Appendix J

Noise and Vibration Impact Assessment

Sportsmans Creek new bridge

Noise and Vibration Impact Assessment

Construction and Operation

Report Number 610.12404-R2

9 May 2014

Kellogg Brown & Root Pty Ltd
Level 13, 201 Kent Street
SYDNEY NSW 2000

Version: Revision 1

Sportsmans Creek new bridge

Noise and Vibration Impact Assessment

Construction and Operation

PREPARED BY:

SLR Consulting Australia Pty Ltd
ABN 29 001 584 612
2 Lincoln Street
Lane Cove NSW 2066 Australia
(PO Box 176 Lane Cove NSW 1595 Australia)
+61 2 9428 8100   +61 2 9427 8200
sydney@slrconsulting.com   www.slrconsulting.com

DOCUMENT CONTROL

Reference	Status	Date	Prepared	Checked	Authorised
610.12404-R2	Revision 1	9 May 2014	Dominic Sburlati	Matthew Harrison	Matthew Harrison
610.12404-R2	Revision 0	19 February 2014	Dominic Sburlati	Antony Williams	Matthew Harrison

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1 INTRODUCTION

1.1 Background

Roads and Maritime Services (Roads and Maritime) have engaged Kellogg Brown & Root Pty Ltd (KBR) to develop and assess options for a new bridge over Sportsmans Creek at Lawrence. To safely meet traffic demands, a new bridge is required to replace the existing Sportsmans Creek bridge.

The project will be delivered in consultation with Clarence Valley Council and the Lawrence community, and forms part of the 'Bridges for the Bush' initiative – a NSW and Federal Government commitment to improving road freight productivity by replacing or upgrading bridges throughout regional New South Wales over the next five years.

Several possible bridge locations have been considered with one option being identified as the preferred concept design after the relative benefits and impacts were assessed.

The Sportsmans Creek bridge is located on the southern approach to the village of Lawrence, within the Clarence Valley Council Local Government Area. Lawrence is located 25 km north of Grafton on the Lawrence Road (MR152). This road is managed and maintained by Clarence Valley Council.

1.2 Report Objectives

SLR Consulting (SLR) has been commissioned by KBR to undertake a noise and vibration assessment of the chosen concept design for the Sportsmans Creek new bridge project. This assessment forms part of the proposal's Review of Environmental Factors (REF).

1.3 Terminology

Specific acoustic terminology is used within this assessment. An explanation of common acoustic terms is included as **Appendix A**.

Relevant Guidelines

The noise and vibration guidelines for construction and operations are based on the publications managed by the Environmental Protection Authority[1] (EPA). The guidelines applicable to this assessment include:

- Operational Noise – *Road Noise Policy* (RNP), DECCW 2011
- Construction Noise – *Interim Construction Noise Guideline* (ICNG), DECC 2009
- Construction Vibration (human comfort) – *Assessing Vibration - a technical guideline,* DEC 2006

The following additional guidelines and standards are also referenced in this study:

- Construction Vibration (human comfort) – BS 6472:2008 Guide to evaluation of human exposure to vibration in buildings
- Construction Vibration (damage limits) – BS 7385-2:1993 Evaluation and measurement for vibration in buildings. Guide to damage levels from groundborne vibration
- Construction Vibration (heritage buildings) - German standard DIN 4150: Part 3 – 1999 Effects of Vibration on Structures
- Noise measurement procedure (operational) – AS 2702:1984 Acoustic Methods of Measurement of Road Traffic Noise

[1] Noise and Vibration guidelines are available at the following web address: http://www.environment.nsw.gov.au/noise

- Noise measurement procedure (construction) – AS 1055:1997 Acoustics – Description and Measurement of Environmental Noise
- Roads and Maritime assessment requirements – *Preparing an Operational Noise and Vibration Assessment*, Roads and Maritime July 2011
- Roads and Maritime noise management response – *Environmental Noise Management Manual* (ENMM), RTA 2001

2 PROJECT DESCRIPTION

2.1 Proposed Upgrade Details

The objectives of the project are:

- Construct a new bridge over Sportsmans Creek, Lawrence
- Enhance road safety for motorists, residents, cyclists and pedestrians
- Improve traffic efficiency within Lawrence
- Improve road transport productivity, efficiency, maintainability and reliability
- Support local and regional economic development
- Allow for safe removal of the existing bridge, in support of the Timber Truss Bridge Conservation Strategy
- Minimise the impact on the natural, cultural, social and built environment
- Consider community members' views
- Deliver value for money
- Facilitate handover of the new bridge and associated roadwork to Clarence Valley Council.

2.2 Recommended Option

Several possible bridge/route options were considered within Roads and Maritime report *"Sportsmans Creek new bridge, Recommended Option Report"*, dated November 2013.

The proposed road alignment and future bridge location for the preferred option is approximately 100 m west of the existing bridge and approximately parallel to it, as shown in **Figure 1**. The proposed alignment will direct traffic along Grafton Street instead of Bridge Street. Traffic on Grafton Street will therefore increase over existing levels while traffic on Bridge Street will be seen to decrease.

Figure 1 Project Area

2.3 Identified Noise and Vibration Sensitive Receivers

A desktop review of the project area identified residential, commercial, and other noise and vibration sensitive receivers within the project area. The most potentially affected receivers are located in the southern part of Lawrence village along Bridge Street and Grafton Street.

A map of the project area showing the locations of different classification of noise sensitive receivers is displayed in **Figure 2**.

2.3.1 Residential Receivers

Several residential receivers have been identified within close proximity to the proposed project alignment. Residential receivers most potentially affected by the alignment are located along Grafton Street and Bridge Street.

The residential receivers closest to the proposed alignment are located approximately 10 m from the proposed carriageway on Grafton Street. Residential receivers are shown in green shading in **Figure 2**.

It is understood that the residential property at address 1-9 Grafton Street will be acquired as part of the project. This residential receiver has therefore not been considered as part of this assessment.

2.3.2 Commercial Receivers

Commercial receivers potentially affected by the proposed alignment are located on Grafton Street and Bridge Street in the southern section of Lawrence village. A commercial receiver (general store) is located on the corner of Grafton Street and Richmond Street, and another commercial receiver (tavern) is located between Bridge Street and Grafton Street. Commercial receivers are shown in orange shading in **Figure 2**.

2.3.3 Other Sensitive Receivers

Other sensitive receivers potentially affected by the proposed alignment include a community building located at 33 Bridge Street, Lawrence.

The community building named “Lawrence Public Hall” is located 18 m from the existing Bridge Street carriageway. Other sensitive receivers are shown in purple shading in **Figure 2**.

2.3.4 Passive Recreation Areas

Passive recreation areas potentially affected by the proposed alignment include several park areas either side of Bridge Street.

There are two passive recreation areas on the southern bank of Sportsmans Creek. Flo Clark Park is located between the western side of Bridge Street and the northern side of Riverbank Road, and Sportsmans Park is located on the opposite side of Bridge Street.

Lawrence Memorial Park is located on both sides of Bridge Street and extends from the Lawrence Public Hall to the Bridge Street and Grafton Street intersection. Passive recreation areas are shown in blue shading in **Figure 2**.

Figure 2 Sensitive Receiver Locations

Image from Google

3 EXISTING AMBIENT NOISE ENVIRONMENT

In order to characterise the noise environment across the proposal area (for the assessment of both construction and operation) and to establish existing ambient noise levels upon which to base the noise emission targets, environmental noise monitoring was performed at representative locations within the proposal area.

The ambient noise monitoring locations NM1 to NM3 are indicated in **Figure 2**. Both attended and unattended ambient noise measurements were taken at each monitoring location.

Detailed descriptions of the ambient noise monitoring environments are provided in **Appendix B**.

3.1.1 Ambient Noise Metrics

This section makes reference to certain statistical noise level descriptors, in particular the L_{A10}, L_{Aeq}, L_{A90}, and L_{A1} noise levels. These descriptors are defined below.

- The L_{A10} noise level is the A-weighted sound pressure level exceeded for 10% of a given measurement period and is normally utilised to characterise typical average maximum noise levels.
- The L_{Aeq} is the energy averaged sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound over the same measurement period.
- The L_{A90} noise level is the A-weighted sound pressure level exceeded for 90% of a given measurement period and is representative of the average minimum background sound level (in the absence of the source under consideration), or simply the “background” level.
- The L_{A1} noise level is the A-weighted sound pressure level exceeded for 1% of a given measurement period and is normally utilised to characterise typical maximum noise levels.

Further descriptions of acoustical terminology, including a description of A-weighting, are included in **Appendix A**.

3.2 Continuous Unattended Monitoring

3.2.1 Noise Monitoring Procedure

Unattended noise loggers were deployed adjacent to sensitive receivers over a minimum period of one week in order to measure the prevailing levels of ambient noise. The measurements were generally conducted at a height of 1.5 m above the local ground level.

All noise measurement instrumentation used in the surveys was designed to comply with the requirements of Australian Standard AS IEC 61672.1 2004 Electroacoustics – Sound level meters, Part 1: Specifications and carried appropriate and current NATA calibration certificates.

The equipment utilised for the continuous unattended noise surveys comprised of Svantek Type 957 noise loggers. All noise loggers were fitted with microphone wind shields. The calibration of the loggers was checked before and after each measurement survey, and the variation in calibration at all locations was found to be within acceptable limits at all times. All noise loggers were set to record statistical noise descriptors in continuous 15 minute sampling periods for the duration of their deployment.

The results of the noise monitoring have been processed with reference to the procedures contained in the NSW EPA Industrial Noise Policy (INP) and RNP so as to establish representative sensitive receiver noise levels.

Weather data recorded during the noise monitoring survey periods by the Bureau of Meteorology (at Grafton) was used to assist in identifying potentially adverse weather conditions, such as excessively windy or rainy periods, so that weather affected data could be discarded..

The RNP notes that noise levels attributable to sources other than road traffic should be discarded from the noise logging data. Therefore in order for the measured data to reflect the prevailing levels of road traffic noise, the data was also processed to remove uncharacteristic changes in noise which are not related to road traffic noise.

Three environmental noise loggers were deployed from 9 December to 19 December 2013 as outlined in **Table 1**. The logger locations are indicated in **Figure 2**.

Table 1 Ambient Noise Logging Locations

Loc.	Address	Logger Position	Distance to Project Carriageway Centreline	Serial Number
NM1	4 Grafton Street	Western side of the residence, 1 m away from the veranda awning, 60 m from nearest significant traffic source (Bridge Street). No line of sight to significant traffic source.	15 m	20673
NM2	10 Bridge Street	Western side of the residence, 1 m away from the facade. Direct line-of-sight to the Bridge Street Carriageway. 8 m from nearest significant traffic source (Bridge Street).	90 m	20644
NM3	3 Grafton Street	Eastern side of the residence, 1 m away from the facade, 40 m from nearest significant traffic source (Bridge Street).	20 m	21425

The ambient noise monitoring locations were selected based on an inspection of the potentially affected areas, giving consideration to other noise sources which may influence the recordings, security issues for the noise monitoring devices and gaining permission for access to the location from the resident or landowner.

3.2.2 Noise Monitoring Results

The results of the noise monitoring have been processed in accordance with the procedures contained in the *NSW Industrial Noise Policy* (INP) so as to establish representative noise levels from all noise sources in the area at the residences.

A summary of the unattended continuous noise monitoring undertaking at the locations displayed in **Figure 2** during INP defined time periods is contained in **Table 2.** A full graphical representation of the noise levels recorded is provided in **Appendix B**.

Table 2 Unattended Noise Logger Results

Location	Period[1]	Noise Parameter (dBA)			
		LA90	LAeq	LA10	LA1
NM1	Daytime	33	47	47	55
	Evening	36	46	46	51
	Night	35	44	45	46
NM2	Daytime	31	56	58	67
	Evening	32	52	49	63
	Night	30	48	40	52
NM3	Daytime	32	51	53	60
	Evening	32	48	48	57
	Night	29	47	45	53

Note 1: - INP Governing Periods - Day: 7.00 am to 6.00 pm Monday-Saturday, 8.00 am to 6.00 pm Sundays, Evening: 6.00 pm to 10.00 pm, Night: 10.00 pm to 7.00 am Monday to Saturday, 10.00 pm to 8.00 am Sunday.

The L90 background noise levels for all periods are considered to be relatively low. This reflects the intermittent nature of vehicle traffic in this area where there are also no major noise sources of a continuous nature (such as industrial plant or natural sources such as waves breaking on an ocean foreshore).

3.2.3 Concurrent Traffic Counting

In accordance with Roads and Maritime document *'Preparing an Operational Traffic and Construction Noise and Vibration Assessment Report',* traffic counting was undertaken concurrently with the noise monitoring during the period 9 December to 15 December 2013.

Traffic data recorded during the survey period for the purpose of validating the noise prediction methodology, is shown in **Table 3**.

Table 3 Vehicle Counts during Noise Monitoring – NM2

Location	Vehicle Class[1]	Number of Vehicles (Average Daily Traffic)		
		Northbound	Southbound	Combined
GTA02 10 Bridge Street	Car	582	602	1184
	Car+Trailer	21	23	44
	2 axle Truck	26	29	55
	3 axle Truck	5	4	9
	4 axle Truck	1	1	2
	3 axle Semi	2	2	3
	4 axle Semi	1	1	2
	5 axle Semi	1	0	1
	6 axle Semi	1	1	2
	Unknown	1	6	7

3.3 Operator Attended Noise Measurements

3.3.1 Noise Measurement Procedure

Operator attended noise surveys were conducted on 9 December 2013 at noise monitoring locations NM1 to NM3 in order to support the results of the continuous unattended measurements.

Attended measurements were performed using a calibrated Brüel and Kjær 2250 Precision Sound Level Meter (serial number 2600507). The acoustic instrumentation complies with AS IEC 61672.1 2004 *'Electroacoustics - Sound Level Meters'* and is designated as a Type 1 instrument suitable for laboratory and field use.

The sound level meter was calibrated prior and subsequent to the measurement period using a Bruel & Kjaer Type 4231 calibrator. No significant drift in calibration was observed. All equipment carries current NATA certification (or if less than two years old, manufacturers certification).

3.3.2 Noise Measurement Results

A summary of the 15 minute operator attended measurements undertaken at the three measurement sites is displayed in **Table 4**.

Table 4 Operator Attended Noise Survey Results

Loc.	Measurement Details	Noise Parameter (dBA)				Description of Noise Sources – Typical Maximum Levels L_{Amax} (dBA)
		L_{Amax}	L_{A10}	L_{Aeq}	L_{A90}	
NM1	4 Grafton St. 09/12/2013 15:32 Daytime Light wind	73	52	51	48	Wind in trees: 50-52 Distant Heavy Vehicles: 53 Dogs barking: <50 Distant construction: <50
NM2	10 Bridge St. 09/12/2013 15:00 Daytime Light wind	84	65	63	49	Wind in trees: 46-48 Patron noise from tavern: 55 Light road vehicle: 67-70 4WD road vehicle: 72-73 Heavy road vehicle: 81 Tavern car park: 81
NM3	3 Grafton St. 09/12/2013 15:32 Daytime Light wind	74	55	54	47	Wind in trees: 50-54 Light road vehicle: 59 4WD road vehicle: 59 Motorbike: 74 Insects: ~50

Daytime ambient noise levels at locations NM1 and NM3 were largely dominated by natural environmental noise from wind in trees, birds and/or insects, with some influence from nearby road traffic sources. Measured daytime ambient noise levels at location NM2 were dominated by road traffic from Bridge Street.

4 NOISE GOALS

4.1 Operational Noise – NSW Road Noise Policy

4.1.1 Guideline Overview

The NSW *Road Noise Policy* (RNP) is applicable to assess potential road traffic noise impacts from traffic operating on public roads. The RNP identifies strategies that address the issue of road traffic noise from:

- Existing roads
- New road projects
- Road redevelopment projects
- New traffic-generating developments

The RNP specifies development of a new arterial road as follows:

> *"A freeway, arterial or sub-arterial road that is proposed on a 'corridor' that has not previously been a freeway, arterial or sub-arterial road; or an existing freeway, arterial or sub-arterial road that is being substantially realigned."*

The RNP aims to protect amenity inside and immediately around permanent residences, schools, hospitals and other sensitive land uses, rather than at all points in a given locality, which would not be practical or possible. Although it is not mandatory to achieve the noise goals in the RNP, project proponents need to provide justification if it is not considered feasible or reasonable to achieve them.

The guideline recognises that there are generally more opportunities to minimise noise impacts from new roads and road corridors, especially those in greenfield locations, through judicious road design and land use planning. The scope to reduce noise impacts from existing roads and corridors is more limited.

The RNP considers impacts both at the time of project opening and also in a design year, typically taken to be ten years after project completion.

4.1.2 Operational Noise Criteria

Residential Receivers

The proposed project alignment (Option 2) includes a new bridge outside of the existing road corridor and also includes significant corridor alignment changes to Grafton Street and Lawrence Road.

As such the proposed project alignment is classified as a new arterial road corridor for the purposes of assessment. The relevant criteria for residential receivers for the project alignment are shown in **Table 5** in shaded cells.

Table 5 Road Traffic Noise Criteria for Residential Land Uses

Road Category	Type of Project / Land Use	Day (7.00 am to 10.00 pm)	Night (10.00 pm to 7.00 am)
Freeway / arterial / sub-arterial roads	1. Existing residences affected by noise - from **new** freeway/arterial/sub-arterial road corridors	$L_{Aeq(15hour)}$ 55 dBA	$L_{Aeq(9hour)}$ 50 dBA
	2. Existing residences affected by noise - from **redevelopment** of existing freeway / arterial / subarterial roads 3. Existing residences affected by **additional traffic** on existing freeways / arterial / sub-arterial roads generated by land use developments	$L_{Aeq(15hour)}$ 60 dBA	$L_{Aeq(9hour)}$ 55 dBA
Local roads	4. Existing residences affected by noise from **new** local road corridors 5. Existing residences affected by noise - from **redevelopment** of existing local roads - 6. Existing residences affected by **additional traffic** on existing local roads generated by - land use developments -	$L_{Aeq(1hour)}$ 55 dBA	$L_{Aeq(1hour)}$ 50 dBA

Note: All criteria are external, applicable at the facade of the affected residence.

Other Non-Residential Land Uses

The RNP also describes assessment criteria for non-residential land uses. For this project, non-residential receivers are the three passive recreation areas at Lawrence Memorial Park, Flo Clark Park and Sportsmans Park. Details on these passive recreation areas are provided in **Section 2.3**. The applicable assessment criteria for non-residential receivers are presented in **Table 6**.

Table 6 Non-Residential Road Traffic Noise Assessment Criteria

Existing Sensitive Land Use	Assessment Criteria		Additional Considerations
	Day (7.00 am to 10.00 pm)	**Night (10.00 pm to 7.00 am)**	
5. Open space (passive use)	$L_{Aeq(15hour)}$ 55 dBA (external) when in use	-	Passive recreation is characterised by contemplative activities that generate little noise and where benefits are compromised by external noise intrusion, e.g. playing chess, reading.

Relative Increase Criteria

In addition to the noise criteria in **Table 5** and **Table 6**, the RNP describes "Relative Increase Criteria" of 12 dB above existing traffic noise during both the daytime and night-time periods ($L_{Aeq(15hour)}$ and $L_{Aeq(9hour)}$). These criteria are primarily intended to protect existing quiet areas from excessive changes in amenity. Residences experiencing increases in total traffic noise level above the relative increase criteria should also be considered for noise mitigation. Where the existing $L_{Aeq(period)}$ road traffic noise levels are found to be less than 30 dBA, they are deemed to be 30 dBA.

4.2 Construction Noise Goals

4.2.1 Construction Noise Metrics

The noise metrics used to describe construction noise emissions in assessments are:

$L_{A1(1minute)}$ The "typical maximum noise level" for an event, used in the assessment of potential sleep disturbance during night-time periods. Alternatively, the assessment may be conducted using the L_{Amax} or maximum noise level.

$L_{Aeq(15minute)}$ The "energy average noise level" evaluated over a 15-minute period. This parameter is used to assess the potential construction noise impacts.

L_{A90} The "background noise level" in the absence of construction activities. This parameter represents the average minimum noise level during the daytime, evening and night-time periods respectively. The $L_{Aeq(15\ minute)}$ construction noise management levels are based on the L_{A90} background noise levels.

The subscript "A" indicates that the noise levels are filtered to match normal human hearing characteristics (i.e. A-weighted).

4.2.2 Noise Management Levels

Residential Receivers

The applicable construction noise goals (Noise Management Levels - NMLs) for this proposal are described in the *Interim Construction Noise Guideline* (ICNG - DECC 2009).

For construction work during standard hours, a Noise Management Level ($L_{Aeq(15minute)}$) of RBL + 10 dB applies for residential receivers. Construction work outside of the recommended standard hours should not be undertaken without strong justification. Where construction work outside standard hours is required, a Noise Management Level ($L_{Aeq(15minute)}$) of RBL + 5 dB applies for residential receivers.

These NMLs aim to represent the level above which there may be some community reaction to construction noise. Where the predicted levels exceed the noise management level, all feasible and reasonable work practices should be applied to minimise the potential noise impacts. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details for the project team.

Where $L_{Aeq(15minute)}$ construction noise levels are predicted to exceed 75 dBA (highly noise affected), the relevant authority (consent, determining or regulatory) may require respite periods to be observed. This may include restricting the hours that the very noisy activities can occur, taking into account:

- Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences).
- If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.

In order to minimise the potential noise impacts upon nearby sensitive receivers, construction works are proposed to be undertaken during standard daytime periods (7.00 am to 6.00 pm Monday to Friday and 8.00 am to 1.00 pm on Saturdays). As such, night-time noise impacts are not included in this assessment.

Commercial Receivers

The ICNG explains that due to the broad range of sensitivities that commercial or industrial land can have to noise from construction, the process of defining management levels is separated into three categories:

- Industrial premises: external $L_{Aeq(15minute)}$ 75 dBA
- Offices, retail outlets: external $L_{Aeq(15minute)}$ 70 dBA
- Other businesses that may be very sensitive to noise, where the noise level is project specific as discussed below.

The external noise levels should be assessed at the most-affected occupied point of the premises.

Other Sensitive Land Uses

The ICNG's quantitative assessment method provides NMLs for other sensitive land uses, such as educational institutes, hospital, medical facilities, etc. These land uses are considered potentially sensitive to construction noise only when the properties are in use.

The ICNG NMLs for the other sensitive receivers identified in the project area are reproduced in **Table 7**

Table 7 ICNG Noise Management Levels – Other Sensitive Land Uses

Receiver		Land Use	Management Level $L_{Aeq(15min)}$ (dBA) (applies when property is in use)
NCA5_PAS	Lawrence Memorial Park	Passive recreation area	60

Note 1: Passive Recreational Reserve assumed to be in use during the daytime period.

The ICNG does not provide an NML for all classifications of sensitive land use. Where sensitive land uses with no ICNG classification are identified within a construction noise catchment, the following guidance is given:

> *The proponent should undertake a special investigation to determine suitable noise levels on a project-by-project basis; the recommended 'maximum' internal noise levels in AS 2107 Acoustics – Recommended design sound levels and reverberation times for building interiors may assist in determining relevant noise levels (Standards Australia 2000).*

As such, the recommended 'maximum' internal noise levels from AS 2107 for other sensitive land uses surrounding the proposed works with no ICNG classification are reproduced in **Table 8**.

Table 8 AS 2107 Recommended Maximum Internal Noise Levels

Receiver		Description	Time Period	AS 2107	
				Classification	Recommended "Maximum" Internal LAeq (dBA)
NCA4_SPC	Lawrence Public Hall	Public Space	Daytime & evening	Municipal Buildings- *Public spaces*	50

Note 1: Design noise levels specified in AS 2107 internal noise levels.

Where *internal* Noise Management Levels are presented for the facility shown in **Table 8**, the corresponding *external* noise level (which the assessments are based upon) has been determined on the basis of a 10 dB noise reduction from outside to inside for open windows. Typically, significantly greater noise reduction would be expected for a purpose-build structure of this nature, hence the assumed 10 dB noise reduction (windows open) is considered conservative, particularly when the windows are closed.

4.3 Construction Vibration Goals

The effects of vibration in buildings can be divided into three main categories – those in which the occupants or users of the building are inconvenienced or possibly disturbed, those where the building contents may be affected and those in which the integrity of the building or the structure itself may be prejudiced.

4.3.1 Human Comfort Vibration

The EPA's *Assessing Vibration: a technical guideline* provides guideline values for continuous, transient and intermittent events that are based on a Vibration Dose Value (VDV) rather than a continuous vibration level. The VDV is dependent upon the level and duration of the short-term vibration event, as well as the number of events occurring during the daytime or night-time period.

The VDVs recommended in the document for vibration of an intermittent nature (i.e. construction works where more than three distinct vibration events occur) are presented in **Table 9**.

Table 9 Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$) (*Assessing Vibration: a technical guideline)*

Location	Daytime[1]		Night-time[1]	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas[2]	0.10	0.20	0.10	0.20
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 Daytime is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.
2 Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous or impulsive criteria for critical areas.
Source: BS 6472–1992

4.3.2 Effects on Building Contents

People can perceive floor vibration at levels well below those likely to cause damage to building contents or affect the operation of typical equipment. For most receivers, the controlling vibration criterion will be the human comfort criterion, and it is therefore not normally required to set separate criteria in relation to the effect of construction vibration on most building contents.

Where appropriate, objectives for the satisfactory operation of critical instruments or manufacturing processes should be sourced from manufacturer's data and/or other published objectives

4.3.3 Structural Damage Vibration

Structural damage vibration limits are based on Australian Standard AS 2187: Part 2-2006 *Explosives - Storage and Use - Part 2: Use of Explosives* and British Standard BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2*. These standards provide frequency-dependent vibration limits related to cosmetic damage, noting that cosmetic damage is very minor in nature, is readily repairable and does not affect the structural integrity of the building. The recommended vibration limits from BS 7385 for transient vibration for minimal risk of cosmetic damage to residential and industrial buildings are shown in **Table 10**. These levels are judged to give a minimum risk of vibration-induced damage, where minimal risk is usually taken as a 95% probability of no effect.

Table 10 Transient Vibration Guide Values for Minimal Risk of Cosmetic Damage (BS7385)

Line	Type of Building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s at 4 Hz and above	
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Further to the above guide values, BS 7385 advises that:

> *'A building of historical value should not (unless it's structurally unsound) be assumed to be more sensitive.'*

The German Standard DIN 4150-3 *Effects of Vibration on Structures* identifies more stringent vibration levels for building damage than BS 7385 (effectively, no risk of damage), and includes a category specifically for heritage buildings. The DIN 4150-3 recommendations for frequency dependent values for peak particle velocity for heritage buildings are shown in **Table 11**.

Table 11 Guide Values for Heritage Buildings (DIN 4150-3)

Type of Building	Foundation peak particle velocity in frequency range			Vibration at the horizontal plane of highest floor (all frequencies)
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz	
Heritage buildings	3 mm/s	3 mm/s at 10 Hz increasing to 8 mm/s at 50 Hz	8 mm/s at 50 Hz increasing to 10 mm/s at 100 Hz	8 mm/s

4.3.4 Ground-Borne (Regenerated) Noise

Ground-borne (or regenerated) construction noise can be present on construction projects where vibration from activities such as rockbreaking, road heading, rotary cutting and rock drilling/sawing can be transmitted through the ground and into the habitable areas of nearby buildings. Ground-borne noise occurs when this vibration in the ground and/or building elements is regenerated as audible noise within areas of occupancy inside the building.

The NSW EPA's ICNG defines internal ground-borne noise goals for residential receivers of 40 dBA $L_{Aeq(15minute)}$ during the evening (6:00 pm to 10:00 pm) and 35 dBA $L_{Aeq(15minute)}$ during the night-time (10:00 pm to 7:00 am). The goals are only applicable when ground-borne noise levels are higher than airborne noise levels.

5 OPERATIONAL NOISE ASSESSMENT

5.1 Assessment Methodology

A three-dimensional noise model of the proposal area was prepared using SoundPLAN V7.1 software, implementing the UK Department of Transport *Calculation of Road Traffic Noise* (CoRTN) algorithms. The CoRTN algorithm variables include traffic volume and mix, type of road surface, vehicle speed. The 'build' and 'no build' scenarios have been assessed using the road features presented in **Section 5.3**.

The assessment undertaken focuses on establishing existing road traffic noise levels and discusses the potential for changes to the characteristics of the noise which may result from the proposal.

5.2 Noise Model Validation

The predicted operational noise levels for the existing scenario have been compared to the noise levels measured during the ambient noise survey, discussed in **Section 3**, for the purpose of model validation. This is shown in **Table 12**.

Table 12 Model Validation – Comparison of Predicted Noise Levels to Measured Noise Levels

Noise Logging Location	Noise Logging Address	Noise Level (dBA)					
		Measured Existing		Predicted Existing		Comparison – Predicted Minus Measured	
		Daytime LAeq(15hour)	Night-time LAeq(9hour)	Daytime LAeq(15hour)	Night-time LAeq(9hour)	Daytime LAeq(15hour)	Night-time LAeq(9hour)
NM2	10 Bridge St	55	48	55	48	0	0

The predicted noise levels for the existing scenario were consistent with the measured noise levels during the daytime and night-time at the model validation location NM2 with the predicted levels being well within the prediction tolerance of +/- 2 dB of the measured levels.

Noise monitoring locations NM1 and NM3 were not chosen for road traffic noise model validation as the existing ambient noise at these locations was observed to be dominated by the natural environment and not road traffic noise.

The ENMM notes that "*it should be recognised that noise prediction modelling has some accuracy limitations and will commonly produce acceptable errors of around 2 dBA*". On the basis of the comparison of the noise model predictions with the baseline measurement results, it is concluded that the noise model provides results which enable a reliable assessment of the project.

5.3 Road Features and Upgrade Details

The existing road features (including road speeds and traffic volumes) are outlined in **Table 13**. The at-opening and future 10 years after project opening road features, used for the assessment of operational noise, are provided in **Table 14** and **Table 15**, respectively.

Future traffic volumes in the design year have been calculated assuming a natural growth rate of 1.7% per annum.

Table 13 Existing Road Features

Road Name	Current Posted Speed	Observed Speeds	Traffic Numbers[1]		Percentage Heavy Vehicles[1]		Driving Lanes
			Day	Night	Day	Night	
Bridge Street (NB)	50	47	600	39	6%	11%	1
Bridge Street (SB)	50	48	621	48	7%	9%	1

Table 14 Proposed Road Features – At Opening

Road Name	Posted Speed	Modelled Speed	Traffic Numbers		Percentage Heavy Vehicles		Driving Lanes
			Day	Night	Day	Night	
Grafton Street (NB)[1]	50	50	600	39	6%	11%	1
Grafton Street (SB) [1]	50	50	621	48	7%	9%	1

Note 1: Future traffic data for Grafton Street includes alignment traffic from new bridge.

Table 15 Proposed Road Features – Design Year (10 Years After Opening)

Road Name	Posted Speed	Modelled Speed	Traffic Numbers[1]		Percentage Heavy Vehicles		Driving Lanes
			Day	Night	Day	Night	
Grafton Street (NB)	50	50	710	46	6%	11%	1
Grafton Street (SB)	50	50	735	57	7%	9%	1

Note 1: - The traffic volumes in the design year have been calculated assuming a natural growth at a rate of 1.7% per - annum from the time of proposal opening. -

Traffic volumes and mix are not anticipated to change as a result of the proposal. The 'build' and 'no build' traffic scenarios required by the RNP are therefore consistent.

5.4 Predicted Operational Noise Levels

The predicted operational noise levels for the at-opening ‘no build’ and ‘build’ scenarios, as well as the change in noise levels, are shown in **Table 16**.

The predicted operational noise levels for the design year (10 years after project opening) ‘no build’ and ‘build’ scenarios, as well as the change in noise levels are shown in **Table 17**.

Operational noise contours have been calculated for at-opening ‘no build’ and ‘build’, as well as design year ‘no build’ and ‘build’ scenarios and are presented in **Appendix C**.

Noise predictions have been undertaken at *every* facade of every potentially affected sensitive receiver, given the proposed alignment will direct traffic along Grafton Street instead of Bridge Street and thereby change the likely most affected facade of certain individual houses from the front to the rear of the property,

As such, the at-opening and design year assessment tables present the change in noise level from the project as both minimum and maximum values. The minimum values typically represent facades which face Bridge Street and would therefore be subject to a notable noise reduction from the project when traffic is switched to Grafton Street. Conversely, maximum values typically represent facades facing Grafton Street which have no or little existing traffic noise exposure.

As per Appendix B2 of the RNP, the following numerical rounding methods have been applied:

- Noise levels are rounded to the nearest integer.
- Differences between two noise levels are rounded to a single decimal place.
- Symmetric arithmetic rounding has been used.

The above rounding methods have only been applied to the final result of a calculation.

Table 16 At-Opening Predicted Operational Noise Levels

Receiver Address	Predicted Noise Levels (dBA)				Change in Noise Levels (dB)				RNP Criteria (dBA)		At-Opening 'Build' Scenario Level Above RNP Criteria (dB)	
	At-Opening – 'No Build' Scenario		At-Opening – 'Build' Scenario									
	Daytime LAeq(15hr)	Night-time LAeq(9hr)	Daytime LAeq(15hr)	Night-time LAeq(9hr)	Daytime LAeq(15hr)		Night-time LAeq(9hr)		Daytime LAeq(15hr)	Night-time LAeq(9hr)	Daytime LAeq(15hr)	Night-time LAeq(9hr)
					Min	Max	Min	Max				
16-22 Grafton St	45	37	46	38	-1.0	1.7	-0.4	1.7	55	50	-	-
14 Grafton St	46	39	49	41	-0.8	2.5	-0.3	2.6	55	50	-	-
12 Grafton St	48	40	50	43	-0.6	2.3	-0.1	2.5	55	50	-	-
10 Grafton St	44	36	45	38	-4.1	1.7	-2.7	1.7	55	50	-	-
15 Richmond St	54	46	**56**	49	-0.3	1.9	-0.2	2.4	55	50	1	-
3 Grafton St	49	42	54	47	0.4	4.9	0.5	5.3	55	50	-	-
19 Grafton St	50	42	**57**	49	2.2	7.1	2.3	7.4	55	50	2	-
31b Bridge St	41	33	55	47	-5.7	**14.4**	-3.2	**14.4**	55	50	-	-
31a Bridge St	42	34	49	41	-9.1	6.7	-4.4	6.9	55	50	-	-
29 Bridge St	41	34	48	40	-9.1	6.8	-4.3	6.9	55	50	-	-
25-27 Bridge St	41	34	49	41	-9.0	7.2	-4.2	7.3	55	50	-	-
21-23 Bridge St	41	33	49	41	-9.0	7.7	-4.2	7.9	55	50	-	-
4 Grafton St	38	30	51	43	-9.3	**12.9**	-5.7	**12.9**	55	50	-	-
11 Bridge St	42	34	48	41	-12.0	6.4	-7.5	6.5	55	50	-	-
10 Bridge St	40	32	34	28	-9.5	-5.6	-5.5	-4.0	55	50	-	-
8 Bridge St	41	33	34	28	-12.8	-6.4	-9.5	-5.1	55	50	-	-
6 Bridge St	41	34	34	27	-15.9	-7.2	-14.0	-6.6	55	50	-	-
4 Bridge St	41	33	34	26	-16.1	-7.4	-15.7	-7.1	55	50	-	-
9 Bridge St	42	34	48	41	-17.1	6.3	-13.0	6.3	55	50	-	-
7 Bridge St	42	34	49	41	-21.9	6.4	-21.4	6.4	55	50	-	-
1-3 Bridge St	41	33	49	41	-25.7	7.9	-24.3	8.0	55	50	-	-

Receiver Address	Predicted Noise Levels (dBA)				Change in Noise Levels (dB)				RNP Criteria (dBA)		At-Opening 'Build' Scenario Level Above RNP Criteria (dB)	
	At-Opening – 'No Build' Scenario		At-Opening – 'Build' Scenario									
	Daytime LAeq(15hr)	Night-time LAeq(9hr)	Daytime LAeq(15hr)	Night-time LAeq(9hr)	Daytime LAeq(15hr)		Night-time LAeq(9hr)		Daytime LAeq(15hr)	Night-time LAeq(9hr)	Daytime LAeq(15hr)	Night-time LAeq(9hr)
					Min	Max	Min	Max				
2 Bridge St	43	35	34	26	-15.3	-9.5	-15.0	-9.3	55	50	-	-
16 Bridge St	45	37	41	35	-8.7	-4.6	-4.7	-2.7	55	50	-	-
Flo Clark Park	47	39	48	40	-11.2	0.6	-11.2	0.6	55	-	-	-
Memorial Park	47	39	52	45	-4.8	5.6	-3.0	6.0	55	-	-	-
Sportsmans Park	46	38	37	30	-14.8	-8.6	-14.8	-8.4	55	-	-	-

NOTE: Results in **BOLD** indicate an exceedance of the operational noise criteria

Table 17 Design Year Predicted Operational Noise Levels

Receiver Address	Predicted Noise Levels (dBA)				Change in Noise Levels (dB)				RNP Criteria (dBA)		Design Year 'Build' Scenario Level Above RNP Criteria (dB)	
	Design Year – 'No Build' Scenario		Design Year – 'Build' Scenario		Daytime LAeq(15hr)		Night-time LAeq(9hr)					
	Daytime LAeq(15hr)	Night-time LAeq(9hr)	Daytime LAeq(15hr)	Night-time LAeq(9hr)	Min	Max	Min	Max	Daytime LAeq(15hr)	Night-time LAeq(9hr)	Daytime LAeq(15hr)	Night-time LAeq(9hr)
16-22 Grafton St	45	38	47	39	-1.0	1.7	-0.6	1.8	55	50	-	-
14 Grafton St	47	39	50	42	-0.8	2.5	-0.4	2.6	55	50	-	-
12 Grafton St	49	41	51	44	-0.7	2.4	-0.2	2.5	55	50	-	-
10 Grafton St	44	37	46	38	-4.2	1.6	-3.1	1.6	55	50	-	-
15 Richmond St	55	47	**57**	49	-0.3	1.9	-0.3	2.3	55	50	2	-
3 Grafton St	52	45	**56**	49	0.4	4.0	0.5	4.4	55	50	1	-
19 Grafton St	50	43	**57**	50	2.1	7.2	2.2	7.5	55	50	2	-
31b Bridge St	42	34	**56**	48	-6.0	**14.3**	-3.8	**14.4**	55	50	1	-
31a Bridge St	43	35	49	42	-10.1	6.7	-5.4	6.9	55	50	-	-
29 Bridge St	42	34	49	41	-10.1	6.7	-5.3	6.9	55	50	-	-
25-27 Bridge St	42	35	49	42	-9.9	7.2	-5.2	7.2	55	50	-	-
21-23 Bridge St	42	34	49	42	-9.8	7.7	-5.2	7.8	55	50	-	-
4 Grafton St	38	31	51	44	-9.8	**13.0**	-6.5	**12.9**	55	50	-	-
11 Bridge St	43	35	49	42	-12.8	6.4	-8.4	6.5	55	50	-	-
10 Bridge St	40	33	35	28	-10.5	-5.7	-6.4	-4.3	55	50	-	-
8 Bridge St	42	34	35	28	-13.6	-6.7	-10.5	-5.5	55	50	-	-
6 Bridge St	42	35	35	28	-16.6	-7.4	-14.8	-6.9	55	50	-	-
4 Bridge St	42	34	34	27	-16.6	-7.6	-16.1	-7.2	55	50	-	-
9 Bridge St	43	35	49	41	-17.9	6.2	-14.0	6.4	55	50	-	-
7 Bridge St	43	35	49	42	-22.3	6.3	-21.7	6.4	55	50	-	-
1-3 Bridge St	41	34	49	42	-26.0	7.8	-24.9	7.9	55	50	-	-

Receiver Address	Predicted Noise Levels (dBA)				Change in Noise Levels (dB)				RNP Criteria (dBA)		Design Year 'Build' Scenario Level Above RNP Criteria (dB)	
	Design Year – 'No Build' Scenario		Design Year – 'Build' Scenario									
	Daytime LAeq(15hr)	Night-time LAeq(9hr)	Daytime LAeq(15hr)	Night-time LAeq(9hr)	Daytime LAeq(15hr)		Night-time LAeq(9hr)		Daytime LAeq(15hr)	Night-time LAeq(9hr)	Daytime LAeq(15hr)	Night-time LAeq(9hr)
					Min	Max	Min	Max				
2 Bridge St	44	36	34	27	-15.8	-9.6	-15.5	-9.4	55	50	-	-
16 Bridge St	46	38	41	35	-9.6	-4.9	-5.5	-3.1	55	50	-	-
Flo Clark Park	48	40	49	41	-11.2	0.6	-11.3	0.6	55	-	-	-
Memorial Park	48	40	53	46	-5.1	5.7	-3.6	5.9	55	-	-	-
Sportsmans Park	47	39	38	30	-14.9	-8.6	-14.9	-8.5	55	-	-	-

NOTE: Results in **BOLD** indicate an exceedance of the operational noise criteria

The change in sensitive receiver noise levels due to the proposal depends on the location of the specific facade in question and its orientation to the existing and future source of road traffic noise. Facades facing Bridge Street will typically be subject to a noise reduction, whereas facade facing Grafton Street will generally see an increase.

The proposal does not change or alter the mix of traffic along the route, therefore the predicted change in noise levels is solely due to the redirection of traffic from Bridge Street to Grafton Street.

The predicted noise levels in **Table 16** show that the change in noise levels between the at-opening 'build' and 'no build' scenarios range from -25.7 dB to +14.4 dB for the daytime and -24.3 dB to +14.4 dB for the night-time. For two receivers this increase is greater than +12 dB, therefore the project exceeds the RNP relative increase criteria at project opening at these receivers (see **Section 4.1.2**).

Predicted noise levels for the at-opening 'build' scenario exceed the RNP $L_{Aeq(15hour)}$ daytime criteria by up to 2 dB. Exceedances are predicted at two receivers for the daytime period.

The predicted noise levels in **Table 17** show that the change in noise levels between the design year 'build' and 'no build' scenarios range from -26.0 dB to +14.3 dB for the daytime and -24.9 dB to +14.4 dB for the night-time. This increase is greater than +12 dB for two receivers, therefore the project also exceeds the RNP relative increase criteria in the design year at these receivers.

Predicted noise levels for the design year 'build' scenario exceed the RNP $L_{Aeq(15hour)}$ daytime criteria by up to 2 dB. Exceedances are predicted at four receivers for the daytime period.

A total of five receivers exceed either the relative increase or the $L_{Aeq(15hour)}$ daytime noise criteria. Where exceedances of the noise criteria are identified, the RNP requires that all feasible and reasonable noise mitigation measures should be considered.

Predicted facade noise levels for the design year 'build' scenario, and exceedances of the RNP $L_{Aeq(15hour)}$ and relative increase criteria are shown in **Appendix D**.

5.5 Maximum Noise Levels

In accordance with the Roads and Maritime Procedure *Preparing an Operational Noise and Vibration Assessment* (July 2011), a maximum noise level assessment has been conducted. This includes an evaluation of the number and distribution of night-time passby events where the L_{AFmax} - $L_{Aeq(1hour)}$ difference is greater than 15 dB and the maximum noise level of that event is greater than 65 dBA.

The maximum noise level assessment has been conducted on the results of the noise logging conducted at location NM2 as this location is the closest of the monitoring locations to the existing alignment, and is therefore less likely to be influenced by extraneous noise sources.

The distance from noise monitoring location NM2 to the existing alignment is less than the closest receiver facade to the future alignment. As such, results of the maximum noise level assessment can be considered conservative. For reference the distance of the monitoring position to the existing alignment was approximately 8 m, whereas the closest receiver to the future alignment is approximately 20 m away.

It is noted that the RNP and ENMM stipulates the maximum noise assessment should be used as a tool to help prioritise and rank mitigation strategies, but should not be applied as a decisive criterion in itself.

Results of the assessment are provided in **Table 18** and include the maximum noise level range for the passby events.

Table 18 Maximum Noise Level Events – Noise Logger NM2

Date	Number of Maximum Noise Events per Hour / LAFmax Noise Levels (dBA)									
	00:00-01:00	01:00-02:00	02:00-03:00	03:00-04:00	04:00-05:00	05:00-06:00	06:00-07:00	22:00-23:00	23:00-00:00	Total/ (Range)
9-Dec-13	n/a [1]	n/a [1]	n/a [1]	n/a [1]	n/a [1]	n/a [1]	n/a [1]	7 / 72-75	4 / 69-71	11 / 69-75
10-Dec-13	3 / 70-72	5 / 66-77	1 / 70	2 / 72-73	7 / 70-77	6 / 77-81	2 / 76-79	7 / 67-75	4 / 66-74	37 / 66-81
11-Dec-13	3 / 92-102	5 / 69-72	2 / 72-78	4 / 71-81	7 / 71-78	6 / 72-74	2 / 77-83	3 / 72-75	5 / 72-74	37 / 69-102
12-Dec-13	3 / 70-71	2 / 69-71	3 / 70-75	- / -	6 / 71-75	6 / 72-74	4 / 77-79	8 / 69-75	2 / 68-70	34 / 68-79
13-Dec-13	2 / 70-71	3 / 68-70	- / -	1 / 70	6 / 72-78	5 / 73-76	5 / 78-84	5 / 70-76	8 / 70-75	35 / 68-84
14-Dec-13	9 / 67-73	2 / 68-69	5 / 68-76	4 / 70-74	4 / 66-73	5 / 72-77	4 / 74-82	10 / 67-71	10 / 67-72	53 / 66-82
15-Dec-13	7 / 68-75	1 / 72	- / -	2 / 66-74	4 / 67-74	2 / 84-91	6 / 71-74	6 / 68-77	1 / 69	29 / 66-91
16-Dec-13	3 / 70-74	1 / 70	- / -	1 / 78	7 / 70-76	4 / 73-80	5 / 76-80	8 / 68-74	2 / 68-73	31 / 68-80

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

From the results presented in **Table 18**, Approximately 37 maximum noise level events may be expected (on average) during the night-time period, with typical external LAmax noise levels of 79 dBA to 91 dBA, and a small number of events up to 102 dBA.

The noise levels reported in **Table 18** were recorded at noise logging location NM2, giving a worst-case assessment of maximum noise level events as this is the closest receiver in the proposal area. Maximum noise level events at other sensitive receivers in the proposal area would be expected to be lower than those presented above.

With regard to reaction to potential sleep disturbance events, the RNP gives the following guidance:

From the research on sleep disturbance to date it can be concluded that:

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

It is generally accepted that internal noise levels in a dwelling, with the windows open are 10 dB lower than external noise levels. Based on a worst case minimum attenuation of 10 dB, with windows open, the first conclusion above suggests that short term external noises of 60 dBA to 65 dBA are unlikely to cause awakening reactions.

The second conclusion suggests that one or two noise events per night with maximum external noise levels of 75 dBA to 80 dBA are not likely to affect health and wellbeing significantly.

It is predicted that maximum noise level events at sensitive receivers in the proposal area are likely to exceed the guideline levels. Therefore, maximum noise level impacts should be considered when prioritising and ranking mitigation strategies (**Section 5.8**).

It is noted that the increased traffic volumes due to natural growth in the design year would be likely to increase the frequency of maximum noise level events. However, it is noted that as the proposal is not increasing traffic volumes, the likely increase in the frequency of maximum noise level events occurs in both the ‘build’ and ‘no build’ scenarios.

It should also be noted that strategies are currently being implemented to reduce road traffic noise across the state’s road network which may reduce the number of maximum noise levels events. These include local council requirements to include noise mitigation in new dwellings, metropolitan plans to increase the use of public transport, State-wide plans for upgrades of major transport routes, and national initiatives to reduce heavy vehicle engine brake noise and road freight haulage.

The *NSW Freight Strategy* being developed by Transport for NSW is expected to result in reduced noise from heavy vehicle freight on roads in many areas and a corresponding reduction in high noise level events from road traffic.

5.6 Seasonal Variation in Heavy Vehicle Traffic

It is understood that during peak periods of local agricultural harvest, increased levels of heavy road vehicles are expected to use the project alignment. Such peaks in heavy vehicle traffic are likely to increase the road traffic noise at nearby sensitive receivers.

5.7 Dominant Traffic Noise Source Relocation

The existing dominant road traffic noise source is located directly in front of receivers fronting Bridge Street. The project alignment will relocate the dominant traffic noise source to the rear of residential receivers on the western side Bridge Street, and will therefore change the most noise affected building facade for these receivers.

This affect may be noticeable in noise sensitive habitable spaces such as bedrooms, which are likely to be located towards the rear of the dwelling and would have been shielded from the previous alignment.

The change in noise source location and relative change in facade exposure has been accounted for in the results presented in **Section 5.4** where all building facades have been assessed individually.

5.8 Assessment of Reasonable and Feasible Mitigation Measures

5.8.1 Procedure Overview

Where exceedances of the noise criteria are identified, the RNP describes noise mitigation measures to be considered in order of priority:

1. Road design and traffic management
2. Quieter pavement surfaces
3. In-corridor noise barriers/mounds
4. At-property treatments or localised barriers/mounds

The priority of mitigation measures recognises that noise control at the source is preferable over noise path control and noise mitigation at the receiver.

The RNP notes that it is not mandatory to achieve the noise assessment criteria, and that noise mitigation measures should be both feasible and reasonable. Selecting reasonable measures from those that are feasible involves judging whether the overall noise benefits outweigh the overall adverse social, economic and environmental effects, including the cost of the abatement measure. To make such a judgement, consideration may be given to noise impacts, noise mitigation benefits, the cost effectiveness of noise mitigation and community views.

5.8.2 Reasonable and Feasible Definition

Where the noise goals in the design year ‘build’ scenario are found to be exceeded as a result of a project, the RNP and the ENMM require the project to adopt all feasible and reasonable mitigation measures to meet the targets.

Practice Note IV of the ENMM defines what feasible and reasonable factors may be considered when investigating noise mitigation measures.

"**Feasibility**" relates to engineering considerations (what can be practically built) and may include:

- The inherent limitations of different techniques to reduce noise emissions from road traffic noise sources
- Safety issues, such as restrictions on road vision
- Road corridor site constraints such as space limitations
- Floodway and stormwater flow obstruction
- Access requirements
- Maintenance requirements

"**Reasonableness**" relates to the application of wider judgements. The factors to be considered are:

- The noise reduction provided and the number of people protected
- The cost of mitigation, including the total cost and cost variations with different benefits provided
- Community views and wishes
- Visual impacts
- Existing and future noise levels, including changes in noise levels
- The benefits arising from the proposed road or road development

5.8.3 Road Design

An options assessment has previously been undertaken for the project which considered several possible bridge/route options as is contained within Roads and Maritime report *"Sportsmans Creek new bridge, Recommended Option Report"*, dated November 2013.

The proposed road design as assessed in this report is the preferred route option which was selected with consideration of project cost, heritage conservation, constructability, and environmental and property impacts. As such, modification to the proposed road design is not considered a reasonable mitigation option.

5.8.4 Pavement Surface

Specification of a low noise pavement surface on the proposed highway in the vicinity of the receivers where exceedances are predicted has the potential to reduce noise impacts by up to around 2 dB, if a low noise pavement such as Open Grade Asphalt or Stone Mastic Asphalt were to be used in place of Dense Grade Asphalt.

This mitigation option also has the benefit of reducing noise levels at source and hence mitigating external areas such as gardens and areas of recreation, as well internal noise levels of sensitive receivers.

Low noise pavement surfaces are however typically more costly to maintain than regular pavement surfaces. Low noise pavements would also not reduce engine and exhaust noise from heavy vehicles, which are often the greatest contributors to sleep disturbance.

Low noise pavement surfaces are also most effective when the traffic is travelling at speeds of 60 km/h and faster, when the tyre-road noise is dominant. Because the design speed for the project road is 50 km/h, it is expected the low noise pavement will not achieve the full 2 dB noise benefit and therefore may not be considered to be a cost effective mitigation strategy.

The properties which are predicted to be subject to exceedances of the RNP criteria are however not closely grouped together therefore a low noise pavement surface would need to extend the length of Grafton Street for a length of approximately 400 m and may therefore not be considered to be a cost effective mitigation strategy.

5.8.5 Noise Barriers/Mounds

The ENMM states that noise barriers are not considered cost-effective:

> *"If residences are closely grouped in numbers of three or less, architectural treatments are preferred over roadside barriers, as it is likely that the cost per residence for barriers will be at least twice that for architectural treatments."*

As the receivers where exceedances are predicted are rural residences which are not closely grouped, shown in **Appendix D**, in-corridor noise barriers/mounds are not considered a reasonable option to mitigate noise at these receivers.

The implementation of noise barriers is also not likely to be considered feasible due to potential for flooding in the area and the raised nature of the houses.

5.8.6 Residual Architectural Property Treatments

Treatments to buildings usually involve higher performance windows, doors and seals to reduce noise ingress to internal spaces of houses. Building treatments effectively require occupants to keep their windows and doors closed and hence alternative ventilation is usually required to maintain adequate airflow.

An advantage of the installation of building treatments is that the maximum noise impacts on internal habitable spaces can also be reduced. Building treatments can therefore be helpful at mitigating sleep disturbance impacts in sleeping areas.

An obvious disadvantage is that building treatments would not have any effect on the noise levels outside dwellings in front or back yards.

5.8.7 Summary

Given the large separation distance between the five receivers where exceedances are predicted, the potential feasible and reasonable noise mitigation options are considered to be limited to architectural treatment of individual properties.

The property treatments would likely be in the form of alternative ventilation (where not currently existing), to allow residents to close windows while maintaining adequate ventilation, and upgraded window glazing.

It is noted that mitigation options require further investigation to determine the extent of the mitigation works required to achieve the desired acoustic outcomes. The requirements of the specific residential buildings may benefit from different acoustic treatments which should be considered in consultation with the owners.

6 CONSTRUCTION NOISE ASSESSMENT

6.1 Construction Modelling

To quantify noise levels from the construction activities a noise prediction model was developed using SoundPLAN V7.1 noise propagation software. The concept designs of the proposal, local terrain, receptor buildings and structures have been digitised in the noise model to develop a three dimensional representation of the construction sites and surrounding environment.

6.2 Construction Scenarios

Consistent with the requirements of the ICNG the construction noise impacts are based on a worst-case assessment. The ICNG recommends that the realistic worst-case or conservative noise levels from the source should be predicted for assessment locations representing the most noise-exposed residences or other sensitive land uses

The proposed equipment for the major works scenarios is shown in **Table 19**. The combined Sound Power Level for each works scenario has been calculated as an estimated worse-case scenario assuming the equipment items are operating simultaneously in the same location. Sound Power Level data for individual construction items is provided in **Appendix E**.

Table 19 Construction Works

Ref	Scenario	Works Reference	Timing			Equipment (realistic worst-case)		Sound Power Level (dBA)
			Day	Start time	Finish time			
1	Site Establishment and Installation of Environmental & Traffic Controls	Multiple Plant - realistic worst-case	M-F	7:00 AM	6:00 PM	2	Excavator (20 tonne)	119
			Sat	8:00 AM	1:00 PM	1	Compactor	
			Sun	no work	no work	1	Truck (10 tonne)	
			P/H	no work	no work	1	Grader	
						1	Bobcat	
						1	Excavator (Breaker)*	
2	Site Preparation - Vegetation Removal	Multiple Plant - realistic worst-case	M-F	7:00 AM	6:00 PM	1	Chainsaw	121
			Sat	8:00 AM	1:00 PM	1	Chipper	
			Sun	no work	no work	1	Stump Grinder	
			P/H	no work	no work	1	Truck (10 tonne)	
3	Site Preparation - Demolish Existing Structures	Multiple Plant - realistic worst-case	M-F	7:00 AM	6:00 PM	1	Bobcat	119
			Sat	8:00 AM	1:00 PM	1	Jackhammer*	
			Sun	no work	no work	1	Dozer	
			P/H	no work	no work	1	Excavator (Breaker)*	
						1	Grader	
						1	Truck (10 tonne)	
						1	Concrete Saw*	
						1	Excavator (20 tonne)	

Ref	Scenario	Works Reference	Timing			Equipment (realistic worst-case)		Sound Power Level (dBA)
			Day	Start time	Finish time			
4	Pilling Works	Multiple Plant - realistic worst-case	M-F	7:00 AM	6:00 PM	1	Pilling Rig (Bored)	110
			Sat	8:00 AM	1:00 PM	1	Truck (10 tonne)	
			Sun	no work	no work	1	Mobile Crane (25 tonne)	
			P/H	no work	no work	1	Concrete Pump	
						1	Concrete Truck / Agitator	
						1	Grinder 4"*	
						1	Welding Equipment	
5	Construction of Headstocks at Abutments A & B	Multiple Plant - realistic worst-case, no hammer/compaction /sucker truck	M-F	7:00 AM	6:00 PM	1	Grinder 4"*	108
			Sat	8:00 AM	1:00 PM	1	Welding Equipment	
			Sun	no work	no work	1	Hand Tools	
			P/H	no work	no work	1	Truck (10 tonne)	
						1	Concrete Pump	
						1	Concrete Truck / Agitator	
6	Construction of Abutment A & B	Multiple Plant - realistic worst-case	M-F	7:00 AM	6:00 PM	1	Grinder 4"*	108
			Sat	8:00 AM	1:00 PM	1	Welding Equipment	
			Sun	no work	no work	1	Hand Tools	
			P/H	no work	no work	1	Truck (10 tonne)	
						1	Concrete Pump	
						1	Concrete Truck / Agitator	
7	Construction of Bridge Deck	Multiple Plant - realistic worst-case, no hammer/compaction /sucker truck	M-F	7:00 AM	6:00 PM	1	Grinder 4"*	106
			Sat	8:00 AM	1:00 PM	1	Welding Equipment	
			Sun	no work	no work	1	Hand Tools	
			P/H	no work	no work	1	Truck (10 tonne)	
						1	Mobile Crane (300 tonne)	
8	Installation of Bridge Parapets	Multiple Plant - realistic worst-case	M-F	7:00 AM	6:00 PM	1	Grinder 4"*	108
			Sat	8:00 AM	1:00 PM	1	Welding Equipment	
			Sun	no work	no work	1	Hand Tools	
			P/H	no work	no work	1	Truck (10 tonne)	
						1	Concrete Pump	
						1	Concrete Truck / Agitator	
9	Earthworks on Road Sections	Multiple Plant - realistic worst-case	M-F	7:00 AM	6:00 PM	1	Excavator (20 tonne)	119
			Sat	8:00 AM	1:00 PM	1	Compactor	
			Sun	no work	no work	1	Truck (10 tonne)	
			P/H	no work	no work	1	Grader	
						1	Bobcat	
						1	Excavator (Breaker)*	
						1	Concrete Saw*	
10	Construction of Road Slabs	Multiple Plant - realistic worst-case	M-F	7:00 AM	6:00 PM	1	Grinder 4"*	108
			Sat	8:00 AM	1:00 PM	1	Welding Equipment	
			Sun	no work	no work	1	Hand Tools	
			P/H	no work	no work	1	Truck (10 tonne)	
						1	Concrete Pump	
						1	Concrete Truck / Agitator	

Ref	Scenario	Works Reference	Timing			Equipment (realistic worst-case)		Sound Power Level (dBA)
			Day	Start time	Finish time			
11	Road Pavement Works	Multiple Plant - realistic worst-case	M-F	7:00 AM	6:00 PM	1	Asphalt Milling Machine	103
			Sat	8:00 AM	1:00 PM	1	Line Marking Plant	
			Sun	no work	no work	1	Mobile Crane (25 tonne)	
			P/H	no work	no work	1	Road Sweeper	
12	Demolition of Existing Bridge	Multiple Plant - realistic worst-case	M-F	7:00 AM	6:00 PM	1	Franna Crane	106
			Sat	8:00 AM	1:00 PM	1	Chainsaw	
			Sun	no work	no work	1	Grinder 4"*	
			P/H	no work	no work	1	Welding Equipment	
13	Site Dis-Establishment	Multiple Plant - realistic worst-case	M-F	7:00 AM	6:00 PM	1	Grinder 4"*	111
			Sat	8:00 AM	1:00 PM	1	Welding Equipment	
			Sun	no work	no work	1	Hand Tools	
			P/H	no work	no work	1	Truck (10 tonne)	
						1	Bobcat	
						1	Excavator (20 tonne)	
						1	Grader	
14	Landscaping	Multiple Plant - realistic worst-case	M-F	7:00 AM	6:00 PM	1	Excavator (12 tonne)	118
			Sat	8:00 AM	1:00 PM	1	Bogies	
			Sun	no work	no work	1	Concrete Vibrator	
			P/H	no work	no work	1	Suction Truck	
						1	Excavator (Breaker)*	

Note 1: - * denotes “annoying” item of equipment, as defined in the ICNG, and as such includes a +5 dBA penalty to - predictions. -

In order to minimise the potential noise impacts upon nearby sensitive receivers, construction works are proposed to be undertaken during standard daytime periods (7.00 am to 6.00 pm Monday to Friday and 8.00 am to 1.00 pm on Saturdays). No out-of-hours works are currently proposed to be required as part of the project.

It is also understood that bored pilling equipment will be used in place of impact pilling for all pilling relative construction scenarios to minimise the potential impacts. If impact pilling were to be used, the construction noise impacts at the nearest potentially affected receiver would be up to 15 dB higher than the noise levels predicted for bored pilling.

6.3 Construction Noise Management Levels

The $L_{Aeq(15minute)}$ NMLs have been determined in accordance with the ICNG. The NMLs which are relevant to the Noise Catchment Areas (NCAs) for the proposed works, shown in **Figure 3,** are detailed in **Table 20**.

Figure 3 Project Area and Noise Catchment Areas

Table 20 Noise Management Levels

NCA	Noise Monitoring Location	Receiver Types	RBL (dBA)			NML - LAeq(15minute) (dBA)
			Day[1]	Eve.[2]	Night [3]	Std. Construction (RBL +10dB)
						Day[1]
NCA1_RES	NM1	Residential	33	36	35	43
NCA2_COM	n/a	Commercial	n/a	n/a	n/a	70
NCA3_RES	NM2	Residential	31	32	30	41
NCA4_SPC	n/a	Special Sensitive: Community Hall	n/a	n/a	n/a	60
NCA5_PAS	n/a	Passive Recreation	n/a	n/a	n/a	60
NCA6_RES	NM3	Residential Commercial[4]	32 n/a	32 n/a	29 n/a	70 42

Note 1: Standard daytime construction period: 7 am to 6 pm Monday to Friday and 8 am to 1 pm on Saturday. -
Note 2: Evening period: 6 pm to 10 pm. -
Note 3: Night-time period: 10 pm to 7 am except on a Sunday/Public Holiday when night-time is extended to 8 am. -
Note 4: One commercial receiver in NCA. Commercial receiver assessed against commercial NMLs -

6.4 Assessment of Construction Works

Based on the scenarios and the sound power levels outlined in **Table 19**, construction noise levels have been predicted at the nearest potentially affected sensitive receivers. The worst-case $L_{Aeq(15minute)}$ noise levels are presented in **Table 21** for the various activities along with the relevant Noise Management Levels at the most potentially affected receiver. A complete list of all construction noise modelling results is presented in **Appendix F**.

In practice, noise levels will depend on the number of plant items and equipment operating at any one time and their precise location relative to the receiver of interest. Noise levels will vary due to the movement of plant and equipment about the worksites and the concurrent operation of plant. In some cases, reductions in noise levels will occur when plant is screened from view behind buildings or other items of equipment.

Table 21 Construction Noise Predictions

Works Ref	Scenario	Most Affected Receiver NCA	Address	Type	Worst-case Predicted LAeq(15min) (dBA)	RBL (dBA)			NML (dBA)				NML Exceedance (dB)				Noise Level – LA1(60second) (dBA)		
						Day	Eve	Night	Day	Day OOH	Eve	Night	Day	Day OOH	Eve	Night	Worst-case Predicted (night-time)	Screening. Crit. (RBL+15 dBA)	Exceedance
1	Site Establishment and Installation of Environmental & Traffic Controls	NCA1_RES	4 Grafton	Residential	87	33	36	35	43	38	41	40	44	n/a	n/a	n/a	n/a	50	n/a
2	Site Preparation - Vegetation Removal	NCA1_RES	4 Grafton	Residential	87	33	36	35	43	38	41	40	44	n/a	n/a	n/a	n/a	50	n/a
3	Site Preparation - Demolish Existing Structures	NCA1_RES	4 Grafton	Residential	74	33	36	35	43	38	41	40	31	n/a	n/a	n/a	n/a	50	n/a
4	Piling Works	NCA1_RES	4 Grafton	Residential	62	33	36	35	43	38	41	40	19	n/a	n/a	n/a	n/a	50	n/a
5	Construction of Headstocks at Abutments A & B	NCA3_RES	1-3 Bridge	Residential	66	31	32	30	41	36	37	35	25	n/a	n/a	n/a	n/a	45	n/a
6	Construction of Abutment A & B	NCA3_RES	1-3 Bridge	Residential	66	31	32	30	41	36	37	35	25	n/a	n/a	n/a	n/a	45	n/a
7	Construction of Bridge Deck	NCA3_RES	1-3 Bridge	Residential	63	31	32	30	41	36	37	35	22	n/a	n/a	n/a	n/a	45	n/a
8	Installation of Bridge Parapets	NCA3_RES	1-3 Bridge	Residential	65	31	32	30	41	36	37	35	24	n/a	n/a	n/a	n/a	45	n/a
9	Earthworks on Road Sections	NCA6_RES	19 Grafton	Residential	88	32	32	29	42	37	37	34	46	n/a	n/a	n/a	n/a	44	n/a
10	Construction of Road Slabs	NCA6_RES	19 Grafton	Residential	77	32	32	29	42	37	37	34	35	n/a	n/a	n/a	n/a	44	n/a

Works Ref	Scenario	Most Affected Receiver NCA	Address	Type	Worst-case Predicted LAeq(15min) (dBA)	RBL (dBA)			NML (dBA)				NML Exceedance (dB)				Noise Level – LA1(60second) (dBA)		
						Day	Eve	Night	Day	Day OOH	Eve	Night	Day	Day OOH	Eve	Night	Worst-case Predicted (night-time)	Screening. Crit. (RBL+15 dBA)	Exceedance
11	Road Pavement Works	NCA6_RES	19 Grafton	Residential	72	32	32	29	42	37	37	34	30	n/a	n/a	n/a	n/a	44	n/a
12	Demolition of Existing Bridge	NCA3_RES	2 Bridge	Residential	71	31	32	30	41	36	37	35	30	n/a	n/a	n/a	n/a	45	n/a
13	Site Dis-Establishment	NCA6_RES	19 Grafton	Residential	**80**	32	32	29	42	37	37	34	38	n/a	n/a	n/a	n/a	44	n/a
14	Landscaping	NCA6_RES	19 Grafton	Residential	**87**	32	32	29	42	37	37	34	45	n/a	n/a	n/a	n/a	44	n/a

Note 1: Standard daytime construction hours: 7.00 am to 6.00 pm Monday to Friday, 8.00 am to 1.00 pm on Saturdays and no work on Sundays or Public Holidays.
Note 2: Out-of-hours daytime hours: 7.00 am to 8.00 am and 1.00 pm to 6.00 pm Saturdays, and 8.00 am to 6.00 pm Sundays.
Note 3: Out-of-hours evening hours: 6.00 pm to 10.00 pm.
Note 4: Out-of-hours night-time hours: 10.00 pm to 7.00 am Sunday to Friday, 10.00 pm Saturday to 8.00 am Sunday.
Note 5: Worst-case predicted noise levels greater than 75 dBA (highly noise affected) are indicated in **red bold** text for residential receivers.

6.4.1 Discussion – Standard Construction Hours Work

The construction noise predictions indicate that exceedances of the NMLs are likely during the worse-case scenarios as assessed. It is however noted that the worse-case scenarios assume works are being carried out in the closest work area to each receiver, therefore noise levels are likely to be lower than predicted for significant periods of time when equipment moves away from a particular receiver.

A worst-case exceedance of the daytime (standard construction hours) $L_{Aeq(15minute)}$ noise goal of up to 46 dB is predicted at the most affected sensitive receiver location within the proposal area. This level of exceedance is common for infrastructure type construction activities that are being completed in vicinity of adjacent sensitive receivers.

6.4.2 Highly Noise Affected Receivers

Residential receivers are considered to be highly noise affected if noise levels exceed 75 dBA during standard construction hours. The worst-case predicted levels indicate that there is the potential for this to occur during scenarios 1, 2, 9, 10, 13 and 14 as indicated in **Table 21**.

Receivers considered to be highly noise affected during these construction scenarios include residential receivers in Noise Catchment Areas NCA1_RES and NCA6_RES.

6.5 Mitigation Measures

The ICNG acknowledges that due to the nature of construction activities it is inevitable there would be some noise from construction sites. The NMLs identified in this report have been applied to prescribe measures for the control of potential construction noise impacts at sensitive receptors.

The proponent should apply all feasible and reasonable work practices to meet the NMLs and inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels, duration of noise generating construction works, and the contact details for the proposal.

6.5.1 Recommended Noise Mitigation

The reasonableness of the identified feasible mitigation measures would be considered during the construction planning and site establishment phases of the proposal, and in the development of CNVMPs. Examples of mitigation measures which may be considered appropriate for these works are:

- Use of localised acoustic hoarding and/or earth bunds around significantly noise generating items of plant (eg rock breaker), where practicable. This would be expected to provide between 5 dB and 10 dB of additional noise attenuation provided the line-of-sight between all receivers and the construction equipment is broken. The barrier is most affective when it is located either close to the noise source or the receiver. This option is considered reasonable for noise intensive stationary items of plant and those operating within a relatively confined area such as those undertaken around the area of the bridge works.
- Planning of the higher Noise Management Level exceedance activities/locations to be undertaken predominantly during less noise-sensitive periods, where available and possible. The adjacent residents should be consulted to assist in identifying less noise sensitive periods.
- Briefing of the work team in order to create awareness of the locality of sensitive receivers and the importance of minimising noise emissions.
- Ensuring any spoil is placed and not dropped into awaiting trucks.
- Locate noisy plant away from receivers where possible.
- Turn noisy plant off when not in use.

- Ensure plant is regularly maintained and repair/replace equipment that becomes noisy
- Establishing load points as far as practicable from sensitive receivers.
- Use of silenced or less noise-intensive equipment, where reasonable and feasible.
- Where possible heavy vehicle movements should be limited to daytime hours.
- Reversing of equipment should be minimised so as to prevent nuisance caused by reversing alarms.
- Non-tonal reversing alarms should be fitted to minimise nuisance caused by reversing alarms.
- Proactive community consultation, including notification of all upcoming works to be completed.

In order to minimise the potential noise and vibration impacts upon nearby sensitive receivers, all construction works are proposed to be undertaken during the standard daytime construction periods (7.00 am to 6.00 pm Monday to Friday and 8.00 am to 1.00 pm on Saturdays).

6.5.2 Construction Noise and Vibration Management Plan

Prior to construction, when more specific information is available in relation to the proposed construction works, a site specific Construction Noise and Vibration Management Plan (CNVMP) would be prepared. This would address each major stage of the construction works and identify the appropriate mitigation and management measures, consistent with the requirements of the ICNG.

The objectives of the CNVMP are as follows:

- Minimising exceedances of the noise Management Levels and goals nominated in **Section 4.2.2**.
- Determine noise and vibration monitoring, reporting and response procedures.
- Describe specific mitigation treatments, management methods and procedures to be implemented to control noise and vibration during construction.
- Describe construction timetabling to minimise noise impacts including time and duration restrictions, respite periods and frequency.
- Describe procedures for notifying residents of construction activities likely to affect their amenity through noise and vibration.
- Define contingency plans to be implemented in the event of non-compliances and/or noise complaints.

7 CONSTRUCTION VIBRATION ASSESSMENT

7.1 Vibration Intensive Equipment

The major potential sources of vibration from the proposed construction equipment are during rock breaking (Scenarios 1, 3, 9 and 14) or during the use of a vibratory roller (Scenario 3). Lesser impacts may be apparent during the use of bored piling, jackhammers, and compactors.

All other proposed activities either contain plant items that are not significantly vibration intensive.

It is understood that the use of bored pilling equipment shall be implemented in place of impact pilling for all construction scenarios including pilling works unless bored piling is not considered to be feasible.

7.2 Safe Working Distances

As a guide, safe working distances for typical items of vibration intensive plant are listed in **Table 22**. The safe working distances are quoted for both “cosmetic” damage and human comfort. The safe working distances must be complied with at all times, unless otherwise approved by the relevant authority.

Table 22 Recommended Safe Working Distances for Vibration Intensive Plant

Plant Item	Rating/Description	Safe Working Distance	
		Cosmetic Damage	**Human Response**
Vibratory Roller	< 50 kN (Typically 1-2 tonnes)	5 m	15 m to 20 m
	< 100 kN (Typically 2-4 tonnes)	6 m	20 m
	< 200 kN (Typically 4-6 tonnes)	12 m	40 m
	< 300 kN (Typically 7-13 tonnes)	15 m	100 m
	> 300 kN (Typically 13-18 tonnes)	20 m	100 m
	> 300 kN (> 18 tonnes)	25 m	100 m
Small Hydraulic Hammer	(300 kg - 5 to 12t excavator)	2 m	7 m
Medium Hydraulic Hammer	(900 kg – 12 to 18t excavator)	7 m	23 m
Large Hydraulic Hammer	(1600 kg – 18 to 34t excavator)	22 m	73 m
Vibratory Pile Driver	Sheet piles	2 m to 20 m	20 m
Pile Boring	≤ 800 mm	2 m (nominal)	N/A
Jackhammer	-Hand held	1 m (nominal)	Avoid contact with structure
Impact Pilling*	< 10,000 kg/m	15 m	70 m

Note: More stringent conditions may apply to heritage or other sensitive structures. -
Note*: Data sourced from published measurement results. -

The safe working distances presented in **Table 22** are indicative only and will vary depending on the particular item of plant and local geotechnical conditions. They apply to typical buildings under typical geotechnical conditions. Building condition surveys should be completed both before and after the works for all potentially affected properties to ensure no damage occurs as a result of the proposal.

During rock breaking activities, receivers would be within the safe working distances for human response. This includes residential receivers located on Grafton Street, South of Richmond Street.

If impact pilling activities are required, nearby receivers would be within the safe working distances for human response. This includes residential receivers located on Grafton Street and on Bridge Street.

The above assessment assumes works are being conducted at the closest point of the works area to each receiver. Potential vibration impacts should be re-assessed during the detailed design stage and addressed in the CNVMP once equipment and construction locations have been defined in more detail.

Attended vibration monitoring should be undertaken in the event that vibration intensive works are required within the cosmetic damage safe working distances, for example if rock breaking is required within 7 m of a receiver (medium rockbreaker), or if impact piling is required within 15m of a receiver.

The aim of the attended vibration monitoring would be to ensure levels remain below the criteria for cosmetic damage at all receivers (heritage or otherwise) as listed in **Table 10** and **Table 11.**

Specific vibration monitoring and survey requirements would also be confirmed in the CNVMP.

7.3 Ground-borne Construction Noise

The nature of the works (surface works with minimal screening effects) means that ground-borne noise impacts are expected to be negligible. This is because the airborne noise emissions in most circumstances are much higher than ground-borne noise levels. For this reason ground-borne noise is not anticipated to be the controlling factor for this proposal and further assessment is not warranted.

7.4 Heritage Buildings

Heritage buildings have been identified within the proposal area as shown in **Figure 4**. -

Figure 4 Clarence Valley Council LEP – Heritage Map (Detail: Project Area)

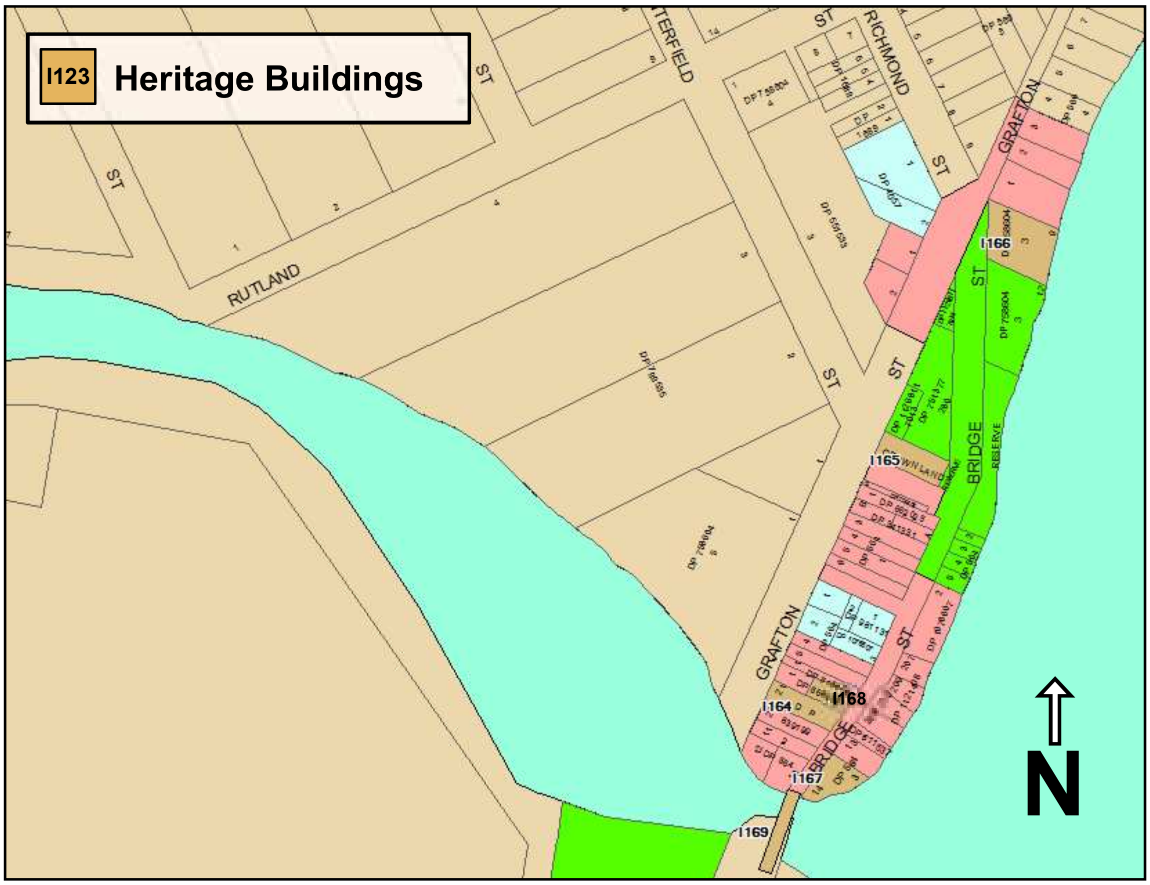


Image courtesy of Clarence Valley Council

Heritage buildings shown in **Figure 4** within the general vicinity of the proposed construction works are defined in **Table 23**.

Table 23 Summary of Identified Listed Heritage Buildings with the Proposal Area

LEP Item Number	Address	Description
I169	Bridge Street	Sportsmans Creek bridge
I167	2 Bridge Street	Former Baptist manse
I164	9 Bridge Street	Baptist Church
I168	11 Bridge Street	Residence
I165	33 Bridge Street	School of Arts building
I166	Bridge Street	War memorial

Several of the buildings listed above are located within 100 m of the proposed construction works. The construction vibration impacts from works surrounding these building should be managed through judicious selection of plant and equipment, as well as other vibration mitigation strategies discussed in **Section 7.5**, due to the potential for significant levels of vibration from construction works.

Building surveys of all nearby heritage structures should be carried out in order to assess the potential for increased susceptibility to building damage from vibration. Should these buildings be considered more susceptible to vibration than regular buildings, reduced vibration criteria levels may be applicable and subsequently adopted for the assessment process. These reduced criteria may influence the selection of appropriate construction processes and equipment to be used in the vicinity of these buildings.

7.5 Vibration Mitigation Measures

The expected construction vibration impacts are likely to be concerning for surrounding residents and particular effort should be directed towards the implementation of reasonable and feasible vibration mitigation and management strategies.

7.5.1 Vibration Management

In order to minimise the potential vibration impacts upon nearby sensitive receivers, demolition works are proposed to be undertaken during the EPA's standard daytime periods (7.00 am to 6.00 pm Monday to Friday and 8.00 am to 1.00 pm on Saturdays).

7.5.2 Vibration Mitigation

Examples of mitigation measures which may be considered appropriate for these works are:

- Use dampened rockbreakers and/or "city" rockbreakers to minimise the impacts associated with rockbreaking works and use a smaller capacity rockbreaker where feasible.
- Use bored pilling and not impact pilling where feasible
- Minimise consecutive works in the same locality.
- Sequence rockbreaking operations so vibration intensive operations do not occur concurrently.
- Schedule rockbreaking works during the less sensitive times of the day.
- Use of hydraulic rocksplitter rather than use of a rockbreaker (if applicable).

8 CONCLUSION

8.1 Operation

An operational noise impact assessment for the Sportsman Creek new bridge project has been undertaken in accordance with the *Road Noise Policy* (RNP) and *Environmental Noise Management Manual* (ENMM).

Exceedances of the RNP criteria have been predicted at five locations for the ‘build’ scenario in the future design year. Feasible and reasonable noise mitigation options to minimise the extend of the exceedances have been considered in accordance with the procedures outlined in the RNP and ENMM.

The potential feasible and reasonable mitigation options for the identified exceeding receivers are considered to be limited to the use of architectural treatment of individual receivers in the form of alternative ventilation and upgraded window glazing.

Maximum noise level events during the night-time period are predicted to exceed the guideline levels causing potential sleep disturbance impacts.

8.2 Construction

The construction noise and vibration impact assessment has been undertaken in accordance with the *Interim Construction Noise Guideline* (ICNG).

The construction noise goals in the proposal area are predicted to be exceeded at sensitive receivers during standard daytime construction hours for all construction scenarios.

It is recommended that the construction noise and vibration impacts be managed through the application of the mitigation measures detailed within this report.

During the detailed design stage, when more specific information is available in relation to the proposed construction works, it is recommended that a site specific Construction Noise and Vibration Management Plan be prepared, consistent with the requirements of the ICNG.

Acoustic Terminology

1 Sound Level or Noise Level

The terms “sound” and “noise” are almost interchangeable, except that in common usage “noise” is often used to refer to unwanted sound.

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

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

2 “A” Weighted Sound Pressure Level

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

People’s hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

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

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

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

3 Sound Power Level

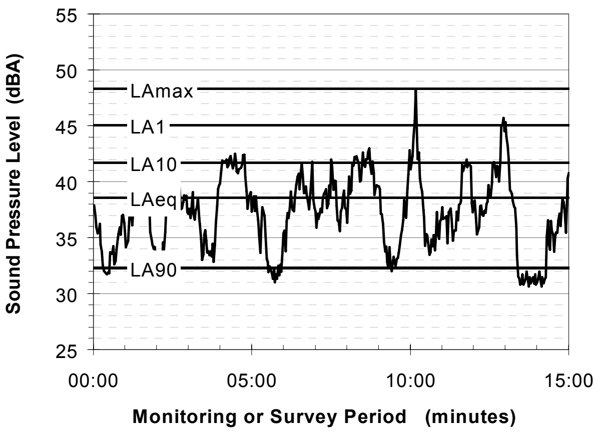
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

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

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

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



Of particular relevance, are:

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceed for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

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

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the “repeatable minimum” L_{A90} noise level over the daytime and night-time measurement periods, as required by the EPA. In addition the method produces mean or “average” levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc).

5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components), and is normally regarded as more offensive than “broad band” noise.

6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

7 Frequency Analysis

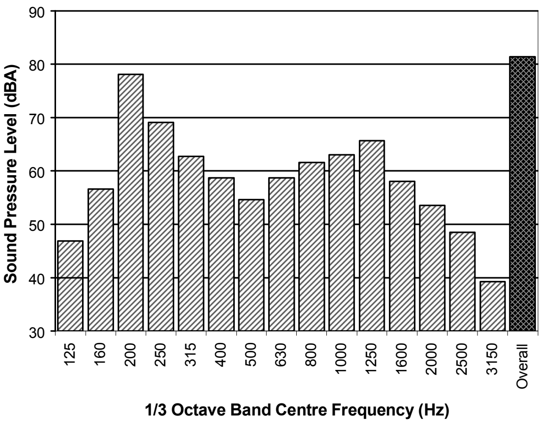
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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

Frequency analysis can be in:

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

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



8 Vibration

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

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

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

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

9 Human Perception of Vibration

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

10 Over-Pressure

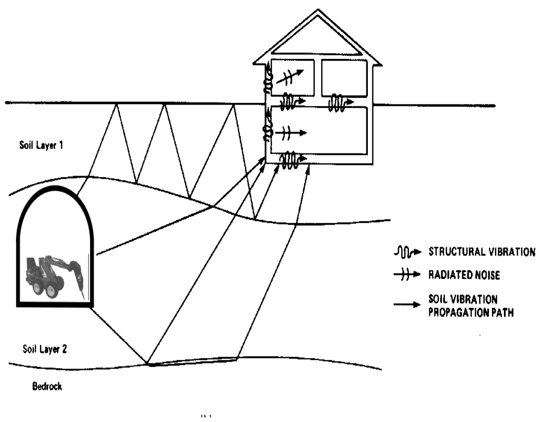
The term "over-pressure" is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 Ground-borne Noise, Structure-borne Noise and Regenerated Noise

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

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

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



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

NM1 - 4 Grafton Street, Lawrence, NSW - Ambient Noise Monitoring Results

Noise Monitoring Location:	**NM1**
Noise Monitoring Address:	**4 Grafton Street, Lawrence, NSW**

Logger Device Type: Svantek 957
Logger Serial No: 20673

Ambient noise logger deployed immediately outside residential address 4 Grafton Street, Lawrence. Logger located in front yard approximately 1m from the veranda awning.

Attended noise measurements indicate the ambient noise environment at this location is dominated by the natural environment with some noise from distant traffic.

Analysis of the daytime ambient noise levels indicated that extraneous noise (expected to be Fauna) influences daytime L90 and Leq noise levels. Periods affected by extraneous noise have been filtered according to the procedure outlined in the NSW INP.

Recorded Noise Levels (LAmax):
Wind in trees: 50-52, Distant Heavy Vehicles: 53, Dogs barking: <50, Distant construction: <50

Map of Noise Monitoring Location

Ambient Noise Logging Results – INP Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	33	47	47	55
Evening	36	46	46	51
Night-time	35	44	45	46

Ambient Noise Logging Results – RNP Defined Time Periods

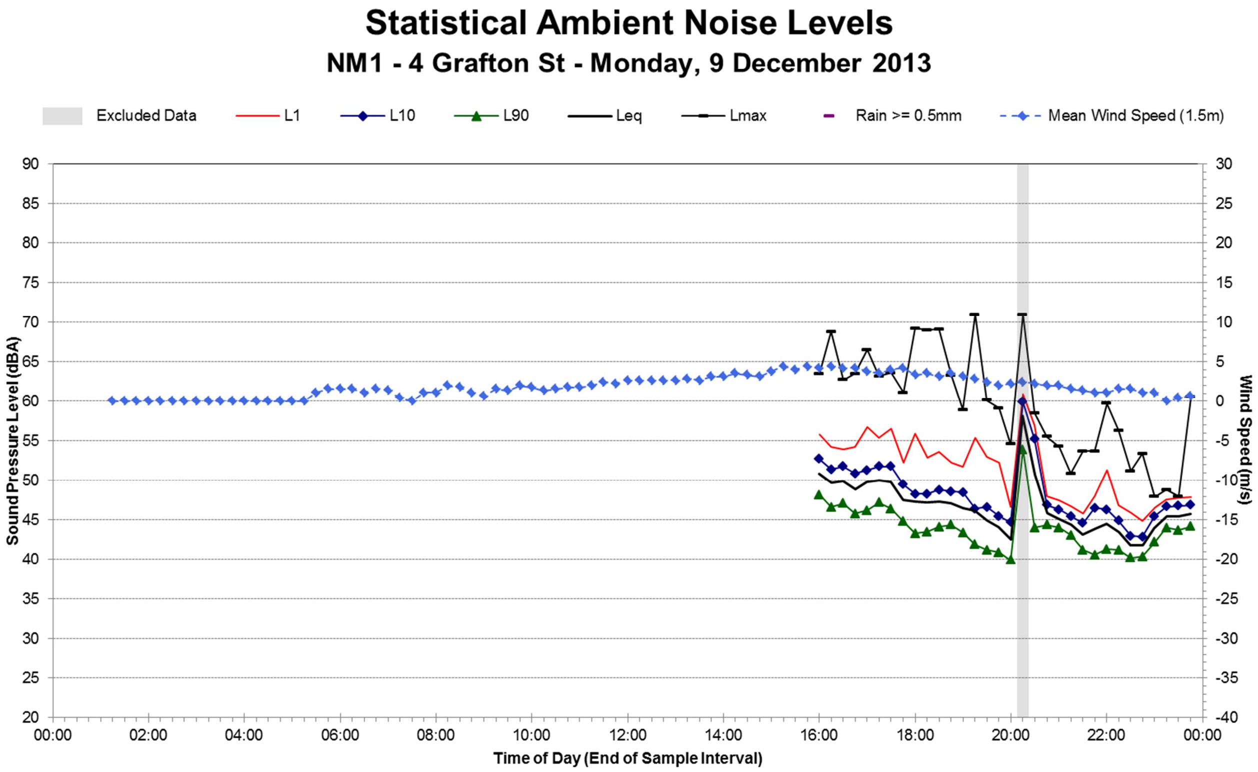
Monitoring Period	Noise Level (dBA)		
	Weekday LAeq(Period)	Weekend LAeq(Period)	Weekly LAeq(Period)
Number of Valid Days	5	2	N/A (7 Day Average)
Number of Valid Nights	8	2	
Daytime (7am-10pm)	46	49	47
Night-time (10pm-7am)	44	44	44

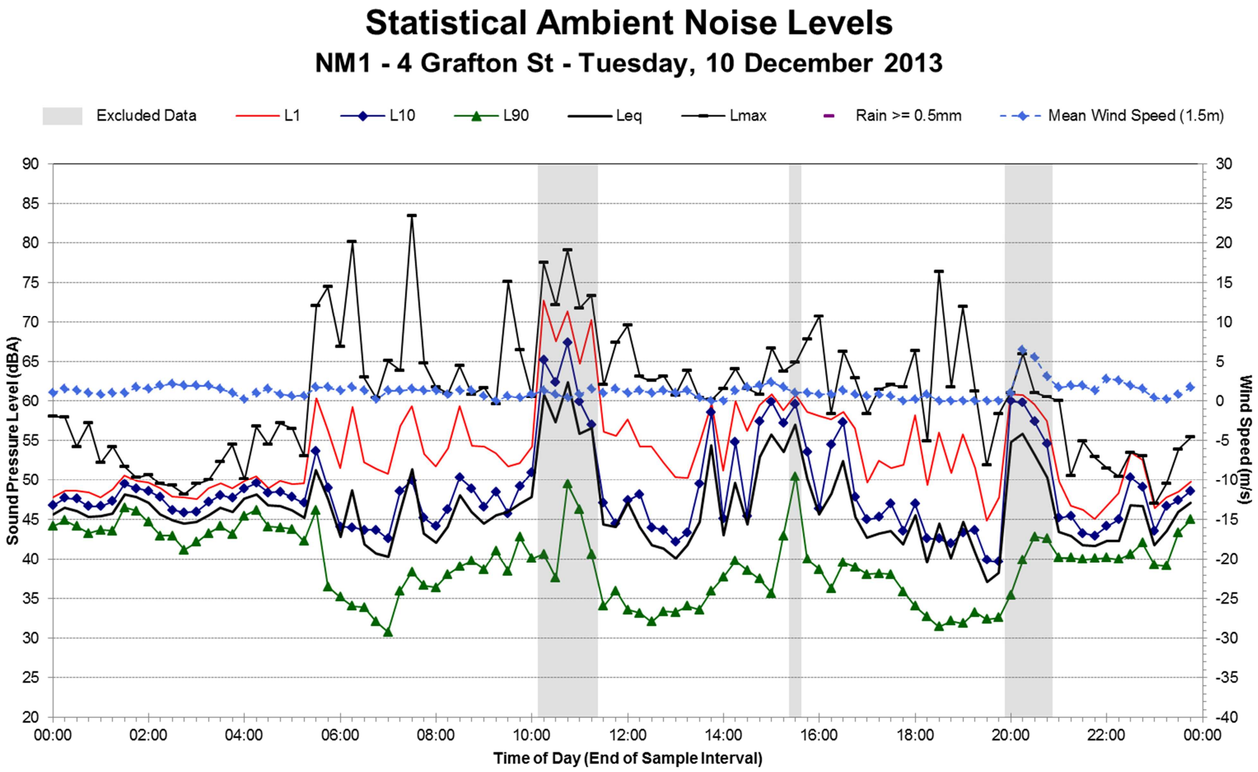
Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
09/12/2013	15:32	48	51	73

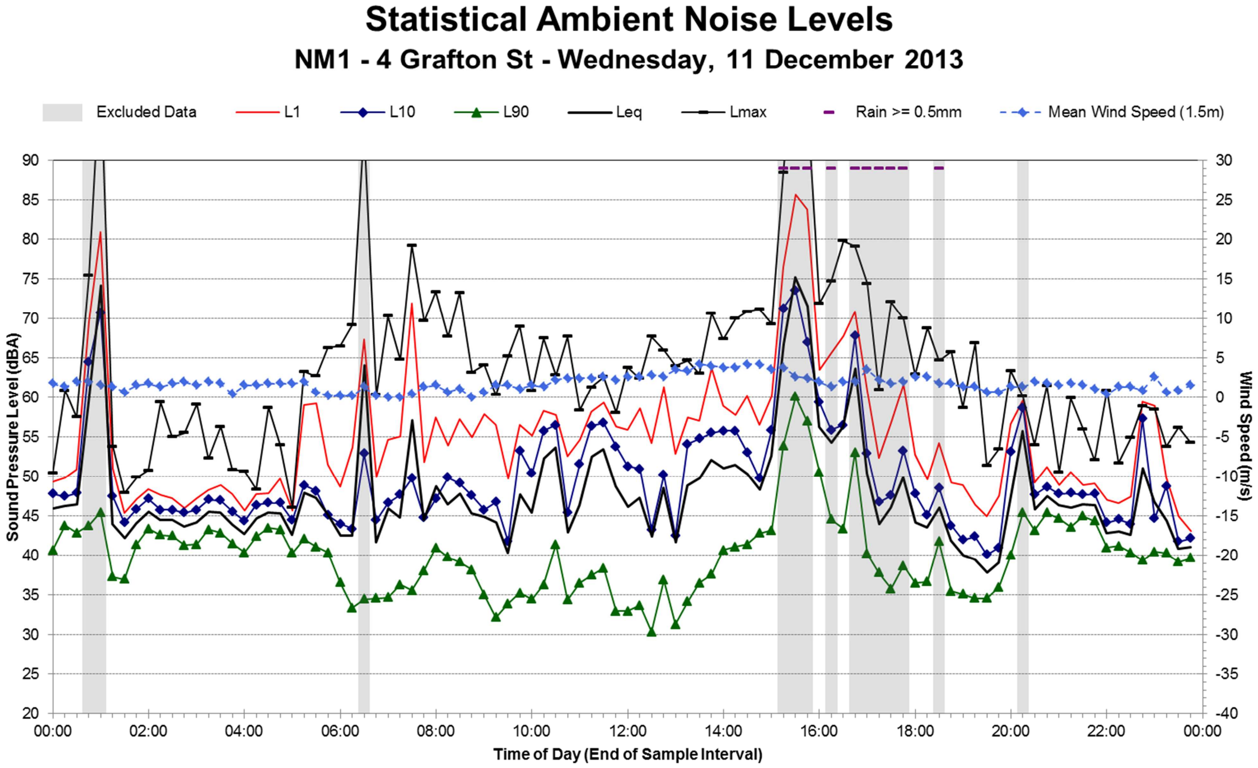
Photo of Noise Monitoring Location

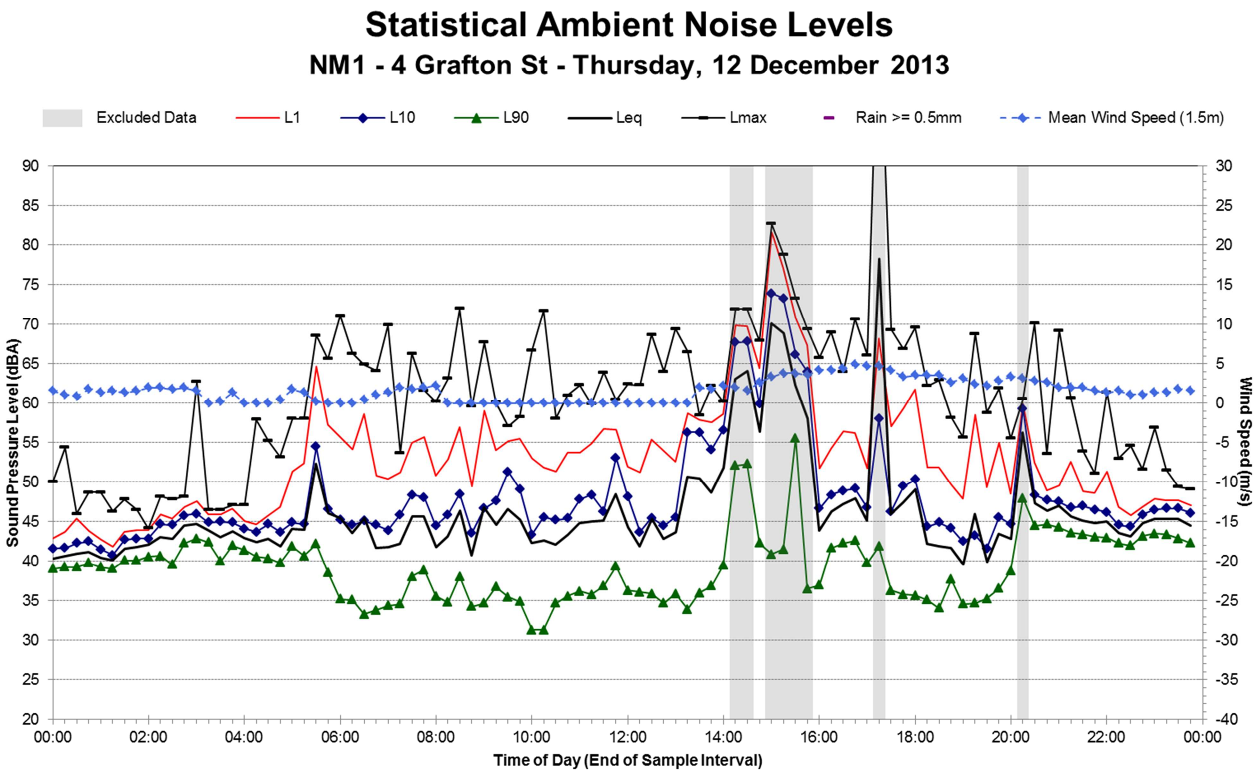
NM1 - 4 Grafton Street, Lawrence, NSW - Ambient Noise Monitoring Results



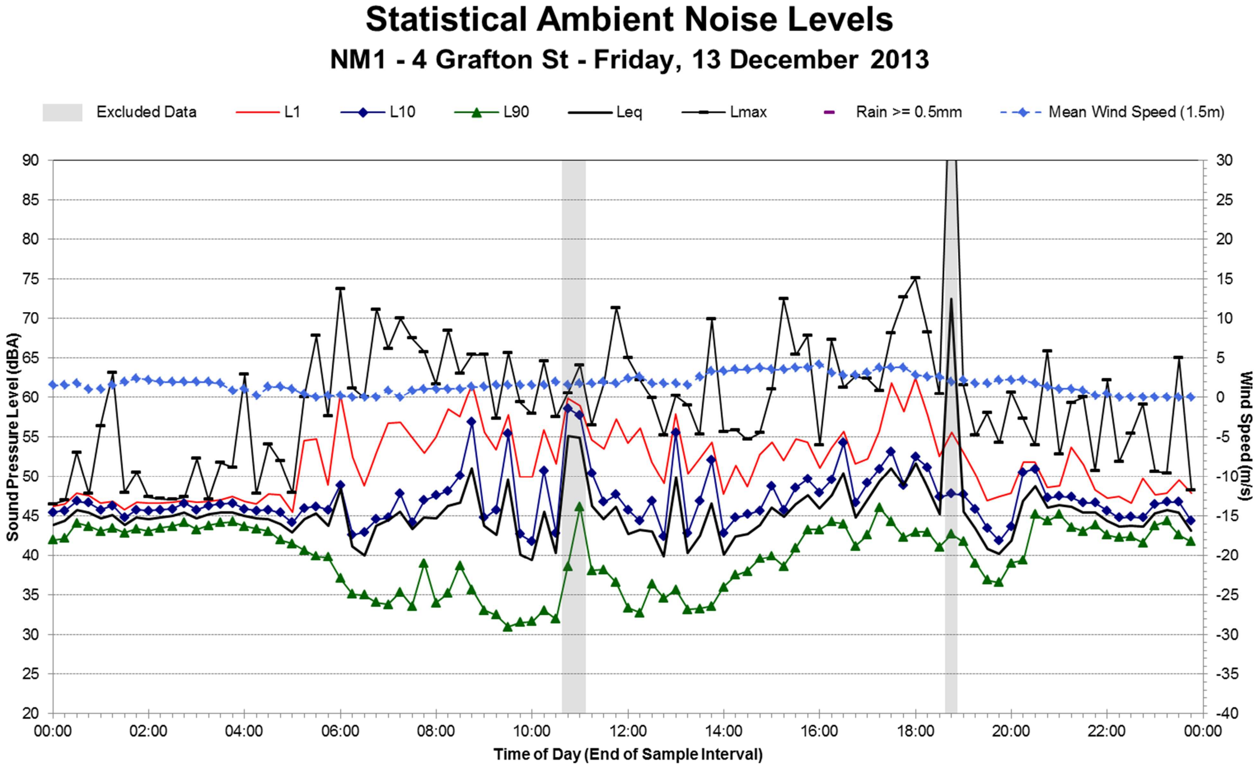


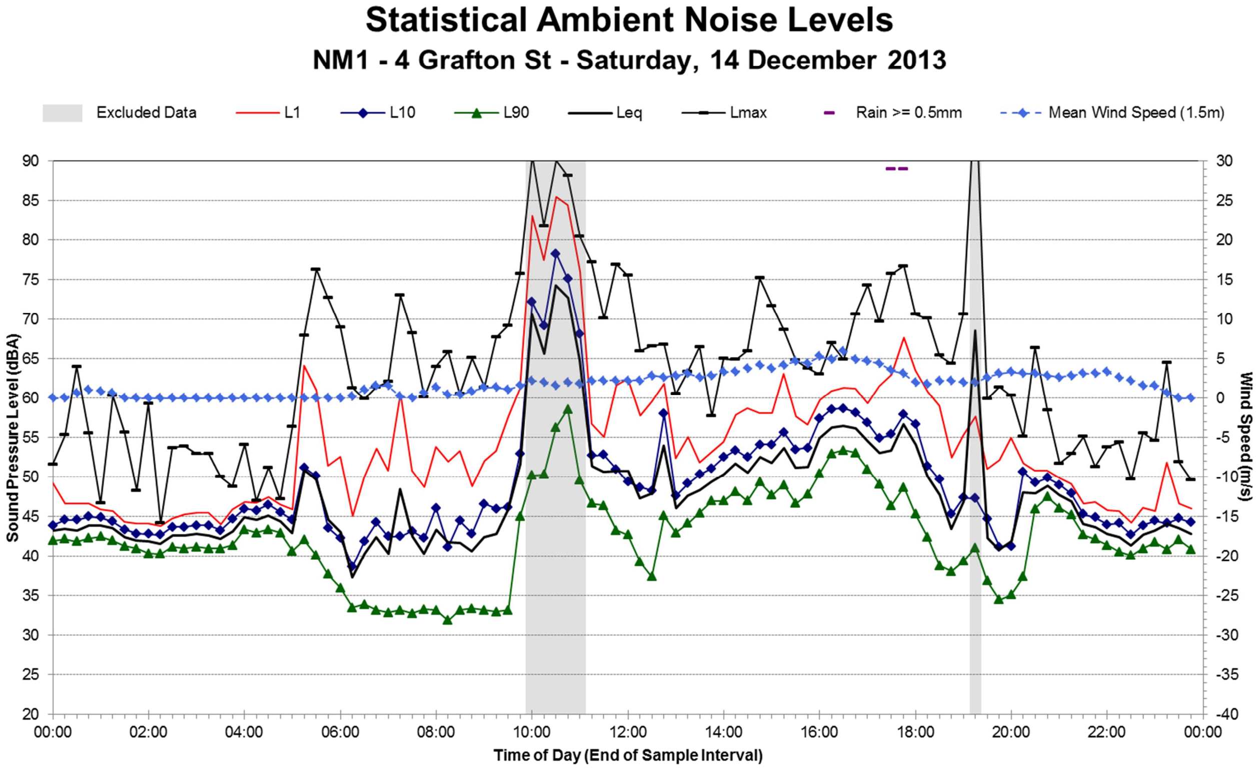
NM1 - 4 Grafton Street, Lawrence, NSW - Ambient Noise Monitoring Results



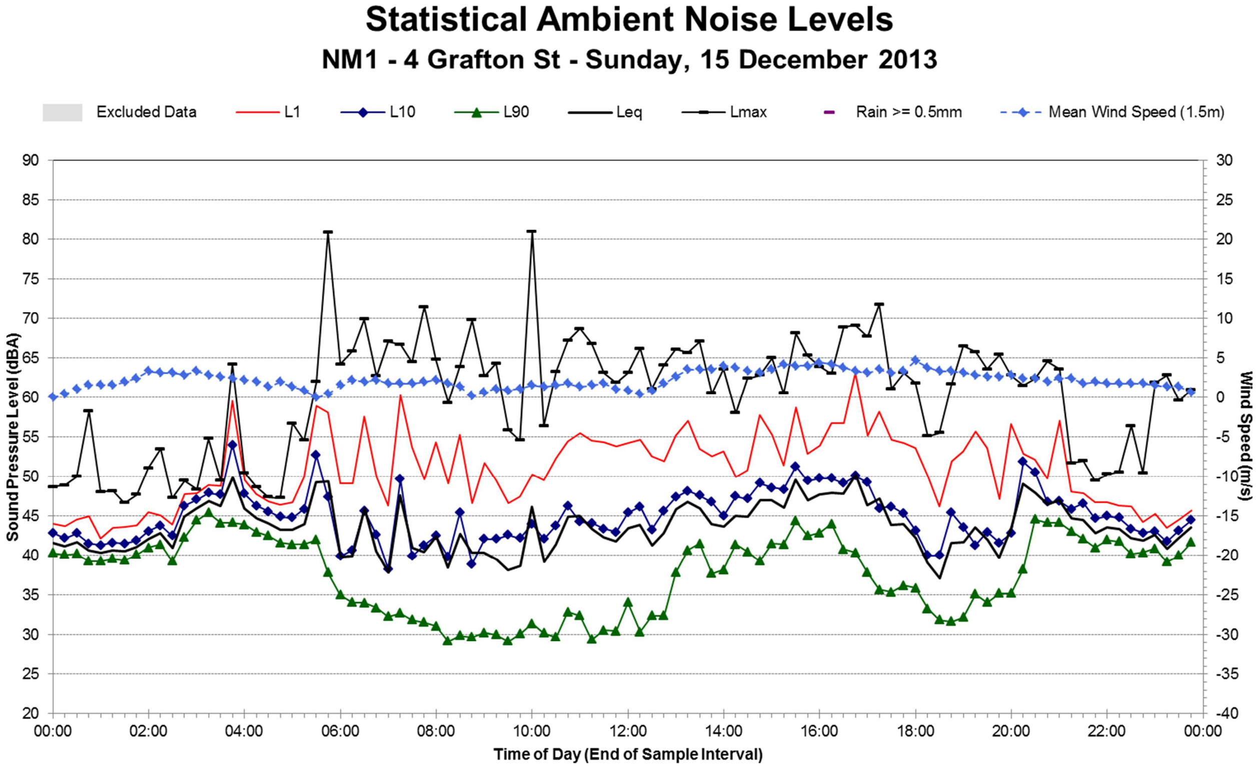


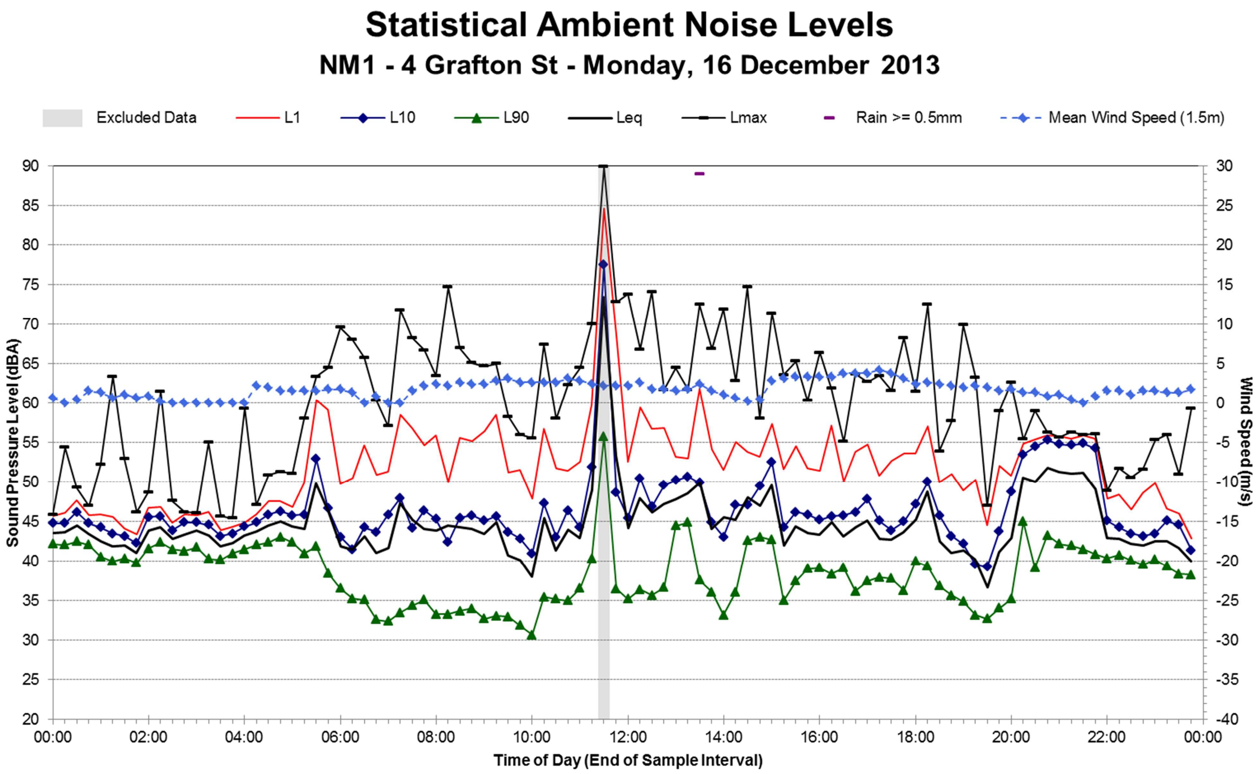
NM1 - 4 Grafton Street, Lawrence, NSW - Ambient Noise Monitoring Results



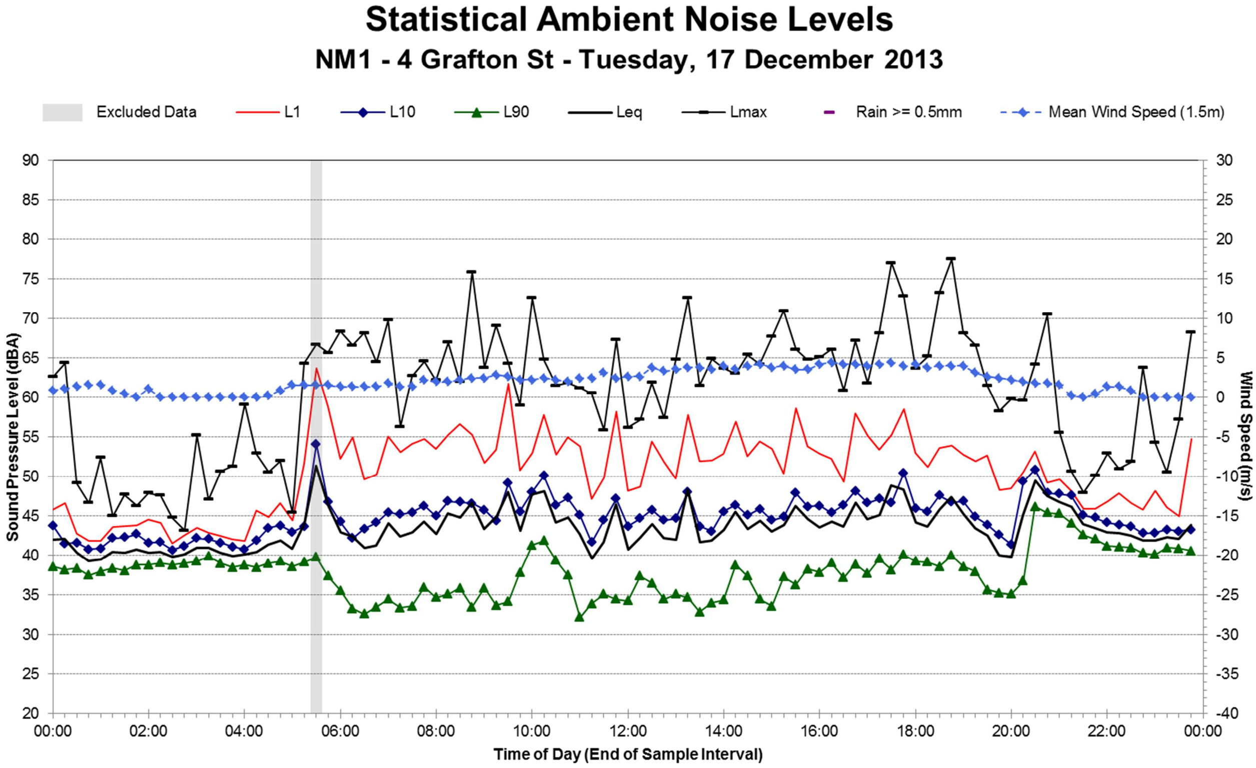


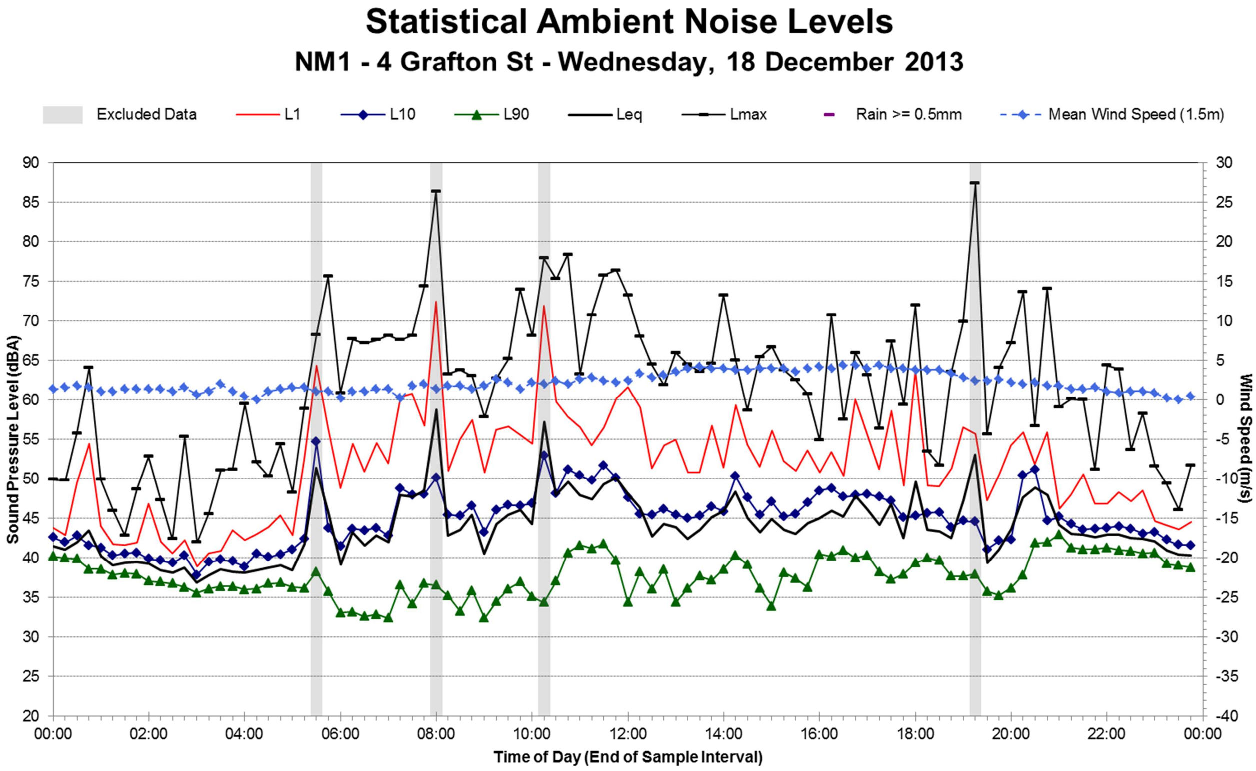
NM1 - 4 Grafton Street, Lawrence, NSW - Ambient Noise Monitoring Results



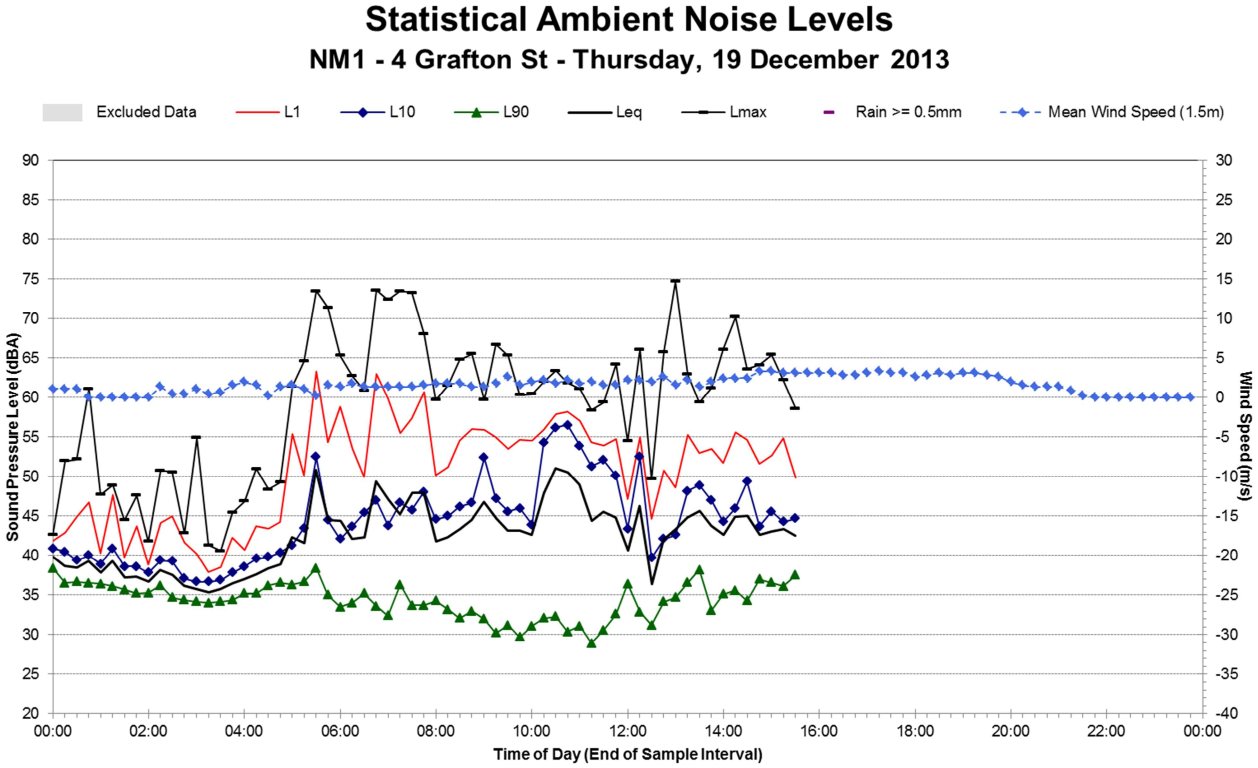


NM1 - 4 Grafton Street, Lawrence, NSW - Ambient Noise Monitoring Results





NM1 - 4 Grafton Street, Lawrence, NSW - Ambient Noise Monitoring Results



NM2 - 10 Bridge Street, Lawrence, NSW - Ambient Noise Monitoring Results

Noise Monitoring Location:	**NM2**
Noise Monitoring Address:	**10 Bridge Street, Lawrence, NSW**

Logger Device Type: Svantek 957
Logger Serial No: 20664

Ambient noise logger deployed immediately outside residential address 10 Bridge Street, Lawrence. Logger located in front yard on western side of the residence, 1m away from the facade. Direct line-of-sight to the Bridge Street Carriageway. 8m from nearest significant traffic source (Bridge Street).

Attended noise measurements indicate the ambient noise environment at this location is dominated by road traffic noise from Bridge Street during the daytime. Other noise sources include the the natural environment and some low level patron noise from the Lawrence Tavern.

Analysis of the daytime ambient noise levels indicated that extraneous noise (expected to be Fauna) influences daytime L90 and Leq noise levels. Periods affected by extraneous noise have been filtered according to the procedure outlined in the NSW INP.

Recorded Noise Levels (LAmax):

Wind in trees: 46-48, Patron noise from tavern: 55, Light road vehicle: 67-70, 4WD road vehicle: 72-73, Heavy road vehicle: 81, Tavern car park: 81

Map of Noise Monitoring Location

Ambient Noise Logging Results – INP Defined Time Periods

Monitoring Period	**Noise Level (dBA)**			
	RBL	**LAeq**	**L10**	**L1**
Daytime	31	56	58	67
Evening	32	52	49	63
Night-time	30	48	40	52

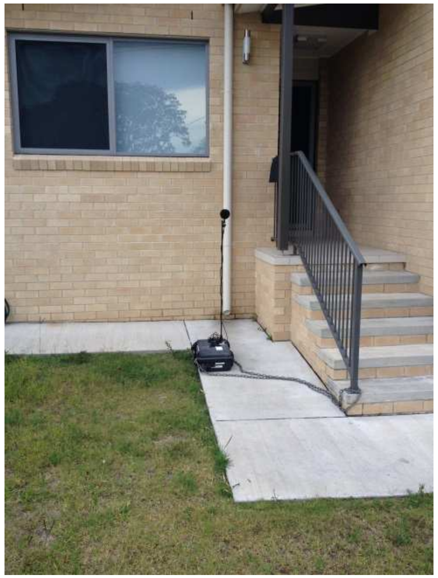
Ambient Noise Logging Results – RNP Defined Time Periods

Monitoring Period	**Noise Level (dBA)**		
	Weekday LAeq(Period)	**Weekend LAeq(Period)**	**Weekly LAeq(Period)**
Number of Valid Days	6	2	N/A (7 Day Average)
Number of Valid Nights	7	2	
Daytime (7am-10pm)	55	54	55
Night-time (10pm-7am)	49	47	48

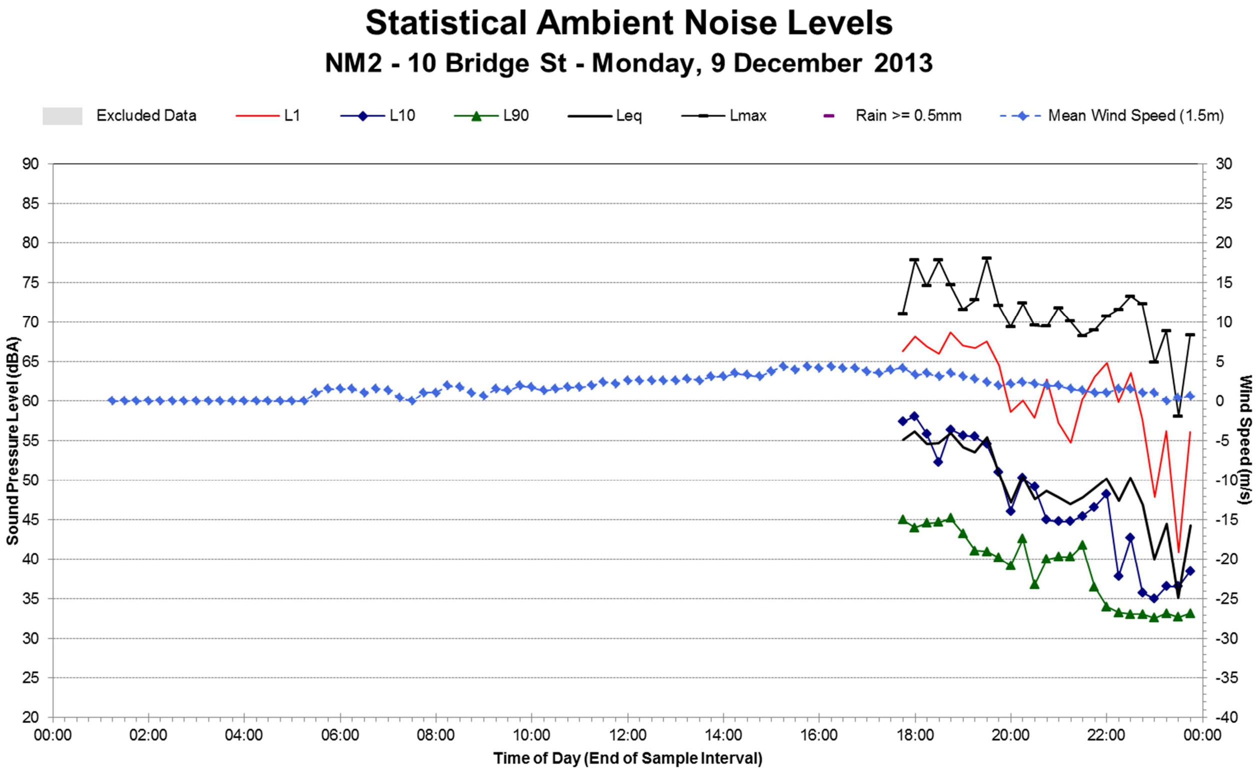
Attended Noise Measurement Results

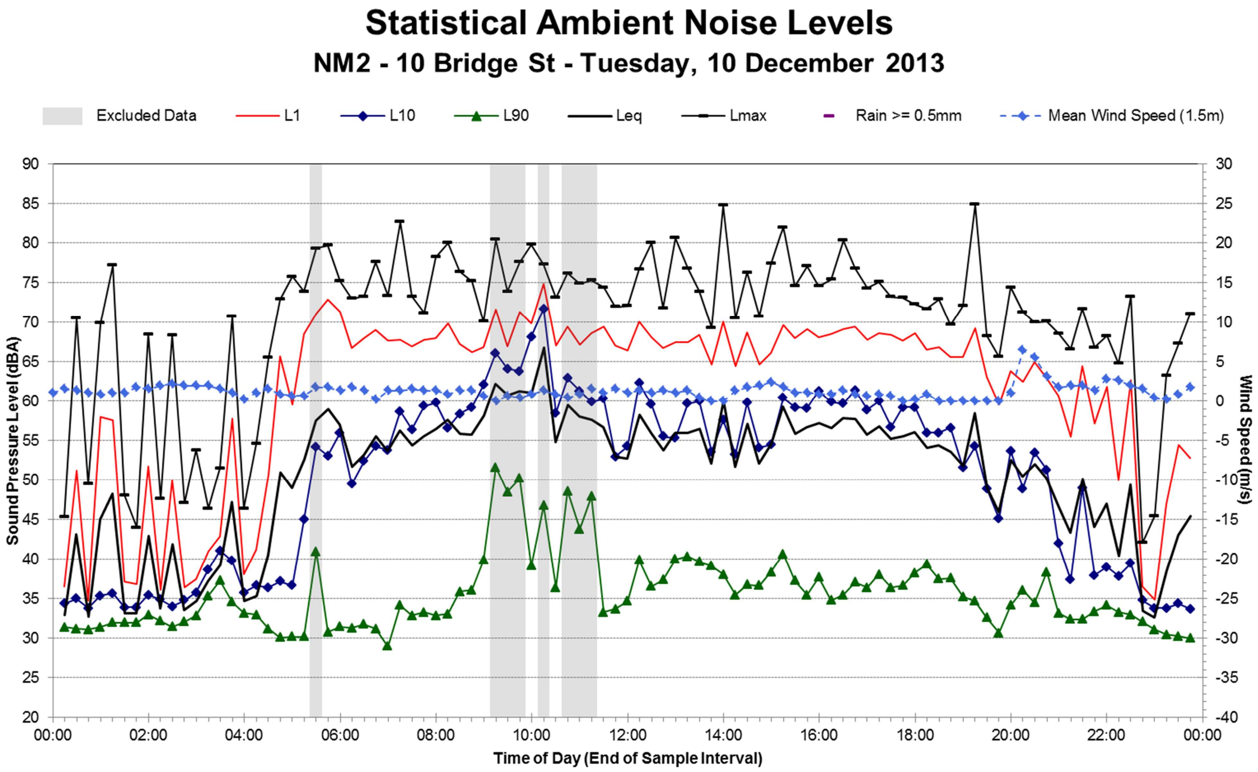
Date	**Start Time**	**Measured Noise Level (dBA)**		
		LA90	**LAeq**	**LAmax**
09/12/2013	15:00	49	63	84

Photo of Noise Monitoring Location

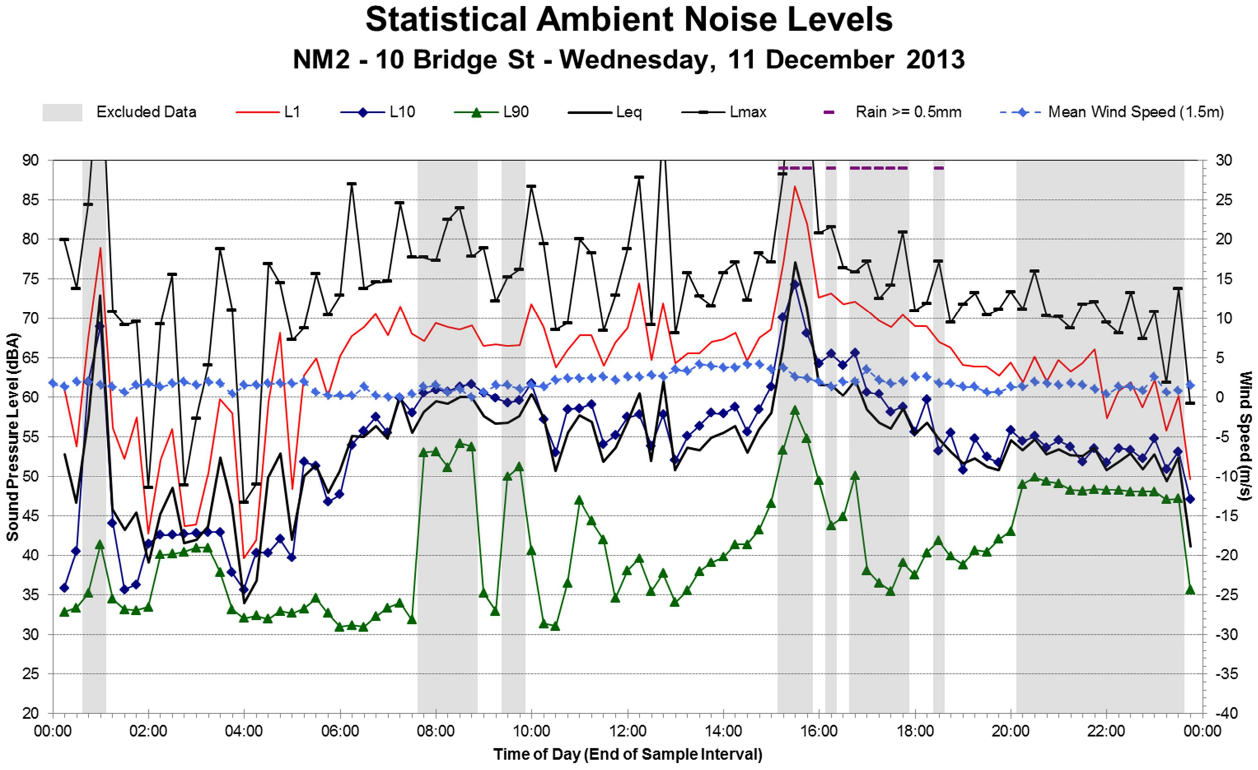


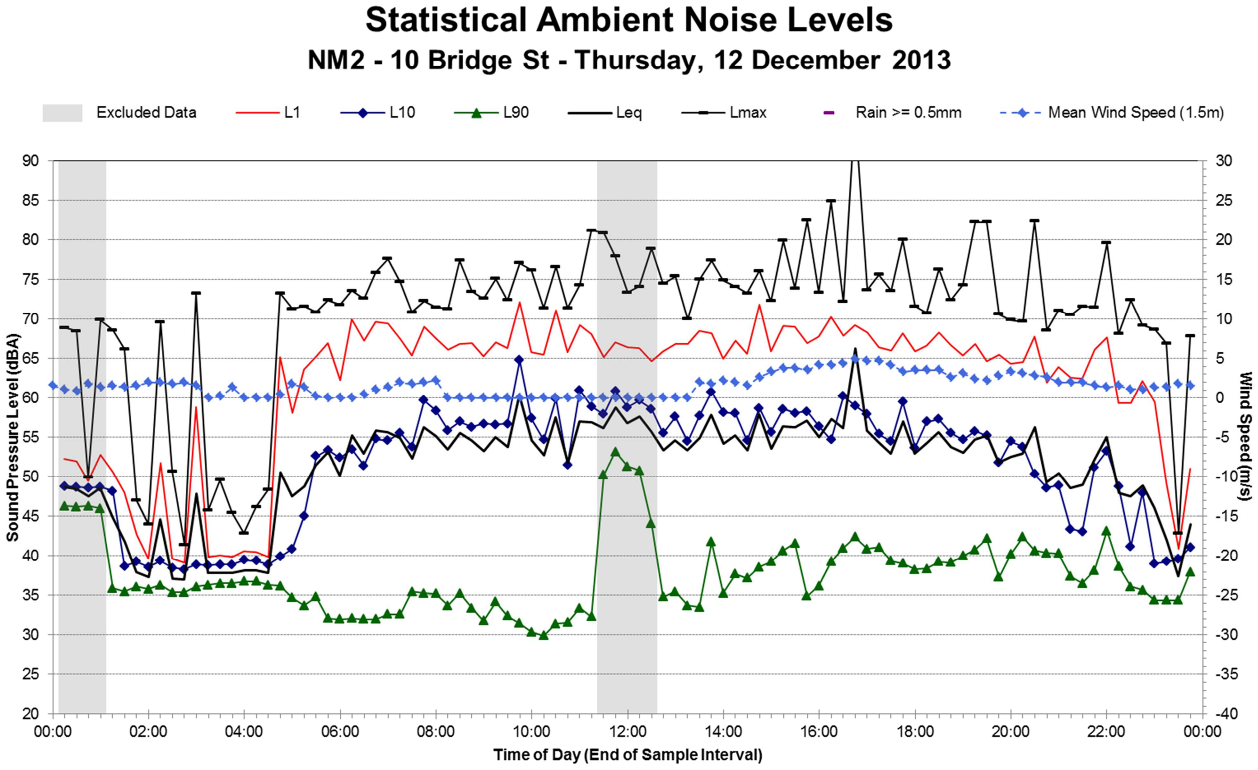
NM2 - 10 Bridge Street, Lawrence, NSW - Ambient Noise Monitoring Results





NM2 - 10 Bridge Street, Lawrence, NSW - Ambient Noise Monitoring Results

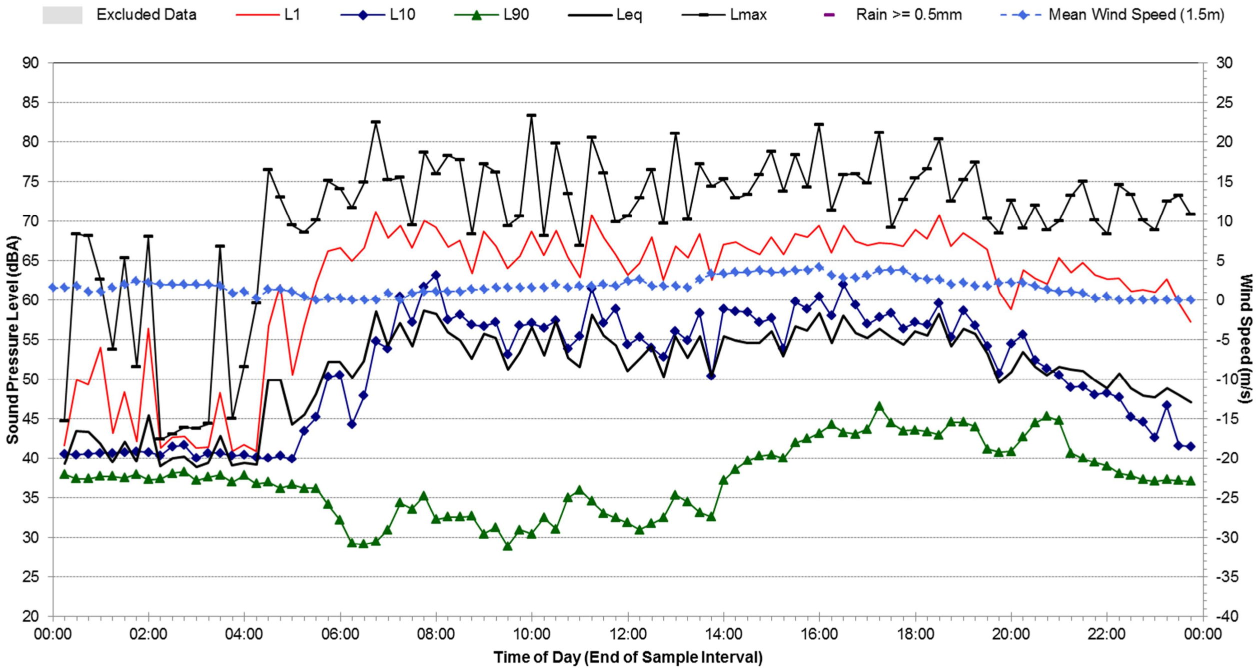




NM2 - 10 Bridge Street, Lawrence, NSW - Ambient Noise Monitoring Results

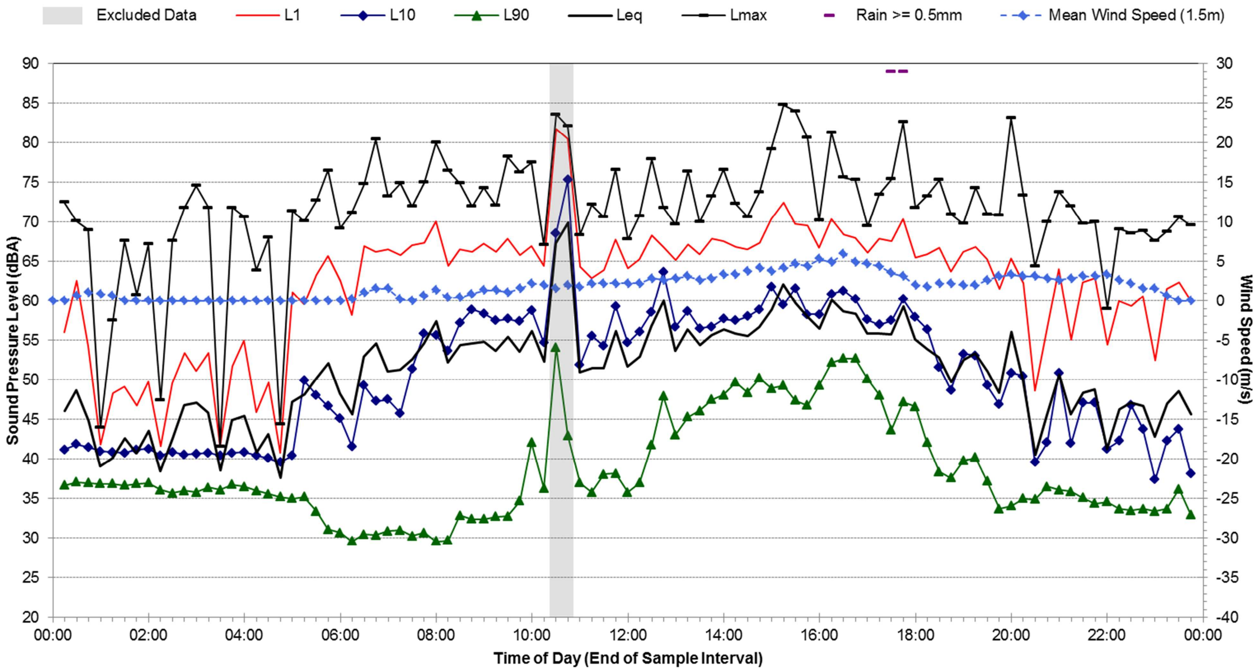
Statistical Ambient Noise Levels

NM2 - 10 Bridge St - Friday, 13 December 2013



Statistical Ambient Noise Levels

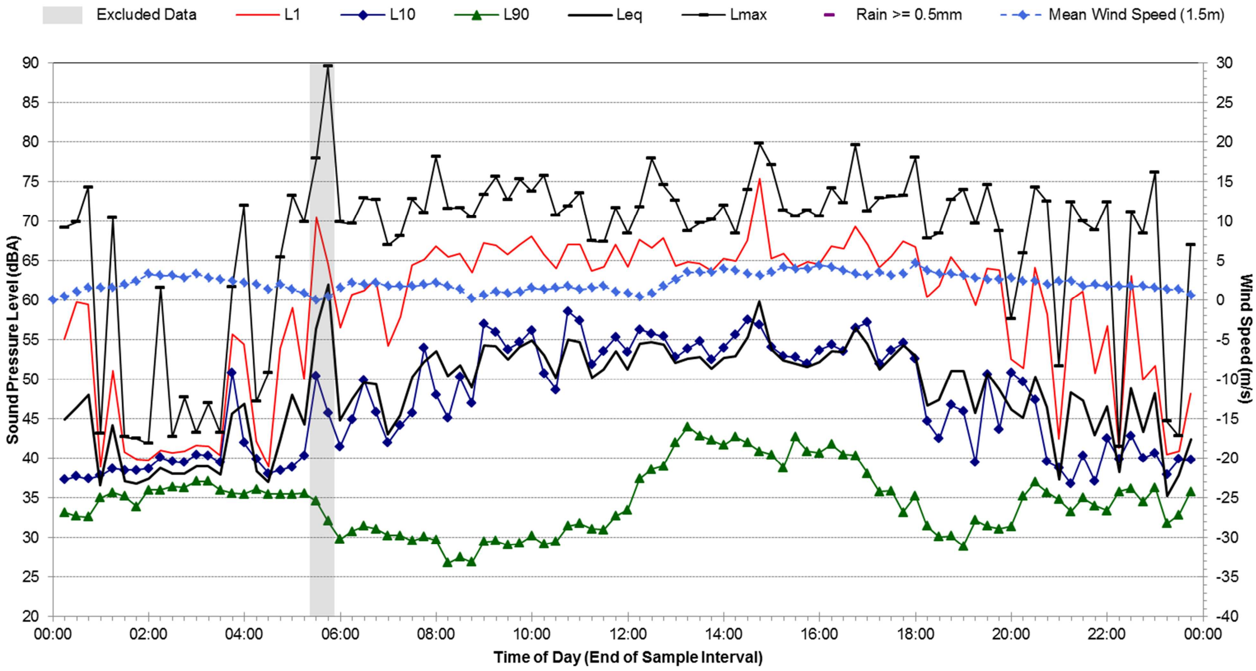
NM2 - 10 Bridge St - Saturday, 14 December 2013



NM2 - 10 Bridge Street, Lawrence, NSW - Ambient Noise Monitoring Results

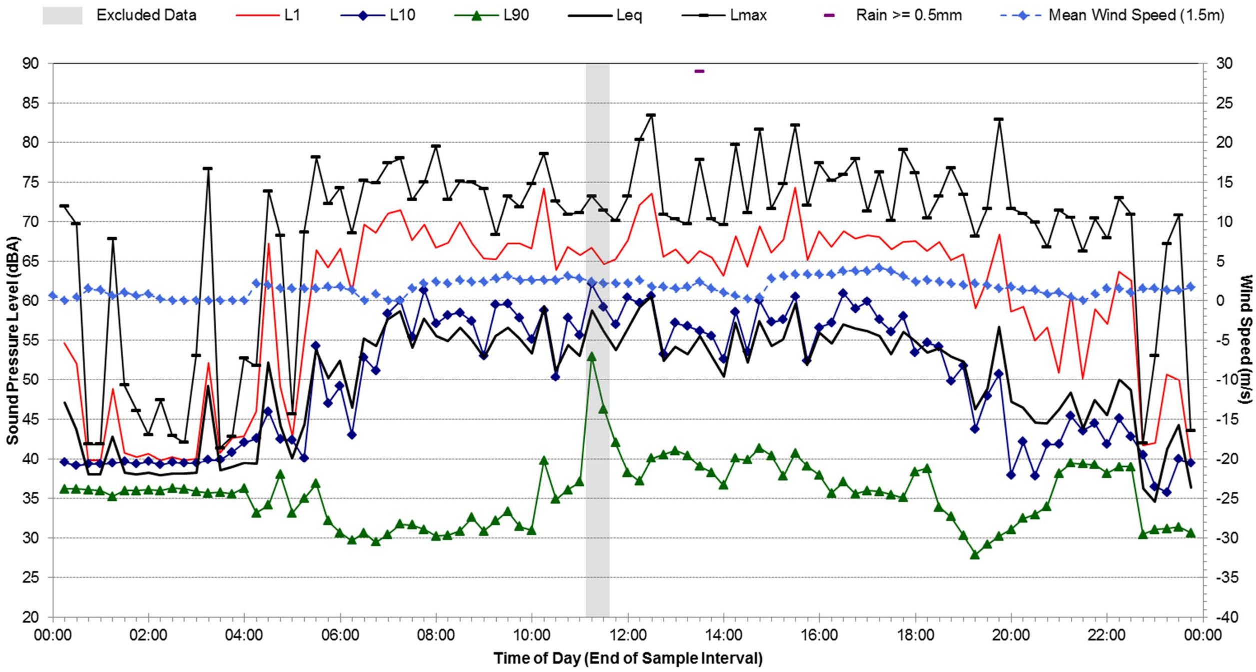
Statistical Ambient Noise Levels

NM2 - 10 Bridge St - Sunday, 15 December 2013

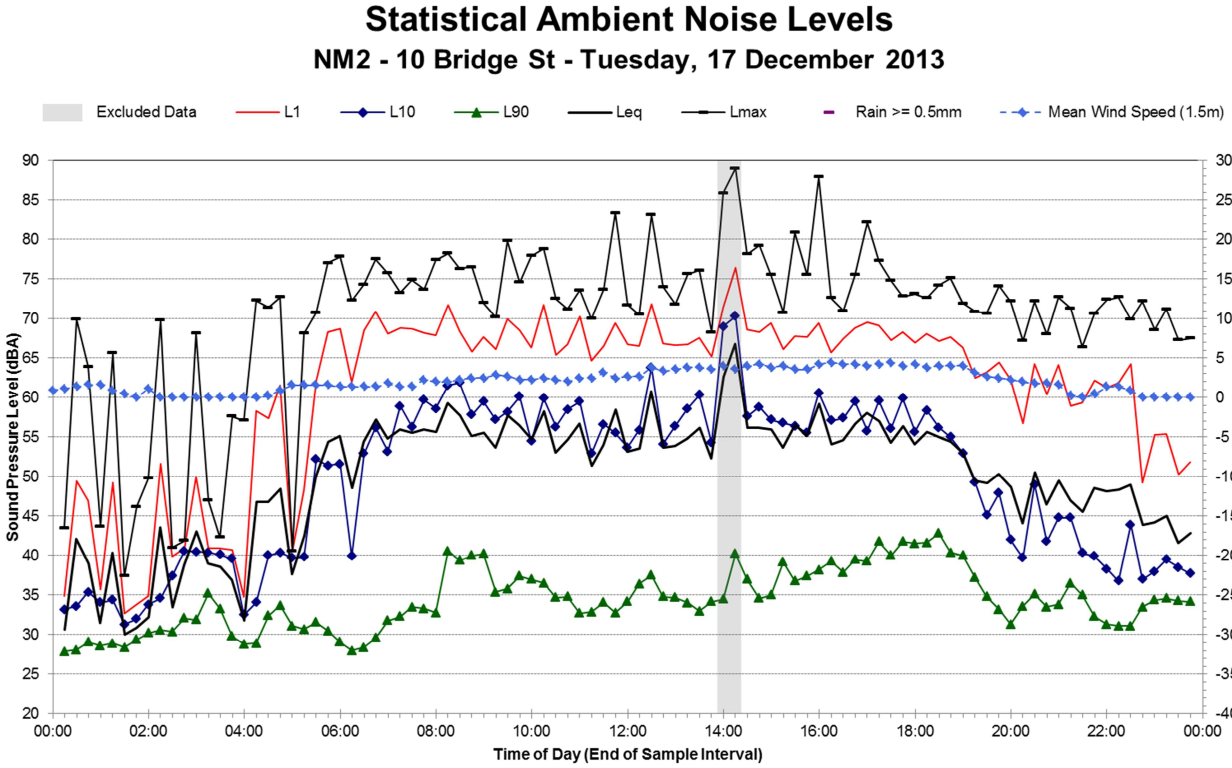


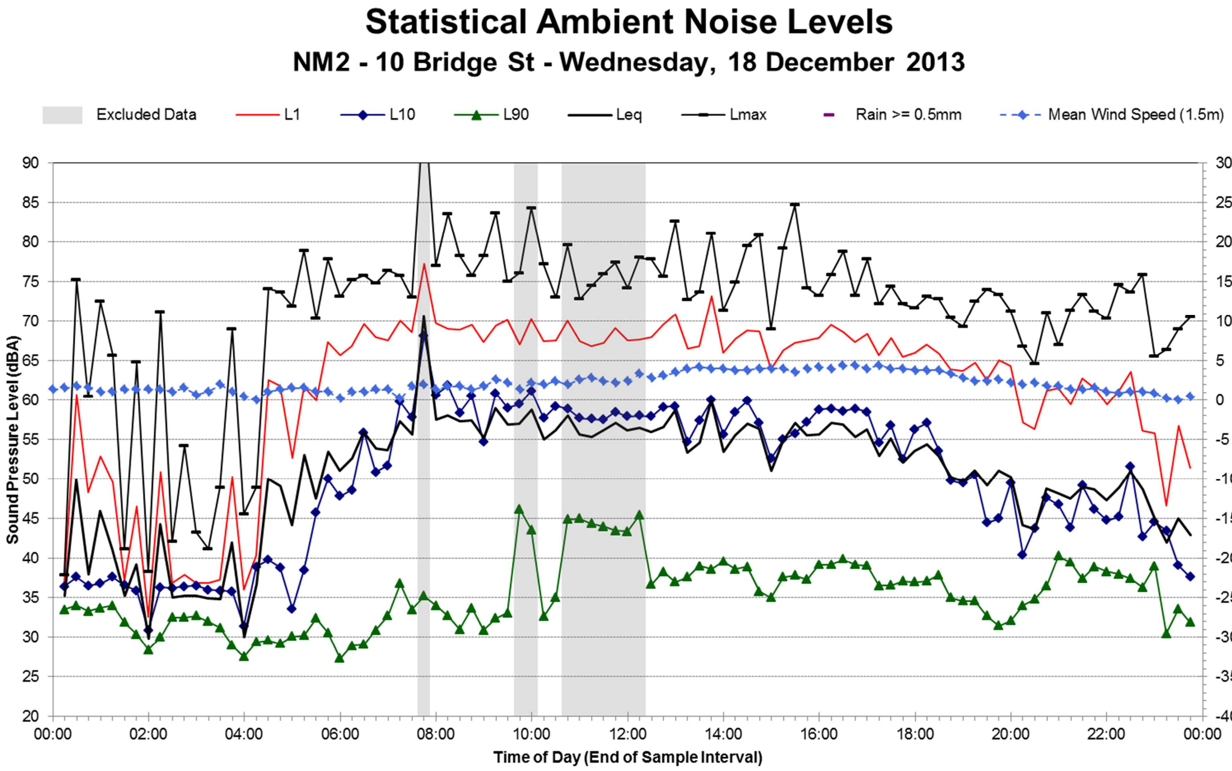
Statistical Ambient Noise Levels

NM2 - 10 Bridge St - Monday, 16 December 2013



NM2 - 10 Bridge Street, Lawrence, NSW - Ambient Noise Monitoring Results

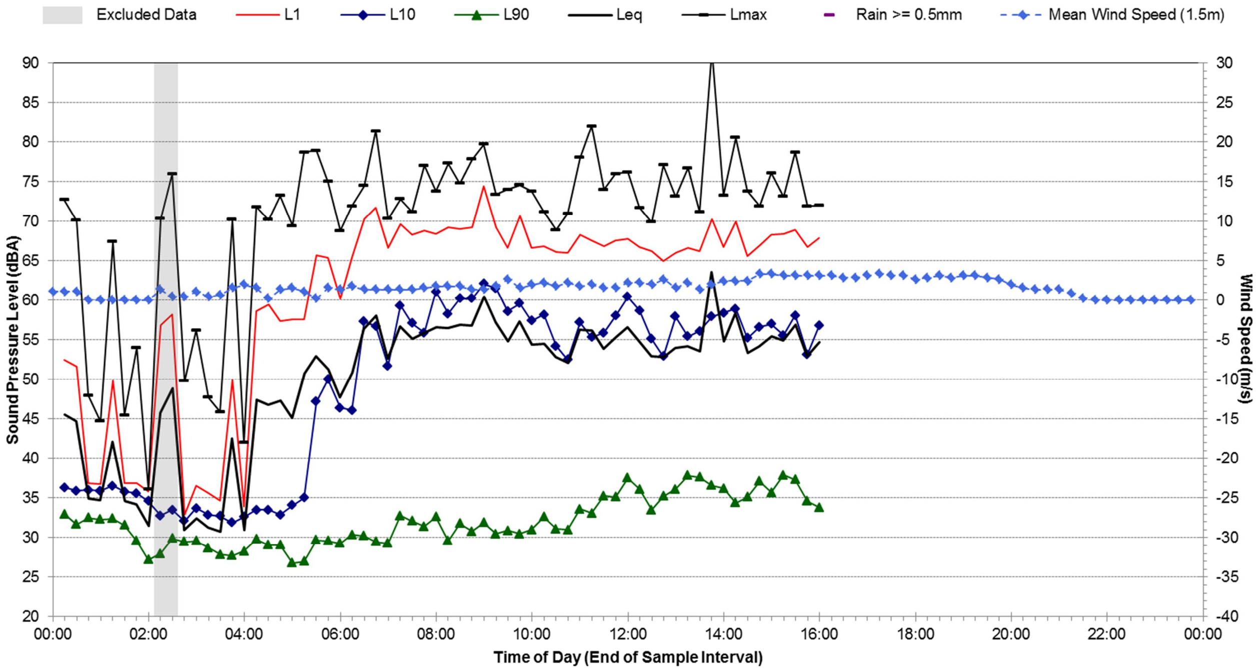




NM2 - 10 Bridge Street, Lawrence, NSW - Ambient Noise Monitoring Results

Statistical Ambient Noise Levels

NM2 - 10 Bridge St - Thursday, 19 December 2013



NM3 - 3 Grafton Street, Lawrence, NSW - Ambient Noise Monitoring Results

Noise Monitoring Location:	NM3
Noise Monitoring Address:	3 Grafton Street, Lawrence, NSW

Logger Device Type: Svantek 957
Logger Serial No: 21425

Ambient noise logger deployed immediately outside residential address 3 Grafton Street, Lawrence. Logger located in front yard, 1m from the eastern facade of the property.

Attended noise measurements indicate the ambient noise environment at this location is dominated by the natural environment and road traffic noise from Bridge Street

Analysis of the daytime ambient noise levels indicated that extraneous noise (expected to be Fauna) influences daytime L90 and Leq noise levels. Periods affected by extraneous noise have been filtered according to the procedure outlined in the NSW INP.

Recorded Noise Levels (LAmax):
Wind in trees: 50-54, Light road vehicle: 59, 4WD road vehicle: 59, Motorbike: 74, Insects: ~50

Map of Noise Monitoring Location

Ambient Noise Logging Results – INP Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	32	51	53	60
Evening	32	48	48	57
Night-time	29	47	45	53

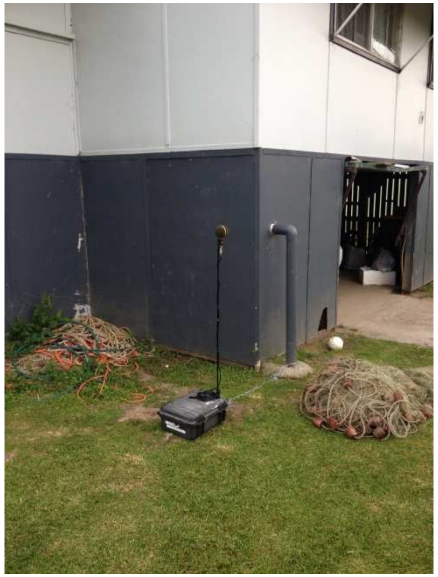
Ambient Noise Logging Results – RNP Defined Time Periods

Monitoring Period	Noise Level (dBA)		
	Weekday LAeq(Period)	Weekend LAeq(Period)	Weekly LAeq(Period)
Number of Valid Days	6	2	N/A (7 Day Average)
Number of Valid Nights	5	1	
Daytime (7am-10pm)	51	52	51
Night-time (10pm-7am)	48	42	47

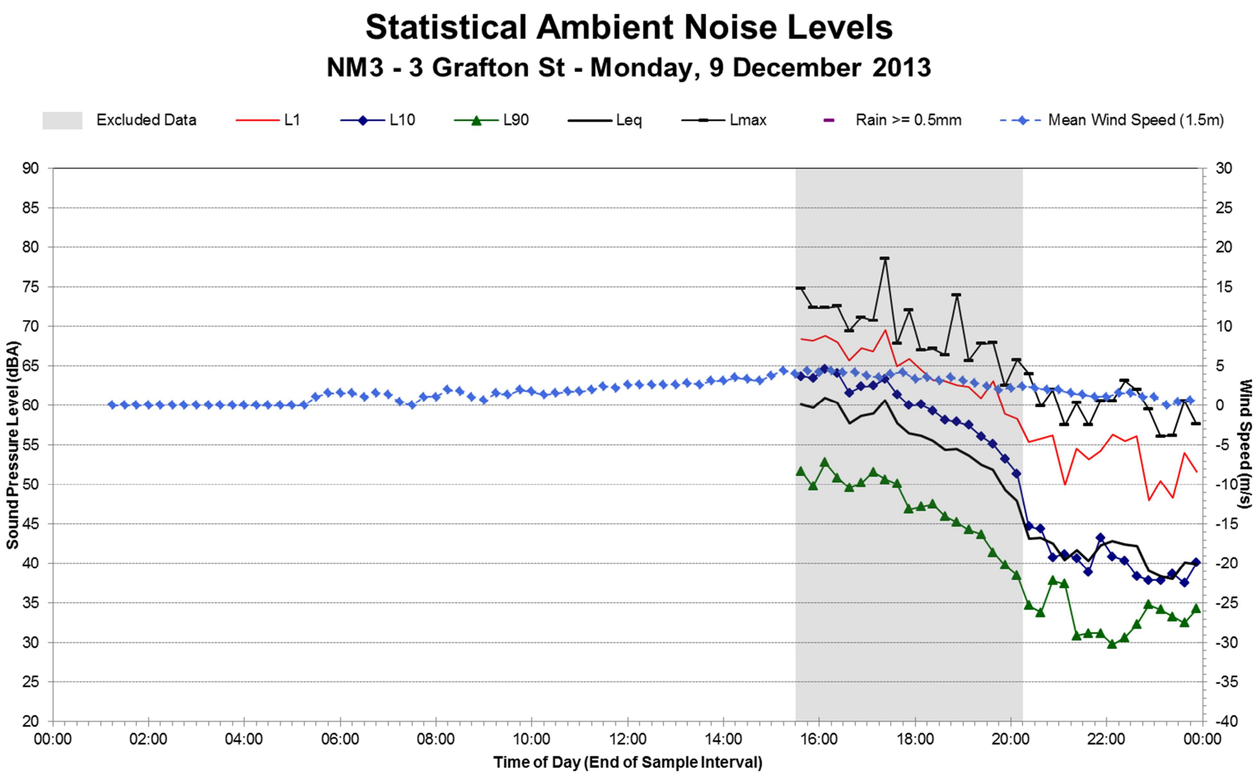
Attended Noise Measurement Results

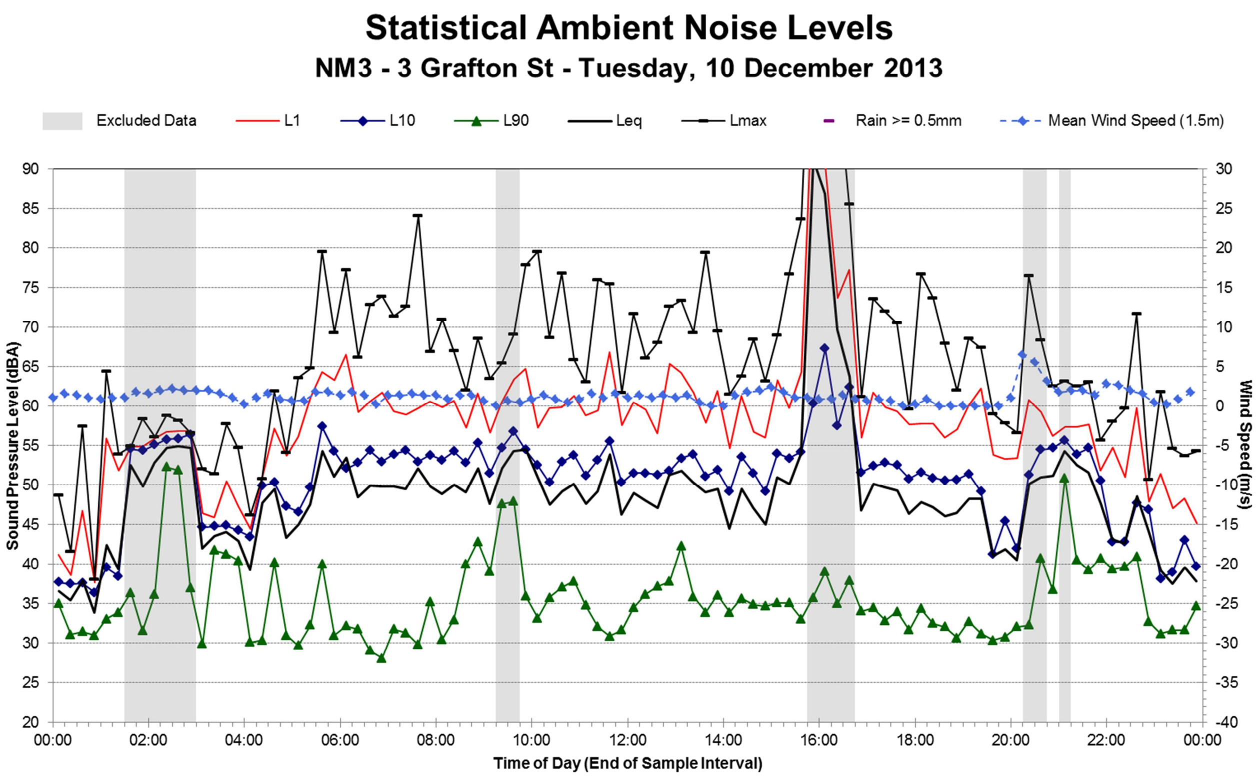
Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
09/12/2013	15:32	47	54	74

Photo of Noise Monitoring Location



NM3 - 3 Grafton Street, Lawrence, NSW - Ambient Noise Monitoring Results

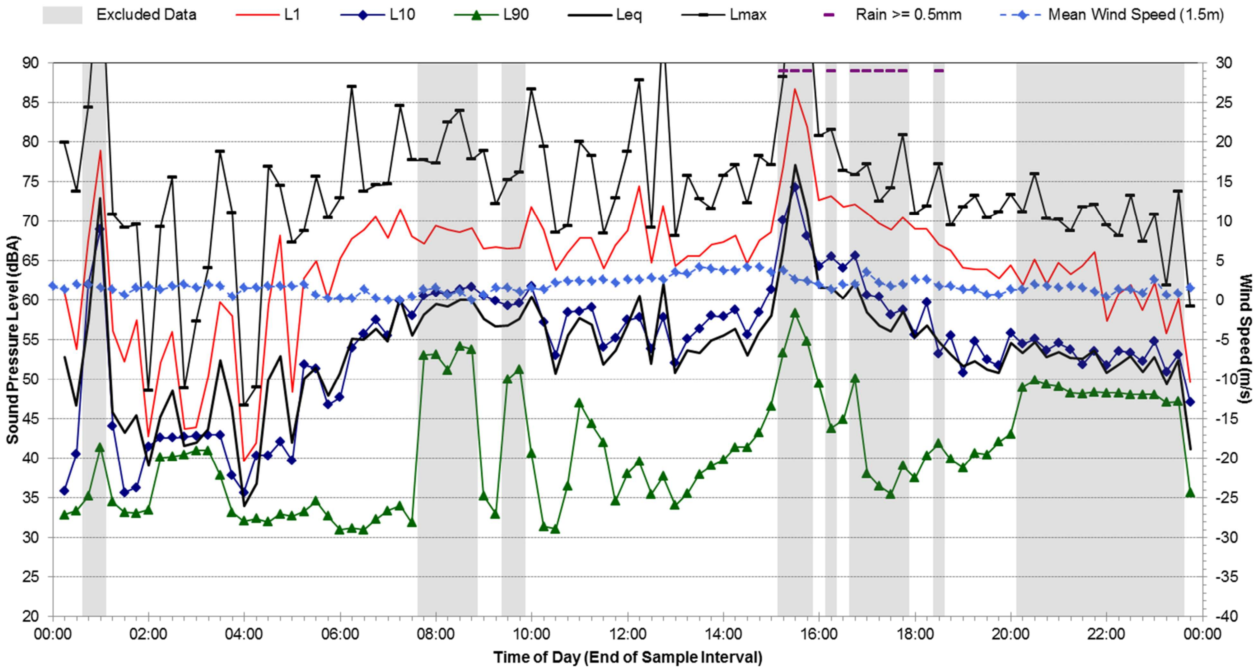




NM2 - 10 Bridge Street, Lawrence, NSW - Ambient Noise Monitoring Results

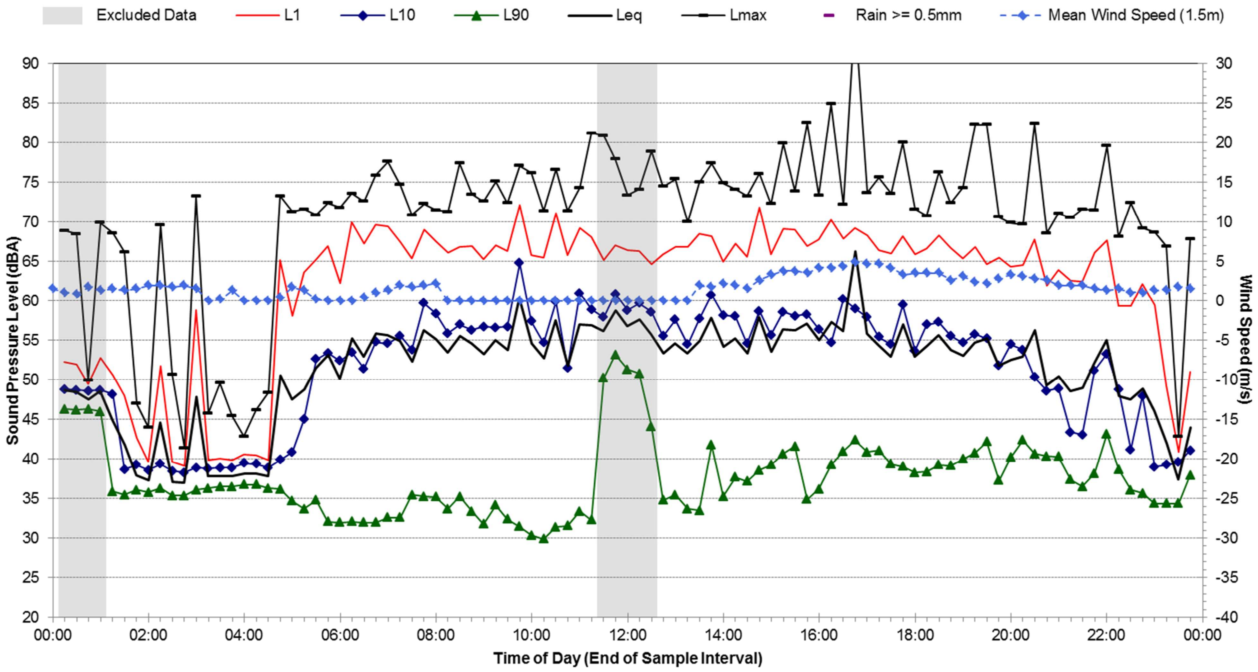
Statistical Ambient Noise Levels

NM2 - 10 Bridge St - Wednesday, 11 December 2013

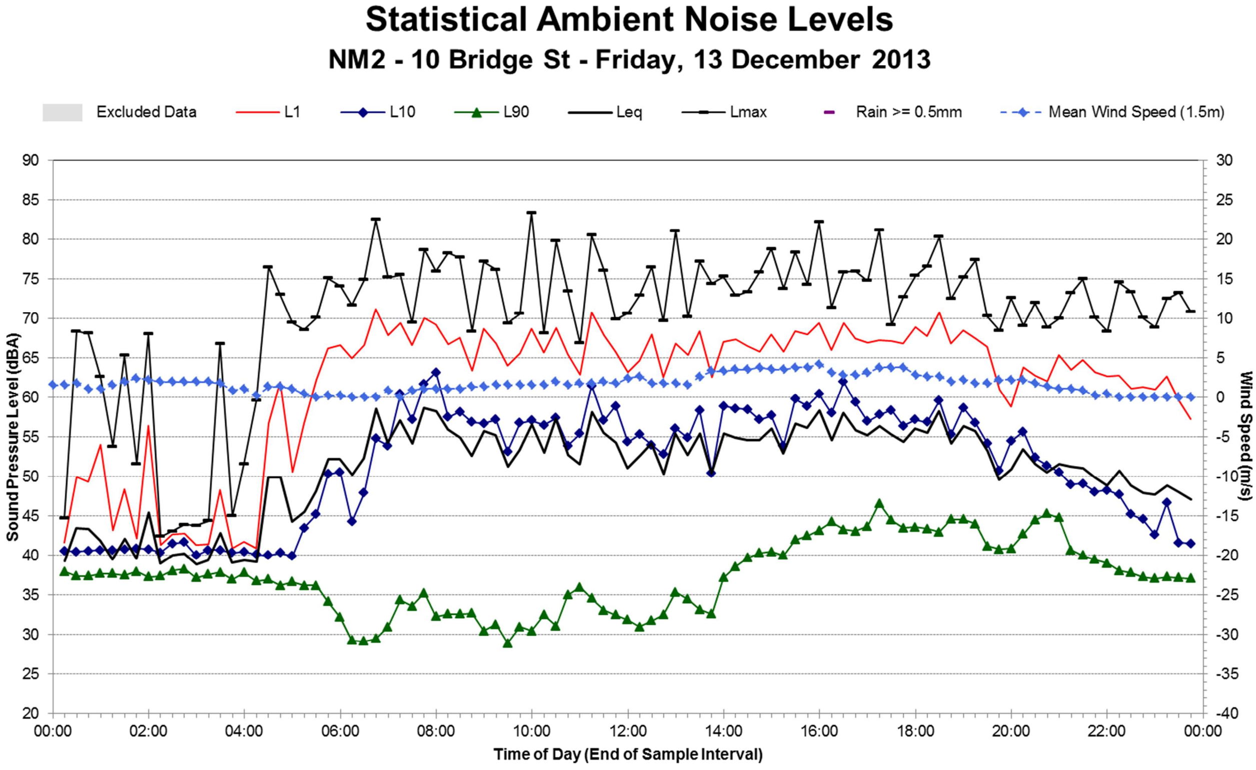


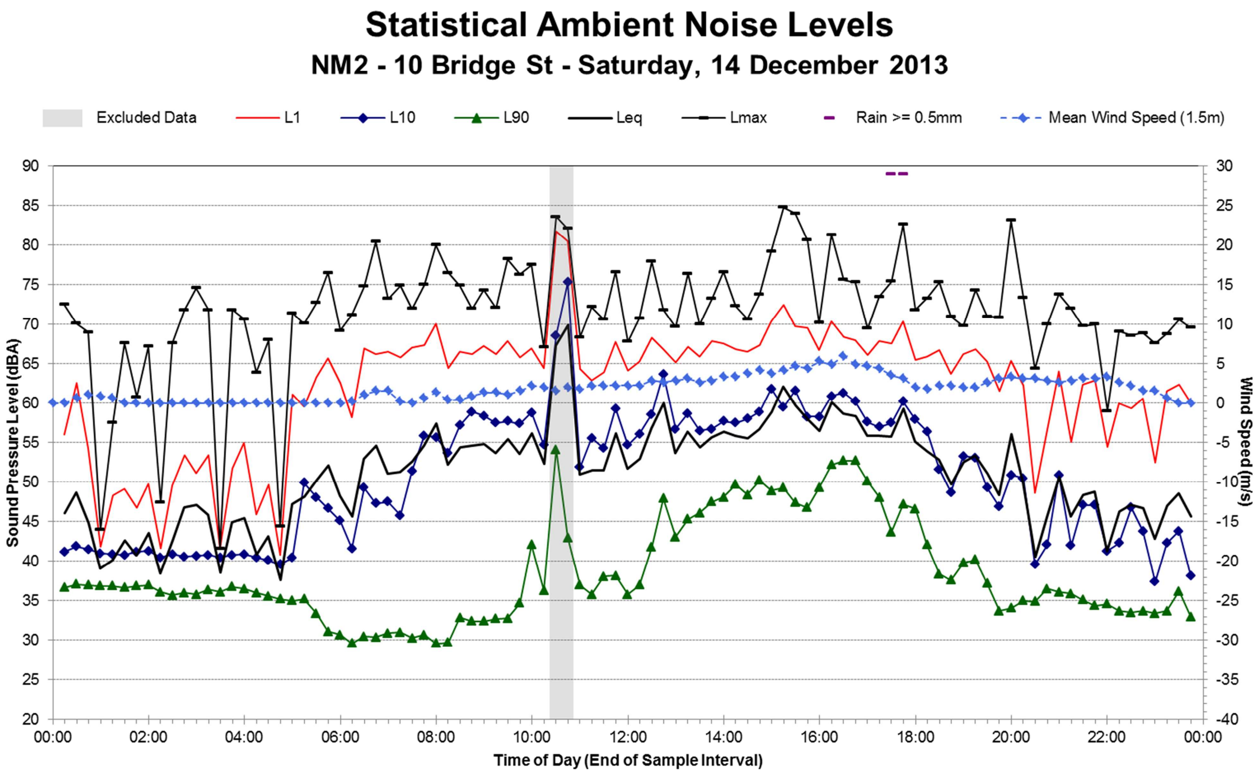
Statistical Ambient Noise Levels

NM2 - 10 Bridge St - Thursday, 12 December 2013



NM2 - 10 Bridge Street, Lawrence, NSW - Ambient Noise Monitoring Results

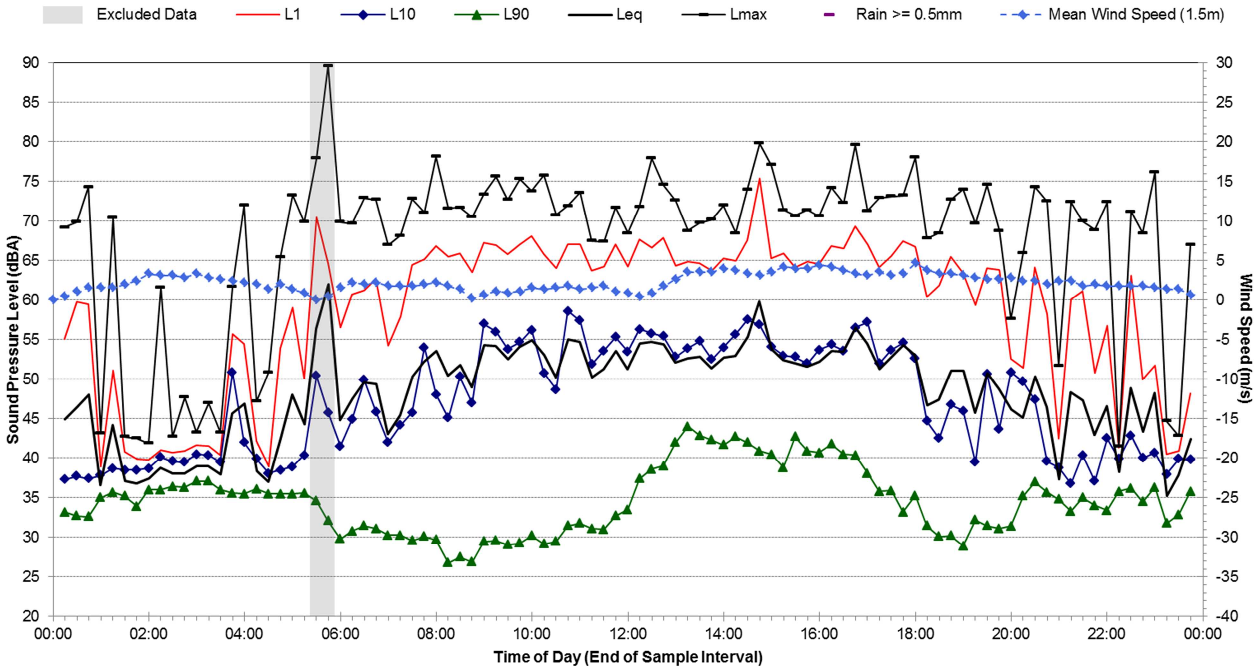




NM2 - 10 Bridge Street, Lawrence, NSW - Ambient Noise Monitoring Results

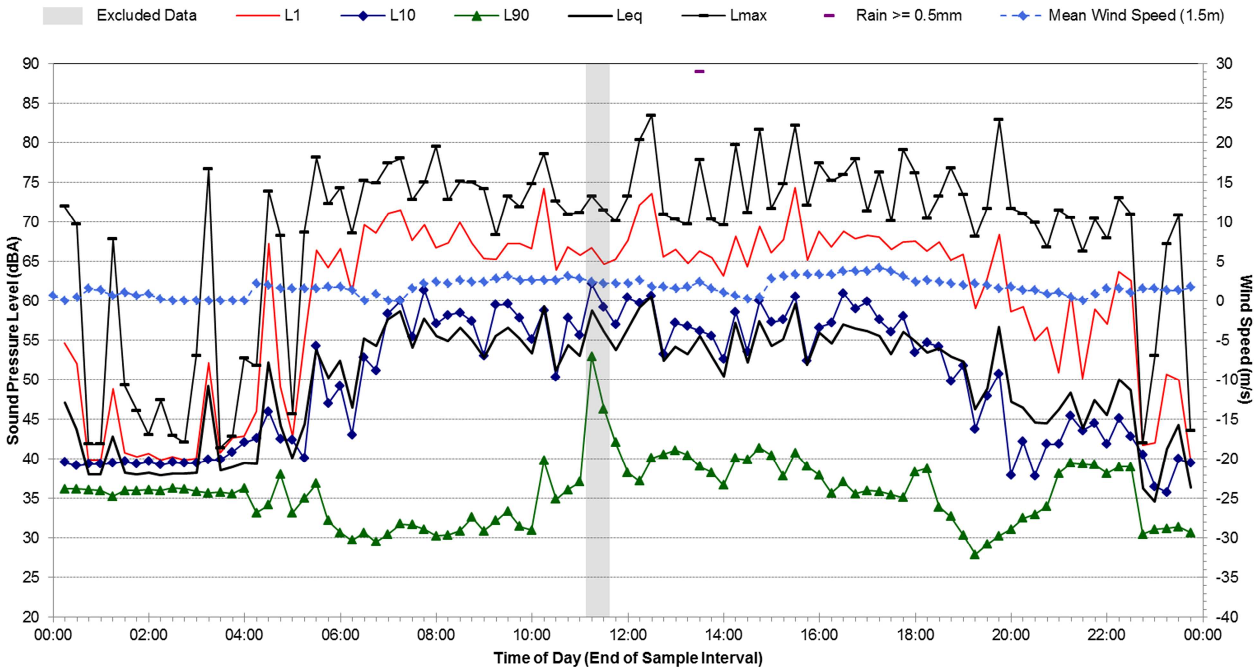
Statistical Ambient Noise Levels

NM2 - 10 Bridge St - Sunday, 15 December 2013

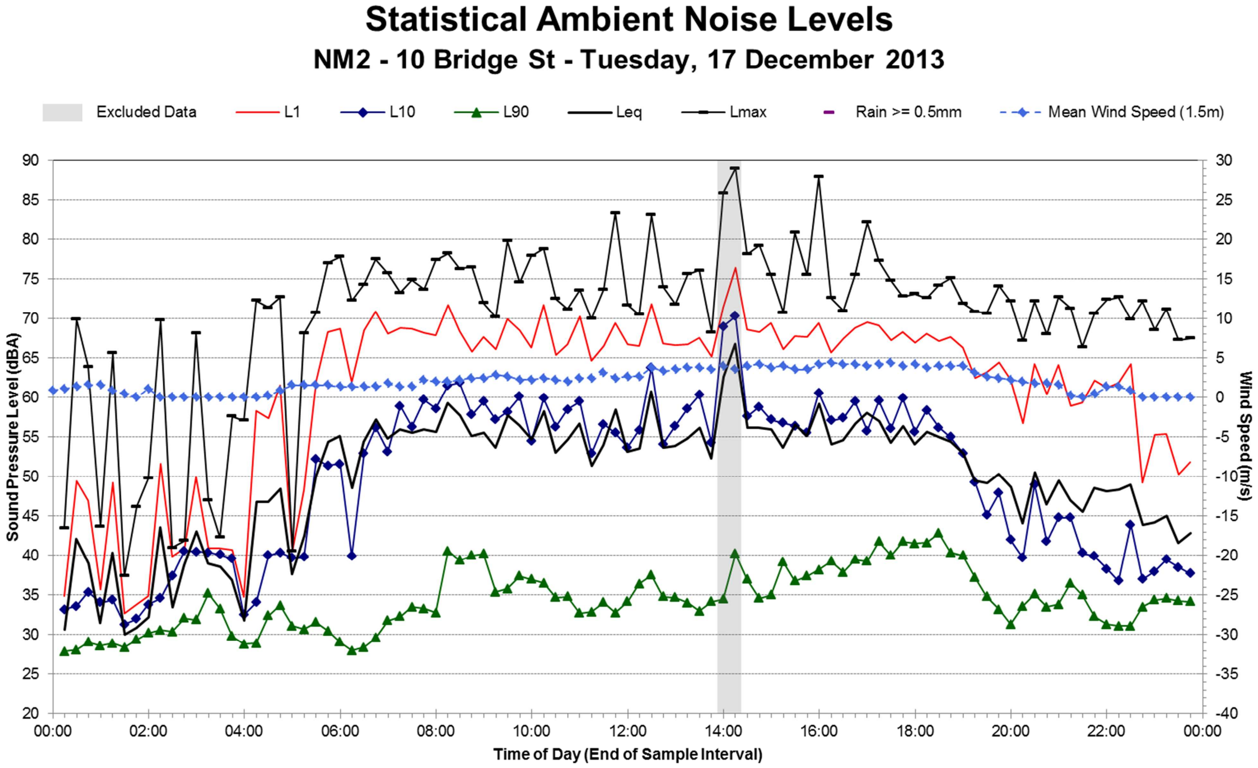


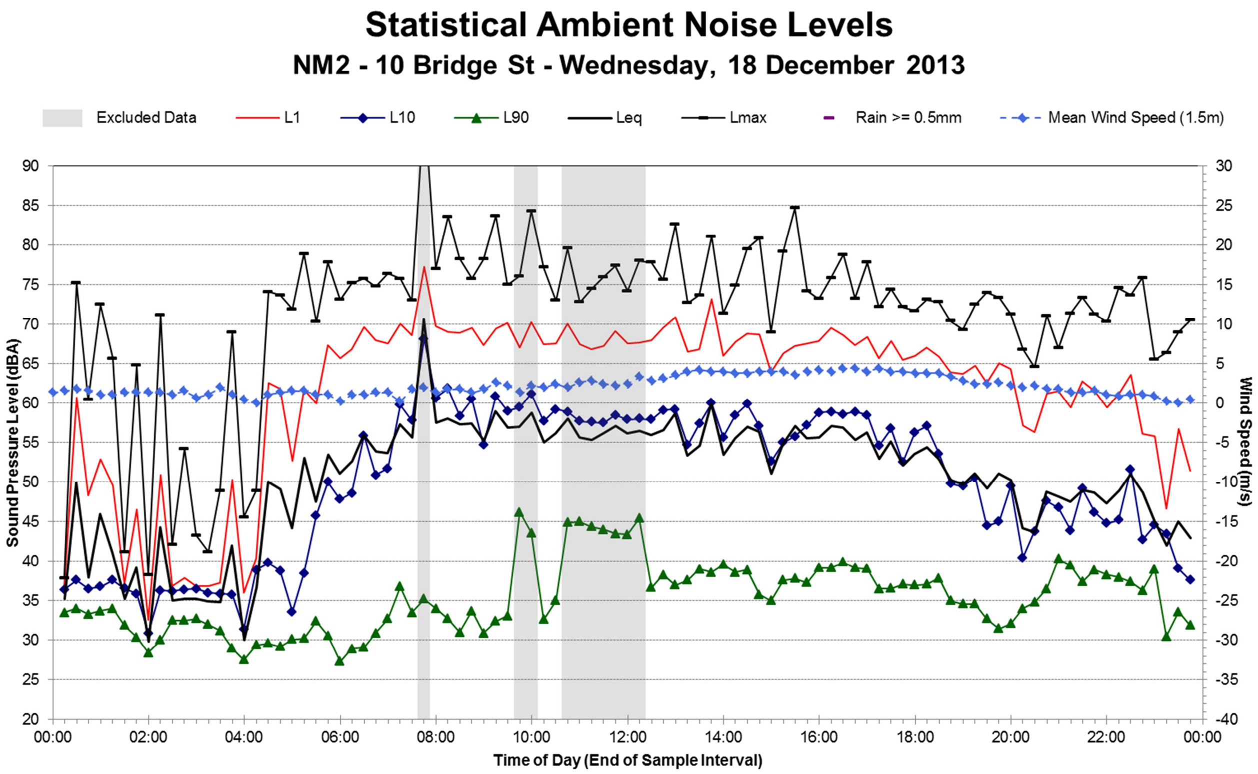
Statistical Ambient Noise Levels

NM2 - 10 Bridge St - Monday, 16 December 2013

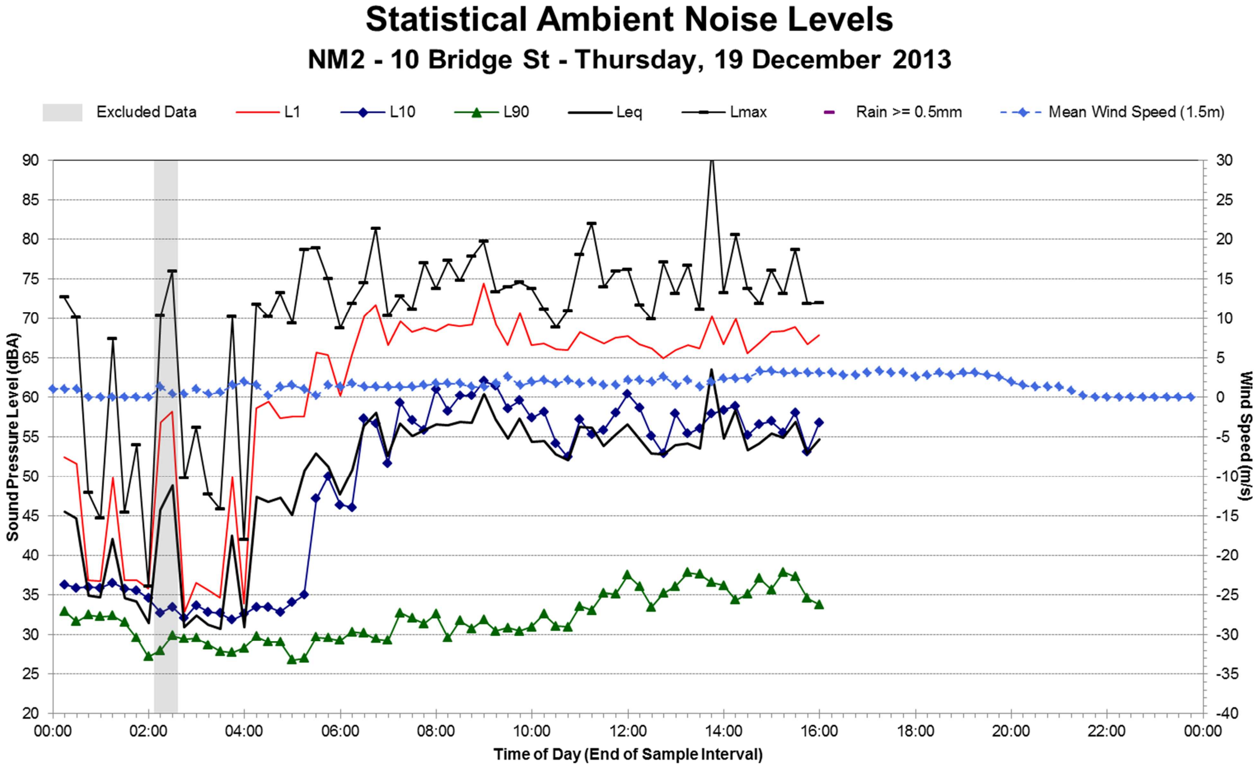


NM2 - 10 Bridge Street, Lawrence, NSW - Ambient Noise Monitoring Results





NM2 - 10 Bridge Street, Lawrence, NSW - Ambient Noise Monitoring Results



NM3 - 3 Grafton Street, Lawrence, NSW - Ambient Noise Monitoring Results

Noise Monitoring Location:	**NM3**
Noise Monitoring Address:	**3 Grafton Street, Lawrence, NSW**

Logger Device Type: Svantek 957
Logger Serial No: 21425

Ambient noise logger deployed immediately outside residential address 3 Grafton Street, Lawrence. Logger located in front yard, 1m from the eastern facade of the property.

Attended noise measurements indicate the ambient noise environment at this location is dominated by the natural environment and road traffic noise from Bridge Street

Analysis of the daytime ambient noise levels indicated that extraneous noise (expected to be Fauna) influences daytime L90 and Leq noise levels. Periods affected by extraneous noise have been filtered according to the procedure outlined in the NSW INP.

Recorded Noise Levels (LAmax):
Wind in trees: 50-54, Light road vehicle: 59, 4WD road vehicle: 59, Motorbike: 74, Insects: ~50

Map of Noise Monitoring Location

Ambient Noise Logging Results – INP Defined Time Periods

Monitoring Period	Noise Level (dBA)			
	RBL	LAeq	L10	L1
Daytime	32	51	53	60
Evening	32	48	48	57
Night-time	29	47	45	53

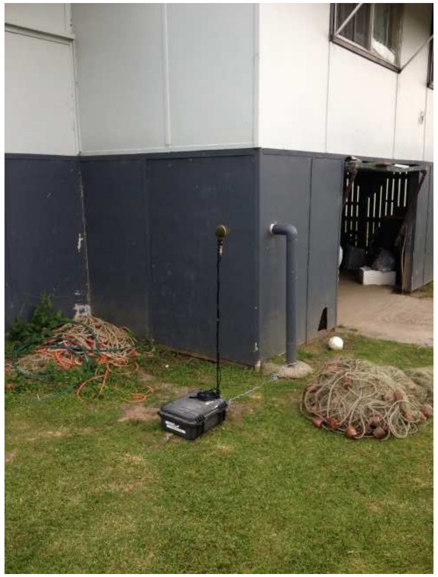
Ambient Noise Logging Results – RNP Defined Time Periods

Monitoring Period	Noise Level (dBA)		
	Weekday LAeq(Period)	Weekend LAeq(Period)	Weekly LAeq(Period)
Number of Valid Days	6	2	N/A (7 Day Average)
Number of Valid Nights	5	1	
Daytime (7am-10pm)	51	52	51
Night-time (10pm-7am)	48	42	47

Attended Noise Measurement Results

Date	Start Time	Measured Noise Level (dBA)		
		LA90	LAeq	LAmax
09/12/2013	15:32	47	54	74

Photo of Noise Monitoring Location



NM3 - 3 Grafton Street, Lawrence, NSW - Ambient Noise Monitoring Results