REPORT

The Perception and Effect of Wind Farm Noise
At Two Victorian Wind Farms

An Objective Assessment

June 2012

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NOISE MEASUREMENT SERVICES

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Signed

Bob Thorne

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DISCLAIMER

This Report by Noise Measurement Services Pty Ltd is prepared for a particular Client (Mr N. Dean) and is based on the agreed objective, scope, conditions and limitations as may be stated in the Executive Summary. The Report presents only the information that the Author believes, in his professional opinion, is relevant and necessary to describe the issues involved. The technical and informative text is in the process of continuing peer review and must be considered as being of a preliminary nature. No responsibility is acknowledged or accepted by Noise Measurement Services Pty Ltd as to any use of this Report as it is a continuing 'work-in-progress' and open to professional debate. The intellectual property of this Report remains with Noise Measurement Services Pty Ltd. The Report is Confidential to the Client and is not intended for the use of, for or by any third-party.

ACKNOWLEDGEMENTS

We thank the residents who participated in this study for their willingness to share their experiences. Our appreciation is expressed to our Contributors and Reviewers (Daniel, Huub, Bruce, Rachel and Greg) for reviewing drafts of this Report and providing insightful feedback.

Noise Measurement Services Pty Ltd acknowledges that all the information from this study is confidential and belongs to the respective participants. The permission of the Client and participants to present summary data in this report and papers for publication is acknowledged.

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EXECUTIVE SUMMARY

Scope

This Report is part of a research program commenced in 2003 – 2005 into the human perception of low amplitude intrusive noise[1].

The objective of this Report is to respond to a request from a number of families living or working near wind farms in Victoria for an independent impartial wind farm noise assessment and is a follow-up to the 2009 - 2010 reports for Mr and Mrs N. Dean with respect to the Waubra wind farm. At the time concerns about wind farm noise were raised by local residents and are recorded in evidence before planning hearings in 2010 and the 2011 Senate Inquiry into the social and economic impact of rural wind farms.

The current study consists of formal objective measurement tools for quality of life, sleep disturbance, noise sensitivity, environmental amenity and sound character analysis; as well as standard measures for sound levels, sound quality and (special) audible characteristics including amplitude modulation and tonality. The confidential acoustical, attitudinal survey data and human perception analysis is summarised in this Report following professional peer-review.

Two wind farm locales (Waubra, Cape Bridgewater) and one 'green-fields' location (Berrybank) were surveyed. Persons affected live between 700 metres to a distance of around 3500 metres from the turbines, with an 'average' of 1400 metres. Residents participating in this study record considerable stress and identifiable adverse health effects due to wind farm noise.

It is not within the scope of the Report to determine compliance or non-compliance with respective wind farm development approvals; this is the task solely of the Minister for Planning. It is not within the scope of the Report and author to discuss these initial findings with any party other than the respondents and the peer reviewers.

Report Format and Limitations

The format of this Report is in summary form; discussion as to cause and effect has been canvassed previously in evidence by the author before the Environment Court New Zealand (Turitea wind farm application) and VCAT Victoria (Berrybank, Moorabool, Mortlake, Stockyard Hill, The Sisters wind farm applications) as well as the 2011 Senate Inquiry into the social and economic impact of rural wind farms. The contents of this Report are confined to:

1. Wind Farm Sound - A summary discussion of noise measurement methods, levels recorded and assessments made;
2. Health and Perception - A summary discussion of methods for quality of life assessments and adverse health effects recorded;
3. Discussion.

   Annex A: The AcouStar Methodology for Environmental Impact Assessment

[1] Thorne, R., (2007). Assessing intrusive noise and low amplitude sound. Doctoral thesis and analysis software, Massey University, Palmerston North, New Zealand. Access from: *http://kea.massey.ac.nz/search~S1?/aThorne+Robert/athorne+robert/1%2C2%2C2%2CB/frameset&FF=athorne+robert&1%2C1%2C*

Annex B: Summary of Recorded Sound Levels, Observations, and Assessments

Annex C: NZS6808:1998 - instrumentation for sound measurement

Annex D: Reference – Marshall Day Waubra compliance assessment

Annex E: Quality of Life - Instruments and Summary of Responses

Glossary of Terms

Outcomes

- Sound from the Waubra wind farm, when measured at residence 2 (Lobbs Road), exceeds the night-time criteria and is therefore assessed as being **non-compliant** on a frequent and regular basis with or without the special audible characteristics penalty applied under NZS6808.
- Based on the results of the study it can be argued that, when exposed to wind farm noise and wind turbine generated air pressure variations, some will more likely than not be so affected that there is serious harm (also termed 'significant adverse effect') to health. By 'serious harm' it is meant harm that is more than mere annoyance and that can be quantified in terms of reported illness, sleep disturbance or other physical effect. A measure of serious harm is if the exposed individual is adversely affected to the extent that he or she is obliged to remove themselves from the exposure in order to mitigate the harm.
- The technical outcome of the report is to emphasise the need for, and practicality of, the 2km setback that the Minister has implemented for new wind farms.

Recommendation

- It is recommended that the 2 km setback be implemented at Waubra, Cape Bridgewater and other existing wind farms.

1 WIND FARM SOUND MEASUREMENT and ASSESSMENT

1.1 Purpose of the study

The purpose of the study was to record and report sound levels and the character of the sound in the environments of the Waubra and Cape Bridgewater wind farms.

1.2 Wind farm sound measurement and assessment

In establishing the measurement and assessment program for the study the particular requirements of the development approvals were established. The sound levels recorded in this study are referenced to the Waubra approval conditions that require compliance with the New Zealand NZS6808:1998 *Acoustics-The Assessment and Measurement of Sound from Wind Turbine Generators*. The approval conditions for Cape Bridgewater have not been sighted. The significant sound assessment requirements for Waubra are contained in compliance Approval Condition 14 which applies NZS6808:1998 to a dwelling existing at the time of approval:

> *Condition 14(a)*
>
> The sound level from the wind energy facility, when measured outdoors within 10 metres of a dwelling at any relevant nominated wind speed, should not exceed the background level (L95) by more than 5 dBA or a level of 40 dBA L95, whichever is the greater.
>
> *Condition 14(b)*
>
> When sound has a special audible characteristic, the measured sound level of the source shall have a 5dB penalty applied.
>
> *Condition 14(c)*
>
> Compliance at night must be separately assessed with regard to night time data. For these purposes the night is defined as 10:00pm to 7:00am. For sleep protection purposes, a breach of the standard set out at 13(a), for 10% of the night, amounts to a breach of the condition.
>
> Note: In this Report the reference to 13(a) in 14(c) above is taken as meaning 14(a).

Comments.

Condition 14(a) applies a defined measurement location being a maximum of 10 metres from the dwelling. NZS6808 clause 4.5.2 states that background measurements shall be "more than 5 metres from any significant vertical reflecting surface, or other structures or objects (such as trees, power lines, etc) so that "natural" wind sound generated at or near the microphone is excluded as far as possible from the measurements". Compliance level measurements are to be consistent with clause 4.5 with the exception that the wind farm is now operational. The 'compliance' wind speeds are taken as being in the range 0 m/s to rated wind speed (13 m/s – 15 m/s) measured at an anemometer height consistent with the anemometer height for the 'background' sound level measurements.

Condition 14(b) requires assessment of special audible characteristics as described in the standard. These characteristics are described as being clearly audible tones, impulses or modulation of sound levels. The standard states that "at present, there is no simple objective procedure available to quantify special audible characteristics, and subjective assessment is therefore necessary, supported by objective evidence (e.g. frequency analysis) where appropriate".

> Audible tones and modulation of sound levels are often described as rumble, whoosh, clanking and tonality, for example, and can be readily measured using standard acoustical and sound quality analysis methodologies.

Individual operational turbines can often have different audible characteristics compared to the cumulative effect of a number of turbines.

Condition 14(c) specifically states requirements for breach of condition: broadly this amounts to 54 minutes of non-compliance in the 9 hours between 10:00pm and 7:00am the next day (or 12 midnight to 7:00am the same day). The condition is to protect sleep and MUST therefore be continuously monitored at any non-stakeholder dwelling that has raised a complaint of sleep disturbance. Night time analysis is the primary measure in this Report.

Compliance under NZS6808 is assessed as: "To determine conformance with the [approval limits] a comparison shall be made between the best fit regression line of the background sound levels and the regression curve of the operational wind farm corrected for any special audible characteristics".

There are, of course, obvious difficulties of establishing the "level" of wind farm noise in ambient noise but under night-time conditions relating to sleep disturbance this must be determined. It is clear that any "compliance" report that fails to specifically address special audible characteristics and night-time levels must in itself be non-compliant. In this Report assessment is made under observed conditions. The reasons for this are:

- The constantly changing nature of the wind farm noise from inaudible (turbines stopped) to audible (turbines operating)
- Variable number and location of operating turbines
- Changing wind direction and wind speeds that change noise propagation characteristics leading to increased or decreased noise
- Residents sleep with windows open and wind farm noise disturbs sleep

1.3 Sound measurements

The study investigates sound levels inside and outside residences affected by wind farms and in 'green-field' localities. Annexes A, B, C and D provide the detail of the acoustical investigations.

Observational sound levels were recorded with a Class 1 Larson Davis sound level meter with sound recording facility. A GRAS 40AZ extended frequency response microphone replaced the standard Larson Davis microphone. Standard measures were recorded with time history settings at 100ms and standard measurement times of 10 minutes. A-weighted values were recorded for time-history (LAeq, Ln levels) and Z-weighted third octave band levels. Soundfiles were recorded at a sampling rate of 16000samples/sec to give an audio file, 16-bit wav format, to 8000Hz. Sound character was determined from soundfiles of 10 second, 60 second, and 10 minute duration with dBSONIC v4.12, SpectraPLUS v5 and Adobe Audition v1.5. Soundfiles analysed were calibrated to the time-history or measurement datafile so the overall LAeq level were the same for both formats. Additional sound levels for longer-term (7-day) sound levels were recorded with Rion NL21 Class 2 sound level meters. Each sound level meter was field calibrated with a Class 1 Quest CA22 dual level calibrator before and after each survey. Each instrument holds current NATA calibration certificates. Weather conditions including wind speed and direction were recorded at 2 metres above ground level for each survey.

1.4 Does the Waubra wind farm meet its development approval

The question often raised during the course of the study was: 'Does the Waubra wind farm meeting its development approval?'. The study in January 2012 measured wind farm sound levels at 4 residences in the locale of the Waubra wind farm. This section provides, as an example of the assessment process, the sound level measurements at a home that is

affected by a group of 4 or more turbines. The measurements and assessment illustrate the application of NZS6808:1998 and the development approval for Waubra.

This section presents an example of the basic information and methodology needed in order to assess compliance or non-compliance with NZS6808 and night-time criteria. The night-time levels are the most significant as these are the established criterion for compliance. Measured background levels were recorded in association with physical observations of the operation of the turbines and weather conditions, as well as bird noise and so on. The wind speeds during the recordings at ground level were below 5 m/s and blowing from the south and south-south east; that is, from the southern and eastern turbines to the home. The weather was fine and cool. Sound recordings were taken on a regular basis inside and outside the home.

Figure 1.4.1 illustrates the measured background levels with turbines operating at Residence 2 (see following Plate 1 for location). The "pre-construction or non-operational" background level is calculated as 35.5 dB(A) (using the 'average' background level in Table 2.1 of Annex B for Saturday night 21 Jan and Sunday morning 22 January as an example) giving a compliance level of 41 dB(A). Even though the turbines were operating (see the operational power charts in Annex B) these two days give a good range of background levels from a low of 28.2 dB(A) to a high of 50.7 dB(A). The 'background-plus' level of 41 dB(A) is higher than the 'standard' background level of 40 dB(A) and is therefore referenced as the compliance level.

The measured night-time levels for 20, 21, 26 and 27 January are summarised in this section. The background sound levels are above 40/41 dB(A) and, based on on-site observations, due to wind farm activity. It can be argued that there is a contribution to the background sound levels by tree-leaf noise and so-on. This source of noise was not a distinctive feature of the survey and no masking of wind farm noise was observed to the extent that recordings were adversely affected. Taking the NZS6808 background compliance level as 41 dB(A) it is observed that wind farm sound levels exceed the criterion at night.

The observations indicate the sound recorded is turbine-related but ambient noise (birds, insects) confound the measurements. The previous section illustrates the operation of the wind farm and clearly shows that during the day the background levels are not influenced when the wind farm stops operating. This highlights the risk / failure of relying on non-attended monitoring for assessment of compliance. Visual observation of the turbines to the south and east indicates the wind farm was in operation during most of the survey. At night the operation could only be observed by the blades passing and masking the lights on the towers plus audible turbine noise. However, the actual operation of the local turbines should be confirmed as there is no readily verifiable relationship between the power outputs and the measured background sound levels.

There is no proven scientific method available to determine the actual contribution of wind turbine noise and the actual contribution of ambient sound using the LA95 measure alone.

Figure 1.4.1 illustrates the variation in sound levels over 24 hours for 4 days plus a half-day. The data that informs the figure is provided in Annex B Table 2.1. The night-time levels above 41 dB(A) measured as the background level LA95 are marked in yellow. Only the 6 highest time-blocks need to be highlighted to indicate the 10% compliance level. Therefore, if 7 or more time-blocks are marked there is potential non-compliance. A decision is then made if the sound is fully turbine related or a mix of turbine and ambient sound.

Finally a decision is made if the sound contains special audible characteristics. As the wind farm exhibits special audible characteristics (observed, measured and recorded using objective measures) a penalty of 5 dB must be added to the measured levels.

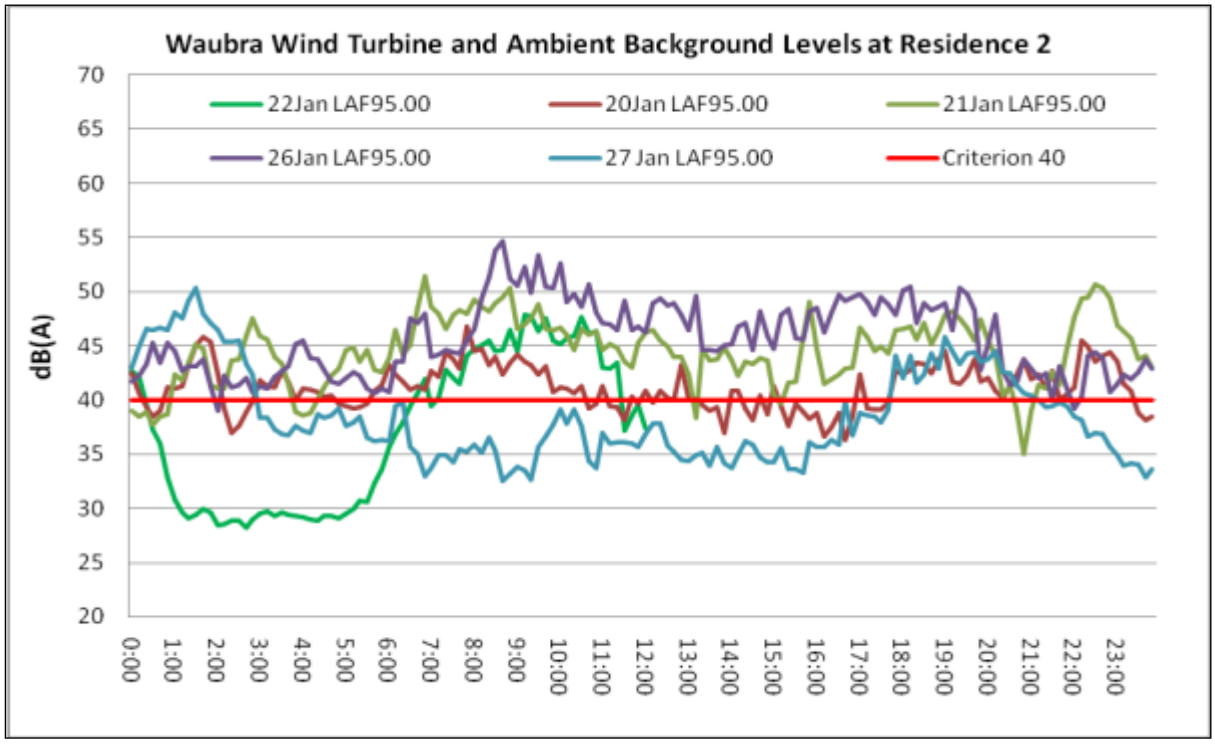


Figure 1.4.1: Background sound levels at Residence 2

1.5 Assessment for Compliance

The measured and observed levels can therefore be reviewed for potential compliance or non-compliance with the background-plus criteria and special audible characteristics both considered. For the purposes of this Report the non-turbine night-time background level is assessed as 36 dB(A) giving a background plus criterion of 41 dB(A) and compliance is assessed in Tables 1.4.1 and 1.4.2.

Table 1.4.1: Assessment for Compliance or Non-compliance, by 10 minute Night-time recordings; the LA95 criterion is 41 dB(A)

Date	Average LA95	In compliance	7^{th} Highest LA95 value	In compliance
20	40.8	Just	42.6	No
21	42.7	No	45.6	No
26	42.7	No	45.1	No
27	39.9	Yes	46.7	No

Special audible characteristics are recorded so the 5 dB(A) penalty is applied, Table 1.4.2.

Table 1.4.2: Assessment for Compliance or Non-compliance, by 10 minute Night-time recordings; the LA95 criterion is 41 dB(A); special audible characteristics (SAC) penalty of 5 dB(A)

Date	Average LA95	With SAC	In compliance	7th Highest LA95 value	With SAC	In compliance
20	40.8	46	No	42.6	48	No
21	42.7	48	No	45.6	51	No
26	42.7	48	No	45.1	50	No
27	39.9	45	No	46.7	52	No

Observation

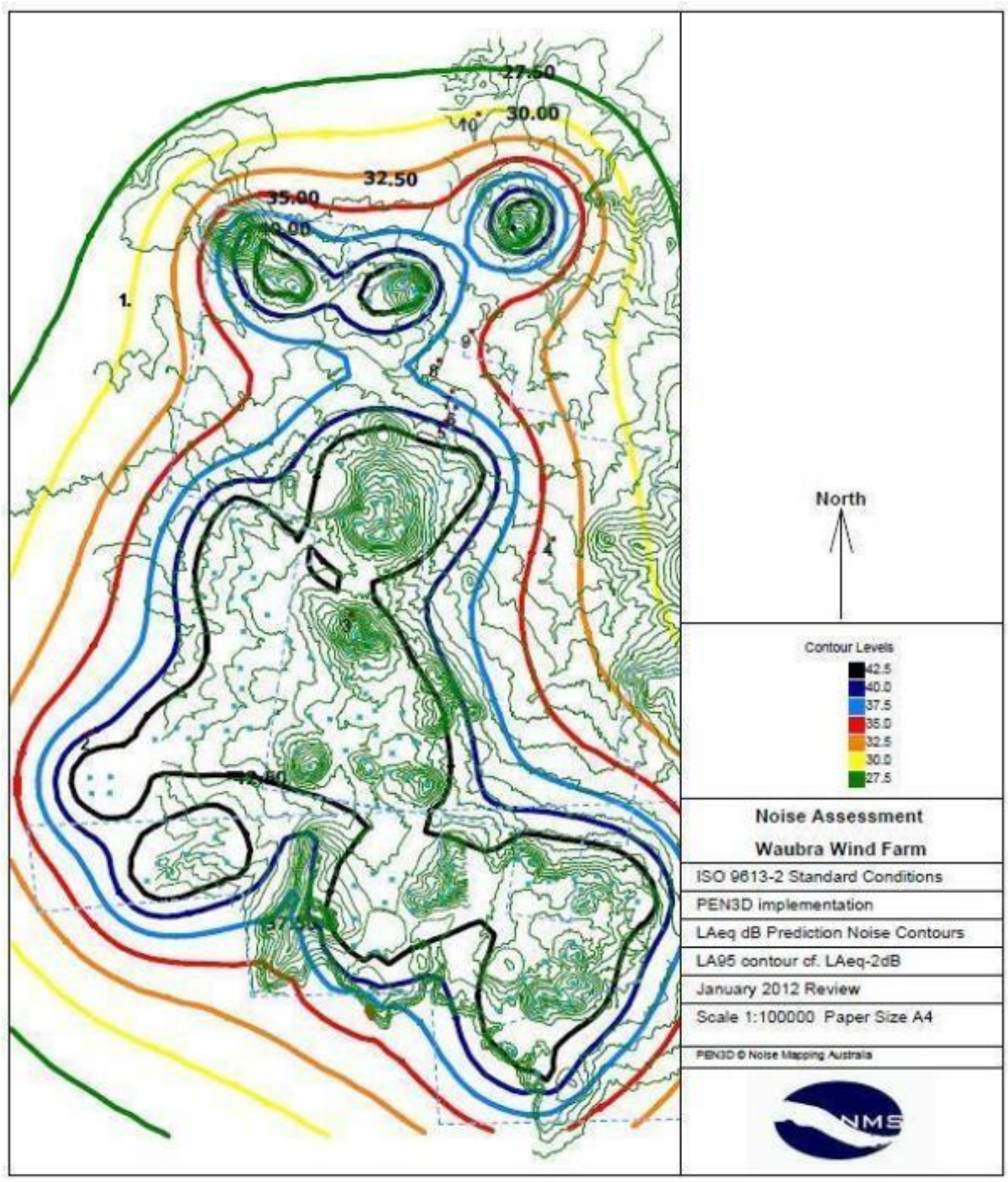
Sound from the Waubra wind farm, when measured at residence 2 (Lobbs Road), exceeds the night-time criteria and is therefore assessed as being **non-compliant** on a frequent and regular basis with or without the special audible characteristics penalty applied under NZS6808.

1.6 Predicted Sound Levels at Residences

Plates 1 and 2 present predicted sound levels at respondent's homes. The predicted levels are calculated with ISO9613-2:1996 *Acoustics-Attenuation of sound during propagation outdoors-Part 2 General method of calculation* and have an uncertainty of ±3dB(A) at 100-1000 metres. The predictions are acceptable for wind speeds to 5 m/s. A wind turbine source sound power level of 104dB(A) at 8m/s is applied in the predictions.

The predicted levels do not necessarily occur all the time. Variations will always occur due to changes in wind speed and direction, the number of turbines operating, and the effect of downstream turbulence interaction between different turbines. A sound level variation of ±3dB(A) is expected on a regular basis over a 12-month period.

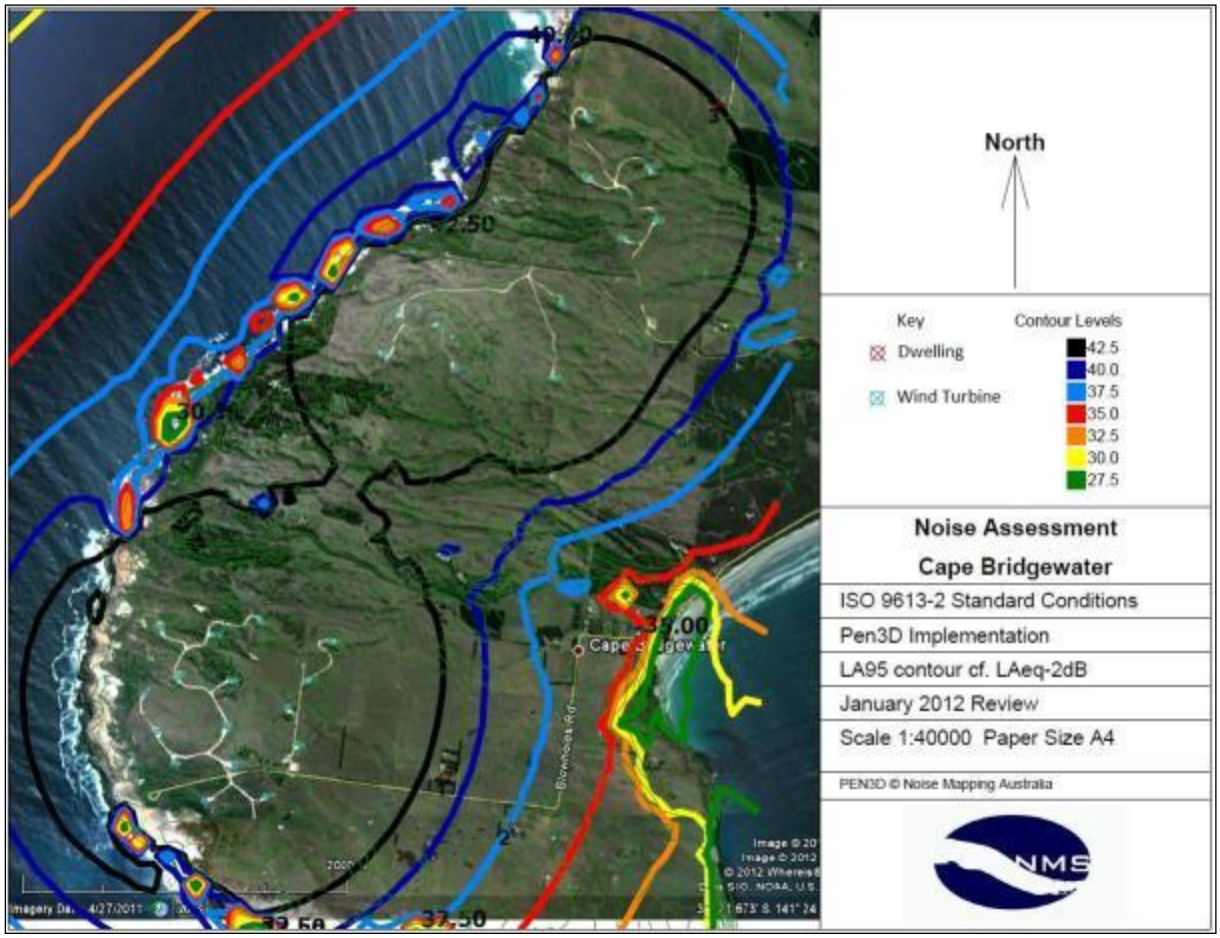
Plate 1: Waubra Residents, Wind Turbine Locations and Predicted Noise Contours



Receiver	LAeq	LA95	Receiver	LAeq	LA95
1	30	28	**6**	38	36
2	40	38	**7**	37	35
3	44	42	**8**	37	35
4	34	32	**9**	36	34
5	40	38	**10**	30	28

Predicted sound levels at 8m/s

Plate 2: Cape Bridgewater Residents, Wind Turbine Locations and Predicted Noise Contours



Receiver	LAeq	LA95	Receiver	LAeq	LA95
1	41	39	**2**	38	36
3	42	40			

Predicted sound levels at 8m/s

1.7 Turbines and sound levels

Wind turbine sound has a unique nature that is variable over time and is highly dependent on wind speed and directions, as well as locale. Objective measurement of such sound is not easy yet can be achieved using suitable measurement methods. NZS6808 refers to "special audible characteristics".

Observations at the different wind farms under different weather conditions and measurement distances indicate the sound of turbines are individually observable (swish, rumbles, clunks, whines) at distances of 200 – 500 metres. At around 900 metres only clearly distinctive turbines are identifiable (swish, rumbles) and by 2000-3000 metres the sound of turbines is cumulative and is heard as a general source of noise. At each location the wind farm could be clearly heard at dwellings approximately 2000 metres from the nearest turbines. The sound of turbines can be heard 2000 metres upwind and 2000 metres downwind, as well at an angle to the turbines. The sound, with turbines operating, can be described as a steady rumble with a mixture of rumble – thumps. Turbine sound character varies regularly both in "loudness" and "tonality". The general character of a long time period of an hour or so is of a steady rumble. This, however, depends considerably on wind speed and direction.

The sound of turbines is also evident and sometimes more pronounced inside a dwelling, windows open or closed. It is concluded that wind turbine sound at residences around 2000 metres or so is perceptible outside or inside a dwelling. The sound of turbines is often clearer inside a dwelling as higher frequencies from wind and insect activity are reduced through the building fabric. Masking of turbine sound by tree rustle, wind noise or insects was not observed at the time of the study. The general wind speed at ground level was 2-3m/s with the breeze blowing from the turbines to the observer. Insect noise however affects the measurement at all the different sound levels (LAeq, Ldn, Lden, LA95).

The outcomes of this study confirm that the measurement of 'special audible characteristics' as required under NZS6808 can be described subjectively and measured objectively in a scientific, repeatable manner.

Table 1.4.4, following, summarises the measured and predicted sound levels for the locales of the Waubra and Cape Bridgewater wind farms. Further detail is provided in the relevant Annex's of this Report.

Table 1.4.4: Measured and predicted sound levels at participant's homes.

Waubra - Cape Bridgewater Wind Farm Study Jaunary 2012									
DISTANCE TO TURBINES and OUTDOOR PREDICTED AND MEASURED SOUND LEVELS									
Distances (metres) Residences to Turbines			Predicted Sound Levels		Measred Outdoor Sound Levels (24hr)				
nearest turbine	group 3+ turbines	direction	LAeq	LA95	LAeq	Ldn	Lden	LA95	LA95 night
930	930-1280	S & E	35	33					
930	930-1280	S & E	35	33	50	54	54	41	28 - 51
GF	2000	270 degrees	40	38					
GF	2000	270 degrees	40	38	50	54	55	40	38 - 47
715	715-970	270 degrees	44	42					
715	715-970	270 degrees	44	42	48	56	56	31	38 - 45
1375	1375-1670	West	37	35					
2130	2130-2360	south	30	28					
2130	2130-2360	south	30	28					
1034	1034-1340	south	40	38					
1235	1235-1640	south	38	36					
1235	1235-1640	south	38	36					
1200	1200-1950	W & N	36	34	61	65	65	41	36 - 43
3500	3500-3800	south	<28	<28					
1400	1400	S & W	34	32					
1200	1200-1950	W & N	36	34					
1540	1540-1940	south	38	36	43	46	47	33	25 - 35
3400	3400	south	<28	<28					
3400	3400	south	<28	<28					
915	915-1100	west	41	39					
1750	1750-2080	west	38	36	49	54	54	38	39
1750	1750-2080	west	38	36					
915	915-1100	west	41	39					
600	600-1000	south-west	42	40					
600	600-1000	south-west	42	40					

1.8 Working Observation

Based on this study we define our working observation in relation to health effects and noise to:

"Adverse health effects are experienced by some individuals due to modulating noise broadly measured as infrasound (also as modulating air pressures), low frequency and audible noise."

2 QUALITY of LIFE

2.1 Introduction

The study presented pre-existing and validated health surveys in a face-to-face interview process. Twenty-one of the 26 respondents participating in this study verbally reported severe to moderate adverse health effects. Reported adverse health effects include sleep disturbance, headaches, noise sensitivity, irritability, anxiousness, pressure on ear-drums, sinus problems, panic attacks, balance rotational problems, erratic/high blood pressure, tightened scalp / forehead, eye-strain and nausea. Nausea attacks are cited as being common, with some residents having to leave their home to sleep where there is no turbine noise. People affected by the wind farm appear to respond in two distinct groups: those affected almost as soon as the wind farm started operating and those affected some 6 to 8 months later.

The previous Dean Report and the Author's evidence to VCAT hearings provides substantive observational, complaint and researched material for the consideration of nuisance in the context of individual adverse health effects and potential noise from the wind farm. Many of the residents have themselves reported their concerns to the Department of Planning and Community Development, local Shires, and the 2011 Australian Senate Inquiry into the social and economic impact of rural wind farms.

2.2 Adverse Health Effects

We present evidence in Annex E that both annoyance and sleep disruption mediate the relationship between noise sensitivity and HRQOL. In relation to sleep it has long been accepted that disrupted sleep reduces psychological wellbeing, compromises biological processes such as the immune system, and degrades day-to-day functionality. However, even noise insufficient to cause awakening may cause a brief arousals in state, with the sleeper moving from a deeper level of sleep to a lighter level and back to a deeper level. Because full wakefulness is not reached, the sleeper has no memory of the event but the sleep has been disrupted just as effectively as if wakefulness had occurred.

The WHO Report 'Burden of disease from environmental noise – Quantification of healthy life years lost in Europe', 2011, is a review of the scientific evidence supporting exposure-response relationships and case studies in calculating burden of disease. The Report has been peer reviewed. The report concludes that:

> *There is sufficient evidence from large scale epidemiological studies linking the population's exposure to environmental noise with adverse health effects. Therefore, environmental noise should be considered not only as a cause for nuisance but also a concern for public health and environmental health.*

The Report considers sleep disturbance and its potential for adverse health effects. In 2009, WHO published the *Night Noise Guidelines for Europe*. This publication presented new evidence of the health damage of night-time noise exposure and recommended threshold values that, if breached at night, would threaten health. The WHO recognizes the existence of vulnerable groups (such as children, the elderly, people with ill health) and acknowledges the existence of individual differences in noise sensitivity. Health effects are identified:

- A $L_{night,outside}$ level of 30 – 40 dB: a number of sleep effects are observed; 40 dB is equivalent to the lowest observed adverse effect level (LOAEL).
- A $L_{night,outside}$ level of 40 – 55 dB: adverse health effects are observed among the exposed population. Many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected.

- The outdoor levels are applied with an insulation value of 21 dB from outside to inside the home; a level of 40 dB outside is 19 dB inside
- Supplementary noise indicators (such as LAmax 35 dB) may be needed to describe and assess noise for night period protection.

Health-related Quality of life was measured using the WHOQoL-BREF, which consists of 26 items divided into four domains: physical health (7 items), psychological wellbeing (6 items), social relationships (3 items), and environmental factors (8 items). There are two additional items probing overall quality of life and general health. All 26 items in the WHOQoL-BREF consist of statements that are rated on a five point Likert scale. The respondents are asked to respond to these items, keeping the last two weeks in mind. Lower domain scores indicate more negative perceptions of Helath-related Quality of Life, while higher scores indicate higher and more positive evaluations. The WHOQoL instruments have been shown to have excellent reliability and validity, and its use has been reported in thousands of studies. Furthermore, the WHOQoL-BREF has also been tested for its validity for different cultural groups and results demonstrate that the WHOQoL-BREF is a valid instrument to use across different cultural groups. Quality of life is defined by the WHO (1997) as:

> *"An individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns. It is a broad ranging concept affected in a complex way by the person's physical health, psychological state, personal beliefs, social relationships and their relationship to salient features of their environment"*

and further information on the WHOQOL-BREF can be found in Annex E.

Means, standard deviations (SD) and the Cronbach's alpha (α_c) of the summated scales for the WHOQOL-BREF

	N	No of items	*M*	*SD*	α_c
Physical	25	7	18.8	5.97	.880
Psychological	25	6	17.68	5.15	.887
Social	25	3	10.16	3.14	.695
Environment	25	8	25.15	6.74	.841

The table above displays, for the turbine noise exposure group, mean scores for the four health-related quality of life domains measured by the WHOQOL-BREF. Estimates of Cronbach's alpha are above, or sufficiently close to, α_c=0.7, indicating that the data can be considered statistically reliable. The mean domain scores were then transformed (see table below) to afford comparisons with Australian normative data, and Australian clinical data (the LIDO study). The Longitudinal Investigation of Depression Outcomes (LIDO) Study aimed to explore the relationship between major depressive disorders in primary care patients and their quality of life. The data presented below suggests that the sample of individuals exposed to turbine noise have, on average, substantially lower health-related quality of life compared to the community and clinical samples.

WHOQOL-BREF transformed scores calculated for the turbine samples compared to Australian normative data (Hawthorne, Herrman, & Murphy, 2005) and LIDO (inpatient/outpatient) clinical data.

	Physical	Psychological	*Social*	*Environmental*
Turbine Sample	42.43	48.67	59.67	53.63
Community Norms	73.5	70.6	71.5	75.1
Outpatient Norms (LIDO)	61.47	65.37	62.89	67.93
Inpatient Norms (LIDO)	51.55	64.04	63.36	66.99

Based on the results of the study (see data, Annex E) it can be argued that, when exposed to wind farm noise and wind turbine generated air pressure variations, some will more likely than not be so affected that there is serious harm (also termed 'significant adverse effect') to health. By 'health' it is meant the definition given by the World Health Organization

"A state of complete physical, mental and social well-being and not merely the absence of disease or infirmity"

'Health' refers not only to physiology functioning, but also well-being, quality of life, and amenity.

By 'serious harm' it is meant harm that is more than mere annoyance and that can be quantified in terms of reported illness, sleep disturbance or other physical effect. A measure of serious harm is if the exposed individual is adversely affected to the extent that he or she is obliged to remove themselves from the exposure in order to mitigate the harm.

3 DISCUSSION

3.1 Study Limitations

First, the sample size was a major limiting factor in the analysis and interpretation of the data. However, while the findings reported here may be considered somewhat speculative and need to be confirmed with a larger sample, they are congruent with findings reported overseas on health-related quality of life and exposures to noises. Future studies capturing more participants would afford the use of structural equations modelling, a more powerful multivariate technique capable of elucidating and testing causal relationships.

Second, while we have reported objective measures of sound levels (A-weighted and Z-weighted values) in this study, such measurements have had very limited success in predicting health outcomes and they are severely lacking in predicting individual responses to noise. Additional objective measures of sound character are presented (loudness, sharpness, roughness, and fluctuation) and this study concludes they have limited application although more descriptive than measures of sound levels alone.

Third, while we make use of outdoor noise contours calculated by a professional acoustics company, the study shows that it is essential to undertake outdoor and indoor noise measurements to further elucidate the relationship between noise and health. Additionally, estimating the time that residents are exposed to the measured noise would likely be an important covariate.

Finally, the use of subjective versus objective health measures to detect changes in health due to environmental factors may be viewed as "soft". Objective outcome metrics such as blood pressure or chronically elevated cortisol levels are arguably well defined and easily measured, while noise-induced sleep disruption, stress, and similar subjective symptoms are less easily measured and distinguished from the background levels present in the population. However, objective manifestation of health effects associated with noise-related annoyance may emerge after some years since the onset of exposure, whereas subjective appraisals of wellbeing and health suffer no such time lag. Thus for cross-sectional studies as reported here subjective measures are more suitable.

The objective measurements from this study at Waubra and Cape Bridgewater indicate that noise from wind farm activity can and do exceed development approval conditions. Caveat: there is no proven scientific method available to determine the actual contribution of wind turbine noise and the actual contribution of ambient sound using the LA95 measure alone.

3.2 Study Outcomes

The study is the final in a 7-year research program into low amplitude intrusive noise. The persons who took part in the study (apart from the greenfields' respondents) are all adversely affected by wind farm activity and, as recorded in individuals' case study, there is evidence of serious harm to health. The subjective experience of annoyance is a common reaction to noise. Different individuals can exhibit different annoyance reactions to the same noise, and these individual differences can be ascribed partly to differences in noise sensitivity. The findings suggest that the individuals living near the wind farms of this study have a degraded Health-Related Quality of Life through annoyance and sleep disruption and that their health is significantly and seriously adversely affected (harmed) by noise.

Wind farms consist of clusters of wind turbines, which, when placed in rural areas, are associated with intrusive and unwanted sound. Wind turbine noise has characteristics sufficiently different from other, more extensively studied, noise sources to suggest that standard industrial noise standards are not appropriate for measurement and assessment purposes. Though research into the human impacts of wind turbine noise has appeared only in small quantity, the data suggest that, for equivalent exposures, wind turbine noise is more annoying than road or aviation noise. Furthermore, the particular characteristics of wind turbine noise may be likely to cause sleep disruption. Time-aggregated noise metrics have limited utility in assessing individual human health and well-being, and a cluster of metrics should be used in order to describe and estimate potential effects on individuals and communities. At this time, however, the quantity and quality of research are insufficient to effectively describe the relationship between wind turbine noise and health, and so legislation should apply the precautionary principle or conservative criteria when assessing proposed wind farm developments.

The World Health Organization considers noise pollution to be of sufficient threat to public health to justify the publication of numerous treatises and guidelines on noise effects and mitigation. The impact of 'community noise' on health has largely been studied in the context of transportation and general neighborhood noise, and extends beyond noise-induced hearing loss. Community exposure to wind turbine noise has been relatively understudied, for historical, methodological, and political reasons. This Report present the findings from a small study undertaken in Victoria, Australia. A sample of individuals (*n*=25) exposed to wind farm noise completed a survey probing health-related quality of life (WHOQOL), health status (SF-36), sleep (Epworth Sleepiness Scale, Pittsburgh Sleep Quality Index), noise sensitivity (NoiSeQ), and noise annoyance (generic items). Compared to normative data, the sample had lower health-related quality of life, and health status average or below average. Self-report changes to sleep patterns (*re:* pre-wind farm operation) were common amongst the sample, as were re-evaluations of the local soundscape. The use of a case study approach limits the

generalization of the results, but as an inductive exercise the study successfully identifies a number of avenues for future research.

Based on the results of the study it is argued that, when exposed to wind farm noise and wind turbine generated air pressure variations, some individuals will more likely than not be so affected that there is a known risk of serious harm (also termed 'significant adverse effect') to health. By 'serious harm' it is meant harm that is more than mere annoyance and that can be quantified in terms of reported illness, sleep disturbance or other physical effect such as *"landsickness"* nausea created by pulsing (modulating) infrasonic pressure waves. Definitions of 'serious harm' are postulated:

1) A measure of serious harm is if the exposed individual is adversely affected to the extent that he or she is obliged to remove himself or herself from the exposure in order to mitigate the harm; and / or

2) A measure of serious harm is if three or more serious adverse health effects are recorded for an individual. Three serious adverse health effects are established from this study as being:

a) sleep disturbance with a global PSQI greater than 5,

b) a state of constant anxiety, anger and helplessness,

c) an SF36v2 mental health value of less than 40.

The outcomes of the study are concerned with the potential for adverse health effects due to *wind farm modified* audible and low frequency sound and infrasound. The study confirms that the logging of sound levels without a detailed knowledge of what the sound levels relate to renders the data uncertain in nature and content. Observation is needed to confirm the character of the sound being recorded. Sound recordings are needed to confirm the character of the sound being recorded. The measures of wind turbine noise exposure that the study has identified as being acoustical markers for excessive noise and adverse health effects are:

1. Criterion: An LAeq or 'F' sound level of 32 dB(A) or above over any 10 minute interval, outside;

2. Criterion: An LAeq or 'F' sound level of 22 dB(A) or above over any 10 minute interval inside a dwelling with windows open or closed.

3. Criterion: Measured sound levels shall not exhibit unreasonable or excessive modulation ('fluctuation').

4. Criterion: An audible sound level is modulating when measured by the A-weighted LAeq or 'F' time-weighting at 8 to 10 discrete samples/second and (a) the amplitude of peak to trough variation or (b) if the third octave or narrow band characteristics exhibit a peak to trough variation that exceeds the following criteria on a regularly varying basis: 2dB exceedance is negligible, 4dB exceedance is unreasonable and 6dB exceedance is excessive.

5. Criterion: A low frequency sound and infrasound is modulating when measured by the Z- weighted LZeq or 'F' time-weighting at 8 to 10 discrete samples/second and (a) the amplitude of peak to trough variation or (b) if the third octave or narrow band characteristics exhibit a peak to trough variation that exceeds the following criteria on a regularly varying basis: 2dB exceedance is negligible, 4dB exceedance is unreasonable and 6dB exceedance is excessive.

6. Definitions: 'LAeq' means the A-weighted equivalent-continuous sound pressure level [18]; 'F' time-weighting has the meaning under IEC 61672-1 and [18]; "regularly varying" is where the sound exceeds the criterion for 10% or more of the measurement time interval [18] of 10 minutes; and Z-weighting has the meaning under AS IEC 61672.1.

7. Approval authorities and regulators should set wind farm noise compliance levels at least 5 dB(A) below the sound levels in criterion (1) and criterion (2) above. The compliance levels then become the criteria for unreasonable noise.

Measures (1-6) above are appropriate for a 'noise' assessment by visual display and level comparison. Investigation of 'special audible characteristics' and low frequency – infrasonic health effects and the complex nature of wind turbine noise require the more detailed perceptual measures of sound character such as audibility, loudness, modulation, fluctuation strength, and dissonance.

3.3 Critique of Wind Farm Noise Assessment Criteria

The significant outcome from the study is that the compliance regime for wind farm activity fails persons affected by wind farm noise. This is due, in part, through the lack objective measures that address the real concerns of affected persons. This critique can be met by establishing an over-arching philosophy that addresses the issues of noise measurement and compliance; a simplified version of the Study Outcomes, for example:

Purpose

The purpose of this condition is to establish environmental values to be enhanced or protected in the acoustic environment of an area or place. Acoustic quality objectives are stated to enhance or protect the stated environmental values.

Environmental Values

The environmental values are

(a) the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems; and

(b) the qualities of the acoustic environment that are conducive to human health and well-being, including by ensuring a suitable acoustic environment for individual's to do any of the following - (i) sleep; (ii) study or learn; (iii) be involved in recreation, including relaxation and conversation; and

(c) the qualities of the acoustic environment that are conducive to protecting the amenity of the community.

Acoustic quality objectives for wind turbine activity

It is not intended that, as part of achieving these acoustic quality objectives, any part of the existing acoustic environment should be allowed to deteriorate. An acoustic quality objective for an area or place means the maximum level of sound from individual or cumulative wind turbine operation that should be experienced in the acoustic environment of the area or place. In meeting these objectives the following apply:

1. Wind turbine activity shall not exceed a time average A-weighted sound level of 32 dB(A), adjusted for tonal character, over any 10 minute interval at the façade outside a noise sensitive receptor.

2. Wind turbine activity shall not exceed a time average A-weighted sound level of 22 dB(A) or above over any 10 minute interval within a habitable room with windows open or closed.

3. Measured A-or Z-weighted sound levels shall not exhibit unreasonable or excessive modulation ('variation').

4. Measured audible, low frequency and infrasound Z-weighted sound levels in any single 10 minute interval from wind turbine activity shall not exceed the pre-existing sound levels of the acoustic environment in an area or place by more than 6 dB.

5. The pre-existing time average A-weighted sound levels shall be measured continuously in 10 minute intervals for not less than 12 months in order to provide an assessment of the environment

under most, if not all, meteorological conditions typical for the locale in the absence of any influence by wind turbine activity.

6. The pre-existing audible, low frequency and infrasound Z-weighted sound levels shall be measured continuously in 10 minute intervals for not less than 12 months in order to provide an assessment of the environment under most, if not all, meteorological conditions typical for the locale in the absence of any influence by wind turbine activity.

7. The Z-weighted sound levels shall be measured in one-third and one-twelfth octave bands over the frequency range 1 Hz to 1,000 Hz with a microphone frequency response of ±1 dB.

8. In order to assess compliance wind farm activity in time average A-weighted sound levels and Z-weighted one-third octave bands (1 Hz to 1000 Hz) should be predicted to the nearest potentially affected noise sensitive receptors. Details of all source levels, assumptions, methods of analysis, meteorological conditions and measures of uncertainty must be stated.

Definitions:

'excessive' and 'unreasonable' have the meaning given in 'Modulating';

'meteorological', 'non-steady', 'time average', 'tonal', 'variation' have meanings expressed in AS1055.1-1997 *Acoustics-Description and measurement of environmental noise Part 1: General procedures*;

'time average' may also be expressed as 'LAeq';

Z-weighting is expressed in AS/IEC 61672.1-2004 *Electroacoustics-Sound level meters, Part 1-Specifications*;

'Modulating' is non-steady sound (audible or inaudible) when measured by the time average A-weighted sound level for audible sound or the Z-weighted sound level for low-frequency or infrasound at 10 discrete samples/second; and (a) the amplitude of peak to trough variation or (b) the third octave or narrow band characteristics exhibit a peak to trough variation that exceeds the following on a non-steady basis: 2dB (exceedance is negligible), 4dB (exceedance is unreasonable) and 6dB (exceedance is excessive).

'Wind farm activity' means the sound and vibration emissions from the physical operation of an individual turbine or number of turbines including generator noise, blade aerodynamics, tower resonances, and wake and turbulence interactions.

3.4 Conclusions

The objective measurements at Waubra indicate that noise from wind farm activity can exceed development approval conditions. A detailed acoustical study was not conducted at Cape Bridgewater. Analysis indicates that both the Waubra and Cape Bridgewater wind farms have measurable noise problems.

Insect noise adversely affects dB(A) sound level measurements by raising the background sound levels compared to when the insects are silent. This gives a 'false' high background sound level that does not correspond to or mask wind turbine sound levels.

Investigation of 'special audible characteristics' and low frequency – infrasonic health effects and the complex nature of wind turbine noise require the more detailed perceptual measures of sound character such as audibility, loudness, modulation, fluctuation strength, and dissonance.

The subjective experience of annoyance is a common reaction to noise. Different individuals can exhibit different annoyance reactions to the same noise, and these individual differences can be ascribed partly to differences in noise sensitivity.

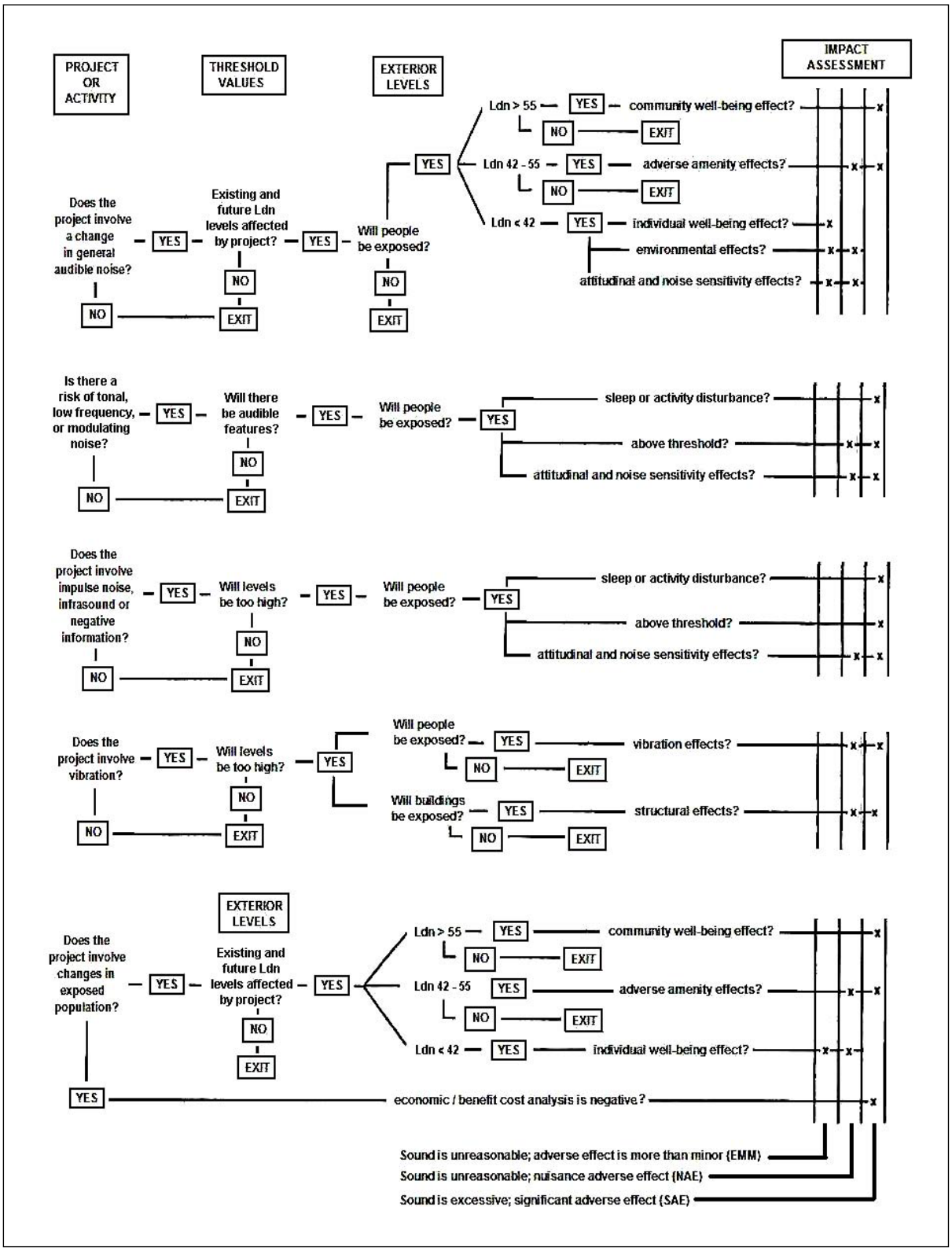
The findings suggest that the individuals living near the wind farms of this study have a degraded Health-Related Quality of Life through annoyance and sleep disruption and that their health is significantly and seriously adversely affected (harmed) by noise.

Annex A

The AcouStar Methodology for Environmental Impact Assessment

AcouSTAR SCHEMA FOR NOISE EMISSION RISK ANALYSIS

This Annex is in answer to the question: 'what guidelines were used in the study?'. The AcouSTAR schema for noise emission risk analysis is designed to provide a complete check on environmental noise based on detailed Performance Standards and Environmental Measures to validate compliance with acoustical performance goals and incident reporting. The Study Design follows.



The Study Design

The following is the full study proposed in 2011 to the Minister of Health. Modifications have been made to accommodate the 2012 study.

A. To investigate the relationship between psychological factors

Aims and Objectives

To investigate the relationship between psychological factors (e.g., personality and noise sensitivity) and annoyance; to investigate the relationship between social and cultural factors (e.g., attitudes and locality) and annoyance, and; to investigate the relationship between annoyance and health. The survey will estimate the perceived intrusiveness of noise, annoyance towards the noise, sleep interference due to the noise exposure, and general health as measured by the WHO. These measurements will afford an examination of the correlation between annoyance and health, and differences between groups in wind turbine areas vs. quiet areas in quality of life, noise sensitivity, and general health.

The study will investigate the claims of adverse health effects and bring them into context with the overall study design. Of necessity, investigation will need to be with residents who claim they are adversely affected and who are willing to undertake intensive medical testing for sleep disturbance and other health-related effects. This component of the Study is to be refined subject to various approvals and epidemiological study design. The study design will be reviewed by an independent group of experts before the final design is implemented.

HYPOTHESES

The study will be exploratory in nature; though will still yield a number of testable hypotheses. It should be noted that it is not within the scope of the study to determine if a causal relationship exists between variables. Hypotheses:

I) There will be a relationship between poor health and annoyance.
II) More negative attitudes towards noise generators will lead to great annoyance responses.
III) There will be a small but significant positive correlation between annoyance and noise exposure for those individuals residing close to the wind farms.
IV) Psychological variables such as personality will predict annoyance scores.
V) There will be differences in quality of life domains and general health between noisy and quiet areas.
VI) There will be a correlation between annoyance and physical distance from wind farm.

i) Design

The research is survey-based, and is largely exploratory in nature, that is, hypothesis generating. It will involve convenience samples from four areas proximal to wind farms and one SES-matched quiet area. There will be multiple comparisons conducted between and within the groups. The study design will be reviewed by an independent group of experts before the final design is implemented.

ii) Methods

The study will use convenience sampling to obtain completed questionnaires. It is hoped that 1000 completed questionnaires will be obtained from those living around wind farms and a SES-matched quiet locale that will be used as a comparison group. The purpose of the survey is to describe the study population from the information received from the sample. The probability level can be either 90% or 95%. For a sample size of 1000 completed surveys we would expect a range of ±3.09% for a confidence of 95% and ±2.60% for a confidence of 90%. We have recommended 1000 completed questionnaires to insure a maximum range of ±3.09% at the 95% level. For example, if 40% of the sample replied that there were no annoying noise problems, then we could estimate that the population value is with a confidence of 40 ±3.09%, i.e. 38% to 43% with a probability of 95%. The population to be sampled from is all residents within 5 kilometres of the Waubra wind farm and a quiet area that is unaffected by wind farm noise. Exclusions will include people normally residing outside the region (e.g., tourists).

MATERIALS

A social attitudinal survey designed to compliment future research involving physical noise measurements will be developed. The survey will include self-report assessments on exposure to community noise and perceived intrusiveness of noise; annoyance and sleep interference due to noise exposure; psychological wellbeing, quality of life, and general health; noise sensitivity and personality traits; attitudes to noise sources; and demographic information. Questions will be guided by pre-existing studies in the literature or by the use of pre-existing and validated inventories, including:

Construct	Measure
Psychological Wellbeing	The Depression, Anxiety, and Stress Scale (DASS-42)
Quality of Life and general health	The World Health Organisation Quality of Life Scale (WHOQOL-BREF)
Annoyance	Four questions taken from Kroesen et al., 2008.
Personality	The NEO PI-R

Noise sensitivity	Noise Sensitivity Questionnaire (NoiSeQ)
Attitude	Eight questions taken from Katsuya (2002)

Specific questionnaires relating to adverse health effects include:

Construct	**Measure**
Health survey	SF-36v2
Sleep disturbance	Epworth Sleepiness Scale, Pittsburgh Sleep Quality Index
Turbines and health	Questions taken from Nissenbaum (2010)

ANALYSIS

Returned questionnaires will be entered into a computer-based spreadsheet (Microsoft Excel) and from here exported to appropriate data analytical software packages (e.g., SPSS, LISREAL). Analysis will progress in distinct steps:

1) Data will be assessed for suitability of inclusion (i.e., a missing value analysis / outlier analysis).

2) Where appropriate items will be reverse-coded.

3) The psychometric properties of the scales will be assessed using reliability analyses (e.g., Cronbach's alpha), descriptive statistics for floor and ceiling effects (e.g., means / standard deviations), and validated for dimensionality using data ordination techniques (e.g., item-total correlations / Factor Analysis).

4) Contingent on 3) composite variables will be computed and, if necessary, normalised.

5) Inferential tests will be carried out (e.g., zero-order correlations, multiple linear regression, one-way analysis of variances, *t*-tests) to address research hypotheses.

6) If afforded by the data, structural Equation Modelling will be performed using two pre-existing models

7) Two pre-existing models of attitude formation, the deficit model and the dual process model, will be applied to the attitudinal data.

As part of the Quality of Life Study a separate question will be asked of respondents whether they would be prepared to be involved in a more detailed study of adverse health effects. The adverse health effects study presents more detailed questionnaires on a person-to-person basis. The respondent will be invited to participate in a physical study involving sleep disturbance analysis and other health measures. Respondents accepted for this part of the study will include susceptible individuals and non-susceptible individuals, as recorded by their initial survey responses. Strict confidentiality will be maintained. Each study site will have intensive acoustical studies undertaken for low frequency noise and vibration.

HYPOTHESES

The study will be exploratory and essentially a Pilot study in nature; though will still yield a number of testable hypotheses. It should be noted that it is not within the scope of this Pilot study to determine if a causal relationship exists between variables. Hypotheses:

I) There will be a relationship between adverse health effects and annoyance with respect to susceptible and non-susceptible individuals.

II) There will be a relationship between adverse health effects and perceived noise with respect to susceptible and non-susceptible individuals.

ANALYSIS

An analysis protocol will be developed as part of the Peer Review process as it is considered that this will be the most controversial, yet vital, part of the study.

B. Acoustic and Psychoacoustic factors affecting health

Aims and Objectives

To investigate the relationship between acoustical and psychological factors (e.g., sound levels in the environment, noise perception and noise sensitivity) and annoyance. The survey will estimate the perceived intrusiveness of noise, unbiased annoyance due to sound and noise, and sleep interference due to the noise exposure. These measurements will afford an examination of the correlation between sound, perceived noise, annoyance and health, and differences between groups in wind turbine areas vs. quiet areas in quality of life, noise sensitivity, and general health.

HYPOTHESES

The study will be exploratory in nature; though will still yield a number of testable hypotheses.

I) There will be a relationship between measured sound levels outside a residence and annoyance.

II) There will be a relationship between measured sound levels inside a residence (windows open; windows closed) and annoyance.

III) There will be measurable low frequency sound and noise inside and outside a residence;

IV) There will be a measurable variation between the noise character of the wind affected by, and unaffected by, the operation of wind turbines;
V) There will be a small but significant positive correlation between annoyance and noise exposure for those individuals residing close to the wind farms.
VI) Psychological variables such as personality will affect noise sensitivity scores.
VII) There will be differences in quality of life domains and general health between noisy and quiet areas.
VIII) There will be a correlation between annoyance and physical distance from wind farm.
IX) There will be a correlation between sound character, annoyance and physical distance from the wind farm.

iii) Design

The research is survey-based, and is largely exploratory in nature, that is, hypothesis generating. It will involve convenience samples from four areas proximal to wind farms and one SES-matched quiet area. There will be multiple comparisons conducted between and within the groups. The study design will be reviewed by an independent group of experts before the final design is implemented.

iv) Methods

The study will use spatial sampling to obtain sound levels from wind farm locales and non-affected locales. A minimum of 20 sites will be measured for statistical sound levels over a period of 4 weeks and at least 4 sites will be measured for 3 months. One master site at an affected locale and at an unaffected locale will be established as permanent monitoring stations. Each study locale will have a weather station. At selected sites measurements will be maintained in real-time data-streaming mode. Selected sites will have full monitoring for low frequency sound and infrasound. The population to be sampled from is all residents within 5 kilometres of the Waubra wind farm and a quiet area that is unaffected by wind farm noise.

MATERIALS

An acoustical and psychoacoustical survey designed to compliment future research involving physical noise measurements will be developed. The survey will include self-report assessments on exposure to community noise and perceived intrusiveness of noise; annoyance and sleep interference due to noise exposure; relational questionnaires to the health effects surveys. Questions will be guided by pre-existing studies in the literature or by the use of pre-existing and validated inventories, including:

Construct	**Measure**
VCAT compliance	Statistical measures to AS1055 and NZS6808
Noise Exposure	USEPA. Lden, Sleep Disturbance Index
Special audible characteristics	Amplitude modulation, tonality, impulsiveness to ISO 1996-2 and UK High Court decision
Special audible characteristics	Loudness to DIN 45631 and ANSI S3.4
Unbiased annoyance	Zwicker, Thorne

ANALYSIS

Returned questionnaires and sound level datasets will be entered into a computer-based spreadsheet (Microsoft Excel) and from here exported to appropriate data analytical software packages (e.g., SPSS). Analysis will progress in distinct steps:

1) Data will be assessed for suitability of inclusion (i.e., a missing value analysis / outlier analysis).
2) Where appropriate items datasets relating weather and sound levels will be integrated.
3) The psychometric properties of the scales will be assessed using reliability analyses, descriptive statistics for floor and ceiling effects (e.g., means / standard deviations), and validated for dimensionality using data ordination techniques (e.g., item-total correlations / Factor Analysis).
4) Contingent on 3) composite variables will be computed and, if necessary, normalised.
5) Inferential tests will be carried out (e.g., zero-order correlations, multiple linear regression, one-way analysis of variances, *t*-tests) to address research hypotheses.
6) Sound quality analysis will be determined with methods of analysis for amplitude modulation, dissonance, impulsiveness, loudness, roughness, sharpness, salience and tonality.
7) The Unbiased Annoyance models of attitude formation will be applied to the psychoacoustical data.

Annex B

Summary of Recorded Sound Levels, Observations, and Assessments

Introduction

This Annex presents a summary of sound levels, environmental noise measurements, observations and assessments recorded for the study. Sound level recordings were made of ambient noise in the Waubra and Cape Bridgewater environments in January 2012 using both fixed and observed measurements over the time of the study. The study was not instituted to determine compliance or non-compliance at either wind farm.

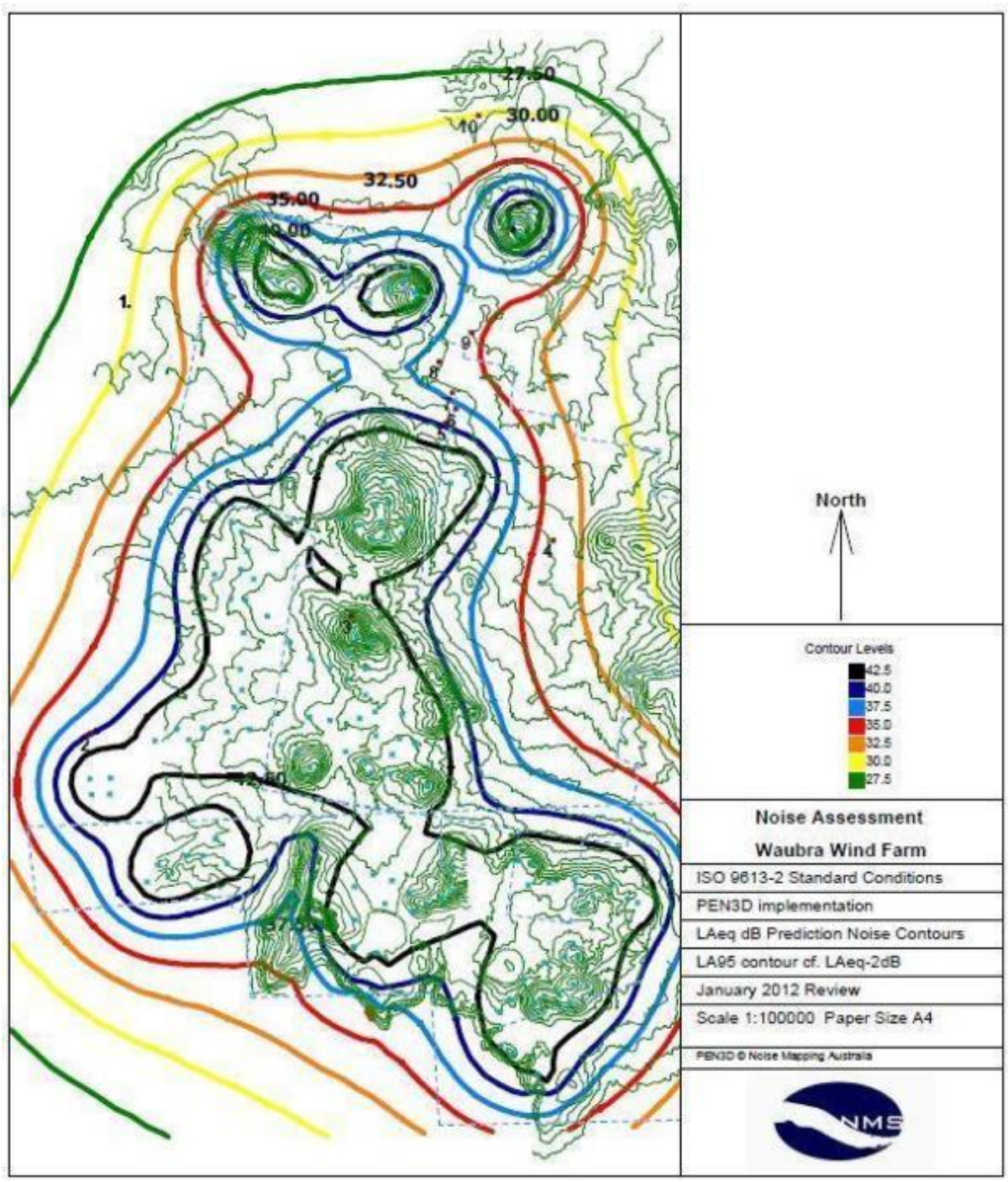
The objective measurements from this study at Waubra indicate that noise from wind farm activity can exceed development approval conditions. A detailed study was not conducted at Cape Bridgewater. The study confirms that both the Waubra and Cape Bridgewater wind farms have measurable noise problems.

Observational sound levels were recorded with a Class 1 Larson Davis sound level meter with sound recording facility. A GRAS 40AZ extended frequency response microphone replaced the standard Larson Davis microphone. Standard measures were recorded with time history settings at 100ms and standard measurement times of 10 minutes. A-weighted values were recorded for time-history (LAeq, Ln levels) and Z-weighted third octave band levels. Soundfiles were recorded at a sampling rate of 16000samples/sec to give an audio file, 16-bit wav format, to 8000Hz. Sound character was determined from soundfiles of 10 second, 60 second, and 10 minute duration with dBSONIC v4.5, SpectraPLUS v5 and Adobe Audition v1.5. All soundfiles analysed were calibrated to the time-history or measurement datafile so the overall LAeq level were the same for both formats.

Additional sound levels for longer-term (7-day) sound levels were recorded with RionNL21 Class 2 sound level meters. Each sound level meter was field calibrated with a Class 1 Quest CA22 dual level calibrator before and after each survey. Each instrument holds current NATA calibration certificates. Weather conditions including wind speed and direction were recorded for each survey using hand-held sensors at 2 metres above ground level.

The locations of the homes of the participants are shown in Plates 1 and 2, following. The Plates show the wind farms and the predicted sound levels at each residence. A sound power level of 104 dB(A) at 8m/s was ascribed to each turbine and the sound levels predicted to ISO9613-2 Acoustics-*Attenuation of sound during propagation outdoors-Part2: General method of calculation.* The prediction uncertainty is ±3 dB at 100-1000 metres and under the standard predictions are acceptable to wind speeds of 5m/s or less.

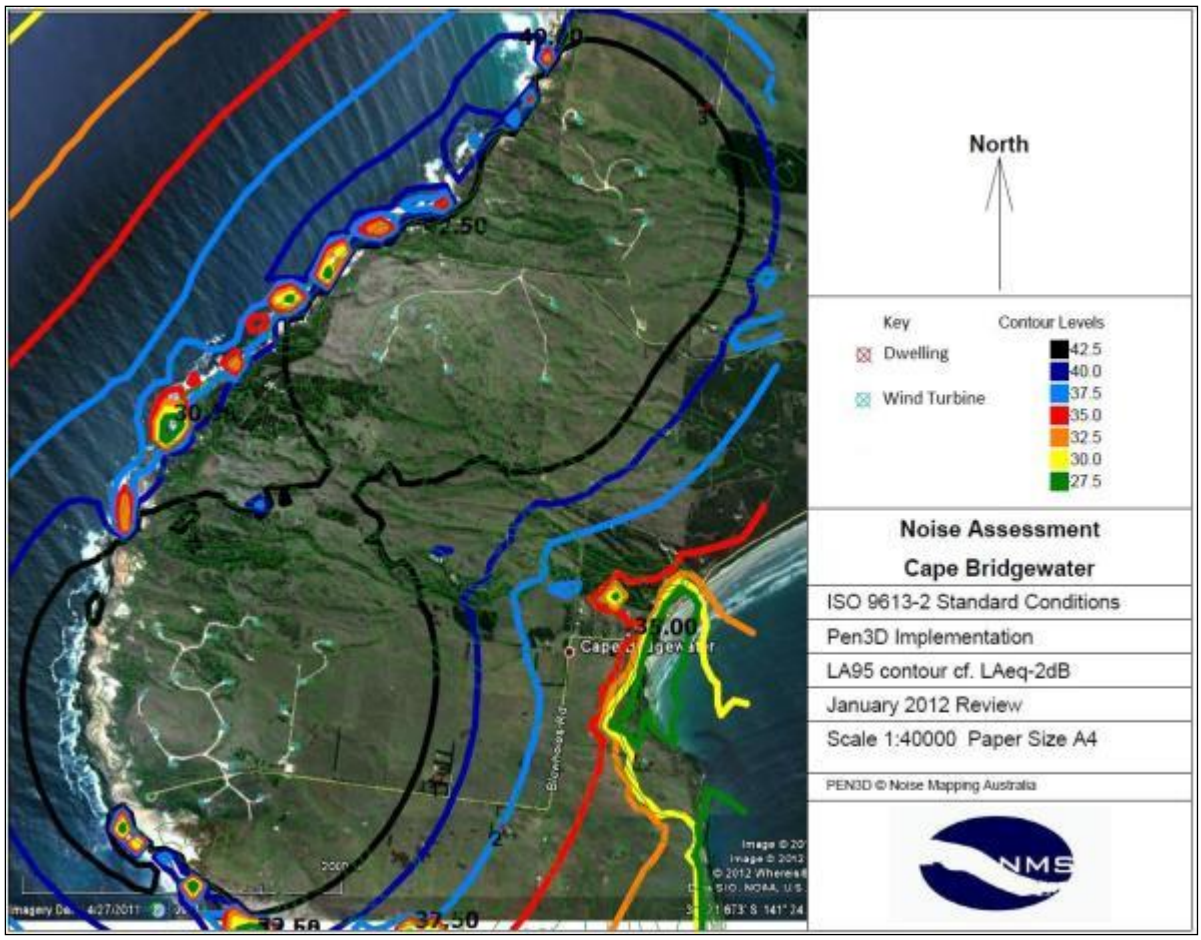
Plate 1: Waubra Residents, Wind Turbine Locations and Predicted Noise Contours



Receiver	LAeq	LA95	Receiver	LAeq	LA95
1	30	28	**6**	38	36
2	40	38	**7**	37	35
3	44	42	**8**	37	35
4	34	32	**9**	36	34
5	40	38	**10**	30	28

Predicted sound levels at 8m/s

Plate 2: Cape Bridgewater Residents, Wind Turbine Locations and Predicted Noise Contours



Receiver	LAeq	LA95	Receiver	LAeq	LA95
1	41	39	**2**	38	36
3	42	40			

Predicted sound levels at 8m/s

Turbines and sound levels

Wind turbine sound has a unique nature that is variable over time and is highly dependent on wind speed and directions, as well as locale. Objective measurement of such sound is not easy yet can be achieved using suitable measurement methods. Some standards refer to "special audible characteristics". Others standards and guidelines refer to amplitude modulation, tonality, impulsiveness and so on. Observations at the different wind farms under different weather conditions and measurement distances indicate the sound of turbines are individually observable (swish, rumbles, clunks, whines) at distances of 200 – 500 metres. At around 900 metres only clearly distinctive turbines are identifiable (swish, rumbles) and by 2000-3000 metres the sound of turbines is cumulative and is heard as a general source of noise. At each location the wind farm could be clearly heard at dwellings approximately 2000 metres from the nearest turbines. The sound of turbines can be heard 2000 metres upwind and 2000 metres downwind, as well at an angle to the turbines. The sound, with turbines operating, can be described as a steady rumble with a mixture of rumble – thumps. Table 1 presents the distances of the respondents' homes from turbines and the predicted sound levels at each location. The measured sound levels at key locations are included.

Table 1: Measured and predicted sound levels at participant's homes.

Waubra - Cape Bridgewater Wind Farm Study Jaunary 2012									
DISTANCE TO TURBINES and OUTDOOR PREDICTED AND MEASURED SOUND LEVELS									
Distances (metres) Residences to Turbines			Predicted Sound Levels		Measred Outdoor Sound Levels (24hr)				
nearest turbine	group 3+ turbines	direction	LAeq	LA95	LAeq	Ldn	Lden	LA95	LA95 night
930	930-1280	S & E	35	33					
930	930-1280	S & E	35	33	50	54	54	41	28 - 51
GF	2000	270 degrees	40	38					
GF	2000	270 degrees	40	38	50	54	55	40	38 - 47
715	715-970	270 degrees	44	42					
715	715-970	270 degrees	44	42	48	56	56	31	38 - 45
1375	1375-1670	West	37	35					
2130	2130-2360	south	30	28					
2130	2130-2360	south	30	28					
1034	1034-1340	south	40	38					
1235	1235-1640	south	38	36					
1235	1235-1640	south	38	36					
1200	1200-1950	W & N	36	34	61	65	65	41	36 - 43
3500	3500-3800	south	<28	<28					
1400	1400	S & W	34	32					
1200	1200-1950	W & N	36	34					
1540	1540-1940	south	38	36	43	46	47	33	25 - 35
3400	3400	south	<28	<28					
3400	3400	south	<28	<28					
915	915-1100	west	41	39					
1750	1750-2080	west	38	36	49	54	54	38	39
1750	1750-2080	west	38	36					
915	915-1100	west	41	39					
600	600-1000	south-west	42	40					
600	600-1000	south-west	42	40					

Sound Character of Turbines

Turbine sound character varies regularly both in "loudness" and "tonality". The general character of a long time period of an hour or so is of a steady rumble. This, however, depends considerably on wind speed and direction. Masking of turbine sound by tree rustle, wind noise or insects was not observed at the time of the study. The general wind speed at ground level was 2-3m/s with the breeze blowing from the turbines to the observer. Insect noise and bird-calls affect the measurements at all the different sound levels (LAeq, Ldn, Lden, LA95) and at specific times of the day and night – most commonly towards dawn.

In order to confirm that 'special audible characteristics' exist and can be measured, measures of sound quality are applied in Table 2 to describe the character of the sound of the turbines. Loudness, sharpness, fluctuation, and roughness are calculated as the maximum levels and the Unbiased Annoyance (UBA) metric is also calculated as a maximum value. Modulation is shown as a percentage in the relevant bands with the frequency variation in Hz.

Table 2: Measured sound character at a Waubra home				
Psychoacoustic Measures	**Inside bedroom**		**Outside bedroom**	
	Windows closed 4:00am	Windows open 4:40am	(Windows closed) 4:00am	(Windows open) 4:40am
Loudness N soneGF	2.5	3.0	2.9	8.5
Sharpness S acum	1.7	1.1	1.7	1.5
Fluctuation F vacil	0.10	0.03	0.07	0.08
Roughness R asper	0.17	0.02	0.12	0.36
UBA day au	4.05	4.33	4.87	19.13
UBA night au	6.91	7.69	8.58	44.07
Modulation v band	5Hz, 85% at 400Hz band	5Hz, 40% at 25/31.5/40Hz	5Hz, 40% at 25/31.5/40Hz	5Hz, 40% at 25/31.5/40Hz
Tone PR dB (ANSI)	2.7dB @ 453 Hz	5.7dB @ 3523Hz	10.9dB @ 3582Hz	6.2dB @ 3582Hz
Lmean dB(A)	19	24	33	32

The following figures provide more detail as to the different measures summarised in Table 2. The figures further confirm that special audible characteristics such as modulation can be measured with a variety of standard pyschoacoustical – sound quality measures.

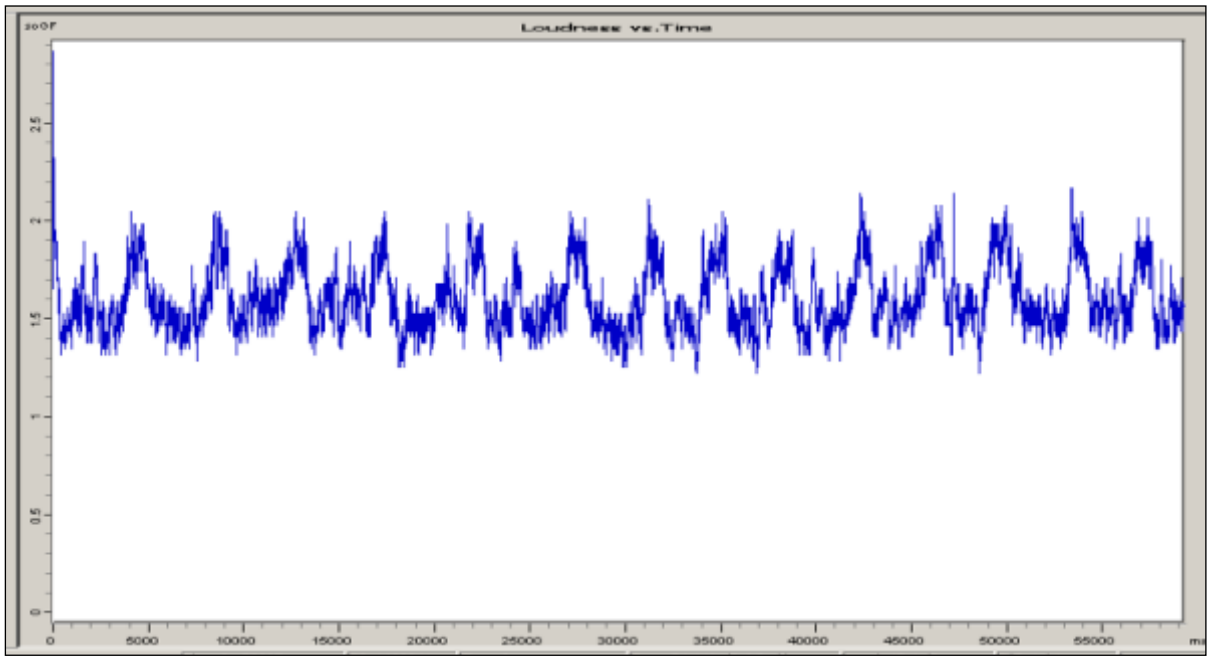


Figure 1: Time variation of turbine noise, outdoors, turbines 930-1280 metres distant, showing regular amplitude modulation (loudness) at 4am outside the bedroom

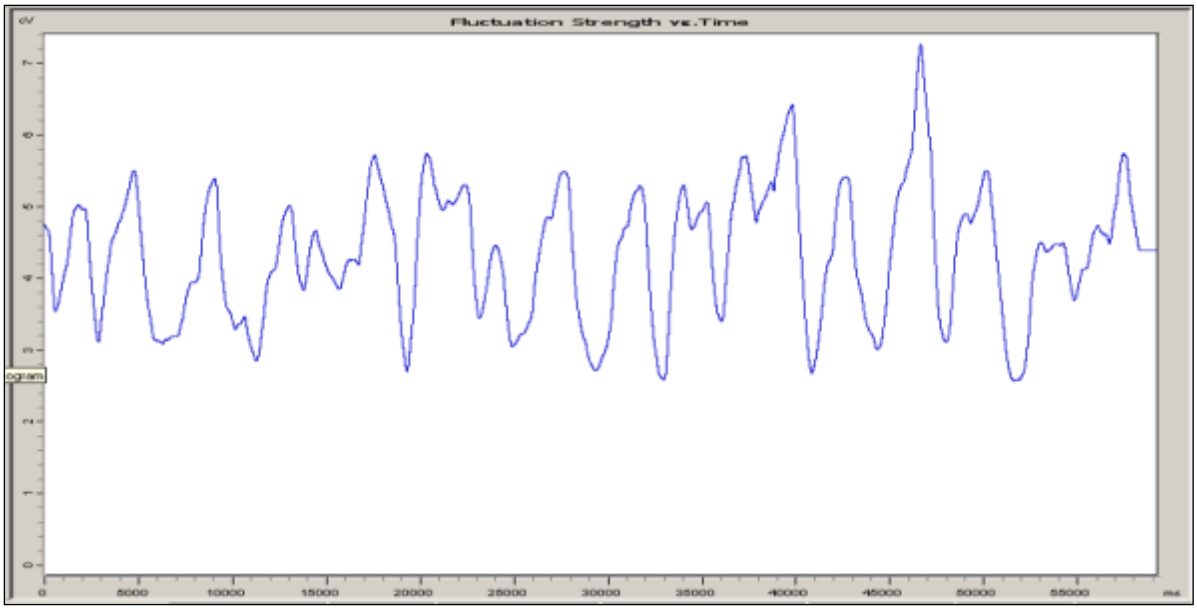


Figure 2: Time variation of turbine noise, outdoors, turbines 930-1280 metres distant, showing regular modulation (fluctuation strength) at 4am outside the bedroom

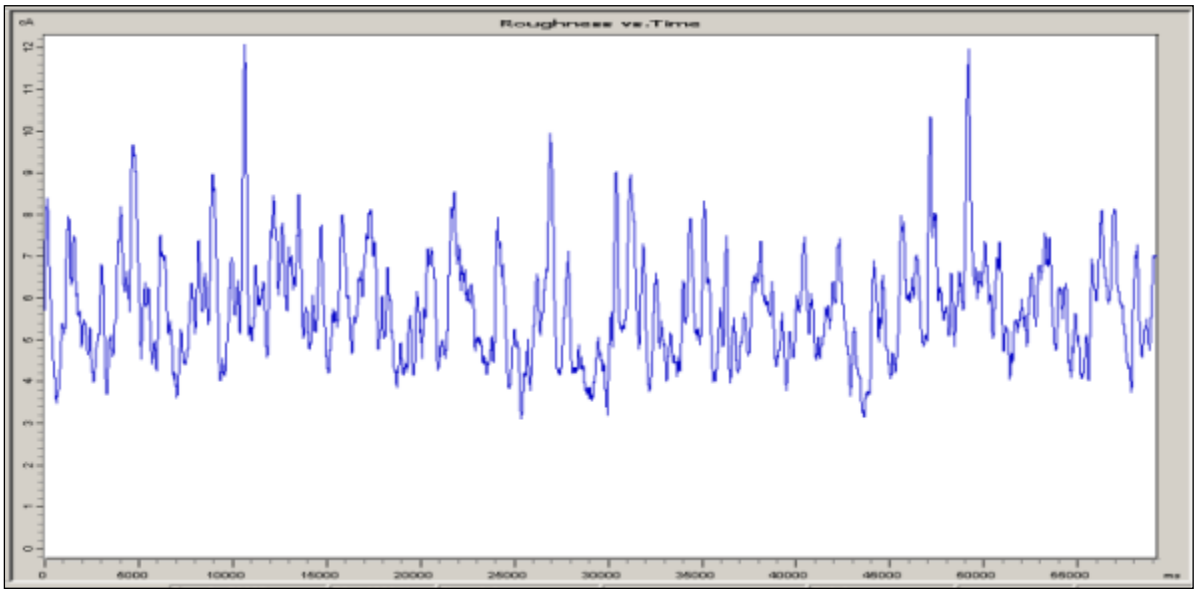


Figure 3: Time variation of turbine noise, outdoors, turbines 930-1280 metres distant, showing regular modulation (roughness) at 4am outside the bedroom

The next figure illustrates the variability of sound by character. The figure shows distinct 'peaks' at different frequencies and these peaks can be attributed to different types of noise sources. Broadly, for example, below 1000 Hz belongs to wind turbine sound; 3000-4000Hz belongs to insects; 6000Hz belongs to bird-calls, and so on. This illustrates the extremely difficult task of attributing A-weighted 'background' sound levels to any one source. For much of the time the sound levels will be a mixture of short-term sound (such as bird-calls), medium-term sound (such as insect noise) and long-term sound from turbine activity. The turbines – when running – provide a constant source of 'background' noise into the environment. This source can be affected by wind in vegetation which can be identified by reference to spectrum analysis. Standard sound analysis using 'background' LA95 measures fail to differentiate between different types of sound that make up the total acoustic environment.

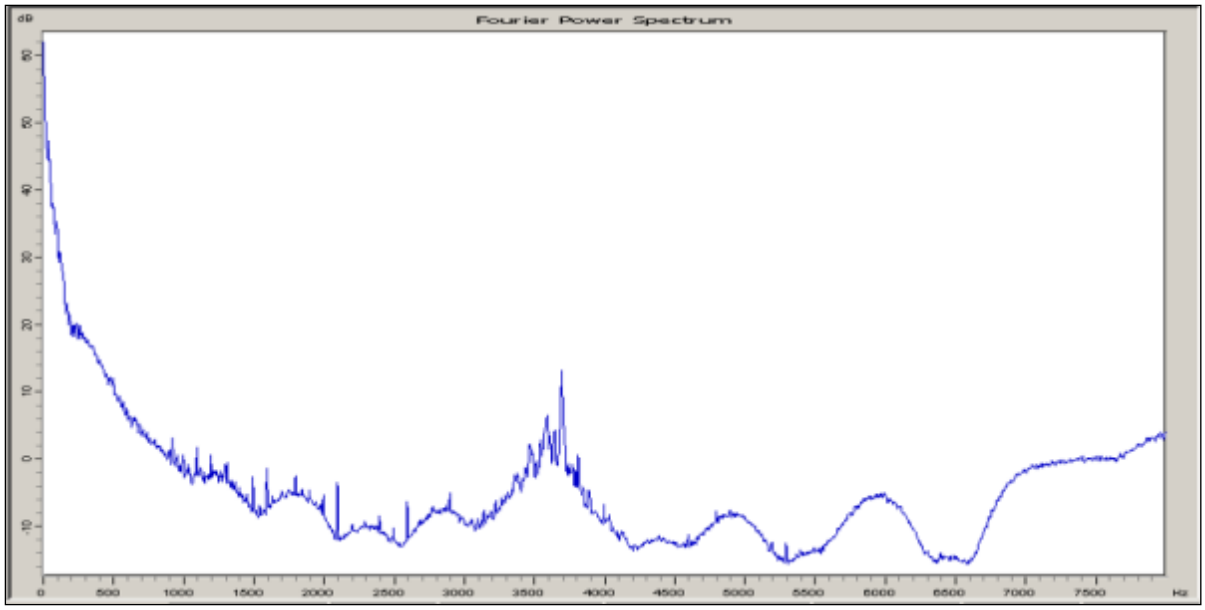


Figure 4: FFT spectrum of turbine noise, outdoors, turbines 930-1280 metres distant, at 4am outside the bedroom showing the effect of insect/animal/bird noise at 3500Hz and at other frequencies.

Sonograms

The method used to display sound character, modulation, tonality or tonal complexes in the Dean Reports is through sonograms[2]. These show the 'special audible characteristics' of sound at various frequencies over time and are similar to the modulation charts in this Report. Sound levels such as these presented in one-twelfth and one-twenty fourth octave bands are often described as 'narrow-band analysis'. FFT band analysis is also known as narrow-band analysis but such analysis is more open to variation in implementation. Amplitude and frequency modulation can be identified in the sonograms by distinctive regular patterning at 1 second (or longer or shorter) intervals. Tonality and tonal complexes can also be identified using sonograms. At the time of recording it is possible to include reference sound levels in order to assess the sonogram values against measured values.

The sonograms illustrate the presence of turbines even though the activity may not be audible. Different time segments are used to illustrate the effects. The important features are:

- The significant amount of sound energy in the low frequency and infrasonic ranges
- The variation of 20 decibels between high and low values in the sonograms at low frequencies; this variation is audible under observed conditions.

The overall levels in one-third octave band charts are provided to illustrate the difference between maximum and minimum sound levels in the measurement time period. These correspond to the peak and trough values and give a "first-cut" assessment of whether or not audible modulation, audible tonality, perceptible modulation or perceptible tonality may exist. The charts are provided as examples of the sound character.

[2] Various methodologies are available to display sonograms or modulation. The methodology by Dr H. Bakker, Astute Engineering, is adopted in the previous Dean Reports. This report references the method by 01dB.

Sound Character Changes with Distance

Sound character changes over distance and the effect is critical in noise assessment for human perception. Observations at Waubra show that as sound moves away from the turbines it changes its character with a rapid loss of higher frequencies leaving the lower frequencies audible. Changes in wind speed and direction also modify this change in character and low frequencies can be enhanced (increased) downwind. Upwind the lower frequencies are still audible even when there is a ground level breeze of 2m/s - 3m/s blowing against the turbines. It is also observed that as the temperature drops to around 10°C and a shifting breeze of 2m/s - 3m/s it becomes harder to physically distinguish sound because of the wind chill on the ears. Sound level meters may detect the variation in sound character but cannot identify the source. This must be done by observation.

Sound level decay rates by distance are shown following for a Vestas V90 wind turbine that has a sound power level of 104 dB(A) at a wind speed of 8 m/s. The overall A-weighted sound level for a single turbine decreases from 37 dB(A) at 500 metres to 13 dB(A) at 4500 metres, figure 5. The low frequencies, however, do not attenuate as quickly with distance, as shown in the figure. Note: the sound levels have been calculated from the published third octave sound power levels.

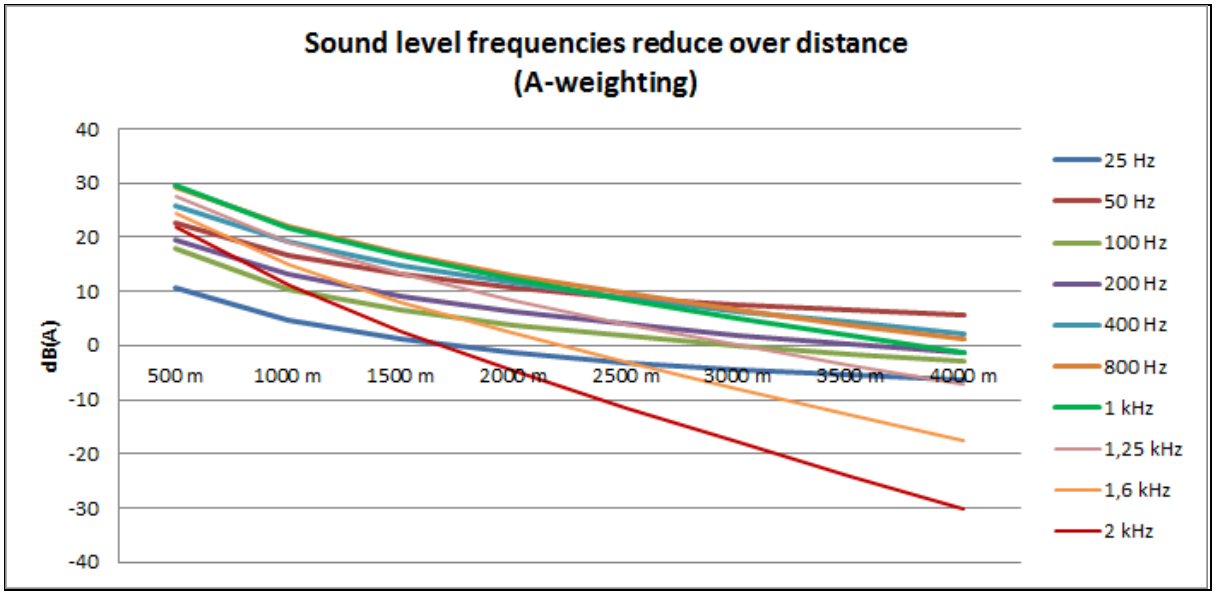
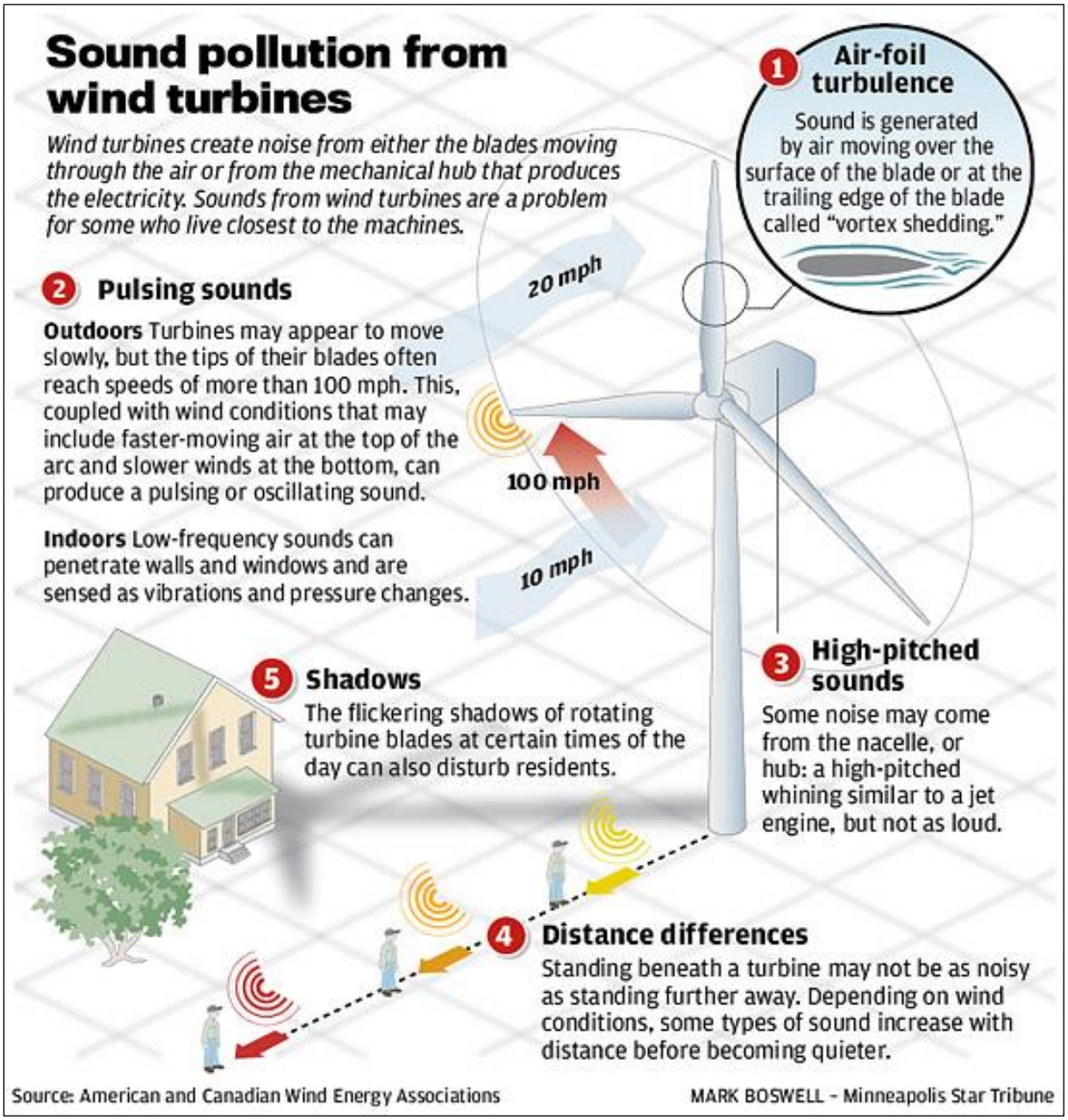


Figure 5: Sound level frequencies reduce over distance (Vestas V90 turbine, A-weighted values)

The character of noise from a wind turbine is clearly indicated in the following graphic ascribed to the American and Canadian Wind Energy Associations.

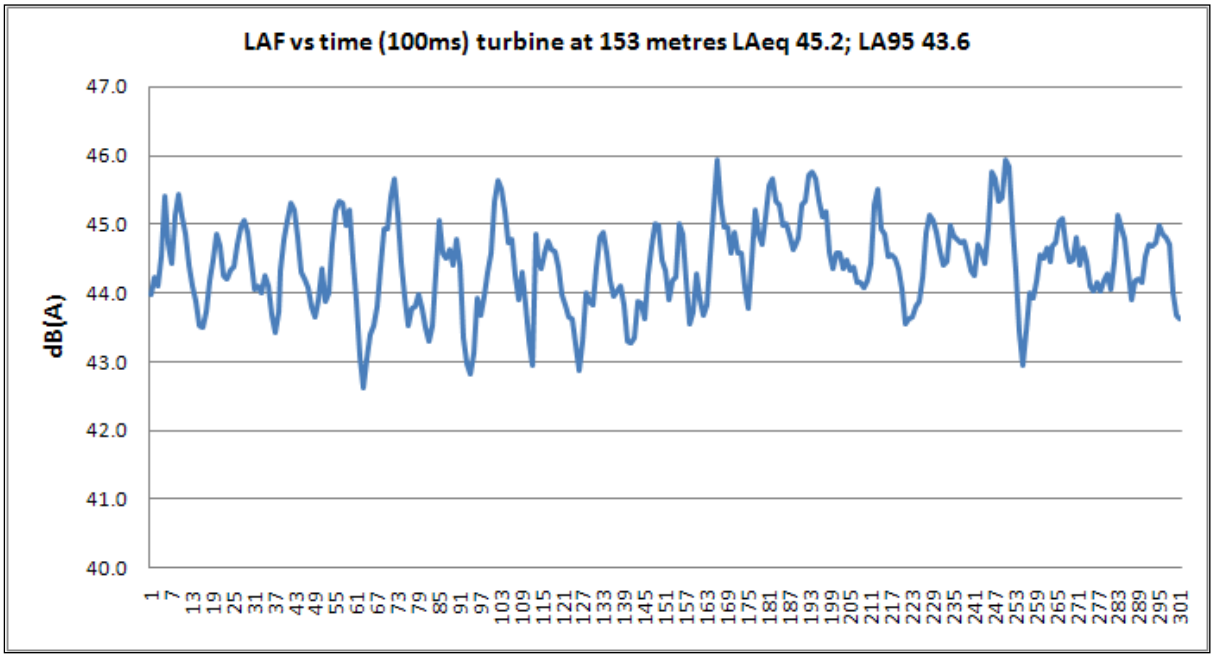


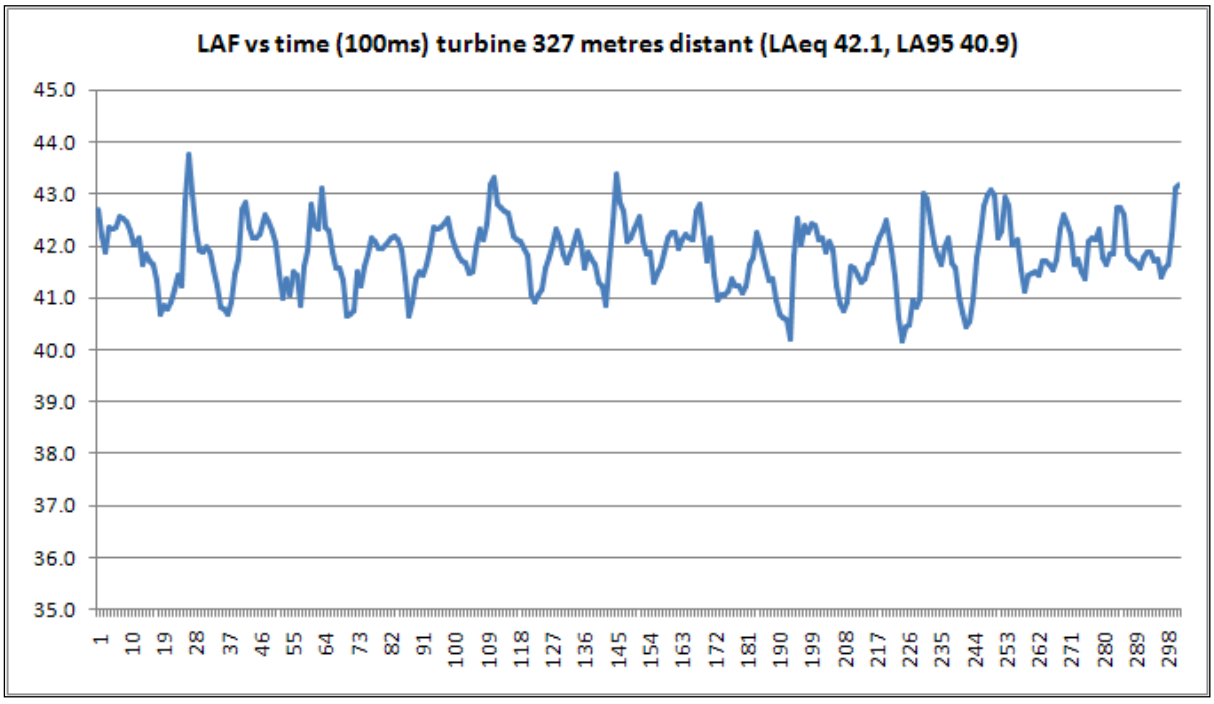
Observation indicates that the turbine blades change from 'flat' to horizontal'. When stopped the blades are horizontal (sharp edge to the wind). It is understood that a turbine 'roars' at 70%-plus efficiency because to govern blade speed the wind has to be 'split'. Noise therefore varies by wind speed; to govern the speed wind is split in practice or the turbine works too hard. Fully deployed in the wind the blades are relatively quiet. The dynamics change as the blade angle changes. The turbines are governed to an optimum speed (understood to be 19rpm = 57 tower pass-bys per minute). The Waubra wind farm has been observed with turbines running at 44 and 54 pass-bys per minute. It is understood that this data is recorded in the power station control room and the operators therefore know when and for how long individual turbines operating in a 'noisy' condition.

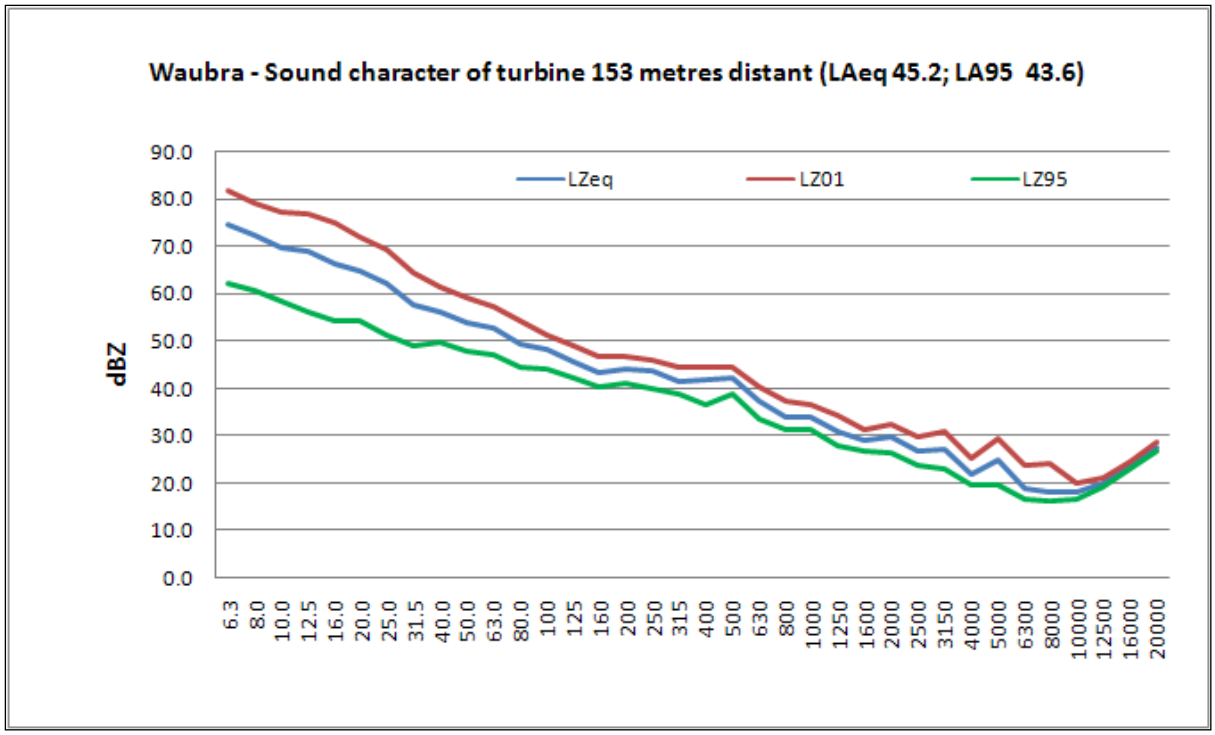
The sound levels from the turbines near the corner of Beaufort Rd and Lobb Rd are illustrated following. It is noted that there is a 4.5 dB(A) LA95 noise reduction with a doubling of distance from the measurement location to the turbines (153 metres v 327 metres). This indicates noise reduction per doubling of distance between that for a point source (-6dB) and of a line source (-3dB).

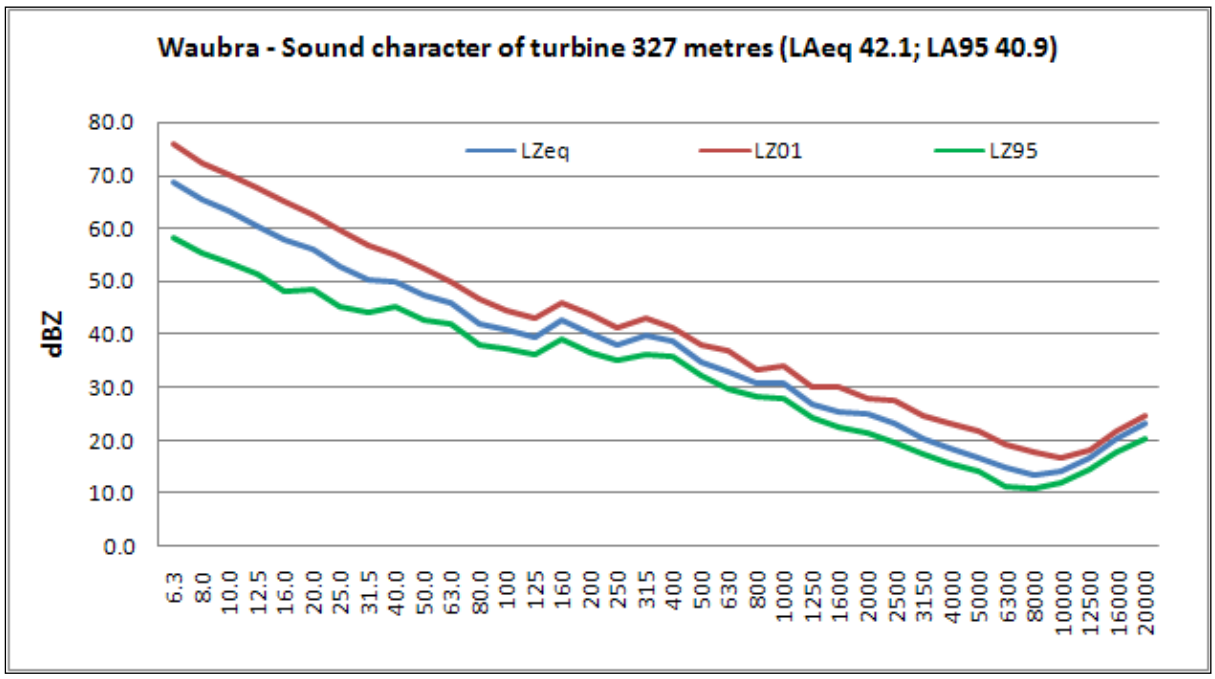
Notes

- File 03: by gate, LAeq 45.2, LA95 43.6, nearest turbine at 153 metres
- Nice clean 'whrr' sound, no thumps, turbines running but no audible turbulence noise, wind blowing from turbines to measurement, breeze 2.5m/s – 4.8m/s at ground level, some bird calls
- File 02: by shed, LAeq 40.6, LA95 39.1, nearest turbine at 327 metres
- Nice clean 'whrr' sound, no thumps, tonal noise, turbines running but no audible turbulence noise, wind blowing from turbines to measurement, 1.6m/s at ground level, some bird calls









Notes:

The 4 turbines to the south appear to have their loudest 'whoosh' on the downstroke, approximately 30 degrees from the horizontal. There are deep 'whoomph' lasting for approximately 3 to 6 blade / tower pass-bys. The whoosh can also be heard on the upstroke, as well as whines and clunks.

The following section outlines the operational power generation of the wind farm and therefore it's potential for noise generation.

Sound Inside the Home

The sound of turbines is also evident and sometimes more pronounced inside a dwelling, windows open or closed. Observations at Waubra confirm that wind turbine sound at residences around 2000 metres or so is perceptible outside or inside a dwelling. The sound of turbines is often clearer inside a dwelling as higher frequencies from wind and insect activity are reduced through the building fabric. Figure 6 presents measured sound levels inside and outside a home located approximately 900 metres from turbines at Waubra, windows closed and open, at 4am. Table 2 (see previous section 'Sound character of turbines') analyses the character of the sound at the same times.

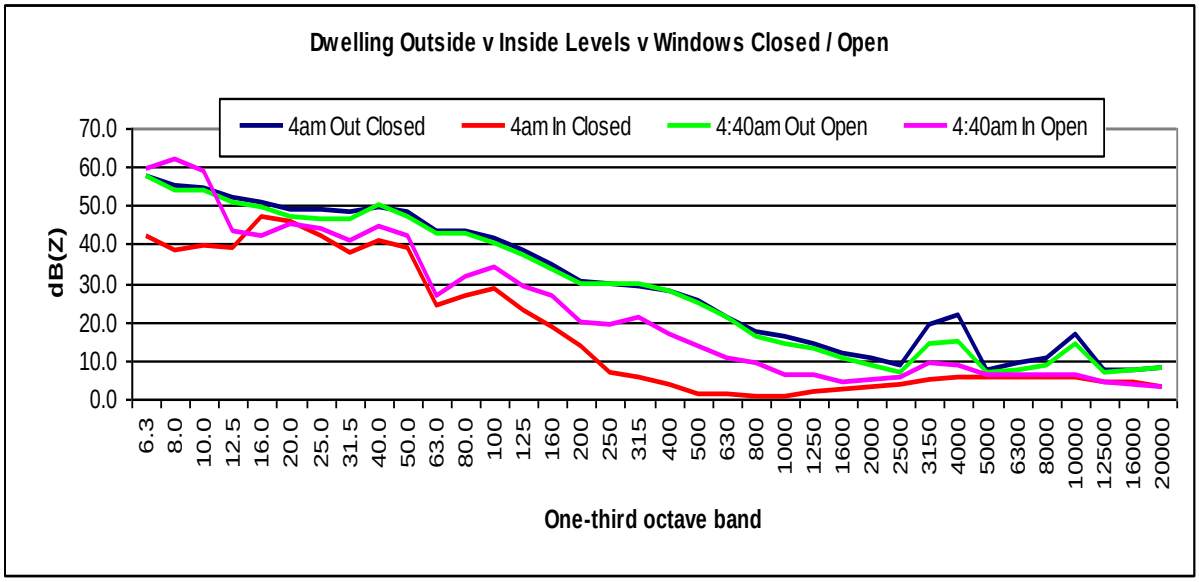


Figure 6: Measured Leq sound levels inside and outside a home, windows closed and open.

The figure shows that insect and bird noise (3150-4000Hz and 10,000Hz) heard outside the bedroom is not significant inside with the windows closed. The sound is audible with the windows open. Critically, however, the infrasound and low frequency sound levels (12.5Hz to 60HZ) are not reduced as much as the higher frequencies. Most importantly the infrasound levels at 6.3Hz – 10Hz actually increase. These are the frequencies (to 20Hz) of interest in this research with respect to nausea and general wellbeing.

Low frequency Noise and Infrasound

Low frequency noise and infrasound are normal characteristics within the environment. Wind itself has measurable low frequency and infrasound character. Measured levels of infrasound inside and outside a dwelling as described in the previous section give an indication of potential effect. Putting aside the question of audibility the levels in the following figures 7(a) and 7(b) are assessed on the basis of their energy variation at an analysis rate of 10 'samples' per second. The pulses are seen as being regular in nature with a confined peak to trough shift of 6 dB to 7dB over a range of approximately 13 dB. Modulating sound with these characteristics outside and inside a home indicates that the sound is not natural but is being generated by an external source. In this case the operation of the wind farm. The people living in the home are affected by wind farm activity outside and inside the home.

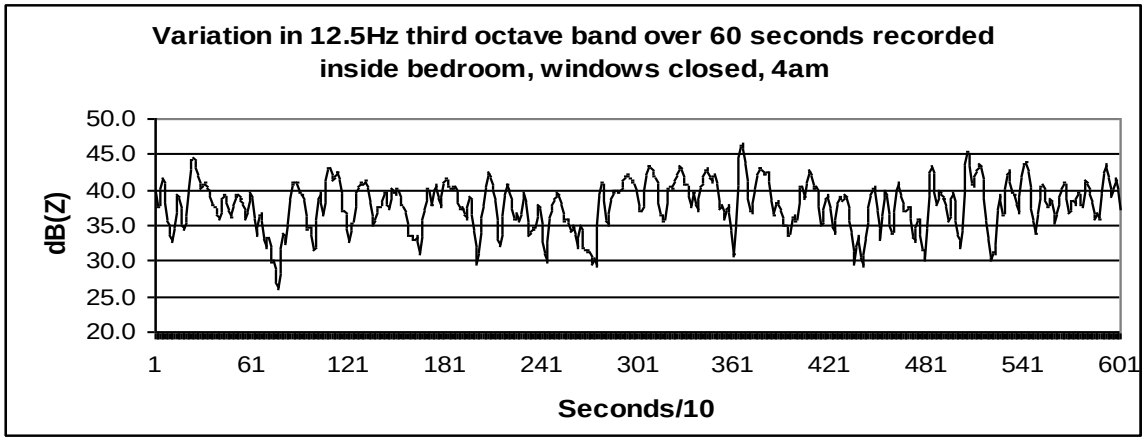


Figure 7 (a): Comparison of infrasound levels, LZeq, inside a bedroom

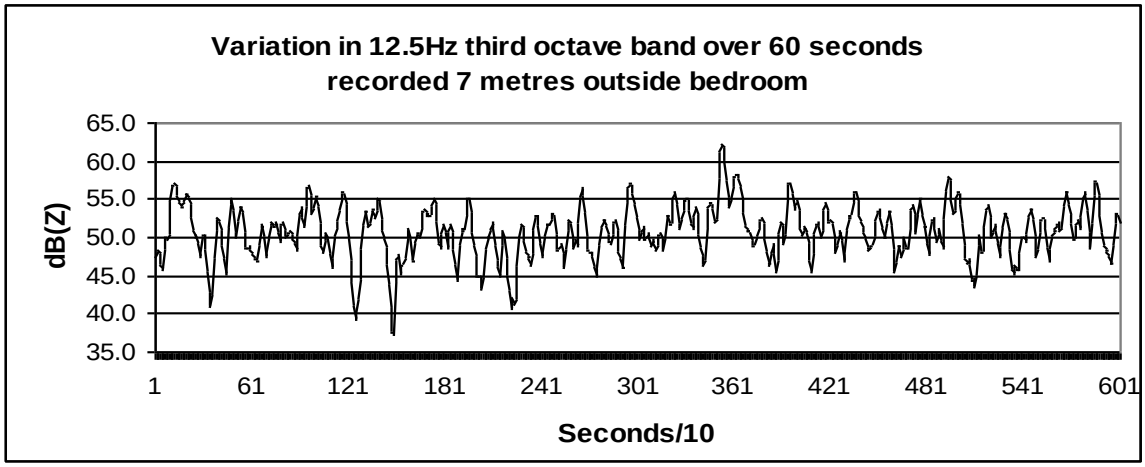


Figure 7(b): Comparison of infrasound levels, LZeq, outside a bedroom

In comparison to the relatively consistent wind farm affected levels (above) figure 8 illustrates the natural sound levels in the 12.5 Hz third octave band level recorded in a rural environment without turbines. At a mild breeze of 2m/s the levels vary considerably from 32dB to 78 dB, with distinctive shifts in 100ms LZeq levels over the 60 seconds.

Figure 8: Outdoor rural natural sound levels in the 12.5Hz LZeq third octave band

Not all wind farms recorded as part of this research appear to have adverse health effects recorded for the infrasound frequencies and this is a confounder relating to the physical properties (wind turbine power rating and design, wind farm

layout, topography, wind speeds and wind direction) of specific wind farms. The outcomes of this study are concerned with the potential for adverse health effects due to *wind farm modified* audible and low frequency sound and infrasound.

Sound Perception

An outcome of the observations and interviews of the previous studies indicated a need to establish a baseline reference point with sounds of known characteristics that could be reviewed by any person at any time. The purpose was (and is) to identify the perceptions of the sound as experienced by the person listening to the sound. The study was expanded by presenting a series of environmental sounds or 'soundfiles' to be judged by the respondents. Each soundfile was recorded at a sampling rate of 44100Hz, 16 bit, mono and saved in Microsoft PCM .wav format. The character of the soundfile was not made known to the respondents until after the person had made an initial assessment. The character was then discussed.

The reference soundfiles consist of: (1) Amplitude modulated fluctuating noise; (2) Outdoor residential neighbourhood and wind farm noise; (3) Outdoor rural environment with sound of wind farm 2200 mteres distant, through trees; (4) sound plus tones at 150Hz, 990Hz and 4000Hz; (5) sound plus tones at 330Hz, 400Hz and 471Hz; (6) Sound of wind turbines 930 metres distant, inside bedroom, windows closed. Each sound has a unique character or characteristics and these are correlated to significant acoustical, musical and sound quality measures. The measures for loudness, sharpness, roughness, modulation and unbiased annoyance are calculated with dBSONIC v4.12, a sound quality analysis program.

The aim of this part of the study is to observe if respondents can identify wind turbine sound in ambient sound. The perception soundfile (6) records the 'clearest' wind farm noise. Figure 9 illustrates audible sound as well as both low frequency and infrasound as heard inside a bedroom approximately 930 metres from a set of wind turbines. The modulating character of the sound is clearly defined in the first 5 seconds as a pattern of 3 spikes. The chart shows that low levels of sound are clearly audible inside a dwelling. The interior level for the 60 sconds is LAeq 31.6 dB(A). There are clear and distinctive audible, low frequency and infrasound levels. The character of the 'spikes' is shown as an A-weighted chart within the main chart. The frequencies of interest are in the 63 Hz - 400 Hz third octave bands. The residents (UK) have vacated the home.

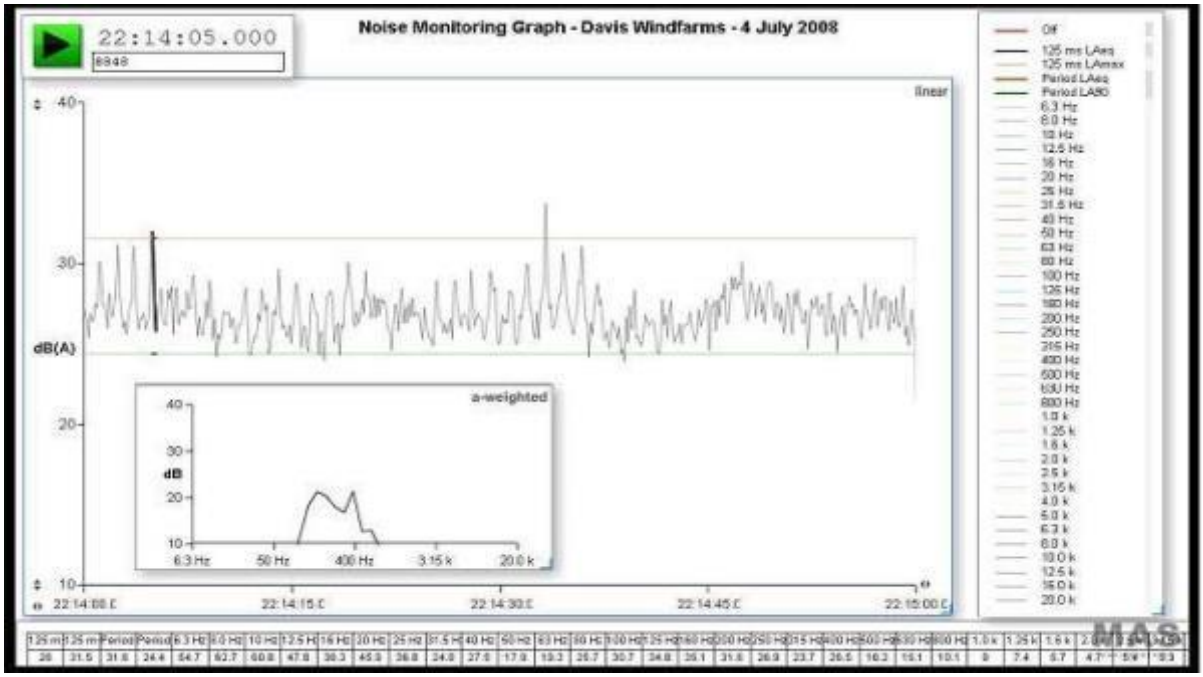


Figure 9: sound of wind turbines at 930 metres, inside residence

Special Audible Characteristics

The personal(individual) perceptions of the character of soundfile 6 are presented in Table 3 following. Respondents could mark one or more different characteristics to describe the sound. The dominant characteristics are described as being: Fluctuating, undulating, beating; Rumble; Repetitive; Impulsive; Thumping; Annoying.

It is therefore reasonable to apply these subjective terms to the definition of 'special audible characteristics' and apply them to objective measures described in this report. That is, 'special audible characteristics' as required under NZS6808 can be described subjectively and measured objectively in a scientific, repeatable manner. The relevant section state:

5.3 Special audible characteristics

5.3.1
Sound from a WTG that has special audible characteristics (clearly audible tones, impulses, or modulation of sound levels) is likely to arouse adverse community response at lower levels than sound without such characteristics. At present, there is no simple objective procedure available to quantify special audible characteristics, and subjective assessment is therefore necessary, supported by objective evidence (e.g. frequency analysis) where appropriate.

5.3.2
When sound has a special audible characteristic, the measured sound level of the source shall have a 5 dB penalty applied. This is because the subjective reaction to a sound containing a special audible characteristic is generally found to be similar to a sound 5 dB louder, but without the special audible characteristic. A maximum penalty of 5 dB shall be applied by adjustment of the measured sound level by arithmetic addition of +5 dB .

NOTE – The objective method for determining whether a sound exhibits a tonal character shall be that used in IEC DIS 1400-11 for assessing wind turbine tonal character close to the turbine, i.e. The Joint Nordic Method. The method takes a number of narrow band spectra over a period of 2 minutes and compares the sound level of the tonal frequency to the 'masking sound level' in that of a critical band positioned around the tonal frequency. As the method takes the five highest tonal values within the 2 minute monitored period, it automatically considers those cases where the sound level of the tonal frequency is fluctuating.

SOUND 6																				
The Character Sound is																				
Smooth	Bright	Warm	Gentle	Waterfall	Rich	Powerful	Wind in trees	Rough	Sharp or metallic	Percussive	Dull	Tonal	Harsh	A distinctive hum	Fluctuating, undulating or beating	Rumble	Impulsive	Repetitive	Thumping	Annoying
															1		1	1	1	1
															1	1	1	1	1	1
																1			1	1
															1	1			1	1
														1	1	1		1		1
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						1									1	1		1	1	1
								1		1		1	1	1	1	1	1	1	1	1
						1		1		1	1	1	1		1	1	1	1	1	1
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						1				1	1	1	1	1	1	1	1	1		1
						1		1	1	1	1			1	1	1		1	1	1
						1		1		1						1	1	1	1	1
						1				1	1			1	1	1	1	1	1	1

Table 3: Individuals' Perception of the Character of Soundfile 6.

Study Instrumentation

The study locations were monitored (short-term) with Larson Davis 831 Class 1 sound level meters and PRM831 preamplifiers (serial numbers 2635, 2377, 1256, 1255). Recording time was 50ms for events, 1 second for continuous time logging and 10 minutes for global data. Peak levels were C weighted, maximum. One third octave band Z-weighted data was recorded. Soundfiles were recorded at a sampling rate of 8000Hz and 16000Hz. The instrument noise floor is approximately 15 dB(A) and varies by frequency, gain and range setting.

The sound level meters have type 377B02 microphones as standard. Frequency response of microphones

Larson Davis type 377B02 ±1dB 5Hz – 10kHz ±2dB 3.15Hz – 20 kHz

Lower limiting frequency -3dB at 1.0 to 2Hz

Larson Davis type 831 with PRM831 preamplifier typical Z-weighted frequency response

Lower limiting frequency -3dB at 2Hz to 3Hz

GRAS 40AZ low frequency microphones were fitted to two Larson Davis 831 sound level meters (serial number 2635 and 2377) for this study.

Frequency response of microphones

±1dB 1Hz – 10kHz ±2dB 10 kHz – 20 kHz

Longer term monitoring (7 or more days) was undertaken using Rion NL21 Class 2 sound level meters with UC52 microphones (serial numbers 6376, 7035). Recording time was continuous 10 minute intervals. The calibrated A-weighted noise floor for these instruments is approximately 10dB to 13dB, depending on instrument and microphone.

Each instrument was sited at a distance of between 7m and 9.5m from any dwelling or wall; the microphone was 1.35m above ground and fitted with a standard manufacturer's windscreen.

Wind speed and direction were recorded at each site using hand-held instruments. A 10 metre high fixed station is provided at the greenfields monitoring location

Each instrument was calibrated before and after each survey with a Class 1 Quest CA22 dual level calibrator. Each instrument is laboratory certified for its respective specification. Calibration certificates are available on request from Noise Measurement Services.

The software measurement instruments are

- Adobe Audition v1.5 for soundfile analysis and calibration
- SpectraPLUS Professional v5
- dBSONIC v4.12
- NoiseLab 3

Background Sound Levels and Regression Analysis

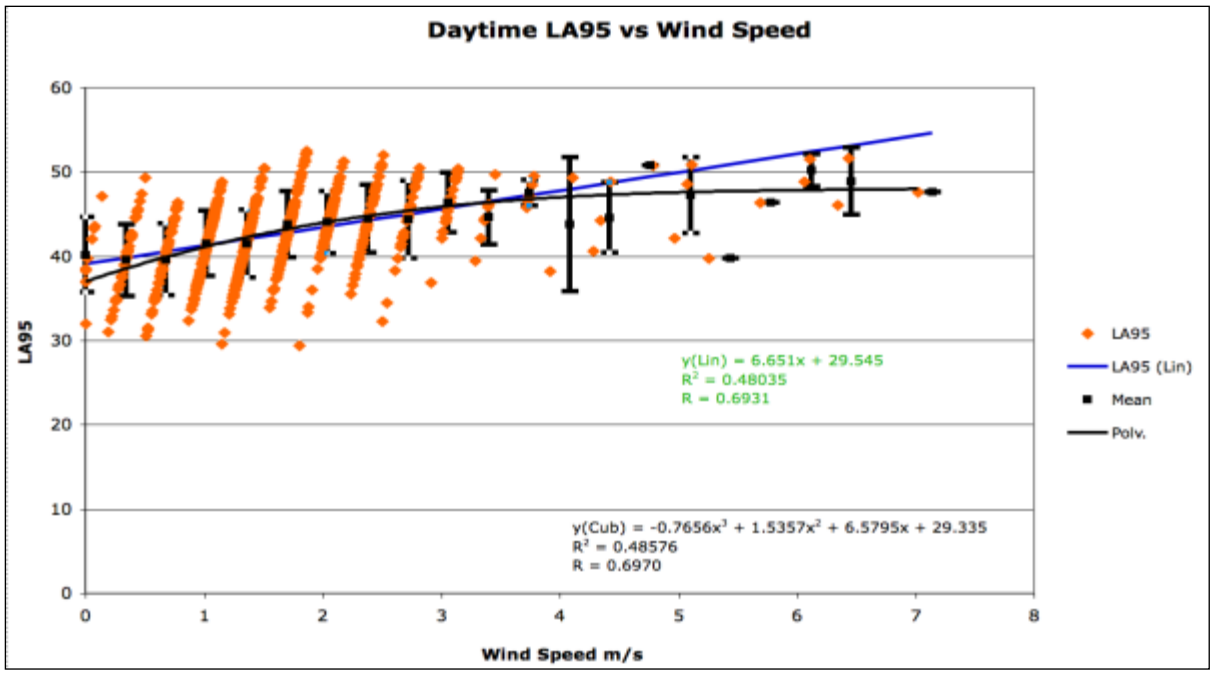
NZS6808:1998 states "To determine conformance with the [approval limits] a comparison shall be made between the best fit regression line of the background sound levels and the regression curve of the operational wind farm corrected for any special audible characteristics". Although NZS6808:1998 indicates third-order polynomials for regression curves for data-fitting the standard does not state the best-fit regression to be chosen, treatment of uncertainty, the treatment and recognition of a valid spread of values, and the treatment of outliers. This section discusses the methods of analysis and applies them to 'greenfield' results from a rural locale unaffected by wind turbines.

The Pearson product-moment, (correlation coefficient), ***R***, is a measure of the correlation (linear dependence) between two variables X and Y, giving a value between +1 and −1 inclusive. It is widely used in the sciences as a measure of the strength of linear dependence between two variables:

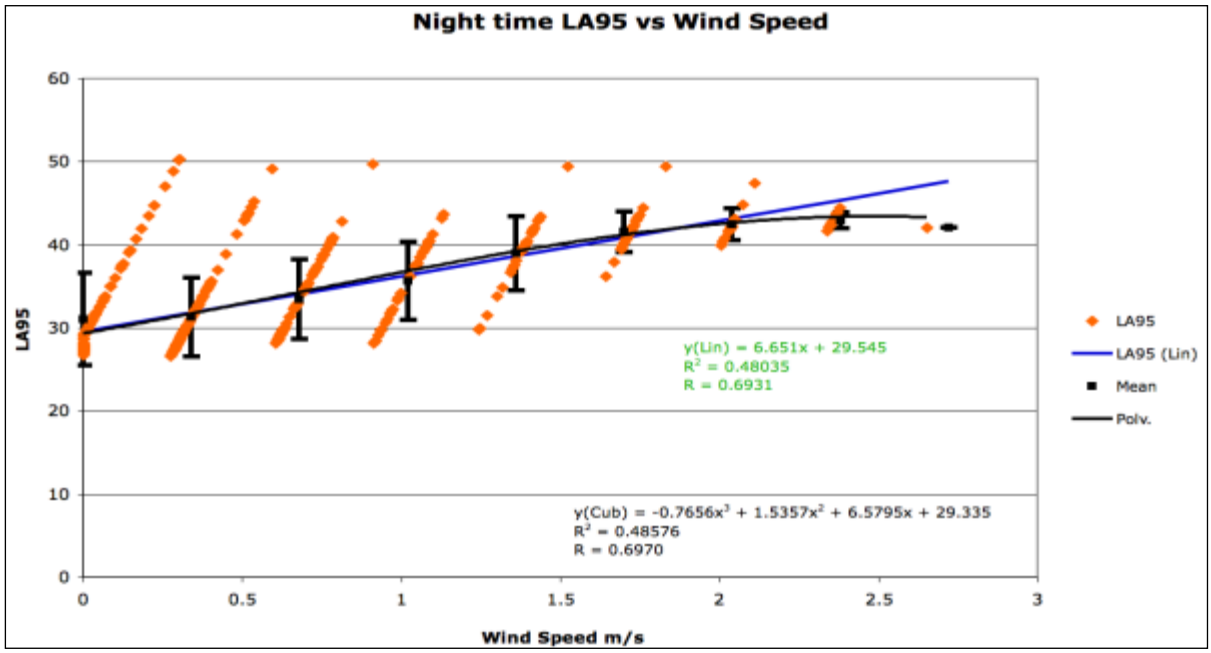
- A Pearson correlation of 1 means that the two variables are very closely correlated, the popular mis-conception is that changes in one variable is ***causing*** changes in the other.
- It is important to remember that **Correlation *does not prove* Causation**.
- A correlation of 0 means that there is no correlation (interaction) between the variables.
- A correlation of -1 shows a very strong correlation between the two variables, however this is negative. That is, as one increases, the other decreases.
- The R^2 value is an indication of the percentage of data which is explained by the regression model. In the following example about 50% of the data is represented by the regression model.
- The following data is analysed to illustrate the difference between two regression models: linear and polynomial. Regression curves by themselves do not give sufficient information with which to assess the values of the data recorded or the potential causal relationships. The polynomials are fitted with confidence intervals of ±1 standard deviation which accounts for 68% of the data.
- The mean is the arithmetic average of binned values.
- The independent variable is wind speed and the dependent variable is decibels.

The following wind speed vs background sound levels are recorded at the Berrybank green-fields location for the period 17-31 January 2012. The data is highly influenced by insect noise during the evening, night and early morning. The sound level meter applied was a Rion NL21 at 9 metres from the home. The weather station is a Jaycar model situated 10 metres above ground. The weather station is approximately 30 metres distant from the noise meter. The residence is surrounded by high trees, approximately 50 metres distant. There is a low shrubbery near the sound level meter. In the daytime and night-time data the sound levels are insect noise (from observations) and wind speed (by measurement). It is considered from observation that the lower marker of the confidence interval is more indicative of the actual relationship between wind speed and sound level.

Daytime LA95 with Confidence Interval vs wind speed m/s



Night-time LA95 with Confidence Interval vs wind speed m/s



STUDY RESULTS

The measurements and assessments from the study follow. The measurements are recorded to assist in the evaluation of adverse health effects on persons living and working in the vicinity of the wind farms. The study is not a compliance or non-compliance report.

The study confirms the following:

1. The logging of A-weighted sound levels without a detailed knowledge of what the sound levels relate to renders the data uncertain in nature and content.
2. The logging of A-weighted third-octave sound levels without a detailed knowledge of what the sound levels relate to renders the data uncertain in nature and content.
3. The logging of Z-weighted sound levels without a detailed knowledge of what the sound levels relate to renders the data uncertain in nature and content.
4. Observation is needed to confirm the character of the sound being recorded.
5. Sound recordings are needed to confirm the character of the sound being recorded.

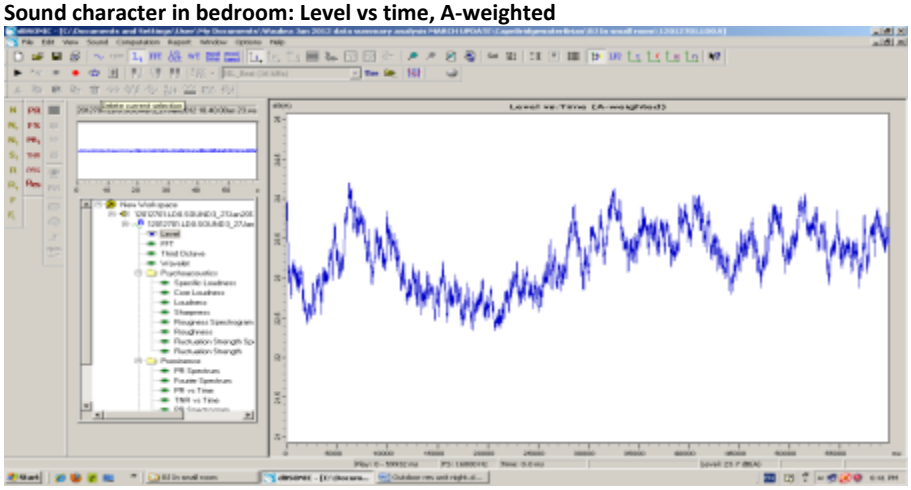
The data summarised following is for:

1. Cape Bridgewater (one location)
2. Waubra (four locations)

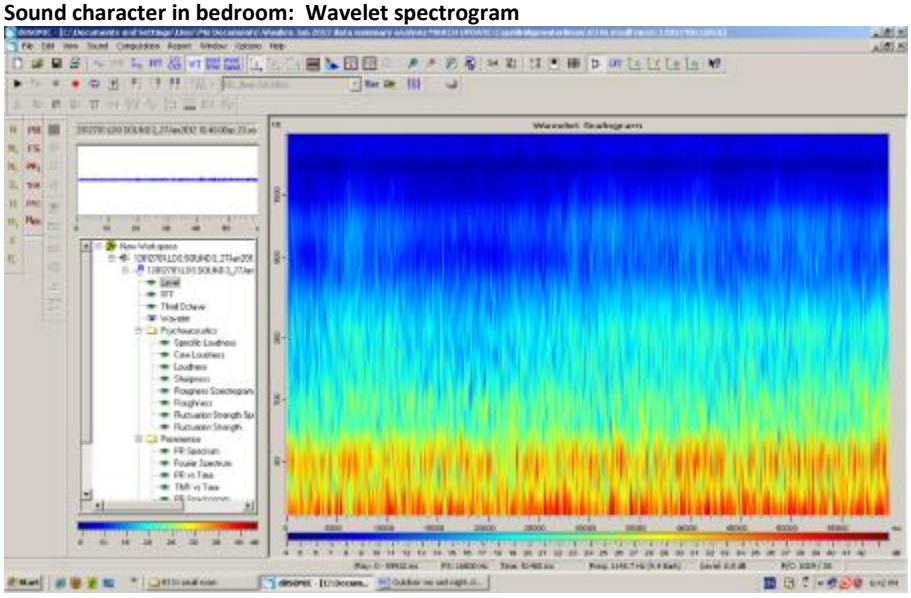
CAPE BRIDGEWATER

Cape Bridgewater Residence 2, Inside sleep-out, 27 Jan 2012, 10:40pm – 10:50pm

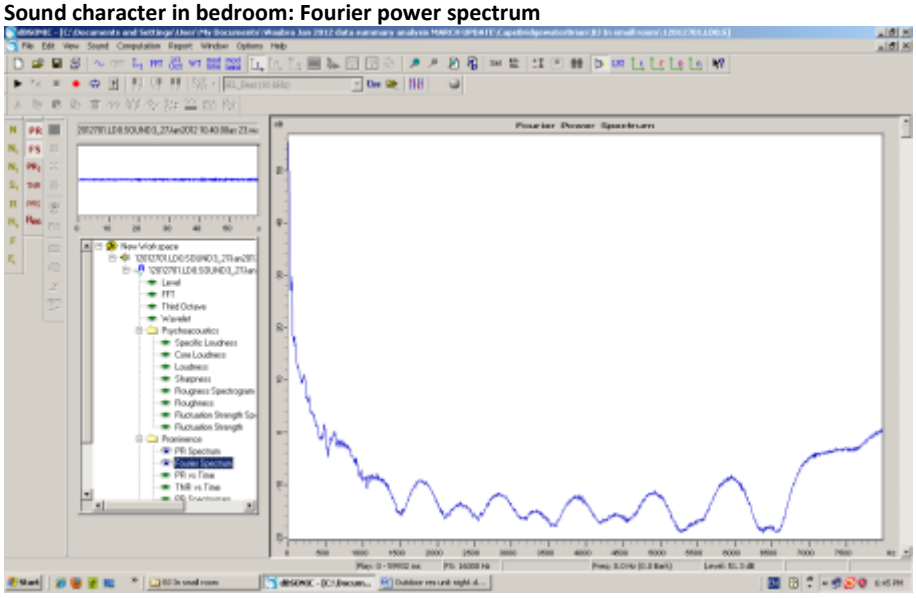
Sound character in bedroom: Level vs time, A-weighted



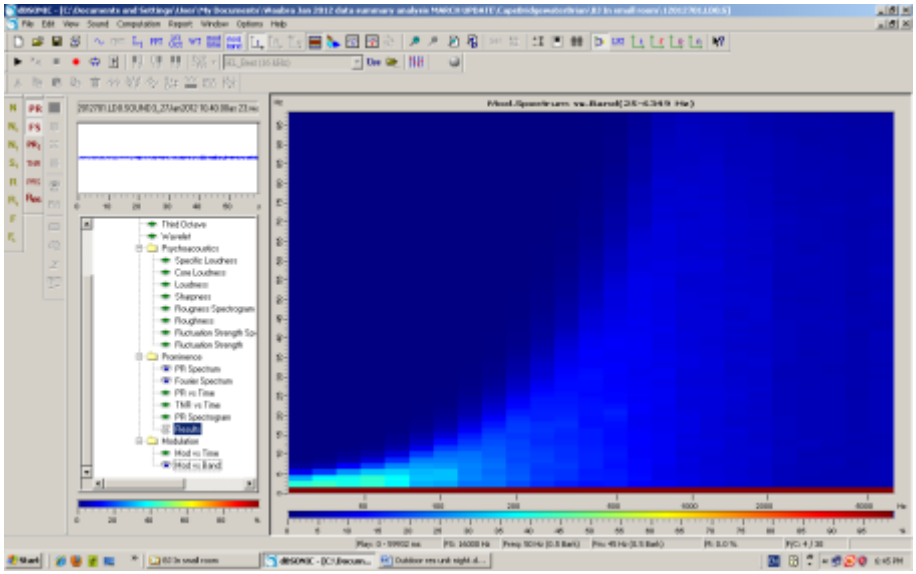
Sound character in bedroom: Wavelet spectrogram



Sound character in bedroom: Fourier power spectrum



Sound character in bedroom: Modulation of sound levels



Modulation shown at 35%, modulating at 3Hz-5Hz, to 75Hz bands

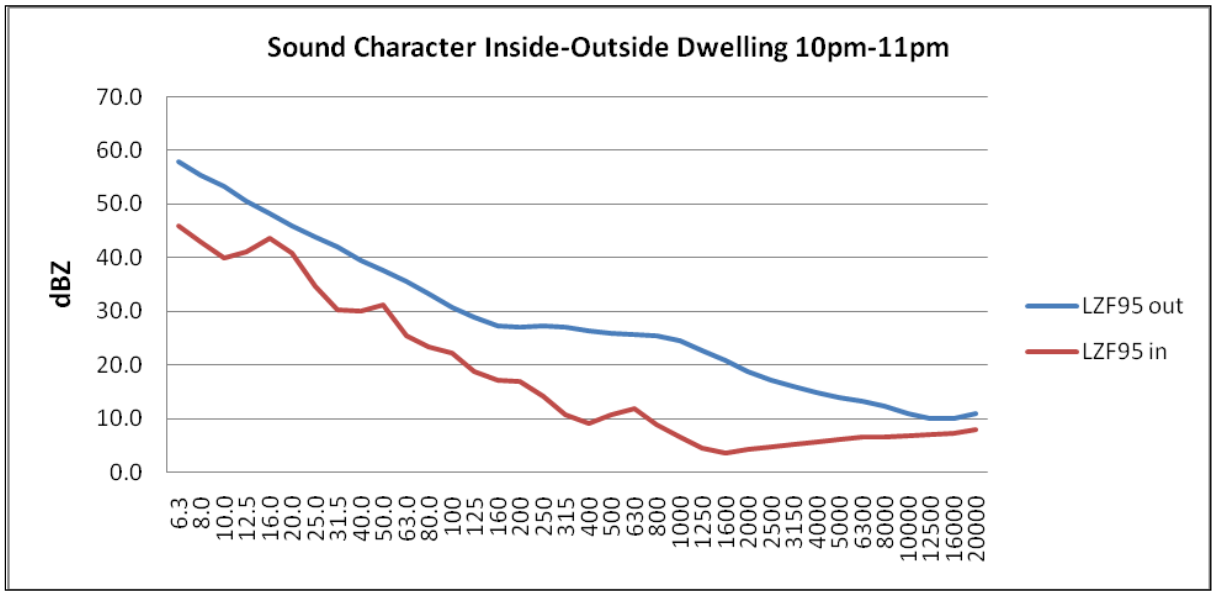
Sound Levels inside dwelling

Light breeze outside, windows closed; LAeq 23.1 LA95 20.1

Measurements on the 'turbine' side of the house, outside, 7 metres from home

Light breeze, cold; LAeq 50.1 LA95 41.6
Sound character is wave sounds on shore (actual sound)

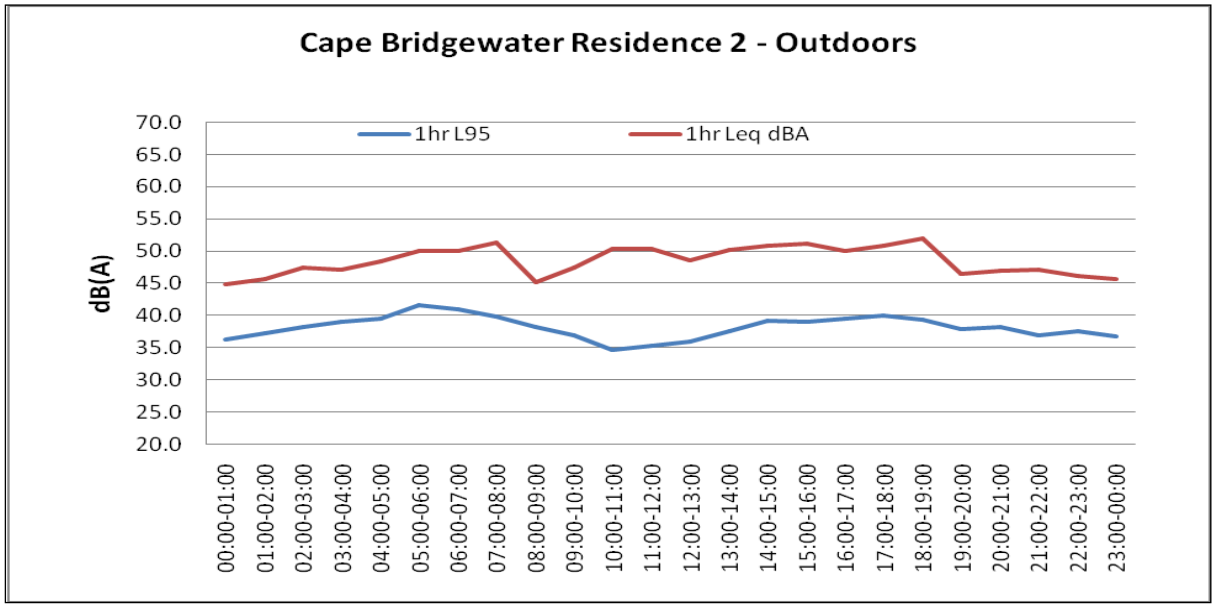
Sound Character inside -outside dwelling 10pm – 11pm



The sound of the turbines can be heard at residence 2 and is illustrated in the wavelet graphic. Low frequency sound is enhanced within the dwelling compared to outside. The character of the interior sound is illustrated in the fourier power spectrum (above).

The sound in the environment is a mixture of wind farm sound, waves on the shore, and the breeze.

The turbines to the west were observed to be operating in a random pattern; that is, not all turbines were operating all the time. The following chart illustrates the sound environment over 24 hours at residence 2. The sound level meter was 7 metres to the north of the home, on grass, and not subject to noise from trees. The weather was fine and cold, with a light easterly breeze of 2 – 3m/s. The background was ordinarily in the range of 35dB(A) to 40 dB(A). The average background level (24hr) was 39 dB(A) and the night-time (10pm-7am) background level 39dB(A). The range in background levels was 35-42 dB(A) measured in 10-minute intervals over 24 hours.

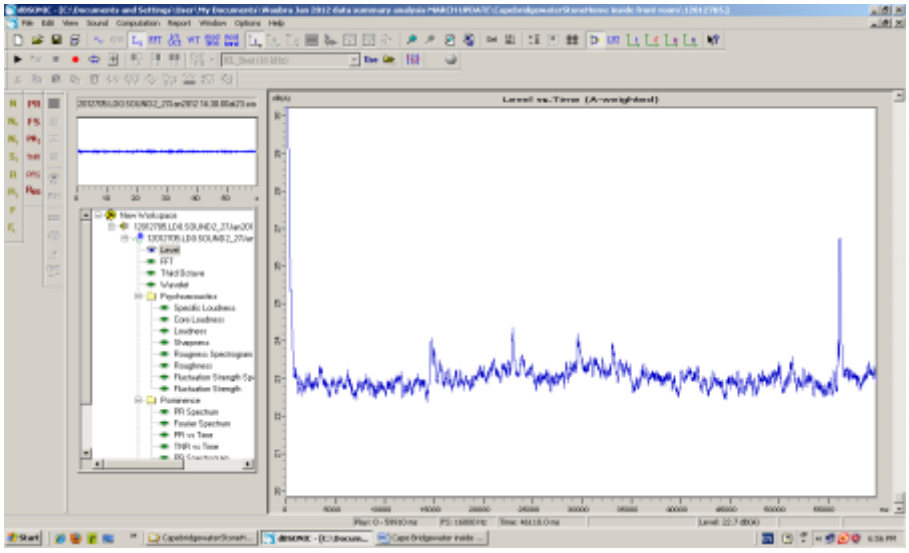


The sound character at this location is such that it is difficult to establish the sound of turbines outside the home. Inside the home (or the sleep-out) determining the character is easier because standard measures can be employed to identify turbine levels compared to (say) noise of waves on the shore. It was observed that when moving around the property there were specific locations where the sound of the turbines to the west were more noticeable than in other locations. The western-most turbines to the south-west of the wind farm were operating at different angles to the off-sea wind compared to the more 'in- land' turbines. It is possible that this physical phenomenon may influence the creation on audible noise and turbulent infrasound at residences.

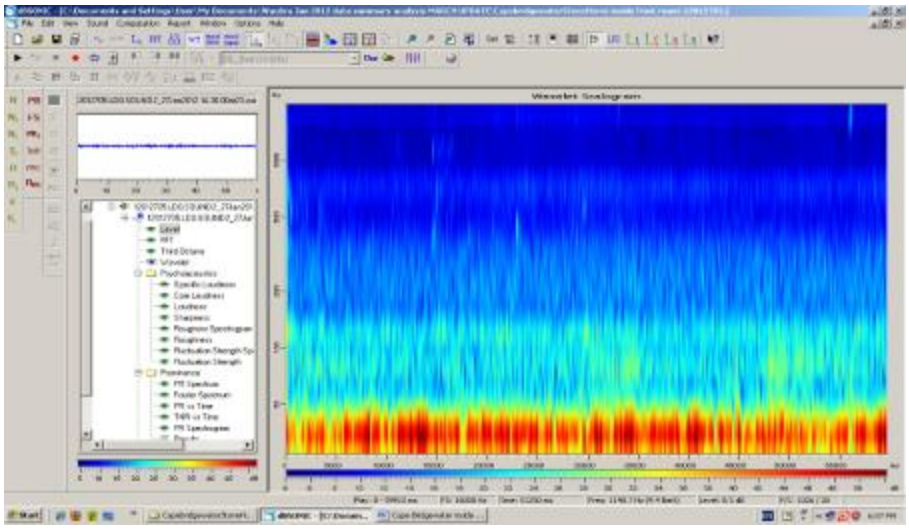
It is not possible to readily separate the different 'background' LA95 contributions of sound from the wind farm vs wave action vs wind. With an observer present it is possible to assess the contributions. With 'standard' sound level meters measuring LA95 only, as shown in the above figure, an assessment for compliance is not possible. Additional sound character information is essential.

Cape Bridgewater: Residence 1, Inside front bedroom, 27 Jan 2012, 2pm – 3pm

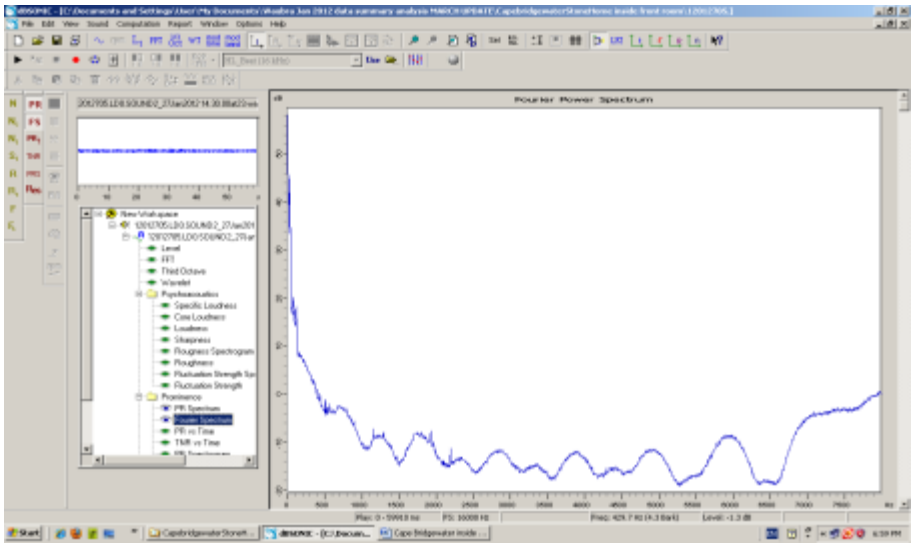
Sound character in bedroom



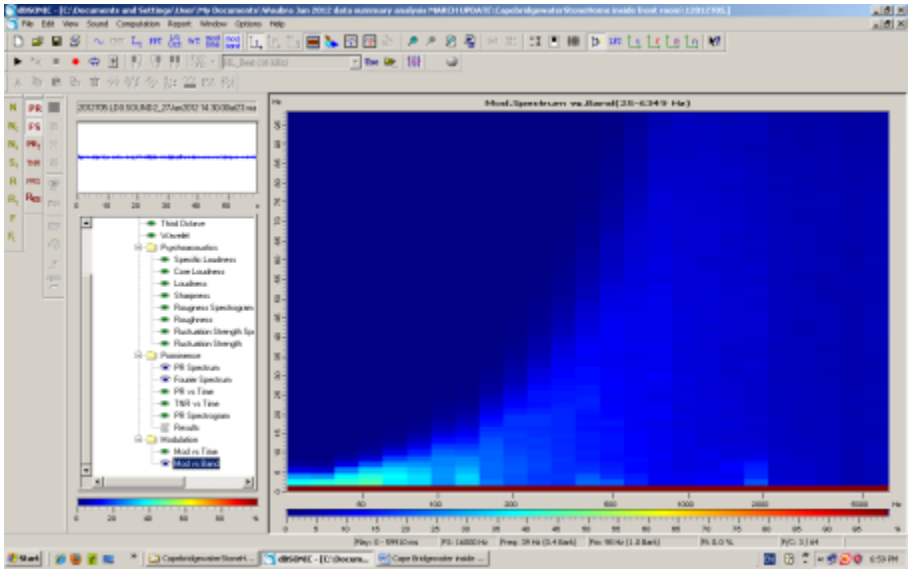
Steady variation of Sound Level vs time



Low frequencies below 40 Hz clearly measureable



The spectrum chart shows evidence of distinctive tonal complexes



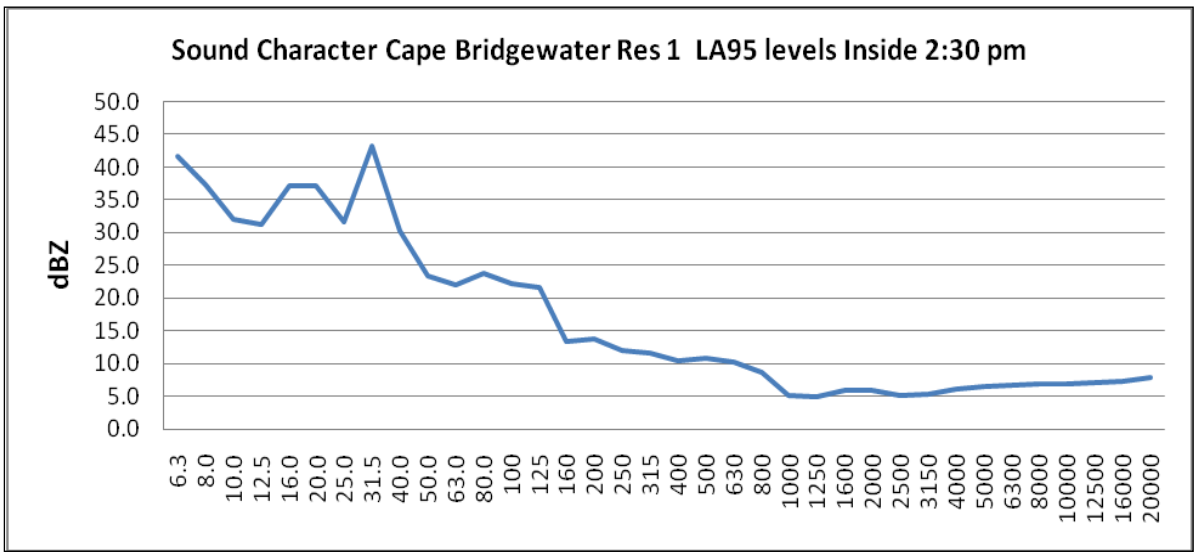
Modulation shown at 35%, modulating at 3Hz-5Hz, to 75Hz bands

Sound Levels Inside Dwelling

No breeze outside, windows closed; LAeq 36.7 LA95 20.5

Measurements taken at 1 metre from window at mid-height. Floors, wall and ceiling of solid material, light glazing in timber frame. The wind turbines to the west were operating at the time of the survey.

Sound Character LA95 levels inside dwelling 2:30 pm (10 minute survey)

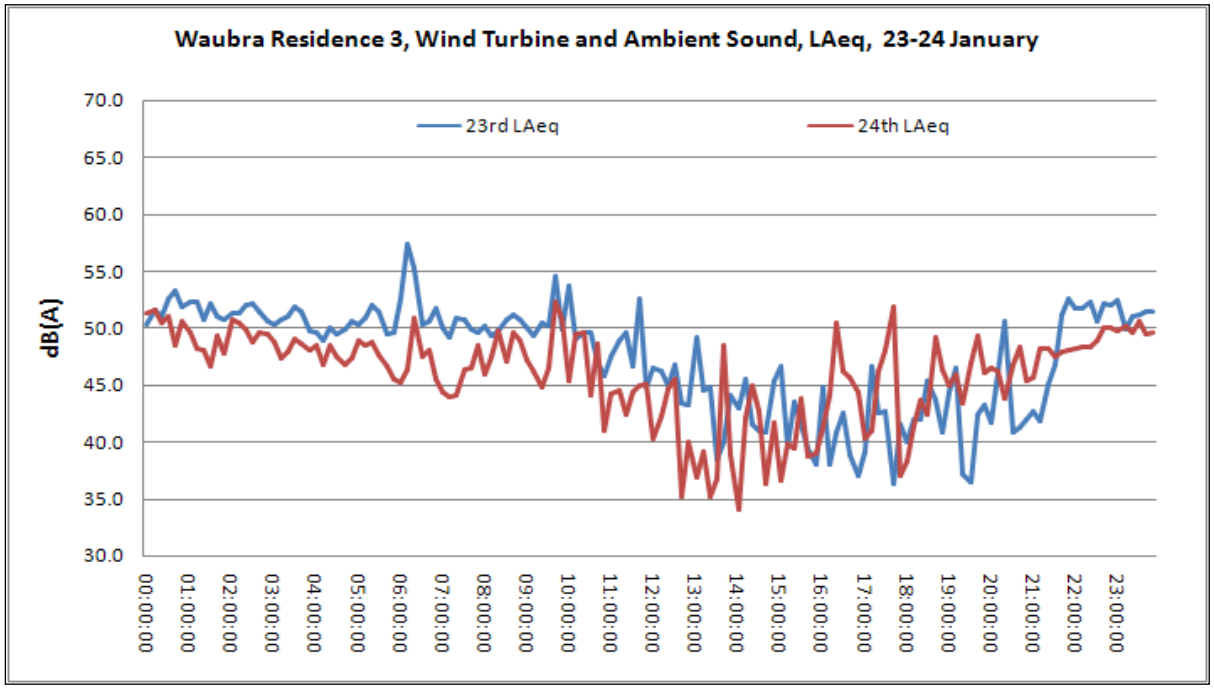


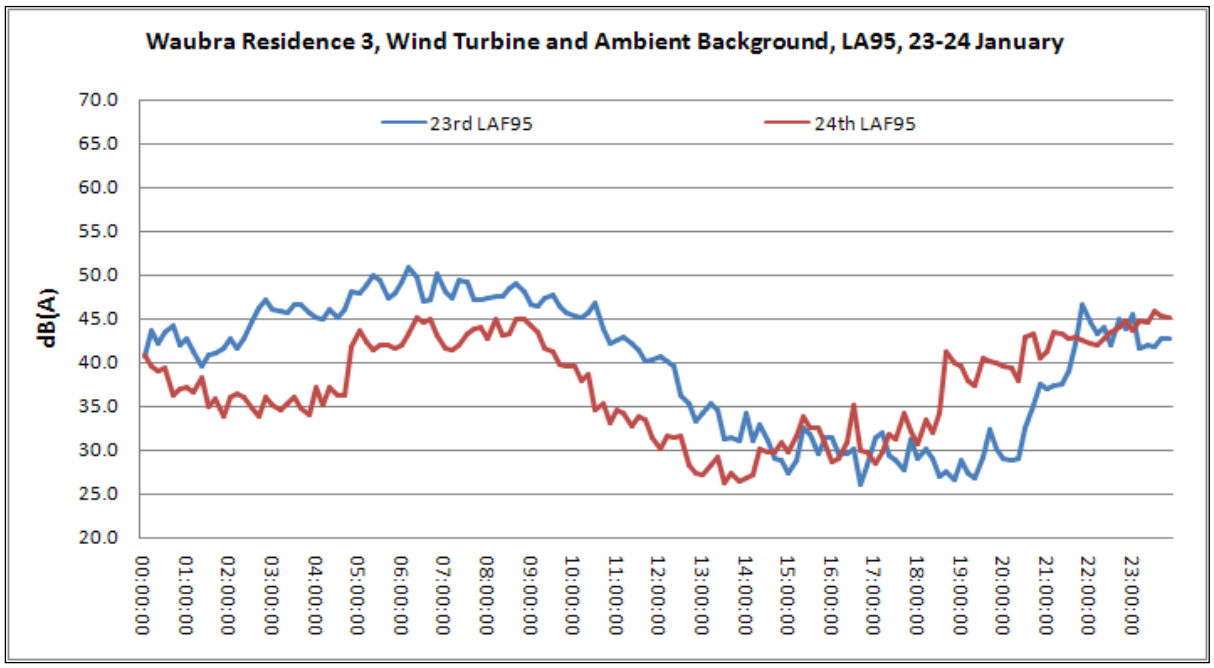
The interior sound character of the front bedroom in residence 1 is illustrated in the wavelet graphic. Turbine sound is measurable. Low frequency sound is highly enhanced within the dwelling compared to outside. The character of the interior sound is illustrated in the fourier power spectrum.

Although not monitored, it is concluded that residence 3 will be affected in the same way as residences 1 and 2. Residence 3 is of timber frame constructions. Residences 1 and 2 have significant stonework. Each residence has a metal roof and light-weight glazing.

CENTRAL WAUBRA – RESIDENCE 3

This location has turbines on approximately 3 sides of the home and is subject to consistent sound from the wind farm. The measurement location was 7 metres to the north of the residence and was the optimum location in order to comply with NZS6808. The following figures illustrate representative sound levels in ambient sound (LAeq) and background (LA95) sound levels for 23 and 24 January. The turbines were operating during the survey.



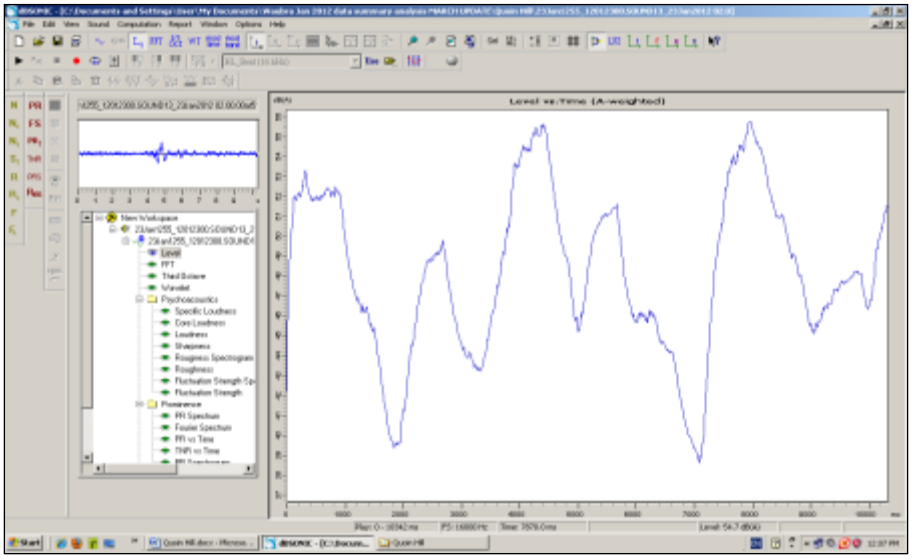


There is a significant increase in background sound levels at night. At this time of the year insects and bird / animal noise is common. Background sound level measurements in 'LA95' do not identify the influence of insects, etc, noise. This means that unless an observer is present, or automated sound character analysis is available, there is no practical way to identify wind farm noise from ambient noise. The night-time levels include insects and turbines, the levels at midday are turbines only. The following table summarises sound analyses made at this location on 23 – 24 January.

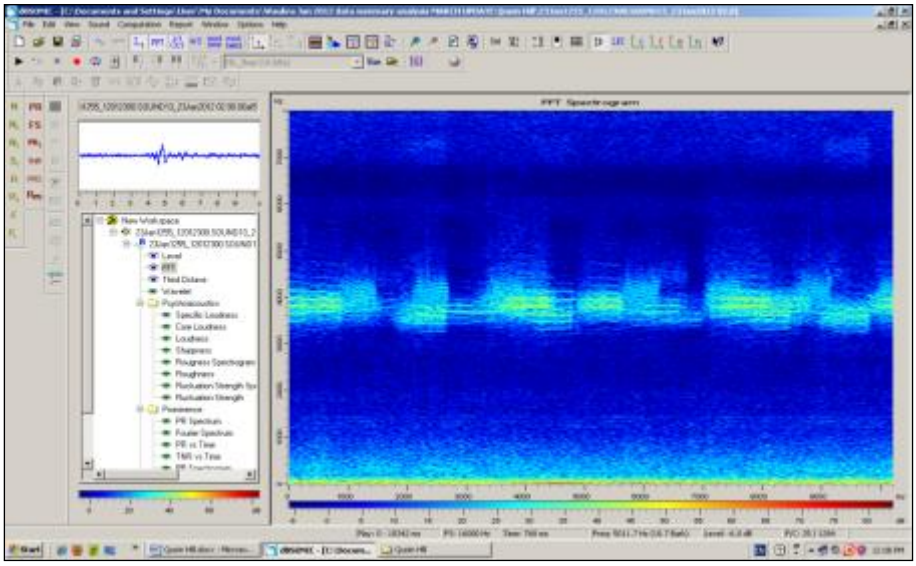
Date	Time	LAeq	LA95
23 Jan	2 am	51.4	42.8
	4 am	49.7	45.2
	6 am	52.6	49.2
	12 noon	46.2	44.5
	10 pm	51.7	44.5
	Over 24 hours	49.4	31.2
	Night-time		45.4
24 Jan	2 am	50.8	36.1
	4 am	46.6	35.2
	6 am	45.2	42.0
	12 noon	40.3	30.1
	Over 24 hours	47.3	31.6
	Night-time		38.4

The following charts illustrate the character of sound in 10-second blocks in the environment at different times of day on 23 January. Similar results are evident in the analyses for 24 January.

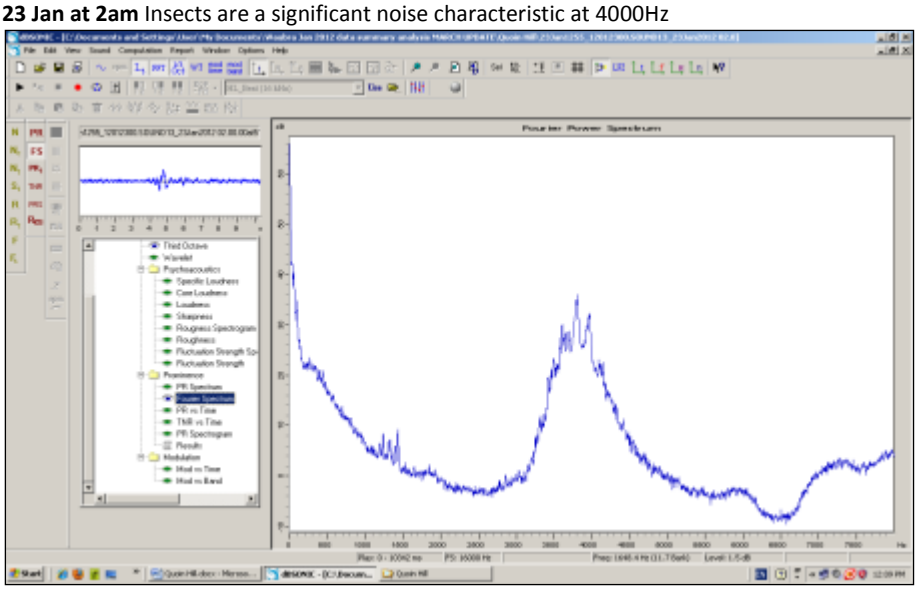
23 Jan at 2am level v time – sound levels shifts are significant in the survey period



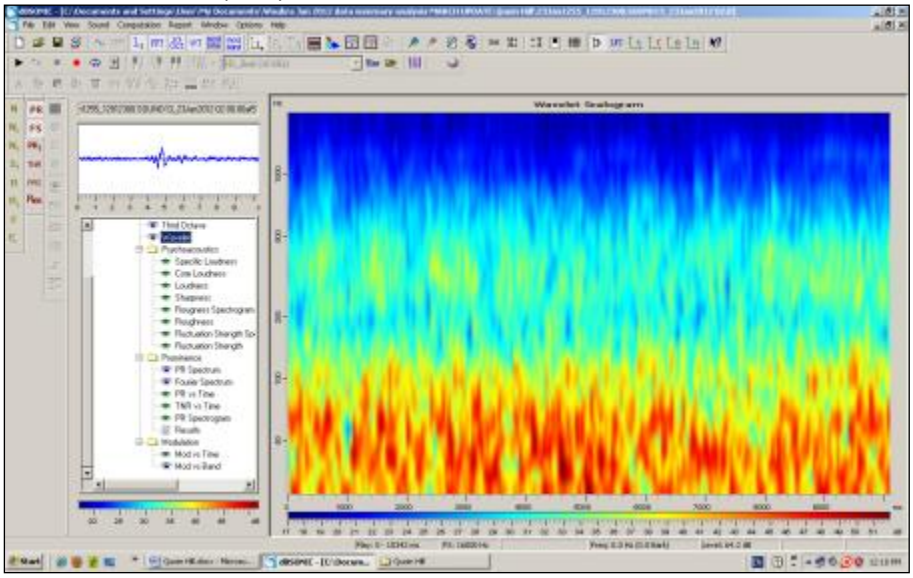
23 Jan at 2am Insect noise is evident at 4000Hz



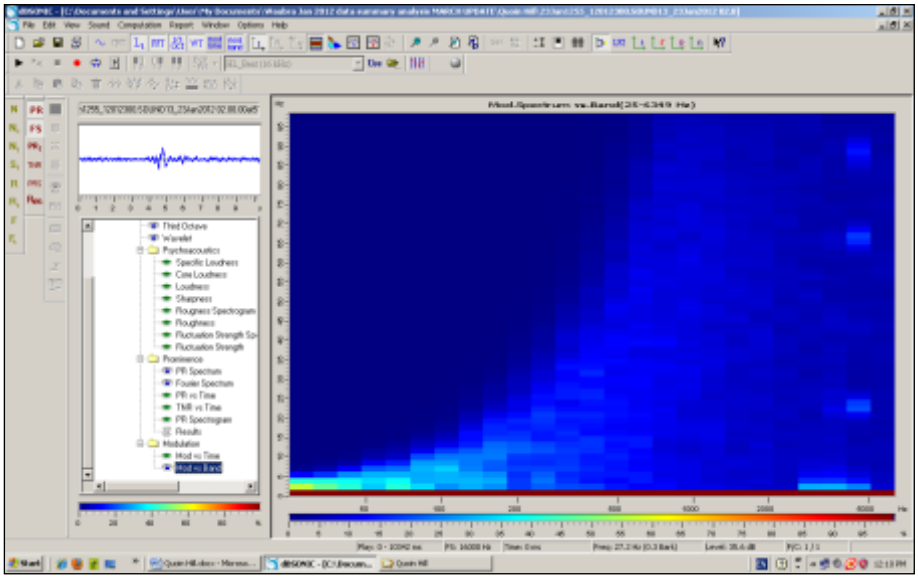
23 Jan at 2am Insects are a significant noise characteristic at 4000Hz



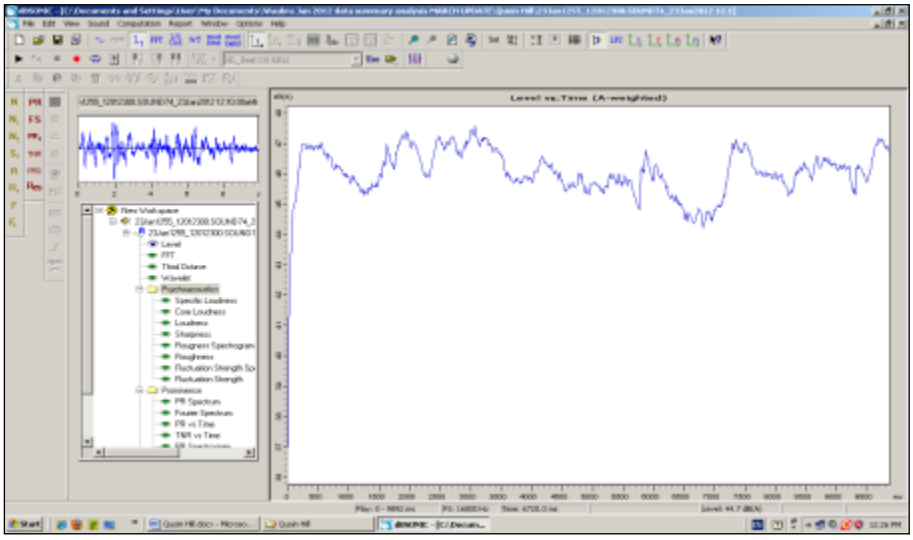
23 Jan at 2am Low frequency modulation is evident in the chart below



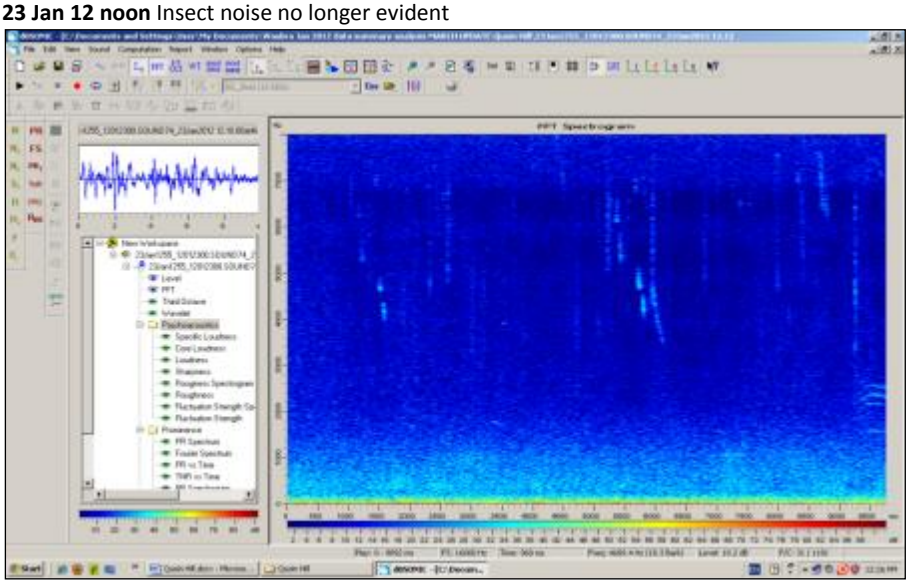
23 Jan at 2am Low frequency modulation is evident in the chart (yellow block).



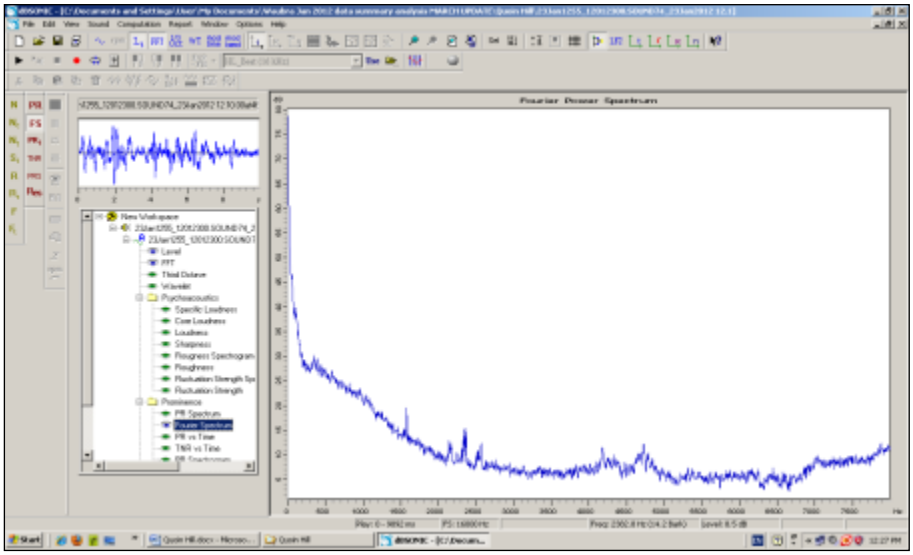
23 Jan 12 noon Level vs time – sound levels relatively steady compared to other times of day



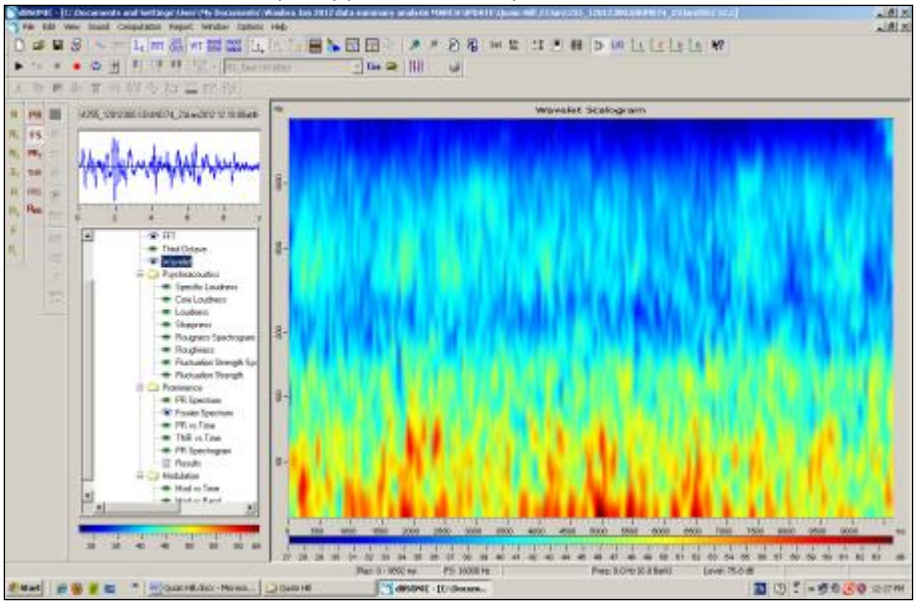
23 Jan 12 noon Insect noise no longer evident



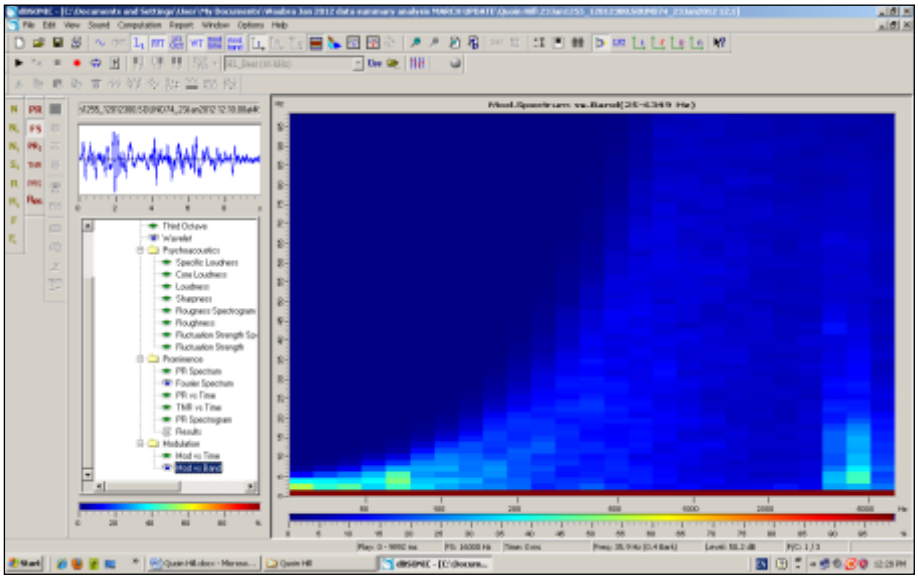
23 Jan 12 noon Insect noise at 4000 Hz has now gone



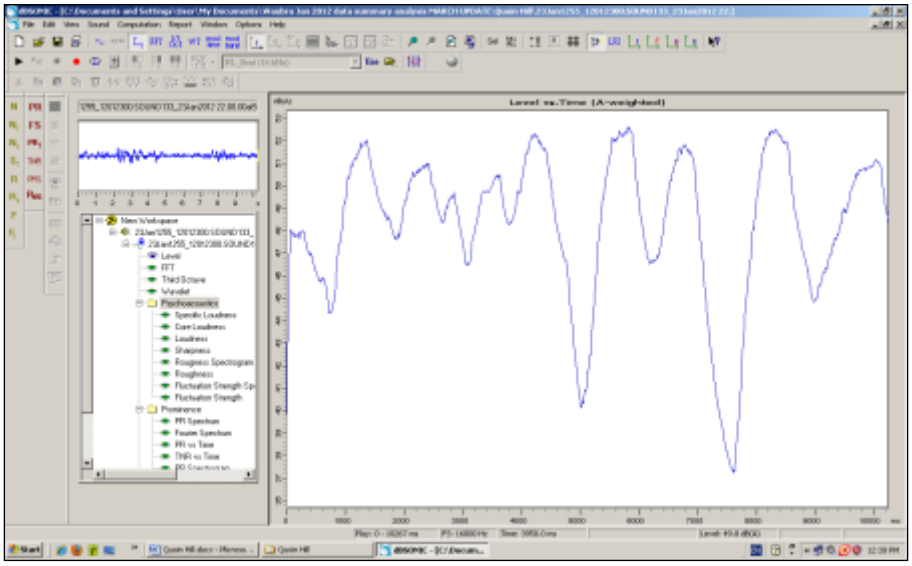
23 Jan 12 noon Less low frequency prominence compared to other times



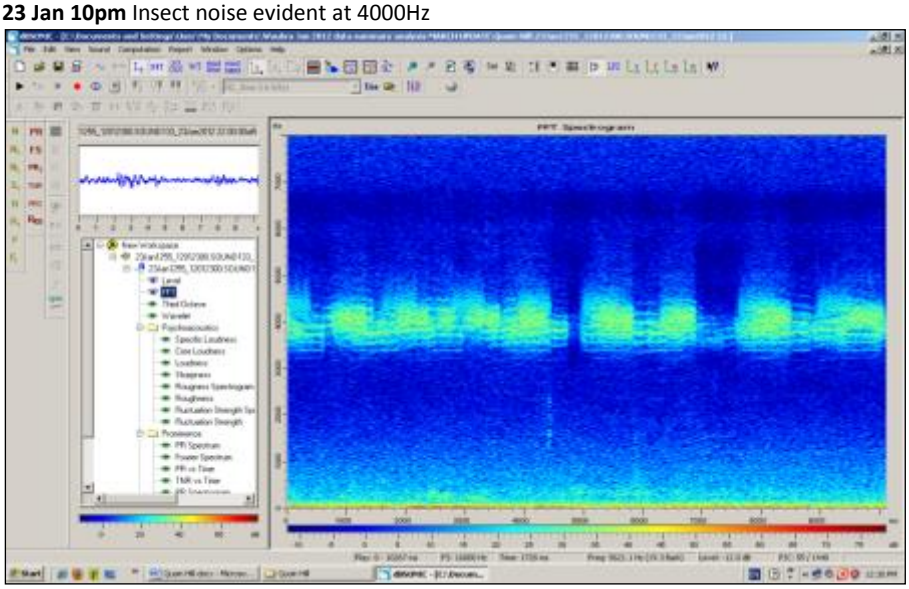
23 Jan 12 noon Modulation evident in 25 Hz band



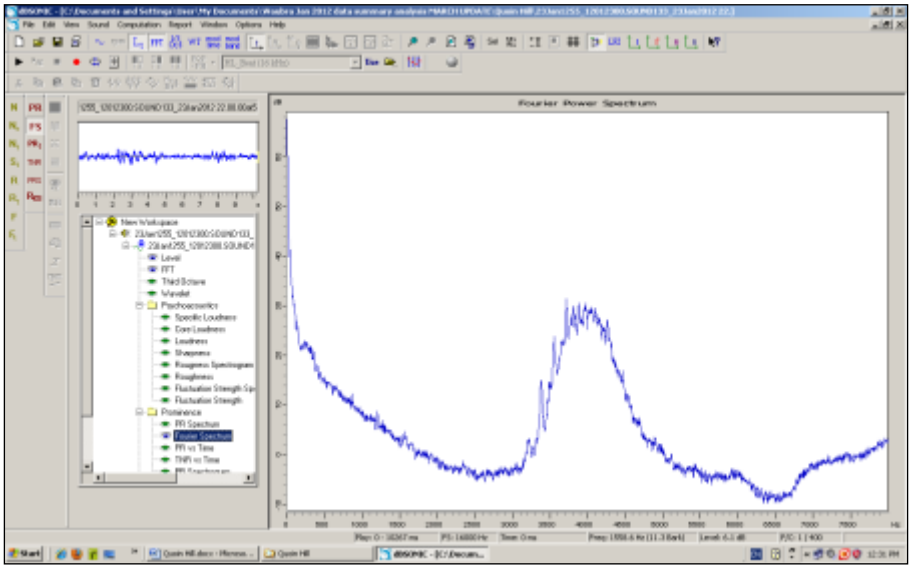
23 Jan 10pm Level v time variation in sound level



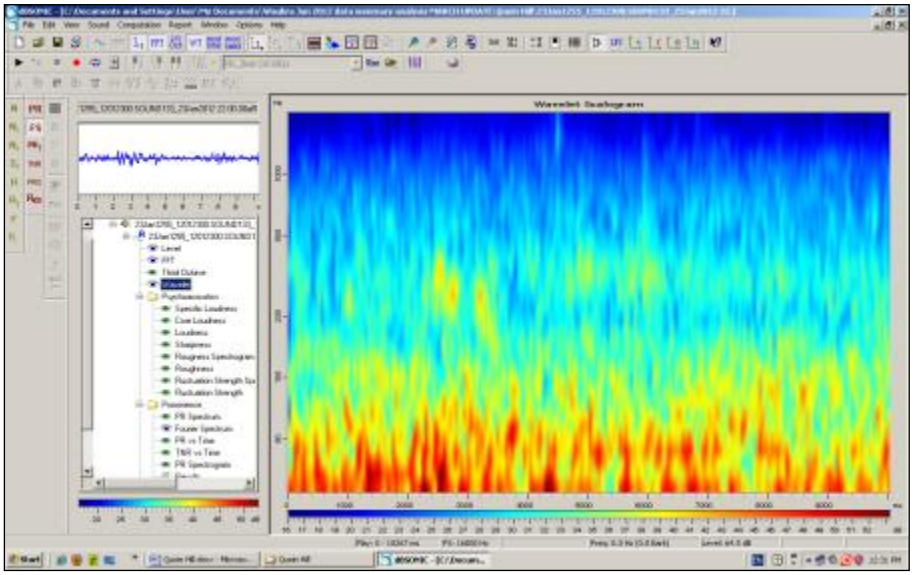
23 Jan 10pm Insect noise evident at 4000Hz



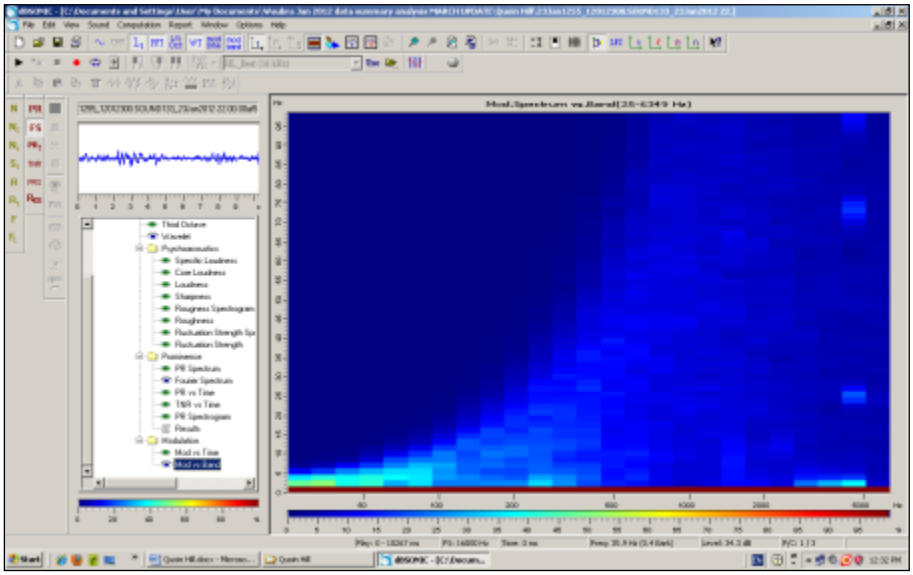
23 Jan 10pm Insect noise evident at 4000Hz



23 Jan 10pm Low frequency modulation clearly evident



23 Jan 10pm Modulation shown to 25Hz band (yellow block)



The above charts illustrate the variation in audible sound character – special audible characteristics – that can be readily measured to identify the influence of wind turbine noise (modulation), tonality (insects), and sound level variations in time (turbines, insects, bird calls).

The home is of light timber framed construction with the bedrooms facing toards turbines. Walls and floors are of timber. Windows are of light glazing in timber frames. From previous investigations a sound attenuation of 5 dB(A) to 10dB(A) can be expected, outside to inside with windows closed. The bedrooms are large in size and room resonance is expected.

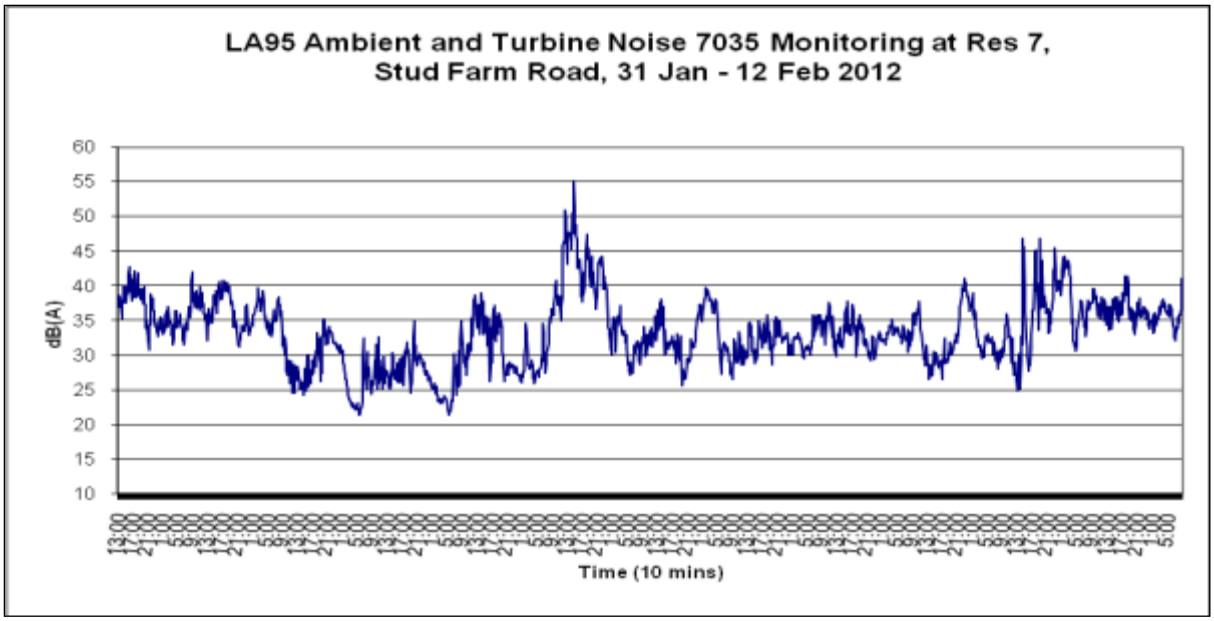
A more detailed study outside and inside this home is warranted.

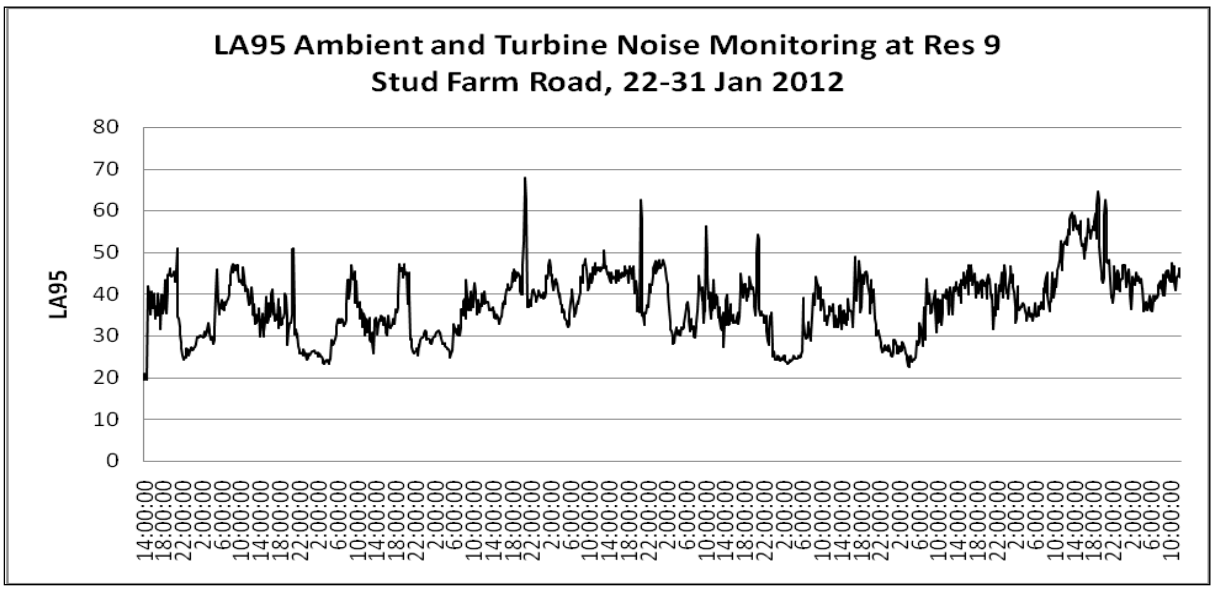
STUD FARM ROAD

As series of surveys were made along Stud Farm Road with both Rion and Larson Davis instruments. Stud Farm Road provides a longitudinal study from the 'central' group of turbines to three groups of turbines that influence the environment adjacent to the road to the village of Evansford. Many of the residents involved with this study live along Stud Farm Road and in the Evansford locale. By reference to Plate 1 of Part 1 the residents at locations 5, 6, 7, 8, 9 and 10 are affected. The home at location 5 is affected and a sound survey has yet to be made here. The home at location 6 is significantly affected but the density of shrubs and trees make siting a station to measure to NZS6808 is difficult. The home at location 7 is affected and has been monitored. Indicative sound surveys have been made at residences 5, 7, 8 and 10 and are not recorded futher in this Annex. The surveys at residences 7 and 9 provide an indication of noise levels and issues relating to wind farm noise measurement to NZS6808.

A 'walk-trough survey was taken on 20 January from residence 6 to 7 to 8 to 5 and back to 7. Observations made of wind speed were a consistent 2m/s – 3m/s blowing from the south along Stud Farm Road. Gusts to 5m/s were recorded. The wind was consistently from the south, south-south east during the surveys. The weather was fine and mild, no rain recorded. There is a large belt of trees along Stud Farm Road between residences 6 and 7. The wind was noticeably stronger on the eastern side of trees, with consistent wind speeds of 4m/s – 5m/s recorded. Turbine sound was more audible on the western side of the trees compared to the eastern side. Walking along the road to the north of residence 7 it was observed that the sound of the turbines to the *north-west* became clearly audible with a rumble-thump sound even though they are approximately 2000 metres distant and the sound was against the wind. The turbines approximately 1800-2000 metres to the south were also clearly audible downwind as a rumbling sound. The sound of the southern turbines faded at the entrance to Mitchell Road. It is observed that tree rustle does not mask turbine noise; both sources of sound can be clearly identified by listening. When the wind gusts increased above 5m/s (at 2m above the road) the sound of the turbines faded. The overall background (LA95) sound level was 44.2 dB(A) during the walk-through survey. Individual locations were then re-surveyed.

The predicted turbine-generated background (LA95) levels at residence 7 is 35dB(A) and 34dB(A) at residence 9. The turbines were seen to be operating during the survey (18 -27 January); operation was not consistent and for comparison a chart showing power generation from the wind farm during the study is given later in this Report. Unfortunately it is not possible to identify physical turbines in operation from the overall power data. The overall background sound level measurements for residences 7 and 9 are shown following. The survey is 7 days for residence 7 and 4 days for residence 9. The measurement location at Residence 9 is affected by wind in trees, road traffic and intermittent operation of an air conditioner. The levels are not taken as being examples of wind farm noise. The measurement location at Residence 7 is in the garden and not affected by wind in trees or road traffic. The sound levels can be considered in a NZS6808 assessment.





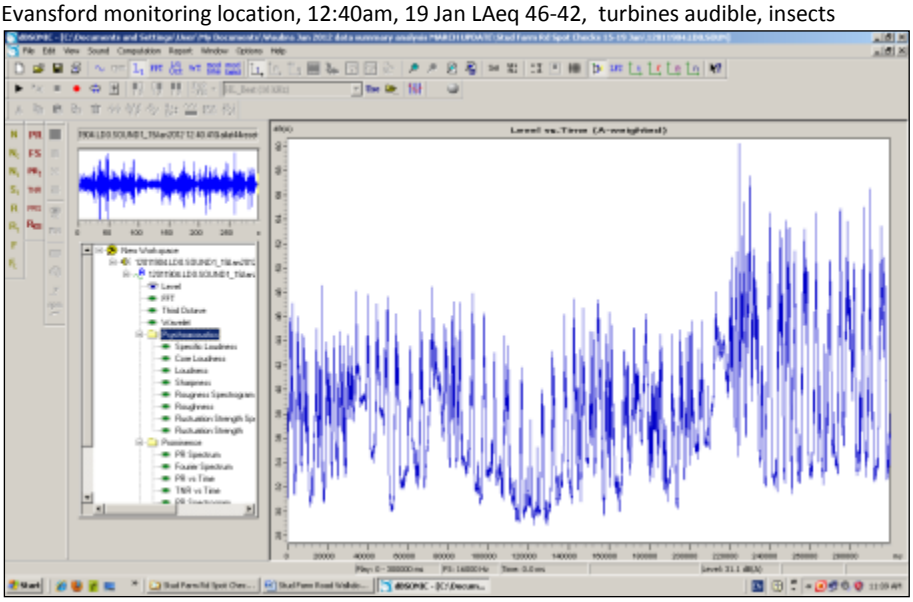
Residence	LAeq 24hr	LA95 24hr	LA95 range	LA95 night	LA95 night range
7	43	33	30 - 37	31	25 - 35
9	61	41	40 - 44	40	36 - 43

NZS6808 comment: The measurements indicate that the wind farm is probably in compliance at residence 7 during the time of the survey.

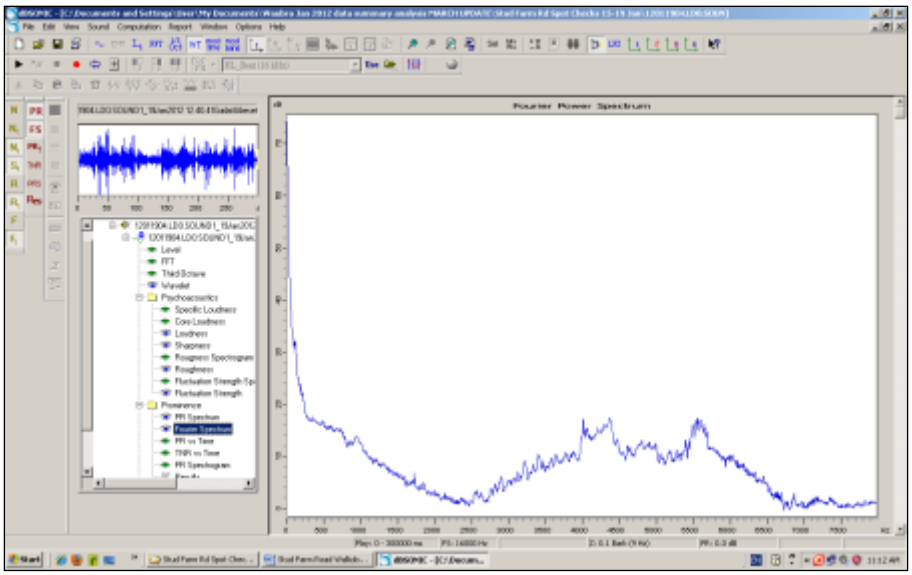
EVANSFORD

The study extended to the village and locale of Evansford. Noise measurements in the locality indicate that turbines are audible at Evansford and in the locale. Further studies are warranted as two homes situated just "outside" the village have reported audible turbine noise inside and outside the home. The topography of the locale appear to have a directional effecteven though the homes are in the range of 3000 – 4000 metres distant from the nearest turbines. Insect and bird noise is an audible characteristic and is a significant confounding factor in analysis. Measurements at Evansford during mid-day provide an LAeq level of 58.7 dB(A) and an LA95 level of 42.6 dB(A). Night-time levels are significantly lower, following, showing audible turbine character as well as insect noise. This illustrates why unattended noise logging cannot be considered for compliance monitoring. The assessment of levels purely on a "background" LA95 basis is subject to significant error.

Evansford monitoring location, 12:40am, 19 Jan LAeq 46-42, turbines audible, insects



Evansford monitoring location, 12:40am, 19 Jan LAeq 46-42, turbines audible, insects



The above chart illustrates the measureable 'loudness' of the sound character in the locale

LOBBS ROAD

Residence 2 on Lobbs Road was the primary noise survey location. The measured background levels were recorded by fixed sound level measurement instrumentation and on-site observations. For much of the survey observations were made of the operation of the southern and eastern turbines, weather conditions, as well as bird noise and so on. The wind speed at the residence was generally 1m/s to 3m/s and gusts below 5 m/s blowing from the south; that is, from the southern turbines to the home. The weather was fine and mild. Sound recordings were taken on a regular basis inside and outside the home. An example of the observations made follow:

Saturday and Sunday 21-22 Jan Inside and Outside Observed levels at residence

Benchmark Notes

Over the 1-hour period 2am – 3am on 16 January and calm weather the benchmark night-time level is recorded as LAeq 31.9 dB and LA95 24.5 dB.

Over the 1-hour period 5am – 6am on 16 January and 3m/s-plus wind the benchmark night-time level is recorded as LAeq 47.2 dB and LA95 39.1 dB.

Sat 21 Jan

7:30pm *Turbines turned off at Waubra (they were working earlier in the day) with blades turned flat for minimum wind resistance*

8:36pm 2635 in rear yard with NL21 (see separate file); turbines not running, light breeze, fine

8:46pm *2377 in bedroom at "above bed" position, windows closed, NO air conditioning*

10pm *turbines are turning;*

11pm *turbines are "roaring"*

Sunday 22 Jan

3:46am *Wind has completely dropped, calm and cool. Turbines to the east are roaring; turbines to the south are audible, one with a noticeable 'clunk' sound. Some insect 'chirp'. No AC in bedroom.*

a) *Turbines are audible outside*
b) *Turbines are just audible inside the main bedroom with door and windows closed.*

4:00am *moved logger from rear yard to 6m in front of the house veranda (approx 7.6m from wall) re the main bedroom large eastern windows. Rion NL21 s/n 7035 left in rear yard location.*

4:32am *Small bedroom to side of the house. Opened window beside bed and turbines clearly audible as a 'roar' 10min LAeq 24.1dB; LA95 20.9dB; 8Hz-12Hz around 59dB and modulating 53dB-63dB; logger 1256*

a) *The rear yard is a lot quieter than the front yard as the eastern turbines are a lot more noticeable*
b) *Turbines to the east clearly audible inside living room with window open*
c) *Opened windows in main bedroom (above bed, large window to the east).*

Shifting character of the turbine noise noticeable inside and outside the home. The sound of the turbines began to fade at first light – weather still calm. At dawn the wind picked up and tree rustle plus infrequent bird song and infrequent dog bark.

6:50am *sun is up and birds are chirping. No insect noise. Turbines audible in the bedroom but not as audible compared to 4am.*

7:00am *Logger 1256 window open LAeq 46, LA95 31 and 6.3Hz-12.5Hz around 53-62dB; window closed LAeq 30, 6.3Hz 53dB, 8Hz 42-55dB, 10Hz 32-42dB, 12.5HZ 36-48dB. The wind is from the north-east and the 4 turbines to the south are clearly noticeable in the main bedroom with the windows open as a 'swish-swish'. All turbines running. Stopped 2377 at 7:15 as dogs are barking. LAeq 32 dB*

9:15pm *Logger 1256 reset at Lobb St BBQ recording at 1min/10min. Breeze in trees running at 2-2.5m/s at ground level from the east. Leaf ratlle is a constant sound but turbines audible.*

Turbine sound generation

The 4 turbines to the south appear to have their loudest 'whoosh' on the downstroke, approximately 30 degrees from the horizontal. There are deep 'whoomph' lasting for approximately 3 to 6 blade / tower passbys. The whoosh can also be heard on the upstroke, as well as whines and clunks.

Summary of Morning Levels Sunday 22 Jan, No AC operating in bedroom

Windows closed	2377 BR	2377 BR	2635 Rear	2635 Rear
Time	LAeq	LA95	LAeq	LA95
4.00 – 4:10	19.0	18.2	33.2	31.8
4:10 – 4:20	18.7	18.0	32.4	31.3
4:20 – 4:30	18.6	17.9	32.7	31.4
Windows Open	2377 BR	2377 BR	2635 Front	2635 Front
4:30 – 4:40 moving	35.0	18.4	32.4	31.2
4:40 - 4:50	24.1	22.5	32.2	31.0
4:50 – 5:00	23.9	22.8	32.4	31.2
5:00 – 5:10	29.8	22.8	36.2	31.1
5:10 – 5:20	24.6	23.1	33.5	31.6
5:20 – 5:30	26.0	22.8	39.3	31.4
5:30 – 5:40	29.2	23.4	41.2	32.2
5:40 – 5:50	29.2	24.1	41.9	33.3
5:50 – 6:00	30.4	25.7	43.9	37.3

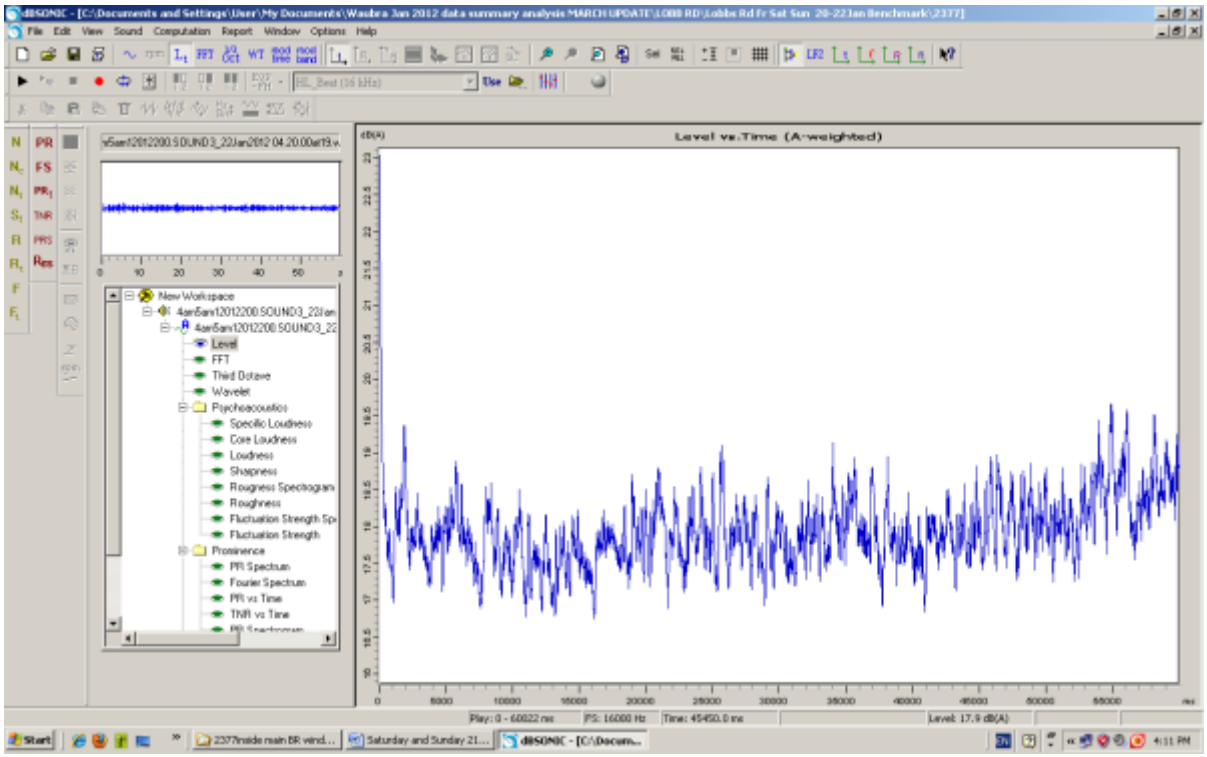
The following data is from night-time, 21-22 January

shifting character of the turbines noticeable
7:30pm turbines all off, 10pm turbines are turning; 11pm turbines are roaring and breeze in trees
3:45am Sunday wind has completely dropped; turbines to east are roaring; turbines to SE audible, 1 has a clunk
turbines audible inside bedroom with windows closed
rear yard quieter than the front yard - turbines from the east are the noisy turbines
turbines just audible inside main bedroom with windows closed
turbines to east clearly audible inside lounge and main bedroom with windows open
shifting character of the turbines noticeable
At first light the sound of the turbines began to fade

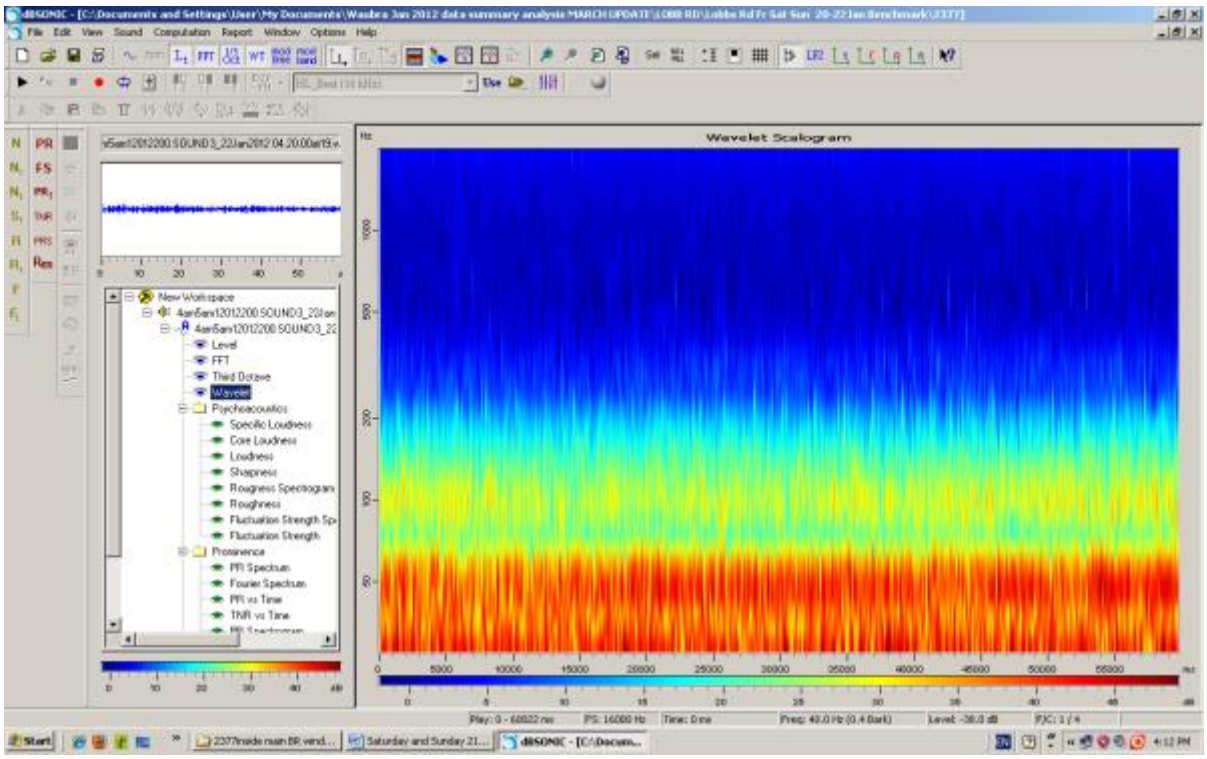
Windows	Date	Time	LAeq	LAF95.00
closed	21/01/2012	00:00:00	20.0	19.1
closed	21/01/2012	00:10:00	19.8	19.1
closed	21/01/2012	00:20:00	19.9	19.2
closed	21/01/2012	00:30:00	20.3	19.1
closed	21/01/2012	00:40:00	21.0	19.6
closed	21/01/2012	00:50:00	20.9	19.5
closed	21/01/2012	02:00:00	22.3	19.9
closed	21/01/2012	02:10:00	21.8	19.9
closed	21/01/2012	02:20:00	23.3	20.5
closed	21/01/2012	02:30:00	23.3	20.7
closed	21/01/2012	02:40:00	24.6	21.5
closed	21/01/2012	02:50:00	24.5	22.0
closed	21/01/2012	03:00:00	23.6	21.5
closed	21/01/2012	03:10:00	24.1	21.2
closed	21/01/2012	03:20:00	22.4	21.0
closed	21/01/2012	03:30:00	22.2	20.7
closed	21/01/2012	03:40:00	20.9	19.8
closed	21/01/2012	03:50:00	19.9	19.0
closed	21/01/2012	04:00:00	19.6	18.8
closed	21/01/2012	04:10:00	19.4	18.6
closed	21/01/2012	04:20:00	20.2	19.1
Windows	Date	Time	LAeq	LAF95.00
closed	21/01/2012	21:00:00	19.7	17.1
closed	21/01/2012	21:10:00	21.2	17.9
closed	21/01/2012	21:20:00	22.5	19.6
closed	21/01/2012	21:30:00	21.7	19.6
closed	21/01/2012	21:40:00	21.4	19.6
closed	21/01/2012	21:50:00	24.3	21.1
closed	21/01/2012	22:00:00	24.7	21.7
closed	21/01/2012	22:10:00	26.4	23.0
closed	21/01/2012	22:20:00	24.8	22.9
closed	21/01/2012	22:30:00	26.0	23.0
closed	21/01/2012	22:40:00	25.6	22.6
closed	21/01/2012	22:50:00	25.0	21.8
closed	21/01/2012	23:00:00	23.1	21.0
closed	21/01/2012	23:10:00	23.8	21.2
closed	21/01/2012	23:20:00	22.8	20.5
closed	21/01/2012	23:30:00	21.5	20.0
closed	21/01/2012	23:40:00	21.4	20.2
closed	21/01/2012	23:50:00	21.0	19.6
closed	22/01/2012	00:00:00	21.3	19.8
closed	22/01/2012	00:10:00	20.5	19.5
closed	22/01/2012	00:20:00	19.9	19.0
closed	22/01/2012	00:30:00	20.3	18.8
closed	22/01/2012	00:40:00	19.1	18.1
closed	22/01/2012	00:50:00	19.0	17.9
closed	22/01/2012	01:00:00	18.4	17.6
closed	22/01/2012	01:10:00	18.9	17.6
closed	22/01/2012	01:20:00	18.3	17.6
closed	22/01/2012	01:30:00	17.9	17.3
closed	22/01/2012	01:40:00	18.1	17.4
closed	22/01/2012	01:50:00	18.0	17.3
closed	22/01/2012	02:00:00	18.3	17.6
closed	22/01/2012	02:10:00	18.3	17.6
closed	22/01/2012	02:20:00	19.4	17.7
closed	22/01/2012	02:30:00	18.4	17.7
closed	22/01/2012	02:40:00	18.9	17.8
closed	22/01/2012	02:50:00	19.9	18.7
closed	22/01/2012	03:00:00	19.9	18.6
closed	22/01/2012	03:10:00	19.3	18.4
closed	22/01/2012	03:20:00	19.0	18.2
closed	22/01/2012	03:30:00	18.7	18.0
closed	22/01/2012	03:40:00	21.3	18.0
closed	22/01/2012	03:50:00	19.9	18.0
closed	22/01/2012	04:00:00	19.0	18.2
closed	22/01/2012	04:10:00	18.7	18.0
closed	22/01/2012	04:20:00	18.6	17.9
open	22/01/2012	04:30:00	35.0	18.4
open	22/01/2012	04:40:00	24.1	22.5
open	22/01/2012	04:50:00	23.9	22.8
open	22/01/2012	05:00:00	29.8	22.8
open	22/01/2012	05:10:00	24.6	23.1
open	22/01/2012	05:20:00	26.0	22.8
open	22/01/2012	05:30:00	29.2	23.4
open	22/01/2012	05:40:00	29.2	24.1
open	22/01/2012	05:50:00	30.4	25.7
open	22/01/2012	06:00:00	32.9	26.9
open	22/01/2012	06:10:00	31.7	27.9
open	22/01/2012	06:20:00	35.5	28.7
open	22/01/2012	06:30:00	42.4	30.1
open	22/01/2012	06:40:00	41.1	30.7
open	22/01/2012	06:50:00	40.0	30.9

Inside Main Bedroom 4:20 am 22 Jan No AC, windows closed.

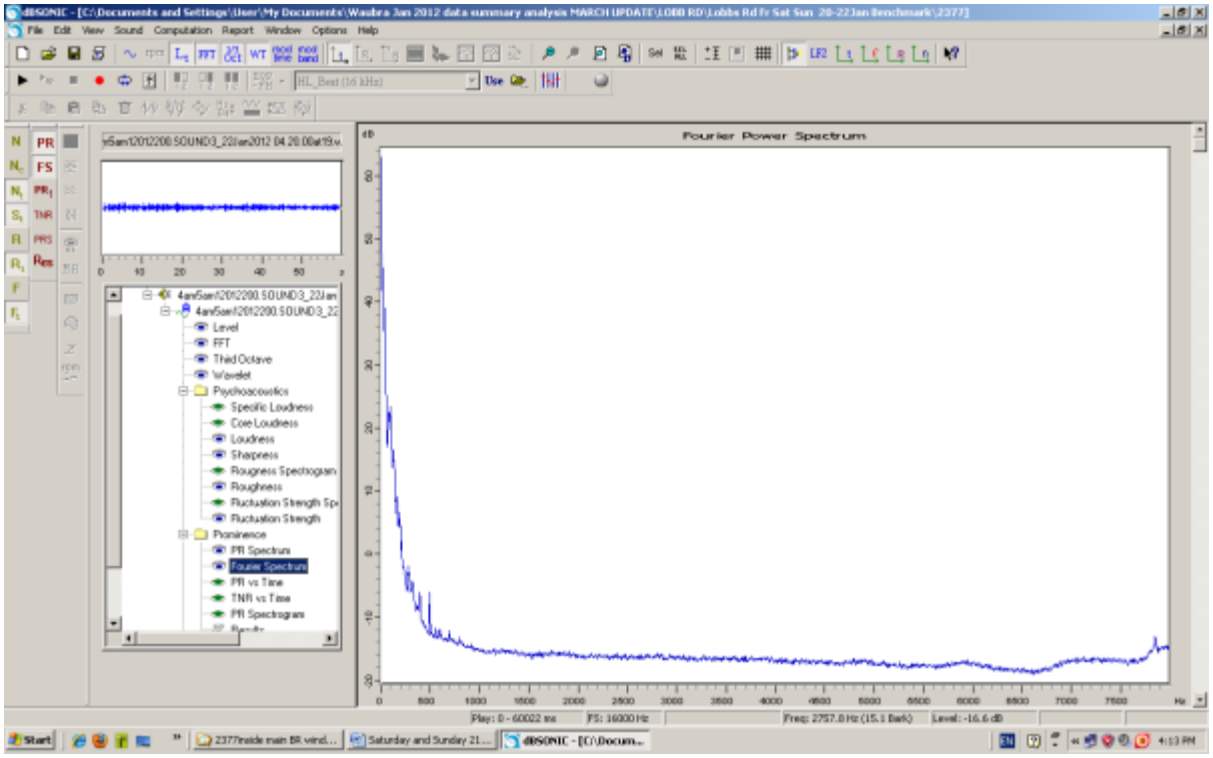
LAeq 18.6. Microphone at head position on the bed (150 mm above the bed). Turbines not clearly audible.



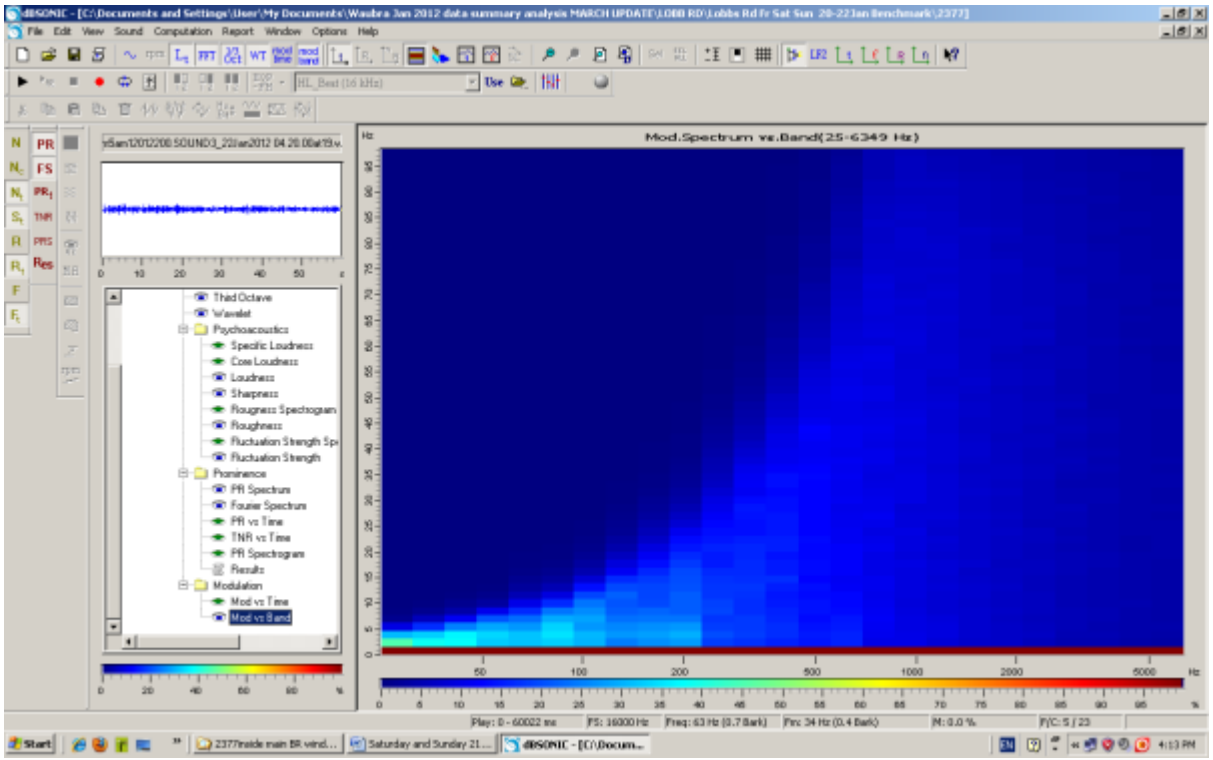
Turbine effect clearly audible



Low frequency modulation clearly evident



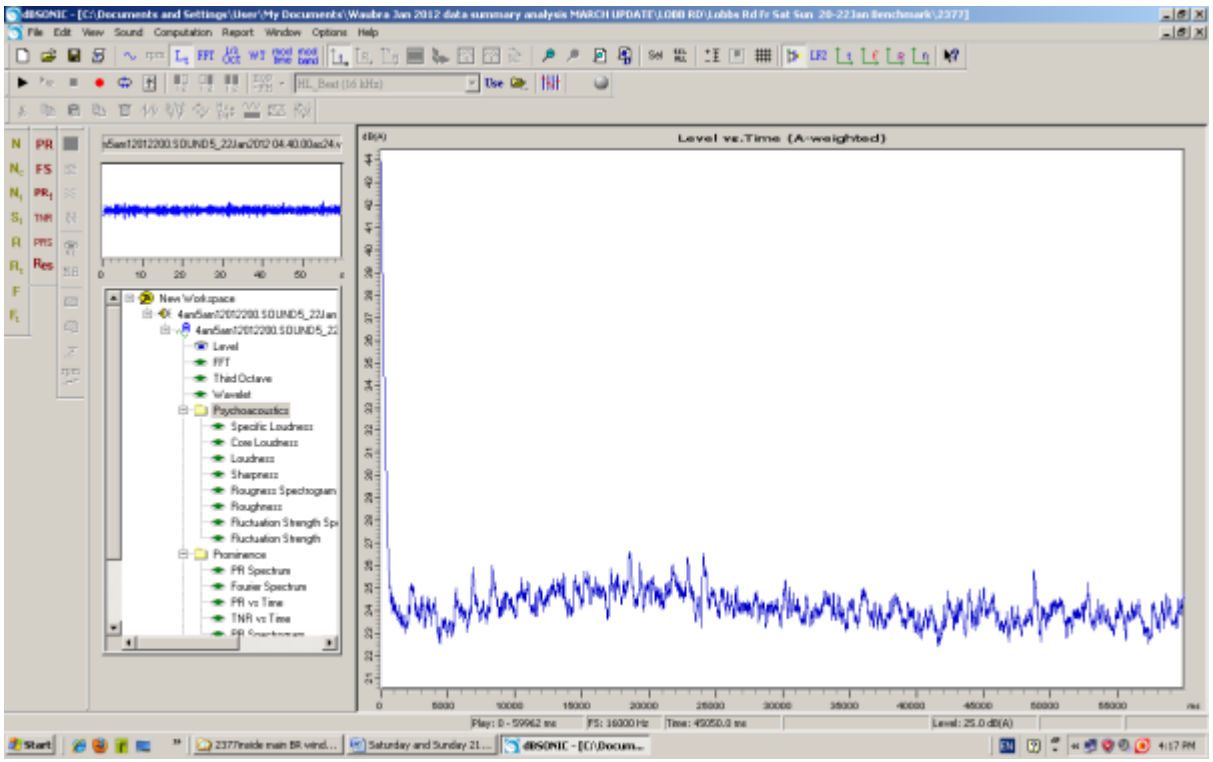
Fourier spectrum shows that insects do not affect this location (i.e. inside the room)



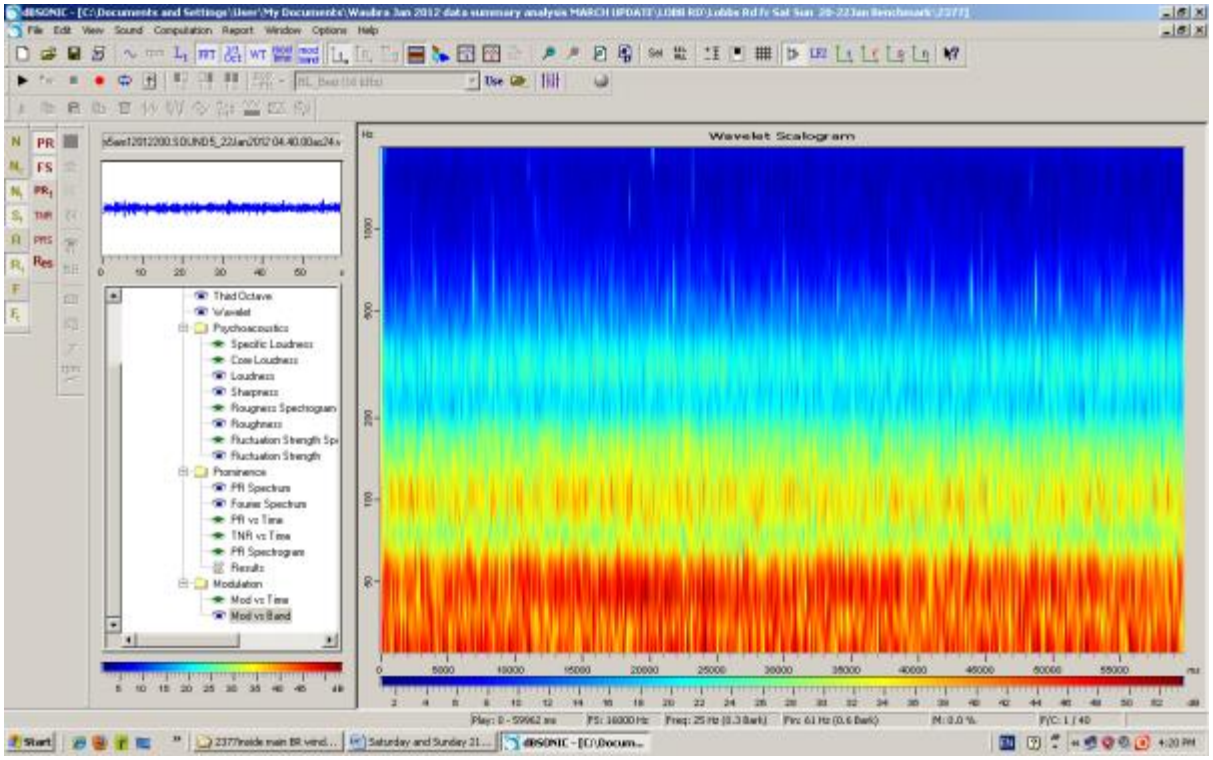
Modulation to 25 Hz is shown in the above chart

Inside Main Bedroom 4:40 am 22 Jan No AC windows open. LAeq 24.1

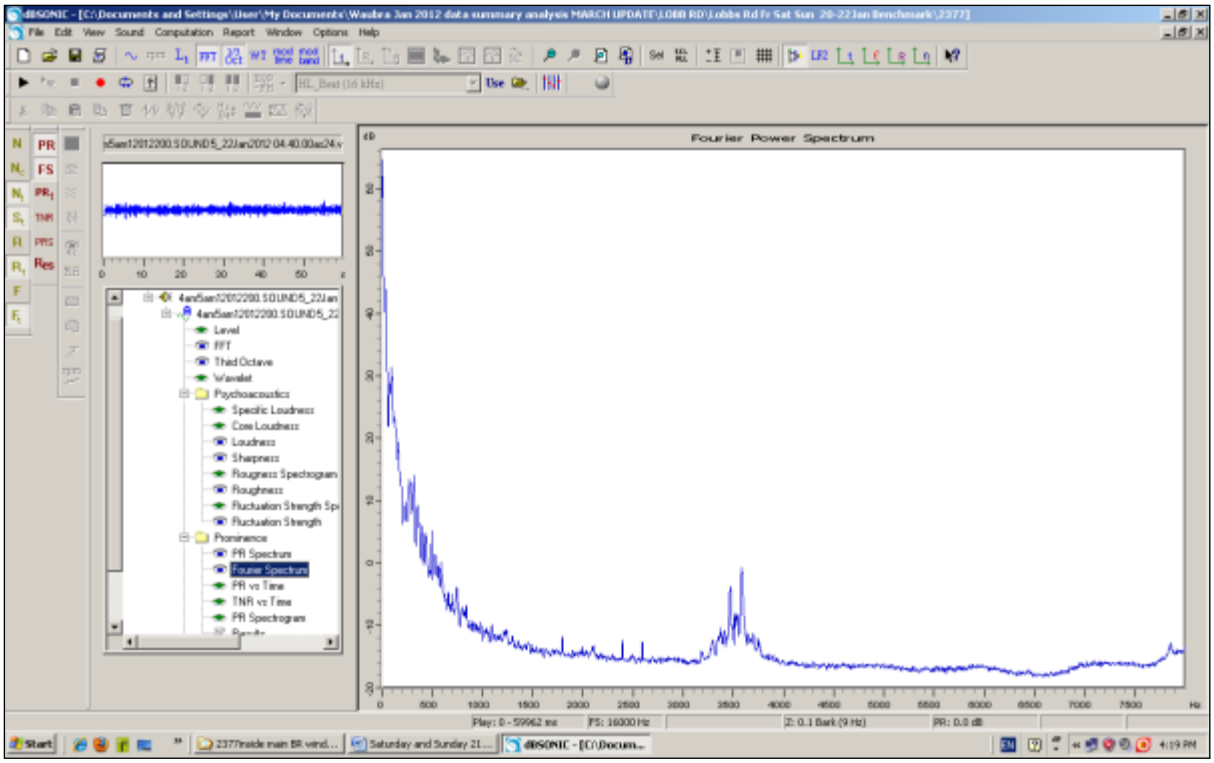
Turbines audible as rumble and clunks, plus insects



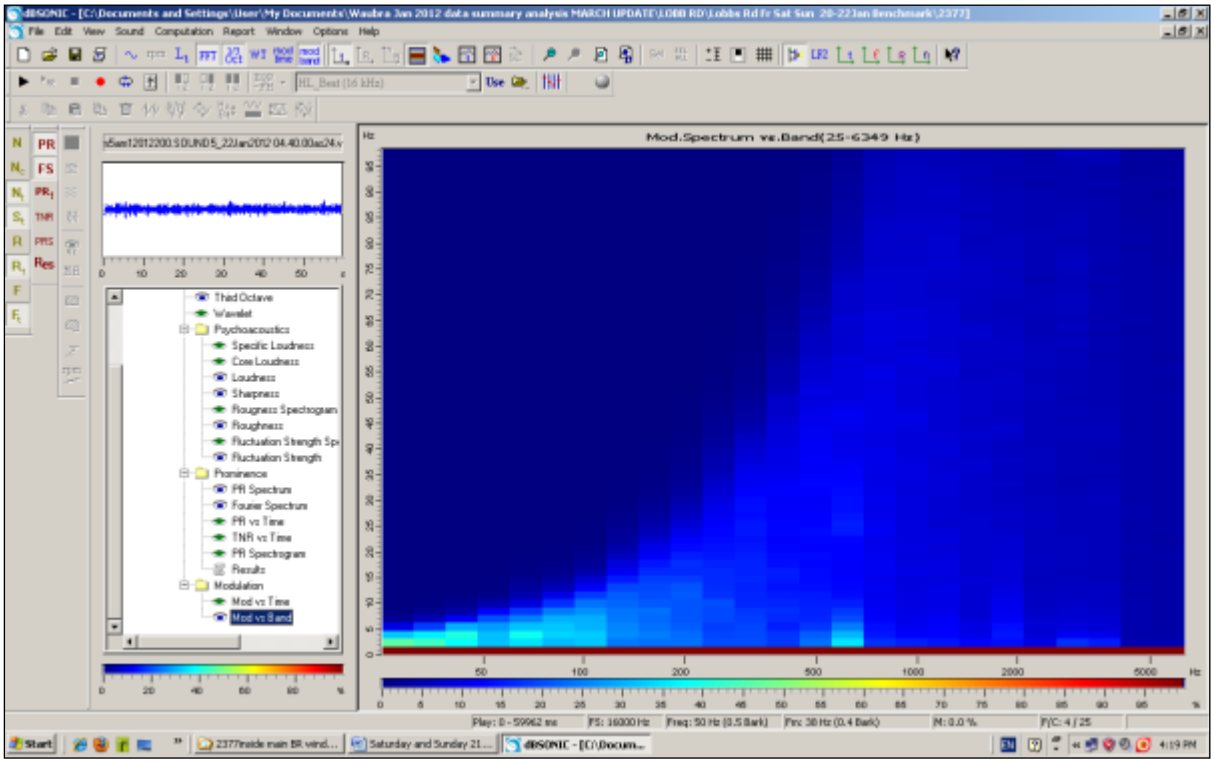
Turbine effect clearly audible



Low frequency modulation clearly evident



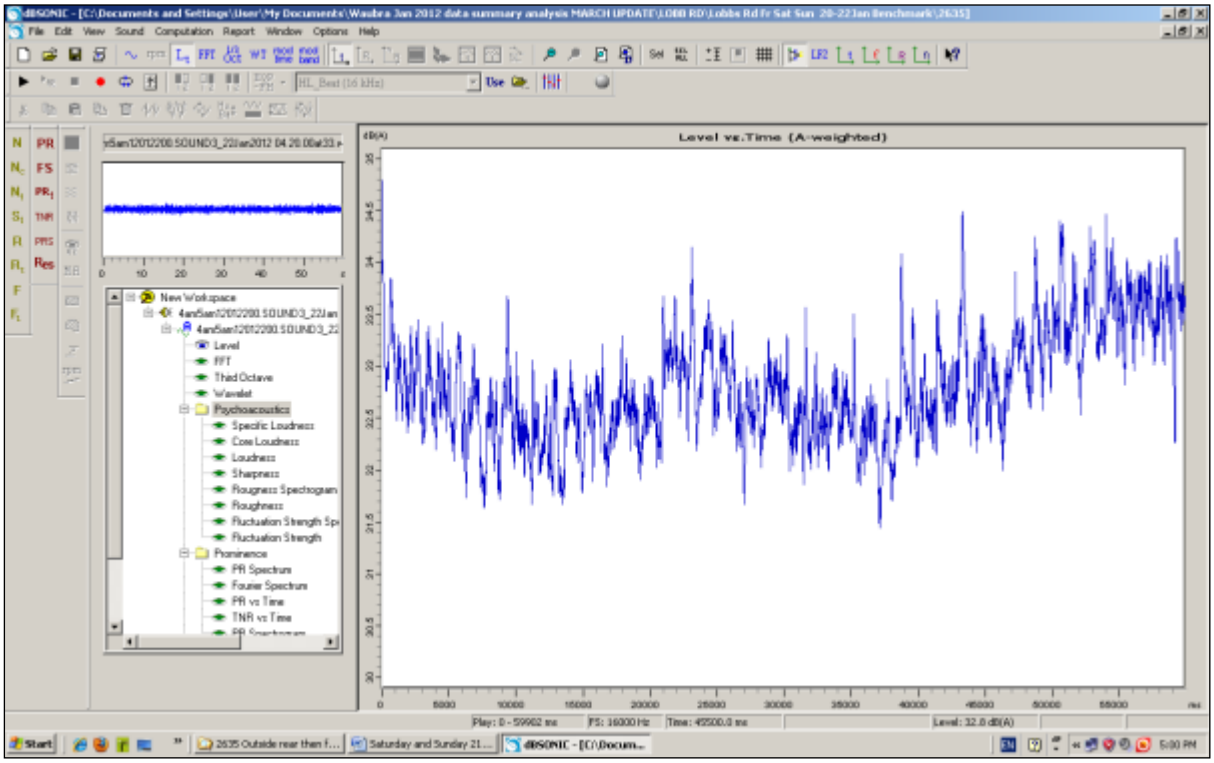
The spectrum shows insects at 3000 Hz



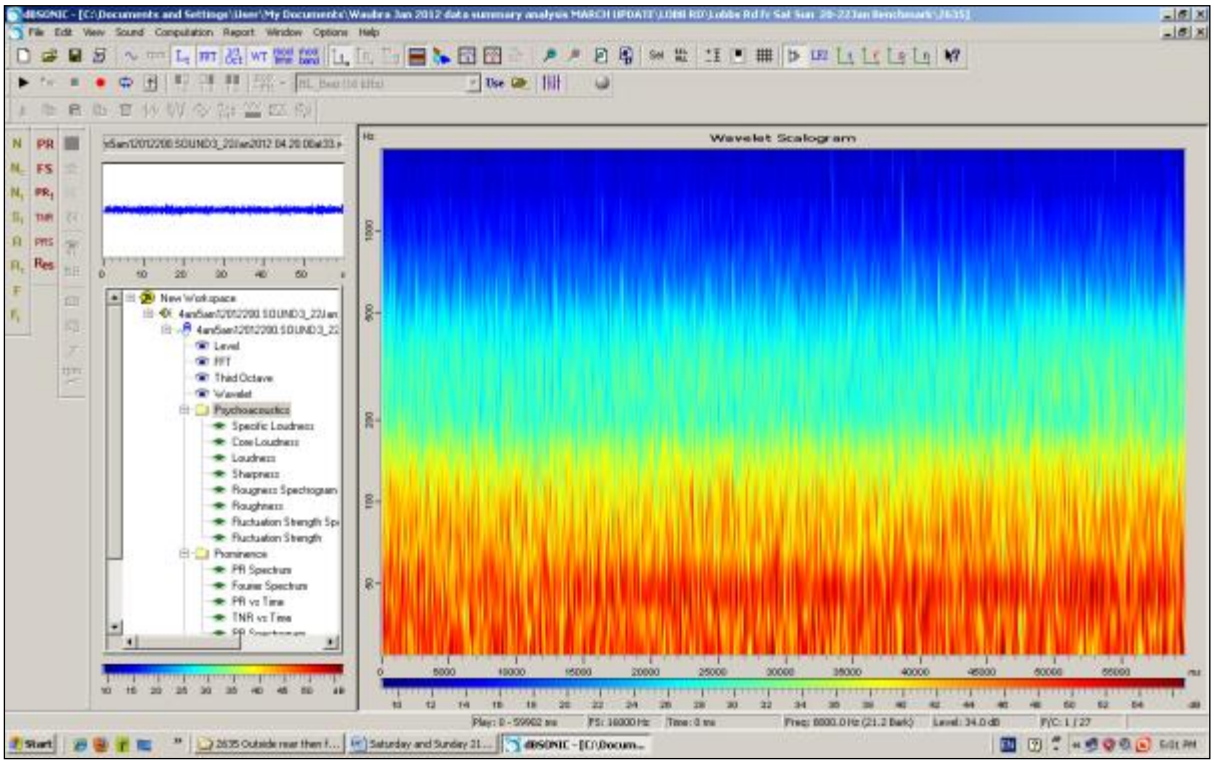
Modulation to 25 Hz is shown in the above chart

Front yard 4:20 am 22 Jan. LAeq 32.7

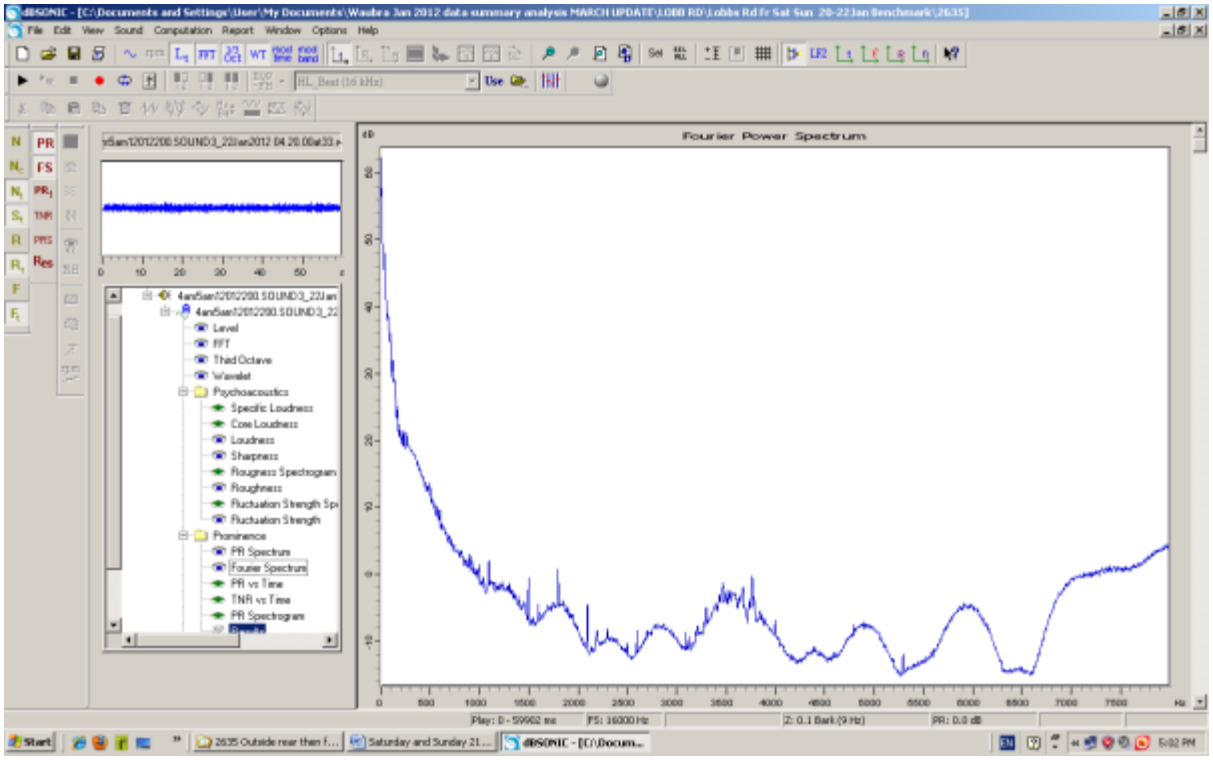
Turbines clearly audible as rumble and clunks. Insects / animal / bird noise loud.



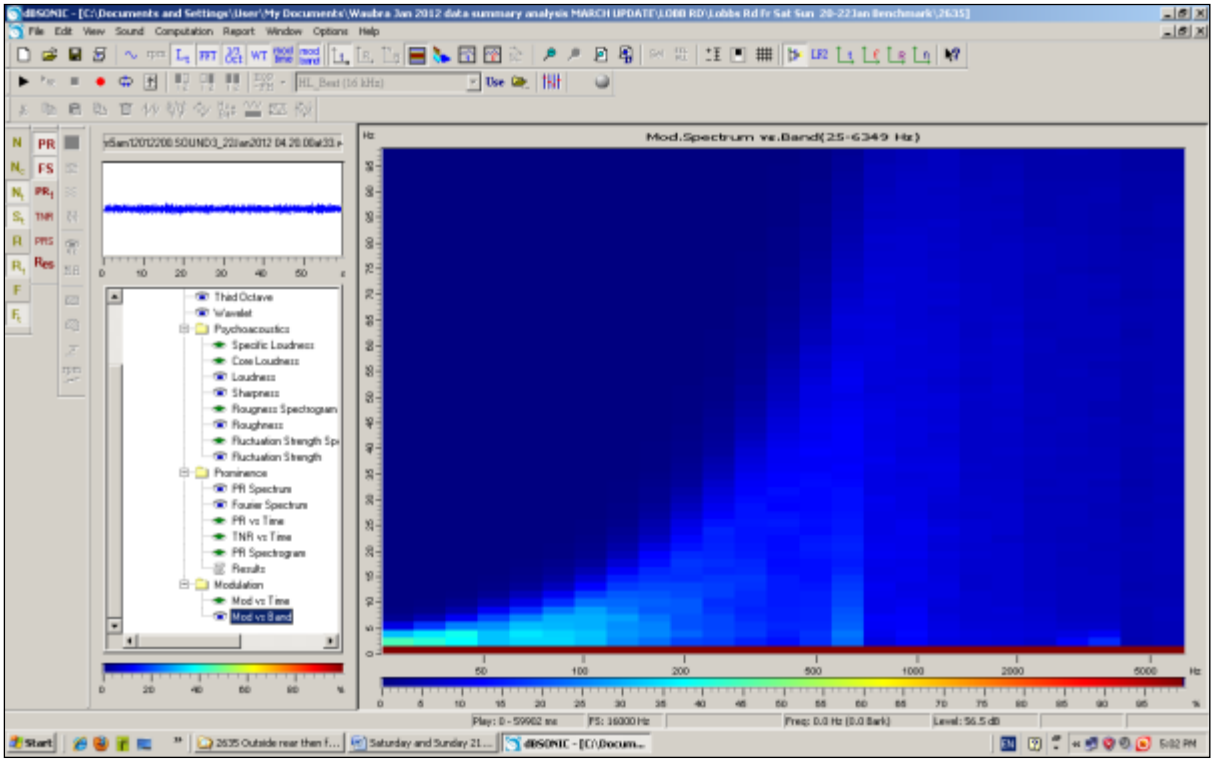
Time history chart showing fluctuating sound levels



Sound character showing modulating low frequency sound



Sound character showing outdoor effect of insects and other life



Modulation showing at 25-50Hz bands

Wind Farm Power Output over the term of the Study

The following chart derived from data on the NEMMCO site illustrates the overall power generation of the Waubra wind farm during the term of the study. This allows an assessment of sound in the environment due to wind farm activity.

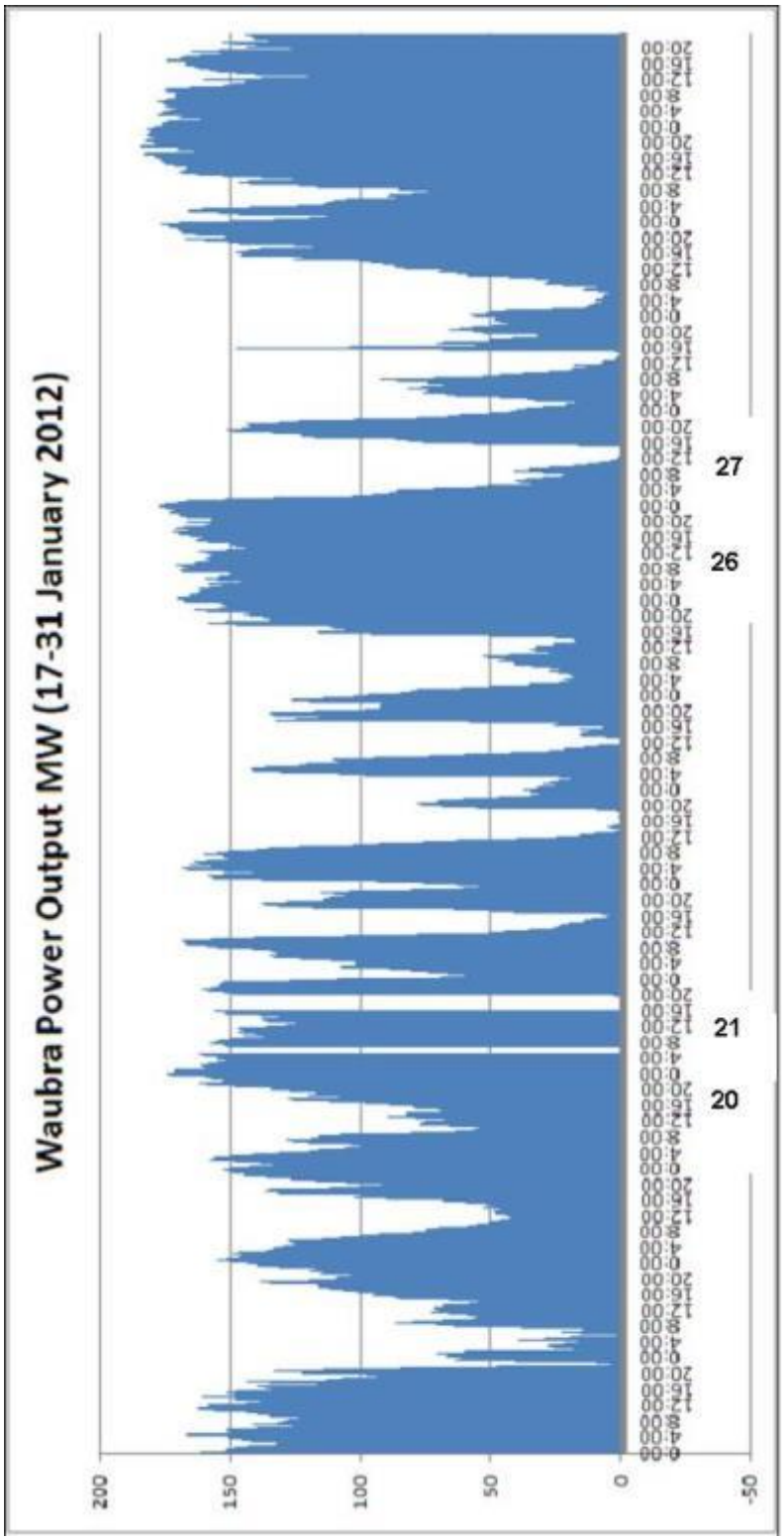
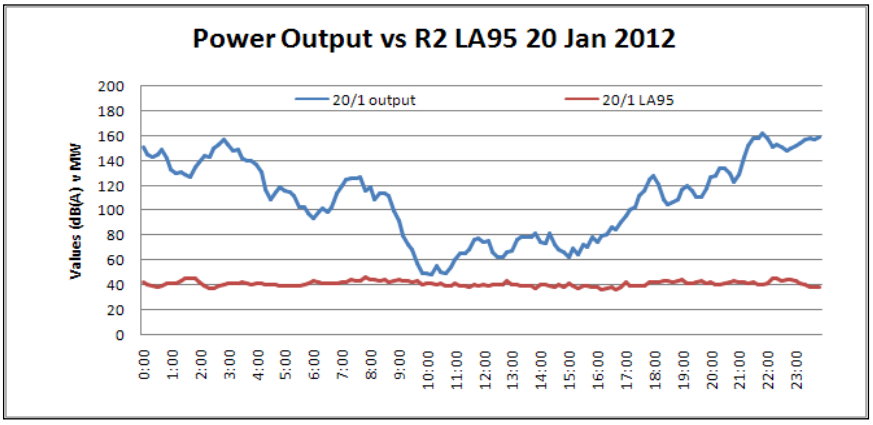
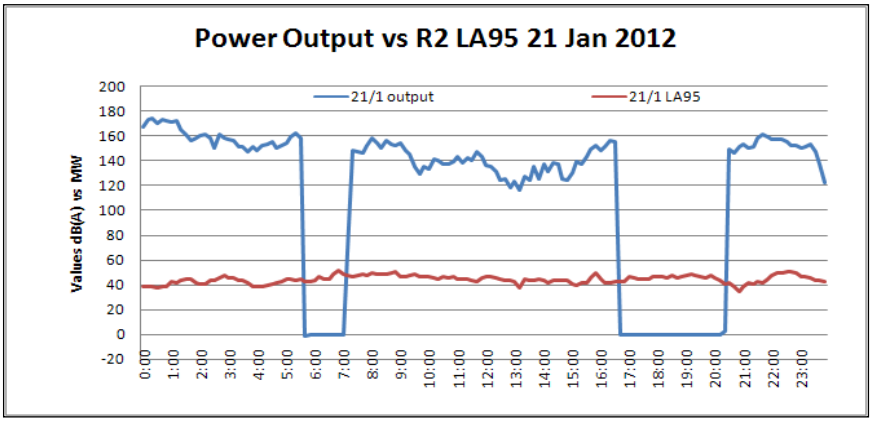
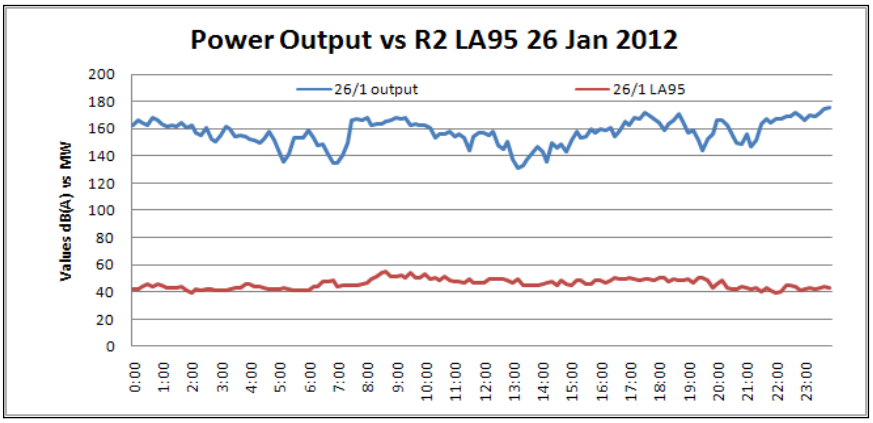


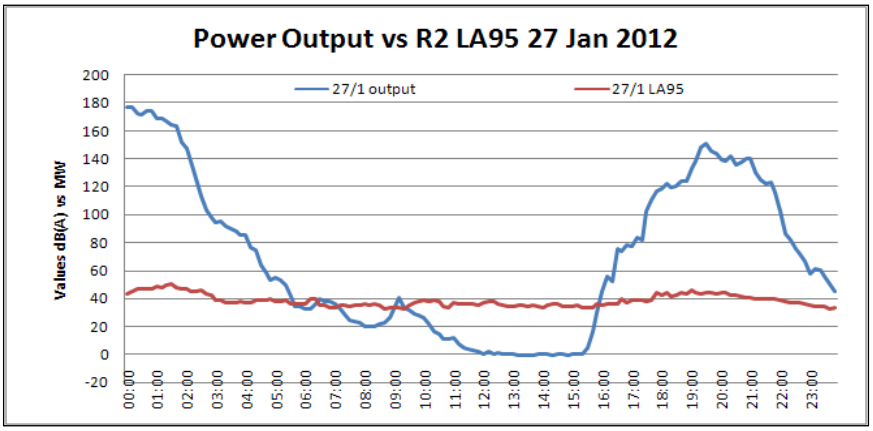
Chart 1: Waubra wind farm power output during the survey 17-31 January 2012 (source NEMMCO) with the dates of the Lobb Rd survey noted

The following charts present the operational power output vs the measured sound levels at residence R2.









Assessment of Waubra Wind Farm at Residence 2

The January 2012 survey employed sound level meters to record sound levels and audio, plus on-site observations. The following figure illustrates the measured background levels with turbines operating at Residence 2 (see following Plate 1 for location). The night-time levels are the most significant as these are the established criterion for compliance. The "pre-construction or non-operational" background level is calculated as 35.5 dB(A) (using the 'average' background level in table 2.1 of this section for Saturday night 21 Jan and Sunday morning 22 January as an example) giving a compliance level of 41 dB(A). Even though the turbines were operating (see the operational power charts in the previous section) these two days give a good range of background levels from a low of 28.2 dB(A) to a high of 50.7 dB(A). The 'background-plus' level of 41 dB(A) is higher than the 'standard' 40 and is therefore referenced as the compliance level.

Measured background levels were recorded in association with physical observations of the operation of the turbines and weather conditions, as well as bird noise and so on. The wind speeds during the recordings at ground level were below 5 m/s and blowing from the south and south-south east; that is, from the southern and eastern turbines to home. The weather was fine and cool. Sound recordings were taken on a regular basis inside and outside the home.

The measured night-time levels for 20, 21, 26 and 27 January are above 40/41 dB(A) and, based on on-site observations, due to wind farm activity. It can be argued that there is a contribution to the background sound levels by tree-leaf noise and so-on. This was not a distinctive feature of the survey and no masking of wind farm noise was observed to the extent that recordings were adversely affected. Taking the NZS6808 background compliance level as 41 dB(A) it is observed that wind farm sound levels exceed the criterion at night.

The observations indicate the sound recorded is turbine-related but ambient noise (birds, insects) confound the measurements. The previous section illustrates the operation of the wind farm and clearly shows that during the day the background levels are not influenced when the wind farm stops operating. This highlights the risk / failure of relying on non-attended monitoring for assessment of compliance. Visual observation of the turbines to the south and east indicates the wind farm was in operation during most of the survey. At night the operation could only be observed by the blades passing and masking the lights on the towers plus audible turbine noise. However, the actual operation of the local turbines should be confirmed as there is no readily discernable relationship between the power outputs and the measured background sound levels.
There is no proven scientific method available to determine the actual contribution of wind turbine noise and the actual contribution of ambient sound using the LA95 measure alone.

The following figure R2.1 illustrates the variation in sound levels over 24 hours for 4 days plus a half-day. The data that informs the figure is provided in Table R2.1. The night-time levels above 41 dB(A) measured as the background level LA95 are marked in yellow. Only the 6 highest time-blocks need to be highlighted to indicate the 10% compliance level.

Therefore, if 7 or more time-blocks are marked there is potential non-compliance. A decision is then made if the sound is fully turbine related or a mix of turbine and ambient sound.

Finally a decision is made if the sound contains special audible characteristics. As the wind farm exhibits special audible characteristics (observed, measured and recorded using objective measures) a penalty of 5 dB must be added to the measured levels.

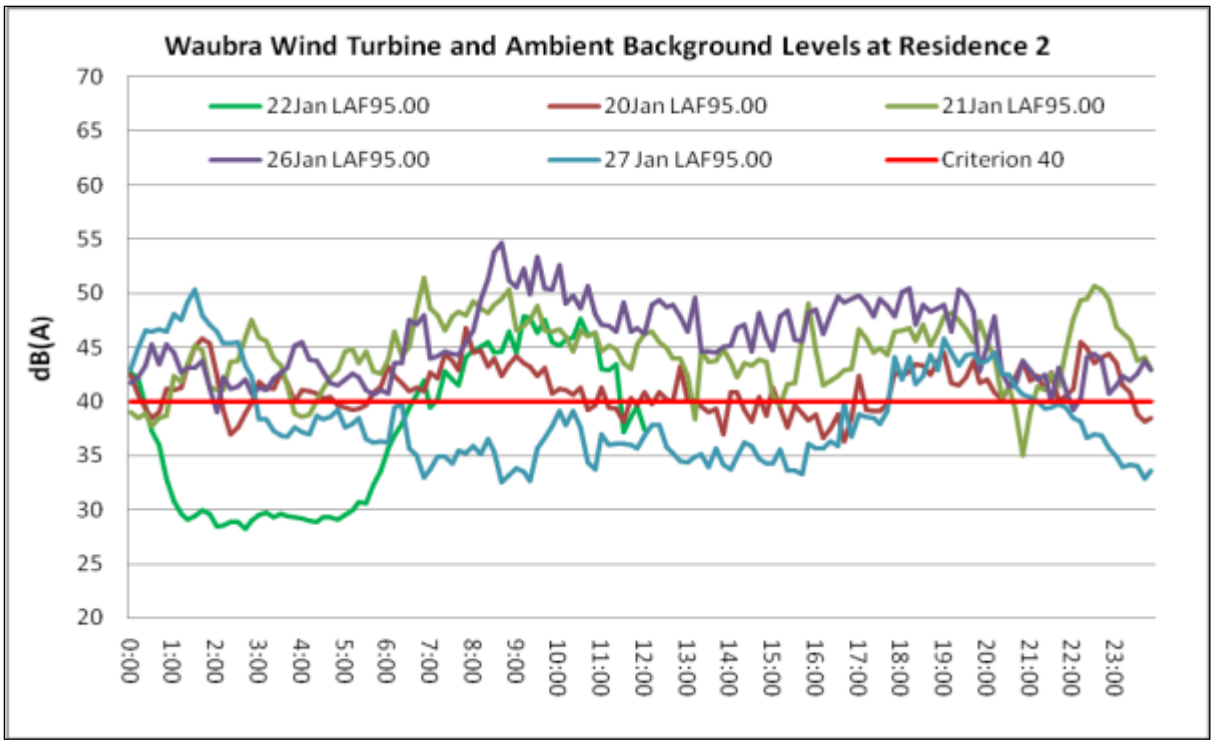


Figure R2.1: Background sound levels at Residence 2

Time	22Jan LAF95.00	20Jan LAF95.00	21Jan LAF95.00	26Jan LAF95.00	27 Jan LAF95.00	Criterion 40
00:00:00	42.7	42.5	39	41.7	43.0	40
00:10:00	42.1	40.6	38.5	42.2	44.9	40
00:20:00	39.5	39.3	38.9	43.3	46.6	40
00:30:00	37.3	38.5	37.7	45.3	46.5	40
00:40:00	36	39	38.5	43.4	46.7	40
00:50:00	32.8	41.2	38.7	45.3	46.5	40
01:00:00	30.8	41	42.3	44.5	48.1	40
01:10:00	29.6	41.3	41.8	42.7	47.5	40
01:20:00	29.1	43.2	43.4	43.1	49.1	40
01:30:00	29.4	45	45.1	43.1	50.3	40
01:40:00	29.9	45.8	44.7	43.8	48.0	40
01:50:00	29.6	45.4	41.4	41.3	47.1	40
02:00:00	28.4	42.3	41.1	39.0	46.4	40
02:10:00	28.5	39.2	41.1	42.2	45.4	40
02:20:00	28.8	36.9	43.6	41.2	45.4	40
02:30:00	28.8	37.6	43.8	41.4	45.5	40
02:40:00	28.2	38.9	45.9	42.0	43.3	40
02:50:00	29	39.9	47.5	40.7	42.3	40
03:00:00	29.5	41.8	45.9	41.3	38.3	40
03:10:00	29.7	41.3	45.6	41.0	38.3	40
03:20:00	29.3	41.2	44	42.1	37.3	40
03:30:00	29.6	42.7	43.3	42.7	36.8	40
03:40:00	29.4	41.7	41.5	43.1	36.7	40
03:50:00	29.3	40	38.9	45.1	37.6	40
04:00:00	29.2	41.1	38.6	45.5	37.2	40
04:10:00	29	40.9	38.8	43.9	36.9	40
04:20:00	28.8	40.7	40.1	43.7	38.7	40
04:30:00	29.3	40.3	41.2	42.8	38.3	40
04:40:00	29.3	40.4	42.2	41.7	38.6	40
04:50:00	29.1	39.7	42.9	41.5	39.2	40
05:00:00	29.5	39.4	44.6	42.0	37.6	40
05:10:00	29.9	39.2	44.8	42.6	37.9	40
05:20:00	30.7	39.3	43.5	42.2	38.5	40
05:30:00	30.6	39.7	44.6	41.1	36.5	40
05:40:00	32.3	40.8	42.8	40.6	36.2	40
05:50:00	33.6	41.4	42.6	41.0	36.3	40
06:00:00	35.7	43.2	43.9	40.7	36.2	40
06:10:00	36.8	42.3	46.5	43.5	39.4	40
06:20:00	37.9	41.7	44.2	43.5	39.8	40
06:30:00	39.4	40.9	45	47.5	35.6	40
06:40:00	40.6	41.3	48.5	47.1	35.0	40
06:50:00	41.9	40.9	51.4	48.0	33.0	40
07:00:00	39.4	42.7	48.6	44.0	33.7	40
07:10:00	40.2	42.1	48	44.2	34.9	40
07:20:00	42.8	44.4	46.6	44.6	34.9	40
07:30:00	42	43.7	47.8	44.4	34.2	40
07:40:00	41.5	42.9	48.3	44.3	35.4	40
07:50:00	44.1	46.8	48	45.5	35.2	40
08:00:00	44.7	44.5	49.3	46.6	35.9	40
08:10:00	45	44.7	48.6	49.4	35.1	40
08:20:00	45.5	43.2	48.2	51.3	36.5	40
08:30:00	44.5	44	48.9	53.8	35.3	40
08:40:00	44.6	42.3	49.5	54.7	32.5	40
08:50:00	46.5	43.4	50.3	51.2	33.2	40
09:00:00	44.5	44.2	46.6	50.6	33.8	40
09:10:00	47.8	43.5	47	52.3	33.5	40
09:20:00	47.7	43.2	47.5	49.9	32.6	40
09:30:00	46.3	42.4	48.8	53.4	35.6	40
09:40:00	47.5	43.1	46.6	50.4	36.6	40
09:50:00	45.5	40.7	46.4	50.3	37.7	40
10:00:00	45.2	41.2	46.7	52.6	39.1	40
10:10:00	45.7	41	46	49.0	37.8	40
10:20:00	45.9	40.6	44.6	49.8	39.1	40
10:30:00	47.6	41.3	46.6	48.6	37.6	40
10:40:00	46.1	39.2	46	50.7	34.4	40
10:50:00	46.3	39.7	46.3	48.1	33.7	40
11:00:00	43	41.3	44.6	47.1	36.9	40
11:10:00	42.9	39.4	45.1	47.0	36.0	40
11:20:00	43.4	39.3	44.8	46.4	36.1	40
11:30:00	37.2	38.1	43.5	49.2	36.1	40
11:40:00	38.6	40.3	43	46.4	36.0	40
11:50:00	39.5	39.7	45.3	46.8	35.6	40
12:00:00	37.4	40.8	46.2	46.2	36.8	40
12:10:00		39.8	46.5	48.9	37.8	40
12:20:00		40.8	45.5	49.4	37.8	40
12:30:00		40.2	44.9	48.7	35.8	40
12:40:00		40	44	48.9	35.2	40
12:50:00		43.2	44	47.9	34.5	40
13:00:00		40.1	42.4	46.4	34.4	40
13:10:00		40.1	38.3	49.6	34.9	40
13:20:00		39.5	44.7	44.6	35.1	40
13:30:00		39	43.6	44.6	33.9	40
13:40:00		39.3	43.7	44.5	35.6	40
13:50:00		37	44.8	45.0	34.1	40
14:00:00		40.8	43.6	45.2	33.7	40
14:10:00		40.8	42.2	46.8	34.9	40
14:20:00		39.2	43.5	47.1	36.2	40
14:30:00		38.1	43.3	44.6	35.9	40
14:40:00		40.4	43.9	48.2	34.7	40
14:50:00		38.7	43.6	45.9	34.2	40
15:00:00		41.3	40.5	44.7	34.2	40
15:10:00		39.4	39.7	47.8	35.5	40
15:20:00		37.6	41.6	48.4	33.6	40
15:30:00		39.6	41.7	45.7	33.6	40
15:40:00		38.9	45.8	45.6	33.3	40
15:50:00		38.2	49	48.2	36.1	40
16:00:00		38.8	44.7	48.5	35.6	40
16:10:00		36.6	41.5	46.2	35.7	40
16:20:00		37.5	41.9	48.1	36.3	40
16:30:00		38.8	42.3	49.7	35.9	40
16:40:00		36.3	42.9	49.2	39.9	40
16:50:00		38.5	43	49.5	36.7	40
17:00:00		42.3	46.7	49.8	38.8	40
17:10:00		39.2	45.8	49.0	38.6	40
17:20:00		39.1	44.5	47.9	38.5	40
17:30:00		39.1	44.9	49.5	37.9	40
17:40:00		39.8	44.3	48.8	39.1	40
17:50:00		42.7	46.5	47.9	44.1	40
18:00:00		42.3	46.6	50.1	42.0	40
18:10:00		42.8	46.8	50.4	44.1	40
18:20:00		43.4	45.6	47.1	41.6	40
18:30:00		43.3	47.1	48.9	42.4	40
18:40:00		42.5	45.2	48.3	44.3	40
18:50:00		43.7	46.4	48.6	42.9	40
19:00:00		44.5	47.9	48.9	45.8	40
19:10:00		41.7	48.2	46.5	44.5	40
19:20:00		41.5	47.5	50.3	43.3	40
19:30:00		42.2	46.7	49.8	44.3	40
19:40:00		43.7	45.5	48.3	44.4	40
19:50:00		41.7	47.4	42.8	43.5	40
20:00:00		42	45.5	45.2	43.7	40
20:10:00		40.8	44.1	47.9	44.5	40
20:20:00		40.2	40.4	42.7	42.6	40
20:30:00		41.4	41.3	41.4	42.5	40
20:40:00		42.2	39.2	41.5	41.4	40
20:50:00		43.7	35	43.8	40.6	40
21:00:00		41.9	39	42.9	40.4	40
21:10:00		42.4	41.4	42.0	40.0	40
21:20:00		41	41.1	42.5	39.3	40
21:30:00		42.7	42.6	40.0	39.4	40
21:40:00		40.1	41.4	43.1	39.8	40
21:50:00		40.5	44.7	41.1	39.4	40
22:00:00		41.2	47.6	39.2	38.5	40
22:10:00		45.5	49.4	40.3	38.1	40
22:20:00		44.9	49.5	44.1	36.6	40
22:30:00		43.5	50.7	44.4	37.0	40
22:40:00		44.1	50.3	43.9	36.8	40
22:50:00		44.4	49.4	40.7	35.7	40
23:00:00		43.5	46.9	41.5	34.9	40
23:10:00		41.5	46.3	42.3	33.9	40
23:20:00		40.8	45.7	41.9	34.1	40
23:30:00		38.8	43.8	42.6	34.0	40
23:40:00		38.1	44.1	43.8	32.9	40
23:50:00		38.5	43	42.9	33.6	40

Table R2.1 Background levels

Assessment for Compliance

The measured and observed levels can therefore be reviewed for potential compliance or non-compliance with the background-plus criteria and special audible characteristics both considered. For the purposes of this Report the non-turbine night-time background level is assessed as 36 dB(A) giving a background plus criterion of 41 dB(A) and compliance is assessed in Tables R2.2 and R2.3.

Table R2.2: Assessment for Compliance or Non-compliance, by 10 minute Night-time recordings; the LA95 criterion is 41 dB(A)

Date	Average LA95	In compliance	7th Highest LA95 value	In compliance
20	40.8	Just	42.6	No
21	42.7	No	45.6	No
26	42.7	No	45.1	No
27	39.9	Yes	46.7	No

Special audible characteristics are recorded so the 5 dB(A) penalty is applied, Table 2.3.

Table R2.3: Assessment for Compliance or Non-compliance, by 10 minute Night-time recordings; the LA95 criterion is 41 dB(A); special audible characteristics (SAC) penalty of 5 dB(A)

Date	Average LA95	With SAC	In compliance	7th Highest LA95 value	With SAC	In compliance
20	40.8	46	No	42.6	48	No
21	42.7	48	No	45.6	51	No
26	42.7	48	No	45.1	50	No
27	39.9	45	No	46.7	52	No

Observation

Sound from the Waubra wind farm, when measured at residence 2, Lobbs Road, exceeds the night-time criteria and is therefore considered to be **non-compliant** on a frequent and regular basis with or without the special audible characteristics penalty applied under NZS6808.

Annex C

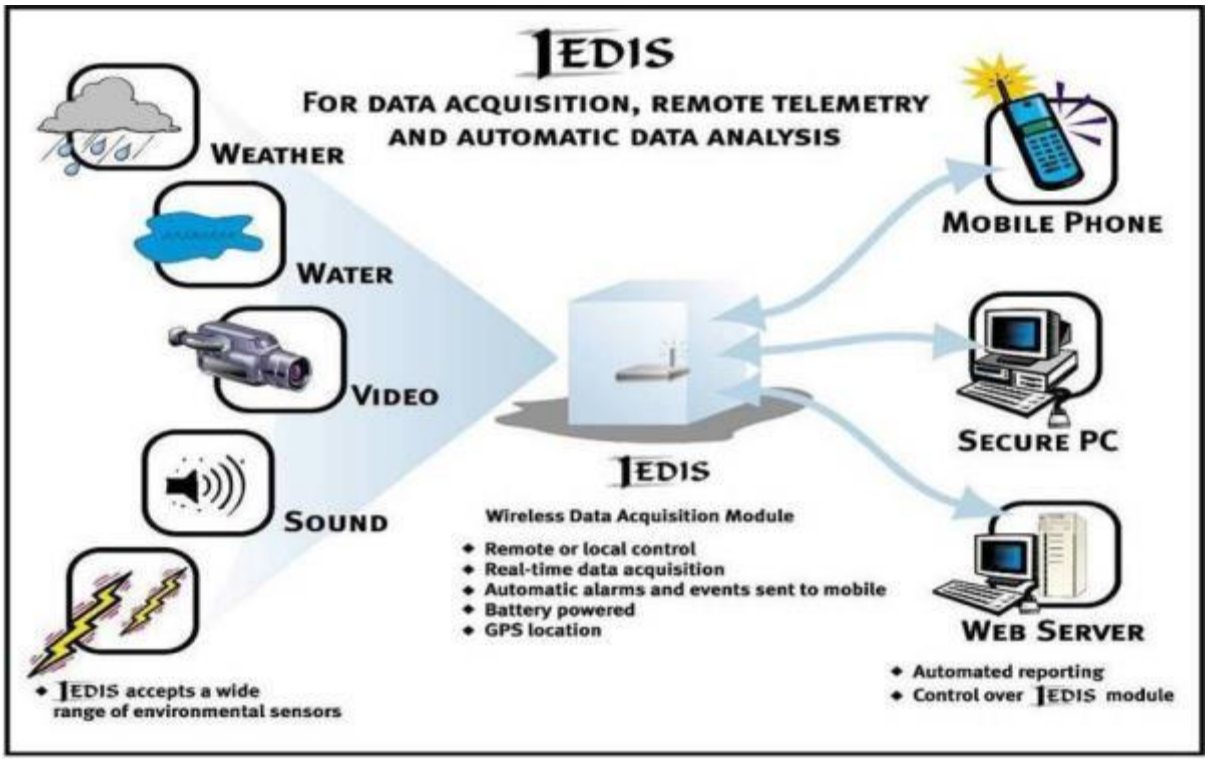
NZS6808:1998 - instrumentation for sound measurement

The question was asked during the study: 'what do you use to measure wind farm noise and how much does it cost?'. This Annex answers that question. Measurement of sound levels under NZS6808 is in two parts:

(a) Measurement of valid background and turbine sound levels; and

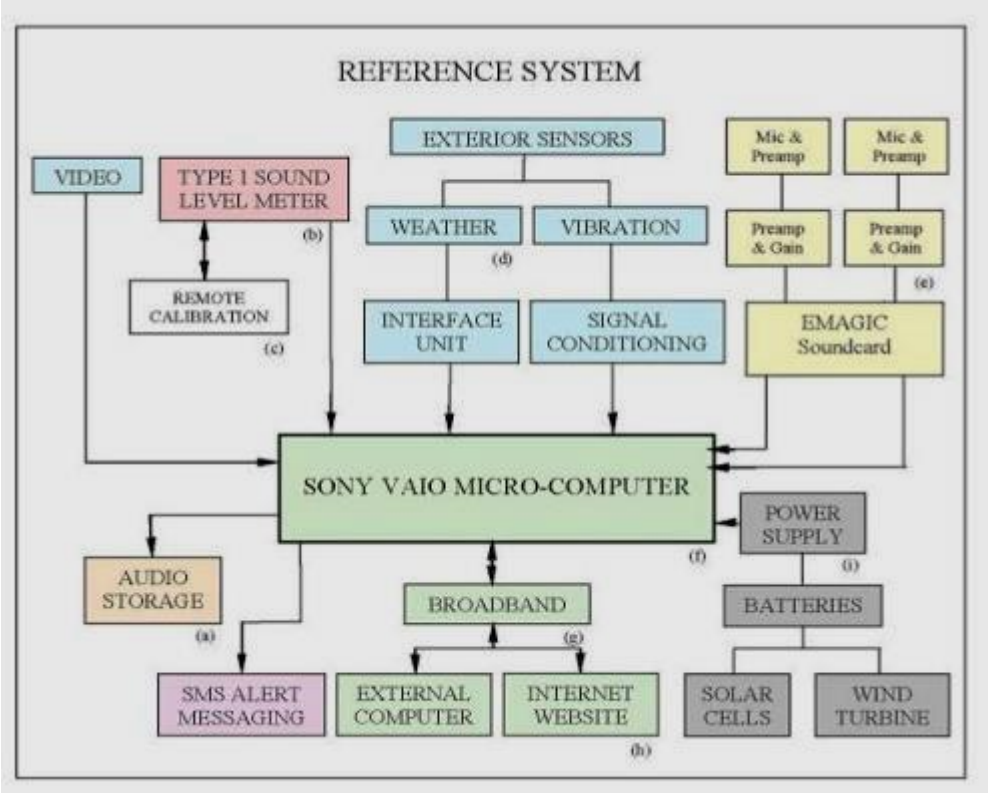
(b) Measurement of special audible characteristics.

Noise Measurement Services Pty Ltd implements *IEDIS* (Intelligent Environmental Data and Interfacing Systems) to complement the AcouSTAR measurement, assessment, training and reporting methodologies. Accurate background (L95) measurements under NZS 6808 requires continuous A-weighted sound recordings in 10-minute blacks, day and night. Additional recordings are required for third-octave or narrow band analysis plus sound-files to determine special audible characteristics and to identify turbine sound as distinct from confounding sound such as wind in vegetation, insect and animal noise. Weather data with wind speed and direction is required for correlation to the sound level measurements. Video may be required to validate turbine operation. In order to reduce on-site data analysis datafiles are processed and sent automatically to remote servers, emails or mobile phone. Standard acquisition is presented in the following figure:



Technical Capability of Measurement Systems

1. Standard, Customised and Turn-Key systems are available from different manufacturers. A customised noise monitoring system is designed, for example, to record Lmax, Lpeak, Leq, SEL, and statistical (e.g. L99 to L1) noise level indices in broad band and 1/1 and 1/3 octave band data (6.3 Hz to 20kHz) in defined time intervals [programmable times: 10ms, 50ms, 100ms, 1s, 10s, 30s; 1, 5, 10, 15, 60 minutes; 24-hr], Ldn, Lden.
2. Standard noise level indices are recorded with two of A-weighting, C-weighting and Z-weighting frequency profiles. 'G' weighting can be calculated.
3. Identification of noise sources is provided through soundfile recording and live real-time audio streaming a remote data connection.
4. The system is designed to record audio (.wav or Apple lossless format) either continuously, during defined programmable periods (preferred) or using a noise level trigger. Sound files are recorded at 48kHz 24-bit (or 44.1kHz 16-bit as a minimum) sampling for narrow band analysis, sound quality analysis and infrasound measurements (0.5 Hz to 100Hz) with data storage in time-stamped measurement blocks.
5. A typical system is shown in the following figure:



System Costs

The cost of systems varies depending on features required. A standard Larson Davis 831 system (for example) configured for sound recording and logging with automatic data return to website or email, solar panel, an outdoor case and weather station is approximately $22,000 plus GST. Less expensive NATA calibrated systems from other manufacturers that do not have remote access reporting functions are available from $5300 plus GST.

Annex D

Reference – Marshall Day Waubra compliance assessment

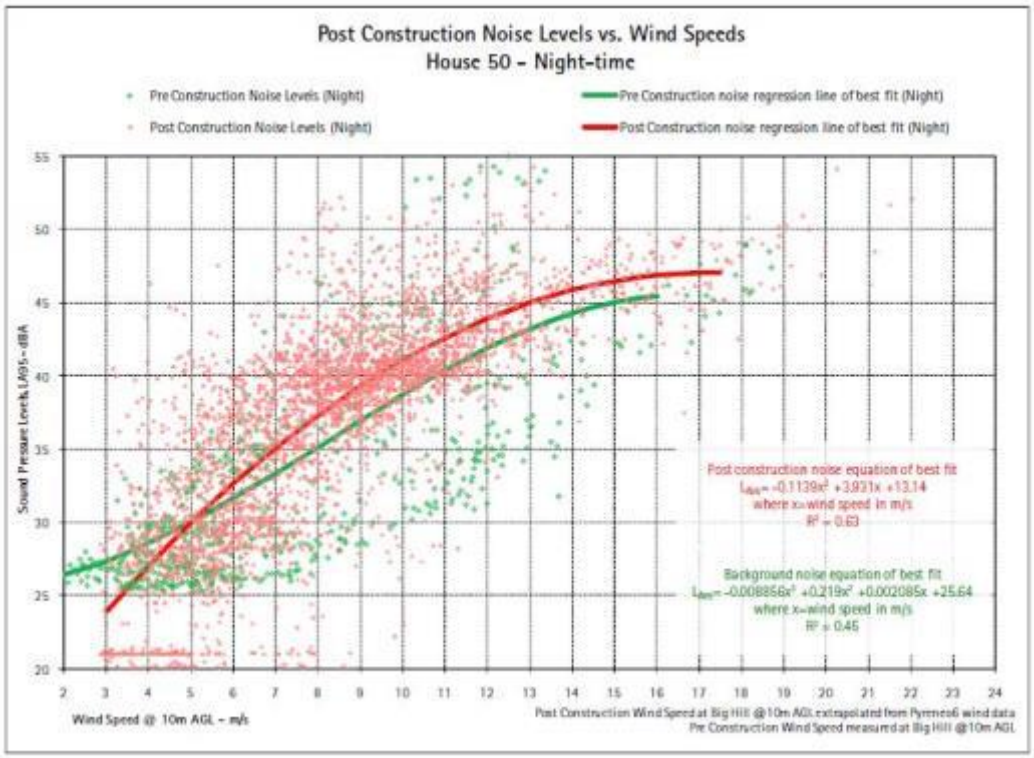
A common question that participants in the study asked is: "Is the wind farm complying with its approval conditions?" To help address this question the 2010 Waubra wind farm compliance report RP001-2009107 prepared by Marshall Day Acoustics was reviewed. Compliance is assessed under NZS6808 as: "To determine conformance with the [approval limits] a comparison shall be made between the best fit regression line of the background sound levels and the regression curve of the operational wind farm corrected for any special audible characteristics". Although NZS6808:1998 applies regression curves for data-fitting the standard does not state the treatment of uncertainty, the treatment and recognition of a valid spread of values, and the treatment of outliers. Condition 14(c) of the development approval for Waubra does not require regression analysis of sound levels. It is a specific condition applying specific percentile analysis to determine compliance.

The application of regression curves for background levels and operational levels is illustrated by reference to night-time noise levels for the Waubra wind farm given in the 2010 Marshall Day Acoustics Waubra compliance report RP001-2009107. The following Plate H50 presents an example of preconstruction and operational sound levels with a measured spread (10 minute night-time LA95 calculation intervals) over two weeks', a relatively short period of time compared to the seasonal variations over (for example) 12 months. NZS6808 does not state how preconstruction background LA95 sound levels taken at a fixed time under fixed weather conditions are relevant to post-construction operational background sound levels taken at another time and under different weather conditions.

Background measurements require regression analysis if and when 14 days of measurements are acquired. The regression data is clearly one of the weaknesses of the system, but it should not be if it is used effectively. If not applied effectively the standard allows the regressions to be used such that the error factors are so large, the results become meaningless yet meet the criteria of the standard. To understand wind turbine sound the regressions of wind speed vs sound must be determined for the different compass directions and speeds. Wind noise from the north, for example, will not be the same as the wind for the southwest. So when the data is combined the variability of the data is confounded (i.e. mixed together). The direction of the wind will present a different audible sound character and sound level yet by putting all the data together for all the wind directions, it implies there is a single wind condition and sound character that drives 'noise'. This is incorrect and the issue has been discussed in the 'regression analysis' section of this report. Significantly, 10 to 14 days of on-site measurements cannot represent 12 months. One of the reasons that 10-14 days has been considered acceptable is the number of data points measured in the 10-14 day period. A few hundred data points in a small window of time do not, however, give good prediction of what is to be expected over the time period of 12 months. The argument is that the hundreds of points give acceptable regression coefficients (i.e. measurements of precision). This is only partly true, the more data points the more precise the measurements. What isn't true is that the precision can be used to predict the accuracy of the model or measurements over 12 months.

The sound levels for the night-time periods are the most critical. There are occasions when insect noise and bird song is very noticeable and these levels are normally excluded. Plate H50 from the Marshall Day report presents night-time background and operational sound levels.

Plate H50 - Example of a sound level dataset and regression curves



There is no evidence in the Marshall Day report to identify recorded sound levels for content. The background levels and compliance levels cannot, therefore, be verified as being in accordance with the standard. The Marshall Day report shows that compliance depends on the interpretation of the data. It is clear from Plate H50 that the operational levels for night-time consistently exceed the compliance levels at dwelling H50, adjusted for wind speed with and without special audible characteristics. Plate H50 provides a quick visual assessment of the measured levels and the regressions curves. The scatter data presented in Plate H50 show a significant number of red dots (post-construction 10 minute sound levels) at least 5 dB above the green preconstruction regression curve. Confidence curves should be calculated differently when the data is being predicted vs confidence intervals on actual data. Prediction curves should be larger than actual confidence intervals on measured data. The night-time dataset of Plate H50 is chosen as an example to test the application of the compliance protocol:

1. The sound level from the wind energy facility, when measured outdoors within 10 metres of a dwelling at any relevant nominated wind speed, should not exceed the background level (L95) by more than 5 dBA or a level of 40 dBA L95, whichever is the greater;
2. When sound has special audible characteristics, the measured sound level of the source shall have a 5 dB penalty added; and
3. Compliance at night must be separately assessed with regard to night-time data. For these purposes the night is defined as 10:00pm to 7:00am. **For sleep protection purposes, a breach of the standard set out in (2), for 10% of the night, amounts to a breach of the condition.**

The scatter data and regression curves in the Plate are insufficient in themselves to determine with certainty compliance or non-compliance with the approval conditions. There is, in fact, no certainty that the measured data preconstruction or post-construction are measuring "like-with-like". There is no indication given as to the 'quality' of the data and whether it has been influenced by significant sources of noise such as from insects/birds/animals/vegetation/other extraneous noise

that characterised the ambient soundscape at the time of recording. The preconstruction background levels below 25 dB(A) are significantly higher than the post-construction levels indicating mismatched recording instruments or ambient conditions. Special audible characteristics are identified in the standard (clearly audible tones, impulses or modulation of sound levels) and must be assessed continuously along with the LA95 data. The data must be recorded in the correct location, exclude extraneous noise and be analysed on a 'nightly' basis, 24/7, in accordance with the approval conditions. The data in Plate H50 is, therefore, the start of the compliance assessment, not the final outcome.

Plate H50 indicates **potential non-compliance** over 10% in night-time from 10pm to 7am at wind speeds above 7m/s **with** the 5 dB penalty for special audible characteristics and above 9m/s **without** the penalty for special audible characteristics.

Annex E

Quality of Life - Instruments and Summary of Responses

1. Introduction

Health is multifaceted and encompasses not only disease and infirmity but also wellbeing. Numerous factors interact to influence health and wellbeing, including biological (e.g., genetic makeup), lifestyle (e.g., diet), and environmental (e.g., noise pollution) factors. Noise, defined as an unwanted sound, is recognised as an environmental factor negatively impacting health.

In the context of wind farm activity recorded in this Report serious harm to health – also termed significant adverse health effect – is experienced by vulnerable individuals.

The study presented a range of objective instruments to assess individual quality of life, health effects and perception of the environment and wind farm noise. The following instruments are acknowledged:

- *World Health Organisation Quality of Life Assessment*, WHO-BREF New Zealand Version 2010; applied and analysed by Dr Daniel Shepherd, Auckland University of Technology.
- *SF-36v2 Health Survey*, Quality Metric Inc, demo version and analysis from http://www.qualitymetric.com/demos/TP_Launch.aspx?SID=100#
- Noise Sensitivity Questionnaire (NoiSeQ); Schütte M et al. *The development of the noise sensitivity questionnaire*, Noise and Health, Jan-Mar 2007, Vol 9, pp.15-24; German sensitivity norm; as stated in Thorne[3].
- *Epworth Sleepiness Scale*, http://epworthsleepinessscale.com/
- *Pittsburgh Sleep Quality Index*, http://www.sleep.pitt.edu/content.asp?id=1484&subid=2316
- *Environmental Noise Annoyance*, Amended Questionnaire as stated in Thorne.
- *Sound Character and Perception*, Questionnaire and Soundfiles as stated in Thorne.
- Questionnaires relating to *Sleep, Headaches, Before and After turbines were installed*, Dr Michael M. Nissenbaum M.D., Maine, USA.

All questionnaires were administered personally after discussions with each respondent and collected by the Author. Respondents completed the surveys independently in their own time, and no incentives were offered. It was each person's choice whether or not a specific instrument would be completed. The responses were recorded into spreadsheets and analysed. Not all the recorded data is presented in this Annex. The questionnaires and summary analysis follow.

2. Participants

The participants were 23 adults residing in rural locales nominally within 1000 to 3500 metres of clusters of 3 or more wind turbines. Two participants were chosen from a locale that does not currently have wind turbine activity. Participants were selected on the basis of health concerns evidenced through statutory declarations, submissions to hearings or through the research program interview process. Two participants were chosen from a locale that does not currently have wind turbine activity. The survey instruments were interviewer-assisted and then self-administered as respondents had sufficient reading ability and understanding to complete the instruments. The demographic profile of the respondents is reported in Table 1.

[3] Thorne, R., (2007). Assessing intrusive noise and low amplitude sound. Doctoral thesis and analysis software, Massey University, Palmerston North, New Zealand. Access from: *http://kea.massey.ac.nz/search~S1?/aThorne+Robert/athorne+robert/1%2C2%2C2%2CB/frameset&FF=athorne+robert&1%2C1%2C*

Table 1. Demographic characteristics of participants (*n*=25).

Variable	Category	Number	Percent
Sex	Male	13	52
	Female	12	48
Age	25 - 34	1	4
	35 - 44	2	8
	45 - 54	10	40
	55 - 64	8	32
	65 - 74	0	0
	75 and over	4	16
Martial	Married	20	80
	Single	4	16
	Widowed	1	4
Education	High School	9	36
	Technical	12	48
	University	4	16
Occupation	Employed	16	64
	Retired/Sick	4	16
	Unemployed	4	16
	Householder	1	4
Total		25	100

In practice the respondents were grouped in 4 distinct locales: one set of respondents in a longitudinal section of road stretching between 3 sets of turbines; one set fully surrounded by turbines; one set affected primarily by one block of turbines; and one set affected by a string of turbines. The wind farm locales, turbine placement and respondent locales are reported in the noise prediction plates of this study.

3. Instruments – WHOQOL BREF

In addition to items requesting demographic information, the survey contained three self-report assessments, providing measures of HRQOL, noise annoyance, and noise sensitivity. Participants were asked to make their ratings with respect to the previous two weeks. Health-related quality of life was assessed using the World Health Organization Quality of Life (short-form) scale, the WHOQOL-BREF. The WHO[4] defines quality of life as:

> "an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns. It is a broad ranging concept affected in a complex way by the person's physical health, psychological state, personal beliefs, social relationships and their relationship to salient features of their environment" (p. 1404).

Quality of life, as defined above, is a multifaceted concept, and thus the WHOQOL-BREF produces a descriptive multi-dimensional profile of HRQOL, not a single index. The WHOQOL-BREF consists of 26 items divided into four domains: physical health (7 items), psychological wellbeing (6 items), social relationships (3 items), and environmental factors (8

[4] The World Health Organization quality of life assessment (WHOQOL): Position paper from the World Health Organization. Social Science & Medicine **1995**, 41, 1403-1409

items). There are two additional items probing overall quality of life and self-rated health. All 26 items in the WHOQOL-BREF are rated on a five point Likert-type scale. A low score on any domain or item equates to negative evaluations of that aspect of life, while a high score indicates a positive evaluation. The BREF is well suited to public health use, and the inclusion of environmental items extends the WHOQOL-BREF beyond traditional HRQOL measures which lack such perspective. The WHOQOL-BREF has excellent reliability and validity.

The WHOQOL-BREF produces four domain scores. There are also two items that are examined separately: an individual's overall perception of quality of life and an individual's overall perception of his or her health. Domain scores are scaled in a positive direction (i.e. higher scores denote higher quality of life). The mean score of items within each domain is used to calculate the domain score.

4. Instruments – SF36v2

The online Demo version of the SF36v2 Questionnaire was applied as an adjunct to the WHOQOL-BREF. The SF36v2 Questionnaire is a multi-purpose, short-form health survey that, for the purposes of this report, has application as part of the International Quality of Life Assessment (IQOLA) Project. It yields an 8-scale profile of functional health and well-being scores as well as psychometrically-based physical and mental health summary measures and a preference-based health utility index: physical functioning (10 items) social functioning (2 items) role limitations due to physical problems (4 items), role limitations due to emotional problems (3 items), mental health (5 items), energy/vitality (4 items), pain (2 items), and general health perception (5 items). Two standardised summary scores are calculated from the SF-36; the physical component summary (PCS) and the mental health component summary (MCS). The summary scores of the questionnaire are presented with both the online US-Demo and the Australian norm noted to support or clarify clinical impressions for individuals, rather than as a population study.

5. Instruments – NoiSeQ

Noise sensitivity was estimated using the Noise Sensitivity Questionnaire (NoiSeQ) scale which measures global noise sensitivity as well as sensitivity for different domains of everyday life: leisure, work, sleep, communication, and habitation. The subjective experience of annoyance represents the most frequent human reaction to noise. Different levels of annoyance show considerable inter-individual variations and are ascribed to the differences in the noise sensitivity. Noise sensitivity is considered as a stable personality trait, which affects an individuals' reactivity toward noise sources. According to the results of psycho-acoustic studies, noise sensitivity has no relation to auditory acuity but reflects a judgmental, evaluative predisposition towards the perception of sounds. The NoiSeQ questionnaire was presented and global noise sensitivity is computed as the average of the leisure, work, habitation, communication and sleep subscales, with higher means indicating greater sensitivity. The survey was analysed[5] to categorize respondents into 'more than average', 'average' and 'less than average' noise sensitive persons.

The WHOQOL study also incorporates a noise sensitivity instrument.

[5] The survey norm was established by Dr Schütte referencing a decision study (D study) of 288 persons in Germany to establish the range of sensitivities. The calculation procedure for the confidence interval is found in Cardinet, J, Tourneur, Y & Allal, L 1976 *The symmetry of generalizability theory: Application to educational measurement*, Journal of Educational Measurement, 13, 119-135.

6. Instruments – Sleep Disturbance

The significant concern with respect to sleep disturbance was assessed through application of the Pittsburgh Sleep Quality Index (PSQI), the Epworth Sleepiness Scale (ESS) and the Nissenbaum sleep quality – health effects questionnaire.

The Pittsburgh Sleep Quality Index is scored on the basis of 7 components: Subjective sleep quality; Sleep latency; Sleep duration; Habitual sleep efficiency; Sleep disturbances; Use of sleeping medication; and daytime dysfunction. Sleep problems commonly co-occur with anxiety and changes in mood (especially depression). All scores are combined according to the scoring criteria included with the form to produce a Global PSQI Score. Scores above 5 indicate clinically meaningfully disturbed or poor sleep.

The Epworth Sleepiness Scale is used to assess the level of daytime sleepiness. A score of 10 or more is considered sleepy. A score of 18 or more is very sleepy. General environmental awareness was investigated to standard measures. The Nissenbaum sleep quality – health effects questionnaire provides supplemental questions relating to headaches and satisfaction ratings before and after the turbines went online.

7. Instruments – Annoyance

Susceptibility to noise annoyance was assessed within the WHOQOL study questionnaire and 7 items from Thorne.

8. Results - Noise Sensitivity (NoiSeQ)

A detailed noise sensitivity analysis was performed in addition to the WHO Quality of Life analysis. The NoiSeQ analysis allows comparison with an earlier study of a rural locale affected by wind farms (Manawatu, New Zealand) and a totally urban locale (Brisbane city) [38]. The respondents are generally either self-employed or professional persons. The sensitivity of the respondents can vary depending on the subscale being measured. Higher values indicate higher noise sensitivity.

The subscales of the NoiSeQ exhibited medians and confidence intervals (p =0.05) re the German norm as follows: Communication (*M*=1.14, *CI*=0.55), Habituation (*M*=1.43, *CI=0.56*), Leisure (*M*=1.36, *CI=0.68*), Sleep (*M*=1.29, *CI=0.56*) and Work (*M*=1.64, *CI=0.56*). From these subscales, a global noise sensitivity measure was computed by computing the mean of the five NoiSeQ subscales (*M*=1.37, *CI=0.26*). The higher the global noise sensitivity score the more noise sensitive the individual, with 88% of our sample having scores greater than the upper band (*M+CI= 1.63*) of the average band.

Noise sensitivity influence annoyance and noise sensitivity also has an effect on the sound level-related changes of annoyance. Both rural locales of Manawatu and Victoria exhibit elevated levels of higher than average noise sensitivity for 'Sleep' and 'Global' compared to the urban respondents.

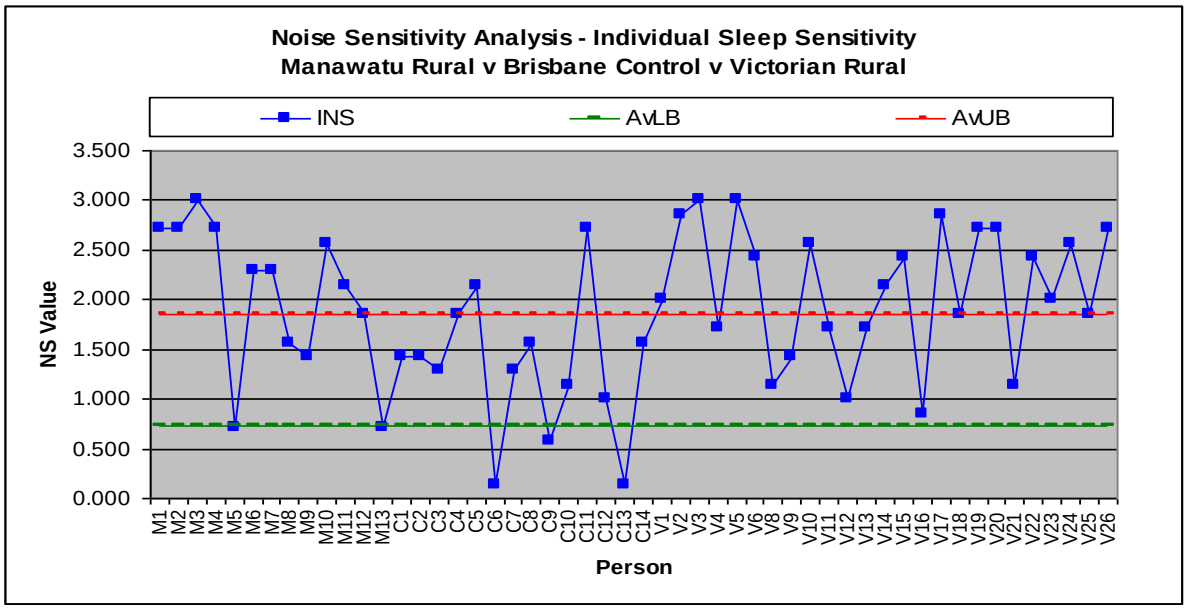
(1) The responses for Global Noise Sensitivity are: Above average - Manawatu 85%; Victoria 88%; Brisbane 71%. Average responses are Manawatu 15%; Victoria 18%; Brisbane 29%, making 100% in total.

(2) The responses for Habituation Noise Sensitivity are: Above average - Manawatu 69%; Victoria 56%; Brisbane 50%. Average responses are Manawatu 31%; Victoria 44%; Brisbane 43%. The below average for Brisbane is 7%, making 100% in total.

(3) The responses for Sleep Noise Sensitivity are: Above average - Manawatu 70%; Victoria 60%; Brisbane 21%. Average responses are Manawatu 15%; Victoria 40%; Brisbane 58%. The below average values are Manawatu 15%, Victoria 0%, Brisbane is 21%, making 100% in total.

(4) The relationship between the different participants and their Global Noise Sensitivity scores is illustrated in Figure 1. The 'average' Global Sensitivity is shown by upper (AvUB) and lower (AvLB) bands.

Figure 1: Global noise sensitivity responses for Rural v Urban residents



9. Results - Noise Annoyance

In the following four noise annoyance questions the responses from the Victorian participants are compared to the previous study in the Manawatu. Both are rural communities but the turbines are generally 3000+ metres from the Manawatu residents, whereas the Victorian respondents have turbines 1000-2000 metres distant.

(1) In response to the question "Do you find noise in your environment (including your home environment) a problem?" 36% of the Victorian respondents have some experience of noise being a problem sometimes, 8% did not and 56% did find noise a problem. In the Manawatu group, 62% found noise a problem sometimes, 15% did not and 23% did find noise a problem.

(2) In response to the question "Thinking about where you live, could you please say how quiet or noisy you think your area is" 36% of the Victorian respondents recorded their locality as being quiet or very quiet, 24% as moderately noisy and 40 found their locality noisy or very noisy. For the Manawatu group 84% of the respondents recorded their locality as being quiet or very quiet, 16% as moderately noisy and nil found their locality noisy or very noisy.

(3) In response to "Are you ever disturbed or annoyed by noise at home (not including from those living in your household?" 76% of the Victorian respondents said "Yes" while 24% said "No". In the Manawatu group, 85% said "Yes" and 15% said "No".

(4) In response to the question "Does noise from your neighbourhood (not including from those living in your household) affect you while reading, watching tv, listening, talking, relaxing or sleeping" provided a range of responses, Table 3.

The following six noise annoyance questions are specific to the Victorian study. In response to the question about what sort of noise annoys and at what time of day, the respondents all stated that wind farm noise annoys, generally and particularly at night.

(a) The question "Generally how would you rate your area as a place to live" was rated by the Victorian respondents as low by 44%, moderate by 8% and high by 48%.

(b) The respondents were asked to further describe their environment. A range of questions were posed and the respondents could answer more than once to the various elements within each question.For example, a respondent may find the environment quiet, sometimes noisy, sometimes unpleasant. In response to the question "Select the best

description descriptions for sounds heard in your local environment – my local environment is…" 48% selected quiet, 68% sometimes noisy, 20% noisy, 36% pleasant, 12% often pleasant, and 60% sometimes unpleasant.

(c) In response to the question "Select the best description descriptions for sounds heard in your local environment – I find the sounds are…" 40% selected pleasant, 20% sometimes pleasant, 12% often pleasant, 80% sometimes disturbing/irritating, 56% sometimes annoying, 40% ugly/negative, 56% intrusive, 0% able to be ignored, 76% disturbing my sleep, 52% disturbing my rest or relaxation, 60% making me anxious, and 44% 'I'm sensitized to a particular sound'. The respondents who reported being sensitized to a particular sound emphasised wind turbine noise.

Wind turbine noise was referred to as the sound most often affecting the respondents.

(d) In response to the question "Choose, from the following list, the words that best describe the quality or character or 'soundscape' of your environment that you hear when you are here at home. The usual character is…" selected 28% smooth, 16% bright, 4%warm, 44% gentle, 12% rich, 24% powerful, and 44% rough. In this question there was some confusion between different homes, with some referring to homes away from the wind farm locale. The responses have been adjusted for the wind farm or greenfields locales only. The words used by respondents to describe the 'rough' quality of their environment used the words industrial, monotonous, irritating, invasive and beating and these referred to the activity of the wind turbines.

(e) The question 'Choose, from the following list, the words that best describe any one sound that is clearly noticeable when you are here at home. The sound is…' was answered by the respondents to describe the environment, including wind turbine sound as gentle 24%, powerful 32%, rough 16%, sharp or metallic 12%, percussive 32%, dull 16%, tonal 36%, harsh 16%, a distinctive hum or drone 48%, fluctuating or beating 60%, impulsive 36%, and repetitive 60%. Post response interviews with respondents indicated that this question was answered with people providing an impression of the environment when the turbines were not operating (e.g. gentle) and when they are operating (e.g. beating).

(f) In response to the question 'Do the turbines annoy you inside the home' 80% of the respondents stated 'yes' and 20% stated 'no'. For noise heard outside the home 85% of the respondents stated 'yes' and 15% stated 'no'. The greenfields participants accounted for half of the 'no' responses.

All report that wind turbines affect sleep and the ability to work is dramatically affected. Nausea and vertigo are constants for some, occasional for others, as well as feelings of anger and helplessness; irritation with the turbine noise. Stress, anger and hopelessness are constants; not all day every day but recorded as frequent each week. One respondent observes that nausea experienced at 1000 metres is not experienced at 4200 metres downwind. Families have moved away to sleep, must still work the land, will not sell. Two families report farm property is devalued; they have heritage homes and cannot rebuild. All of these factors compound the general feeling of annoyance with the placement and operation of the wind farm(s).

Building construction generally is inadequate to reduce or mitigate sound levels and, hence, annoyance. All homes except for the heritage homes are generally of light timber frame construction with metal roofing. Glazing is light-weight and thermal or acoustic glazing is not installed in any home.

10. Results - Pittsburgh Sleep Quality Index

The Pittsburgh Sleep Quality Index is scored on the basis of component scores, each of which has a range of 0-3 points. In all cases, a score of '0' indicates no difficulty, while a score of '3' indicates severe difficulty. The seven component scores are added together to yield a single global score, with a range of 0-21 points. A score of '0' indicates no difficulty and a score of '21' indicates severe difficulties in all areas. In the responses to the component relating to Sleep Disturbances,

44% of the respondents recorded being disturbed 3 or more times a week; 28% recorded once or twice a week; 28% less than once a week; and 0% reported no disturbances at all. Of the people disturbed less than once per week, 8% have moved from the locale and 8% are in a greenfields locale that does not yet have turbines installed.

Of the 25 participants, 92% have noted a change in sleeping patterns since the turbines went online. The 8% who have not experienced sleep changes are living in a greenfields locale. The changed sleep patterns are described as being entirely new by 80% of the respondents, with 8% of the non-affected persons being in the greenfields locale. For 24 % of the participants the sleep problems described (with the exception of getting up to use the bathroom) existed before but are now worsened since the turbines went online. With the exception of the greenfields participants, 80% of the respondents agreed that sleep improves when away from home (that is, home near the turbines).

Overall, 80% of the participants had a global score greater than 5 points, the marker for good sleep. Above 6 points, sleep is gradually more difficult. Forty percent (40%) of the participants have a score of 15 or more, indicating severe difficulties in all areas of sleep quality. There is a 'zero' response for participant 7.

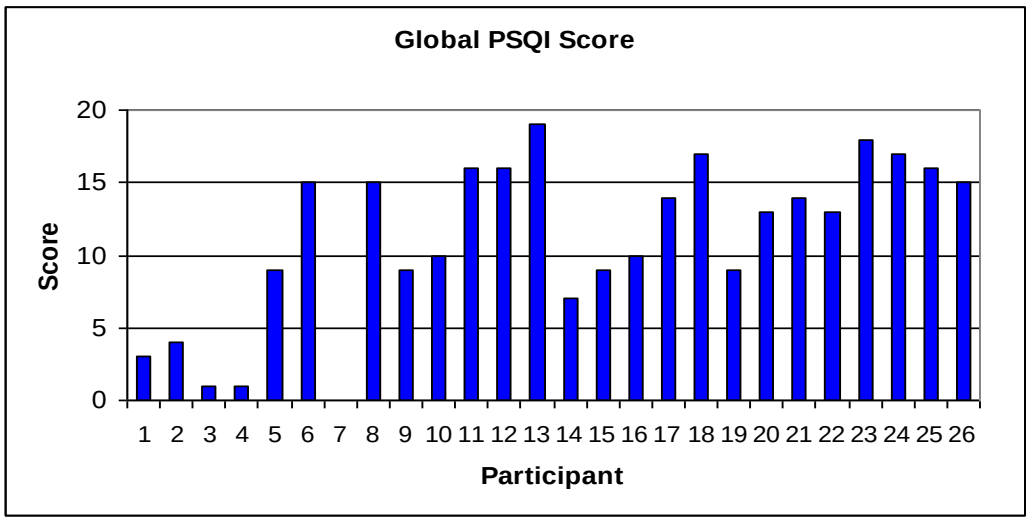


Figure 10.1: Global PSQI Score

11. Results - Epworth Sleepiness Scale

Of the 25 participants 4 (responses 9, 10, 17, 21) scored with 10 or more points and should consider whether they are gaining enough sleep. All other participants scored less than 10 are considered 'non-sleepy'.

12. Results - Satisfaction with wind energy and the nearby project

A series of question were asked concerning the participants' satisfaction with wind energy. To the Statement *"I felt favourably towards wind energy prior to the turbines going online"* 40% answered in strong agreement; 12% partially agree; 28% were neutral; 12% partially disagree; and 8% strongly disagree. In contrast, to the Statement *"I feel favourably towards the nearby wind energy project since the turbines went online"* 8% answered in strong agreement; 0% partially agree; 12% were neutral; 0% partially disagree; and 80% strongly disagree. The statement *"I would move further away from the nearby wind energy project if I could afford to"* was responded to with 64% in strong agreement; 0% partially agree; 12% were neutral; 4% partially disagree; and 20% strongly disagree. The general comment was that many of the respondents were 3rd or 4th generation landowners with valuable stakeholdings in their properties and that they would not move. They would, however, live elsewhere if practical to do so. Only 4% of the respondents agreed with the statement that *"The nearby wind energy project has improved my quality of life"*; the balance (96%) strongly disagreed. One hundred

percent of the affected residents affirmed the statement that *"The nearby wind energy project has resulted in a deterioration of my quality of life"*. The respondents all strongly disagreed with the statement that *"The nearby wind energy project has had no effect on my quality of life."*

13. Results - Headaches and associated health effects

In order to more fully assess the potential for adverse health effects experienced by the respondents a series of general health questions were presented. In response to general questions that asked 'What health effects such as headaches have you experienced since the turbines went online that did not exist previously" 24% responded with daily or constant headaches, 56% experienced headaches 2-4 times per week, 64% experienced a tight scalp or band-effect around the head, 52% experienced blurred vision, 40% stated dizziness was experienced, 4% experienced chest pains, 52% experienced nausea, 76% stated ear-ringing was experienced, 12% experienced pressure in the ears, and 60% experience vertigo/balance problems. Of the persons who responded citing headaches as a problem 80% observe that headaches occur only when the turbines are operating.

Most of the respondents noted that these effects are not experienced all the time but often enough to be debilitating. The responses relating to nausea and the time before symptoms were experienced were probed further. In response to the question 'How long did it take after the turbines started before you felt unwell' 36% of the respondents said fairly quickly (a month or less) and 56% said 6-8 months. Of the people who responded 'fairly quickly' there were some who became unwell almost immediately. These respondents now find it very difficult to return to the locale to work when the turbines are operating as they suffer from headaches and/or nausea almost immediately. In 56% of the responses the symptoms improve/abate fairly quickly when the person leaves the locality.

14. Results - Infrasound and health effects

This study, and previous studies, have all raised the question as to the reasons for the adverse health effects experienced by people living near wind farms. Annoyance and sleep disturbance, with associated adverse health effects, are described in this paper. These effects, however, usually take some time before they become significant as stressors. The reported immediate health effects of nausea and headaches do not correspond to the readily perceived audible sound issues.

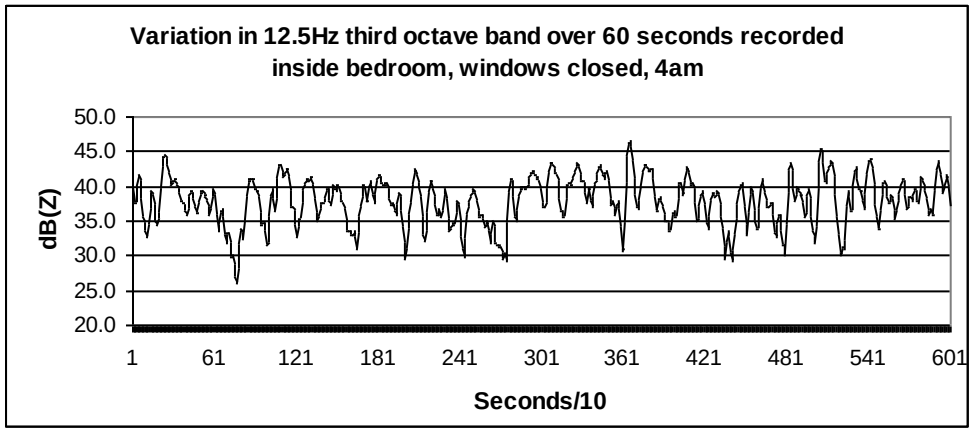
The observation from this and earlier studies is that there is a physical effect affecting sensitive individuals. The premise for this is based on the fact that the individuals did not experience adverse health effects before the wind farm started operation but do so now when the turbines are operating. Some researchers suggest that this is an "infrasound" effect but this is not adopted as such by this Report. This is because the term is too broad to be acceptable. Individuals are always affected by "infrasound" as this is a natural component of our environment. The wind, for example, is measured as "infrasound". The fundamental difference between an environment without a wind farm (no health effects) and a wind farm (health effects) is the physical action of the turbines. The turbine blades turn and extract energy from the wind and create pressure variations.

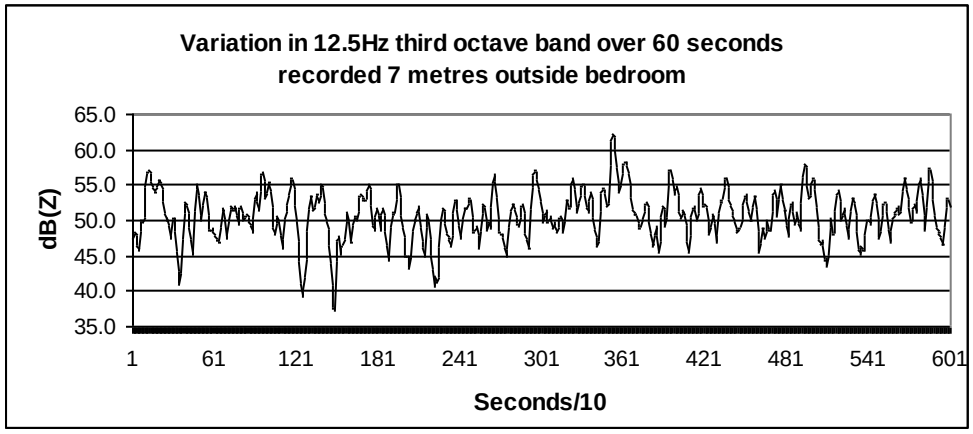
The general effect can be termed as "land-sickness', similar to sea-sickness or car-sickness as the described symptoms are very similar. Of the 13 individuals who experience nausea, 6 are susceptible sea-sickness or car-sickness. Two individuals who are significantly adversely affected by nausea are not susceptible to sea-sickness or car-sickness, however. Instead of noise as such the effect may be better described as being due to vibration.

Measured levels of infrasound inside and outside a dwelling give an indication of potential effect. Putting aside the question of audibility the levels in the following figures (a) and (b) are assessed on the basis of their energy variation at a

rate of 10 'pulses' per second. The pulses are seen as being regular in nature with a peak to trough shift of 6 dB to 7dB over a range of approximately 13 dB. Modulating sound with these characteristics outside and inside a home indicates that the sound is not natural but is being generated by an external source. In this case the operation of the wind farm. The people living in the home are affected by wind farm activity outside and inside the home.

Figures (a) and (b): Comparison of infrasound levels, inside and outside bedroom





Not all wind farms in this study appear to have these adverse health effects recorded, however, and this is a confounder relating to the physical properties (wind turbine power rating and design, wind farm layout, topography, wind speeds and wind direction) of specific wind farms.

15. Working Observation

Based on this study we define our working observation in relation to health effects and noise to:

"Adverse health effects are experienced by some individuals due to modulating noise broadly measured as infrasound (also as modulating air pressures), low frequency and audible noise."

WORLD HEALTH ORGANISATION
QUALITY OF LIFE Assessment

WHOQOL-BREF

New Zealand Version
(2010)

Please read instructions carefully before responding

This assessment asks how you feel about your quality of life, health, & other areas of your life. Please answer all the questions by circling the number that indicates your choice. If unsure about which response to give to a question, please choose the one that appears most appropriate. This can often be your first response.

Please keep in mind your standards, hopes, pleasures and concerns. We ask that you think about your life in the **LAST TWO WEEKS.**

Thank you for your help.

Please read each question and assess your feelings, FOR THE LAST TWO WEEKS, and circle the number on the scale for each question that gives the best answer for you.

Q1) How would you rate your quality of life?

1	2	3	4	5
Very poor	Poor	Neither Poor nor good	Good	Very Good

Q2) How satisfied are you with your health?

1	2	3	4	5
Very Dissatisfied	Fairly Dissatisfied	Neither Satisfied nor Dissatisfied	Fairly Satisfied	Very Satisfied

The following questions ask about how much you have experienced certain things in the last two weeks. Circle the number on the scale for each question that gives the best answer for you.

Q3) To what extent do you feel that physical pain prevents you from doing what you need to do?

1	2	3	4	5
Not at all	A Small amount	A Moderate amount	A Great deal	An extreme amount

Q4) How much do you need any medical treatment to function in your daily life?

1	2	3	4	5
Not at all	A Small amount	A Moderate amount	A Great deal	An extreme amount

Q5) How much do you enjoy life?

1	2	3	4	5
Not at all	A Small amount	A Moderate amount	A Great deal	An extreme amount

Q6) To what extent do you feel your life to be meaningful?

1	2	3	4	5
Not at all	A Small amount	A Moderate amount	A Great deal	An extreme amount

Q7) How well are you able to concentrate?

1	2	3	4	5
Not at all	Slightly	Moderately	Very	Extremely

Q8) How safe do you feel in your daily life?

1	2	3	4	5
Not at all	Slightly	Moderately	Very	Extremely

Q9) How healthy is your physical environment?

1	2	3	4	5
Not at all	Slightly	Moderately	Very	Extremely

The following questions ask about <u>how completely</u> you have experienced or were able to do certain things in the <u>last two weeks.</u> Circle your best answer number.

Q10) Do you have enough energy for everyday life?

1	2	3	4	5
Not at all	Slightly	Moderately	Very	Extremely

Q11) Are you able to accept your bodily appearance?

1	2	3	4	5
Not at all	Slightly	Moderately	Very	Extremely

Q12) Have you enough money to meet your <u>needs</u>?

1	2	3	4	5
Not at all	Slightly	Moderately	Very	Extremely

Q13) How available to you is the information you need in your daily life?

1	2	3	4	5
Not at all	Slightly	Moderately	Very	Extremely

Q14) To what extent do you have the opportunity for leisure activities?

1	2	3	4	5
Not at all	Slightly	Moderately	Very	Extremely

Q15) How well are you able to get around physically?

1	2	3	4	5
Not at all	Slightly	Moderately	Very	Extremely

The following questions ask you to say how good or satisfied you have felt about various aspects of your life over the last two weeks. Circle your best answer number.

Q16) How satisfied are you with your sleep?

1	2	3	4	5
Very Dissatisfied	Fairly Dissatisfied	Neither Satisfied nor Dissatisfied	Fairly Satisfied	Very Satisfied

Q17) How satisfied are you with your ability to perform your daily living activities?

1	2	3	4	5
Very Dissatisfied	Fairly Dissatisfied	Neither Satisfied nor Dissatisfied	Fairly Satisfied	Very Satisfied

Q18) How satisfied are you with your capacity for work?

1	2	3	4	5
Very Dissatisfied	Fairly Dissatisfied	Neither Satisfied nor Dissatisfied	Fairly Satisfied	Very Satisfied

Q19) How satisfied are you with yourself?

1	2	3	4	5
Very Dissatisfied	Fairly Dissatisfied	Neither Satisfied nor Dissatisfied	Fairly Satisfied	Very Satisfied

Q20) How satisfied are you with your personal relationships?

1	2	3	4	5
Very Dissatisfied	Fairly Dissatisfied	Neither Satisfied nor Dissatisfied	Fairly Satisfied	Very Satisfied

Q21) How satisfied are you with your sex life?

1	2	3	4	5
Very Dissatisfied	Fairly Dissatisfied	Neither Satisfied nor Dissatisfied	Fairly Satisfied	Very Satisfied

Q22) How satisfied are you with the support you get from your friends?

1	2	3	4	5
Very Dissatisfied	Fairly Dissatisfied	Neither Satisfied nor Dissatisfied	Fairly Satisfied	Very Satisfied

Q23) How satisfied are you with the conditions of your living place?

1	2	3	4	5
Very Dissatisfied	Fairly Dissatisfied	Neither Satisfied nor Dissatisfied	Fairly Satisfied	Very Satisfied

Q24) How satisfied are you with your access to health services?

1	2	3	4	5
Very Dissatisfied	Fairly Dissatisfied	Neither Satisfied nor Dissatisfied	Fairly Satisfied	Very Satisfied

Q25) How satisfied are you with your transport?

1	2	3	4	5
Very Dissatisfied	Fairly Dissatisfied	Neither Satisfied nor Dissatisfied	Fairly Satisfied	Very Satisfied

The following question refers to how often you have felt experienced or experienced certain things in the last two weeks. Circle your best number answer.

Q26) How often do you have negative feelings such as blue mood, despair, anxiety, depression?

1	2	3	4	5
Never	Infrequently	Sometimes	Frequently	Always

About You

Please provide a little information about yourself by marking or ticking the correct answer or by filling in the space provided.

Are you (please tick): ☐ Male ☐ Female

Please mark your age group: ☐ 18-20 ☐ 21-30 ☐ 31-40 ☐ 41-50
☐ 51-60 ☐ 61-70 ☐ 71 or above

Which ethnic group do you belong to? Tick the option or options that most apply to you.

☐ New Zealand European ☐ Maori ☐ Samoan
☐ Cook Island Maori ☐ Tongan ☐ Niuean
☐ Chinese ☐ Indian ☐ European
☐ Other, please state: _____

What is the highest level of education you have completed?

Primary school ☐ Secondary school ☐ Technical College ☐ University Degree

What is your marital status?

☐ Single ☐ Married ☐ Living as married
Separated ☐ Divorced ☐ Widowed

What is your current employment status?

☐ Full-time work ☐ Part-time work ☐ Retired ☐ Student ☐ Unemployed
☐ On leave or sick-leave ☐ Own household work ☐ Other: _____

Are you currently ill or do have a medical condition? ☐ Yes ☐ No

If you answered yes, what is the diagnosis? _____

OR

What do you think the condition is? _____

THANK YOU FOR YOUR HELP

NoiSeQ Questionnaire

In the following questionnaire your opinion is asked concerning a variety of sounds. Please try to imagine the situation presented in each statement, and indicate to which extent you agree or disagree with it. It is **your own personal assessment** of the topics presented here that is of interest, so there is *no right or wrong* answer, only your opinion.

Please give your opinion spontaneously by marking that answering option which best reflects your opinion. Please answer all statements in turn, always marking a single option only. If you are unsure as to which option to mark, please choose that option which comes closest in reflecting your opinion.

No	Item	Strongly disagree	Slightly disagree	Slightly agree	Strongly agree
1	I find it hard to relax in a noisy environment	0	1	2	3
2	I need peace and quiet to do difficult work	0	1	2	3
3	For a quiet place to live I would accept other disadvantages	0	1	2	3
4	I am very sensitive to neighbourhood noise	0	1	2	3
5	I find it hard to communicate while it is noisy	0	1	2	3
6	I have no problems to do routine work in a noisy environment	0	1	2	3
7	I become very agitated if I can hear someone talking while I am trying to fall asleep	0	1	2	3
8	When I am absorbed in a conversation I do not notice if it is noisy around me	0	1	2	3
9	I can fall asleep even when it is noisy	0	1	2	3
10	My performance is much worse in noisy places	0	1	2	3
11	Listening to loud music helps me relax after work	0	1	2	3
12	In a restaurant I cannot concentrate well on my conversation when people are talking loudly at other tables	0	1	2	3
13	I need quiet surroundings to be able to work on new tasks	0	1	2	3
14	When people around me are noisy I don't get on with my work	0	1	2	3
15	I need an absolutely quiet environment to get a good night's sleep	0	1	2	3
16	Even the slightest noise can prevent me from falling asleep	0	1	2	3

No	Item	Strongly disagree	Slightly disagree	Slightly agree	Strongly agree
17	When I am at home, I become accustomed to noise quickly	0	1	2	3
18	In the cinema I am annoyed by other people whispering and by rustling paper	0	1	2	3
19	I think music interferes with conversations	0	1	2	3
20	I find it very hard to follow a conversation when the radio is playing	0	1	2	3
21	If my workplace was noisy I would always try to find a way for me to change this	0	1	2	3
22	When dancing I don't mind how loud the music is	0	1	2	3
23	It would not bother me to live in a noisy street	0	1	2	3
24	When other peoples' children are noisy I would prefer that they should not play in front of my house	0	1	2	3
25	At weekends I prefer quiet surroundings	0	1	2	3
26	I do not feel well rested if there has been a lot of noise the night before	0	1	2	3
27	When I am at home I find it uncomfortable if the radio or TV is left on in the background	0	1	2	3
28	Loud music in a restaurant makes me stop my conversation	0	1	2	3
29	I can do complicated work even while background music is playing	0	1	2	3
30	I wake up at the slightest noise	0	1	2	3
31	I avoid leisure activities which are loud	0	1	2	3
32	I don't like noisy activities in my residential area	0	1	2	3
33	Noises from neighbours can be extremely disturbing	0	1	2	3
34	The sound of loud thunder does not usually wake me up	0	1	2	3
35	High noise levels make it hard for me to concentrate on my conversation	0	1	2	3

PLEASE INDICATE HOW MUCH NOISE BOTHERS, DISTURBS OR ANNOYS YOU WHEN YOU ARE HERE AT HOME.

1. Do you find noise in your environment (including your home environment) a problem?

YES ☐ NO ☐ SOMETIMES ☐

2. Thinking about where you live, could you please say how quiet or noisy you think your area is?

Very quiet	☐
Quiet	☐
Moderately noisy	☐
Noisy	☐
Very noisy	☐

3. Does noise from your neighbourhood (not including from those living in your household) affect you-

While reading	YES ☐	NO ☐
While watching TV	YES ☐	NO ☐
While listening/talking	YES ☐	NO ☐
While relaxing	YES ☐	NO ☐
While sleeping	YES ☐	NO ☐

4. Are you ever disturbed or annoyed by noise at home (not including from those living in your household)?

YES ☐ NO ☐

5. If yes - Could you please tell us what sort of noise and at what time of day?

Please mark the boxes that apply

Source*	**Morning** 6 am - 12noon	**Afternoon** 12 noon - 6pm	**Evening** 6pm - 10pm	**Night** 10pm - 6am	**All the time**

**Please add noises that bother, disturb or annoy you.*

6. Where do you live? *Please mark the boxes that apply*

Near a main road or a busy local road?	YES ☐	NO ☐
Near or in an industrial area?	YES ☐	NO ☐
Under or near aircraft overflight?	YES ☐	NO ☐
In an urban or rural area?	Urban ☐	Rural ☐

7. **Generally, how would <u>you</u> rate your area as a place to live?**

1	2	3	4	5
☐	☐	☐	☐	☐
Low				High

8. **Are you?** MALE ☐ FEMALE ☐

9. **Please mark your age group-**

10-14	☐	15-19	☐	20-29	☐	30-39	☐
40-49	☐	50-59	☐	60-69	☐	70 and over	☐

PLEASE DESCRIBE THE CHARACTER OF SOUND IN THE LOCALITY WHEN YOU ARE HERE AT HOME.

1. Please select the best description(s) for sounds heard in your local environment. You can choose as many words as you like.

My local environment is-

- □ Quiet
- □ Sometimes noisy
- □ Noisy
- □ Pleasant
- □ Often pleasant
- □ Unpleasant

2. Please select the best description(s) of sounds heard in your local environment. You can choose as many words as you like.

I find the sounds are-

- □ Pleasant
- □ Sometimes pleasant
- □ Often pleasant
- □ Sometimes disturbing / irritating
- □ Sometimes annoying
- □ Ugly / negative
- □ Intrusive
- □ Able to be ignored
- □ Disturbing my sleep
- □ Disturbing my rest or conversation
- □ Making me anxious
- □ I'm sensitized to a particular sound

3. Please choose, from the following list, the words that best describe the quality or character or "soundscape" of your environment that you hear when you are here at home. You can choose as many words as you like.

The usual character of the soundscape is-

- □ Smooth
- □ Bright
- □ Warm
- □ Gentle
- □ Rich
- □ Powerful
- □ Rough
- □ Other (please state)

4. Please choose, from the following list, the words that best describe any one sound that is clearly noticeable when you are here at home. You can choose as many words as you like.

The sound is from:

The sound is-

- □ Smooth
- □ Bright
- □ Warm
- □ Gentle
- □ Rich
- □ Powerful
- □ Rough
- □ Sharp or metallic
- □ Percussive
- □ Dull
- □ Tonal
- □ Harsh
- □ A distinctive hum or drone
- □ Fluctuating, undulating or beating
- □ Impulsive
- □ Repetitive

5. My home is in a locality that is rural □ urban (town) □

SOUNDFILE QUESTIONNAIRE

A series of 6 soundfiles are included in this survey. You can listen to the soundfiles in any order. The soundfiles are in Microsoft .wav format and need to be played through a computer. Each soundfile is 2 minutes long.

- ☐ I listened to the soundfile while using headphones or earbuds
- ☐ I listened to the soundfile using speakers

Listen to the soundfile as many times as you like before completing the response sheet. It is **your own personal assessment** of the sound presented that is of interest, so there is *no right or wrong* answer, only your opinion. Please select the best description or descriptions concerning the character of the sound. The descriptions are in no particular order. The sound is-

Character of the Sound	Soundfiles					
	1	2	3	4	5	6
Smooth						
Bright						
Warm						
Gentle						
Waterfall						
Rich						
Powerful						
"Wind in trees"						
Rough						
Sharp or metallic						
Percussive						
Dull						
Tonal						
Harsh						
A distinctive hum						
Fluctuating, undulating or beating						
Rumble						
Impulsive						
Repetitive						
Thumping						
Annoying						

SF-36v2™ Health Survey

This survey asks for your views about your health. This information will help you keep track of how you feel and how well you are able to do your usual activities.

Answer every question by selecting the answer as indicated. If you are unsure about how to answer a question, please give the best answer you can.

1. In general, would you say your health is:

Excellent	Very good	Good	Fair	Poor
☐	☐	☐	☐	☐

2. Compared to one year ago, how would you rate your health in general now?

Much better now than one year ago	Somewhat better now than one year ago	About the same as one year ago	Somewhat worse now than one year ago	Much worse now than one year ago
☐	☐	☐	☐	☐

3. The following questions are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

	Yes, limited a lot	Yes, limited a little	No, not limited at all
a Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports	☐	☐	☐
b Moderate activities, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf	☐	☐	☐
c Lifting or carrying groceries	☐	☐	☐
d Climbing several flights of stairs	☐	☐	☐
e Climbing one flight of stairs	☐	☐	☐
f Bending, kneeling, or stooping	☐	☐	☐
g Walking more than a mile	☐	☐	☐
h Walking several hundred yards	☐	☐	☐
i Walking one hundred yards	☐	☐	☐
j Bathing or dressing yourself	☐	☐	☐

4. During the past 4 weeks, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of your physical

health?

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
a Cut down on the amount of time you spent on work or other activities	☐	☐	☐	☐	☐
b Accomplished less than you would like	☐	☐	☐	☐	☐
c Were limited in the kind of work or other activities	☐	☐	☐	☐	☐
d Had difficulty performing the work or other activities (for example, it took extra effort)	☐	☐	☐	☐	☐

5. During the past 4 weeks, how much of the time have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
a Cut down on the amount of time you spent on work or other activities	☐	☐	☐	☐	☐
b Accomplished less than you would like	☐	☐	☐	☐	☐
c Did work or activities less carefully than usual	☐	☐	☐	☐	☐

6. During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?

Not at all	Slightly	Moderately	Quite a bit	Extremely
☐	☐	☐	☐	☐

7. How much bodily pain have you had during the past 4 weeks?

None	Very mild	Mild	Moderate	Severe	Very severe
☐	☐	☐	☐	☐	☐

8. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)?

Not at all	A little bit	Moderately	Quite a bit	Extremely
☐	☐	☐	☐	☐

9. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling.

How much of the time during the past 4 weeks...

	All of the time	Most of the time	Some of the time	A little of the time	None of the time
a Did you feel full of life?	☐	☐	☐	☐	☐
b Have you been very nervous?	☐	☐	☐	☐	☐
c Have you felt so down in the dumps that nothing could cheer you up?	☐	☐	☐	☐	☐
d Have you felt calm and peaceful?	☐	☐	☐	☐	☐
e Did you have a lot of energy?	☐	☐	☐	☐	☐
f Have you felt downhearted and depressed?	☐	☐	☐	☐	☐
g Did you feel worn out?	☐	☐	☐	☐	☐
h Have you been happy?	☐	☐	☐	☐	☐
i Did you feel tired?	☐	☐	☐	☐	☐

10. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting friends, relatives, etc.)?

All of the time	Most of the time	Some of the time	A little of the time	None of the time
☐	☐	☐	☐	☐

11. How TRUE or FALSE is each of the following statements for you?

	Definitely true	Mostly true	Don't know	Mostly false	Definitely false
A I seem to get sick a little easier than other people	☐	☐	☐	☐	☐
B I am as healthy as anybody I know	☐	☐	☐	☐	☐
C I expect my health to get worse	☐	☐	☐	☐	☐
D My health is excellent	☐	☐	☐	☐	☐

Thank you for completing these questions!

Section: Sleep

Epworth Sleepiness Scale

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired?

This refers to your usual way of life in recent times.

Even if you haven't done some of these things recently try to work out how they would have affected you.

Use the following scale to choose the **most appropriate number** for each situation:

0 = would **never** doze
1 = **slight chance** of dozing
2 = **moderate chance** of dozing
3 = **high chance** of dozing

It is important that you answer each question as best you can.

Situation	Chance of Dozing (0-3)
Sitting and reading	
Watching TV	
Sitting, inactive in a public place (e.g. a theatre or a meeting)	
As a passenger in a car for an hour without a break	
Lying down to rest in the afternoon when circumstances permit	
Sitting and talking to someone	
Sitting quietly after a lunch without alcohol	
In a car, while stopped for a few minutes in the traffic	

THANK YOU FOR YOUR COOPERATION

PITTSBURGH SLEEP QUALITY INDEX

INSTRUCTIONS:
The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, what time have you usually gone to bed at night?

   BED TIME _____

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

   NUMBER OF MINUTES _____

3. During the past month, what time have you usually gotten up in the morning?

   GETTING UP TIME _____

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

   HOURS OF SLEEP PER NIGHT _____

For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you . . .

a) Cannot get to sleep within 30 minutes

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

b) Wake up in the middle of the night or early morning (Not to use the bathroom)

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

c) Have to get up to use the bathroom

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

d) Cannot breathe comfortably

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

e) Cough or snore loudly

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

f) Feel too cold

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

g) Feel too hot

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

h) Had bad dreams

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

i) Have pain

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

j) Other reason(s), please describe_____

_____

How often during the past month have you had trouble sleeping because of this?

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

6. During the past month, how would you rate your sleep quality overall?

Very good _____

Fairly good _____

Fairly bad _____

Very bad _____

7. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

No problem at all _____

Only a very slight problem _____

Somewhat of a problem _____

A very big problem _____

10. Do you have a bed partner or room mate?

No bed partner or room mate _____

Partner/room mate in other room _____

Partner in same room, but not same bed _____

Partner in same bed _____

If you have a room mate or bed partner, ask him/her how often in the past month you have had . . .

a) Loud snoring

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

b) Long pauses between breaths while asleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

c) Legs twitching or jerking while you sleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

d) Episodes of disorientation or confusion during sleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

e) Other restlessness while you sleep; please describe_____

_____

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ: Psychiatry Research, 28:193-213, 1989.

As regards the sleep patterns you described above, please check off the appropriate box:

1. There has been no change in my sleep habits since the turbines went online: Correct____ Not Correct ____
2. The sleep problems I describe above (with the exception of getting up to use the bathroom) are entirely new since the turbines went online: Correct____ Not Correct ____
3. The problems I describe above (with the exception of getting up to use the bathroom) existed before but are now worsened since the turbines went online: Correct____ Not Correct ____

Does your sleep improve when you are away from home? Yes____ No_____

Have you seen a doctor about this? Yes____ No____

Do you take any new medications for sleep since the turbines went online? Yes____ No____

If yes, which one(s)? _____

Do you do anything else to help you sleep that you did not do before the turbines went online (e.g earplugs, white noise, changed bedrooms, etc): _____

Section: Headaches

Headache questionnaire

I suffer from NO headaches whatsoever: _____ (skip to next section)

How long have you suffered from headaches? _____ weeks / months / years

Age at onset of headaches _____ years old

Childhood headaches?

Family history of migraine? _____

Family history of headache? _____

Usual headaches:

Approximate frequency: 1x/month 1x/week 2-4x/week daily constant

Quality: pounding throbbing boring aching tight band shooting pressure

Associated complaints flashing lights blurred vision dizziness nausea vomiting

Circle average severity: Mild 1 2 3 4 5 6 7 8 9 10 Worst imaginable

Comment: _____

How do you identify a severe headache starting? _____

Are there warning signs before the headache pain starts? _____

How many headache-free days per week do you have? 1 2 3 4 5 6 7

Factors which worsen the headaches: _____

Medications: _____

The things that bring on my headaches include: _____

_____

How many days work/school have you missed in the last month due to headache? _____

How many Tylenol, Tylenol #3, aspirin, naproxen, or ibuprofen do you take per week? _____

How many Imitrex or other headache drugs do you take per week? _____

Stress

Work Family Financial Death in family Illness

Other_____

What time of day do you usually get headaches?

Morning Afternoon Night There is no pattern

Other _____

Have you been diagnosed with any of the following?

Facial Fracture _____ Obstructive sleep apnea _____

Have you seen a neurologist ___, family doctor ____, or other specialist (type_____) about your headaches? Yes____ No____ Did he/she prescribe any medication? Yes_____ No _____

Which medication(s)_____ Did you fill the prescription? Yes____ No_____

Please list any diagnostic tests and approximate dates performed (CT Scans, MRI, etc):

_____

As regards the headache patterns you described above, please check off the appropriate box:

1. There has been no change in my headaches since the turbines went online:
   Correct____ Not Correct ____

2. The headache problems I describe above are entirely new since the turbines went online: Correct____ Not Correct ____
3. The headaches I describe above existed before but are now worsened in INTENSITY since the turbines went online: Correct____ Not Correct ____
4. The headaches I describe above existed before but are now worsened in FREQUENCY since the turbines went online: Correct____ Not Correct ____

Do your headaches improve when you are away from home? Yes____ No_____

If yes, how so?

Do not occur when I am away____

Are less frequent when I away _____

Are less intense when I am away _____

Have you seen a doctor about this? Yes____ No____

Do you take any new medications for headaches since the turbines went online? Yes____ No____

If yes, which one(s)? _____

When you do see the shadow flicker, or the flashing or movement of light as the sun's rays are interrupted by the turbine blades, to what extent are you affected by it?

I do not see or experience 'shadow flicker' at all _____.

Very affected 1 2 3 4 5 not affected at all

If it does affect you, how does it affect you ? _____

Section: Before and After

Before and After the Turbines Online (TO)

	1	2	3	4
What medical conditions did you have prior to turbines online?				
What medications were you taking prior to turbines online?				
What medical conditions have been diagnosed by your doctor(s) since the turbines went online?				
What medications have you started taking since the turbines went online?				

Sign/Symptom	Frequency/Severity	Freq/Sev PRIOR to TO	Improves when away?	Seen a doc? New Rx or Tx?	Comment
Nausea					
Ears ringing					
Vertigo/ Balance problems					
Unusual body sensations (specify):					
weight gain ___ or loss___	Current weight _____	Weight before turbines online _____	X		

Palpitations					
Changes in appetite (spec):					
Feelings of 'Stress'		Same ___ Less ___ More ___			
Feelings of 'Anger'		Same ___ Less ___ More ___			
Feelings of 'hopelessness'		Same ___ Less ___ More ___			
Feelings of 'anxiety'		Same ___ Less ___ More ___			
Feelings of 'happiness'		Same ___ Less ___ More ___			
Feelings of 'satisfaction'		Same ___ Less ___ More ___			
Feelings of 'irritability'		Same ___ Less ___ More ___			

Considered moving away Yes ____ No ____	Since turbines online Yes ____ No ____	Prior to turbines online Yes ____ No ____	X	X	

Please answer the following questions by indicating which of the choices are most applicable

1: Strongly agree with the statement
2: partially agree
3: neutral
4: partially disagree
5: Strongly disagree

I felt favorably towards wind energy prior to the turbines going online:

Strongly agree 1 2 3 4 5 strongly disagree

I feel favorably towards the nearby wind energy project since the wind turbines went online:

Strongly agree 1 2 3 4 5 strongly disagree

I would move farther away from the nearby wind energy project if I could afford to:

Strongly agree 1 2 3 4 5 strongly disagree

The nearby wind energy project has improved my quality of life:

Strongly agree 1 2 3 4 5 strongly disagree

The nearby wind energy project has resulted in a deterioration of my quality of life:

Strongly agree 1 2 3 4 5 strongly disagree

The nearby wind energy project has had no effect on my quality of life:

Strongly agree 1 2 3 4 5 strongly disagree

World Health Quality of Life Summary Results Waubra - Cape Bridgewater Study January 2012

T-Physical	T-Psychological	T-Social	T-Environment
60.7	66.7	75.0	62.5
53.6	66.7	83.3	62.5
92.9	83.3	83.3	75.0
75.0	70.8	75.0	68.8
46.4	41.7	66.7	59.4
39.3	41.7	75.0	56.3
21.4	29.2	25.0	40.6
53.6	25.0	58.3	53.1
28.6	50.0	91.7	56.3
46.4	37.5	50.0	40.6
25.0	16.7	16.7	31.3
35.7	70.8	66.7	90.6
71.4	83.3	83.3	84.4
57.1	62.5	100.0	68.8
39.3	70.8	83.3	53.1
21.4	54.2	58.3	75.0
3.6	37.5	66.7	31.3
64.3	75.0	75.0	84.4
64.3	58.3	75.0	68.8
21.4	25.0	16.7	12.5
17.9	8.3	8.3	21.9
25.0	25.0	25.0	28.1
25.0	45.8	33.3	34.4
35.7	41.7	66.7	50.0
35.7	29.2	33.3	31.3
42.4	**48.7**	**59.7**	**53.6**

Gender	Health Status	Physical	Psychological	Social	Environment
Male	Excellent	93.7	86.9	81.3	83.8
	Very good	83.3	76	72.9	79.5
	Good	75.8	70.3	69.8	75.4
	Fair	60.7	63.2	61.5	67.8
	Poor	46.2	55.5	57.4	67.4
Female	Excellent	89	82	82	83.9
	Very good	82.1	74.5	75.8	77.6
	Good	72.1	69.1	70.9	74.6
	Fair	61.8	64.4	71.3	70.5
	Poor	45.7	56.2	61.3	63.1
All	***Excellent***	***91.4***	***84.5***	***81.6***	***83.9***
	Very good	***82.6***	***75.1***	***74.7***	***78.4***
	Good	***73.8***	***69.6***	***70.5***	***75.1***
	Fair	***61.5***	***63.9***	***67.5***	***69.4***
	Poor	***45.7***	***55.5***	***58.7***	***65.6***

The above are Australian mean values Table 3, Hawthorne et al.

US Demo version 2 analysis		
PCS	**MSC**	**Age**
54	37	35 - 44
59	41	35 - 44
60	58	55 - 64
58	56	55 - 64
54	34	45 - 54
45	39	45 - 54
37	29	75 and over
58	19	45 - 54
36	36	45 - 54
39	43	45 - 54
49	24	55 - 64
37	44	55 - 64
39	64	75 and over
48	30	45 - 54
37	40	25 - 34
23	58	75 and over
23	23	55 - 64
47	42	55 - 64
48	37	55 - 64
41	28	55 - 64
37	20	45 - 54
35	23	45 - 54
30	23	45 - 54
37	32	75 and over
41	26	45 - 54

US Demo Assessment	
64	very much above average
56-	above average
51-55	about average
50	average
45-49	about average
40-44	below average
<39	very much below average

ABS National Health Survey SF36 Norms 1995

Means - Combined male and female profiles

Age	PCS	MSC
18 - 24	53.1	49
25 - 34	53	49.6
35 - 44	52.3	49.4
45 - 54	50	50.6
55 - 64	46.6	50.8
65 - 74	42.8	51.3
75 and over	38.5	51.8

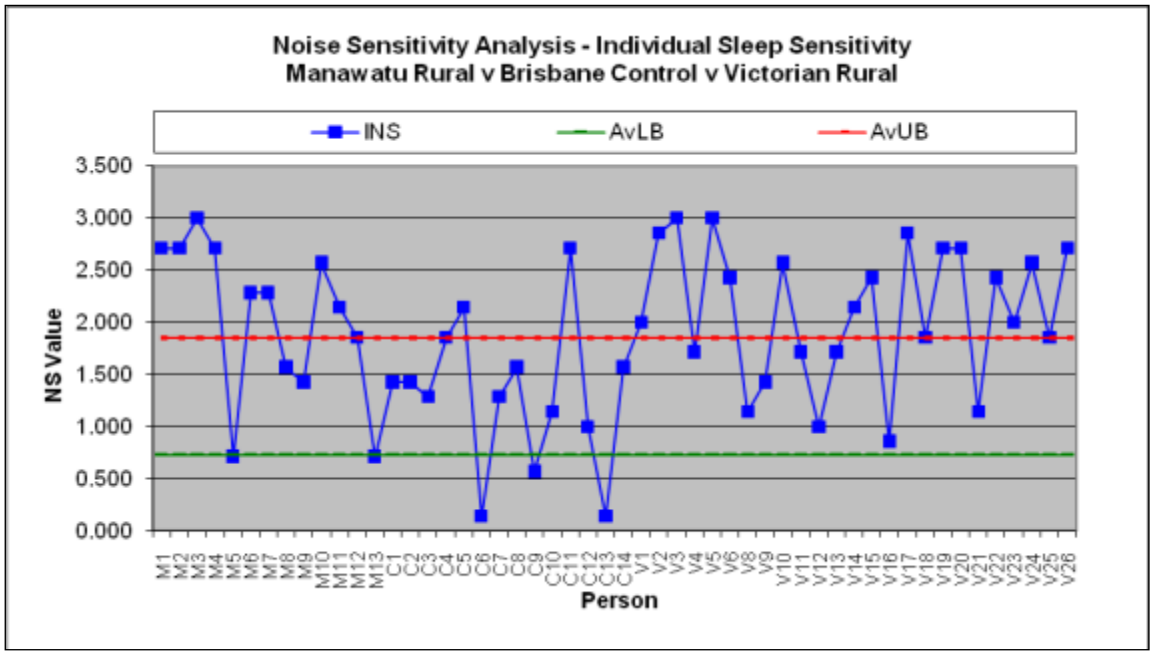
Aust Norm has a standard deviation

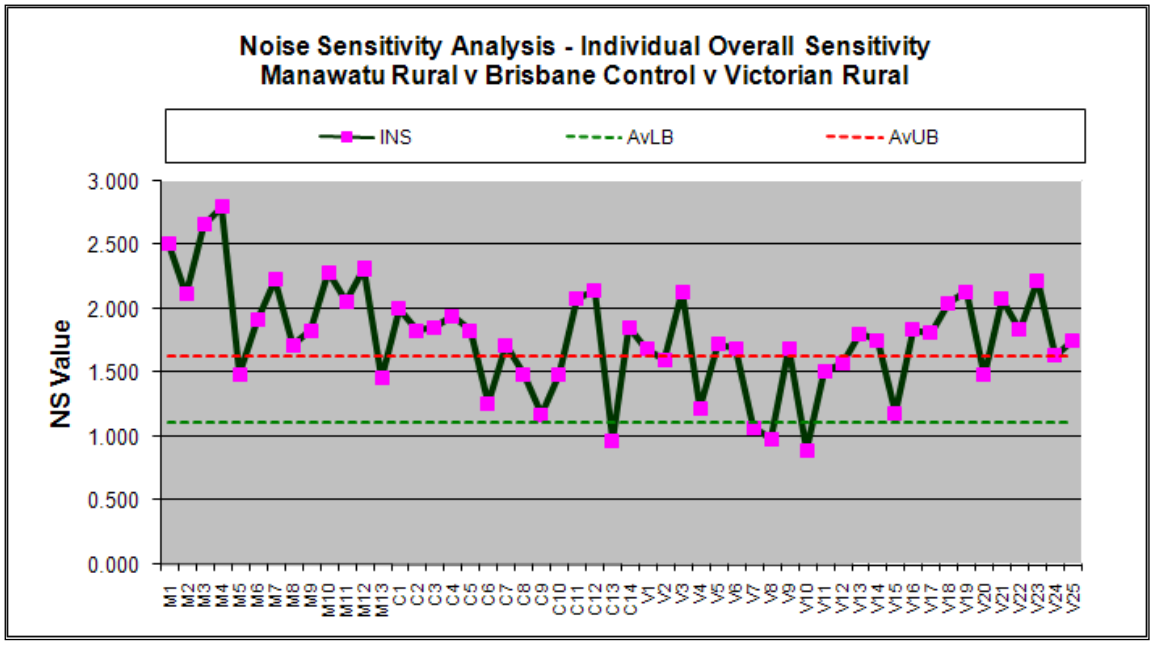
of 10 points re a mean of 50

Quality of Life Responses Waubra – Cape Bridgewater Study January 2012
SF36v2 Analysis accessed from US Demo Site

Comparison of Noise Sensitivity between New Zealand wind farm locale (M), Brisbane urban (B) and this study (V)

Noise Sensitivity	Comm	Habtn	Leisure	Sleep	Work	Global
M: >average	92%	69%	54%	69%	31%	85%
M: average	8%	31%	46%	15%	69%	15%
M: <average	0%	0%	0%	15%	0%	0%
B: >average	71%	50%	21%	21%	14%	64%
B: average	29%	43%	79%	57%	86%	28%
B: <average	0%	7%	0%	21%	0%	7%
V: >average	88%	56%	64%	60%	44%	88%
V: average	12%	44%	36%	40%	56%	12%
V: <average	0%	0%	0%	0%	0%	0%





Pittsburgh Sleep Quality Index Analysis Waubra - Cape Bridgewater Study January 2012							
COMPONENT SCORES							
Subjective sleep quality	Sleep latency	Sleep duration	Habitual Sleep Efficiency	Sleep disturbance	Sleep Medication	Daytime disfunction	Global PSQI Score
0	1	0	0	1	0	1	3
1	2	0	0	1	0	0	4
0	0	0	0	1	0	0	1
0	0	0	0	1	0	0	1
2	2	1	0	1	1	2	9
3	2	3	3	2	0	2	15
2	1	2	3	3	3	1	15
3	1	1	0	2	0	2	9
3	2	1	1	1	0	2	10
3	1	3	3	2	3	1	16
3	3	1	2	3	2	2	16
3	3	2	3	3	3	2	19
1	1	1	2	1	0	1	7
2	1	1	1	2	0	2	9
2	2	0	1	2	2	1	10
1	1	2	3	2	3	2	14
3	2	2	3	3	2	2	17
2	1	1	1	3	0	1	9
2	2	1	1	3	3	1	13
3	1	3	3	2	0	2	14
3	1	1	0	3	2	3	13
2	2	2	3	3	3	3	18
3	2	2	3	3	1	3	17
3	2	3	2	3	2	1	16
3	2	3	3	3	0	1	15

Sleep General as an addenda to Pittsburgh

1. There has been no change ...		2. The sleep problems I describe...		3. The problems .. Worsened		4. Sleep improve away from home			5. Seen doctor		6. Medication		7. Help to sleep?
Correct	Not correct	Correct	Not correct	Correct	Not correct	Yes	No	Comment	Yes	No	Yes	No	
	1	1			1	1		moved away from turbin	1			1	moved away from home
	1	1			1	1		moved away from turbin	1			1	moved away from home
greenfields													
greenfields													
	1	1			1	1				1	1		earplugs
	1	1			1				1			1	changed bedrooms
	1	1		1		1			1		1		
	1	1			1	1			1			1	
	1	1			1	1				1		1	
	1	1		1			1		1		1		
	1	1		1		1			1		1		sleeping pills
	1	1		1		1			1		1		relaxation tapes
	1		1			1				1		1	
	1	1			1	1				1		1	
	1	1			1		1		1			1	significant sleep disorder
	1	1			1	1			1		1		
	1	1			1	1			1			1	
	1	1			1	1			1		1		rescue remedy
	1		1		1	1			1		1		earplugs do not work, can't sell, trapped in a hoe we can't live in.
	1	1			1	1				1			
	1	1			1	1			1			1	natural products for sleep relaxation
	1		1		1	1			1			1	natural products for sleep relaxation
	1	1			1	1			1			1	
	1	1			1	1				1		1	
	1	1			1	1				1		1	

General comment: many of the respondents report refusing to take sleeping tablets

Responses to Questions

1	There has been no change in my sleep habits since the turbines went online
2	The sleep problems I describe above (with the exception of getting up to use the bathroom) are entirely new since the turbines went online
3	The sleep problems I describe above (with the exception of getting up to use the bathroom) existed before but are now worsened since the turbines went online
4	Does your sleep improve when you are away from home?
5	Have you seen a doctor about this?
6	Do you take any new medications for sleep snce the turbines went online?
7	Do you do anything else to help you sleep that you did not do before the turbines went online (e.g. earplugs, white noise, changed bedrooms etc)

Sleep Responses from Waubra – Cape Bridgewater Study January 2012
Key: 1 = yes

Satisfaction Responses from Waubra – Cape Bridgewater Study January 2012

Before and After the arrival of the turbines

a	b	c	d	e	f
2	5	1	5	1	5
5	5	1	5	1	5
1	5	1	5	1	5
1	5	1	5	1	5
3	5	5	5	1	5
3	5	1	5	1	5
1	5	1	5	1	5
3	5	1	1	1	5
4	1	1	5	1	5
1	5	5	5	1	5
1	5	1	5	1	5
2	5	1	5	1	5
4	5	5	5	1	5
3	5	1	5	1	5
1	5	5	5	1	5
1	5	5	5	1	5
1	5	1	5	1	5
1	1	1	5	1	5
1	5	1	5	1	5
4	5	1	5	1	5
5	5	1	5	1	5
2	5	4	5	1	5

Question Responses

a I felt favourably towards wind energy prior to the turbines going online

b I feel favourably towards the nearby wind energy project since the turbines went online

c I would move further away from the nearby wind energy project if I could afford to

d The nearby wind energy project has improved my quality of life

e The nearby wind energy project has resulted in a deterioration of my quality of life

f The nearby wind energy project has had no effect on my quality of life

1 strongly agree with the statement

2 partially agree

3 neutral

4 partially disagree

5 strongly disagree

Satisfaction Responses from Waubra – Cape Bridgewater Study January 2012

				Time after turbines started before feeling unwell		
Do the turbines annoy you		Do you suffer from		Fairly Quickly	A While	Not at all
inside the home	outside the home	sea-sickness	car-sickness	(a month or less)	6-8 months+	
1	1	0	0		1	
1	1	0	0	1		
0	0					0
0	0					0
1	1	1	0	1		
1	1	0	0	1		
1	1				1	
1	1	0	0		1	
1	1	1	1		1	
1	1				1	
1	1	0			1	
1	1	1			1	
0	1				1	
0	1				1	
0	0	0	1		1	
1	1			1		
1	1	0	0	1		
1	1	0	0		1	
1	1	0	0	1		
1	1	0	0		1	
1	1	1	0	1		
1	1	1	1		1	
1	1	1	0	1		
1	1	0	0	1		
1	1	0	0		1	

Waubra – Cape Bridgewater Study Responses concerning adverse health effects (1)

Key to Table:

1 = yes

0 = no

Satisfaction Responses from Waubra – Cape Bridgewater Study January 2012

headaches																improves when away	
daily/constant	2-4x week	tight scalp / band	blurred vision	dizziness	chest pains	sleep disorder	nausea	ear ringing	ear pressure	vertigo / balance problems	depression	high blood pressure	yes	no
1			1	1	1	1	1	1		1			1	
	1	1	1				1	1	1	1			1	
gf														
gf														
	1	1											1	
nil								1		1				
not completed														
	1	1			1			1		1	1			
	1	1						1				1		
	1	1	1	1				1		1	1		1	
	1	1	1				1			1		1		
	1	1		1				1					1	
		1	1	1			1	1		1			1	
1		1	1			1	1		1	1	1		1	
	1	1	1	1				1		1			1	
	1	1	1				1	1		1		1	1	
	1	1	1					1		1			1	
1								1		1			1	
1		1	1	1			1	1		1			1	
1		1		1			1	1	1				1	
1				1			1	1		1		1	1	
	1			1			1	1		sometimes			1	

Waubra – Cape Bridgewater Study Responses concerning adverse health effects (2)

Glossary of Terms

Term	Definition
Acoustic environment	The part of the environment of a place or locality characterised by the noise that may be experienced there (*cf. soundscape*)
A-weighting	A-frequency weighting is the weighted sound pressure over the frequencies between 10 Hz and 20,000 Hz. (See the figure following this table for a comparison of the A-, C- and Z-weightings)
Algorithm	A well-defined procedure to solve a problem
Ambience	Our physical surroundings and personal perception of those surroundings; sense of place
Amenity	Pleasantness or a useful feature of a place
Amenity (2)	The psychophysical responses of an individual or community to that person's (or community's) immediate or local environmental and includes ascribed spiritual values
Amenity values	Means those natural or physical qualities and characteristics of an area that contributes to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes.
Amplitude	The equivalence of "loudness" and "volume" to intensity in decibels
Annoyance	A feeling of displeasure associated with any agent or condition, known or believed by an individual or group to adversely affect them
Attribute	Property, e.g., the pitch, loudness or timbre of a sound sensation
Audible	Capable of being heard
Audible level	Level of a pure tone (component) above masked threshold
Audibility	Audibility can be considered as a psychophysical quantitative relationship between physical and psychological events: - the physical relationship is considered as being the role of signal detection; - the psychological or behavioural and perceptive reactions of an individual are considered as psychoacoustical or sound quality relationships
Aural texture	The perception by a person of the interaction of the characteristics of all the sounds in a particular environment at a particular time
Background Sound Level (L95)	An indicator of the quietest times of day, evening or night. The L95 level is calculated as the noise level equalled and exceeded for 95% the measurement time. The measured L95 time-intervals are arithmetically averaged to present the "average background" levels of the environment for day/evening/night. The level is recorded in the absence of any noise under investigation. The level is not adjusted for tonality or impulsiveness.
Bark	Unit of critical band rate equal to one critical bandwidth
Beats	Periodic variations that result from the superposition of two simple harmonic quantities of different frequencies f_1 and f_2. They involve the periodic increase and decrease of amplitude at the beat frequency ($f_1 - f_2$)
Calibration	A standard test method for an instrument to check its performance against a standard measure
Cent	1/100 of an equal temperament semitone
Character	Distinctive features
Chroma (1)	Pitch class without specification of octave register, eg "C" instead of "C_4"
Chroma (2)	Interval in semitones between a pitch category and the nearest "C" below
Chroma salience	Measure of the perceptual importance of a particular chroma in a musical sound or sequence, as perceived by an average or "ideal" listener
Complex sound	Sound whose pressure waveform is not sinusoidal, and whose spectrum therefore contains more than one pure tone component

Complex tonalness	Measure of tonalness; the audibility of the most audible complex tone sensation of a sound
Conservative	Cautiously moderate or purposefully low
Consonance	How well the tones of a simultaneity or sounds in a sequence sound together, depending on roughness, tonalness, pitch commonality, pitch distance, context, familiarity and cultural conditioning (*cf. sensory consonance*)
Costs and benefits	Includes costs and benefits of any kind, whether monetary or non-monetary, and valuation of amenity
Critical band	Maximum range of frequencies over which the ear is like a single band-pass acoustic filter (so loudness is independent of bandwidth); at wider ranges, it is like a bank of band-pass filters (so loudness increases with increasing bandwidth)
Critical bandwidth	Width of a critical band (in semitones or Hz), equal to about 3 semitones above 500 Hz, and 50 - 100 Hz below 500 Hz; contains a constant number of pitch difference thresholds
Day-Night Level	Day-night average sound level; the cumulative 24-hour level is calculated by the hour or second and sound exposure levels at night (10pm to 7am) are weighted by +10dB
dB	decibel; one-tenth of a bel
dB(A)	decibel, where the sound pressure is A-frequency weighted
Decision support systems	computer based information systems that combine models and data in an attempt to solve non-structured problems with extensive user involvement
Disease (Humans)	An abnormal condition affecting the body; often used more broadly to refer to any condition that causes pain, distress, social problems or death.
Dissonance	Roughness, unpleasant *(cf sensory dissonance)*
DNL	See Day-Night Level
Environment	Ecosystems and their constituent parts, including people, their communities, and their amenity values and the social, economic, aesthetic, and cultural conditions which affect them.
Environmental value (personal)	The qualities of the acoustic environment that are conducive to the well-being of an individual, including the individual's opportunity to have sleep, relaxation and conversation without unreasonable interference from intrusive noise.
Environmental value (community)	The qualities of the acoustic environment that are conducive to the well-being of the community, or part of the community, including its social and economic amenity
Epidemiology	is the study of factors affecting the health and illness of populations
Equal temperament	Term for the 12-tone tuning system of 12-TET that divides the octave into 12 equal parts
Equivalent frequency	Measure of pitch; frequency of a standard reference tone whose pitch is the same as that of a particular tone sensation
Erb	Equivalent rectangular bandwidth. The Erb of a given auditory filter using Patterson's method are typically between 11% and 17% of the centre frequency.
Excessive noise	Any noise that is under human control and of such a nature as to unreasonably interfere with the peace, comfort, and convenience of any person.
Expert system	A computer based system that applies reasoning methodologies on knowledge in a specific domain in order to render advice or recommendations, much like a human expert.
Extrinsic	Not inherent or essential to an individual; community values that may have potential effect on the individual
FFT	Fast Fourier Transform. A mathematical algorithm to compute the discrete Fourier transform (frequency domain) from a digital (time domain) signal or soundfile
Forward masking	The condition in which the masking sound appears before the masked sound
Fundamental	First harmonic; lowest pure tone component of a full complex tone
Harmonic	Whole multiple of a specified number; pure tone component whose frequency is (close to) n times the waveform (fundamental) frequency of a complex tone
Harmony	General term embracing consonance

Health (1)	A state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity
Health (2)	Includes physical, mental, emotional, social and spiritual wellbeing. *(for NZ health impact assessment)*
Hearing threshold level	The hearing level at which a tone of specified frequency is heard by an ear in a specified fraction of trials
Heuristics	Decision rules regarding how a problem should be solved
High amplitude sound	Sound levels above 80 dB
Holistic	The treating of the whole person including mental and social factors rather than just the symptoms of a disease *(cf. wholistic)*
Hz	Hertz; frequency in cycles per second
Intensity	Of a sound: amount of energy transmitted per unit time, per unit area perpendicular to the direction of propagation
Intrinsic	inherent, essential, belonging naturally; reflecting personal noise sensitivity, personal and cultural attitudes to sound in the environment, the environment itself, and habituation effects
Intrusive noise	To an individual, is a sound whose variance in character (such as audibility, dissonance, duration, loudness, tonality, pitch or timbre) is perceived adversely compared to the character of the environment in the absence of that sound
Intrusive sound	A sound that, by its characteristics, is audible and intrudes upon the well-being or amenity of an individual
ISO	International Organization for Standardization
Just noticeable difference (1)	The differential threshold, or difference limen, is the change in stimulus that can be correctly judged as different from a reference stimulus in a specified fraction of trials
Just noticeable difference (2)	Under careful testing, the just noticeable difference can be 2 to 3 cents
Knowledge base	A collection of facts, rules, and procedures organized into schemas. The assembly of all information and knowledge of a specific field of interest
L10, L90, L95	The time-weighted and frequency-weighted sound pressure level that is exceeded for 10%, 90% or 95% of the time interval considered, in decibels
LAeq	See Time-average sound level
Lden	Day-evening-night noise exposure; the long term time-average level to which penalties of 5dB for evening and 10 dB for night-time hours are added
Loudness	Attribute of auditory sensation by which different sensations may be ordered on a scale extending from “soft” to “loud”
Loudness Level	Value in phons that has the same numerical value as the sound pressure level in decibels of a reference sound, consisting of a frontally incident, sinusoidal plane progressive wave at a frequency of 1000 Hz, which is judged as loud as the given sound
Loudness Level (2)	Normal equal-loudness-level contour
Low amplitude	Sound levels below 50 dB to nominal threshold of hearing
Masked threshold	Threshold of audibility in the presence of maskers
Masker	A sound that masks other sounds
Masking	Complete or partial “drowning-out” of one tone by another
MIDI	Musical Instrument Digital Interface – a protocol for electronic musical devices
Moderate amplitude sound	Sound levels ranging between 50 dB to 80 dB
Modulation (1)	Periodic change in the amplitude or frequency of a sound (beating)
Modulation (2)	‘Amplitude modulation’ is a spectral modification process that produces discrete upper and lower sidebands determined by the modulation frequency and the modulation depth *m*.

Modulation (3)	'Amplitude modulation depth' is a measure of the spectral energy spread of an amplitude modulated signal.
Modulation (4)	Modulation, by amplitude, is defined as a peak to trough variation that exceeds 3dB on a regular basis (3dB is taken as negligible, 6dB as unreasonable and 9dB taken as excessive); by frequency, modulation is defined as a variation that exceeds one semi-tone on a regular basis.
Modulation frequency	The difference between the frequencies of two beating pure tone components
ms	milli-second (1/1000 of a second)
Negligence	A failure to exercise duty of care in a professional situation
Noise	A sound that is perceptible to an individual and has definable characteristics that modify the individual's emotional and informational responses to that sound from pleasurable or neutral to adverse.
Noise annoyance	An emotional and attitudinal reaction from a person exposed to noise in a given context.
Noise sensitivity	A person's condition enhancing their reactivity to noise
Normal equal-loudness-level contour	Equal-loudness-level-contour that represents the average judgment of otologically normal persons within the age limits from 18 years to 25 years inclusive
Octave	Distance between two tones or frequencies corresponding to a frequency ratio of 2:1; a frequency level difference of 12 semitones
Peer Review	Professional or scholarly. An impartial critique of someone else's work to determine if it is sound and robust. The review is based on the reviewer's own research / experience and knowledge of the current literature in the field. The role of the reviewer is not to bring in new information, but rather to say whether or not, in the reviewer's expert opinion, that the person's work being reviewed is sound. If there are errors or critical omissions, these need to be highlighted with appropriate justification. If the information / data is considered accurate, this should be noted.
Perceive	To observe; to apprehend; to understand
Phon	The loudness level of a given sound or noise
Pitch (1)	Attribute of a tone sensation by which it may be ordered on a scale from "low" to "high"
Pitch (2)	An auditory attribute in terms of which sine tones can be ordered on the low-high dimension *(cf. spectral pitch and virtual pitch)*
Pitch (3)	Perceived fundamental frequency of a sound
Pitch difference thresholds	Just noticeable difference in pitch, smallest perceptible physical change in a stimulus
Pitch prominence	Audibility, salience of a pure tone
Precautionary Principle	Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation
Prediction methods	Methods to calculate sound levels emitted from a source(s) to a distant receiver(s); an estimate defined by the model's calculation assumptions and uncertainties
Psychoacoustics (1)	The science that deals with the psychological correlates of the physical parameters of acoustics
Psychoacoustics (2)	Human perception of sound and noise
Psychophysics	The science that deals with the qualitative relationships between physical and psychological events
Pulsing	A rhythmic beat or vibration; as in a pulsating sphere
Pure tone	Tone whose pressure waveform is sinusoidal
QEPA	Environmental Protection Agency, Queensland, Australia
Qld EPP (Noise)	Environmental Protection (Noise) Policy 1997 (revised 2008), Queensland, Australia
Root mean square (RMS)	Average value of a waveform calculated by taking the square root of the mean of the square of the function

Roughness	Sensation associated with beating at frequencies in the range 20 – 300 Hz
Rule	A formal way of specifying a recommendation, directive or strategy, expressed as IF premise, AND statement(s), THEN conclusion
Salience	Perceptual importance or prominence of a stimulus; probability of being noticed or sensation being experienced
Semitone	Unit of frequency level; twelfth part of an octave; equal to 100 cents (equal temperament)
Sensation	The consciousness of perceiving or seeming to perceive some state or condition of one's body or its parts or senses or of one's mind or its emotions
Sensory consonance	The absence of dissonant beats
Sharpness	Sharpness is a measure of the high frequency content of a sound, the greater the proportion of high frequencies the 'sharper' the sound.
Significant	(in statistics) most unlikely to have occurred by chance (e.g., p<0.05 means that the probability of a given result occurring by chance is less than 5%.
Socio-acoustic	Social attitudinal study combined with an acoustical survey within the same community
Sone	Loudness. The numerical definition of the strength of a sound which is proportional to its subjective magnitude as estimated by normal observers. One sone is the loudness of a sound whose loudness level is 40 phons.
Sound exposure	The total sound energy produced from a sound source over a specified time or event
Soundfile	Sound recording (often) in Microsoft PCM .wav format
Sound quality	The character of sound as perceived by a person
Soundscape	The part of the environment of a place or locality characterised by the sounds that may be experienced there (*cf. acoustic environment*)
Special audible characteristics	Sound that has distinct features such as impulsiveness, modulation or tonality that makes the sound stand out from other sounds in the same soundscape
Spectral pitch	An elementary auditory object that immediately represents a spectral singularity, e.g., a sine tone *(cf virtual pitch)*
Subharmonic	Whole multiple of a particular number (e.g., 2.5 is the 4^{th} subharmonic of 10)
Threshold of audibility	Threshold sound pressure (defined for an average "ideal" listener) below which a pure tone is inaudible, expressed as a function of its frequency *(cf Hearing threshold level)*
Threshold of hearing	Level of a sound at which, under specified conditions, a person gives 50% of correct detection responses on repeated trials
Threshold of pitch	Lowest (20 Hz, E_0) or highest (16 kHz, C_{10}) audible pitch
Timbre	Timbre or tone quality or tone colour is a function in time of the frequency content or spectrum of a sound, including its transients and pitch, loudness, duration and manner of articulation. Timbre allows a person to distinguish between different sounds, instruments and voices.
Time-average sound level	Time-average sound level or equivalent continuous sound level, no frequency weighting stated but normally A-weighted
Tonal	Evoking pitch or tone sensation(s)
Tonality (1)	Pitch structure in music in which some pitches are more important (salient, stable) than others
Tonality (2)	A sound sensation having unambiguous pitch; other attributes include loudness or salience, timbre, and apparent duration *Cf. tone sensation*
Tonalness	The extent to which a sound evokes (pure or complex) pitch or audible tone sensations
Tone (1)	Sound which evokes a tone sensation; approximately or exactly periodic sound in the audible range of frequencies; sound whose various possible pitches belong mostly to a single chroma

Tone (2)	A sound sensation having pitch
Tone sensation	Auditory sensation having one, unambiguous pitch; other attributes include loudness or salience, timbre, and apparent duration
Unbiased Annoyance	The response of subjects annoyed exclusively by sound under describable acoustical circumstances in laboratory conditions without relation to the nature of the source
Unreasonable noise	Unreasonable noise is a sound or vibration that is: - annoying to a reasonable person; or - injurious to personal comfort or health, including sleep disturbance; or - a disturbance to the quiet enjoyment of land including the grazing of stock or keeping of animals; or - observed to have a detrimental affect on wildlife or the environment
USEPA	United States Environmental Protection Agency
Virtual Pitch	An attribute of auditory sensation with the fundamental pitch 'extracted' by the auditory system from a range of the Fourier spectrum that extends above the fundamental
.wav	Microsoft uncompressed PCM audio file format for storing audio in digital format in a computer
WHO	World Health Organization
Wholistic	Whole, complete, comprising or involving all parts
Z-weighting	Z- weighting (very similar to the previous 'Lin' or 'Flat' response) gives the unweighted sound pressure level with lower and upper cut-off as specified by the manufacturer; generally 20 Hz to 20,000 Hz (see figure, following)

WEIGHTINGS

A-, C-, Z Weighting