – ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L_{10}	L_1
Daytime	43	56	58	65
Evening	40	57	60	66
Night-time	28	55	57	64

Ambient Noise Logging Results – RNP Defined Time Periods

Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	57	59
Night-time (10pm-7am)	55	57

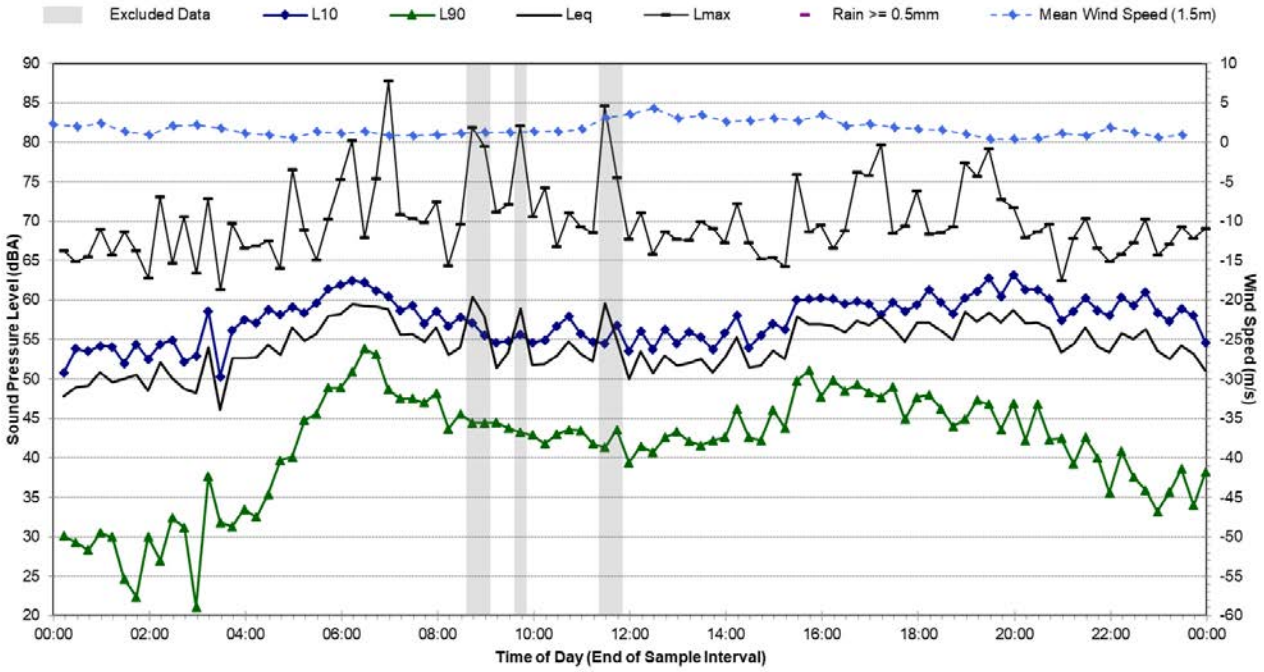
Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
18/11/2019	14:38	51	58	72

Photo of Noise Monitoring Location

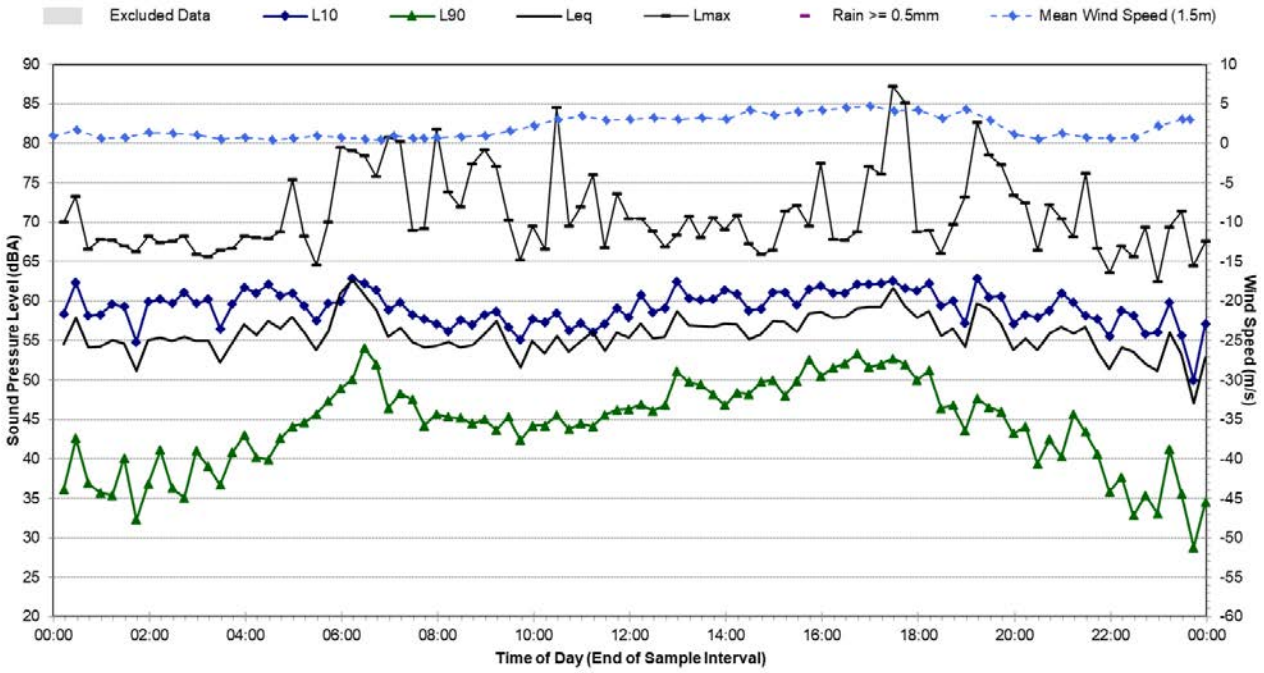
Statistical Ambient Noise Levels

L.04 - 2 P J Moodie Memorial Drive, Raglan - Monday, 9 December 2019



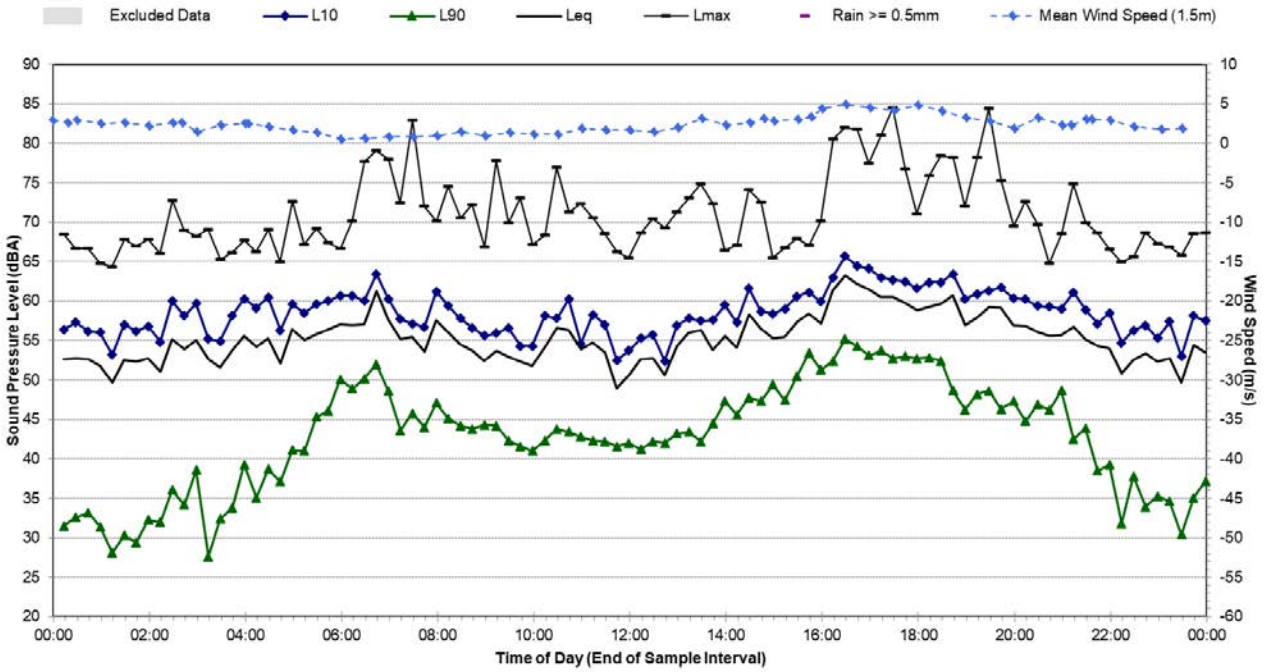
Statistical Ambient Noise Levels

L.04 - 2 P J Moodie Memorial Drive, Raglan - Tuesday, 10 December 2019



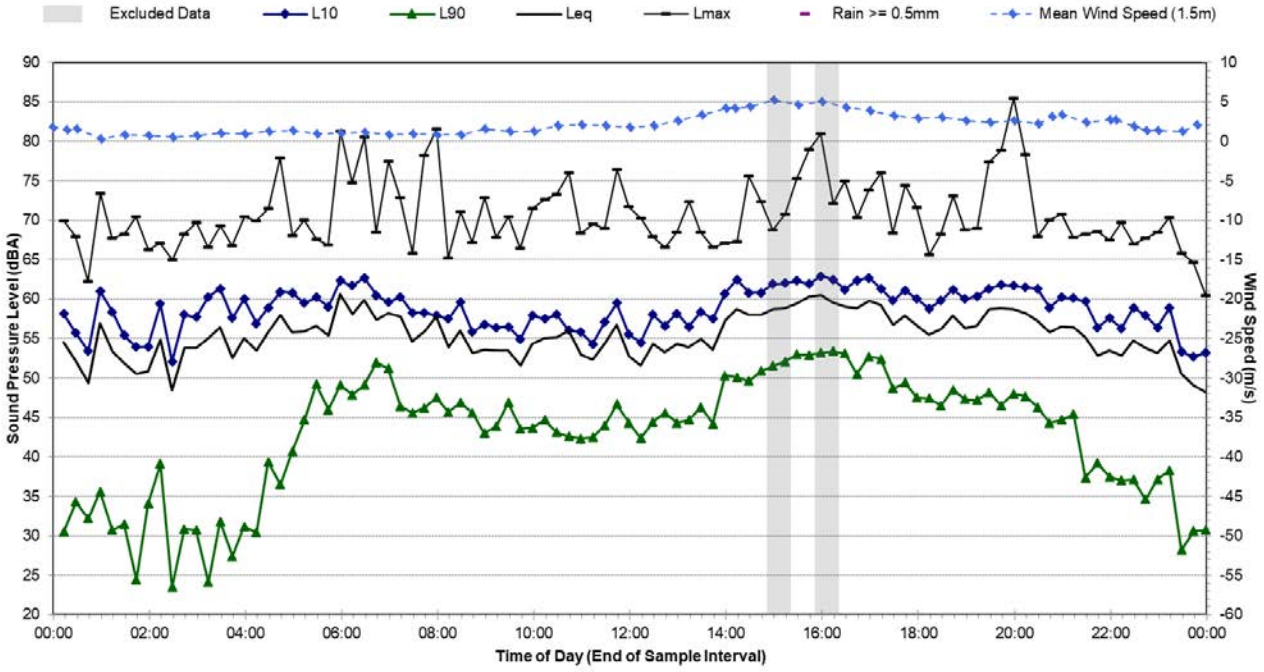
Statistical Ambient Noise Levels

L.04 - 2 P J Moodie Memorial Drive, Raglan - Wednesday, 11 December 2019



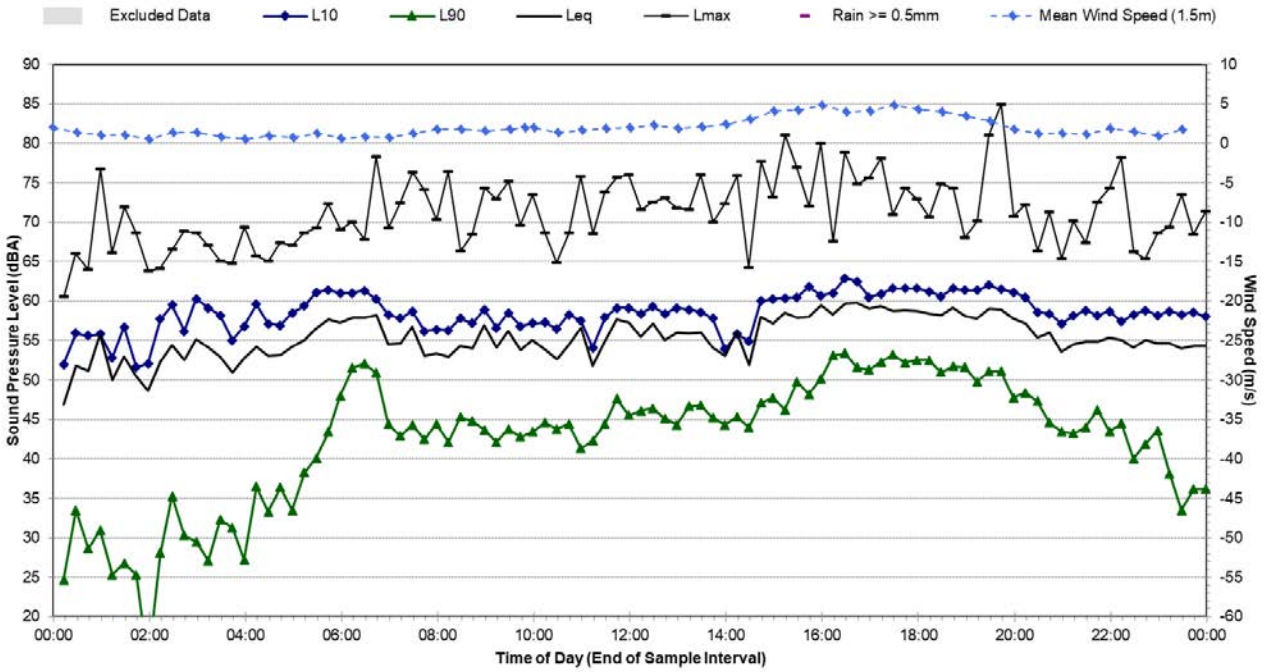
Statistical Ambient Noise Levels

L.04 - 2 P J Moodie Memorial Drive, Raglan - Thursday, 12 December 2019



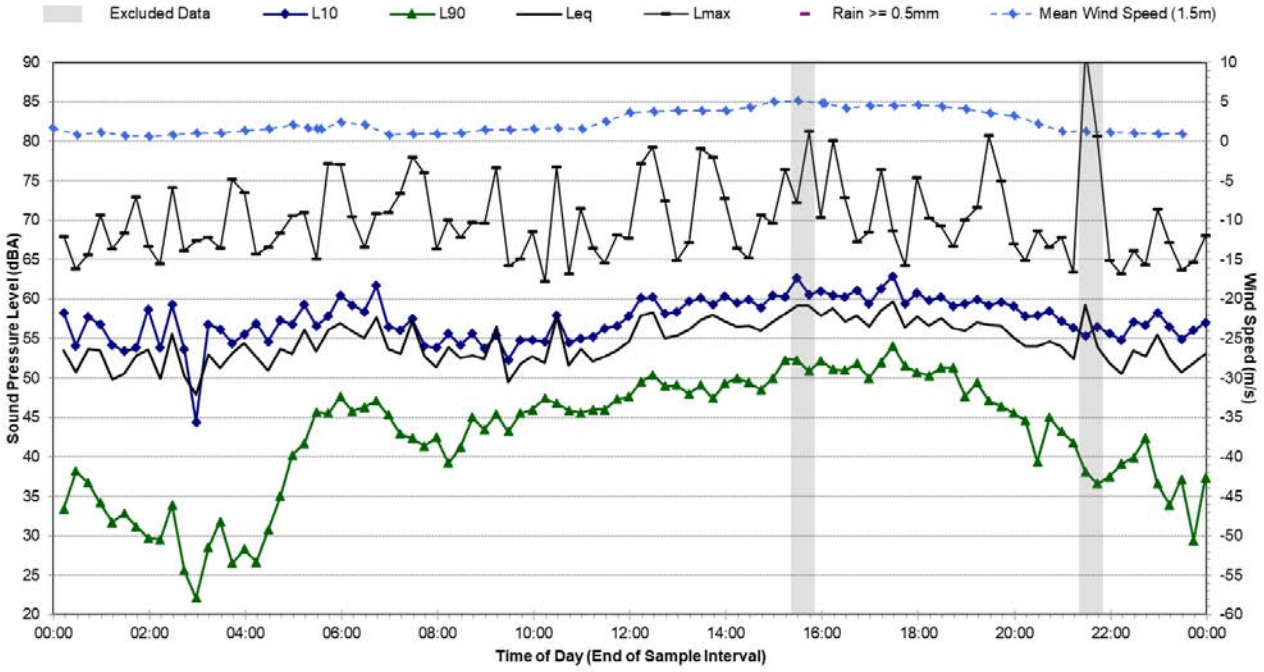
Statistical Ambient Noise Levels

L.04 - 2 P J Moodie Memorial Drive, Raglan - Friday, 13 December 2019



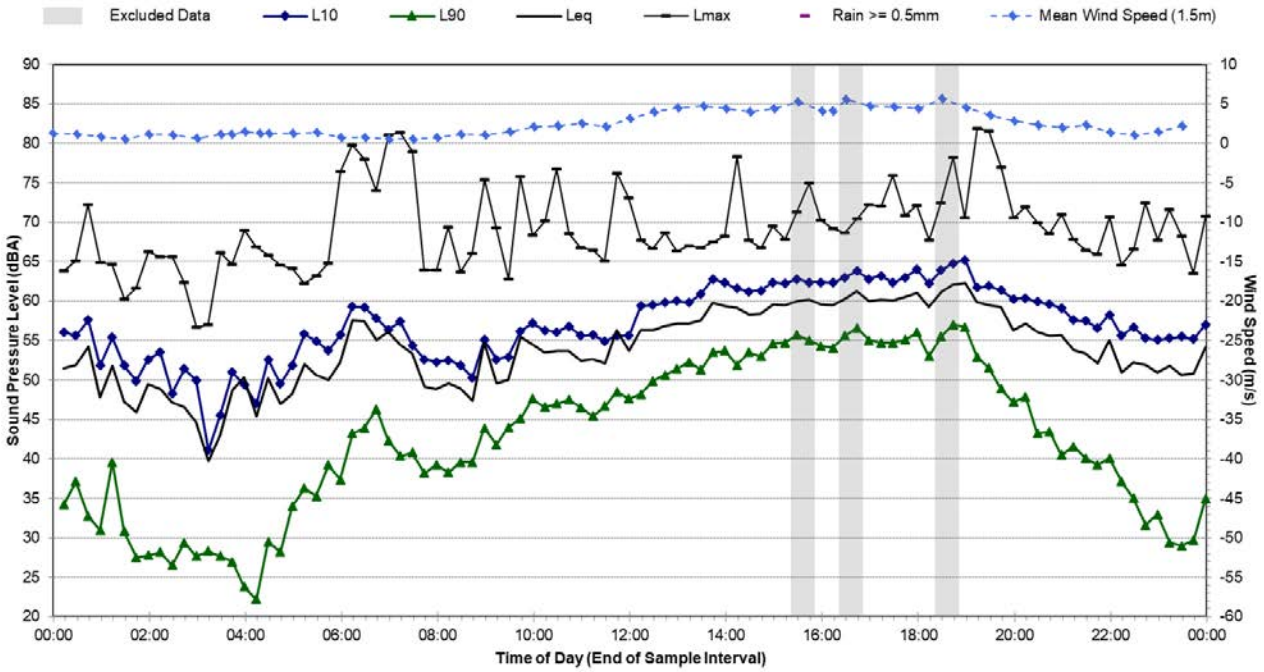
Statistical Ambient Noise Levels

L.04 - 2 P J Moodie Memorial Drive, Raglan - Saturday, 14 December 2019



Statistical Ambient Noise Levels

L.04 - 2 P J Moodie Memorial Drive, Raglan - Sunday, 15 December 2019



APPENDIX C

Construction Information

Table 1 Equipment Lists and Sound Power Levels

Equipment	Back Hoe (7.5 tonne JCB)	Bobcat	Chainsaw[1]	Concrete Mixer Truck	Concrete Pump	Concrete Saw[1]	Concrete Vibrator	Excavator - Breaker[1]	Excavator (22 tonne)	Front End Loader	Grader	Hand Tools	Lighting - Diesel Generator	Line Marking Plant	Mobile Crane - Franna	Paving Machine	Roller - Vibratory (12 tonne)[1]	Truck	Underbore Rig
Sound Power Level[2]	102	104	114	103	106	119	102	121	99	104	108	94	98	98	98	105	109	107	102
Ref **Scenario**																			
W.01 Early Works & Utilities - Noise Intensive Works	X					X		X	X			X	X		X			X	X
W.02 Early Works & Utilities - Typical Works	X								X			X	X		X			X	
W.03 Early Works & Utilities	X								X			X	X		X			X	
W.04 Compounds - Establishment		X							X		X	X			X			X	
W.05 Vegetation Clearing			X									X						X	
W.06 Road Works - Eastbound				X	X		X			X		X	X			X	X	X	
W.07 Road Works - Westbound				X	X		X			X		X	X			X	X	X	
W.08 Road Works - Pavement Works				X	X		X			X		X	X			X	X	X	
W.09 Finishing Works	X											X		X	X			X	
W.10 Compound - Operation									X	X		X			X			X	

Note 1: Equipment classed as 'annoying' in the ICNG and requires an additional 5 dB correction.

Note 2: Sound power level data is taken from the DEFRA Noise Database, RMS *Construction and Vibration Guideline* and TfNSW *Construction Noise and Vibration Strategy*.

Table 2 Predicted Worst-case Construction Noise Levels (dBA) – Residential Receivers

Period	ID	Scenario	NCA01	NCA02	NCA03	NCA04
Daytime	W.01	Early Works & Utilities - Noise Intensive Works	58	69	67	87
	W.02	Early Works & Utilities - Typical Works	46	57	55	75
	W.03	Early Works & Utilities	42	50	39	75
	W.04	Compounds - Establishment	45	44	45	76
	W.05	Vegetation Clearing	49	60	58	78
	W.06	Road Works - Eastbound	51	61	61	69
	W.07	Road Works - Westbound	52	63	58	81
	W.08	Road Works - Pavement Works	54	63	61	81
	W.09	Finishing Works	45	56	54	74
	W.10	Compound - Operation	40	39	40	71
Evening	W.01	Early Works & Utilities - Noise Intensive Works	-	-	-	-
	W.02	Early Works & Utilities - Typical Works	-	-	-	-
	W.03	Early Works & Utilities	42	50	39	75
	W.04	Compounds - Establishment	-	-	-	-
	W.05	Vegetation Clearing	-	-	-	-
	W.06	Road Works - Eastbound	-	-	-	-
	W.07	Road Works - Westbound	-	-	-	-
	W.08	Road Works - Pavement Works	54	63	61	81
	W.09	Finishing Works	-	-	-	-
	W.10	Compound - Operation	40	39	40	71
Night-time	W.01	Early Works & Utilities - Noise Intensive Works	-	-	-	-
	W.02	Early Works & Utilities - Typical Works	-	-	-	-
	W.03	Early Works & Utilities	42	50	39	75
	W.04	Compounds - Establishment	-	-	-	-
	W.05	Vegetation Clearing	-	-	-	-
	W.06	Road Works - Eastbound	-	-	-	-
	W.07	Road Works - Westbound	-	-	-	-
	W.08	Road Works - Pavement Works	54	63	61	81
	W.09	Finishing Works	-	-	-	-
	W.10	Compound - Operation	40	39	40	71

Table 3 Predicted Worst-case NML Exceedances (dB) – Residential Receivers

Period	ID	Scenario	NCA01	NCA02	NCA03	NCA04
Daytime	W.01	Early Works & Utilities - Noise Intensive Works	13	14	14	32
	W.02	Early Works & Utilities - Typical Works	1	2	2	20
	W.03	Early Works & Utilities	-	-	-	20
	W.04	Compounds - Establishment	-	-	-	21
	W.05	Vegetation Clearing	4	5	5	23
	W.06	Road Works - Eastbound	6	6	8	14
	W.07	Road Works - Westbound	7	8	5	26
	W.08	Road Works - Pavement Works	9	8	8	26
	W.09	Finishing Works	-	1	1	19
	W.10	Compound - Operation	-	-	-	16
Evening	W.01	Early Works & Utilities - Noise Intensive Works	-	-	-	-
	W.02	Early Works & Utilities - Typical Works	-	-	-	-
	W.03	Early Works & Utilities	2	3	-	30
	W.04	Compounds - Establishment	-	-	-	-
	W.05	Vegetation Clearing	-	-	-	-
	W.06	Road Works - Eastbound	-	-	-	-
	W.07	Road Works - Westbound	-	-	-	-
	W.08	Road Works - Pavement Works	14	16	16	36
	W.09	Finishing Works	-	-	-	-
	W.10	Compound - Operation	-	-	-	26
Night-time	W.01	Early Works & Utilities - Noise Intensive Works	-	-	-	-
	W.02	Early Works & Utilities - Typical Works	-	-	-	-
	W.03	Early Works & Utilities	7	15	4	40
	W.04	Compounds - Establishment	-	-	-	-
	W.05	Vegetation Clearing	-	-	-	-
	W.06	Road Works - Eastbound	-	-	-	-
	W.07	Road Works - Westbound	-	-	-	-
	W.08	Road Works - Pavement Works	19	28	26	46
	W.09	Finishing Works	-	-	-	-
	W.10	Compound - Operation	5	4	5	36

Table 4 Predicted NML Exceedances, All Receiver Types – NCA01

ID	Scenario	Number of Receivers																
		Total	HNA[1]	With NML Exceedance[2]														
				Standard Daytime			Out of Hours Works[3]											
							Daytime OOH			Evening			Night-time			Sleep Disturbance		
				1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
W.01	Early Works & Utilities - Noise Intensive Works	993	-	302	3	-	-	-	-	-	-	-	-	-	-	-	-	-
W.02	Early Works & Utilities - Typical Works	993	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.03	Early Works & Utilities	993	-	-	-	-	1	-	-	1	-	-	55	-	-	15	-	-
W.04	Compounds - Establishment	993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.05	Vegetation Clearing	993	-	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.06	Road Works - Eastbound	993	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.07	Road Works - Westbound	993	-	31	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.08	Road Works - Pavement Works	993	-	47	-	-	247	4	-	247	4	-	679	47	-	150	3	-
W.09	Finishing Works	993	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.10	Compound - Operation	993	-	-	-	-	-	-	-	-	-	-	11	-	-	7	-	-

Note 1: Highly Noise Affected, based on ICNG definition (ie predicted noise at residential receiver is 75 dBA or greater).
Note 2: Based on worst-case predicted noise levels.
Note 3: OOH = Out of hours.

Table 5 Predicted NML Exceedances, All Receiver Types – NCA02

ID	Scenario	Number of Receivers																
		Total	HNA[1]	With NML Exceedance[2]														
				Standard Daytime			Out of Hours Works[3]											
							Daytime OOH			Evening			Night-time			Sleep Disturbance		
				1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
W.01	Early Works & Utilities - Noise Intensive Works	155	-	6	2	-	-	-	-	-	-	-	-	-	-	-	-	-
W.02	Early Works & Utilities - Typical Works	155	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.03	Early Works & Utilities	155	-	-	-	-	-	-	-	1	-	-	-	1	-	-	1	-
W.04	Compounds - Establishment	155	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.05	Vegetation Clearing	155	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.06	Road Works - Eastbound	155	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.07	Road Works - Westbound	155	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
W.08	Road Works - Pavement Works	155	-	3	-	-	1	1	-	-	1	-	3	-	1	-	-	1
W.09	Finishing Works	155	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.10	Compound - Operation	155	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-

Note 1: Highly Noise Affected, based on ICNG definition (ie predicted noise at residential receiver is 75 dBA or greater).
Note 2: Based on worst-case predicted noise levels.
Note 3: OOH = Out of hours.

Table 6 Predicted NML Exceedances, All Receiver Types – NCA03

ID	Scenario	Number of Receivers																
		Total	HNA[1]	With NML Exceedance[2]														
				Standard Daytime			Out of Hours Works[3]											
							Daytime OOH			Evening			Night-time			Sleep Disturbance		
				1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
W.01	Early Works & Utilities - Noise Intensive Works	60	-	3	2	1	-	-	-	-	-	-	-	-	-	-	-	-
W.02	Early Works & Utilities - Typical Works	60	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.03	Early Works & Utilities	60	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-
W.04	Compounds - Establishment	60	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.05	Vegetation Clearing	60	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-
W.06	Road Works - Eastbound	60	-	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-
W.07	Road Works - Westbound	60	-	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-
W.08	Road Works - Pavement Works	60	-	4	1	-	3	3	-	4	3	-	15	4	3	9	4	-
W.09	Finishing Works	60	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.10	Compound - Operation	60	-	-	-	-	-	-	-	-	-	-	8	-	-	6	-	-

Note 1: Highly Noise Affected, based on ICNG definition (ie predicted noise at residential receiver is 75 dBA or greater).
Note 2: Based on worst-case predicted noise levels.
Note 3: OOH = Out of hours.

Table 7 Predicted NML Exceedances, All Receiver Types – NCA04

ID	Scenario	Number of Receivers																
		Total	HNA[1]	With NML Exceedance[2]														
				Standard Daytime			Out of Hours Works[3]											
							Daytime OOH			Evening			Night-time			Sleep Disturbance		
				1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB	1-10 dB	11-20 dB	>20 dB
W.01	Early Works & Utilities - Noise Intensive Works	449	19	77	41	15	-	-	-	-	-	-	-	-	-	-	-	-
W.02	Early Works & Utilities - Typical Works	449	1	32	13	-	-	-	-	-	-	-	-	-	-	-	-	-
W.03	Early Works & Utilities	449	1	4	2	-	5	3	1	15	3	2	178	14	5	131	10	4
W.04	Compounds - Establishment	449	1	33	3	1	-	-	-	-	-	-	-	-	-	-	-	-
W.05	Vegetation Clearing	449	3	44	18	1	-	-	-	-	-	-	-	-	-	-	-	-
W.06	Road Works - Eastbound	449	-	20	8	-	-	-	-	-	-	-	-	-	-	-	-	-
W.07	Road Works - Westbound	449	5	20	12	3	-	-	-	-	-	-	-	-	-	-	-	-
W.08	Road Works - Pavement Works	449	6	21	14	4	60	12	11	141	19	18	253	140	37	241	42	22
W.09	Finishing Works	449	-	29	11	-	-	-	-	-	-	-	-	-	-	-	-	-
W.10	Compound - Operation	449	-	16	1	-	34	2	1	56	14	1	215	54	15	179	50	13

Note 1: Highly Noise Affected, based on ICNG definition (ie predicted noise at residential receiver is 75 dBA or greater).
Note 2: Based on worst-case predicted noise levels.
Note 3: OOH = Out of hours.

Table 8 CNVG Standard Mitigation and Management Measures

Action Required	Applies To	Details
Management measures		
Implementation of any project specific mitigation measures required.	Airborne noise	Implementation of any project specific mitigation measures required.
Implement community consultation or notification measures.	Airborne noise Ground-borne noise & vibration	Notification detailing work activities, dates and hours, impacts and mitigation measures, indication of work schedule over the night time period, any operational noise benefits from the works (where applicable) and contact telephone number. Notification should be a minimum of 7 calendar days prior to the start of works. For projects other than maintenance works more advanced consultation or notification may be required. Please contact Roads and Maritime Communication and Stakeholder Engagement for guidance. Website (If required) Contact telephone number for community Email distribution list (if required) Community drop in session (if required by approval conditions).
Site inductions	Airborne noise Ground-borne noise & vibration	All employees, contractors and subcontractors are to receive an environmental induction. The induction must at least include: • all project specific and relevant standard noise and vibration mitigation measures • relevant licence and approval conditions • permissible hours of work • any limitations on high noise generating activities • location of nearest sensitive receivers • construction employee parking areas • designated loading/unloading areas and procedures • site opening/closing times (including deliveries) • environmental incident procedures.
Behavioural practices	Airborne noise	No swearing or unnecessary shouting or loud stereos/radios on site. No dropping of materials from height, throwing of metal items and slamming of doors.
Verification	Airborne noise Ground-borne noise & vibration	Where specified under Appendix C of the CNVG a noise verification program is to be carried out for the duration of the works in accordance with the Construction Noise and Vibration Management Plan and any approval and licence conditions.
Attended vibration measurements	Ground-borne vibration	Where required attended vibration measurements should be undertaken at the commencement of vibration generating activities to confirm that vibration levels are within the acceptable range to prevent cosmetic building damage.
Update Construction Environmental Management Plans	Airborne noise Ground-borne noise & vibration	The CEMP must be regularly updated to account for changes in noise and vibration management issues and strategies.
Building condition surveys	Vibration Blasting	Undertake building dilapidation surveys on all buildings located within the buffer zone prior to commencement of activities with the potential to cause property damage

Action Required	Applies To	Details
Source controls		
Construction hours and scheduling	Airborne noise Ground-borne noise & vibration	Where feasible and reasonable, construction should be carried out during the standard daytime working hours. Work generating high noise and/or vibration levels should be scheduled during less sensitive time periods.
Construction respite period during normal hours and out-of-hours work	Ground-borne noise & vibration Airborne noise	See Appendix C of the CNVG for more details on the following respite measures: • Respite Offers (RO) • Respite Period 1 (R1) • Respite Period 2 (R2) • Duration Respite (DR)
Equipment selection.	Airborne noise Ground-borne noise & vibration	Use quieter and less vibration emitting construction methods where feasible and reasonable. For example, when piling is required, bored piles rather than impact-driven piles will minimise noise and vibration impacts. Similarly, diaphragm wall construction techniques, in lieu of sheet piling, will have significant noise and vibration benefits. Ensure plant including the silencer is well maintained.
Plant noise levels.	Airborne-noise	The noise levels of plant and equipment must have operating Sound Power or Sound Pressure Levels compliant with the criteria in Appendix H of the CNVG. Implement a noise monitoring audit program to ensure equipment remains within the more stringent of the manufacturers specifications or Appendix H of the CNVG.
Rental plant and equipment.	Airborne-noise	The noise levels of plant and equipment items are to be considered in rental decisions and in any case cannot be used on site unless compliant with the criteria in Table 2 of the CNVG.
Use and siting of plant.	Airborne-noise	The offset distance between noisy plant and adjacent sensitive receivers is to be maximised. Plant used intermittently to be throttled down or shut down. Noise-emitting plant to be directed away from sensitive receivers. Only have necessary equipment on site.
Plan worksites and activities to minimise noise and vibration.	Airborne noise Ground-borne vibration	Locate compounds away from sensitive receivers and discourage access from local roads. Plan traffic flow, parking and loading/unloading areas to minimise reversing movements within the site. Where additional activities or plant may only result in a marginal noise increase and speed up works, consider limiting duration of impact by concentrating noisy activities at one location and move to another as quickly as possible. Very noise activities should be scheduled for normal working hours. If the work can not be undertaken during the day, it should be completed before 11:00pm. Where practicable, work should be scheduled to avoid major student examination periods when students are studying for examinations such as before or during Higher School Certificate and at the end of higher education semesters. If programmed night work is postponed the work should be re-programmed and the approaches in this guideline apply again.
Reduced equipment power	Airborne noise Ground-borne vibration	Use only the necessary size and power.
Non-tonal and ambient sensitive reversing alarms	Airborne noise	Non-tonal reversing beepers (or an equivalent mechanism) must be fitted and used on all construction vehicles and mobile plant regularly used on site and for any out of hours work. Consider the use of ambient sensitive alarms that adjust output relative to the ambient noise level.

Action Required	Applies To	Details
Minimise disturbance arising from delivery of goods to construction sites.	Airborne noise	Loading and unloading of materials/deliveries is to occur as far as possible from sensitive receivers. Select site access points and roads as far as possible away from sensitive receivers. Dedicated loading/unloading areas to be shielded if close to sensitive receivers. Delivery vehicles to be fitted with straps rather than chains for unloading, wherever possible. Avoid or minimise these out of hours movements where possible.
Engine compression brakes	Construction vehicles	Limit the use of engine compression brakes at night and in residential areas. Ensure vehicles are fitted with a maintained Original Equipment Manufacturer exhaust silencer or a silencer that complies with the National Transport Commission's 'In-service test procedure' and standard.
Path controls		
Shield stationary noise sources such as pumps, compressors, fans etc.	Airborne noise	Stationary noise sources should be enclosed or shielded where feasible and reasonable whilst ensuring that the occupational health and safety of workers is maintained. Appendix D of AS 2436:2010 lists materials suitable for shielding.
Shield sensitive receivers from noisy activities.	Airborne noise	Use structures to shield residential receivers from noise such as site shed placement; earth bunds; fencing; erection of operational stage noise barriers (where practicable) and consideration of site topography when situating plant.
Receptor control		
Structural surveys and vibration monitoring	Ground-borne vibration	Pre-construction surveys of the structural integrity of vibration sensitive buildings may be warranted. At locations where there are high-risk receptors, vibration monitoring should be conducted during the activities causing vibration.
See Appendix C of the CNVG for additional measures	Airborne noise Ground-borne vibration	In some instances additional mitigation measures may be required.

Table 9 CNVG 'Additional Mitigation Measures'

Additional Mitigation Measure	Description
Notification (letterbox drop or equivalent)	Advanced warning of works and potential disruptions can assist in reducing the impact on the community. The notification may consist of a letterbox drop (or equivalent) detailing work activities, time periods over which these will occur, impacts and mitigation measures. Notification should be a minimum of five working days prior to the start of works.
Specific notifications (SN)	Specific notifications are letterbox dropped (or equivalent) to identified stakeholders no later than seven calendar days ahead of construction activities that are likely to exceed the noise objectives. The specific notification provides additional information when relevant and informative to more highly affected receivers than covered in general letterbox drops.
Phone calls (PC)	Phone calls detailing relevant information made to affected stakeholders within seven calendar days of proposed work. Phone calls provide affected stakeholders with personalised contact and tailored advice, with the opportunity to provide comments on the proposed work and specific needs.
Individual briefings (IB)	Individual briefings are used to inform stakeholders about the impacts of high noise activities and mitigation measures that will be implemented. Project representatives would visit identified stakeholders at least 48 hours ahead of potentially disturbing construction activities. Individual briefings provide affected stakeholders with personalised contact and tailored advice, with the opportunity to comment on the project.
Respite Offers (RO)	Respite Offers should be considered where there are high noise and vibration generating activities near receivers. As a guide work should be carried out in continuous blocks that do not exceed three hours each, with a minimum respite period of one hour between each block. The actual duration of each block of work and respite should be flexible to accommodate the usage of and amenity at nearby receivers. The purpose of such an offer is to provide residents with respite from an ongoing impact. This measure is evaluated on a project-by-project basis, and may not be applicable to all projects.
Respite Period 1 (R1)	Out of hours construction noise in 'out of hours period 1' shall be limited to no more than three consecutive evenings per week except where there is a Duration Respite. For night work these periods of work should be separated by not less than one week and no more than six evenings per month.
Respite Period 2 (R2)	Night time construction noise in 'out of hours period 2' shall be limited to two consecutive nights except for where there is a Duration Respite. For night work these periods of work should be separated by not less than one week and six nights per month. Where possible, high noise generating works shall be completed before 11pm.
Duration Respite (DR)	Respite offers and respite periods 1 and 2 may be counterproductive in reducing the impact on the community for longer duration projects. In this instance and where it can be strongly justified it may be beneficial to increase the work duration, number of evenings or nights worked through Duration Respite so that the project can be completed more quickly. The project team should engage with the community where noise levels are expected to exceed the NML to demonstrate support for Duration Respite.
Alternative Accommodation (AA)	Alternative accommodation may be offered to residents living in close proximity to construction works that are likely to experience highly intrusive noise levels. The specifics of the offer should be identified on a project-by-project basis. Additional aspects for consideration shall include whether the highly intrusive activities occur throughout the night or before midnight.
Verification (V)	Verification of construction noise and vibration levels should occur to ensure the actual impacts are consistent with the predicted levels. Appendix F of the CNVG contains further details about verification of Noise and Vibration levels as part of routine checks of noise levels or following reasonable complaints.

APPENDIX D

Operational Information

Table 1 Traffic Volumes – No Build (Without Project)

Section ID	2026				2036			
	Day Light	Day Heavy	Night Light	Night Heavy	Day Light	Day Heavy	Night Light	Night Heavy
Great Western Highway west of Napoleon Street (eastbound)	5582	784	662	198	6514	909	773	229
Great Western Highway west of Napoleon Street (westbound)	6131	866	638	237	7156	1015	745	277
Great Western Highway west of Eugenie Street (eastbound)	4342	734	490	193	5074	859	572	226
Great Western Highway west of Eugenie Street (westbound)	4882	720	488	171	5688	842	568	200
Great Western Highway east of Eugenie Street (eastbound)	3200	669	307	168	3734	785	359	197
Great Western Highway east of Eugenie Street (westbound)	5464	751	647	212	6370	870	754	246
Napoleon Street (northbound)	1525	45	212	6	1781	54	248	7
Napoleon Street (southbound)	1285	94	106	5	1500	105	124	5
Eugenie Street (northbound)	305	18	42	2	358	27	50	4
Eugenie Street (southbound)	326	11	27	1	384	11	32	1
PJ Moodie Memorial Drive (northbound)	225	9	31	1	267	9	37	1
PJ Moodie Memorial Drive (southbound)	204	11	17	1	233	11	19	1

Table 2 Traffic Volumes – Build (With Project)

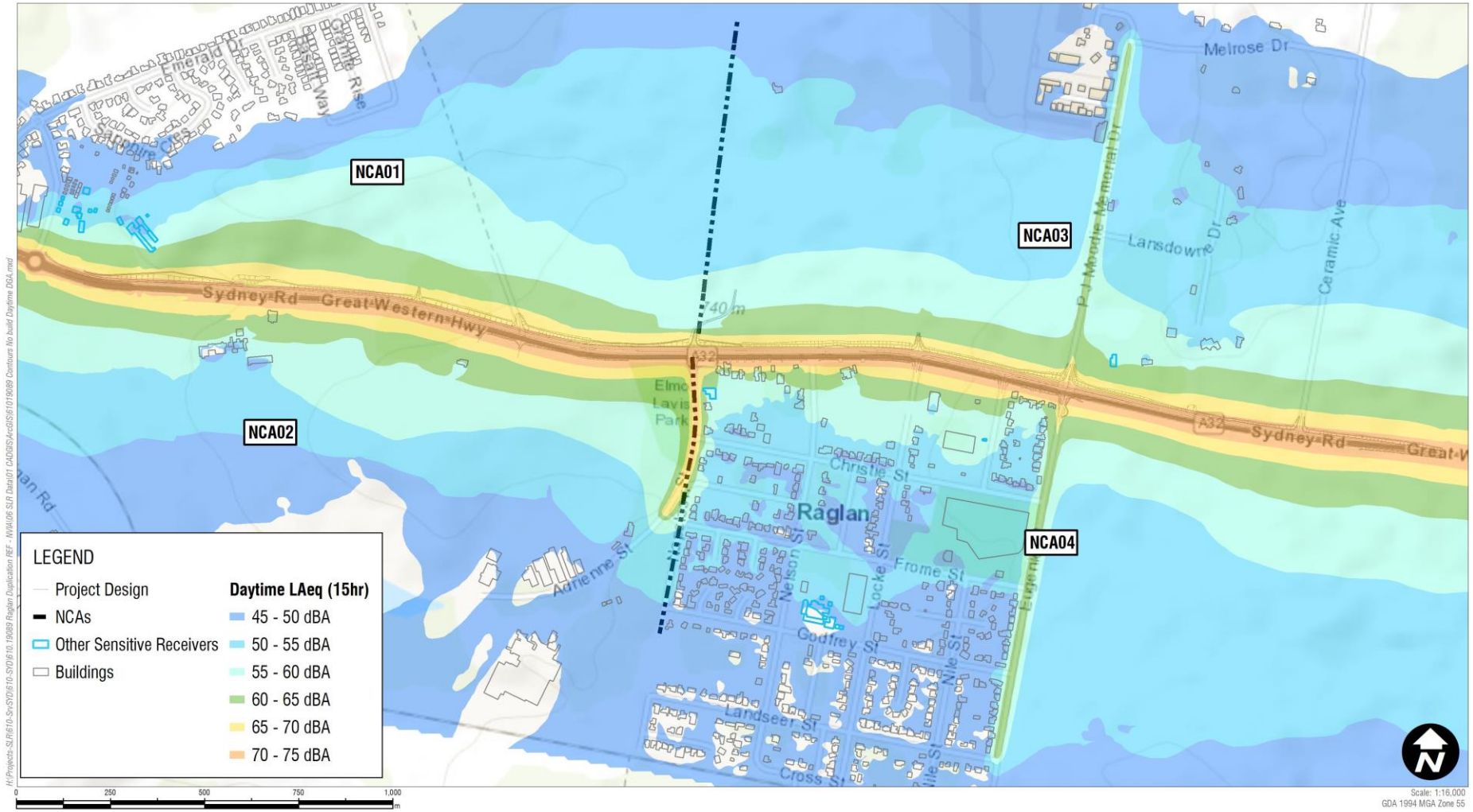
Section ID	2026				2036			
	Day Light	Day Heavy	Night Light	Night Heavy	Day Light	Day Heavy	Night Light	Night Heavy
Great Western Highway west of Napoleon Street (eastbound)	5582	784	662	198	6514	909	773	229
Great Western Highway west of Napoleon Street (westbound)	6131	866	638	237	7156	1015	745	277
Great Western Highway west of Eugenie Street (eastbound)	4392	734	495	193	5136	859	579	226
Great Western Highway west of Eugenie Street (westbound)	4882	720	488	171	5688	842	568	200
Great Western Highway east of Eugenie Street (eastbound)	3200	669	307	168	3734	785	359	197
Great Western Highway east of Eugenie Street (westbound)	5464	751	647	212	6370	870	754	246
Napoleon Street (northbound)	1525	45	212	6	1781	54	248	7
Napoleon Street (southbound)	1285	94	106	5	1500	105	124	5
Eugenie Street (northbound)	305	18	42	2	358	27	50	4
Eugenie Street (southbound)	372	11	31	1	442	11	37	1
PJ Moodie Memorial Drive (northbound)	225	9	31	1	267	9	37	1
PJ Moodie Memorial Drive (southbound)	204	11	17	1	233	11	19	1

Table 3 Traffic Volumes – Validation

Section ID	2019			
	Day Light	Day Heavy	Night Light	Night Heavy
Great Western Highway west of Napoleon Street (eastbound)	5046	596	1072	278
Great Western Highway west of Napoleon Street (westbound)	5489	523	819	251
Great Western Highway west of Eugenie Street (eastbound)	3776	430	1042	274
Great Western Highway west of Eugenie Street (westbound)	3372	298	1194	282
Great Western Highway east of Eugenie Street (eastbound)	3573	303	986	258
Great Western Highway east of Eugenie Street (westbound)	3498	410	873	253
Eugenie Street (northbound)	245	44	46	8
Eugenie Street (southbound)	281	20	36	3

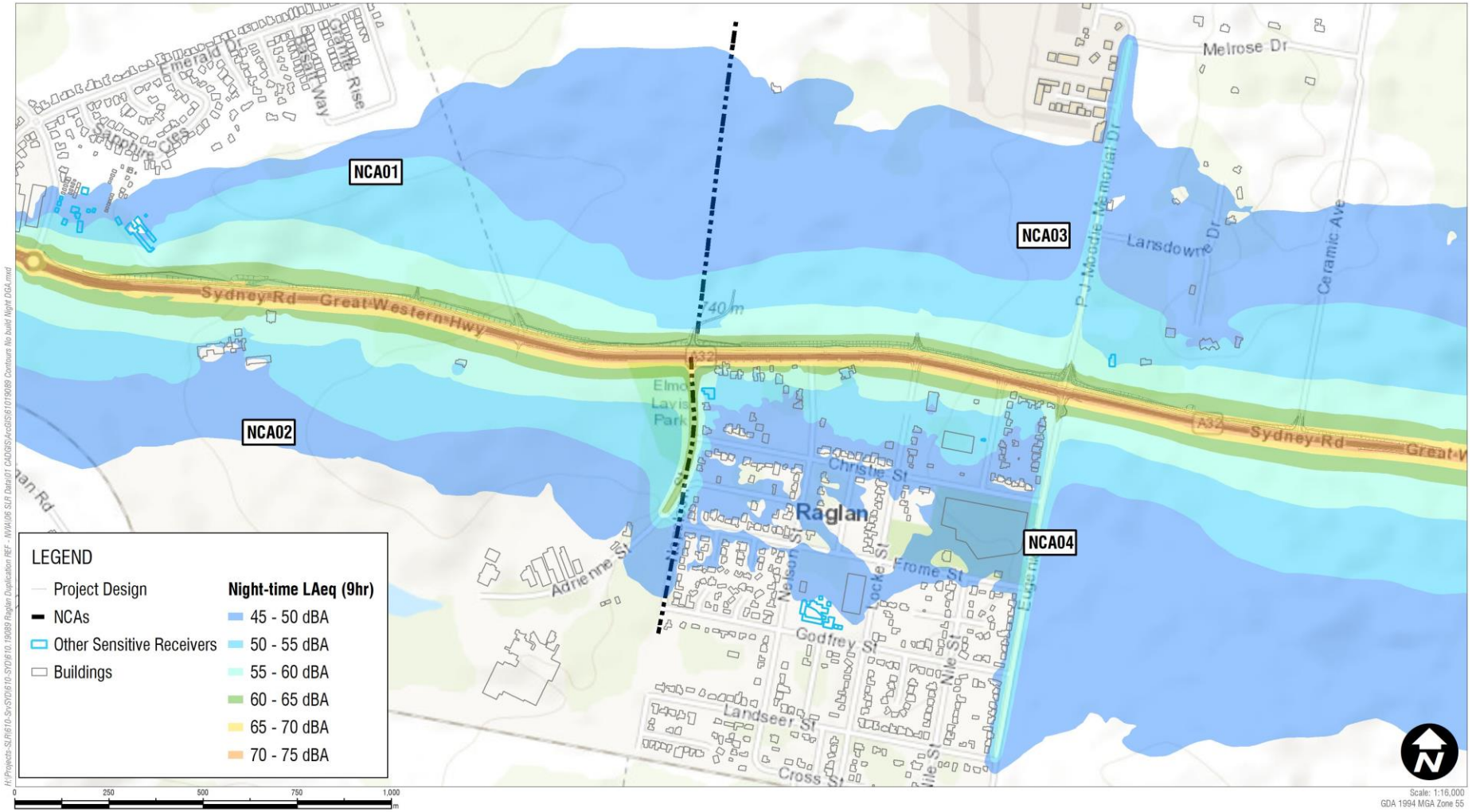
Operational Road Traffic Noise Contours

No Build 2036 Daytime



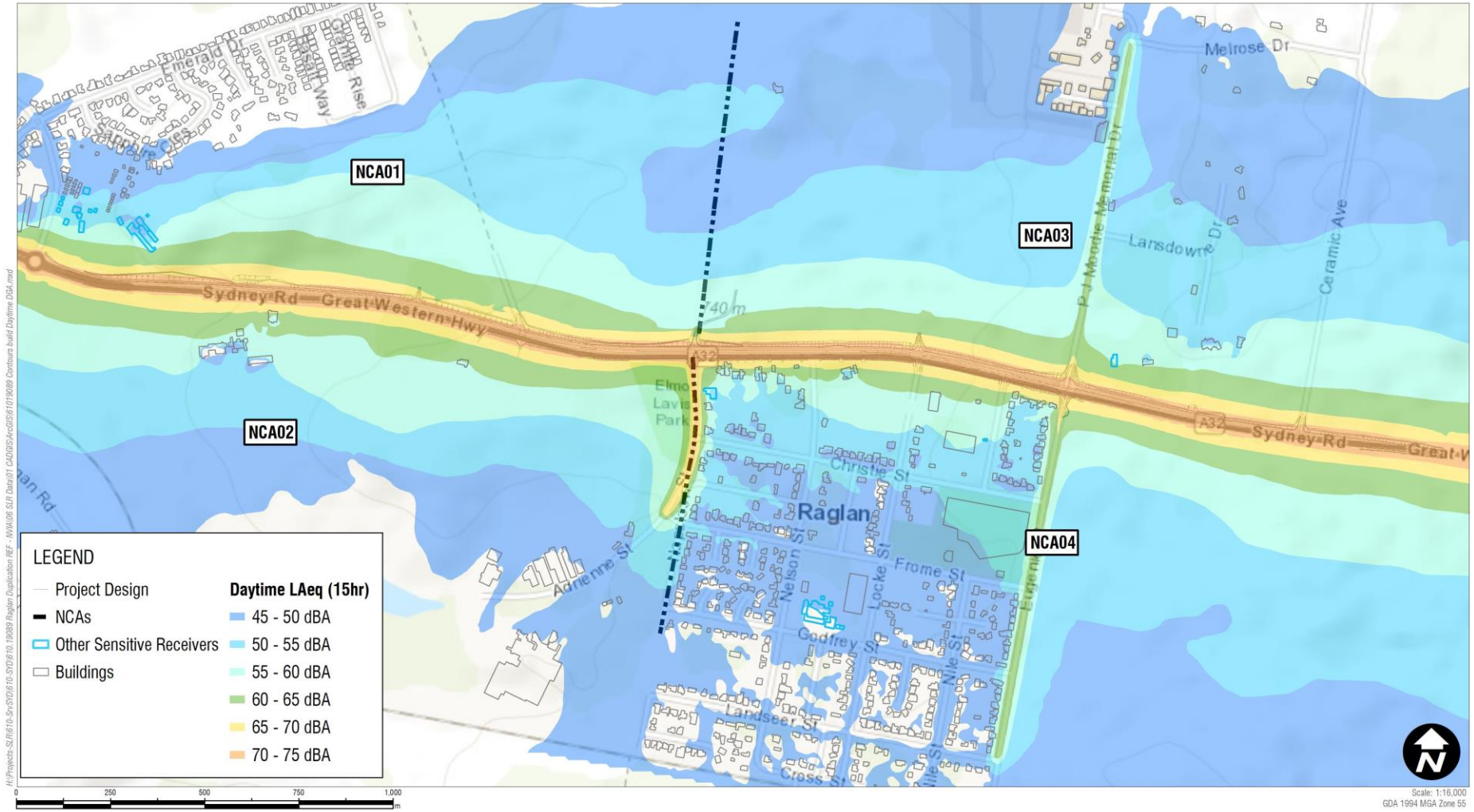
Note: Contours are at 1.5 m height and are facade reflected

No Build 2036 Night-time



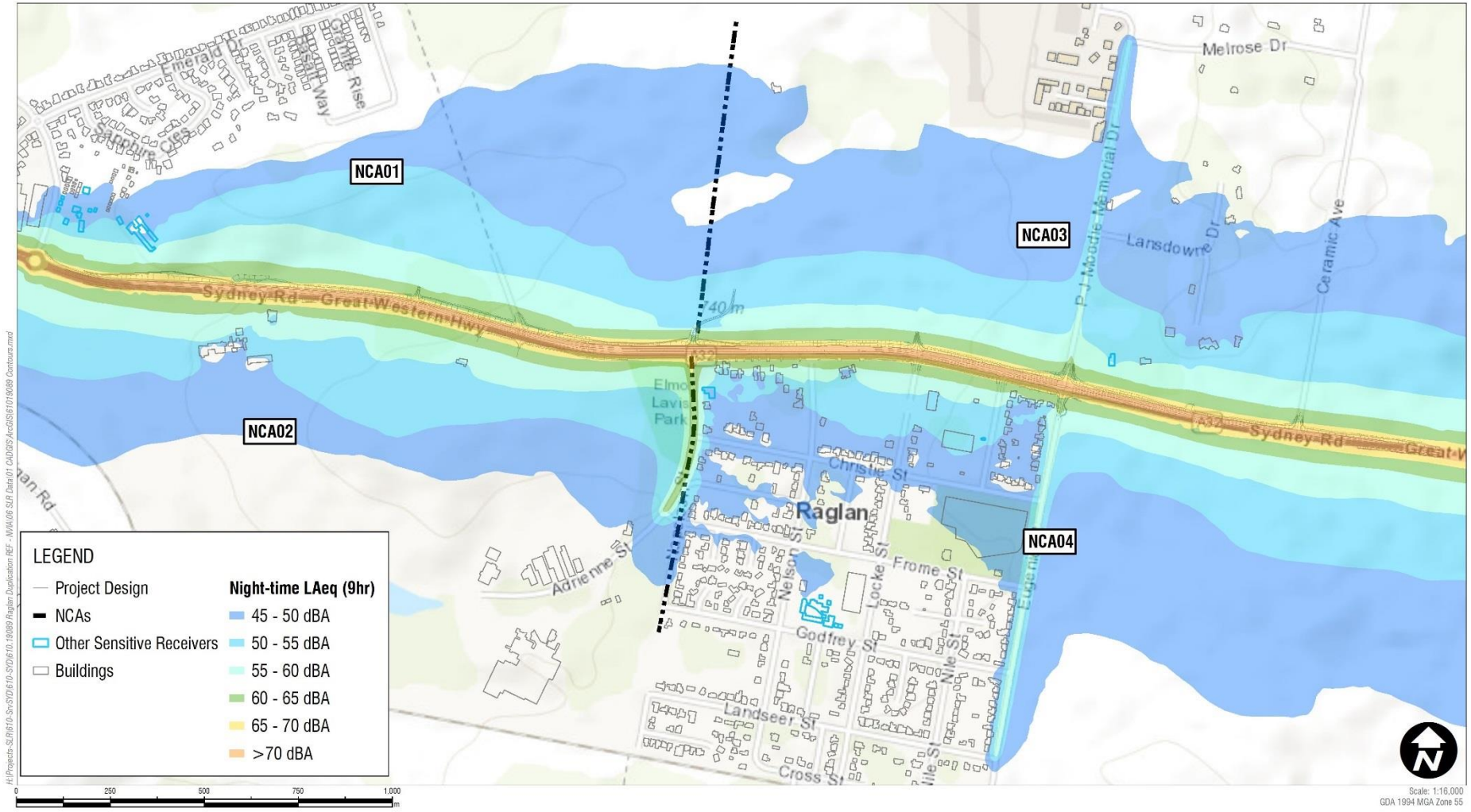
Note: Contours are at 1.5 m height and are facade reflected.

Build 2036 Daytime (DGA)

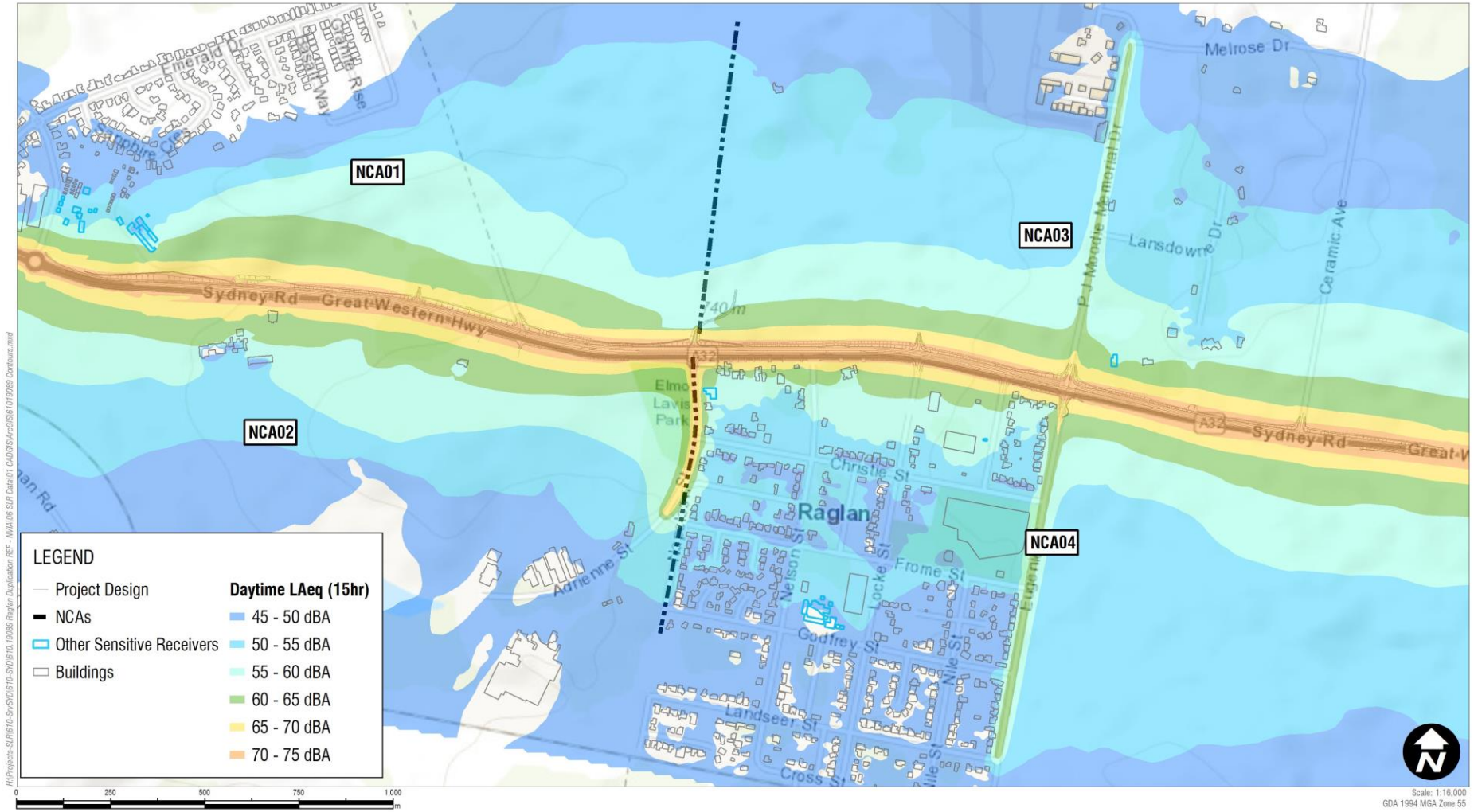


Note: Contours are at 1.5 m height and are facade reflected.

Build 2036 Night-time (DGA)

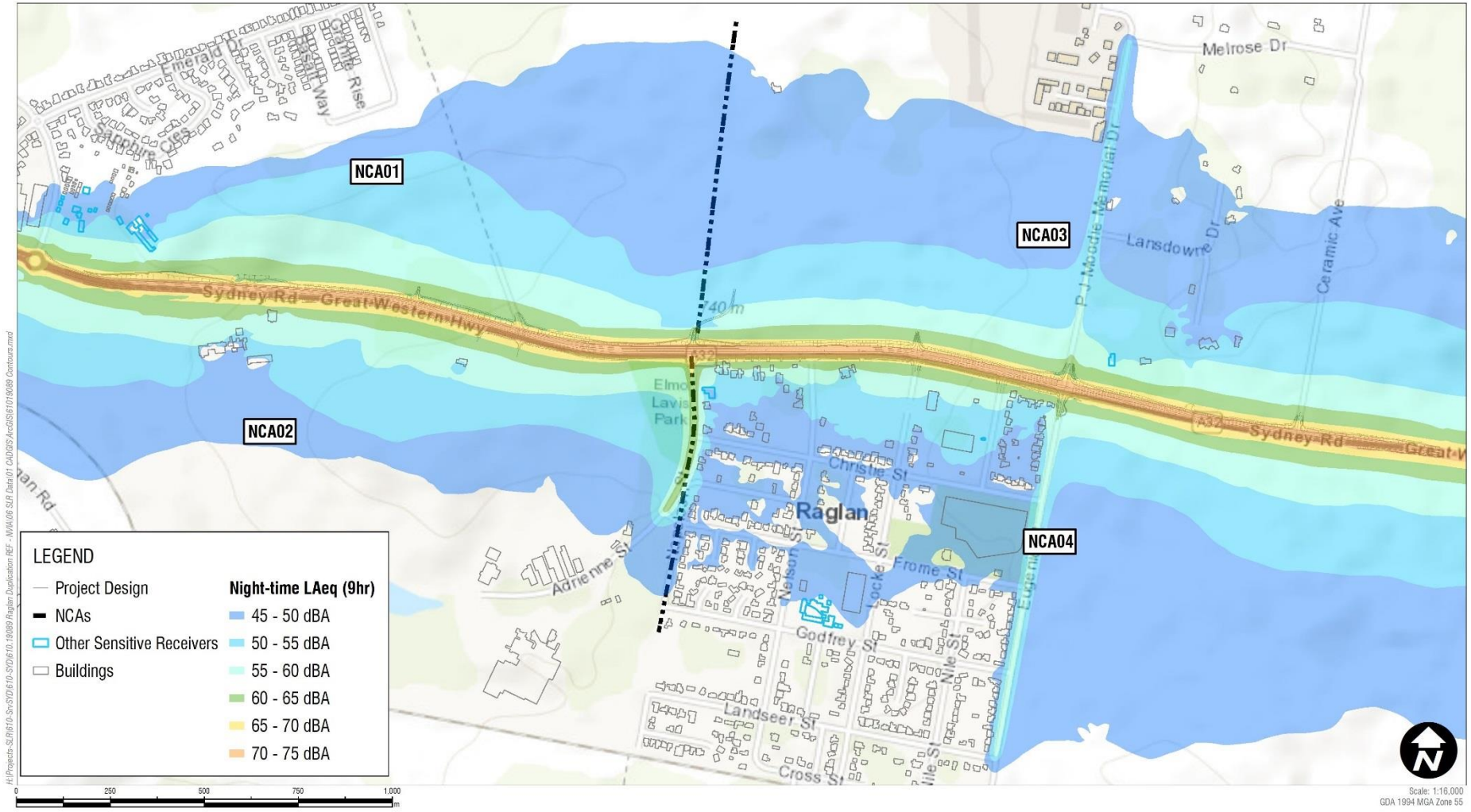


Build 2036 Daytime (Chip Seal)



Note: Contours are at 1.5 m height and are facade reflected.

Build 2036 Night-time (Chip Seal)



Note: Contours are at 1.5 m height and are facade reflected.

Existing Maximum Noise Levels

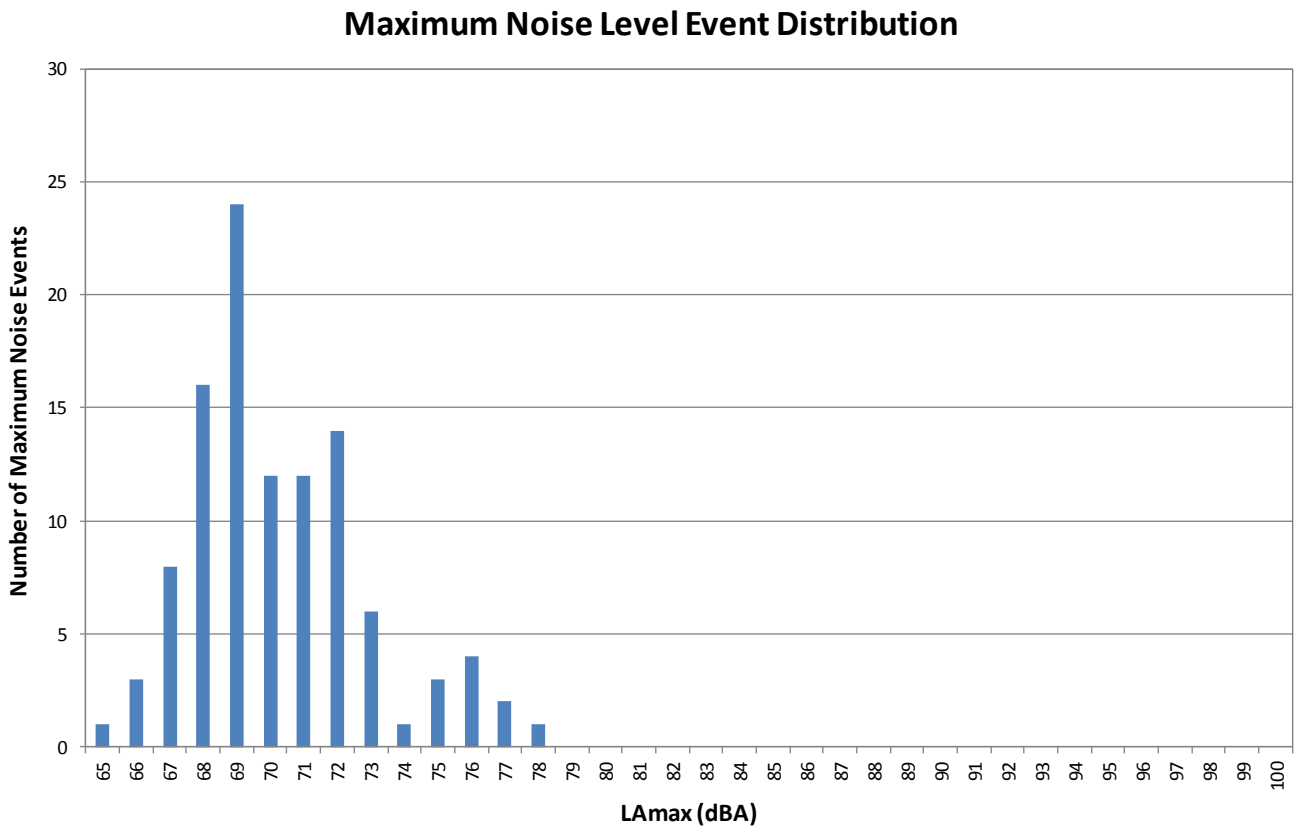
L02 – 5815 Great Western Highway, Kelso NSW

Table 4 L.02 Maximum Noise Level Events

Monitoring Date	Number of Maximum Noise Events per Hour (LAmax Noise Levels, dBA)									
	00:00-01:00	01:00-02:00	02:00-03:00	03:00-04:00	04:00-05:00	05:00-06:00	06:00-07:00	22:00-23:00	23:00-00:00	Total/ (Range)
27-Nov-19	3 (68)	1 (68)	-	1 (72)	-	2 (76)	1 (75)	2 (71-73)	2 (71-73)	12 (68-76)
28-Nov-19	3 (71-75)	2 (68-69)	1 (70)	-	-	-	3 (75-77)	1 (72)	-	10 (68-77)
29-Nov-19	1 (72)	5 (69-70)	-	-	2 (70-72)	-	1 (74)	-	1 (72)	10 (69-74)
30-Nov-19	-	3 (69-73)	2 (68)	5 (69-73)	-	-	-	1 (70)	-	11 (68-73)
1-Dec-19	1 (68)	4 (67-69)	3 (66-68)	4 (65-68)	5 (67-71)	2 (69)	-	3 (69)	4 (69-73)	26 (65-73)
2-Dec-19	6 (67-71)	4 (67)	2 (69)	1 (72)	3 (69)	1 (76)	-	3 (72)	3 (70-71)	23 (67-76)
3-Dec-19	3 (70-71)	1 (70)	1 (70)	2 (72)	1 (71)	-	-	1 (71)	1 (71)	10 (70-72)
4-Dec-19	2 (72)	-	1 (73)	-	-	-	2 (77-78)	n/a[1]	n/a[1]	5 (72-78)

Note 1: This period was outside of the period of unattended noise logging.

Figure 1 L.02 Maximum Noise Level Event Distribution of Monitoring Period



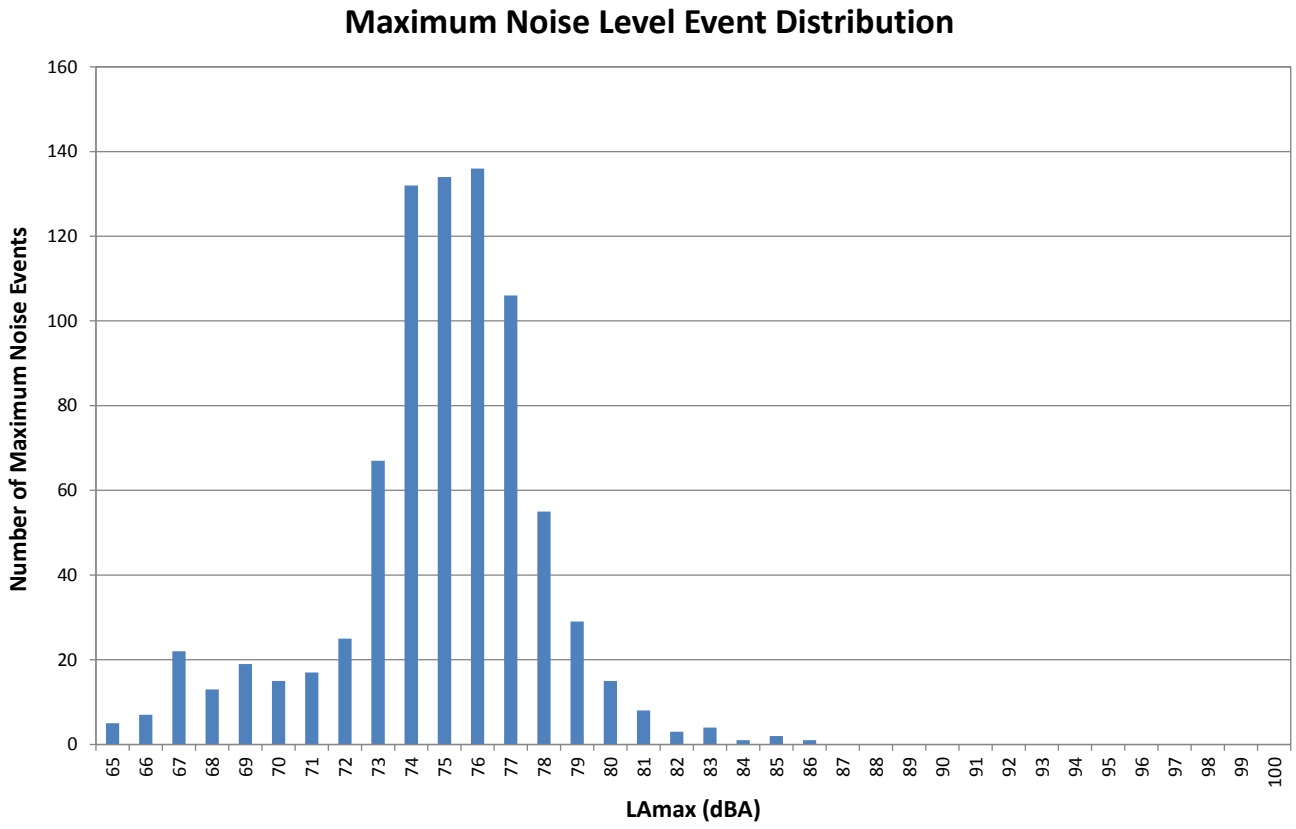
L.03 – 77 Sydney Road, Raglan NSW

Table 5 L.02 Maximum Noise Level Events

Monitoring Date	Number of Maximum Noise Events per Hour (LAmax Noise Levels, dBA)									
	00:00-01:00	01:00-02:00	02:00-03:00	03:00-04:00	04:00-05:00	05:00-06:00	06:00-07:00	22:00-23:00	23:00-00:00	Total/ (Range)
27-Nov-19	7 (74-80)	18 (75-78)	15 (77-79)	13 (78-80)	5 (79-81)	-	1 (81)	8 (77-81)	13 (76-80)	80 (74-81)
28-Nov-19	11 (76-80)	15 (76-78)	16 (77-79)	8 (78-82)	8 (77-79)	2 (80-81)	2 (83-86)	8 (78-81)	14 (77-81)	84 (76-86)
29-Nov-19	13 (77-81)	15 (75-77)	10 (77-80)	13 (77-82)	12 (77-80)	2 (79-83)	3 (81-86)	7 (76-79)	7 (77-80)	82 (75-86)
30-Nov-19	11 (77-81)	11 (75-81)	16 (74-79)	15 (75-80)	12 (75-77)	10 (77-81)	3 (79)	5 (75-77)	9 (74-77)	92 (74-81)
1-Dec-19	6 (73-79)	7 (73-80)	9 (70-77)	12 (70-76)	10 (72-77)	8 (75-77)	5 (77-79)	15 (77-81)	17 (76-81)	89 (70-81)
2-Dec-19	15 (75-81)	16 (75-81)	16 (76-81)	9 (78-79)	8 (77-79)	2 (81)	-	10 (78-81)	11 (77-79)	87 (75-81)
3-Dec-19	15 (77-80)	15 (77-84)	16 (77-79)	12 (77-79)	7 (78)	1 (80)	1 (84)	11 (77-78)	17 (76-79)	95 (76-84)
4-Dec-19	11 (77-79)	17 (76-79)	9 (78-81)	8 (79-81)	5 (79-81)	3 (81-82)	-	n/a[1]	n/a[1]	53 (76-82)

Note 1: This period was outside of the period of unattended noise logging.

Figure 2 L.02 Maximum Noise Level Event Distribution of Monitoring Period



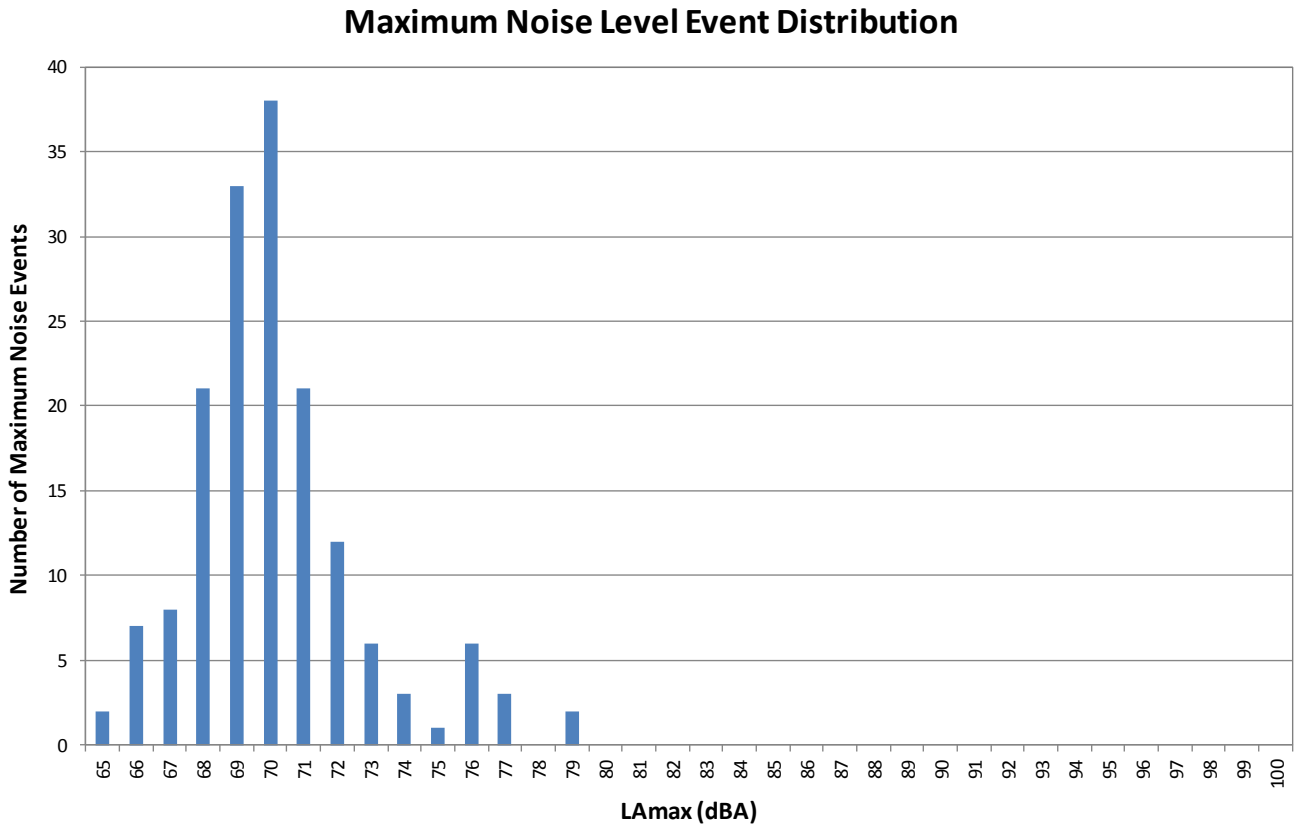
L.04 – 2 PJ Moodie Memorial Drive, Raglan NSW

Table 6 L.03 Maximum Noise Level Events

Monitoring Date	Number of Maximum Noise Events per Hour (LAmax Noise Levels, dBA)									
	00:00-01:00	01:00-02:00	02:00-03:00	03:00-04:00	04:00-05:00	05:00-06:00	06:00-07:00	22:00-23:00	23:00-00:00	Total/ (Range)
27-Nov-19	5 (68-72)	2 (68-70)	1 (70)	1 (71)	1 (71)	-	3 (74-79)	1 (69)	2 (68)	16 (68-79)
28-Nov-19	1 (70)	1 (70)	1 (69)	-	-	1 (74)	3 (75-77)	-	-	7 (69-77)
29-Nov-19	2 (68-69)	3 (68-70)	2 (70-71)	2 (70-71)	-	2 (71-72)	2 (74-77)	3 (69-70)	1 (69)	17 (68-77)
30-Nov-19	3 (68-69)	3 (67-70)	7 (69-72)	4 (67-69)	-	1 (71)	3 (73-76)	3 (68-69)	1 (68)	25 (67-76)
1-Dec-19	2 (66-72)	4 (66-68)	3 (65-66)	2 (66)	3 (65-69)	1 (73)	1 (76)	4 (67-68)	-	20 (65-76)
2-Dec-19	5 (67-69)	4 (68)	7 (68-73)	1 (70)	3 (69-71)	-	-	3 (73-76)	7 (70-72)	30 (67-76)
3-Dec-19	4 (69-70)	5 (69-70)	4 (69-71)	1 (71)	-	-	-	4 (70-71)	4 (69-71)	22 (69-71)
4-Dec-19	9 (70-72)	9 (69-71)	3 (72)	-	2 (71-72)	-	3 (76-79)	n/a[1]	n/a[1]	26 (69-79)

Note 1: This period was outside of the period of unattended noise logging.

Figure 3 L.04 Maximum Noise Level Event Distribution of Monitoring Period



Receiver Assessment Table – DGA Pavement

Name	NCA	Flr	Easting	Northing	RecType	Name	Address	NCG Criteria		Period	Predicted Noise Level (dBA)								> 2 dB(A) Increase		Cumulative Limit		Project Acute		Eligible for Consideration of Mitigation
											At Opening (2026)				Future Design (2036)										
											No Build		Build		No Build		Build								
								D	N		D	N	D	N	D	N	D	N	D	N	D	N	D	N	
NCA03.OCC.0155.01	NCA03	1	746959	6238750	Other (Childcare)	PJ Moodie Memorial Drive		45	-	H	63	59	63	60	63	60	63	61	-	-	Y	-	-	-	Y
NCA04.OPW.0480.01	NCA04	1	745889	6238666	Other (Place of Worship)	Kingdom Hall of Jehovah's Witnesses		50	50	H	63	59	62	57	64	59	62	58	-	-	Y	Y	-	-	Y
NCA04.RES.0625.01	NCA04	1	745913	6238724	Residential		5 Sydney Road, Raglan	60	55	P	67	62	63	59	68	63	64	60	-	-	-	Y	-	Y	Y
NCA04.RES.0624.01	NCA04	1	745931	6238730	Residential		7 Sydney Road, Raglan	60	55	P	75	69	68	63	75	70	68	64	-	-	Y	Y	Y	Y	Y
NCA04.RES.0771.01	NCA04	1	745952	6238714	Residential		9 Sydney Road, Raglan	60	55	P	65	60	62	57	66	61	62	58	-	-	-	-	-	-	-
NCA04.RES.0772.01	NCA04	1	745969	6238716	Residential		11 Sydney Road, Raglan	60	55	P	67	62	63	59	68	63	64	60	-	-	-	Y	-	Y	Y
NCA04.RES.0483.01	NCA04	1	746012	6238718	Residential		15 Sydney Road, Raglan	60	55	P	70	65	65	61	71	66	66	61	-	-	Y	Y	Y	Y	Y
NCA04.RES.0617.01	NCA04	1	746028	6238708	Residential		17 Sydney Road, Raglan	60	55	P	63	58	60	55	63	58	60	56	-	-	-	-	-	-	-
NCA04.RES.0855.01	NCA04	1	746053	6238730	Residential		19 Sydney Road, Raglan	60	55	P	71	66	66	61	71	66	66	62	-	-	Y	Y	Y	Y	Y
NCA04.RES.0610.01	NCA04	1	746073	6238702	Residential		21 Sydney Road, Raglan	60	55	P	63	58	60	56	63	58	61	56	-	-	-	-	-	-	-
NCA04.RES.0909.01	NCA04	1	746115	6238735	Residential		25 Sydney Road, Raglan	60	55	P	71	66	66	61	72	67	67	62	-	-	Y	Y	Y	Y	Y
NCA04.RES.0586.01	NCA04	1	746696	6238653	Residential		69 Sydney Road, Raglan	60	55	P	70	65	65	61	71	66	66	61	-	-	Y	Y	Y	Y	Y
NCA04.RES.0595.01	NCA04	1	746717	6238646	Residential		71 Sydney Road, Raglan	60	55	P	66	61	63	59	67	62	64	60	-	-	-	Y	-	Y	Y
NCA04.RES.0597.01	NCA04	1	746743	6238638	Residential		73 Sydney Road, Raglan	60	55	P	67	62	64	59	68	63	64	60	-	-	-	Y	-	Y	Y
NCA04.RES.0589.01	NCA04	1	746763	6238635	Residential		75 Sydney Road, Raglan	60	55	P	68	63	64	60	69	64	65	61	-	-	Y	Y	Y	Y	Y
NCA04.RES.0596.01	NCA04	1	746795	6238632	Residential		77 Sydney Road, Raglan	60	55	P	69	64	64	60	69	64	65	60	-	-	Y	Y	Y	Y	Y

Receiver Assessment Table – Chip Seal Pavement

Name	NCA	Flr	Easting	Northing	RecType	Name	Address	NCG Criteria		Period	Predicted Noise Level (dBA)								> 2 dB(A) Increase		Cumulative Limit		Project Acute		Eligible for Consideration of Mitigation
											At Opening (2026)				Future Design (2036)										
											No Build		Build		No Build		Build								
								D	N		D	N	D	N	D	N	D	N	D	N	D	N	D	N	
NCA03.OCC.0155.01	NCA03	1	746959	6298750	Other (Childcare)	PJ Moodie Memorial Drive		45	-	H	63	59	64	61	63	60	65	61	-	-	Y	-	-	-	Y
NCA04.OPW.0480.01	NCA04	1	745889	6298666	Other (Place of Worship)	Kingdom Hall of Jehovah's Witnesses		50	50	H	63	59	62	58	64	59	63	58	-	-	Y	Y	-	-	Y
NCA04.RES.0625.01	NCA04	1	745913	6298724	Residential		5 Sydney Road, Raglan	60	55	P	67	62	65	60	68	63	65	60	-	-	Y	Y	Y	Y	Y
NCA04.RES.0624.01	NCA04	1	745931	6298730	Residential		7 Sydney Road, Raglan	60	55	P	75	69	69	64	75	70	70	65	-	-	Y	Y	Y	Y	Y
NCA04.RES.0771.01	NCA04	1	745952	6298714	Residential		9 Sydney Road, Raglan	60	55	P	65	60	63	58	66	61	64	59	-	-	-	-	-	-	-
NCA04.RES.0772.01	NCA04	1	745969	6298716	Residential		11 Sydney Road, Raglan	60	55	P	67	62	65	60	68	63	65	60	-	-	Y	Y	Y	Y	Y
NCA04.RES.0483.01	NCA04	1	746012	6298718	Residential		15 Sydney Road, Raglan	60	55	P	70	65	67	62	71	66	67	62	-	-	Y	Y	Y	Y	Y
NCA04.RES.0617.01	NCA04	1	746028	6298708	Residential		17 Sydney Road, Raglan	60	55	P	63	58	61	56	63	58	62	56	-	-	-	-	-	-	-
NCA04.RES.0855.01	NCA04	1	746053	6298730	Residential		19 Sydney Road, Raglan	60	55	P	71	66	67	62	71	66	68	63	-	-	Y	Y	Y	Y	Y
NCA04.RES.0610.01	NCA04	1	746073	6298702	Residential		21 Sydney Road, Raglan	60	55	P	63	58	61	56	63	58	62	57	-	-	-	-	-	-	-
NCA04.RES.0909.01	NCA04	1	746115	6298735	Residential		25 Sydney Road, Raglan	60	55	P	71	66	67	62	72	67	68	63	-	-	Y	Y	Y	Y	Y
NCA04.RES.0586.01	NCA04	1	746696	6298659	Residential		69 Sydney Road, Raglan	60	55	P	70	65	66	61	71	66	67	62	-	-	Y	Y	Y	Y	Y
NCA04.RES.0595.01	NCA04	1	746717	6298646	Residential		71 Sydney Road, Raglan	60	55	P	66	61	64	59	67	62	65	60	-	-	Y	Y	Y	Y	Y
NCA04.RES.0597.01	NCA04	1	746743	6298638	Residential		73 Sydney Road, Raglan	60	55	P	67	62	65	60	68	63	65	60	-	-	Y	Y	Y	Y	Y
NCA04.RES.0589.01	NCA04	1	746763	6298635	Residential		75 Sydney Road, Raglan	60	55	P	68	63	66	61	69	64	66	61	-	-	Y	Y	Y	Y	Y
NCA04.RES.0596.01	NCA04	1	746795	6298632	Residential		77 Sydney Road, Raglan	60	55	P	69	64	66	61	69	64	67	62	-	-	Y	Y	Y	Y	Y

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