VOLUME 3 APPENDICES J - Q FEBRUARY 2009

AGL Leafs Gully Power Project Environmental Assessment

MP 08_0077

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VOLUME 3 APPENDICES FEBRUARY 2009

AGL Leafs Gully Power Project Environmental Assessment

MP 08_0077

Appendix J

Noise Assessment

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Switched on Business.

LEAFS GULLY GAS TURBINE POWER STATION, APPIN

NOISE & VIBRATION ASSESSMENT

A C O U S T I C S   A N D   A I R

REPORT NO. 06049
VERSION I

WILKINSON MURRAY

LEAFS GULLY GAS TURBINE POWER STATION, APPIN

NOISE & VIBRATION ASSESSMENT

REPORT NO. 06049
VERSION I

NOVEMBER 2008

PREPARED FOR

URS AUSTRALIA PTY LTD
LEVEL 3, 116 MILLER STREET
NORTH SYDNEY NSW 2060

Wilkinson Murray Pty Limited
ABN 41 192 548 112 • Level 2, 123 Willoughby Road, Crows Nest NSW 2065, Australia • **Asian Office: Hong Kong**
t +61 2 9437 4611 • f +61 2 9437 4393 • e acoustics@wilkinsonmurray.com.au • w www.wilkinsonmurray.com.au

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1 INTRODUCTION

AGL Energy (AGL) proposes to construct a gas turbine power station at Leafs Gully, northwest of Appin, in southwest Sydney. The location of the site is shown in Figure 1-1.

AGL are seeking approval for 2 turbines in this assessment, however allowance is made in the footprint for an additional 2 turbines to be installed at a later date subject to another assessment as required, should AGL successfully demonstrate the performance of the site with 2 turbines. Each of the turbines are rated nominally at 150MW.

The facility will operate as a "peaking plant" which means the turbine(s) only operate during periods of high demand. It is anticipated that the plant will operate up to 15% of the time.

In terms of utilities, the site is currently serviced by two (different) gas pipelines and a high voltage electricity line.

Wilkinson Murray (WM) has been engaged to conduct a noise and vibration assessment forming part of an Environmental Assessment (EA). This assessment covers the environmental noise and vibration aspects relating to the construction and operation of the gas turbine power station.

With respect to noise, the development has been assessed primarily in accordance with the following policy guidelines published by the NSW Department of Environment & Climate Change (DECC):

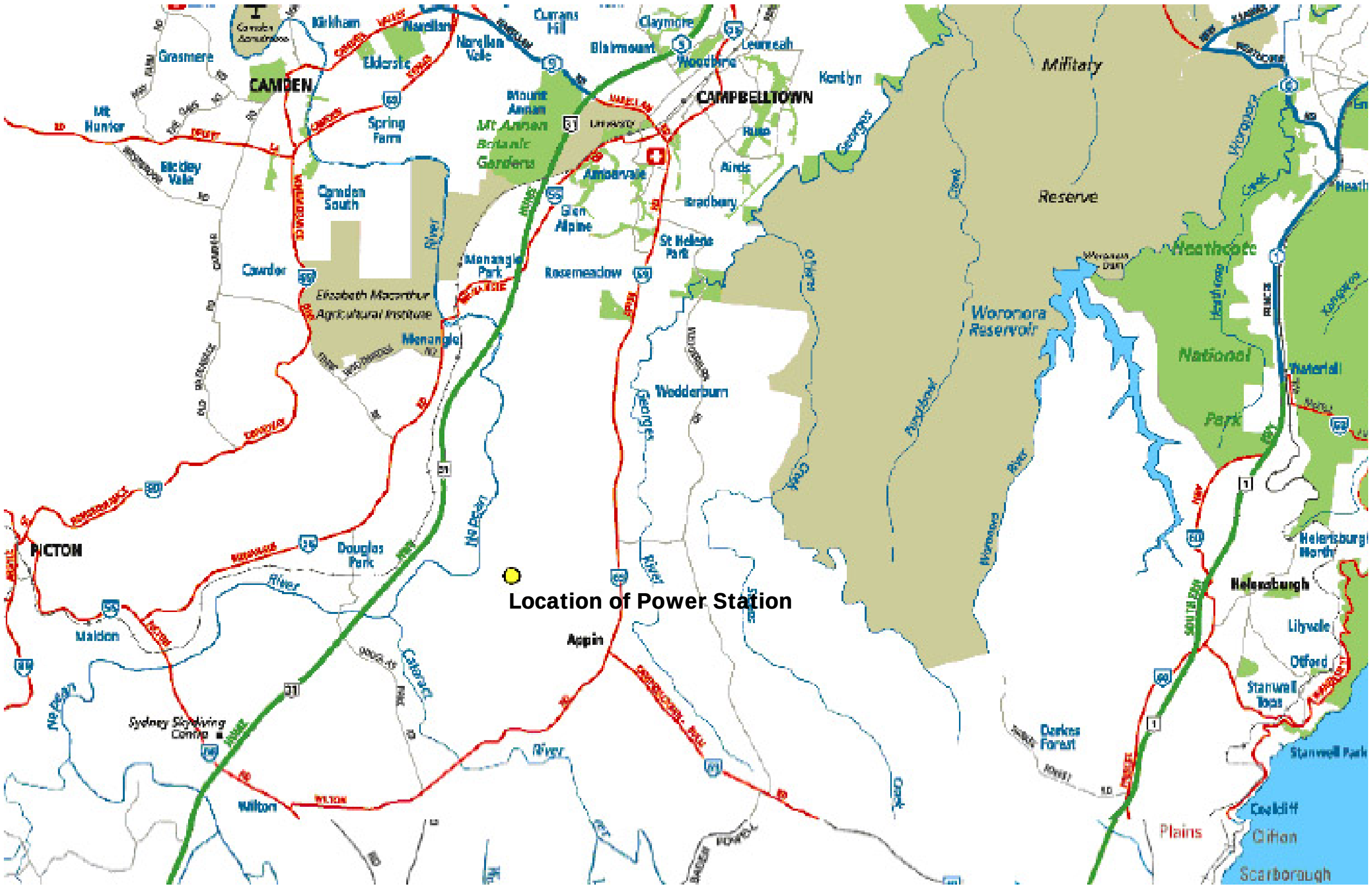
- *NSW Industrial Noise Policy (INP)*, dated January 2000;
- *Environmental Criteria for Road Traffic Noise (ECRTN),* dated May 1999;
- *Noise Guide for Local Government (NGLG),* dated June 2004; and
- *Environmental Noise Control Manual (ENCM),* dated 1984.

Vibration has been assessed by considering:

- The DECC's – *Assessing Vibration – A Technical Guideline (AVTG),* dated February 2006; and
- German Standard 4150-3 – *Structural Vibration - Part 3: Effects of Vibration on Structures (DIN4150-3),* dated February, 1999.

It is to be noted that as of May, 2007, the DEC became known as the NSW Department of Environment & Climate Change (DECC).

Figure 1-1 Locality Map



2 DESCRIPTION OF PROPOSAL, SITE & SURROUNDS

The proposed facility would comprise of two gas turbines each rated at nominally 150MW. The electricity generated from these turbines will feed into the 330kV transmission network via a new switchyard that will be constructed on the site as part of these works. The turbines would be supplied by gas from either of the two gas lines that run through the site.

Given that the two turbines are proposed to operate as a "peaking plant", there would only be a limited number of hours that any of the turbines would operate. However, it may be the case that this could occur during the night time period, although unlikely given that generally "peak demand" is likely to coincide with periods in the morning and evening.

The section of the site that will house this facility is located in the northern end of the site, central to the east and west boundaries. It covers an area of approximately 300m (N-S) by 200m (E-W). This section will require some earthworks such that the existing topography is lowered to an RL ranging from approximately 142 to 146m across the site.

The site is known as Leafs Gully and is located within the Campbelltown local government area, 4.5km northwest of Appin. The site currently operates as a trotting, horse breeding and training enterprise. The majority of the land is cleared and used for grazing and horse yards. The site includes three residences, farm buildings and a purpose-built trotting track.

Adjoining the site to the north and east are rural lands that include residences. To the south of the site, Ingham's Appin boiler complex is located and the Nepean River forms the western boundary of the site. Further to the west across the river are also rural home sites that include residences.

With respect to residential receivers, the surrounding existing six residences and their location, including RL are summarised in Table 2-1.

Table 2-1 Location of the Surrounding Existing Residences

Residence No.	East (AMG)	North (AMG)	RL (m)
1	295689	6218895	206
2	294649	6217587	172
3 (1)	294768	6219818	170
4	292327	6217517	134
5	292115	6218869	119
6	292369	6217945	127

Note: 1) This property is known as Meadowvale.

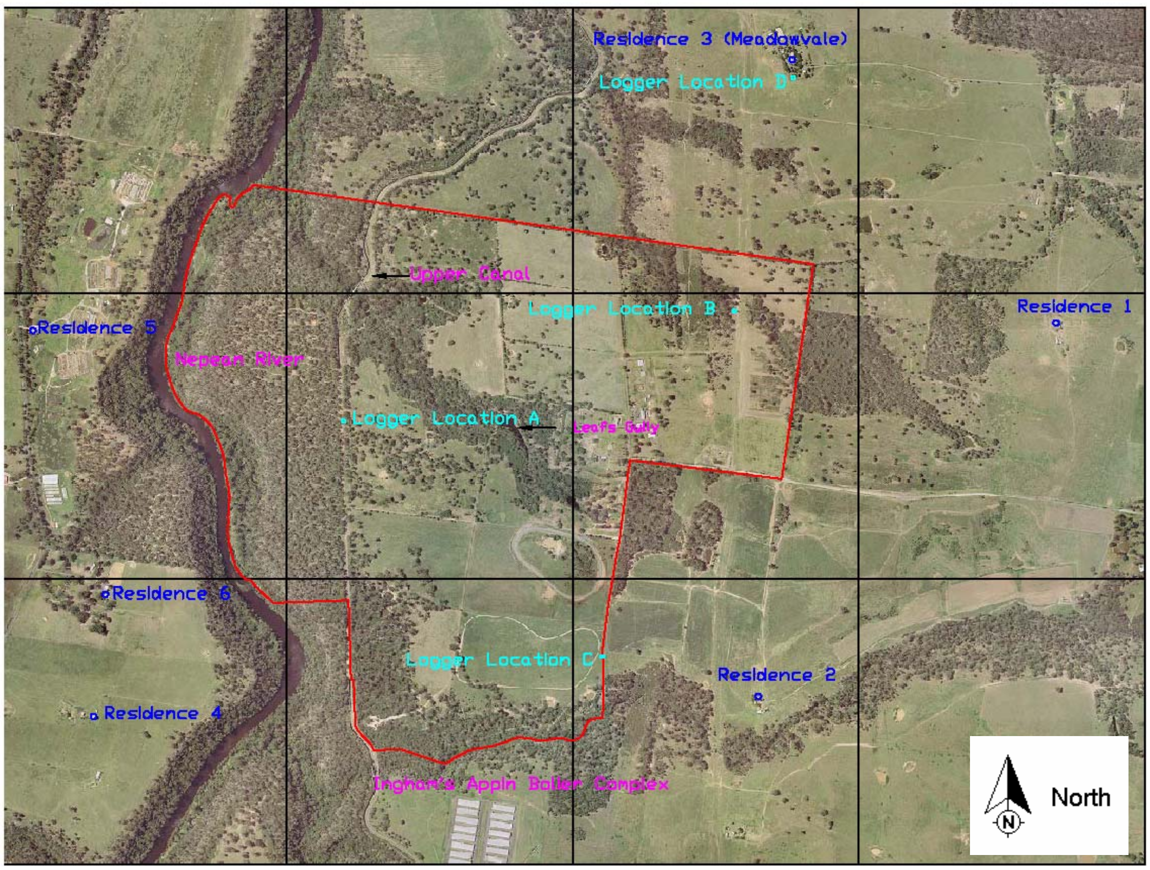
Figure 3-1 shows the location of these residences.

3 EXISTING ACOUSTIC ENVIRONMENT

AGL via their community consultant, Coakes Consulting, liaised with many of the nearby residences in order for a noise logger to be placed onto their land. However, this proved to be difficult as the nearby residences preferred not to participate in the collection of noise data. In the first instance WM were forced to place noise loggers on the proposed site in strategic locations that were deemed representative of the noise currently experienced by the nearby residences. Later, AGL offered the owners of the Meadowvale property (Residence 3) additional background monitoring at the residence, to which the owners agreed.

Figure 3-1 shows the location of the proposed site with the site boundary (red), the four noise monitoring locations (A to D) and the six closest existing residential receivers (1 to 6).

Figure 3-1 Noise Monitoring Locations



The detailed measurement results are shown in graphical format in Appendix B.

The loggers were set to A-weighting, fast response and to monitor every 15-minutes. This equipment is capable of remotely monitoring and storing noise level descriptors for later detailed analysis. The calibration was checked before and after the survey and no significant drift was noted. All loggers hold current NATA calibration certificates.

The loggers determine a variety of noise descriptors, including L_{A90} and L_{Aeq} levels (see Appendix A for definitions) of the existing noise environment. From the background noise levels (L_{A90}) the Rating Background Levels (RBLs) were determined using methodology as recommended by the NSW Department of Environment & Conservation (DEC) document, the *NSW Industrial Noise Policy (INP)*. The DEC considers the RBL to represent the background noise level. The following locations (refer to Figure 3-1) were monitored:

- Logger Location A – located in the central west of the site and representative of residences 4, 5 and 6.
- Logger Location B – located in the north eastern sector of the site and representative of residences 1 and 3.
- Logger Location C – located in the southern central sector (along site boundary) and representative of residence 2.
- Logger Location D – located in the south western corner of the Meadowvale property.

Table 3-1 summarises the results of the noise monitoring.

Table 3-1 Measured Noise Levels – Unattended

Location	Measurement Date	Time Period (1)	Rating Background Level RBL (dBA)
Logger Location A	09/05/06 – 18/05/06	Daytime	30
		Evening	32
		Night Time	33
Logger Location B	09/05/06 – 18/05/06	Daytime	36<2>
		Evening	36<2>
		Night Time	36<2>
Logger Location C	09/05/06 – 18/05/06	Daytime	28<3>
		Evening	31
		Night Time	31
Logger Location D	27/10/06 – 05/11/06	Daytime	30<4>
		Evening	31
		Night Time	28<3>

Note: 1) The *INP* considers daytime (7.00am-6.00pm); evening (6.00pm-10.00pm); night time (10.00pm-7.00am). On Sundays and Public Holidays, daytime begins at 8.00am and night time ends at 8.00am.
2) Level likely to be influenced by local environment, possibly wind, insects, frogs.
3) The *INP* considers the lowest RBL as 30, any level lower is assigned a 30dBA level.
4) A level of 31dBA was derived from measured levels, however given that there may have been influence from wind, a level of 30dBA has been assigned (see Note 3).

As required by the *INP*, extraneous noise and any effects due to adverse meteorological conditions (either rain or wind greater than 5m/s at a height of 1.5m) have been excluded.

With regards to exclusion of adverse weather conditions, hourly data from the Bureau of Meteorology's (BoM) Camden weather station located at Camden Airport has been used.

The INP also requires the exclusion of any extraneous noise. These sources are not always easily identifiable and were considered by assessing each time period of each day, looking for patterns and also considering the expected noise levels in the area. Where these patterns were obviously dissimilar and not likely attributed to the "typical" environment, then this data was excluded.

The measured noise levels, together with the charts (Appendix B) suggest that the initial data collected (particularly during the evening and night and at Logger Location B) was influenced by the local environment. At Logger Location B, the noise levels appear to be elevated compared to Logger Locations A and C, furthermore the day, evening and night-time RBL's are identical. This was possibly due to noise from insects, frogs or wind in the trees. The noise data measured at Location D is similar to the data collected at Logger Locations A and C and would be more reliable than the data measured at Location B.

Furthermore, the DEC has issued application notes to consider the situations where the calculated RBL for the evening is higher than that calculated during the day and the RBL for the night is higher than the RBL in the evening. The application notes suggest that these situations may be from insect related noise or from temperature inversions. The objective of conducting long-term noise monitoring is to establish levels indicative of the entire year and inline with the expectation of the community (where the night is the quietest and the day the noisiest).

Based on this analysis, the most appropriate RBL for all time periods and all locations is 30dBA. This is the lowest permissible RBL as recommended within the *INP.*

4 NOISE CRITERIA

With respect to noise criteria, the NSW Department of Planning has provided the environmental assessment requirements under part 3(a) of the *Environmental Planning & Assessment Act* 1979 to be compliant with the *INP* and Chapter 171 of the *ENCM*. Similarly, the DECC requires that impacts of noise be assessed in accordance with the *INP* and that vibration impacts be considered.

4.1 Operational Noise Criteria - Continuous

The *INP* is designed to assess "industrial noise" using the more stringent of the following two approaches:

- Intrusive noise impacts in the short term for residences; and
- Amenity for particular land uses such as residences.

The *INP's* intrusive goal is set 5dBA above the Rating Background Level (RBL) for each time period (daytime, evening or night time) of interest. The RBL's are derived from the measured L_{A90} noise levels as per the DECC guidelines.

The amenity goal sets an upper limit to the total noise level (L_{Aeq}) in an area from all industrial noise (existing and future). The criterion depends on the time of day, area classifications and the relationship of the total measured L_{Aeq} (and contribution from existing industrial noise) to determine the Acceptable Noise Level (ANL) for the development.

The potentially affected area is classified as "Rural" by the *INP*. Given this, the "acceptable" amenity levels (L_{Aeq} dBA) which apply over the whole day, evening or night period are as follows and are applicable as there are no other "industrial" noise sources:

- Daytime 50dBA
- Evening 45dBA
- Night time 40dBA

The "maximum" amenity levels are 5dBA higher.

It can be seen that the intrusive criteria will be at least 10dBA more stringent than that of amenity, therefore a criterion of $L_{Aeq,15min}$ 35dBA from the source (power plant), based on 5dBA above 30dBA has been adopted for this development as the residential receivers are rural, and applies within 30m of the existing residences. This is the most stringent criterion possible based on the *INP*.

Further to this, the INP requires where noise sources contain certain characteristics, such as tonality, impulsiveness, intermittency or dominate low frequency content, a modifying factor of +5dBA (to a maximum of +10dBA) should be applied because these type of noises typically cause greater annoyance to the community.

These modification factors take effect at the residential receiver and would typically be judged by measurement at the residential receiver where the measurement would be made up of both the plant noise and existing ambient noise environment as experienced by the residential receiver.

4.2 Operational Noise Criteria – Sleep Disturbance

Where there exists the possibility that instantaneous, short-duration, high-level noise events may occur during night time hours (10.00pm-7.00am), the DECC requires that consideration be given to the potential for the disturbance of sleep within residences.

The INP does not specifically address sleep disturbance, however the DECC undertake a literature review concerning research on sleep disturbance (primarily due to transportation noise). This review concluded that the range of results is sufficiently diverse that it was not reasonable to issue new noise criteria for sleep disturbance.

From the research DECC recognised that current sleep disturbance criterion (with reference to the NGLG) of an $L_{A1\ (1\ minute)}$ not exceeding the background noise (considered to be the RBL) by more that 15dBA is not ideal. Nevertheless, as there is insufficient evidence to determine what should replace it, DECC will continue to use it as a guide to identify the likelihood of sleep disturbance. This means that were the criterion is met, sleep disturbance is not likely, but where it is not met, a more detailed analysis is required.

The detailed analysis should cover at least the following:

- Absolute level (either $L_{A1\ (1\ minute)}$ or L_{Amax})
- The amount the absolute level "emerges" above the general ambient (L_{Aeq}) and background (L_{A90}) at the time of the event (usually the $L_{A90,\ 1\ hour}$ or $L_{Aeq,1hour}$)
- Number of events per hour (usually between 10.00pm and 7.00am inclusive)

Some guidance on possible impact is contained in the review of research results in the appendices to the ECRTN.

The primary sleep arousal level adopted for this project is 45dBA L_{Amax} (based on the adopted RBL of 30dBA + 15dBA) during the hours 10.00pm-7.00am assessed external to a bedroom window.

4.3 Construction Noise Criteria

With respect to construction noise, the requirements outlined in Chapter 171 of the *ENCM* are usually applied and this approach is reproduced as follows:

Level Restrictions

(i) Construction period of 4 weeks and under.
The L_{10} level measured over a period of not less than 15 minutes when the construction site is in operation must not exceed the background level by more than 20 dB(A).

(ii) Construction period greater than 4 weeks and not exceeding 26 weeks.
The L_{10} level measured over a period of not less than 15 minutes when the construction site is in operation must not exceed the background level by more than 10 dB(A).

Time Restrictions

Monday to Friday	*7am–6pm*
Saturday	*7am–1pm (if inaudible at residential premises)*
	8am–1pm (if audible at residential premises)

No construction work to take place on Sundays or Public Holidays

Silencing

All possible steps should be taken to silence construction site equipment. It is particularly important that silenced equipment should be used on road or rail works where 24 hour operation is necessary.

There is no suggested criterion for projects that occur for greater than 26 weeks. However, the following criterion is typically used and appropriate:

The L_{10} level measured over a period of not less than 15 minutes when the construction site is in operation must not exceed the background level by more than 5 dB(A).

It is anticipated that construction will most likely take place from 7.00am to possibly up to 6.00pm during weekdays and 8.00am-1.00pm on Saturdays. Should the contractor wish to work outside these "standard" hours, they will need to apply to the relevant authorities for approval.

The construction of 2 turbines will require approximately 18 months.

Considering construction will be greater than 26 weeks duration and based on the lowest permissible RBL of 30dBA, the daytime construction noise criteria adopted for this project is $L_{A10,\ 15min}$ 35dBA assessed within 30m of the existing residences.

5 NOISE PREDICTIONS

5.1 Introduction

Intervening topography attenuates noise before it reaches receivers. Additionally, noise propagation over distances of at least several hundred metres is influenced by meteorological factors such as wind speed, wind direction and the presence of temperature inversions. In addition to increasing noise levels, these meteorological conditions significantly reduce the attenuating effect of intervening topography (and bunds) since the sound waves follow a curved path that can go over such barriers.

For this assessment, noise predictions were made using the Environmental Noise Model (ENM) modelling software algorithm. This is a point-to-point model that takes into account the attenuation factors including; distance, topography, ground absorption, air absorption and meteorological conditions. ENM predictions have been validated in the field (on Australian projects) by many researchers and is approved to be used in NSW by the DECC.

5.2 Noise Model Inputs

ENM requires a variety of inputs including; sound power levels (SWL) of each source (in octaves), location of sources (including height above ground), topographic information and the ground type. Meteorological conditions are also required.

5.2.1 Sound Power Levels and Location of Sources

AGL have provided WM with the noise levels (including octave band levels) of the main components of a comparable "Standard" generic power station and some specific data from a potential Tenderer. This information was further supplemented with data previously used by WM together with data from various manufacturers

Only the larger and potentially noisier plant / equipment items have been modelled in detail. Other plant items that have been assessed (but not modelled) include the transformers – both low and high voltage that typically have sound power levels < 80dBA and the air compressor that typically would have a sound power level of 80 to 85dBA, however this is to be located within a building.

Any small or localised noise sources, such as pipe-work could be treated individually with screens/enclosures or lagging and the like. Correct vibration isolation will be necessary.

Table 5-1 and Table 5-2 provide information such as noise emissions and source heights (overall and octave band).

Table 5-1 Noise Emissions and Source Height of Main Plant for a Standard Power Station

Plant Item	Sound Power Level (SWL) L_{Aeq} (dBA)	Source Height (m)	Comments
Generator Transformer	96	5	Standard Acoustic Design.
Exhaust Stack	109	35	Directional – vertical. Includes some mitigation in the form of a silencer. Model assumed 90 degree directivity from the top of the stack to the residences.
Air Intake	103	13	Directional - to the east (also assumed by model). Includes some mitigation in the form of a silencer.
Turbine & Generator Enclosure	112	5	SWL derived by manufacturer from measurements taken outside the enclosure (single skin metal clad building). Assumed the middle 2 enclosures be shielded by the outer enclosures.

At total of 4 sources was considered for each turbine set. Two sets of noise sources (i.e 8 sources) were used to represent the noise from all 2 turbines sets. The sources were modelled as point sources. Given the large distances (>1km), this approach is considered to be appropriate.

With respect to the location and height of the noise sources, URS provided WM with typical layout drawings.

Table 5-2 Noise Emissions Model Inputs

Plant Item	Octave Band Levels (dBLin)								Overall	
	63Hz	125Hz	250Hz	500Hz	1KHz	2KHz	4KHz	8KHz	dBA	dBLin
Generator Transformer	95	95	95	90	85		85	80	96	101
Exhaust Stack (1)	122	113	100	90	87	84	83	64	101	123
Air Intake (2)	110	90	69	69	81	92	97	101	103	111
Turbine and Generator Enclosure (3)	112	113	112	105	105	104	104	100	112	118

Notes: 1) SWL of 109dBA used as provided by AGL by manufacturer. Typical spectrum with silencer used and adjusted to account for 90 degree directivity.

Note: 2) Typical spectrum with silencer used.

Note: 3) Spectrum as provided by AGL by manufacturer. Single skin metal clad (≈ 0.42mm thick) building assumed.

5.2.2 Meteorological Conditions

During the night time period, the worst case noise levels are likely to be experienced during both temperature inversions and wind. Temperature inversions are rarely present during the daytime or evening periods. Therefore, the most significant meteorological effect during the daytime and evening periods is wind. Acoustically neutral noise enhancing weather conditions have also been considered.

Hourly data for an entire year (2004) was processed for the site by URS using CSIRO's The Air Pollution Model (TAPM) and compared with actual data from Camden (Bureau of Meteorology). This data included the stability class ratings for inversions (Class A to F), which is relevant in determining the inversion class of the area.

Wilkinson Murray has developed a process to assess the weather conditions of an area and their effect on noise that is more rigorous than that required by the *INP*, however, provides the impact due to adverse weather to all receivers by calculating the noise level that occurs 10% of the time. This process has been accepted by the DECC. The weather conditions that have been considered when calculating the noise levels for this project are as follows and include tabulated data. Refer to Appendix C for detailed tabulated meteorological conditions modelled.

Day & Evening

Acoustically neutral conditions – calm wind (≤0.5m/s) together with a temperature of 17.5ºC and relative humidity of 63.2%, modelled during the day and evening. Wind speed at; 0.75m/s, 1.25m/s, 1.75m/s, 2.25m/s and 2.75m/s (encompassing a 0.25m/s range either side). Wind direction at every 45 degrees (encompassing a 22.5 degree range either side). A total of 40 conditions are considered for both the day and evening for each season.

Night

Acoustically neutral conditions – calm wind (≤0.5m/s) together with a temperature of 12.7ºC and relative humidity of 79.7%. This is modelled both with a temperature inversion of 3º/100m and without a temperature inversion. Stability class being either Class A to E (0°/100m inversion), or a Class F (3°/100m inversion). In both cases, the enhancement due to wind is included. A total of 80 conditions are considered for each season.

The probability of occurrence for all the above-mentioned conditions have been calculated and the noise level that occurs 10% of the time for each DECC defined time period (day, evening and night) during each season is presented at each receiver and this is compared against the relevant criteria.

5.2.3 Topography

Kellogg Brown & Root Pty Ltd has supplied a detailed 3D digital terrain map of the immediate surrounding area using 2m contours.

The locations of all residences and the site boundary were added by WM.

The ground between sources and receivers has been modelled as "soft ground".

6 ASSESSMENT OF OPERATIONAL NOISE

Given the potential that this power station may operate at any time, it is appropriate to develop operating scenarios for all time periods. This section of the report assesses the potential noise impact to the existing six residences.

6.1 Operational Activities

The power station is intended to operate as a "peaking plant", with initially two turbines. Although AGL are only seeking approval for the operation of 2 turbines, they may, in the future apply to upgrade to 4 turbines. Therefore, the scenario all four turbines operating at any time has been modelled considering acoustically neutral and meteorological conditions that enhance noise propagation.

AGL have advised that during operations there will, on occasion, be the need for operators and maintenance staff to visit the site during the day. Vehicles would travel along Appin Road and onto the access road. This does not represent an increase over current traffic movements on site which presently has 4 occupied residences so the noise impact to existing residences (nearest being some 600m away) would be negligible and has not been modelled.

6.2 Low Frequency Noise Assessment

The *INP* recommends for low frequency noise that an assessment be conducted of the difference between C and A weighting levels and if a 15 dB difference exits, a correction of 5 dB applied.

From current information it would appear to be possible for a gas turbine plant to exceed the (dBC-dBA) difference. At the most affected receiver (Residence 3) a difference between C and A weighting levels of 15 dB was calculated. It should be noted that the noise modelling data used for the predictions was in octaves and that the calculation of the difference between C and A weighting levels was dominated by two octave bands being 63 and 125 Hz. Data below 63 Hz is generally not available. The uncertainty of the calculation of the difference between C and A weighting levels would appear to be quite large.

Recent international research has shown that the use of this difference approach is not suitable when the noise levels are low, since the low frequencies may then be below threshold of hearing levels (A review of Published Research on Low Frequency Noise and its Effects, Report for Department for Environment, Food and Rural Affairs (UK) by Dr Geoff Leventhall, 2003). Current research suggests that (dBC-dBA) difference should not be used as an annoyance predictor, but as a simple indicator of whether further investigation may be necessary (Low Frequency Noise and Annoyance, Noise & Health 2004, 6:23, 59-72).

Recently the UK Department for Environment, Food and Rural Affairs (DEFRA) has developed a new procedure to assess low frequency noise.

A measurement of L_{Aeq}, L_{10} and L_{90} is taken in third octave bands between 10Hz and 160Hz. If the L_{Aeq} taken over a time when the noise is said to be present exceeds the reference curve in Table 6-1, it may indicate a source of low frequency noise that could cause disturbance. The character of the sound should be checked if possible by playing back an audio recording at an amplified level.

Table 6-1 Proposed Reference Curve

Hz	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160
dB, L_{eq}	92	87	83	74	64	56	49	43	42	40	38	36	34

If the noise occurs only during the day then a 5dB relaxation may be applied to all third octave bands. If the noise is steady then a 5dB relaxation may be applied to all third octave bands. A noise is considered steady if either of the conditions below is met:

- $L_{10} – L_{90}$ <5dB
- The rate of change of sound pressure level (fast time weighting) is less than 10dB per second.

The above parameters are evaluated and the assessment process is a comparison with the with the reference curve. An exceedance of the reference curve requires the reduction of the low frequency noise level. The AGL Leafs Gully Facility would be likely to be able to meet this criterion outside the most affected residential receiver let alone within a room. It should be noted that room resonances could enhance low frequency noise however this can not be estimated at an environmental assessment stage of a project.

AGL is committed to ameliorating any low frequency noise issues if they arise for the project consistent with the most recent low frequency noise assessment process that have been developed overseas, namely:

- Proposed criteria for the assessment of low frequency noise disturbance, 2005, Prepared for Defra by Dr. Andy Moorhouse, Dr. David Waddington, Dr. Mags Adams; and
- Procedure for the assessment of low frequency noise complaints 2005, Prepared for Defra by Dr. Andy Moorhouse, Dr. David Waddington, Dr. Mags Adams.

6.3 Calculated Noise Levels to Existing Residences

The noise levels assuming a standard power station has been calculated using the ENM modelling software and are summarised in Table 6-2. Levels for both acoustically neutral and meteorological conditions that will enhance the propagation of noise are presented.

The calculated noise levels for acoustically neutral conditions meets the criteria at all residential receivers. During the day and evening periods and considering when the wind speeds are between 0.5 and 3m/s (as per *INP*) the range of noise level exceeded 10% of the time is presented (considering all four seasons). Similarly, the noise level for the night time period considering meteorological conditions that enhance noise propagation (both temperature inversions and wind) are presented.

The following observations as a result of the noise predictions are presented:

- the noise predictions indicate that there is minor 1-2 dB exceedance of the criteria at Residence 5 under weather conditions that enhance noise levels.

- the noise predictions indicate that there is a marginal exceedance of up to 5 dB of the criteria at Residence 3 under weather conditions that enhance noise levels..

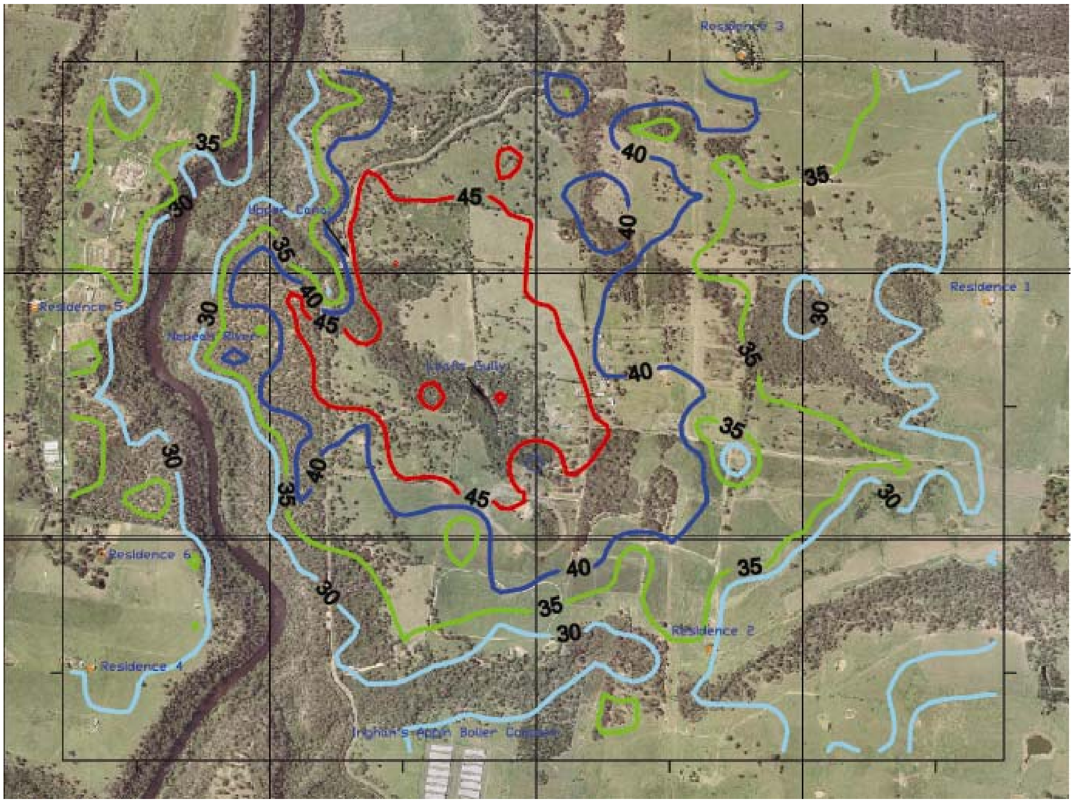
The exceedances of the criteria indicate that noise mitigation would need to be considered for the project.

Table 6-2 Calculated Noise Levels to Existing Residences using a Standard Power Station

Residence No.	Time Period	Calculated $L_{Aeq,15min}$ Noise Level (dBA) Meteorological Condition. Acoustically Neutral	Enhanced	Noise Criteria $L_{Aeq,15min}$ (dBA)
1	Daytime	25	25-28	35
	Evening		27-29	
	Night Time		28-29	
2	Daytime	27	29-30	
	Evening		30-31	
	Night Time		30-31	
3	Daytime	30	*32-38*	
	Evening		*35-39*	
	Night Time		*38-40*	
4	Daytime	29	*32-33*	
	Evening		*33-34*	
	Night Time		*33-34*	
5	Daytime	29	*31-35*	
	Evening		*36-37*	
	Night Time		*35-37*	
6	Daytime	30	*31-34*	
	Evening		*34-35*	
	Night Time		*33-35*	

Figure 6-1 presents the calculated noise contour without mitigation for the worst case scenario, being temperature inversions plus adverse wind occurring during the night-time period.

Figure 6-1 Predicted Noise Contour Without Mitigation



6.4 Mitigation Options

Detailed modelling has confirmed that the use of barriers for this project have limited capacity to reduce the noise levels, in particular due to height of the sources with respect to each residence and the adverse meteorological conditions. At best a 6m high barrier, surrounding the area immediately adjacent the four turbines would provide 5dB shielding to the noise associated with the enclosures. Notwithstanding this, the cost and practicality of constructing such barriers needs to be considered. Given the limited benefit and other likely constraints, the use of barriers is not seen as a justified mitigation. A reduction in the noise levels at residences will therefore need to be achieved by controlling noise directly from each of the contributing sources.

Using the sound power levels and spectra, a detailed analysis of the dominant sources at each of the residences confirms that for five of the six residences the noise from the generator and turbine enclosure (assumed to be contained in a simple metal clad enclosure) is the main contributor followed by the stack and then the transformer. Provided that a good quality silencer is fitted to the air intake, it has been shown that this item does not contribute to the overall noise levels at any of the receivers, with the highest contribution being approximately 21dBA.

It must be noted that until each Tenderer finalises the plant selection, including details of the sound power levels (in octave bands), the mitigations can only be conceptual. This is due to the fact that not only will there be some differences in the overall noise levels of comparable plant items between manufacturers, but the spectrum shape can also be different. These differences may require different designs of the respective mitigations. Therefore the following information is to be treated as conceptual only and provides typical mitigations to meet 35dBA at the residential receiver number 3, being the most affected.

At residence 3, the following contributions have been calculated:

- Turbine and generator enclosure 40dBA
- Stack 32dBA
- Intake 30dBA
- Transformer 29dBA

Therefore further reductions are required from the enclosure and stack.

Assuming the unmitigated building for the turbine and generator is constructed from metal cladding of nominally 0.42mm thickness, the acoustic rating will be approximately Rw 20. A further 14dBA (from 112 to 98dBA) reduction can be achieved from upgrading the building enclosure from a single skin to a double skin and cavity construction. Upgrading of this building envelope could involve internally cladding with metal of at least 0.6mm thickness, forming a cavity of at least 100mm and the addition of acoustic insulation (such as 100mm thick polyester or glasswool of at least 32kg/m^3 density) within this cavity, rated at approximately Rw 34. It is assumed that ventilation will be required and as such appropriate silencers will need to be appropriately sized and selected with consideration to the insertion loss required not to reduce the effectiveness of the building envelope.

The final contribution from the enclosure (overall and spectrum shape), will depend on the final façade design. This form of mitigation is considered to be simple and the provision of a higher acoustic rated building envelope be considered to provide more flexibility to the reductions required from other plant items such as the stack.

With respect to the stack, a reduction of nominally 5dBA (from 109 to 104dBA) is required and would be possible by upgrading the silencer.

Again, these items are to be further assessed during the Detail Design, where all relevant details of all final sound power levels of plant items including mitigation measures can be confirmed.

In considering these conceptual mitigations, further noise modelling has been undertaken by Wilkinson Murray. Table 6-3 is a summary of the revised octave band and overall sound power levels for the enclosure and stack assumed with the additional mitigation.

Table 6-3 Noise Emission Model Input - Mitigated

Plant Item	Octave Band Levels (dBLin)								Overall	
	63Hz	125Hz	250Hz	500Hz	1KHz	2KHz	4KHz	8KHz	dBA	dBLin
Exhaust Stack	119	107	92	84	84	78	77	59	96	119
Turbine and Generator Enclosure	110	111	103	88	85	81	81	77	98	113

Table 6-4 is a summary of the noise levels resulting from the additional mitigation measures.

Table 6-4 Summary of Calculated Noise Levels to Existing Residences – Assuming Further Conceptual Mitigation

Residence No.	Time Period	Calculated $L_{Aeq,15min}$ Noise Level (dBA) Meteorological Condition.		Noise Criteria $L_{Aeq,15min}$ (dBA)
		Neutral	Enhanced	
1	Daytime	22	22-26	35
	Evening		24-26	
	Night Time		26-27	
2	Daytime	22	23-24	
	Evening		24-25	
	Night Time		24-25	
3	Daytime	26	28-32	
	Evening		29-33	
	Night Time		32-33	
4	Daytime	22	25-26	
	Evening		*26-27*	
	Night Time		26-27	
5	Daytime	23	24-27	
	Evening		28-29	
	Night Time		27-28	
6	Daytime	23	25-27	
	Evening		27-28	
	Night Time		27-28	

In addition to the calculated noise levels as presented in Table 6-4, which shows levels of 35dBA or less, Figure 6-2 presents the calculated noise contour with mitigations for the worst case scenario, being temperature inversions plus adverse wind occurring during the night-time period. It should be noted that the calculated (point to point) levels as presented in Table 6-4 are more accurate than the contours.

Figure 6-2 Predicted Noise Contour With Mitigation

6.5 Assessment of the Potential for Sleep Disturbance

The potential for sleep disturbance within the residences will likely be greatest during the early morning hours (notionally, 2.00am-4.00am) when background noise levels are at their lowest. It is to be noted that this time period is not when the demand for a peaking power station is likely to occur and as such operation of plant is unlikely. However, the potential for sleep disturbance has been assessed for completeness.

AGL have confirmed that there are no sources that will produce instantaneous, short-duration, high-level noise events. If a turbine begins (or ceases) operation in the early hours of the morning, this will not occur instantaneously but a gradual process. Should a turbine be operating into the night or early morning period, the process is relatively steady state and free of instantaneous events. The mains pressure from the gas line will be adequate and therefore no gas compressor is required for this development.

Furthermore there is no reason for the site to be visited during the night-time period even it there is a need to operate the plant.

Any repairs or maintenance would obviously be scheduled during the daytime period.

It can be concluded that the potential risk of activities associated with the development that may disturb the sleep of nearby residences is negligible.

7 OPERATIONAL TRAFFIC NOISE ASSESSMENT

This section assesses the impact of increased noise potentially impacting residential receivers due to additional road traffic generated by the development.

With respect to access to the power station, all road traffic movements (construction and operation) will travel along Appin Road (this is the only option) and then via the access road into Leafs Gully Farm. The functional category of this road is considered to be "sub-arterial" (RTA Road Design Guide 1996) and using the *ECRTN*, the applicable noise criteria refer to a day time (7.00am-10.00pm) $L_{Aeq,15hr}$ 60dBA level and a night time (10.00pm-7.00am) $L_{Aeq,9hr}$ 55dBA level. Traffic generating developments are allowed an increase above these limits of 2dB, once all reasonable and feasible mitigation is considered. Analysing the classified traffic data and the estimated vehicle movements during the construction phase as supplied by URS, and given the fact that this is the only access, the 2dB limit applies.

There will be minor increases in road noise during the peak construction activities however there is minimal risk of exceeding the 2dB limit. During the operational stage, there would be minor, light vehicle activity as required and as such negligible impact expected. Given the low risk of exceeding the 2dB limit, a further detailed assessment is not deemed necessary.

In addition to the assessment of Appin Road, the noise from the use of the access road has been considered as part of the operational noise on-site in Section 6.

8 VIBRATION ASSESSMENT

This section provides a qualitative appreciation of the effect of vibration from both the operation of the facility and its construction. Both existing residential receivers as well as the upper canal have been assessed.

In terms of vibration sources identified during the construction stage, the plant would most likely be limited to rollers, however should rock be encountered there may be the need to use an excavator fitted with a hydraulic hammer. Given that the nearest existing residential receivers will be at least 1000m away from the closest area of works, the vibration levels would not be perceptible (this corresponds to a peak velocity of no greater than 0.14mm/s in the vertical as per the base curve – Curve 1 contained within the AVTG) and therefore not impact on the residences.

Once operational, all rotating plant items of the power station will be required to be correctly aligned and balanced. It is therefore unlikely that any vibration levels will be perceptible past the site boundary, which is at least 350m away and therefore no impact on the existing residences, located even further from the power station, is expected.

The upper canal has been identified by the Sydney Catchment Authority as potentially fragile due to its age and therefore they require an assessment of the vibration impact on this structure. This canal is located at least 350m from the closest construction area. In the absence of any specific criteria for this structure, WM have adopted a very stringent 3mm/s vibration limit as guided by DIN4150-3, with reference to heritage listed structures. WM consider this vibration limit to be conservative, nonetheless, the anticipated vibration levels during the construction phase of this project would be less than 0.5mm/s and significantly less during the operation.

Given the low risk associated with vibration impacts (both annoyance and structural damage) a detailed vibration assessment is not deemed necessary.

9 CONSTRUCTION NOISE ASSESSMENT

This section of the report is a preliminary assessment of the potential impact of noise during construction.

The works would involve the following:

- General site clearing and earthworks for the site establishment;
- Drainage, utility and internal road works;
- Construction of the slab;
- Construction of the building, and fitout;
- Landscaping; and
- Commissioning.

It would require approximately 18 months to construct 2 turbines.

9.1 Construction Activities Involving Fixed & Mobile Plant

To predict the typical worst case noise levels at typical construction stages over the duration of the project, the following typical scenarios have been considered:

Scenario 1

A worst case month where activities, including earthworks, construction of the internal roads and construction of the slab is anticipated to occur simultaneously.

Scenario 2

A worst case month where activities including, construction of the building, fit out and landscaping is anticipated to occur simultaneously.

Scenario 3

This represents the activities occurring towards the end associated with commissioning. This essentially is the noise that will be experienced during operation and as such is not assessed.

Conservatively, the noise generated by the average traffic movement along the access road is also modelled and added to the total noise generated for each construction scenario.

9.2 Plant Items & Assigned Sound Power Levels

URS have supplied indicative information and activities of the likely plant to be used. The sound power level (SWL) of these plant items has been sourced from WM's extensive database of actual measured plant items under different usage. Table 9-1 summarises the plant used during each scenario together with its respective SWL and number of items. It is not a total of all plant used over the entire project duration.

Table 9-1 Equipment Numbers & Sound Power Levels

Plant / Equipment Item	Sound Power Level L_{Amax} (dBA)	No. of Items Modelled	
		Scenario 1	Scenario 2
Grader	110	1	0
Water Cart	108	1	0
20 to 30t Excavator	110	1	0
Hydraulic Hammer	115	1	0
D8 Dozer	113	1	0
Scraper	115	2	0
Roller	112	0	1
Crane	103	0	1
Concrete/Brick/Tile Saw	105	0	1
Concrete/Haul Truck	112	4	2
Concrete Pump	108	1	0
Compressor	103	0	1
General Power Tools	95	0	1
Portable Generator	110	0	1

Using the assumed plant items and their associated maximum sound power levels (with consideration given to the operational changes, intermittent processes and changes in distance of mobile plant), the next section assigns a combined L_{A10} sound power levels for each scenario. The maximum sound power levels would be over-estimating the $L_{A10,15min}$ noise level by typically 3 to notionally 10dB. Therefore the L_{Amax} levels have been conservatively reduced by 5dB.

- Scenario 1 118dBA
- Scenario 2 113dBA

9.3 Calculated Noise Levels

Table 9-2 summarises the calculated noise levels (unmitigated) at the existing residences for neutral conditions and also considering the noise emission from the average vehicle movement along the access road.

Table 9-2 Calculated Construction Noise Levels at Existing Receivers

Residence No.	Calculated Noise Level $L_{A10,15min}$ (dBA)		Noise Criteria $L_{A10,15min}$ (dBA)
	Scenario 1	Scenario 2	
1	35	31	35
2	33	32	
3	36	28	
4	33	26	
5	31	27	
6	31	27	

Table 9-2 shows when assessed to all six residential receivers (assuming activities in a worst case month for each scenario) that a 1dB exceedance has been predicted at residence 3 during Scenario 1. A change in 1dB is negligible and cannot be detected by the human ear.

Once the contractor is selected, the plant, processes and duration will be better known and a Construction Noise Management Plan is to be developed so that our assumptions confirmed and reasonable and feasible noise mitigation measures can be investigated if necessary. In brief, these may include:

- Selection of quiet plant and processes;
- Retrofitting reversing alarms that are quieter and display less annoying characteristics, such alarms include "smart alarms" and "quaker alarms";
- Use of temporary barriers;
- Positioning of plant / processes; and
- Limiting the "clustering" of plant / processes.

10 CONCLUSION

The construction, operational, traffic noise and vibration impacts due to the proposed gas turbine power station at Leafs Gully have been assessed by Wilkinson Murray.

With respect to noise, the following policy guidelines published by the NSW Department of Environment & Climate Change have been referenced:

- *NSW Industrial Noise Policy (INP)*, dated January 2000
- *Environmental Criteria for Road Traffic Noise (ECRTN),* dated May 1999
- *Noise Guide for Local Government (NGLG),* dated June 2004
- *Environmental Noise Control Manual (ENCM),* dated 1984

Vibration has been assessed by considering:

- The DECC's – *Assessing Vibration – A Technical Guideline (AVTG),* dated February 2006
- German Standard 4150-3 – *Structural Vibration - Part 3: Effects of Vibration on Structures (DIN4150-3),* dated February, 1999.

In assessing the noise impact to the existing 6 residences during the operation of the power station, a total of 2 turbines has been assessed.

Considering acoustically neutral meteorological conditions, no exceedances have been predicted. During weather conditions that can enhance noise propagation, the noise level at residences 3 to 5 inclusive exceeds the 35dBA noise criterion by up to 5dB. These exceedances can be controlled using standard plant items installed with an upgraded silencer on the stack and upgrading the enclosure for the turbine and generator to Rw34.

Further information with respect to design will be provided during the detail design assessment once the final selection of the turbine system is complete.

AGL have advised that during operations there will, on occasion, be the need for operators and maintenance staff to visit the site during the day. Vehicles would travel along Appin Road and onto the access road. This does not represent an increase over current traffic movements on site which presently has four occupied residences so the noise impact to existing residences (nearest being some 600m away) would be negligible and has not been modelled.

The potential of sleep disturbance from the operation of the development were found to be negligible. Noise impacts due to extra traffic along Appin Road (both during construction and operation) were found to be negligible.

An assessment of low frequency noise identified that the Facility has the potential for low frequency noise, however using a more detailed assessment it was found that it would be unlikely that low frequency noise impacts would result from the Facility. AGL is committed to ameliorating any low frequency noise issues if they arise for the project consistent with the most recent low frequency noise assessment process that have been developed overseas.

A preliminary assessment of noise during the construction phase (two scenarios considered) showed an exceedance at residence 3 during scenario 1. This exceedance is negligible and would not be able to be detected. No other exceedances at the existing residential receivers were predicted. These scenarios are to be confirmed prior to commencement with the Contractor. A Construction Noise Management Plan should be developed to ensure a suitable program and that the noise and vibration during construction is managed. The assessment of construction noise considered noise emanating from vehicle movements along the access road.

No vibration impacts are envisaged to occur at either the residential receivers or to the upper canal.

Version	Status	Date	Prepared by	Checked by
A	Draft	4 July 2006	Sam Demasi	-
B	Draft	18 July 2006	Sam Demasi	John Wassermann
C	Draft	10 August 2006	Sam Demasi	John Wassermann
D	Draft	9 October 2006	Sam Demasi	-
E	Final	18 April 2007	Sam Demasi	John Wassermann
F	Final	21 June 2007	Sam Demasi	John Wassermann
G	Draft	30 August 2008	Jimi Ang	John Wassermann
H	Draft	09 October 2008	Jimi Ang	-
I	Final	2 November 2008	John Wassermann	-

APPENDIX A

GLOSSARY OF TERMS

GLOSSARY

Most environments are affected by environmental noise which continuously varies, largely as a result of road traffic. To describe the overall noise environment, a number of noise descriptors have been developed and these involve statistical and other analysis of the varying noise over sampling periods, typically taken as 15 minutes. These descriptors, which are demonstrated in the graph overleaf, are here defined.

dB(A) -A-weighting: Unit used to measure 'A-weighted' sound pressure levels. A-weighting is an adjustment made to sound-level measurement to approximate the response of the human ear.

dB(C) -C-weighting: C-weighting is an adjustment made to sound-level measurements which takes account of low-frequency components of noise within the audibility range of humans.

Low frequency: Noise containing major components in the low-frequency range (20 Hz to 250 Hz) of the frequency spectrum.

Maximum Noise Level (L_{Amax}) – The maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.

L_{A1} – The L_{A1} level is the noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the L_{A1} level for 99% of the time.

L_{A10} – The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The L_{A10} is a common noise descriptor for environmental noise and road traffic noise.

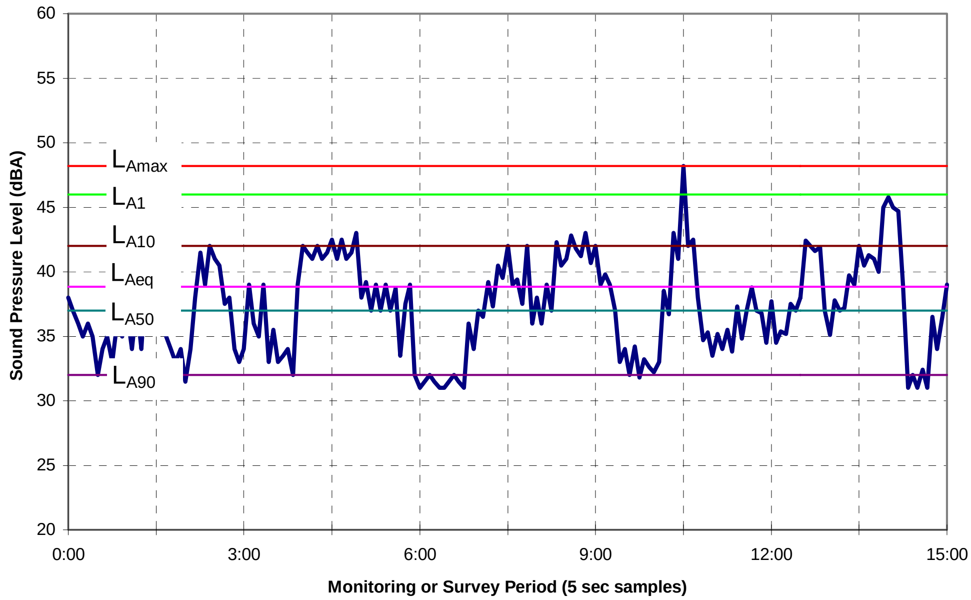
L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.

L_{A50} – The L_{A50} level is the noise level which is exceeded for 50% of the sample period. During the sample period, the noise level is below the L_{A50} level for 50% of the time.

L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

ABL – The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10^{th} percentile (lowest 10^{th} percent) background level (L_{A90}) for each period.

RBL – The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period – daytime, evening and night time.



60
55
50
45
40
35
30
25
20
L_{Amax}
L_{A1}
L_{A10}
L_{Aeq}
L_{A50}
L_{A90}
Sound Pressure Level (dBA)
0:00
3:00
6:00
9:00
12:00
15:00
Monitoring or Survey Period (5 sec samples)

APPENDIX B

NOISE MEASUREMENT RESULTS

Location A

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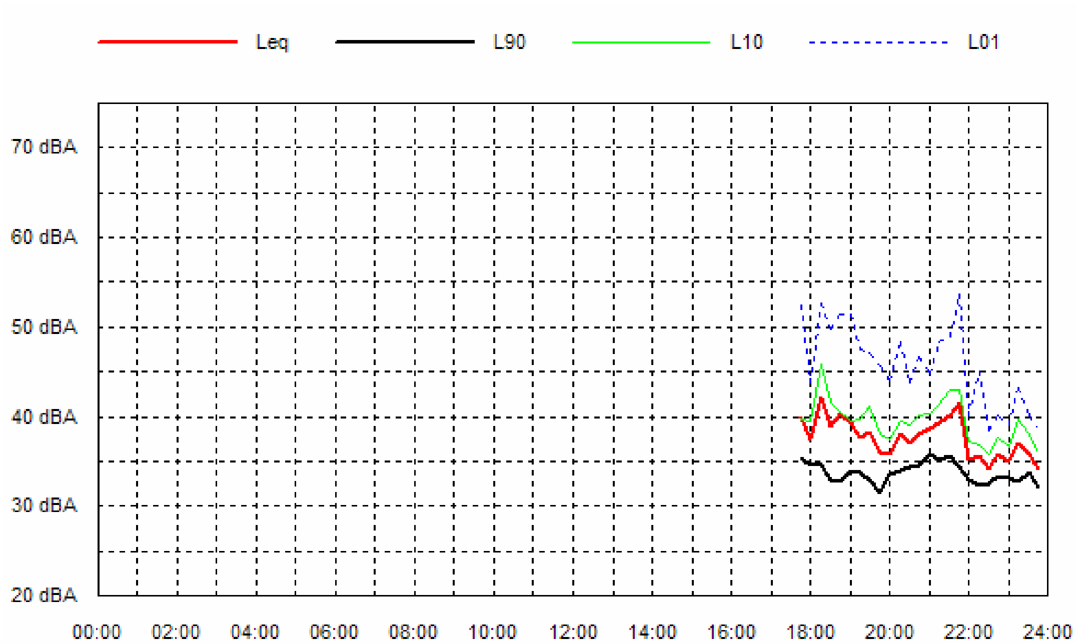

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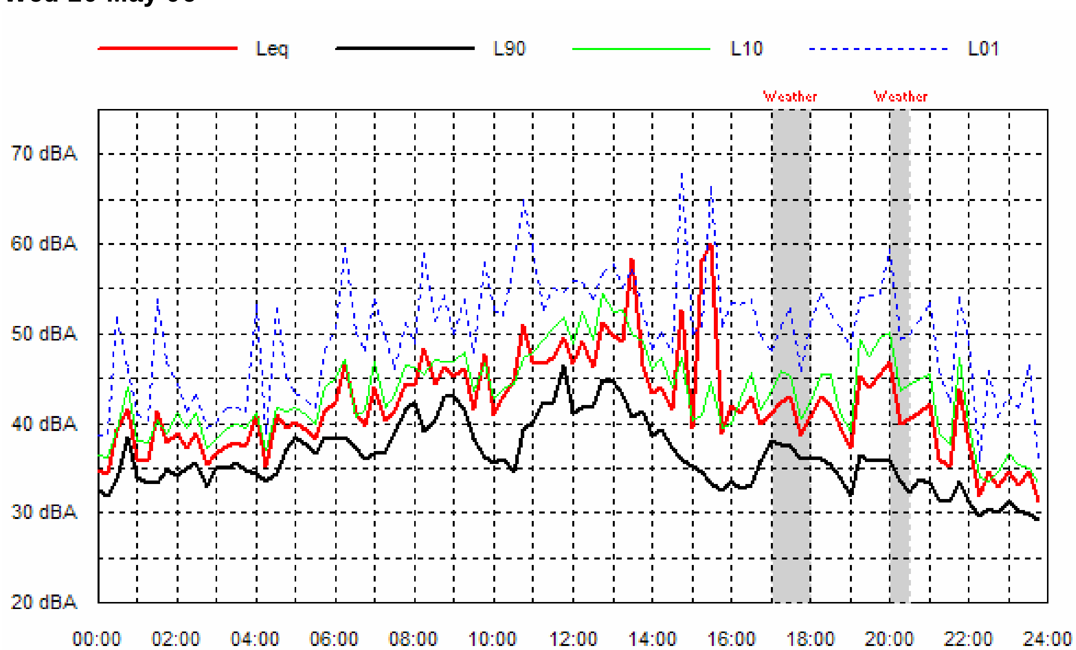

Location A

Data shaded: Weather

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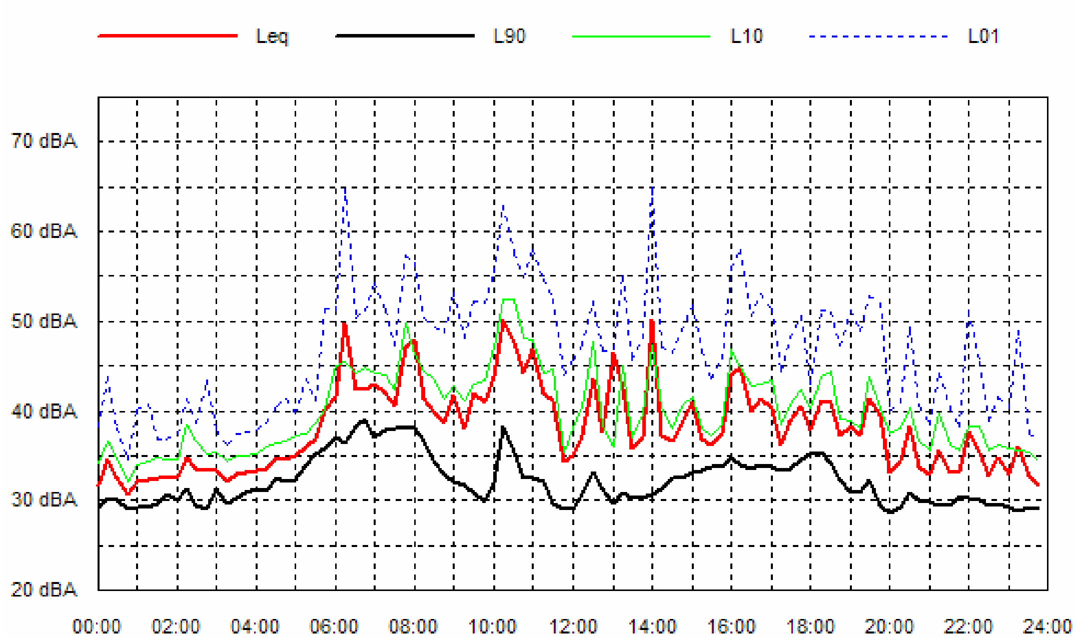

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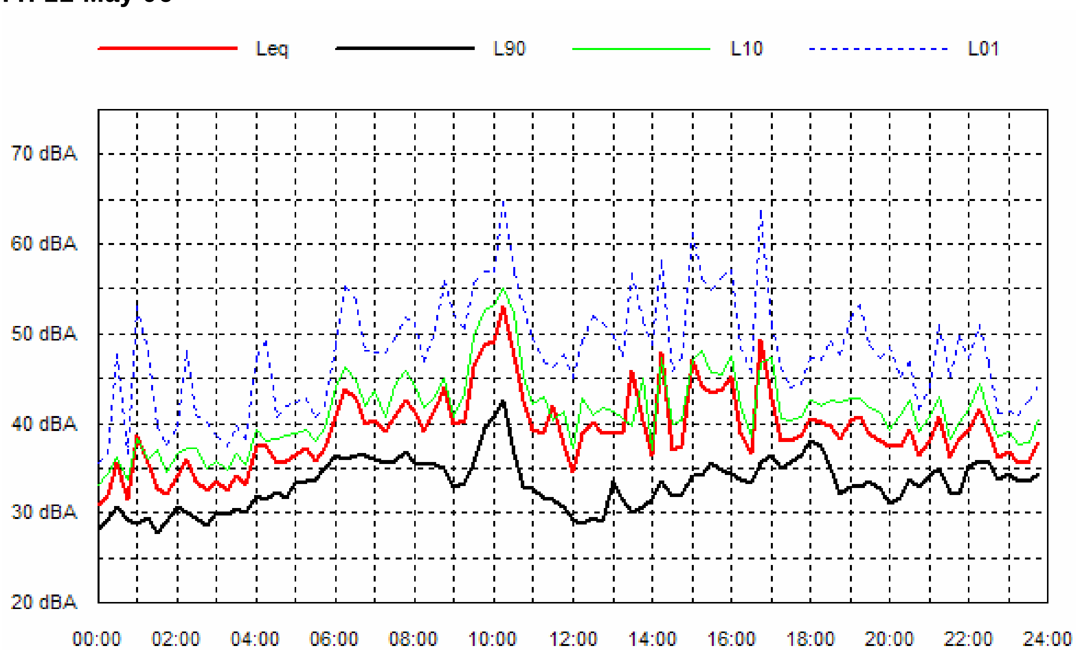

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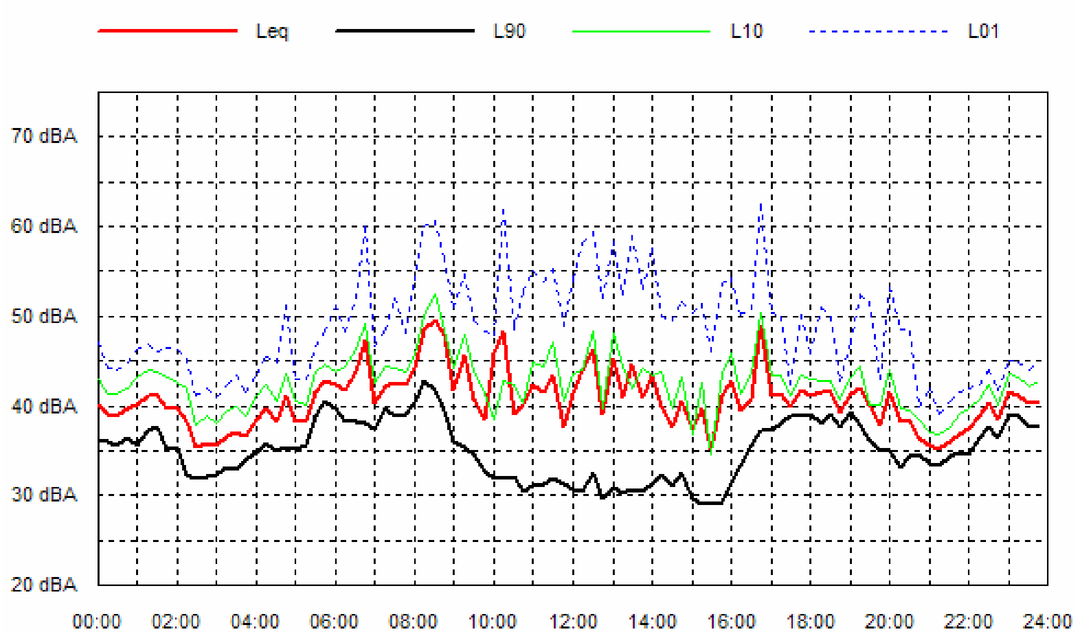

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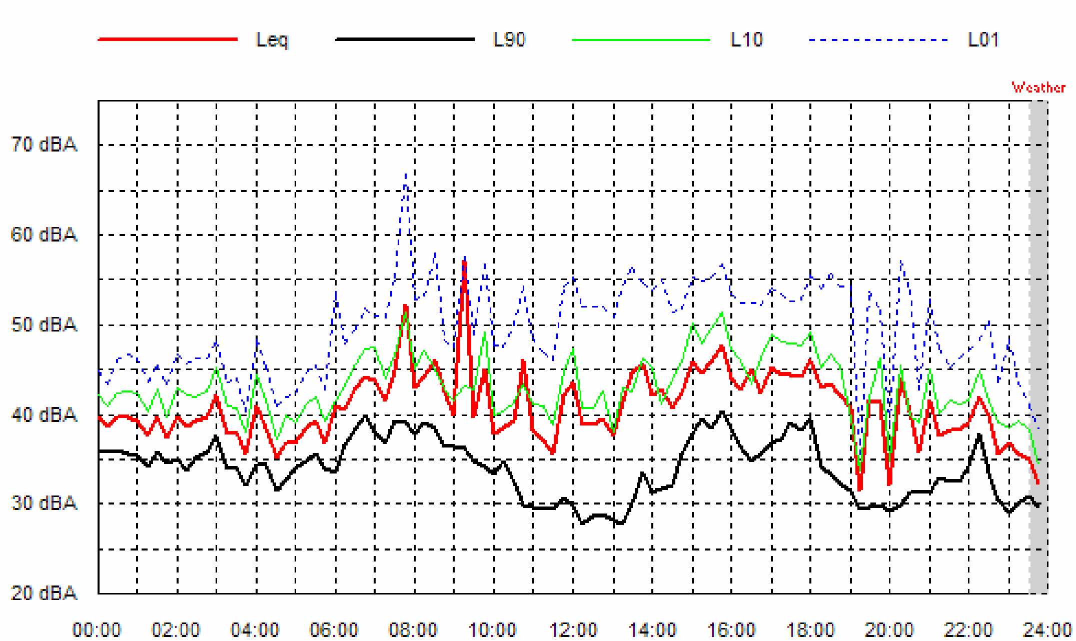

Location A

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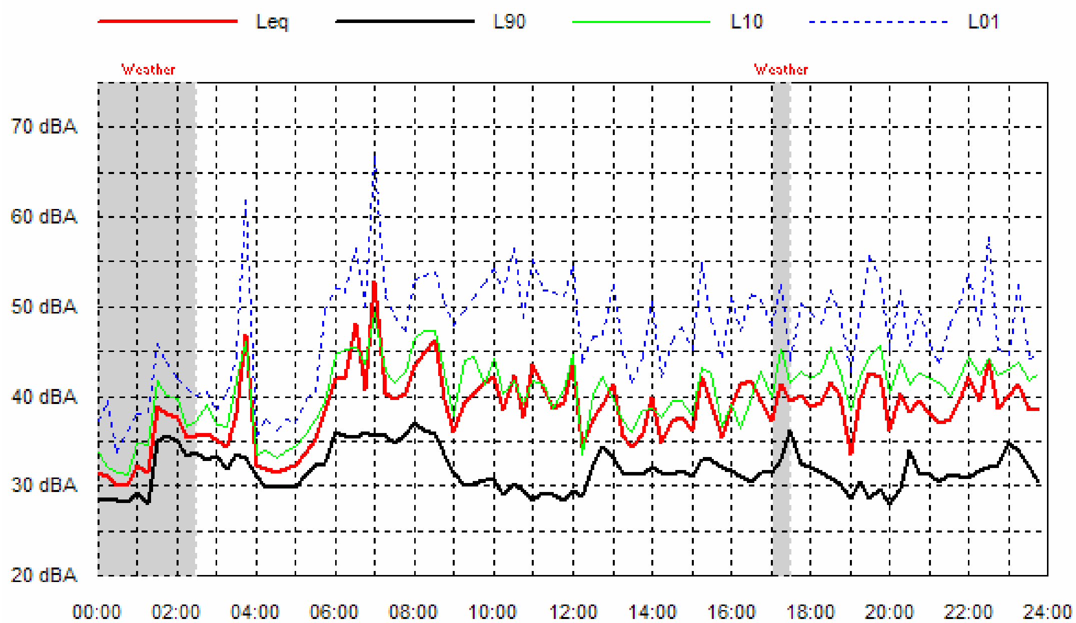

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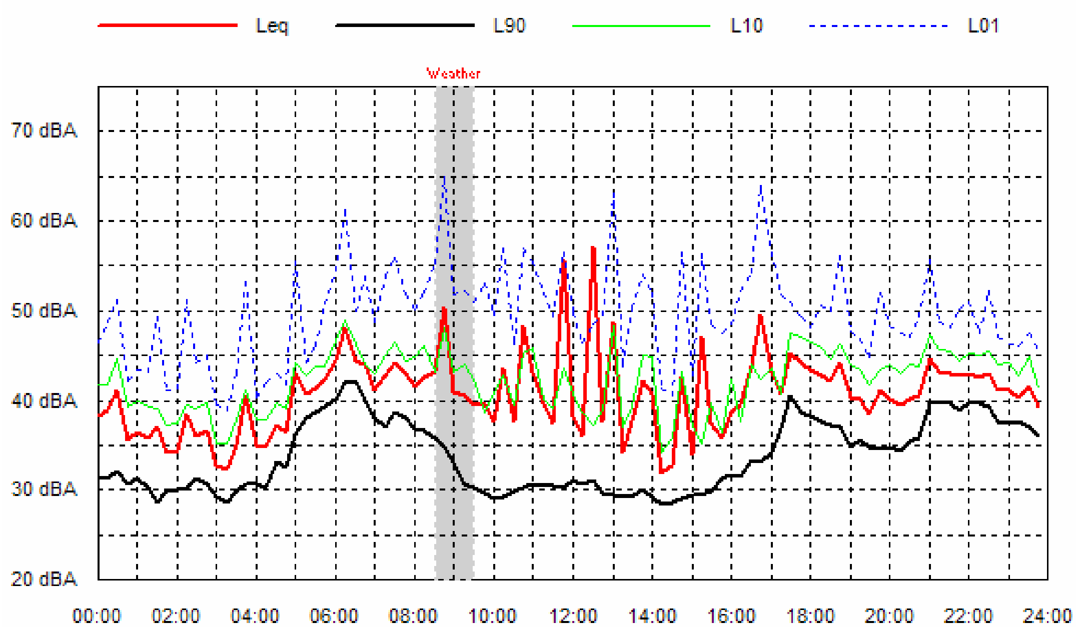

Location A
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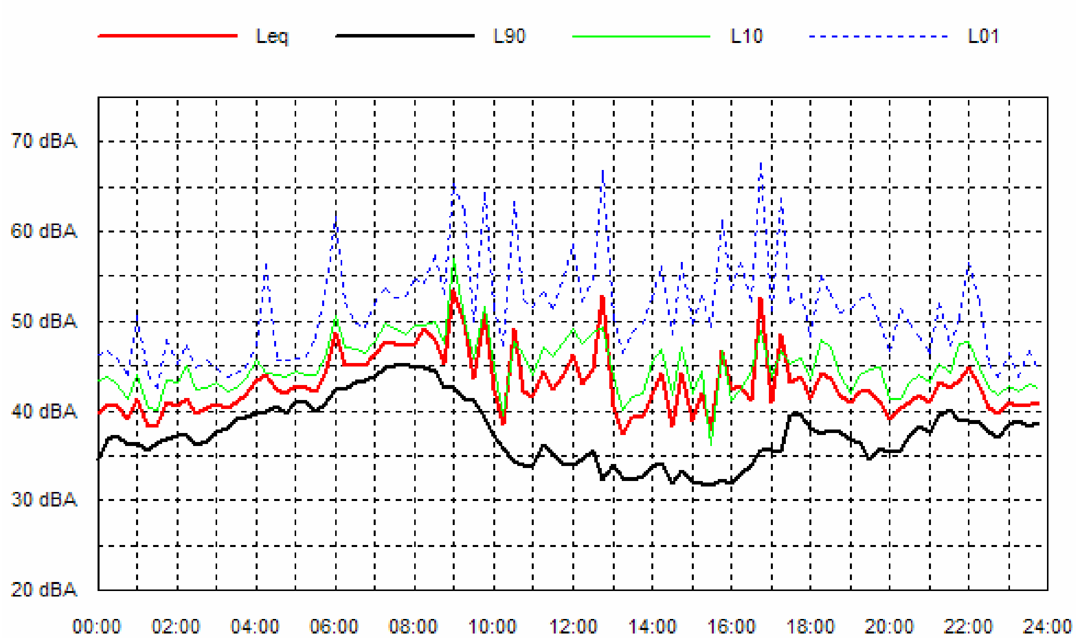

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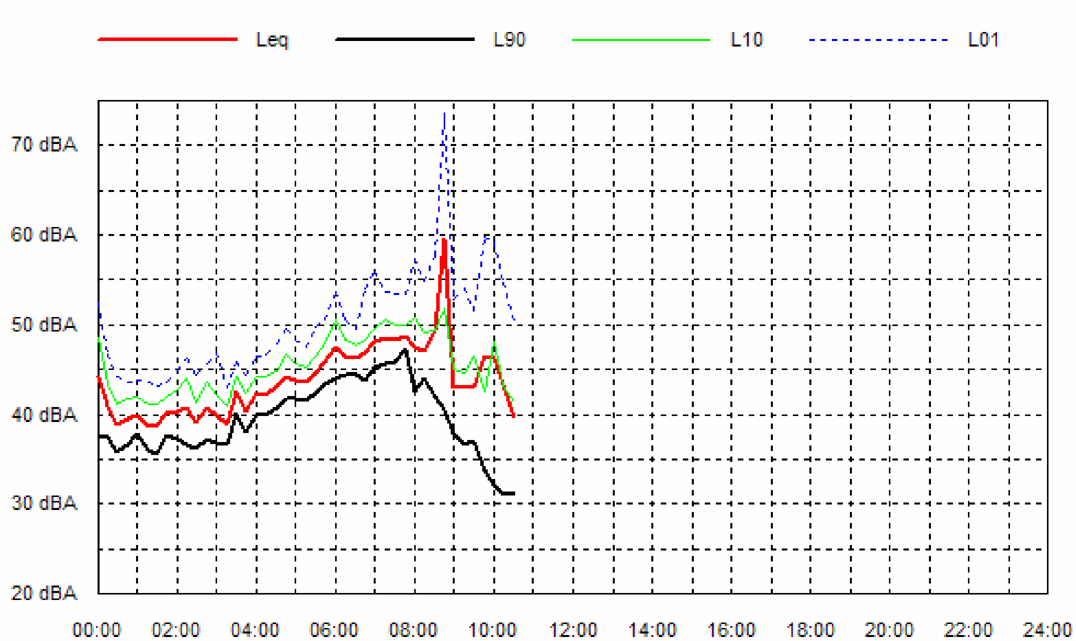

Location B

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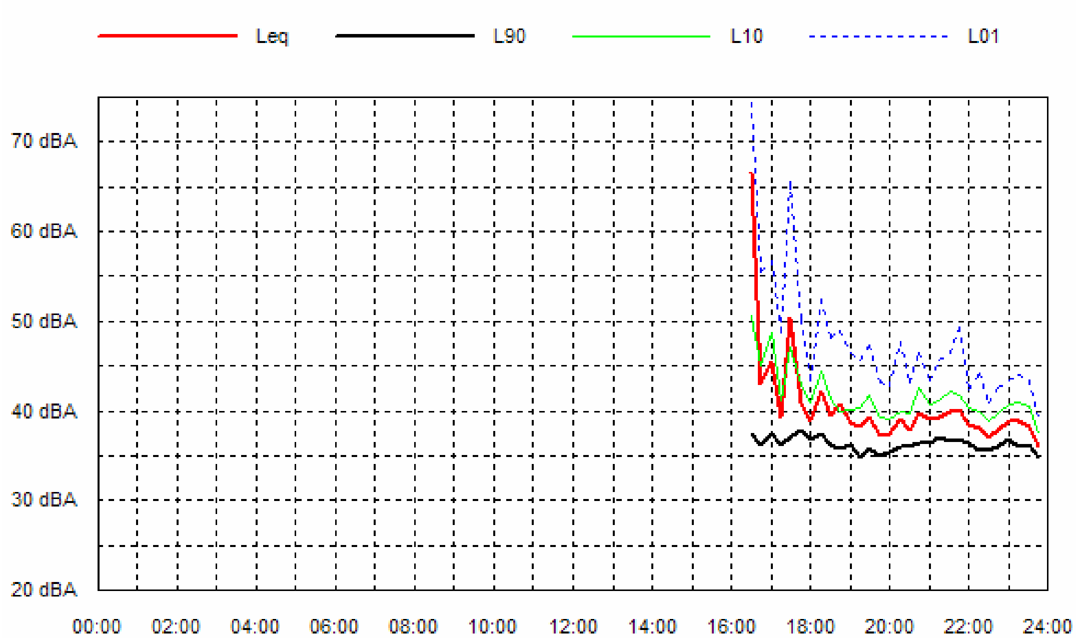

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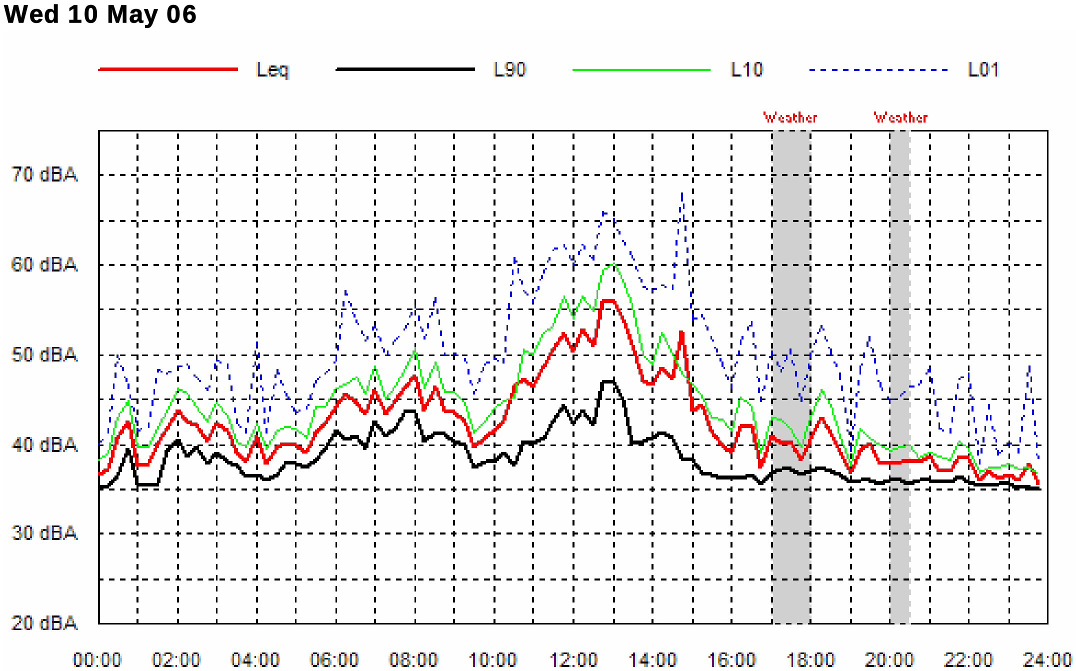

Location B

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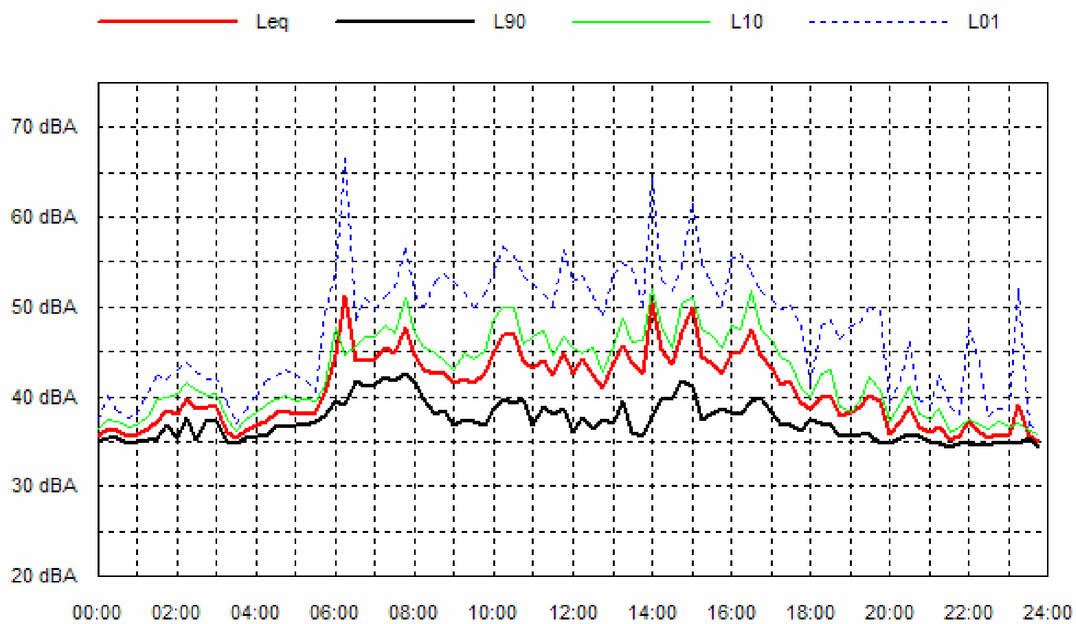

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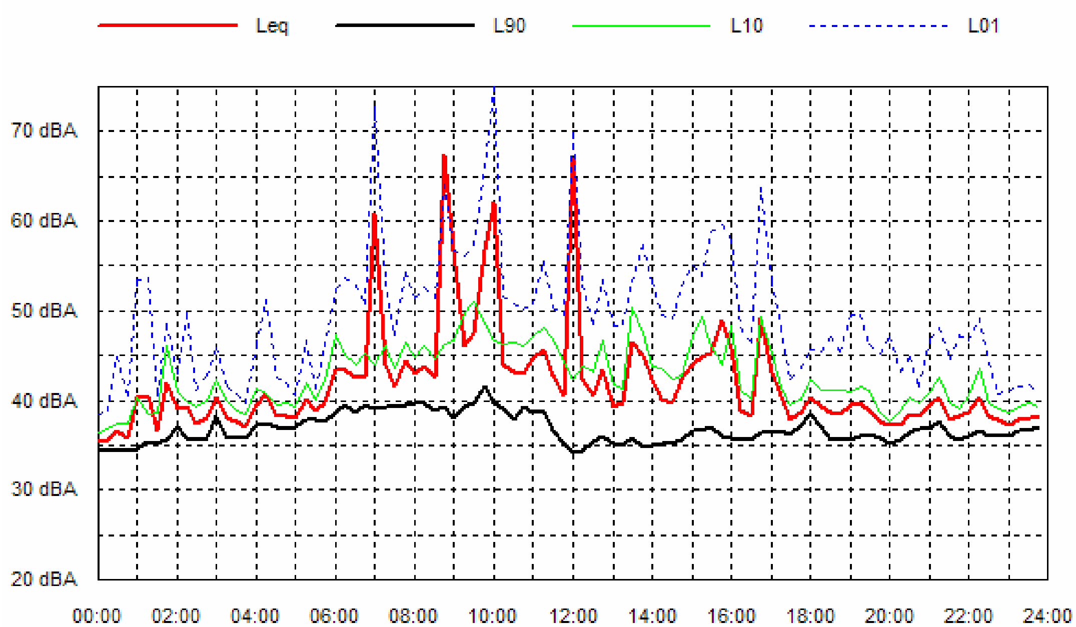

Location B

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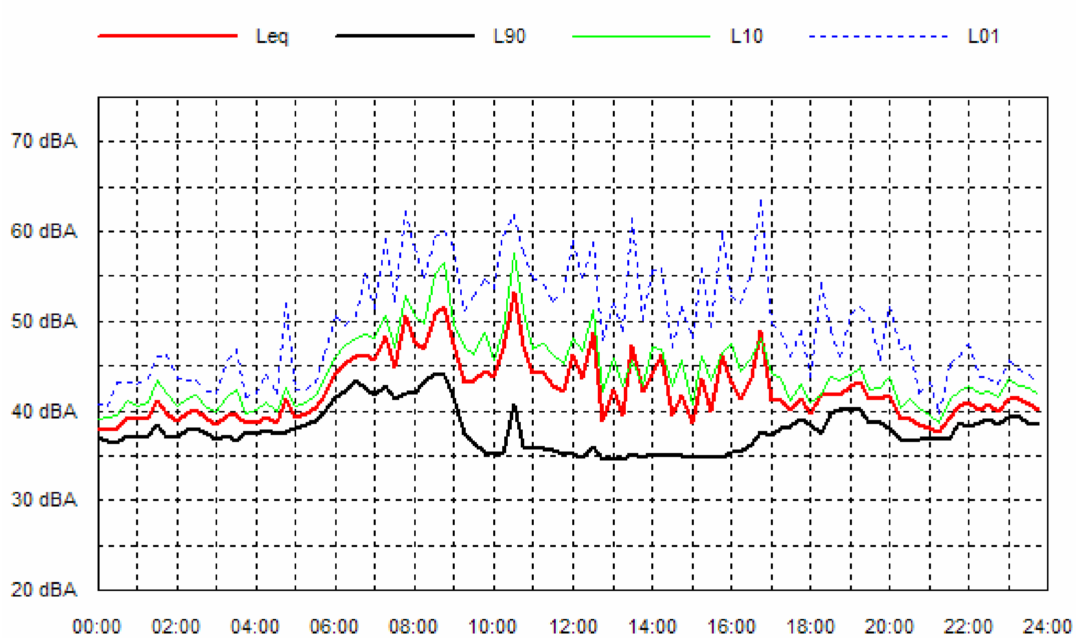

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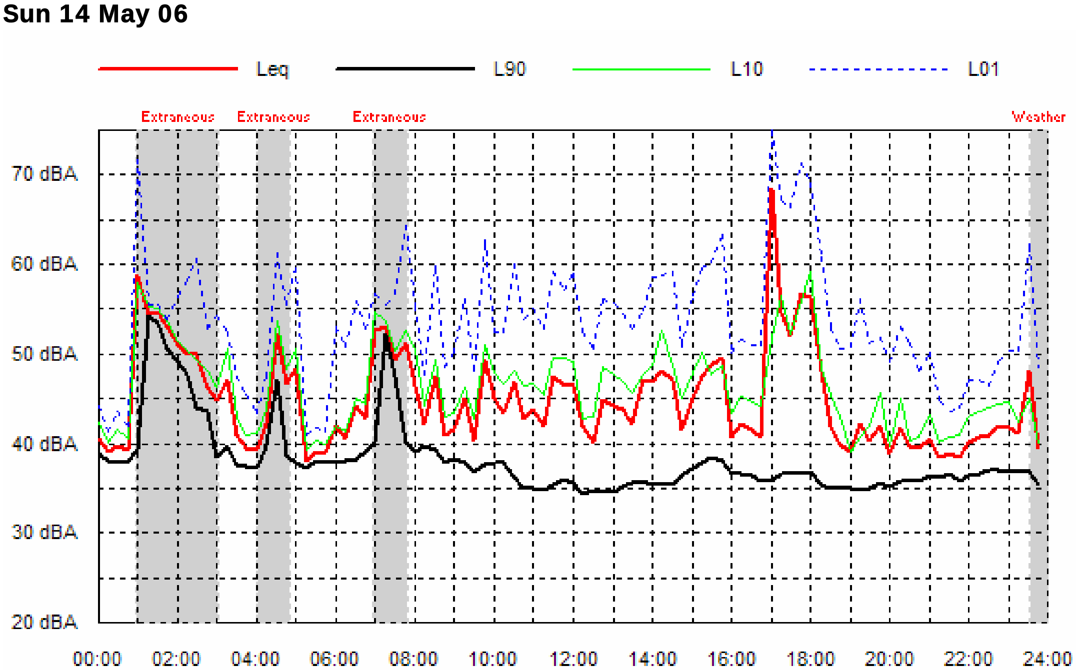
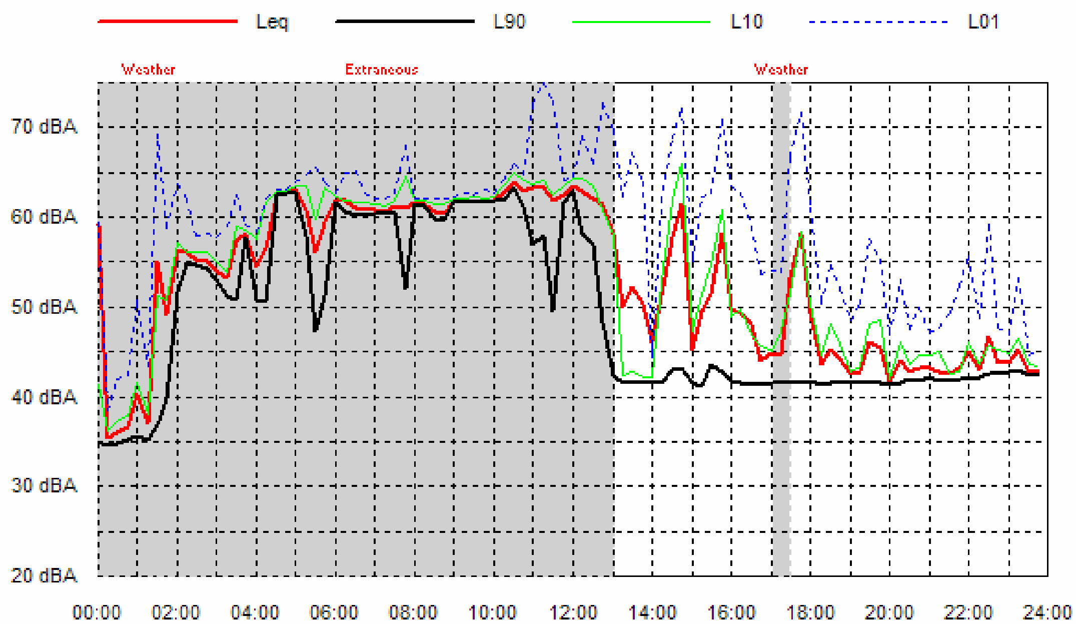


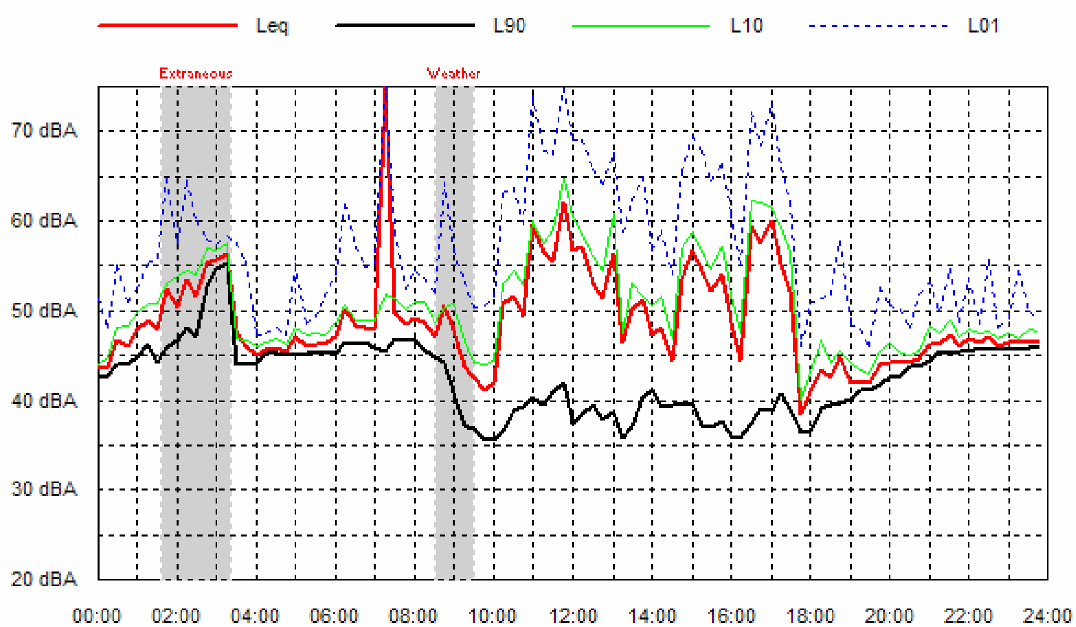
Location B

Data shaded: Weather; Extraneous

Mon 15 May 06



Tue 16 May 06



Location B

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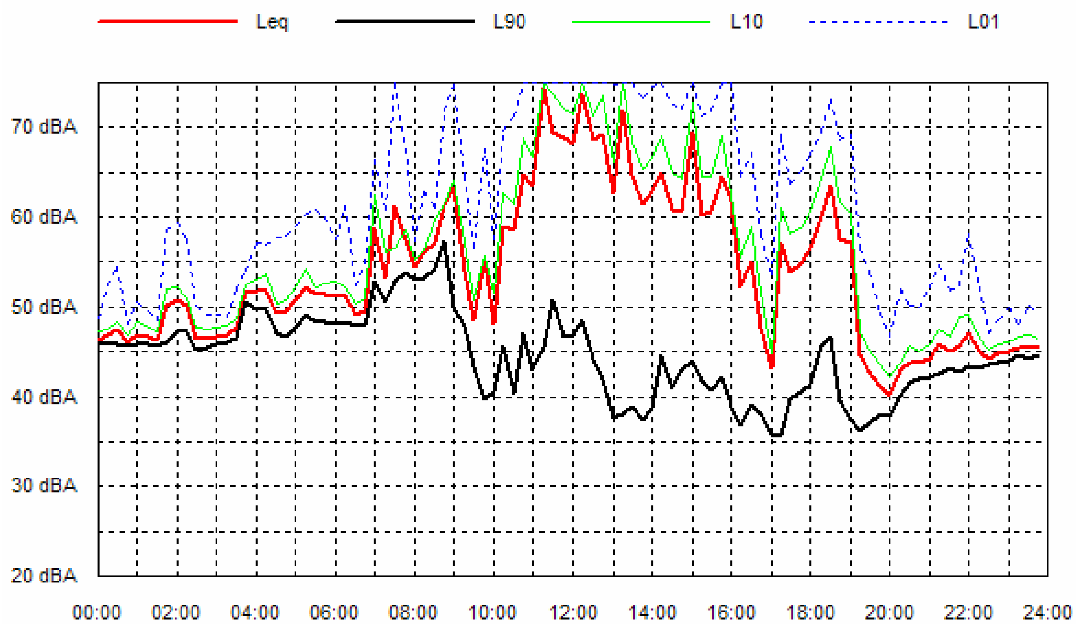

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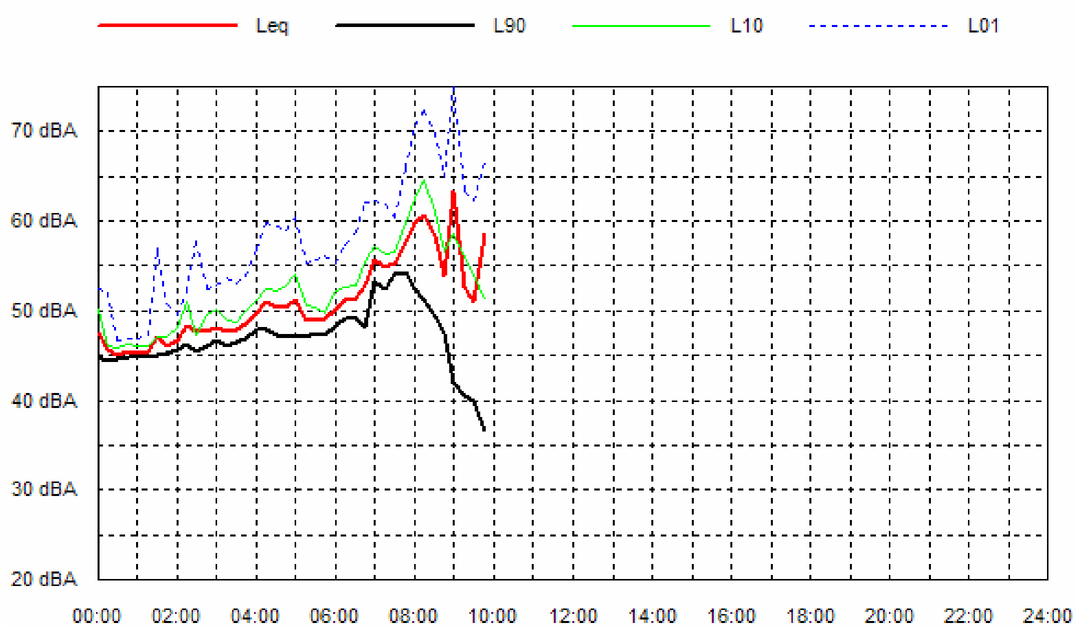

Location C

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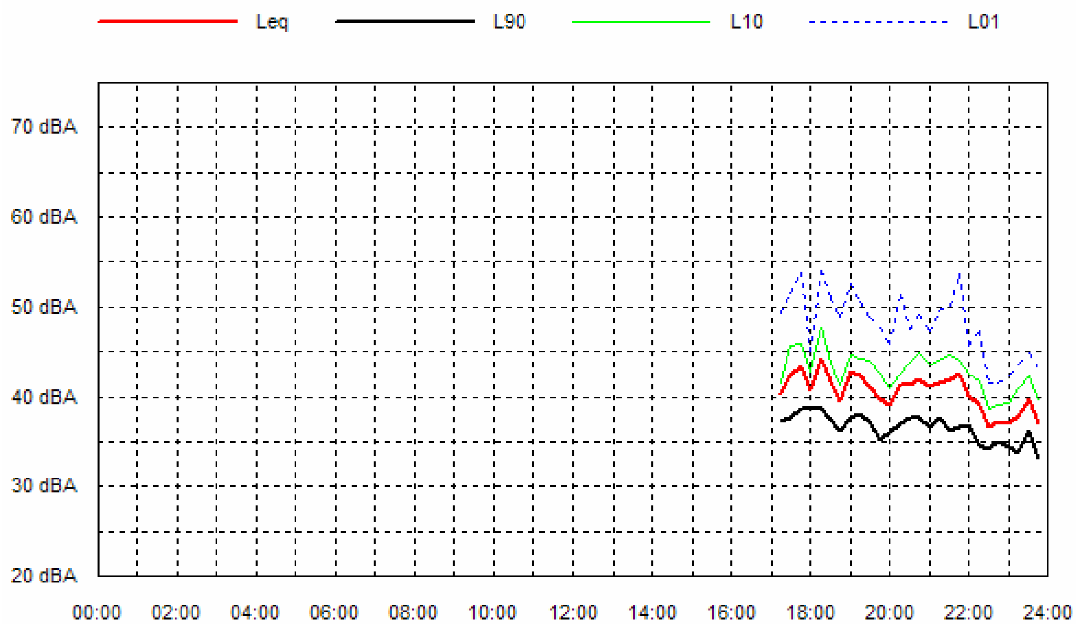

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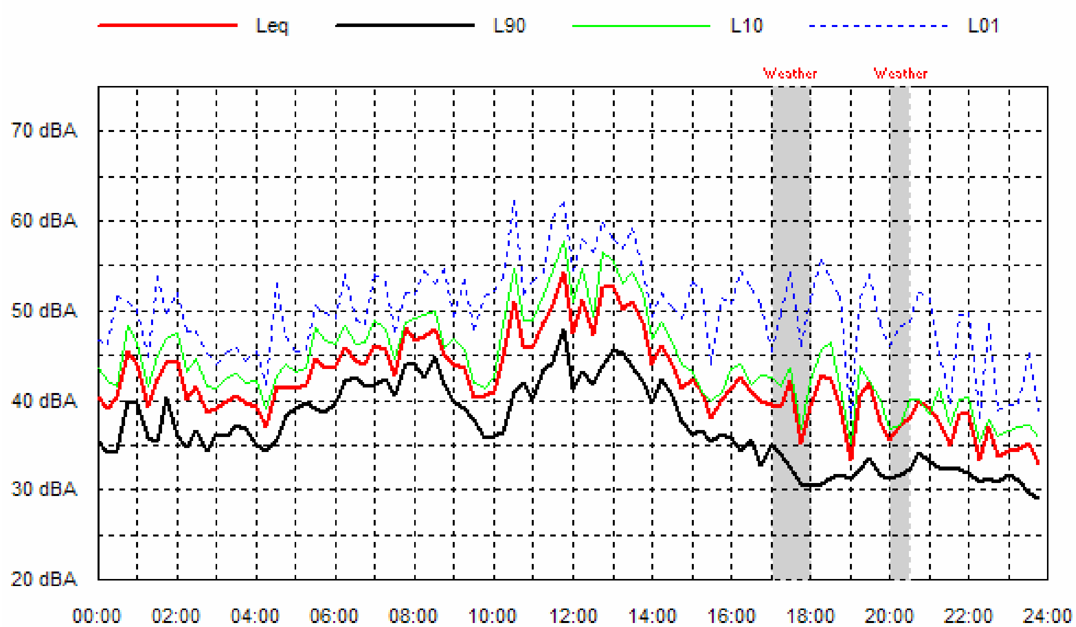
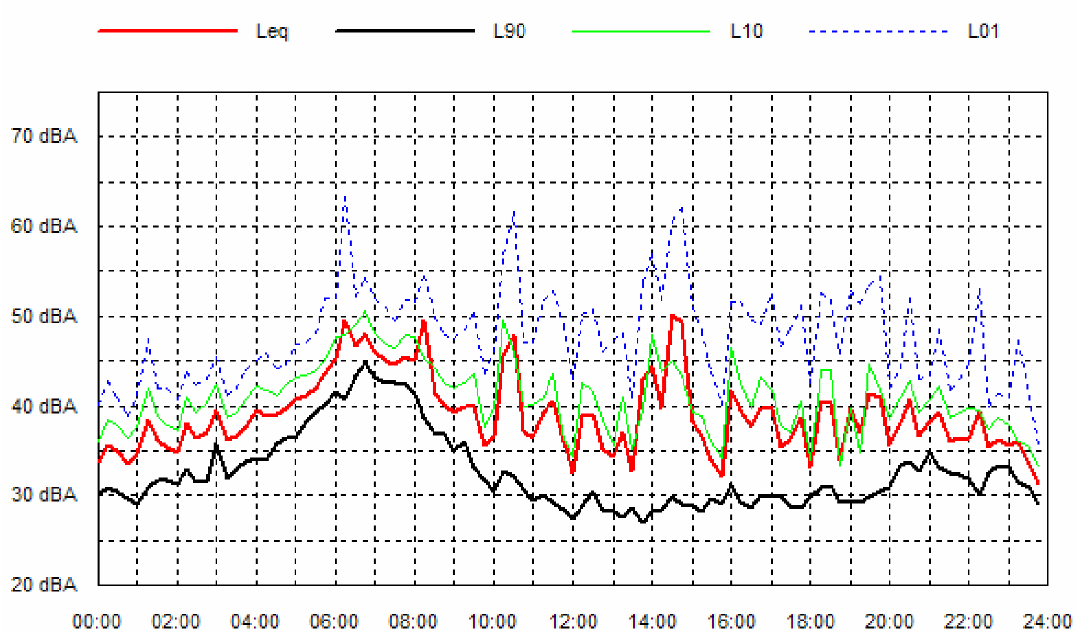
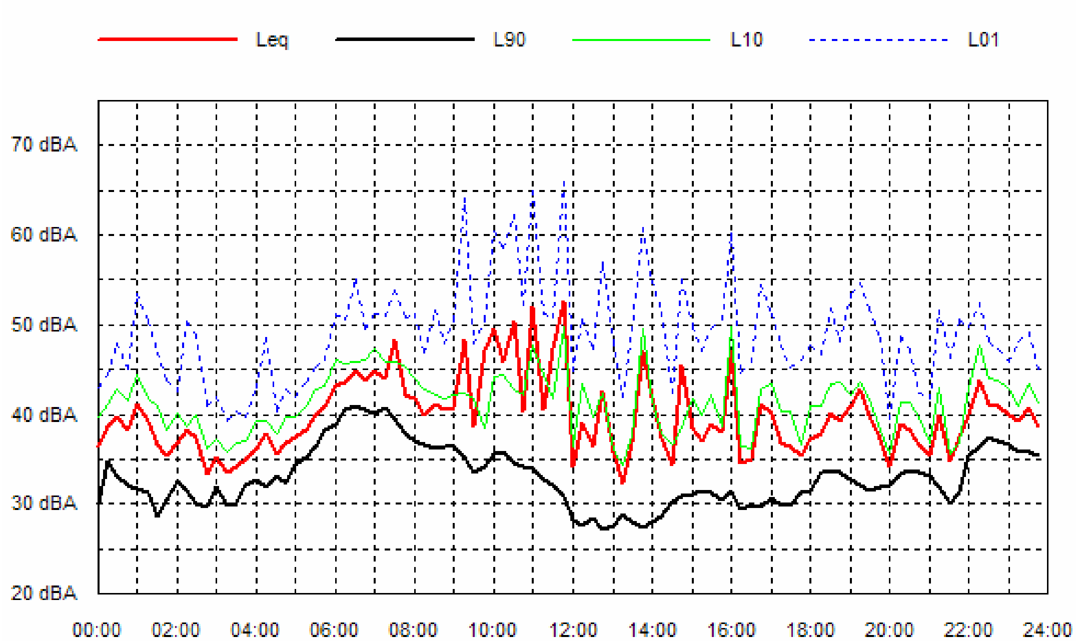


Location C
Data shaded: Weather; Extraneous

Thu 11 May 06

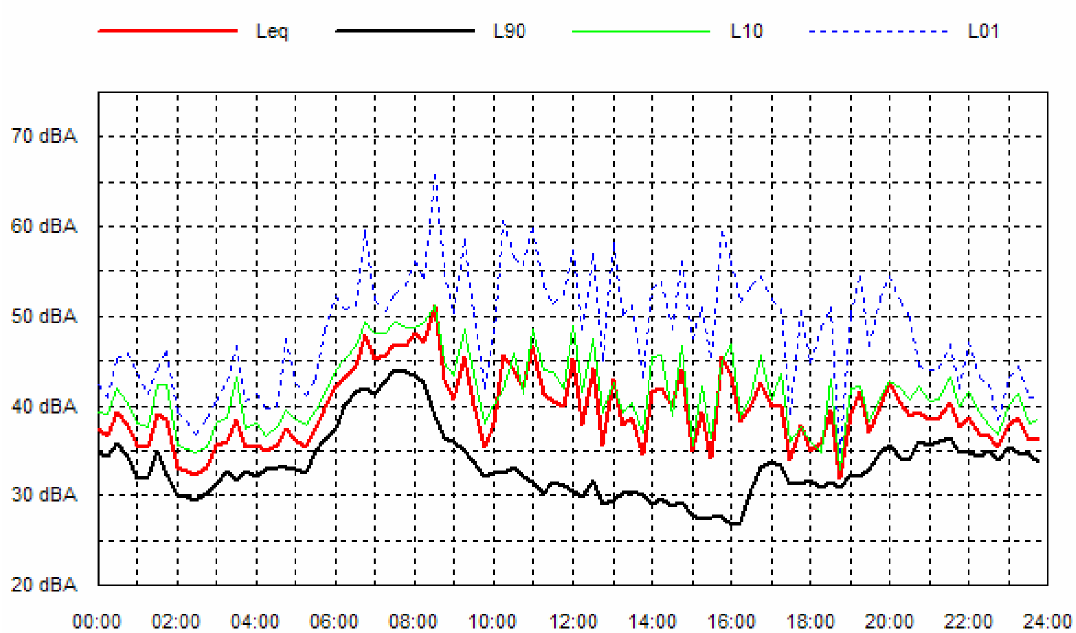


Fri 12 May 06

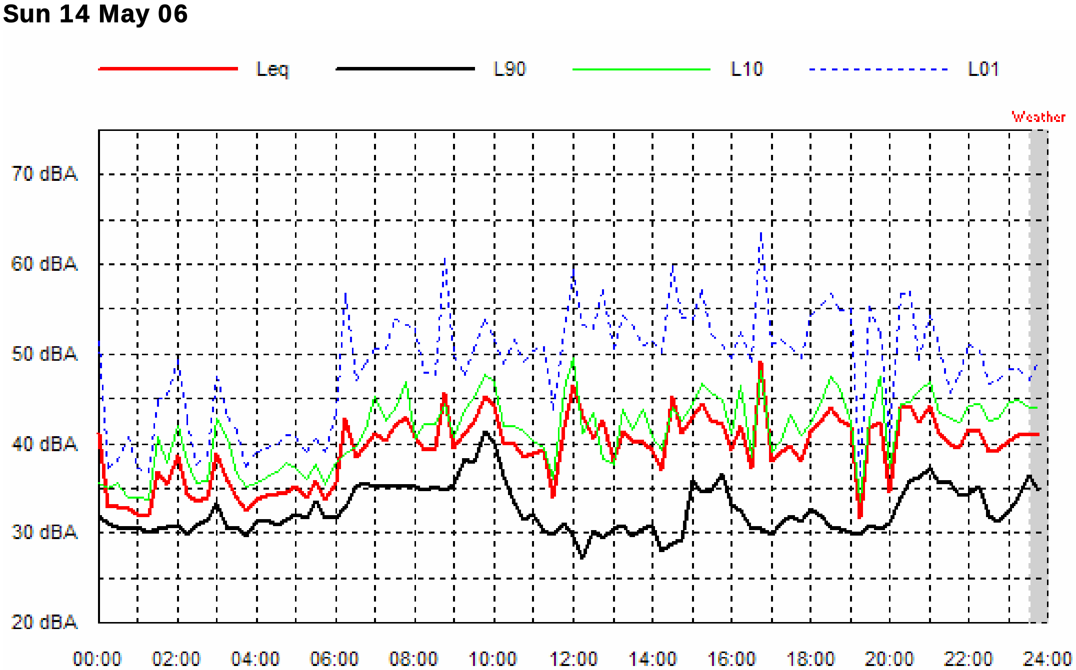


Location C
Data shaded: Weather; Extraneous

Sat 13 May 06



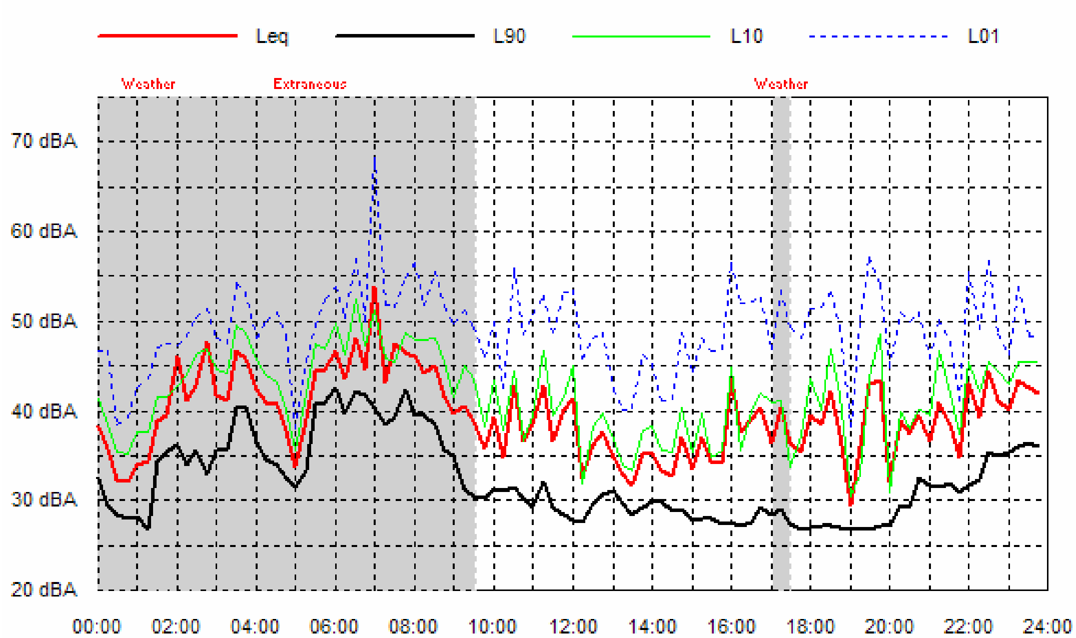
Sun 14 May 06



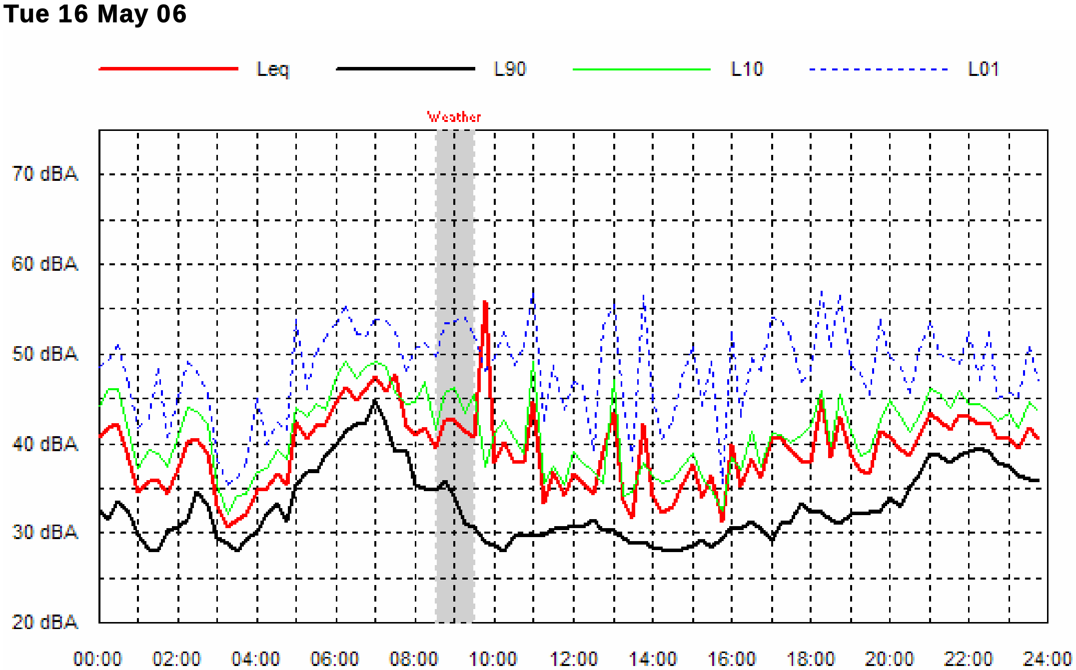
Location C

Data shaded: Weather; Extraneous

Mon 15 May 06



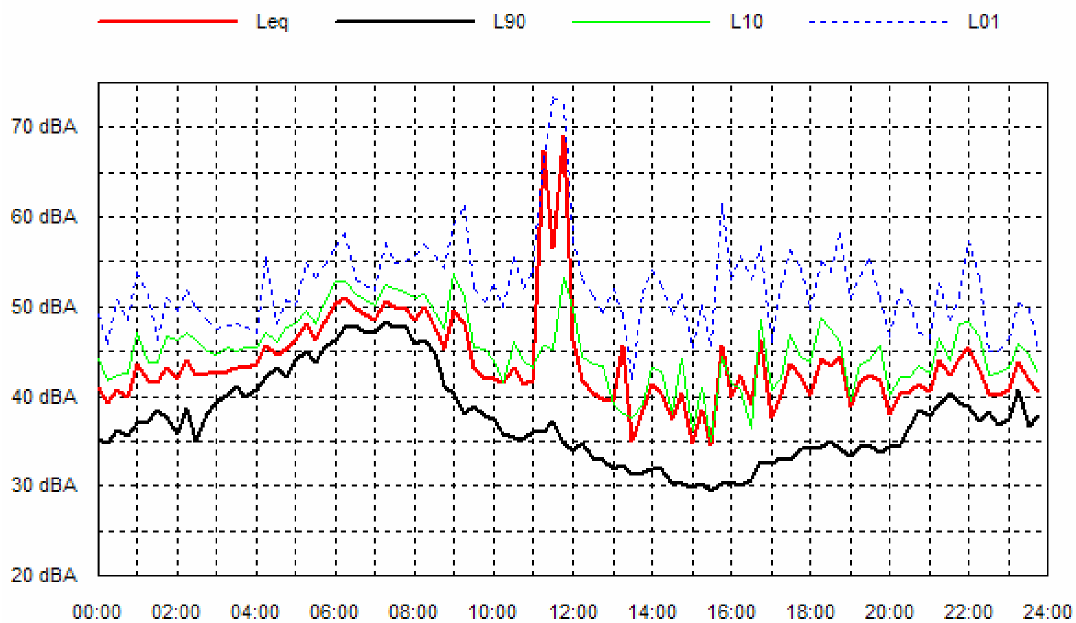
Tue 16 May 06



Location C

Data shaded: Weather; Extraneous

Wed 17 May 06



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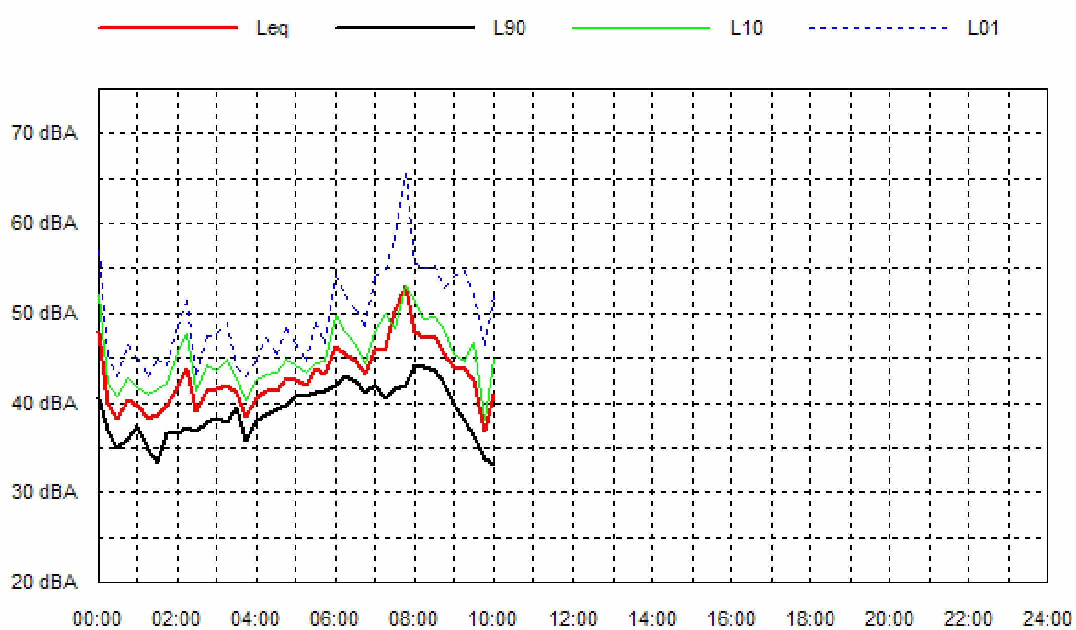
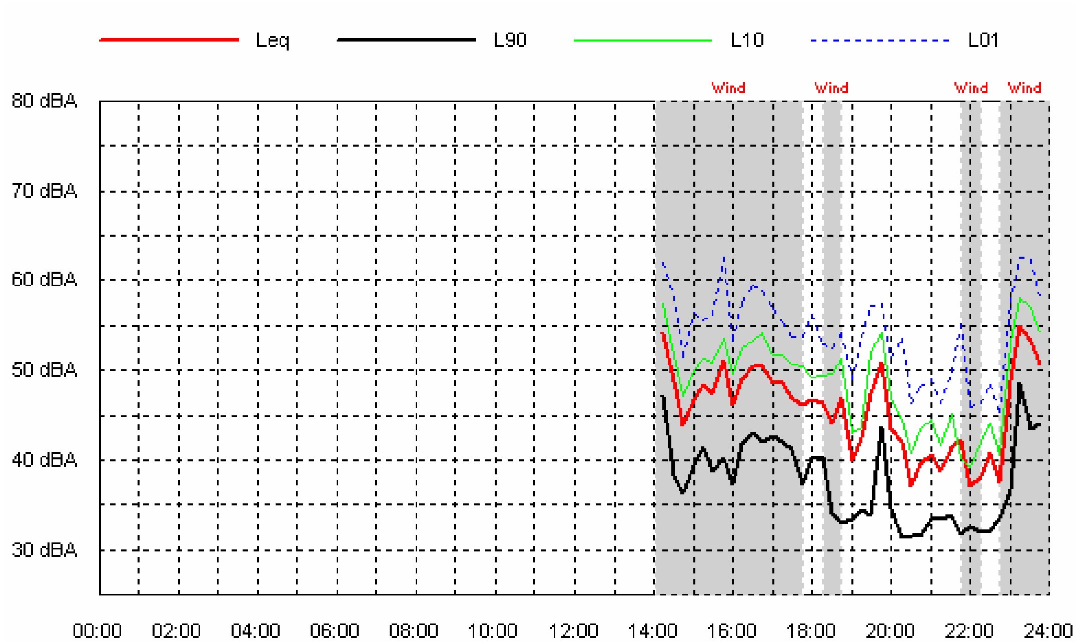


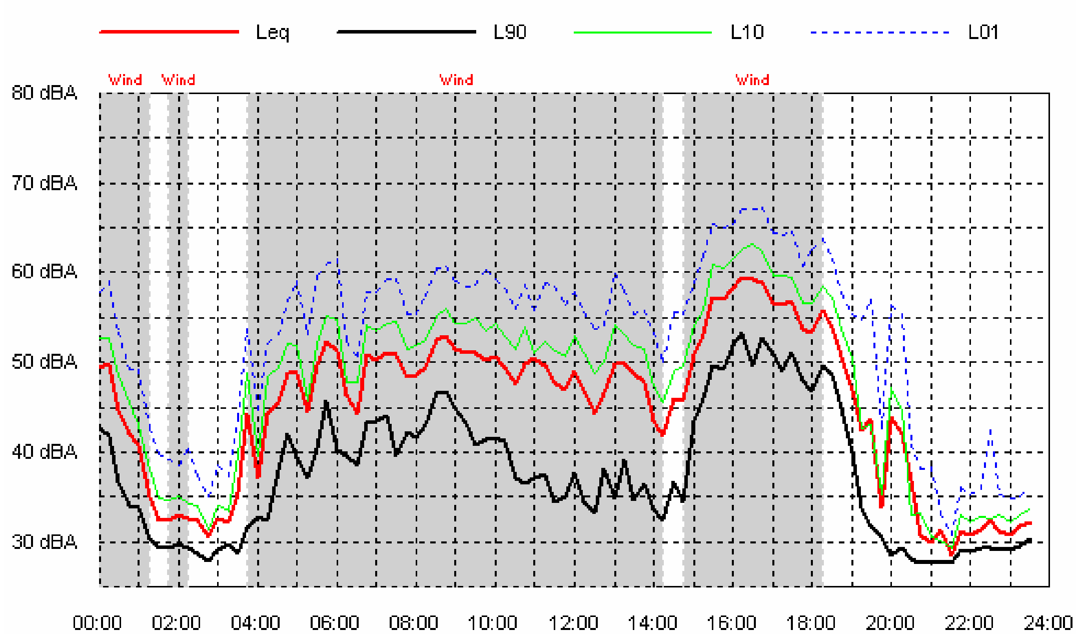
Location: Location D

Data shaded: Wind; Rain

Fri 27 Oct 06



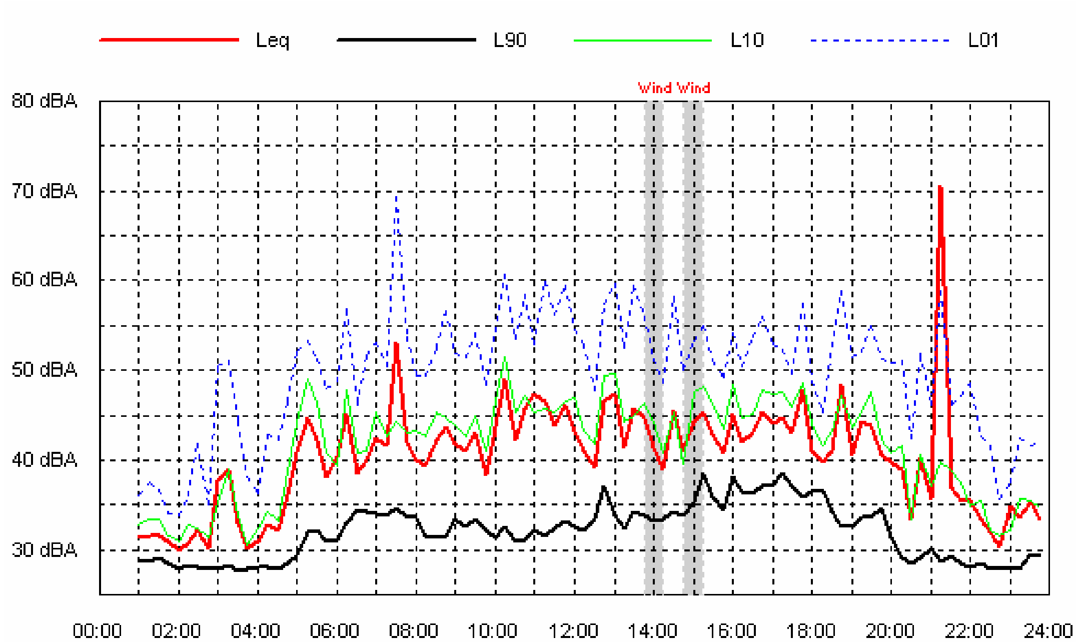
Sat 28 Oct 06



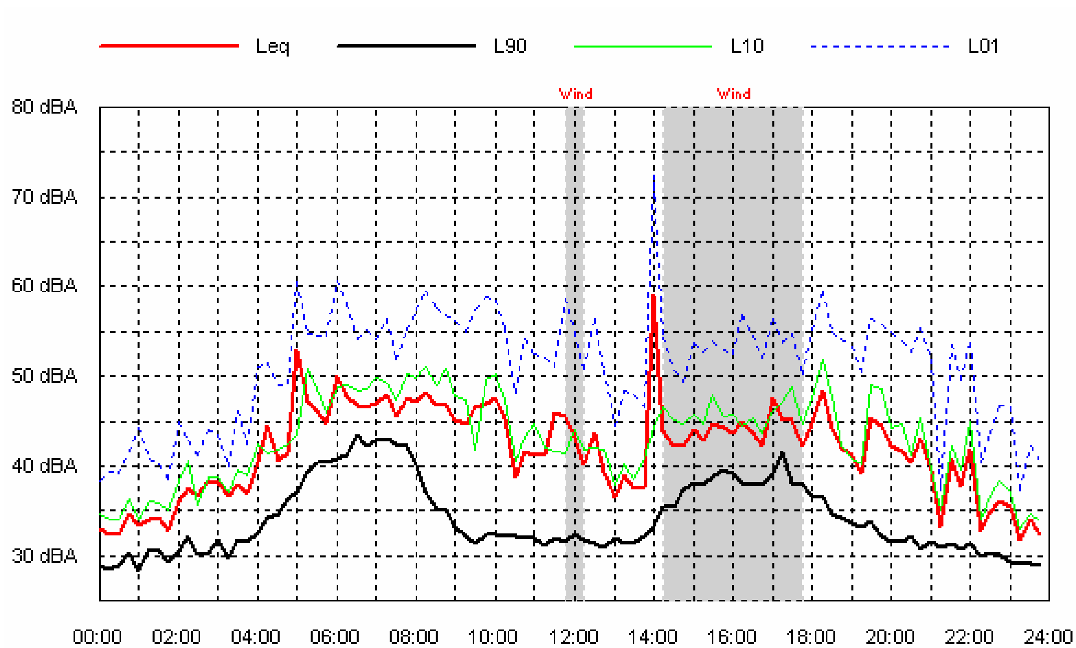
Location: Location D

Data shaded: Wind; Rain

Sun 29 Oct 06



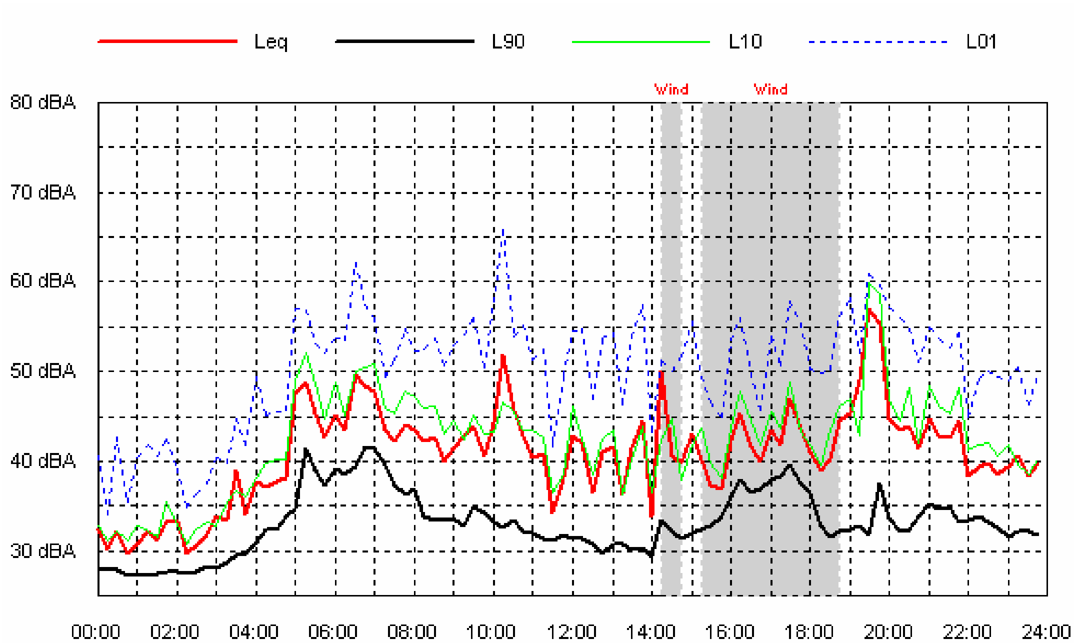
Mon 30 Oct 06



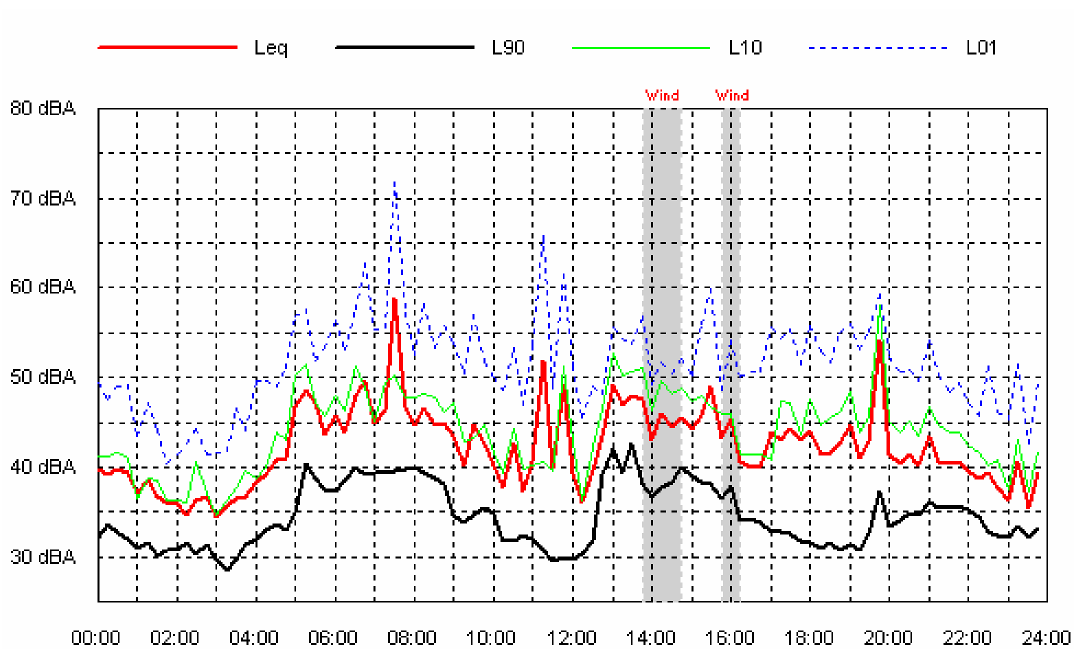
Location: Location D

Data shaded: Wind; Rain

Tue 31 Oct 06



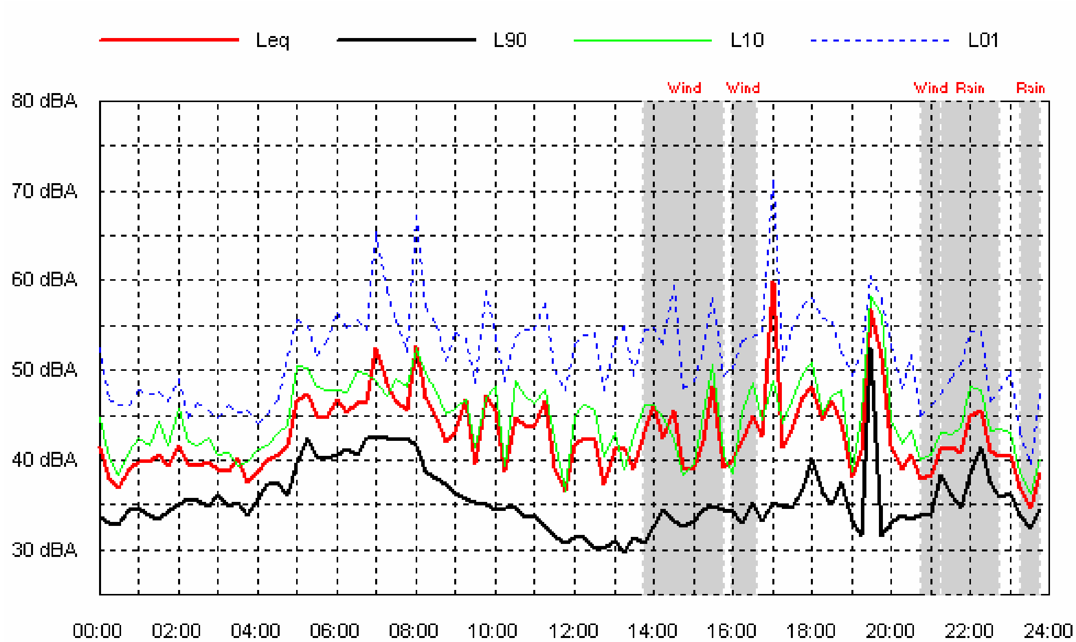
Wed 01 Nov 06



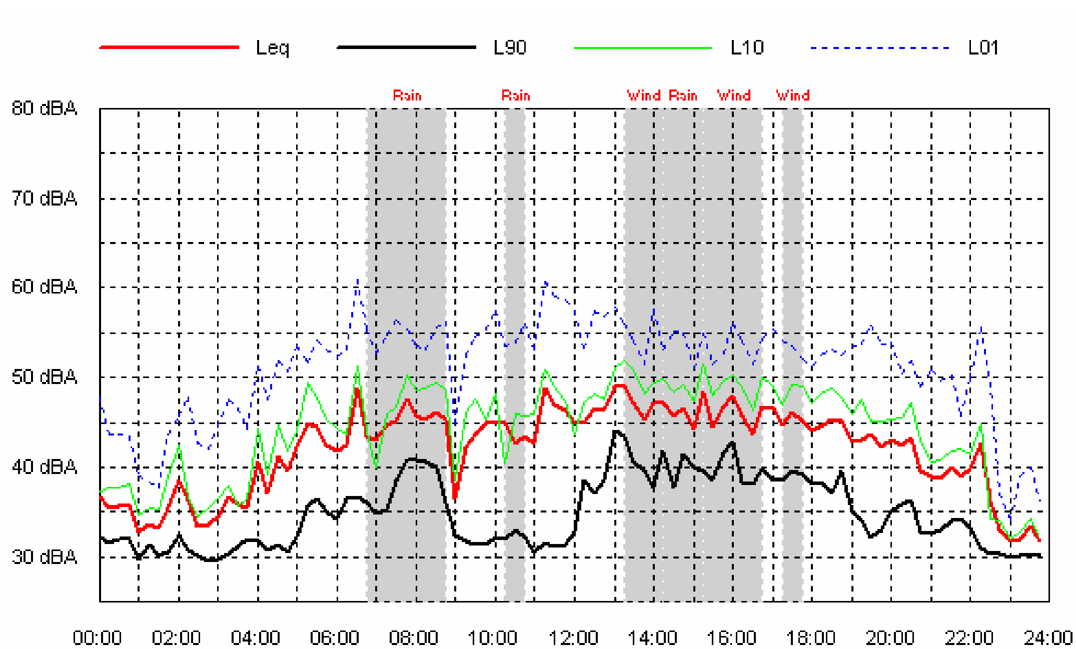
Location: Location D

Data shaded: Wind; Rain

Thu 02 Nov 06



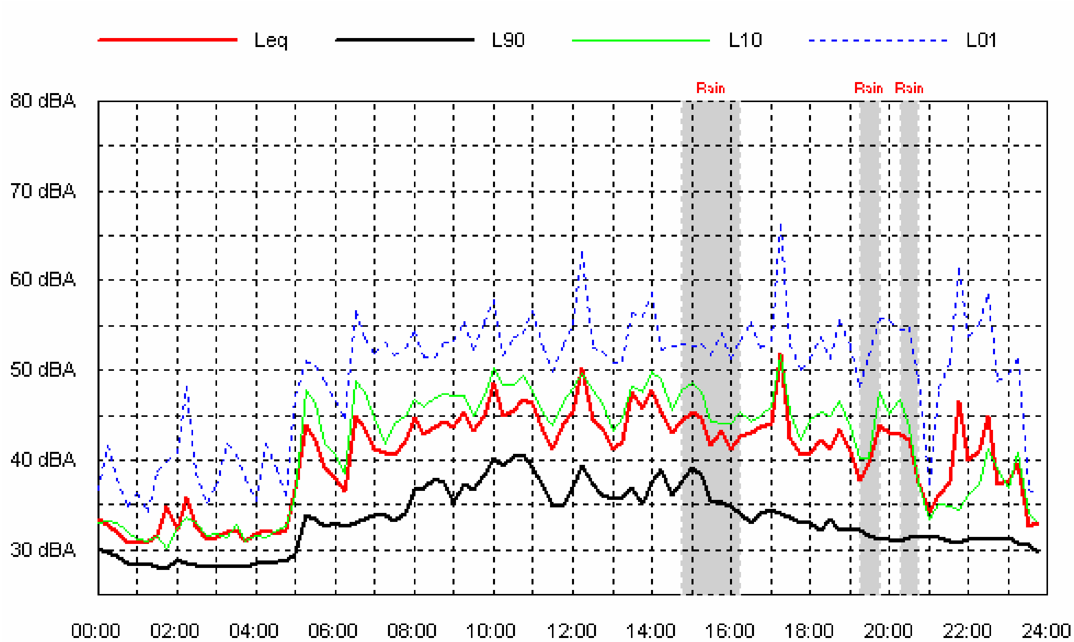
Fri 03 Nov 06



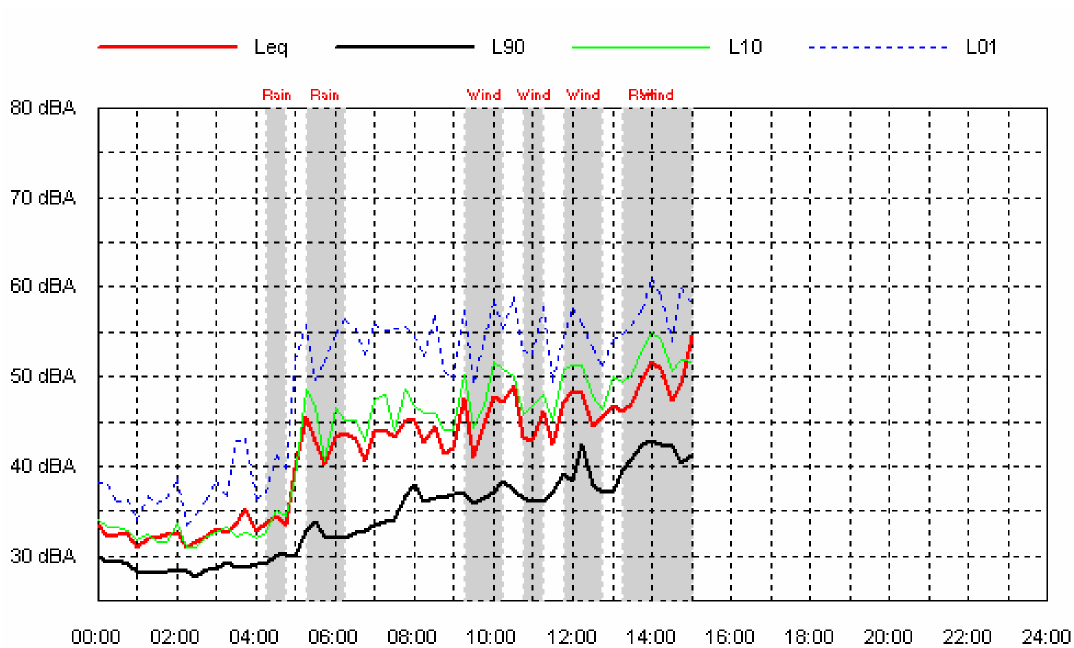
Location: Location D

Data shaded: Wind; Rain

Sat 04 Nov 06



Sun 05 Nov 06



APPENDIX C

SUMMARY OF METEOROLOGICAL CONDITIONS MODELLED

Season	Period	Wind Dir	Wind Speed	% Occurr.
Autumn	Day	0	0	42.4
Autumn	Day	0	0.75	0.9
Autumn	Day	0	1.25	2.0
Autumn	Day	0	1.75	1.6
Autumn	Day	0	2.25	1.0
Autumn	Day	0	2.75	2.0
Autumn	Day	45	0.75	0.3
Autumn	Day	45	1.25	0.8
Autumn	Day	45	1.75	1.6
Autumn	Day	45	2.25	3.9
Autumn	Day	45	2.75	3.7
Autumn	Day	90	0.75	0.8
Autumn	Day	90	1.25	0.9
Autumn	Day	90	1.75	1.4
Autumn	Day	90	2.25	3.8
Autumn	Day	90	2.75	3.9
Autumn	Day	135	0.75	0.2
Autumn	Day	135	1.25	0.4
Autumn	Day	135	1.75	1.2
Autumn	Day	135	2.25	1.8
Autumn	Day	135	2.75	1.9
Autumn	Day	180	0.75	1.1
Autumn	Day	180	1.25	2.1
Autumn	Day	180	1.75	3.1
Autumn	Day	180	2.25	2.7
Autumn	Day	180	2.75	1.4
Autumn	Day	225	0.75	1.3
Autumn	Day	225	1.25	1.2
Autumn	Day	225	1.75	1.6
Autumn	Day	225	2.25	1.8
Autumn	Day	225	2.75	2.7
Autumn	Day	270	0.75	0.4
Autumn	Day	270	1.25	0.4
Autumn	Day	270	1.75	0.4
Autumn	Day	270	2.25	0.2
Autumn	Day	270	2.75	0.5
Autumn	Day	315	0.75	0.6
Autumn	Day	315	1.25	0.7
Autumn	Day	315	1.75	1.0
Autumn	Day	315	2.25	0.4
Autumn	Day	315	2.75	0.6
Spring	Day	0	0	55.4
Spring	Day	0	0.75	0.7
Spring	Day	0	1.25	1.3
Spring	Day	0	1.75	0.7
Spring	Day	0	2.25	1.4
Spring	Day	0	2.75	0.5
Spring	Day	45	0.75	0.2
Spring	Day	45	1.25	0.5
Spring	Day	45	1.75	0.9

Season	Period	Wind Dir	Wind Speed	% Occurr.
Spring	Day	45	2.25	0.8
Spring	Day	45	2.75	1.6
Spring	Day	90	1.25	0.2
Spring	Day	90	1.75	1.4
Spring	Day	90	2.25	1.9
Spring	Day	90	2.75	2.3
Spring	Day	135	1.25	0.8
Spring	Day	135	1.75	1.5
Spring	Day	135	2.25	1.8
Spring	Day	135	2.75	1.2
Spring	Day	180	0.75	0.3
Spring	Day	180	1.25	1.1
Spring	Day	180	1.75	1.0
Spring	Day	180	2.25	1.5
Spring	Day	180	2.75	0.7
Spring	Day	225	0.75	1.2
Spring	Day	225	1.25	1.7
Spring	Day	225	1.75	2.4
Spring	Day	225	2.25	2.5
Spring	Day	225	2.75	3.1
Spring	Day	270	0.75	0.3
Spring	Day	270	1.25	0.7
Spring	Day	270	1.75	1.6
Spring	Day	270	2.25	1.2
Spring	Day	270	2.75	2.1
Spring	Day	315	0.75	0.8
Spring	Day	315	1.25	0.5
Spring	Day	315	1.75	0.5
Spring	Day	315	2.25	0.9
Spring	Day	315	2.75	0.8
Summer	Day	0	0	57.5
Summer	Day	0	0.75	0.2
Summer	Day	0	1.25	1.2
Summer	Day	0	1.75	1.3
Summer	Day	0	2.25	1.3
Summer	Day	0	2.75	2.5
Summer	Day	45	0.75	1.1
Summer	Day	45	1.25	2.4
Summer	Day	45	1.75	2.4
Summer	Day	45	2.25	2.8
Summer	Day	45	2.75	3.4
Summer	Day	90	0.75	0.5
Summer	Day	90	1.25	0.6
Summer	Day	90	1.75	0.9
Summer	Day	90	2.25	2.1
Summer	Day	90	2.75	2.6
Summer	Day	135	0.75	0.2
Summer	Day	135	1.25	0.1
Summer	Day	135	1.75	0.5
Summer	Day	135	2.25	0.7

Season	Period	Wind Dir	Wind Speed	% Occurr.
Summer	Day	135	2.75	1.7
Summer	Day	180	0.75	0.7
Summer	Day	180	1.25	0.5
Summer	Day	180	1.75	0.2
Summer	Day	180	2.25	0.5
Summer	Day	180	2.75	1.3
Summer	Day	225	0.75	0.5
Summer	Day	225	1.25	0.7
Summer	Day	225	1.75	0.2
Summer	Day	225	2.25	1.0
Summer	Day	225	2.75	2.0
Summer	Day	270	0.75	0.7
Summer	Day	270	1.25	0.3
Summer	Day	270	1.75	0.4
Summer	Day	270	2.25	0.3
Summer	Day	270	2.75	1.1
Summer	Day	315	0.75	0.7
Summer	Day	315	1.25	1.1
Summer	Day	315	1.75	0.5
Summer	Day	315	2.25	0.6
Summer	Day	315	2.75	0.7
Winter	Day	0	0	52.2
Winter	Day	0	0.75	0.4
Winter	Day	0	1.25	1.2
Winter	Day	0	1.75	1.6
Winter	Day	0	2.25	2.1
Winter	Day	0	2.75	1.7
Winter	Day	45	0.75	0.1
Winter	Day	45	1.75	0.4
Winter	Day	45	2.25	1.0
Winter	Day	45	2.75	1.2
Winter	Day	90	0.75	0.3
Winter	Day	90	1.25	0.2
Winter	Day	90	1.75	1.4
Winter	Day	90	2.25	0.8
Winter	Day	90	2.75	0.8
Winter	Day	135	0.75	0.1
Winter	Day	135	1.25	0.3
Winter	Day	135	1.75	1.2
Winter	Day	135	2.25	0.5
Winter	Day	135	2.75	0.8
Winter	Day	180	0.75	0.6
Winter	Day	180	1.25	0.8
Winter	Day	180	1.75	2.3
Winter	Day	180	2.25	2.3
Winter	Day	180	2.75	2.2
Winter	Day	225	0.75	1.0
Winter	Day	225	1.25	2.0
Winter	Day	225	1.75	2.5
Winter	Day	225	2.25	3.0

Season	Period	Wind Dir	Wind Speed	% Occurr.
Winter	Day	225	2.75	4.5
Winter	Day	270	0.75	1.3
Winter	Day	270	1.25	1.4
Winter	Day	270	1.75	1.4
Winter	Day	270	2.25	1.2
Winter	Day	270	2.75	1.5
Winter	Day	315	0.75	1.0
Winter	Day	315	1.25	0.6
Winter	Day	315	1.75	0.7
Winter	Day	315	2.25	0.8
Winter	Day	315	2.75	1.1

Season	Period	Wind Dir	Wind Speed	% Occurr.
Autumn	Evening	0	0	48.6
Autumn	Evening	0	1.25	0.5
Autumn	Evening	0	1.75	0.3
Autumn	Evening	45	0.75	0.3
Autumn	Evening	45	1.25	0.3
Autumn	Evening	45	1.75	1.1
Autumn	Evening	45	2.25	1.6
Autumn	Evening	45	2.75	2.7
Autumn	Evening	90	0.75	0.3
Autumn	Evening	90	1.25	0.3
Autumn	Evening	90	1.75	0.3
Autumn	Evening	90	2.25	2.4
Autumn	Evening	90	2.75	8.7
Autumn	Evening	135	0.75	0.3
Autumn	Evening	135	1.75	0.3
Autumn	Evening	135	2.25	3.5
Autumn	Evening	135	2.75	9.0
Autumn	Evening	180	0.75	0.5
Autumn	Evening	180	1.25	1.1
Autumn	Evening	180	1.75	1.4
Autumn	Evening	180	2.25	2.7
Autumn	Evening	180	2.75	3.0
Autumn	Evening	225	0.75	0.3
Autumn	Evening	225	1.25	0.3
Autumn	Evening	225	1.75	0.3
Autumn	Evening	225	2.25	1.6
Autumn	Evening	225	2.75	3.8
Autumn	Evening	270	1.75	0.3
Autumn	Evening	270	2.25	0.8
Autumn	Evening	270	2.75	1.6
Autumn	Evening	315	0.75	0.3
Autumn	Evening	315	2.25	0.8
Autumn	Evening	315	2.75	0.8
Spring	Evening	0	0	54.7
Spring	Evening	0	0.75	0.3
Spring	Evening	0	1.75	0.3
Spring	Evening	0	2.25	0.5
Spring	Evening	45	1.25	0.3
Spring	Evening	45	2.25	0.3
Spring	Evening	45	2.75	2.2
Spring	Evening	90	0.75	0.5
Spring	Evening	90	1.25	0.3
Spring	Evening	90	1.75	0.5
Spring	Evening	90	2.25	1.9
Spring	Evening	90	2.75	6.6
Spring	Evening	135	1.75	0.8
Spring	Evening	135	2.25	2.2
Spring	Evening	135	2.75	6.9
Spring	Evening	180	1.25	0.3

Season	Period	Wind Dir	Wind Speed	% Occurr.
Spring	Evening	180	1.75	0.5
Spring	Evening	180	2.25	1.9
Spring	Evening	180	2.75	4.1
Spring	Evening	225	1.25	0.5
Spring	Evening	225	1.75	0.3
Spring	Evening	225	2.25	2.5
Spring	Evening	225	2.75	5.5
Spring	Evening	270	1.25	0.3
Spring	Evening	270	1.75	0.3
Spring	Evening	270	2.25	0.3
Spring	Evening	270	2.75	1.9
Spring	Evening	315	0.75	0.3
Spring	Evening	315	1.25	0.5
Spring	Evening	315	2.25	0.8
Spring	Evening	315	2.75	1.6
Summer	Evening	0	0	67.6
Summer	Evening	0	1.25	0.3
Summer	Evening	45	2.25	0.8
Summer	Evening	45	2.75	3.3
Summer	Evening	90	1.25	1.1
Summer	Evening	90	1.75	0.5
Summer	Evening	90	2.25	2.5
Summer	Evening	90	2.75	8.8
Summer	Evening	135	1.75	0.3
Summer	Evening	135	2.25	2.2
Summer	Evening	135	2.75	7.4
Summer	Evening	180	2.25	0.5
Summer	Evening	180	2.75	1.1
Summer	Evening	225	1.75	0.3
Summer	Evening	225	2.25	0.5
Summer	Evening	225	2.75	1.9
Summer	Evening	270	1.75	0.8
Winter	Evening	0	0	40.8
Winter	Evening	0	0.75	0.3
Winter	Evening	0	1.25	0.3
Winter	Evening	0	1.75	0.3
Winter	Evening	0	2.25	0.5
Winter	Evening	0	2.75	0.8
Winter	Evening	45	1.25	0.3
Winter	Evening	45	1.75	0.5
Winter	Evening	45	2.25	0.3
Winter	Evening	45	2.75	2.7
Winter	Evening	90	0.75	0.3
Winter	Evening	90	1.25	0.3
Winter	Evening	90	1.75	0.5
Winter	Evening	90	2.25	0.8
Winter	Evening	90	2.75	4.9
Winter	Evening	135	1.25	0.3
Winter	Evening	135	1.75	0.3
Winter	Evening	135	2.25	1.1

Season	Period	Wind Dir	Wind Speed	% Occurr.
Winter	Evening	135	2.75	3.5
Winter	Evening	180	0.75	0.5
Winter	Evening	180	1.25	1.1
Winter	Evening	180	1.75	1.9
Winter	Evening	180	2.25	3.5
Winter	Evening	180	2.75	10.1
Winter	Evening	225	0.75	0.3
Winter	Evening	225	1.25	0.5
Winter	Evening	225	1.75	2.4
Winter	Evening	225	2.25	1.6
Winter	Evening	225	2.75	6.8
Winter	Evening	270	1.25	0.3
Winter	Evening	270	1.75	1.6
Winter	Evening	270	2.25	1.1
Winter	Evening	270	2.75	2.4
Winter	Evening	315	1.25	0.3
Winter	Evening	315	1.75	1.9
Winter	Evening	315	2.25	3.3
Winter	Evening	315	2.75	1.6

Season	Period	Wind Dir	Wind Speed	Inv Strength	% Occur.
Autumn	Night	0	0	0	19.2
Autumn	Night	45	0.75	0	0.6
Autumn	Night	90	0.75	0	0.4
Autumn	Night	135	0.75	0	0.4
Autumn	Night	180	0.75	0	1.9
Autumn	Night	225	0.75	0	0.2
Autumn	Night	45	1.25	0	0.6
Autumn	Night	90	1.25	0	0.2
Autumn	Night	135	1.25	0	1.9
Autumn	Night	180	1.25	0	2.7
Autumn	Night	225	1.25	0	0.2
Autumn	Night	45	1.75	0	0.4
Autumn	Night	90	1.75	0	1.1
Autumn	Night	135	1.75	0	1.6
Autumn	Night	180	1.75	0	5.3
Autumn	Night	225	1.75	0	0.2
Autumn	Night	270	1.75	0	0.2
Autumn	Night	45	2.25	0	0.2
Autumn	Night	90	2.25	0	0.8
Autumn	Night	135	2.25	0	1.2
Autumn	Night	180	2.25	0	6.2
Autumn	Night	225	2.25	0	0.4
Autumn	Night	90	2.75	0	0.8
Autumn	Night	135	2.75	0	0.5
Autumn	Night	180	2.75	0	1.0
Autumn	Night	225	2.75	0	0.2
Autumn	Night	270	2.75	0	0.1
Autumn	Night	0	0	3	20.7
Autumn	Night	45	0.75	3	0.1
Autumn	Night	0	1.25	3	0.1
Autumn	Night	45	1.25	3	0.1
Autumn	Night	90	1.25	3	0.2
Autumn	Night	180	1.25	3	0.7
Autumn	Night	225	1.25	3	0.2
Autumn	Night	45	1.75	3	0.4
Autumn	Night	90	1.75	3	0.2
Autumn	Night	135	1.75	3	0.1
Autumn	Night	180	1.75	3	1.6
Autumn	Night	225	1.75	3	0.1
Autumn	Night	45	2.25	3	0.2
Autumn	Night	90	2.25	3	2.4
Autumn	Night	135	2.25	3	2.8
Autumn	Night	180	2.25	3	4.8
Autumn	Night	225	2.25	3	0.6
Autumn	Night	45	2.75	3	0.2
Autumn	Night	90	2.75	3	3.3
Autumn	Night	135	2.75	3	3.1
Autumn	Night	180	2.75	3	6.4
Autumn	Night	225	2.75	3	2.2
Autumn	Night	270	2.75	3	0.6

Season	Period	Wind Dir	Wind Speed	Inv Strength	% Occur.
Spring	Night	0	0	0	17.7
Spring	Night	45	0.75	0	0.6
Spring	Night	90	0.75	0	0.2
Spring	Night	135	0.75	0	0.7
Spring	Night	180	0.75	0	0.6
Spring	Night	225	0.75	0	0.2
Spring	Night	270	0.75	0	0.2
Spring	Night	45	1.25	0	0.9
Spring	Night	90	1.25	0	0.1
Spring	Night	135	1.25	0	0.4
Spring	Night	180	1.25	0	2.2
Spring	Night	270	1.25	0	0.2
Spring	Night	0	1.75	0	0.1
Spring	Night	45	1.75	0	0.7
Spring	Night	135	1.75	0	1.2
Spring	Night	180	1.75	0	3.8
Spring	Night	225	1.75	0	0.7
Spring	Night	270	1.75	0	0.9
Spring	Night	315	1.75	0	0.2
Spring	Night	0	2.25	0	0.1
Spring	Night	45	2.25	0	0.6
Spring	Night	90	2.25	0	0.7
Spring	Night	135	2.25	0	2.0
Spring	Night	180	2.25	0	5.3
Spring	Night	225	2.25	0	0.5
Spring	Night	270	2.25	0	0.2
Spring	Night	45	2.75	0	0.5
Spring	Night	90	2.75	0	0.2
Spring	Night	135	2.75	0	0.9
Spring	Night	180	2.75	0	1.7
Spring	Night	225	2.75	0	1.6
Spring	Night	270	2.75	0	0.1
Spring	Night	0	0	3	20.6
Spring	Night	135	0.75	3	0.1
Spring	Night	270	0.75	3	0.1
Spring	Night	315	0.75	3	0.1
Spring	Night	0	1.25	3	0.1
Spring	Night	45	1.25	3	0.2
Spring	Night	90	1.25	3	0.2
Spring	Night	180	1.25	3	0.4
Spring	Night	225	1.25	3	0.4
Spring	Night	0	1.75	3	0.1
Spring	Night	45	1.75	3	0.7
Spring	Night	90	1.75	3	0.4
Spring	Night	135	1.75	3	0.1
Spring	Night	180	1.75	3	0.5
Spring	Night	225	1.75	3	0.2
Spring	Night	270	1.75	3	0.6
Spring	Night	45	2.25	3	0.7
Spring	Night	90	2.25	3	1.3

Season	Period	Wind Dir	Wind Speed	Inv Strength	% Occur.
Spring	Night	135	2.25	3	2.0
Spring	Night	180	2.25	3	4.0
Spring	Night	225	2.25	3	1.0
Spring	Night	270	2.25	3	0.5
Spring	Night	315	2.25	3	0.1
Spring	Night	0	2.75	3	0.4
Spring	Night	90	2.75	3	1.2
Spring	Night	135	2.75	3	5.0
Spring	Night	180	2.75	3	7.3
Spring	Night	225	2.75	3	4.8
Spring	Night	270	2.75	3	0.4
Summer	Night	0	0	0	20.5
Summer	Night	0	0.75	0	0.4
Summer	Night	45	0.75	0	0.7
Summer	Night	90	0.75	0	1.6
Summer	Night	135	0.75	0	1.0
Summer	Night	180	0.75	0	0.6
Summer	Night	225	0.75	0	0.5
Summer	Night	270	0.75	0	0.2
Summer	Night	315	0.75	0	0.1
Summer	Night	0	1.25	0	0.4
Summer	Night	45	1.25	0	1.2
Summer	Night	90	1.25	0	1.8
Summer	Night	135	1.25	0	1.1
Summer	Night	180	1.25	0	2.3
Summer	Night	225	1.25	0	0.6
Summer	Night	270	1.25	0	0.1
Summer	Night	0	1.75	0	0.2
Summer	Night	45	1.75	0	1.3
Summer	Night	90	1.75	0	3.2
Summer	Night	135	1.75	0	1.7
Summer	Night	180	1.75	0	4.6
Summer	Night	225	1.75	0	1.1
Summer	Night	270	1.75	0	0.1
Summer	Night	45	2.25	0	0.4
Summer	Night	90	2.25	0	1.6
Summer	Night	135	2.25	0	1.2
Summer	Night	180	2.25	0	2.7
Summer	Night	225	2.25	0	1.7
Summer	Night	45	2.75	0	0.9
Summer	Night	90	2.75	0	0.5
Summer	Night	135	2.75	0	0.2
Summer	Night	180	2.75	0	1.3
Summer	Night	225	2.75	0	1.3
Summer	Night	0	0	3	11.2
Summer	Night	0	0.75	3	0.1
Summer	Night	0	1.25	3	0.1
Summer	Night	45	1.25	3	0.5
Summer	Night	90	1.25	3	0.2
Summer	Night	180	1.25	3	0.6

Season	Period	Wind Dir	Wind Speed	Inv Strength	% Occur.
Summer	Night	225	1.25	3	0.2
Summer	Night	0	1.75	3	0.1
Summer	Night	45	1.75	3	1.5
Summer	Night	90	1.75	3	1.1
Summer	Night	135	1.75	3	0.2
Summer	Night	180	1.75	3	0.2
Summer	Night	225	1.75	3	0.9
Summer	Night	270	1.75	3	0.2
Summer	Night	45	2.25	3	2.4
Summer	Night	90	2.25	3	3.9
Summer	Night	135	2.25	3	3.2
Summer	Night	180	2.25	3	2.1
Summer	Night	225	2.25	3	0.4
Summer	Night	45	2.75	3	2.0
Summer	Night	90	2.75	3	5.4
Summer	Night	135	2.75	3	1.8
Summer	Night	180	2.75	3	2.6
Summer	Night	225	2.75	3	1.6
Winter	Night	0	0	0	13.6
Winter	Night	315	0.75	0	0.1
Winter	Night	0	1.25	0	0.1
Winter	Night	135	1.25	0	0.2
Winter	Night	180	1.25	0	0.5
Winter	Night	225	1.25	0	0.8
Winter	Night	270	1.25	0	0.4
Winter	Night	315	1.25	0	0.1
Winter	Night	0	1.75	0	0.4
Winter	Night	45	1.75	0	0.2
Winter	Night	135	1.75	0	0.1
Winter	Night	180	1.75	0	2.1
Winter	Night	225	1.75	0	0.1
Winter	Night	270	1.75	0	0.6
Winter	Night	0	2.25	0	0.6
Winter	Night	45	2.25	0	0.2
Winter	Night	90	2.25	0	0.4
Winter	Night	180	2.25	0	2.1
Winter	Night	225	2.25	0	1.3
Winter	Night	270	2.25	0	0.5
Winter	Night	135	2.75	0	0.1
Winter	Night	180	2.75	0	1.0
Winter	Night	225	2.75	0	0.5
Winter	Night	315	2.75	0	0.1
Winter	Night	0	0	3	27.1
Winter	Night	135	0.75	3	0.1
Winter	Night	0	1.25	3	0.1
Winter	Night	135	1.25	3	0.1
Winter	Night	180	1.25	3	0.1
Winter	Night	225	1.25	3	0.1
Winter	Night	270	1.25	3	0.7
Winter	Night	315	1.25	3	0.2

Season	Period	Wind Dir	Wind Speed	Inv Strength	% Occur.
Winter	Night	180	1.75	3	0.6
Winter	Night	225	1.75	3	1.7
Winter	Night	270	1.75	3	2.3
Winter	Night	315	1.75	3	2.1
Winter	Night	0	2.25	3	0.1
Winter	Night	45	2.25	3	1.0
Winter	Night	90	2.25	3	1.3
Winter	Night	135	2.25	3	0.4
Winter	Night	180	2.25	3	3.4
Winter	Night	225	2.25	3	4.2
Winter	Night	270	2.25	3	2.3
Winter	Night	315	2.25	3	1.4
Winter	Night	0	2.75	3	0.5
Winter	Night	45	2.75	3	0.7
Winter	Night	90	2.75	3	0.1
Winter	Night	135	2.75	3	1.1
Winter	Night	180	2.75	3	10.9
Winter	Night	225	2.75	3	7.2
Winter	Night	270	2.75	3	3.4
Winter	Night	315	2.75	3	0.5