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Noise Impact Assessment

Proposed Residential Development

Whiteside Street, North Ryde

Report Number 610.10199-R1

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EGC Custodian Services
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SYDNEY NSW 2000

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Noise Impact Assessment

Proposed Residential Development

Whiteside Street, North Ryde

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1 INTRODUCTION

This Noise Impact Assessment (the assessment) has been prepared for EGC Custodian Services Pty Ltd in support of a Concept Plan Application for the proposed residential development (the development) at the Whiteside Street site (the site).

As part of the assessment, Heggies Pty Ltd (SLR Heggies) successfully completed a baseline noise survey to quantify the existing and potential noise impacts for the development.

The northern site boundary abuts Epping Road with Whiteside Street and David Avenue flanked to the west and east respectively. The site is surrounded by existing residences with the exception of the neighbouring Greenfield site to the north and north-west.

2 SITE DESCRIPTION AND STUDY OVERVIEW

The site boundaries are presented graphically in **Figure 1** below. The land is proposed to be redeveloped to contain a mix of apartment buildings ranging in height from 4 to 10 storeys (refer **Figure 3**).

Figure 1 Proposed Residential Development Site and Noise Monitoring Locations

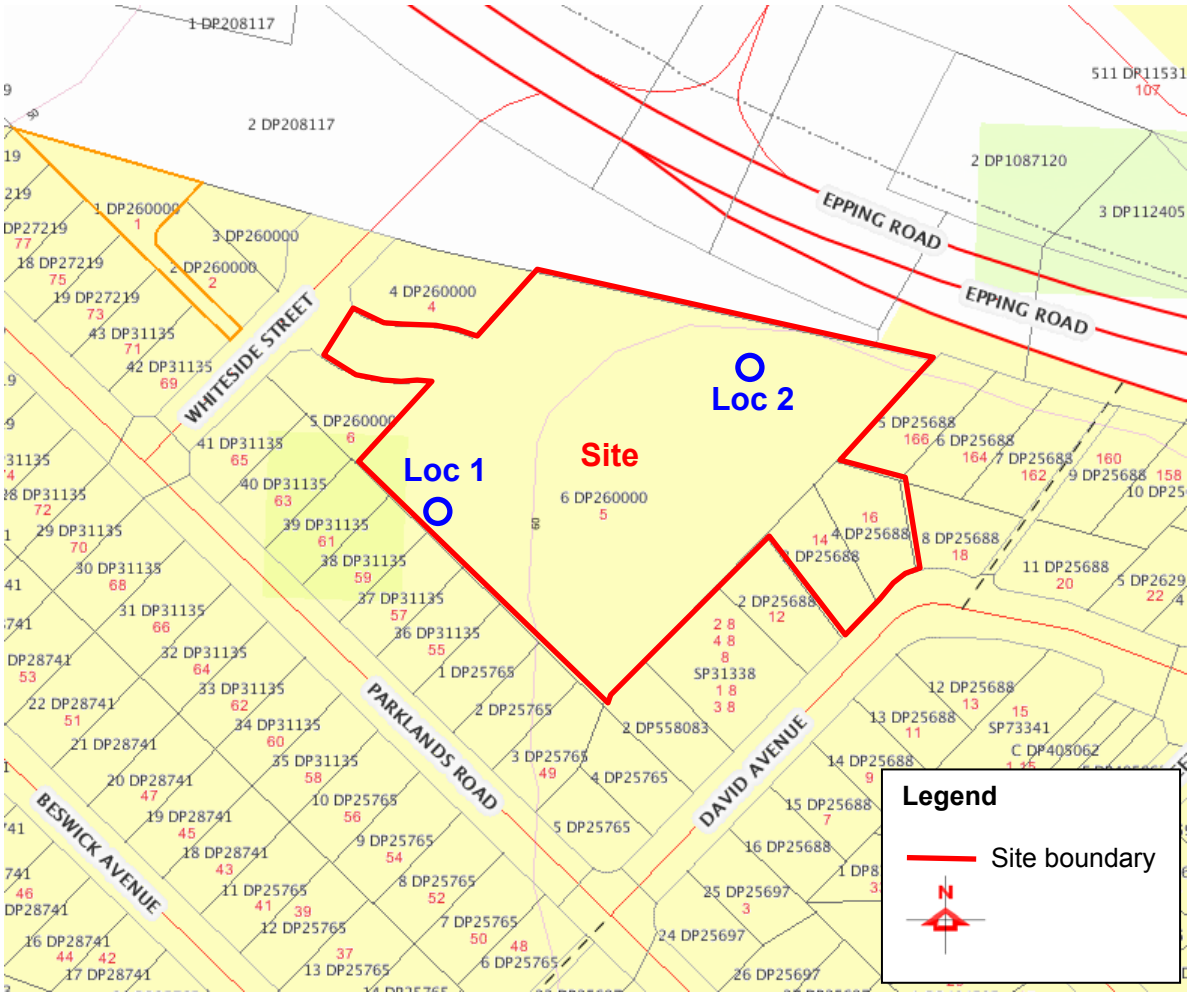


Image Source: Department of Lands Six Viewer

The local topography is characterised by a gentle up-gradient to the south as illustrated in the aerial image (**Figure 2**). Parts of the completed development will have facades overlooking Epping Road resulting in a direct line of sight from the development to the road. Road traffic noise level reductions can be effectively achieved by preventing direct lines of sight to the road.

The main noise source which has the potential to impact on the subject site includes:

- Road traffic noise along Epping Road to the north-east.

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

Figure 2 Aerial View of Epping Road from Site

3 AMBIENT NOISE SURVEY

3.1 General

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

3.1 Unattended Noise Monitoring

3.1.1 Methodology

Unattended noise monitoring was conducted at two representative locations onsite between Thursday 2 December and Thursday 9 December 2010.

ARL Type 215 noise loggers were deployed to continuously record ambient noise levels. The locations where selected to determine traffic noise intrusion onsite mainly from Epping Road (Loc 2) and ambient noise levels in the quieter residential area at the south western site boundary (Loc 1) shielded from traffic. The locations as identified in **Figure 1** are:

- Loc 1 5 Whiteside Street
  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" position at this location with the ambient noise environment dominated by road traffic noise.
- Loc 2 5 Whiteside Street
  This location was chosen to provide existing background levels at a location shielded from traffic along Lane Cove Road.

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 dB(A). 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 tabulated in **Table 1** and **Table 2** and graphically presented in **Appendix C3**.

The NSW Department of Environment Climate Change and Water's (DECCW's) recommended Environmental Criteria for Road Traffic Noise (ECRTN) are based on the noise level contributions from traffic noise along public roads 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 L_{Aeq} noise data relevant to the assessment of operational road traffic noise.

Table 1 Summary of Ambient L_{Aeq} Traffic Noise Indices

Noise Monitoring Location	Main Traffic Noise Indices			
	LAeq(15hour)	LAeq(9hour)	LAeq(1hour) Daytime [1]	LAeq(1hour) Night-time [1]
Loc 1	54 dB(A)	46 dB(A)	55 dB(A)	47 dB(A)
Loc 2	58 dB(A)	53 dB(A)	59 dB(A)	55 dB(A)

Note 1: The $L_{Aeq(1hour)}$ values shown are the upper ten percentile (or typical maximum) of the total 15 (daytime) and 9 (night-time) individual $L_{Aeq(1hour)}$ measurements occurring over the survey duration.

To assess noise emissions from future mechanical plant or similar facilities serving the proposed development, the data obtained from the noise logger at Loc 2 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 L_{Aeq} Noise Level		
	Day	Evening	Night	Day	Evening	Night
Loc 1	47 dB(A)	49 dB(A)	37 dB(A)	54 dB(A)	56 dB(A)	47 dB(A)

Note 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.

Note 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:

- **L_{Aeq}** The L_{Aeq} 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.
- **L_{A90}** The L_{A90} is the level of noise exceeded for 90% of the sample time (15 minutes). The L_{A90} noise level is described as the average minimum background sound level or simply the background level.
- **L_{A10}** The noise level exceeded for 10% of the sample time (15 minutes) and is typically described as the average maximum noise level.
- **L_{A1}** 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 development has the potential to be impacted by noise from the existing traffic along Epping Road.

Traffic noise criteria have been based on DECCW guidelines 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, Epping Road would be an arterial (or at least sub-arterial) roadway. The criteria relating to new residential developments affected by freeway/arterial road networks are 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 dB(A)	$L_{Aeq(9hr)}$ 50 dB(A)	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.
Sensitive Land Use	**Criteria**	**Noise mitigation Measures**	
Passive recreation and school playgrounds	Freeway / arterial roads $L_{Aeq(15hr)}$ 55 dB(A)	To achieve internal noise criteria in the short term, the most practicable mitigation measures are often related to building or façade treatments. In the medium to longer term, strategies such as exhaust noise from in-service vehicles, limitations on exhaust brake use, and restricting access for sensitive areas or during sensitive times to low noise vehicles can be applied to mitigate noise impacts across the road system. Other measures include improved planning, design and construction of sensitive land use developments; reduced new vehicle emission standards; greater use of public transport; and alternative methods of freight haulage. These medium- to long-term strategies apply equally to mitigating internal and external noise levels. Where existing levels of traffic noise exceed the criteria, all feasible and reasonable noise control measures should be evaluated and applied. Where this has been done and the internal or external criteria (as appropriate) cannot be achieved, the proposed road or land use development should be designed so as not to increase existing road traffic noise levels by more than 0.5 dBA for new roads and 2 dBA for redeveloped roads or land use development with potential to create additional traffic.	

Note 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 non-mandatory whereby the guideline values are based on a performance-based approach. Accordingly, consideration of further design aspects such as aesthetics, cost implications, equity, community preferences and practicality is required.

Although ECRTN does not explicitly provide specific internal noise criteria for dwellings, it does suggest that night-time noise levels between 35 dB(A) and 40 dB(A) within sleeping spaces and noise levels 10 dB(A) lower than the external daytime criteria, i.e. 45 dB(A) 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 dB(A)	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

Note 1: Airborne noise is calculated as $L_{Aeq(15hour)}$ daytime and $L_{Aeq(9hour)}$ night-time

Reference has been made to the following guidance to the criteria:

> *"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 dB(A) 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 dB(A), 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 that the outside to inside noise reduction with windows open is typically 10 dB(A) assuming a standard construction. Accordingly, the external noise threshold where a dwelling will require mechanical ventilation is an $L_{Aeq(9hour)}$ of 55 dB(A) for bedrooms and $L_{Aeq(15hour)}$ of 60 dB(A) 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. Further to this, the building construction shall comply with the Building Code of Australia in order to minimise potential impacts for intertenancy noise.

Mechanical noise emissions should aim to comply with the DECCW's *Industrial Noise Policy* (INP), which provides a framework and process for deriving noise criteria for this purpose. 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 noise source should not be more than 5 dB(A) 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. If existing industrial noise levels 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

Noise criteria for the site have been determined according to the local noise climate which is largely dictated by transportation noise. The intrusive and amenity criteria have been compared and the lower limiting values have been set as the project-specific noise levels as shown in bold font (**Table 5**).

Table 5 Criteria for Mechanical Noise Emissions to Nearby Residences

Location	Time of Day	Noise Level dB(A) 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[3]
					$L_{Aeq(15minute)}$	L_{Aeq} (per period)
Loc 1	Day	55	47	54	**52**	55
	Evening	45	49	56	54	**45**
	Night	40	37	47	42	**40**

Note 1: ANL Acceptable Noise Level for a suburban area.
Note 2: RBL Rating Background Level.
Note 3: Assuming existing noise levels assuming no existing industrial noise.
Note 4: Project Specific Criteria are shown in bold.

Mechanical plant (such as air-conditioning or car-park exhaust fans) or any other external noise sources onsite are recommended to be strategically placed to avoid direct line of sight to neighbouring residences where practicable.

Mechanical noise has not been further considered in this assessment as specific plant selection has not been made at this stage of the development.

5 NOISE MODELLING

A three dimensional computer noise model of the site was carried out employing the UK Department of Transport, *Calculation of Road Traffic Noise* (CoRTN 1988) algorithms. The modelling allows for input of traffic volume and mix, vehicle speed, type of road surface and angle of view (from the receiver). The noise model was calibrated based on the measured traffic noise levels at Loc 1 and Loc 2, as well as known distances to the roadside kerb so that traffic noise levels could be predicted throughout the site.

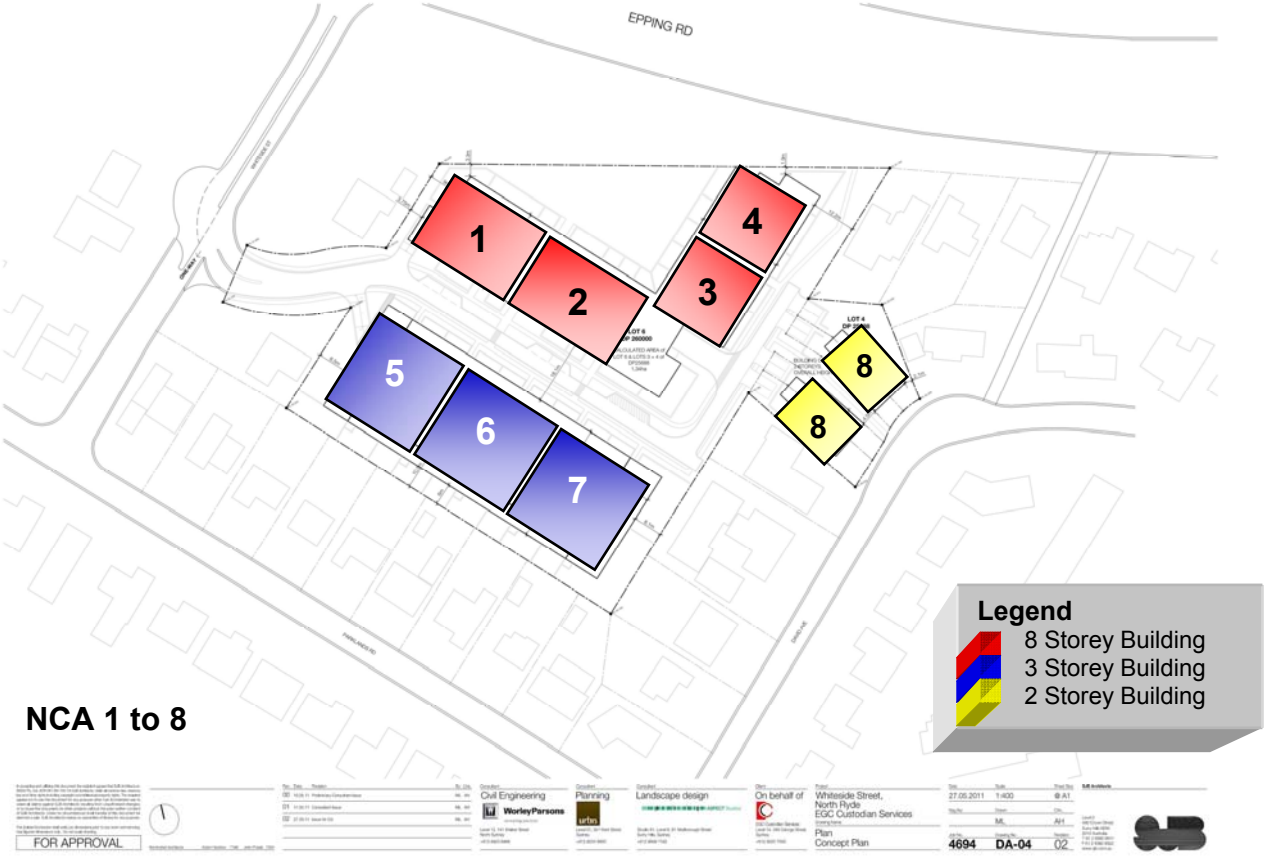
Whilst noise walls along the road boundaries are effective for receivers at ground level, they are not considered practical (due to the noise wall height required) for the upper levels of multilevel residential buildings. In lieu thereof, dwellings will be required to incorporate acoustic façade treatments as well as incorporating passive acoustic designs such as locating habitable areas away from the most potentially affected façade.

5.1 Façade Noise Levels

A development concept plan has been obtained from SJB Architects and reproduced in **Figure 3**.

Noise Catchment Areas (NCA) 1 - 8 (**Figure 3)** have been identified according to the proximity to Epping Road and the corresponding angle of view to the road.

Figure 3 Concept Plan - Typical Level



Road traffic noise levels have been predicted at the building facades onsite and are presented in **Table 6**.

In predicting the noise levels, the following considerations have been made:

- The L shaped eight storey building on the northern side of the site is assumed to be solid and continuous
- There is an upward topographical slope towards the south-eastern side of the site increasing potential lines of sight from the development to the road.

Table 6 External Building Façade Predicted Traffic Noise Levels

NCA	Exposed Facade	Predicted Noise Levels L_{Aeq}, dB(A)		Mechanical Ventilation Required Yes/No	Minimum Required Building Noise Reduction Rw+Ctr, dB	Recommended Building Noise Reduction Rw, dB
		Daytime	Night-time			
1	NE	67	62	Y	27	33
	NW	65	60	Y	25	31
	SW	36	31	N	-	-
2	NE	66	61	Y	26	32
3	NW	65	60	Y	25	31
	SE	60	55	Y	20	26
4	NE	69	64	Y	29	35
	NW	67	62	Y	27	33
	SE	63	58	Y	23	29
5	NE	58	53	N	18	24
	NW	59	54	N	19	25
6	NE	54	49	N	14	20
7	NE	50	45	N	10	16
	SE	48	43	N	8	14
8	NE	56	51	N	16	22

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. At facades not shown (eg the south-western façade of NCA 2 to NCA 8) noise levels will be below those expected at the SW façade of NCA 1 due to increased shielding.

The minimum building noise reduction values predicted at the representative Noise Catchment Areas are indicative only and reflect the simplistic noise model employed in this assessment. Therefore due care should be taken so as not to compromise the overall noise reduction performance of the building façades by avoiding large glazing areas and sealants that are not acoustically rated.

The minimum required building noise reductions presented as Rw (Weighted Sound Reduction Index) + Ctr (Spectrum Adaptation Factor) refer to the outside to inside noise reduction of the composite wall with the windows closed to achieve the internal noise levels presented in **Table 4**.

Rw values are used to rate the effectiveness of a construction system in reducing the transmission of airborne noise, with consideration of low frequency noise components (Ctr) which are generally present in road traffic noise. The Rw+Ctr ratings of the construction elements should be based on manufacturer-provided data tested by a National Association of Testing Authority (NATA) registered laboratory or a laboratory approved by the NSW DECCW.

It is important to address the low frequency content (usually up to 250 Hz) of road traffic noise which may cause the noise levels to fluctuate at the facade locations. Accordingly, indicative Rw values have been provided under the Recommended Building Noise Reduction Values column as recourse (in the absence of Ctr data).

Kjelberg and coworkers (1997) have suggested that where the subject noise source contains high levels of low frequency content, an addition of 6 dB to the measured A-weighted level would address any potential undue disturbance to the local community. Similarly, the NSW Industrial Noise Criteria suggests a modifying factor correction of 5 dB when dealing with noise sources with dominant low frequency noise content. Based on this review of Australian and overseas practices and relevant literature, a reasonable correction of 6 dB has been applied to the recommended Rw values as shown in **Table 6.**

Mechanical or alternative means of passive ventilation will be required where the predicted noise level exceeds 60 dB(A) during the daytime or 55 dB(A) during the night-time.

5.2 Architectural Façade Treatments - Overview

Noise ingress mostly occurs via glazing areas, doors, ventilation openings (or any other fixed or operable apertures) and roofs.

The overall sound reduction of a building element is dependent upon the:

- Mass of the construction;
- The effective surface area; and
- The extent of any gaps or openings.

Glazing on facades directly 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 dB(A) with windows slightly open for natural ventilation and 25 dB(A) with windows closed. To increase the outdoor to indoor noise reduction to 30-35 dB(A) (necessary to some parts of the proposed development) acoustically upgraded glazing will be required.

The selection of 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 onsite.
- Calculated road traffic noise at the assessment locations.
- Room dimensions and internal finishes.
- Window area.

To provide an outdoor to indoor noise reduction of 30-35 dB(A), indicative glazing systems have been provided in **Table 7**.

Table 7 Upgraded Glazing Requirements

Required Reduction	Glass Area	Typical Glazing System
30 dB(A)	< 1.8 m^2	6.38 mm laminate
	> 1.8 m^2	10.38 mm laminate
35 dB(A)	< 1.8 m^2	4.00 mm, 100 mm air gap, 6.00 mm
	> 1.8 m^2	3.00 mm, 100 mm air gap, 6.38 mm laminate

Furthermore, acoustic window sealants, with the provision of solid core doors also sealed with acoustic grade seals (not brush seals), are recommended to be incorporated into the built form. This would maintain the acoustic integrity of the window/balcony door systems.

5.3 Passive Recreation Areas

The proposed Whiteside residential development incorporates a passive recreation area between the main 8 storey building and the northern site boundary, and also on the roof top terrace located on the south-eastern side of the 8 storey building. As presented in **Table 3** for areas affected by Freeway/arterial roads the criteria is an $L_{Aeq(15hr)}$ of 55 dBA. It is noted that the noise criteria presented within the ECRTN noise policy document are guidelines and non mandatory.

Noise levels where predicted to be typically 56 dBA to 62 dBA at the ground passive recreation area and 59 dBA to 61 dBA on the northern end of the roof terrace. To ameliorate the traffic noise at the ground passive recreation area a 2.6 m high noise wall is required to be located along the site northern boundary. To ameliorate the traffic noise on the northern side of the roof top terrace a 1.2 m high perimeter wall facing the road as well as to the south-east can be used (noting a wall of this height would be in any event required for roof terrace safety). Alternatively the terrace passive recreation areas can be set-back to utilise shielding provided by the building.

6 CONCLUSION

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

An ambient noise survey was conducted to determine the existing traffic noise intrusion for the proposed residential buildings onsite. Based on the analysed noise survey results, traffic noise levels have been predicted at representative façades of a concept plan.

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 dB(A) for bedrooms and 40 dB(A) 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 dB(A), the design of the ventilation for these rooms should be such that occupants can leave the 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 facade) noise reduction of Rw+Ctr ranges from 10 dB to 29 dB with the recommended Rw values from 16 dB to 35 dB. As such, it is predicted that mechanical or alternative means of passive ventilation will be required to the most exposed of the living and bedroom areas within the residential buildings.

The required building façade construction required to achieve the minimum required traffic noise reduction will range from "standard" to "acoustically upgraded", where the upgraded component will indicatively comprise heavier glazing with the windows and doors acoustically sealed. Such treatments would be determined during the detailed design phase concurrent with the development of the building envelopes and internal layout details.

Compliance with the relevant internal noise criteria can be achieved with standard and acoustically upgraded building design and construction methods.

Passive recreation areas are proposed at ground level and on the roof terrace. To ameliorate the traffic noise at these areas it is proposed to used noise walls.

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

7 CLOSURE

This report has been prepared by Heggies Pty Ltd with all reasonable skill, care and diligence, and taking account of the manpower and resources devoted to it by agreement with the client. Information reported herein is based on the interpretation of data collected and has been accepted in good faith as being accurate and valid.

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

Heggies disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.

8 REFERENCE

Kjelberg, A., Tesarz, M., Holberg, K., and Landström, U. 1997. *Evaluation of frequency-weighted sound level measurements for prediction of low-frequency noise annoyance.* Environment International*. Vol. 23, pp. 519-527. Cited in Leventhall, G. 2003.*

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.

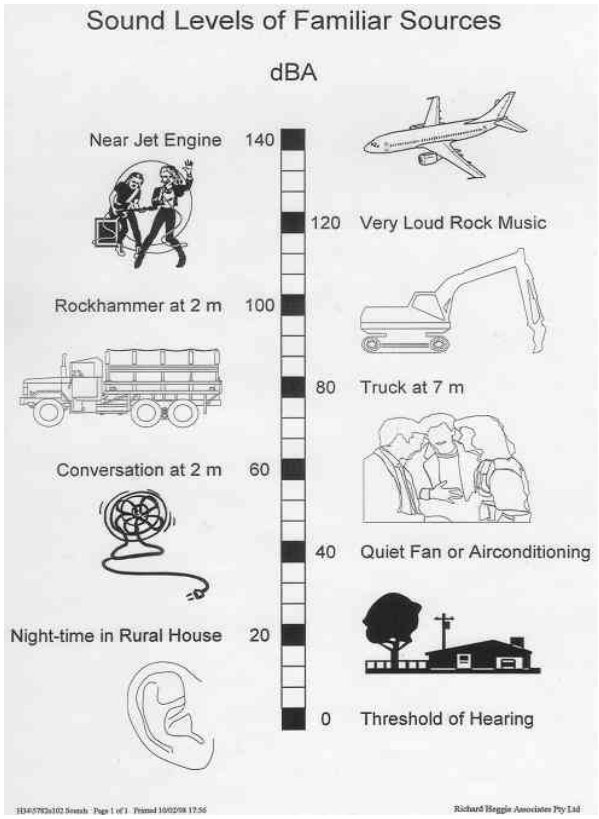
The symbols SPL, L or L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2×10^{-5} Pa.

2 "A" Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dB(A), 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 dB(A) is a good measure of the loudness of that sound. Different sources having the same dB(A) level generally sound about equally loud.

A change of 1 dB(A) or 2 dB(A) in the level of a sound is difficult for most people to detect, whilst a 3 dB(A) to 5 dB(A) change corresponds to a small but noticeable change in loudness. A 10 dB(A) 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

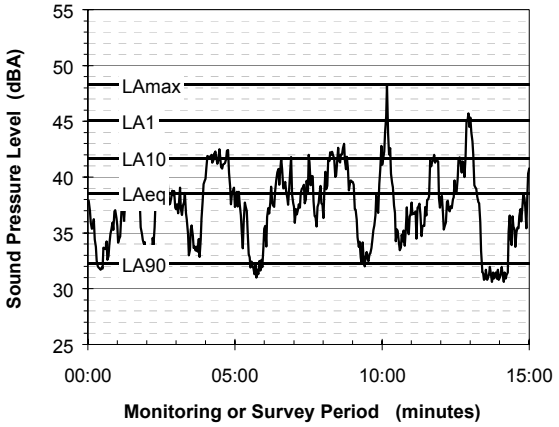
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dB(A)), but may be identified by the symbols SWL or LW, or by the reference unit 10-12 W.

The relationship between Sound Power and Sound Pressure 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).

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

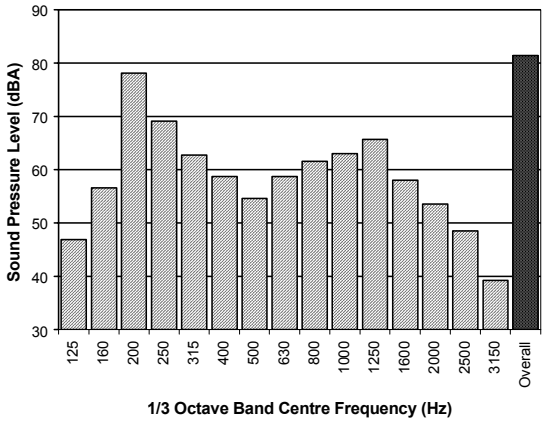
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters, but is now normally carried out using Fast Fourier Transform (FFT) analysers.

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

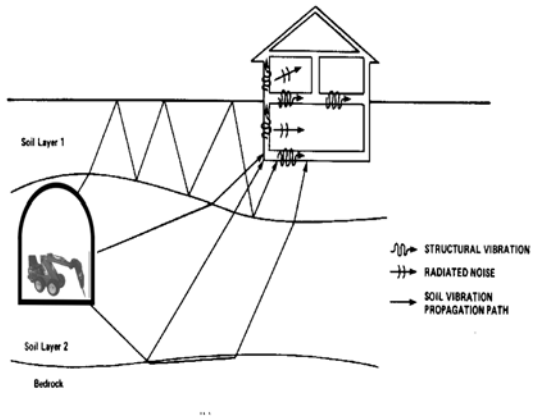
The term "over-pressure" is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

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

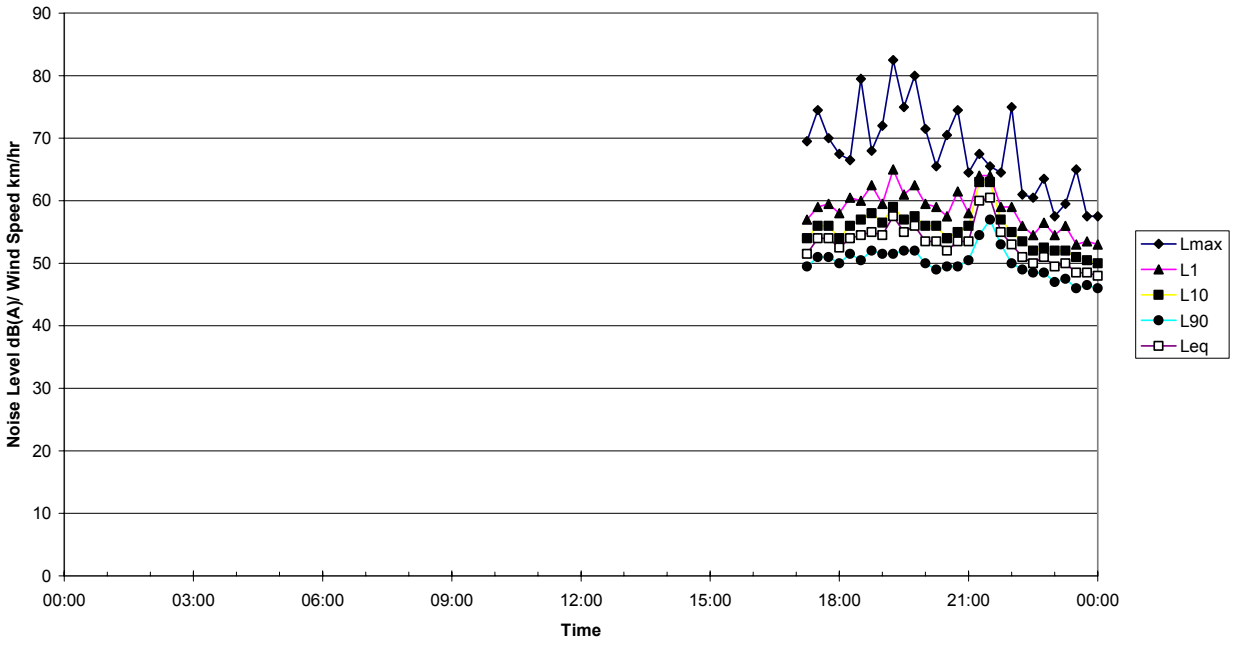
ABL	Assessment Background Level - In accordance with the INP, the single figure background noise level representing each assessment period - day, evening and night. The ABL noise level is determined by calculating the lower 10 percentile level of all $L_{A90(15minute)}$ samples for each assessment period.
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.
dB(A)	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.

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.
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.

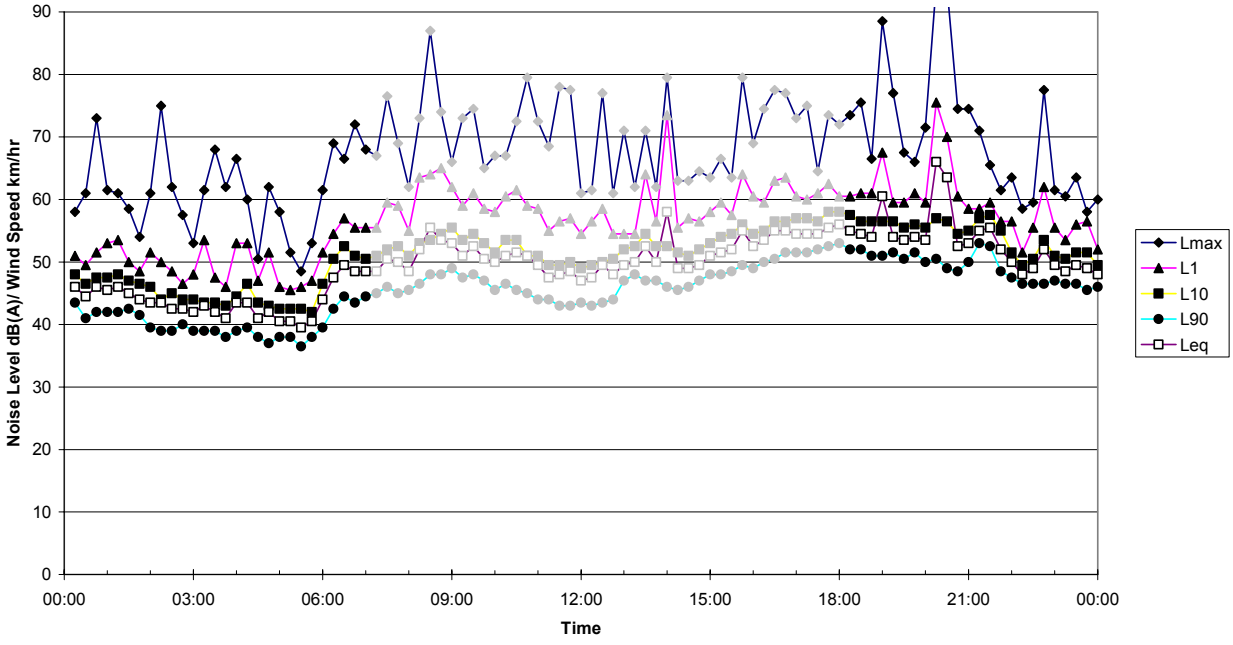
$L_{Aeq(15minute)}$	The L_{Aeq} noise level over a 15 minute period. In accordance with the NSW INP's intrusive criteria, $L_{Aeq(15minute)}$ from industry is assessed against the RBL + 5 dB(A).
$L_{Aeq(period)}$	The L_{Aeq} noise level over the relevant assessment period. Based on the NSW INP, day is 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 dB(A), as measured by a standard sound level meter with a pressure microphone. The sound pressure level in dB(A) 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 - LOC 1

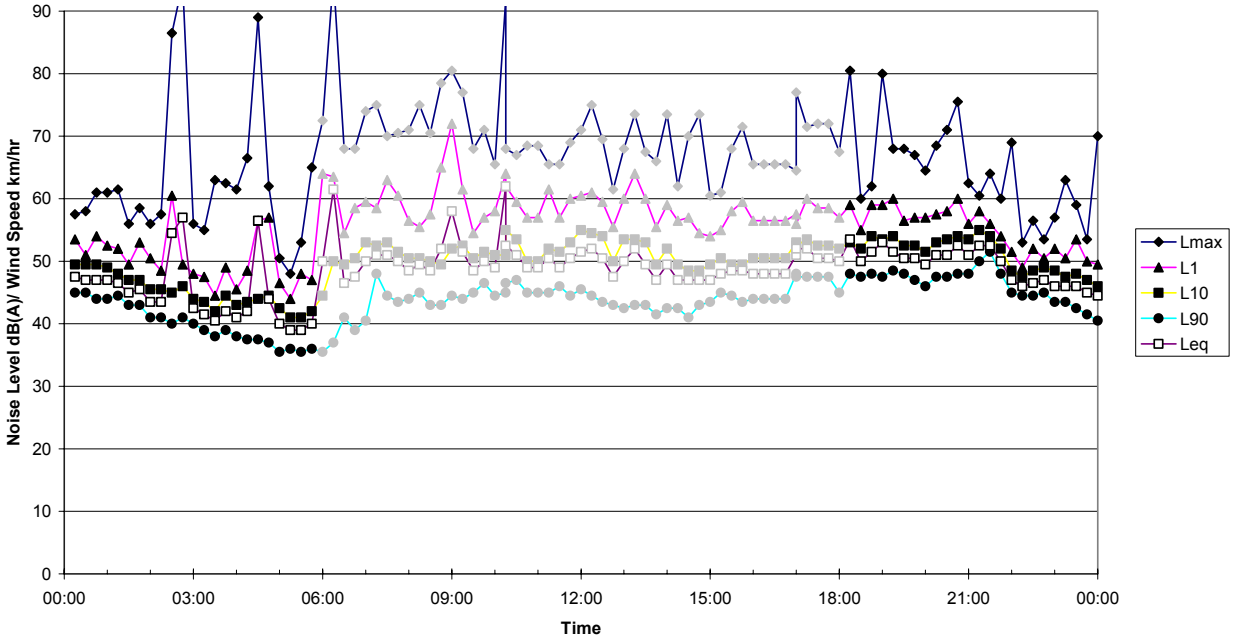
Measured Noise Levels
Location 1 - Thursday 02-12-2010



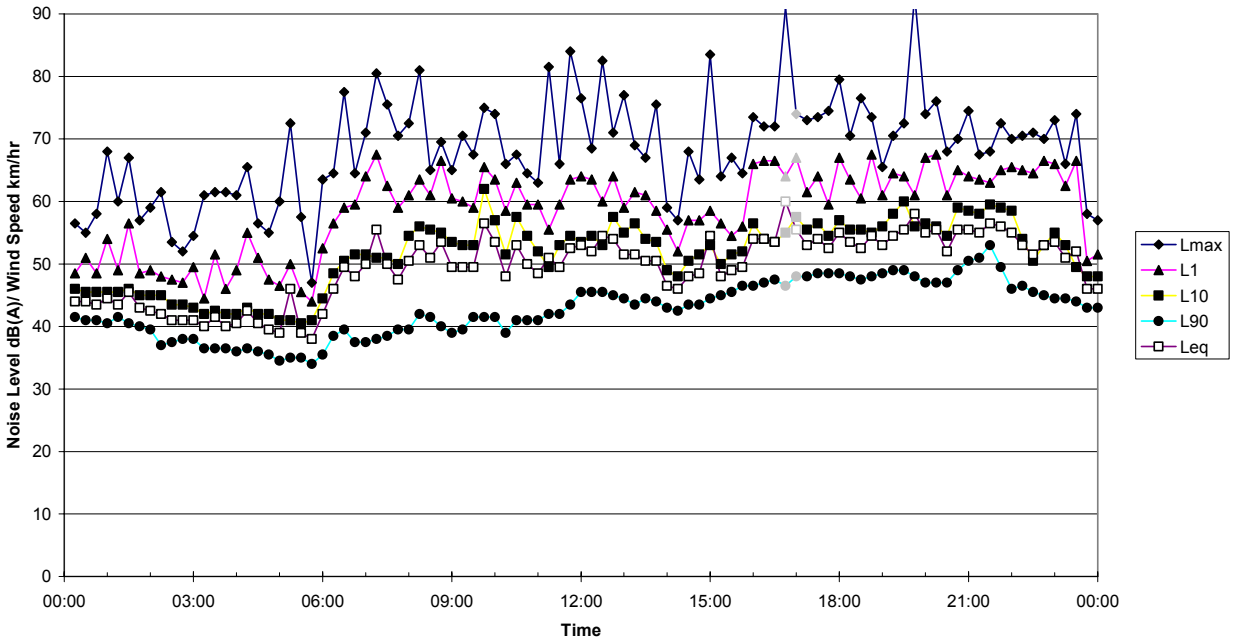
Measured Noise Levels
Location 1 - Friday 03-12-2010



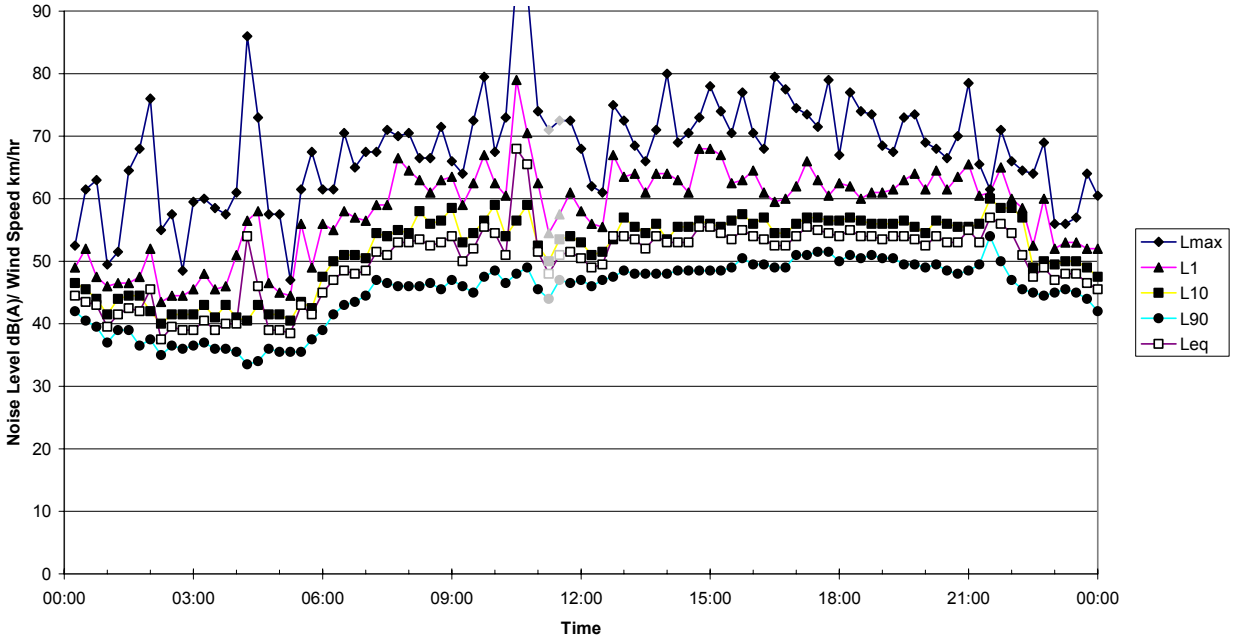
Measured Noise Levels
Location 1 - Saturday 04-12-2010



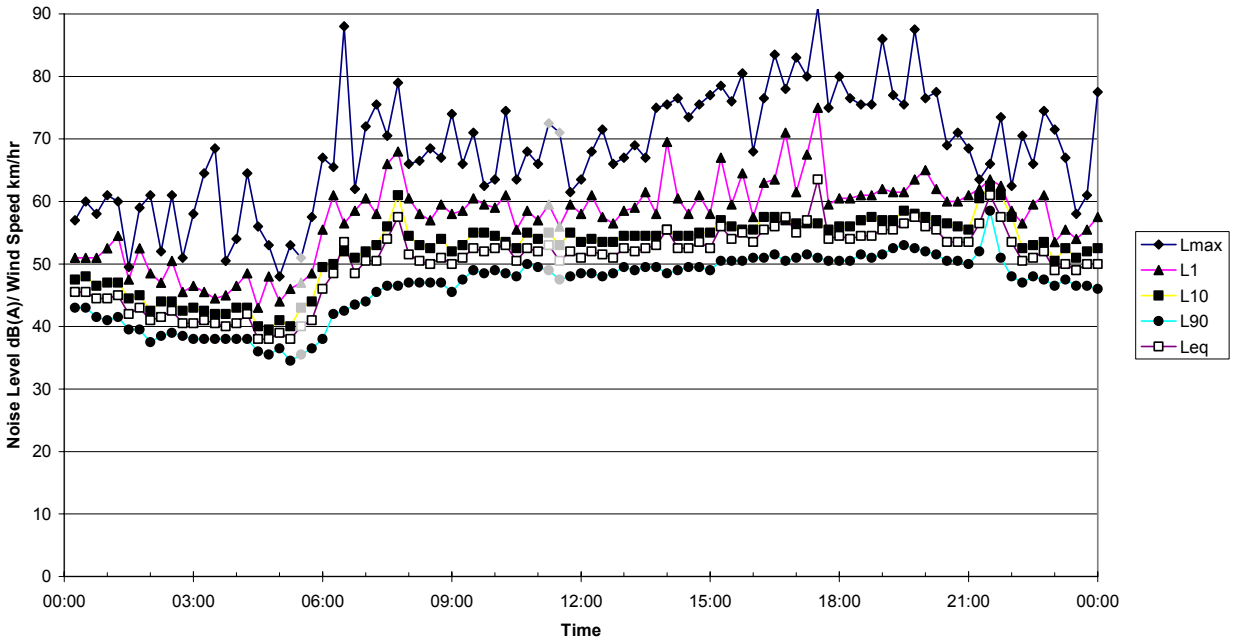
Measured Noise Levels
Location 1 - Sunday 05-12-2010



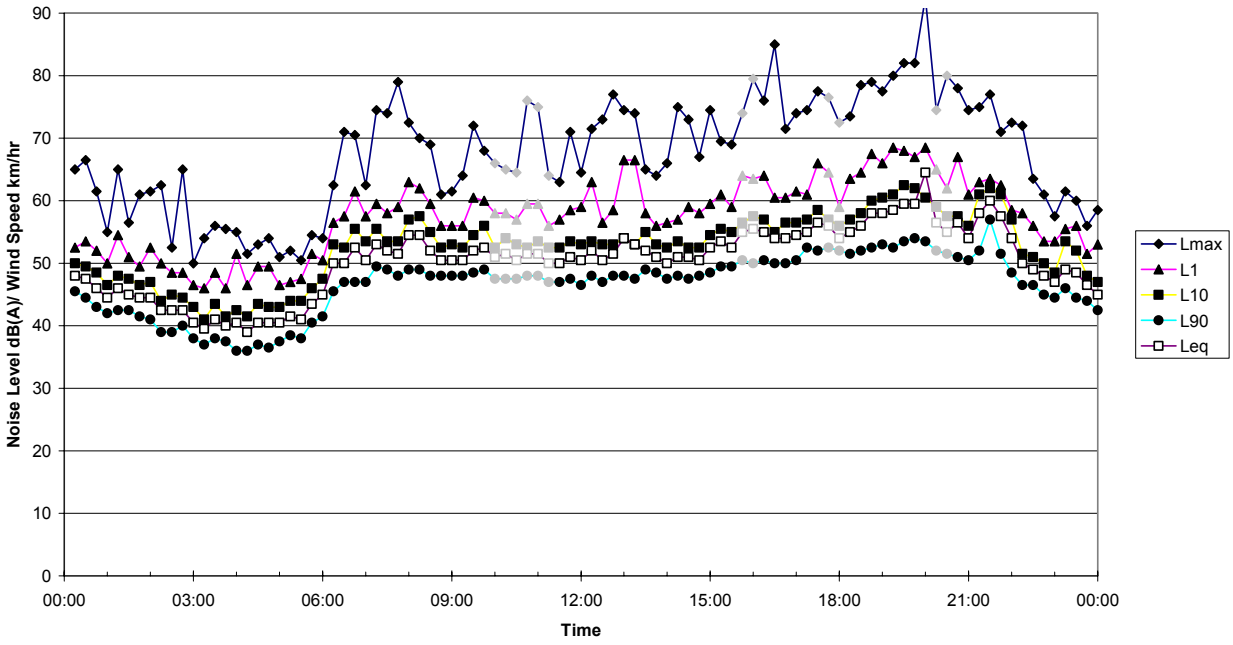
Measured Noise Levels
Location 1 - Monday 06-12-2010



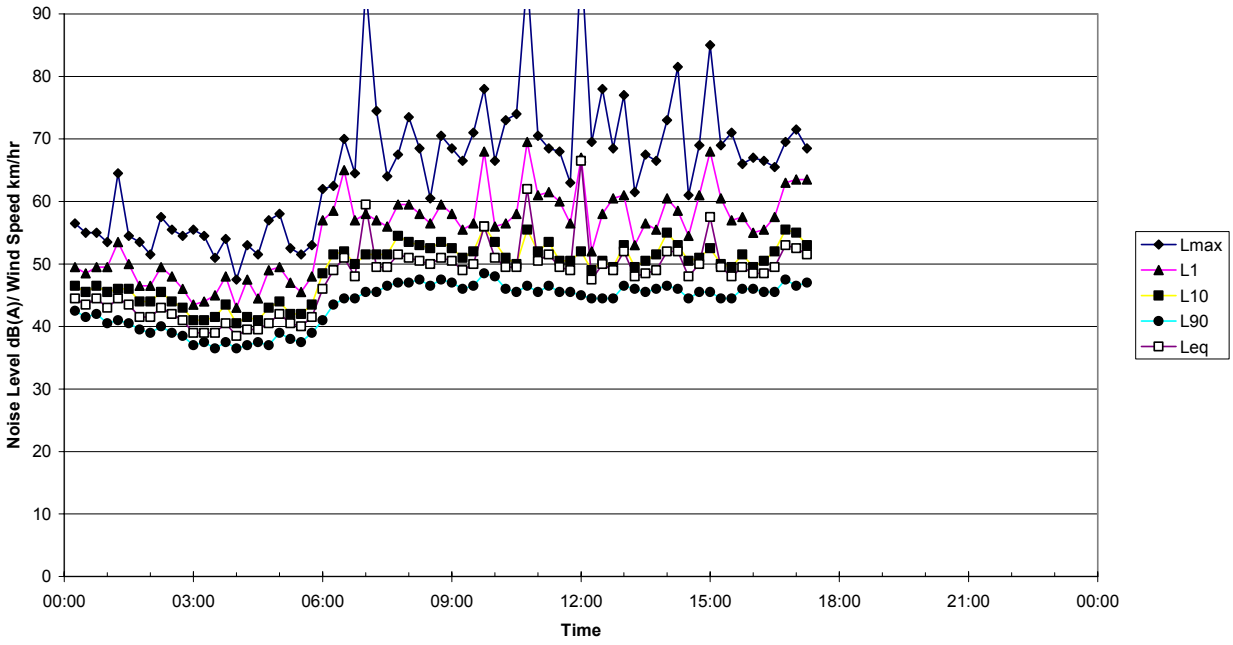
Measured Noise Levels
Location 1 - Tuesday 07-12-2010



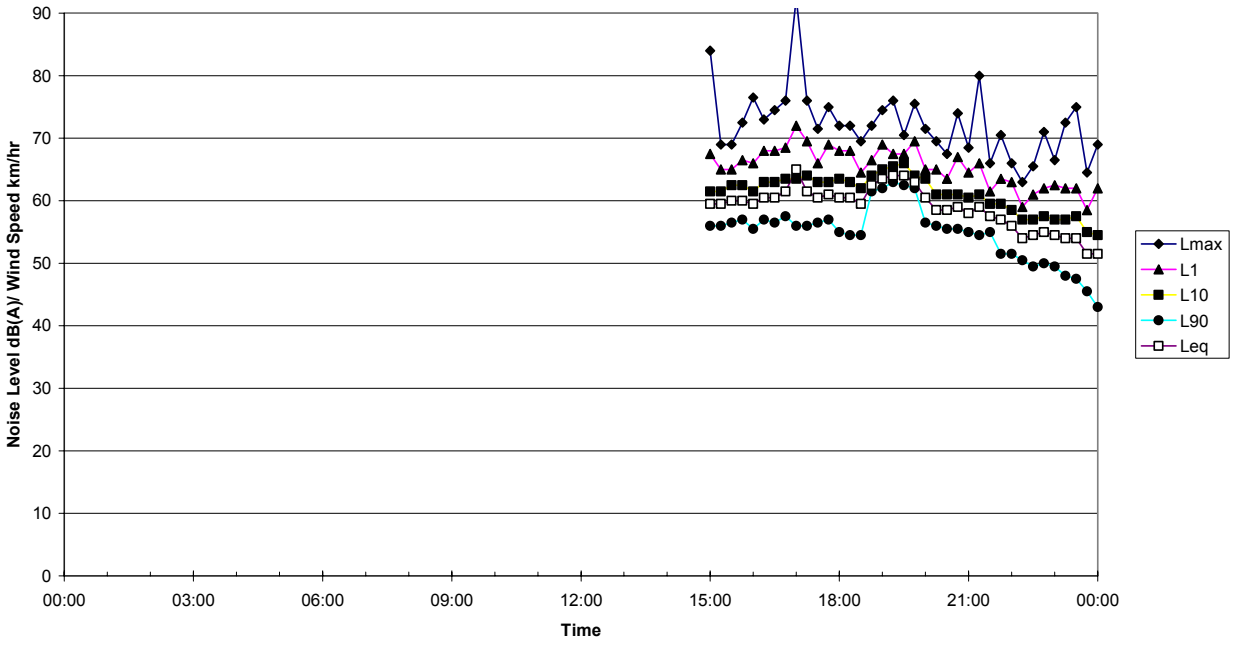
Measured Noise Levels
Location 1 - Wednesday 08-12-2010



Measured Noise Levels
Location 1 - Thursday 09-12-2010



Measured Noise Levels
Location 2 - Thursday 02-12-2010



Measured Noise Levels
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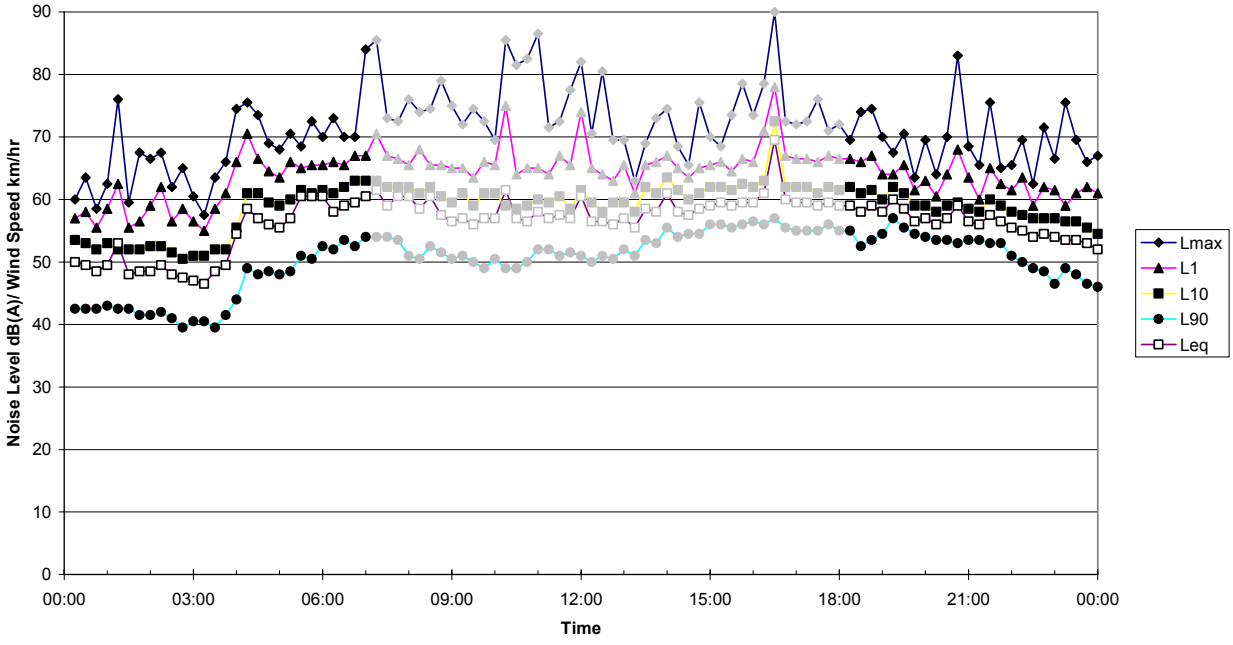

Measured Noise Levels
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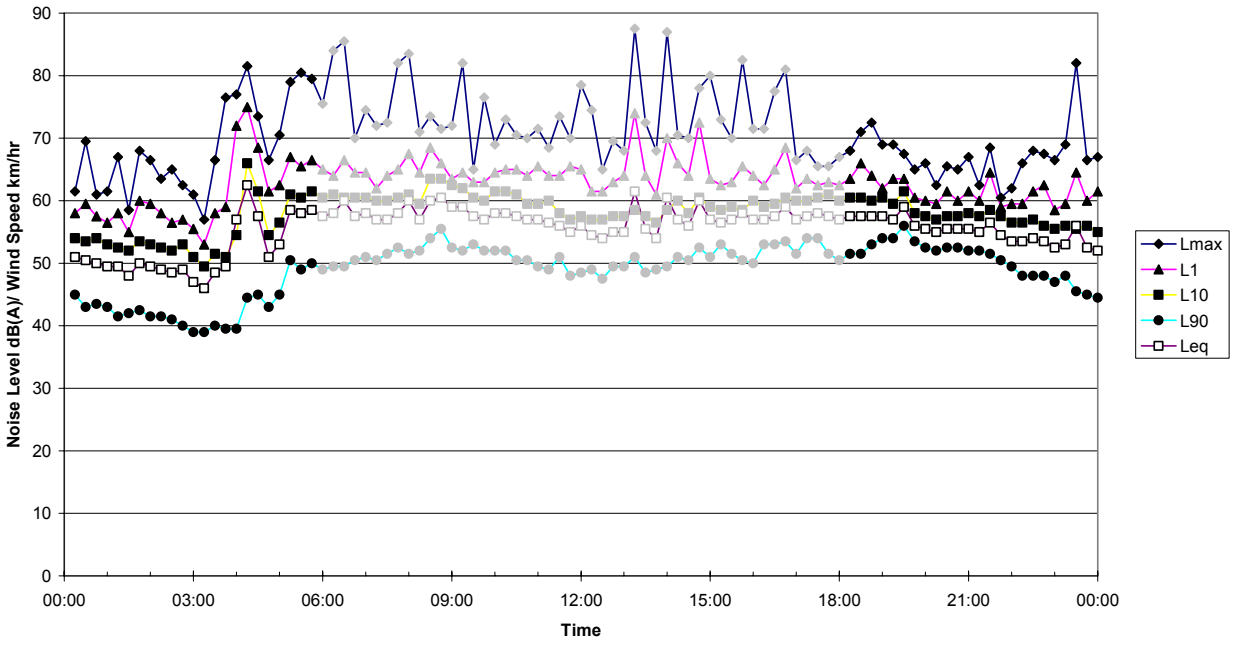
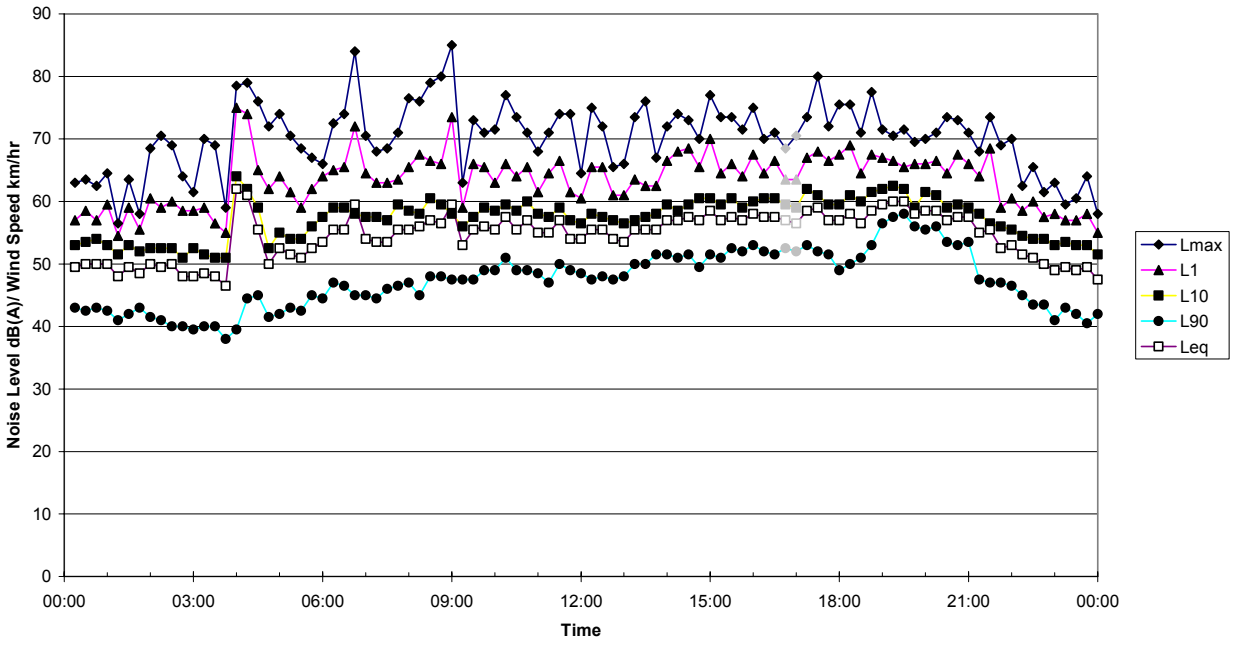
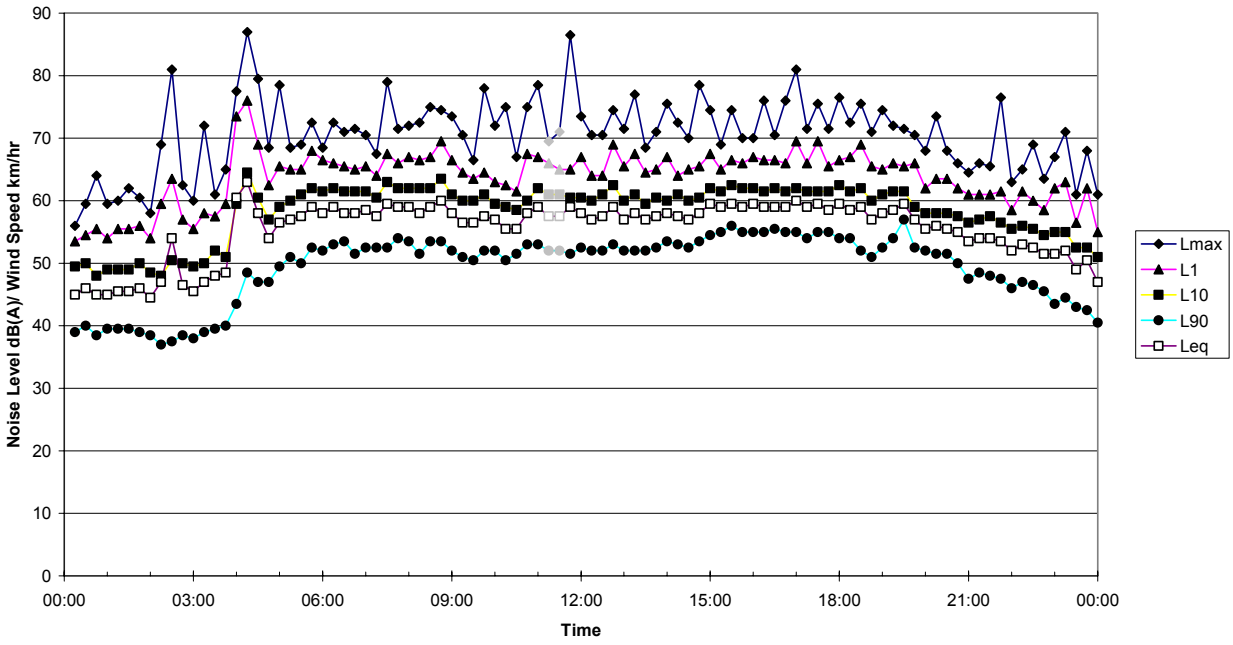


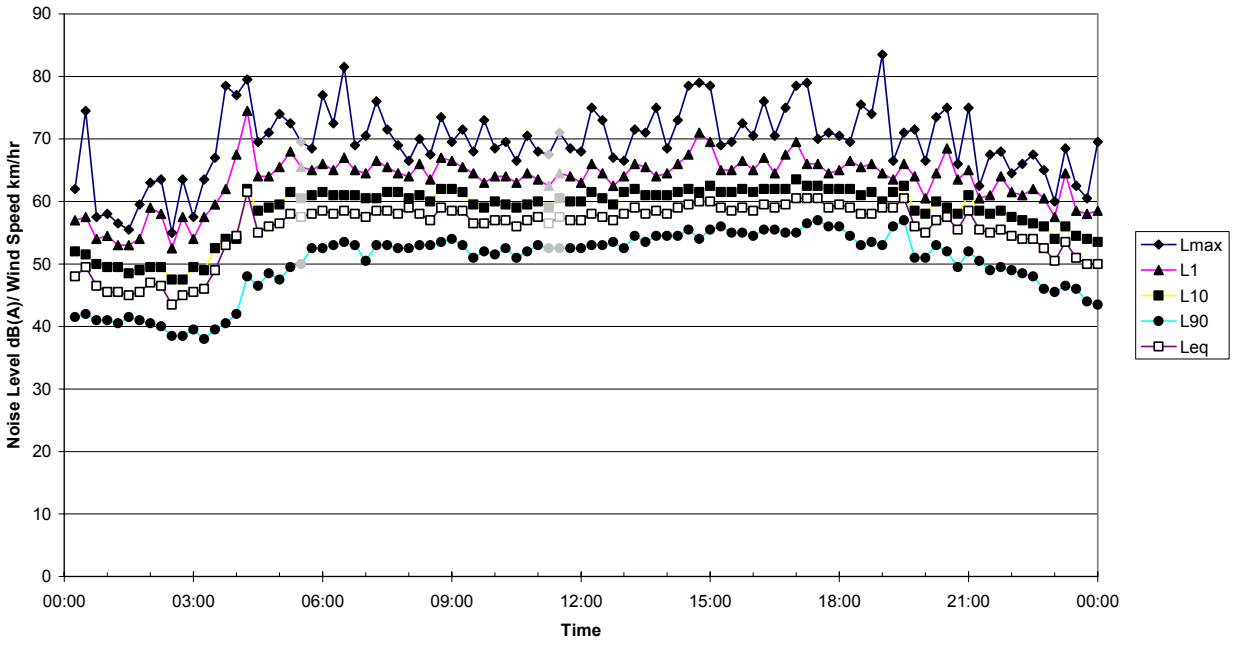
Measured Noise Levels
Location 2 - Sunday 05-12-2010



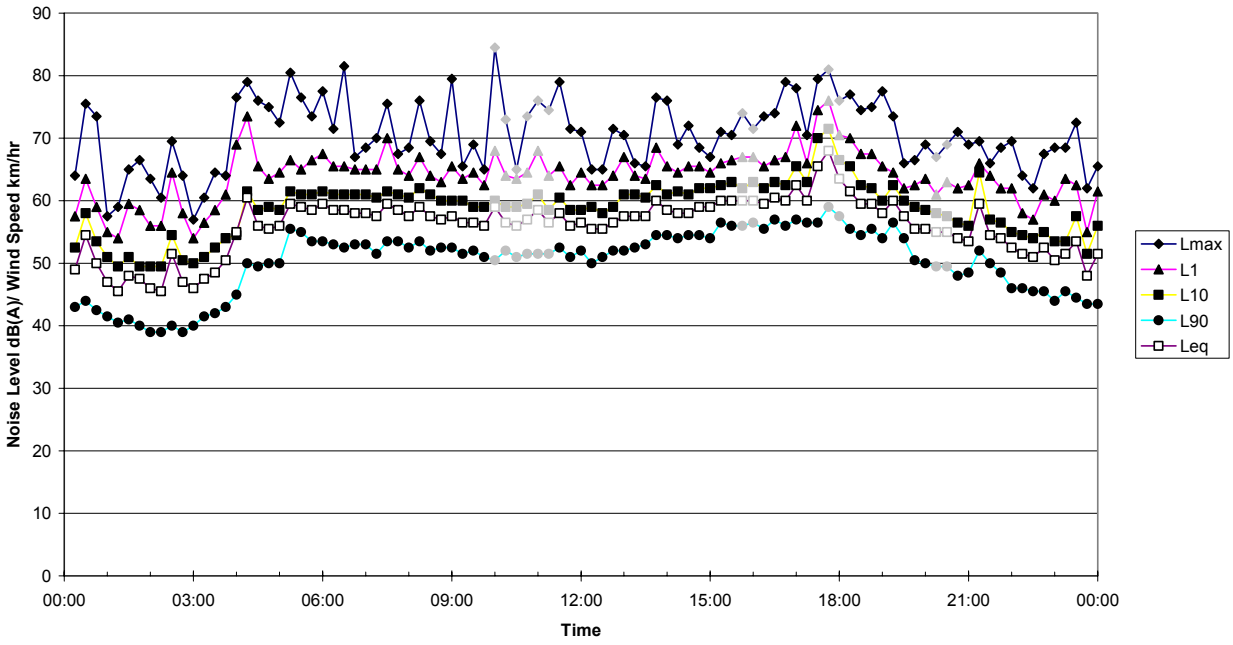
Measured Noise Levels
Location 2 - Monday 06-12-2010



Measured Noise Levels
Location 2 - Tuesday 07-12-2010



Measured Noise Levels
Location 2 - Wednesday 08-12-2010



Measured Noise Levels
Location 2 - Thursday 09-12-2010