HEGGIES

REPORT 10-8928-R1

Revision 1

Acoustic Assessment
Proposed Residential Development
Allengrove Crescent, North Ryde

PREPARED FOR

EGC Custodian Services
Level 14, 345 George Street
Sydney NSW 2000

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Acoustic Assessment
Proposed Residential Development
Allengrove Crescent, North Ryde

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1 INTRODUCTION

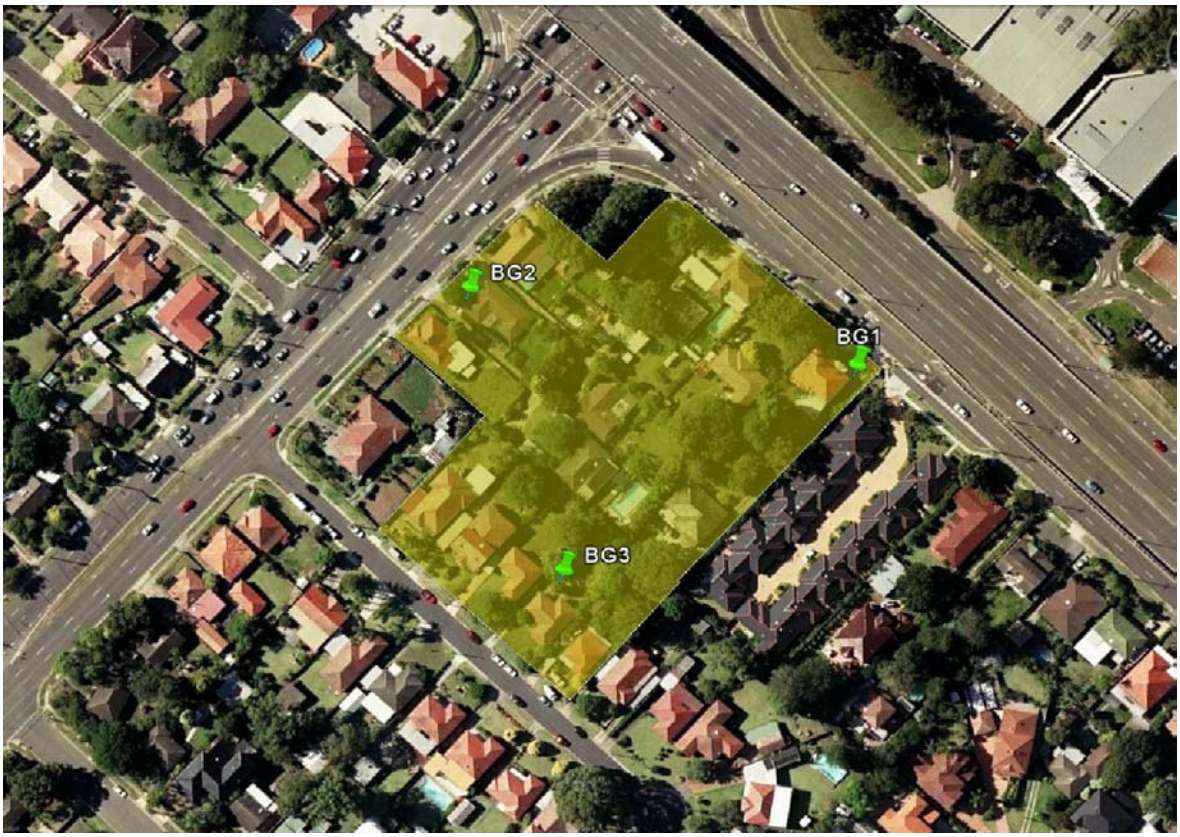
EGC Custodian Services is currently coordinating the residential development of the Allengrove Crescent site. Heggies Pty Ltd (Heggies) has been commissioned to conduct a strategic assessment of the existing and potential noise impacts for the proposed residential development.

The site is approximately 1.3 hectares and is bounded by Epping Road, Lane Cove Road, Allengrove Crescent and the existing residences to the south-east. The site is essentially square and comprises all the existing residences, with the exception of 1 Allengrove Crescent, which is located on the south-western corner.

2 SITE DESCRIPTION AND STUDY OVERVIEW

The proposed residential development site is presented graphically in **Figure 1**. It is proposed to be redeveloped to contain a mix of apartment buildings ranging in height from 3 to 10 storeys (refer **Figure 2** on page 10).

Figure 1 Proposed Residential Development Site and Noise Monitoring Locations



There are a traffic noise sources which have the potential to impact on the subject site, these include:

- Traffic noise from Epping Road to the north-east; and
- Traffic noise from Lane Cove Road to the north-west.

This report provides an overview of the relevant criteria and discussion of possible impacts that require further consideration, as the planning of the development progresses.

3 AMBIENT NOISE SURVEY

3.1 General

In order to quantify the prevailing noise environment, and in particular the level of traffic noise impacting on the site, noise surveys were conducted at selected locations.

3.1 Unattended Noise Monitoring

3.1.1 Methodology

Unattended noise monitoring was conducted at three representative locations on the site between Thursday 22 July and Monday 2 August 2010.

ARL Type 315 noise loggers were deployed to continuously record ambient noise levels. The locations where selected to determine traffic noise intrusion on the site from Epping Road and Lane Cove Road and ambient noise levels in the quieter residential area at the south east corner of the site shielded from traffic. The locations as identified in **Figure 1** are:

- BG1 118 Epping Road
  This location was chosen to provide an unshielded view of traffic from both Epping Road and the Epping Road off ramp. The logger was in a 'free field' at this location with the ambient noise environment dominated by traffic noise.
- BG2 261 Lane Cove Road
  This location was chosen to provide an unshielded view of traffic from Lane Cove Road. The logger was adjacent to the building façade (façade reflected) at this location with the ambient noise environment dominated by traffic noise.
- BG3 7 Allengrove Crescent
  At this location the noise logger was located in the rear yard, such that the house and other buildings provided shielding from Lane Cove Road. This location will be representative of potential residences on the south-eastern corner of the site, as well as existing residences on Allengrove Crescent, that are distant from and shielded from Lane Cove Road (and Epping Road) traffic.

All items of acoustic instrumentation employed during the noise monitoring surveys were designed to comply with the requirements of AS IEC 61672.1-2004: *"Electroacoustics-Sound level meters – Specifications"* and carried appropriate and current NATA (or manufacturer) calibration certificates.

The loggers were calibrated before and after the noise monitoring with a drift in noise levels not exceeding ±0.5 dBA. The sample time interval was set at 15 minutes and the time weighting function set to "Fast".

3.1.2 Ambient Noise Monitoring Results

The results of the ambient noise surveys are presented in tabular form in **Table 1** and **Table 2** and graphically in Appendices C1 to C3.

The NSW Department of Environment Climate Change and Water's (DECCW's) recommended noise criteria (Environmental Criteria for Road Traffic Noise (ECRTN)) are based on the noise level contributions from road traffic noise only. Therefore, in order for the measured data to reflect the prevailing levels of road traffic noise, the data was processed and some individual extraneous readings excluded taking into account:

- Prevailing weather conditions.

- Uncharacteristic changes in the noise indices which might be attributed to noise from lawn mowers, air-conditioners, owner's vehicle, etc, primarily indicated by sudden and uncharacteristic variations of the noise descriptors.

Table 1 presents ambient LAeq noise data relevant to the assessment of operational road traffic noise.

Table 1 Summary of Ambient LAeq Traffic Noise Indices

Noise Monitoring Location	Main Traffic Noise Indices			
	LAeq(15hour)	LAeq(9hour)	LAeq(1hour) – Daytime [1]	LAeq(1hour) – Night-time [1]
BG 1	67 dBA	62 dBA	68 dBA	64 dBA
BG 2	71 dBA	66 dBA	72 dBA	69 dBA

Notes 1. The LAeq(1hour) values shown are the upper ten percentile (or typical maximum) of the total 15 (daytime) and 9 (night-time) individual LAeq(1hour) measurements occurring over the survey duration.

To assess noise emission from future mechanical plant or similar facilities serving the proposed development, the data obtained from the noise logger at BG 3 has been processed in accordance with the procedures contained in the DECCW's *Industrial Noise Policy* (INP) to establish representative noise levels on site. The results of this analysis are presented in **Table 2**.

Table 2 Measured Ambient Noise Levels Corresponding to Defined INP Periods

Noise Monitoring Location	Measured RBL [1]			Measured LAeq Noise Level		
	Day	Evening	Night	Day	Evening	Night
BG 3	45 dBA	45 dBA	36 dBA	54 dBA	51 dBA	48 dBA

Notes 1, The Rated Background Level (RBL) is representative of the typical minimum background sound level. By definition, the RBL is the lowest 10 percent value of the 15 minute background noise level measurements taken over the assessment period.

2. The LAeq is the logarithmic average of the 15 minute sample in each assessment period (daytime, evening and night-time).

3.1.3 Statistical Noise Levels

The statistical descriptors shown on the graphs are:

- **LAeq** The LAeq is the energy-average sound level. It is defined as the steady sound level that contains the same amount of acoustical energy as a given time-varying sound.
- **LA90** The LA90 is the level of noise exceeded for 90% of the sample time (15 minutes). The LA90 noise level is described as the average minimum background sound level or simply the background level.
- **LA10** The noise level exceeded for 10% of the sample time (15 minutes) and is typically described as the average maximum noise level.
- **LA1** The noise level exceeded for 1% of the sample time (15 minutes) and representative of the highest noise level events (eg passing heavy vehicles, aircraft, etc).

4 NOISE CRITERIA

4.1 Road Traffic Noise Intrusion

The residential development has the potential to be impacted by traffic noise from existing traffic on Epping Road and Lane Cove Road.

Traffic noise criteria have been based on DECC criteria and relevant Australian Standards.

4.1.1 External Traffic Noise Criteria

Responsibility for the control of noise emission in New South Wales is vested in Local Government and the DECCW, formerly the *Environment Protection Authority* (EPA), and traffic noise emission impacting on the proposed development should be assessed in accordance with the NSW Government's ECRTN for vehicle-related noise emissions on public roads.

The ECRTN presents recommended road traffic noise criteria for various types of road and land use developments. From a road classification perspective both Epping Road and Lane Cove Road would be arterial (or at least sub-arterial) roadways. The criteria relating to new residential developments affected by freeway/arterial road networks is summarised in **Table 3.**

Table 3 Acceptable Road Traffic Noise Levels for New Residential Developments

Type of Development	Criteria		
	Day (7am to 10pm)	**Night (10pm to 7am)**	**Where Criteria are Already Exceeded**
New residential land use developments affected by freeway / arterial traffic noise.	$L_{Aeq(15hr)}$ 55 dBA	$L_{Aeq(9hr)}$ 50 dBA	Where feasible and reasonable, existing noise levels should be reduced to meet the noise criteria via judicious design construction of the development. Locations, internal layouts, building materials and construction should be chosen so as to minimise noise impacts.

Notes 1. The criteria presented are 'façade reflected' noise levels.

It should be noted that the noise criteria presented within the ECRTN noise policy document are guidelines and non-mandatory. In achieving compliance with the noise criteria, consideration needs to be given to aesthetics, cost implications, equity, community preferences and practicality.

Although ECRTN does not explicitly provide specific internal noise criteria for dwellings, it does suggest that night-time noise levels between 35 dBA and 40 dBA within sleeping spaces and noise levels 10 dBA lower than the external daytime criteria (i.e. 45 dBA in this case) within other habitable spaces may be taken as satisfactory internal noise levels.

4.1.2 Internal Traffic Noise Criteria

The NSW Department of Planning *'Development near Rail Corridors and Busy Roads – Interim Guideline'* provides noise criteria for residential buildings and these are presented in **Table 4**.

Table 4 DoP Interim Guideline Noise Criteria

Residential Buildings		
Type of occupancy	Noise Level dBA	Applicable time period
Sleeping areas (bedroom)	35	Night 10 pm to 7 am
Other habitable rooms (excl. garages, kitchens, bathrooms & hallways)	40	At any time

Notes 1. Airborne noise is calculated as $L_{Aeq(15h)}$ daytime and $L_{Aeq(9h)}$ night-time

Furthermore the following guidance to the criteria is provided in the guideline:

'These criteria apply to all forms of residential buildings as well as aged care and nursing home facilities. For some residential buildings, the applicants may wish to apply more stringent design goals in response to market demand for a higher quality living environment.

The night-time 'sleeping areas' criterion is 5 dBA more stringent than the 'living areas' criteria to promote passive acoustic design principles. For example, designing the building such that sleeping areas are less exposed to road or rail noise than living areas may result in less onerous requirements for glazing, wall construction and acoustic seals. If internal noise levels with windows or doors open exceed the criteria by more than 10 dBA, the design of the ventilation for these rooms should be such that occupants can leave windows closed, if they so desire, and also to meet the ventilation requirements of the Building Code of Australia.'

It is noted the outside to inside noise reduction with windows open is typically 10 dBA, therefore the external criteria for mechanical ventilation is an LAeq(9hr) of 45 dBA for bedrooms and LAeq(15hr) of 50 dBA for other areas.

4.2 Noise Emissions from the Development

The noise emission from mechanical plant associated with the residential development should be controlled to avoid impacting upon the acoustic amenity of the surrounding residences, and residences within the development.

Industrial noise emissions should aim to comply with the DECCW's *Industrial Noise Policy* (INP), which provides a framework and process for deriving noise criteria. The INP criteria for industrial/commercial noise sources have two components:

- Controlling the intrusive noise impacts for residents and other sensitive receivers in the short term; and
- Maintaining noise level amenity for particular land uses for residents and sensitive receivers in other land uses.

4.2.1 Assessing Intrusiveness

For assessing intrusiveness, the background noise generally needs to be measured. The intrusiveness criterion essentially means that the equivalent continuous noise level (L_{Aeq}) of the source should not be more than 5 dBA above the measured Rated Background Level (RBL), over any 15 minute period.

4.2.2 Assessing Amenity

The amenity criterion is based on land use and associated activities (and their sensitivity to noise emission). The cumulative effect of noise from industrial sources needs to be considered in assessing the impact. The criteria relate only to other industrial-type noise sources and do not include road, rail or community noise. The existing noise level from industry is measured. If it approaches the criterion value, then noise levels from new industrial-type noise sources, (including air-conditioning mechanical plant) need to be designed so that the cumulative effect does not produce total noise levels that would significantly exceed the criterion. For areas of high road traffic, there are further considerations that influence the selection of the noise criterion.

4.2.3 Project Specific Noise Levels

Having defined the area type, the processed results of the unattended noise monitoring have been used to generate project specific noise criteria.

Since the noise environment at the monitoring site used to establish industrial noise criteria is not controlled by industrial type noise sources (it is largely transportation noise) the project specific noise levels, which are shown in bold in **Table 5**, are the lower of the ANL or intrusive criteria.

Table 5 Criteria for Mechanical Noise Emissions to Nearby Residences

Location	Time of Day	Noise Level dBA re 20 µPa				
		ANL[1] L_{Aeq} (period)	Measured RBL[2] $L_{A90(15minute)}$	Measured Noise Level $L_{Aeq(15minute)}$	Criteria for New Industrial Sources	
					Intrusive	Amenity Criteria
					$L_{Aeq(15minute)}$	L_{Aeq} (per period)
BG 1	Day	55	45	54	50	**44**
	Evening	45	45	51	50	**41**
	Night	40	36	48	41	**38**

Notes
1. ANL Acceptable Noise Level for a suburban area.
2. RBL Rating Background Level.
3. Assuming existing noise levels unlikely to decrease in the future, and assuming no existing industrial noise.
4. Project Specific Criteria are shown in bold

The criteria provided on the right-hand column of **Table 5** will apply to noise contribution from noise sources (ie air-conditioning, carpark exhaust fans etc), should such activities be included as part of the development.

5 NOISE MODELLING

A simple noise model of the project area was carried out using noise modelling software. The program implements the UK Department of Transport, *"Calculation of Road Traffic Noise"* (CoRTN 1988) algorithms. The modelling allows for traffic volume and mix, vehicle speed, type of road surface and angle of view. Based on the measured traffic noise levels at BG1 and BG2, and known distances to the roadside kerb, the noise model was calibrated and traffic noise levels have been predicted across the site.

The modelling indicates that without any barriers, an offset or buffer distance of more than 240 m from Lane Cove Road and 180 m from the Epping Road off-ramp would be required to achieve the ECRTN criterion. The corresponding DoP Interim Guideline Noise Criteria is nominally 5 dBA more stringent for mechanical ventilation, and the corresponding distances are 500 m from Lane Cove Road and 360 m from the Epping Road off-ramp.

Whilst this offset can be significantly reduced (or eliminated) by incorporating sufficiently high boundary walls (that act as a noise barrier) along the road boundaries these are not considered practical for the multilevel residential buildings proposed. Without noise walls dwellings will be required to incorporate façade treatments or locate habitable areas away from the impacted façade.

5.1 Façade Noise Levels

A concept plan for residential development on the site has been developed by Candalepas Associates and this has been reproduced in **Figure 2**.

Figure 2 Concept Plan

Traffic noise levels have been predicted at the building facades for comparison with the DoP Interim Guideline Noise Criteria and are presented in **Table 6**. .

Table 6 Building Façade Predicted Traffic Noise Levels

Building	Facade	Predicted Daytime/Night Noise Level in dBA	Mechanical Ventilation	Required Building Noise Reduction
Northern	North - east end	67/62	Y	27
	North – west end	68/63	Y	28
	West	69/65	Y	30
	South – west end	65/61	Y	26
	South - centre	58/53	Y	18
Central	North – west end	65/61	Y	26
	North – centre	58/53	Y	18
	West	68/64	Y	29
	South – west end	65/61	Y	26
	South - centre	62/58	Y	23
Southern	North – west end	60/56	Y	21
	North – centre	57/53	Y	18
	West	66/62	Y	27
	South – west end	60/56	Y	21
	South - centre	61/57	Y	22

Notes 1. The predicted noise levels are for upper levels and do not include the effects of topography, or any potential shielding at the lower building levels.

The table shows predicted noise levels for the daytime period (7.00 am to 10.00 pm) and night-time (10.00 pm to 7.00 am) at location representative along the building facades. Mechanical ventilation will be required where the predicted noise level exceeds 50 dBA during the daytime or 45 dBA during the night-time. The required building noise reduction refers to the outside to inside noise reduction with windows closed to achieve the internal noise levels presented in **Table 4.**

Note the predicted noise levels presented in **Table 6** are indicative only and as part of the detailed design for the project it is anticipated the computer model would be refined to consider building shielding, ground topography, angle of view etc.

5.2 Architectural Façade Treatments - Overview

Noise ingress generally involves several pathways, and is most common via the windows, doors, ventilation openings and roofs. The overall sound reduction of a building element is dependent upon the mass of the construction, the effective area and the extent of any gaps or openings. Glazing on facades exposed to traffic noise usually represents the “weak acoustic link” in any building construction.

The typical outdoor to indoor noise reductions provided by most standard dwellings (ie without special acoustical treatment) is generally accepted as being 10 dBA with windows open (allowing for natural ventilation) and 25 dBA with windows closed. To increase the outdoor to indoor noise reduction to 30 dBA (which will be required to some parts of the proposed development) will involve the upgrading of the glazing, which includes the provision of quality seals such that the integrity of the window/balcony door system is maintained.

The selection of enhanced glazing should be made at the detailed design stage when the building envelope and construction details are known. When determining glazing requirements for affected residences, the following parameters need to be considered:

- Typical traffic noise spectrum measured on site.
- Calculated road traffic noise at the assessment locations.

- Room dimensions and internal finishes.
- Window area.

To provide an outdoor to indoor noise reduction of 30 dBA indicatively 6.38 mm laminate glazing for glass areas of less than 1.8 m^2 and 10.38 mm laminate glazing for glass areas more than 1.8 m^2 would be required combined with quality window sealing, with the provision of solid core doors with seals.

6 CONCLUSION

A noise impact assessment has been conducted in relation to the proposed residential development at Allengove Crescent, North Ryde.

An ambient noise survey was conducted to determine the traffic noise intrusion on the site. Based on the noise survey results, traffic noise levels have been predicted at the facades of a concept plan for residential buildings on the site.

The predicted traffic noise levels have been compared to the NSW Department of Planning *'Development near Rail Corridors and Busy Roads – Interim Guideline'.* The guideline recommends internal noise levels of 35 dBA for bedrooms and 40 dBA for other habitable rooms (excluding bathrooms, garages etc). Furthermore if internal noise levels with windows or doors open exceed the criteria by more than 10 dBA, the design of the ventilation for these rooms should be such that occupants can leave windows closed, if they so desire, and also to meet the ventilation requirements of the Building Code of Australia.

Based on the predicted traffic noise levels the required building (or façade) noise reduction ranges from 18 dBA to 30 dBA. Furthermore in accordance with the *Interim Guideline* it is likely that mechanical ventilation will be required to most of the living and bedroom areas within the residential buildings.

The required building façade construction to achieve the required traffic noise reduction will range from 'standard' construction to 'upgraded' where the upgraded will indicatively comprise heavier glazing in window and door frames with quality seals. Such treatments would be determined during the detailed design coupled with development of the building envelopes and internal layout details.

Compliance with the relevant noise criteria can be achieved with standard building design and construction methods and therefore the noise impacts do not preclude the residential development of the site as proposed.

Details of the requirements of the *Industrial Noise Policy* (which apply to any mechanical plant within the site) are provided for future reference.

ACOUSTIC TERMINOLOGY USED IN THE REPORT

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.

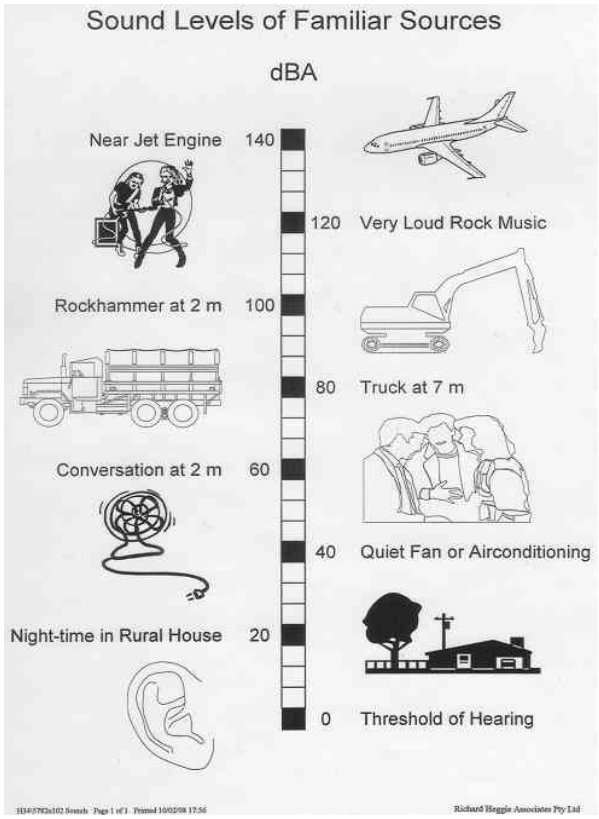
The symbols SPL, L or L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-5} Pa.

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



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.

2 Sound Power Level

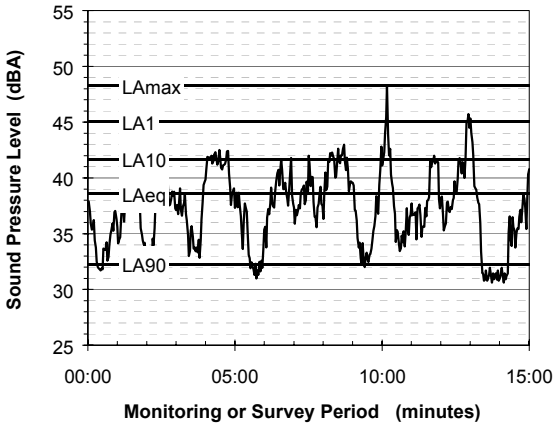
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_W, or by the reference unit 10^{-12} W.

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.

3 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_{Amax} The maximum noise level of the 15 minute interval.

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 DECCW. In addition the method produces mean or "average" levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc).

ACOUSTIC TERMINOLOGY USED IN THE REPORT

4 Tonality

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

5 Impulsiveness

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

6 Frequency Analysis

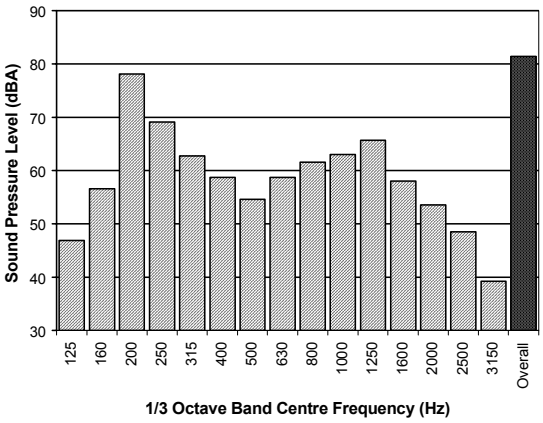
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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.



7 Vibration

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

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

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. 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.

8 Human Perception of Vibration

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

9 Over-Pressure

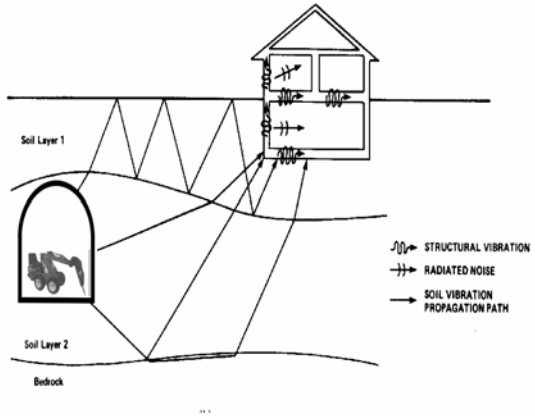
The term "over-pressure" is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

10 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.

GLOSSARY AND ABBREVIATIONS

ABL	Assessment Background Level - In accordance with the INP, the single figure background noise level representing each assessment period - day, evening and night. The ABL noise level is determined by calculating the lower 10 percentile level of all $L_{A90(15minute)}$ samples for each assessment period.
Ambient Noise	The all-encompassing noise associated with a given environment. It is the composite of sounds from many sources, both near and far.
Amenity Noise Criteria	Industrial noise level within each INP time period (day, evening and night) deemed acceptable by the INP Policy for specific to land use and area usage.
AS	Australian Standard
Attenuation	The reduction of noise level.
A-weighting	Adjustment carried out to the measured noise spectra via use of an electronic filter, to approximate the response of the human ear.
Background Noise	The underlying level of noise present in the ambient noise, excluding the noise source under investigation, when extraneous noise is removed. This is described using the L_{A90} statistical noise descriptor.
Compliance	Where noise levels meet noise level goals, noise criteria, or noise requirements.
Concept design	Initial functional layout of a concept, such as a road or road system, providing a level of understanding leading to later establishment of detailed design parameters.
CORTN	Calculation of Road Traffic Noise - United Kingdom Department of Transport guidelines for the calculation of road traffic noise.
Day	For industrial noise, in accordance with the INP, it is the period from 07.00 am to 6.00 pm (Monday to Sunday).
DECCW	NSW Department of Environment, Climate Change and Water formerly known as the Environment Protection Authority (EPA) and the Department of Environment and Conservation (DEC) and the Department of Environment and Climate Change (DECC).
DoP	NSW Department of Planning
dB	Abbreviation for decibel - a unit of sound measurement. It is equivalent to 10 times the logarithm (to base 10) of the ratio of a given sound pressure to a reference pressure.
dBA	A-weighted decibel: A single number measurement of the sound pressure based on the decibel but weighted to approximate the response of the human ear with respect to frequencies.
ECRTN	Environmental Criteria for Road Traffic Noise NSW Government's policy in relation to the assessment of road traffic noise impacts.

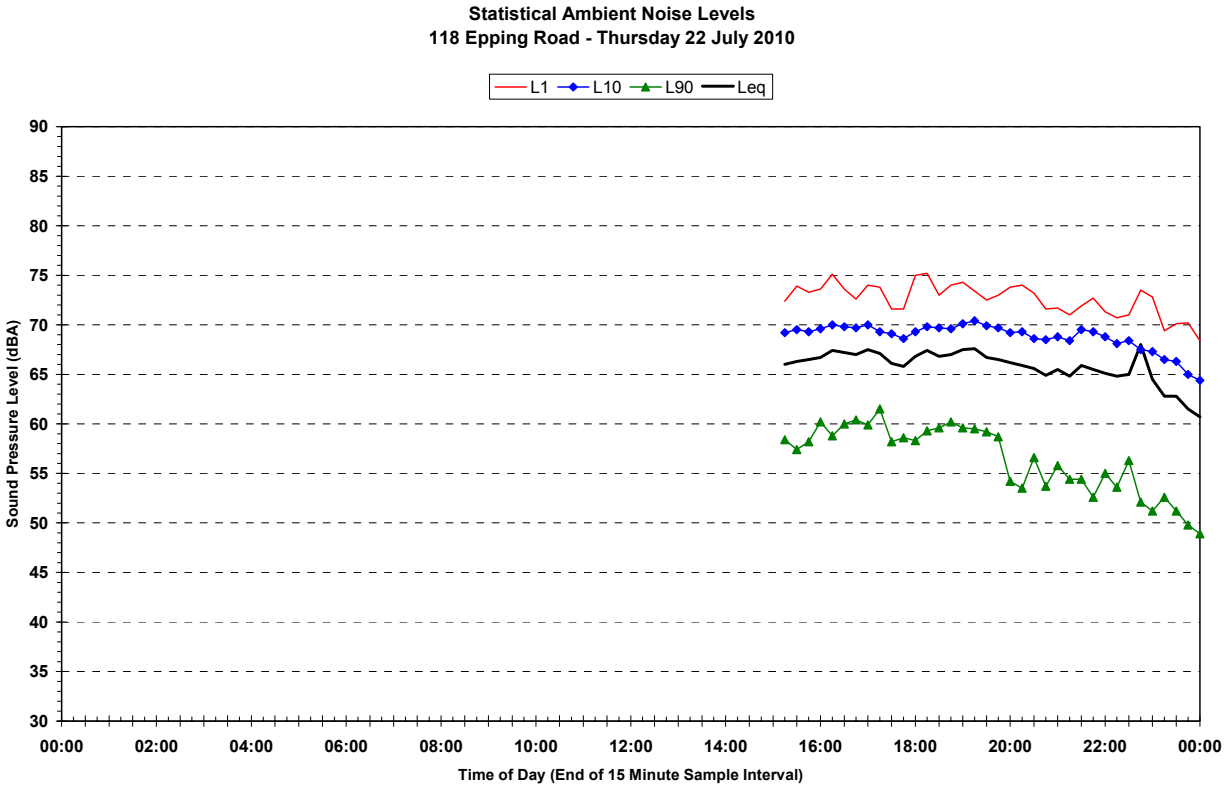
GLOSSARY AND ABBREVIATIONS

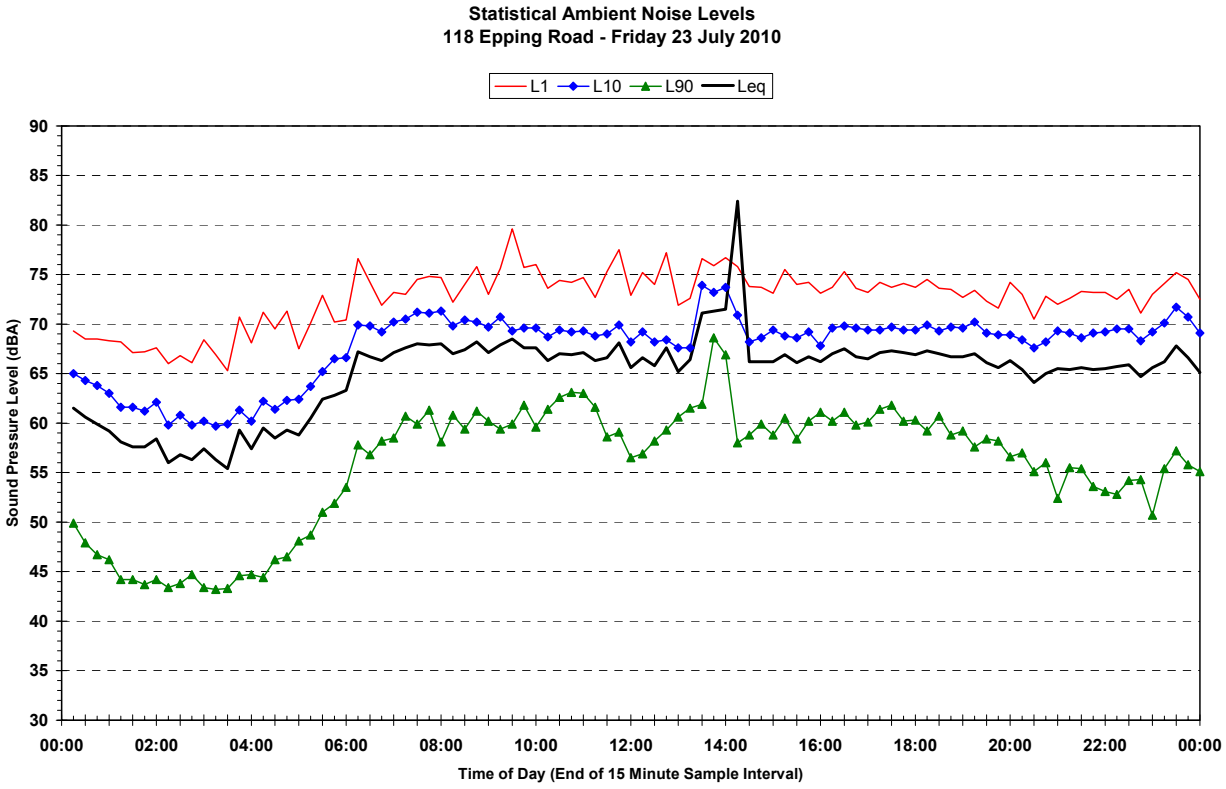
EIS	Environmental Impact Statement - A study that assesses potential environmental and social impacts associated with the construction and operation of a project.
EPA	Environment Protection Authority, now known as the Department of Environment and Conservation.
Evening	For industrial noise, in accordance with the INP, it is the period from 6.00 pm to 10.00 pm (Monday to Sunday).
Feasible and Reasonable	Terms used in relation to noise mitigation measures: Feasibility relates to engineering considerations and what is practical to achieve in terms of mitigation. Reasonableness relates to the application of judgement in arriving at a decision.
Guideline	Information intended to provide advice on a procedure. Guidelines are non-mandatory.
Heavy Vehicle	A truck, transport or other vehicle with a gross vehicle weight above a specified level (for example over 8 tonnes).
Heggies	Heggies Pty Ltd
INP	Industrial Noise Policy (INP) - the NSW Government's INP is administered by the DECCW. The policy provides a framework and process for assessment of industrial noise including deriving noise limits, conditions for consents and licenses that will enable the DEC to regulate premises.
Intrusive Noise Criteria	Noise level for each INP time period (day, evening and night) above which the industrial noise contribution from a particular industrial noise source is expected to clearly noticeable and potentially objectionable. The noise criteria are dependant on the underlying background noise level.
L_{Amax}	Maximum noise level measured at a given location.
L_{AN}	L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period
L_{A1}	The A-weighted sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{A10}	The sound pressure level that is just exceeded for 10% of the time for which the given sound is measured. This descriptor is often referred to as the average maximum noise level. During a 15 minute survey, it would represent the loudest 90 seconds.
L_{A90}	The A-weighted sound pressure level that is just exceeded for 90% of the time over which a given sound is measured. This is considered to represent the background noise. This descriptor is often referred to as the average minimum noise level. During a 15 minute survey, it would represent the quietest 90 seconds.

GLOSSARY AND ABBREVIATIONS

L_{Aeq}	Equivalent A-weighted sound pressure level - the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level occurring over that period.
$L_{Aeq(15minute)}$	The L_{Aeq} noise level over a 15 minute period. In accordance with the NSW INP's intrusive criteria, $L_{Aeq(15minute)}$ from industry is assessed against the RBL + 5 dBA.
$L_{Aeq(period)}$	The L_{Aeq} noise level over the relevant assessment period. Based on the NSW INP, day is 7:00 am to 6.00 pm, evening 6.00 pm to 10:00 pm and night 10.00 pm to 7.00 am. In accordance with the INP's amenity criteria, $L_{Aeq(period)}$ from industry is assessed against the appropriate day/evening/night amenity goal.
Level	The level of noise, usually expressed in dBA, as measured by a standard sound level meter with a pressure microphone. The sound pressure level in dBA gives a close indication of the subjective loudness of the noise.
Mitigation	Measure to manage and minimise noise impacts.
Night	For industrial noise, in accordance with the INP, it is the period from 10.00 pm to 6.00 am (Monday to Sunday).
Noise Level Goal or Noise Level Objective	A noise level that should be adopted for planning purposes as the highest acceptable noise level for the specific area, land use and time of day
Noise Logger	An electronic sound level logging device which continuously monitors the ambient noise and stores L_{AN} statistical noise levels over a given pre-set sample time period.
RBL	A single statistical noise descriptor describing the L_{A90} background noise level of the relevant assessment period. In accordance with the INP, the Rating Background Level (RBL) for each assessment period is obtained by calculating the median values of the relevant day/evening/night assessment background levels (ABLs), for each day of the survey. For example, for a weeks worth of monitoring, the night RBL is the median of the seven ABLs.
RTA	Roads and Traffic Authority

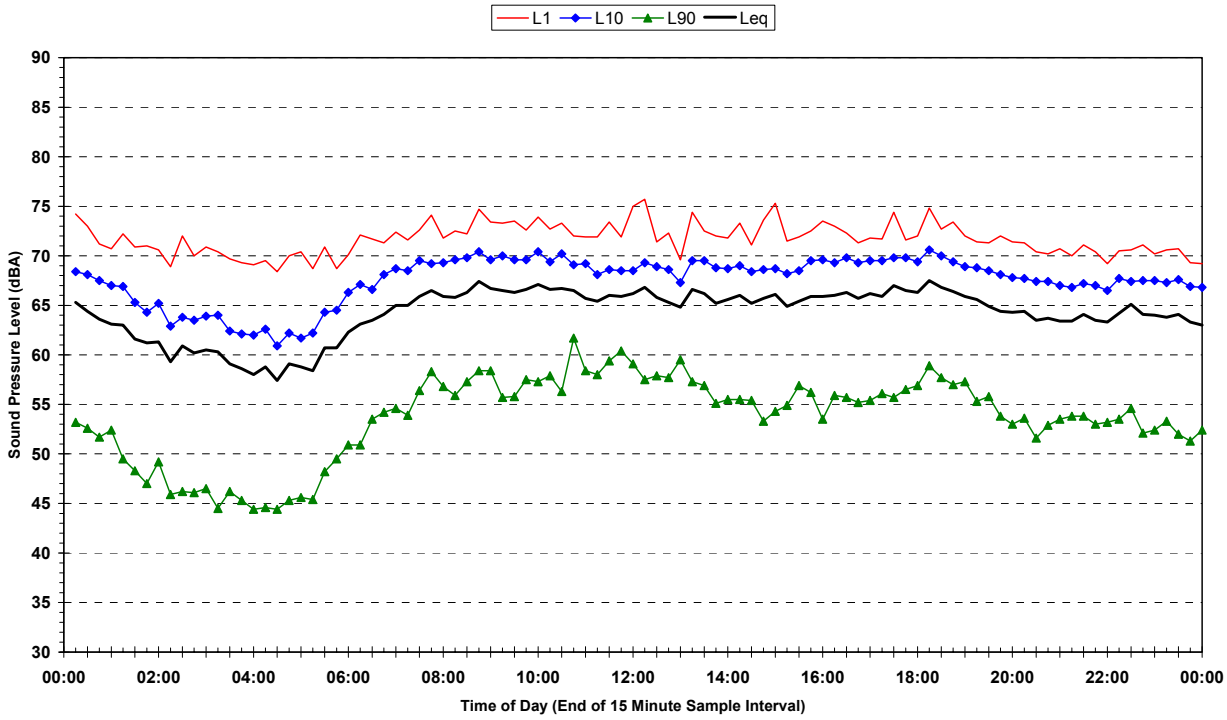
UNATTENDED AMBIENT NOISE DATA – 118 EPPING ROAD



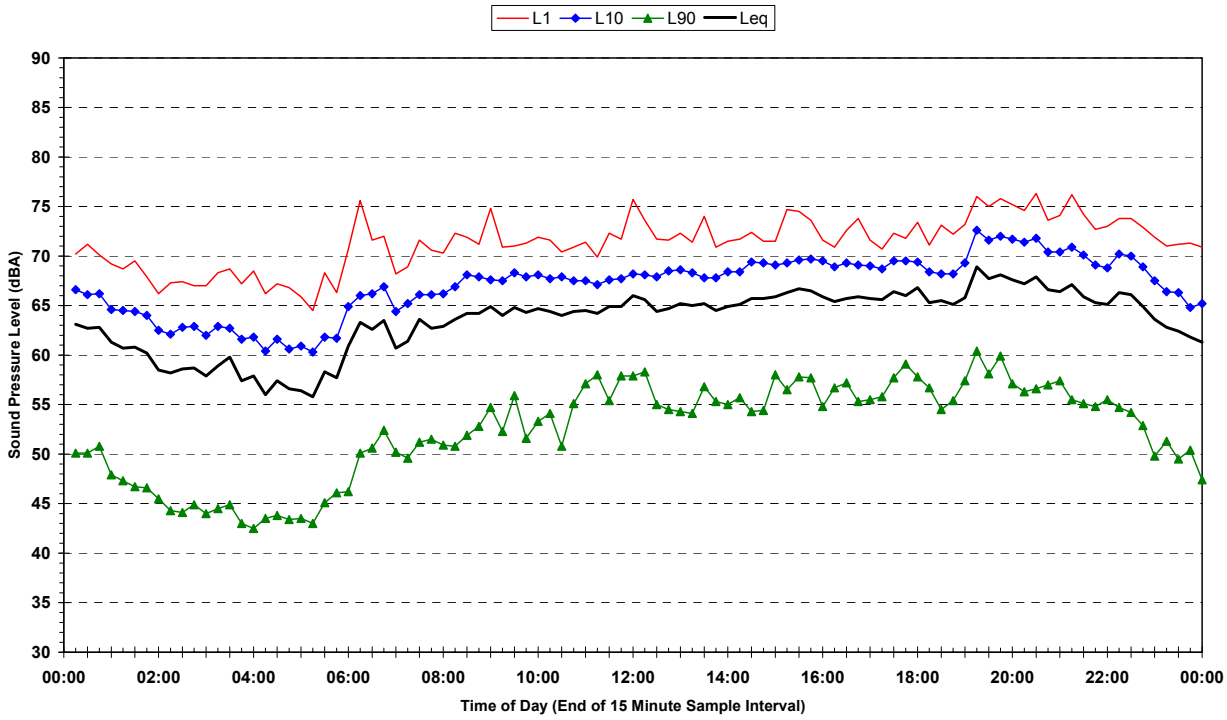


UNATTENDED AMBIENT NOISE DATA – 118 EPPING ROAD

Statistical Ambient Noise Levels
118 Epping Road - Saturday 24 July 2010

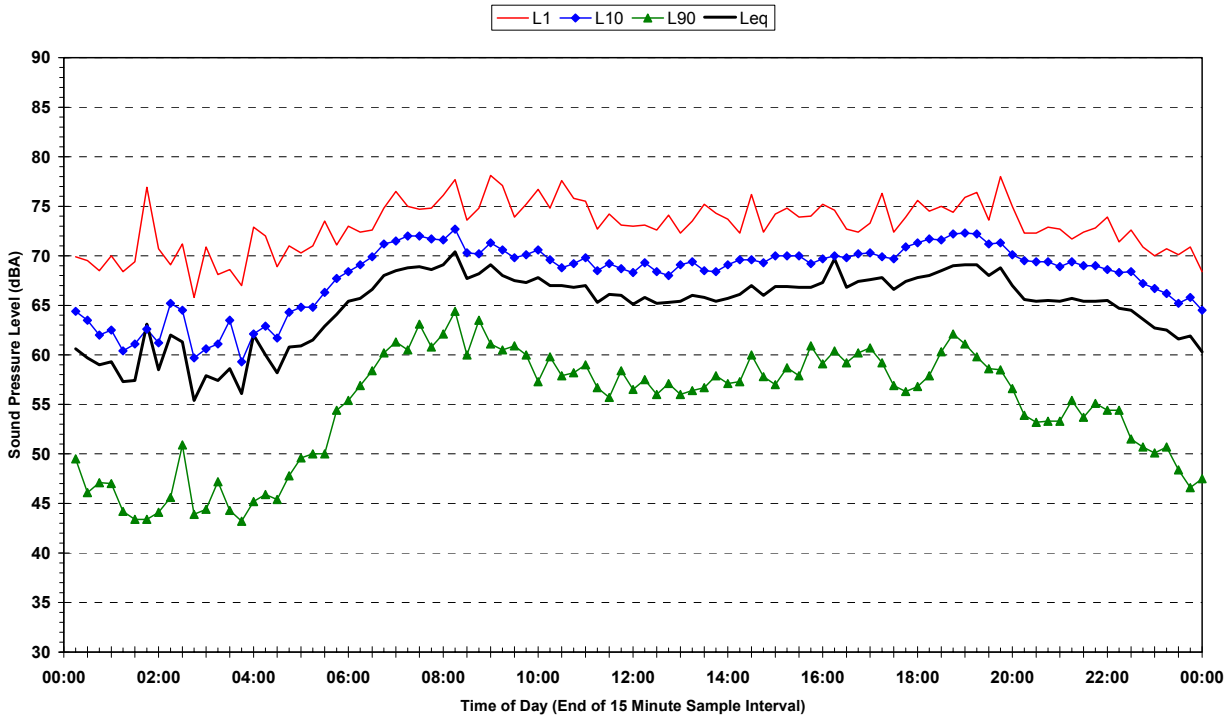


Statistical Ambient Noise Levels
118 Epping Road - Sunday 25 July 2010

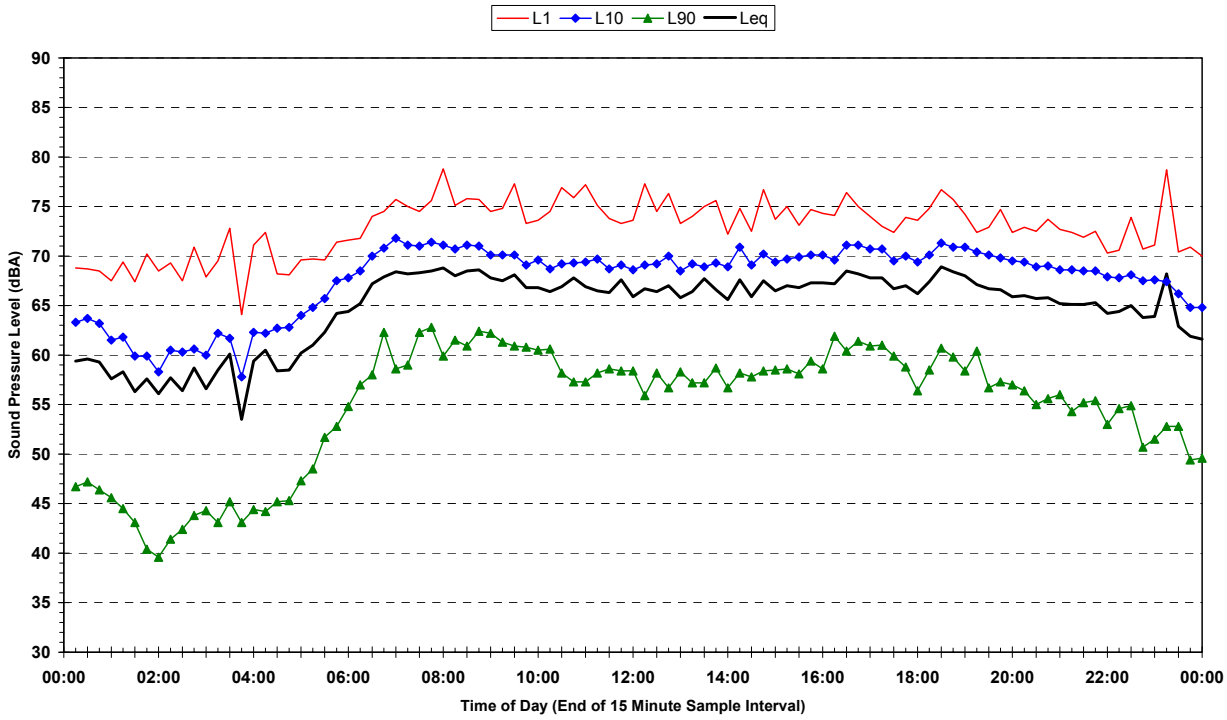


UNATTENDED AMBIENT NOISE DATA – 118 EPPING ROAD

Statistical Ambient Noise Levels
118 Epping Road - Monday 26 July 2010

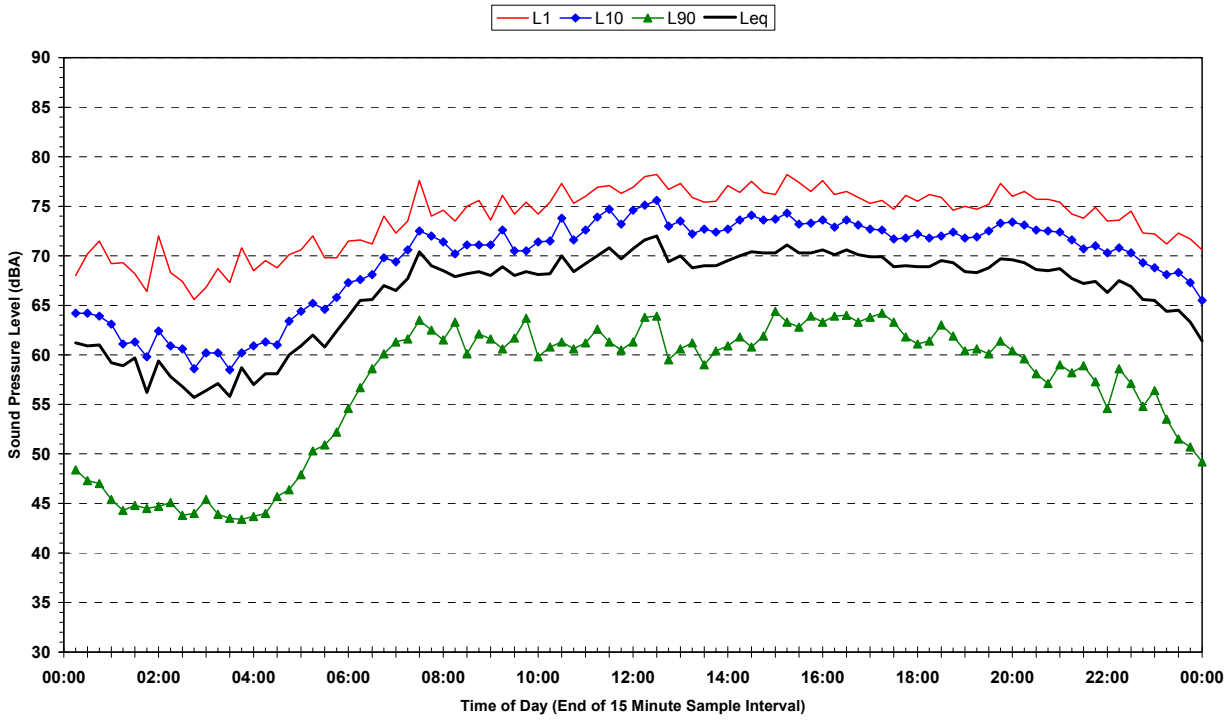


Statistical Ambient Noise Levels
118 Epping Road - Tuesday 27 July 2010

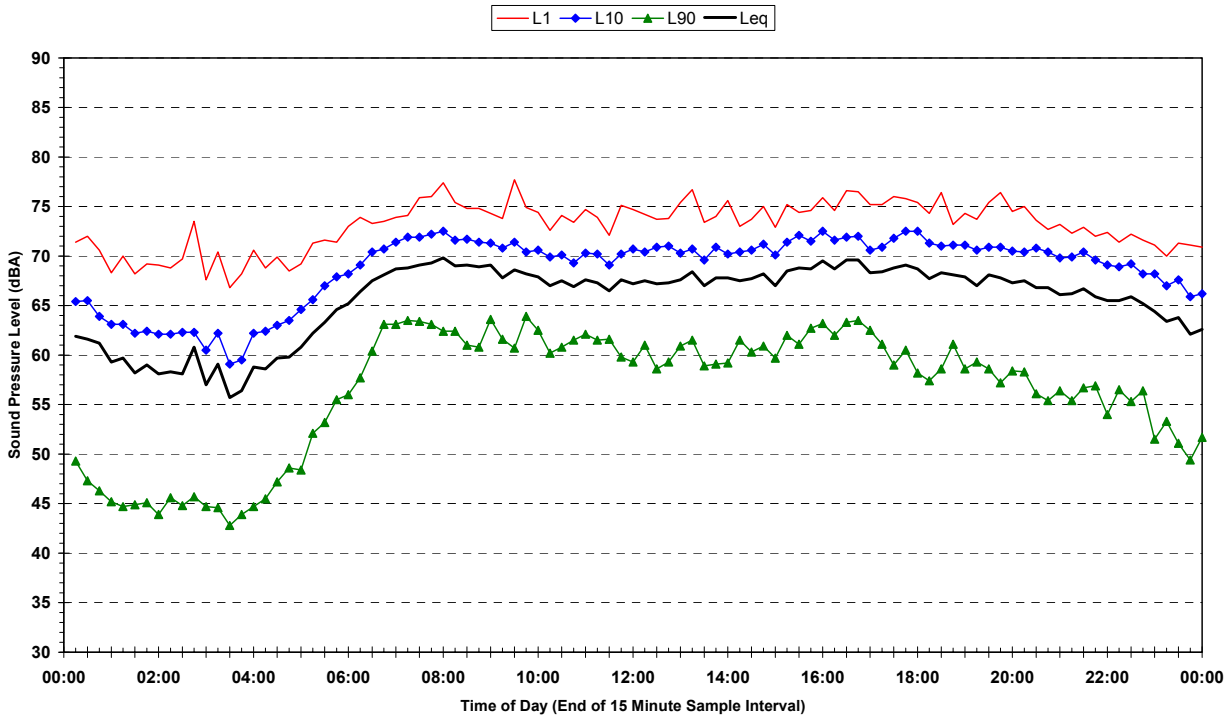


UNATTENDED AMBIENT NOISE DATA – 118 EPPING ROAD

Statistical Ambient Noise Levels
118 Epping Road - Wednesday 28 July 2010

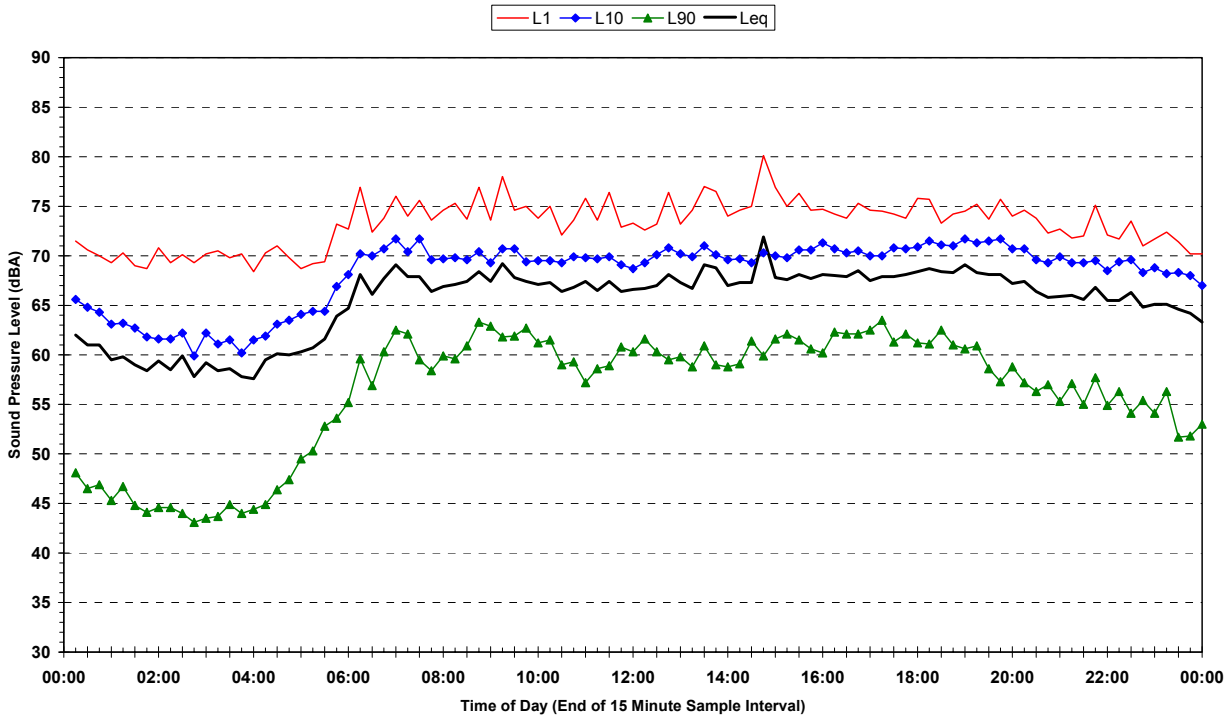


Statistical Ambient Noise Levels
118 Epping Road - Thursday 29 July 2010

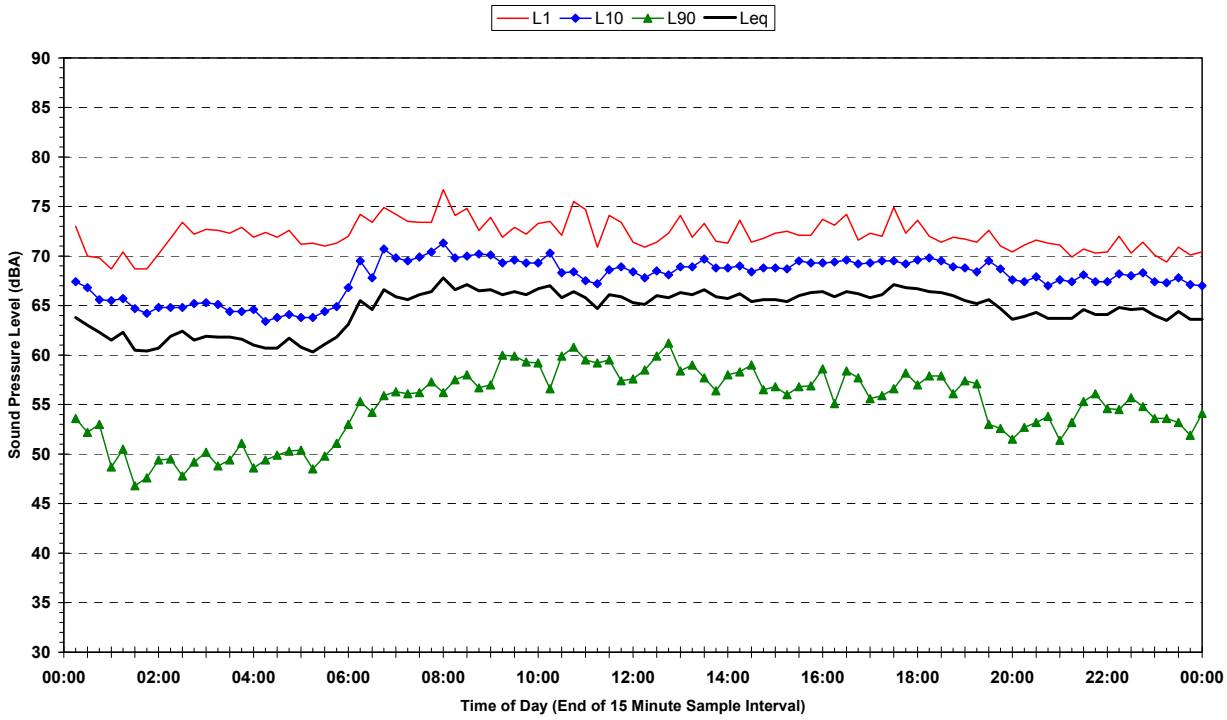


UNATTENDED AMBIENT NOISE DATA – 118 EPPING ROAD

Statistical Ambient Noise Levels
118 Epping Road - Friday 30 July 2010

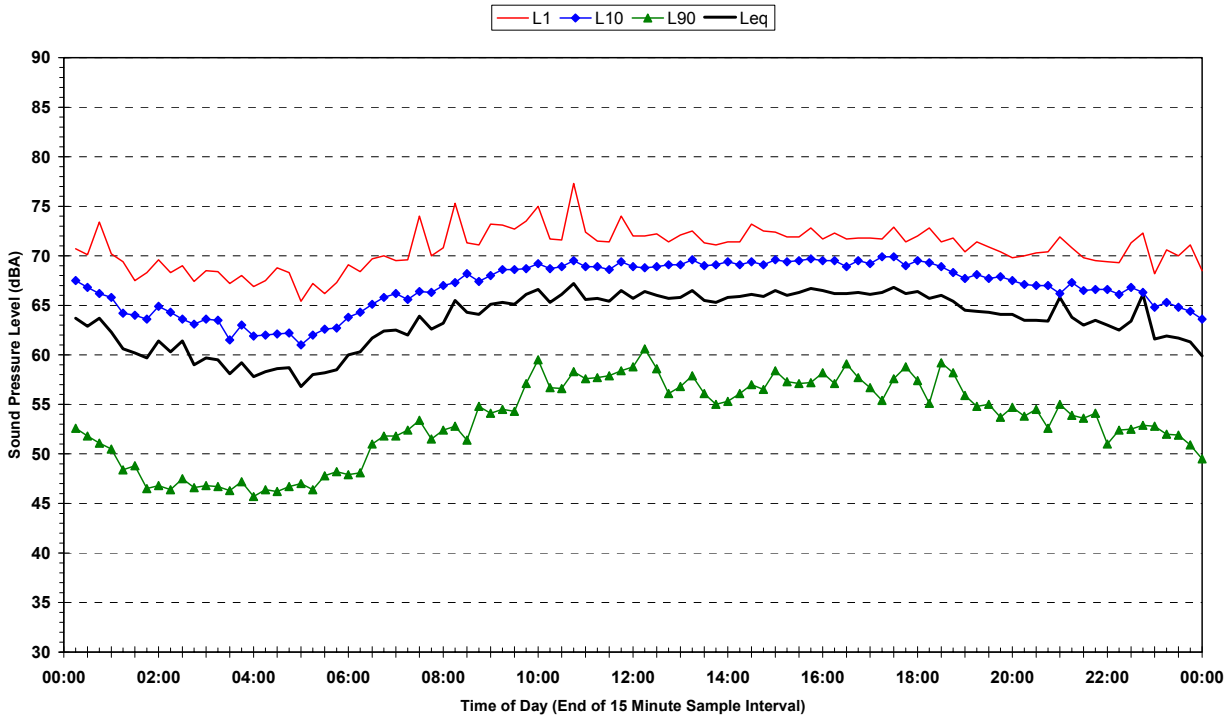


Statistical Ambient Noise Levels
118 Epping Road - Saturday 31 July 2010

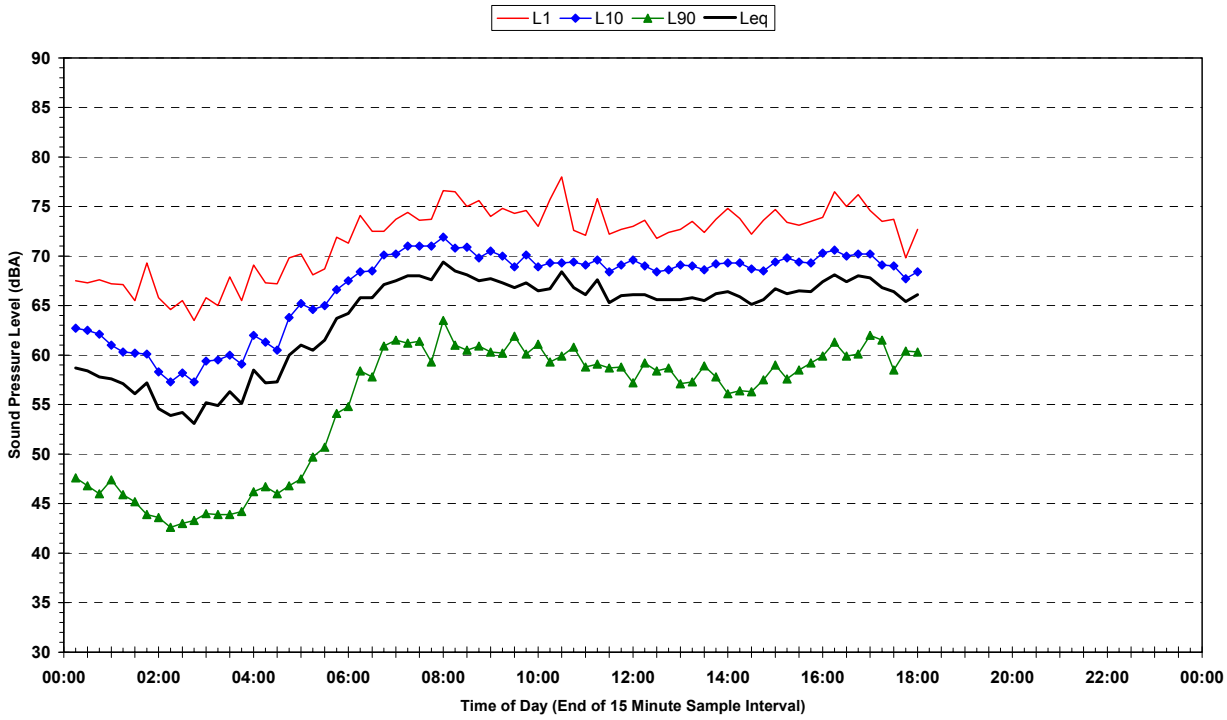


UNATTENDED AMBIENT NOISE DATA – 118 EPPING ROAD

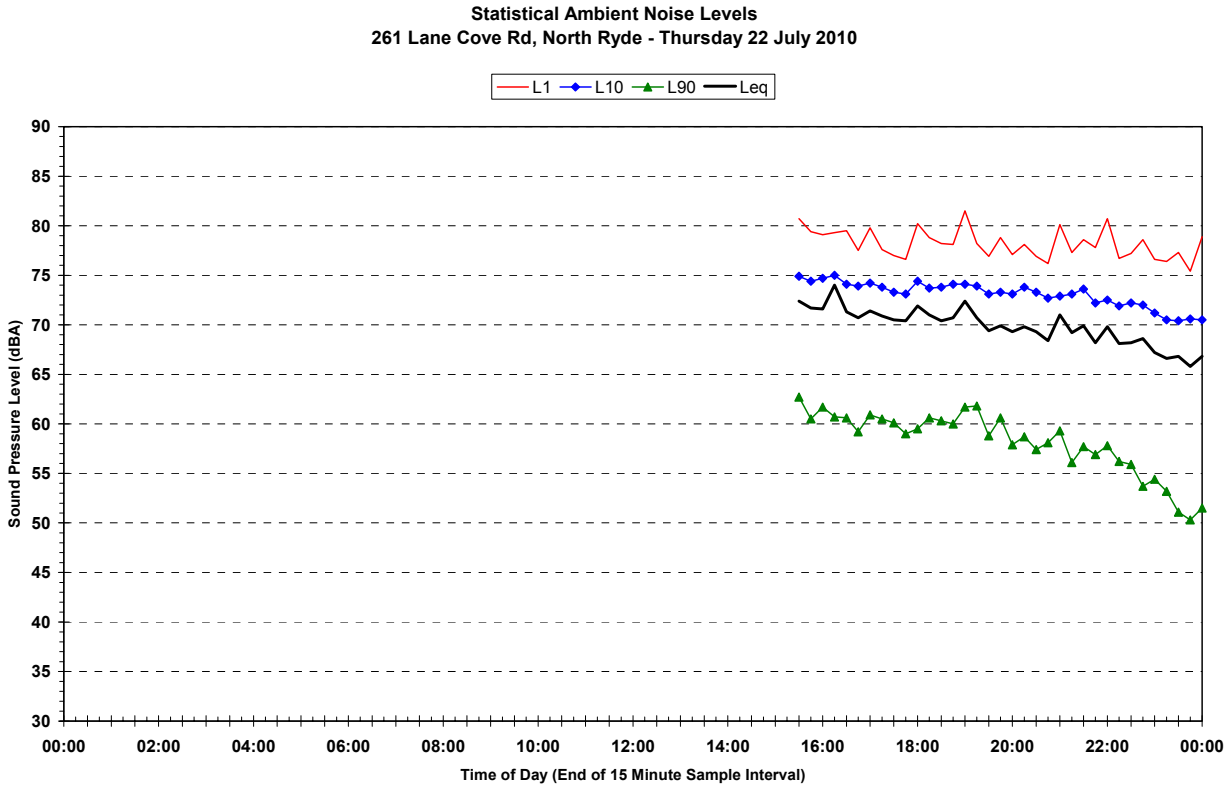
Statistical Ambient Noise Levels
118 Epping Road - Sunday 1 August 2010

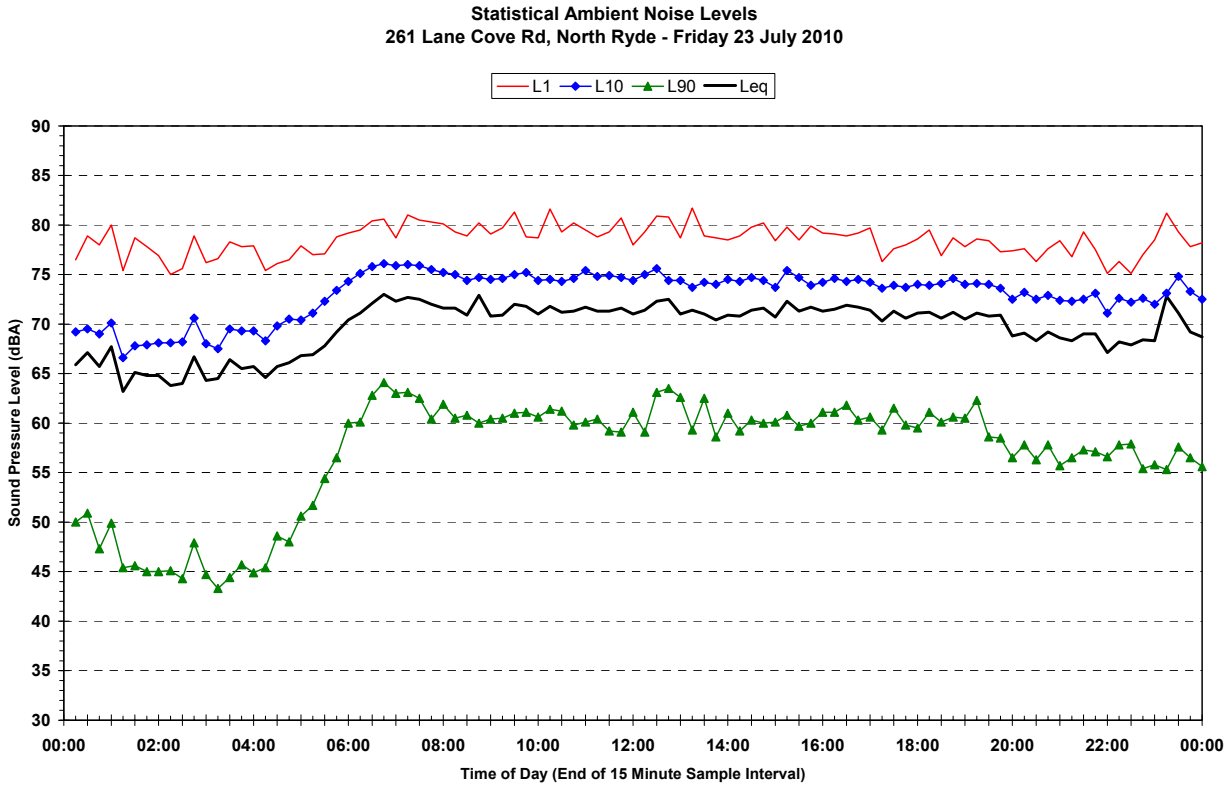


Statistical Ambient Noise Levels
118 Epping Road - Monday 2 August 2010



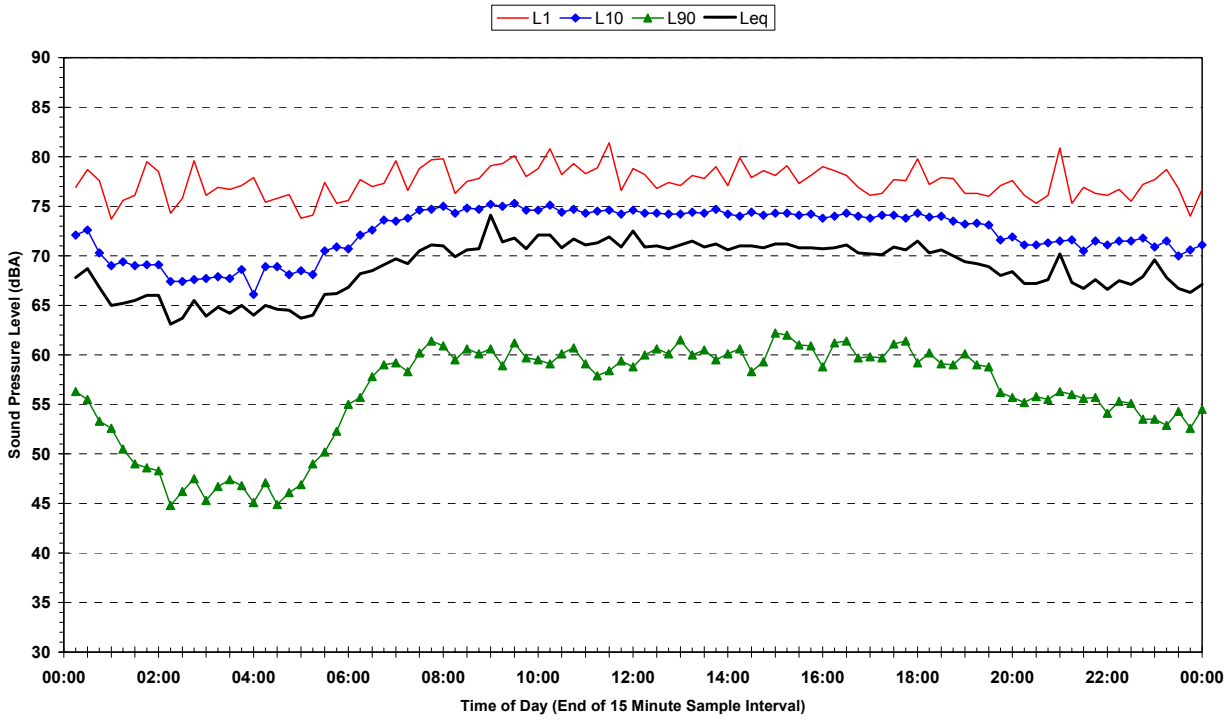
UNATTENDED AMBIENT NOISE DATA – 261 LANE COVE ROAD



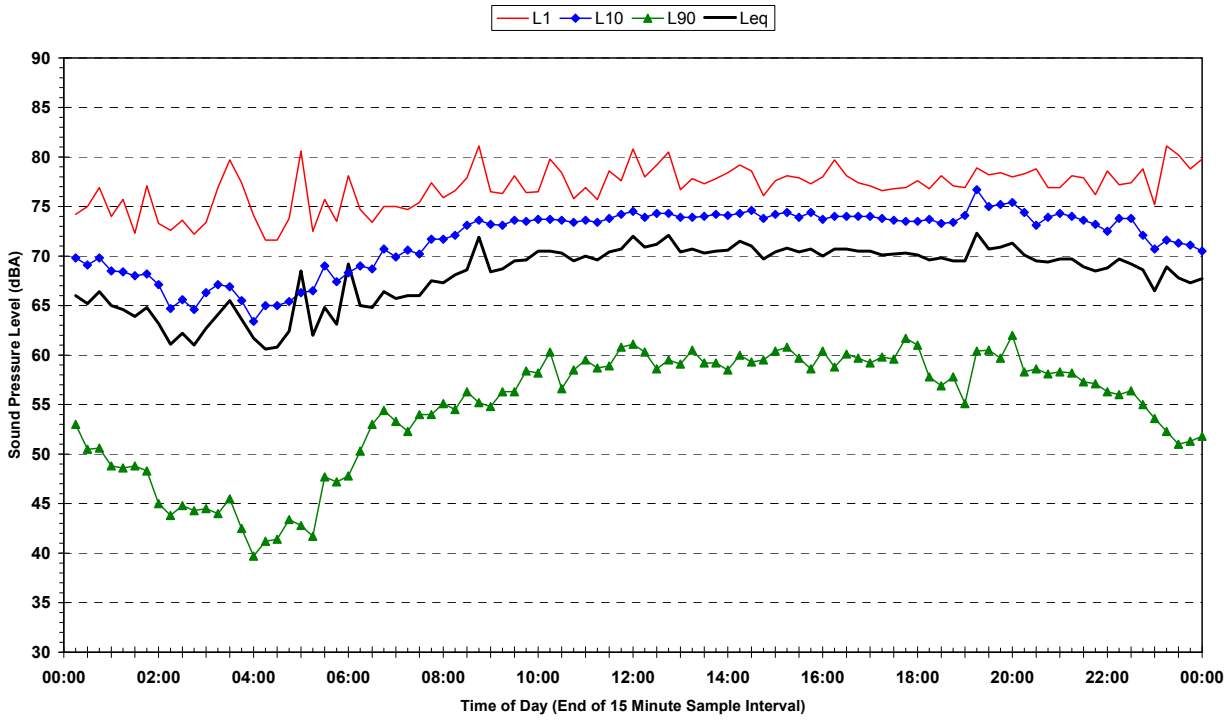


UNATTENDED AMBIENT NOISE DATA – 261 LANE COVE ROAD

Statistical Ambient Noise Levels
261 Lane Cove Rd, North Ryde - Saturday 24 July 2010

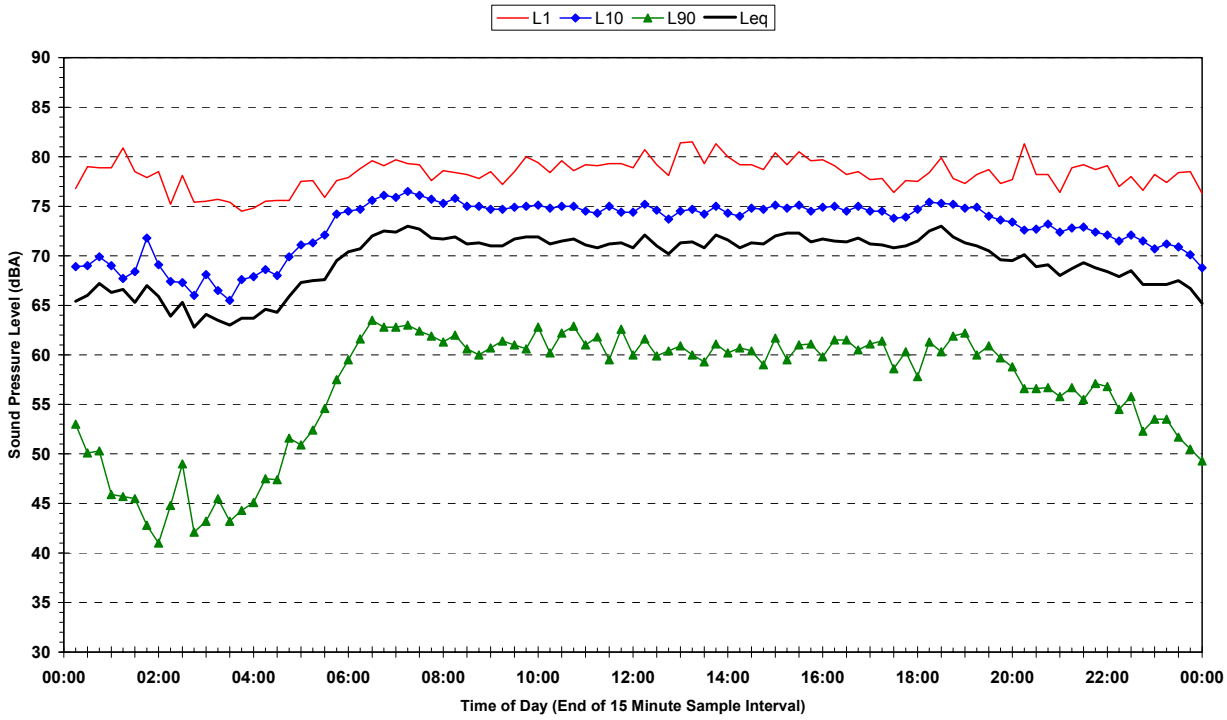


Statistical Ambient Noise Levels
261 Lane Cove Rd, North Ryde - Sunday 25 July 2010

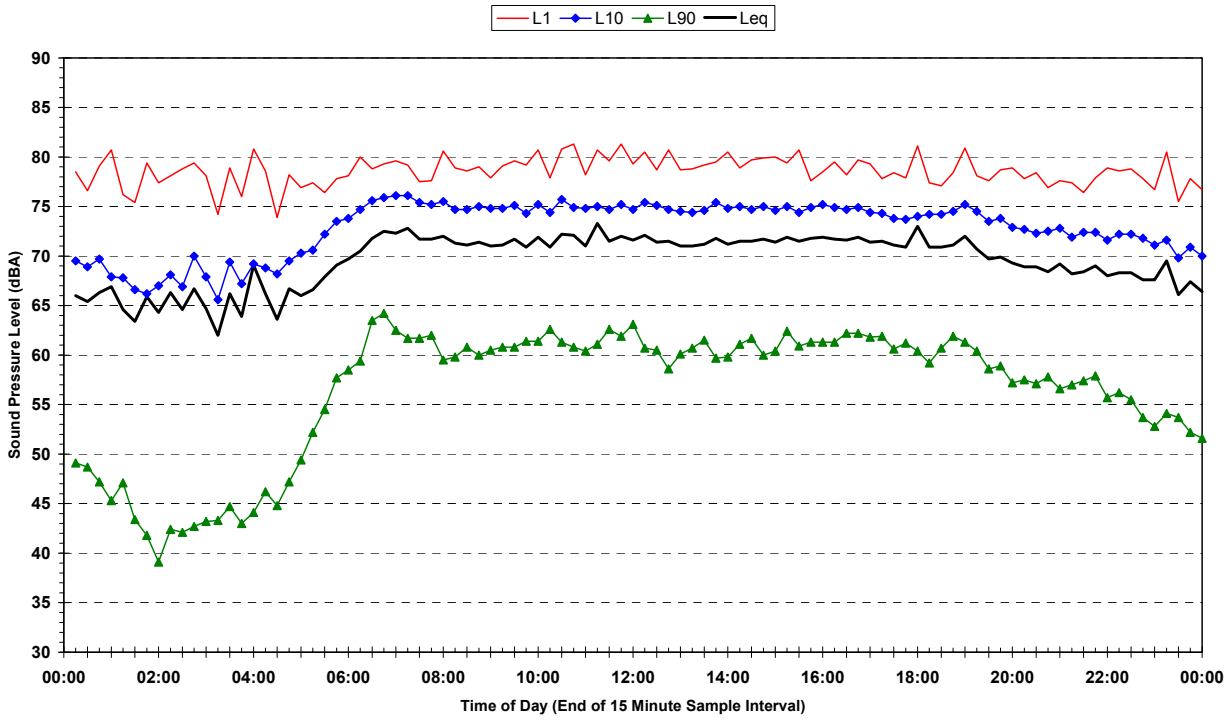


UNATTENDED AMBIENT NOISE DATA – 261 LANE COVE ROAD

Statistical Ambient Noise Levels
261 Lane Cove Rd, North Ryde - Monday 26 July 2010

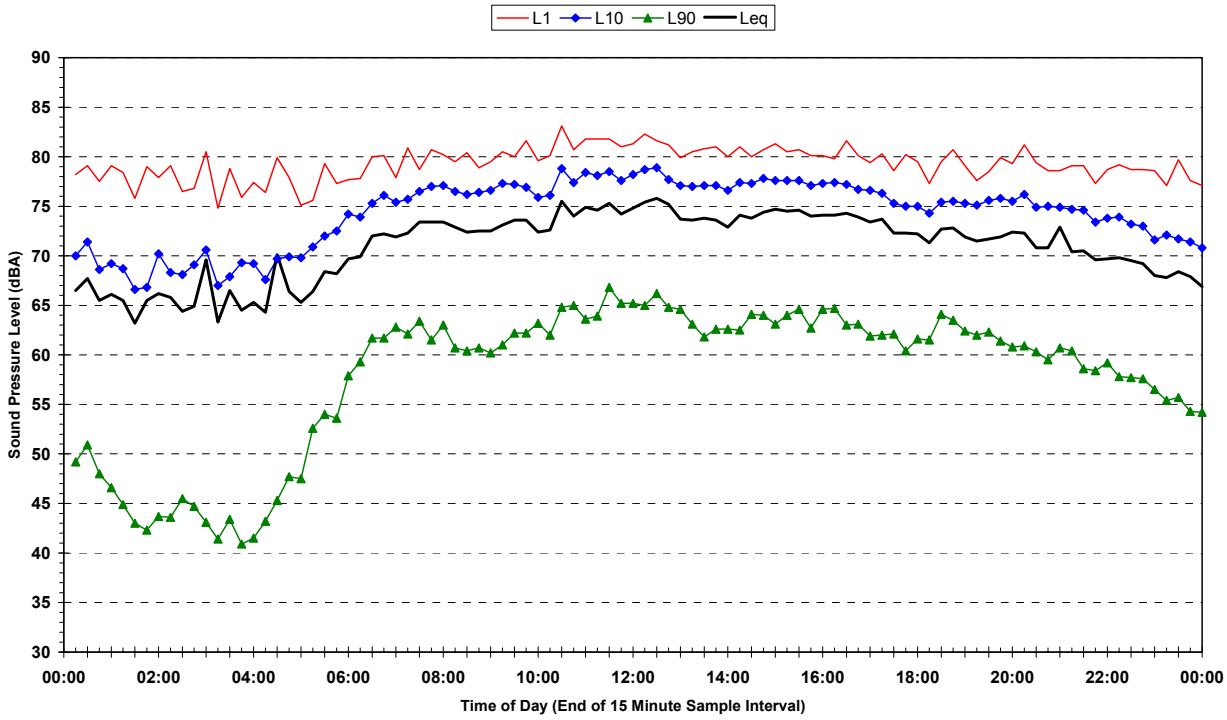


Statistical Ambient Noise Levels
261 Lane Cove Rd, North Ryde - Tuesday 27 July 2010

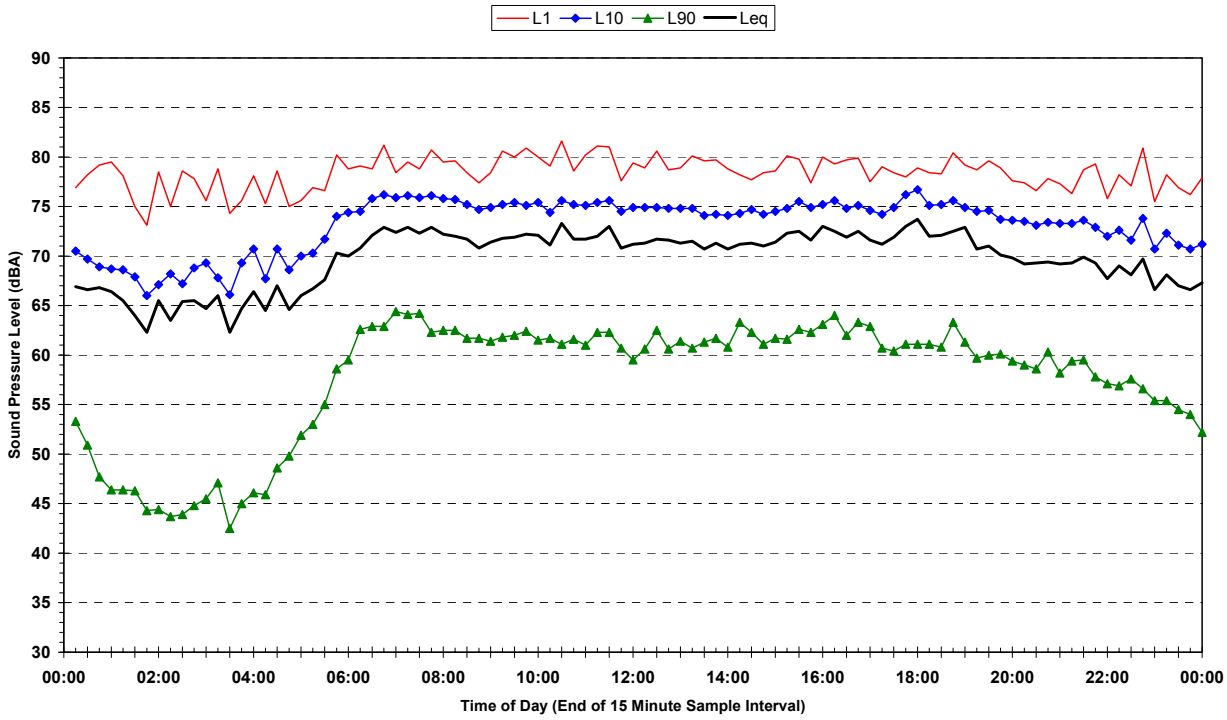


UNATTENDED AMBIENT NOISE DATA – 261 LANE COVE ROAD

Statistical Ambient Noise Levels
261 Lane Cove Rd, North Ryde - Wednesday 28 July 2010



Statistical Ambient Noise Levels
261 Lane Cove Rd, North Ryde - Thursday 29 July 2010



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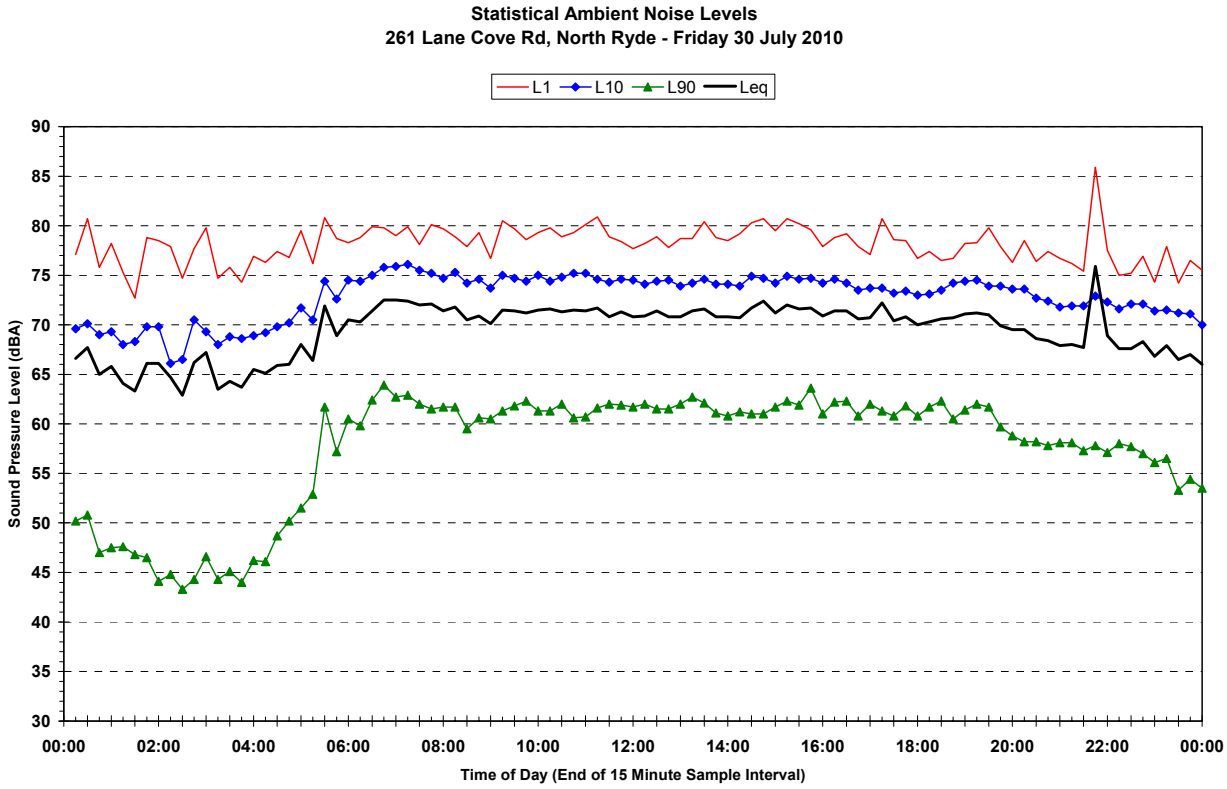
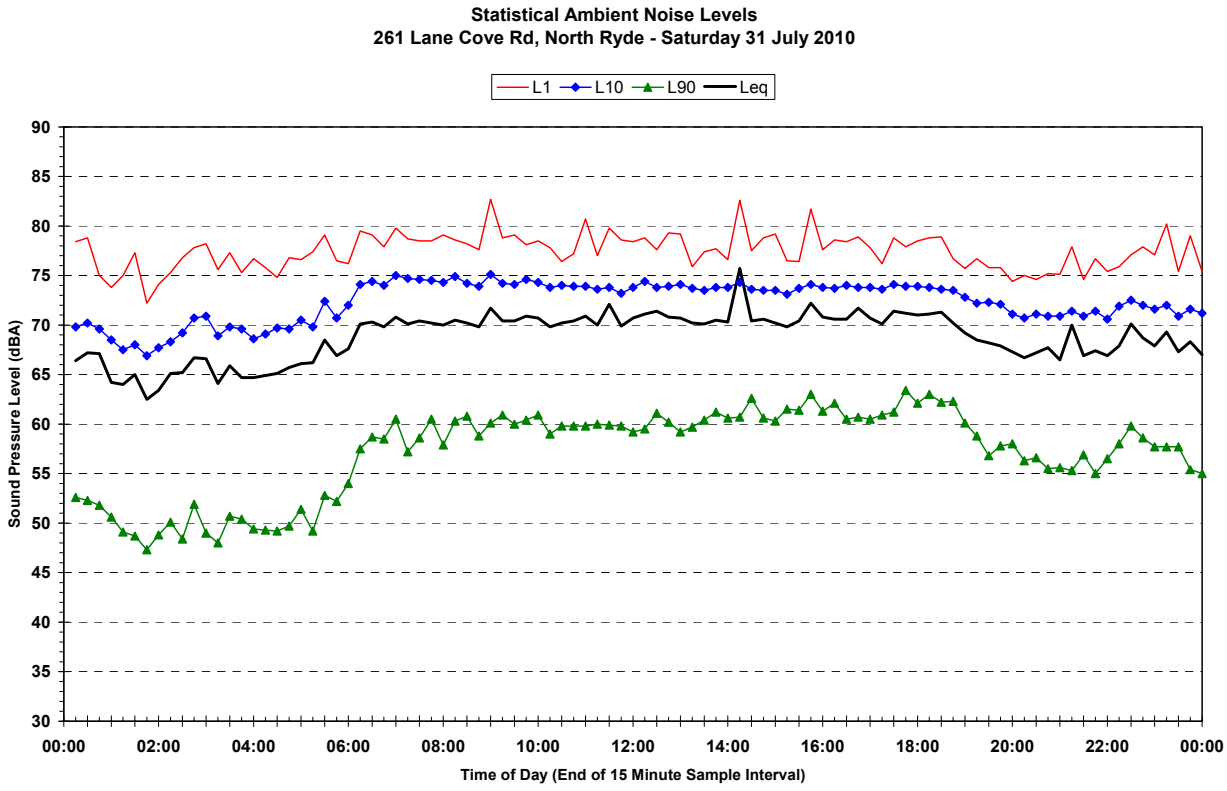
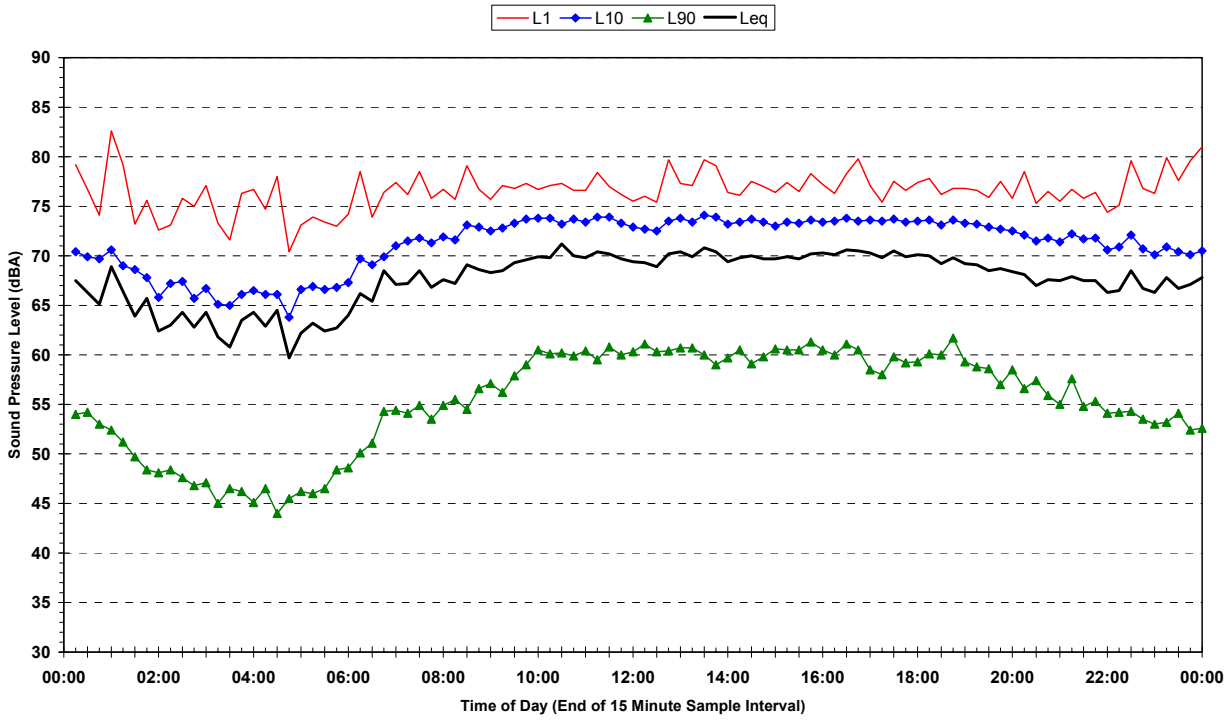


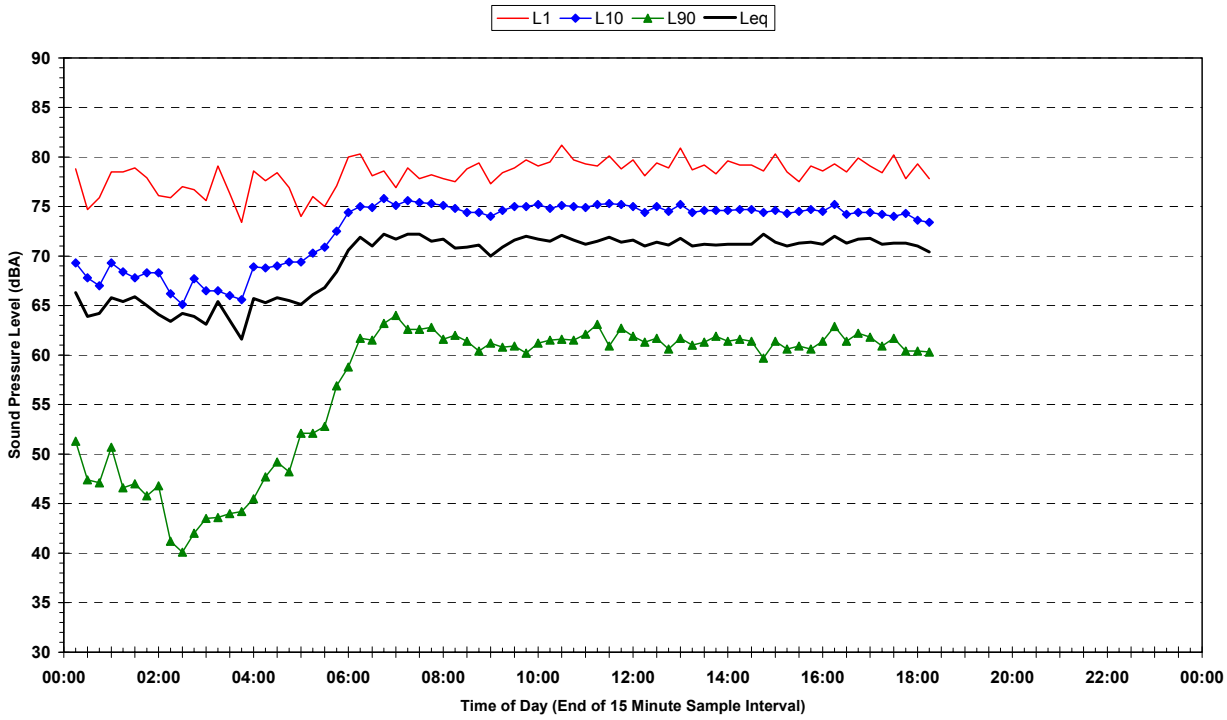


UNATTENDED AMBIENT NOISE DATA – 261 LANE COVE ROAD

Statistical Ambient Noise Levels
261 Lane Cove Rd, North Ryde - Sunday 1 August 2010

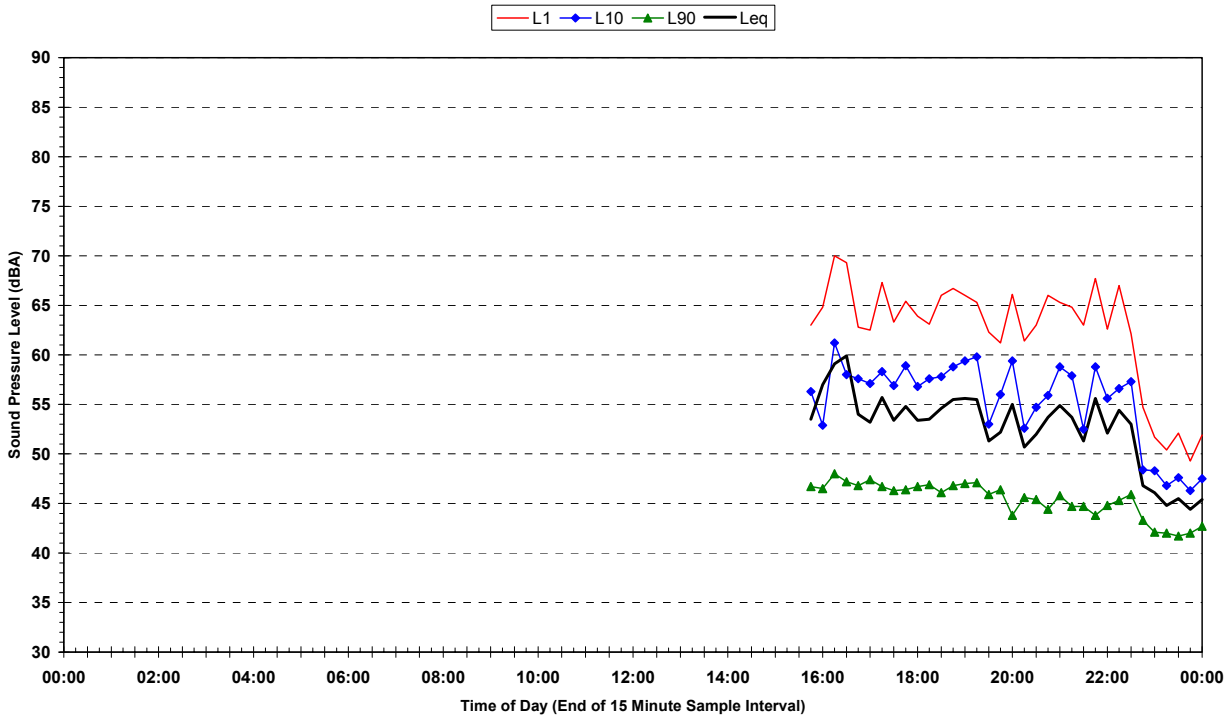


Statistical Ambient Noise Levels
261 Lane Cove Rd, North Ryde - Monday 2 August 2010

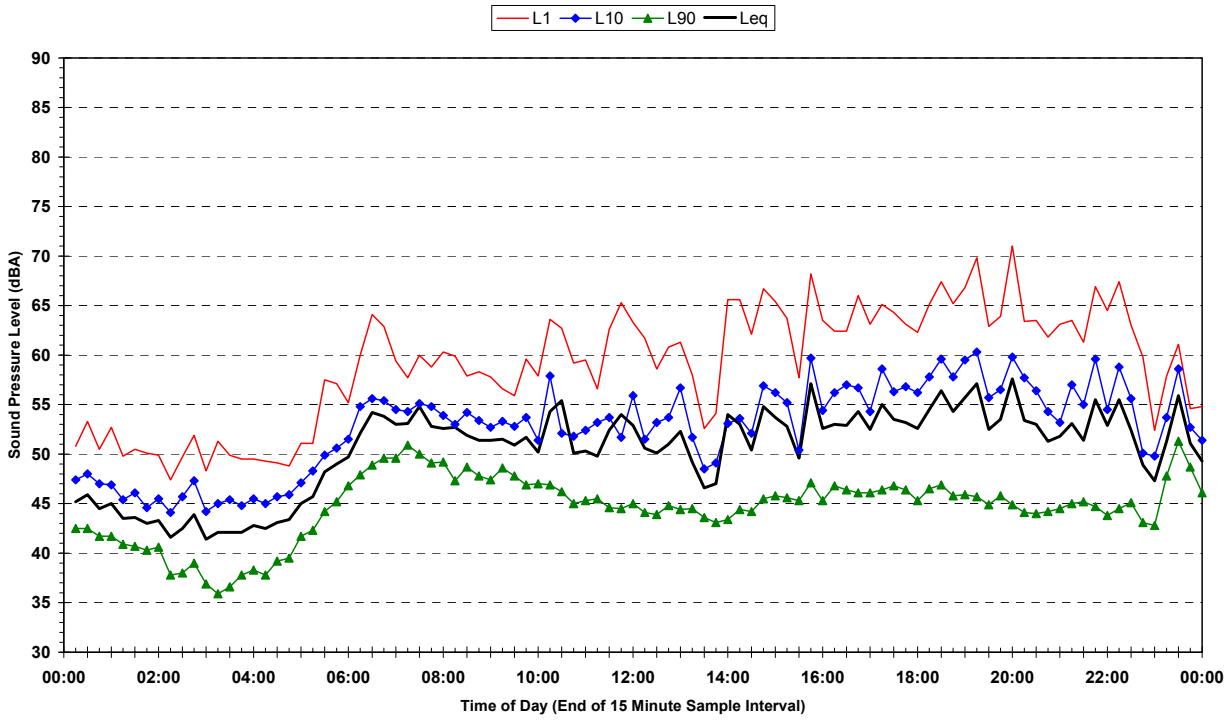


UNATTENDED AMBIENT NOISE DATA – 7 ALLENGROVE CRESCENT

Statistical Ambient Noise Levels
7 Allengrove Crescent, North Ryde - Thursday 22 July 2010

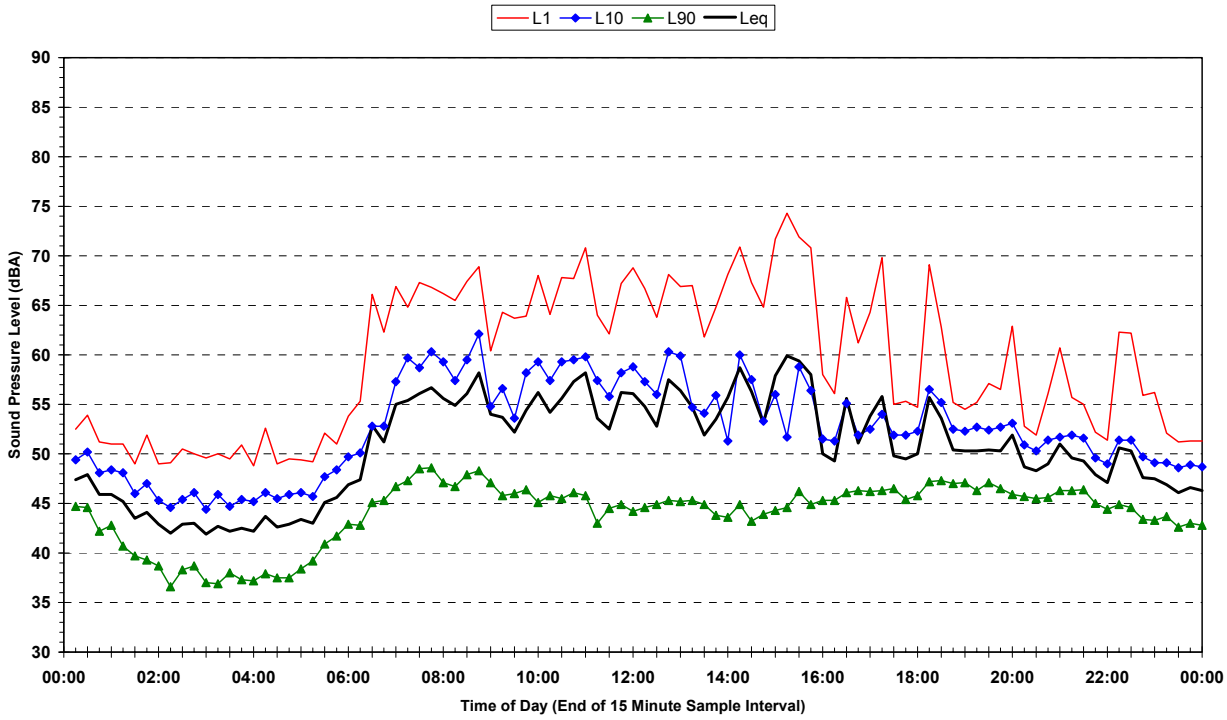


Statistical Ambient Noise Levels
7 Allengrove Crescent, North Ryde - Friday 23 July 2010

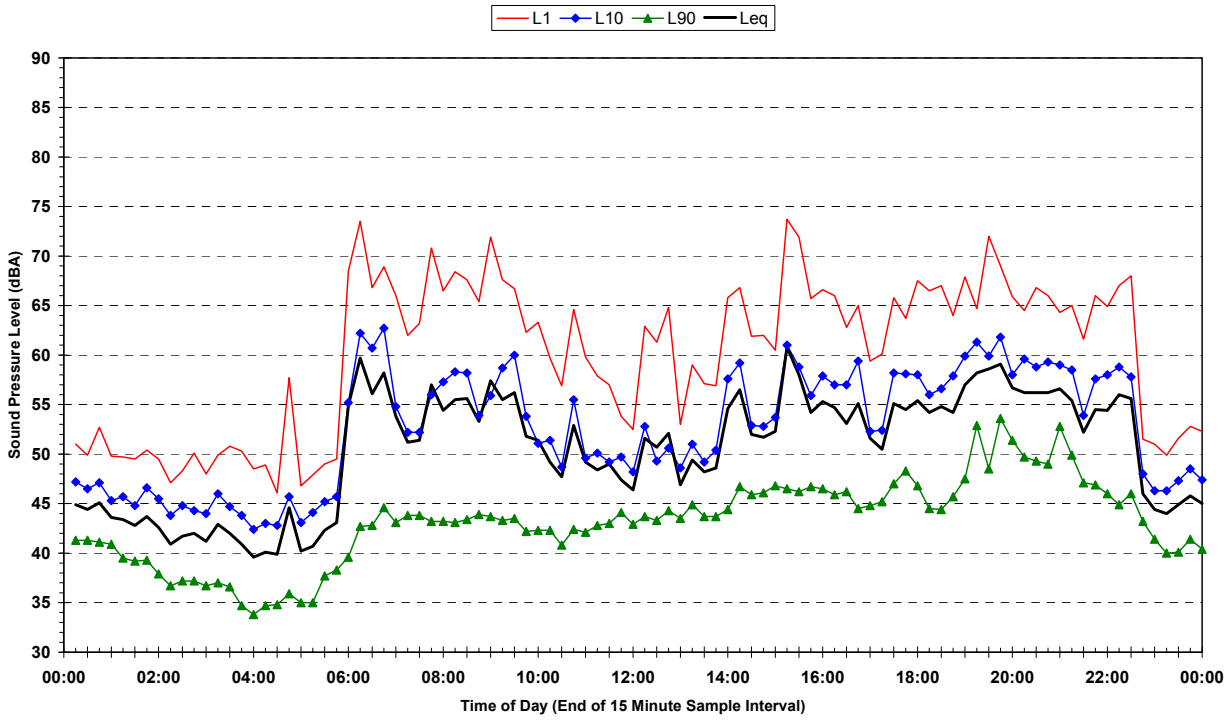


UNATTENDED AMBIENT NOISE DATA – 7 ALLENGROVE CRESCENT

Statistical Ambient Noise Levels
7 Allengrove Crescent, North Ryde - Saturday 24 July 2010

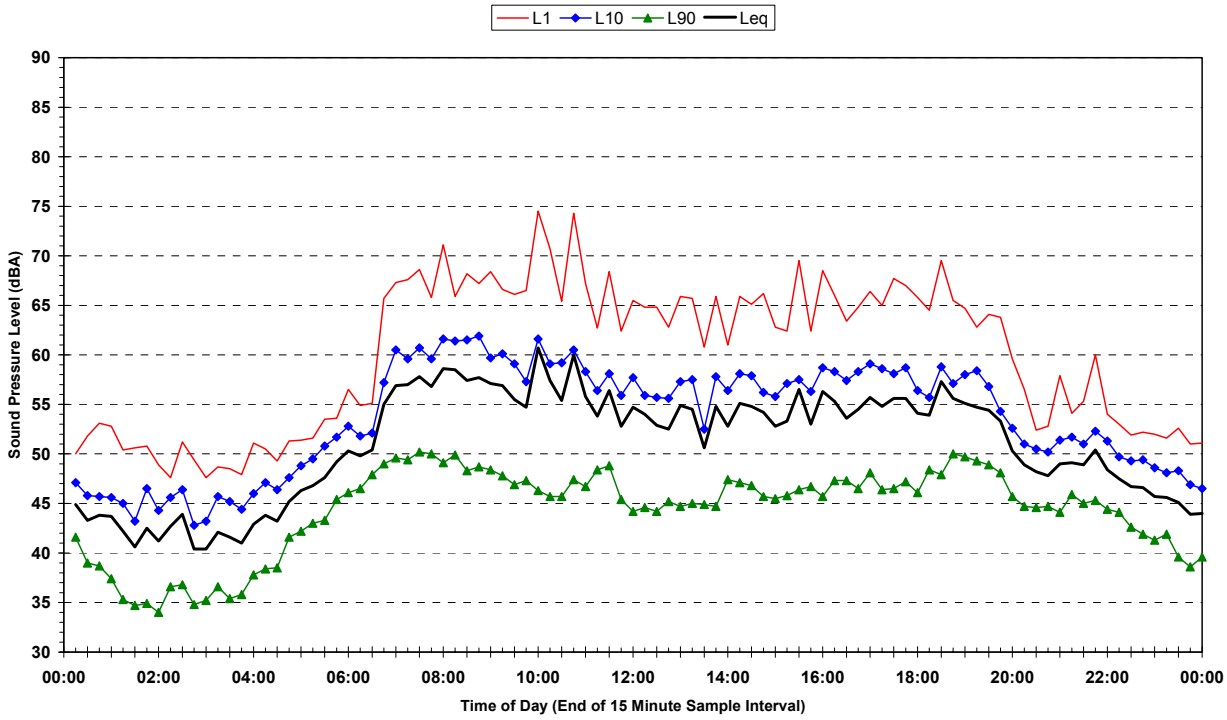


Statistical Ambient Noise Levels
7 Allengrove Crescent, North Ryde - Sunday 25 July 2010

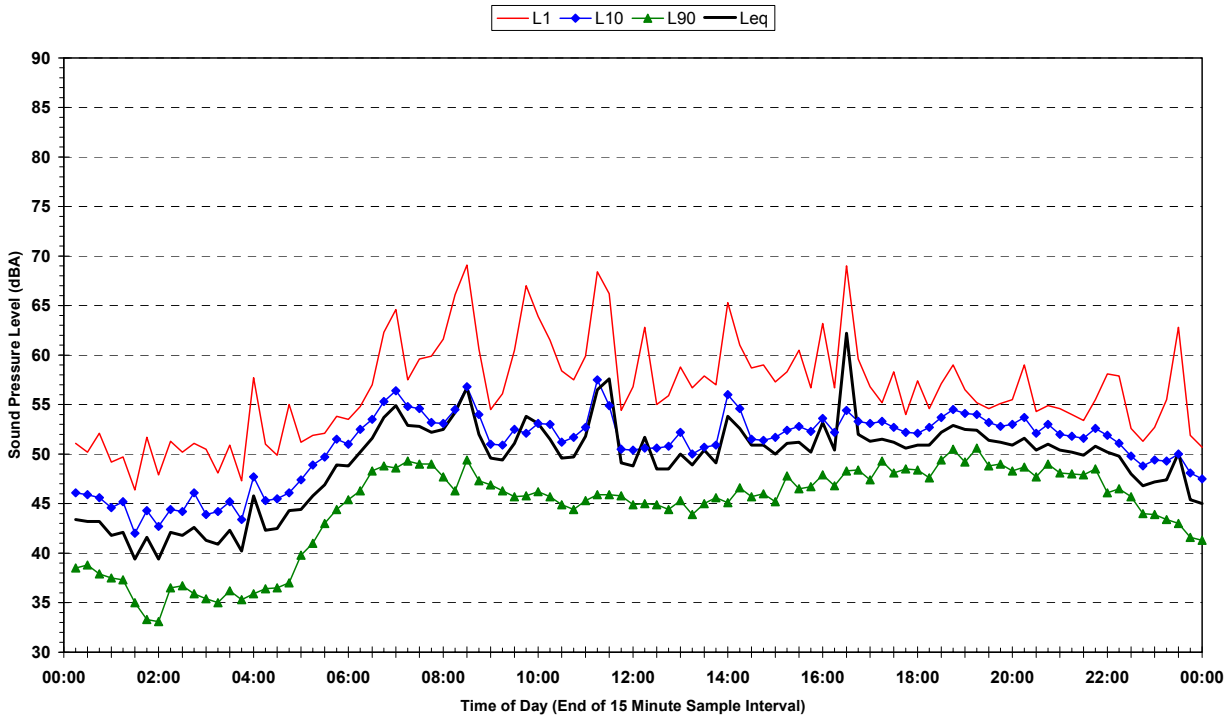


UNATTENDED AMBIENT NOISE DATA – 7 ALLENGROVE CRESCENT

Statistical Ambient Noise Levels
7 Allengrove Crescent, North Ryde - Monday 26 July 2010

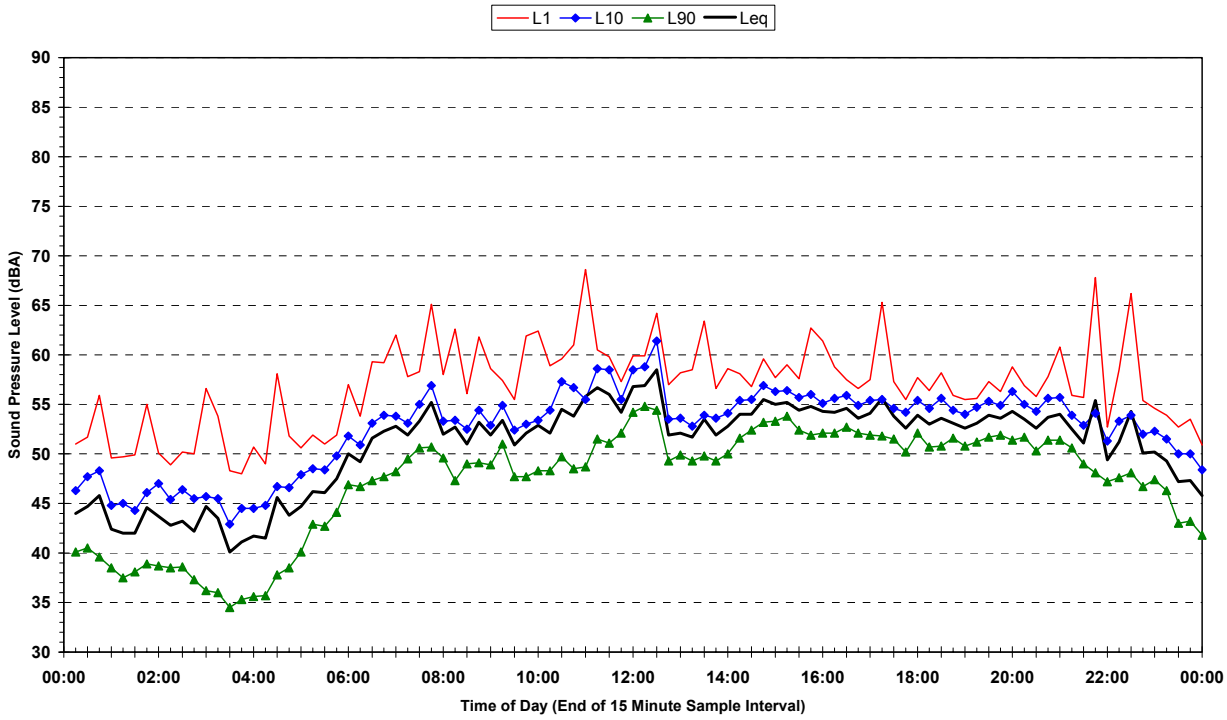


Statistical Ambient Noise Levels
7 Allengrove Crescent, North Ryde - Tuesday 27 July 2010

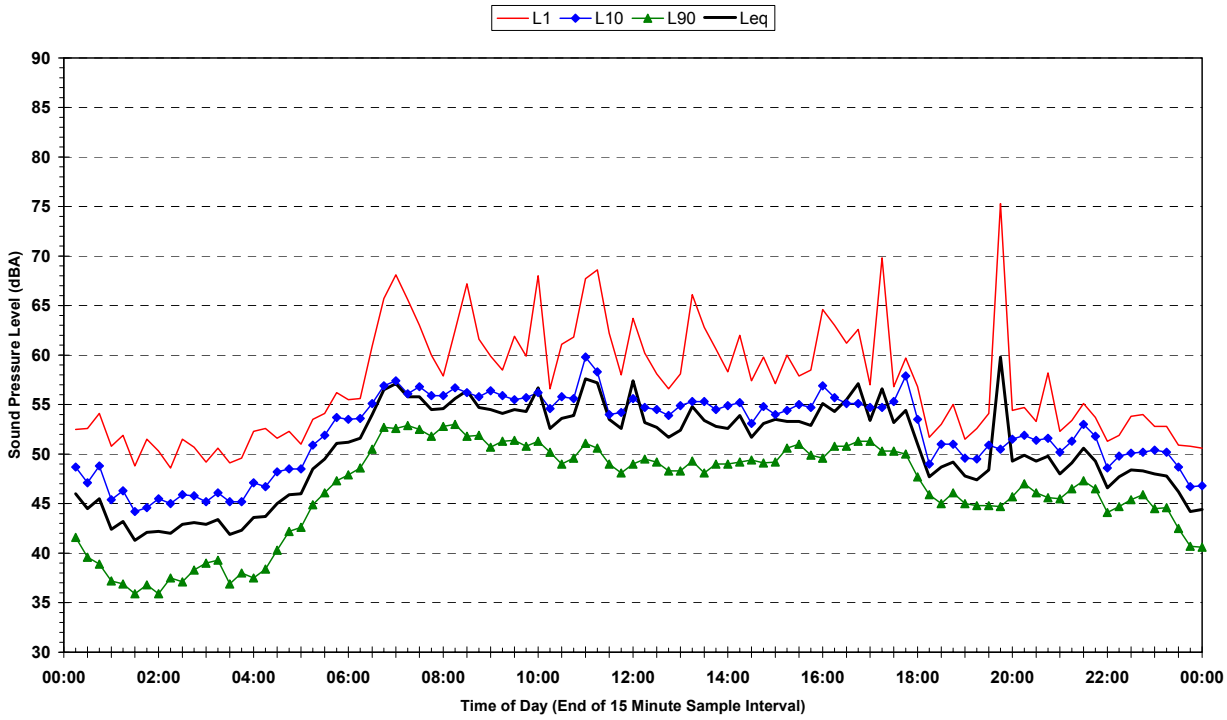


UNATTENDED AMBIENT NOISE DATA – 7 ALLENGROVE CRESCENT

Statistical Ambient Noise Levels
7 Allengrove Crescent, North Ryde - Wednesday 28 July 2010

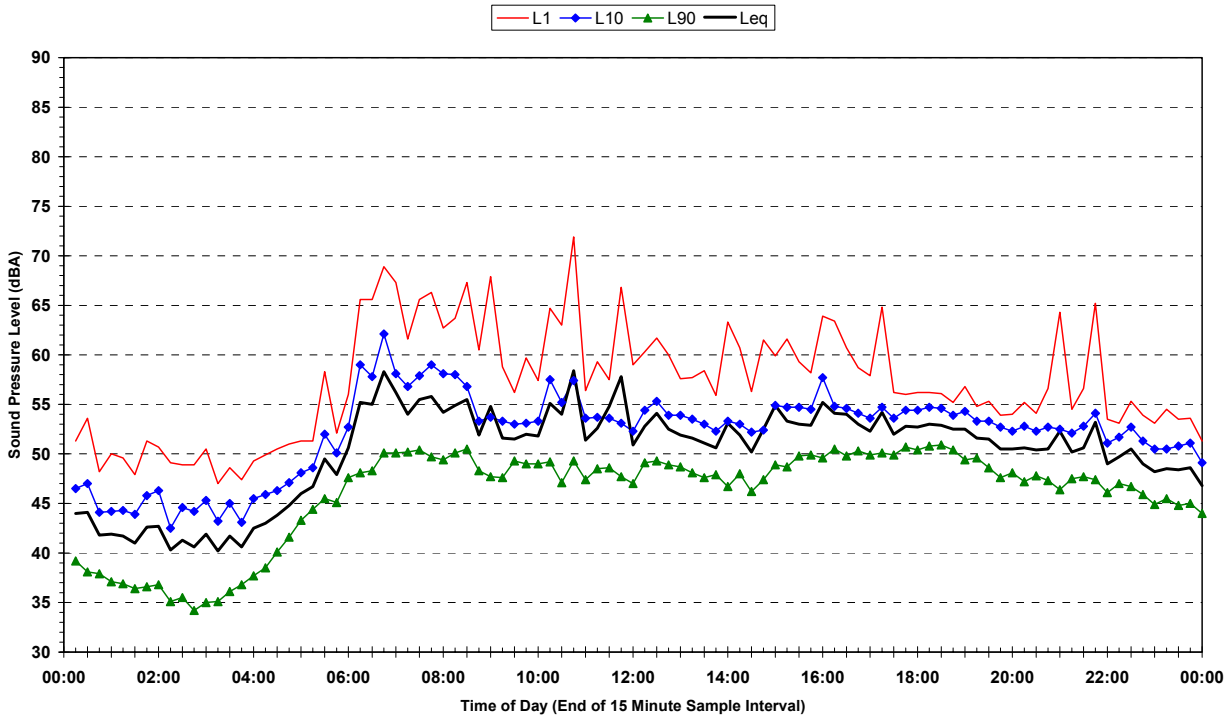


Statistical Ambient Noise Levels
7 Allengrove Crescent, North Ryde - Thursday 29 July 2010

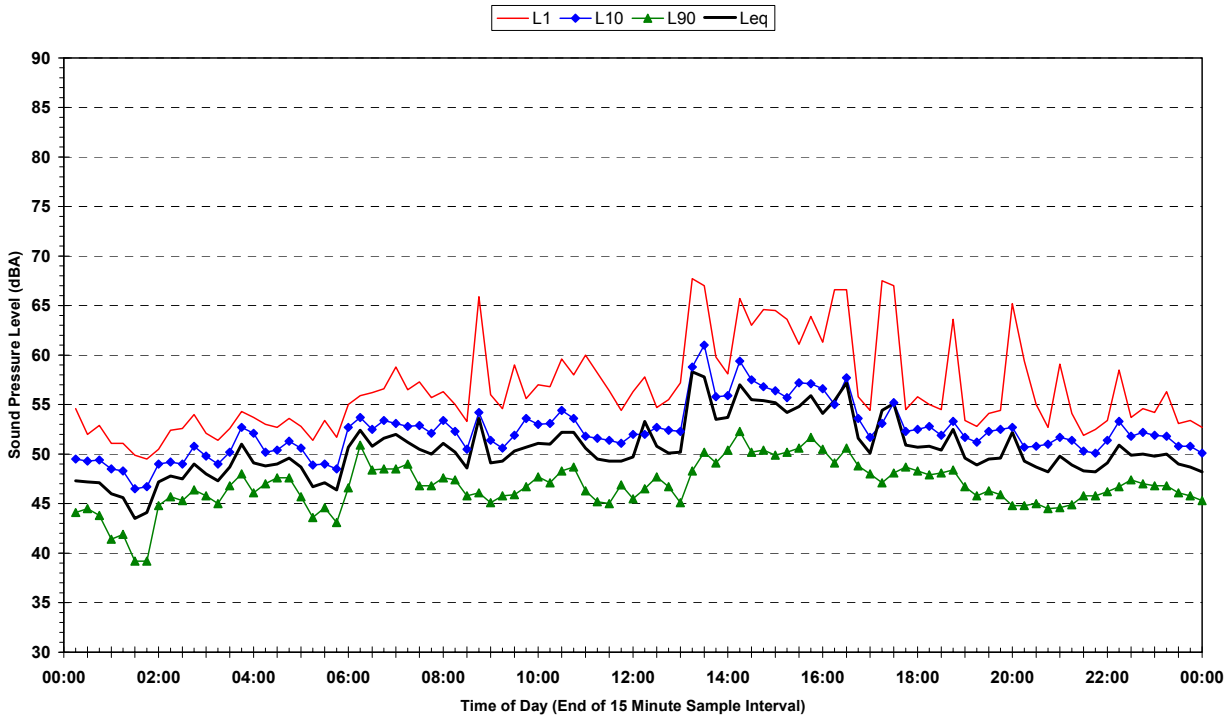


UNATTENDED AMBIENT NOISE DATA – 7 ALLENGROVE CRESCENT

Statistical Ambient Noise Levels
7 Allengrove Crescent, North Ryde - Friday 30 July 2010

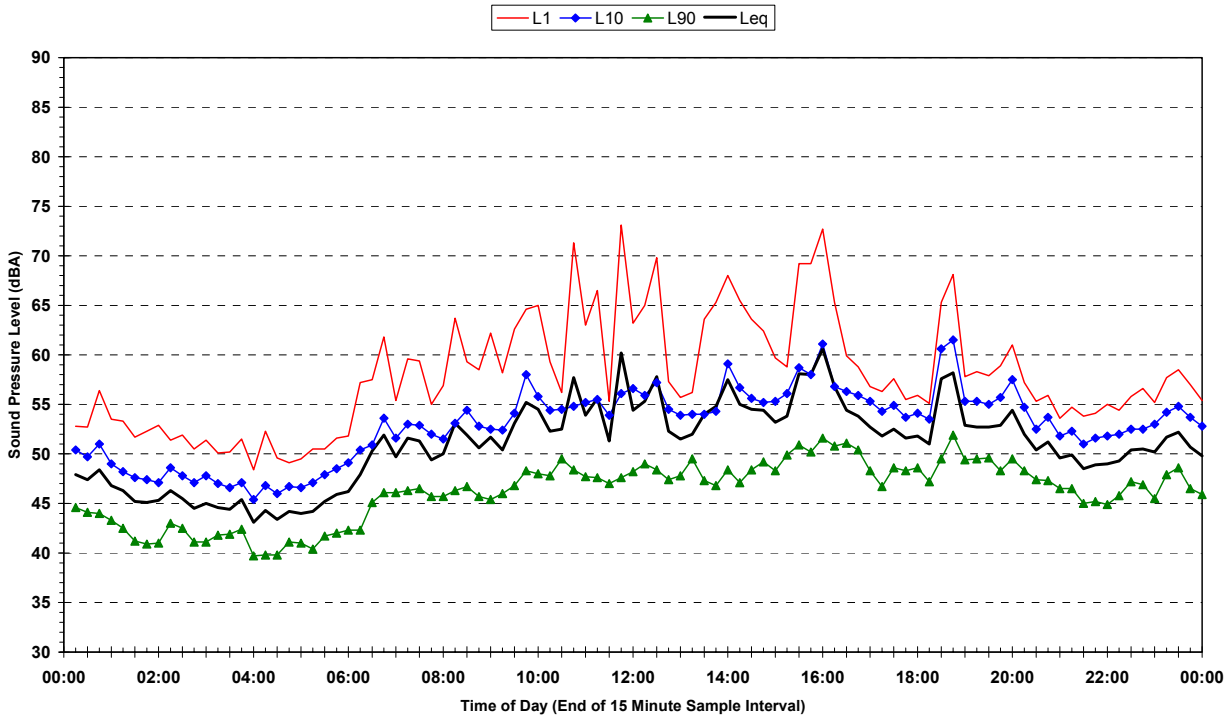


Statistical Ambient Noise Levels
7 Allengrove Crescent, North Ryde - Saturday 31 July 2010



UNATTENDED AMBIENT NOISE DATA – 7 ALLENGROVE CRESCENT

Statistical Ambient Noise Levels
7 Allengrove Crescent, North Ryde - Sunday 1 August 2010



Statistical Ambient Noise Levels
7 Allengrove Crescent, North Ryde - Monday 2 August 2010