THE ACOUSTIC GROUP PTY LTD
CONSULTING ACOUSTICAL & VIBRATION ENGINEERS

REVIEW OF DRAFT WIND FARM GUIDELINES

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EXECUTIVE SUMMARY

In late 2011 The Acoustic Group performed a desk-top review of the acoustic documents comprising the acoustic assessment for the Flyers Creek Wind Farm and conducted preliminary sound monitoring at an existing operational wind farm (the Capital Wind Farm) which was approved in New South Wales on the basis of similar analyses, guidelines and reports to that provided for the Flyers Creek Wind Farm. The assessment found deficiencies and inadequate information in the acoustic assessment of the Flyers Creek proposal such that the true acoustic impact of the proposed wind farm had not been presented to the community.

In the intervening period a set of Draft Wind Farm Guidelines have been issued by the NSW Department of Planning and Infrastructure ("the Department") for public comment.

The Acoustic Group was requested by FCWTAG to examine the Draft Wind Farm Guidelines with respect to acoustic issues. As there are no acoustic compliance reports for operational wind farms in NSW in the public domain, The Acoustic Group was also requested to conduct additional testing to assess the Draft Guidelines with respect to practical aspects of their application to operating wind farms.

The Draft Wind Farm Guidelines have identified that they closely follow the existing South Australian Guidelines in relation to the noise criteria. The problem for the broader community in comprehending the Guidelines is that from a noise perspective by definition, the Guidelines must be expressed in technical terms which are not readily understood by the community. The community therefore relies on the preparation by the Department of noise guidelines that set rigorous criteria and assessment procedures as well as a rigorous compliance regime. A reasonable person would expect that such Guidelines would be drawn from and based upon solid data and measurements. Despite the fact that the Department has had the opportunity to scrutinize data and undertake scientific investigations of operating wind farms for the purpose of the Draft Guidelines, it has not done so.

The Draft Wind Farm Guidelines set out measurement, assessment and compliance procedures which are likely to be unworkable in practice. This review highlights a number of outstanding issues in relation to noise impacts from wind farms that require the Draft Guidelines to be amended in order to safeguard the acoustic amenity of residents in areas where wind farms are proposed and where there has previously been no such noise source.

It is recommended that the proposed base criteria for wind farms be amended to 30 dB(A) when assessed under the worst case scenario. In particular, it is concluded:

1. There is no material or reference in the Guidelines supporting the use of 40 dB(A) as an acceptable amenity level in rural NSW. Examination of the Department's compliance review of the Capital Wind Farm confirms Leq levels when turbines are shut down which are significantly lower than 40dB(A) and which undermine this standard as an acceptable amenity.

2. The Draft Wind Farm Guidelines ignore "Offensive Noise." In so doing, the Guidelines set criteria which are inconsistent with the EPA's Industrial Noise Policy. Examination of noise data from the Capital Wind Farm confirms that the current Draft Guidelines will permit noise significantly above background level i.e. offensive noise which is likely to interfere unreasonably with a person's health, comfort or repose.

3. **The base limit for wind farms should be 30 dB(A) when assessed under the worst case scenario.** Testing establishes that this limit would be consistent with EPA guidelines for the protection of acoustic amenity in rural areas.

4. The Guidelines are vague and inconsistent in relation to the assessment of and measurement during **temperature inversions.** This undermines the efficacy of the noise criteria.

5. The use of the A-weighting filter is not sufficient to account for the audibility and annoying characteristics of wind farm noise. This is demonstrated with data obtained from the Capital Wind Farm, Woodlawn Wind Farm and Cullerin Range wind Farm.

6. The guidelines do not specifically require full spectrum noise monitoring inside residential properties. Data obtained demonstrates that such monitoring is essential to reflect noise impact and specific noise characteristics.

7. The Guidelines require more detailed acoustic analysis at the proposal stage to identify the effects of different weather scenarios. These scenarios are typically required for industrial noise assessments and in their absence, proper compliance monitoring is impossible.

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8. The measurement procedure in relation to specific noise characteristics describes measurements conducted over a 10 minute period. **This does not permit identification of these characteristics which are associated with swish, modulation, discrete tones and low frequency noise**. This is demonstrated with analysis of data from operating wind farms. Criteria in relation to amplitude modulation are uncertain.

9. Examination of data demonstrates that compliance monitoring can only be effective with the provision of permanent noise monitoring within the wind farm, recording noise levels, wind speed and direction at receiver locations and recording wind speed and direction at hub height. **The Guidelines do not, but should, provide for such permanent noise monitoring supplemented with temporary remote monitoring in real time to deal with complaints.**

10. The provision of permanent noise monitoring data together with real time presentation of the wind speed and direction at the hub, the power output and operational status of individual turbines must be provided in the **public domain** to permit independent compliance testing. There is no provision for this in the Draft Guidelines.

11. **Compliance procedures are ineffective. The Guidelines do not provide a clear indication of what triggers non-compliance. The specified effects of non-compliance are vague.** There are no provisions requiring a cessation of operations if the wind farm is not compliant.

It has been asserted elsewhere that the Draft Guidelines will bring into place the most stringent standards for wind farms in Australia. In order to do so, the Guidelines will require modification to deal with the matters raised in this report.

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1.0 INTRODUCTION

I Steven Edwin Cooper the Principal of The Acoustic Group Pty Ltd, Consulting Acoustical and Vibration Engineers, prepared a desk top review of the acoustic assessment that had been prepared for the Flyers Creek Wind Farm. My desk top audit was contained in a submission from the Flyers Creek Turbine Awareness Group ("FCTAG") in relation to the proposed Flyers Creek Wind Farm.

The desk top review was supplemented by preliminary noise testing in proximity to the Capital Wind Farm. The preliminary testing highlighted a number of issues with respect to the assessment and evaluation of wind farm noise where the predominant acoustic descriptor is the dB(A) level.

The preliminary testing was not a compliance test as under the SA EPA guidelines one needs to undertake testing for at least two weeks and one needs to include wind data at the receiver location and the hub height of the turbines (or for an earlier version of the SA Guidelines 10 m height at the wind farm). The hub height wind data and the operational parameters of the wind farm are not available to the public.

The unattended measurements revealed ambient background levels in the night to be significantly below the nominal base level of 35 dB(A) for noise emission from a wind farm.

Contrary to the suggestion in the Flyers Creek Environmental Assessment the attended measurements to Capital found the turbines to be audible inside residential premises and when the turbines were operational there were discrete sound levels measured in the bedrooms that were below the audible threshold of hearing.

At the time of the preparation of my desktop audit there were no noise guidelines issued by the NSW entities of the Department of Environment, Climate Change and Water ("DECCW"), the Office of Environment and Heritage ("OEH"), or the Environment Protection Authority ("EPA") with respect to wind farms.

Since the FCWTAG submission was lodged with the Department of Planning, Draft Wind Farm Guidelines have been issued by the Department for public comment.

In addition, a detailed acoustic assessment of turbine operations in Falmouth, Massachusetts by Rand and Ambrose ("The Bruce McPherson ILFN Study Report") has since been issued that identifies a number of matters raised and discussed in my desk top review document. There has also been a paper issued by Shepherd, McBride, Welch, Dirks and Hill ("Evaluating the impact of wind turbine noise on health – related quality of life") concerning the adverse impact of wind farm noise on people.

On 22nd February 2012 the Australian Acoustical Society (NSW Division) hosted a technical seminar in relation to the Draft Wind Farm Guidelines with the author of the acoustic section of the Draft Wind Farm Guidelines giving a presentation of the acoustic issues. The acoustic matters presented at the AAS meeting appeared to be slightly different to the draft wind farm guidelines issued for public comment.

In view of having conducted the preliminary measurements of Capital Wind Farm, and attendance at other wind farms to collect data, I have been requested to examine the Draft Wind Farm Guidelines with respect to acoustic issues and ascertain their practical application an operational wind farm

Page 35 of the Draft Wind Farm Guidelines requires that details of the acoustician's qualifications and experience should be included in the assessment report. Therefore it is appropriate to identify my qualifications to undertake an acoustic assessment of the Draft Guidelines.

I have been in practice as an Acoustical Consulting Engineer for 34 years. I hold a Bachelor of Science (Engineering) degree from the University of New South Wales and a Master of Science (Architecture) degree from the University of Sydney and am a Chartered Professional Engineer. I am a Fellow of the Institution of Engineers Australia, a Member of the Australian Acoustical Society and a Member of the Institute of Noise Control Engineering (USA).

In the course of my Acoustical Consulting practice I have been involved in numerous projects for private, commercial and government organisations requiring expertise in acoustics, noise and vibration issues.

Furthermore as a practising Acoustical Consulting Engineer I am or have been a member of the Standards Association of Australia Committees AV4, AV/10, AV/10/4 and EV/11 dealing with Architectural Acoustics, Whole-Body Vibration, Rail Traffic Noise, and Aircraft Noise respectively. I was a member of the Australian Acoustical Society NSW Membership Grading Committee from 1979 to 1997 and was a member of the Australian Acoustical Society Federal Grading Committee in 1998. My curriculum vitae is set out in Annexure A.

In relation to acoustic compliance of large industrial projects I am aware of EPA/DECCW/OEH requirements for compliance testing and the nature of the variability of such testing and different noise propagation issues for large developments. I have conducted compliance testing of large industrial plants, determined acoustic non-compliance of the Polythene Plant at Botany when the German contractor Linde and the NSW EPA said the measurements could not determine compliance. After the implementation of additional noise controls I demonstrated to the satisfaction of the NSW EPA that acoustic compliance had been achieved.

I was a member of a working group between industry and the EPA for amendments of the Draft Stationary Noise Source Policy that were subsequently incorporated into the Industrial Noise Policy.

I prepared the ICI Noise Reduction Program which became the draft version of Chapter 10 of the EPA's Industrial Noise Policy.

I provided input to a revision of the INP that resulted in the issue by the EPA of the "Application notes – NSW industrial noise policy".

My Master's thesis was research work that involved the testing and review of previous Standards and experiments into reverberation time and absorption measurements that uncovered anomalies and errors in previous research and reporting (by others).

I have conducted measurements and research into the propagation of aircraft noise for military aircraft with one set of research proving there were errors in the lateral attenuation algorithms used in the US Federal Aviation Administration's INM program. The errors were acknowledged by the US Aircraft Noise Standards Committee SAE21 in 2003 and the INM program (used for aircraft noise assessment around the world) was amended with a public release some two years later.

I have continued research into the atmospheric attenuation used in INM and the ICAO (International Civil Aviation Organisation) certification procedures for aircraft and found errors in the high frequency absorption coefficients that have been presented in a number of papers in Australia, New Zealand and the USA – see Appendix A.

It is noted that in the course of my professional career I have been involved in projects where I have appeared for Applicants, Objectors, Councils, Government Departments (State and Federal) or as a Court Appointed Expert. I am not a member of any political parties and have not been retained or approached by any wind farm proponents to undertake an assessment of wind farm noise.

With respect to the review of the Draft Wind Farm Guidelines the following documents (in addition to those discussed in my desk top audit of the Flyers Creek proposal) that are relevant to the subject review are:

- Ambrose S, Rand R, The Bruce McPherson ILFN Study Report, December 14, 2011.
- Dickinson PJ, A pragmatic view of a wind turbine noise standard, Acoustics 2009, Adelaide.

- Lenchine V, Amplitude modulation in wind turbine noise, Acoustics 2009, Adelaide.
- Zwicker E and Fastl H, Psychoacoustics, Facts and Models (Springer – Verlag Berlin 1990).
- Shepherd D, McBride D, Welch D, Dirks K, Hill E, Evaluating the impact of wind turbine noise on health – related quality of life, Noise & Health, September-October 2011, vol 13.
- Hanning C, Evans A, Wind turbine noise, British Medical Journal 2012,:344:e1527.

2.0 THE BASIS OF THE ACOUSTIC ASSESSMENT IN THE GUIDELINES

The introduction to the Draft Wind Farm Guidelines claims that the objective:

> "is to provide practical guidance to proponents, planners, regulatory authorities, acousticians and the broader community on how to measure and assess environmental noise impacts from wind farms".

Therefore, one would assume that the requirements for noise monitoring, and in particular compliance would be presented in a clear and concise manner that could be easily understood.

However, reviewing the Draft Wind Farm Guidelines it would seem that the document is a cut and paste of a number of documents and that there are a number of technical errors.

The introduction identifies that the guidelines closely follow the South Australian 2009 wind farm guidelines and Australian Standard AS4959-2010. The introduction also identifies that the guideline "draws on experience gained in the assessment and operation of wind farms in NSW and community input". It does not identify that the guideline is based on experience of compliance testing of wind farms undertaken in NSW by Applicants or the Department.

The Draft Wind Farm Guidelines state that the noise criteria is based on a limit of "35 dB(A) or the background noise (L90) by more by than 5 dB(A), whichever is the greater, at all receiver locations not associated with the wind farm", and refers to Figure 1 as a typical noise criteria curve.

The Draft Wind Farm Guidelines require the noise criteria to be established on the basis that the daytime period (7am – 10pm) is assessed separately to the night time period (10pm – 7am).

The Draft Wind Farm Guidelines claim that in New South Wales endeavours are made to retain an acoustic amenity commensurate with the objectives of the surrounding land uses and provide an extract that is from Table 2.1 of the INP. This extract suggests that a recommended amenity level in a rural area at night is 40 dB(A).

There is no material or reference supporting the use of 40 dB(A) as an acceptable amenity level in rural NSW.

The paragraph following Table 1 (in the Draft Wind Farm Guidelines) seems to suggest that the acceptable amenity level is 10 dB(A) above the average background level of 30 dB(A), but that where the background is higher than 30 dB(A) the criterion becomes background + 5 dB(A). There is a reference to Australian Standard AS1055.2 as "Average background level for an area with negligible transportation noise set by AS 1055.2.Acoustics – Description and measurement of environmental noise".

There is an error in the reference in that firstly **AS1055.2 does not "set" an average background level**. The background level appears in Appendix A of the Standard which is an informative Appendix and is not actually part of the Standard. The Appendix is provided for information and guidance.

The second point in using AS1055.2 as setting the limit, is that the (informative) Appendix states above a table of estimated background levels:

> "Whenever possible values of $L_{A90,T}$ shall be measured in accordance with Clause 4.2.1. Where the measured values are obtainable, this Appendix shall not be used."

The third point in using AS1055.2 as a reference is that the notes to Appendix A identify that the basis of the estimated background levels appears to relate to traffic affected areas, viz:

NOTES:

1. The division into noise area categories is necessary in order to accommodate existing sound levels encountered at residential sites in predominantly commercial or industrial districts, or in areas located close to main land transport routes, i.e. road and rail
2. The noise area category most appropriate should be selected irrespective of metropolitan or rural zoning and will vary from location to location.
3. Some industrial and commercial sites are not predominant sources of high background sound levels.

In undertaking the measurements, page 30 of the Draft Wind Farm Guidelines indicates the use of background noise is defined by the 90 percent exceeded noise level in the absence of any wind farm noise prior to construction, and again for the compliance assessment in the presence of the operational wind farm.

For compliance purposes the Draft Wind Farm Guidelines indicate the relationship between the background L90 level and the equivalent noise level (Leq) to be Leq = L90 + 1.5 dB(A).

The Draft Wind Farm Guidelines indicate the measurement locations should be an outdoor area within 30m of the sensitive non-associated wind farm receiver and placed in the direction of the wind farm. The location must not be near trees or any reflecting surfaces other than the ground.

One can measure the wind at the wind farm and at the receiver location.

The "wind monitoring location" in the guideline is defined as at the wind farm site and is referenced to the wind turbine hub.

For measurements of wind at the microphone the height is 1.2 – 1.6 m above the ground.

The noise data collection nominates the measurement of background level in ten minute intervals with a meter/logger of at least Class 2 and capable of a noise floor no greater than 20 dB(A).

The microphone is to have a wind shield with a limitation of no more than 1 dB(A) attenuation before the data is to be excluded. The Guidelines do not identify at what wind speed this limitation occurs, but refers the reader to Section 5. **There is no Section 5 in the Guideline**.

There is no requirement in the long term monitoring to include measurements under temperature inversions, although the first paragraph indicates it is advisable to schedule the collection of noise data when there is a high probability that worst case scenarios will be captured.

The measurement duration for long term monitoring is indicated to be at least 2000 valid measurement intervals (or the equivalent of two weeks' worth of data) and at least 500 points should be from the worst-case wind direction. There is a qualification - a wind direction spread of 45^{o} either side of the direct line from the nearest wind turbine and the relevant receiver is considered acceptable.

The inclusion of attended monitoring to include at least four site visits with each site visit including 8 hours of monitoring (or more) and equally include day and night periods is a significant improvement on the SA guidelines.

The data analysis suggests a polynomial order (from linear up to third order) be carried out of the background levels. **The example provided in Figure 3 does not show levels below 24 dB(A) and therefore would appear to contradict the monitoring requirements specified in the draft guidelines. Furthermore the data shown does not extend down to still conditions so as to describe the range of the acoustic environment at the receiver location.**

The Draft Wind Farm Guidelines proceed to discuss adjustments to specific noise characteristics that to the broader community would be expected to be addressed using the loggers nominated for measurement. **However the use of A-weighted 10 minute sampling does not provide for the analysis of specific characteristics as discussed later in this review.**

The Draft Wind Farm Guidelines then discuss noise predictions and the assessment report before then identifying that for assessing compliance one requires to adjust the measured levels to assess the worst case situation. **Yet the following section "Conditions of consent" indicates noise monitoring (for compliance) is to be undertaken during period(s) commensurate with the 'worst case' operational and meteorological factors (including temperature inversions).** The manner in which the Draft Wind Farm Guidelines deal with worst case scenario situations and temperature inversions is, at best, vague and, at worst, contradictory.

3.0 THE BASE CRITERIA AND OFFENSIVE NOISE

There is a fundamental problem with the selection of the base criteria if it is meant to ensure there are no adverse noise impacts. What constitutes an acceptable acoustic amenity for residents in a rural area has not been established. The issue of offensive noise is not addressed even though it must automatically flow on from the base criteria.

If noise from wind farms interferes unreasonably with the comfort or repose of a person then there is offensive noise. Similarly if the noise affects a person's health then it must be offensive. The Draft Wind Farm Guidelines have ignored offensive noise and this is a major issue for residents impacted by wind farms.

The concept of background + 5 dB(A) for noise limits has been provided in AS1055 in the format of when a noise exceeds the background level it is likely to be annoying with exceedances of up to 5 dB(A) being considered marginal.

The INP uses this background + 5 dB(A) concept as the intrusive noise. The INP does refer to wind farms. In the INP the Rating Background Level is used for assessment of the intrusive noise criterion of background + 5 dB(A). The INP uses the intrusive noise criterion and the amenity noise criterion. The Application Notes to the INP require compliance with both criteria.

Similarly the EPA in their advice to councils in the *Noise Guide for Local Government* use the background + 5 dB(A) as the basic assessment tool. The *DECCW Noise Guide for Local Government* ("NGLG" - 2011 version) uses the intrusive noise concept.

NGLG Table 1.3 ("Approaches to managing common neighbourhood noise issues") refers to typical noise sources encountered in suburban situations and identifies who is responsible to control the noise, the assessment procedure, and the suggested management/Regulation for those noise sources. Wind farms as a noise source appear in Table 1.3 on page 1.33 but there is no assessment procedure of management/Regulation.

Section 2.1.1 of the NGLG addresses Offensive Noise by stating:

Depending on the type of noise under consideration, noise can be considered as offensive in three ways according to its:

- audibility
- duration
- inherently offensive characteristics.

'Offensive noise' is defined in the dictionary of the POEO Act as noise:

> *(a) that, by reason of its level, nature, character or quality, or the time at which it is made, or any other circumstances:*
> *(i) is harmful to (or is likely to be harmful to) a person who is outside the premises from which it is emitted, or*
> *(ii) interferes unreasonably with (or is likely to interfere unreasonably with) the comfort or repose of a person who is outside the premises from which it is emitted, or*
> *(b) that is of a level, nature, character or quality prescribed by the regulations or that is made at a time, or in other circumstances, prescribed by the regulations.*

The POEO Act and Noise Control Regulation allow for an assessment of offensive noise in some neighbourhood noise situations without the use of a sound level meter to measure actual noise levels.

The Draft Wind Farm Guidelines do not identify the use of an intrusive noise criterion for compliance purposes, in that by utilising 10 minute sampling and not requiring compliance for any ten minute period one automatically moves away from the intrusive noise target.

It could be argued that the 35 dB(A) base line addresses the concept of intrusiveness by assuming a minimum background level of 30 dB(A) as nominated in the INP. However this position does not agree with the reality of background noise levels in rural areas, nor does it address the fact that page 14 of the INP (in Section 2.1) states that the intrusive noise "is assessed at the most-affected point on or within the **residential** property boundary – or, if that is more than 30m from the residence, at the most –affected point within 30 m of the residence" {EPA emphasis}.

The rural properties impacted by wind farms are not residential properties but residences on rural properties that exist in an acoustic environment entirely different to that of urban or suburban areas.

The first two paragraphs of Section 2.1 of the INP state:

> The intrusiveness of an industrial noise source may generally be considered acceptable if the equivalent continuous (energy average) A-weighted level of noise from the source (represented by the L_{Aeq} descriptor), measured over a 15-minute period, does not exceed the background noise level measured in the absence of the source by more than 5 dB.
>
> To account for the temporal variation of background noise levels, the method outlined in Section 3.1 is recommended for determining the background noise level (rating background level – RBL) to be used in the assessment. This approach aims to result in the intrusive noise criterion being met for at least 90% of the time periods over which annoyance reaction can occur (taken to be periods of 15 minutes).

The EPA's INP utilises the concept of requiring the noise to satisfy the relevant criteria for 90% of the time for 90% of the population. This concept is derived by determining a noise target that satisfies 90% of the population and using the Rating Background Level method (as identified in the INP to determine the lowest tenth percentile) would therefore reveal a level that occurs for 90% of the time.

However, the Draft Wind Farm Guidelines contradict the EPA concept. The guidelines nominate 35 dB(A) or background + 5 dB(A) whichever is the higher.

For background levels less than 35 dB(A) the use of a 35 dB(A) limit results in a level greater than the EPA fundamental concept of background + 5 dB(A).

By use of a regression line analysis of background levels at receiver locations versus the wind speed at the hub height one must by definition for background levels greater than 35 dB(A) have a noise limit based on say 50% of the time. Does the limit relate to 90% of the population? To substantiate the regression line to community reaction it would be necessary to obtain a dose-response curve for the background levels related to the hub wind speed.

Any measurements at residential receivers would involve the noise level at the receiver location versus the wind speed at the monitoring location. That situation leads to the more appropriate dose-response of wind affected background at the receiver versus the noise impact. **It would appear that such a dose-response has never been provided, i.e. the basis of the acceptability at the higher wind speeds has not been obtained.**

To accord with the EPA assessment procedures in rural environments the base limit for wind farms should be 30 dB(A) when assessed under the worst case scenario. On the basis of background level measurements under 25 dB(A) recorded at rural properties it is suggested that such a limit would ensure consistency with offensive noise requirements and the objects of the Guidelines as well as the EPA criteria.

4 THE CAPITAL WIND FARM - A CASE STUDY OF THE DRAFT WIND FARM GUIDELINES

Initial results from preliminary testing at the Capital Wind Farm confirmed concerns that the Flyers Creek Wind Farm will result in the generation of intrusive and offensive noise in that testing found the Capital Wind Farm to be generating audible noise above predicted levels. The testing suggested that at times there were levels above that prescribed by its consent at the residential site tested. The attended measurements validated complaints of adverse impacts.

Additional testing has been carried out to assess practical aspects of the application of the proposed Draft Wind Farm Guidelines to an operating wind farm and, in particular, with a view to ascertaining the impact (if any) of the Draft Wind Farm Guidelines in their proposed form on the documented problems of the Capital Wind Farm.

4.1 Unattended Noise Monitoring.

My desktop audit report included attended and unattended noise monitoring at a number of residences in proximity to the Capital Wind Farm. During some of the attended measurements noise from the wind farm was found to be audible outside the residences with noise levels at one house above that predicted in the Application.

Noise from the operation of the wind farm could be detected inside residences and were the subject of measurements set out in the previous report.

Unattended noise monitoring was conducted at a number of houses with different types of instrumentation and included at one house a comparison of a Type 1 logger (Type 1 as described in AS1259) versus a Type 1 sound level meter that has a noise floor below 20 dB(A). The comparison identified an issue with the preparation of regression curves without all the data points.

In view of the 20 dB(A) noise limit it would seem unlikely that a Class 2 meter would achieve that level. However the use of a Class 2 meter has a greater tolerance than a Type 1 meter and therefore would be less accurate for measurements than a Class 1 meter.

The previous ambient noise measurements when plotted with the output power of the two wind farms (Capital Wind Farm and Woodlawn Wind Farm from windfarmperformance) revealed a clear pattern of increased background level corresponding to the operation of the wind farms. The results provided on windfarmperformance are identified as having the data obtained from Australian Energy Market Operator.

For this review unattended noise monitoring was carried out at House G16 using a Class 1 sound level meter (SVAN 957 S/N 23806) located 12 metres to the west of the residence being towards the group of turbines to the north west on Groses Hill. The logger microphone had a clear line of sight to a bank of turbines on the Woodlawn wind farm to the north east and also line of sight to the Capital wind farm turbines 35 – 38 on Hammonds Hill (see Appendix B).

Appendix B1 provides an expanded view of the separation distances from the Capital wind farm and indicates house G16 is about 2.5 kilometres from the Groses Hill turbines and 2.1 kilometres from the Hammonds Hill turbines.

For the purpose of obtaining wind data at the microphone, wind direction and speed were obtained by a Windlog wind data logger and recorded in ten minute periods to accord with the noise measurements.

Appendix D sets out the results of the unattended monitoring and includes the wind speed at the microphone. One cannot plot the turbine hub speed on the graphs as that material is not available.

The absence of the turbine hub speed or any data in the Environmental Assessment for the Capital Wind Farm to identify the relationship of the hub wind speed to residential locations presents some difficulty in undertaking an independent compliance test.

Table 5 in the Background Noise Monitoring Report for the Capital Wind Farm provides the background noise level at integer wind speeds. This is the wind noise level which is suggested in the Guidelines as the value taken of the measured noise level of wind and turbines in order to determine a contribution.

	Wind Speed (m/s)													
	4	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*
Site 1	30	31	33	34	36	37	38	39	41	42	43	44	45	45
Site 2	28	29	30	31	32	33	35	36	38	40	42	44	46	48
Site 3	27	28	30	31	32	34	35	37	38	39	41	42	44	45
Site 5	31	32	33	34	35	36	37	38	39	39	40	41	42	42
Site 6	29	29	29	30	31	32	34	35	37	38	40	41	42	42
Site 8	25	27	30	33	35	38	40	42	44	46	49	50	52	54
Site 9	28	29	30	32	33	34	35	36	37	38	39	39	40	41
Site 10	27	28	30	31	32	34	35	36	38	39	40	42	43	44

Table 5: Background noise levels at various wind speeds (at 10mAGL).

The data in Appendix D to the Capital Wind Farm background noise monitoring report suggest the difference between the 10m wind farm speed at site 3 could be up to twice the speed of that at the residence. The provision of data to identify this situation is required for further analysis.

If one assumes a doubling of the wind farm wind speed at 10m to that at the residence then for 2m/s at house G16 one could subtract 27 dB(A) off the background level, 30 dB(A) off at 3m/s, 35 dB(A) off 5 m/s and say 41 dB(A) off at 7m/s to gain some appreciation of the noise impact from unattended measurements (as contemplated by the Draft Guideline).

On this basis there are periods of time from the logger graphs that indicate excessive noise. **Obviously this method of estimating the noise impact is not satisfactory for compliance purposes and automatically requires the Draft Guidelines to require the wind farm weather details to be available in the public domain.**

It is noted that the Capital Wind Farm does not provide any noise or weather data on their web site, nor any acoustic compliance report(s). Without such material and identification of the output of the wind farm it is impossible for anybody to check the "compliance" testing/ reports.

As identified in my previous report the use of dB(A) as the assessment index is limited in addressing the noise that residents receive. Furthermore the use of an external noise criteria is questioned, when the major noise impact for residents is inside their homes.

4.2 Attended Monitoring

For the consideration of internal noise levels, modulation, infrasound and tonality the provision of dB(A) results as a Leq level over 10 minutes is totally inadequate. To address these issues with respect to the draft guidelines it is necessary to review measurements that have been undertaken both inside and outside residential properties to examine the methodology proposed in the draft guideline.

My previous report included noise measurements inside and outside residential premises. Appendix G1 reproduces the measurements previously shown for **house G16** that were recorded in the evening on 7th December 2011.

The audible noise detected outside the residence was from the Woodlawn turbines as under the prevailing conditions the house was downwind of those turbines.

Inside the residence a distinct audible tone was evident and as shown by the 1/3 octave band information in the second figure of Appendix G1 there were distinct frequency peaks below 20 Hz. The 1/3 octave data provides the statistical spread of noise levels over a 10 minute period for the two locations (measured simultaneously).

Appendix G2 shows the A-weighted and 25 Hz 1/3 octave band levels over a 3 minute period at a sampling rate of 10 times a second FAST response.

The results show a significant variation in the 25 Hz 1/3 octave band level in excess of 10 dB.

Appendix G3 shows the results of 2 minute FFT 400 line analysis for a bandwidth to 50 Hz. As for the 1/3 octave band spectra the external noise environment does not show any distinct spectral components whilst the internal measurements show distinct peaks. The lower figure in Appendix G3 shows noticeable peaks around 11 Hz and 25 Hz which is not evident in the external FFT spectrum.

Appendix G4 reproduces Appendix G3 but only displays the frequencies out to 30 Hz.

Appendix H1 reproduces the wind turbine spectra nominated in the **Capital Wind Farm** EA. However the spectra are A-weighted and as such do not provide a true indication of the potential for low frequency noise issues.

The upper figure in Appendix H2 presents 1/3 octave band Leq levels recorded on Taylors Creek Road approximately 750 metres from the nearest turbine on Groses Hill. The other turbines were in excess of 850 metres from the measurement location. The location was upwind of the turbines.

The blue line in the upper graph is the linear (un-weighted) spectrum whilst the purple line is the A-weighted spectrum for the same noise source. **The graph shows the A-weighting curve significantly attenuates the low frequency noise generated by the turbines that renders the use of A-weighted levels to be useless for wind farms.**

In dealing with the 1/3 octave band graphs and the narrow band FFT results when looking at frequencies below 10Hz one needs to consider the frequency response of the instrumentation. The manufacturer provides tolerance limits for the microphones and meters and outside those limits the measured levels require adjustments to obtain a relative (or normalised) dB level.

The graphical results presented in the attached Appendices are the raw results without any corrections. This means that for frequencies below 10Hz in an absolute sense the stated levels would need to be increased.

For the data attached to this report the 1/3 octave band data and the FFT data used the same instrumentation and microphone so as to maintain the relative nature of the raw data.

The lower figure in Appendix H2 has un A-weighted the Capital EA sound power data and on assuming a distance of 750 metres and hemispherical radiation my Capital measurements (red line) have been converted to a sound power level. **The measurement data aligns with the Capital EA source levels.**

As the wind turbine spectra measurements were conducted shortly after the aforementioned measurements at house G16, Narrow band measurements of the Capital turbine were undertaken as shown in Appendix H3. The upper graph is for a frequency bandwidth to 200Hz and shows a low frequency peak around 1 Hz and a peak around 25 Hz.

The lower graph shows the results for a 50 Hz bandwidth and reveals distinct peaks in the regions of 22 – 26 Hz. The patterns are not dissimilar to sidebands found when measuring vibration of rotating gears. **There is a marked and obvious similarity to the internal results for house G16**.

Appendices H4 and H5 are 1/3 octave band results for 350 metres upwind of a **Cullerin turbine**.

The spectrum graph in the upper figure of Appendix H4 are the statistical results over a ten minute sample. The lower figure shows the dB(A) and 25 Hz 1/3 octave band trace over the ten minutes. **The nature of identifying amplitude modulation cannot be ascertained from the 10 minute sample.**

The upper graph in Appendix H5 shows a two minute sample (sample rate 10 times a second) for the dB(A) and 25 Hz 1/3 octave band and shows the modulation in the 25 Hz 1/3 octave band. The lower graph compares the A-weighted level and the Linear (un-weighted) level for the same time period (to be discussed later).

Appendix H6 shows similar results in relation to the Woodlawn turbines at a position approximately 500 metres downwind of the turbines, with Appendix H6 providing an FFT chart.

4.3 INP Criteria v's Draft Guideline Criteria

In relation to the noise of a wind farm impacting upon the community it appears from discussions with residents near the Capital Wind Farm and the Cullerin Wind Farm that it is not the high wind speeds that are the issue but the low wind turbine speeds and the impact that arises in the low ambient level prevailing in the area.

The turbines can be operating whilst there is no wind at the receiver locations. Therefore the background regression curves provided in an environmental assessment that do not identify the background level at residential receivers in the context of the INP (for winds less than 5 m/s) fail to identify the true background level that is used for the assessment of all other industrial noise sources.

Appendix E provides the regression line analysis relevant for house G16 from the Capital Wind Farm Application. It shows an instrument limit of around 23 dB(A) with the regression line suggesting a background level of around 23 dB(A) for a wind farm wind speed of 1m/s at 10 m height and around 25 dB(A) at 3m/s. On the basis of the regression curve the INP method of background would suggest a background level about 2 dB lower.

But if the instrumentation had been able to measure a lower noise floor it must follow that one would obtain lower background levels, even under the regression analysis method.

Utilising the logger measurements at house G16 set out in Appendix D, pages D1 and D2 show that under the INP method the background level at night (without any extraction of wind farm noise or adverse weather) varied from 18 - 42 dB(A) with a rating background level at night for the two fortnight periods of monitoring being 22.3 dB(A) and 28.7 dB(A). These levels are significantly less than 35 dB(A) and highlight a substantial difference between the two fortnight periods of monitoring.

The significant difference in the background level and the possible different regression curves for two sets of two week data are shown in Appendix F.

If the Capital regression graph for location G3 is considered appropriate for house G16 (as identified in the Capital EIS) then the first graph in Appendix F suggests as an approximation the wind speed at the hub is about twice that at the residence. In the absence of hub wind data one can only speculate the relationship. However in the Capital EIS Ambient Background Level charts, the noise logger summary versus the hub wind speed (and the notations of 5m/s at the microphone) seems to give a similar concept.

If one assumes the Capital Wind Farm regression curve is valid (shown in Appendix E) then if the cut in speed is 3m/s the regression line suggests a background of around 26 dB(A) with an INP type background (at the same wind speed) at or below 23 dB(A).

Utilising the regression analysis curve for all the data in the first fortnight of testing at house G16 and assuming the cut in speed at the turbine is 1.5 metres at the house, the regression line would suggest a background level around 24 dB(A) whilst the INP method for the same wind speed would be around 20 dB(A).

Utilising the regression analysis curve for all the data in the second fortnight of testing at house G16 and assuming the cut in speed at the turbine is 1.5 metres at the house, the regression line for the upper graph in Appendix F3 would suggest a background level around 30 dB(A) whilst the INP method for the same wind speed would be around 23 dB(A).

However I have personally observed the turbines to be operating whilst no wind could be felt or measured at house G16 and at the time of my site visits the background level was less than 25 dB(A).

Consideration of the night time operations separately to the day or the entire period as used in the SA guidelines reveals background levels more than 5 dB(A) below the base criterion of 35 dB(A) **and therefore a noise impact that would on the basis of the EPA criteria automatically become an intrusive noise.**

The concept of permitting a noise some 12 dB(A) above the background level as authorised by the draft guidelines will create an adverse acoustic impact. This would be avoided with the suggested base limit of 30 dB(A) measured under the worst case scenario.

4.4 Management of specific noise characteristics

The Draft Wind Farm Guidelines state of on page 33 the "use of the A-weighting filter will account for both the level of noise generated by the wind farms and any annoying characteristics of this noise". Measurements conducted at Capital Wind Farm demonstrate that this is not correct.

The measurement procedure described in the Draft Wind Farm Guidelines that utilise statistical measurements conducted over a 10 minute period does not permit the identification of the additional noise characteristics associated with swish, modulation, discrete tones and low frequency noise.

4.4.1 Tonality

With respect to the issue of tonality the Draft Wind Farm Guidelines identify that the "emergence of discreet frequency bands in the broader frequency spectrum can increase adverse reaction to a particular noise" and "These tonal characteristics typically do not occur in well-designed and well maintained wind turbines. If present, they are typically caused by a maintenance issue". For the 1/3 octave bands below 160 Hz the Draft Wind Farm Guidelines nominate the use of a double sided assessment with a qualification of a 15 dB difference to either side bands.

The measurement results set out in Appendix G1 show that the noise spectrum measured **external** to house G16 do not exhibit any particular tonal characteristics that would be established by the use of the two sided method of assessing the Leq (10 min) level in one third octave bands.

However, the lower figure in Appendix G1, being conducted **inside** the dwelling, clearly identified the presence of tones when assessed in a one third octave band analysis.

Applying the concept of a double sided 15 dB requirement below 160 Hz to describe tonality as required by the Draft Wind Farm Guidelines would show that there were no tones present. Similarly with respect to the small exceedance in level i.e. on the basis of a double sided analysis it would appear from the internal measurements that the peak around 630 Hz would not be considered tonal.

There is dispute in acoustic analysis as to whether tonality in the broad sense requires a double sided band analysis (as described in the Guidelines) or whether the provision of one sided band exceedance is appropriate. If there are multiple tones present in the noise signature (and clearly audible) then those tones can cause a broadening of the 1/3 octave band spectra.

There are also very narrowband tones which can be described as "discrete frequency bands" and which can have tonal components present that do not necessarily fit into the concept of tonality described on page 34 of the Draft Guidelines.

Appendix G3 clearly identifies the presence of narrowband tones in the acoustic signature inside the dwelling, in the absence of such tones external to the dwelling. This data accords with the complaints received from residents. It confirms that the Guidelines require adjustment to the tonality section.

In addition to the above, the last paragraph of the tonality section states:

> The tonal characteristic penalty applies only if the tone from the wind farm is audible at the relevant receiver. Absence of tone in noise emissions measured at an intermediate location is sufficient proof that the tone at the receiver is not associated with the wind farm's operation.

The measurement data in Appendices G3, G4 and H3 show that the last sentence in the tonality section of the draft guidelines is incorrect.

If one considers the measurement data in relation to house G16 in Appendix G3 it is an undeniable fact that there are discreet frequencies contained in the spectrum recorded inside the bedroom of that dwelling.

The narrow band spectrum in appendix H3, recorded approximately 30 minutes after the measurement in house G16, shows the noise emission from the Capital turbines to contain narrow band components that would appear to be similar to the peaks shown in Appendix G3 around 25 Hz.

4.4.2 Amplitude modulation

Amplitude modulation is a matter that appears to be somewhat confusing in the description of what is occurring with respect to noise from wind farms. The literature indicates a number of proposals for the measurement of amplitude modulation with no clear result as to the appropriate mechanism.

By definition amplitude modulation in broadcast radio transmitter terminology is the mixing of a high frequency carrier signal with the audio signal that varies (or modulates) the intensity of the carrier signal in direct proportion to the audio component of the signal.

For transmitters associated with broadcast facilities the concept of amplitude modulation is when one adds two different frequencies together the output of a mixer will give the same two individual frequencies, the summation of the two frequencies, and the difference of the two frequencies.

If one looks to Appendix H3 to consider the narrowband analysis of a series of turbines at Capital Wind Farm then in looking at a bandwidth to 200 Hz there is a peak around 25 Hz. On using a greater resolution by reducing the bandwidth to 50 Hz, the lower figure in Appendix H3 indicates that the 25 Hz in the upper figure is a combination of various discrete frequencies.

If one considers the blade pass frequency of the turbine is around 1 Hz then as a general concept if amplitude modulation is present one can have an output of 25 Hz -1 Hz = 24, and 25 Hz +1 Hz = 26 Hz. This pattern appears in the lower figure to Appendix H3.

But if the Guidelines require amplitude modulation to be assessed in terms of the A-weighted value then how does that show in a 10 minute statistical analysis?

More specifically, the Draft Wind Farm Guidelines state on page 34:

> An excessive level of modulation is taken to be a variation of greater than 4 dB(A) at the blade passing frequency.

The statement would appear to have a number of interpretations. For example does it mean you measure A-weighted level at the blade passing frequency of around 1 Hz to look for a 4 dB(A) variation? There would appear to be an issue with this concept in that the Class 2 meters nominated for use are unlikely to measure sufficiently at that low frequency. By reference to Appendix H2 the A-weighted level at that frequency is some 170 dB below the linear level and would seem to be outside the dynamic range of the sound level meter when using an A-weighting filter.

Or does the guideline mean you look at the dB(A) level and see if it varies by more than 4 dB(A) at a rate of say every second (if the blade pass frequency is 1 Hz)?

But if the results are in 10 minute Leq level then this cannot be carried out.

Clarification as to the ambiguous nature of the amplitude modulation definition was sought by the author at the Acoustical Society meeting on 22nd February 2012 referred to in the Introduction to this report. There was a response from a member of the audience that the results would be obtained from a Wave file from the logger. The use of a Wave file was then confirmed by the spokesperson from the Department.

However, the Draft Wind Farm Guidelines do not mention the recording of, or any analysis of, data using Wave files. If Wave files are to be required (or identified in another set of guidelines not issued to the public) then the technical specification of the Wave file requirements should be provided.

But is the amplitude modulation evident in the dB(A) level or is it in other frequencies?

Appendix H4 is for a different wind farm with the statistical analysis across the frequency spectrum for a 10 minute sample showing no discrete tones. The lower graph shows the variation of the dB(A) and the 25 Hz 1/3 octave band. There are variations in the time signature (sampling at 10 times a second FAST response).

The upper figure in Appendix H5 shows a two minute sample to reveal some fluctuations in the A-weighted level but a regular fluctuation in the 25 Hz 1/3 octave band. If the amplitude modulation is the blade pass frequency rate of the variation of the 25 Hz 1/3 octave band, by reference to Appendix H3, then is that the mechanism for assessing amplitude modulation?

What actual measurements has the Department undertaken to obtain their methodology for detecting amplitude modulation?

A paper by Valeri Lenchine at the ACOUSTICS 2009 conference in Adelaide refers to the work of Fastl and Zwicker on psychoacoustics and suggests the annoyance caused by amplitude modulation can be expressed by the fluctuating strength model for noise with the frequency modulation of up to 20 – 30 Hz.

A formula for the fluctuation strength (F) of a wind turbine is provided by Lenchine and suggested to be from Van den Berg, although the constant in the equation is different to that proposed by Fastl and Zwicker on page 229 of their book Psychoacoustics, Facts and Models (Springer – Verlag Berlin 1990).

Fastl and Zwicker consider the fluctuation strength of amplitude-modulated broad-band noise can be considered in terms of a Model of Fluctuation Strength. For an amplitude modulated signal at low frequencies the sensation is described as fluctuation. At about 10Hz the sensation is then described as “roughness” and applies to the modulation of frequencies between about 15 to 300 Hz.

Therefore is the 25 Hz frequency found in the turbine spectra a frequency being generated or is it the modulation effect of other frequencies, or multiple turbines?

The summary of the Lenchine paper suggests one should look to the linear (non-weighted) time history of the signal. Hence the provision of the lower graph in Appendix H5 showing the dB(A) and Linear variation for the same two minute sample in the upper graph.

Appendix H5 shows the fluctuation of the 25 Hz for the Cullerin turbine is greater in the 25 Hz 1.3 octave band frequency than for the dB(A) value.

The upper figure in Appendix H6 identifies the first peak around 1 Hz with the similar peaks around 2 ½ and 3 Hz then multiple discrete frequencies. Similarly Appendix H8 shows the same situation for the Woodlawn turbines.

The limited data that I have obtained suggests the possibility that the assessment of amplitude modulation could be more simply addressed by viewing the time signature of the low frequency 1/3 octave peak recorded inside a dwelling.

4.4.3 Low Frequency Noise

Page 34 of the Guidelines suggests that low frequency noise is not a significant feature of modern wind turbine noise and is generally less than that of other industrial environmental sources.

Any presentation of noise utilising the A-weighted curve will automatically reduce the impact of low frequency on the A-weighted measured level.

The EPA in their INP document refers to modifying factors with respect to characteristics of sound where the modification is adjusted to the A- weighted level.

One method of modification is to measure the C-weighted noise level and if the difference between the A-weighted level and the C- weighted level is more than 15 dB then a 5 dB penalty is added to the A-weighted measured level. But the C-weighted curve significantly attenuates the blade pass frequency, albeit not as much as the A-weighted curve.

If the compliance or ambient noise monitoring utilises only A-weighted measurements, as identified in the Draft Guidelines, then how during compliance does one obtain a low frequency assessment?

It may be that the intent of the Guideline is to rely upon the modifications to the characteristics of the sound to occur during the attended measurements and not the unattended measurements. **If so this intent should be identified in the guidelines**.

The Guidelines suggest utilising a 65 dB(C) noise level during the day time and 60 dB(C) during the night time as a trigger point for a more detailed low frequency assessment. However it would appear that the modification of low frequency noise, just as the tonal correction and the amplitude modulation correction, simply relates to external locations and not internal locations.

The matter of infrasound has been raised by other researchers in relation to wind farm operations. My measurement results obtained inside dwellings show there are low frequency levels below the audible frequency range which occurred in those dwellings. By definition those frequencies are defined as infrasound and are not considered in the Draft Guidelines.

This becomes important in that the Guidelines have ignored the issue of Infrasound, being noise below 20 Hz which is defined as the lower limit of the audible frequencies detected by the human ear. The previous report showed low frequency levels (classified as infrasound) to occur inside dwellings as do the graphs in this review.

My previous report identified infrasound to be present in one house when the turbines were not operating. That description should have identified that a few turbines were turning. Subsequent measurements have shown that if some turbines just start to operate (not all of them) infrasound can be recorded – particularly the blade pass frequency.

All turbines would need to be stopped to provide comparison measurements. Such testing cannot be undertaken without the assistance of the wind farm.

Documentation referenced by the Department in relation to infrasound appears to relate to the audibility of infrasound and **does not address or consider the issue of inaudible infrasound which may be present all the time the turbines are operating and is below the threshold of hearing.**

Definitions and additional management of noise characteristics is identified on page 35 which discusses the specific noise characteristics.

This section initially defines a single exceedance. A single exceedance occurs when the wind farm displays a characteristic described in Section 6.1.1 to 6.1.3. If such a characteristic occurs in the average period then a penalty shall be applied to the Leq level for that period. It is unclear where the reference to Section 6 has come from. **There is no Section 6 contained in the guidelines**. I assume the drafting of the guidelines was meant to indicate that the noise characteristics to which the penalty would apply are tonality, amplitude modulation and low frequency noise.

As identified previously if the measurements are conducted using unattended noise loggers for a Class 2 instrument and only the A-weighted level are recorded then those results cannot provide any identification of the specific characteristic requiring a penalty for the one exceedance.

If wave file measurement and subsequent analysis of the file is required for the purpose of monitoring then in a practical sense there would be significant cost implications for such monitoring with the likely outcome that the wind industry would seek to place pressure on the Department to downgrade the matter of adjustments of noise characteristics.

A repeated exceedance is identified as where single exceedance events occur for more than 10% of an assessment period, with the period defined as an individual day or night.

The effect of this definition is that a wind farm may be compliant notwithstanding repeated exceedance if it does not operate throughout the entire assessment period. This becomes relevant in that a sustained exceedance relies upon the repeated exceedance to occur for greater than 30% of the season.

This is a different procedure to the INP which outlines individual 15 minute periods during the assessment period and the concept for adverse weather effects to occur on 30% of the nights in a season.

A similar issue with the INP as a result of a requirement to use the lowest of the amenity or the intrusive noise criterion. If a factory only operated for part of the night then whilst it could generate noise levels well above the intrusive criterion for say one hour or two hours a night, when assessed as the amenity limit (over the entire night) the same factory could achieve compliance.

My submission to the review of the INP was to require compliance with both the intrusive noise limit and the amenity noise limit. This was incorporated into the Application Notes to the INP.

The Draft Wind Farm Guidelines contain no similar concept to that of the EPA in addressing industrial noise by requiring compliance with the intrusive noise limit and the amenity noise limit.

If sustained exceedances occur the Draft Wind Farm Guidelines suggest the operation the wind farm should be modified to minimise the exceedance of noise characteristics but do not require that the operation of the wind farm must be modified.

In the application of penalties for specific noise characteristics the Draft Wind Farm Guideline proposes a maximum penalty of 5 dB(A) for the relevant time period.

This is contrary to the position set out by the EPA. The INP identifies the modifying factors corrections that may be applied for different noise levels. The maximum adjustment that would occur to industrial noise sources (other than wind farms) is 10 dB(A).

The application of penalties for wind farms as expressed in the Draft Wind Farm Guidelines on page 35 is clearly less stringent than that for other industrial operations.

4.5 Compliance Testing

The Project Approval for the Capital Wind Farm from the Minister for Planning states that the conditions are required to:

- Prevent, minimise, and/or offset adverse environmental impacts;
- Set standards and performance measures for acceptable environmental performance; require regular monitoring and report; and
- Provide for the ongoing environmental management of the project.

Complaints from residents of sleep disturbance and headaches would suggest that the selection of noise criteria and the conditions/management of the Wind Farm have failed to prevent, minimise and/or offset adverse environmental impacts.

As identified in the FCWTAG submission there are no acoustic compliance reports for the Capital Wind Farm in the public domain. A review report ("Technical Review of the Capital Wind Farm Noise Compliance Assessment Report. Including a review of a Specialist Reports on Noise by Vipac Engineers") by an officer of the Department of Planning is on the Department's website under major projects - Capital Wind Farm. The officer's report relies upon reports prepared by Vipac that are not in the public domain or on the Department's website.

Accordingly there is no material from Capital to permit an examination of the subject wind farm's apparent "acoustic compliance".

To this end a FOI application was made last year on behalf of residents to access the Vipac compliance reports for Capital Wind Farm. The two documents released under FOI have the majority of the reports blanked out – apparently due to the reports being "commercial in confidence". The material that remains in the reports is of no assistance in ascertaining acoustic compliance – or in fact non-compliance.

As a result, the FCWTAG requested that additional measurements be conducted at house G16 over a period of time to gain an insight into the matter of the compliance testing procedure nominated in the Draft Guidelines.

In the compliance assessment review undertaken by the Department Figures 2 and 3 (reproduced below) provide the results of noise testing at location H15 on 22nd April 2010.

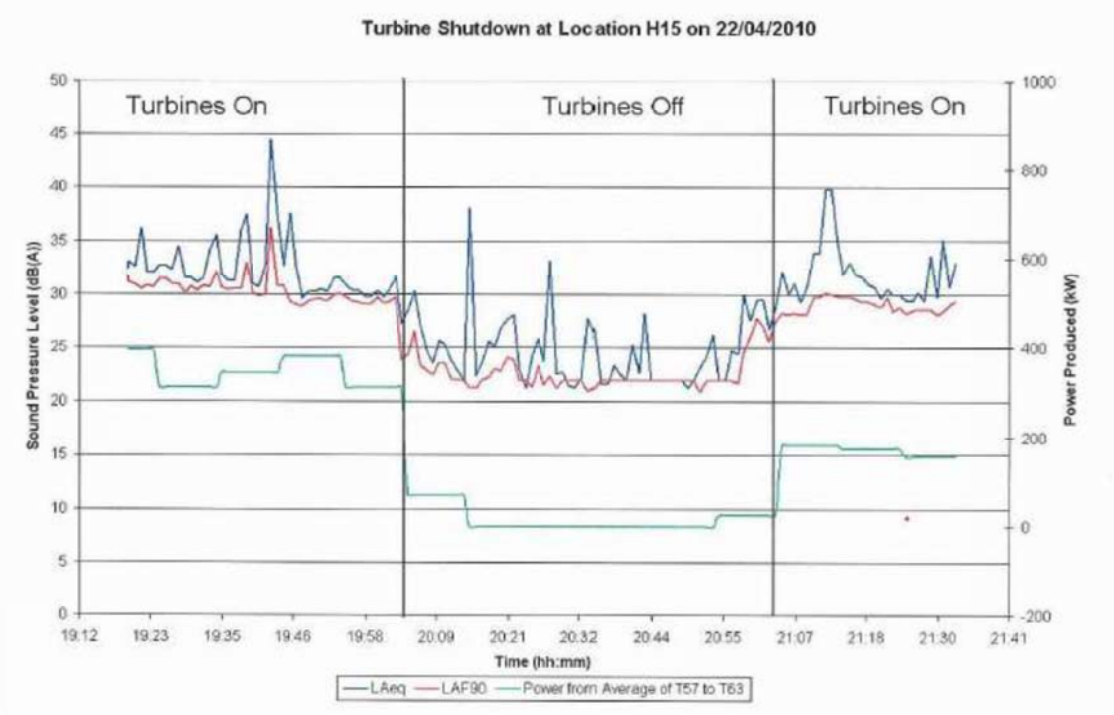

Figure 2. Example of turbine shut down (H15)

TABLE 7-7: H15 Shut Down Noise Summary

	Turbines on Before Shut Down	Turbines on After Shut Down	Average Level when Turbines on	Turbines Shut Down	Impact of Wind Farm ($L_{on} - L_{off}$)
Average L_{Aeq} dB(A)	32.5	31.9	32.2	24.5	7.7
Average L_A90 dB(A)	30.4	29	29.7	22.4	7.3

Figure 3. Example of shut down noise summary (H15)

In examining the above information it can be seen that the turbines were turned off for a period of time and a background level of 22 dB(A) was obtained. House H15 is identified as "The Patch" and was site 5 in the background monitoring report.

Table 5 in the background monitoring report for Capital Wind Farm advised that the background level at site 5 (H15) for a wind farm 10m wind speed of 4 m/s was 31 dB(A). The background level of 22 dB(A) with the turbines off (shown above) for an implied wind of 4 m/s says that there is a significant difference with the regression curve and real measurements.

If one is to use the regression curve determined at the preconstruction phase for compliance purposes then by the Department's own report there is a significant issue of concern that is highlighted by the only compliance report/review that can be found for Capital Wind Farm.

If one takes the concept of background + 1.5 to obtain the Leq then the turbine contribution would be 29 .7 + 1.5 = 31.2 dB(A). This level therefore represents some 7 dB(A) above the background level and as confirmed by the Departments text under Figure 3 the wind farm was audible. There is no information as to the frequency characteristics of the audible noise in the Department's report.

There is no information in the Department's review report as to the wind direction at the time of the "compliance" measurements at house H15.

If the regression line background level pre wind farm at The Patch is 31 dB(A) for a wind farm wind speed of 4 m/s and 32 dB(A) for 5 m/s then under the requirement to use the pre-construction regression analysis one could use the above compliance results and say that the operation of the wind farm reduces the background level, i.e. 32 dB(A) without the wind farm and 31.2 dB(A) with the wind farm – whereas the above results show a Leq level of 31.2 dB(A) attributed to the wind farm is nearly 10 dB(A) above the background level without the turbines.

Examination of the summary results in Figure 3 above show that the L_{eq} level with the turbines shutdown was 24.5 dB(A). This level is significantly lower than the "acceptable amenity" level of 40 dB(A) for a rural area nominated in the draft guidelines. On the Department's own review document there appears to be no basis for the 40 dB(A) acceptable amenity level for rural properties.

If one is to consider in the real word an intrusive criterion of background + 5 dB(A) then the material shown in the Department's review report reveals levels greater than that limit. If one considers the background and the wind farm were similar in character then on a subjective loudness the difference between the rural background of 22 dB(A) and a 35 dB(A) level is approximately 2 ½ times louder. If one adds the "aircraft type drone" as a characteristic reported by residents near house H15 then a 5 dB penalty should apply.

The Capital "compliance reports" provided under FOI have no information as to actual noise levels, regression curve adjustments, tonal or other adjustments but includes the above graph (extracted from the Department's report).

My logger graphs and the Department's report clearly show the background level in the area around Capital Wind Farm is significantly less than 40 dB(A), with typical night time background levels for wind speeds at the cut-in speed to be between 20 and 25 dB(A).

The current concept of 35 dB(A) or background + 5 dB(A) (whichever is greater) is clearly unsatisfactory for residents in proximity to the wind farm – even if corrections for low frequency and tonality or modulation found inside houses is taken into account.

The Draft Wind Farm Guidelines indicate the conditions would apply under temperature inversions. There does not appear to be any consideration of temperature inversion in the Capital Wind Farm application or the Department's compliance review report. Under the INP inversion tables the noise emission under temperature inversions would be greater than shown in the above table.

As a first approximation if one utilises the inversion tables in the EPA's INP for a distance of 2km one can have an enhancement for a temperature inversion and light wind drift of up to 4.5 dB.

The approval conditions for Capital Wind Farm nominate the same base limit of 35 dB(A) and background + 5 dB(A) whichever is greater (as suggested in the Draft Guidelines) but without any requirement for night time separate to daytime or worst case scenario.

If from the Department's report there is an evening background level of 22 dB(A) for a 4m/s wind and a Leq of 25 dB(A) then the case starting point should be 30 dB(A) or background + 5 dB(A) whichever is the greater. But if the worst case scenario is to apply then the 30 dB(A) limit is to occur under temperature inversions which for neutral propagation conditions or light wind from source to receiver requires for the majority of the occasions the noise limit is set at 25 dB(A) – if there are no tonal or modulation components.

To accord with the EPA assessment procedures in rural environments the base limit for wind farms should be 30 dB(A) when assessed under the worst case scenario. Such a limit in a practical sense would reduce the impact experienced by residents less than 4 km from the turbines and would appear to approach the intent of the Minister's consent for Capital Wind Farm.

4.6 Noise Assessment

From the above material arising from the attempt to undertake compliance testing it is apparent that the matters set out on page 36 for the noise assessment report require modification.

There is a need to identify the background noise level at receiver locations under varying wind strengths and wind direction as part of the environmental impact statement.

The logger measurements for house G16 (Capital wind farm) show that there can be a significant difference between the background levels for different two week periods. For house H15, there is a significant difference for the application background level and the compliance shut down level. **The variability in the data demonstrate that the monitoring period for background level must be increased.** It is noted that it is highly unlikely given the capital expenditure for a wind farm that the assessment of a site would restrict wind measurements to only a two week period.

For the purpose of a future compliance and clarification as to the assessment that has been undertaken, one needs to provide a correlation between the wind speed and wind direction at the wind farm weather monitoring position, versus the background levels that occur at residential receivers. **Such a correlation requires significantly more than two weeks of data.**

Typically noise conditions for industrial developments may be expressed with respect to weather conditions as:

> The maximum allowable noise contributions apply under wind speeds up to 3 ms-1 (measured at 10 metres above ground level), or under temperature inversion conditions of up to 3ºC/100 metres and under wind speeds up to 2 ms-1 (measured at 10 metres above ground level), i.e. covering a range of weather conditions.

It therefore follows that there should be at least two weeks of valid data points for **each of the various weather scenarios** that can be experienced at the receiver site.

As in the course of environmental assessment for large scale industrial developments the noise modelling should in the first instance provide the noise contributions at critical receiver locations with the wind farm operating under neutral weather conditions for the cut – in speed and say the maximum power speed.

One can then provide the noise predictions for a downwind scenario from source to receiver for the same two wind speeds and the noise prediction for an upwind scenario of a light wind from the receiver to the source.

The modelling should then consider the propagation under temperature inversion conditions.

This would give a range of levels that can be generated from the wind farm and clearly identify the range of noise emission levels, and the controls to ensure the intent as set out on page 35 of the Draft Wind Farm Guidelines for the noise to be under the nominated limit for a worst-case scenario.

The application of the above material to identify the background level expected at residential receivers for different wind speed and direction scenarios, together with the predicted noise levels under different weather scenarios would then permit in a compliance regime to take account of the propagation factors in considering the measured levels at receiver locations. This would then permit the adjustment of the results to account for the prevailing weather conditions.

At the present time without identification of the prevailing weather at the receiver location and the relationship of predicted noise levels under those specific weather conditions **then it is impossible to ascertain the matter of acoustic compliance**.

This would then permit the normalised emission levels of the wind farm to be assessed under temperature inversion conditions if such conditions did not occur during the compliance testing.

5 COMPLIANCE

At the present point in time the "compliance testing" procedure set out in the Draft Guidelines does not follow the EPA procedure for industrial noise sources. It can therefore be asserted that from a resident's perspective, it is set up with a clear bias towards the wind industry. It may be argued that the compliance mechanism in effect follows that of the South Australian guidelines. Given public criticism by residents in other states that the South Australian guidelines are inadequate, generate noise and health problems, it may also be asserted that it was incumbent upon the author of the noise guidelines for New South Wales to have investigated the South Australian compliance procedures in order to provide justification for the statement (attributed to the Minister) that the NSW Draft Wind Farm Guidelines "would be the most stringent noise guidelines in Australia." On examining the Draft Wind Farm Guidelines one finds that such an investigation cannot have occurred.

5.1 General Issues

- Page 27 of the Draft Wind Farm Guidelines identifies that the Protection of the Operations Act 1997 is to be strengthened with the EPA to have a regulatory role for wind farms classified at State Significant Development. What constitutes "strengthen" of the POEA is not known or specified, nor what happens to wind farms that are not State Significant Development.

- Use of an external noise assessment is inconsistent with some general noise assessments as identified in Section 2.1.2 of the NGLG where the EPA state:

Tips for assessing audibility

Where an authorised officer is having difficulty accessing the habitable rooms of a complainant's residence, they could consider conducting the audibility test outside the affected neighbour's house and making an allowance for a reduction in the noise level from the outside to the inside of the residence. In these cases, the officer should be aware that there is no certainty in determining the level of noise inside the complainant's residence. There have been instances where noise levels inside a dwelling from an external source have been higher than the outside noise level because 'standing sound waves' in the room produce noticeably louder noise inside than outside.

If cases involving the audibility test go to court, the hearing ability of the assessing officer may be brought into question. Officers likely to perform these assessments should obtain an audiogram every one or two years. Audiograms assess a person's ability to hear the normal range of frequencies and identify those frequencies where hearing is impaired.

- Section 2.1.4 of the NGLG discusses an offensive noise test and sets out six questions.

Offensive noise test: Checklist of considerations

Q1: Is the noise loud in an absolute sense? Is it loud relative to other noise in the area?

This establishes that the noise is likely to be heard by neighbours. Its volume alone may be annoying. An example would be music being played at a very high volume in a residence so it can be heard over very noisy activity outside, such as construction work. The noise may also be loud relative to the background noise. An example would be loud fireworks set off late at night. Noise measurements using a sound level meter would help to determine how loud the noise is relative to the background noise level in the area.

Q2: Does the noise include characteristics that make it particularly irritating?

The presence of tones, impulses or fluctuations in volume can make people more likely to react to the noise. These can be judged subjectively but noise measurements will help to quantify the extent of these characteristics. Examples might be screeching sounds from poorly maintained equipment or a 'beeper' alarm that uses a pulsed sound made up of one or two alternating frequency tones, usually higher pitched, that are louder than the background noise in the area.

Q3: Does the noise occur at times when people expect to enjoy peace and quiet?

People usually expect their surroundings to be quieter during the evening and at night. Talk to the complainants about how the noise affects them to see if it is interfering unreasonably with their comfort at home. Is it regularly disturbing their sleep, making it difficult to have a conversation, study, read or hear the TV? Noise that regularly disturbs sleep is likely to be considered offensive by complainants and this should be taken into account in your assessment.

Q4: Is the noise atypical for the area?

Where noise from an activity that is causing nuisance is new or unusual for an area, people are more likely to react. Look at the typical uses of the area and determine whether the activity is consistent with the local environmental plan. An example might be a rock drill used on a residential construction site.

Q5: Does the noise occur often?

Noise can be more annoying when it occurs frequently. Examples might be a leaf blower used every morning or a band that practises frequently without regard to the impact on neighbours.

Q6: Are a number of people affected by the noise?

Only one person needs to be affected by the noise for it to be deemed offensive. However, talking to other neighbours likely to be exposed to the same noise about how it affects them may assist in deciding what action to take. Some councils have a policy of requiring a minimum number of complaints from different individuals before taking formal action.

- Under the NGLG offensive noise test the wind farm noise would be described as offensive noise For a rural environment without turbines one must conclude for the above checklist that the noise from a wind farm at times is loud, is atypical of the area, occurs often, occurs at night when people expect peace and quiet, contains audible characteristics, and affects more than just one household.

- The Draft Wind Farm Guideline does not require the assessment to identify the actual acoustic impact. The specification of complying with a noise limit without advising the community that the permitted noise is significantly above the background level, clearly audible inside houses, interferes with a person's sleep and is deemed to be an offensive noise is entirely contrary to intent the expressed in the consent for Capital Wind Farm and is an issue that must be addressed.

- The Draft Wind Farm Guidelines do not provide a clear indication of what action arises from non-compliance. There are no conditions requiring the wind farm to reduce its operations if non-compliance occurs. There is no strict requirement to achieve compliance. For example in the approval for the Uranquinty Gas Fired Power Station where I understand there has been an issue of low frequency noise and infrasound the consent from the Minster states:

3.12A In the event that noise complaints are received under adverse weather conditions from the residences described as "Pine Grove", "The Wardrobe" or "Wallace", the Applicant shall within one week of receiving the complaint undertake night-time operational noise monitoring at the affected residence for a period of two weeks to confirm the occurrence of operational noise levels greater than LAeq(15 minute) 35 dB(A) once the modification factors described in Section 4 of the New South Wales Industrial Noise Policy have been taken into account. Should such an exceedance exist, the Applicant shall employ a suitably qualified independent acoustic professional to prepare, in consultation with the landowner, a Noise Mitigation Design Report with the objective of providing a satisfactory level of internal noise amenity. The report is to be completed within two months of the completion of monitoring or as otherwise agreed by the landowner.

3.12B Within one month of completing the report referred to in condition 3.12A, Applicant is to have entered into an agreement with the landowner to implement suitable feasible and reasonable noise mitigation measures. In the event of a dispute in reaching an agreement or over the agreement itself, either party may refer the matter to the Director-General for resolution. The Director-General's determination of any such dispute shall be final and binding on the parties. Any formal advice or further assessment required by the Director-General to resolve this matter shall be funded by the Applicant.

3.12C Within three months of this consent, the Applicant shall notify all applicable landowners that they are entitled to receive additional noise mitigation measures, per that described by conditions 3.12A and 3.12B.

Noise Monitoring

4.5 15 Within 90 days of the commencement of operation of both Stage 1 and Stage 2 of the development, or as may be agreed by the Director-General, and during a period in which the development is operating under design loads and normal operating conditions, the Applicant shall undertake a program to confirm the noise emission performance of the development. The program shall meet the requirements of the DEC, and shall include, but not necessarily be limited to:

a) noise monitoring, consistent with the guidelines provided in the *New South Wales Industrial Noise Policy* (EPA, 2000), to assess compliance with condition 3.11 of this consent;
b) methodologies for noise monitoring;
c) location of noise monitoring;
d) frequency of noise monitoring;
e) identification of monitoring sites at which pre- and post-development noise levels can be ascertained; and
f) details of any entries in the Complaints Register (condition 5.3 of this consent) relating to noise impacts.

A report providing the results of the program shall be submitted to the Director-General and the DEC with 28 days of completion of the testing required under a).

4.6 In the event that the program undertaken to satisfy condition 4.5 of the consent indicates that the operation of the development, under design loads and normal operating conditions, will lead to greater noise impacts than permitted under condition 3.11 of this consent, then the Applicant shall provide details of remedial measures to be implemented to reduce noise impacts to levels required by that condition. Details of the remedial measures and a timetable for implementation shall be submitted to the Director-General for approval within such period as the Director-General may require, and be accompanied by evidence that the DEC is satisfied that the remedial measures are acceptable.

5.2 Permanent Monitoring

To be able to ascertain compliance it is necessary to have **the wind speed at the hub height at the time of the measurements, and also the wind direction.**

The original environmental assessment must provide details of the **ambient noise level at receiver locations versus the wind speed at the receiver location** to provide meaningful results of the ambient noise versus the wind so as to place the relationship of the acoustic environment (without the wind farm) in the correct context.

Furthermore, **the original environmental assessment must indicate the noise levels at residential receivers that could be obtained under wind turbine operation under neutral conditions relative to the residential receivers**. These noise levels would become the base case upon which would then permit identification of the noise levels under adverse weather conditions of wind from the turbines to the receiver, wind from the receiver to the turbines, and a temperature inversion with a light wind from the turbines to the receiver.

With this information to hand and the measured noise levels at the residential receiver, together with the wind speed and direction at the hub height then, and only then, can an acoustic compliance be evaluated.

In light of the above explanation it becomes obvious that the conduct of two weeks of noise compliance testing is clearly inadequate for the task at hand.

Therefore, what is required is identification of the different propagation characteristics that would occur from the wind farm to residential receivers, both for host receivers and non-host receivers.

The provision of permanent noise monitoring occurring inside the wind farm land or host receivers, say 1000 metres from turbines should occur. With the monitoring results and the benefit of the aforementioned propagation characteristics one could provide a mask to the overall level at each permanent monitoring location to indicate compliance or theoretical non-compliance at residential receivers. This concept of monitoring is identified in the draft guideline on page 30 under the heading of "Supplementary noise measurement locations" and should be placed in the new section to address permanent monitoring.

The permanent noise monitoring can be supplemented by temporary remote monitoring which would occur simultaneously in real time for a residential complainant to supplement and verify the propagation characteristics. This is not dissimilar to the monitoring of aircraft noise for major civilian and military aerodromes.

The provision of permanent noise monitoring together with real time presentation of the measured noise levels, wind speed and direction at the hub, the power output and operational status of individual turbines must be provided in the public domain to permit independent compliance testing.

6.0 CONCLUSION

Since the operation of large scale wind farms in rural areas around Australia there have been complaints from residents in proximity to those wind farms concerning health and noise impacts. In some cases the magnitude of disturbance generated by a wind farm has caused residents to leave their dwellings and relocate elsewhere. In some situations the wind farm proponent has bought out the people impacted and it has been alleged that nondisclosure agreements have been required as a condition of acquiring the property.

The Draft Wind Farm Guidelines that have been issued by the Department of Planning and Infrastructure identified that they closely follow the South Australian Wind Farm Noise Guidelines. In parts, the document does appear to be a cut-and-paste of existing guidelines with some additional components that may be expressed as "tweaking around the edges".

The problem for the broader community in comprehending the guidelines is that from a noise perspective, by definition, they must be expressed in technical terms which are not necessarily readily understood by the community. The community must rely on the Department. Accordingly, in the preparation of noise guidelines that set criteria, assessment procedures and purport to identify a rigorous compliance regime one would expect that, rather than the exercise being an academic one, the guidelines would be based on solid data and measurements.

It is a fundamental criticism of the Guidelines that there is nothing in the noise portions to suggest that proper or indeed, any, attention has been paid to investigating their adequacy. If the Department of Planning and Infrastructure has prepared a set of noise guidelines for wind farms without carrying out investigations of existing wind farms then that situation needs to be explained and to be rectified. The preparation of guidelines that set out measurement and assessment procedures that in the real world are unworkable is an issue of concern to the community. The preparation of guidelines on a cut-and-paste method without examining the source data or undertaking measurements to investigate claims (perceived or real) concerning noise impact is a matter about which any reasonable person aware of the issues would have concerns.

The author's concerns in relation to the above were highlighted at the presentation made by the Department to the Australian Acoustical Society (NSW division). The presentation demonstrated unfamiliarity with the spectral characteristics of wind farm noise. It appeared (with prompting from some members of the audience) that there may very well be another set of guidelines addressing technical inadequacies of the current Draft Wind Farm Guidelines that were issued to public comment.

To provide a basis to assess the impact of wind farms on the community I attended rural properties in proximity to Capital Wind Farm last year and conducted a series of acoustic measurements outside and inside rural dwellings to ascertain if there was an issue in terms of noise impact that could be related to actual measurements. That testing was not in the form of a compliance test as described in the South Australian Wind Farm Guidelines. However, the testing found that there were issues in relation to noise received by residents that were not appropriately addressed in the South Australian Wind Farm Guidelines. As this report demonstrates, these same concerns are not addressed by the proposed Draft Wind Farm Guidelines.

The issue of conducting measurements using only the A-weighted value has problems in terms of addressing the special noise characteristics identified for an external environment. The Guidelines do not identify the application of criteria to inside residential properties, nor acknowledge the difference in attenuation from outside to inside that occurs for different frequencies. The matter of amplitude modulation of noise emission from the turbines has not been examined in detail in the Draft Guidelines, nor the application of any modulation characteristics which are found to occur inside dwellings. The fact that the modulation is not directly related to the turning speed of a turbine, but appears to be a combination/interaction of various noise sources, or may be further complicated due to turbines noise interacting with one another, is an issue that needs to be explored.

The noise disturbance that communities in proximity to wind farms experience is a matter of record and becomes obvious from an acoustic perspective if one considers the threshold for non-compliance of a wind farm is placed at more than 10dB(A) above the prevailing background level. There is no material contained in the Draft Wind Farm Guidelines to support the claim of an acceptable noise environment for rural dwellings is 40 dB(A) at night. On the contrary the Department of Planning and Infrastructure's review of a compliance test for Capital Wind Farm clearly shows the background level is less than 25dB(A) and the Leq level is just under 25dB(A). The fact that the compliance testing revealed a background level significantly less than the regression curve identified in the environmental assessment for the same location highlights the problems associated with the regression analysis currently proposed in the Draft Guidelines.

Under the ambient background assessment utilised by the EPA for industrial premises (which could be located on the same site if the zoning permitted) the background level is automatically lower than the methodology proposed for the wind farms. If one is to ensure that offensive noise does not occur then the general concept as used by the EPA of the background plus 5 dB when applied in residential areas must also apply for rural dwellings with the acknowledgement of the lower background level.

On the basis of the material that is available in relation to wind farms and rural environments the appropriate base criteria under worst case scenario of temperature inversions or light wind from source to receiver should be 30 dB(A) or background plus 5 dB whichever is the greater value.

If, as indicated in the Guidelines the intent is to have noise limits for wind farms being the most stringent in Australia, then in addition, it is essential that the Guidelines are modified to deal with each of the matters summarised in the Executive Summary and the matters detailed in the body of this report.

Yours faithfully,

THE ACOUSTIC GROUP PTY LTD

STEVEN E. COOPER