Appendix J

Noise and Vibration Assessment

Cessnock Road Upgrade at Testers Hollow

Noise and Vibration Working Paper

Roads and Maritime Services | July 2019

Contents

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to assess potential noise impacts associated with the proposed upgrade of Cessnock Road in accordance with the scope of services set out in the contract between Jacobs and Roads and Maritime Services for this proposal. That scope of services, as described in this report, was developed with the Client.

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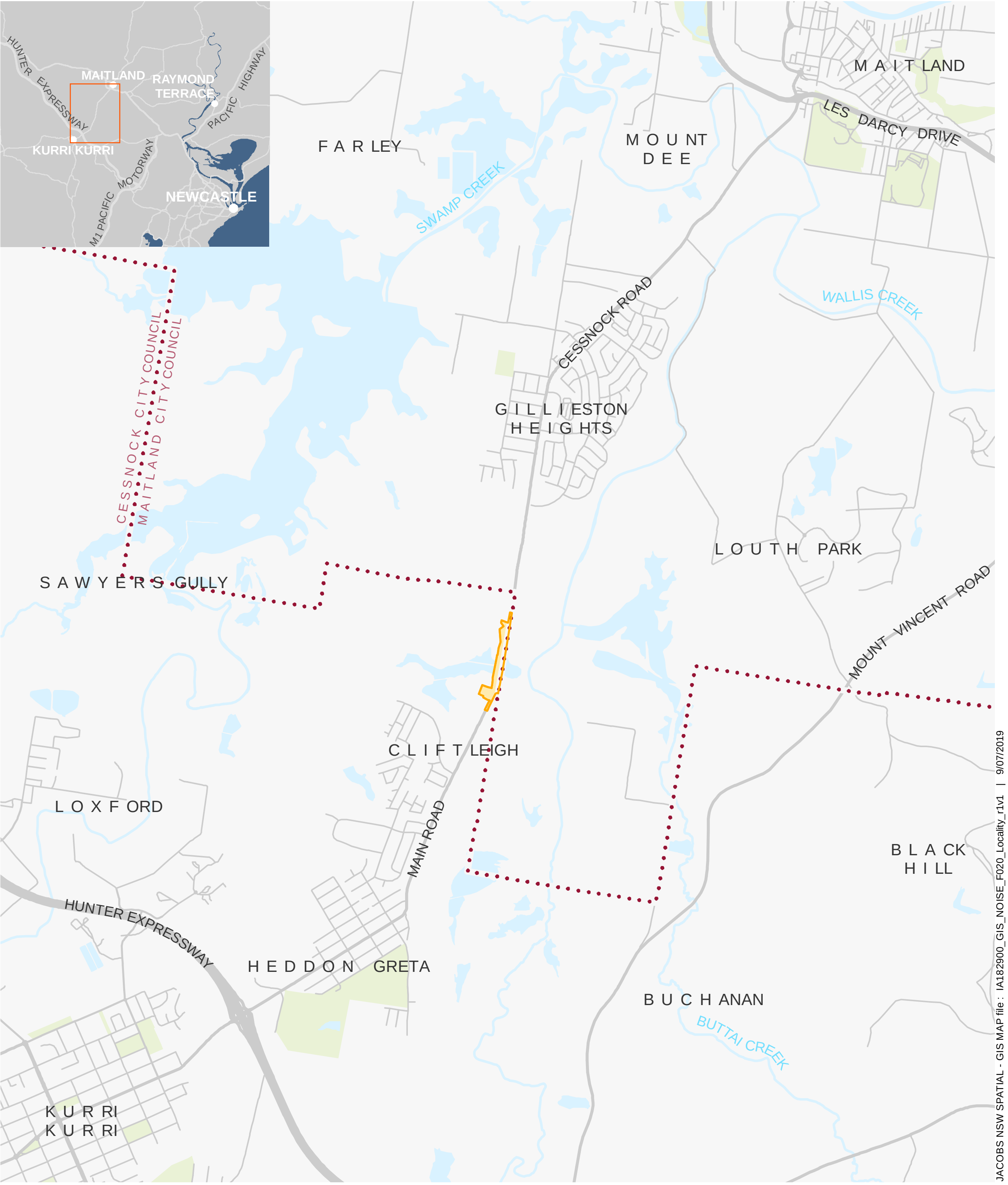
1. Introduction

Roads and Maritime Services NSW (Roads and Maritime) proposes to upgrade MR195 Cessnock Road (also known as Main Road) at Testers Hollow, between Gillieston Heights and Cliftleigh. The proposal is located in the Maitland Local Government Area (LGA) and the Cessnock LGA. The proposal would improve the flood immunity of Cessnock Road at Testers Hollow as it would bring the road up to the standard for new State roads.

Key features of the proposal would include:

- A new two lane 60 and 80 kilometre per hour road, one lane each direction with two metre shoulders, around 900 metres long between Gillieston Heights and Cliftleigh on the western side of the existing road
- The new road would be on an earth embankment at a height of about six metres Australian Height Datum (AHD) which would allow access in a five per cent Annual Exceedance Probability (AEP) flood event
- The new road would tie in with the existing road at the northern and southern extents
- Existing access arrangements would be maintained to private property and to the existing combined U-turn bay and intersection at Avery Lane
- New drainage to allow water to pass under the new earth embankment and through the existing road embankment
- Utility and street light relocations
- Partial property acquisitions
- Ancillary works including drainage works, safety barriers, signs, linemarking, landscaping and environmental protection works
- Temporary ancillary facilities including site compounds and stockpile sites.

The proposal is located in the Lower Hunter, about five kilometres north of the Kurri Kurri Interchange on the Hunter Expressway. It is located between the suburbs of Cliftleigh and Gillieston Heights on the border of the Cessnock and Maitland local government areas. The general location of the proposal is shown on Figure 1-1.



Legend

Proposal area

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Figure 1.1 | Location of the proposal

1.1 Purpose of this report

This report has been prepared to support the Review of Environmental Factors (REF) for the upgrade of Cessnock Road at Testers Hollow (the proposal). This report assesses the potential for noise or vibration impacts upon residences and other sensitive receivers within the study area that may arise from the construction and operation of the proposal. The report also outlines the measures that would be used to mitigate these impacts.

1.2 Structure of this report

This report outlines:

- The proposal and a description of the noise and vibration impact assessment study area (Section 2.1)
- The existing ambient noise environment (Section 3)
- Noise criteria used to assess operational noise impacts (Section 6)
- Noise modelling assumptions and the validation of the noise model (Sections 7.1 and 7.4)
- Predictions of operational noise impacts and identifying receivers eligible for operational noise mitigation (Sections 7.6)
- Criteria applied for assessing potential construction noise impacts (Section 4.6)
- Predictions of construction noise impacts (Section 4.9)
- Criteria used to assess potential construction vibration impacts (Section 5.2)
- Predicted construction vibration impacts (Section 5.3
- A summary of noise and vibration impacts and mitigation measures for receivers impacted within each region of the proposal (Section 4.12 and Section 5.4).

1.3 Relevant guidelines

This impact assessment report has been prepared in accordance with the regulatory guidelines summarised in Table 1-1.

Table 1-1: Relevant noise and vibration guidelines

Standard / Guideline	Authority	Date
In relation to the procedure for undertaking noise measurements		
Australian Standard AS1055 Acoustics - Description and Measurement of Environmental Noise	Standards Australia	1997
Australian Standard AS IEC 61672.1-2004 - Electroacoustics - Sound Level Meters, Part 1: Specifications	Standards Australia	2004
In relation to the assessment of the proposal's construction noise impacts and their mitigation		
Construction Noise and Vibration Guideline	Roads and Maritime	April 2016
Interim Construction Noise Guideline	Department of Environment and Climate Change NSW	July 2009
In relation to the assessment of the proposal's construction vibration impact and its mitigation		
Construction Noise and Vibration Guideline	Roads and Maritime	Apr 2016
Environmental Noise Management. Assessing Vibration: a technical guideline	Department of Environment and Conservation NSW	Feb 2006
British Standard BS 7385 Part 2-1993 Evaluation and measurement for vibration in buildings Part 2	British Standards Institution	1993

Standard / Guideline	Authority	Date
DIN 4150: Part 3-1999 Structural vibration - Effects of vibration on structures	Deutsches Institute fur Normung	1999
In relation to the assessment of the proposal's operational noise impact and its mitigation		
Road Noise Policy	NSW Environment Protection Authority	2011
Noise Criteria Guideline	Roads and Maritime	Apr 2015
Noise Mitigation Guideline	Roads and Maritime	Apr 2015
Model Validation Guideline	Roads and Maritime	May 2018
In relation to the presentation of this assessment		
Procedure: Preparing an Operational Traffic and Construction Noise and Vibration Assessment Report	Roads and Maritime	June 2016

1.4 Terminology

Definitions of the acoustic terminology used in this report are presented in Appendix A.

1.5 Key acoustic considerations

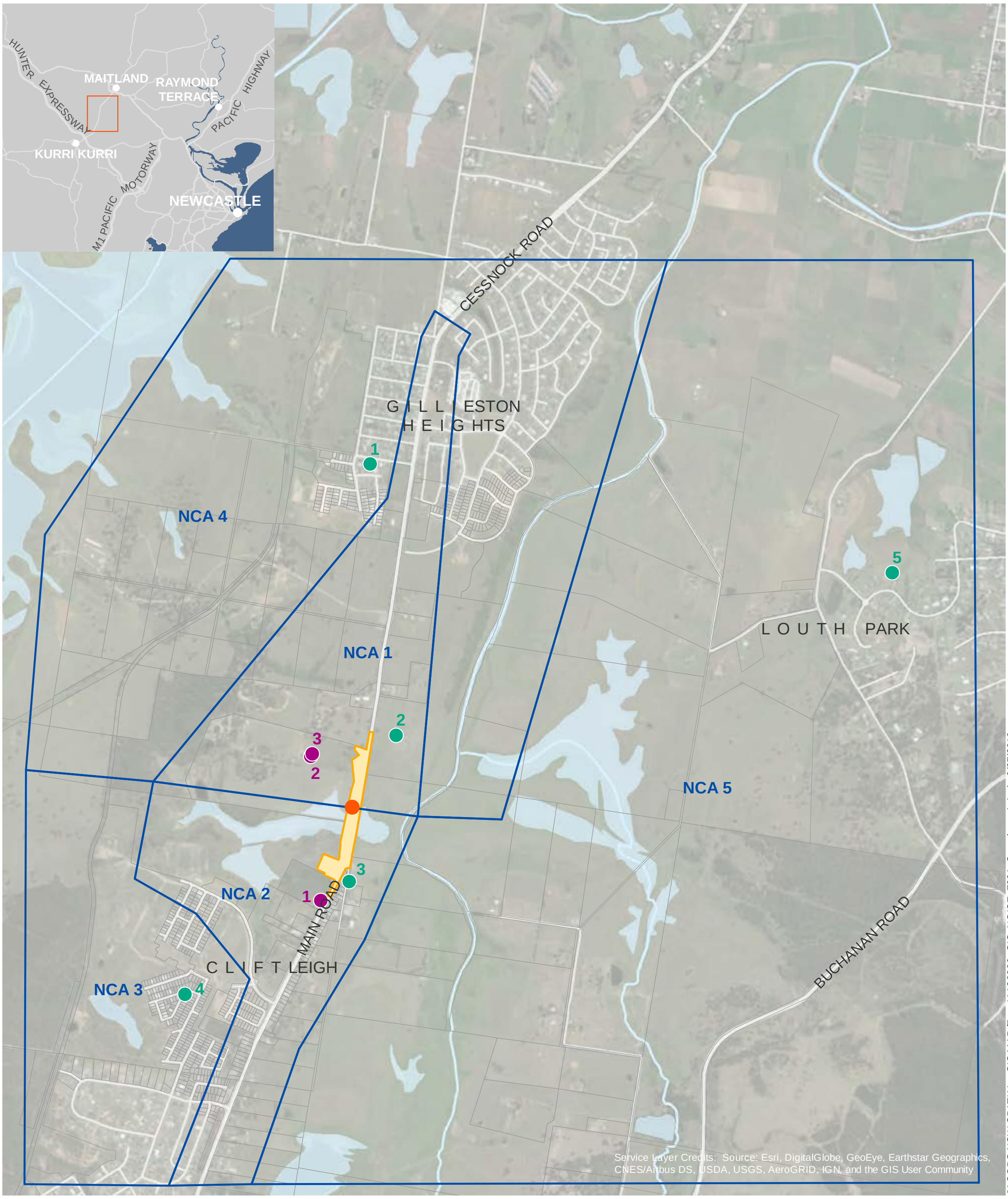
The construction and operation of the proposal may potentially generate noise or vibration impacts to nearby residences and other acoustically-sensitive land uses (e.g. schools and offices). The proposal's potential noise impacts could result from:

- Increased traffic volumes during operation and / or construction on the proposal road or on connecting side roads
- An increase in the number of heavy vehicles during operation and / or construction on the proposal road
- Changes in the transmission of traffic noise due to alignment changes under the proposal design
- Construction of the proposal (particularly during night periods).

Vibration impacts to sensitive receivers may potentially result from vibration-intensive construction works such as impact piling (may potentially be required for bridge construction) or vibratory rolling (road paving) for example.

The types of measures that may be implemented to mitigate any noise or vibration impacts arising from the proposal include:

- Quieter road pavements (operational noise)
- Roadside mounds and/or noise barriers (operational noise)
- At-property building treatments (operational noise)
- Preferentially selecting low-noise construction processes or timings (construction noise)
- Confining construction works to daytime hours whenever possible (construction noise)
- Deploying temporary noise barriers and hoardings around construction processes and compounds (construction noise).



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Legend

- Proposal area
- Noise catchment area
- Additional attended noise monitoring
- Unattended noise monitoring location
- Traffic count location
- Property boundary

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Figure 1.2 | Project study area, noise monitoring locations, addiitonal properties and NCAs

2. Noise and vibration sensitive receivers

The proposal is located in the Maitland and Cessnock Local Government Areas (LGAs) and within Roads and Maritime's Hunter region. The topography of the study area is mostly flat surrounded by undulating hills.

2.1 Assessment study area

The study area for this assessment extends to a minimum of 600 m either side of the proposed road alignment in accordance with Road Noise Policy (RNP) and Section 6 of the Noise Criteria Guideline (NCG). The study area has been extended further from the proposal alignment in some regions to ensure that all exceedances of construction or operational noise limits have been identified. For example, the study area has been extended to 3,000 m from the proposal alignment near Louth Park due to the topography of the area and the potential for night time construction noise impacts. The study area used for this assessment is shown in Figure 1-2.

2.2 Overview of acoustically-sensitive receivers

The type and number of acoustically-sensitive receivers within the study area are summarised in Table 2-1.

No units or similar occupancies have been identified in the work area, and as such each building has been classified as a single receiver.

Table 2-1: Noise sensitive receivers

Receiver type	Number of receivers
Residential	614
Commercial	2
Active Recreational Area	1

Footnote: Commercial receivers are not included in the list of classified "receivers" in the RMS' Noise Criteria Guideline, resulting in commercial properties being considered acoustically-sensitive only to noise or vibration emissions from construction of the proposal but not from its operation (ie, once the proposal is open to public traffic).

Table 2-2 provides more detail on non-residential receivers that have been considered in this assessment.

Table 2-2: Non residential recievers

NCA	Receiver	Address	Receiver type
NCA 2	Metro Petroleum	82 Main Rd, Cliftleigh	Commercial
NCA 4	Gillieston Heights Baseball Field	Cartwright St, Gillieston Heights	Active Recreational Area
NCA 5	Budget Toilet Hire	537 Louth Park Rd, Louth Park	Commercial

2.3 Noise catchment areas

Receivers exposed to a similar noise environment are grouped into Noise Catchment Areas (NCAs). Grouping receivers in this way can assist with identification of criteria, impact assessment, consultation or notification. The NCAs used in this assessment are indicated in Figure 1-2 and summarised in Table 2-3. This table also indicates the likely type of impact for each NCA.

Table 2-3: Description of NCAs and potential noise / vibration impacts

NCA	Location	Overview of potential impacts	Day / Night
1	Cessnock Road north	Noise: Operation and construction Vibration: Construction	Both

NCA	Location	Overview of potential impacts	Day / Night
2	Cessnock Road south	Noise: Operation and construction Vibration: Construction	Both
3	Cliftleigh	Noise: Operation and construction	Both
4	Gillieston Heights	Noise: Operation and construction	Both
5	Louth Park	Noise: Construction	Both

Noise logging was completed in each NCA at a location that was representative of the worst-case impact (highest level of construction noise) to determine the background noise level and criteria. Additional spot check measurements were completed to understand the range in background noise levels and associated criteria within the catchment.

The spot checks were also used to provide greater certainty that the mitigation measures designed to manage the impact at the assumed worst case receiver address the noise impacts predicted across the NCA.

3. Existing ambient noise environment

Determining the existing (pre-proposal) levels of background and traffic noise is necessary to be able to assess the proposal's construction noise impacts, and to validate the operational noise model. This section outlines how the existing background and traffic noise levels were determined.

3.1 Existing ambient noise environment

Existing daytime and night time ambient noise levels in the region are determined by traffic conveyed on the region's major roads. Cessnock Road carries a total of 13,700 vehicles per day and is a designated truck route. Traffic on local roads and generic residential and natural noise sources also contribute to the ambient noise at some times.

3.2 Ambient noise survey methodology

Long-term, unattended noise surveys were undertaken along the study corridor to determine the existing level of ambient noise at all receivers potentially affected by the proposal.

Monitoring sites were selected according to the noise sources affecting the site (e.g. traffic and/or other ambient sources), land access permission and equipment security. These locations are indicated in Figure 1-2 and detailed in Table 3-1.

The background noise monitoring surveys were conducted between 7 August and 15 August 2018 and were undertaken in accordance with:

- The Roads and Maritime Procedure Preparing an Operational Traffic and Construction Noise and Vibration Assessment Report) (POTCNVA, April 2016)
- The DECC's Interim Construction Noise Guideline (ICNG), and
- Australian Standard AS1055 Acoustics - Description and measurement of environmental noise.

Noise monitoring was undertaken at each of the locations listed below in Table 3-1using Type 1 NGARA noise logging devices. Each device was set up consistent with *Australian Standard AS1055:1997 Acoustics – Description and measurement of environmental noise Part 1: General procedures*. The noise logging devices were installed for a period or at least seven days consistent with the long-term method for determining background noise levels described in Section 3 of the *NSW Industrial Noise Policy,* (NSW Environment Protection Authority, 2000) and the POTCNVA. The devices were set in 48 kHz mode, allowing the capture of audio files and 1/3 octave data for post-processing purposes. Details are summarised below in Table 3-1.

Table 3-1: Noise monitoring details

Location ID	Address	Measurement position
1	527 Cessnock Road Gillieston Heights	Façade
2	Avery Lane Cliftleigh	Façade
3	5 Millbrook Road, Cliftleigh	Façade
4	14 Russell Street Gillieston Heights	Façade
5	9 Reflection Drive Louth park	Free field

After excluding results captured during periods of adverse weather (excessive rain or wind), the survey noise level data were used to determine the Rating Background Level (RBL) for the construction noise assessment (as shown in Table 3-2) and existing daytime (15 hour) and night time (9 hour) traffic noise levels for the operational noise assessment (refer Table 3-2), which were also used to validate the noise model (discussed further in Section 7.4).

Table 3-2 presents the results of unattended noise monitoring. Results are presented as two statistical data sets, each describing different time periods:

1) Road noise monitoring – as required for the purposes of noise model validation
2) Construction noise monitoring – as required for the calculation of construction noise criteria in accordance with the RMS Construction Noise and Vibration Guideline.

Table 3-2: Summary of unattended noise measurements

Monitoring location ID / NCA	Road noise monitoring results L_{Aeq} dB(A)		Construction noise monitoring results RBL dB(A)					
	Day (15 hour)	Night (9 hour)	Standard hours of construction (Mon-Fri 7am to 6pm, Sat 8am to 1pm)*		OOHW Period 1 (Mon-Fri 6pm to 10pm, Sat 7am to 8am / 1pm to 10pm, Sun / Pub Hol 8am to 6pm)*		OOHW Period 2 (Mon-Fri 10pm to 7am, Sat 10pm to 8am, Sun / Pub Hol 6pm to 7am)*	
			RBL	L_{Aeq}	RBL	L_{Aeq}	RBL	L_{Aeq}
1**	55	51	52	56	43	53	29	51
2	58	54	55	59	52	57	50	54
3	44	40	37	50	32	43	30	40
4	50	40	38	51	36	48	32	41
5	43	39	37	45	33	40	30	40

** Time periods are referred to in CNVG (refer to Section 4.6)*

*** The noise loggers at Location 1 had been damaged by a dog. These results will not be used in this assessment. Instead Location 2 will be used to consider noise impacts at all of Cessnock / Main Road properties.*

Cessnock Road was the dominant influence on noise at Locations 1, 2 and 4. Road traffic noise from the proposal areas was not audible at the Louth Park or Cliftleigh monitoring locations. Substantial construction of new housing estates is underway in the proposal area, and these works influenced RBLs at Locations 3 and 5.

During monitoring a dog interfered with the noise logger at Location 1 (Cessnock Road). This logger was knocked over during the monitoring period and upon retrieval, the microphone was at ground level. Additionally, the night time L_{Amax} was strongly influenced by the frequent barking of nearby dogs. The quality of these monitoring results are not considered acceptable. The noise environment at Location 2 is considered to be very similar to that at Location 1. Both sites are generally unaffected by non road noise sources, have a wide view of traffic passbys and vehicle speeds / behaviour in the vicinity of both properties is very similar. As such the noise monitoring results from Location 2 will instead be used to describe the noise environment in close proximity to Cessnock Road (i.e. both NCA 1 and NCA 2).

3.3 Concurrent traffic survey

Traffic count surveys were undertaken concurrently with the long-term unattended noise monitoring surveys. These traffic counts were used for the purpose of validating the noise model (Section 7.4).

The tube count traffic surveys along existing highway were undertaken during the period 6 August to 12 August 2018 at the location shown in Figure 1-2. The traffic data collected during the tube counts are detailed in Table 3-3. The bulk flow vehicle speeds recorded by the surveys indicated traffic to be free flowing and not affected by congestion.

Table 3-3: Measured day and night traffic counts used to validate the noise model

Direction	Ave speed km/h	Monitored hourly average traffic flows							
		Daytime (15 hour)				Night time (9 hour)			
		Light	Heavy	Total	% HV	Light	Heavy	Total	% HV
Northbound	75 Day 80 Night	294	19	313	6	32	3	35	8
Southbound	77 Day 82 Night	280	21	300	7	39	4	44	9

4. Assessment of construction noise

4.1 Overview

Noise arising from Roads and Maritime proposals requires assessment under the Construction Noise and Vibration Guideline (CNVG). The CNVG refers to guidance in ICNG which presents guidance values to assist with the management of noise impacts, rather than strict numeric criteria.

This section of the assessment describes the methods applied and results obtained from the assessment of different potential noise and vibration-related impacts associated construction.

4.2 Proposed works

Construction will take place on the western side and away from the current road. Traffic will continue to use the existing road whilst the new embankment and section of road is constructed. Traffic will be diverted, potentially in stages, onto the new section when the embankment and road is completed. After construction, the old road formation will be retained, but will not be accessible to general traffic. A channel will be cut into the old formation to connect to three new pipes built under the new road to improve drainage.

The key work stages and activities that will be undertaken at the stages are described in the following sections. Stages and activities will overlap. Detailed work methodologies and the sequence of construction activities will be refined during construction planning.

- Stage 1 – Early works / utility relocation
- Stage 2 – Site compound and erosion and sediment control establishment
- Stage 3 – Stripping and clearing
- Stage 4 - Under road drainage works
- Stage 5 – Embankment and earthworks
- Stage 5a – Piling and wick drain installation
- Stage 6 – Pavement works
- Stage 7 – Open to traffic (no construction involved with this stage)
- Stage 8 – Finalisation works.

4.3 Temporary ancillary facilities

A temporary construction compound is likely to be set up at either the northern or southern extent of the proposal. Temporary ancillary facilities will be located to the west of the current road formation.

The compound will include temporary site offices, amenities, car parking, secured storage shed and designated stockpile materials areas. Compound areas will be gravelled to protect the ground surface. Power and telecommunications will be installed to the site offices.

Temporary traffic control and speed restrictions may be put in place at the entrance to the site compounds to allow safe movement of construction vehicles.

4.4 Construction hours

Construction works will likely be undertaken during the following working hours:

- Monday to Friday: 7 am to 6 pm
- Saturday: 8 am to 1 pm
- Sundays and public holidays: no work.

Night works may be required for:

- Delivery of oversized plant or structures
- Emergency work to prevent to the loss of life or property or to prevent environmental harm
- Other work periods where there may be a justifiable need to operate outside of normal working hours may include:
  - Temporary night works at the northern and southern tie ins as part of pavement and line marking prior to diverting traffic to the new section of road. These night time works are essential to provide a safe working environment and to reduce traffic impacts
  - Utility relocation and installation works to provide safe work conditions.

4.5 Construction Noise Management Levels

The ICNG describes two methods for assessing noise impacts from construction activities; the quantitative method which is suited to noise intensive works and / or proposals running longer than three weeks; and a qualitative method which is suited for minor, short-term (i.e. duration less than three weeks) activities which would occur during standard hours of construction. Owing to the expected duration of the proposal and the need for the proposal to be completed outside the standard hours of construction, a quantitative approach was considered for this assessment.

The ICNG recommends establishing noise management levels (NMLs) at receiver locations adjacent to the works, using information on the existing background noise level at these locations. Where NMLs may be exceeded as a result of the proposed works and there is potential for adverse noise impacts to occur, appropriate management measures should be implemented.

Table 4-1 details the method for determining NMLs for residential receivers potentially affected by the proposed upgrade. Often works that may cause inconvenience within the community (e.g. traffic congestion) or safety concerns are done outside standard hours. NMLs during these periods are presented in the table for works 'Outside recommended standard hours'.

Table 4-1: Procedure for establishing construction NMLs at residential receivers, (ICNG, DECC 2009)

Time of day	Noise management level $L_{Aeq\ (15\ min)}$	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected (RBL + 10 dB)	The noise affected level represents the point above which there may be some community reaction to noise. - Where the predicted or measured $L_{Aeq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices 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 the duration, as well as contact details.
	Highly noise affected (75 dB(A))	The highly noise affected 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 restricting the hours that the very noisy activities can occur, taking into account: 1. 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) 2. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected (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 practices have been applied and noise is

Time of day	Noise management level $L_{Aeq\ (15\ min)}$	How to apply
		more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.

The ICNG also provides guidance for other types of receivers. Recommended management levels for relevant receiver types within the vicinity of the proposal and construction compound areas have been reproduced below.

Table 4-2 Noise management levels for non-residential land uses (ICNG, DECC 2009)

Land use	Management level $L_{Aeq\ 15\ minute}$ dB(A) (when in use)
Commercial premises	70 dB(A) external noise level
Outdoor recreational area (passive)	60 dB(A) external noise level

4.5.1 Sleep disturbance

Construction noise impacts or events that can cause interruptions to sleeping patterns are considered separately to noise levels during works outside standard hours. The proposal is generally expected to be completed during standard hours of construction, though activities may be required to be undertaken outside standard hours owing to road access and safety reasons. As such, sleep disturbance assessment guidance is introduced below.

The ICNG does not provide a specific method for assessment of potential sleep disturbance noise impacts; and guidance on the acceptability of these events is taken from the RNP.

The RNP provides two criteria:

- Sleep disturbance screening criterion – used to identify situations where there is the potential for sleep disturbance
- Sleep disturbance awakening criterion – levels below which awakening is unlikely to occur.

The sleep disturbance screening criterion recommends that where the $L_{A1\ (1\ minute)}$ does not exceed the $L_{A90\ (15\ minute)}$ by 15 dB(A) or more, sleep disturbance impacts are likely to be maintained at an acceptable level. The $L_{A1,\ (1\ minute)}$ descriptor is meant to represent a maximum noise level when measured using a 'fast' time response.

The sleep disturbance awakening criterion is the threshold at which an awakening reaction is likely to occur. Research discussed in the RNP identified this threshold to be an internal bedroom noise level of around 50 to 55 dB(A).

Windows often allow the greatest amount of sound transmission from outside to inside across a building façade. Noting guidance presented in AS2436-2010: where bedrooms are ventilated by an opened window, a sleep disturbance awakening criterion measured outside the bedroom window of 60 to 65 dB(A) less the conversion from $L_{AEq\ 15\ minute}$ to an $L_{A\ 1\ minute}$ (conservatively assumed to be 10 dB(A) would generally apply (i.e. 55 dB(A)).

4.5.2 Construction traffic noise

Section 9 of the CNVG provides guidance for the assessment of noise associated with additional traffic generated during construction. This guidance was adopted for this assessment and has been reproduced below:

> *'For RMS projects an initial screening test should first be applied by evaluating whether noise levels will increase by more than 2dB(A) due to construction traffic or a temporary reroute due to a road closure. Where increases are 2dBA or less no further assessment is required.*
>
> *Where noise levels increase by more than 2dB(A) [i.e. 2.1 dBA] further assessment is required using Roads and Maritimes Criteria Guideline. This documents RMS' approach to implementing the Road Noise Policy. Consideration should be given under the Noise Criteria Guideline as to whether construction traffic or temporary reroute triggers new road criteria due to changes in road category'.*

4.6 Project specific construction Noise Management Levels

Considering the background noise statistics (RBLs) presented in Table 3-2 and the guidance from the ICNG above in Table 4-1, NMLs shown in Table 4-3 have been established to manage noise impacts during construction.

Table 4-3: Construction Noise Management Levels (NMLs)

NCA	Construction Noise Management Levels dB(A)					
	Standard hours of construction (Mon-Fri 7am to 6pm, Sat 8am to 1pm		OOHW Period 1 (Mon-Fri 6pm to 10pm, Sat 7am to 8am / 1pm to 10pm, Sun / Pub Hol 8am to 6pm)		OOHW Period 2 (Mon-Fri 10pm to 7am, Sat 10pm to 8am, Sun / Pub Hol 6pm to 7am)	
	RBL	NML (+10dB)	RBL	NML (+5dB)	RBL	NML (+5dB)
1*	55	**65**	52	**57**	50	**55**
2	55	**65**	52	**57**	50	**55**
3	37	**47**	32	**37**	30	**35**
4	38	**48**	36	**41**	32	**37**
5	37	**47**	33	**38**	30	**35**

** Noise levels at NCA1 were noted as invalid. Monitoring results from NCA2 were used for residential receivers in NCA1 to establish construction noise management levels.*

4.7 Construction noise modelling

To evaluate potential noise impacts during construction, a site noise model was developed using the SoundPlan 8.0 acoustic software package. Predictions were compared against the NMLs developed in Section 4.5 to determine the potential for impacts. Table 4-4 lists the inputs used in the noise model.

Table 4-4: Construction noise model setup details

Model input	Details
Topography	2m contours intervals obtained from Lands and Property Information (LPI) data
Buildings	Footprints for receiver and other ancillary buildings were determined from aerial photography. Heights were estimated from Google Street view, or otherwise, assuming a building floor height of 3 metres per level.
Non-building receiver areas	Set at a height of 1.5 metres around the worst affected areas of these locations.

Model input	Details
Ground absorption	A ground absorption coefficient of 0.75 (generally soft surfaces) was applied consistent with Section 7 of the Roads and Maritime Noise Model Validation Guideline (NMVG, 2018)
Noise sources	Activity sound power levels were adopted from Roads and Maritime Construction Noise and Vibration Guideline
Meteorology	Moderately adverse wind conditions
Prediction method	The *ISO 9613-2: 1996* acoustic prediction algorithm was applied in the model.
Design	Based on the approved 20% project design. *

** Following the preparation of this report, the 100% project design has been released. It is understood by Jacobs that this design is approximately 20m shorter at both the northern and southern ends of the project extent and involves no major elevation changes to the design. As such this assessment is considered a conservative consideration of potential noise impacts and actual impacts will be marginally lower than those presented here.*

4.8 Construction activities and proposed plant and equipment

The sound power level adopted for each item of plant and equipment in the modelling of construction noise is indicated in Table 4-5. The schedule of plant and equipment to be used would be confirmed with the final construction program. Predictions of construction noise impact consider, variously, each works stage running concurrent with both potential ancillary facilities operating simultaneously.

Table 4-5: Plant sound power levels used in the modelling of construction noise

Construction phase	Typical plant and equipment	Sound power level dB(A) $L_{Aeq(15min)}$
Stage 1 – Early works / utility relocation	Excavator (tracked) 35t	110
	Dump truck (4/hr)	110
	Franna crane 20t	98
	Pneumatic hammer	113
	Concrete saw	118
	Vacuum truck	109
	Backhoe	111
	Power generator	103
	Fixed crane	113
	TOTAL	**121**
Stage 2 – Site compound and erosion and sediment control establishment	Front end loader	112
	Grader	113
	Vibratory roller	109
	Dump truck (4/hr)	110
	Water cart	107
	Power generator	103
	Light vehicles (eg 4WD)	103
	TOTAL	**118**
Stage 3 – Stripping and clearing	Bulldozer D9	116
	Excavator (tracked) 35t	110
	Chainsaw 4-5hp	114
	Tub grinder/ mulcher 40-50hp	116
	Dump truck (4/hr)	110
	TOTAL	**121**
Stage 4 – Under road drainage works	Backhoe	110
	Franna crane 20t	98

Construction phase	Typical plant and equipment	Sound power level dB(A) $L_{Aeq(15min)}$
	Excavator (tracked) 35t	110
	Concrete truck (4/hr)	109
	Truck compressor	75
	Vibratory roller	109
	Road truck (4/hr)	108
	TOTAL	**116**
Stage 5 – Embankment and earthworks	Bulldozer D9	116
	Scraper 651	110
	Excavator (tracked) 35t	110
	Grader	113
	Dump truck (8/hr)	113
	Compactor	106
	Roller (large pad foot)	109
	Water cart	107
	TOTAL	**119**
Stage 5a – Piling and wick drain installation	Piling Rig-Driven	116
Stage 6 – Pavement works	Pavement laying machine	114
	Dump truck (4/hr)	110
	Asphalt truck & sprayer	103
	Smooth drum roller	107
	Concrete saw	118
	TOTAL	**119**
Stage 8 – Finalisation works	Fixed crane	113
	Front end loader	112
	Excavator (tracked) 35t	110
	Dump truck (4/hr)	110
	Water cart	107
	Power generator	103
	Light vehicles (eg 4WD)	103
	TOTAL	**118**
Site compound operation	Power generator	103
	Franna crane 20t	98
	Light vehicles (eg 4WD)	103
	TOTAL	**107**

4.9 Predicted construction noise impact with standard mitigation applied

This section provides an overview of construction noise impacts across the entire proposal.

Construction noise contours for each construction stage are presented in Appendix B.

In general, the following noise impacts are predicted during construction activities. Further information on exceedances is provided in Section.4.12:

- Stage 1 – Early works / utility relocation:
  - The loudest equipment proposed for use during this work stage is the concrete saw. This alone contributes 5dB(A) to overall modelled noise levels

  - Ten properties located in the vicinity of the southern extent of the proposal area are expected to be acutely impacted [>75dB(A)] when works are underway in close proximity to their properties
  - Exceedances of daytime NMLs during early works may extend south as far as 24 Main Road. To the north, exceedances may reach properties within 501 Cessnock Road, Gillieston Heights
  - Where early works are conducted during OOHW period 1, exceedances may extend south into Cliftleigh beyond properties on Trader Way. To the north exceedances are likely to reach into the Gillieston Grove housing estate towards Davies Street
  - During OOHW period 2 activities, exceedances will extend throughout Testers Hollow. Noise levels in Louth Park are expected to remain below that NCAs NMLs.
- Stage 2 – Site compound establishment:
  - This assessment has assumed both site compounds are established simultaneously. This presents a conservative result, and as such noise levels are likely to be lower than the results presented here. It is noted that the current compound sites are not confirmed and may change
  - The loudest equipment included in this work stage is earthmoving equipment around the site office, in particular front end loaders and graders. Where earthmoving equipment is not in use around the office, noise levels will be substantially lower
  - No properties are predicted to be acutely impacted [ie >75dB(A)] by establishment activities at the construction compounds
  - Exceedances of daytime NMLs during site compound establishment may extend south as far as 30 Main Road. To the north, exceedances may reach properties within 501 Cessnock Road, Gillieston Heights
  - Where site compounds are being established during OOHW period 1, exceedances may extend south beyond the front row of properties in the Cliftleigh housing estate. To the north these exceedances may reach the front rows of houses within Gillieston estate. On Cessnock Road, NMLs may be exceeded as far north as 411 Cessnock Road and south to the intersection of Main Road and William Tester Drive
  - During OOHW period 2, exceedances may extend south into Cliftleigh beyond properties on Trader Way. To the north exceedances are likely to reach into the Gillieston Grove housing estate, extending towards Davies Street.
- Stage 3 – Stripping and clearing:
  - Use of the tub mulcher and dozer contribute most to overall noise levels
  - Ten properties located at the southern end of Cessnock / Main Road are expected to be acutely impacted [>75dB(A)] when works are underway in close proximity to their properties
  - Exceedances of daytime NMLs during stripping and clearing may extend south as far as 24 Main Road. To the north, exceedances may reach properties within 501 Cessnock Road, Gillieston Heights
  - Where stripping and clearing activities are conducted during OOHW period 1, exceedances may extend south into Cliftleigh beyond properties on Trader Way. To the north exceedances are likely to reach into the Gillieston Grove housing estate towards Davies Street
  - During OOHW period 2 activities, exceedances will extend throughout Testers Hollow. Noise levels in Louth Park are expected to remain below that NCAs NMLs.
- Stage 4 – Drainage works:
  - Eight properties located at the southern end of Cessnock / Main Road are expected to be acutely impacted [>75dB(A)] when works are underway in close proximity to their properties
  - Exceedances of daytime NMLs during drainage works may extend south as far as 30 Main Road. To the north, exceedances may reach properties within 501 Cessnock Road, Gillieston Heights
  - Where drainage works are conducted during OOHW period 1, exceedances may extend south beyond the front row of properties in the Cliftleigh housing estate. To the north these exceedances may reach

the front rows of houses within Gillieston estate. On Cessnock Road, NMLs may be exceeded as far north as 411 Cessnock Road, Gillieston Heights and south to the intersection of Main Road and William Tester Drive

- During OOHW period 2, exceedances may extend south into Cliftleigh beyond properties on Trader Way. To the north exceedances are likely to reach into the Gillieston Grove housing estate, extending towards Davies Street.

- Stage 5 – Earthworks:
  - Eight properties located at the southern end of Cessnock / Main Road are expected to be acutely impacted [>75dB(A)] when works are underway in close proximity to their properties
  - Exceedances of daytime NMLs during earthworks may extend south as far as 20 Main Road. To the north, exceedances may reach properties within 501 Cessnock Road, Gillieston Heights
  - Where earthworks are conducted during OOHW period 1, exceedances may extend south into Cliftleigh beyond properties on Trader Way. To the north exceedances are likely to reach into the Gillieston Grove housing estate towards Davies Street
  - During OOHW period 2 activities, exceedances will extend throughout Testers Hollow. Noise levels in Louth Park are expected to remain below that NCAs NMLs.
- Stage 5a – Piling and installation of wick drains:
  - No properties are predicted to be acutely impacted [ie >75dB(A)] by activities at the construction compounds
  - Exceedances of daytime NMLs during piling and wick drain installation activities may occur at the nearest three properties to the project area located to the south along Main Road
  - Where piling is conducted during OOHW period 1, exceedances may extend south as far as 26 Main Road, Cliftleigh, beyond the front row of properties in the Cliftleigh housing estate. To the north these exceedances may reach 527 Cessnock Road, Gillieston Heights
  - During OOHW period 2, exceedances may extend south into Cliftleigh beyond properties on Trader Way. To the north exceedances are likely to reach the front row of houses in the Gillieston Grove housing estate.
- Stage 6 – Paving activities:
  - Eight properties located at the southern end of Cessnock / Main Road are expected to be acutely impacted [>75dB(A)] when works are underway in close proximity to their properties
  - Exceedances of daytime NMLs during paving activities may extend south as far as 20 Main Road. To the north, exceedances may reach properties within 501 Cessnock Road, Gillieston Heights
  - Where paving is conducted during OOHW period 1, exceedances may extend south into Cliftleigh beyond properties on Trader Way. To the north exceedances are likely to reach into the Gillieston Grove housing estate towards Davies Street
  - During OOHW period 2 activities, exceedances will extend throughout Testers Hollow. Noise levels in Louth Park are expected to remain below that NCA’s NMLs.
- Stage 8 – Finishing works:
  - Proposed use of a front end loader and crane during this final work stage contribute substantially to overall noise levels
  - Eight properties located at the southern end of Cessnock / Main Road are expected to be acutely impacted [>75dB(A)] when works are underway in close proximity to their properties
  - Exceedances of daytime NMLs during finishing work may extend south as far as 20 Main Road. To the north, exceedances may reach properties within 501 Cessnock Road, Gillieston Heights
  - Where finishing work is conducted during OOHW period 1, exceedances may extend south into Cliftleigh beyond properties on Trader Way. To the north exceedances are likely to reach into the Gillieston Grove housing estate towards Davies Street

  - During OOHW period 2 activities, exceedances will extend throughout Testers Hollow. Noise levels in Louth Park are expected to remain below that NCA's NMLs.
- Site compound operation:
  - This assessment has assumed both site compounds are operating simultaneously. This is not likely and as such noise levels are likely to be somewhat lower than the results presented
  - It is noted that the current compound sites are not confirmed and may change
  - No properties are predicted to be acutely impacted [ie >75dB(A)] by activities at the construction compounds
  - No properties are expected to experience exceedances of daytime NMLs from site compound operation
  - During work outside of standard hours, activities at the southern preliminary compound site may result in exceedances of OOHW period 1 and OOHW period 2 NMLs at the nearest three properties located to the south of the proposal.

Overall, construction noise impacts are predicted to occur where construction activities are undertaken in the southern built up areas of the proposal, along Main Road and the intersection with Avery Lane. These impacts will be more substantial during tie-in works which may be required to be undertaken during night time hours.

4.10 Construction traffic noise impact

Material will be imported to the site to construct the embankment and road.

Materials for the proposal are available from a number of nearby quarries and local heavy vehicle movements will be required to Cessnock Road.

The estimated number of daily light and heavy vehicles to service construction is as follows:

- Light vehicles – construction workforce – up to 20 light vehicles per day
- Heavy vehicles – general fill, asphalt, general deliveries – up to 80 heavy vehicles per day.

In accordance with Section 4.5.2, noise impacts associated with construction traffic is assessed against an increase of 2dB(A) over existing levels. This equates to an increase in heavy vehicle numbers of approximately 60%.

Existing daytime heavy vehicle movements are in the order of 300-500 per direction per day. A peak traffic increase of 40 heavy vehicle movements in each direction equates to an increase of up to 13% and would be likely to result in an increase in road traffic noise along Main and Cessnock Roads of 0.3dB(A). This was verified using the CNE, with input information applied as displayed in Appendix C.

An increase of this magnitude is unlikely to be noticeable and is below the 2.1dB(A) threshold for construction traffic noise. Therefore, it was determined that noise from additional traffic movements generated during construction was not likely to represent an issue during the proposal.

4.11 Sleep disturbance impacts

The construction noise contour maps presented in Appendix B present estimated internal L_{A1} noise levels for the purposes of assessing potential sleep disturbance impacts.

The predicted levels indicate that sleep disturbance screening and awakening criterion may be exceeded at receivers set at distances of up to around 50 metres from the proposed works. This prediction considers the correction of values presented in Section 4.5.1. This prediction is conservative, noting that the sleep disturbance awakening criterion is based on a 'worst-case' façade transmission loss of 10 dB(A), which in reality may be higher. Nevertheless, mitigation and management measures should be developed with the aim of limiting any sleep disturbance impacts during the proposal.

4.12 CNVG additional mitigation measures

The construction noise assessment identified that additional measures may be required at some nearby receivers as presented in Appendix B of the CNVG. Consistent with guidance outlined in Appendix C of the CNVG for additional mitigation, additional measures shown in Table 4-6 are also recommended during the proposal.

These measures are for worst-case circumstances and should be reviewed in relation to the specific location(s) of the works noting the linear nature of the proposal and implemented accordingly. Similarly, should works be required outside standard hours, additional measures should be determined in line with Appendix C of the CNVG.

Table 4-6: Additional measures based on predicted results and present construction methodology

Work phase	Impact level	Receivers where noise impacts have been predicted			Standard hours additional mitigation measures
		Standard hours	OOHW period 1	OOHW period 2	
Stage 1	'Moderately intrusive', 10 to 20 dB(A) above NML	Nil	16,18,20, 22,24 Main Road 1,2,3 Avery Lane	16,18,20, 22,24 Main Road 1,3,4 Avery Lane	Notification, monitoring
	'Highly intrusive, > 20 dB(A) above NML	Nil	Nil	Nil	Notification, monitoring
	'Highly noise affected', >75 dB(A)	2,6,7,8,10,12 Main Road 2 Avery Lane	2,6,7,8,10,12,14 Main Road 2 Avery Lane	2,6,7,8,10,12,14 Main Road 2 Avery Lane	Notification, monitoring, specific engagement, respite offering
Stage 2	'Moderately intrusive', 10 to 20 dB(A) above NML	Nil	2,6,8,10 Main Road 2 Avery Lane	2,6,8,10 Main Road 2 Avery Lane	Notification, monitoring
	'Highly intrusive, > 20 dB(A) above NML	Nil	Nil	Nil	Notification, monitoring
	'Highly noise affected', >75 dB(A)	Nil	Nil	Nil	Notification, monitoring, specific engagement, respite offering
Stage 3	'Moderately intrusive', 10 to 20 dB(A) above NML	Nil	14,16,18,20, 22,24 Main Road 1,3,4 Avery Lane 5,7,8,9,10,11,13,15,17,19,21, 23,25,27 Kelman Drive 3,5,7,9 Colombard Street 3,6,8,10,12,14,16,20,22,24,26, 28,30 Moorebank Road	14,16,18,20, 22,24 Main Road 1,3,4 Avery Lane 5,7,8,9,10,11,13,15,17,19,21, 23,25,27 Kelman Drive 3,5,7,9 Colombard Street 3,6,8,10,12,14,16,20,22,24,26, 28,30 Moorebank Road	Notification, monitoring
	'Highly intrusive, > 20 dB(A) above NML	Nil	Nil	Nil	Notification, monitoring
	'Highly noise affected', >75 dB(A)	2,6,8,10,12 Main Road 2 Avery Lane	2,6,8,10,12 Main Road 2 Avery Lane	2,6,8,10,12 Main Road 2 Avery Lane	Notification, monitoring, specific engagement, respite offering
Stage 4	'Moderately intrusive', 10 to 20 dB(A) above NML	Nil	7,12,14,16 Main Road 1,3 Avery Lane	7,12,14,16 Main Road 1,3 Avery Lane	Notification, monitoring
	'Highly intrusive, > 20 dB(A) above NML	Nil	Nil	Nil	Notification, monitoring
	'Highly noise affected', >75 dB(A)	2,6,8,10 Main Road	2,6,8,10 Main Road	2,6,8,10 Main Road	Notification, monitoring, specific engagement, respite offering
Stage 5	'Moderately intrusive', 10 to 20 dB(A) above NML	Nil	9,14,16,18,20 Main Road 1,2,3 Avery Lane	9,14,16,18,20 Main Road 1,2,3 Avery Lane	Notification, monitoring

Work phase	Impact level	Receivers where noise impacts have been predicted			Standard hours additional mitigation measures
		Standard hours	OOHW period 1	OOHW period 2	
			5,7,9,11 Kelman Drive 2 Millbrook Road 1,3 Colombard Street 6,8,10,12 Moorebank Road	5,7,9,11 Kelman Drive 2 Millbrook Road 1,3 Colombard Street 6,8,10,12 Moorebank Road	
	'Highly intrusive, > 20 dB(A) above NML	Nil	Nil	Nil	Notification, monitoring
	'Highly noise affected', >75 dB(A)	2,6,7,8,10,12 Main Road	2,6,7,8,10,12 Main Road	2,6,7,8,10,12 Main Road	Notification, monitoring, specific engagement, respite offering
Stage 5a	'Moderately intrusive', 10 to 20 dB(A) above NML	Nil	Nil	Nil	Notification, monitoring
	'Highly intrusive, > 20 dB(A) above NML	Nil	Nil	Nil	Notification, monitoring
	'Highly noise affected', >75 dB(A)	Nil	Nil	Nil	Notification, monitoring, specific engagement, respite offering
Stage 6	'Moderately intrusive', 10 to 20 dB(A) above NML	Nil	17,18,20,22,24 Main Road 1,2,3 Avery Lane 5 Kelman Drive 2 Millbrook Road 1,3 Colombard Street	17,18,20,22,24 Main Road 1,2,3 Avery Lane 5 Kelman Drive 2 Millbrook Road 1,3 Colombard Street	Notification, monitoring
	'Highly intrusive, > 20 dB(A) above NML	Nil	Nil	Nil	Notification, monitoring
	'Highly noise affected', >75 dB(A)	2,6,7,8,9,10,12,14,16 Main Road	2,6,7,8,9,10,12,14,16 Main Road	2,6,7,8,9,10,12,14,16 Main Road	Notification, monitoring, specific engagement, respite offering
Stage 8	'Moderately intrusive', 10 to 20 dB(A) above NML	Nil	9,14,16,18 Main Road 1,2,3 Avery Lane 5 Kelman Drive 2 Millbrook Road 1,3 Colombard Street	9,14,16,18 Main Road 1,2,3 Avery Lane 5 Kelman Drive 2 Millbrook Road 1,3 Colombard Street	Notification, monitoring
	'Highly intrusive, > 20 dB(A) above NML	Nil	Nil	Nil	Notification, monitoring
	'Highly noise affected', >75 dB(A)	2,6,7,8,10,12 Main Road	2,6,8,10 Main Road	2,6,8,10 Main Road	Notification, monitoring, specific engagement, respite offering

Work phase	Impact level	Receivers where noise impacts have been predicted			Standard hours additional mitigation measures
		Standard hours	OOHW period 1	OOHW period 2	
Compound operations	'Moderately intrusive', 10 to 20 dB(A) above NML	Nil	Nil	Nil	Notification, monitoring
	'Highly intrusive, > 20 dB(A) above NML	Nil	Nil	Nil	Notification, monitoring
	'Highly noise affected', >75 dB(A)	Nil	Nil	Nil	Notification, monitoring, specific engagement, respite offering

5. Assessment of construction vibration

The following vibration-intensive plant is proposed for use during construction:

- Stage 1 – Early works: jackhammer
- Stage 2 – Site compound: vibratory roller
- Stage 3 – Clearing: nil
- Stage 4 – Drainage: vibratory roller
- Stage 5 – Earthworks: compactor, vibratory roller
- Optional phase – impact piling: hydraulic piling rig
- Stage 6 – Paving: nil
- Stage 8 – Finishing: nil.

5.1 Overview of potential vibration impacts

Vibration from construction processes can potentially cause impacts of the following types:

- Human comfort
- Structural damage
- Heritage items or vibration sensitive activities.

5.2 Vibration Criteria

5.2.1 Human comfort

With respect to human comfort, vibration arising from construction activities must comply with criteria presented in *Assessing Vibration: a technical guideline*, (DECC, February 2006) and *British Standard 6472-1: 2008 Guide to evaluation of human exposure to vibration in buildings Part 1: Vibration sources other than blasting* [BS 6472-1: 2008]. DECC, 2006 identifies three different forms of vibration associated with construction activities:

- Continuous: uninterrupted vibration occurring over a defined period
- Impulsive: short-term (typically less than two seconds) bursts of vibration which occurs up to three times over an assessment period
- Intermittent: interrupted periods of continuous or repeated impulsive vibration, or continuous vibration that varies significantly in magnitude.

Continuous vibration may result from steady road traffic or steady use of construction equipment (e.g. generator). Impulsive vibration may arise during the loading or unloading of heavy equipment or materials or infrequent use of hammering equipment. Intermittent vibration may arise from the varied use of construction equipment (i.e. a dump truck moving around a site, idling while being loaded with materials, and then dumping the materials) or repeated high-noise activities such as hammering, piling or cutting.

Preferred and maximum values of human exposure for continuous and impulsive vibrations are listed in *Assessing Vibration: a technical guideline*, (DECC, February 2006) as outlined in Table 5-1.

Table 5-1: Preferred and maximum values for continuous and impulsive vibration acceleration (m/s^2) 1-80 Hz (DECC, 2006)

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	X and y axis	z-axis	X and y axis
Continuous vibration					
Critical areas[2]	Day or night	0.0050	0.0036	0.010	0.0072
Residences	Day	0.010	0.0071	0.020	0.014
	Night	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day or night	0.020	0.014	0.040	0.028
Workshops	Day or night	0.04	0.029	0.080	0.058
Impulsive vibration					
Critical areas[2]	Day or night	0.0050	0.0036	0.010	0.0072
Residences	Day	0.30	0.21	0.60	0.42
	Night	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day or night	0.64	0.46	1.28	0.92
Workshops	Day or night	0.64	0.46	1.28	0.92

[1] Daytime is 7am to 10pm. Night-time is 10pm to 7am

[2] includes hospital operating theatres or precision laboratories.

Intermittent vibration is assessed differently; using vibration does values (VDV). Preferred and maximum VDVs are also provided in *Assessing Vibration: a technical guideline*, (DECC, February 2006) and have been reproduced in Table 5-2.

Table 5-2: Preferred and maximum VDVs for intermittent vibration ($ms^{-1.75}$), (DECC, 2006)

Location	Day time (7 am to 10 pm)		Night time (10 pm to 7 am)	
	Preferred VDV	Maximum VDV	Preferred VDV	Maximum VDV
Critical areas[1]	0.10	0.20	0.10	0.2
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

[1] Includes operating theatres, precision laboratories and other areas where vibration-sensitive activities may occur.

5.2.2 Structural damage

Section J4.4.3 of *Australian Standard AS2187.2 – 2006 Explosives – Storage and use Part 2: Use of explosives* provides frequency-dependent guide levels for cosmetic damage to structures arising from vibration. These levels are adopted from *British Standard BS7385: 1990 Evaluation and measurement for vibration in buildings Part 2: Guide to damage levels from groundbourne vibration* [BS7385-2:1993] and are shown below in Table 5-3.

Table 5-3: Vibration guide values for cosmetic building damage, (BS7385-2: 1993)

Line	Type of building	Peak particle velocity (PPV) mm/s		
		4 to 15 Hz	15 to 40 Hz	40 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50		
2	Un-reinforced or light-framed structures Residential or light commercial type buildings	15 to 20	20 to 50	50

5.2.3 Heritage and vibration sensitive activities

Guidance for more sensitive structures or vibration sensitive activities is presented in the German Guideline, *DIN 4150-3 Structural vibration Part 3: Effects of vibration on structures* (DIN 4150-3:1999-02). Vibration velocities not exceeding 3 mm/s at 1 to 10 Hz are recommended in this standard.

5.2.4 Construction Noise and Vibration Guideline

Section 7 of the CNVG recommends safe working distances for achieving human comfort (*Assessing Vibration: a technical guideline*, (DECC, February 2006) and cosmetic building damage (BS7385-2:1993) criteria for a range of different plant and equipment. These have been reproduced in Table 5-4.

Table 5-4: Recommended safe working distances for vibration-intensive plant and equipment, (CNVG, Roads and Maritime 2016)

Plant	Rating / description	Safe working distance (metres)	
		Cosmetic damage (BS7385-2: 1993)	Human response (DECC, 2006)
Vibratory Roller	<50 kN (typically 1-2 tonne) <100 kN (typically 2-4 tonne) <200 kN (typically 4-6 tonne) <300 kN (typically 7-13 tonne) >300 kN (typically 13-18 tonne) >300 kN (> 18 tonne)	5 metres 6 metres 12 metres 15 metres 20 metres 25 metres	15 m to 20 metres 20 metres 40 metres 100 metres 100 metres 100 metres
Small hydraulic hammer	300 kg – 5 to 12 tonne excavator	2 metres	7 metres
Medium hydraulic hammer	900 kg – 12 to 18 tonne excavator	7 metres	23 metres
Large hydraulic hammer	1600 kg – 18 to 34 tonne excavator	22 metres	73 metres
Vibratory pile driver	Sheet piles	2 to 20 metres	20 metres
Pile boring	≤800 mm	2 metres (nominal)	4 metres
Jackhammer	Hand held	1 metre (nominal)	2 metres

5.3 Predicted construction vibration levels

Piling activities may be required depending on the final construction methodology and are understood to be proposed in soft soil areas only. These sites are located more than 100m from the nearest residences and 80m from the nearest structures. No vibration sensitive heritage structures have been identified in the vicinity of the proposed construction area. As such vibration impacts are not expected to arise during piling works.

At the nearest point to roadworks, vibratory compaction may be occurring at approximately 20m from the nearest residential properties. At this distance, there is the potential for exceedances of the human comfort criteria, however building damage is unlikely.

5.4 Construction vibration management measures

Assessing Vibration: a technical guideline, (DECC, February 2006) provides general guidance for limiting vibration impacts during construction. Relevant recommendations have been reproduced in Table 5-5, and should be considered as appropriate.

Table 5-5: Vibration management measures from DECC, 2006.

Control measure	Details
Controlling vibration levels from the source	• Choosing alternative, lower-impact equipment or methods wherever possible. • Scheduling the use of vibration-causing equipment at the least sensitive times of the day (wherever possible). • Locating high vibration sources as far away from sensitive receiver areas as possible. • Sequencing operations so that vibration-causing activities do not occur simultaneously. • Keeping equipment well maintained. • Do not conduct vibration intensive works within the building damage distances outlined in Table 5-4. Where possible, avoid the use of vibration intensive plant within the nominated human comfort distances.
Consultation	• Informing nearby receivers about the nature of construction stages and the vibration-generating activities.

Care should be taken to avoid the use of vibratory compaction equipment within the setback distances recommended to avoid human comfort impacts as relevant above in Table 5-5. Wherever practical, static compaction techniques should be utilised for compaction required within the applicable setback distances recommended to avoid human comfort impacts.

6. Operational noise criteria

6.1 Noise Criteria Guideline

In 2015, Roads and Maritime formalised the NCG, Noise Mitigation Guideline (NMG) (RMS, 2015) and other supporting documents including the NMVG to further define and standardise the methods for assessing road noise and its mitigation from the guidance presented in the RNP.

6.2 Applying the Noise Criteria Guideline

The first stage of assessment requires classification of the road in accordance with the NCG. This document states that where a project is not intended to increase the traffic carrying capacity or accommodate a significant increase in heavy traffic, the road is not classified as new or redeveloped.

Impacts of the proposal on traffic numbers are discussed in the Traffic and Transport Assessment for this proposal. This document states that proposal will not change the traffic carrying capacity or accommodate a significant increase in heavy vehicle traffic.

Further consideration of potential changes to the road alignment are outlined in Appendix A1 of the NCG. This section describes the classification of roads as new and presents that where the functional class of a road changes or where the proposed road alignment is substantially re-aligned the road will be classified as a new road. Where the new road lanes are within ‘six times the existing total lane width’ (in this case 42m), the road is not classified as substantially realigned.

At its furthest realignment point, the alignment of Cessnock Road is shifting by a distance of 19m and an as such remains well within the identified 42m allowance.

The functional class of the road is not proposed to change. In accordance with Section 5.5 of the NCG and the factors outlined above, a consideration of traffic impacts should be carried out in accordance with the ‘Minor Works’ methodology.

6.3 Operational noise criteria for residential receivers

For the assessment of noise impacts associated with assessments of ‘Minor Work’ proposal, it must first be evaluated whether noise levels increase by 2.1 dB(A) or more relative to existing levels at the worst-affected residential receiver. If this is found to be the case, all sensitive receivers within the study area must be assessed against this relative increase criterion, as well as the applicable road type criteria from the NCG and RNP reproduced in Table 6-1. It is noted that ‘transition zones’ requirements do not need to be considered for ‘minor works’.

Table 6-1: Road noise control criteria

Road category	Type of project/land use	Assessment criteria dB(A)	
		Day (15 hour)	Night (9 hour)
Freeway/arterial/sub-arterial roads	1. Existing residences affected by noise from new freeway/arterial/sub-arterial road corridors	$L_{Aeq\ (15hr)}$ 55 (external)	$L_{Aeq\ (9hr)}$ 50 (external)
	2. Existing residences affected by noise from redevelopment of existing freeway/arterial/sub-arterial roads	$L_{Aeq\ (15hr)}$ 60 (external)	$L_{Aeq\ (9hr)}$ 55 (external)
	3. Existing residences affected by additional traffic on existing freeways / arterial / sub-arterial roads generated by land use developments.	Existing $L_{Aeq\ (15hr)}$ (external) + 12 dB(A)	Existing $L_{Aeq\ (9hr)}$ (external) + 12 dB(A)

6.4 Operational noise criteria for non-residential receivers

All non-residential receivers along Cessnock Road are located well outside the project operational study area (i.e. 600 m), and are highly unlikely to be affected by changes in road traffic noise as a result of this proposal. As such, these receiver locations were not considered further in this assessment.

6.5 Assessing potential for sleep disturbance

A guide for assessing the potential for sleep disturbance within residences from the proposal’s vehicle passbys is provided in the RNP:

> *‘Triggers for, and effects of sleep disturbance from, exposure to intermittent noise such as noise from road traffic are still being studied. There appears to be insufficient evidence to set new indicators for potential sleep disturbance due to road traffic noise. The NSW Roads and Traffic Authority’s Practice Note iii (NSW Roads and Traffic Authority 2008a) outlines a protocol for assessing and reporting on maximum noise levels and the potential for sleep disturbance’*

The ENMM Practice Note iii indicates that:

- Maximum internal noise levels below 50–55 dB(A) are unlikely to cause awakening reactions, and
- One or two noise events per night with maximum internal noise levels of 65–70 dB(A) are not likely to significantly affect health and wellbeing.

Given the that it is generally accepted that the level of traffic noise within a dwelling having its windows open is 10 dB(A) lower than the corresponding noise level immediately outside the facade (refer ICNG), these internal noise goals may be re-expressed as external noise goals as follows:

- Maximum external noise levels below 60–65 dB(A) are unlikely to cause awakening reactions, and
- One or two noise events per night with maximum external noise levels of 75-80 dB(A) are not likely to significantly affect health and wellbeing.

A ‘maximum noise event’ is defined as any vehicle pass-by for which

$$L_{Amax} - L_{Aeq(1\ hour)} \geq 15\ dB(A)$$

The ENMM Practice Note iii states that the maximum noise level assessment should be used as a tool to help prioritise and rank mitigation strategies, but should not be applied as a decisive criterion in itself.

7. Modelling of operational noise

7.1 Operational noise – Modelling methodology

Potential noise impacts associated with operation of the proposal have been modelled using the CoRTN algorithm within SoundPlan 8.0 noise modelling software. This method is accepted by regulatory authorities for use in road traffic noise assessments.

7.2 Operational noise – Assessment scenarios

As outlined in Section 6.2, the road is classified as Minor Works. Accordingly, it must first be evaluated whether noise levels increase by 2.1 dB(A) or more relative to existing levels at the worst-affected residential receiver. As no increase in traffic numbers are forecast, the results of the traffic survey will be applied to both alignments and the changes in road traffic noise will be predicted. These traffic numbers are provided in Table 3-3.

Where the increase in traffic noise is found to be 2.1dB(A) or more, further assessment against road noise criteria will be carried out.

7.3 Operational noise modelling inputs

The most significant factors in determining the level of noise received from a road are the receiver's distance from the road, shielding, ground absorption, the type and volume of vehicles, vehicles speeds and the road surface type.

The road and traffic parameters used and values adopted in the noise modelling are presented in Table 7-1.

Table 7-1: Operational noise modelling parameters

Parameter	Notes
Facades	Standard +2.5dB(A) correction applied to account for façade reflection
Traffic speeds	Traffic speeds were obtained during traffic counts and have been modelled as follows: Cessnock Road (north bound) daytime 75 km/hr Cessnock Road (north bound) night time 80 km/hr Cessnock Road (south bound) daytime 77 km/hr Cessnock Road (south bound) night time 82 km/hr
Buildings	Footprints taken from aerial photography Heights determined from site inspections and Google Streetview.
Terrain	The TNR terrain data was derived from NSW Land Property Information (LPI) 1m resolution bare earth Digital Elevation Model (DEM). The DEM was produced from a standard LiDAR survey conducted by LPI. *Reference: NSW Land Property Information (LPI) LiDAR Product Specifications, Version 3.0, March 2013.*
Road surface corrections	The existing road surface on Cessnock Road is a worn 10mm chip seal. A road surface correction of +2dB(A) had been applied to recognise the highly worn state of the existing road surface. The proposed road surface is DGA, no road surface correction has been applied for the proposal.
Temperature corrections	In accordance with recent direction from RMS and the published paper '*Evaluation of Road Traffic Noise in Australia*' (Peng, et al 2017), the

Parameter	Notes
	following temperature corrections were applied to modelled traffic noise levels: daytime -0.8dB, night time +0.4dB.
Congestion / intersections	Noise modelling is based on the free-flowing traffic. This is consistent with traffic flow conditions reported during traffic surveys undertaken for this assessment. No corrections have been applied at intersections
Ground surface / absorption	The entire project area has been modelled as open grass. A 75% ground absorbance factor has been applied.
Source heights / corrections	Traffic has been divided into the following source heights and energy levels: Car tyres and engines / 0.5m / 100% Truck tyres / 0.5m / 29% Truck engines / 1.5m / 57% Truck exhaust / 3.6m / 14%
Receiver locations	As the project is considered ‘minor works’, the change in noise levels has been predicted at representative receivers in each noise catchment. These have been modelled at a height of 1.5m and at 1m from the building façade. Noise contours have been presented in Appendix D. These are calculated at a grid spacing of 20m and a height of 1.5m.
LA10 to LAeq conversion	-3dB(A) (applied at all receivers)
Design	Based on the approved 20% project design. *

** Following the preparation of this report, the 100% project design has been released. It is understood by Jacobs that this design is approximately 20m shorter at both the northern and southern ends of the project extent and involves no major elevation changes to the design. As such this assessment is considered a conservative consideration of potential noise impacts and actual impacts will be marginally lower than those presented here.*

7.4 Model validation

The noise model used for the assessment was subjected to a validation process to ensure the accuracy of its traffic noise predictions.

The model validation process allows for the identification of any errors in the modelling setup (e.g. identifying inconsistencies in the geospatial data), and to also then demonstrate that the noise model accurately represents the existing, real-world conditions (within the limitations of the prediction algorithm).

The validation process compared predicted and measured traffic noise levels acquired from those long-term, unattended traffic noise monitoring locations having an unobstructed exposure to traffic noise.

The validation model was configured to reflect actual site conditions (e.g. receiver distance from the road, total angle of view to traffic, type of road surface) and traffic volumes and speeds measured during the monitoring period (refer traffic count locations in Figure 1-2).

Table 7-2 outlines the validation testing for each of the noise monitoring locations selected for model validation for both daytime and night time periods.

Not all monitoring locations are suitable for noise model validation; at monitoring sites 4 and 5 for example, Cessnock Road was not audible and as such these locations are not suitable for validation. The remaining two validation sites are considered adequate for the purposes of noise model validation for a road section of this size.

Table 7-2: Comparison of measured and modelled road traffic noise levels

Location	Monitoring results		Modelled		Difference	
	L_{Aeq} Day	L_{Aeq} Night	L_{Aeq} Day	L_{Aeq} Night	L_{Aeq} Day	L_{Aeq} Night
2	58.2	54.0	60	53.2	+1.8	-0.8
3	50.0	40.0	48.8	41.9	-1.2	+1.9

These results indicate that modelled noise levels are within the permissible +/- 2dB(A) and therefore that this model is expected to provide an accurate indication of road traffic noise for the proposal area.

7.5 Traffic counts and distribution

As outlined in Section 6.2, the road upgrade proposal is classified a ‘minor works’. Accordingly, it must first be evaluated whether noise levels increase by 2.1 dB(A) or more relative to existing levels at the worst-affected residential receiver.

In order to determine this, traffic numbers obtained during the traffic survey will be applied to both alignments and the changes in road traffic noise will be predicted. This method will also be applied to the future scenario years of 2028. Modelled traffic numbers are provided in Appendix D.

7.6 Operational noise impacts prior to consideration of mitigation

Potential changes in operational traffic noise levels may occur as a result of changes in the horizontal and vertical alignment of the road corridor.

Detailed predictions of the existing and proposal’s operational noise at receiver representative of each NCA are presented in Table 7-3. This table also include the worst impacted properties, located to the west of the proposed alignment, in the south of the proposal area. All modelled locations are presented in Figure 1-2.

Properties were selected on the basis of their separation distance from the proposal, with consideration given to local factors such as screening by local buildings or structures.

Where predicted differences between proposal and no proposal are less than 2.1dB(A) at these locations, differences at other potentially affected receivers will also remain below this level.

These results are summarised in Table 7-3 for existing traffic numbers, in addition to forecasts for the years 2028 (refer to Table 7-4). Noise contours comparing road traffic noise under the existing and proposed road alignment have been provided in Appendix E for 2028.

Table 7-3: Comparison of traffic noise under existing traffic numbers

NCA	Location	Existing traffic noise		Predicted traffic noise		Difference	
		LAeq Day	LAeq Night	LAeq Day	LAeq Night	LAeq Day	LAeq Night
1	A1	54	47.1	52.2	45.4	-1.8	-1.7
2	A3	64.3	57.3	62.2	55.2	-2.1	-2.1
3	1	57.7	50.9	55.8	49	-1.9	-1.9
4	2	60	53.2	57.8	50.9	-2.2	-2.3
5	3	36.9	30	34.9	28	-2	-2
1	4	48.8	41.9	46.9	40	-1.9	-1.9
2	5	33.4	26.5	31.5	24.7	-1.9	-1.8

Table 7-4: Comparison of traffic noise in 2028

NCA	Location	Existing traffic noise		Predicted traffic noise		Difference	
		LAeq Day	LAeq Night	LAeq Day	LAeq Night	LAeq Day	LAeq Night
1	A1	56.1	51.2	54.3	49.5	-1.8	-1.7
2	A3	66.4	61.5	64.3	59.4	-2.1	-2.1
3	1	59.8	55	57.9	53.1	-1.9	-1.9
4	2	62.1	57.3	59.9	55	-2.2	-2.3
5	3	39	34.1	37	32.1	-2	-2
1	4	50.9	46	49	44.1	-1.9	-1.9
2	5	35.5	30.6	33.6	28.8	-1.9	-1.8

In summary, without noise mitigation, the assessments identify that:

- Most receivers in the study area are expected to experience a reduction in road traffic noise. This is primarily due to the proposed use of Dense Graded Asphaltic (DGA) road surface instead of the existing 10mm chip seal
- Even where the influence of the road surface is ignored, a maximum increase in road traffic noise of 0.3dB(A) is forecast. This level of increase is well below the permissible 2.1dB(A) and would not be noticeable.

As noise levels are predicted to decrease as a result of this proposal, no further operational noise mitigation is required to be considered.

7.7 Assessing potential for sleep disturbance

Sleep disturbance impacts are generally created by loud short term noise impacts from sources such as heavy vehicle air braking or acceleration. As such they are commonly associated with intersections and changes to truck numbers.

It is expected that the new DGA pavement would reduce noise levels associated with tyre and road interactions for light vehicles. In addition the new road surface would decrease noise levels associated with tyres passing over existing potholes and patching.

There are no traffic related features or proposed design changes along the proposal that would affect the frequency of maximum noise events, particularly from heavy vehicles (i.e. features lending to acceleration and deceleration).

8. Summary

A quantitative assessment was undertaken to determine potential noise and vibration impacts associated with proposed upgrade to Cessnock Road at Testers Hollow.

Regarding construction noise, the assessment predicted that construction noise impacts are likely to occur where construction activities are undertaken in the southern built up areas of the proposal, along Main Road and near the intersection with Avery Lane. These impacts will be more substantial during tie in works which may be required to be undertaken during night time hours.

Standard measures in line with the CNVG were recommended, as well as guidance for the management of residual noise issues after the application of standard measures from the CNVG.

Regarding vibration, measures were recommended in line with *Assessing Vibration: a technical guideline*, (DECC, February 2006) to manage potential issues during the works, as well as specific additional actions to mitigate the potential for human comfort impacts during compaction activities.

Noise from traffic generated during construction was assessed to be negligible using the CNE tool.

Operational noise impacts were assessed against guidance presented in the RNP, NCG and NMG. This review identified that traffic noise is expected to decrease at all receivers as a result of this proposal. As such no specific operational mitigation measures as described in the NMG are required.

Appendix A. Glossary

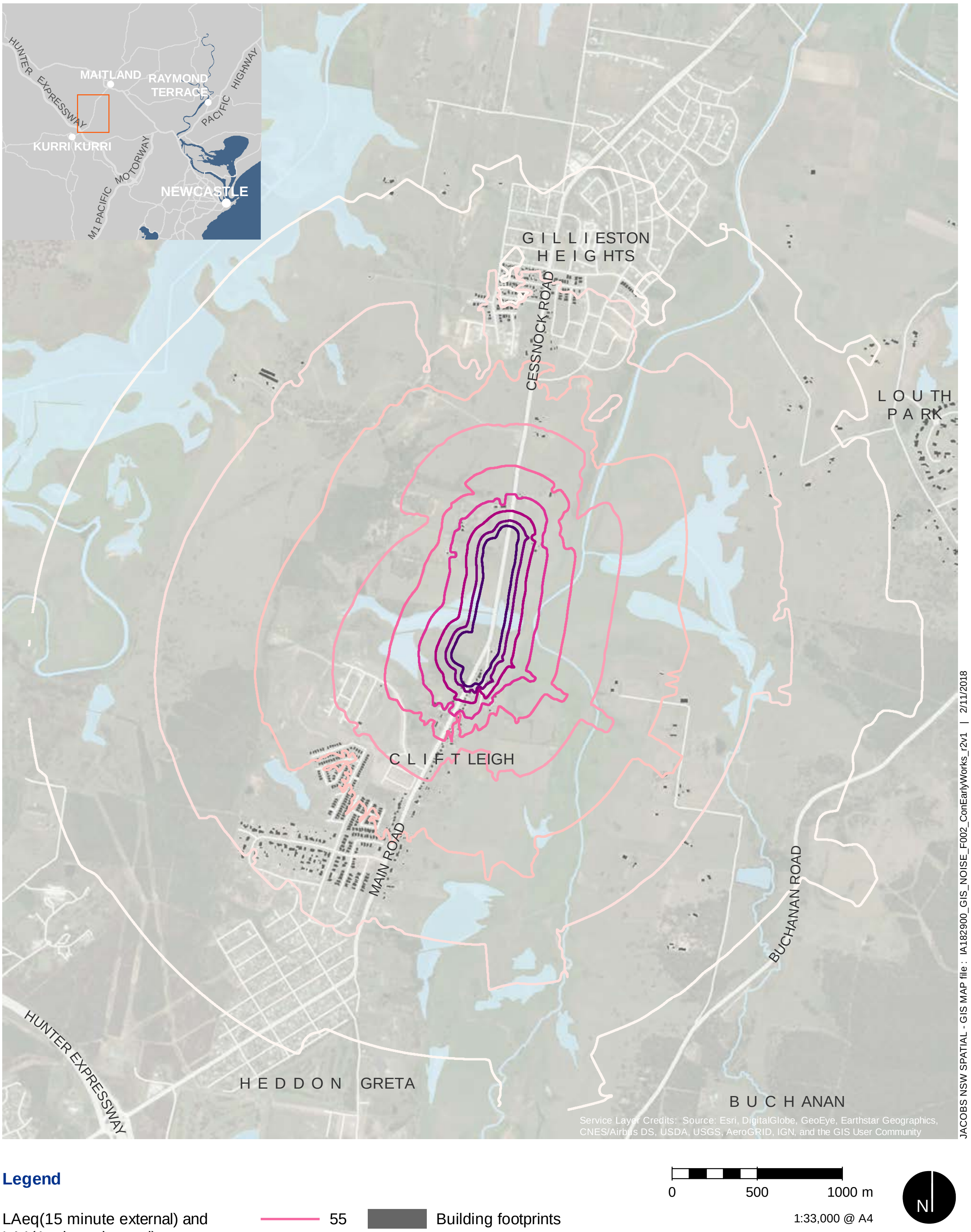
Term	Description
	Acoustic terms (Noise)
Acoustic Barrier	Solid walls or partitions, solid fences, earth mounds, earth berms, buildings, etc used to reduce noise, without eliminating it.
Ambient Noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment Period	The period in a day over which assessments are made.
Audible Range	The limits of frequency which are audible or heard as sound. The normal ear in young adults detects sound having frequencies in the region 20 Hz to 20 kHz, although it is possible for some people to detect frequencies outside these limits.
Background Noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level (see below).
Decibels (dB)	The level of noise is measured objectively using a Sound Level Meter. This instrument has been specifically developed to mimic the operation of the human ear. The human ear responds to minute pressure variations in the air. These pressure variations can be likened to the ripples on the surface of water but of course cannot be seen. The pressure variations in the air cause the eardrum to vibrate and this is heard as sound in the brain. The stronger the pressure variations, the louder the sound is heard. The range of pressure variations associated with everyday living may span over a range of a million to one. On the top range may be the sound of a jet engine and on the bottom of the range may be the sound of a pin dropping. Instead of expressing pressure in units ranging from a million to one, it is found convenient to condense this range to a scale 0 to 120 and give it the units of decibels. The following are examples of the decibel readings of every day steady or quasi-steady sounds. • 0dB the faintest sound we can hear under perfect conditions • 20dB quiet bedroom at night or recording studio • 30dB quiet library or quiet location in the country • 40dB living room • 50dB typical office space or ambience in the city at night • 60dB normal conversational speech • 70dB a car passing by • 80dB kerbside of a busy road • 90dB truck passing by • 100dB nightclub • 110dB rock band or 2m from a jackhammer • 120dB 70m from a jet aircraft • 130dB threshold of pain • 140dB 25m from a jet aircraft

Term	Description
	Acoustic terms (Noise)
dB(A); A-weighted decibels	The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the “A” filter. A sound level measured with this filter switched in is denoted as dB(A). Most environmental noise is measured using the A filter.
dB(C); C-weighted decibels	C weighted adjustments are relatively flat across lower frequencies, and as such are better suited for the assessment of low frequency noise.
Diffraction	The distortion around solid obstacles of waves travelling past.
Frequency	Of a periodic quantity: the time rate of repetition. The reciprocal of the period. Frequency is measured in Hertz (Hz).
Loudness	A 3dB increase represents a doubling of the sound pressure, however an increase of about 10dB is required before the sound will subjectively appear to be twice as loud. That is, a sound of 85dB is twice as loud as a sound of 75dB which is twice as loud as a sound of 65dB and so on. That is, the sound of 85dB is four times as loud as a sound of 65dB. The smallest change which can be readily heard is about 2dB. An increase beyond 5dB is considered to represent the level at which a change in loudness begins to be clearly perceived.
L10	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L90	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
Leq	Equivalent sound pressure level – the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring. The sound weighting of the noise measurement is commonly added, for example LAeq or LCeq.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound Level Meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound Pressure Level	The level of sound pressure, expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound Power Level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Structure-borne noise	Vibration propagating through solid structures in the form of compression or bending waves, heard as sound.

Term	Description
	Acoustic terms (Noise)
Vibration terms	
Acceleration	A vector quantity that specifies the time derivative of velocity.
Accelerometer	A pickup that converts an input acceleration to an output (usually electrical) that is proportional to the input acceleration.
Ambient vibration	The all-encompassing vibration associated with a given environment, usually a composite of vibration from many sources, far and near.
Amplitude	The maximum value of a sinusoidal quantity.
Complex Wave	The resultant form of a number of sinusoidal waves that are summed together forming a periodic wave.
Crest factor	The ratio of the peak value to the r.m.s. value.
Cycle	The complete range of states or values through which a periodic phenomenon or function passes before repeating itself identically.
Displacement	A vector quantity that specifies the change of position of a body or particle with respect to a reference frame.
FFT	Fast Fourier Transform. A computationally efficient mathematical technique which converts digital information from the time domain to the frequency domain for rapid spectral analysis.
Frequency	The reciprocal of the period when the independent variable is time.
Harmonic	Of a periodic quantity. A sinusoidal quantity whose frequency is an integral multiple of the fundamental frequency of the quantity.
Hertz (Hz)	Units in which frequency is expressed. Synonymous with cycles per second.
Peak value	The maximum value of a quantity during a given interval.
Peak-to-peak value	Of an oscillating quantity. The algebraic difference between the extreme values of the quantity.
Periodic vibration	A periodic quantity whose values recur for certain equal increments of the independent variable.
Resonance	Of a system in forced oscillation. The condition of the system when any change in the frequency of excitation, however small the change , causes a decrease in a response of the system.
Resonance frequency	A frequency at which resonance occurs.
Roads and Maritime	Root Mean Square of the acceleration value of the vibration source. This measure allows for the magnitude of the vibration, regardless of its direction.
Spectrum	A description of a quantity as a function of frequency or wavelength.

Term	Description
	Acoustic terms (Noise)
Transducer	A device that receives energy from one system and supplies energy, of either the same or a different kind, to another system in such a manner that the desired characteristics of the input energy appear at the output.
Velocity	A vector quantity that specifies the time derivative of displacement.
Wavelength	Of a periodic wave. The distance, measured perpendicular to the wave front in the direction of propagation, between two successive points on the wave that are separated by one period.

Appendix B. Construction noise contours



Legend

LAeq(15 minute external) and LA1(1 minute internal) construction noise levels

- 35
- 40
- 45
- 50
- 55
- 60
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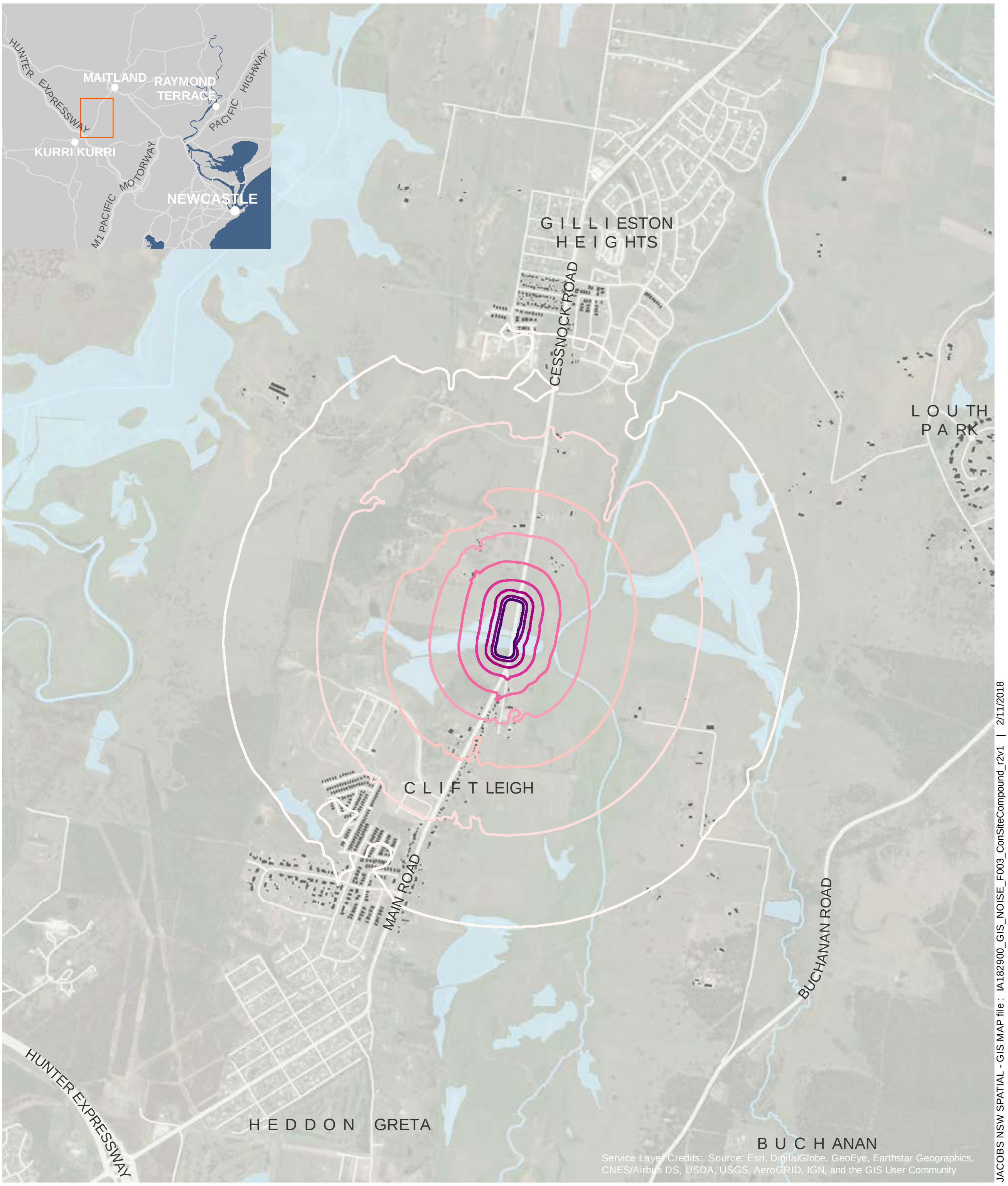
- 70
- 75

Building footprints

Appendix B.1 | Early works / utility relocation



Legend

LAeq(15 minute external) and LA1(1 minute internal) construction noise levels

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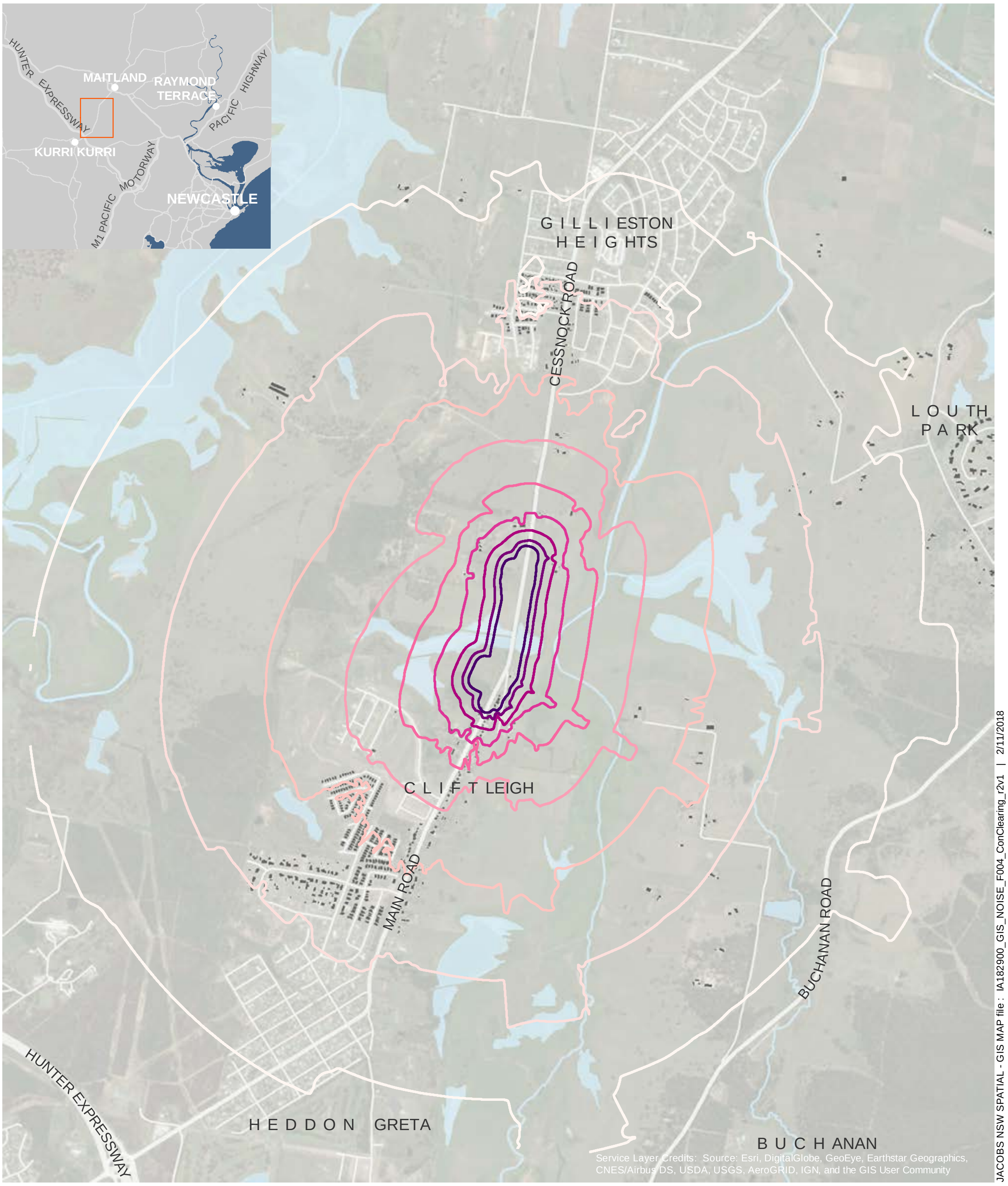
- Building footprints

Appendix B.2 | Site compound



Legend

LAeq(15 minute external) and LA1(1 minute internal) construction noise levels

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Building footprints

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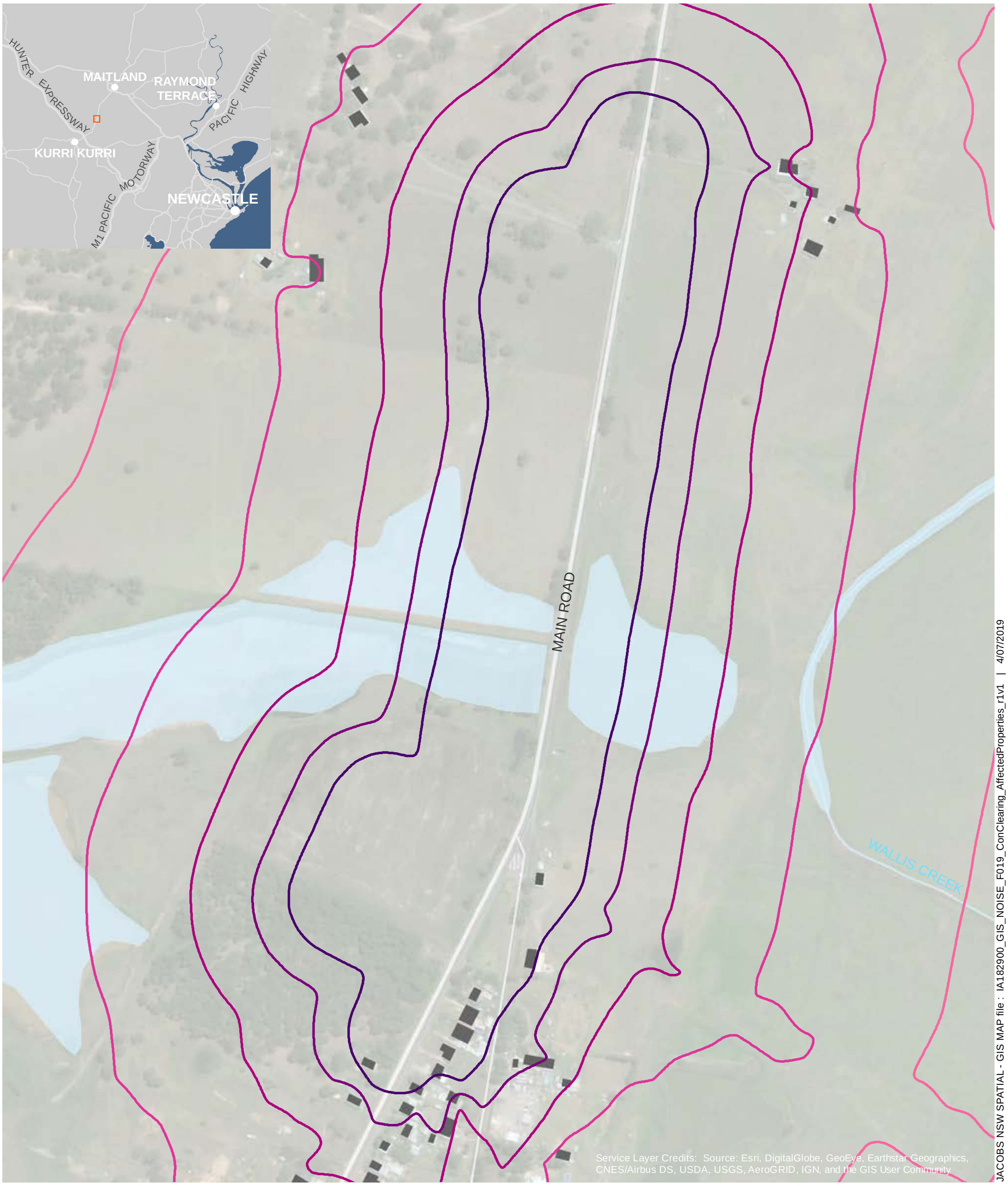
Appendix B.3 | Stripping and clearing



Legend

LAeq(15 minute external) and LA1(1 minute internal) construction noise levels

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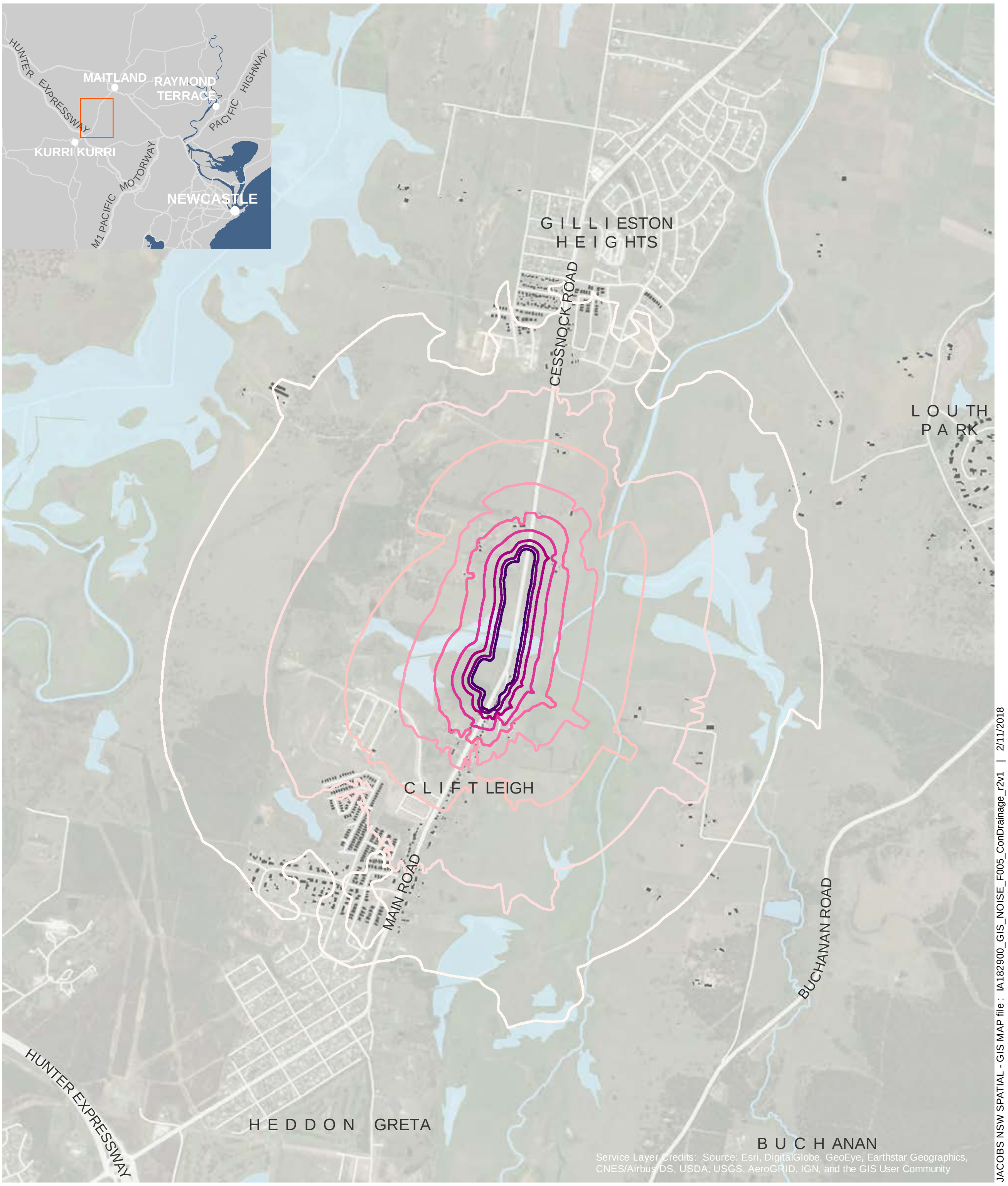
Building footprints



Legend

LAeq(15 minute external) and LA1(1 minute internal) construction noise levels

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Building footprints

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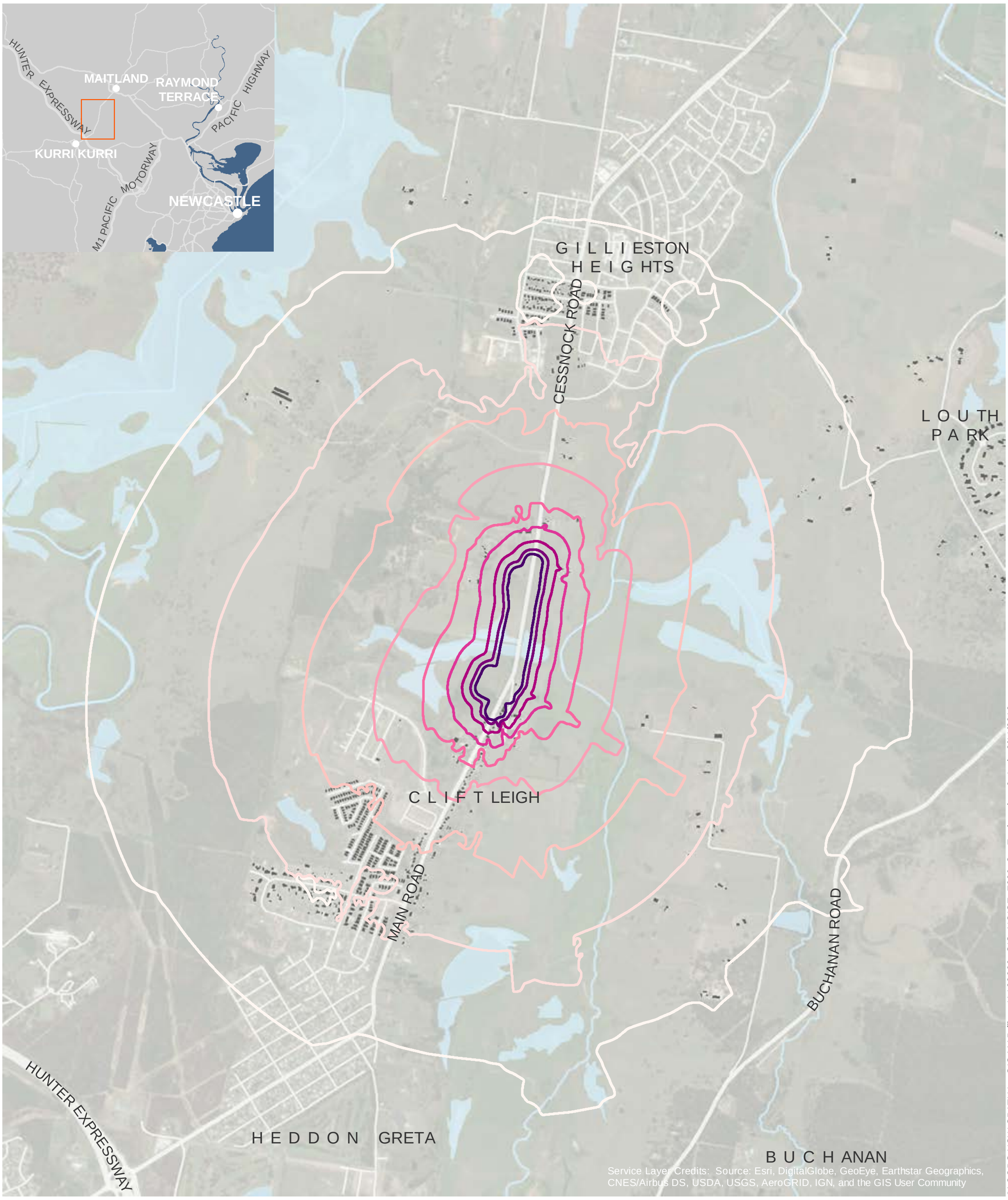

JACOBS NSW SPATIAL - GIS MAP file : IA182900_GIS_NOISE_F006_ConEarthworks_r2v1 | 2/11/2018

Legend

LAeq(15 minute external) and LA1(1 minute internal) construction noise levels

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Building footprints

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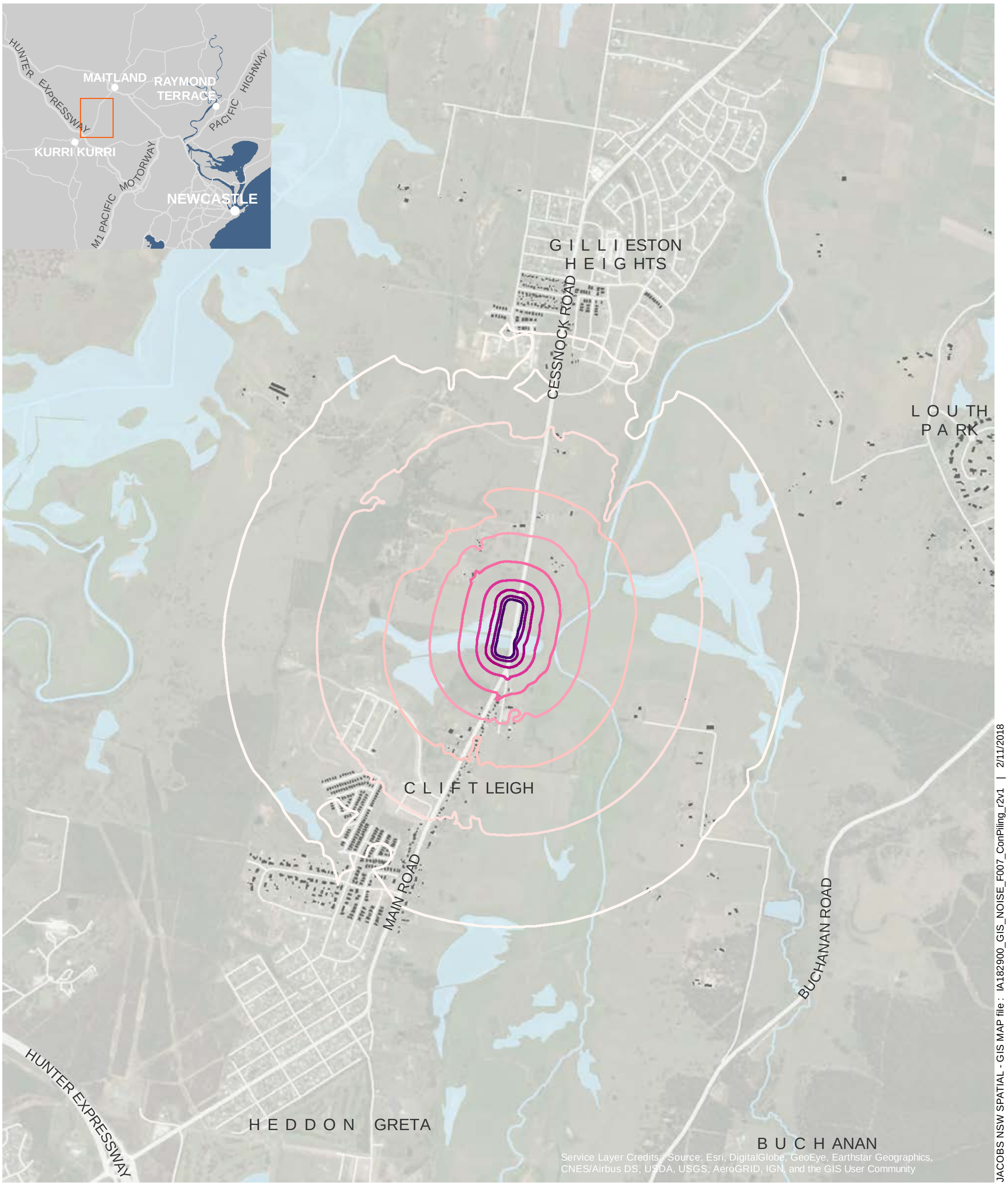

Legend

LAeq(15 minute external) and LA1(1 minute internal) construction noise levels

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Building footprints

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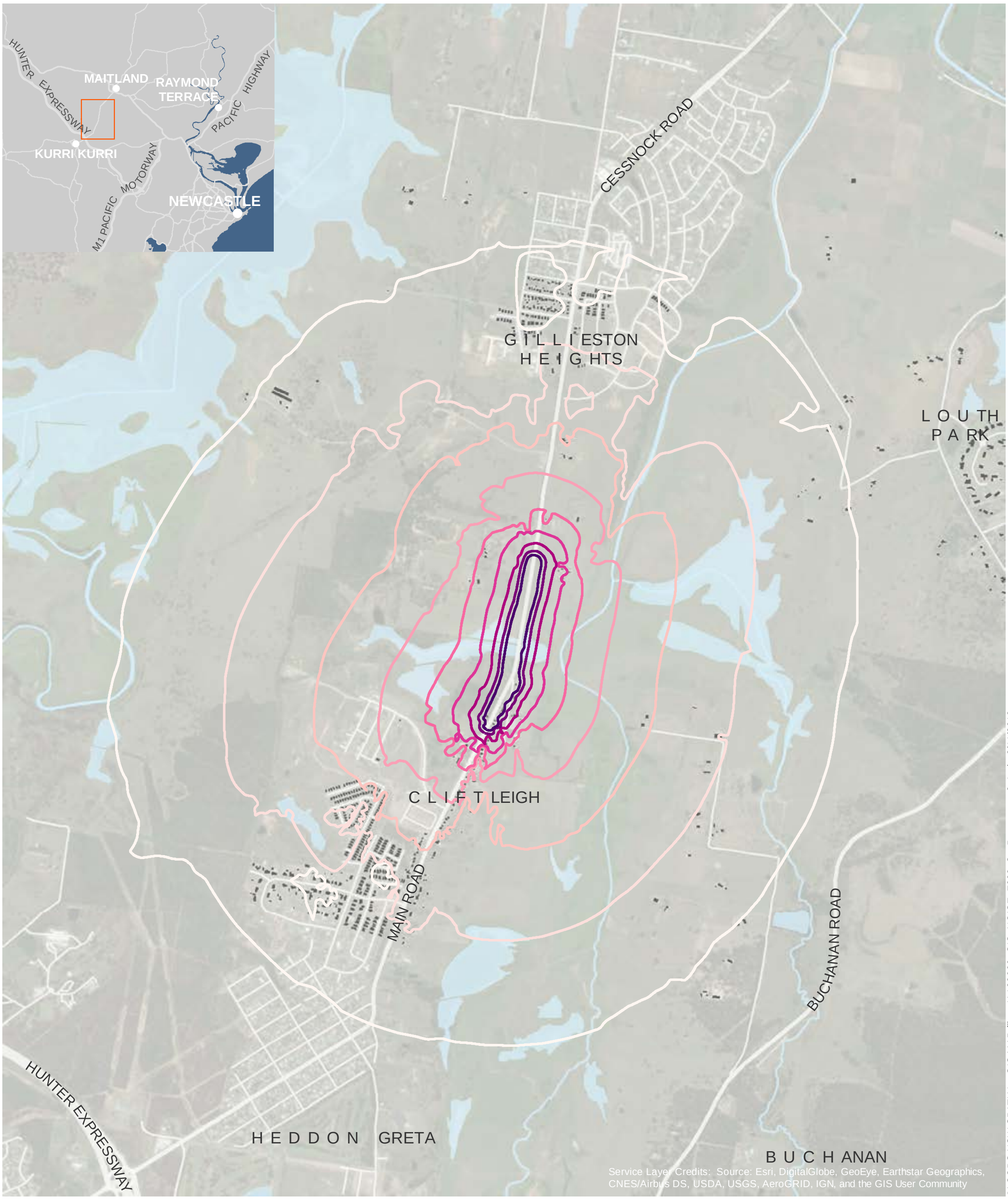
Appendix B.5a | Piling and wick drain installation



JACOBS NSW SPATIAL - GIS MAP file : IA182900_GIS_NOISE_F008_ConPavement_r2v1 | 2/11/2018

Legend

LAeq(15 minute external) and LA1(1 minute internal) construction noise levels

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- 70
- 75

Building footprints

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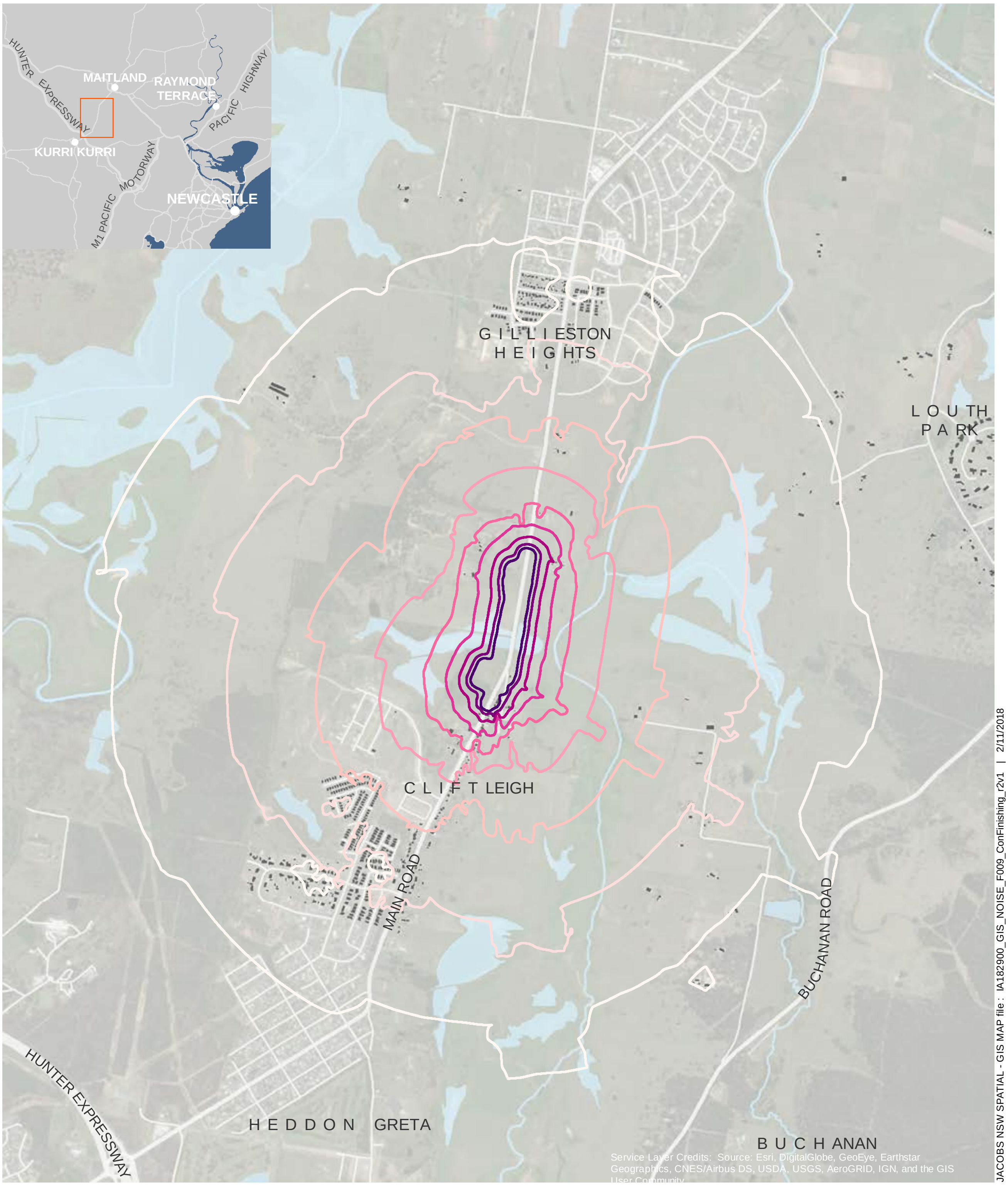

Legend

LAeq(15 minute external) and LA1(1 minute internal) construction noise levels

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Building footprints

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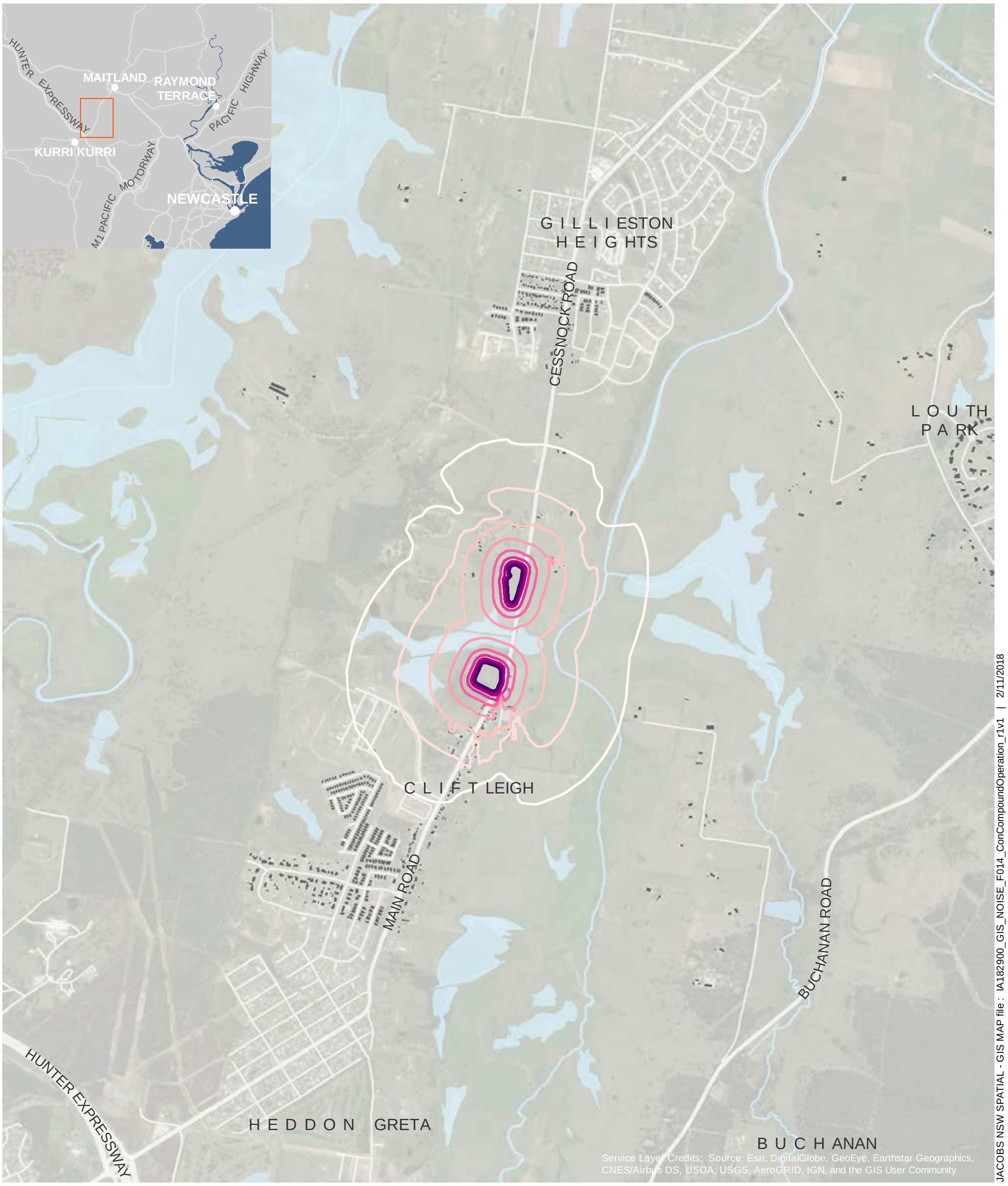
Appendix B.7 | Finishing works



Legend

LAeq(15 minute external) and LA1(1 minute internal) construction noise levels

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Building footprints

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Appendix C. Construction traffic noise estimator

Transport Roads & Maritime Services

Construction Road Traffic Noise Estimator

Please input information into yellow cells
Please pick from drop-down list in orange cells

Ground type	Urban	
Road surface	14mm Chipseal	
Road type	Freeway/arterial/sub-arterial road	
	Day	**Night**
Noise criteria (residences)	60	55
Existing speed	80	80
Speed during construction	80	80

Note that a road is new if a road's functional class changes during construction. For example, rerouting traffic from an arterial road temporarily to a collector road changes the functional class of the collector road for the duration of the temporary reroute.

	Day (7am to 10pm)		Night (10pm to 7am)		Worst Case 1-hour Day		Worst Case 1-hour Night	
Existing traffic	**Light vehicles**	**Heavy vehicles**	**Light vehicles**	**Heavy vehicles**	**Light vehicles**	**Heavy vehicles**	**Light vehicles**	**Heavy vehicles**
Direction (1)	2145	300	243	27	[redacted]			
Direction (2)	2025	300	288	36	[redacted]			
Additional traffic					[redacted]			
Direction (1)	0	40	0	0	[redacted]			
Direction (2)	0	40	0	0	[redacted]			

	Day	**Night**
Change in noise levels (dBA)	0.3	0.0
Mitigation level (dBA)	60	55
Is the change in noise level greater than 2.0 dBA?	No	No
Require consideration of additional mitigation measures?	No	No
Mitigation distance (m)		

Calculating noise level at the receiver

Distance to receiver (m)		
Direction (1)	20	
Direction (2)	20	
	Day	**Night**
Predicted noise levels (dBA) @ 1m from the façade	69.0	61.6

Note that noise reports usually present noise levels rounded to the nearest integer and differences between two noise levels rounded to a single decimal

To assess noise impacts from construction traffic or a temporary reroute due to a road closure or both an initial screening test should be undertaken by evaluating whether noise levels will increase by more than 2dB(A). Where increases are 2dBA or less then no further assessment is required. Where noise levels increase by more than 2dBA (2.1dBA) and noise levels exceed the controlling criterion then the receiver qualifies for consideration of noise mitigation under the Noise Mitigation Guideline. [note: the assessment methodology is similar to minor works so in any instance the only trigger for noise mitigation under the NMG shall be due to noise level increase]

Mitigation Measures

Management of construction related traffic or traffic reroutes noise should as a minimum include the following controls:
- Scheduling and routing of vehicle movements
- Speed of vehicles
- Driver behaviour and avoidance of the use of engine compression brakes
- Ensuring vehicles are adequately silenced before allowing them to access the site

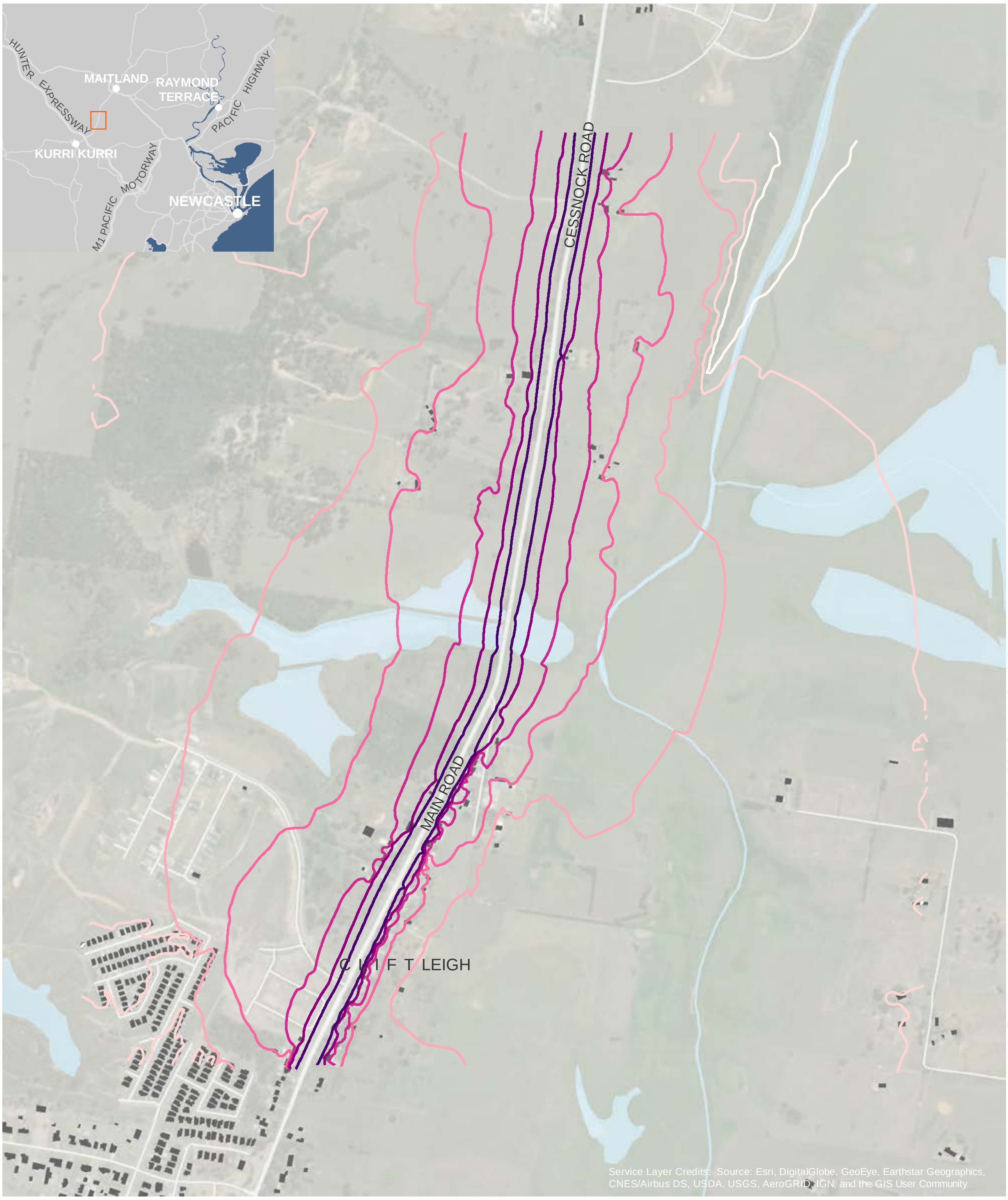
Where noise impacts are greater than one year then consideration should be given to the following measures where feasible and reasonable:
- temporary noise barriers
- at-receiver noise mitigation

Feasible and reasonable considerations should also include:
- time of day of the noise increase and exceedance of criteria
- time of use of affected receivers
- how many decibels the noise levels are to increase
- how long the mitigation will provide benefit to the receiver during the project

Appendix D. Modelled hourly average traffic numbers

Time period	North bound					South bound				
	LV	HV	Total	% HV	Speed	LV	HV	Total	% HV	Speed
Existing traffic numbers										
Daytime	294	19	313	6	75	280	21	300	7	77
Night time	32	3	35	8	80	39	4	44	10	82
2028 traffic numbers										
Daytime	481	30	511	6	75	458	34	492	7	77
Night time	85	7	93	8	80	97	11	108	10	82
2038 traffic numbers										
Daytime	528	33	561	6	75	503	37	540	7	77
Night time	94	8	102	8	80	107	12	119	10	82

Appendix E. 2028 Operational noise contours



JACOBS NSW SPATIAL - GIS MAP file : IA182900_GIS_NOISE_F015_2028DayOpNoiseExistingAlign_r1v1 | 24/10/2018

Legend

LAeq(15 minute external) and LA1(1 minute internal) construction noise levels

- 40
- 45
- 50
- 55
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- 65
- 70

Building footprints

0 500 1000 m

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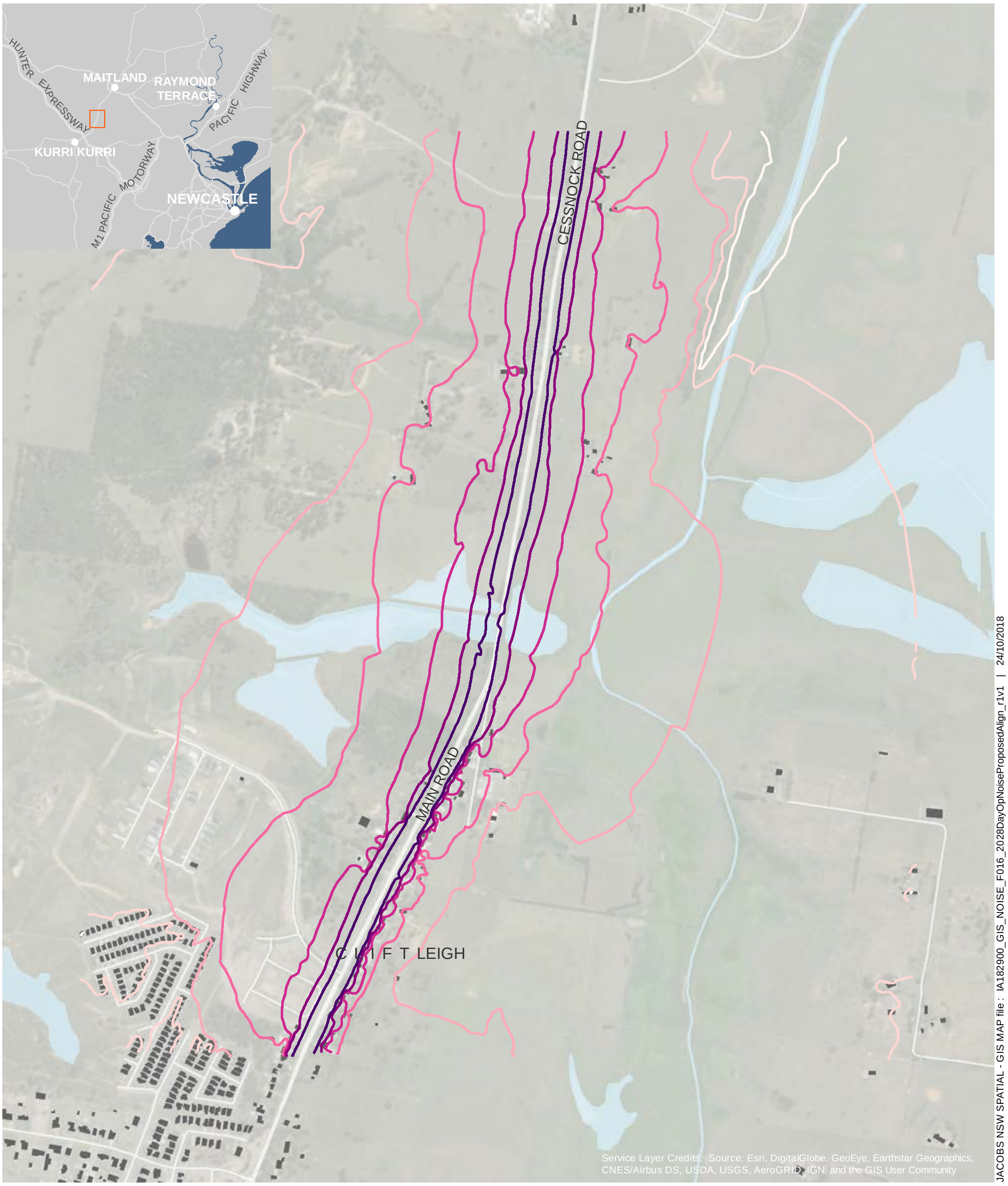
Appendix E.1 | 2028 daytime operational noise contours (Existing alignment)



Legend

LAeq(15 minute external) and LA1(1 minute internal) construction noise levels

- 40
- 45
- 50
- 55
- 60
- 65
- 70

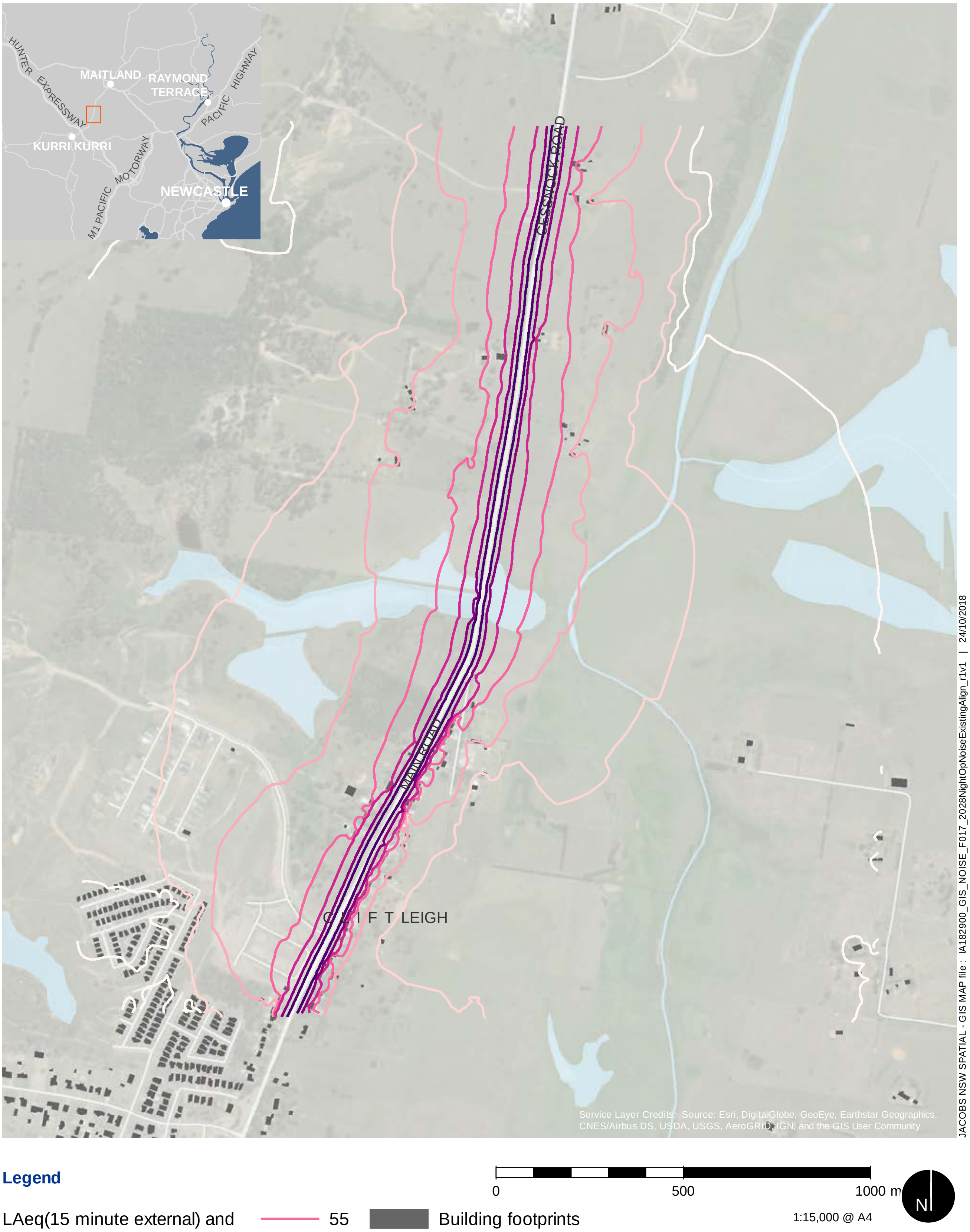
Building footprints

0 500 1000 m

1:15,000 @ A4

N

Appendix E.2 | 2028 daytime operational noise contours (Proposed alignment)

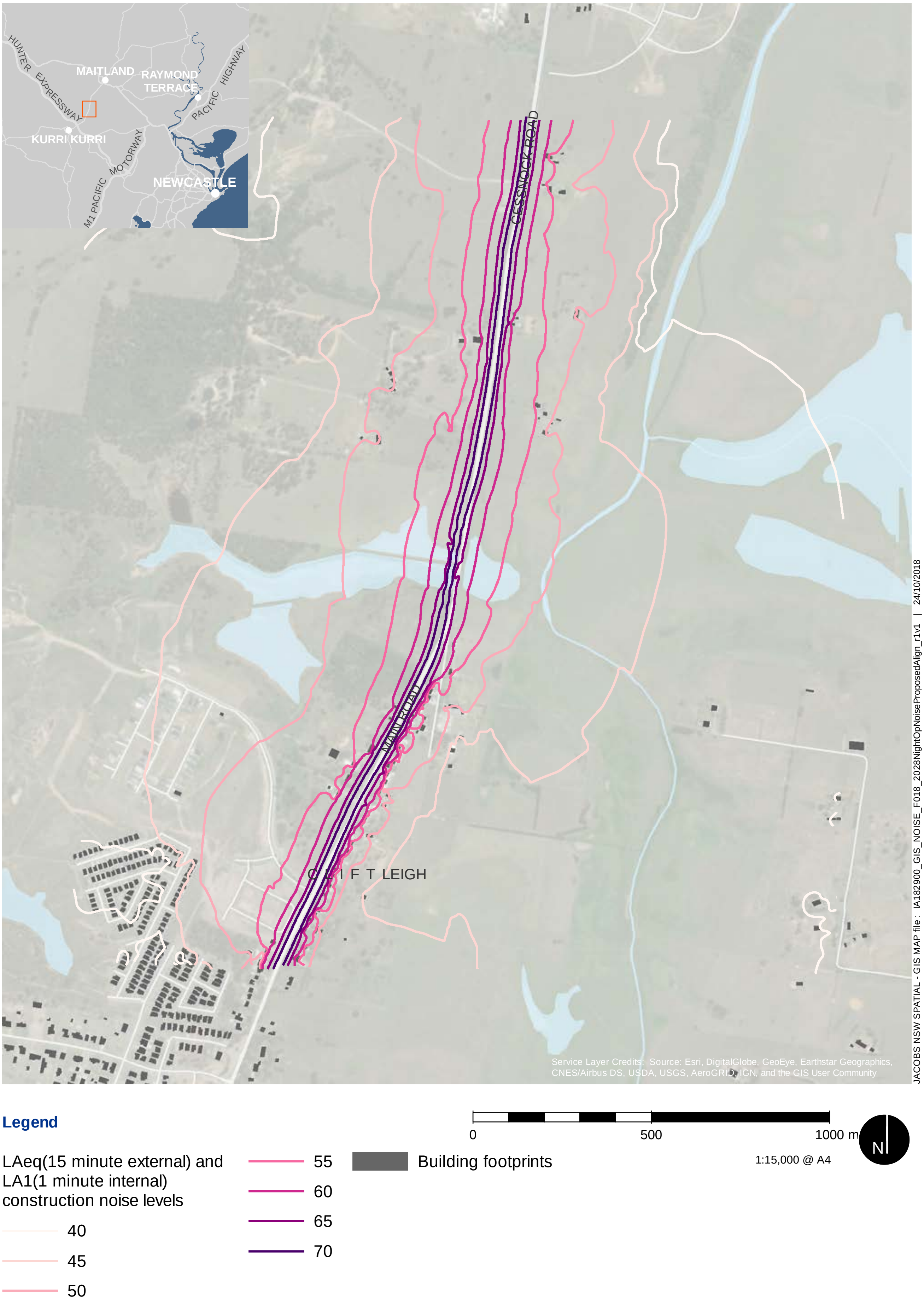


Legend

LAeq(15 minute external) and LA1(1 minute internal) construction noise levels

- 40
- 45
- 50
- 55
- 60
- 65
- 70
- Building footprints

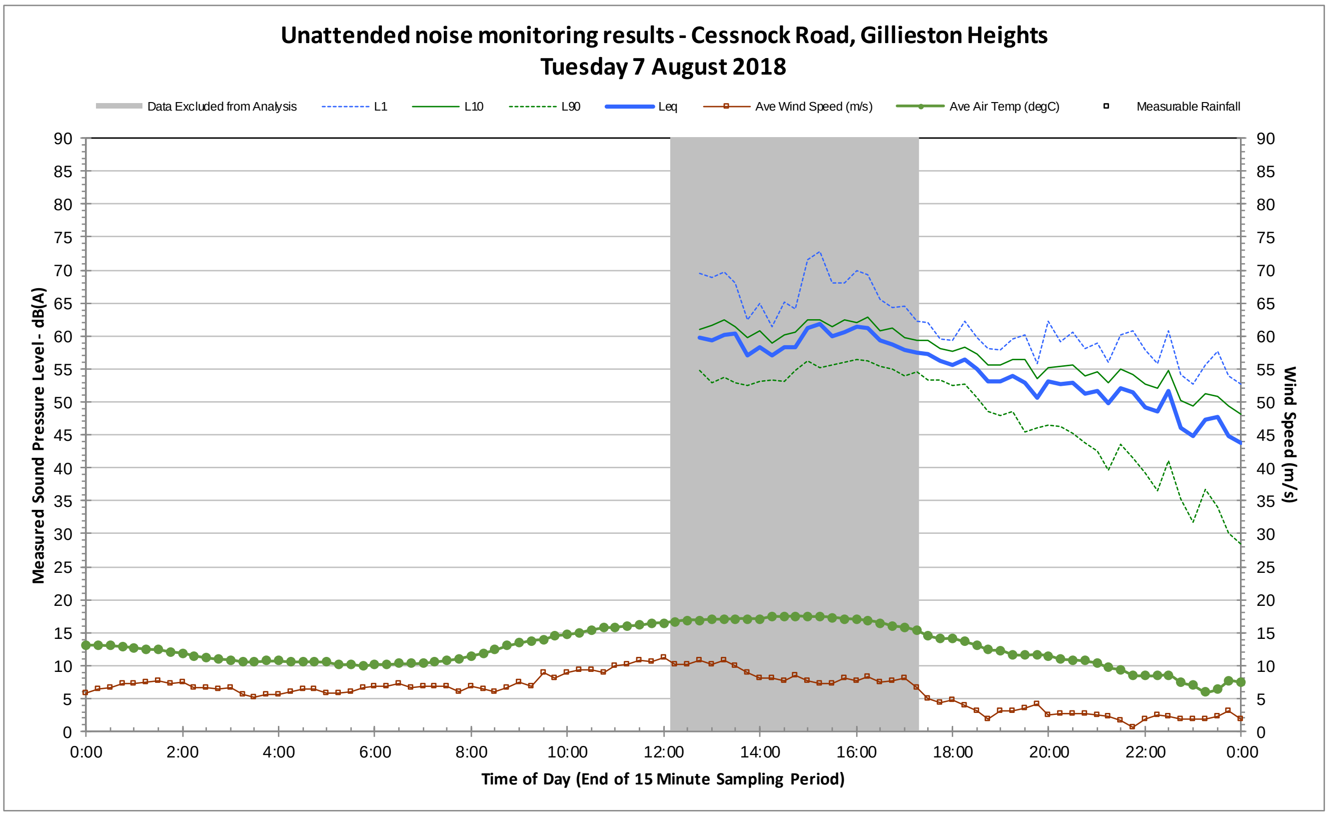
Appendix E.3 | 2028 night time operational noise contours (Existing alignment)

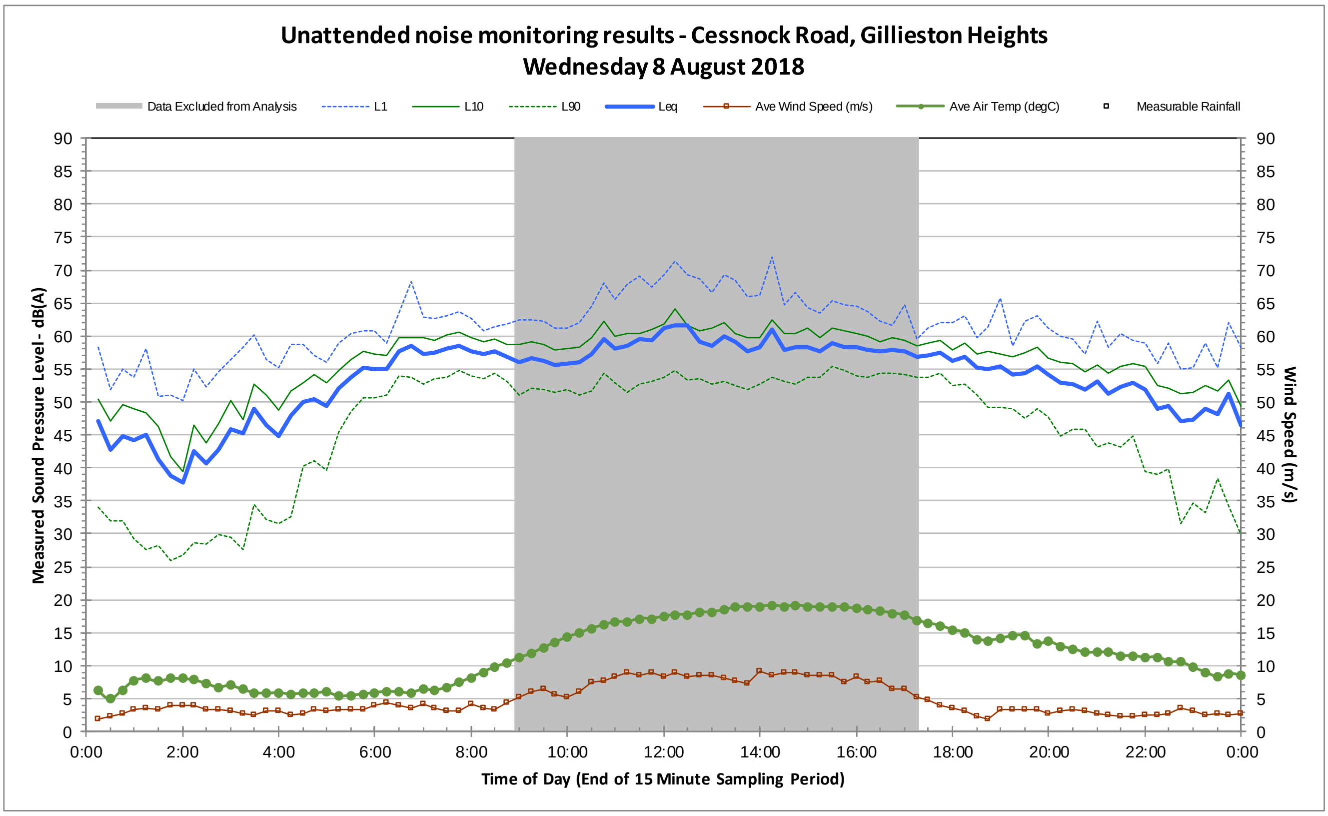


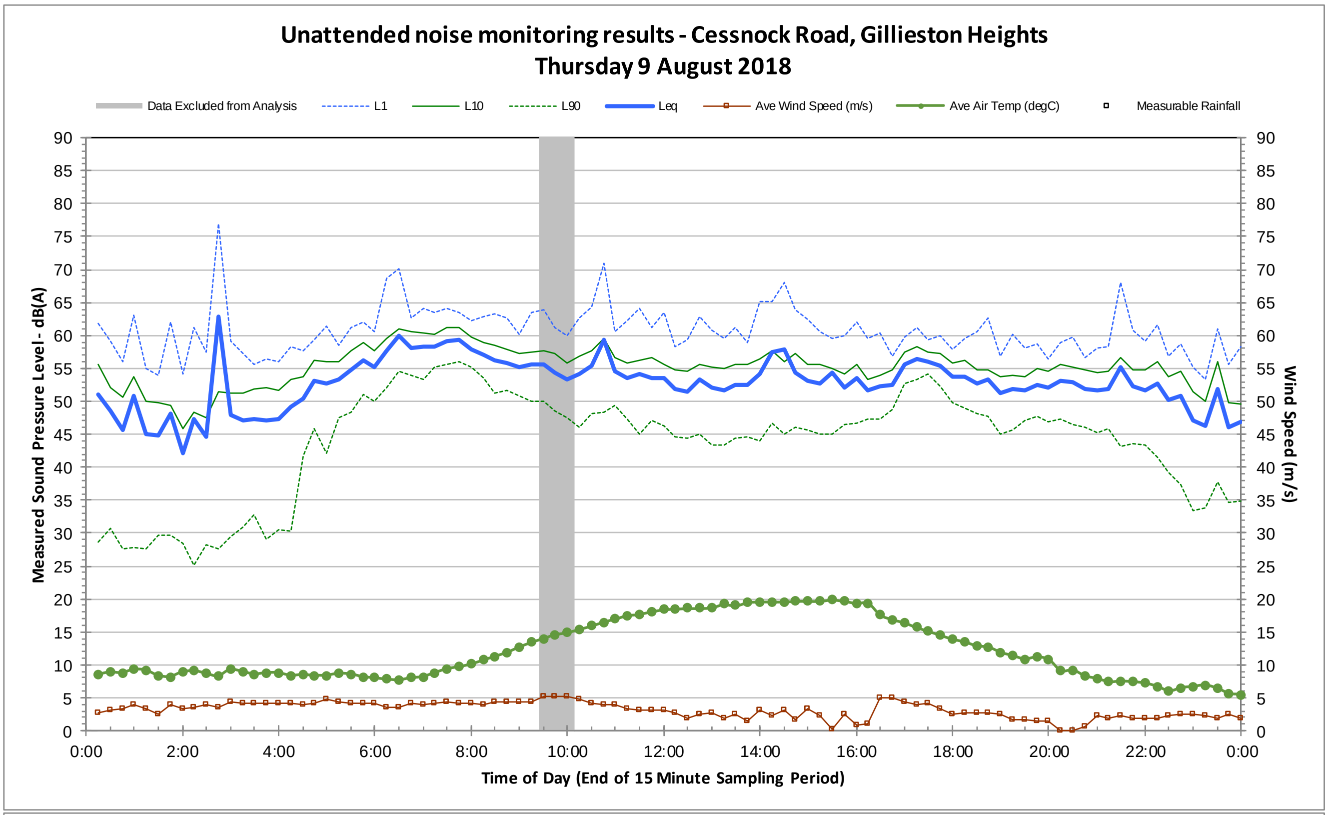
Appendix E.4 | 2028 night time operational noise contours (Proposed alignment)

Appendix F. Noise monitoring results

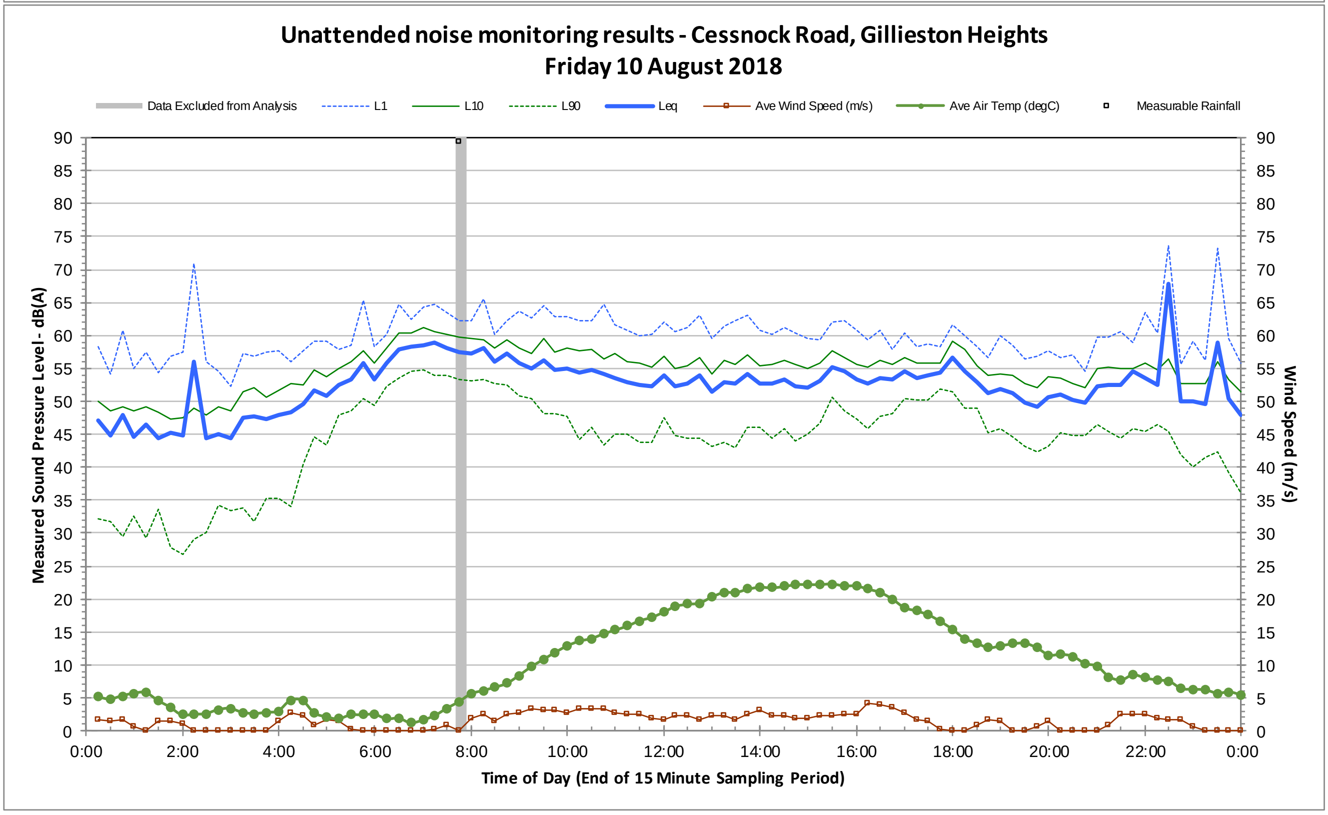
F.1 NCA 1: Cessnock Road, Gillieston Heights



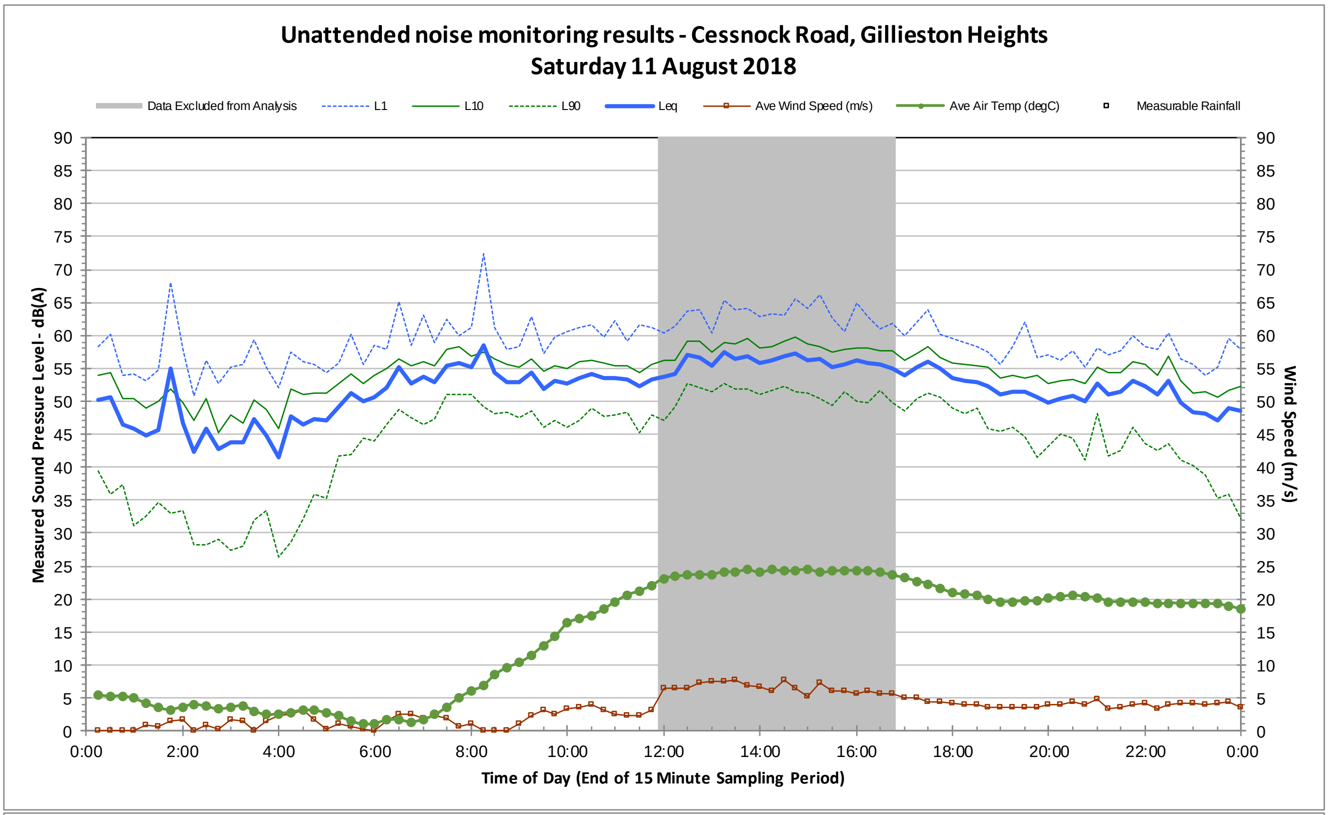


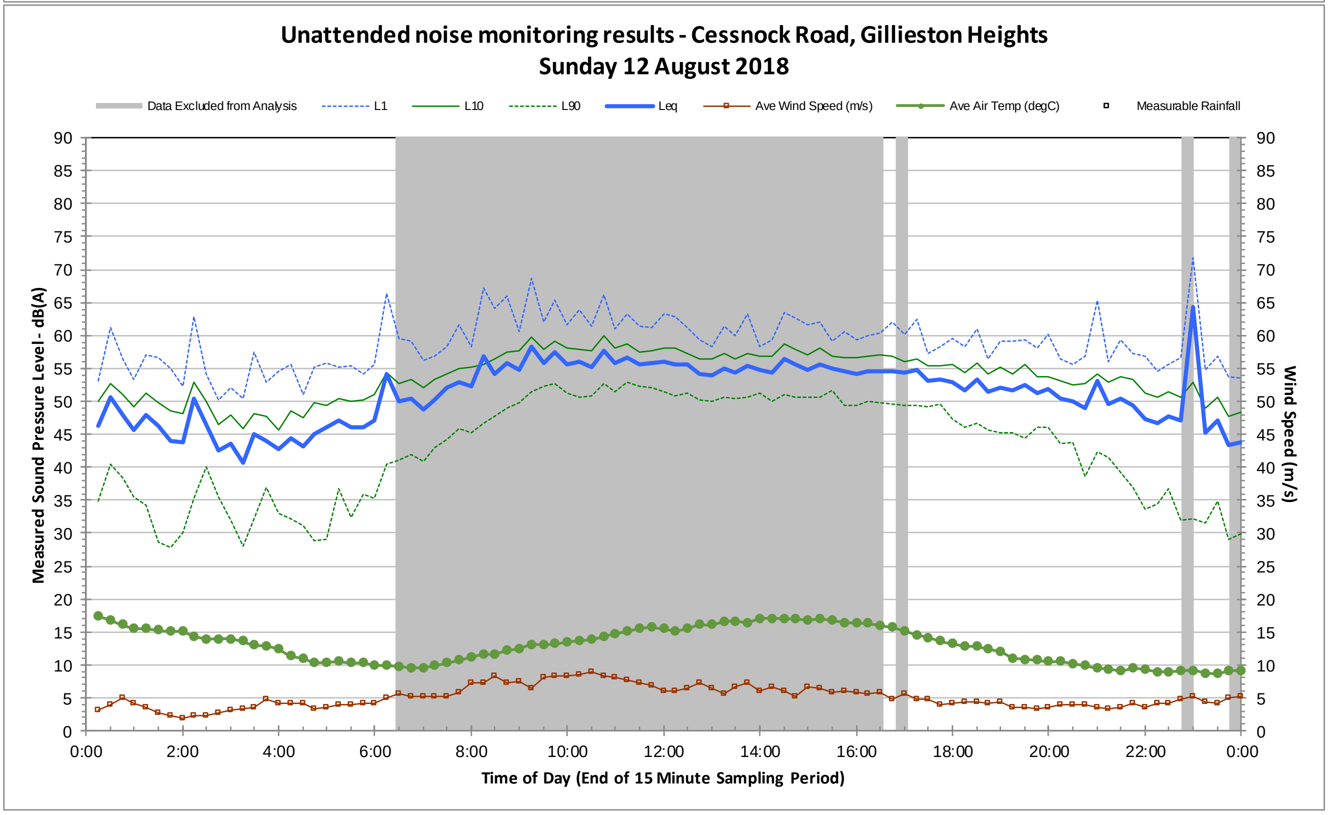


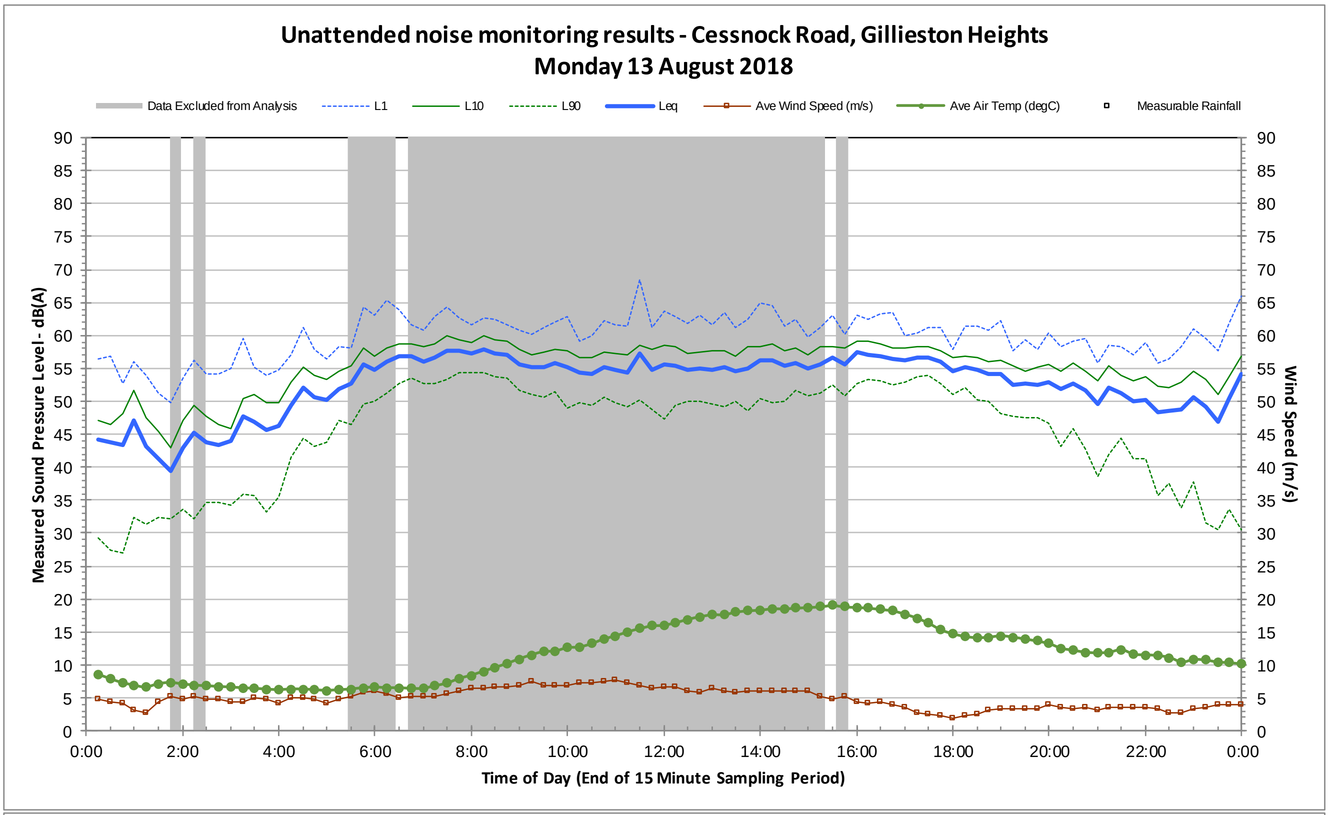
Unattended noise monitoring results - Cessnock Road, Gillieston Heights
Thursday 9 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)



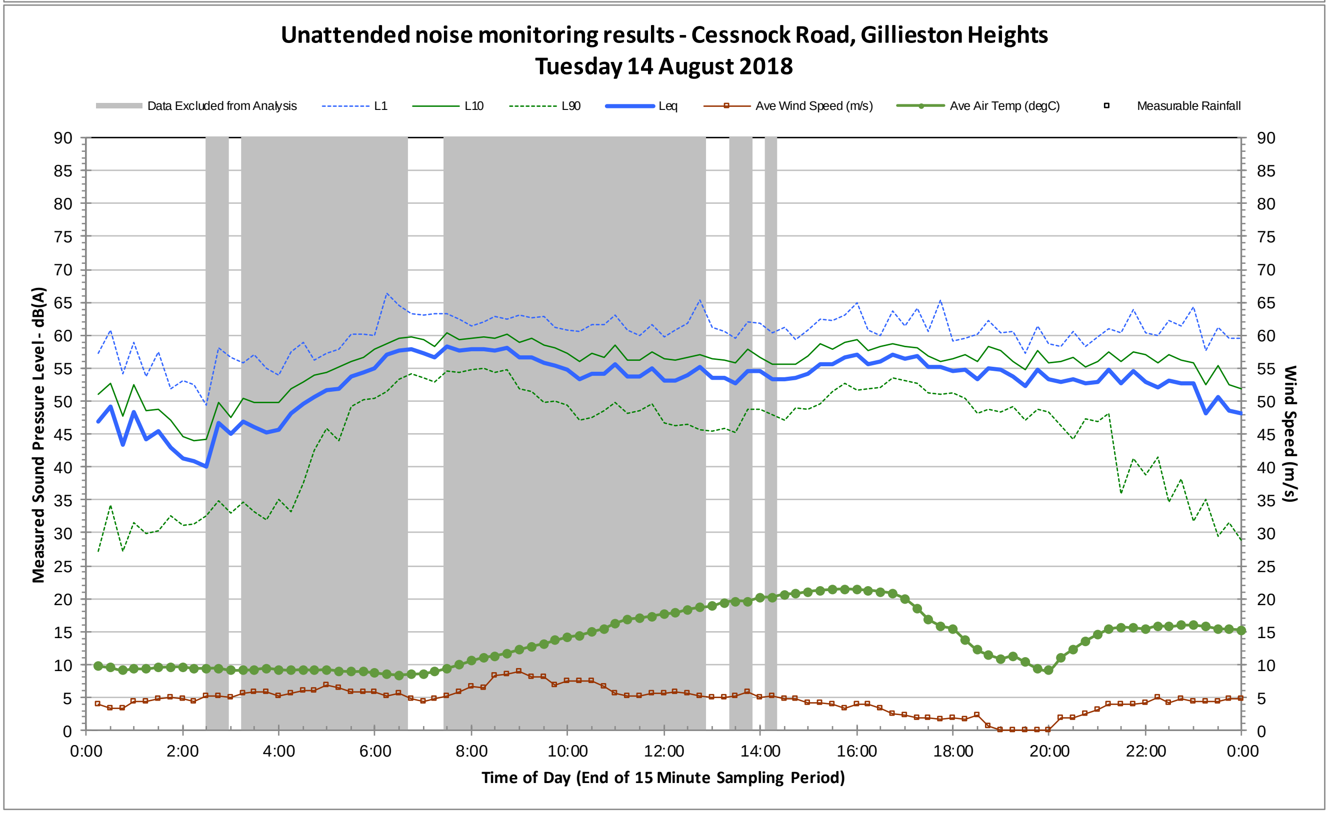
Unattended noise monitoring results - Cessnock Road, Gillieston Heights
Friday 10 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)


Unattended noise monitoring results - Cessnock Road, Gillieston Heights
Saturday 11 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 0:00
Time of Day (End of 15 Minute Sampling Period)

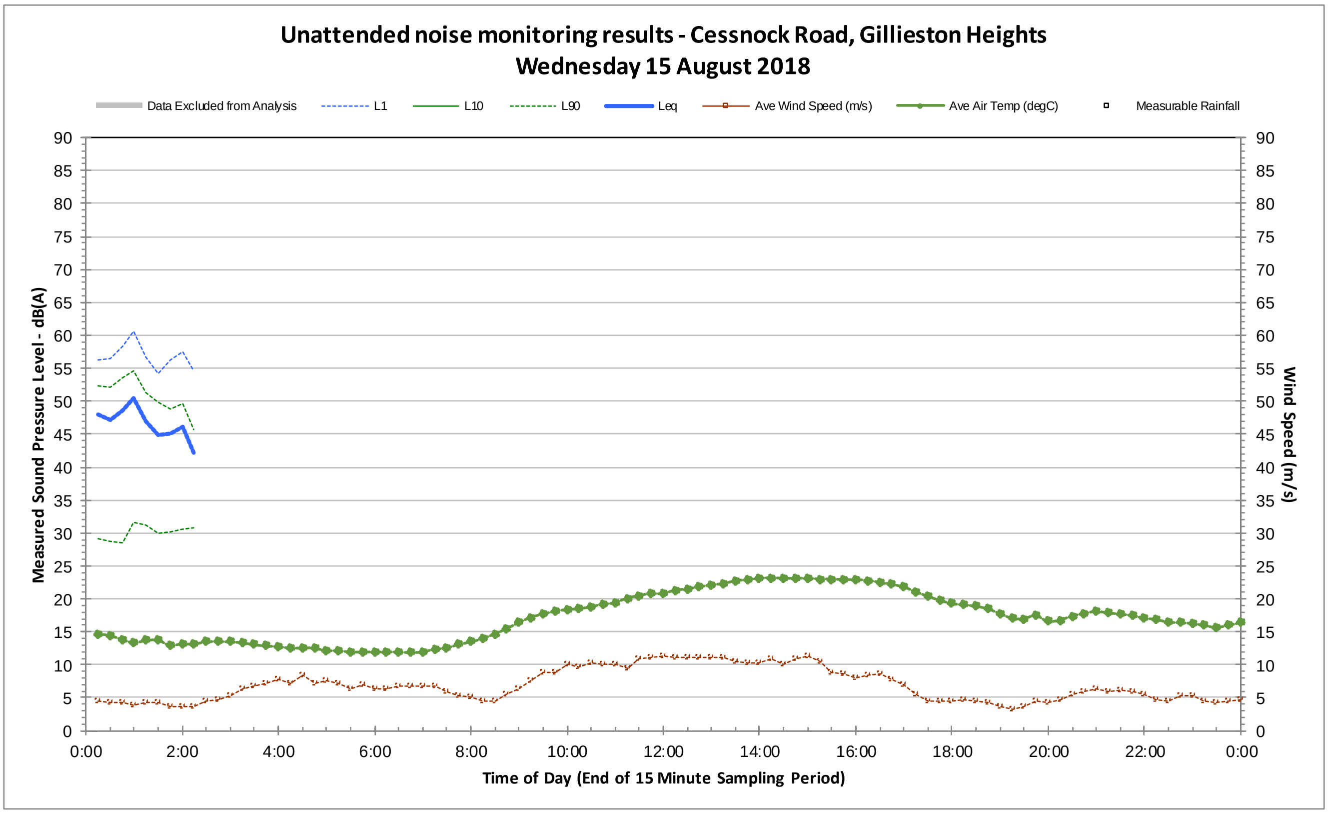

Unattended noise monitoring results - Cessnock Road, Gillieston Heights
Sunday 12 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 0:00
Time of Day (End of 15 Minute Sampling Period)



Unattended noise monitoring results - Cessnock Road, Gillieston Heights
Monday 13 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)

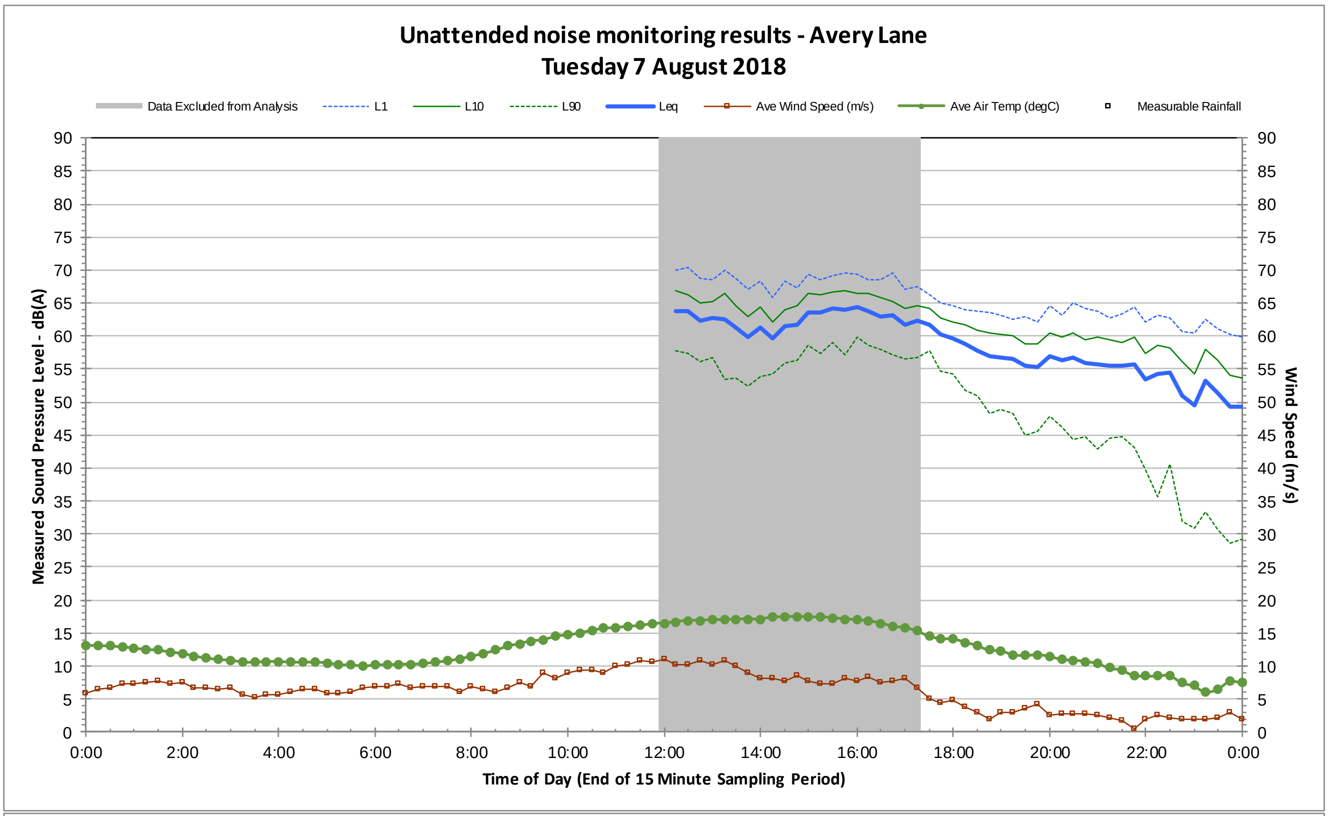


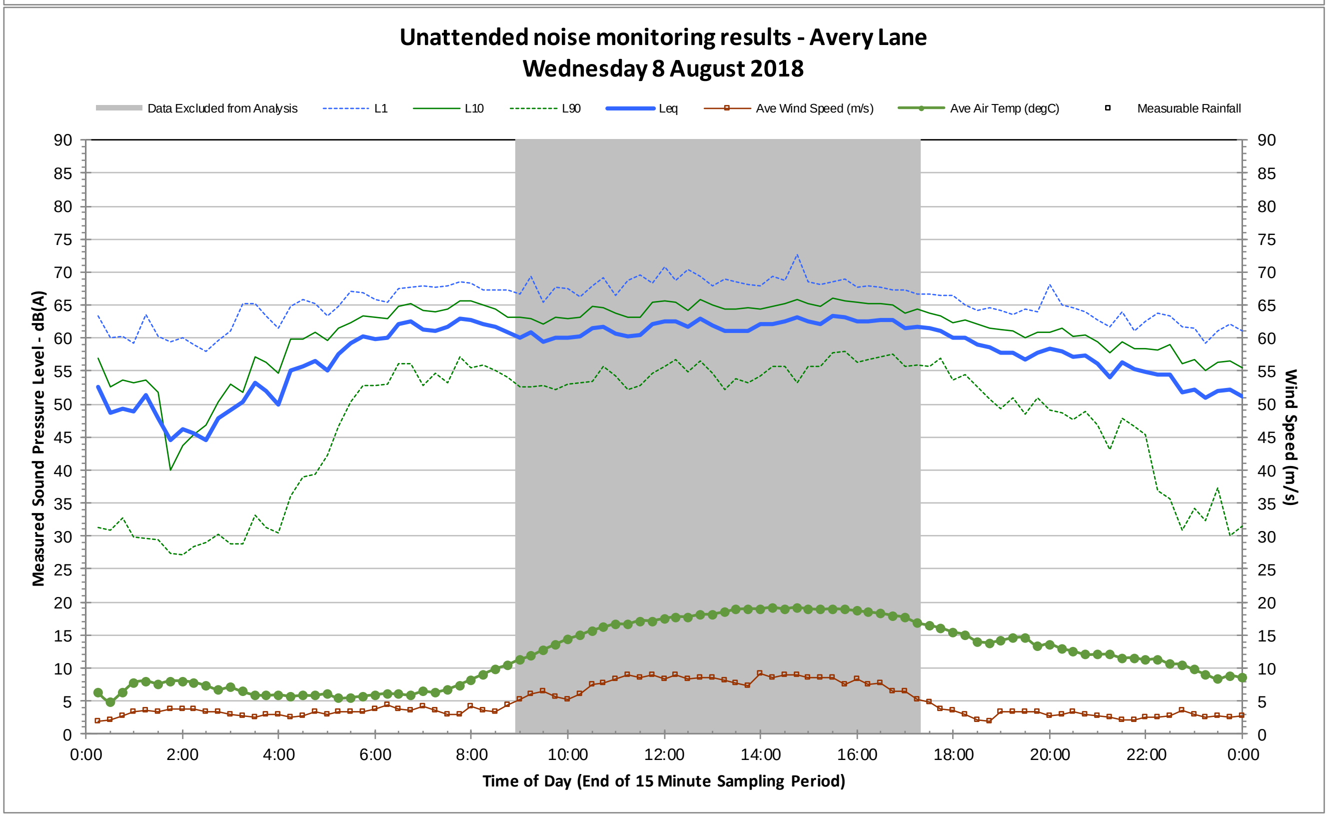
Unattended noise monitoring results - Cessnock Road, Gillieston Heights
Tuesday 14 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)

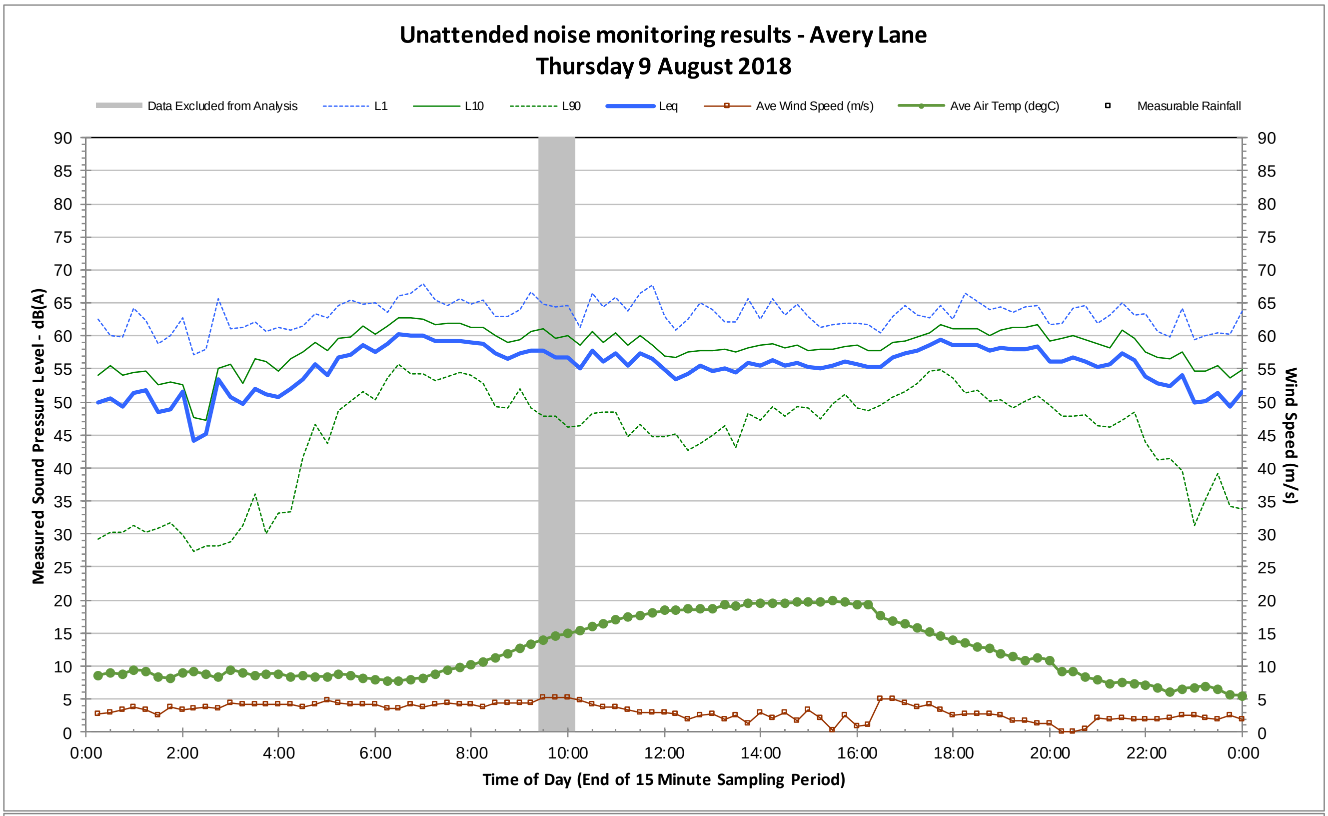


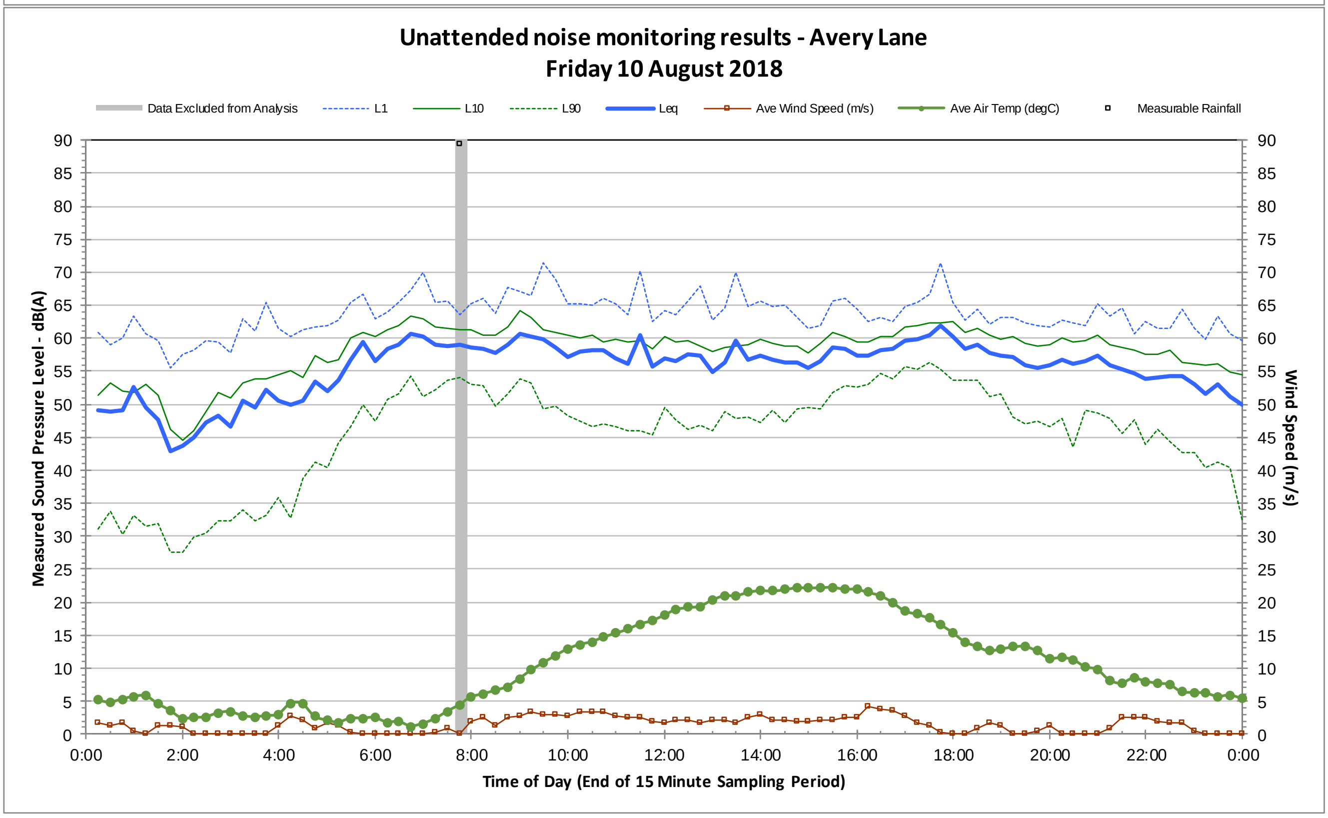
Unattended noise monitoring results - Cessnock Road, Gillieston Heights
Wednesday 15 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00

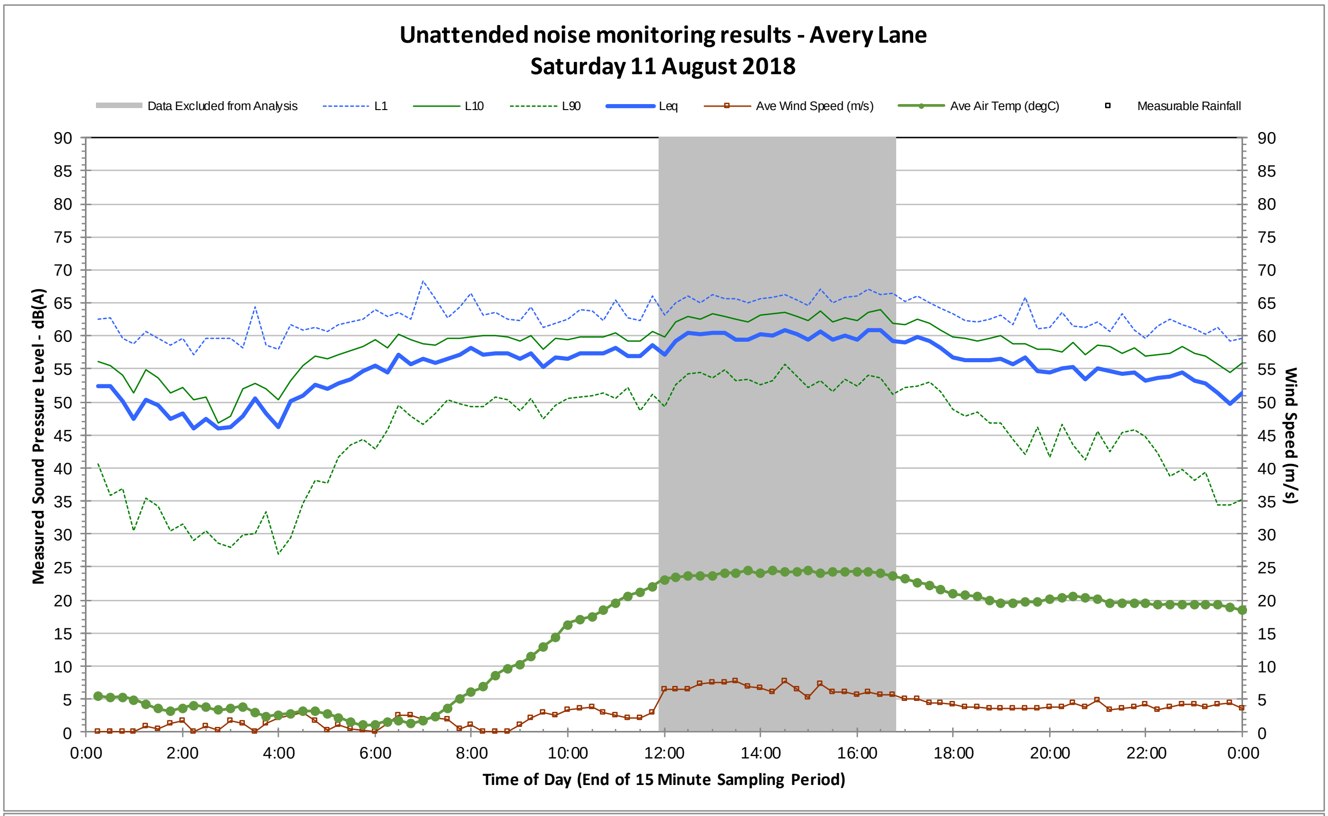
F.2 NCA 2: Avery Lane, Cliftleigh

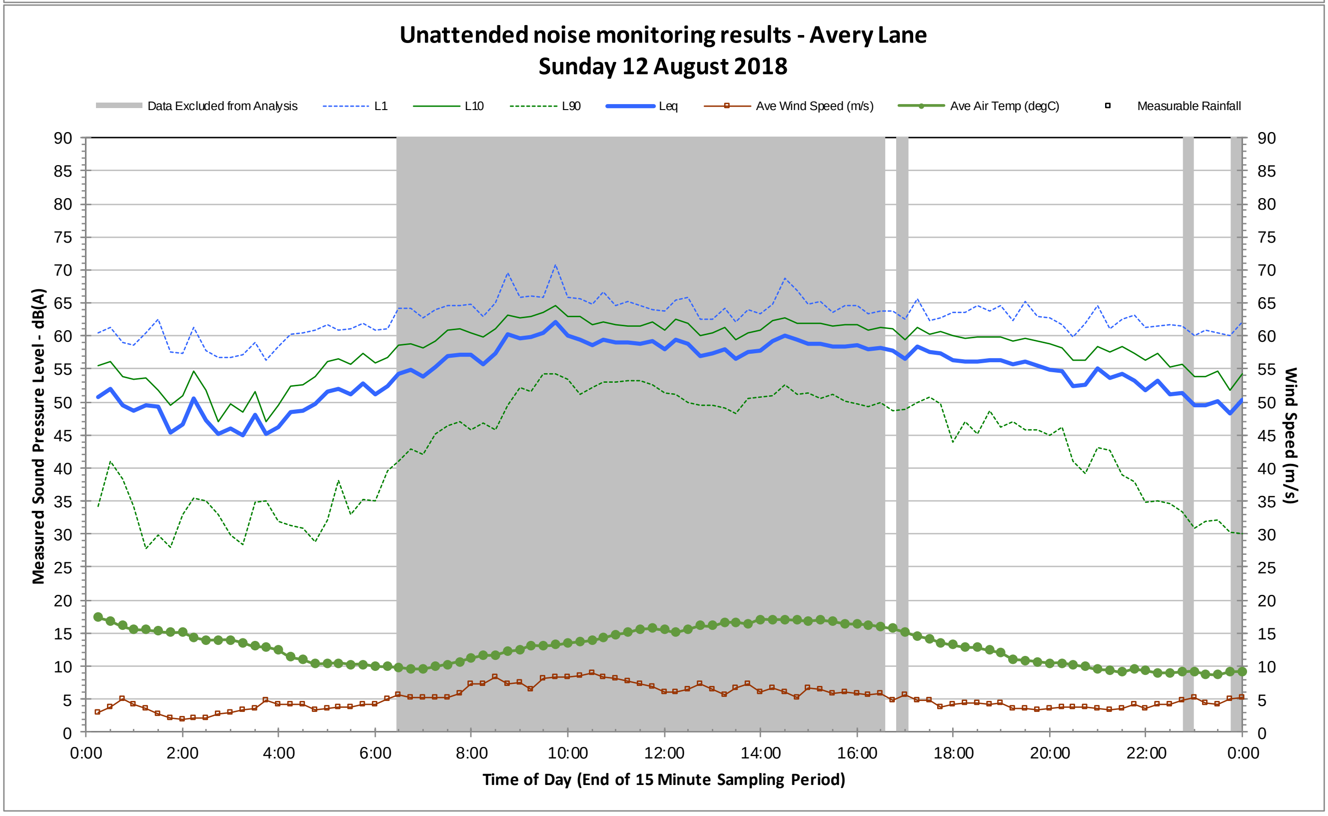


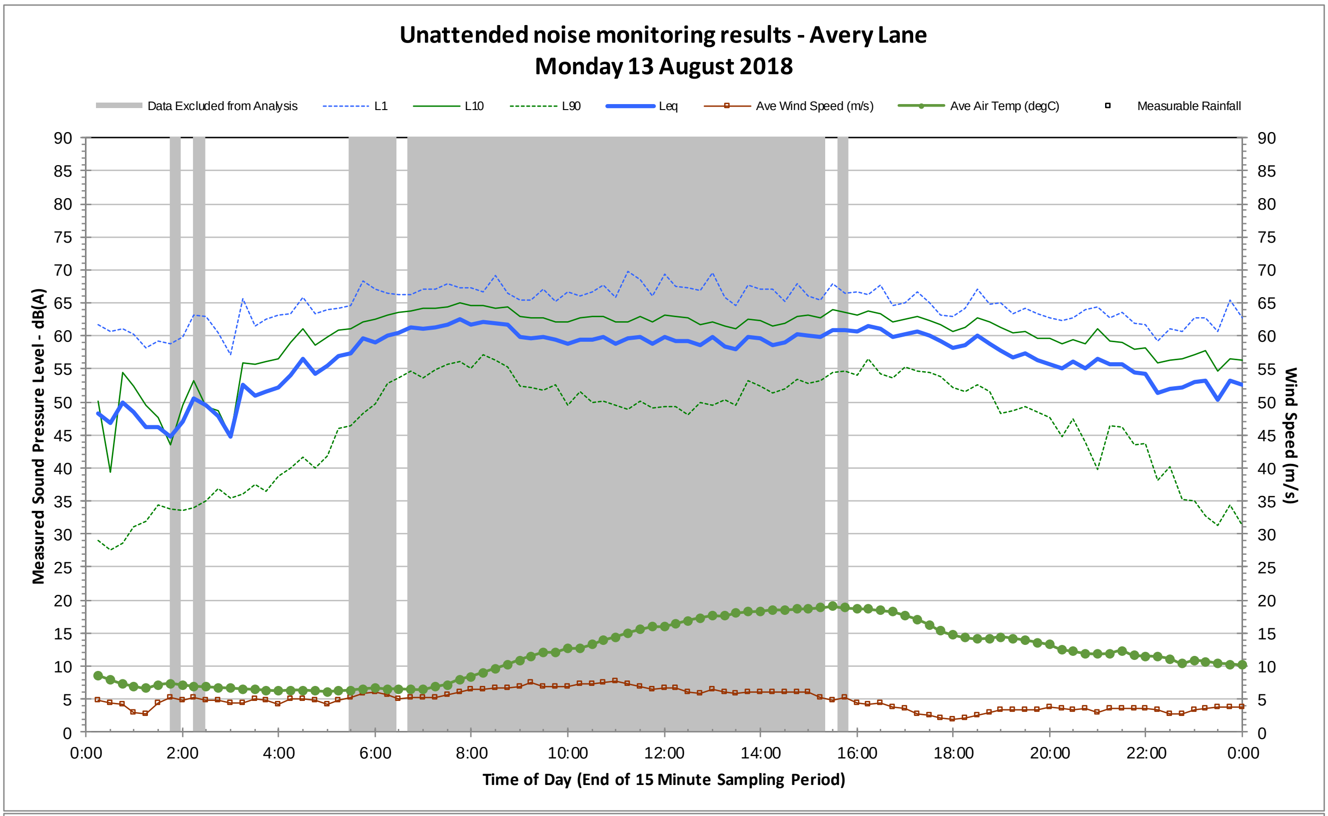


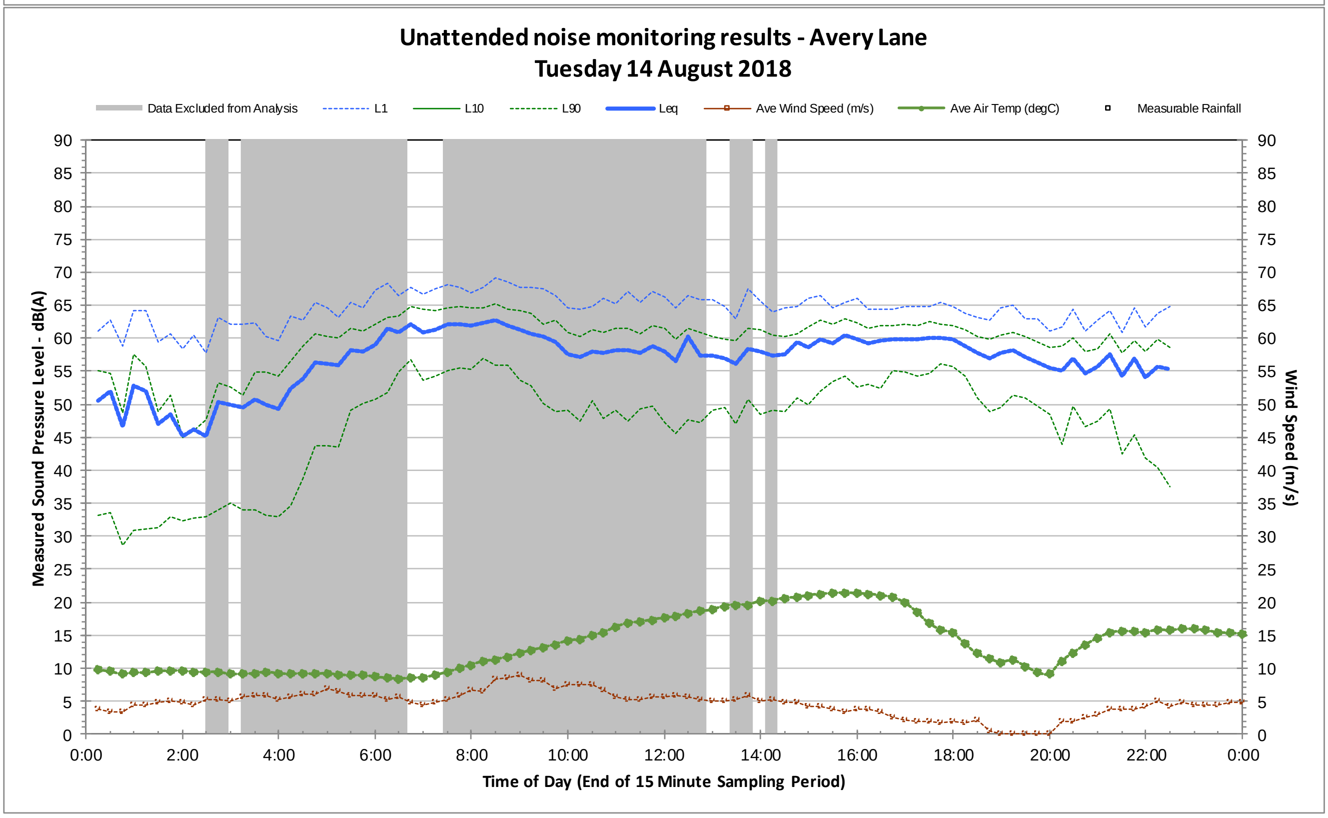

Unattended noise monitoring results - Avery Lane
Thursday 9 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90


Unattended noise monitoring results - Avery Lane
Friday 10 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90

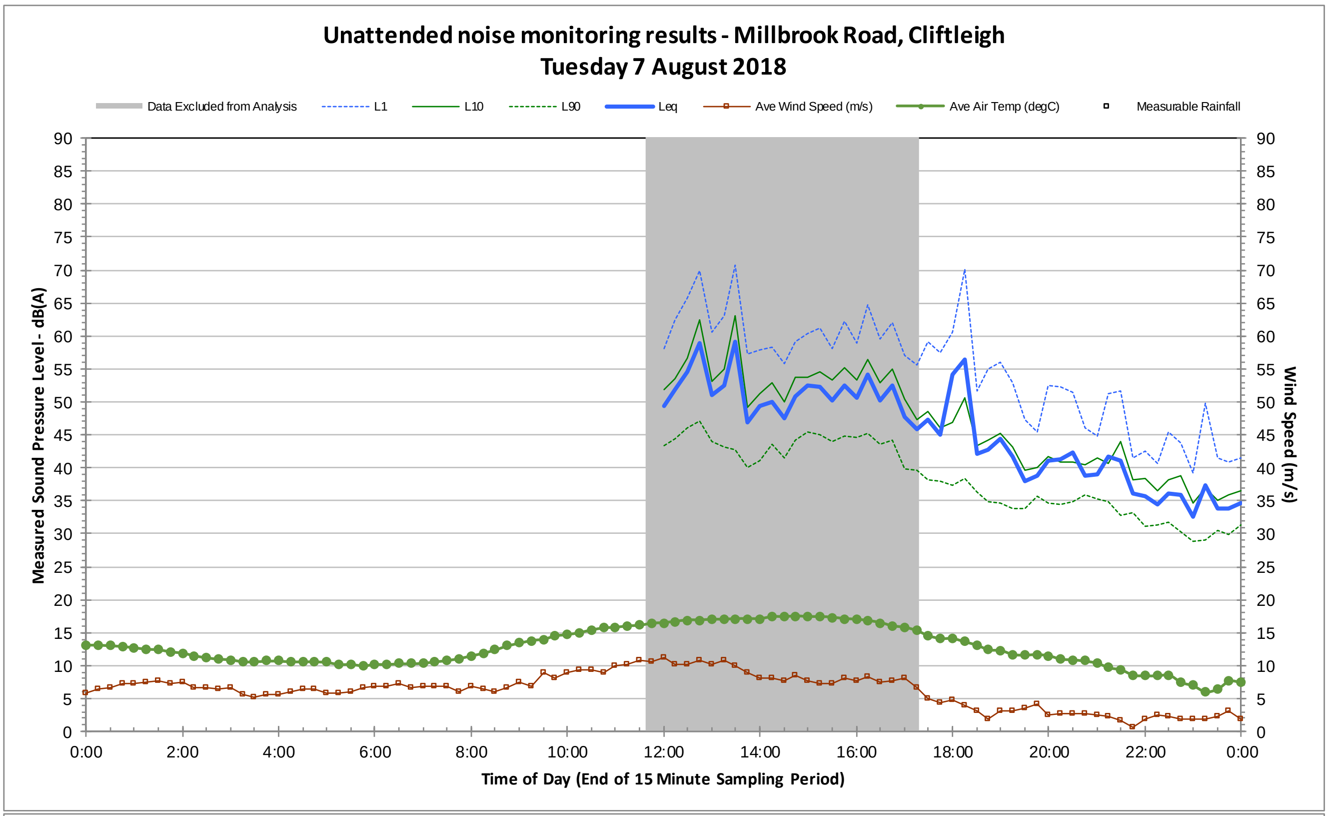

Unattended noise monitoring results - Avery Lane
Saturday 11 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)

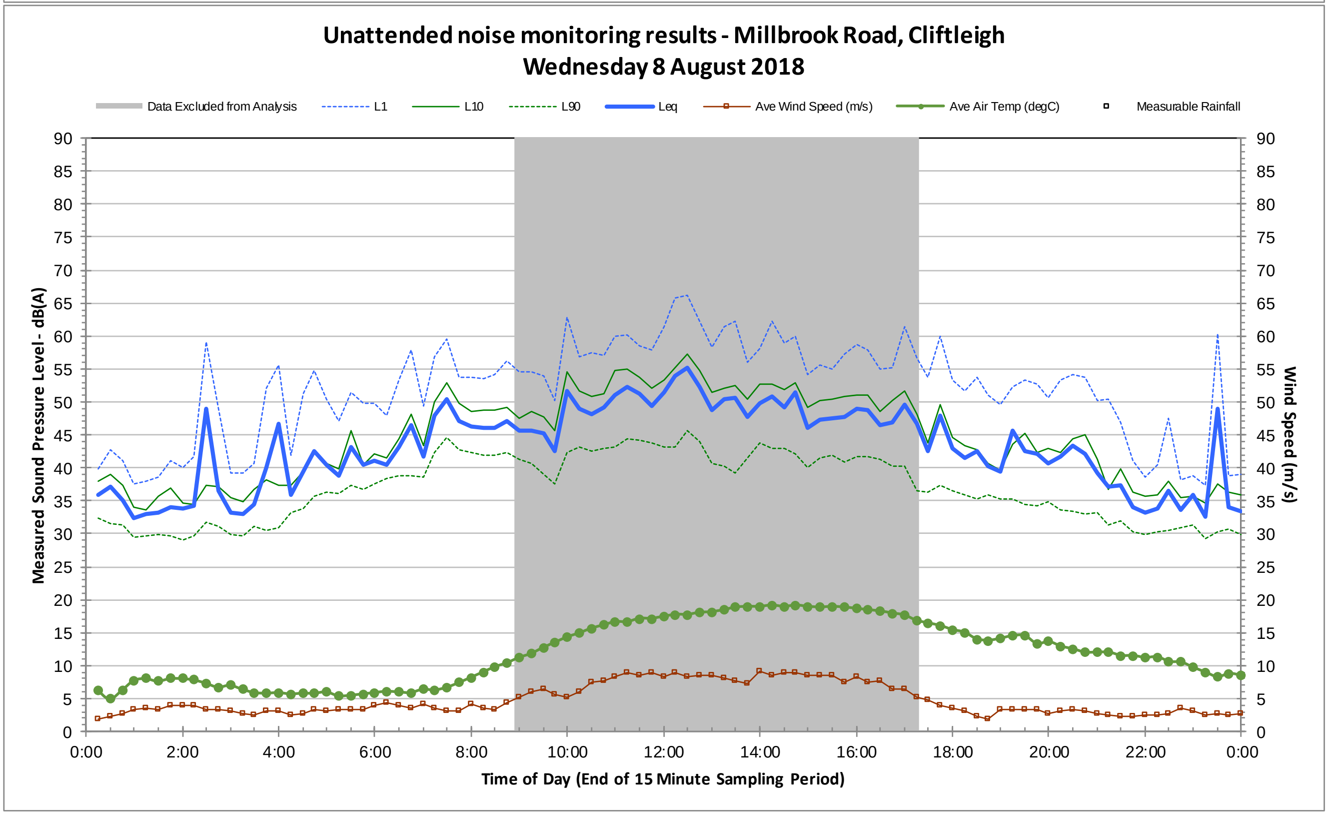

Unattended noise monitoring results - Avery Lane
Sunday 12 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)

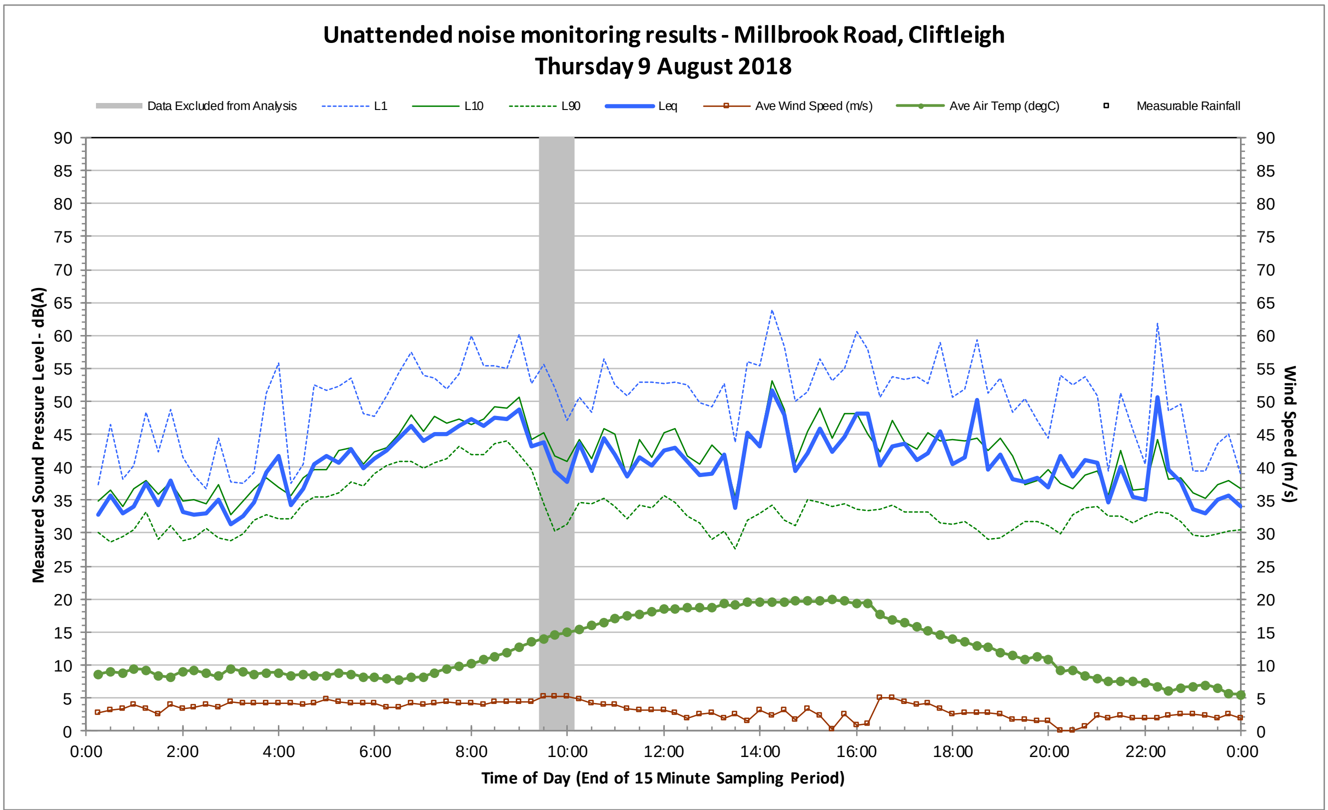

Unattended noise monitoring results - Avery Lane
Monday 13 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 0:00
Time of Day (End of 15 Minute Sampling Period)

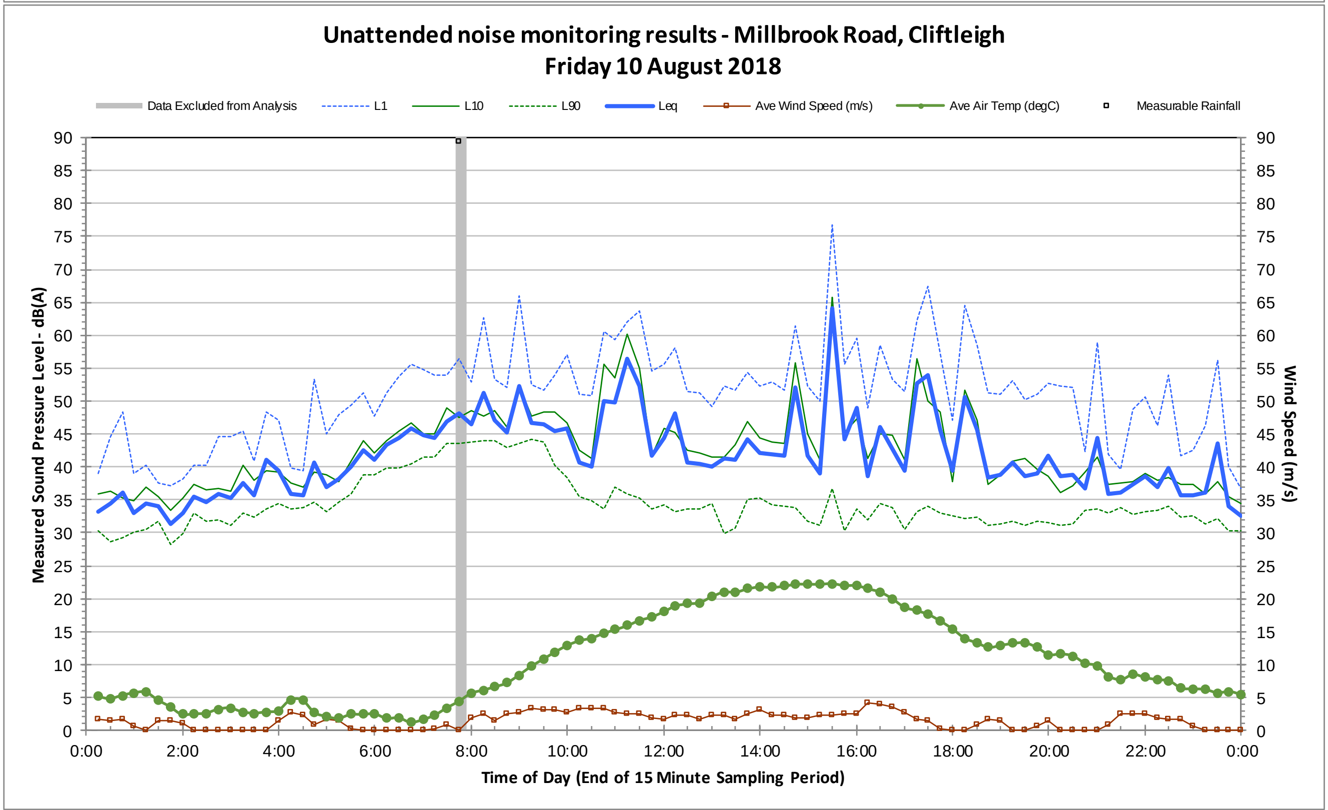

Unattended noise monitoring results - Avery Lane
Tuesday 14 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 0:00
Time of Day (End of 15 Minute Sampling Period)

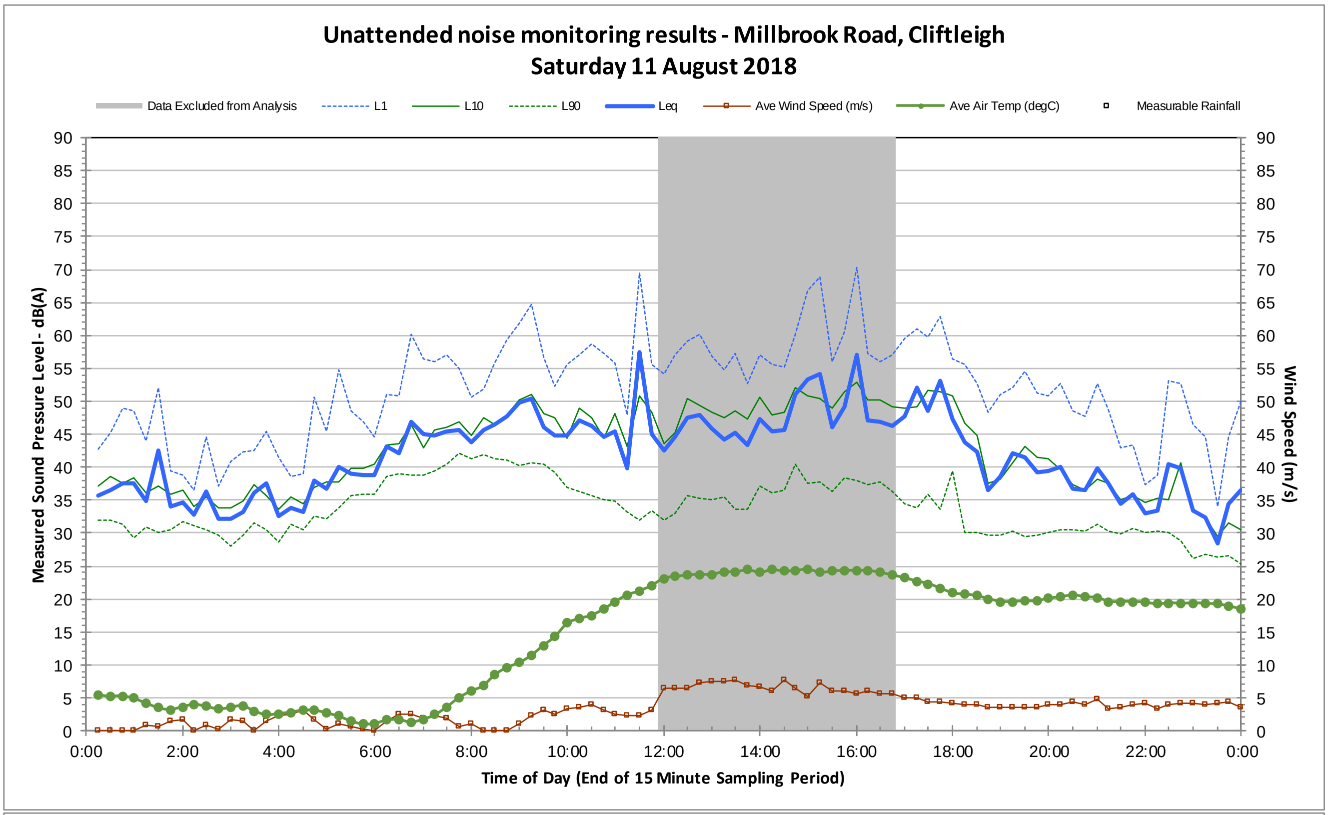
F.3 NCA 3: Millbrook Road, Cliftleigh

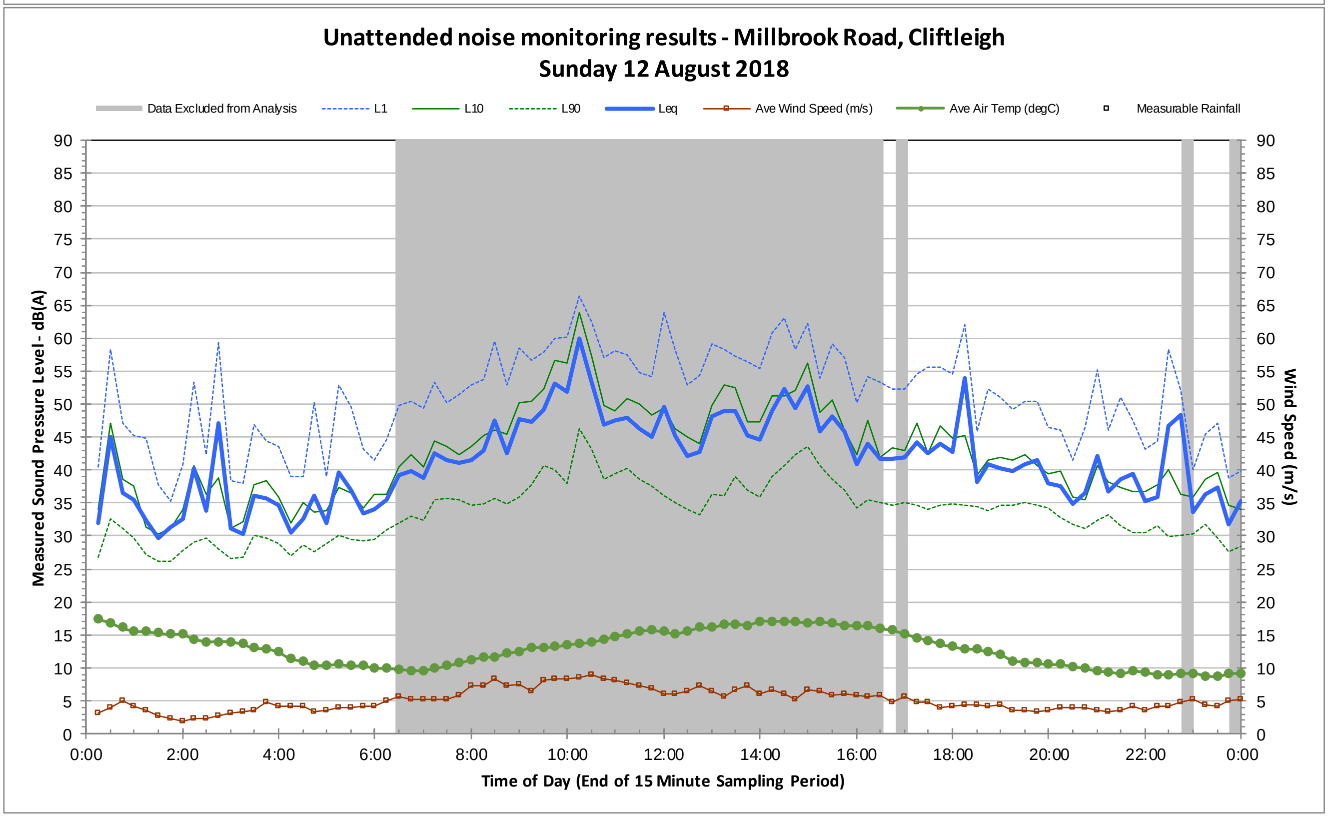


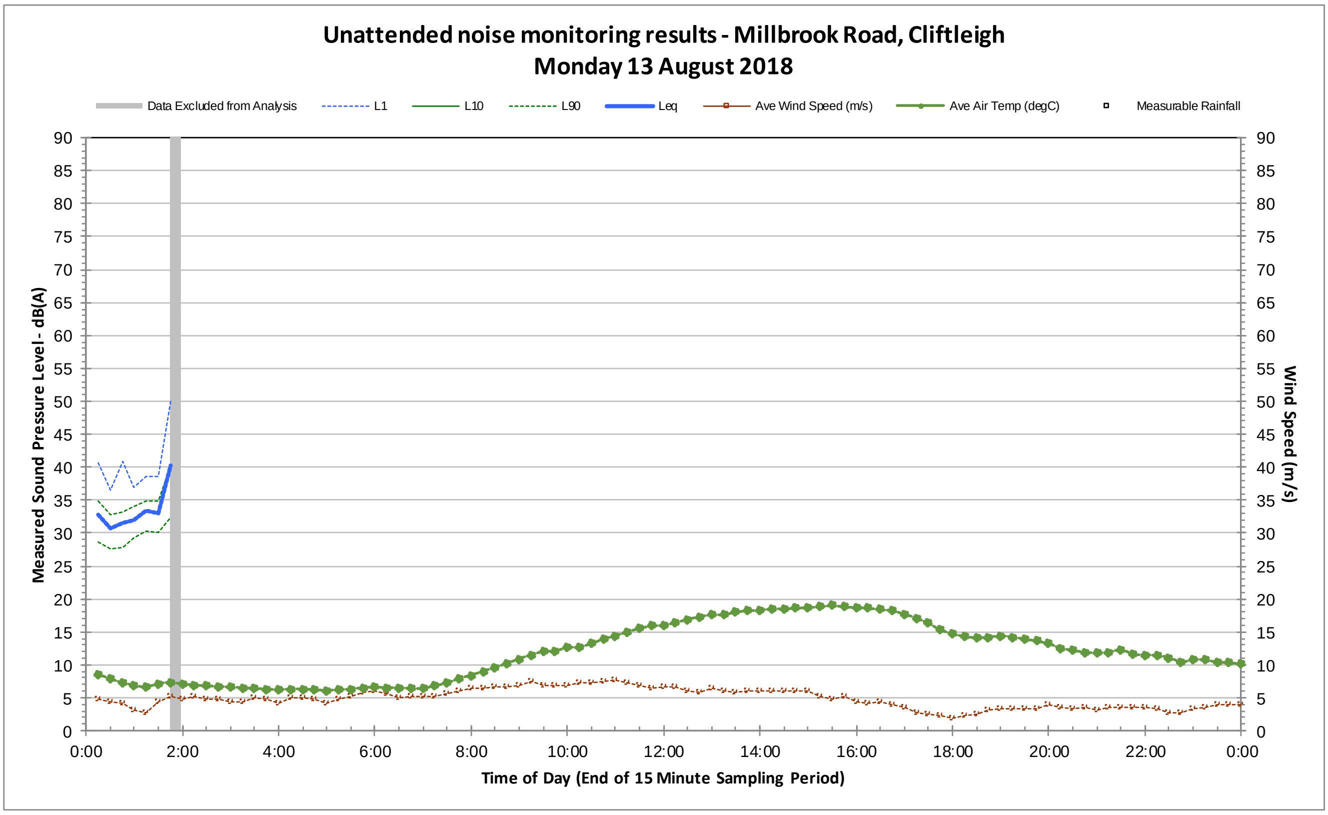



Unattended noise monitoring results - Millbrook Road, Cliftleigh
Thursday 9 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)

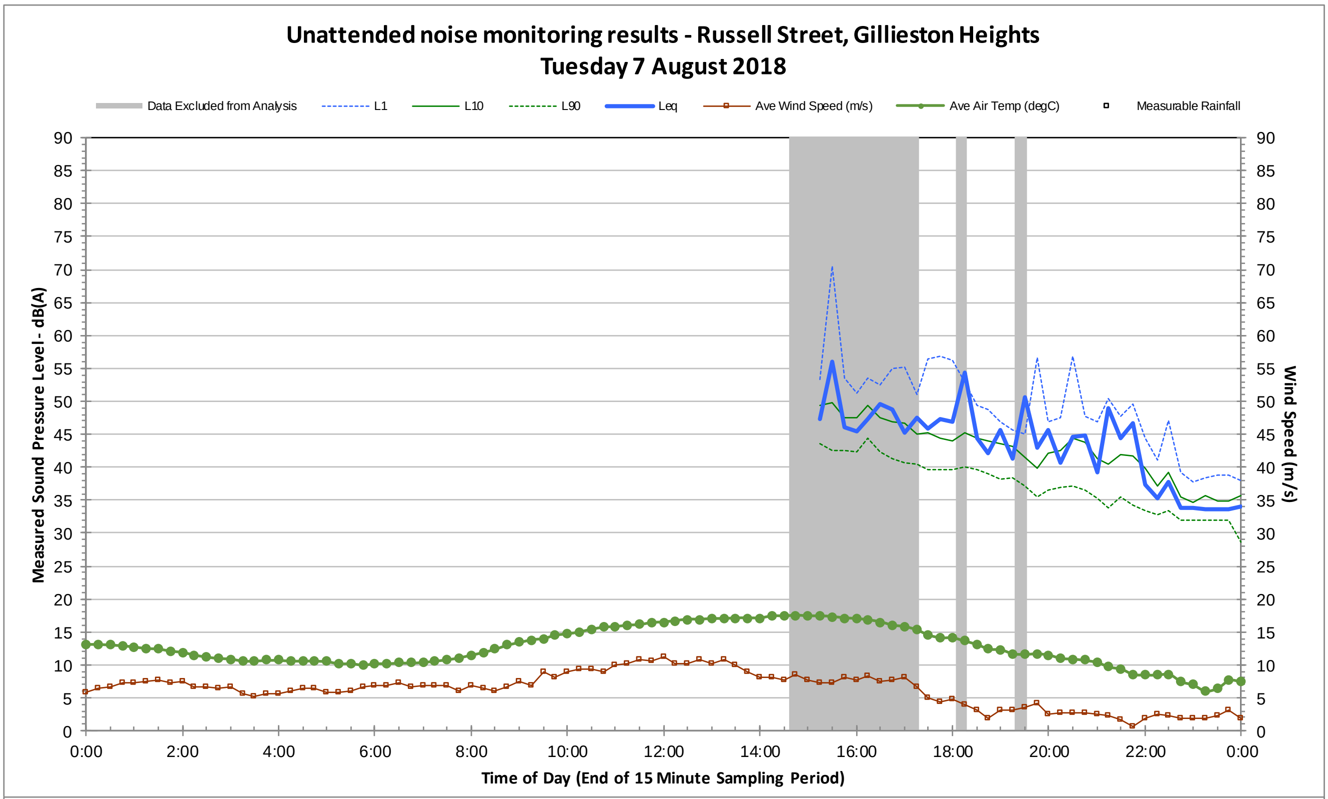

Unattended noise monitoring results - Millbrook Road, Cliftleigh
Friday 10 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)

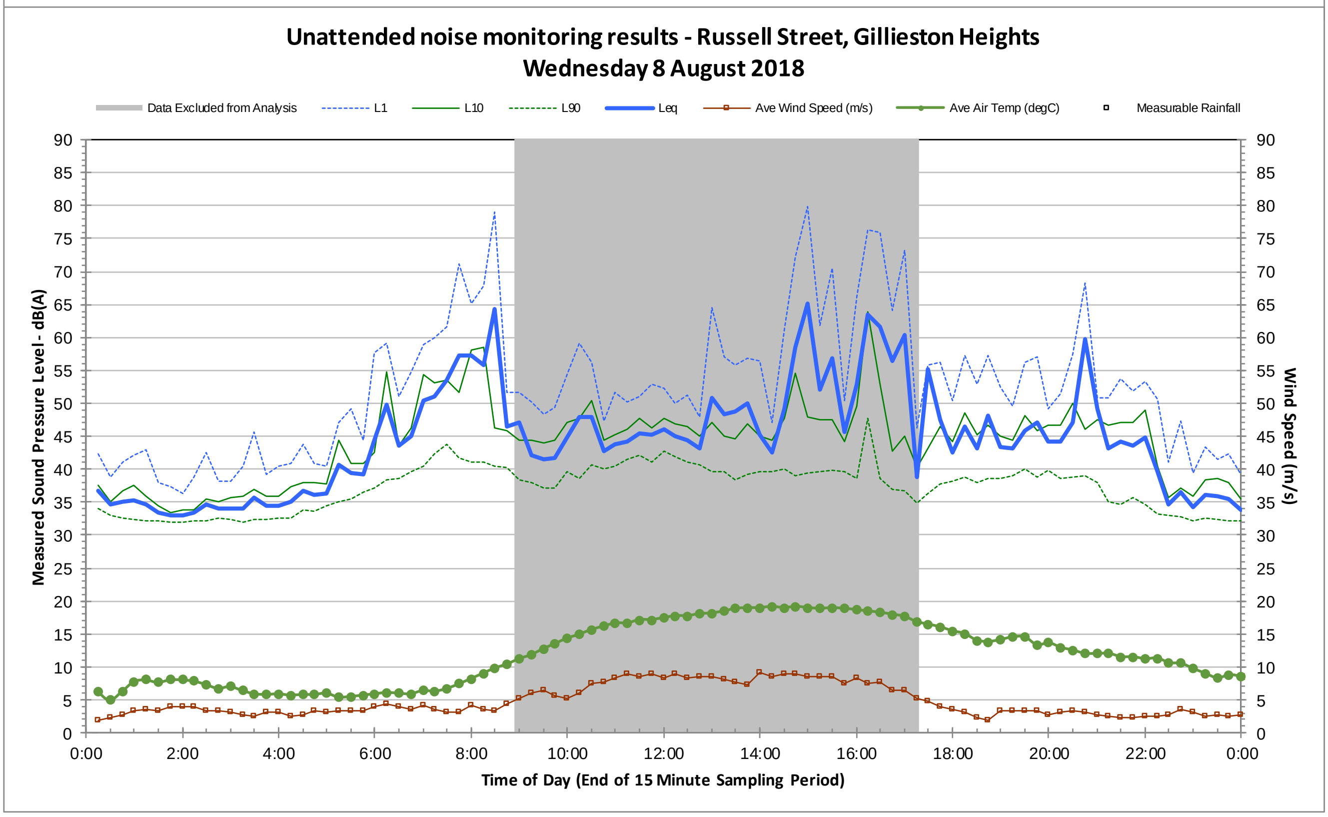

Unattended noise monitoring results - Millbrook Road, Cliftleigh
Saturday 11 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 0:00
Time of Day (End of 15 Minute Sampling Period)

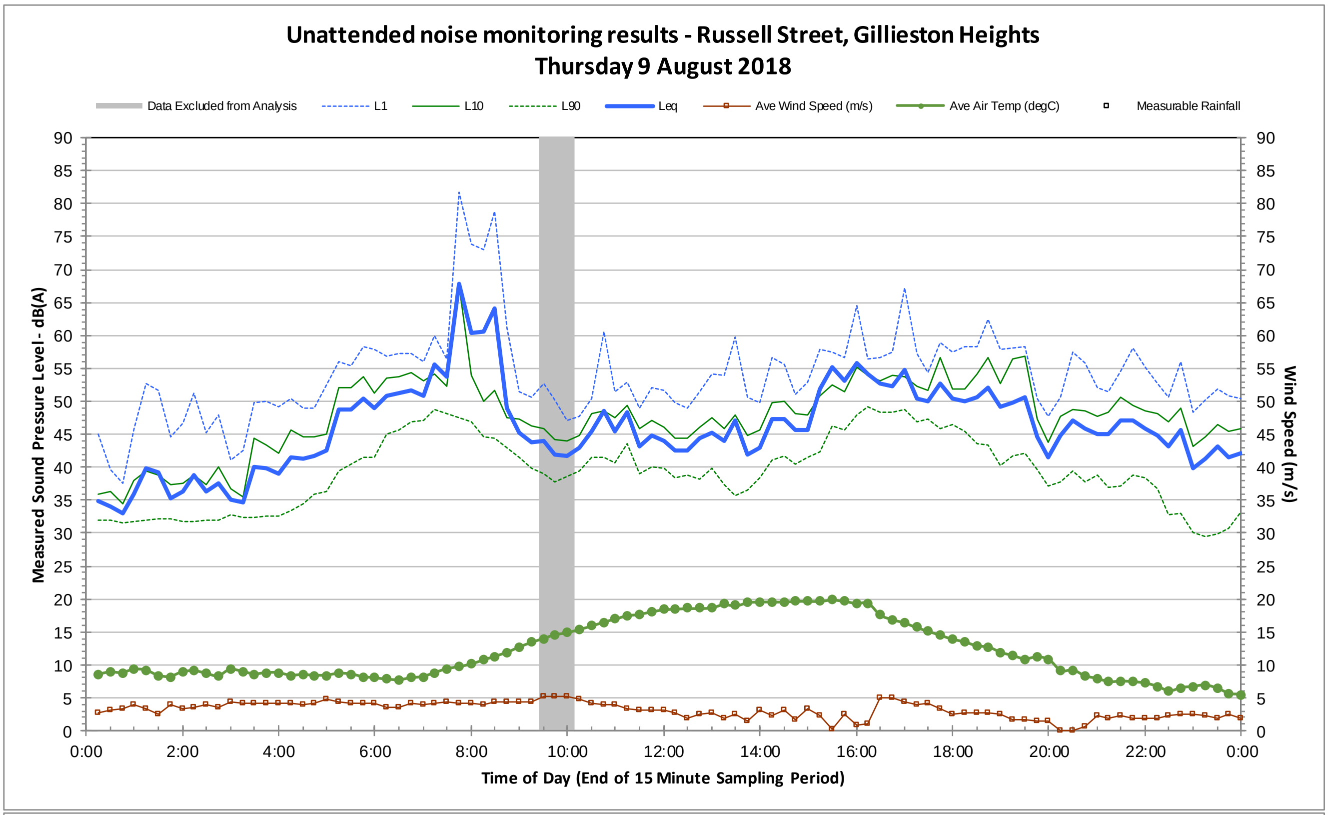

Unattended noise monitoring results - Millbrook Road, Cliftleigh
Sunday 12 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90
0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 0:00
Time of Day (End of 15 Minute Sampling Period)

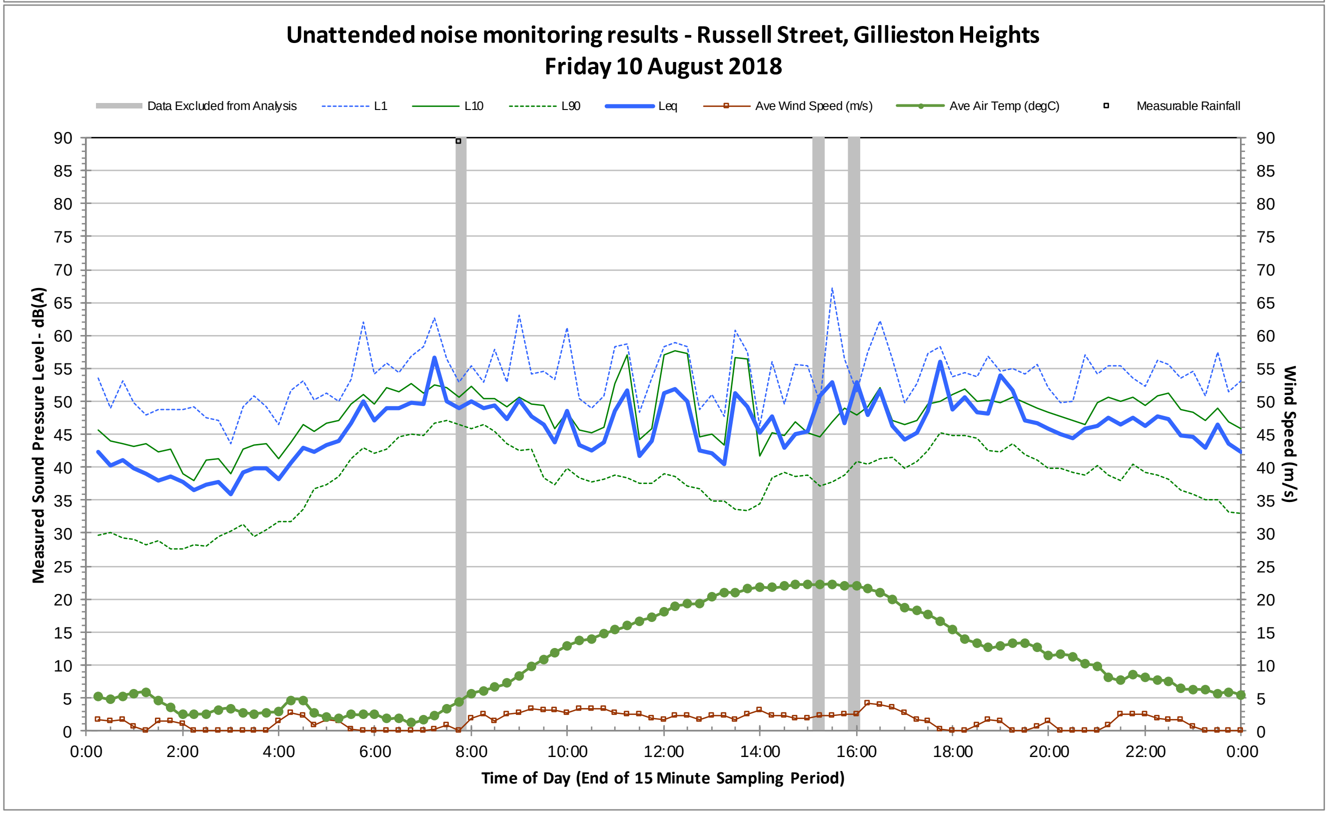


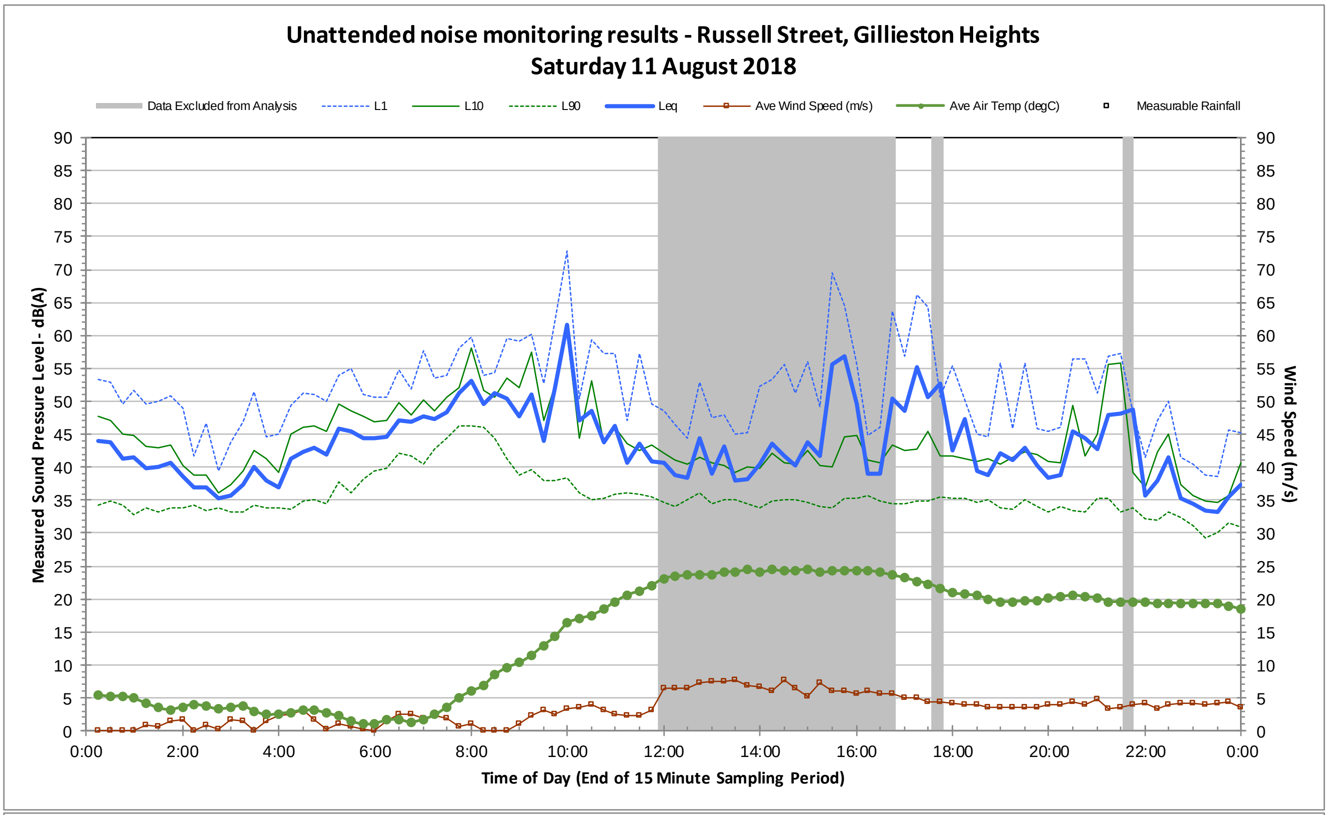
F.4 NCA 4: Russell Street, Gillieston Heights


Unattended noise monitoring results - Russell Street, Gillieston Heights
Tuesday 7 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00

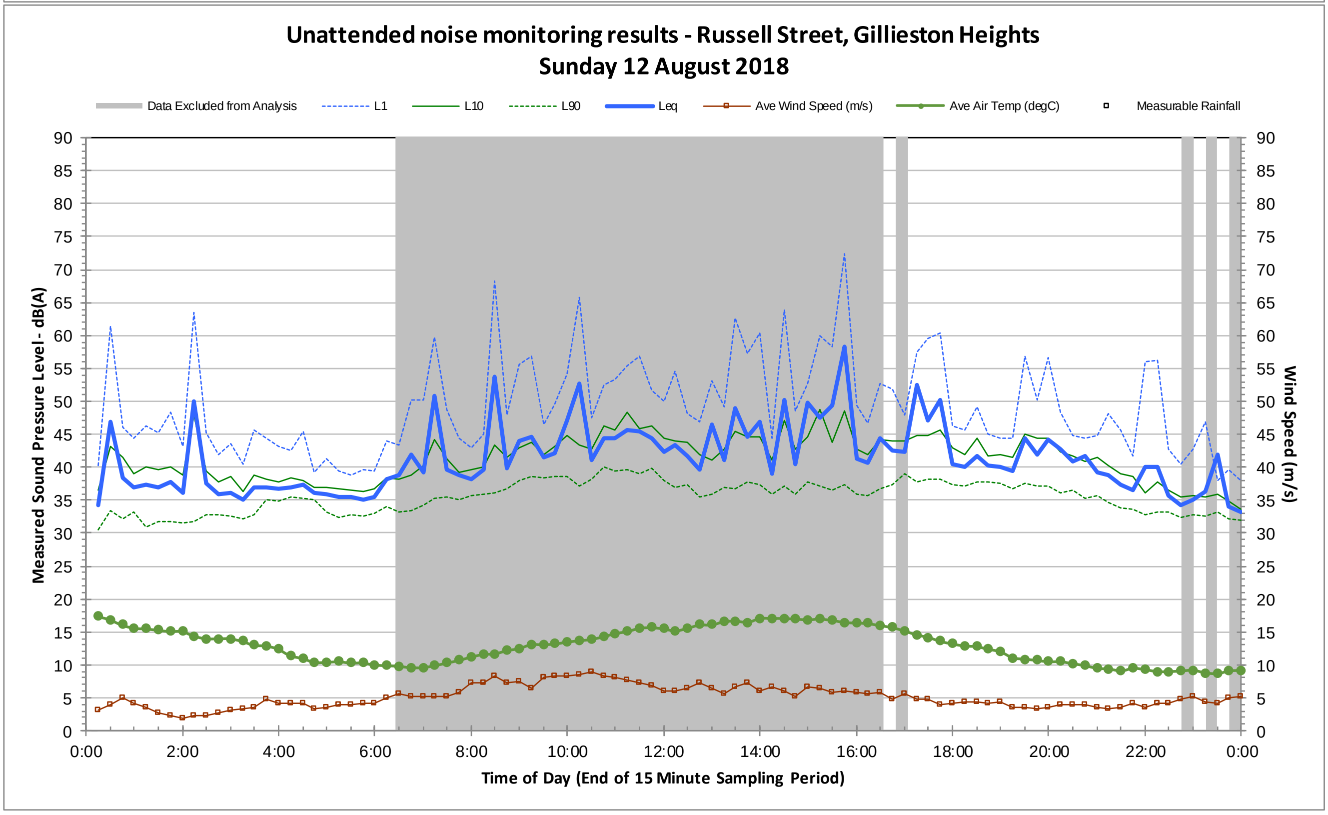

Unattended noise monitoring results - Russell Street, Gillieston Heights
Wednesday 8 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Unattended noise monitoring results - Russell Street, Gillieston Heights
Thursday 9 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)

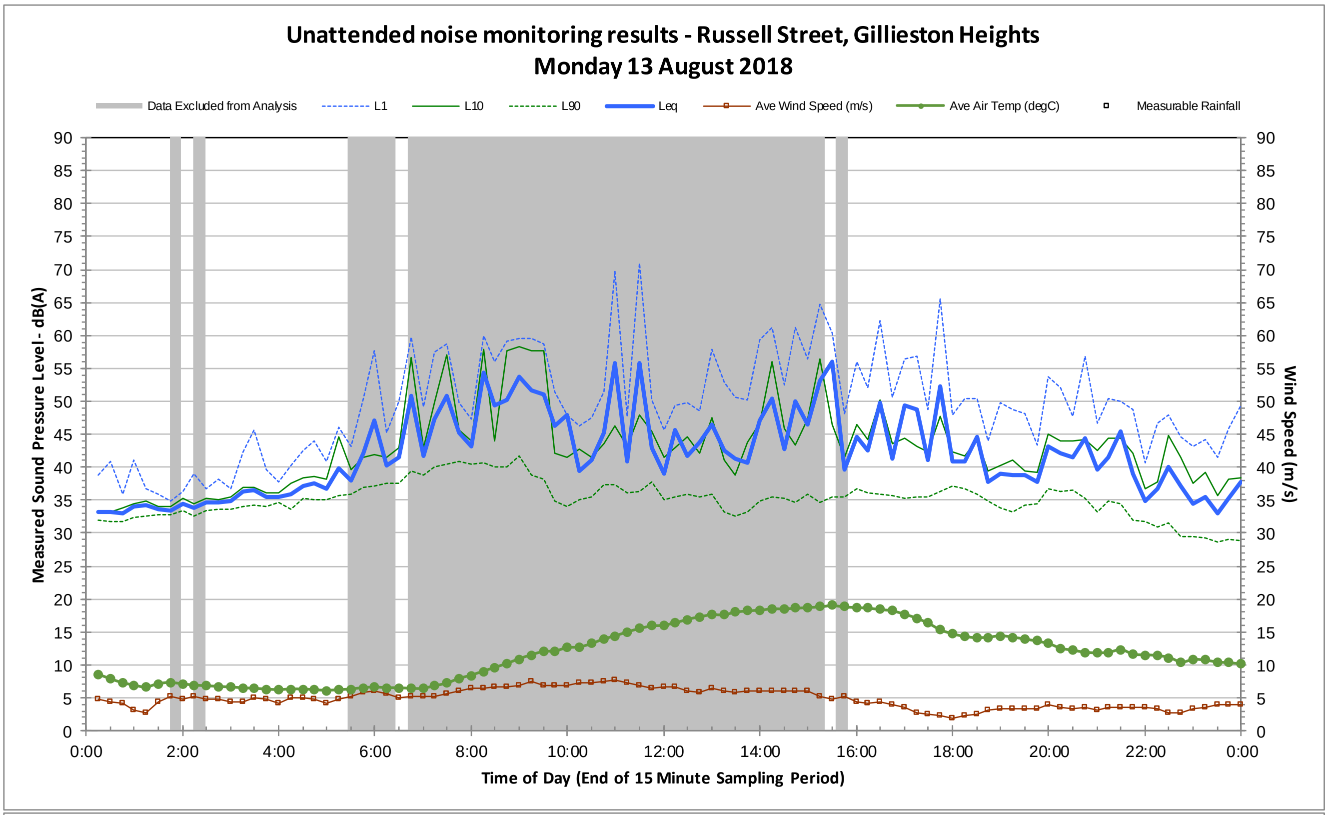

Unattended noise monitoring results - Russell Street, Gillieston Heights
Friday 10 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)

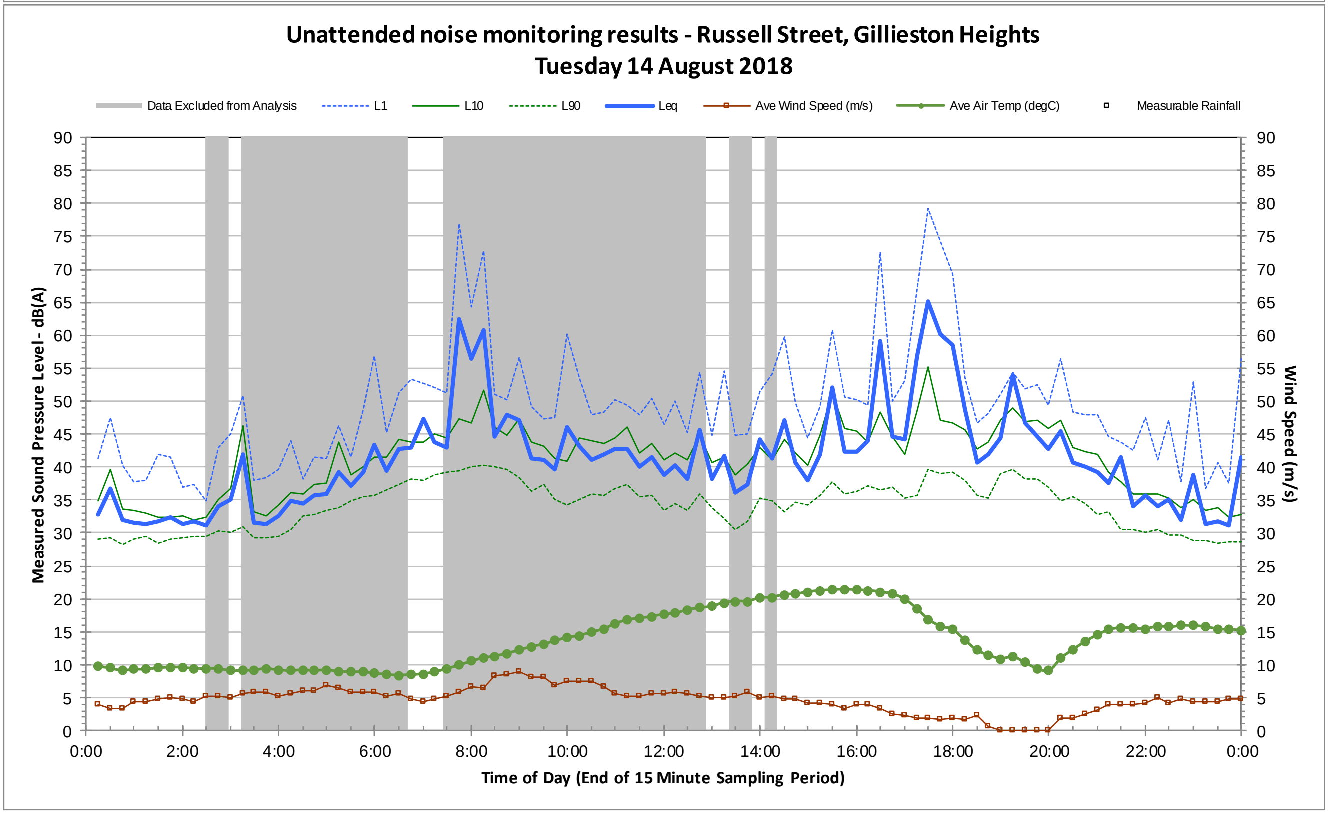


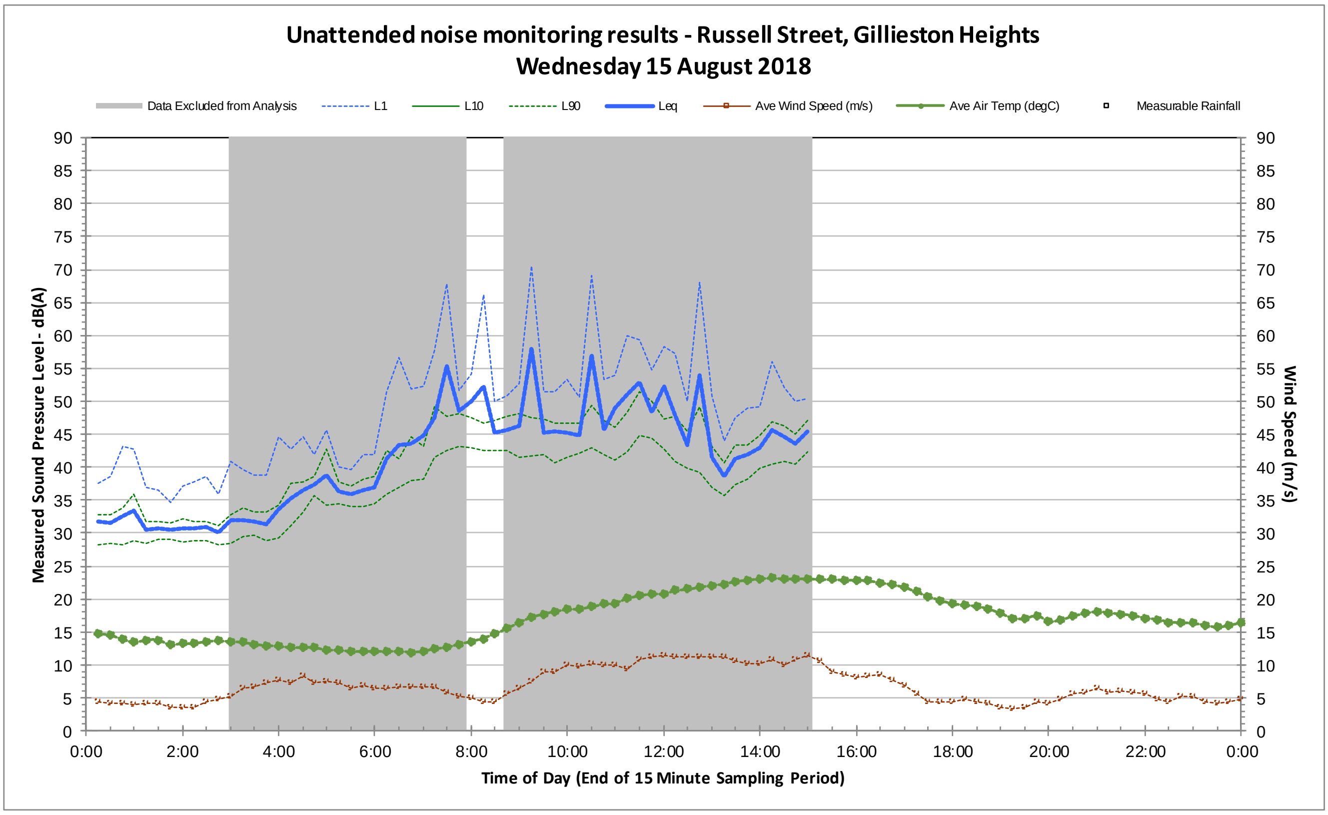
Unattended noise monitoring results - Russell Street, Gillieston Heights
Saturday 11 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)



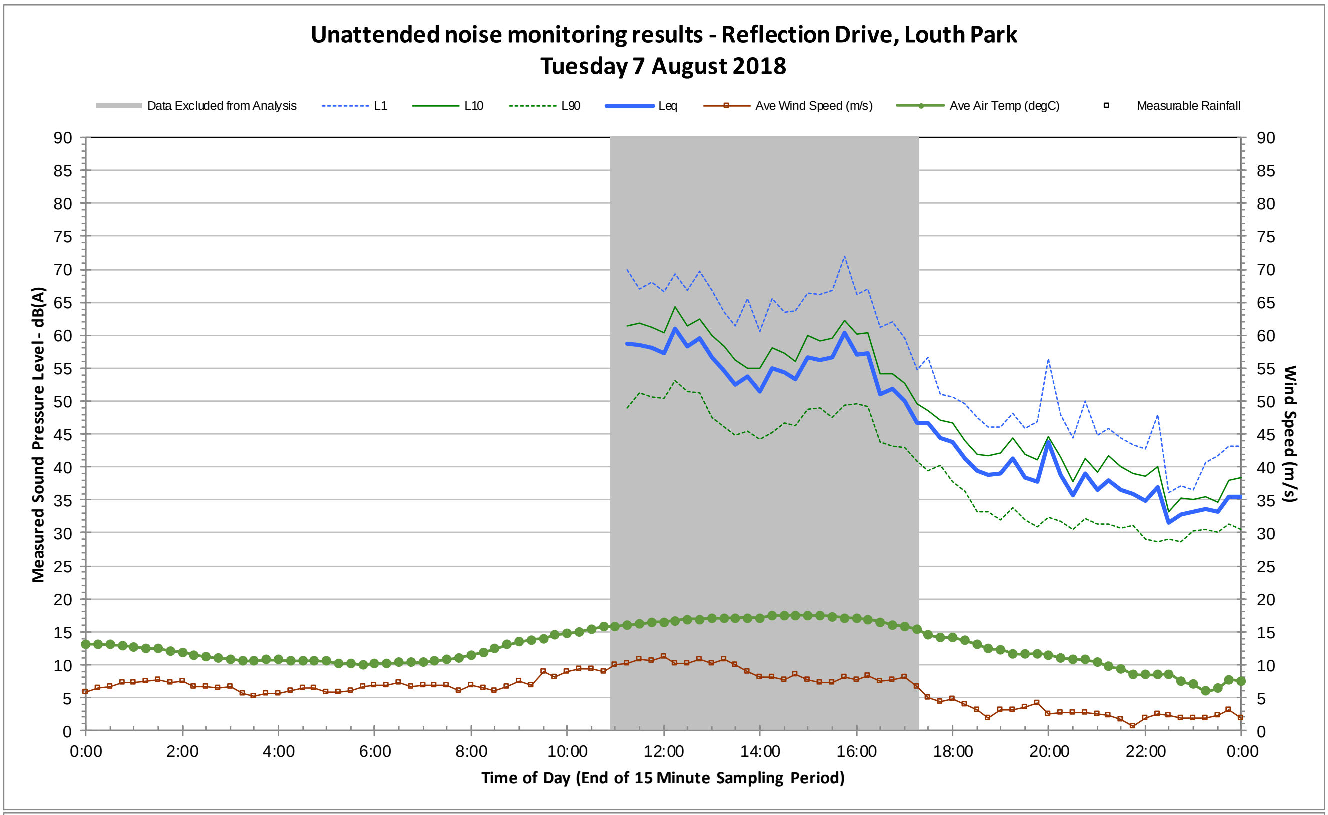
Unattended noise monitoring results - Russell Street, Gillieston Heights
Sunday 12 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)


Unattended noise monitoring results - Russell Street, Gillieston Heights
Monday 13 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00

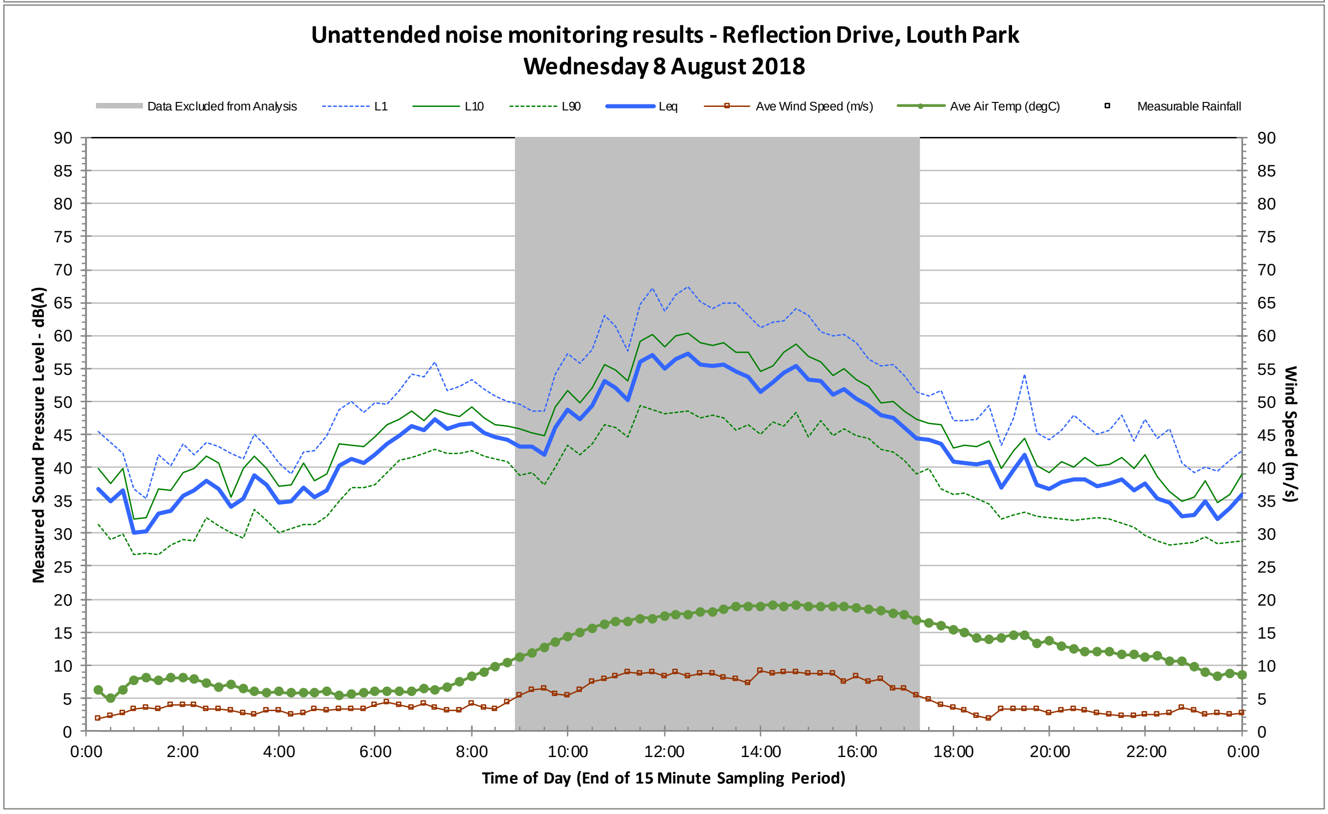

Unattended noise monitoring results - Russell Street, Gillieston Heights
Tuesday 14 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00



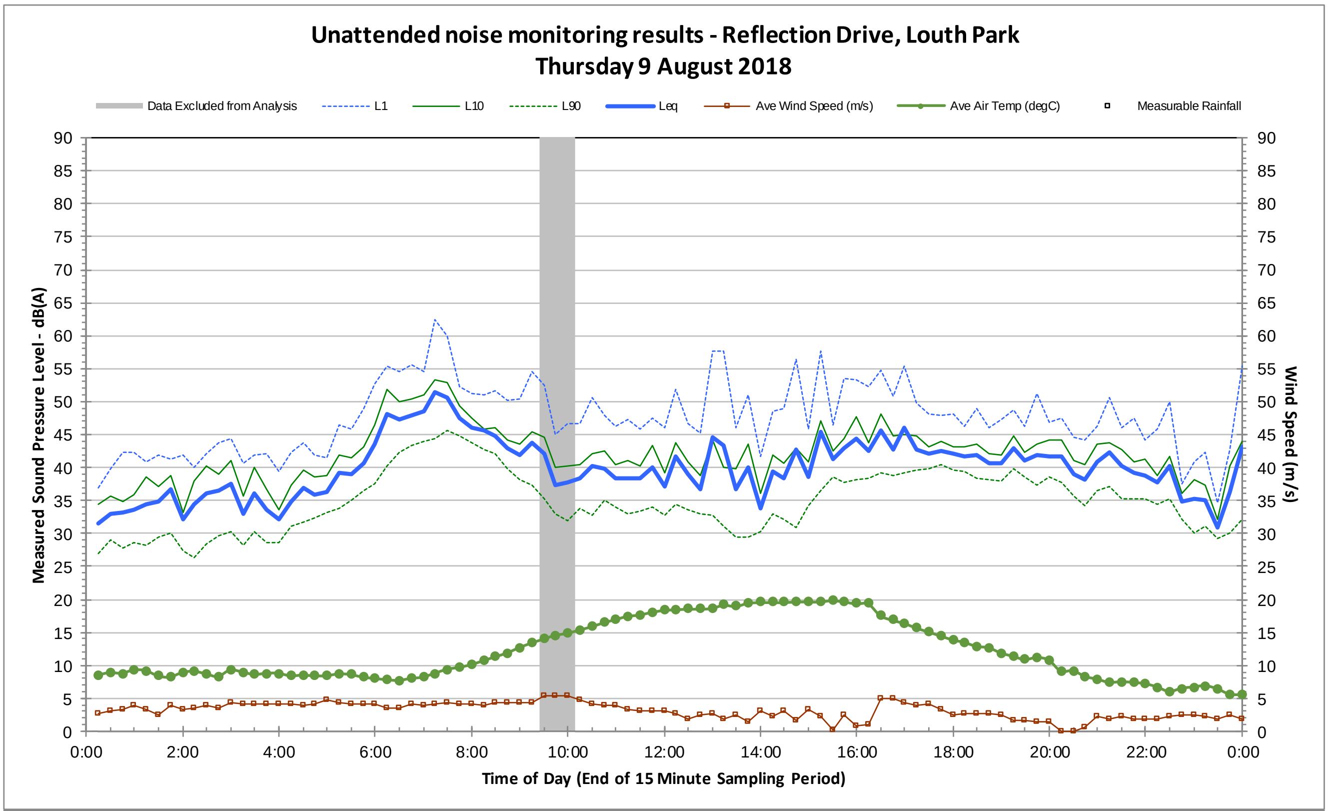
F.5 NCA 5: Reflection Drive, Louth Park



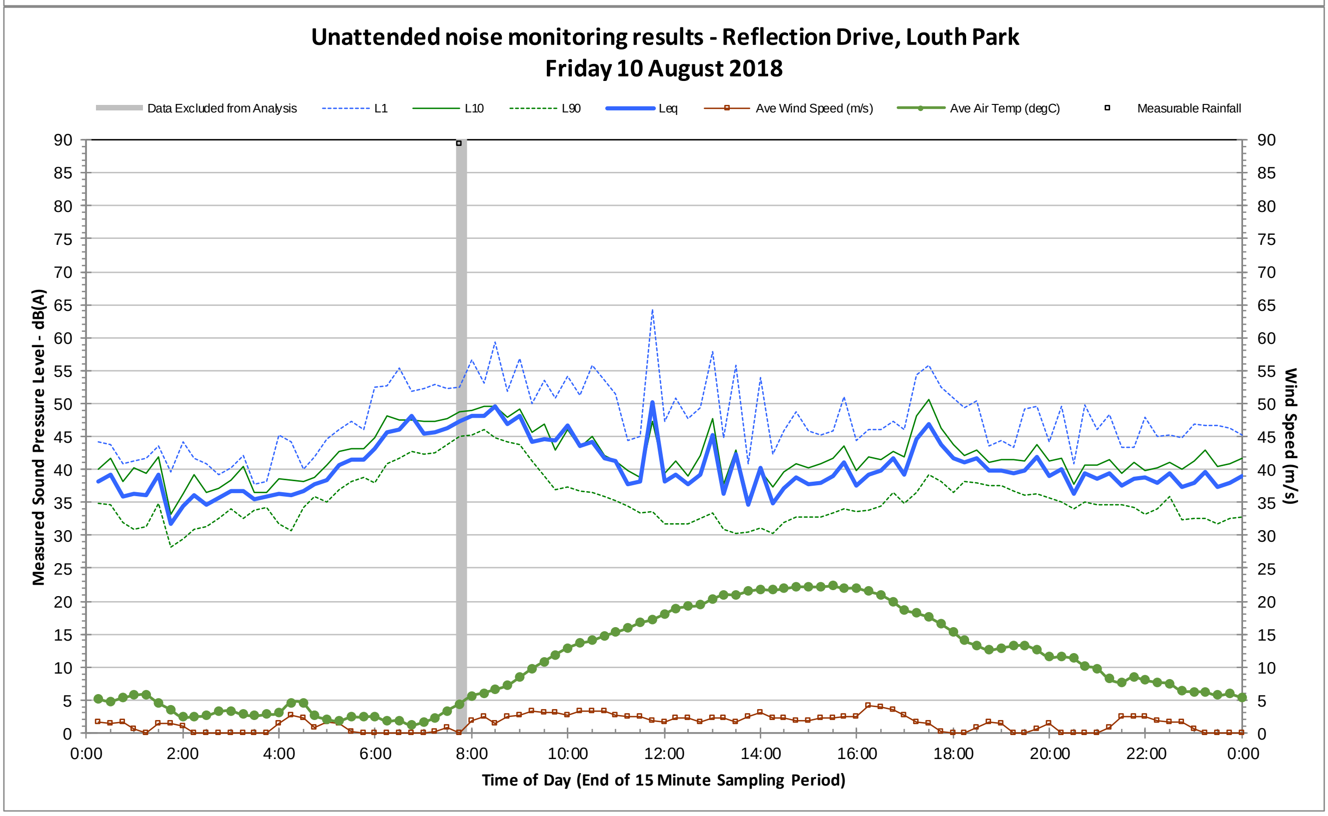
Unattended noise monitoring results - Reflection Drive, Louth Park
Tuesday 7 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)



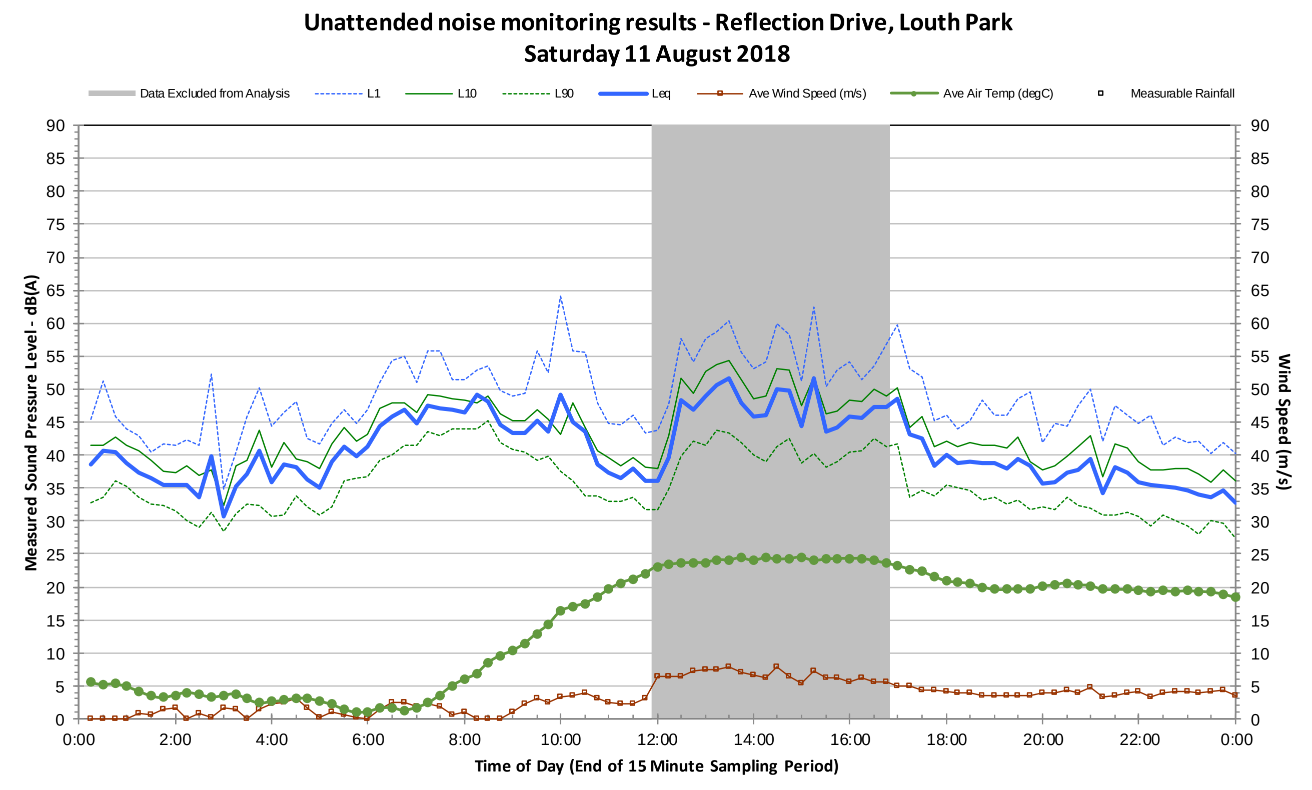
Unattended noise monitoring results - Reflection Drive, Louth Park
Wednesday 8 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)

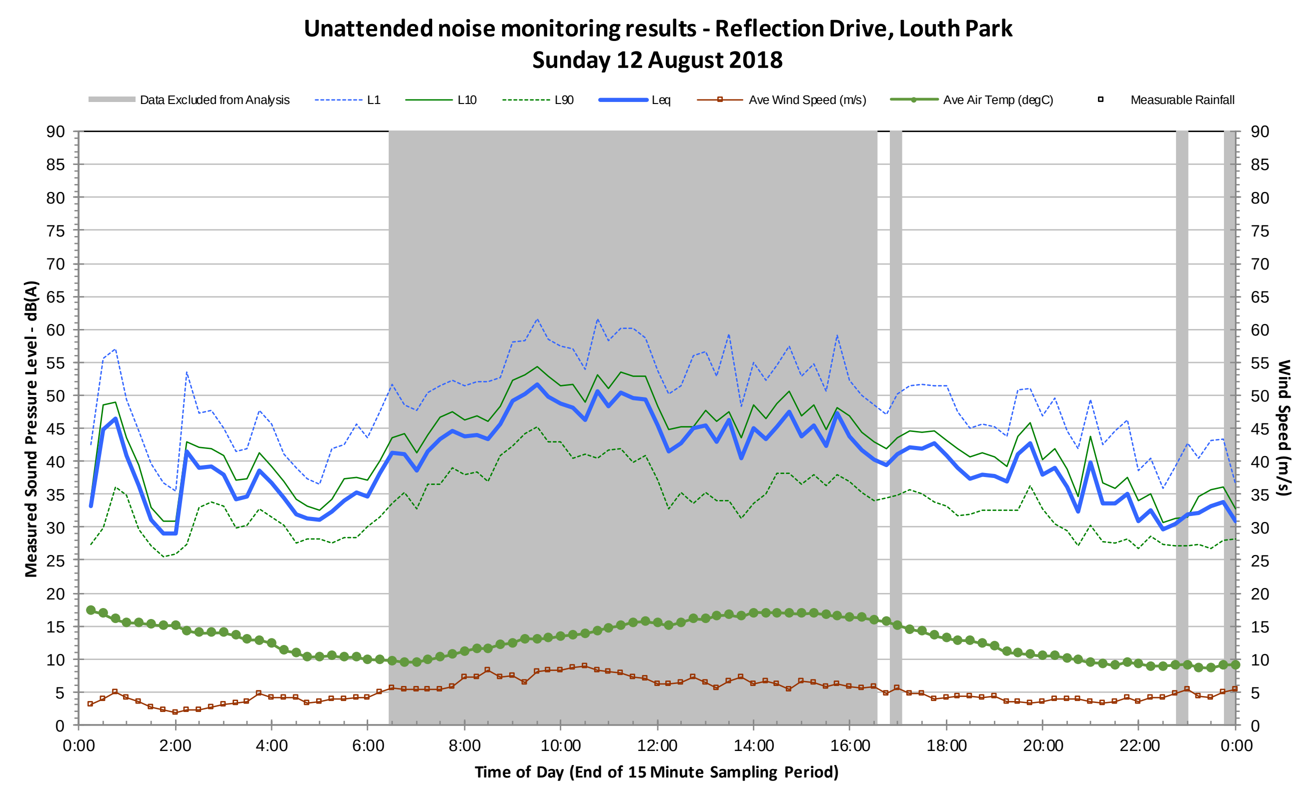


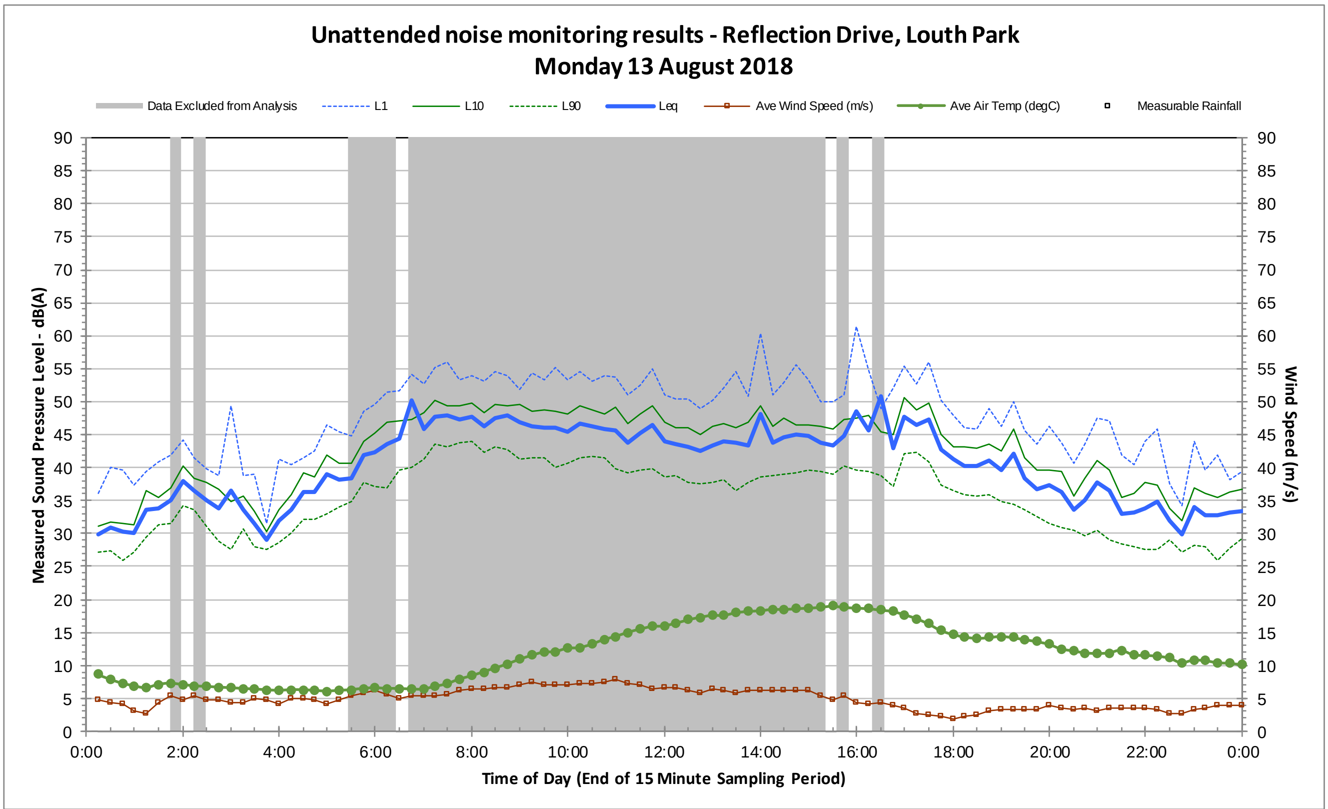
Unattended noise monitoring results - Reflection Drive, Louth Park
Thursday 9 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)

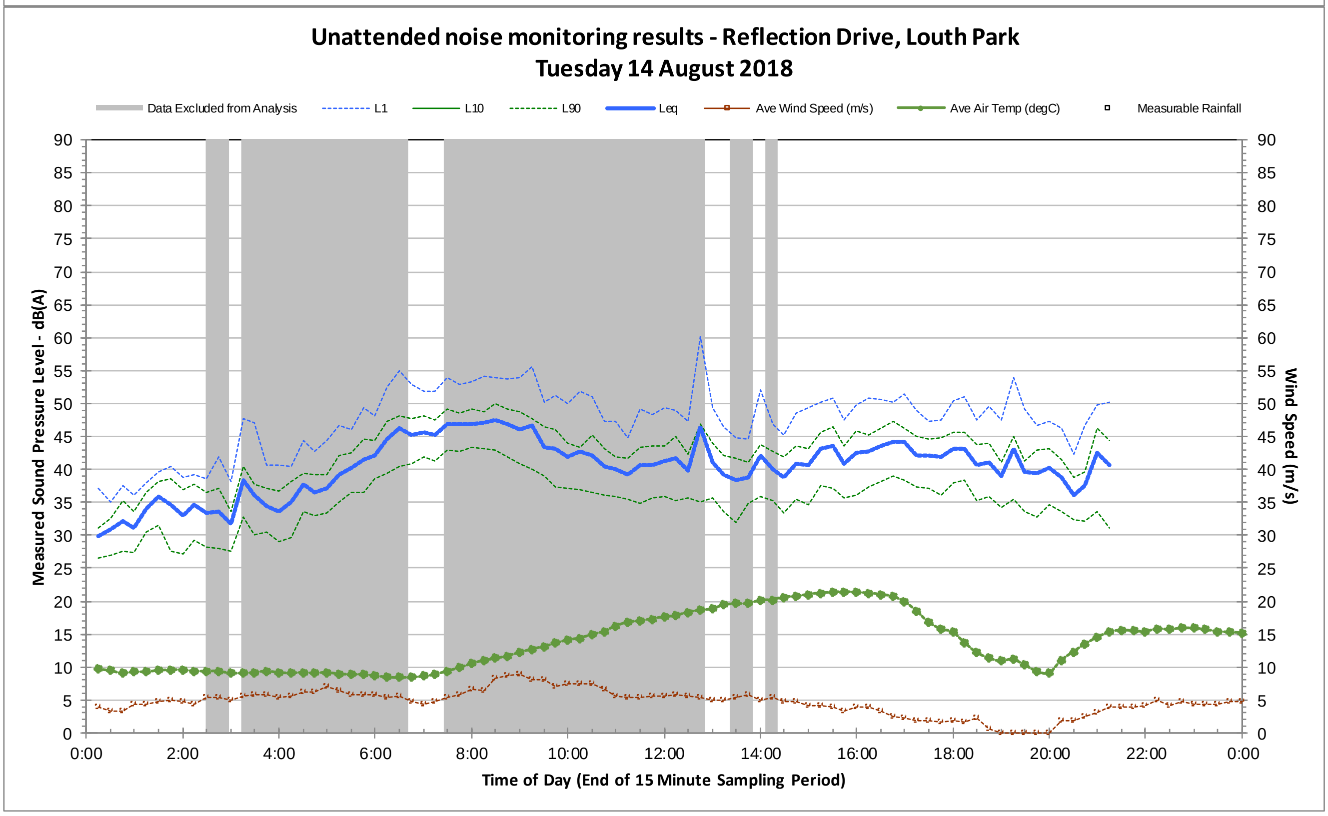


Unattended noise monitoring results - Reflection Drive, Louth Park
Friday 10 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)


Unattended noise monitoring results - Reflection Drive, Louth Park
Saturday 11 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 0:00
Time of Day (End of 15 Minute Sampling Period)


Unattended noise monitoring results - Reflection Drive, Louth Park
Sunday 12 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
0:00 2:00 4:00 6:00 8:00 10:00 12:00 14:00 16:00 18:00 20:00 22:00 0:00
Time of Day (End of 15 Minute Sampling Period)


Unattended noise monitoring results - Reflection Drive, Louth Park
Monday 13 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00


Unattended noise monitoring results - Reflection Drive, Louth Park
Tuesday 14 August 2018
Data Excluded from Analysis
L1
L10
L90
Leq
Ave Wind Speed (m/s)
Ave Air Temp (degC)
Measurable Rainfall
Measured Sound Pressure Level - dB(A)
Wind Speed (m/s)
Time of Day (End of 15 Minute Sampling Period)
0:00
2:00
4:00
6:00
8:00
10:00
12:00
14:00
16:00
18:00
20:00
22:00
0:00