RICHMOND ROAD UPGRADE

Review of Environmental Factors
Noise and Vibration Assessment

Prepared for:

Jacobs Group (Australia) Pty Ltd
177 Pacific Highway
NORTH SYDNEY
NSW 2060

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BASIS OF REPORT

This report has been prepared by SLR Consulting Australia Pty Ltd (SLR) with all reasonable skill, care and diligence, and taking account of the timescale and resources allocated to it by agreement with Jacobs Group (Australia) Pty Ltd (the Client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

This report is for the exclusive use of the Client. No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from SLR.

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DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
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1 Introduction

Transport for NSW (TfNSW) proposes to upgrade about 1.6 kilometres of Richmond Road north of Elara Boulevard in Marsden Park (the proposal). The proposal is located in the Blacktown Local Government Area (LGA).

Key features of the proposal would include:

- A dual carriageway with two lanes in each direction and a central median wide enough to accommodate six lanes in the future.
- Raising the road by about five metres as the first stage of improving the road as a flood evacuation route.
- Provision of two metre wide shoulders on both sides of the road.
- Provision of a separate left-in and left-out access roads to Marsden Park Precinct (MPP) to the west.
- Provision of a new four-way signalised intersection about 800 metres north of Elara Boulevard, to provide access to Marsden Park Precinct to the west and Marsden Park North Precinct to the east (MPNP).
- Provision of bus bays and bus priority measures at the new four-way signalised intersection.
- Provision of a three metre wide shared user path on the western side of the road.
- Relocation and/or adjustments of public utilities and street lighting.
- Road drainage infrastructure including a new culvert
- Ancillary work including safety barriers, signage, line marking and environmental protection work.
- Landscaping and rehabilitation work.
- Offsite compensatory flood storage area.
- Temporary ancillary facilities include site compounds and stockpile sites.

The location of the proposal is shown in **Figure 1** and an overview of the proposal is provided in **Figure 2**. **Chapter 3** of the REF describes the proposal in more detail.

The construction of the proposal is expected to start in mid-2021 and expected to take about 18 months to complete.

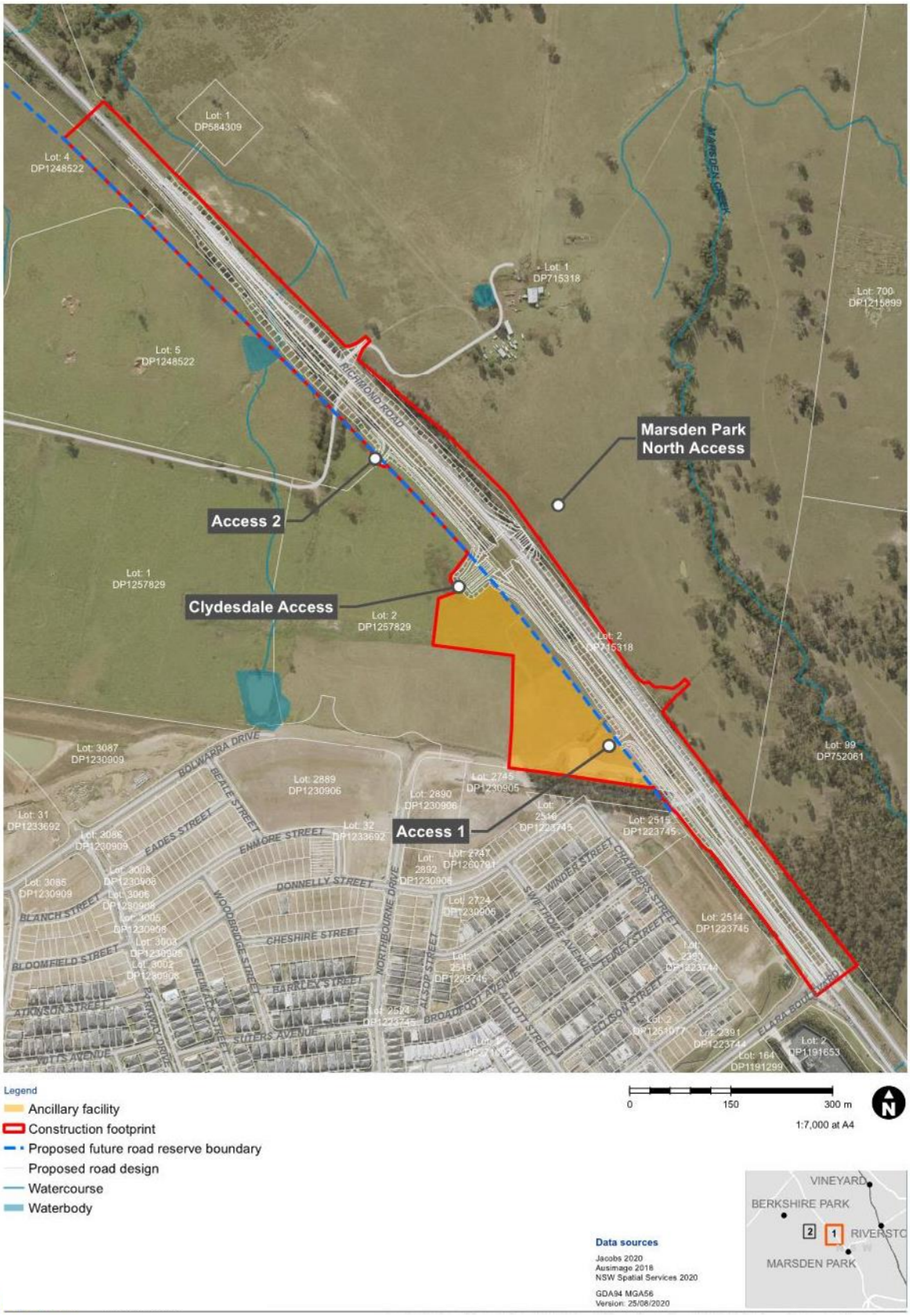
1.1 Terminology

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).

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

Figure 1 Location of the Proposal

Figure 2 The Proposal



2 Existing Environment

The proposal is located in Marsden Park. Existing noise levels in the study area are generally influenced by road traffic noise from Richmond Road. The area surrounding the proposal is progressively being developed. The Marsden Park Precinct to the south of Richmond Road is partially constructed, with houses along Elara Boulevard mostly complete and areas to the north, south and west currently under construction. The future Marsden Park North Precinct is to the north of Richmond Road and is currently in the planning stages.

The nearest receivers to the proposal are residential properties to the west of the Richmond Road in Marsden Park. More distant receivers are also to in the southern section of the study area near Garfield Road West and in the north near St Marys Road.

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 3** and described in **Table 1**.

Table 1 Noise Catchment Areas and Surrounding Land Uses

NCA	Minimum Distance[1]	Description
NCA01	30m	NCA01 covers Marsden Park Precinct which is to the west of Richmond Road and is mostly residential. Sections of the precinct are still under development and it has been necessary to estimate the location of future receivers which may be affected by the proposal using the masterplan of the precinct. NCA01 includes the new Marsden Park Public School to west of Richmond Road. The potential construction impacts from the proposal have been assessed to receivers in Marsden Park Precinct to the south of Beale Street. It is assumed that areas to the north of the this are unlikely to be constructed and habited prior to construction of the proposal. Operational impacts have been assessed to all future receivers in the precinct as mapped by the approved subdivision.
NCA02	150m	NCA02 covers the future Marsden Park North Precinct to the east of Richmond Road. No details of the future receivers are currently available for this precinct. The existing receivers are mostly sparsely distributed residential properties to the east of Richmond Road and to the south of Garfield Road West. This catchment also includes Marsden Park Public School which is also to the south of Garfield Road West.
NCA03	550m	NCA03 is to the north of the study area and consists of sparsely distributed residential receivers on either side of Richmond Road near St Marys Road.

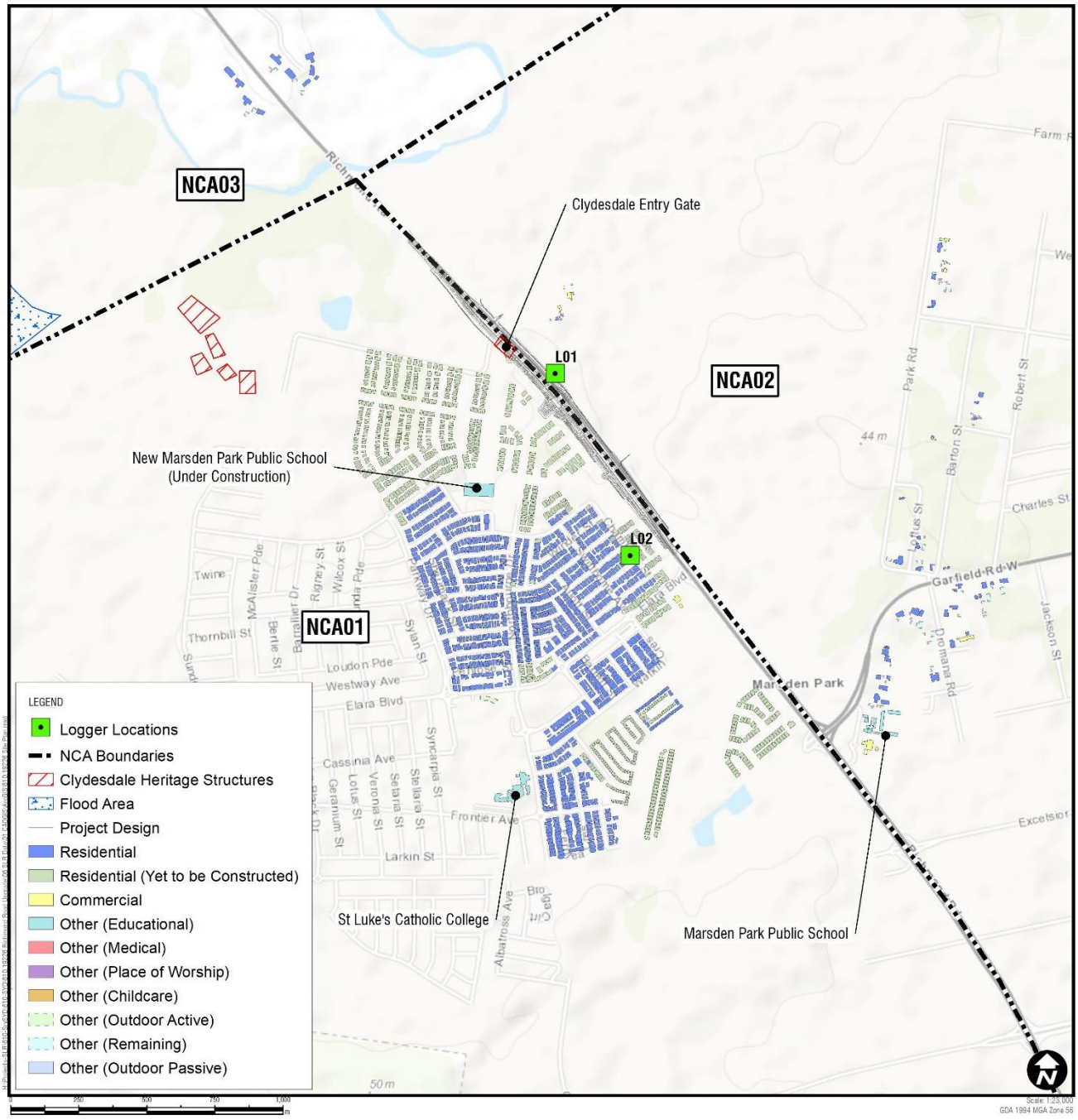
Note 1: Approximate minimum horizontal distance from the proposal to the nearest receiver building in each NCA.

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 educational facilities, and various outdoor recreation areas. Receiver types and locations are shown in **Figure 3**.

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

Figure 3 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	New Marsden Park Public School [1]	Enmore Street, Marsden Park	Education
	St Lukes Catholic College	Northbourne Drive &, Frontier Avenue, Marsden Park	Education
NCA02	Marsden Park Public School	363 Garfield Road West, Marsden Park	Education

Note 1: Marsden Park Public School is currently under construction, with completion expected late 2021.

2.2 Existing Noise Surveys and Monitoring Locations

Unattended noise monitoring was completed in the study area during April 2020. 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 Richmond Airport), to establish representative existing noise levels for each NCA.

The noise monitoring locations are shown in **Figure 3** 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)[3]			Average Noise (L_{Aeq})			Average Noise (L_{Aeq})	
		Day	Evening	Night	Day	Evening	Night	Day	Night
L01	1270 Richmond Road	53	44	34	67	63	62	66	64
L02[4]	35 Ellison Street	47	46	42	56	53	54	56	54

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: It is noted that the noise monitoring survey was completed during the COVID-19 Pandemic and partially during school holidays. Traffic volumes in the study area during the survey are expected to be lower than normal. As background noise levels are generally controlled by traffic on the surrounding road network it is likely that the measured RBLs are also lower than would normally be measured in the study area, which would potentially result in a conservative assessment of the construction impacts from the project (ie the actual impacts would likely be lower than predicted in this report).

Note 4: The wind station was 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
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	L02	57	52	51	47	57
NCA02	L01	63	58	49	39	49
NCA03						

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, 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.

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 8**.

Table 8 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**). 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), as shown in **Table 9**. While the construction activities for the proposal are generally not expected to result in continuous or impulsive vibration impacts, criteria are provided in **Table 10**.
- Those where building contents may be affected (**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 or medical imaging equipment, are in buildings near to construction works. No such equipment has been identified in the study area.
- Those where the integrity of the building may be compromised (**structural/cosmetic damage**). If vibration from construction works is sufficiently high it can cause cosmetic damage to elements of affected buildings. Industry standard cosmetic damage vibration limits are specified in British Standard BS 7385 and German Standard DIN 4150. The limits are shown in **Table 11** and **Table 12**.

Table 9 Human Comfort Vibration – 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.

Table 10 Human Comfort Vibration – 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]	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]	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: Such as operating theatres or precision laboratories where sensitive operations are occurring. No such areas have been identified in the study area.

Table 11 Cosmetic Damage – 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%.

Table 12 Cosmetic Damage – 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 12** can be applied.

The only heritage building or structure identified in the study area is Clydesdale Grand House, Barn, Cottage and entry gate at 1270 Richmond Road, Marsden Park. The buildings are, however, over 800 m to the west of the proposal, as shown in **Figure 3**, and is not expected to be impacted by the proposal. The entry gate is approved to be relocated and it is assumed that it will not be in place during construction of the project.

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 13**. 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 13 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 14**. The guidelines aim to protect the community and environment from excessive noise and vibration impacts from the long-term operation of projects.

Table 14 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 are 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' Richmond Road. 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 15**.

Table 15 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 2026 and the future design year is 2036.

'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 16**. The NCG does not consider commercial and industrial receivers as being sensitive to operational airborne road traffic noise impacts.

Table 16 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.

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 15**) 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.

It is noted that sections of Marsden Park Precinct are still under development. The potential construction impacts from the proposal have been assessed to all receivers in the Marsden Park Precinct to the south of Beale Street. It is assumed that areas to the north are unlikely to be constructed and habited prior to construction of the proposal. Parts of Marsden Park Precinct to the south of Beale Street are currently under construction and it has been necessary to estimate the location and size of certain future receivers in this area. Additionally, as the proposal intends to have a construction compound to the north of Beale Street (see **Figure 4**), buildings in this area have not been included in the construction noise assessment.

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 17** together with a high-level description of each works activity. The locations of the various work scenarios are shown in **Figure 4**.

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 17 Construction Scenario Descriptions

ID	Scenario[1,2]	Description
W.01	Early Works and Utilities - Noise Intensive Works	Early works would include: - Utility investigations typically using a vac-truck in order to expose, positively identify and survey the existing utilities. - Additional topographic, utility and feature survey works. Several utilities are also present along the alignment which require re-location including removal of the redundant utility asset and installation of new underground utilities, comprising pit and pipe systems and associated cabling. Noise intensive equipment such as concrete saws and rock-breakers would be required at times during the works to remove existing pavement, stormwater pipes and concrete structures. Certain utility works along the alignment would require temporary lane closures particularly where they cross the existing road pavement and may be required to be 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 Noise Intensive	
W.04	Early Works and Utilities – OOHWs Typical Works	
W.05	Compounds - Establishment	Site compound construction including clearing & grubbing, top soil stripping, hardstand construction, utilities services, buildings, material storage areas and other compound facilities. A temporary access road may also be necessary for the compound. Temporary security fencing would be installed around the site compound and any other area where public access must be restricted such as storage facilities and water containment areas/basins. Temporary pedestrian fencing may be required at the southern end of the project where an existing shared user path has been previously constructed. Installation of erosion and sedimentation controls throughout the stage 1 works areas including sediment fencing, basins and other dirty water controls. Installation of temporary traffic control barriers along the full length of the existing roadway (western side) in order to separate the construction site from the travelling public. This would also include temporary signage, lighting and other traffic control devices. These barriers may need to installed at night using trucks and franna cranes.
W.06	Vegetation Clearing	Vegetation that would be affected by construction of the proposal would be required to be removed. Clearing is expected to cover the majority of the site. Trees and other large vegetation would be removed using chainsaws and mulched on-site using a wood chipper/ tub grinder. Surplus mulch would be removed from site.

ID	Scenario[1,2]	Description
W.07	Road Works - Northbound	Road works would be required along the entire road alignment. The works would be split into constructing the northbound lanes first and then constructing the southbound lanes. Road construction would include: • Removal/demolition of existing pavements • Removal of unsuitable materials • Embankment foundation treatments • Construction of the new embankment • Excavation of cuttings • Construction of the larger transverse drainage structurers (box culverts) • Installation of drainage pit and pipe systems • Construction of the open drainage channels and permanent controls • Utility works typically including communications, power, gas, water and sewer (where necessary) along with ITS and TCS networks • Construction of the pavement layers including the subbase and the asphalt • Major and minor sign structurers, including piling, concrete works and installation of overhead steel structures • Tie-ins to existing the pavement at the southern and northern limits Vibratory and static rollers would be required during the earthworks to achieve the required strength and support the pavement which would also require compaction equipment for placement of the asphalt courses. Numerous construction activities have the potential to need temporary lane closures. Temporary lane closures and would be required to occur outside Standard Construction Hours to minimise potential traffic disruption.
W.08	Road Works - Southbound	
W.09	Road Works - Pavement Works	
W.11	Finishing Works	After the main construction works are complete, finishing works would be required which would include: • Installation of road furniture (ie lighting, safety barriers, guide posts, etc) • Installation of traffic control signals • Pavement marking • Installation of urban design treatments and features • Landscaping works • Removal of all remaining temporary works such as traffic control barriers, lighting, etc Finishing works generally have no requirement for noise intensive equipment.
W.12	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.
W.13	Flood Storage Area – Earthworks[3]	Earthworks are required to construct a flood storage area to the west of the project site. The works would only occur during Standard Construction Hours. The impacts from these works have been assessed separately in **Section 5.6**.

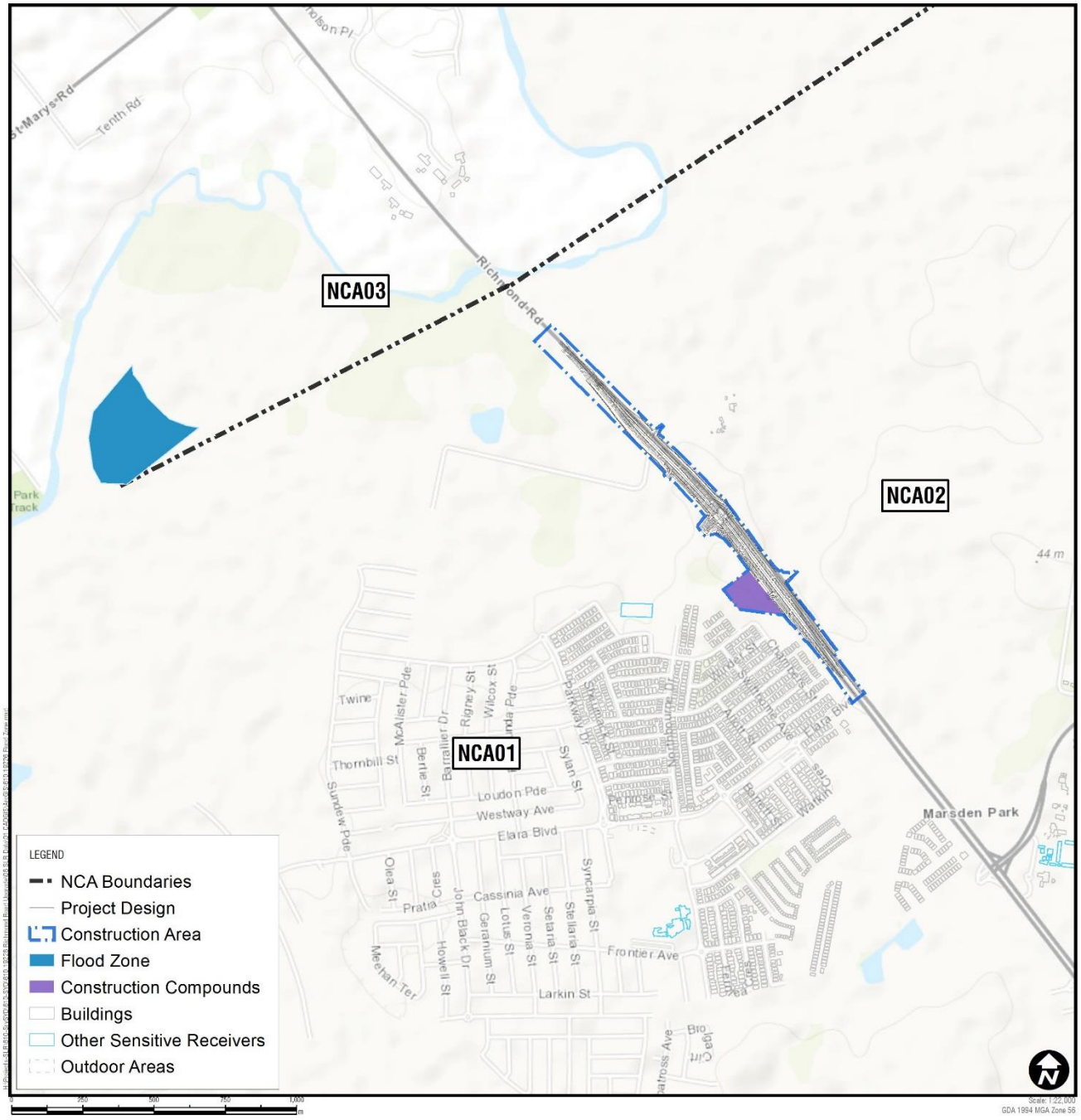
Note 1: Equipment lists for each scenario and Sound Power Level data are provided in **Appendix C**.

Note 2: OOHWs = Out of Hours Works.

Note 3: The flood storage area is away from the main construction works and background noise levels are likely to be lower in this area. A daytime NML of 50 dB has been applied to nearby receivers based on the TfNSW Construction Noise Estimator.

The assessment in **Section 5** presents a summary of the predicted impacts from the above construction scenarios. To gain an understanding of the potential impacts from the project, detailed results are also provided for the scenarios with the predicted worst-case impacts (ie the highest predicted NML exceedances and the greatest number of receivers affected)

Figure 4 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 17**. The expected durations of each scenario are also provided.

Table 18 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	4	✓	-	-	-
W.02	Early Works and Utilities – Typical Works		✓	-	-	-
W.03	Early Works and Utilities – OOHWs Noise Intensive Works		-	✓	✓	✓
W.04	Early Works and Utilities – OOHWs Typical Works		-	✓	✓	✓
W.05	Compounds – Site Establishment	8	✓	-	-	✓
W.06	Vegetation Clearing	4	✓	-	-	-
W.07	Road Works – Northbound	26	✓	-	-	-
W.08	Road Works – Southbound	26	✓	-	-	-
W.09	Road Works – Pavement Works – Noise Intensive Works	12	✓	✓	✓	✓
W.10	Road Works – Pavement Works – Typical Works		✓	✓	✓	✓
W.11	Finishing Works	8	✓	✓	✓	✓
W.12	Compound – Operation[2]	18 months	✓	✓	✓	✓
W.13	Flood Storage Area – Earthworks	4-6 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 13**. 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 4** 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 of Richmond Road to the west. This would move traffic on Richmond Road closer to receivers to the west.
- Introduction of a signalised intersection at the intersection of Richmond Road and the future Clydesdale and Marsden Park North Precinct access roads, 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.

It is noted that sections of Marsden Park Precinct are still under development and it has been necessary to estimate the location and size of certain future receivers in the precinct. No details are available for receivers in the Marsden Park North Precinct and the potential operational road traffic noise impacts have been assessed in this area using noise contours.

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 19**.

Table 19 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 – 4.3m[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 2026 and in the 'future design' year in 2036.

Input Parameter	Source of Data
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 2026 and 2036 assessment years were provided by the project team and are shown in **Appendix D**.
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 Richmond Road are 80 km/h.
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 a combination of Dense Grade Asphalt (DGA) where Richmond Road has previously been upgraded, and Chip Seal to the north. The future surface is DGA. DGA has a 0 dB surface correction factor and Chip Seal has a correction of +2.5 dB for cars and 0 dB for trucks[2].
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, with a ground absorption factor of 50% for the Marsden Park Estate as detailed in the Roads and Maritime *Model Validation Guideline* for residential areas.
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 • L_{Aeq}(15hour) to L_{Aeq}(1hour) +1.3 dB[3] • L_{Aeq}(9hour) to L_{Aeq}(1hour) +4.0 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 2020 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 3** and a summary of the model validation is provided in **Table 20**. Only noise monitoring locations which were used for model validation purposes are shown.

Table 20 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]
L01 – 1270 Richmond Road	65.8	67.7	1.9	63.8	64.3	0.5
L02 – 35 Ellison Street	56.1	57.7	1.6	54.3	53.9	-0.4

Note 1: Validation of the noise model was completed using data from 14 to 20 April 2020. 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 within the accepted tolerances at the validation sites 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 21** which are taken from the CNVG.

Table 21 NML Exceedance Bands and Corresponding Subjective Response to Impacts

CNVG Perception Categories	Daytime Standard Construction Hours		Out of Hours Periods	
	Symbol	NML Exceedance	Symbol	NML Exceedance
Noticeable	·	-[1]	♦	1 to 5 dB
Clearly Audible	●	1 to 10 dB	●	6 to 15 dB
Moderately Intrusive	◆	11 dB to 20 dB	◆	16 dB to 25 dB
Highly Intrusive	■	>20 dB	■	>25 dB

Note 1: Applicable for construction noise levels of 5-10 dB above RBL (see **Table 31**).

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 22**. 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 22 Predicted Worst-case Construction Noise Exceedances – Residential Receivers

Period	ID	Scenario	NCA01	NCA02	NCA03
Daytime	W.01	Early Works and Utilities – Noise Intensive Works	◆	●	.
	W.02	Early Works and Utilities – Typical Works	●	.	.
	W.05	Compounds – Site Establishment	◆	.	.
	W.06	Vegetation Clearing	◆	●	.
	W.07	Road Works – Northbound	◆	●	.
	W.08	Road Works – Southbound	◆	●	.
	W.09	Road Works – Pavement Works – Noise Intensive Works	◆	.	.
	W.10	Road Works – Pavement Works – Typical Works	●	.	.
	W.11	Finishing Works	◆	.	.
	W.12	Compound – Operation	.	.	.
Evening	W.03	Early Works and Utilities – OOHWs Noise Intensive	◆	●	.
	W.04	Early Works and Utilities – OOHWs Typical Works	●	.	.
	W.09	Road Works – Pavement Works – Noise Intensive Works	◆	●	.
	W.10	Road Works – Pavement Works – Typical Works	◆	♦	.
	W.11	Finishing Works	◆	♦	.
	W.12	Compound – Operation	♦	.	.
Night	W.03	Early Works and Utilities – OOHWs Noise Intensive	■	◆	●
	W.04	Early Works and Utilities – OOHWs Typical Works	◆	●	.
	W.05	Compounds – Site Establishment	■	◆	●
	W.09	Road Works – Pavement Works – Noise Intensive Works	■	◆	●
	W.10	Road Works – Pavement Works – Typical Works	■	●	♦
	W.11	Finishing Works	■	●	♦
	W.12	Compound – Operation	●	.	.
Key to Impacts (see Table 21)		♦ Noticeable	● Clearly Audible	◆ Moderately Intrusive	■ Highly Intrusive

The above assessment for residential receivers shows that:

- The worst-case noise levels and impacts are generally limited to NCA01 which is due to residential receivers to the west of Richmond Road being relatively close to the works. Receivers in the other catchments are generally much further from the proposal and the worst-case impacts are correspondingly lower.
- 'Moderately Intrusive' worst-case daytime impacts are seen in NCA01 during most scenarios when works are required to be completed near to these receivers. The worst-case daytime impacts in NCA02 are predicted to be 'Clearly Audible' during the noisier scenarios and compliant with the management levels during less noise generating activities. No exceedances are expected in NCA03.

- 'Highly Intrusive' worst-case impacts are predicted when noisy works are required to be completed during the night-time near to receivers in NCA01, including during:
  - *W.03 – Early Works and Utilities – OOHWs Noise Intensive Works*
  - *W.05 – Compounds – Site Establishment*
  - *W09 – Road Works – Pavement Works – Noise Intensive Works*
  - *W10 – Road Works – Pavement Works – Typical Works*
  - *W.11 – Finishing Works*.

  Night-time noise levels are predicted to be up to 73 dB in NCA01 (see **Appendix C**) when noise intensive equipment, such as a concrete saw or rockbreaker, is being used as part of *'W.03 – Early Works and Utilities – OOHWs Noise Intensive Works'*. When noise intensive equipment is not being used as part of these works the noise levels are expected to be substantially reduced with worst-case levels of 63 dBA predicted during *'W.04 – Early Works and Utilities – OOHWs Typical Works*.
- The worst-case night-time impacts in NCA02 are predicted to be 'Moderately Intrusive' during noisy works and 'Clearly Audible' or compliant with the management levels during less noise generating activities. Worst-case impacts in NCA03 are expected to be 'Clearly Audible' or 'Noticeable'.
- It is noted that for most scenarios, the noisiest works would 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 than the worst-case levels predicted.
- The worst-case predicted noise levels in NCA01 are 76 dBA (see **Appendix C**) meaning residential receivers with line of sight to the construction works are likely to be Highly Noise Affected when noisy works are being completed nearby. This is, however, only predicted to occur during the daytime.
- 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 for the scenarios with the predicted worst-case impacts (ie the highest predicted NML exceedances and the greatest number of receivers affected)

5.2.1 Daytime Scenarios

The worst-case daytime construction impacts are predicted during *Early Works and Utilities* and *Compounds and Site Establishment* 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 5** – *W.01 – Early Works and Utilities – Noise Intensive Works*, when equipment such as concrete saws or rockbreakers are being used.
- **Figure 6** – *W.06 – Compounds and Site Establishment*, when equipment such as chainsaws and chippers are being used

- **Figure 7** – *W.07 – Road Works – Northbound*, which do not require noise intensive equipment but are required to be completed relatively close to the adjacent receivers in NCA01.

Early Works and Utilities are anticipated to last around four weeks, with *Compounds and Site Establishment* anticipated to last around eight weeks. *Road Works – Northbound* are anticipated to last around 26 weeks.

Figure 5 Predicted Impacts '*W.01 – Early Works and Utilities – Noise Intensive Works*' (Daytime)

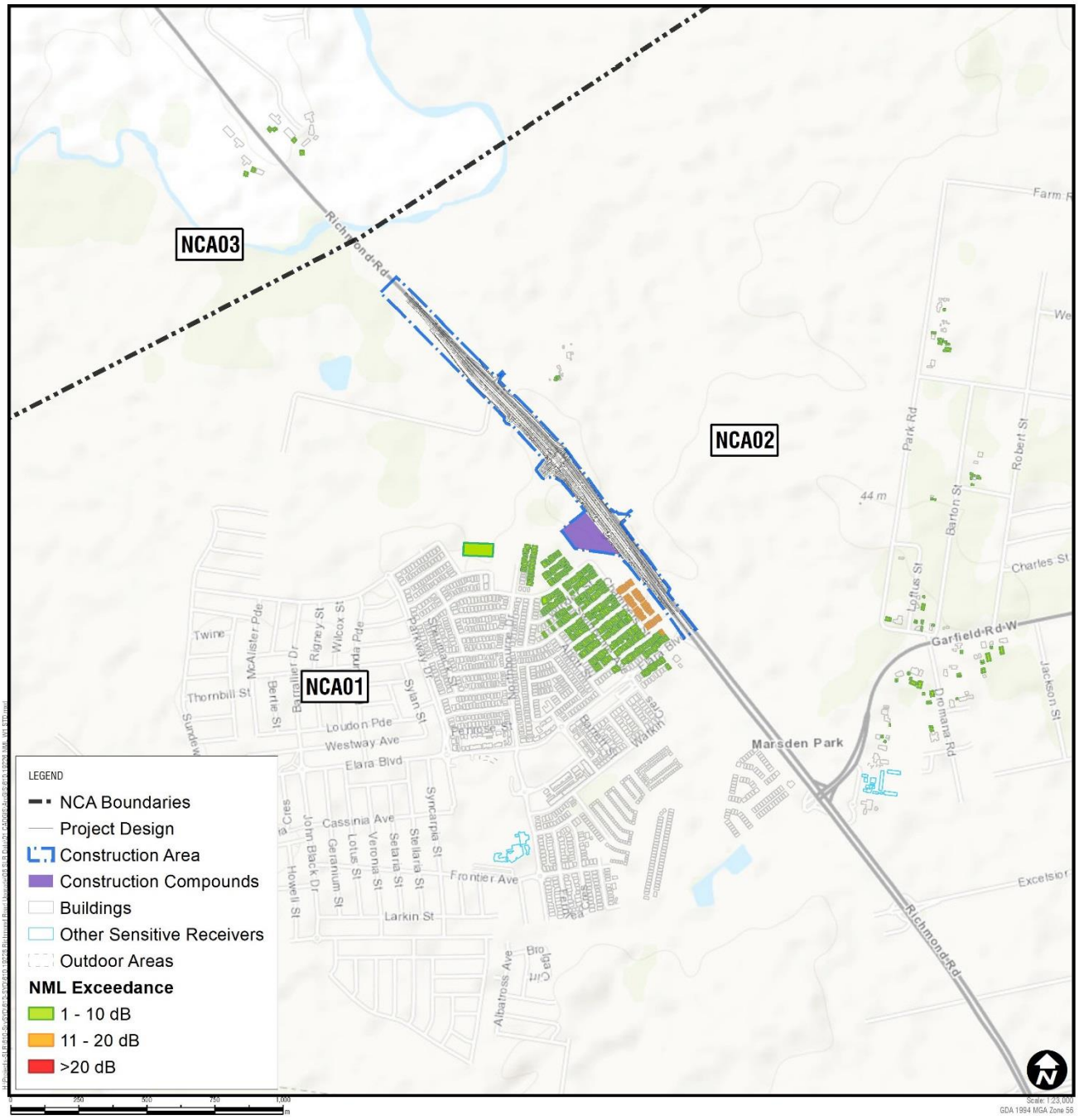


Figure 6 Predicted Impacts '*W.06 – Compounds and Site Establishment*' (Daytime)

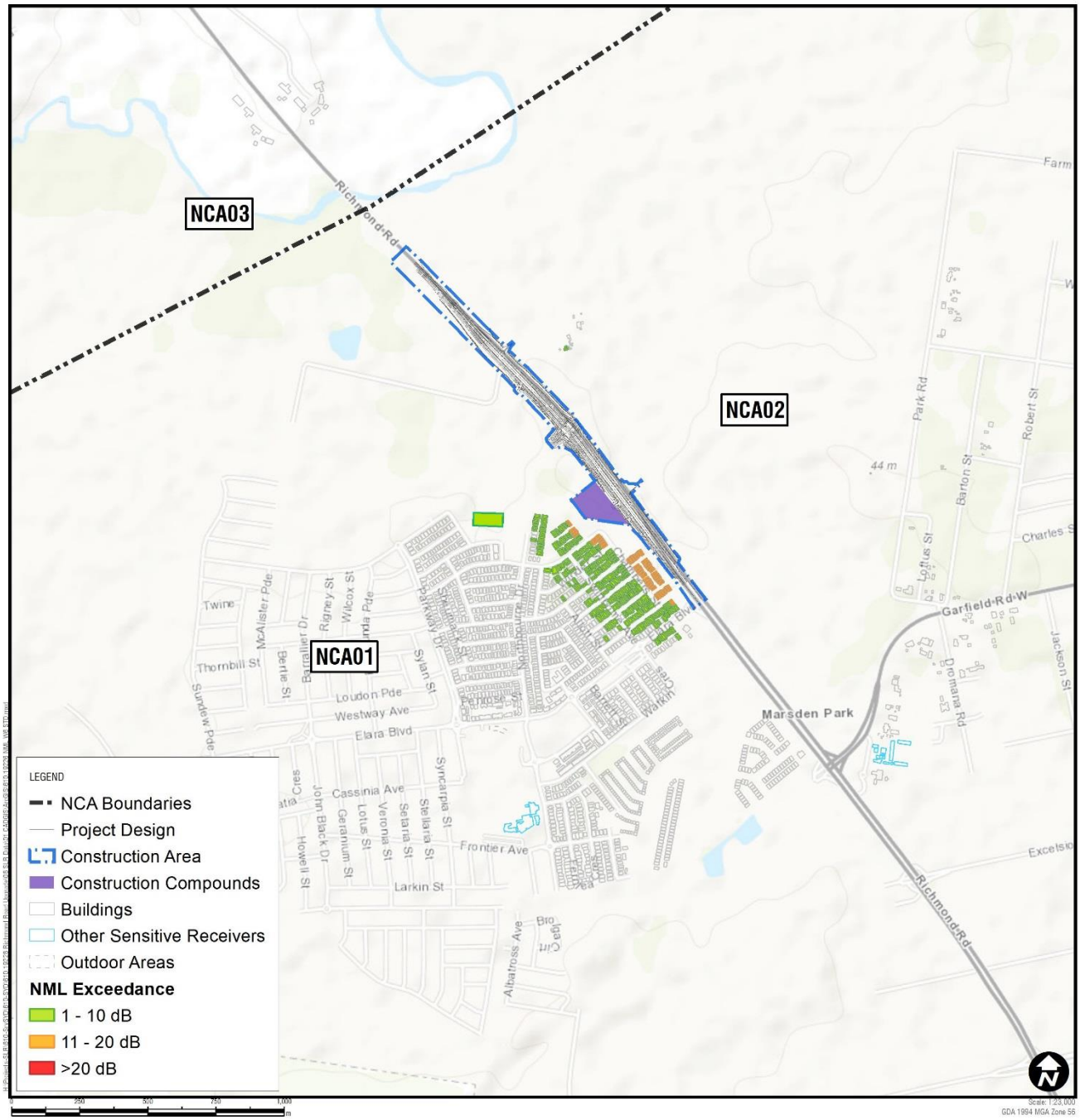
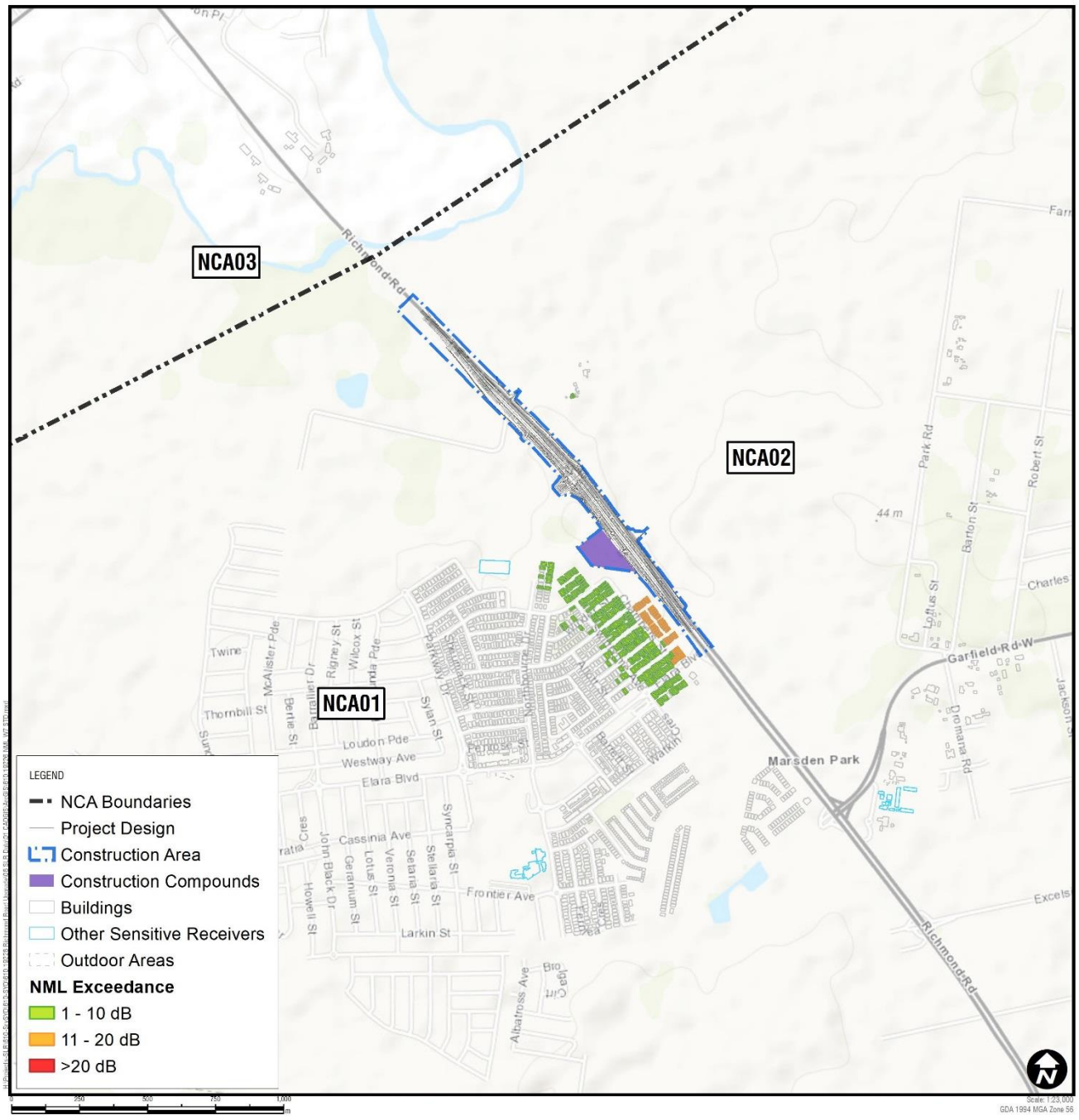


Figure 7 Predicted Impacts '*W.07 – Road Works – Northbound*' (Daytime)



The above figures show that receivers near to the works are predicted to have 'Moderately Intrusive' worst-case daytime impacts when noisy works are being completed nearby. The impacts are limited to the west of Richmond Road in NCA01. Receivers in the other catchments are further away and the daytime impacts are generally expected to be compliant with the noise management levels.

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 construction scenarios required to be completed during the night-time shown in:

- **Figure 8** – *W.03 – Early Works and Utilities – OOHWs Noise Intensive Works*
- **Figure 9** – *W.04 – Early Works and Utilities – OOHWs Typical Works*
- **Figure 10** – *W.10 – Road Works – Pavement Works – Typical Works*
- **Figure 11** – *W.12 – 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. Noise intensive equipment such as rockbreakers or concrete saws would be required at times during out of hours works. Noise levels during typical activities completed as part of *Enabling Works and Utilities* that do not require noise intensive equipment are shown **Figure 9** as a comparison.

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 8 Predicted Impacts '*W.03 – Early Works and Utilities – OOHWs Noise Intensive Works*' (Night-time)

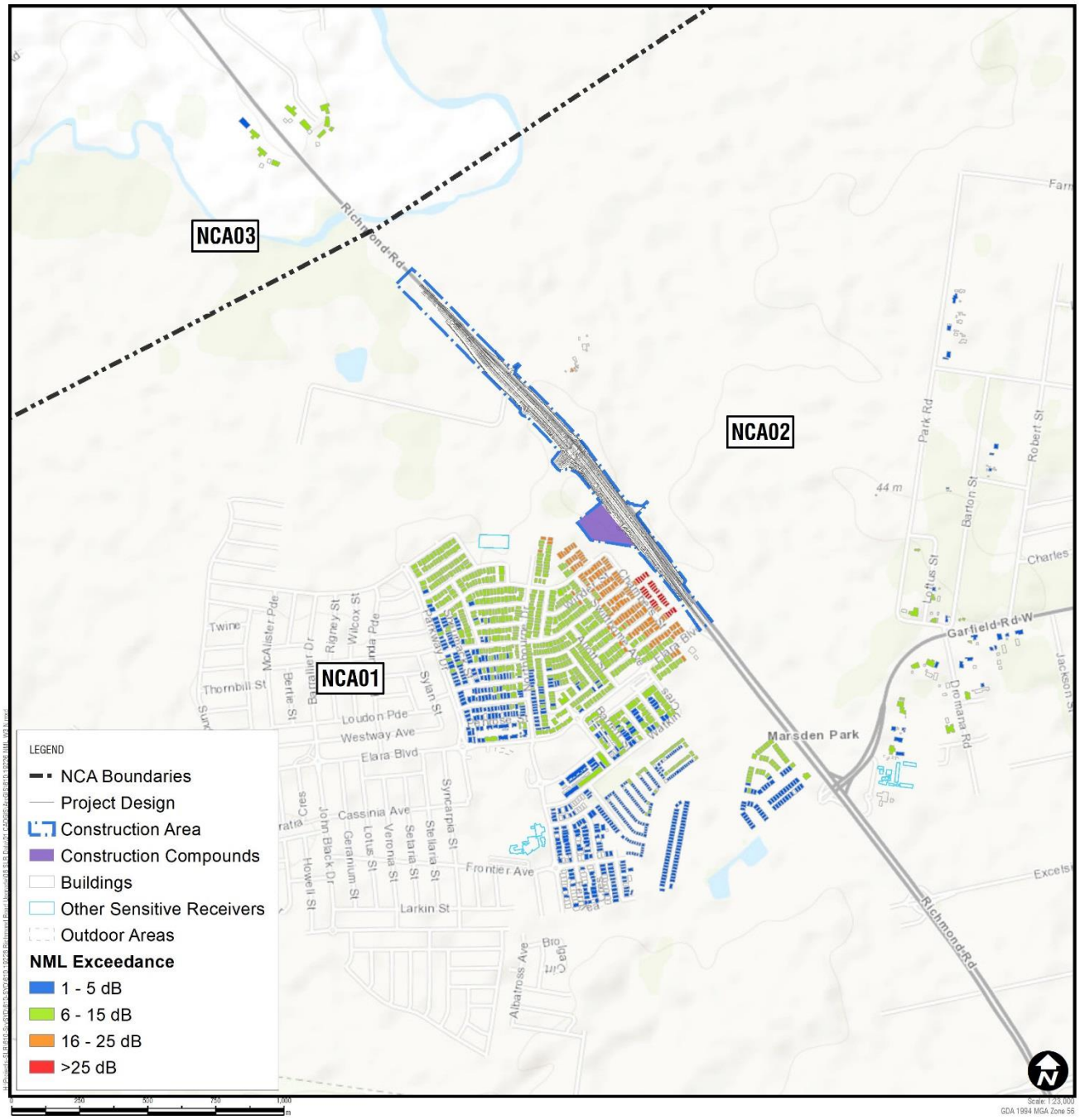


Figure 9 Predicted Impacts '*W.04 – Early Works and Utilities – OOHWs Typical Works*' (Night-time)

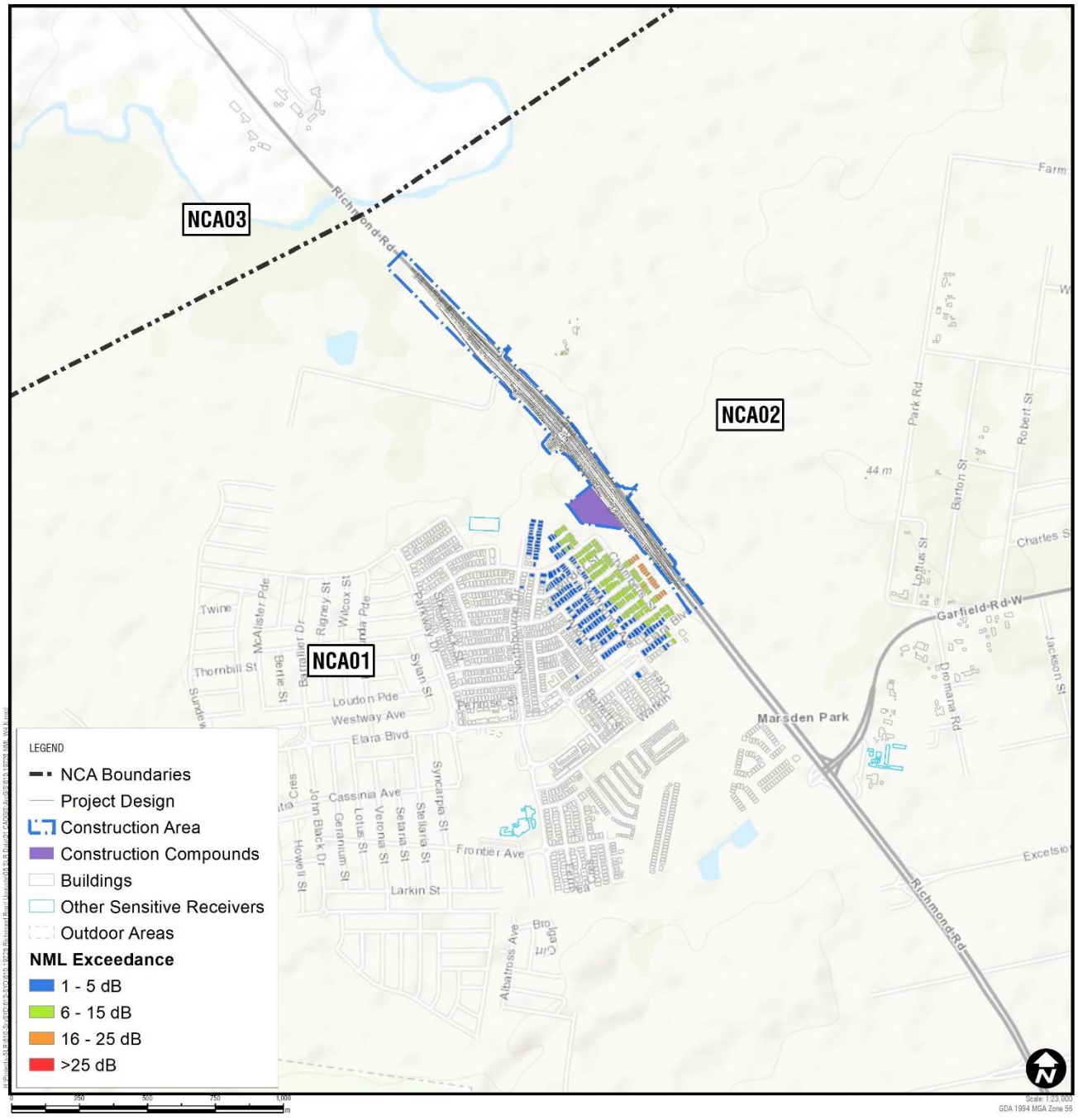


Figure 10 Predicted Impacts '*W.10 – Road Works – Pavement Works*' (Night-time)

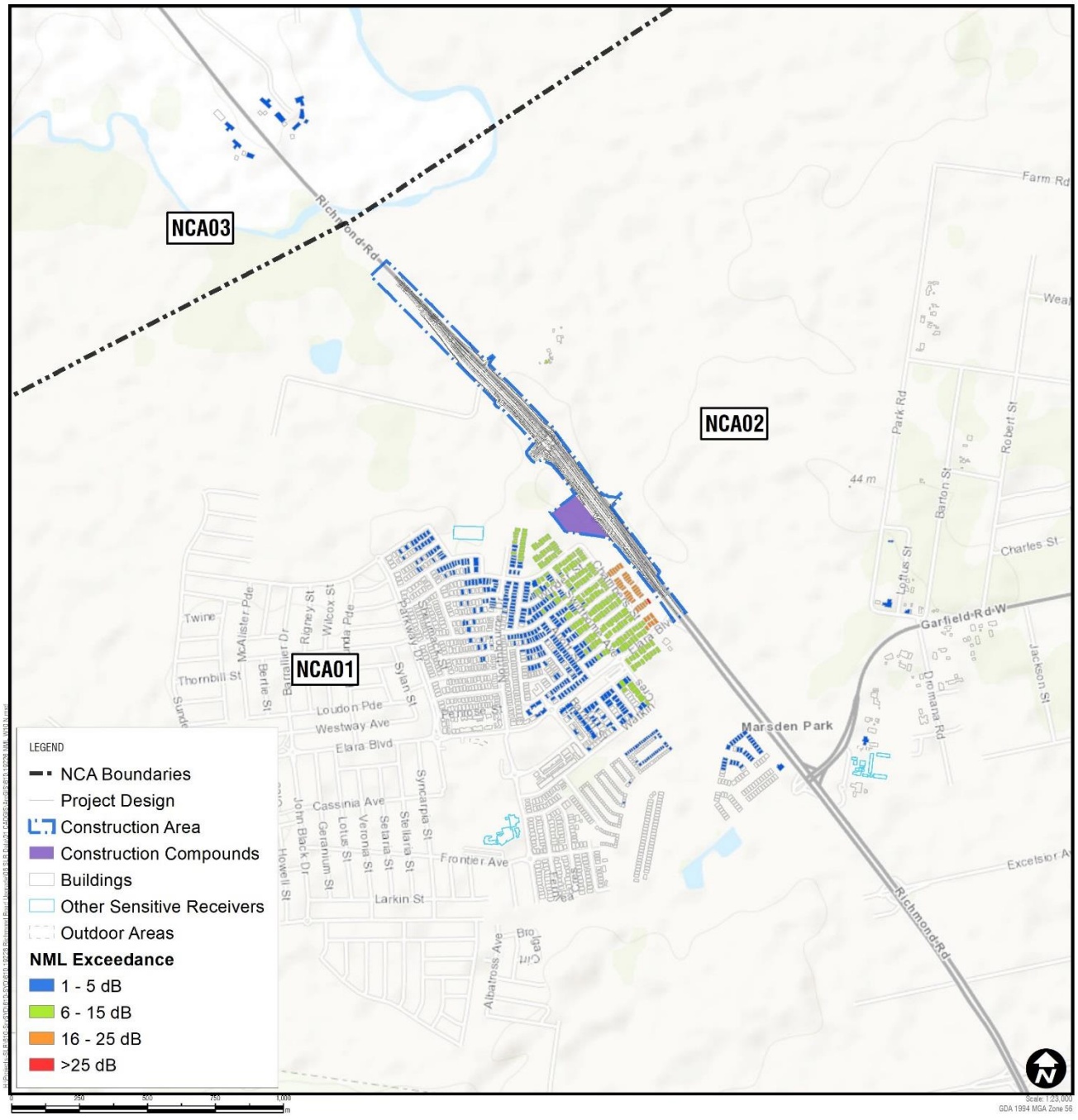
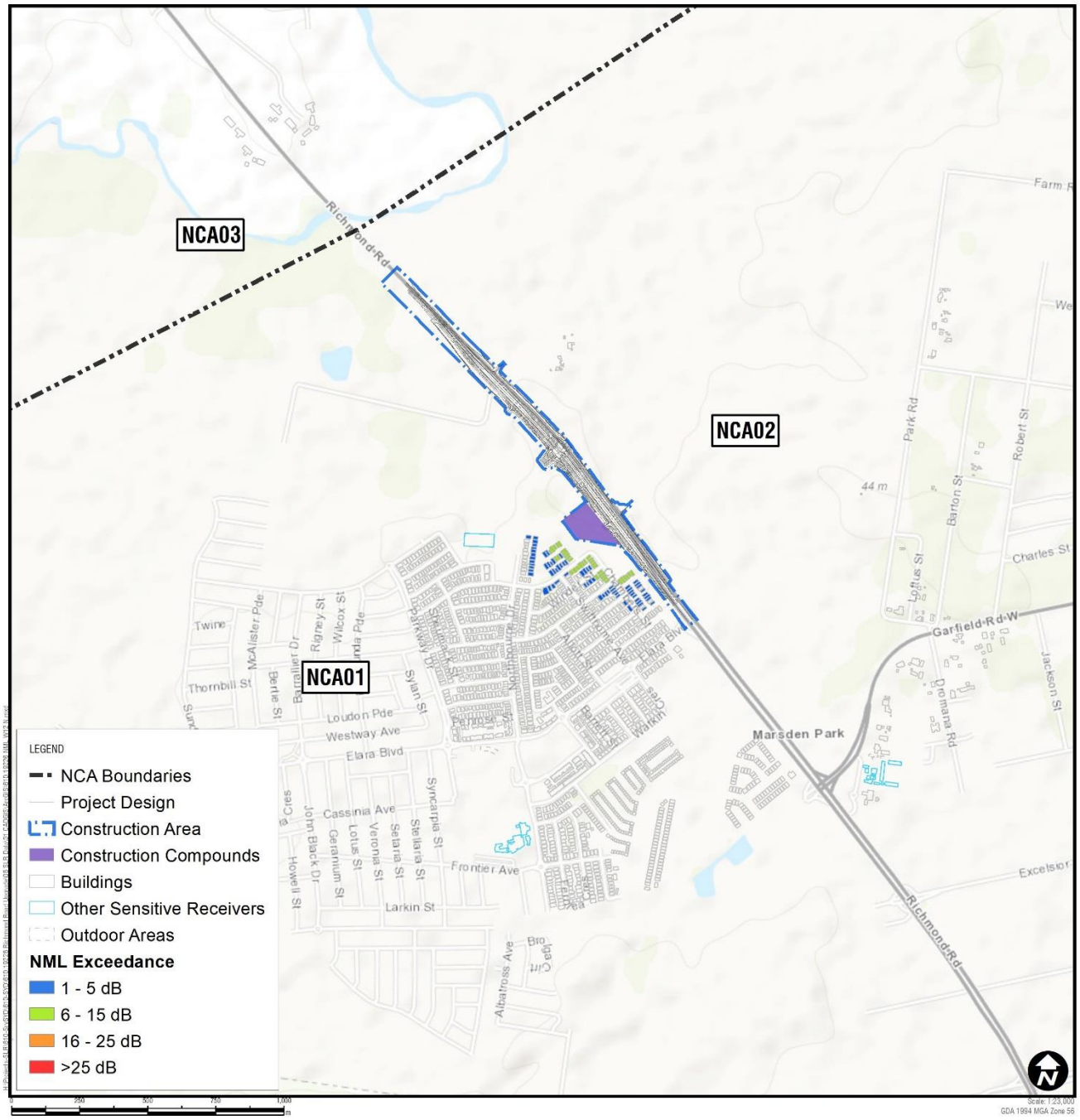


Figure 11 Predicted Impacts '*W.12 – Compound – Operation*' (Night-time)



The above figures show that the impacts during night-time works are more widespread, which is due to lower NMLs during this period. A small group of receivers immediately adjacent to Richmond Road in NCA01 are predicted to have 'Highly Intrusive' worst-case night-time impacts when noisy equipment is being used nearby, with more distant receivers generally having 'Moderately Intrusive' or 'Clearly Audible' worst-case impacts.

Receivers towards the rear of the catchment are predicted to be compliant with the night-time management levels during all works.

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 23**.

Table 23 Overview of Commercial/Industrial and 'Other Sensitive' Receiver NML Exceedances

ID	Scenario	Number of Receiver Buildings Affected								
		Educational[1]			Outdoor Areas[2]			Commercial /Industrial		
		Daytime			Daytime			Daytime		
		1 10 dB	11 20 dB	>20 dB	>20 dB	11 20 dB	>20 dB	1 10 dB	11 20 dB	>20 dB
W.01	Early Works and Utilities - Noise Intensive Works	1	-	-	-	-	-	-	-	-
W.02	Early Works and Utilities - Typical Works	-	-	-	-	-	-	-	-	-
W.03	Early Works and Utilities – OOHWs Noise Intensive	-	-	-	-	-	-	-	-	-
W.04	Early Works and Utilities – OOHWs Typical Works	-	-	-	-	-	-	-	-	-
W.05	Compounds – Site Establishment	-	-	-	-	-	-	-	-	-
W.06	Vegetation Clearing	1	-	-	-	-	-	-	-	-
W.07	Road Works - Northbound	-	-	-	-	-	-	-	-	-
W.08	Road Works - Southbound	-	-	-	-	-	-	-	-	-
W.09	Road Works - Pavement Works - Noise Intensive	-	-	-	-	-	-	-	-	-
W.10	Road Works - Pavement Works – Typical Works	-	-	-	-	-	-	-	-	-
W.11	Finishing Works	-	-	-	-	-	-	-	-	-
W.12	Compound - Operation	-	-	-	-	-	-	-	-	-

Note 1: New Marsden Park Public School.

Note 2: Outdoor area off Elara Boulevard.

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

- Noise levels are generally expected to be compliant with the management levels.
- Minor worst-case impacts are however predicted at the new Marsden Park Public School when noise intensive works are nearby.

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 'Highly Intrusive' 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

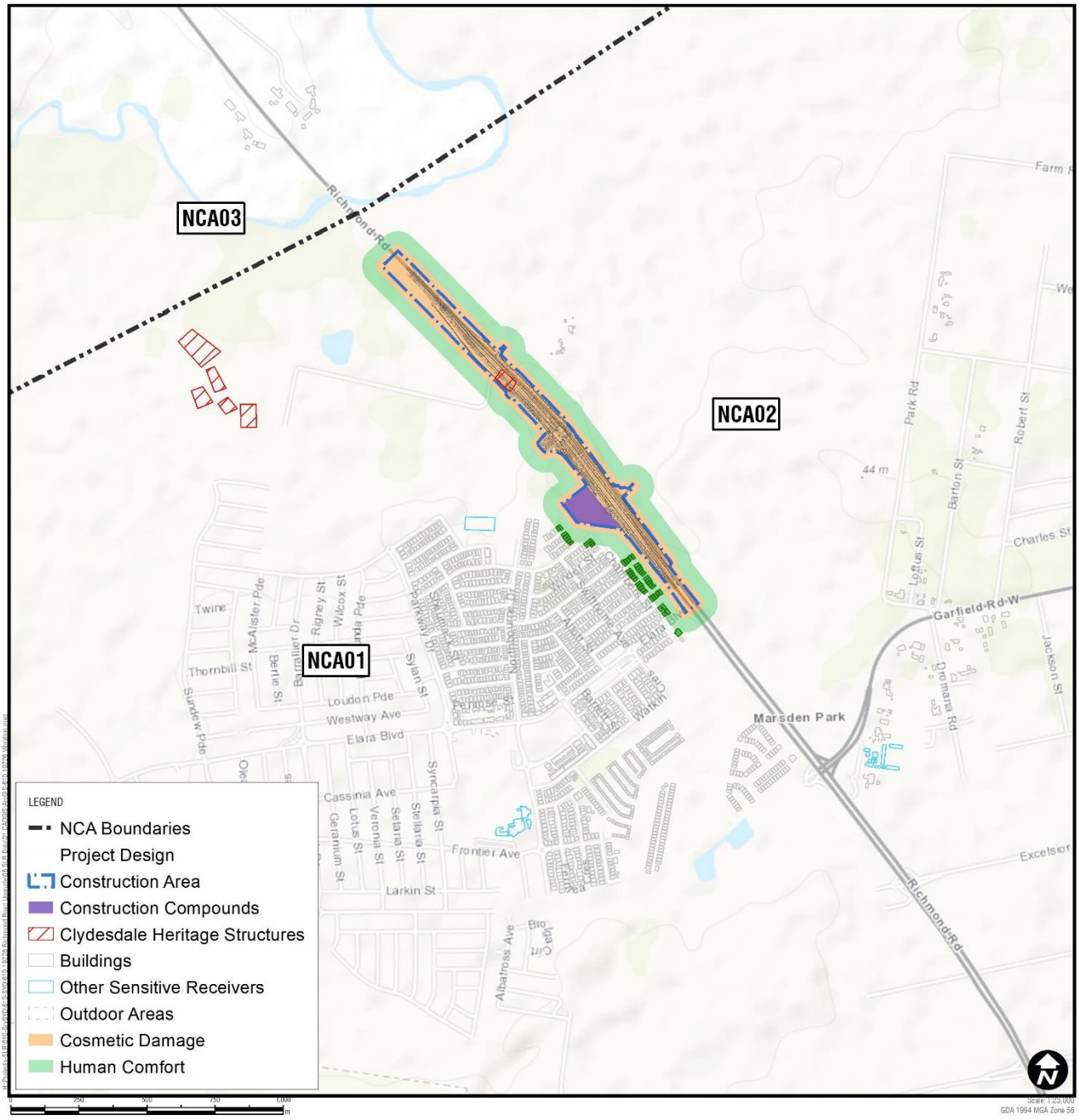
The main potential sources of vibration during construction would be from vibratory rollers and rockbreakers. The construction scenarios which require vibration intensive equipment are shown in **Table 24**.

Table 24 Requirement for Vibration Intensive Equipment

ID	Scenario	Vibration Intensive Equipment
W.01	Early Works / Utilities - Noise Intensive Works	Excavator – Breaker, Underboring Rig
W.03	Early Works / Utilities – OOHW Noise Intensive Works	Excavator – Breaker
W.07	Road Works - Northbound	Roller – Vibratory
W.08	Road Works - Southbound	Roller – Vibratory
W.09	Road Works – Pavement Works – Noise Intensive Works	Roller – Vibratory

Vibration offset distances have been determined from the CNVG minimum working distances for cosmetic damage and human response in **Table 13** and the assessment is summarised in **Figure 12**. Buildings within the minimum working distances are shown on the figure.

Figure 12 Construction Vibration – 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 buildings in the study area to be unlikely to suffer cosmetic damage from the proposed works.

Human Comfort Vibration Assessment

Certain receivers in the study area are however 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 vibration intensive equipment is nearby.

Heritage Structures

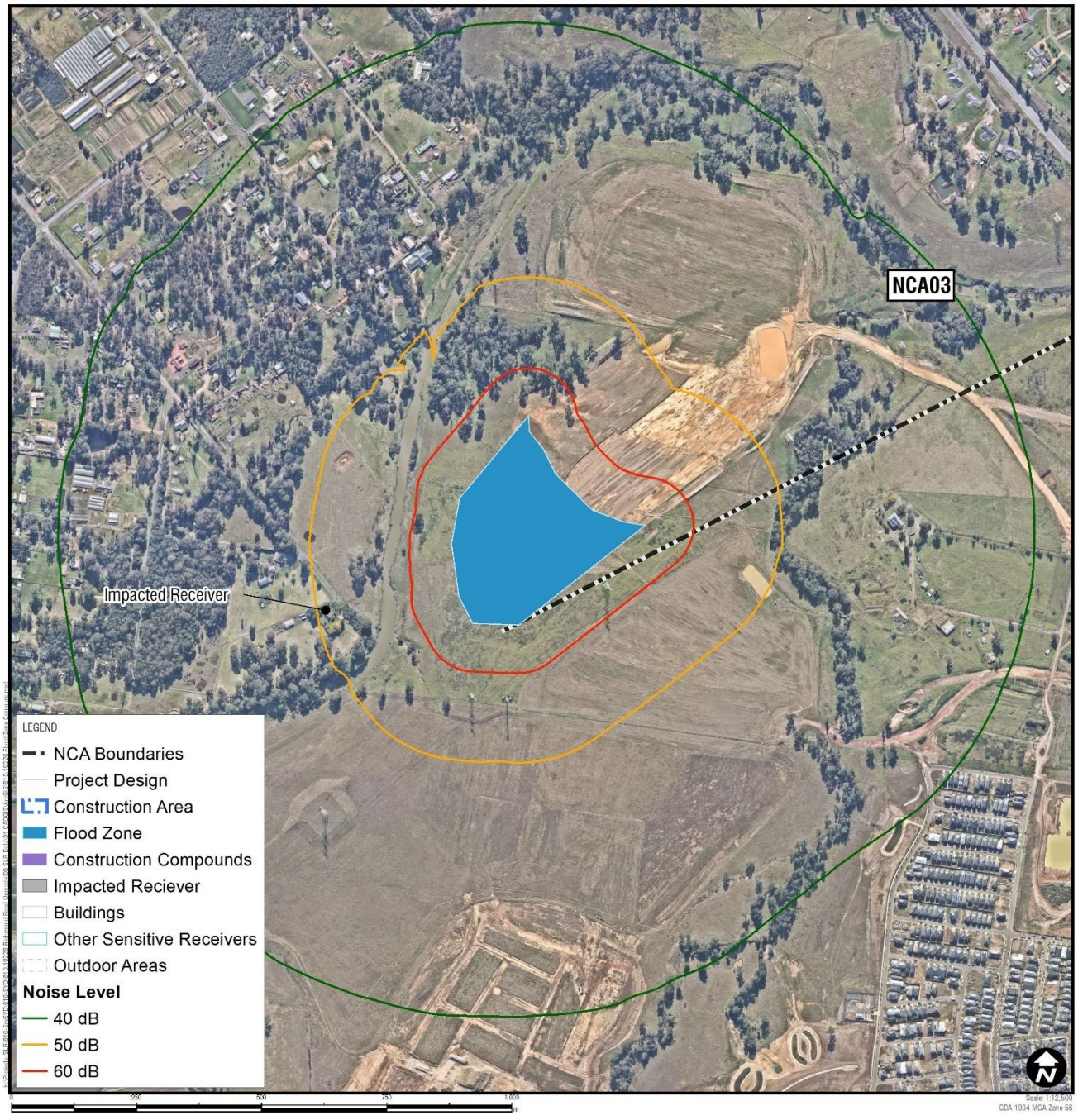
No heritage buildings or structures that have been identified in the study area as being within the cosmetic damage minimum working distances. The current location of Clydesdale entry gate is within the minimum working distances for heritage items (see **Table 13**), however it is approved to be relocated and is assumed to not be in place during construction of the project.

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

5.6 Flood Storage Area

The predicted noise impacts from earthworks required at the flood storage area are shown in **Figure 13**. Works are assumed to only occur during Standard Construction Hours.

Figure 13 Flood Storage Area – Construction Noise Impacts



The above shows that worst-case noise levels during Flood Storage Area construction works are likely to marginally exceed the 50 dBA NML (based on the TfNSW Construction Noise Estimator) at one residential receiver. Noise levels at the other surrounding receivers are expected to comply with the NML.

5.7 Cumulative Impacts

Cumulative construction noise impacts can occur where multiple works are being completed near to a particular receiver at the same time. There is potential for cumulative construction impacts from multiple sets of

Richmond Road Upgrade construction works being completed in different areas of the project site and also from works completed as part of other nearby projects, such as the adjoining Marsden Park Precinct development.

Since the construction scenarios required for various stages of Richmond Road Upgrade and the works at the adjoining development would generally require similar items of equipment, concurrent construction works being completed near to a particular area 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.

5.8 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 25**.

Table 25 Construction Traffic Routes

Construction Stage	Indicative Daily Volume	Route
Construction traffic	25 to 55 trucks 40 to 50 light vehicles	Richmond Road

Construction traffic is proposed to use Richmond Road. The relatively low numbers of construction traffic compared to the high existing volumes (ie around 20,000 vehicles daily) are not expected to result in any noticeable impacts.

Due to access to the construction compound being from Richmond Road, it is not expected that any local roads will be used as a part of the construction stage. It is noted that excavation of the flood storage area may use a haulage route though the Clydesdale development to access Richmond Road. The route would, however, not come closer than 300 metres to the nearest dwelling meaning impacts are unlikely.

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.

6.1 Residential Receivers

The predicted operational road noise levels at residential receivers are summarised in **Table 26** for the 2026 at-opening and 2036 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 2036 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 2036 night-time scenario are shown in **Figure 14** and the predicted change in noise levels (Build (with project) minus No Build (without project)) for the same scenario is in **Figure 15**.

Detailed noise predictions at triggered receivers are in **Appendix D** together with operational road traffic noise contours. As there are currently no details of the future receivers for the Marsden Park North Precinct, operational road traffic noise impacts in this area are shown using noise contours.

Table 26 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 (2026)				Future Design (2036)							
	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	70	66	70	66	70	66	70	66	38	50	44	74
NCA02	60	56	60	57	60	56	61	57	-	-	-	-
NCA03	56	52	55	51	55	52	55	51	-	-	-	-
											Total	74

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 14 Worst-case Predicted Operational Noise Levels (2036 Night-time, Build)

Figure 15 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 west of the proposal in the Marsden Park Precinct are subject to relatively high existing road traffic noise impacts which already exceed the NCG criterion in many cases. It is noted that this area is currently under development and it has been necessary to estimate the location and size of certain future residential receivers in the precinct, including some lots which are immediately adjacent the proposal.

  The predicted operational road traffic noise impacts in areas under development should be regarded as indicative as the noise levels would depend on the final size and location of the future buildings.

- The proposal would widen and realign Richmond Road to the west which increases road traffic noise levels in this direction. Noise levels are predicted to increase by more than 2.0 dB in this area. Increases are also seen to the east due to the widening works removing existing embankment which currently provide screening in this direction.

- Exceedances of the NCG cumulative limit criteria (ie 5 dB or more above the NCG controlling criterion) are predicted at residential receivers in NCA01 which are adjacent to Richmond Road.

- Front row receivers to the west 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:

  - 38 residential receivers having increases of greater than 2.0 dB
  - 50 residential receivers being above the cumulative limit criteria
  - 44 residential receivers having acute noise levels
  - In total, 74 residential receivers (all in NCA01 to the west of the proposal) are triggered for consideration of additional noise mitigation as per the NCG operational road traffic noise criteria. It is noted that some of the triggered receivers are future dwellings that are not currently constructed or approved.

6.2 'Other Sensitive' Receivers

'Other sensitive' receivers that are predicted to have exceedances of the trigger levels are shown in **Table 27** for the controlling 2036 scenario. The location of the triggered 'other sensitive' receiver is shown **Figure 16**.

Table 27 'Other Sensitive' Receivers Triggers

NCA	Receiver	Type	NMG Triggers[1]		
			Trigger 1 >2.0 dB	Trigger 2 Cumulative	Trigger 3 Acute
NCA01	New Marsden Park Public School	Educational	-	Y	-

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

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

6.3 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 28** and shown in **Figure 16**.

Table 28 Receivers Eligible for Consideration for 'Additional Noise Mitigation'

NCA	Number of Triggered Buildings (Floors)		Comments
	Residential	Other Sensitive	
NCA01	74 (74)	1 (1)	Residential receivers are triggered to the west of the proposal in this catchment due to project increasing noise levels by more than 2.0 dB, cumulative limit exceedances and acute noise levels. The triggered 'other sensitive' receiver is the new Marsden park Public School. It is noted that this area currently under development and it has been necessary to estimate the location and size of certain future residential receivers in the precinct, including some lots which are immediately adjacent the proposal.
NCA02	- (-)	- (-)	The future Marsden park North Precinct is located in this catchment. No details of the future receivers are currently available for this precinct and predicted levels are shown as noise contours in **Figure 14** and **Appendix D**.
NCA03	- (-)	- (-)	-
Sub Total	**74 (74)**	**1 (1)**	**-**
TOTAL	**75 (75)**		

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

In summary, the above assessment shows a total of 75 sensitive receiver buildings are predicted to have exceedances of the NCG operational road traffic noise criteria and are therefore eligible for consideration of 'additional noise mitigation'. Operational noise mitigation measures for the proposal are discussed further in **Section 7.2**.

It is noted that some of the triggered receivers are future dwellings that are not currently constructed or approved. Mitigation for receivers constructed after construction of the road upgrade would be the responsibility of the developer to provide.

Figure 16 Receivers Eligible for Consideration of Additional Mitigation

6.4 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 29**. Detailed results are provided in **Appendix D**.

Table 29 Existing Maximum Noise Level Events

Monitoring Location	Total Night time Events	Measured Maximum Noise Levels (dBA L_{Amax})	
		Range	Median
1270 Richmond Road, Marsden Park	532	65-91	73
35 Ellison Street, Marsden Park	44	65-81	67

The above table shows that existing maximum noise level events are a regular feature at the monitoring locations and typically range from 65 to 90 dBA. Higher levels were measured at L01 due to the proximity of this location to Richmond Road.

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 30**.

Table 30 Predicted Change in Maximum Noise Levels

NCA	Worst case Change (dB)	Discussion
NCA01	7	Maximum noise levels are predicted to increase by up to 7 dB from the proposal in this NCA. This is due to Richmond Road being realigned to the west, closer to the residential receivers within the Marsden Park Precinct.
NCA02	2	Maximum noise levels at 1270 Richmond Road (the only existing receiver in this catchment) are predicted to increase by 2 dB which is due to Richmond Road being raised adjacent to this location by up to 5 m.
NCA03	0	Maximum noise levels are not predicted to change in this NCA

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 Richmond Road and the future Clydesdale Access which may affect receivers to the west in NCA01 and receivers to the east in NCA02. 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 31**.

Table 31 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.

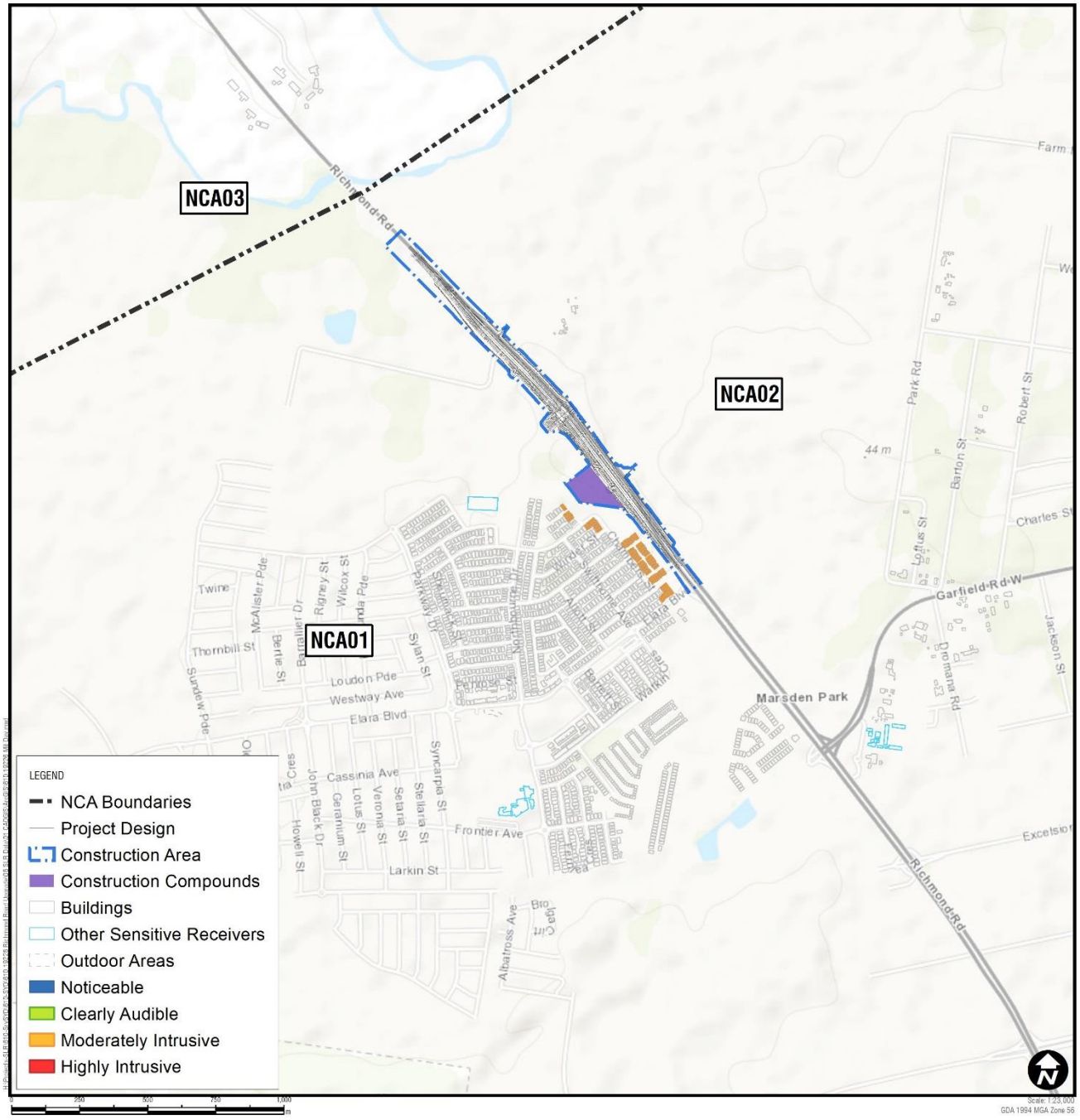
Indicative Additional Mitigation Measures

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 31**). The required 'additional mitigation measures' are shown for:

- Daytime construction noise – **Figure 17**
- Night-time construction noise – **Figure 18**.

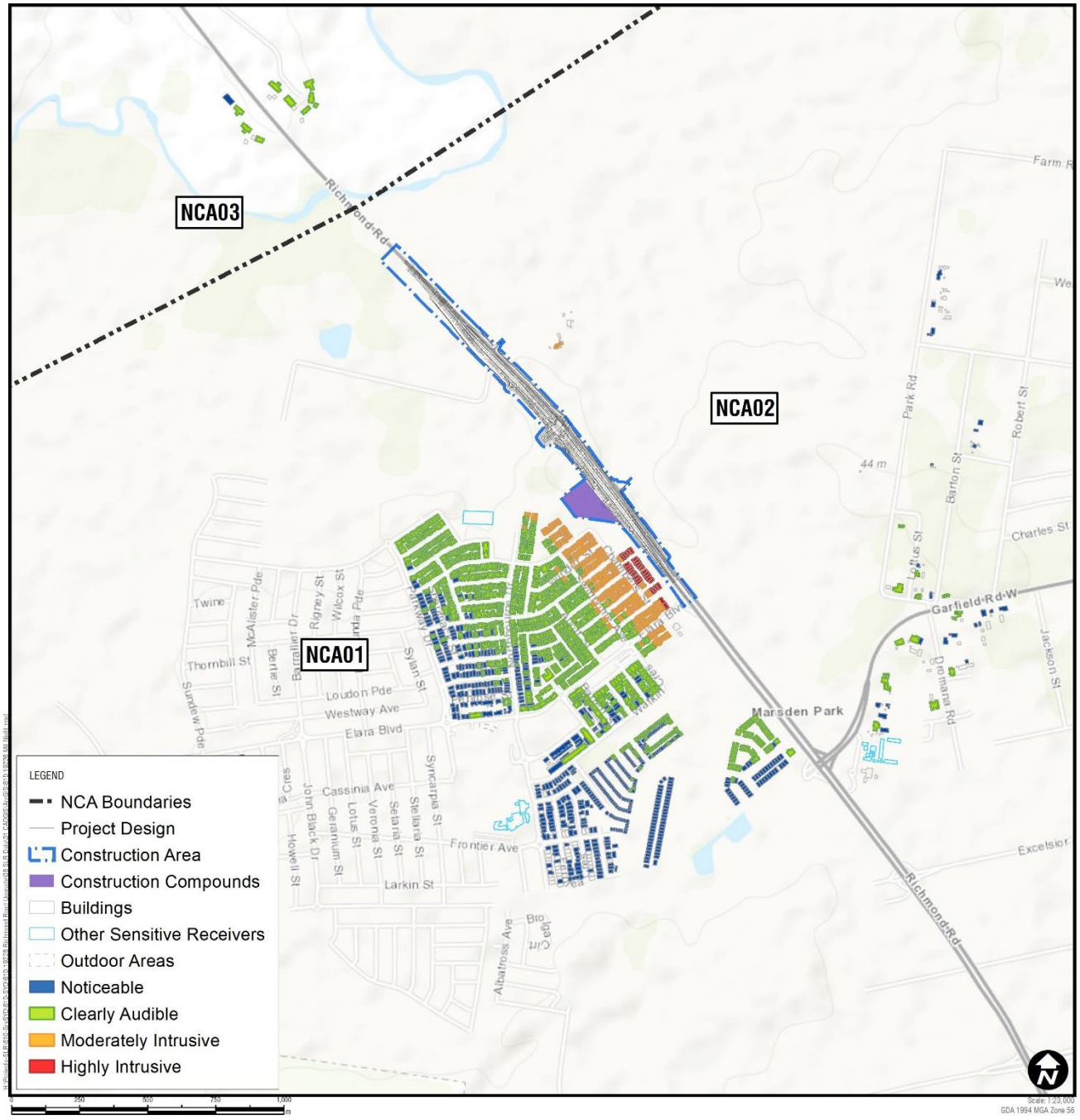
The figures show the required 'additional mitigation measures' based on the CNVG 'perception' categories in **Table 31**.

Figure 17 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 31** for requirement definitions).

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



Note: The night-time 'Additional Mitigation Measures' are: Noticeable = N, 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 31** for requirement definitions).Proposal Specific Construction Mitigation Measures

On the basis of the predictions, **Table 32** lists the proposal specific mitigation measures which are recommended to be used to minimise the impacts.

Table 32 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 Highly Intrusive impacts are likely in NCA01 when noise intensive equipment such as rockbreakers or concrete saws are in use, especially during evening and night-time periods. 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.
Vibration works within minimum working distance	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.

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 Richmond Road and the future Clydesdale Access which would reduce the effectiveness of low noise pavements due to stop/start traffic.

The potential noise benefit from the use of a quieter noise pavement on Richmond Road has been assessed is summarised in **Table 33**.

Table 33 Receivers Eligible for Consideration for 'Additional Noise Mitigation' – Low Noise Pavement (OGA)

NCA	Number of Triggered Buildings (Floors)					
	DGA Pavement		OGA Pavement		Reduction in Triggers	
	Residential	Other Sensitive	Residential	Other Sensitive	Residential	Other Sensitive
NCA01	74 (74)	1 (1)	56 (56)	1 (1)	18 (18)	- (-)
NCA02	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
NCA03	- (-)	- (-)	- (-)	- (-)	- (-)	- (-)
Sub Total	**74 (74)**	**1 (1)**	**56 (56)**	**1 (1)**	**18 (18)**	**- (-)**
TOTAL	**75 (75)**		**57 (57)**		**18 (18)**	

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

In summary, the above assessment shows the number of sensitive receiver buildings predicted to have exceedances with low noise pavement is reduced by 18 to 57.

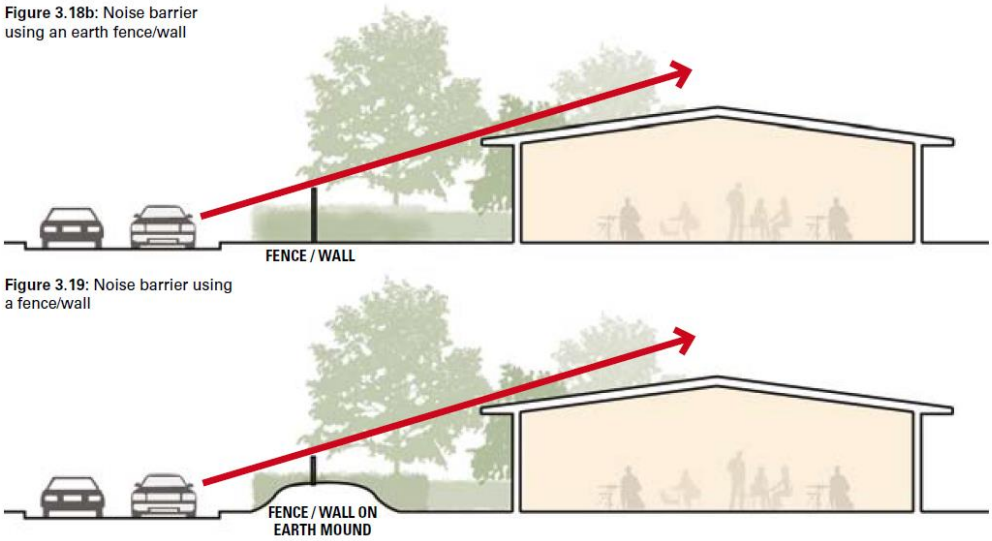
It is noted, however, that the proposal would introduce a new signalised intersection at the intersection of Richmond Road and the future Clydesdale Access. Low noise pavements are generally not considered appropriate where traffic is required to stop and start, meaning low noise pavements are unlikely to be a suitable mitigation approach for the proposal. Low noise pavement should, however, be investigated further as the project progresses 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 19**.

Figure 19 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

The process for determining noise barriers is described in the Roads and Maritime NMG. Noise barriers are to be considered where there are four or more closely spaced receivers with exceedances of the NMG triggers (see **Section 4.5.6**).

Groups of clustered residential receivers are triggered to the west of Richmond Road in NCA01 in the Marsden Park Precinct. It is noted that sections of the precinct are still under development, particularly in the northern portion.

Given the uncertainties regarding the future dwellings, a noise barrier in this area has been considered adjacent to the constructed/approved dwellings. The location of the barrier is shown in **Figure 20** and the assessment of it is detailed in **Table 34**. **Appendix D** provides more details of the barrier analysis.

Figure 20 Indicative Noise Barriers Considered for Further Investigation

Table 34 Indicative Noise Barrier Details

Barrier ID	Noise Barrier Details						Comments
	Type	Length (m)	Height (m)[1]	Triggered Receivers[2]		Reasonable?	
				No Barrier	With Barrier		
NW01	New	392	5.5	37	16	Yes	The optimised barrier height of 5.5 m meets the NMG minimum requirement of 10 dB benefit for barriers over 5 m in height and is, therefore, considered reasonable to construct.

Note 1: Recommended height is subject to further considerations such as construction limitations, overshadowing, urban design and community preference.

Note 2: The count of 'Triggered Receivers' represents the number of individual floors (at ground and first level only) of the affected buildings.

The above assessment, which follows the NMG process for designing noise barriers, results in an optimised barrier height of 5.5 m. The assessment shows that the barrier is reasonable to construct from a noise perspective as it reduces the number of triggered receivers behind the barrier from 37 to 16 and provides at least 10 dB benefit, however, the barrier is subject to further feasible and reasonable considerations, such as construction limitations, overshadowing, urban design, visual impact and community preference which would be considered further during detailed design.

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. Should low noise pavements and noise barriers be determined to not be appropriate mitigation measures then at-property treatment of individual receivers would be the preferred mitigation approach.

Unapproved and Yet to be Constructed Sensitive Receivers

The operational assessment indicates that a number of future residential dwellings are likely to be subject to road traffic noise impacts due to their location adjacent to Richmond Road (see **Figure 20**). As some of these dwellings are not yet constructed, the assessment has made a number of assumptions regarding the likely location and size of the future buildings.

It is noted that noise mitigation for receivers constructed after construction of the road upgrade would be the responsibility of the developer to provide.

8 Conclusion

Transport for NSW are proposing an upgrade to Richmond Road to a dual carriageway about 1.6 kilometres of Richmond Road north of Elara Boulevard in Marsden Park. The proposal comprises realigning Richmond Road to the west of the existing road, 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 west of the proposal in NCA01 where receivers are adjacent to Richmond Road. 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 Richmond Road. As these roads have high existing traffic volumes no noise impacts from construction traffic are predicted for the adjacent receivers.

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 proposal would widen and realign Richmond Road which increases road traffic noise levels, particularly to the west. The nearest receivers to the west are however already close to Richmond Road and are subject to relatively high existing road traffic noise levels.

Exceedances of the criteria are predicted at receivers in NCA01 which are adjacent to Richmond Road due to the project increasing noise levels by greater than 2.0 dB, cumulative limit exceedances and acute noise levels. One school to the west of the proposal near Northbourne Drive is also predicted to exceed the criteria.

A total of 75 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 which would be reviewed further during detailed design.

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

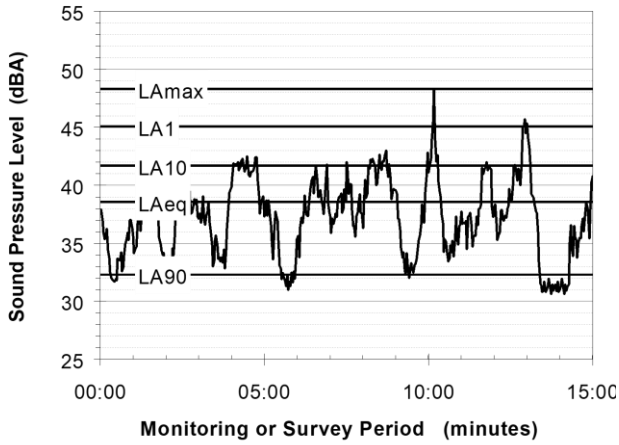
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or LW, or by the reference unit 10^{-12} W.

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

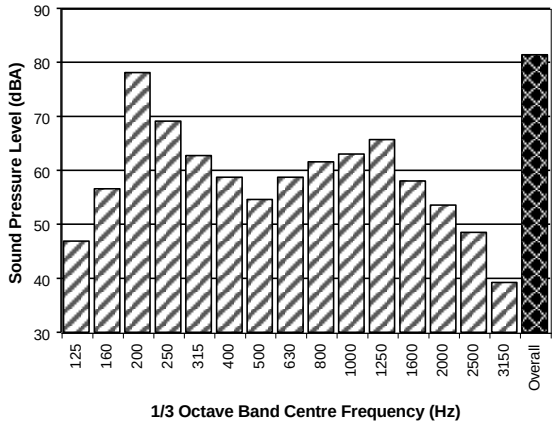
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal.

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

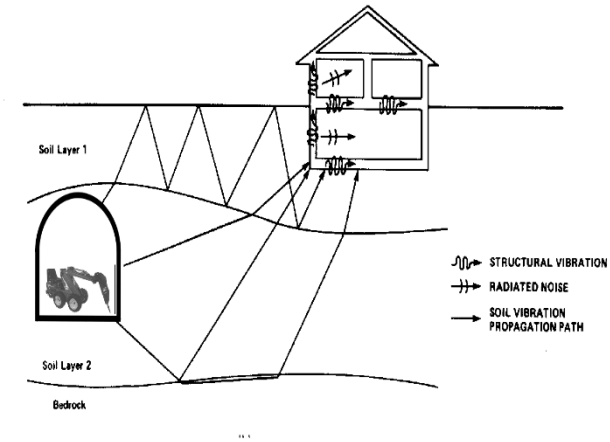
People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience 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	Map of Noise Monitoring Location
Noise Monitoring Address	**1270 Richmond Road, Marsden Park**	

Logger Device Type: Svantek 957, Logger Serial No: 21425
Sound Level Meter Device Type: Brüel and Kjær 2270, Sound Level Meter Serial No: 3027586

Ambient noise logger deployed at residential address 1270 Richmond Road, Marsden Park. Logger located with view of Richmond Rd to the west.

Attended noise measurements indicate the ambient noise environment at this location is dominated by road traffic noise from Richmond Rd to the west.

Recorded Noise Levels (LAmax):
01/04/2020: Light-vehicle traffic Richmond Rd: 55-70 dBA, Heavy-vehicle traffic Richmond Rd: 68-75 dBA, Motorcycle: 75 dBA, Insects: 54 dBA

Ambient Noise Logging Results ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	53	67	70	74
Evening	44	63	67	71
Night-time	34	62	64	70

Ambient Noise Logging Results RNP Defined Time Periods

Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	66	67
Night-time (10pm-7am)	64	68

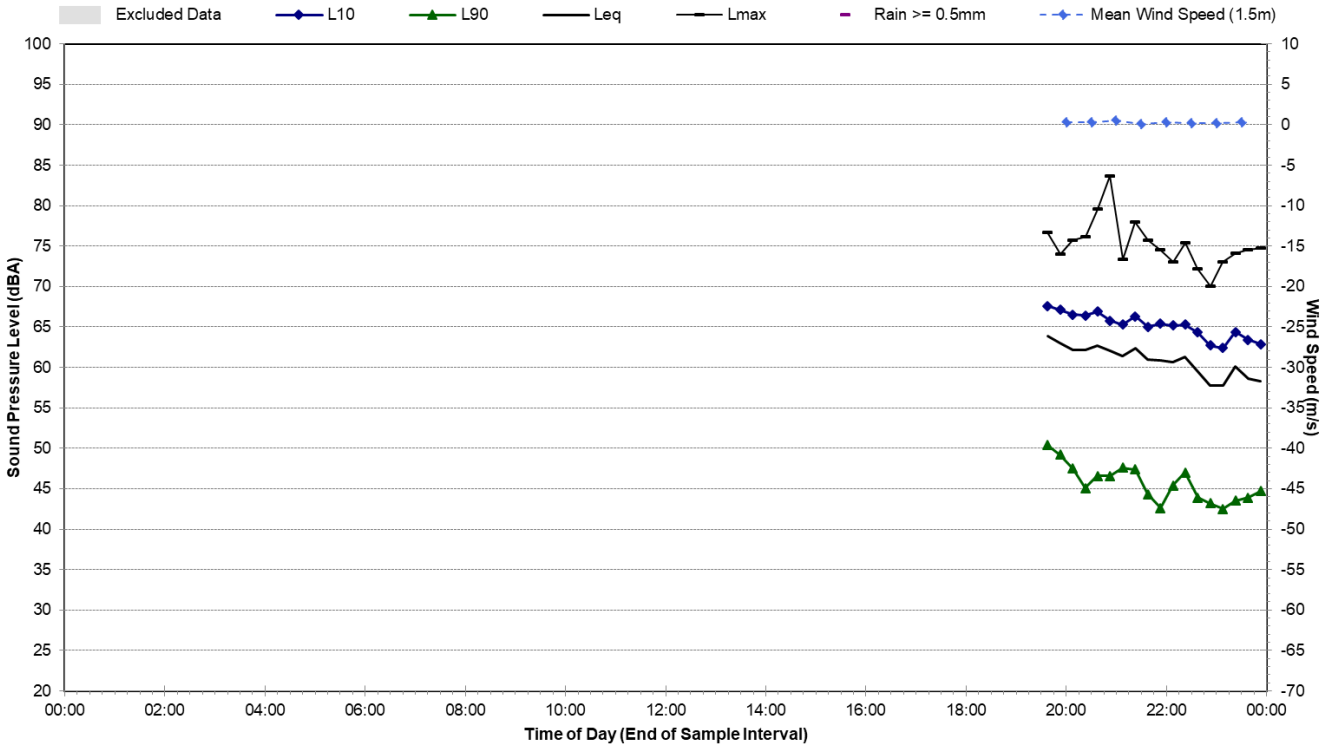
Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
01/04/2020	18:57	52	64	75

Photo of Noise Monitoring Location 10.2 width

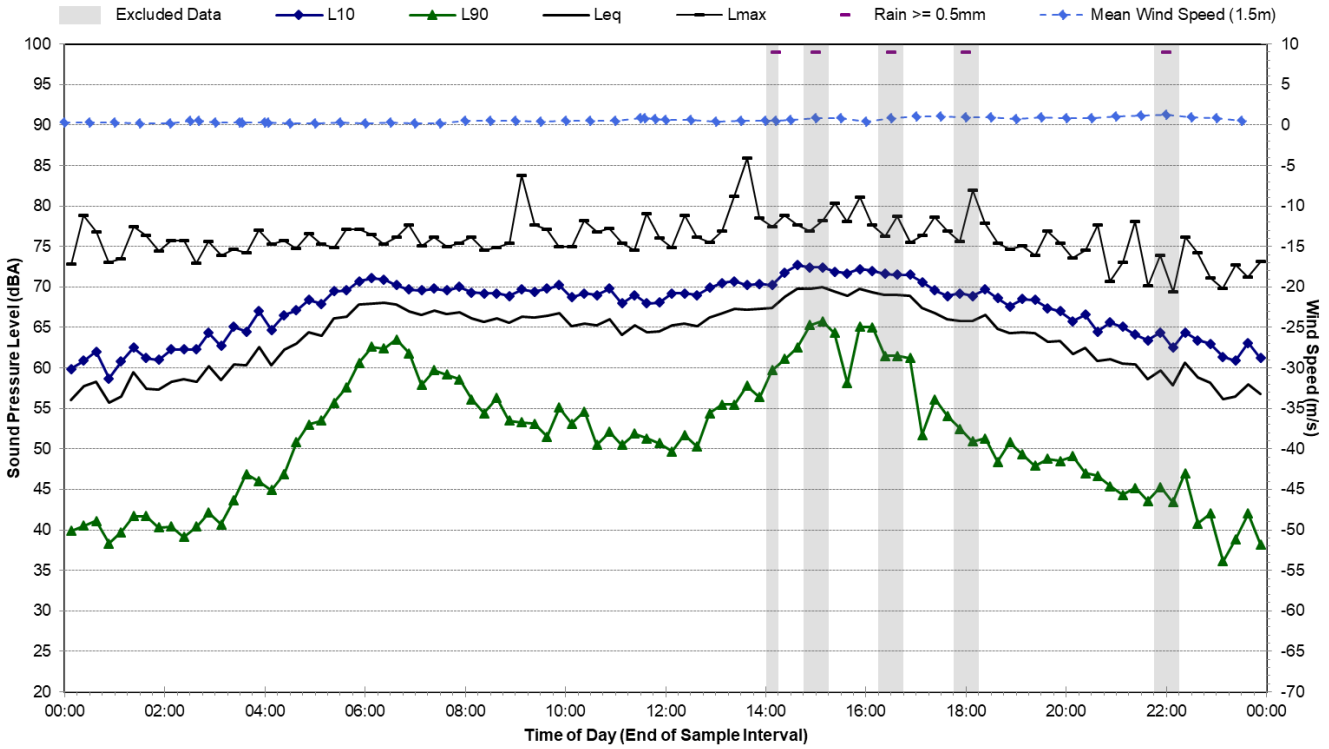
Statistical Ambient Noise Levels

L01 - 1270 Richmond Road, Marsden Park - Wednesday, 1 April 2020



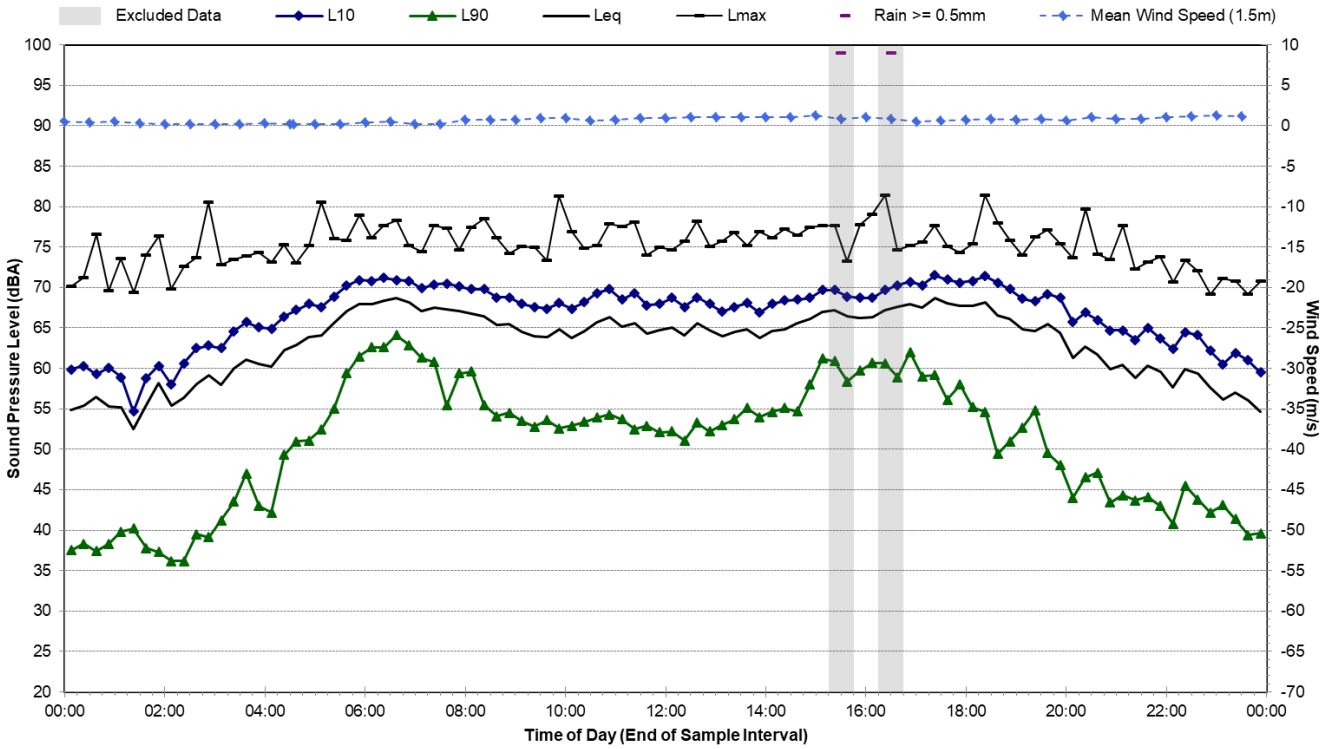
Statistical Ambient Noise Levels

L01 - 1270 Richmond Road, Marsden Park - Thursday, 2 April 2020



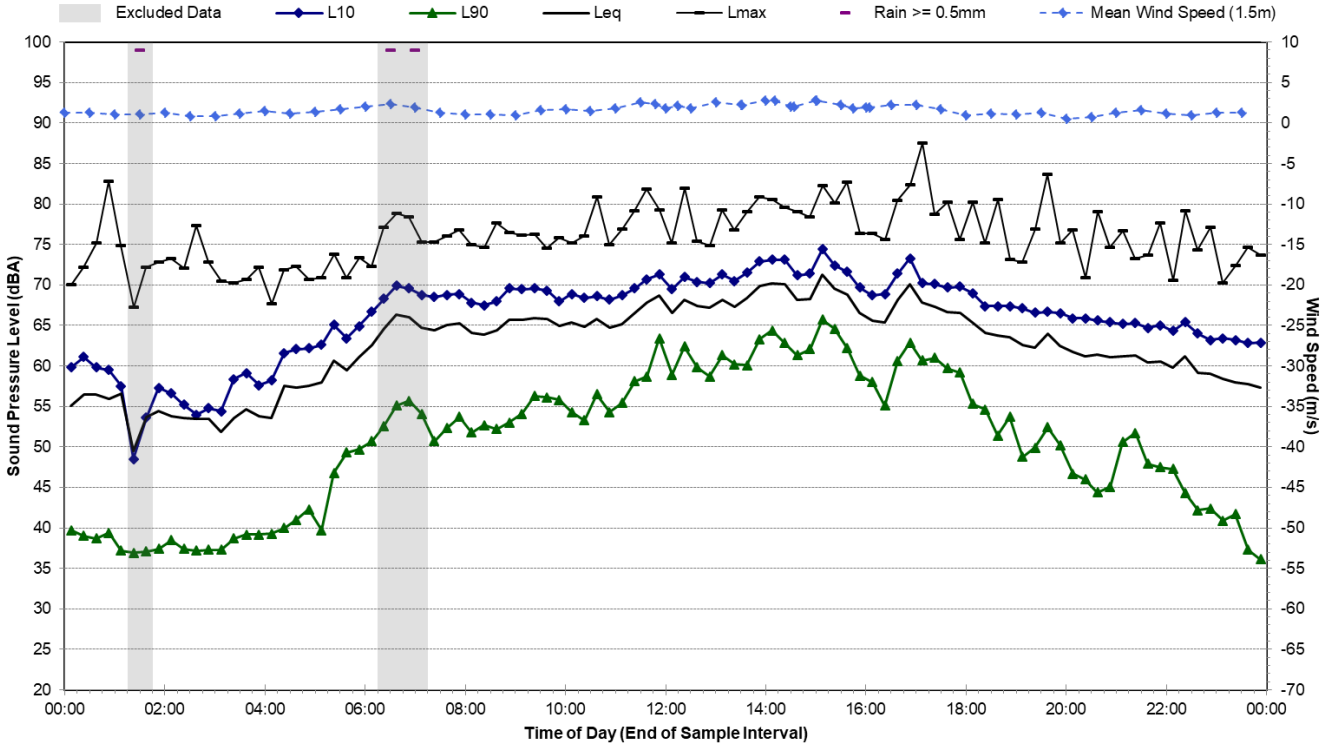
Statistical Ambient Noise Levels

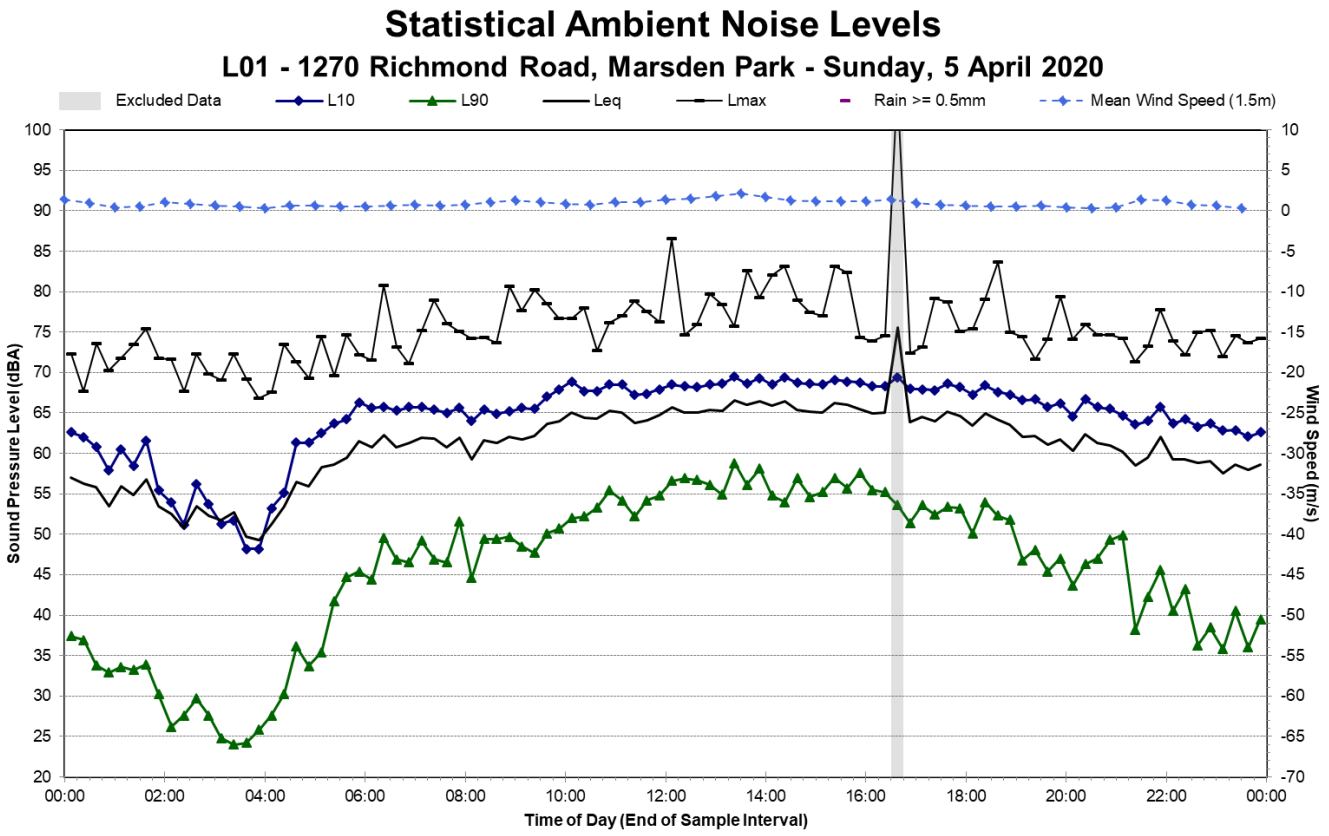
L01 - 1270 Richmond Road, Marsden Park - Friday, 3 April 2020

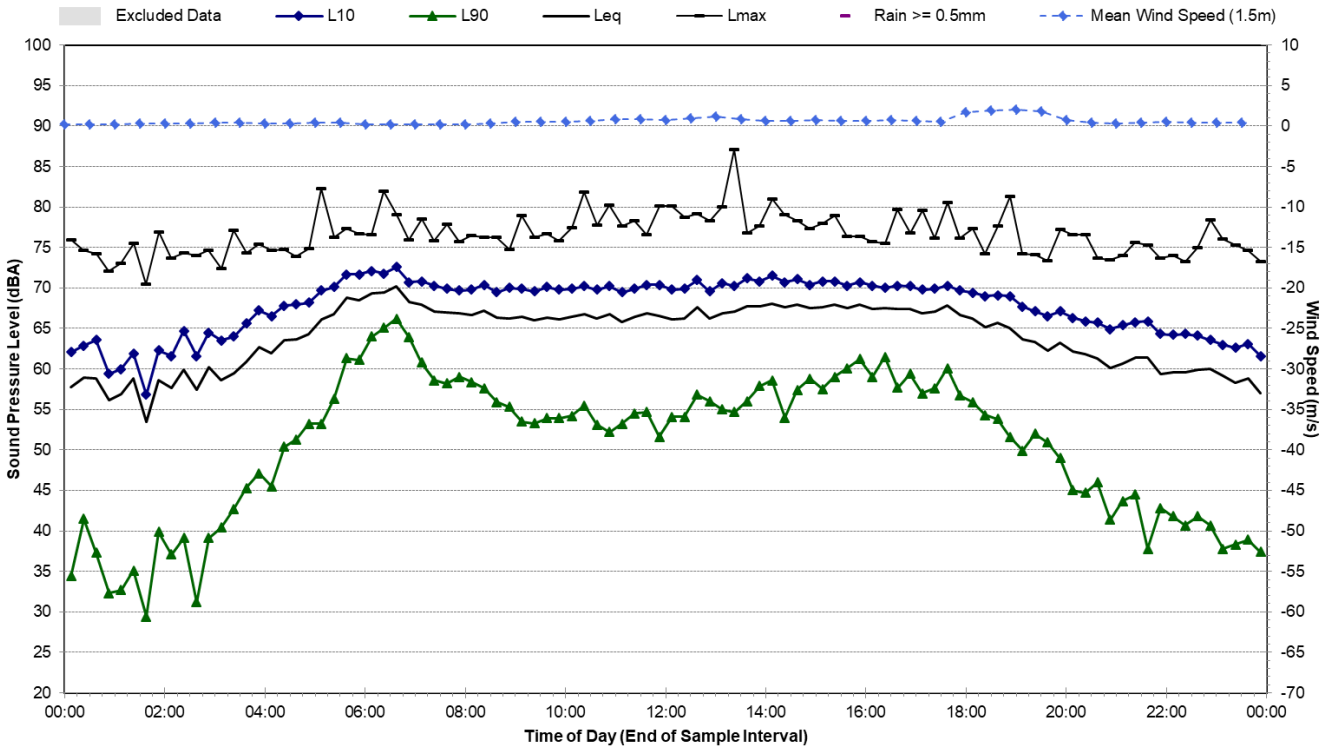


Statistical Ambient Noise Levels

L01 - 1270 Richmond Road, Marsden Park - Saturday, 4 April 2020

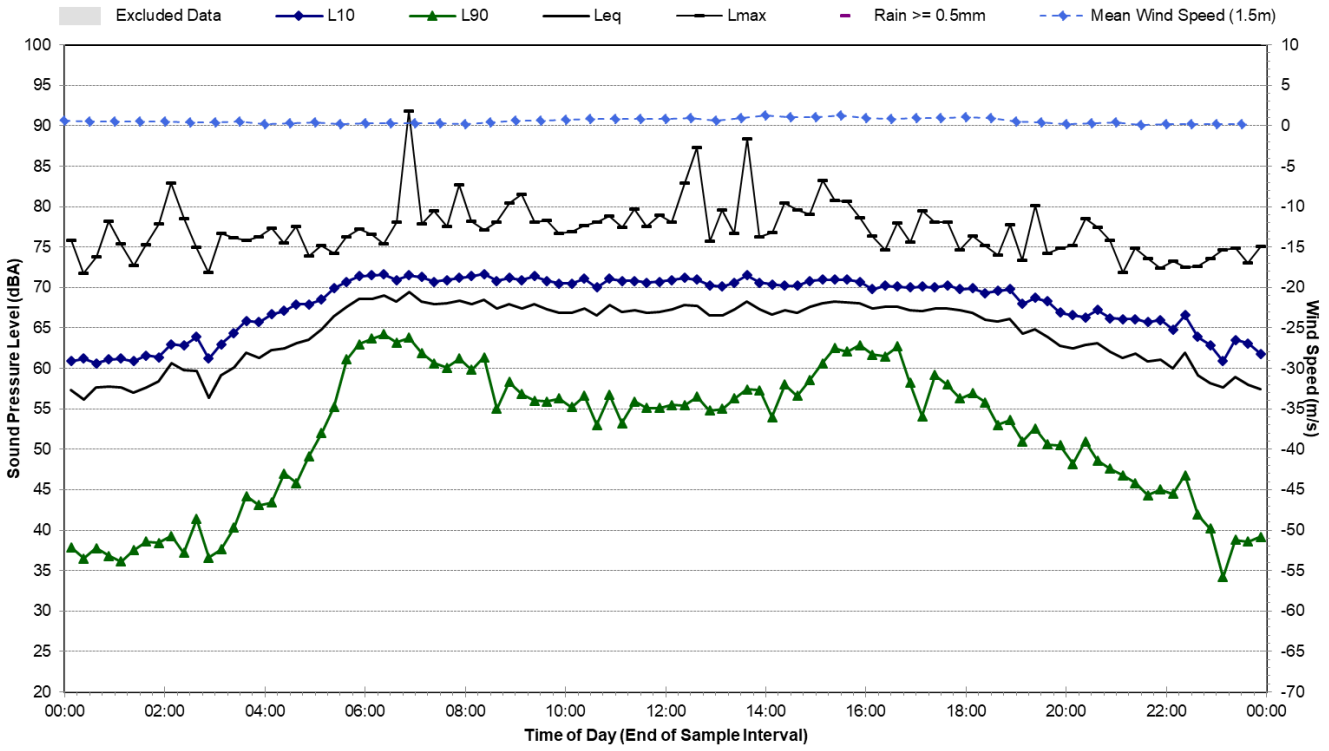



Statistical Ambient Noise Levels
L01 - 1270 Richmond Road, Marsden Park - Sunday, 5 April 2020
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L01 - 1270 Richmond Road, Marsden Park - Monday, 6 April 2020
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

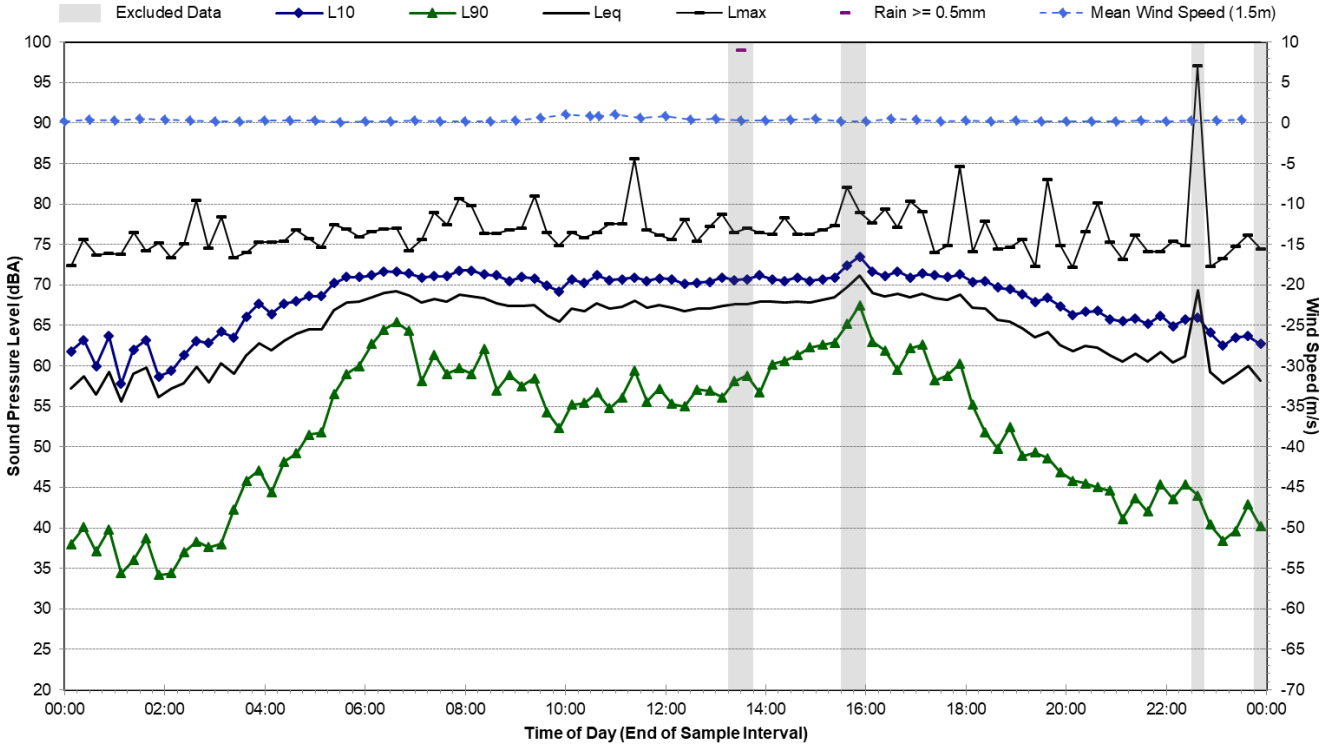
Statistical Ambient Noise Levels

L01 - 1270 Richmond Road, Marsden Park - Tuesday, 7 April 2020



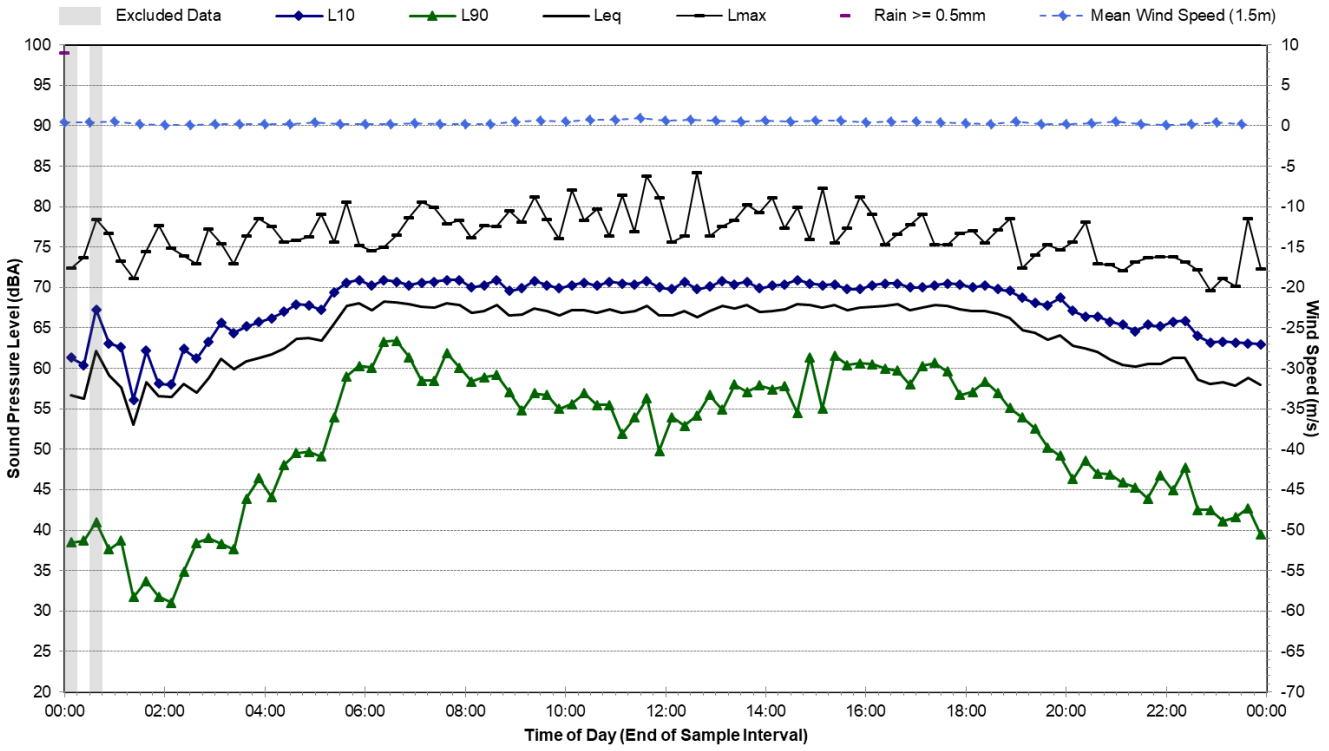
Statistical Ambient Noise Levels

L01 - 1270 Richmond Road, Marsden Park - Wednesday, 8 April 2020



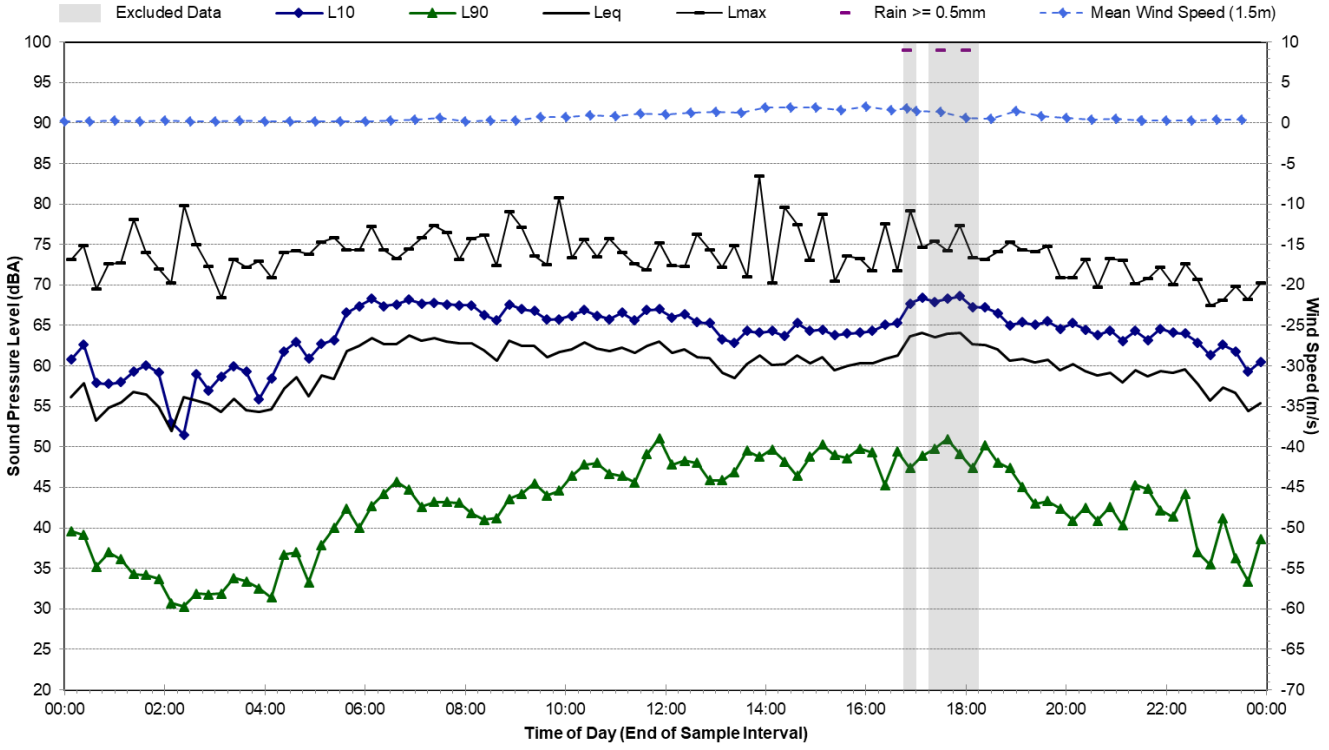
Statistical Ambient Noise Levels

L01 - 1270 Richmond Road, Marsden Park - Thursday, 9 April 2020



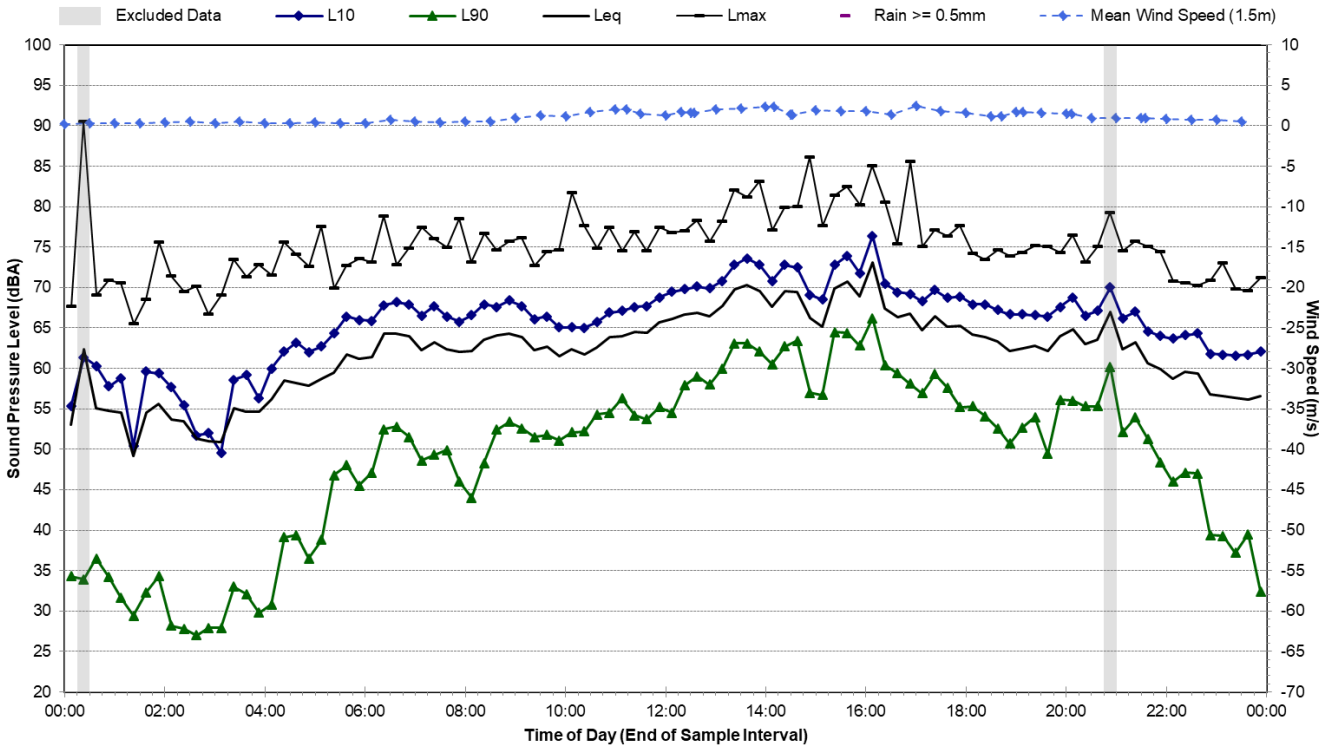
Statistical Ambient Noise Levels

L01 - 1270 Richmond Road, Marsden Park - Friday, 10 April 2020



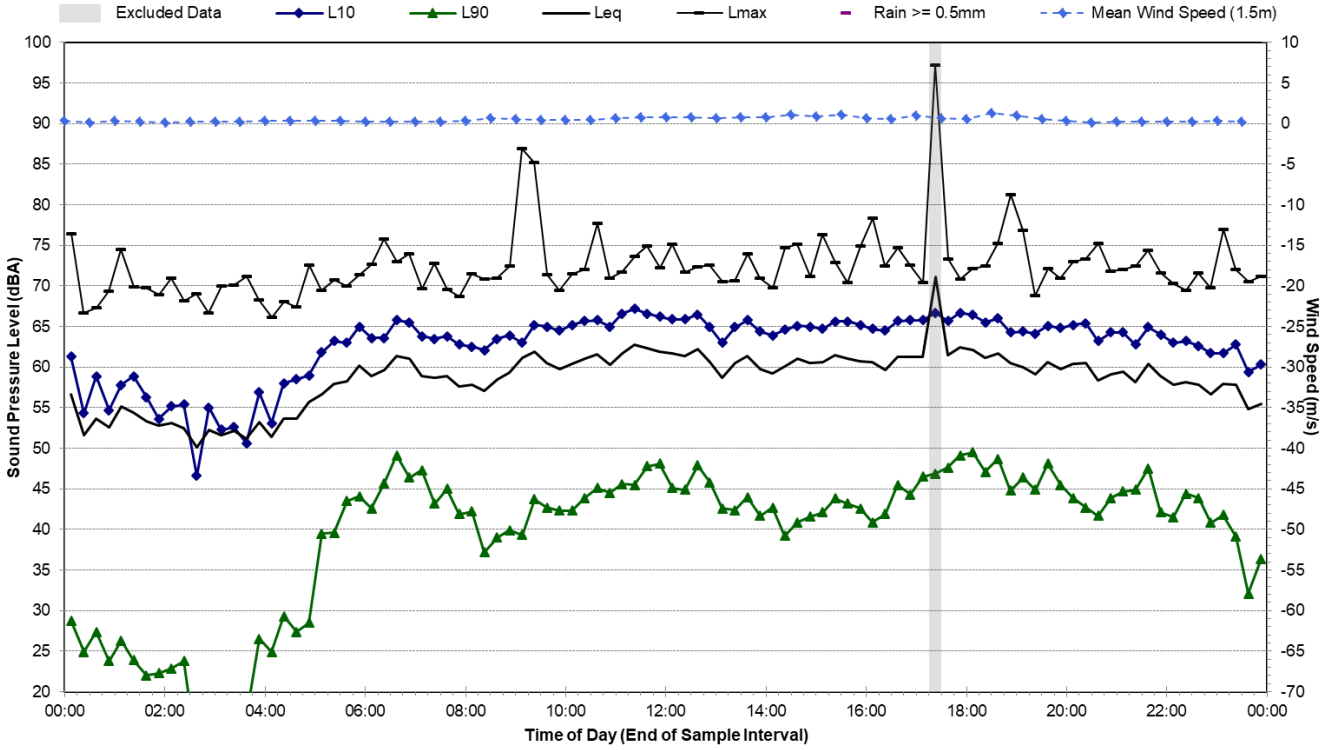
Statistical Ambient Noise Levels

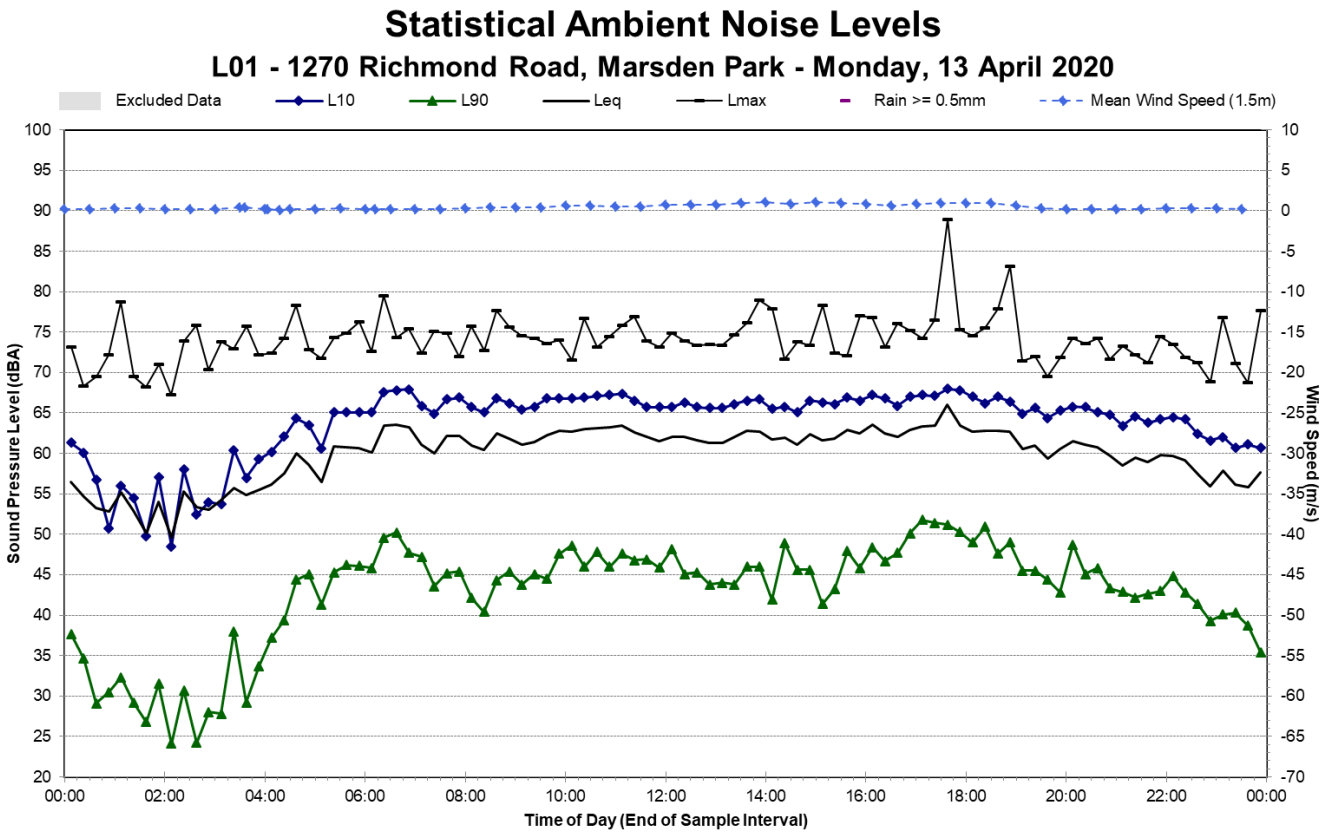
L01 - 1270 Richmond Road, Marsden Park - Saturday, 11 April 2020

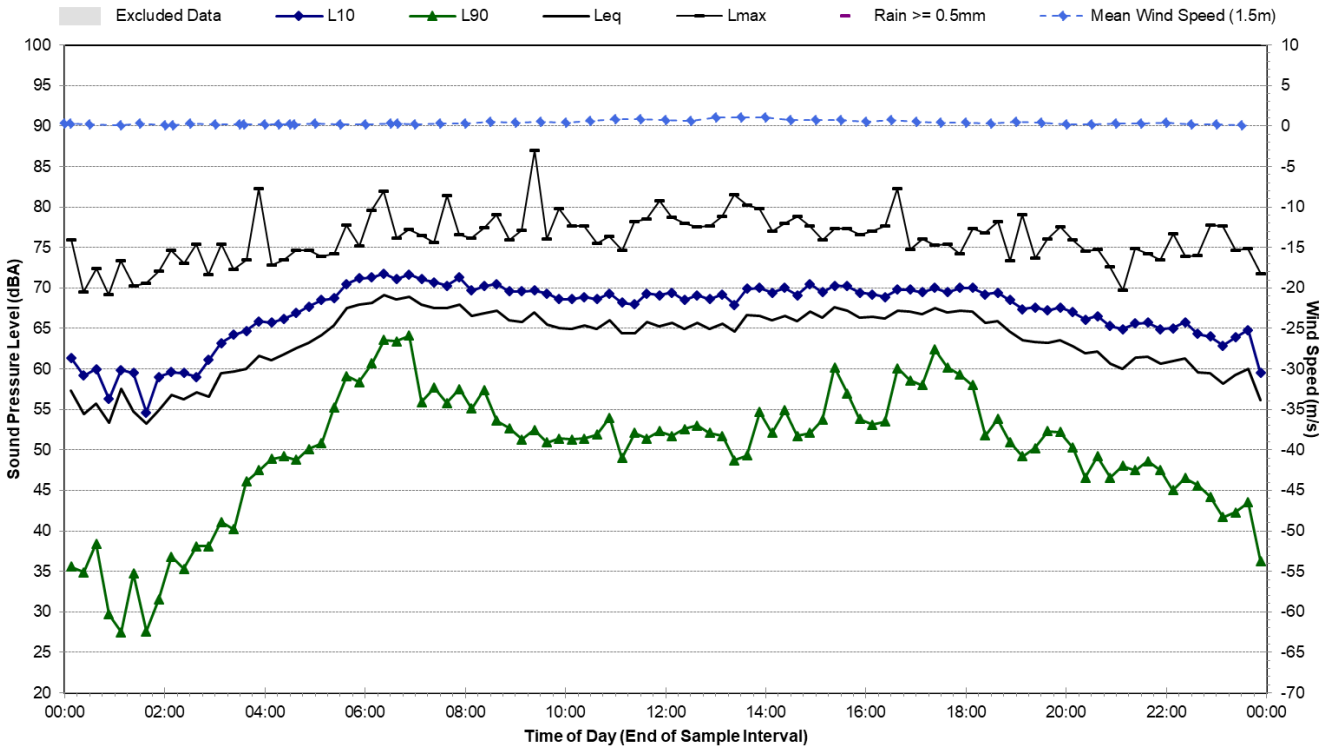


Statistical Ambient Noise Levels

L01 - 1270 Richmond Road, Marsden Park - Sunday, 12 April 2020

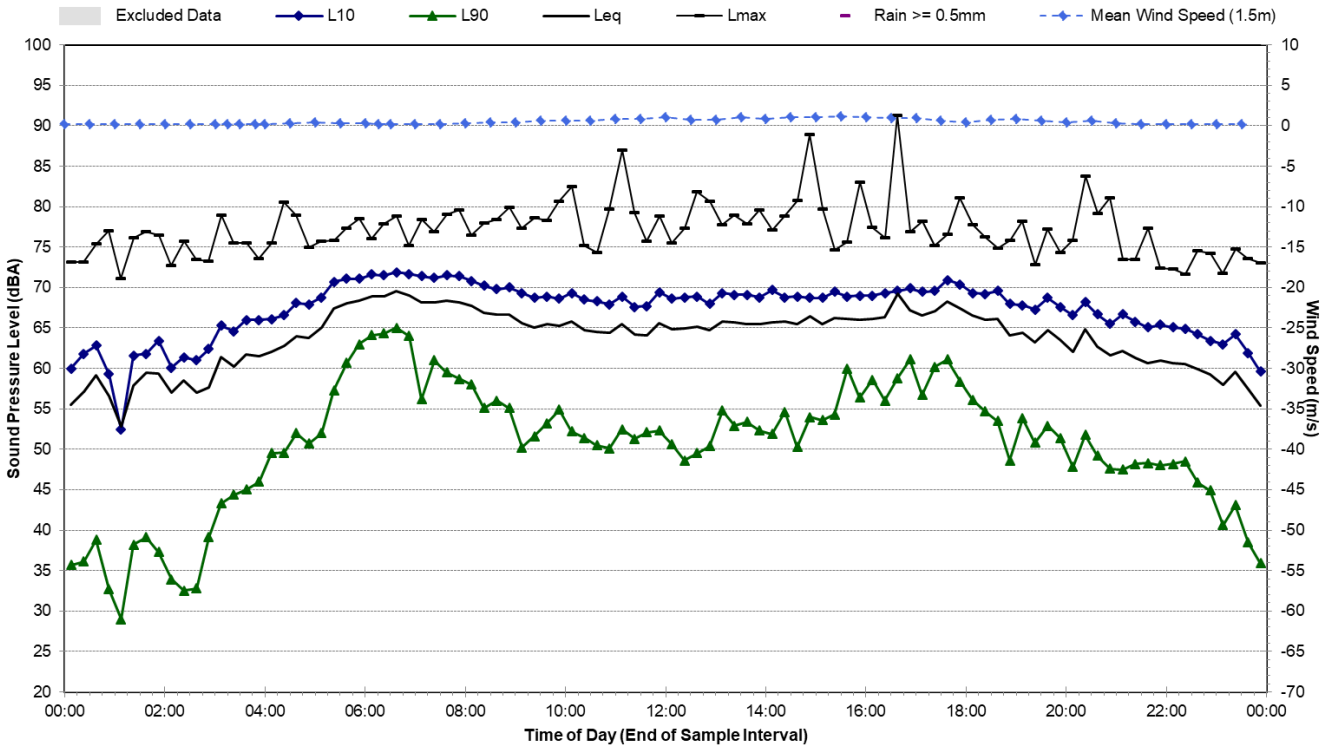



Statistical Ambient Noise Levels
L01 - 1270 Richmond Road, Marsden Park - Monday, 13 April 2020
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L01 - 1270 Richmond Road, Marsden Park - Tuesday, 14 April 2020
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

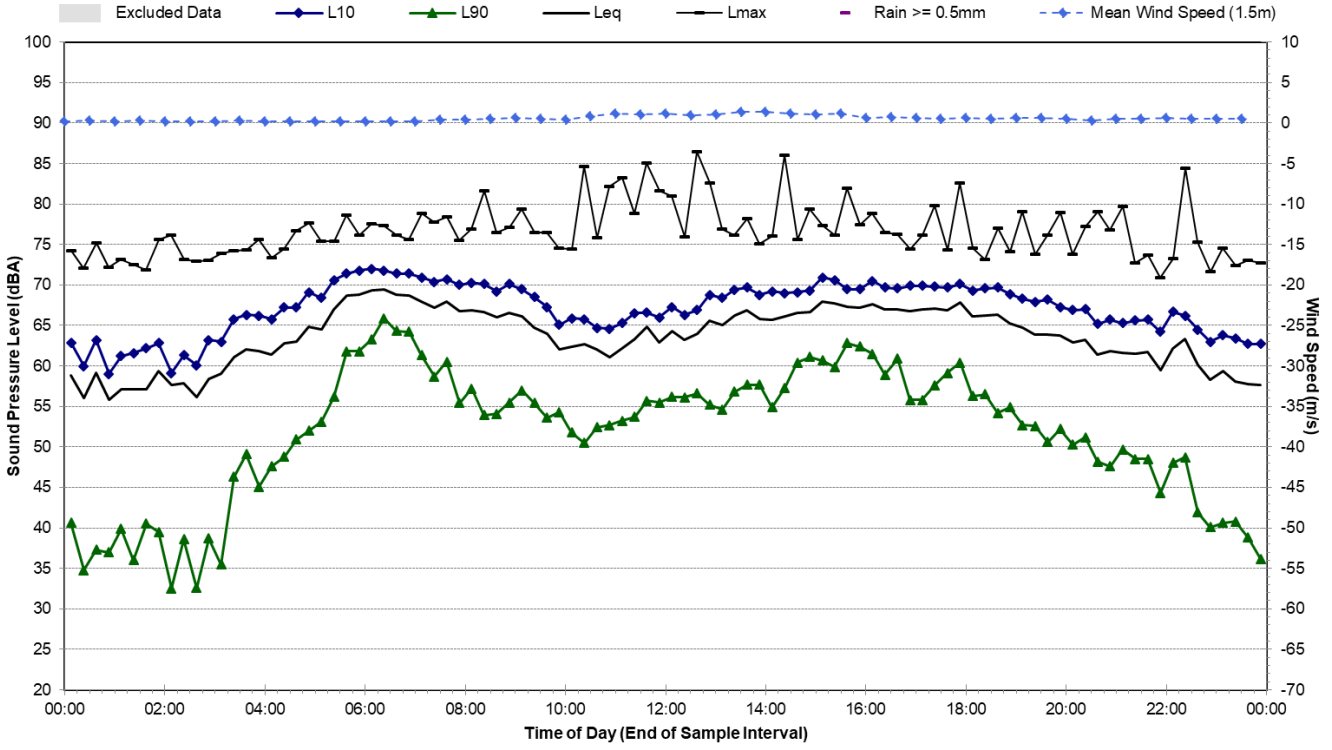
Statistical Ambient Noise Levels

L01 - 1270 Richmond Road, Marsden Park - Wednesday, 15 April 2020



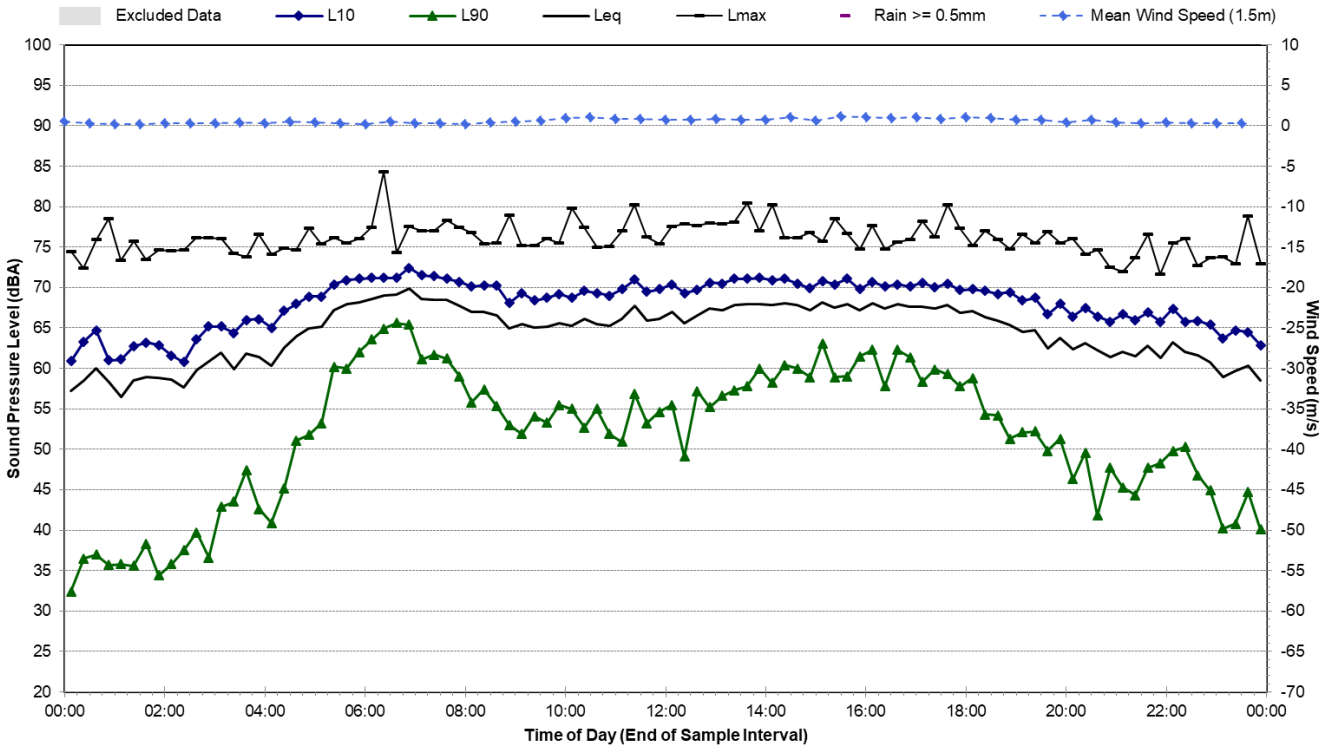
Statistical Ambient Noise Levels

L01 - 1270 Richmond Road, Marsden Park - Thursday, 16 April 2020



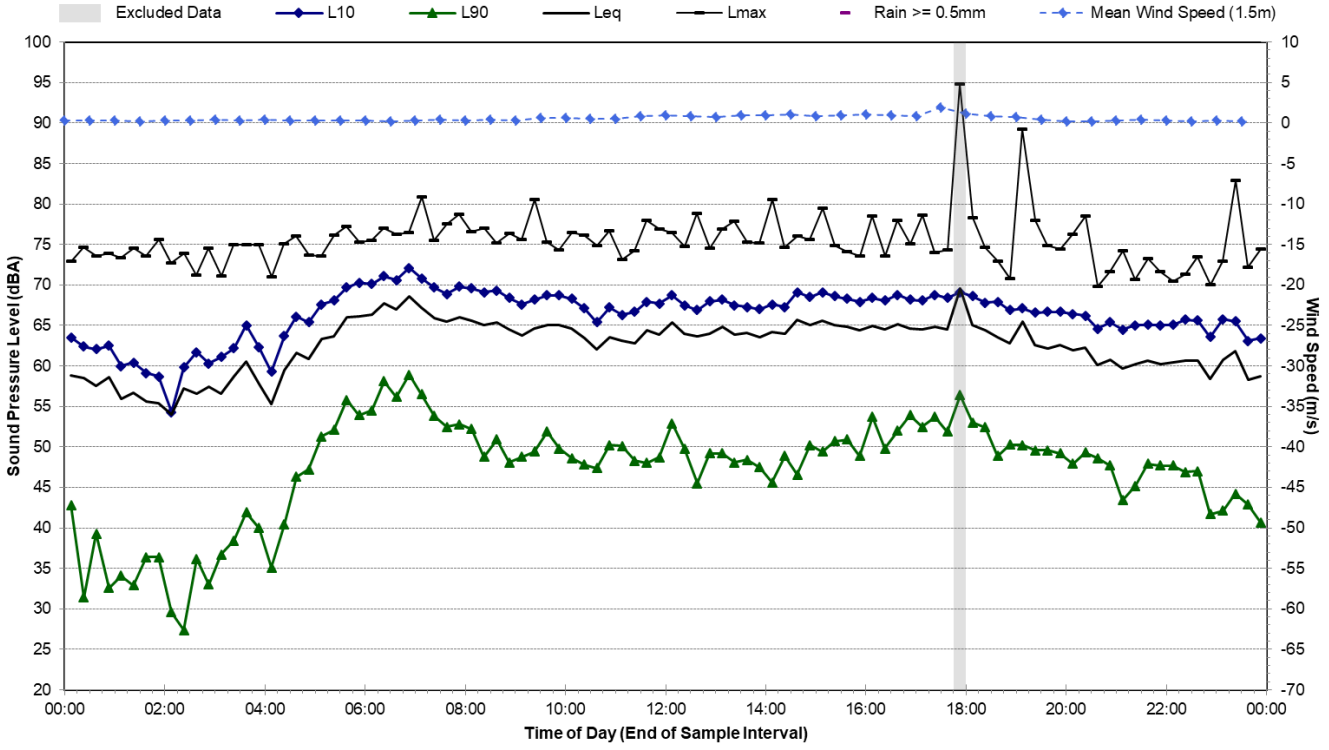
Statistical Ambient Noise Levels

L01 - 1270 Richmond Road, Marsden Park - Friday, 17 April 2020



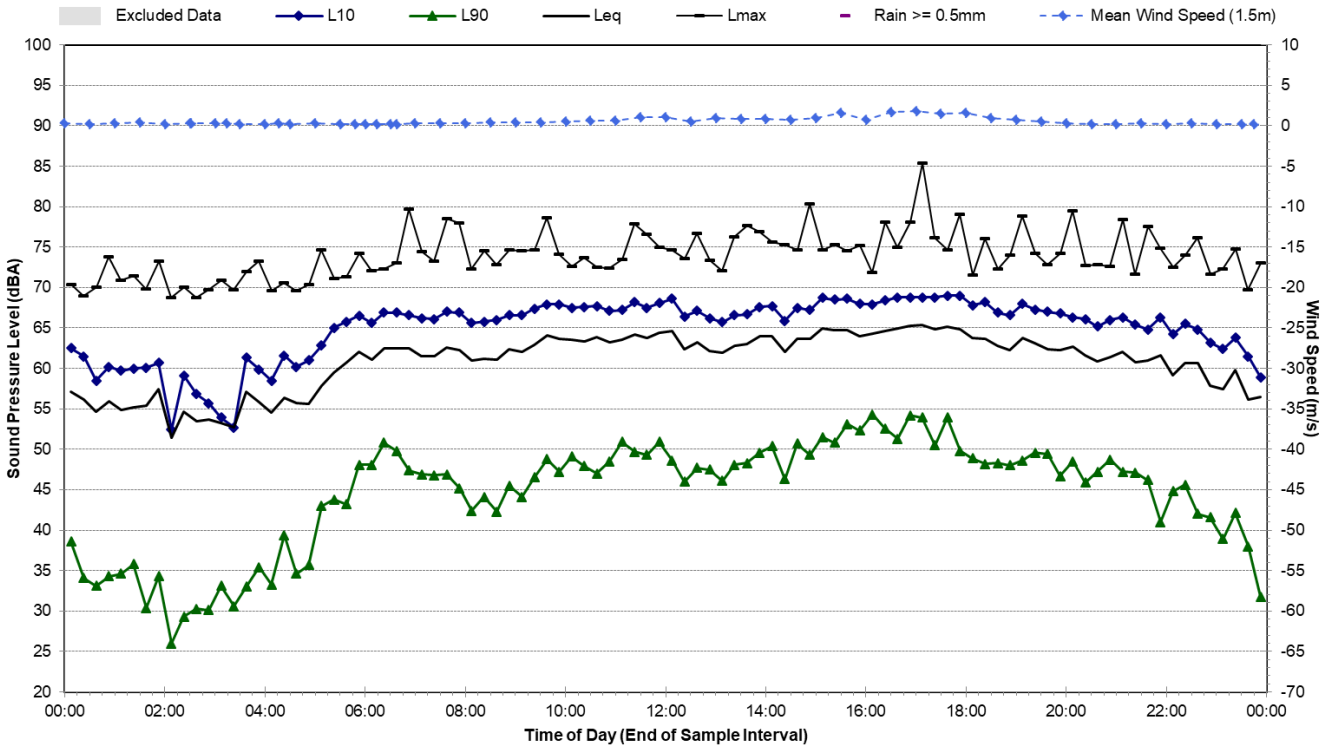
Statistical Ambient Noise Levels

L01 - 1270 Richmond Road, Marsden Park - Saturday, 18 April 2020



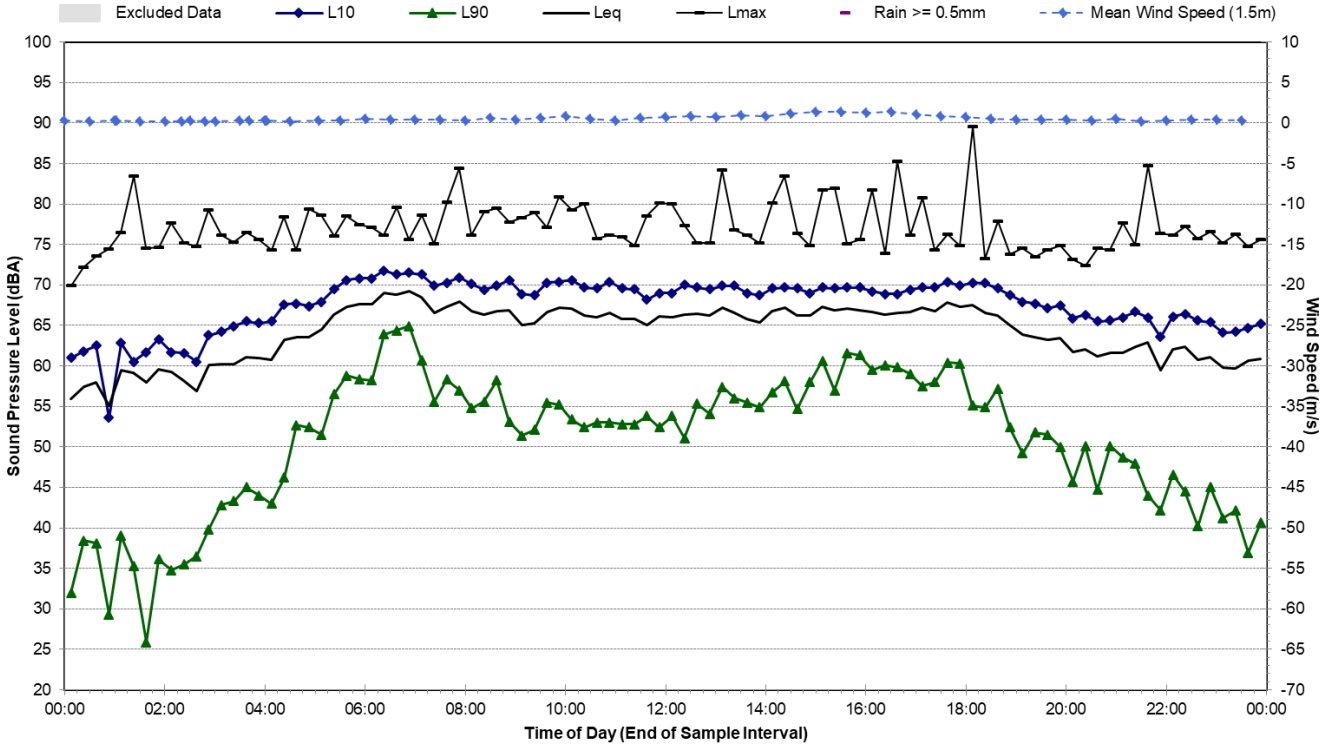
Statistical Ambient Noise Levels

L01 - 1270 Richmond Road, Marsden Park - Sunday, 19 April 2020



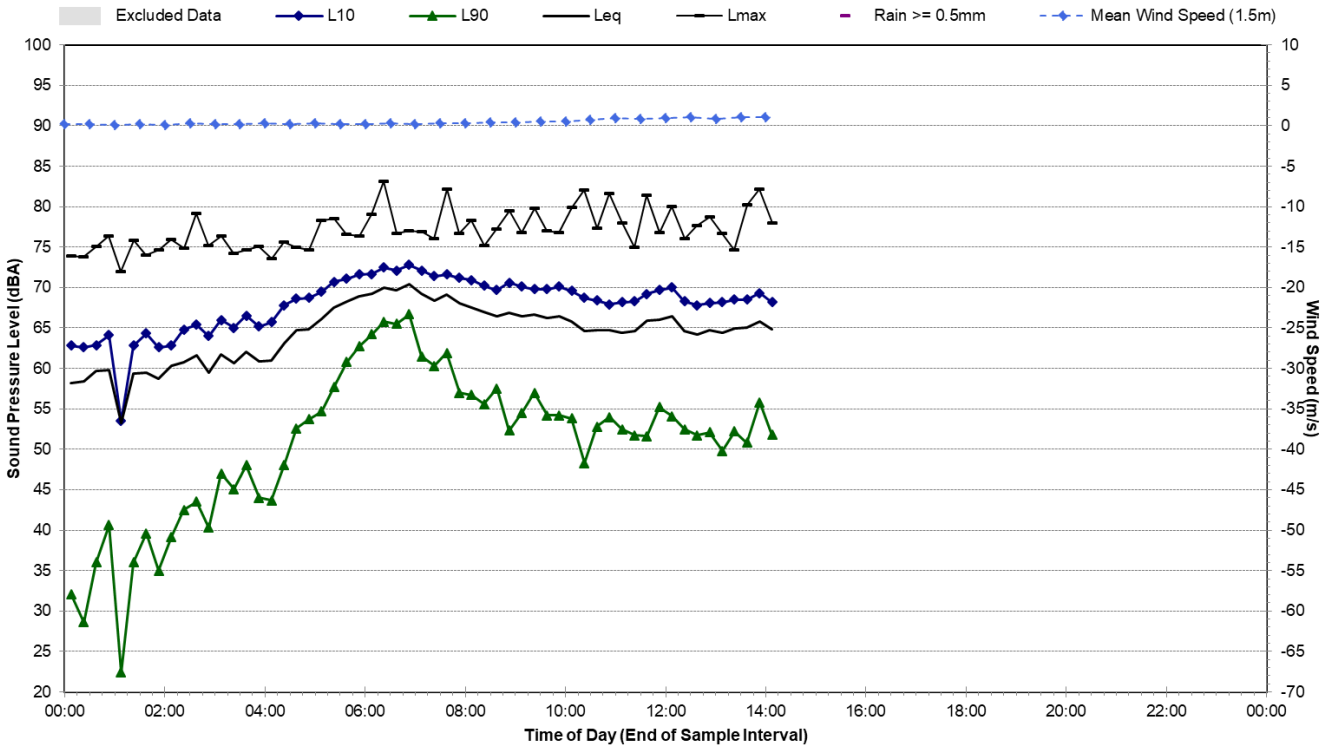
Statistical Ambient Noise Levels

L01 - 1270 Richmond Road, Marsden Park - Monday, 20 April 2020



Statistical Ambient Noise Levels

L01 - 1270 Richmond Road, Marsden Park - Tuesday, 21 April 2020



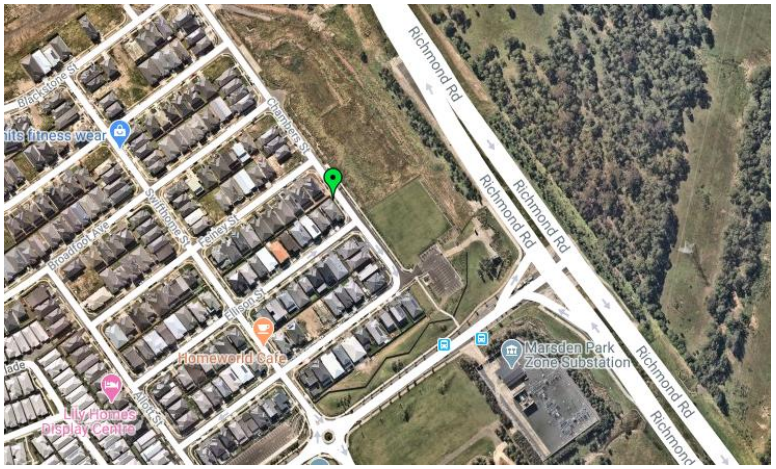
Noise Monitoring Location	L.02	Map of Noise Monitoring Location
Noise Monitoring Address	**35 Ellison Street, Marsden Park**	

Logger Device Type: Svantek 957, Logger Serial No: 20677
Sound Level Meter Device Type: Brüel and Kjær 2270, Sound Level Meter Serial No: 3027586

Ambient noise logger deployed at residential address 35 Ellison Street, Marsden Park. Logger located with view of Richmond Rd to the east and Elara Boulevard to the south.

Attended noise measurements indicate the ambient noise environment at this location is dominated by road traffic noise from Richmond Rd to the west. Road traffic noise from Elara Blvd to the south also contributes to the LAeq at this location.

Recorded Noise Levels (LAmax):
01/04/2020: Light-vehicle traffic Richmond Rd: 50-60 dBA, Heavy-vehicle traffic Richmond Rd: 58-63 dBA, Light-vehicle traffic Elara Blvd: 50-53 dBA, Heavy-vehicle traffic Elara Blvd: 55-60 dBA, Birds: 55 dBA



Ambient Noise Logging Results ICNG Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	47	56	8	64
Evening	46	53	54	59
Night-time	42	54	54	58

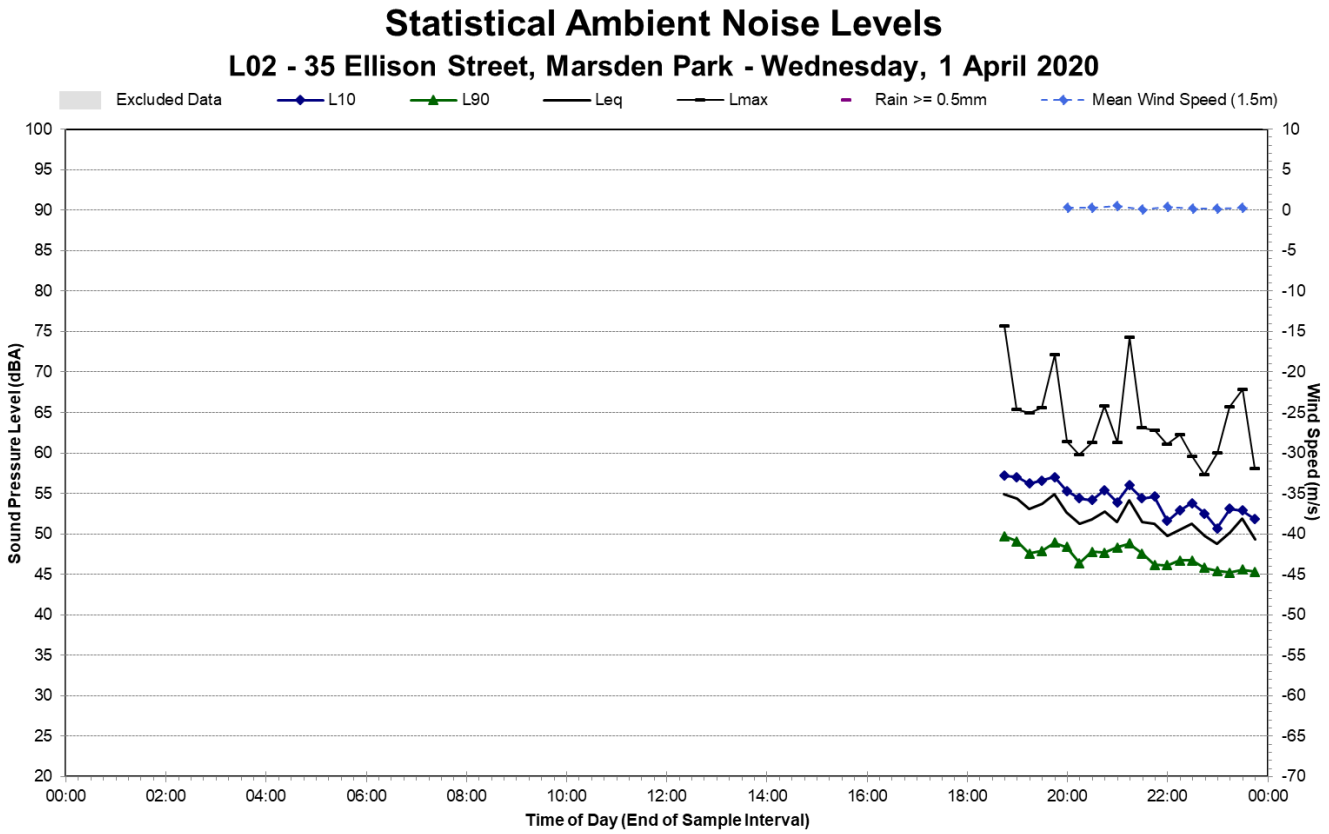
Ambient Noise Logging Results RNP Defined Time Periods

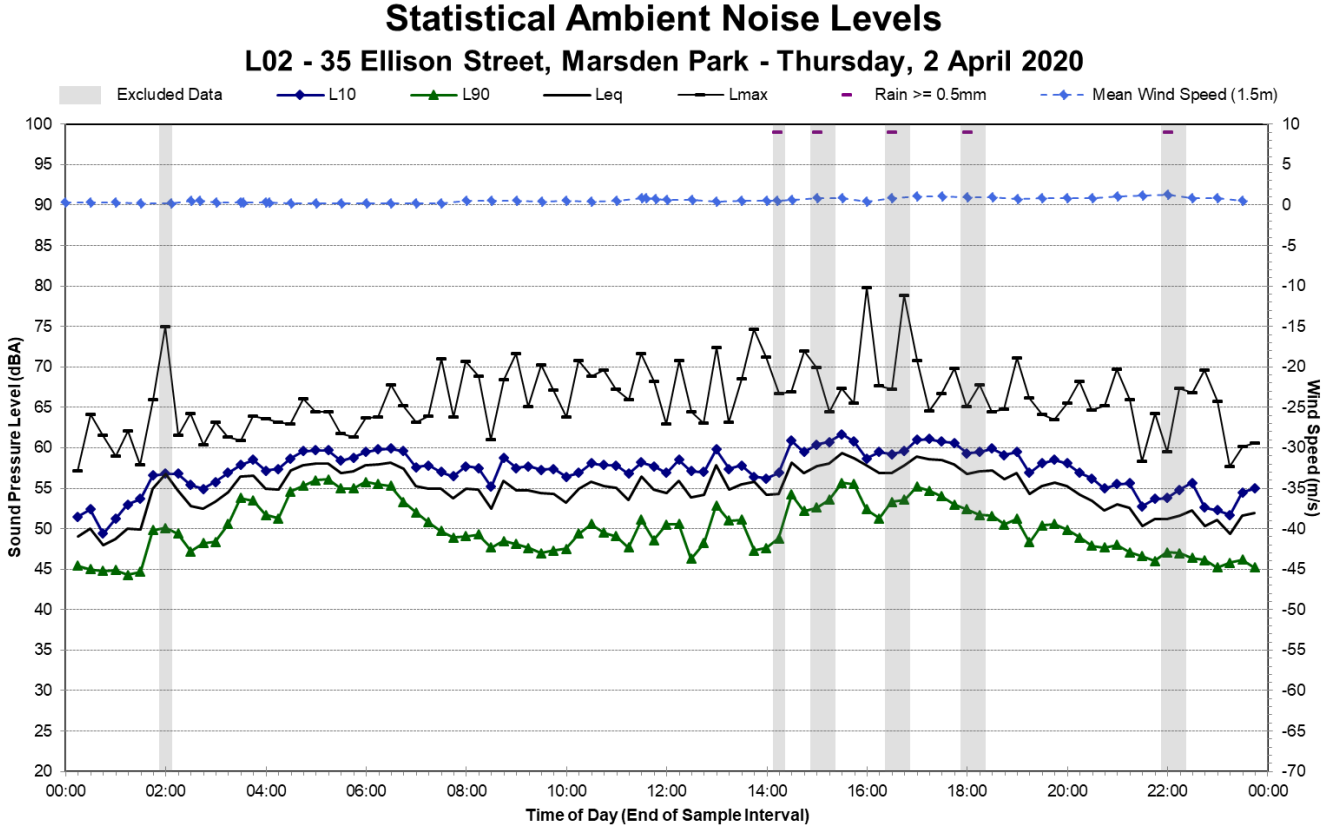
Monitoring Period	Noise Level (dBA)	
	LAeq(period)	LAeq(1hour)
Daytime (7am-10pm)	56	59
Night-time (10pm-7am)	54	59

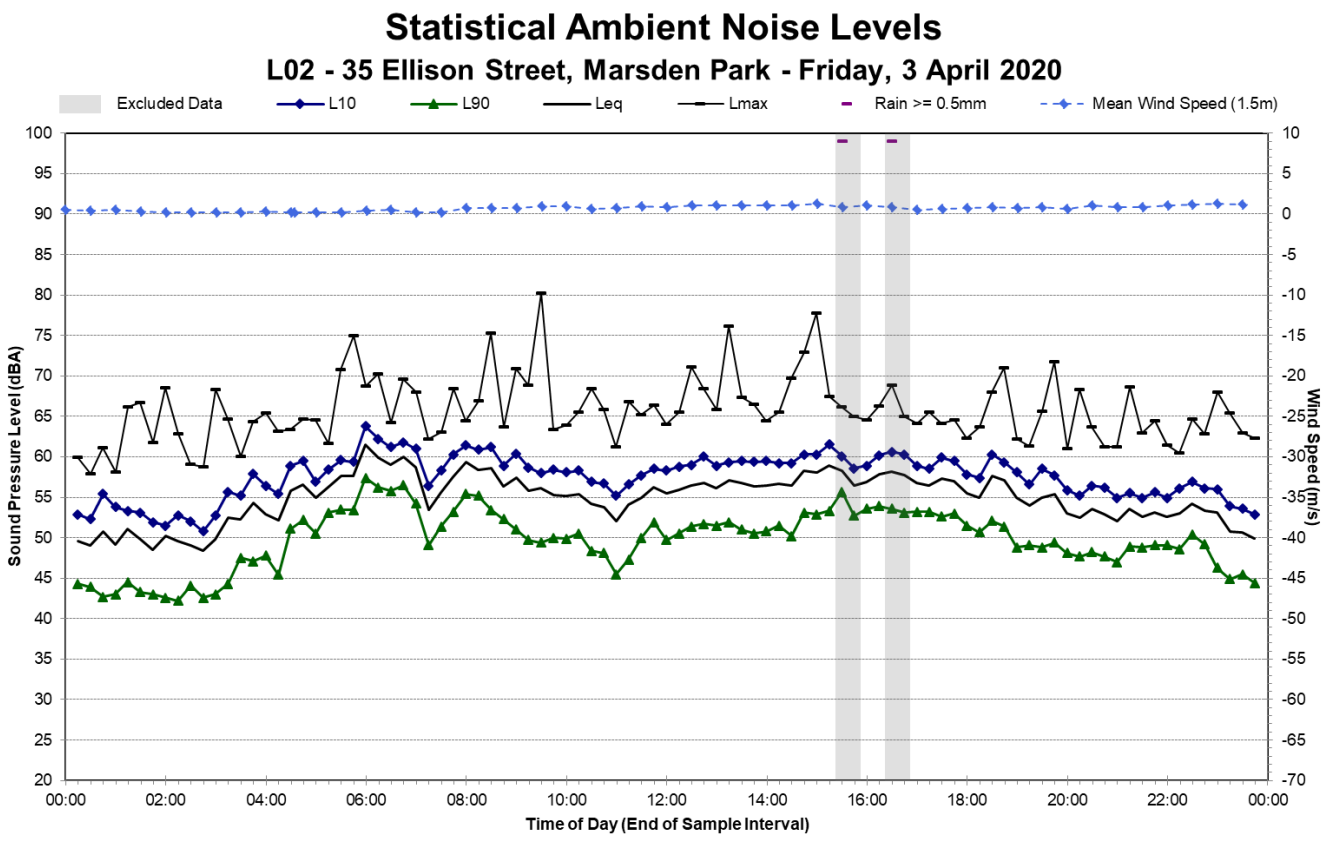
Attended Noise Measurement Results

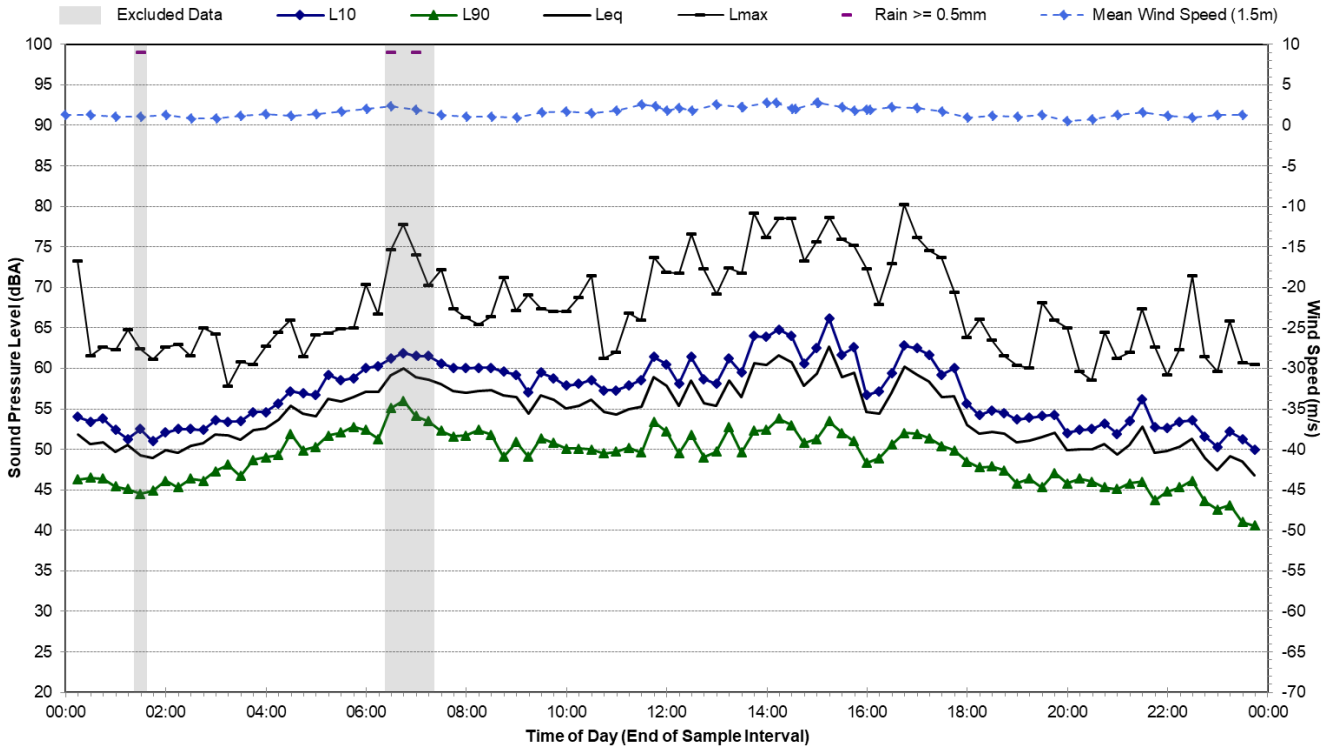
Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
01/04/2020	19:59	50	55	63

Photo of Noise Monitoring Location


Statistical Ambient Noise Levels
L02 - 35 Ellison Street, Marsden Park - Wednesday, 1 April 2020
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

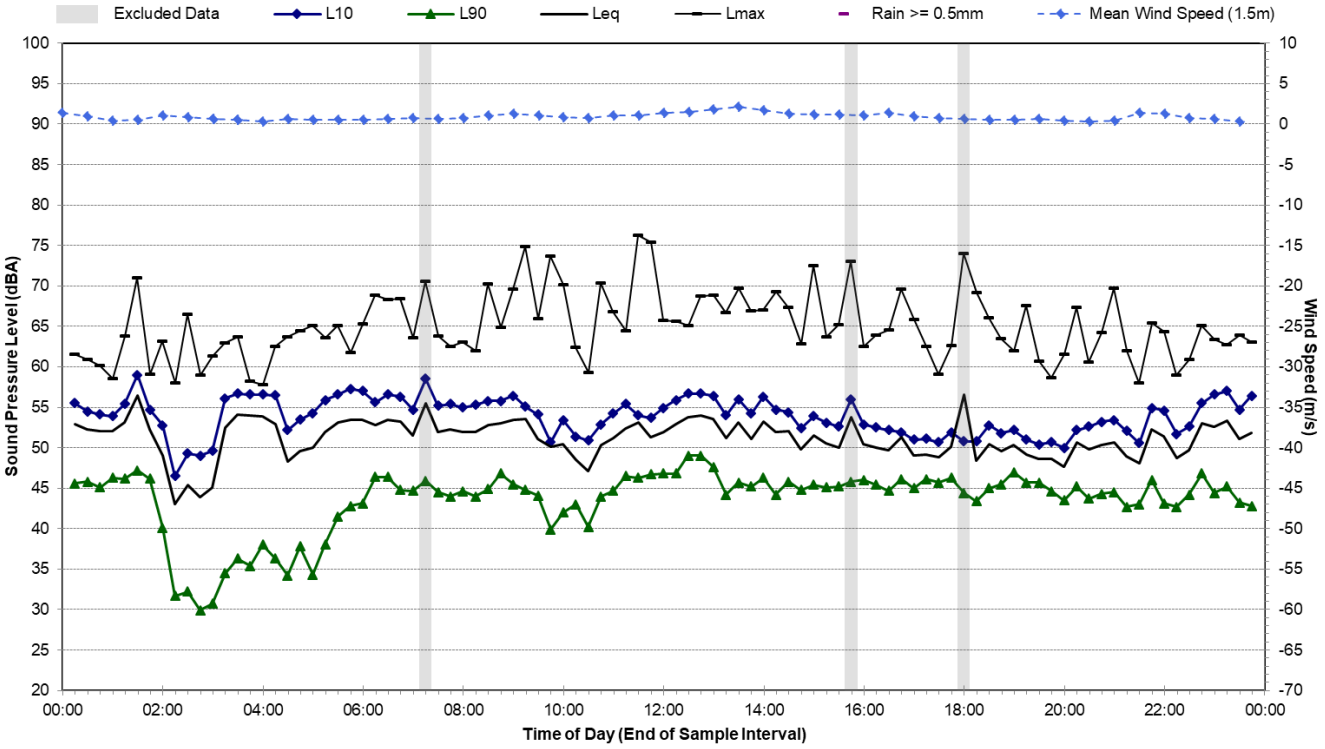

Statistical Ambient Noise Levels
L02 - 35 Ellison Street, Marsden Park - Thursday, 2 April 2020
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - 35 Ellison Street, Marsden Park - Friday, 3 April 2020
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - 35 Ellison Street, Marsden Park - Saturday, 4 April 2020
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

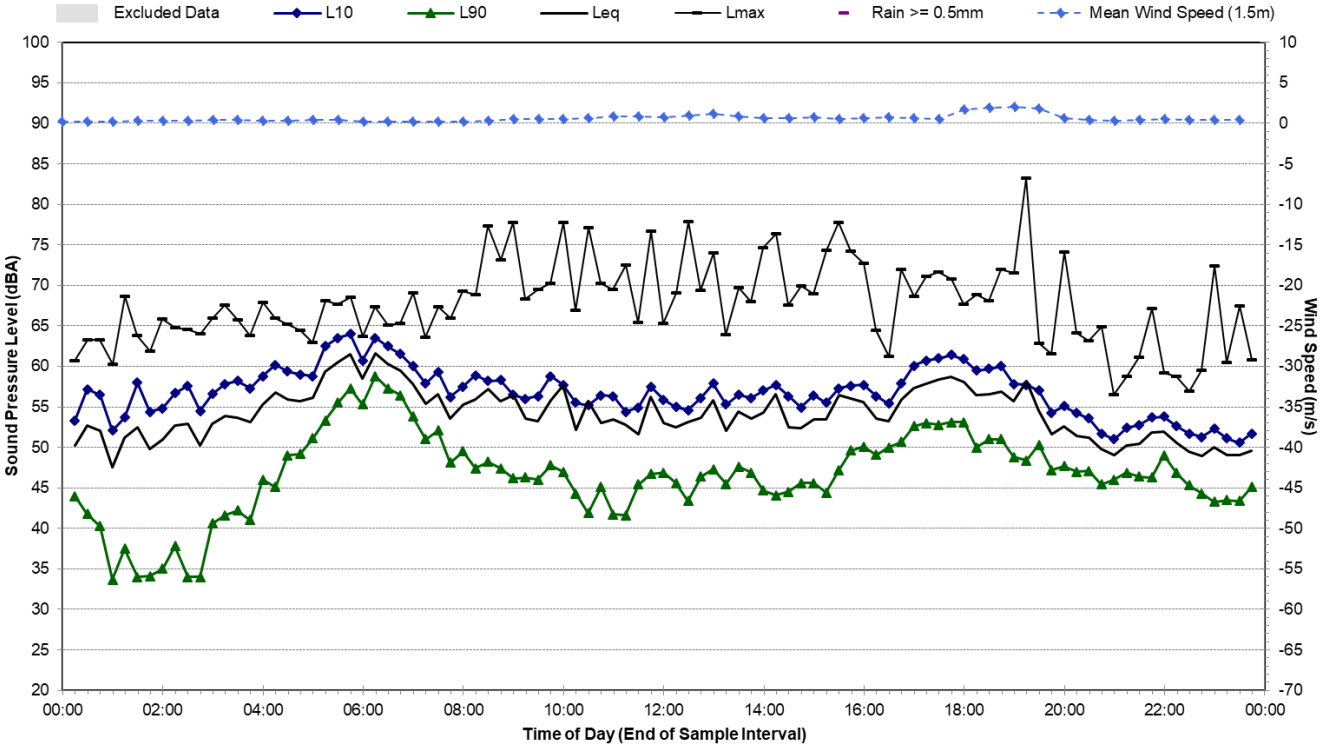
Statistical Ambient Noise Levels

L02 - 35 Ellison Street, Marsden Park - Sunday, 5 April 2020



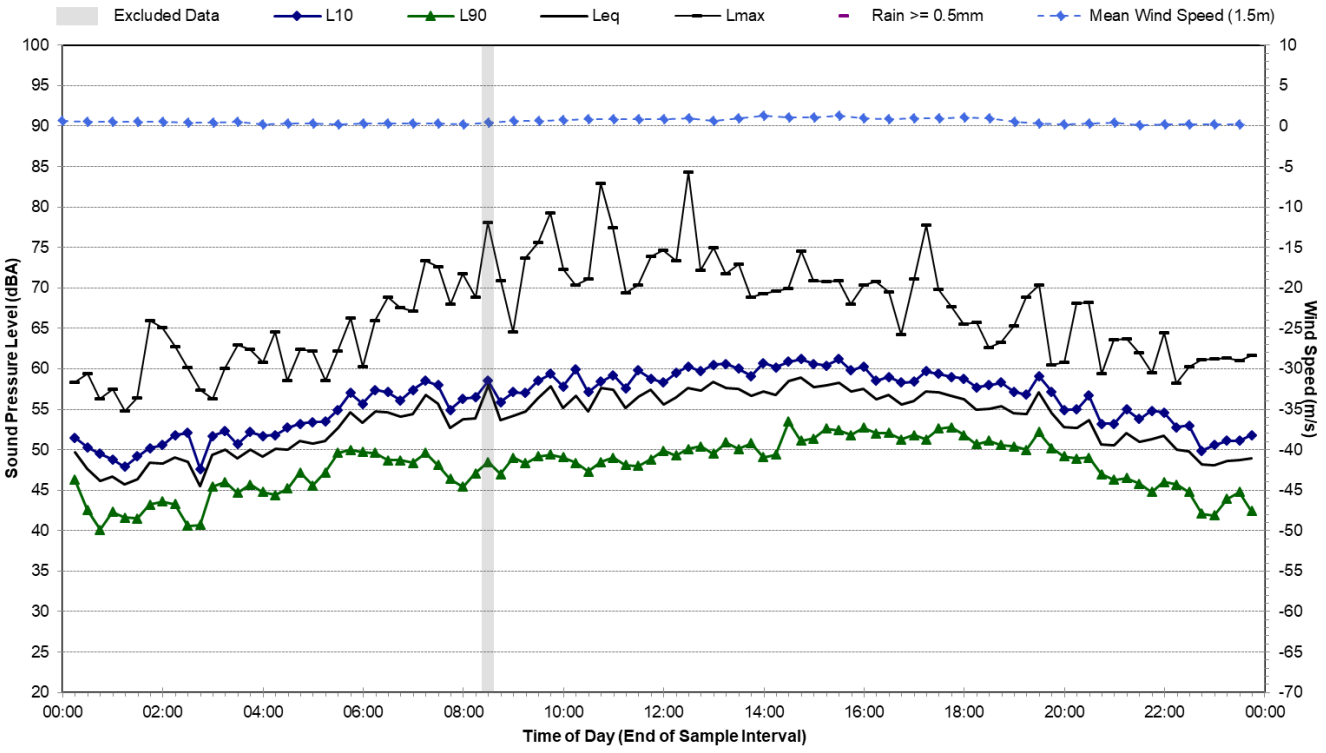
Statistical Ambient Noise Levels

L02 - 35 Ellison Street, Marsden Park - Monday, 6 April 2020



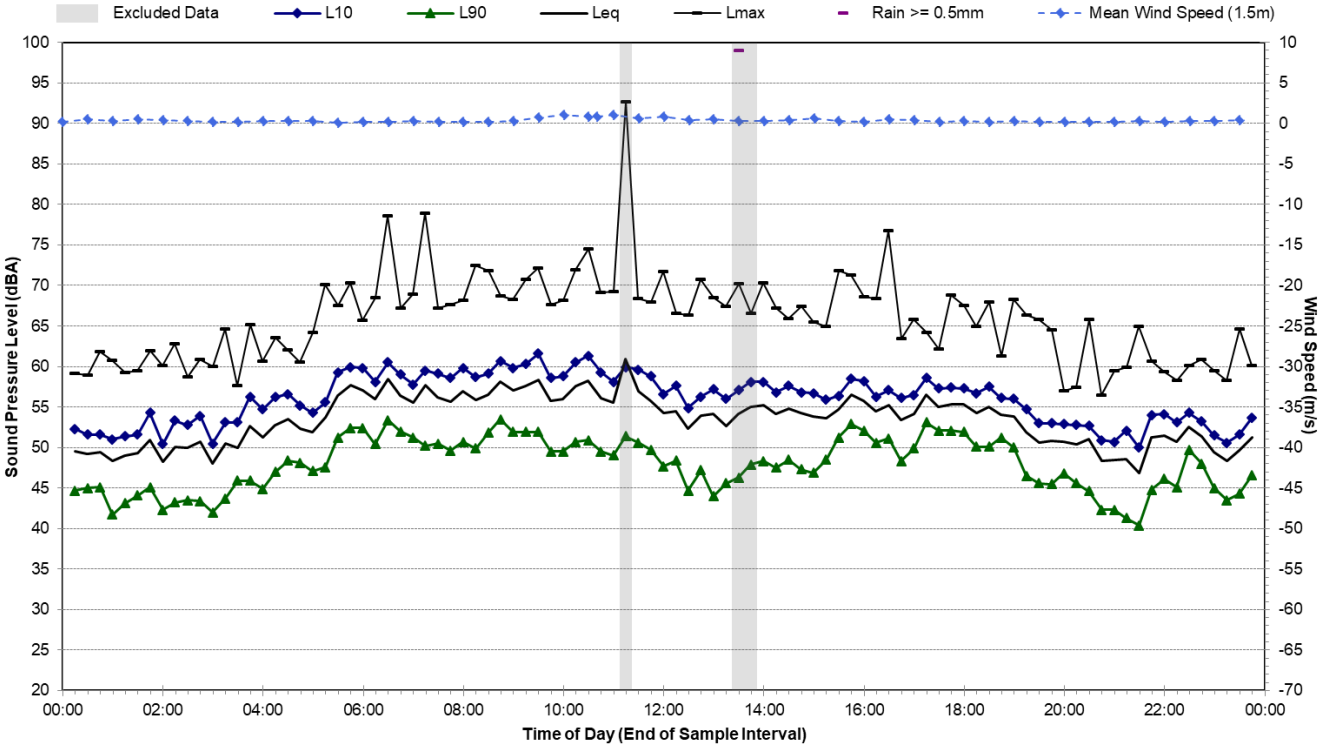
Statistical Ambient Noise Levels

L02 - 35 Ellison Street, Marsden Park - Tuesday, 7 April 2020



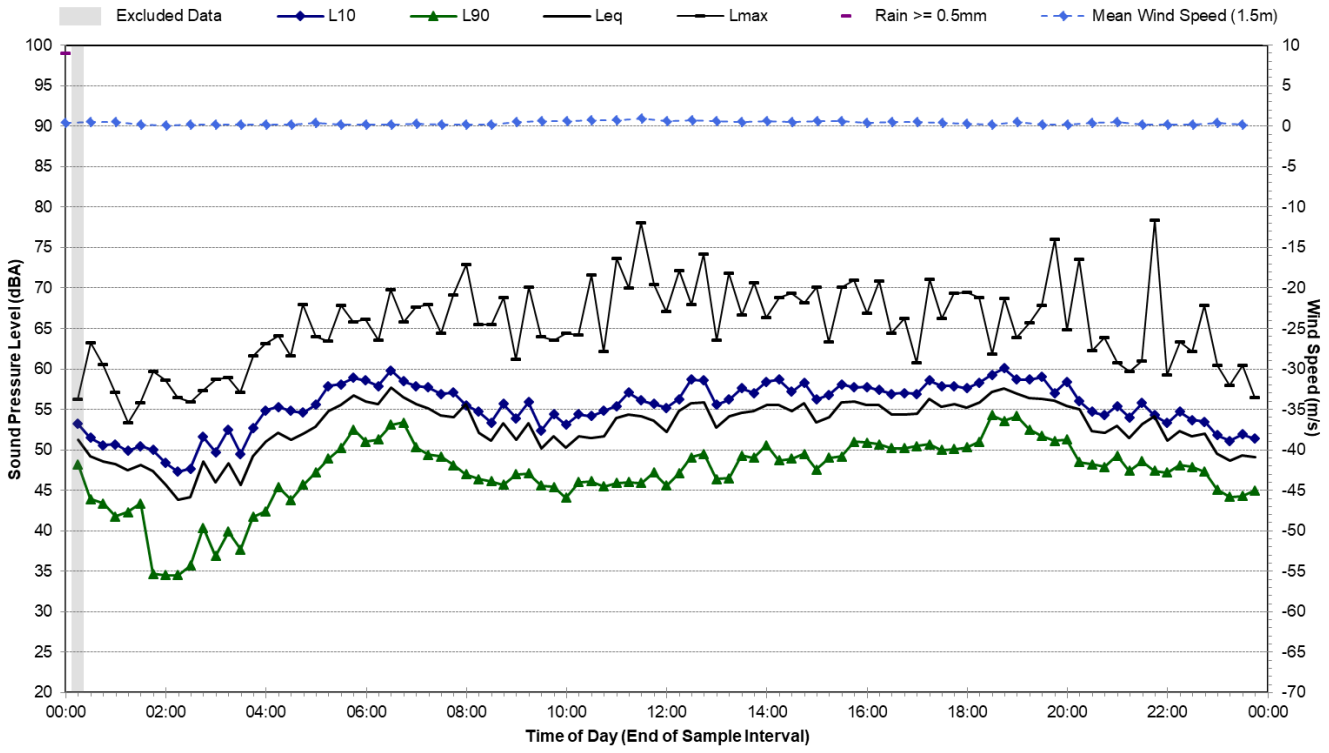
Statistical Ambient Noise Levels

L02 - 35 Ellison Street, Marsden Park - Wednesday, 8 April 2020



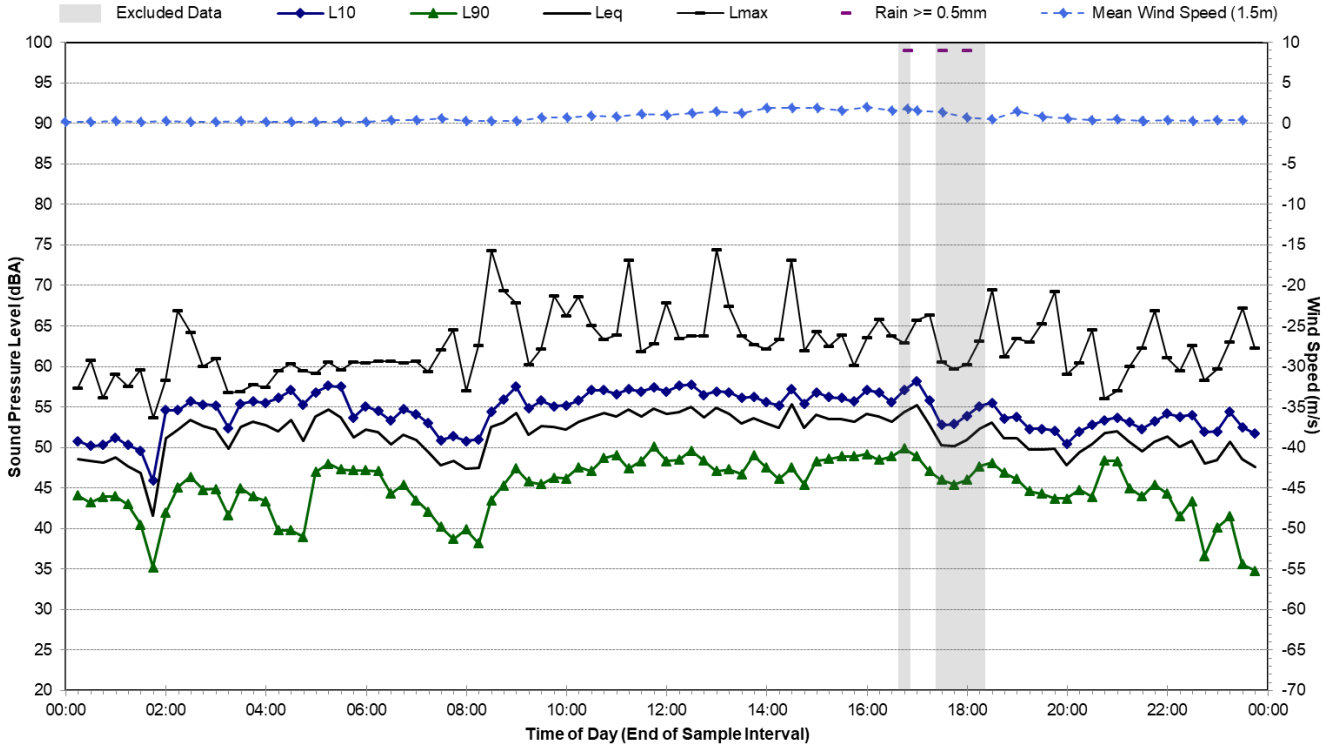
Statistical Ambient Noise Levels

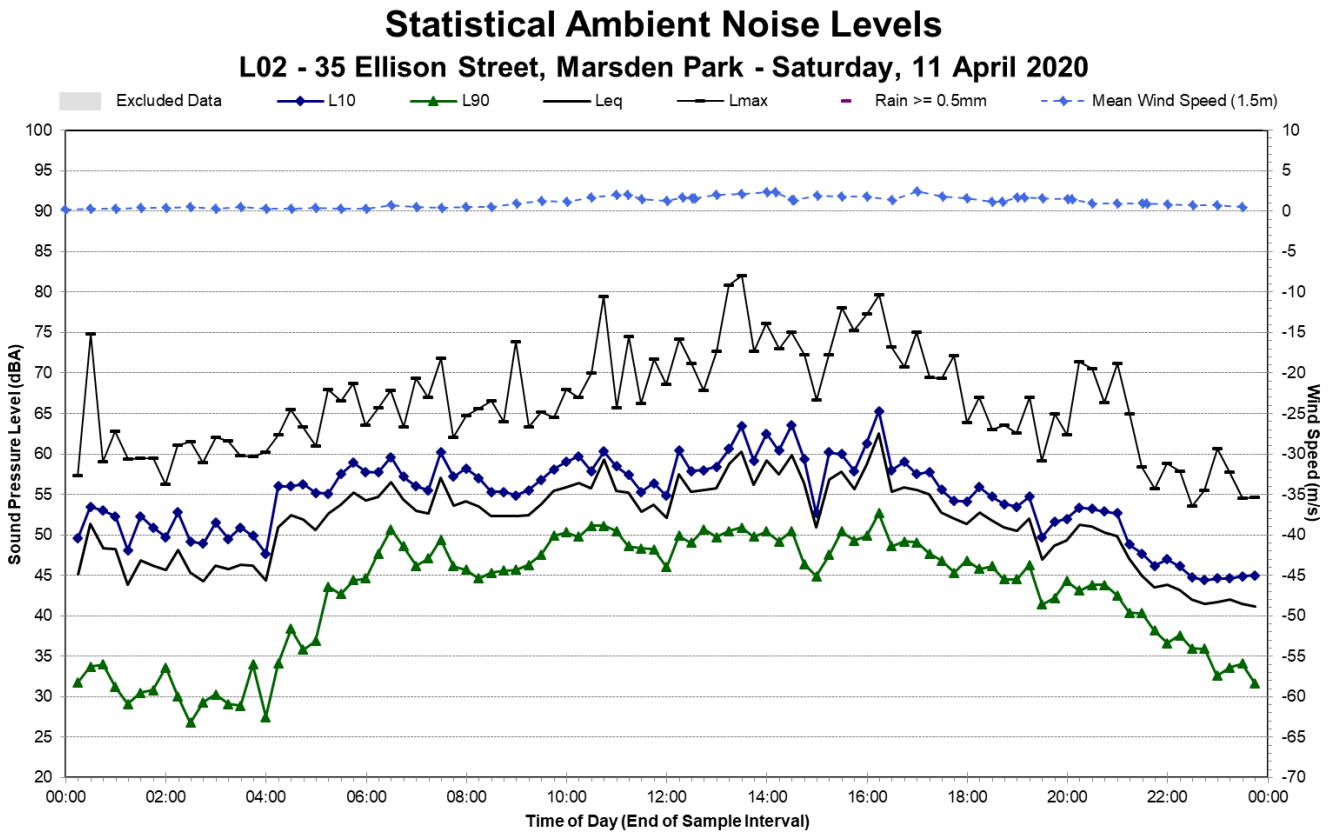
L02 - 35 Ellison Street, Marsden Park - Thursday, 9 April 2020

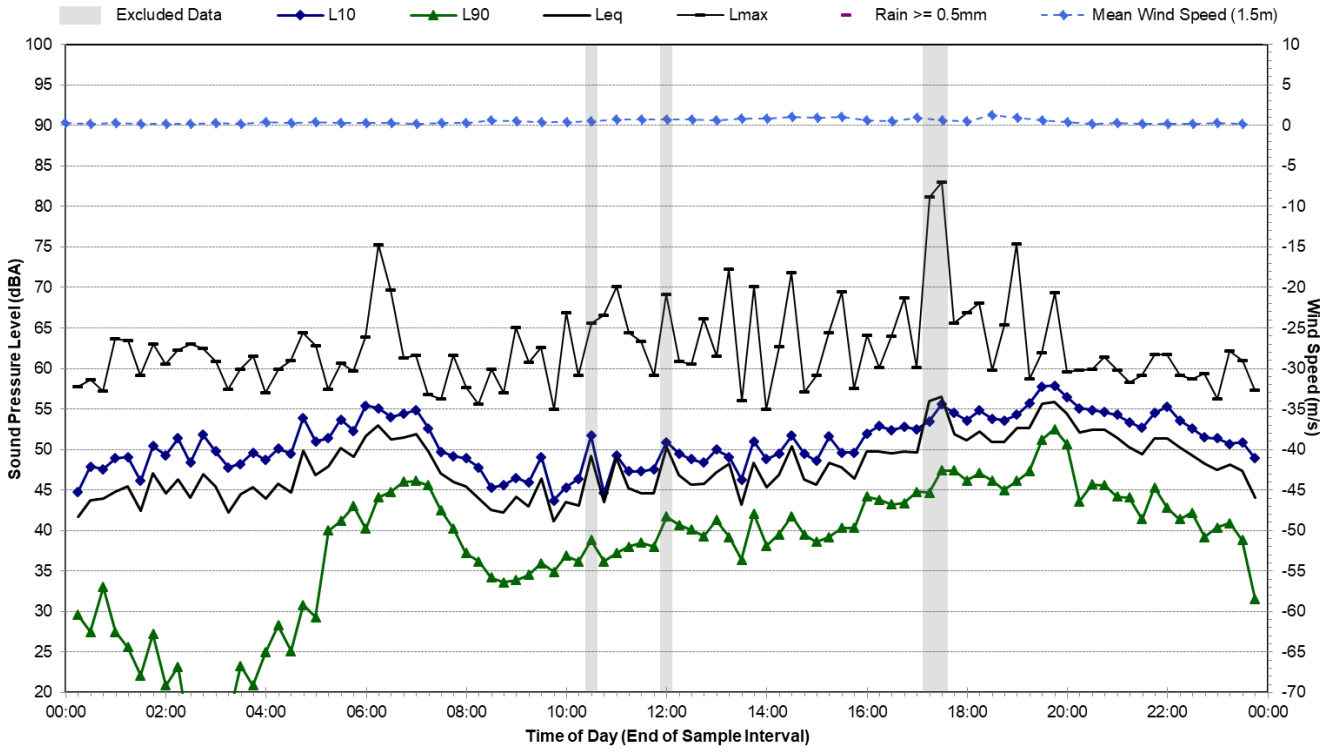


Statistical Ambient Noise Levels

L02 - 35 Ellison Street, Marsden Park - Friday, 10 April 2020

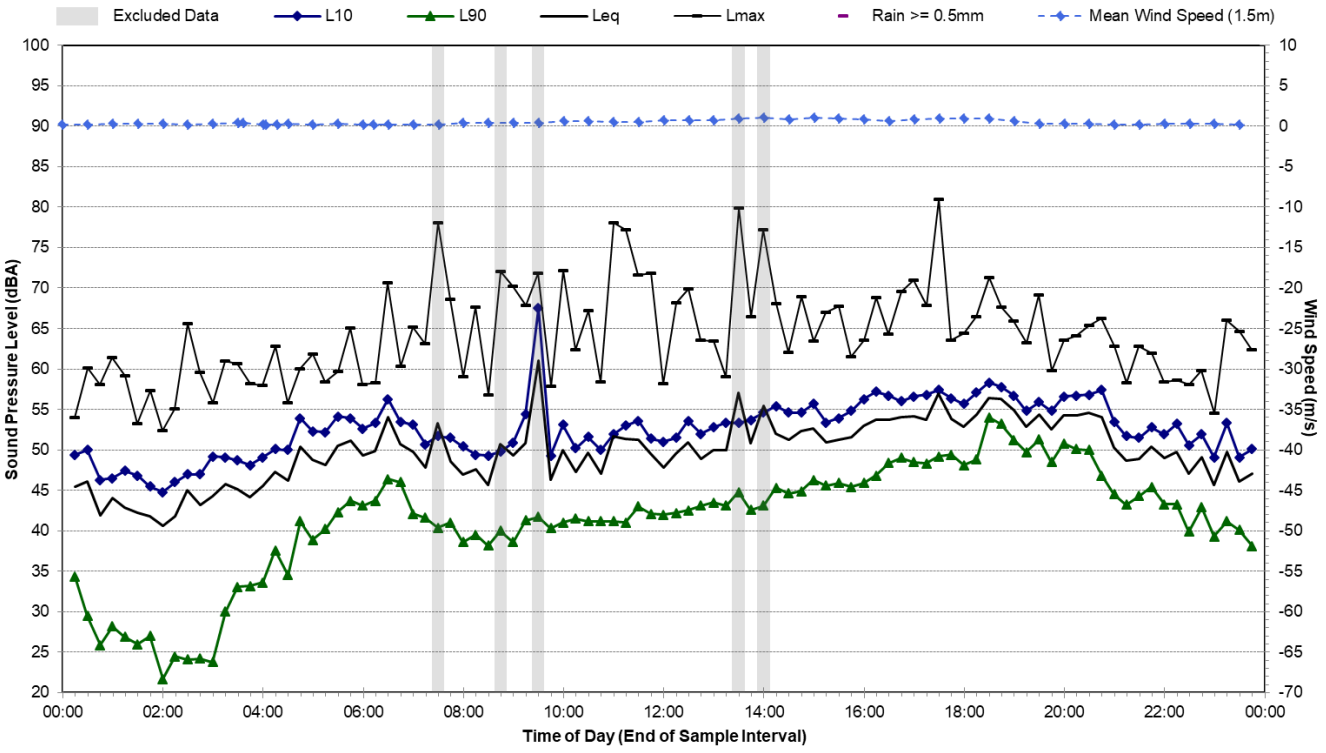



Statistical Ambient Noise Levels
L02 - 35 Ellison Street, Marsden Park - Saturday, 11 April 2020
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - 35 Ellison Street, Marsden Park - Sunday, 12 April 2020
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

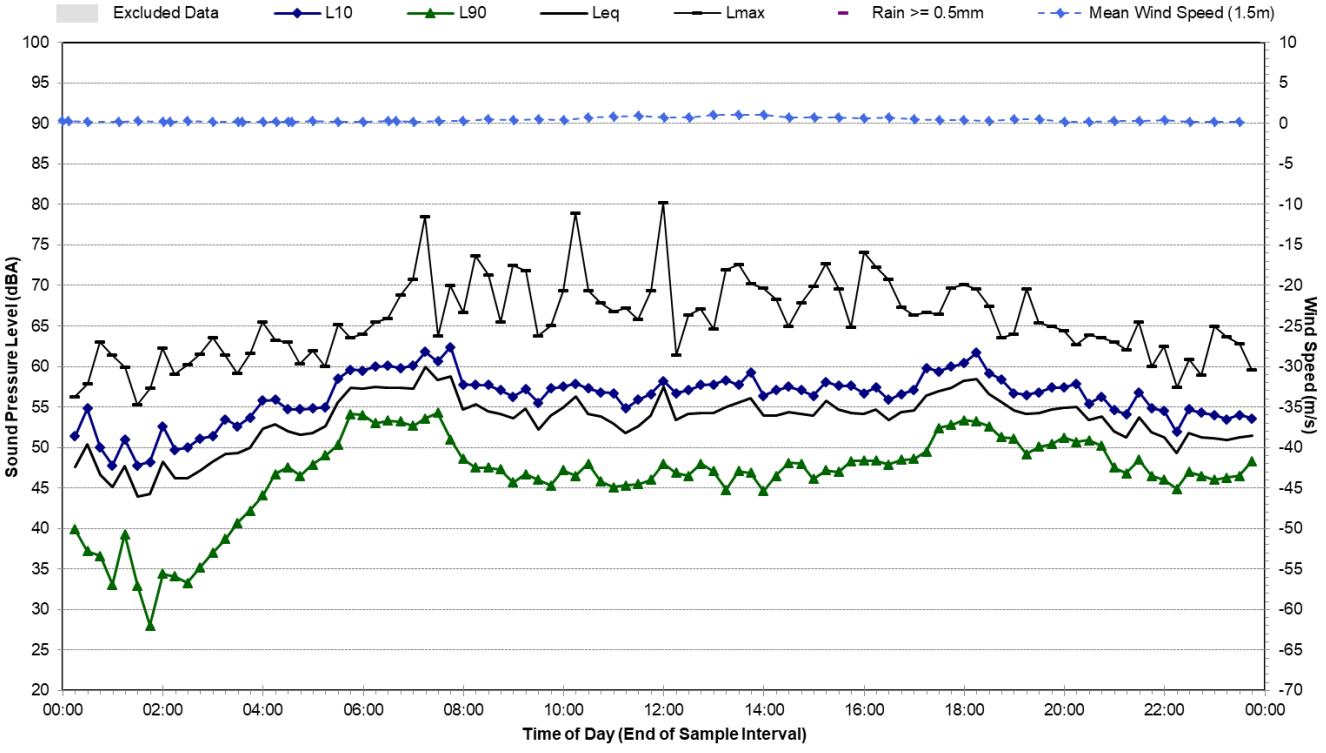
Statistical Ambient Noise Levels

L02 - 35 Ellison Street, Marsden Park - Monday, 13 April 2020



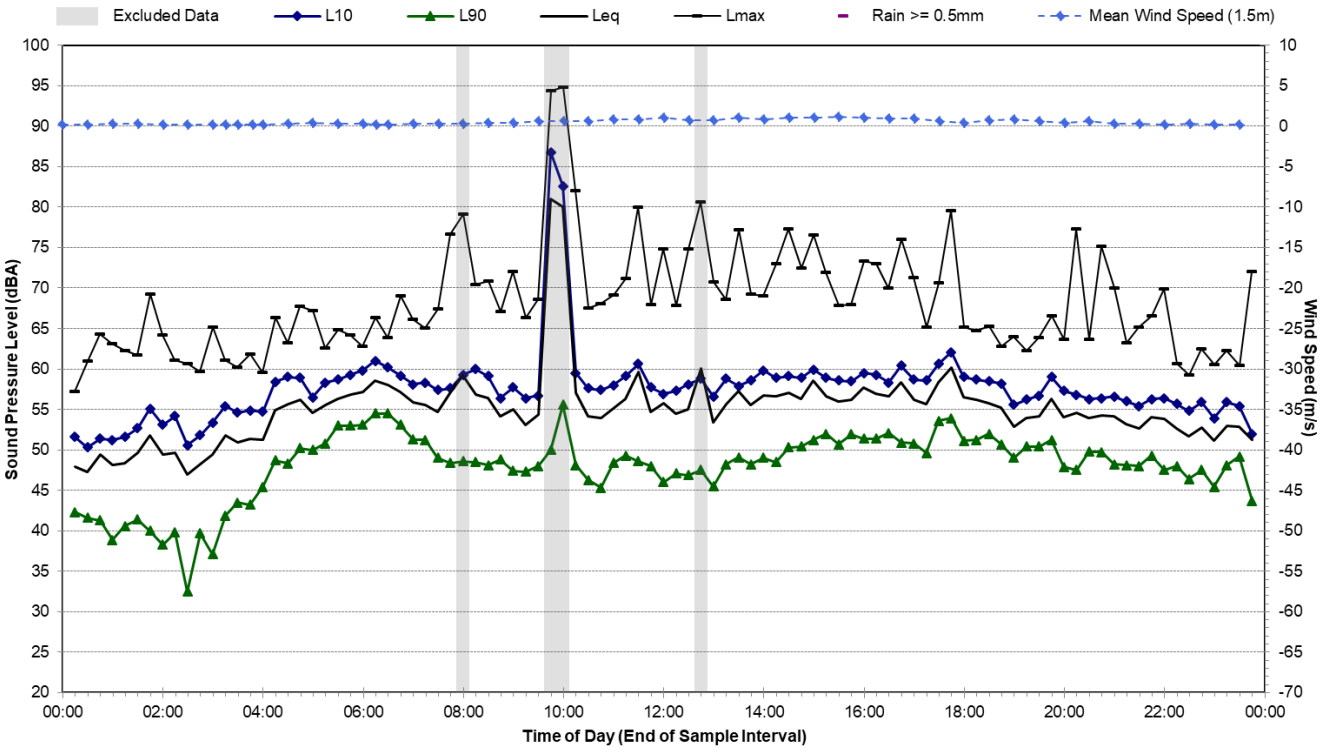
Statistical Ambient Noise Levels

L02 - 35 Ellison Street, Marsden Park - Tuesday, 14 April 2020



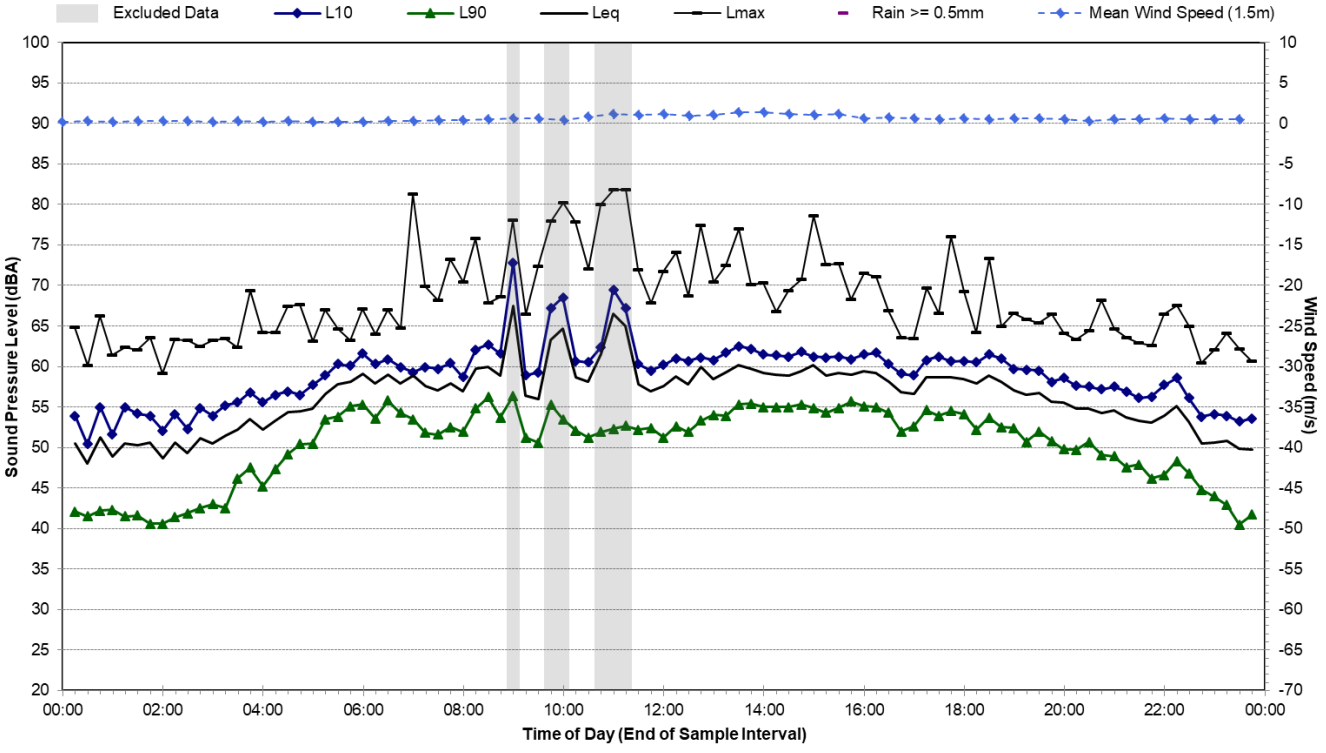
Statistical Ambient Noise Levels

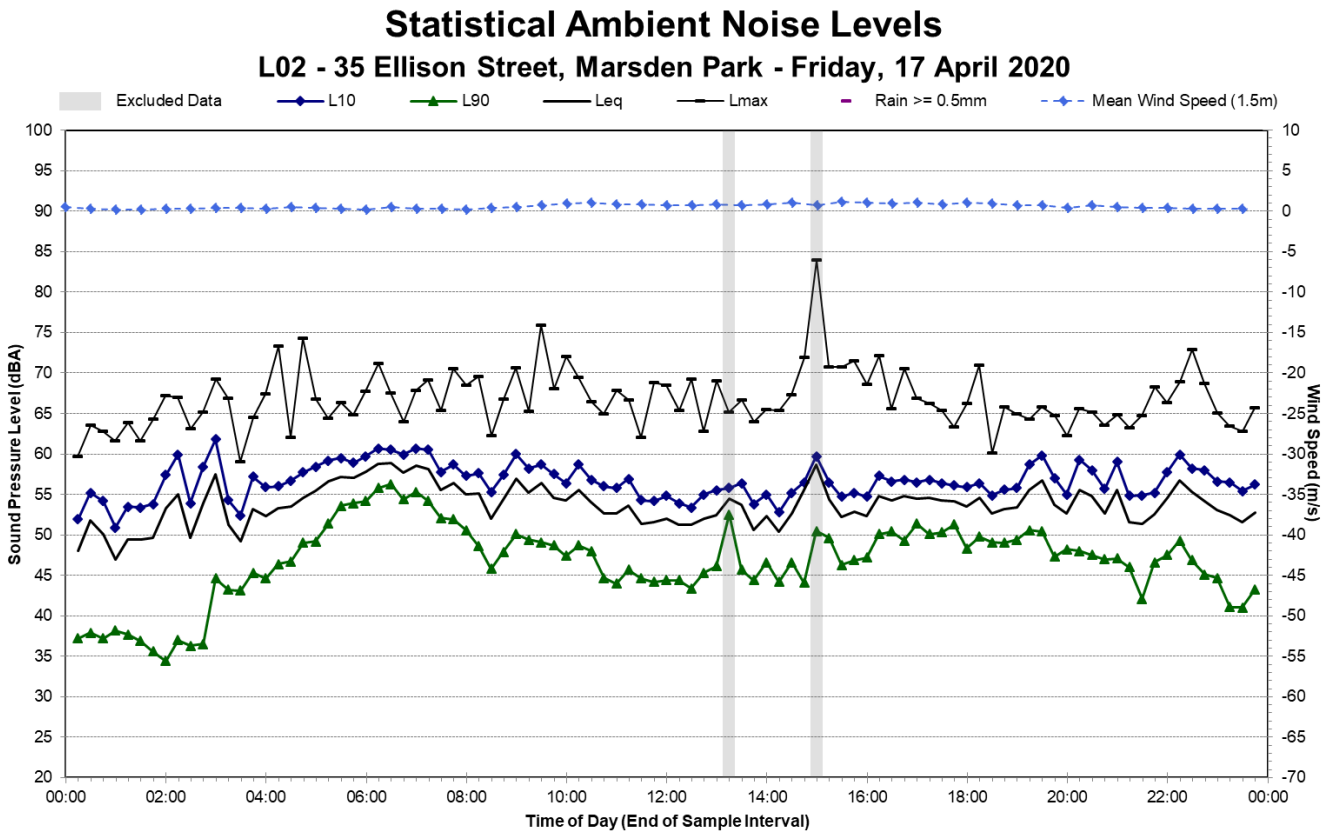
L02 - 35 Ellison Street, Marsden Park - Wednesday, 15 April 2020

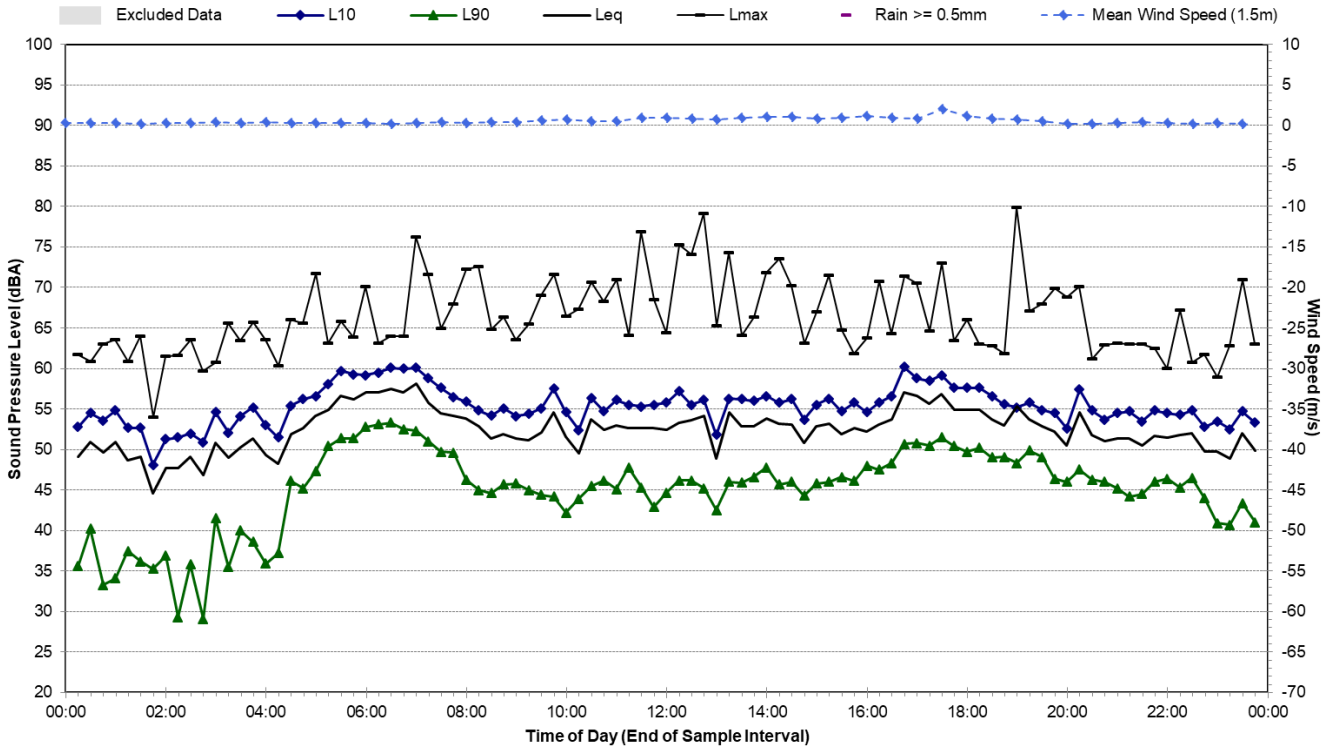


Statistical Ambient Noise Levels

L02 - 35 Ellison Street, Marsden Park - Thursday, 16 April 2020

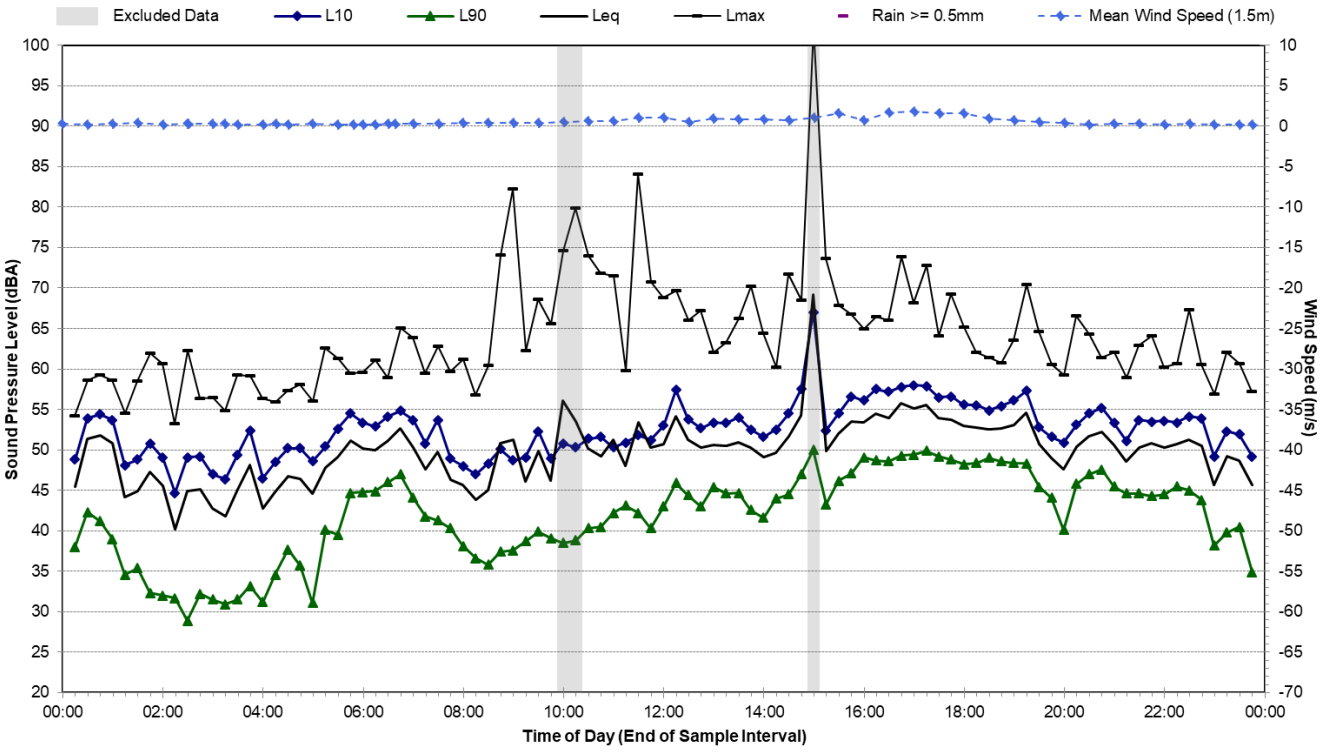



Statistical Ambient Noise Levels
L02 - 35 Ellison Street, Marsden Park - Friday, 17 April 2020
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)


Statistical Ambient Noise Levels
L02 - 35 Ellison Street, Marsden Park - Saturday, 18 April 2020
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)

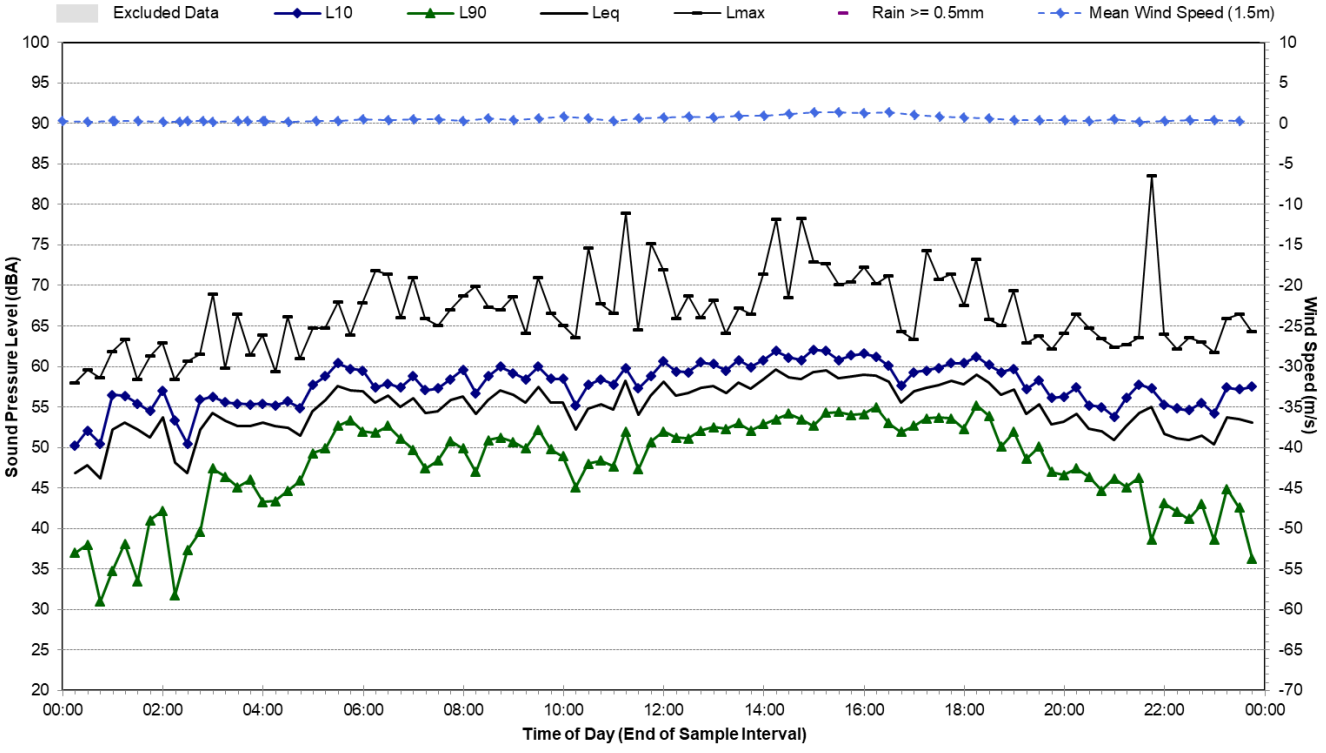
Statistical Ambient Noise Levels

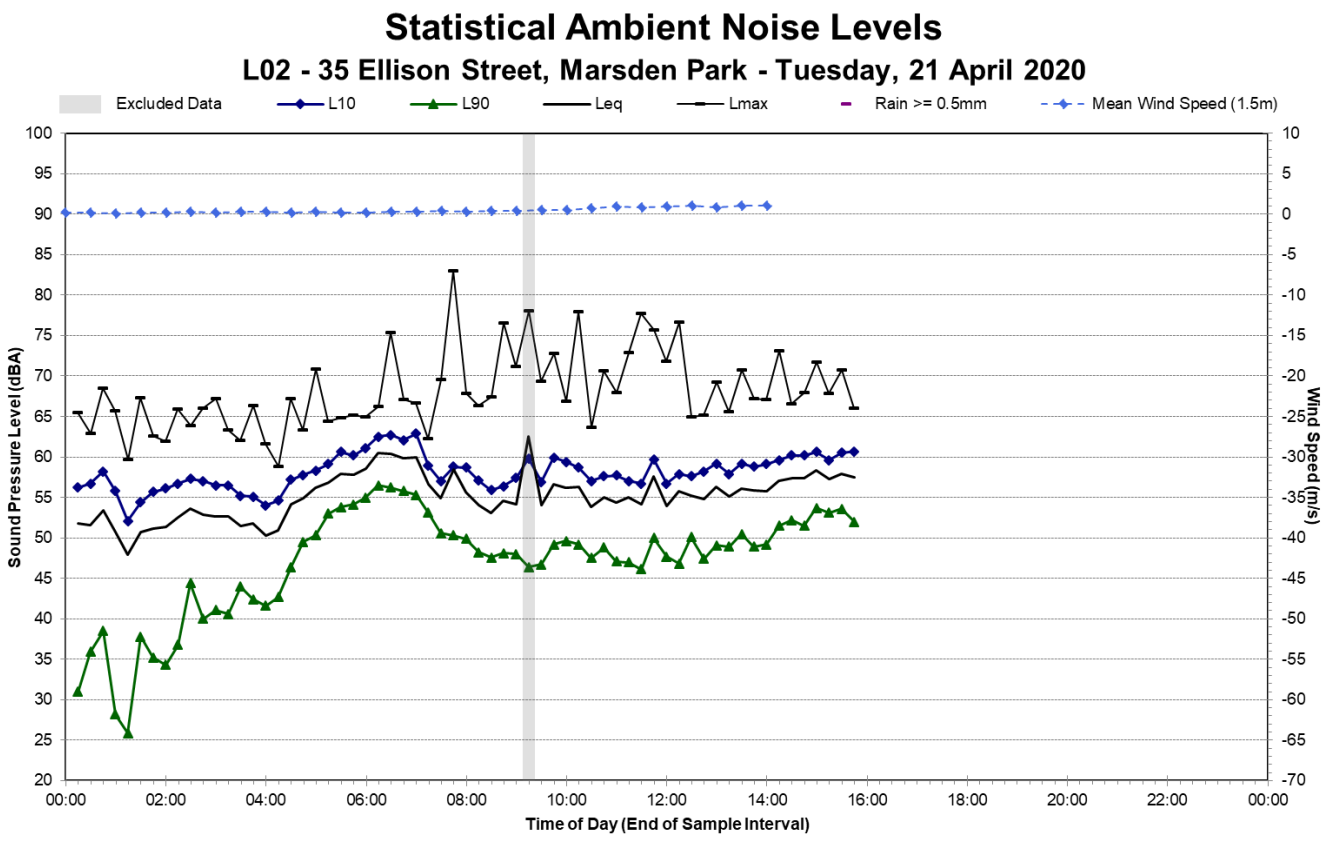
L02 - 35 Ellison Street, Marsden Park - Sunday, 19 April 2020



Statistical Ambient Noise Levels

L02 - 35 Ellison Street, Marsden Park - Monday, 20 April 2020




Statistical Ambient Noise Levels
L02 - 35 Ellison Street, Marsden Park - Tuesday, 21 April 2020
Excluded Data
L10
L90
Leq
Lmax
Rain >= 0.5mm
Mean Wind Speed (1.5m)
Sound Pressure Level (dBA)
Wind Speed (m/s)
Time of Day (End of Sample Interval)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
-55
-60
-65
-70
00:00
02:00
04:00
06:00
08:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
00:00

APPENDIX C

Construction Information

Table 1 Equipment Lists and Sound Power Levels

Equipment		Back Hoe (7.5 tonne JCB)	Bobcat	Chainsaw[1]	Chipper	Concrete Mixer Truck	Concrete Pump	Concrete Saw[1]	Concrete Vibrator	Excavator Breaker[1]	Excavator (22 tonne)	Grader	Hand Tools	Lighting Diesel Generator	Line Marking Plant	Mobile Crane Franna	Paving Machine	Roller Vibratory (12 tonne)[1]	Suction Truck	Truck	Underbore Rig
Sound Power Level[2]		102	104	114	120	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
W.02	Early Works / Utilities - Typical Works	X														X				X	X
W.03	Early Works / Utilities – OOHWs Noise Intensive Works	X								X			X	X		X				X	
W.04	Early Works / Utilities – OOHWs Typical Works	X											X	X		X				X	
W.05	Compounds – Site Establishment	X	X	X		X					X	X		X		X				X	
W.06	Vegetation Clearing			X	X								X							X	
W.07	Road Works - Northbound					X	X			X	X	X					X	X		X	X
W.08	Road Works - Southbound					X	X			X	X	X					X	X		X	X
W.09	Road Works - Pavement Works - Noise Intensive Works					X	X		X			X	X	X			X	X		X	
W.10	Road Works - Pavement Works – Typical Works					X	X		X				X	X			X				
W.11	Finishing Works	X	X			X			X				X		X	X				X	
W.12	Compound - Operation												X			X				X	
W.13	Floor Storage Area - Earthworks										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
Daytime	W.01	Early Works / Utilities - Noise Intensive Works	76	63	50
	W.02	Early Works / Utilities - Typical Works	63	50	37
	W.03	Early Works / Utilities – OOHWs Noise Intensive Works	-	-	-
	W.04	Early Works / Utilities – OOHWs Typical Works	-	-	-
	W.05	Compounds – Site Establishment	71	57	46
	W.06	Vegetation Clearing	76	63	50
	W.07	Road Works - Northbound	76	62	51
	W.08	Road Works - Southbound	71	62	51
	W.09	Road Works - Pavement Works - Noise Intensive Works	72	58	47
	W.10	Road Works - Pavement Works – Typical Works	66	52	41
	W.11	Finishing Works	67	53	42
	W.12	Compound - Operation	53	37	<30
Evening	W.01	Early Works / Utilities - Noise Intensive Works	-	-	-
	W.02	Early Works / Utilities - Typical Works	-	-	-
	W.03	Early Works / Utilities – OOHWs Noise Intensive Works	73	60	47
	W.04	Early Works / Utilities – OOHWs Typical Works	62	49	36
	W.05	Compounds – Site Establishment	-	-	-
	W.06	Vegetation Clearing	-	-	-
	W.07	Road Works - Northbound	-	-	-
	W.08	Road Works - Southbound	-	-	-
	W.09	Road Works - Pavement Works - Noise Intensive Works	72	58	47
	W.10	Road Works - Pavement Works – Typical Works	66	52	41
	W.11	Finishing Works	67	53	42
	W.12	Compound - Operation	53	37	<30
Night-time	W.01	Early Works / Utilities - Noise Intensive Works	-	-	-
	W.02	Early Works / Utilities - Typical Works	-	-	-
	W.03	Early Works / Utilities – OOHWs Noise Intensive Works	73	60	47
	W.04	Early Works / Utilities – OOHWs Typical Works	62	49	36
	W.05	Compounds – Site Establishment	71	57	46
	W.06	Vegetation Clearing	-	-	-
	W.07	Road Works - Northbound	-	-	-
	W.08	Road Works - Southbound	-	-	-
	W.09	Road Works - Pavement Works - Noise Intensive Works	72	58	47
	W.10	Road Works - Pavement Works – Typical Works	66	52	41
	W.11	Finishing Works	67	53	42
	W.12	Compound - Operation	53	37	<30

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

Period	ID	Scenario	NCA01	NCA02	NCA03
Daytime	W.01	Early Works / Utilities - Noise Intensive Works	20	2	-
	W.02	Early Works / Utilities - Typical Works	7	-	-
	W.03	Early Works / Utilities – OOHWs Noise Intensive Works	-	-	-
	W.04	Early Works / Utilities – OOHWs Typical Works	-	-	-
	W.05	Compounds – Site Establishment	15	-	-
	W.06	Vegetation Clearing	20	2	-
	W.07	Road Works - Northbound	20	1	-
	W.08	Road Works - Southbound	15	1	-
	W.09	Road Works - Pavement Works - Noise Intensive Works	16	-	-
	W.10	Road Works - Pavement Works – Typical Works	10	-	-
	W.11	Finishing Works	11	-	-
	W.12	Compound - Operation	-	-	-
Evening	W.01	Early Works / Utilities - Noise Intensive Works	-	-	-
	W.02	Early Works / Utilities - Typical Works	-	-	-
	W.03	Early Works / Utilities – OOHWs Noise Intensive Works	23	10	-3
	W.04	Early Works / Utilities – OOHWs Typical Works	12	-	-
	W.05	Compounds – Site Establishment	-	-	-
	W.06	Vegetation Clearing	-	-	-
	W.07	Road Works - Northbound	-	-	-
	W.08	Road Works - Southbound	-	-	-
	W.09	Road Works - Pavement Works - Noise Intensive Works	22	8	-
	W.10	Road Works - Pavement Works – Typical Works	16	2	-
	W.11	Finishing Works	17	3	-
	W.12	Compound - Operation	3	-	-
Night-time	W.01	Early Works / Utilities - Noise Intensive Works	-	-	-
	W.02	Early Works / Utilities - Typical Works	-	-	-
	W.03	Early Works / Utilities – OOHWs Noise Intensive Works	33	22	9
	W.04	Early Works / Utilities – OOHWs Typical Works	22	11	-
	W.05	Compounds – Site Establishment	31	19	8
	W.06	Vegetation Clearing	-	-	-
	W.07	Road Works - Northbound	-	-	-
	W.08	Road Works - Southbound	-	-	-
	W.09	Road Works - Pavement Works - Noise Intensive Works	32	20	9
	W.10	Road Works - Pavement Works – Typical Works	26	14	3
	W.11	Finishing Works	27	15	4
	W.12	Compound - Operation	13	-	-

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 5 dB	6 15 dB	16 25 dB	>25 dB	1 5 dB	6 15 dB	16 25 dB	>25 dB	1 5 dB	6 15 dB	16 25 dB	>25 dB	1 5 dB	6 15 dB	>25 dB
W.01	Early Works / Utilities - Noise Intensive Works	1635	11	20	33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.02	Early Works / Utilities - Typical Works	1635	-	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.03	Early Works / Utilities – OOHWs Noise Intensive	1635	-	-	-	-	17	11	19	-	19	14	27	-	605	759	145	27	970	202	33
W.04	Early Works / Utilities – OOHWs Typical Works	1635	-	-	-	-	17	16	-	-	31	19	-	-	179	119	19	-	246	29	4
W.05	Compounds – Site Establishment	1635	-	90	13	-	-	-	-	-	-	-	-	-	726	540	114	15	279	60	11
W.06	Vegetation Clearing	1635	11	19	44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.07	Road Works - Northbound	1635	5	19	37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.08	Road Works - Southbound	1635	-	18	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.09	Road Works - Pavement Works - Noise Intensive	1635	-	10	15	-	15	10	15	-	17	11	18	-	706	655	119	18	341	64	12
W.10	Road Works - Pavement Works – Typical Works	1635	-	37	-	-	48	37	-	-	76	38	1	-	402	229	38	1	170	30	-
W.11	Finishing Works	1635	-	38	1	-	76	38	1	-	97	35	5	-	481	271	35	5	271	35	5
W.12	Compound - Operation	1635	-	-	-	-	3	-	-	-	6	-	-	-	68	35	-	-	133	16	-

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 5 dB	6 15 dB	16 25 dB	>25 dB	1 5 dB	6 15 dB	16 25 dB	>25 dB	1 5 dB	6 15 dB	16 25 dB	>25 dB	1 5 dB	6 15 dB	>25 dB
W.01	Early Works / Utilities - Noise Intensive Works	127	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.02	Early Works / Utilities - Typical Works	127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.03	Early Works / Utilities – OOHWs Noise Intensive	127	-	-	-	-	3	-	-	-	-	4	-	-	24	15	4	-	30	4	-
W.04	Early Works / Utilities – OOHWs Typical Works	127	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	4	-	-
W.05	Compounds – Site Establishment	127	-	-	-	-	-	-	-	-	-	-	-	-	28	5	2	-	3	1	-
W.06	Vegetation Clearing	127	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.07	Road Works - Northbound	127	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.08	Road Works - Southbound	127	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.09	Road Works - Pavement Works - Noise Intensive	127	-	-	-	-	1	-	-	-	2	2	-	-	23	11	4	-	3	1	-
W.10	Road Works - Pavement Works – Typical Works	127	-	-	-	-	-	-	-	-	1	-	-	-	4	4	-	-	4	-	-
W.11	Finishing Works	127	-	-	-	-	-	-	-	-	2	-	-	-	11	4	-	-	4	-	-
W.12	Compound - Operation	127	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	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 5 dB	6 15 dB	16 25 dB	>25 dB	1 5 dB	6 15	16 25 dB	>25 dB	1 5 dB	6 15	16 25	>25 dB	1 5 dB	6 15 dB	>25 dB
W.01	Early Works / Utilities - Noise Intensive Works	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.02	Early Works / Utilities - Typical Works	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.03	Early Works / Utilities – OOHWs Noise	17	-	-	-	-	-	-	-	-	-	-	-	-	1	10	-	-	11	-	-
W.04	Early Works / Utilities – OOHWs Typical Works	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.05	Compounds – Site Establishment	17	-	-	-	-	-	-	-	-	-	-	-	-	1	10	-	-	-	-	-
W.06	Vegetation Clearing	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.07	Road Works - Northbound	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.08	Road Works - Southbound	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W.09	Road Works - Pavement Works - Noise	17	-	-	-	-	-	-	-	-	-	-	-	-	1	10	-	-	7	-	-
W.10	Road Works - Pavement Works – Typical Works	17	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-
W.11	Finishing Works	17	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-	-
W.12	Compound - Operation	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

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 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 8 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
Richmond Road – 600m North of Elara Boulevard (Northbound)	15038	2441	3517	530	13573	2203	3175	479
Richmond Road – 600m North of Elara Boulevard (Southbound)	15038	2441	3517	530	13573	2203	3175	479
Richmond Road – 150m North of Elara Boulevard (Northbound)	14766	2830	3319	612	13327	2554	2996	552
Richmond Road – 150m North of Elara Boulevard (Southbound)	14766	2830	3319	612	13327	2554	2996	552
Bandon Rd (Eastbound)	0	0	0	0	10991	1787	1615	233
Bandon Rd (Westbound)	0	0	0	0	10991	1787	1615	233
Richmond Rd – 150m south of Elara Boulevard (Northbound)	14863	2943	3171	494	22165	4388	4729	737
Richmond Rd – 150m south of Elara Boulevard (Southbound)	14863	2943	3171	494	22165	4388	4729	737
Elara Boulevard (Eastbound)	3117	322	456	41	4955	512	725	65
Elara Boulevard (Westbound)	3117	322	456	41	4955	512	725	65

Table 2 Traffic Volumes – Build (With Project)

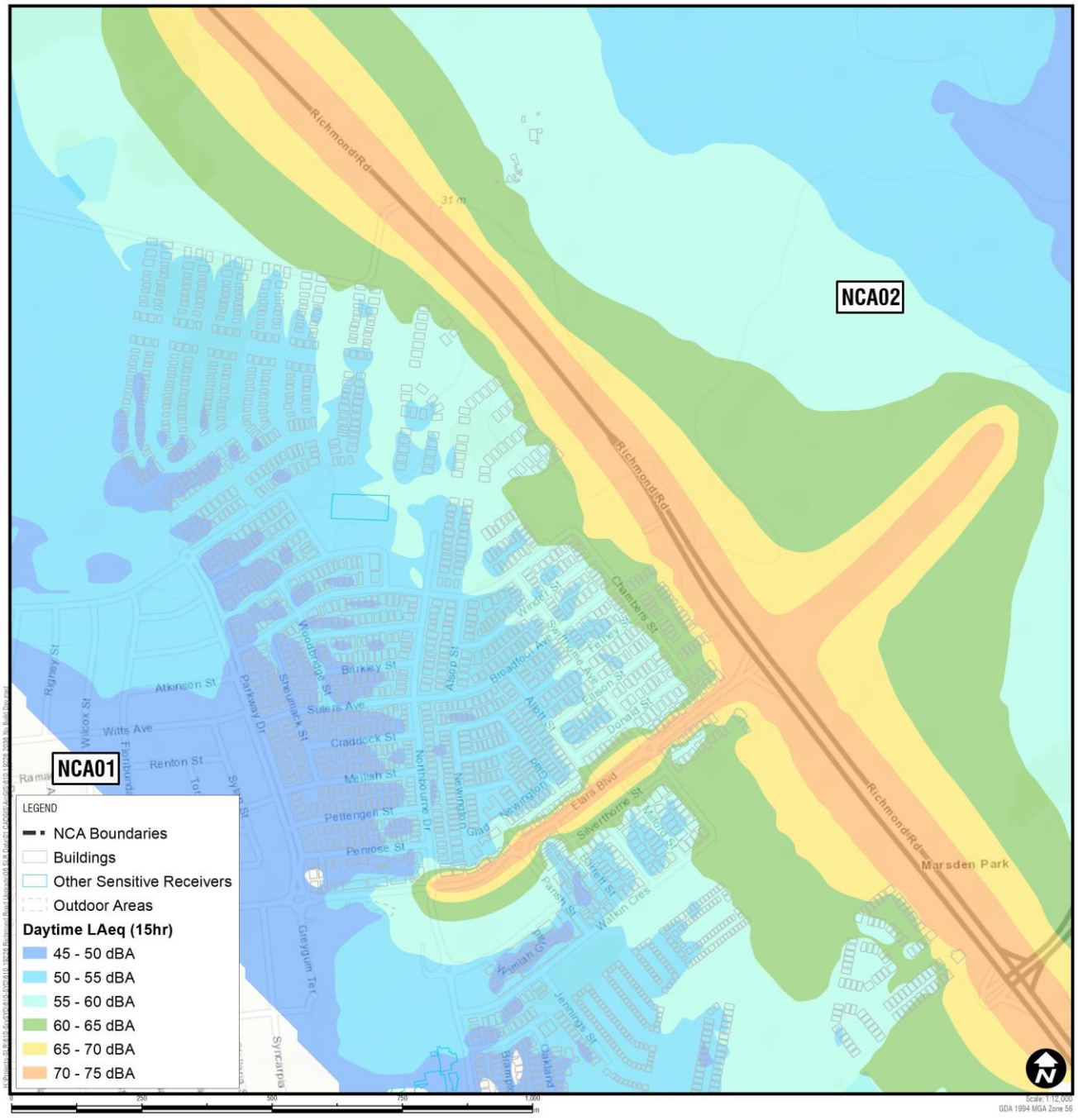
Section ID	2026				2036			
	Day Light	Day Heavy	Night Light	Night Heavy	Day Light	Day Heavy	Night Light	Night Heavy
Richmond Road – 600m North of Elara Boulevard (Northbound)	13451	2184	3146	474	14123	2293	3303	498
Richmond Road – 600m North of Elara Boulevard (Southbound)	13451	2184	3146	474	14123	2293	3303	498
Richmond Road – 150m North of Elara Boulevard (Northbound)	13654	2617	3069	566	15228	2918	3423	631
Richmond Road – 150m North of Elara Boulevard (Southbound)	13654	2617	3069	566	15228	2918	3423	631
Bandon Rd (Eastbound)	0	0	0	0	8353	1358	1227	177
Bandon Rd (Westbound)	0	0	0	0	8353	1358	1227	177
Richmond Rd – 150m south of Elara Boulevard (Northbound)	18084	3580	3858	601	22515	4458	4804	748
Richmond Rd – 150m south of Elara Boulevard (Southbound)	18084	3580	3858	601	22515	4458	4804	748
Elara Boulevard (Eastbound)	3796	393	556	50	5093	527	746	67
Elara Boulevard (Westbound)	3796	393	556	50	5093	527	746	67

Table 3 Traffic Volumes – Validation

Section ID	2019			
	Day Light	Day Heavy	Night Light	Night Heavy
Richmond Road – 600m North of Elara Boulevard (Northbound)	9451	1615	1547	173
Richmond Road – 600m North of Elara Boulevard (Southbound)	8409	1182	2534	435
Richmond Road – 150m North of Elara Boulevard (Northbound)	9082	1897	1480	179
Richmond Road – 150m North of Elara Boulevard (Southbound)	8058	1514	1386	530
Elara Boulevard (Eastbound)	6035	641	942	41
Elara Boulevard (Westbound)	6228	584	817	114
Richmond Rd – 150m south of Elara Boulevard (Northbound)	12341	2433	1864	302
Richmond Rd – 150m south of Elara Boulevard (Southbound)	11320	2005	3084	445

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

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

Build 2036 Night-time

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

Existing Maximum Noise Levels

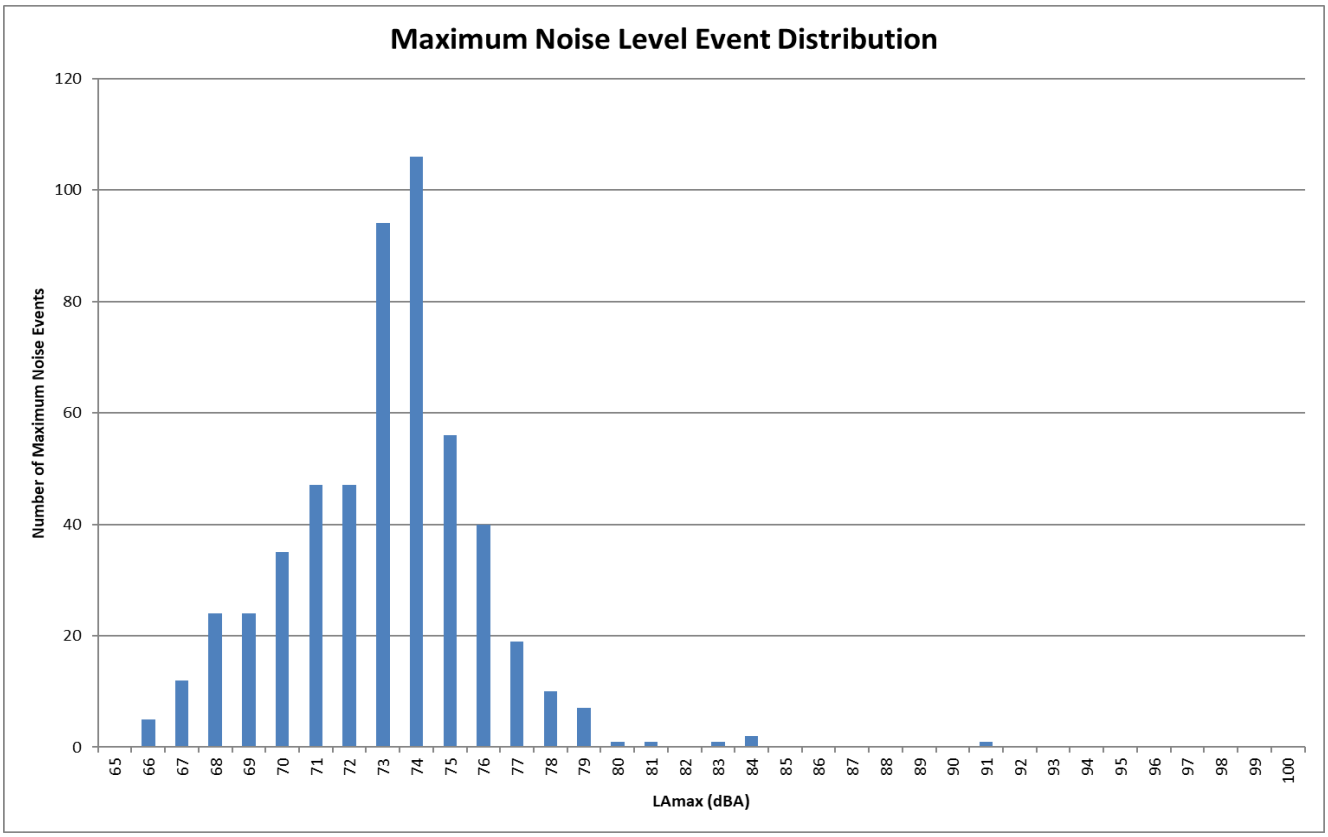
L01 – 1270 Richmond Road, Marsden Park NSW

Table 4 L.01 Maximum Noise Level Events

Monitoring Date	Number of Maximum Noise Events per Hour (L_{Amax} 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)
1-Apr-20	-	-	-	-	-	-	-	1 (75)	4 (74-75)	5 (74-75)
2-Apr-20	7 (72-76)	7 (73-76)	4 (74-75)	1 (77)	-	-	-	3 (74-75)	2 (72-73)	24 (72-77)
3-Apr-20	5 (71-73)	7 (71-73)	4 (73-74)	-	-	-	-	-	-	16 (71-74)
4-Apr-20	6 (71-73)	6 (71-75)	11 (68-71)	4 (69-70)	1 (72)	-	-	2 (76-79)	1 (75)	31 (68-79)
5-Apr-20	2 (71-74)	6 (71-75)	7 (68-71)	10 (67-72)	12 (66-69)	6 (71-74)	-	3 (76-77)	2 (75)	48 (66-77)
6-Apr-20	5 (74-76)	3 (73)	8 (73-74)	2 (74)	1 (76)	-	-	-	3 (75-78)	22 (73-78)
7-Apr-20	8 (73-74)	7 (73-77)	6 (73-76)	6 (74-76)	1 (76)	-	-	-	-	28 (73-77)
8-Apr-20	5 (73-74)	6 (74-76)	9 (73-75)	5 (74-78)	1 (78)	-	-	1 (76)	-	27 (73-78)
9-Apr-20	3 (74-75)	5 (75-77)	9 (72-76)	5 (73-74)	3 (76-79)	-	-	-	-	25 (72-79)
10-Apr-20	1 (79)	6 (71-73)	9 (71-73)	6 (70-78)	6 (70-72)	4 (73-74)	-	-	-	32 (70-79)
11-Apr-20	-	1 (91)	4 (69-76)	8 (68-70)	5 (69-71)	4 (73-76)	1 (77)	-	-	23 (68-91)
12-Apr-20	1 (73)	3 (69-74)	4 (69-71)	7 (67-69)	6 (68-70)	3 (70-72)	-	1 (74)	1 (73)	26 (67-74)
13-Apr-20	4 (72-74)	4 (70-77)	7 (68-70)	7 (69-74)	7 (70-75)	2 (74-75)	1 (76)	1 (74)	1 (73)	34 (68-77)
14-Apr-20	6 (72-78)	4 (71-72)	6 (72-74)	8 (72-75)	1 (77)	-	-	-	3 (76-78)	28 (71-78)
15-Apr-20	3 (74-75)	6 (73-75)	8 (74-77)	6 (73-79)	-	1 (81)	-	1 (77)	-	25 (73-81)
16-Apr-20	3 (73-75)	5 (72-75)	7 (73-75)	7 (73-75)	-	-	-	1 (80)	1 (84)	24 (72-84)
17-Apr-20	1 (74)	3 (74-75)	5 (74)	5 (76)	1 (77)	-	-	-	-	15 (74-77)
18-Apr-20	1 (76)	6 (73-74)	5 (71-75)	6 (72-74)	6 (74)	1 (76)	-	-	-	25 (71-76)
19-Apr-20	1 (78)	2 (71-73)	5 (71-73)	7 (69-71)	8 (70-72)	-	-	2 (77-78)	2 (75-76)	27 (69-78)
20-Apr-20	4 (73-75)	5 (73-77)	6 (75-83)	7 (74-79)	2 (76-77)	3 (78-79)	-	1 (84)	2 (77)	30 (73-84)
21-Apr-20	2 (76)	6 (74-76)	7 (74-76)	2 (76-77)	-	-	-	-	-	17 (74-77)

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

Figure 1 L.01 Maximum Noise Level Event Distribution of Monitoring Period



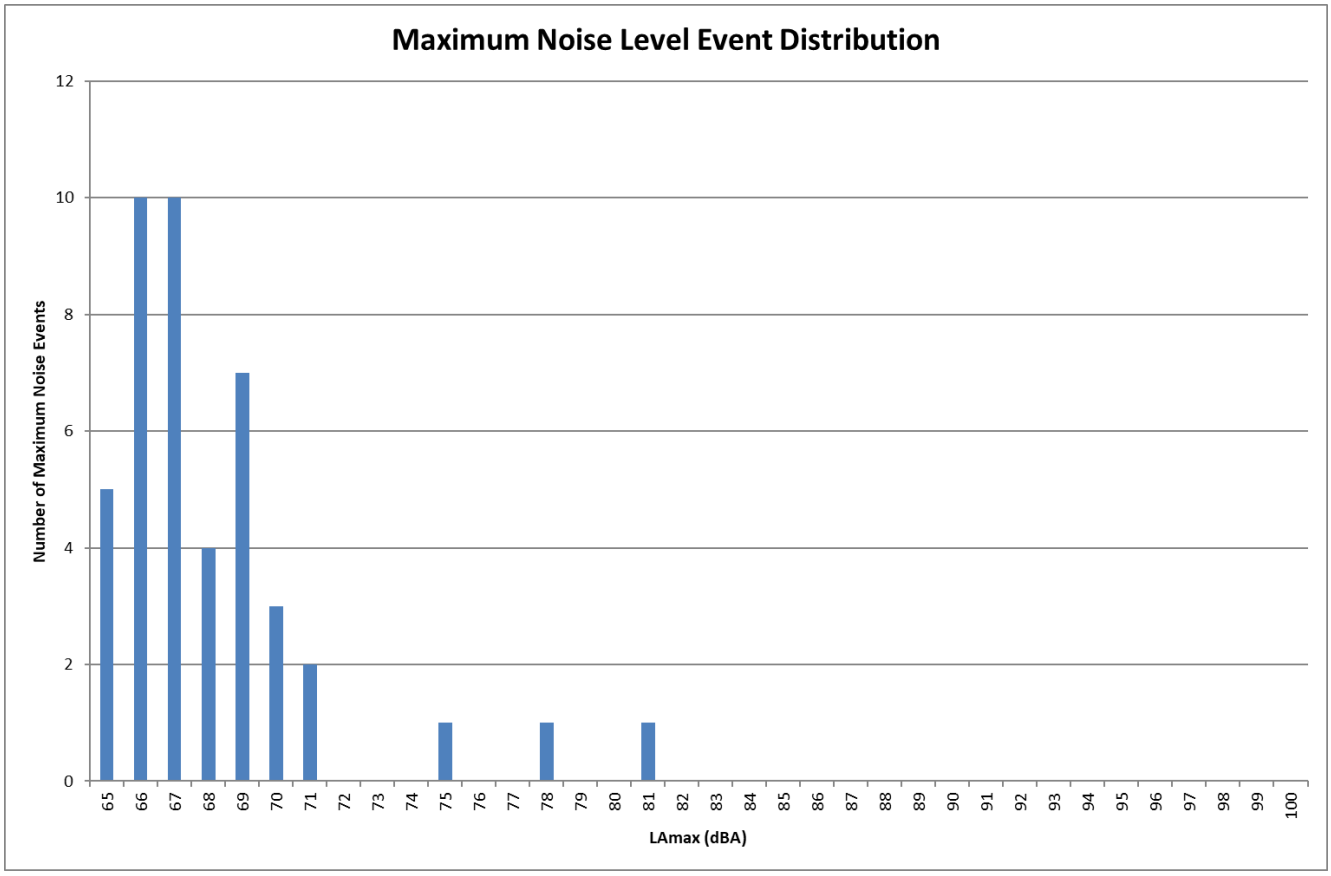
L.02 – 35 Ellison Street, Marsden Park NSW

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)
1-Apr-20	-	-	-	-	-	-	-	-	3 (66)	3 (66)
2-Apr-20	-	-	-	-	-	-	-	2 (67-70)	-	2 (67-70)
3-Apr-20	-	3 (66-68)	-	-	-	1 (75)	-	-	-	4 (66-75)
4-Apr-20	1 (69)	-	-	-	-	-	-	1 (69)	-	2 (69)
5-Apr-20	-	-	-	-	-	-	-	-	-	-
6-Apr-20	-	-	1 (69)	-	-	-	-	1 (67)	-	2 (67-69)
7-Apr-20	1 (65)	-	2 (65-66)	-	-	-	-	-	-	3 (65-66)
8-Apr-20	-	-	-	-	-	-	-	-	-	-
9-Apr-20	-	-	-	-	-	1 (68)	-	2 (71-78)	2 (67)	5 (67-78)
10-Apr-20	-	-	-	-	-	-	-	-	-	-
11-Apr-20	1 (67)	3 (65-71)	-	-	-	-	-	-	-	4 (65-71)
12-Apr-20	-	-	-	-	-	-	-	-	-	-
13-Apr-20	-	-	-	-	-	-	1 (65)	-	-	1 (65)
14-Apr-20	-	-	-	-	-	-	-	-	-	-
15-Apr-20	-	-	1 (66)	1 (65)	-	-	-	1 (69)	-	3 (65-69)
16-Apr-20	2 (69-70)	1 (66)	-	-	-	-	-	-	-	3 (66-70)
17-Apr-20	-	-	1 (67)	-	1 (67)	-	-	-	-	2 (67)
18-Apr-20	-	-	-	-	2 (66)	1 (68)	-	-	-	3 (66-68)
19-Apr-20	1 (69)	-	-	-	-	-	-	-	-	1 (69)
20-Apr-20	-	-	-	1 (67)	-	-	-	1 (81)	-	2 (67-81)
21-Apr-20	-	1 (68)	1 (66)	-	-	2 (69-70)	-	-	-	4 (66-70)

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



Receiver Assessment Table

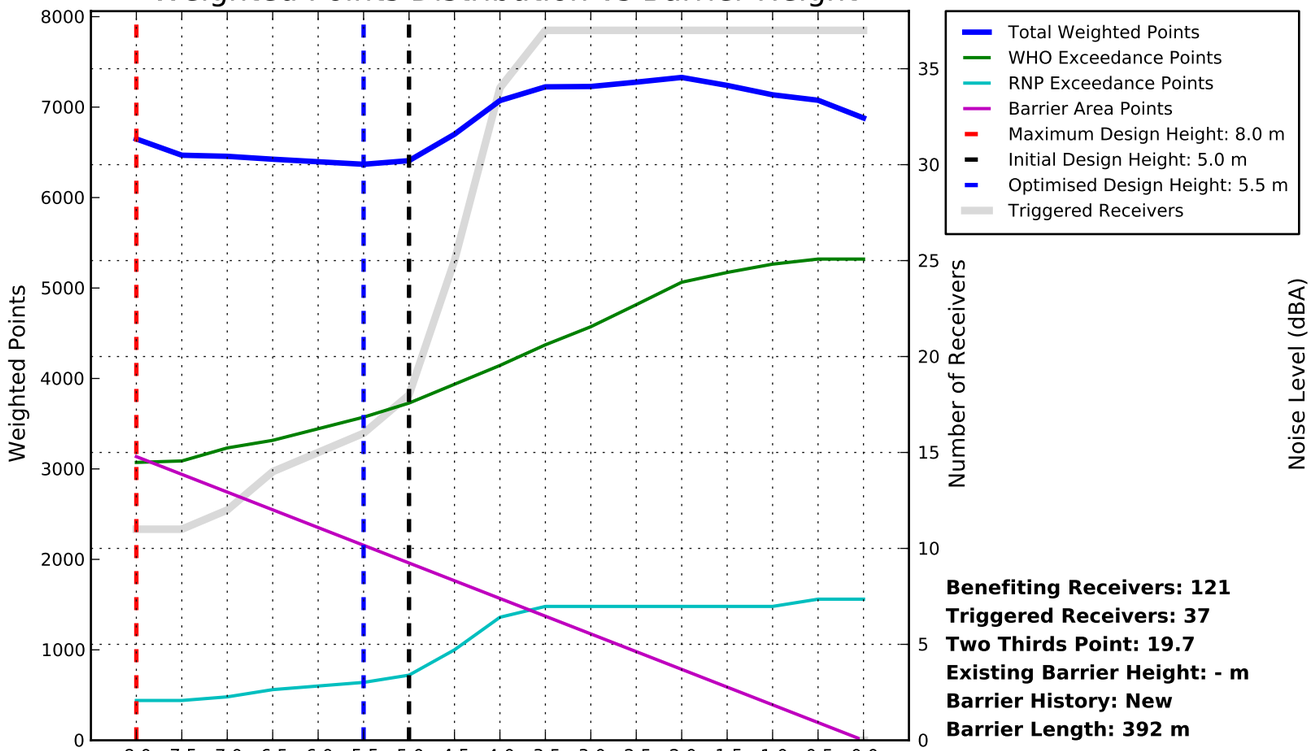
ID	Name	NCA	Flr	Easting	Northing	RecType	Name	Address	NCG Criteria		Period	Predicted Noise Level (dBA)								> 2 dB(A) Increase		Cumulative Limit		Project Acute		Eligible for Consideration of Mitigation
												At Opening (2026)				Future Design (2036)										
												No Build		Build		No Build		Build								
									D	N		D	N	D	N	D	N	D	N	D	N	D	N	D	N	
1	NCA01.OED.2072.01	NCA01	1	297720	6270245	Other (Educational)			50	-	H	56	55	57	56	56	55	57	56	-	-	Y	-	-	-	Y
2	NCA01.RES.0829.01	NCA01	1	298141	6270157	Residential			60	55	P	64	60	64	60	64	60	65	61	-	-	Y	Y	-	Y	Y
3	NCA01.RES.0830.01	NCA01	1	298146	6270149	Residential			60	55	P	64	60	64	60	64	60	65	61	-	-	Y	Y	-	Y	Y
4	NCA01.RES.0831.01	NCA01	1	298129	6270173	Residential			60	55	P	64	61	64	61	64	60	65	61	-	-	Y	Y	Y	Y	Y
5	NCA01.RES.0838.01	NCA01	1	298171	6270119	Residential			60	55	P	64	60	64	60	64	60	65	61	-	-	Y	Y	-	Y	Y
6	NCA01.RES.0839.01	NCA01	1	298176	6270111	Residential			60	55	P	64	60	64	60	64	60	64	60	-	-	-	Y	-	Y	Y
7	NCA01.RES.0840.01	NCA01	1	298182	6270102	Residential			60	55	P	63	60	64	60	63	59	64	60	-	-	-	Y	-	Y	Y
8	NCA01.RES.0841.01	NCA01	1	298190	6270095	Residential			60	55	P	63	60	63	59	63	59	64	60	-	-	-	Y	-	Y	Y
9	NCA01.RES.1142.01	NCA01	1	298134	6270166	Residential			60	55	P	64	60	64	60	64	60	65	61	-	-	Y	Y	Y	Y	Y
10	NCA01.RES.1143.01	NCA01	1	298122	6270182	Residential			60	55	P	64	60	64	60	64	60	65	61	-	-	Y	Y	Y	Y	Y
11	NCA01.RES.1152.01	NCA01	1	298164	6270127	Residential			60	55	P	64	60	64	60	64	60	65	61	-	-	Y	Y	-	Y	Y
12	NCA01.RES.1175.01	NCA01	1	298395	6269940	Residential			60	55	P	66	62	66	62	67	62	67	62	-	-	Y	Y	-	-	Y
13	NCA01.RES.1208.01	NCA01	1	298266	6270072	Residential			60	55	P	64	60	63	60	64	60	64	60	-	-	-	Y	-	Y	Y
14	NCA01.RES.1210.01	NCA01	1	298307	6270017	Residential			60	55	P	63	60	63	59	63	59	64	60	-	-	-	Y	-	-	Y
15	NCA01.RES.1212.01	NCA01	1	298383	6269994	Residential			60	55	P	70	66	70	66	70	66	70	66	-	-	Y	Y	Y	Y	Y
16	NCA01.RES.1213.01	NCA01	1	298348	6270021	Residential			60	55	P	69	65	68	64	69	65	69	65	-	-	Y	Y	Y	Y	Y
17	NCA01.RES.1214.01	NCA01	1	298256	6270105	Residential			60	55	P	62	58	63	59	61	58	64	60	Y	Y	-	Y	-	Y	Y
18	NCA01.RES.1215.01	NCA01	1	298295	6270092	Residential			60	55	P	68	64	68	64	68	64	68	64	-	-	Y	Y	Y	Y	Y
19	NCA01.RES.1216.01	NCA01	1	298337	6270037	Residential			60	55	P	68	64	67	64	67	64	68	64	-	-	Y	Y	Y	Y	Y
20	NCA01.RES.1217.01	NCA01	1	298272	6270118	Residential			60	55	P	63	59	64	60	62	58	65	61	Y	Y	Y	Y	Y	Y	Y
21	NCA01.RES.1218.01	NCA01	1	298373	6269988	Residential			60	55	P	66	62	65	61	65	61	65	61	-	-	Y	Y	Y	Y	Y
22	NCA01.RES.1219.01	NCA01	1	298248	6270099	Residential			60	55	P	62	58	64	60	62	58	64	60	Y	Y	-	Y	-	Y	Y
23	NCA01.RES.1220.01	NCA01	1	298342	6270029	Residential			60	55	P	68	64	68	64	68	64	68	65	-	-	Y	Y	Y	Y	Y
24	NCA01.RES.1221.01	NCA01	1	298272	6270064	Residential			60	55	P	63	59	63	59	63	59	64	60	-	-	-	Y	-	-	Y
25	NCA01.RES.1222.01	NCA01	1	298301	6270026	Residential			60	55	P	64	60	63	59	64	60	64	60	-	-	-	Y	-	Y	Y
26	NCA01.RES.1223.01	NCA01	1	298313	6270009	Residential			60	55	P	63	60	63	59	63	59	63	60	-	-	-	Y	-	-	Y
27	NCA01.RES.1225.01	NCA01	1	298307	6270076	Residential			60	55	P	68	64	68	64	68	64	68	64	-	-	Y	Y	Y	Y	Y
28	NCA01.RES.1226.01	NCA01	1	298278	6270055	Residential			60	55	P	63	59	63	59	63	59	64	60	-	-	-	Y	-	-	Y
29	NCA01.RES.1228.01	NCA01	1	298239	6270093	Residential			60	55	P	62	59	63	59	62	58	64	60	-	-	-	Y	-	Y	Y
30	NCA01.RES.1229.01	NCA01	1	298264	6270110	Residential			60	55	P	61	58	63	59	61	57	64	60	Y	Y	-	Y	-	Y	Y
31	NCA01.RES.1230.01	NCA01	1	298330	6270046	Residential			60	55	P	67	64	67	63	67	63	68	64	-	-	Y	Y	Y	Y	Y
32	NCA01.RES.1231.01	NCA01	1	298283	6270047	Residential			60	55	P	64	60	63	59	64	60	64	60	-	-	-	Y	-	Y	Y
33	NCA01.RES.1232.01	NCA01	1	298292	6270040	Residential			60	55	P	64	60	64	60	64	60	64	60	-	-	-	Y	-	Y	Y
34	NCA01.RES.1233.01	NCA01	1	298321	6270060	Residential			60	55	P	68	64	67	63	67	64	68	64	-	-	Y	Y	Y	Y	Y
35	NCA01.RES.1235.01	NCA01	1	298302	6270084	Residential			60	55	P	68	64	68	64	68	64	68	65	-	-	Y	Y	Y	Y	Y
36	NCA01.RES.1236.01	NCA01	1	298356	6270013	Residential			60	55	P	69	66	69	65	69	65	69	65	-	-	Y	Y	Y	Y	Y
37	NCA01.RES.1238.01	NCA01	1	298313	6270067	Residential			60	55	P	68	64	67	63	67	63	68	64	-	-	Y	Y	Y	Y	Y
38	NCA01.RES.1239.01	NCA01	1	298282	6270124	Residential			60	55	P	68	64	68	64	68	64	69	65	-	-	Y	Y	Y	Y	Y
39	NCA01.RES.1963.01	NCA01	1	298060	6270314	Residential			60	55	P	63	59	63	59	62	59	64	60	-	-	-	Y	-	-	Y
40	NCA01.RES.1966.01	NCA01	1	298057	6270343	Residential			60	55	P	58	54	60	57	58	54	61	57	Y	Y	-	-	-	-	Y
41	NCA01.RES.1967.01	NCA01	1	298085	6270367	Residential			60	55	P	66	62	69	65	66	62	69	66	Y	Y	Y	Y	Y	Y	Y
42	NCA01.RES.1968.01	NCA01	1	298100	6270347	Residential			60	55	P	66	62	68	64	66	62	69	65	Y	Y	Y	Y	Y	Y	Y
43	NCA01.RES.1969.01	NCA01	1	298070	6270354	Residential			60	55	P	59	55	62	58	59	55	63	59	Y	Y	-	-	-	-	Y
44	NCA01.RES.1970.01	NCA01	1	298072	6270324	Residential			60	55	P	63	59	63	59	63	59	64	60	-	-	-	Y	-	Y	Y
45	NCA01.RES.1971.01	NCA01	1	298087	6270336	Residential			60	55	P	64	60	64	61	63	59	65	61	-	-	Y	Y	Y	Y	Y
46	NCA01.RES.1972.01	NCA01	1	297885	6270566	Residential			60	55	P	57	53	61	57	57	53	61	58	Y	Y	-	-	-	-	Y
47	NCA01.RES.2016.01	NCA01	1	298034	6270390	Residential			60	55	P	61	57	62	58	60	56	63	59	Y	Y	-	-	-	-	Y
48	NCA01.RES.2017.01	NCA01	1	298020	6270379	Residential			60	55	P	59	55	60	57	59	55	61	57	Y	Y	-	-	-	-	Y
49	NCA01.RES.2020.01	NCA01	1	298047	6270401	Residential			60	55	P	64	61	68	64	64	60	68	64	Y	Y	Y	Y	Y	Y	Y
50	NCA01.RES.2021.01	NCA01	1	297973	6270476	Residential			60	55	P	57	54	61	57	57	53	61	57	Y	Y	-	-	-	-	Y
51	NCA01.RES.2022.01	NCA01	1	297960	6270465	Residential			60	55	P	56	53	60	57	56	52	61	57	Y	Y	-	-	-	-	Y
52	NCA01.RES.2023.01	NCA01	1	297947	6270455	Residential			60	55	P	56	52	60	56	56	52	60	56	-	Y	-	-	-	-	Y
53	NCA01.RES.2024.01	NCA01	1	297933	6270444	Residential			60	55	P	56	52	60	56	55	51	60	56	-	Y	-	-	-	-	Y
54	NCA01.RES.2025.01	NCA01	1	297987	6270487	Residential			60	55	P	63	59	66	62	62	58	66	62	Y	Y	Y	Y	Y	Y	Y
55	NCA01.RES.2026.01	NCA01	1	297983	6270419	Residential			60	55	P	57	54	60	56	57	53	60	56	-	Y	-	-	-	-	Y
56	NCA01.RES.2028.01	NCA01	1	298024	6270451	Residential			60	55	P	65	61	68	64	64	60	69	65	Y	Y	Y	Y	Y	Y	Y
57	NCA01.RES.2029.01	NCA01	1	298010	6270439	Residential			60	55	P	61	57	64	60	61	57	64	60	Y	Y	-	Y	-	Y	Y
58	NCA01.RES.2030.01	NCA01	1	297997	6270429	Residential			60	55	P	59	55	61	57	58	54	62	58	Y	Y	-	-	-	-	Y
59	NCA01.RES.2035.01	NCA01	1	297747	6270640	Residential			60	55	P	58	54	61	57	58	54	61	57	Y	Y	-	-	-	-	Y
60	NCA01.RES.2036.01	NCA01	1	297743	6270621	Residential			60	55	P	57	53	60	56	57	53	60	56	-	Y	-	-	-	-	Y
61	NCA01.RES.2037.01	NCA01	1	297749	6270661	Residential			60	55	P	62	58	63	59	61	57	63	59	Y	Y	-	-	-	-	Y
62	NCA01.RES.2039.01	NCA01	1	297721	6270668	Residential			60	55	P	59	55	60	56	58	55	60	57	-	Y	-	-	-	-	Y

ID	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	
63	NCA01.RES.2057.01	NCA01	1	297843	6270626	Residential			60	55	P	63	59	65	62	62	58	66	62	Y	Y	Y	Y	Y	Y	Y
64	NCA01.RES.2058.01	NCA01	1	297840	6270610	Residential			60	55	P	59	55	63	59	58	55	63	60	Y	Y	-	Y	-	Y	Y
65	NCA01.RES.2059.01	NCA01	1	297837	6270591	Residential			60	55	P	58	54	62	58	58	54	62	58	Y	Y	-	-	-	-	Y
66	NCA01.RES.2060.01	NCA01	1	297834	6270573	Residential			60	55	P	58	54	60	57	57	53	61	57	Y	Y	-	-	-	-	Y
67	NCA01.RES.2061.01	NCA01	1	297832	6270555	Residential			60	55	P	57	53	60	56	57	53	61	57	Y	Y	-	-	-	-	Y
68	NCA01.RES.2062.01	NCA01	1	297829	6270539	Residential			60	55	P	57	53	60	56	56	53	60	56	-	Y	-	-	-	-	Y
69	NCA01.RES.2063.01	NCA01	1	297825	6270519	Residential			60	55	P	56	52	59	55	56	52	59	56	-	Y	-	-	-	-	Y
70	NCA01.RES.2064.01	NCA01	1	297887	6270599	Residential			60	55	P	63	59	68	64	63	59	68	64	Y	Y	Y	Y	Y	Y	Y
71	NCA01.RES.2065.01	NCA01	1	297903	6270581	Residential			60	55	P	63	59	67	64	63	59	68	64	Y	Y	Y	Y	Y	Y	Y
72	NCA01.RES.2066.01	NCA01	1	297859	6270450	Residential			60	55	P	56	52	59	55	56	52	59	56	-	Y	-	-	-	-	Y
73	NCA01.RES.2068.01	NCA01	1	297869	6270435	Residential			60	55	P	56	52	59	55	56	52	59	56	-	Y	-	-	-	-	Y
74	NCA01.RES.2069.01	NCA01	1	297809	6270473	Residential			60	55	P	57	54	59	55	57	53	59	56	-	Y	-	-	-	-	Y
75	NCA01.RES.2071.01	NCA01	1	297840	6270471	Residential			60	55	P	56	52	59	55	56	52	60	56	-	Y	-	-	-	-	Y


LEGEND
NCA Boundaries
Project Design
Buildings
Other Sensitive Receivers
Outdoor Areas
Triggered Buildings
Richmond Rd
Richmond Rd
Winder St
Winder St
Broadfoot Ave
Broadfoot Ave
Swifthorne Ave
Chambers St
Feiney St
Ellison St
Alsop St
Scale: 1:5,000
GDA 1994 MGA Zone 56

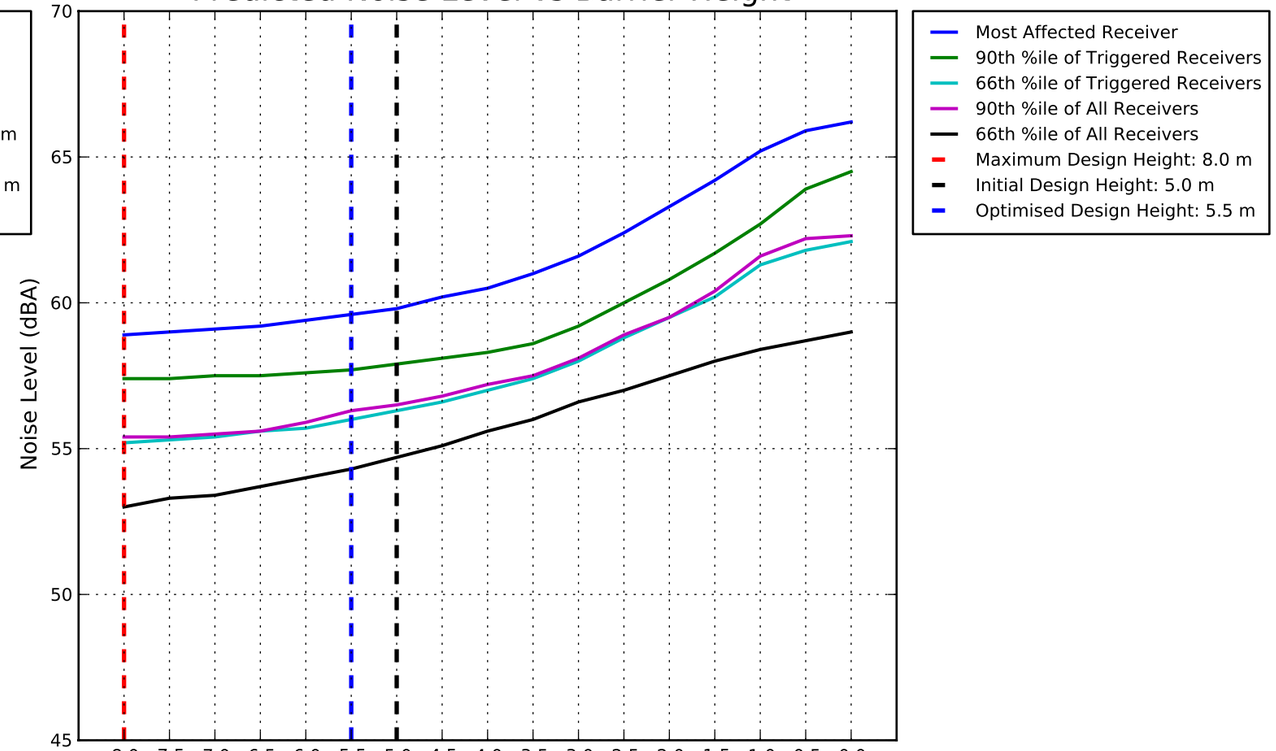
Noise Barrier Optimisation: NW01

Weighted Points Distribution vs Barrier Height

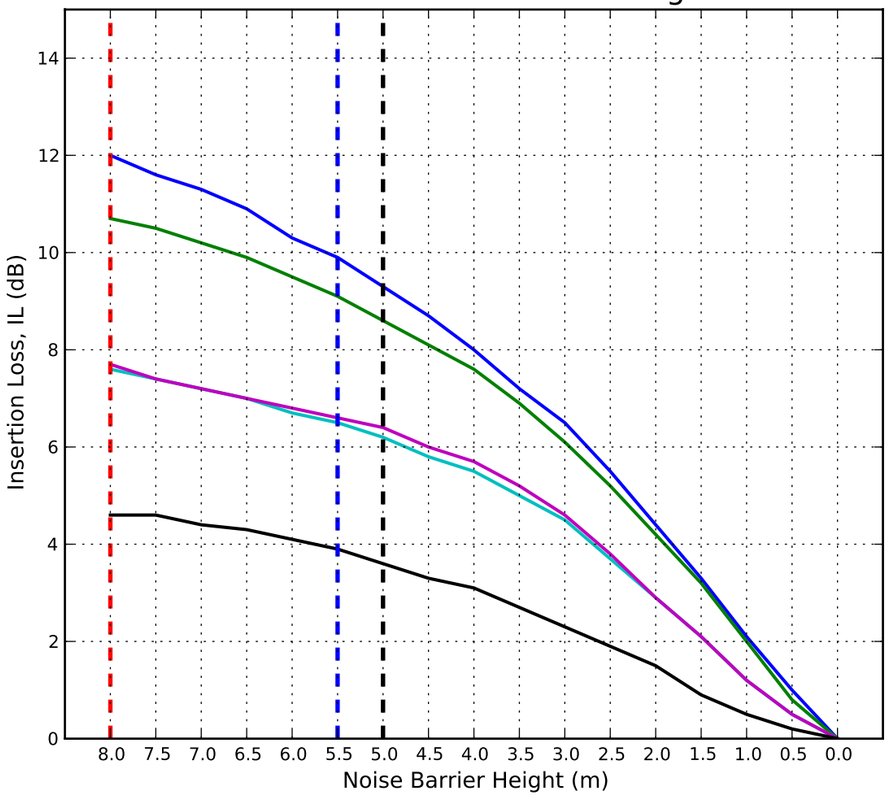


Benefiting Receivers: 121
Triggered Receivers: 37
Two Thirds Point: 19.7
Existing Barrier Height: - m
Barrier History: New
Barrier Length: 392 m

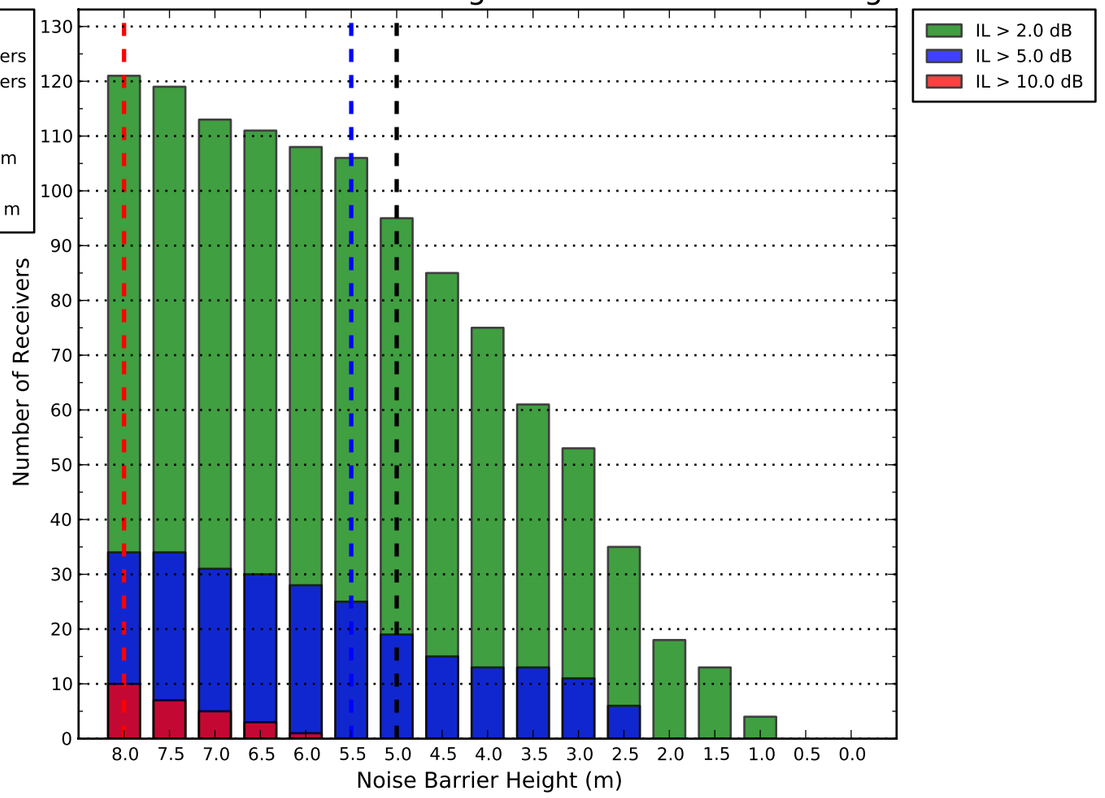
Predicted Noise Level vs Barrier Height



Insertion Loss vs Barrier Height



Insertion Loss of Benefiting Receivers vs Barrier Height



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