THE ACOUSTIC GROUP PTY LTD

CONSULTING ACOUSTICAL & VIBRATION ENGINEERS

PEER REVIEW OF ENVIRONMENTAL NOISE ASSESSMENT

COLLECTOR WIND FARM

42.5006.R1:ZSC

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1.0 INTRODUCTION

An application has been submitted to the NSW Department of Planning and Infrastructure for the proposed Collector Wind Farm to be located on the elevated land to the west of the township of Collector in New South Wales.

Accompanying the application is a report from Marshall Day Acoustics: *Collector Wind Farm, Noise Impact Assessment* dated 4 June 2012 (report ref Rp 002 R07 2010127SY). This report has been posted on the Department's website.

The community has raised concerns in relation to approval of the proposed wind farm, one of the concerns being noise disturbance. The Friends of Collector have cited impacts from existing wind farms in Australia as evidence of potential impacts arising from the proposed wind farm and have requested a peer review of the noise report. In particular the Friends of Collector have experienced impacts from the nearby wind farms of Cullerin and Capital.

The Marshall Day Acoustics document refers to the Director-General's Requirements (DRGs") issued on 12 November 2010, criteria from the noise guidelines for wind farms issued by the South Australia EPA (2003) and the draft NSW Planning guidelines for wind farms.

2.0 QUALIFICATIONS OF REVIEWER

The nature of actual or perceived noise impacts associated with wind farms is the subject of wide debate throughout communities in proximity to wind farms.

To date there are conflicting arguments or claims as to noise and resultant health impacts due to wind farm operations.

In conducting a peer review it is appropriate to identify the reviewer's technical expertise to undertake such an exercise and to identify any potential conflicts.

I Steven Edwin Cooper am the principal of The Acoustic Group Pty Ltd, Consulting Acoustical and Vibration Engineers.

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) being a research degree in Acoustics 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 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) and as a Court Appointed Expert. I am not a member of any political party and have not been retained or approached by any wind farm proponents to undertake an assessment of wind farm noise.

I have extensive experience in the measurement and assessment of large industrial premises where there is a requirement to maintain compliance with specified noise limits under all weather scenarios. I have also conducted research into various acoustic issues concerning the propagation of aircraft noise and sound dispersion in enclosed spaces that has questioned the status quo of various Standards or acoustic texts leading to modification/amendments to Australian Standards and International guidelines.

Whilst I have not been engaged by any wind farm applicant to undertake an acoustic assessment or compliance testing of planned or operational wind farms, I was requested late last year by a community group opposing a proposed wind farm at Flyers Creek (in NSW) to review an application.

I prepared a desk top review of the acoustic assessment that had been prepared for the Flyers Creek Wind Farm. The acoustic assessment of the Flyers Creek Wind Farm was based upon guidelines issued by the South Australian EPA.

My desktop audit was contained in a submission from the Flyers Creek Wind Turbine Awareness Group ("FCWTAG") in relation to the proposed Flyers Creek Wind Farm. The desktop review raised issues as to the ambient background levels, the predicted noise emission levels and the absence of an assessment of the noise impact of the proposed wind farm.

The desktop review was supplemented by preliminary noise testing in proximity to the Capital Wind Farm (in NSW) to experience first-hand wind farm operations and conduct sound level measurements. The preliminary testing highlighted a number of issues with respect to the assessment and evaluation of wind farm noise where currently the predominant acoustic descriptor is the dB(A) level.

I found at times there to be no audible noise inside or outside residential dwellings, whilst on other occasions I was able to detect wind farm noise both outside and inside dwellings.

My testing identified the possibility that noise originating from the wind farm could affect individuals and that further testing/investigations were required as set out in my review of the Flyers Creek Wind Farm application (available on the NSW Department of Planning website).

The NSW Department of Planning issued in late 2011 a draft set of wind farm guidelines for public comment ("the NSW Guidelines). The NSW guidelines are more stringent than the SA wind farm noise guidelines.

As part of my review of the draft NSW guidelines I undertook further measurements and analysis of wind farm noise (Capital, Cullerin and Woodlawn wind farms) to research wind farm noise and assess the practicality of compliance testing as set out in the draft NSW Guidelines.

I prepared a technical submission on the draft NSW Guidelines. I was not engaged by any party to prepare my submission, but as it relied upon previous material prepared for the Flyers Creek submission, my review of the draft NSW Guidelines was added to the Flyers Creek community submissions (available on the NSW Department of Planning website).

As part of my on-going investigations into wind farm noise I have attended residential properties and public roads in proximity to Waterloo and Hallett wind farms (in South Australia) and Cape Bridgewater, Glenthompson and Waubra wind farms (in Victoria) in order to place in context claims of excessive noise/impacts from those wind farms.

As experienced for the NSW wind farms I have attended, at some sites in South Australia and Victoria there was clearly audible noise from the wind farm, at other sites some noise was audible, whilst at other sites there was no audible noise.

In the reporting of wind farm noise, there are claims and counter claims as to bias in the presentation of data that is a fundamental issue to be addressed prior to this peer review.

As a Member of the Australian Acoustical Society (the "AAS") and a Fellow of the Institution of Engineers Australia I am required to abide by the Code of Ethics for those two organisations.

Appendix B provides a copy of the Code of Ethics of the Australian Acoustical Society.

If there is potential for an industry to jeopardise the welfare, health or safety of the public, or affect the well being of the community I am duty bound to identify those issues under the Code of Ethics of the Australian Acoustical Society.

The AAS Code of Ethics requires that the acoustical assessment in relation to a wind farm is accurate and contains all the relevant material. This is the obligation placed on the acoustician. The acoustician has a heavy professional obligation and should be neither pro nor anti wind farm in approach.

In light of matters raised the community concerning acoustic assessments that have accompanied wind farm applications and "acoustic compliance tests" of wind farms I prepared a technical discussion paper "*Wind Farm Noise – An ethical dilemma for the Australian Acoustical Society?*" that was published in the August issue of the society's journal "Acoustics Australia" – see Appendix C.

I approach all my work in accordance with my professional Code of Ethics. Contrary to misleading statement made by some wind industry representatives I make the specific statement in conducting this peer review that **I am not anti-wind farm**.

Any project, be it an industrial application or a wind farm, should operate without giving rise to disturbance, health effects or adverse impacts on the community. If it can do so then, from a noise point of view, it may be permitted.

In relation to the Marshall Day Acoustics report that I am peer reviewing there is no indication of the author(s). I am aware of some of the Marshall Day Acoustics staff and their professional qualifications who are Members of the Australian Acoustical Society. If however the author(s) of the report are not members of the Australian Acoustical Society then the report is required to accord with the Code of Conduct from the Association of Australian Acoustical Consultants of which Marshall Day Acoustics is identified as a member firm.

3.0 THE MARSHALL DAY ACOUSTICS ASSESSMENT

3.1 Outline

The Executive Summary of the document indicates the assessment was undertaken in with the 2003 version of the South Australian EPA wind farm noise guidelines where the base level for noise assessment had been set at 35 dB(A).

The assessment has been based on sixty eight (68) wind turbines with a nominal hub height of 80 m. The specific model of turbine is not identified. "Candidate" turbines that are representative of the range of turbines that could be considered are nominated in Section 2 of the report as Suzlon S88-2MW, V3, Repower 3.4M 104 and Siemens SWT-2.3-101.

However the Marshall Day Acoustics report varies from the Environmental Assessment report that in Table 3 (in Section 2) identify other turbines being considered include Acciona AAW-109/3000, Enercon EB2/2300, Vestas V112-3.0 and GE Wind 2.75-100.

Section 3.1 identifies the Director-Generals Requirements (DGRs) were issued in October 2010 and required the acoustic assessment to accord with the following documents:

- the SA EPA 2003 *Wind Farm Guidelines*
- NSW *Industrial Noise Policy* (for the substation)
- DECC *Interim Construction Noise Guideline*
- NSW EPA *Environmental Criteria for Road Traffic Noise*
- DECC *Vibration – Assessing Vibration: A Technical Guideline*, and
- the ANZECC *Technical Basis for Guidelines to Minimise Annoyance Due to Blasting Overpressure and Ground Vibration*.

Section 3.2 provides extracts from the SA EPS 2003 Guidelines and notes the 2003 version was superseded by a 2009 version.

Section 3.3 refers to the draft NSW guidelines and identifies parts of the draft that are more stringent/specific than the DGRs to use the SA EPA 2003 Guidelines.

Section 3,4 refers to a European document ETSU R-97 *The Assessment and Rating of Noise from Wind Farms* as the basis of selecting 45 dB(A) as a limit for landowners with commercial agreements (normally referred to as "hosts") and claims the criterion is consistent with WHO documentation.

Section 3.5 refers to the DECCW *Interim Construction Noise Guideline*, whilst Section 3.6 refers to vibration criteria and Section 3.7 refers to road traffic noise criteria.

Section 4 indicates the assessment methodology used for the operational wind farm with section 4.1.2 identifying the background noise levels recorded at 8 locations have been referenced to wind speed at the hub height (80m above ground level).

Appendix E indicates that ambient background noise monitoring was conducted in April and May 2010 and November 2010, with measurements being conducted generally in accordance with the SA 2003 EPA Guideline. The documentation indicates the measurements were conducted using ARL EL-316 noise loggers. The graphs in Appendix I suggest the noise floor of the loggers was between 23 and 25 dB(A).

Table 8 is identified as providing the maximum A-weighted noise level for the residential properties that have been assessed with all locations experiencing levels not to exceed the minimum base criterion of 35 dB(A) for non-host dwellings or 45 dB(A) for host dwellings.

Appendix I provides in a series of graphs indicating the expected range of noise levels for different wind speeds to correlate with Table 8, and identifies there is an issue for House N (that is identified as a host dwelling).

Section 4.4 provides the results of predicted C-weighted noise levels indicating levels under a nominal 60 dB(C) threshold suggested in the draft NSW guidelines for night time operations. However there is a qualification of the C-weighted levels in terms of limited source data, assumptions as to prediction methods for low frequency that therefore questions the uncertainty of the predicted levels.

Section 4.5 discusses various characteristics of Infrasound, Low Frequency Noise, Vibration and Amplitude Modulation that may be associated with turbines. References are provided for various authors/documents in relation to the additional characteristics to be discussed later.

Section 4.6 discusses the cumulative impact of the proposed wind farm with the Cullerin Wind Farm to indicate there could be a slight increase but less than the base limit.

Section 4.7 (substation noise), section 4.8 (transmission line noise), section 5.2 (construction noise), section 5.3 (construction vibration) and section 5.4 (construction traffic noise) all claim compliance with the relevant criteria.

Section 8 is the Conclusion of the Marshall Day Acoustics report that identifies that the predicted levels contained in the report show compliance with the various criteria that have been nominated.

However the Conclusion does not provide any identification of the impact the proposed wind farm will create.

3.2 Analysis

The Marshall Day Acoustics report is similar to that provided by that organisation for other wind farms and would appear to fall into a generic type of report, subject to the additional requirements of the draft NSW guidelines to consider night time operations separately to day time operations under "worst case scenarios" and dB(C).

The report appears to be more comprehensive than other generic "acoustic reports" accompanying wind farm applications.

However there are a number of issues arising from this generic approach.

One issue of concern in relation to the generic type of noise assessment prepared by Marshall Day Acoustics for the subject wind farm is that there is a conflict between the title of the report and the contents of the report.

The report is titled "Collector Wind Farm Noise Impact Assessment" yet the report has not actually identified the noise impact that will be generated by the proposed wind farm. This would appear to be a fundamental failure in the obligations of the author(s) of the acoustic assessment i.e. a failure of the obligation to provide a meaningful document in relation to actual noise impacts that the community can understand.

The acoustic assessment has not explained to the community the impact that the proposed wind farm will have upon the existing acoustic environment of the area, nor whether the operation of the wind farm will affect their daily activities or their night time sleeping patterns. Complaints from residents in proximity to Capital and Cullerin wind farms frequently refer to sleep disturbance.

Marshall Day Acoustics is aware of complaints from the community concerning wind farms and the impact that the wind farms are creating on residents.

However, despite there being Marshall Day Acoustics reports/compliance tests for the Waterloo wind farm (in South Australia), the Waubra wind farm (in Victoria) and the Te Rere Hau wind farm (near Palmerston North in New Zealand), where there are numerous complaints and instances of people leaving their properties because of the wind farm operations, **there is no identification or consideration of the acoustic impact** of the proposed wind farm.

The ambient data reveals the existing acoustic environment of the area is significantly less than the base level of 35 dB(A). This automatically raises the question of "What is an acceptable noise impact from the proposed wind farm?" This is not an exercise that has been carried out in the subject assessment by Marshall Day Acoustics.

The acoustic report considers that the description of the acoustic impact is satisfied by identifying compliance with a noise target set out in the SA EPA Guideline, the draft NSW guideline and EPA criteria applied in suburban areas.

However, any experienced acoustic engineer would be aware that generating a noise which is significantly greater than the existing ambient background level of an area could create an impact which should be assessed.

The charts in Appendix G show the background noise levels recorded at the various monitoring locations versus the wind speed at the hub height. However the data is misleading in that the charts fail to show the background levels for the wind speeds below 3 metres per second on the basis that the turbines would not be operating at that speed.

However in determining the noise impact of the development it is necessary to quantify the acoustic environment of the area. This requires one to identify the range of background levels that are currently experienced.

Examination of the charts in Appendix G show a range of background levels for a hub height wind speed that shows there is no direct correlation of wind to the background level – hence the concept of an averaging process by use of a regression curve.

However the significant variation in background levels for houses L, Q, Z and AA must automatically lead one to question the use of such data. Houses L, M & Z are in relatively close proximity to one another yet the differences in the ambient noise levels have not been identified in the Marshall Day Acoustic report.

Appendix H provides a series of regression charts that one assumes corresponds to the material in Appendix G. The first paragraph of Appendix H states:

> *This section describes the environs each noise monitoring location and provides a graphic summary of the background noise and wind data, and where appropriate, the noise limits derived from the background data.*

However, examination of the graphs in Appendix H does not provide data to describe the acoustic environment at each monitoring location.

The regression analysis method set out in Appendix H does not provide data below about 3.5 m/s wind speed and therefore does not identify the true background of the area.

The regression analysis method set out in Appendix H does not differentiate between the background levels that occur at night versus the background levels that occur in the day. One typically expects night time background levels to be lower than in the day.

If one was seeking to conduct an assessment of the impact of the wind farm on the community it would be appropriate to differentiate between the acoustic environments that exist in the day versus that in the night.

Although having identified the draft NSW guideline looks to separate the day time background levels from the night time background levels, the omission of material to describe the day time environs versus the night time environs would seem to be a significant matter for a "Noise Impact Assessment".

The absence of a discussion on night time versus daytime background levels is of interest in that in Appendix I (commencing on page I-12) are regression lines for daytime and night time periods that show there is a significant difference between the daytime and night time background levels.

Whilst the report claims the same instrumentation was used for background monitoring at various locations, the graphs for Houses G, M, N and T show a noise floor of around 23 dB(A) across the range of typical operating wind speeds. Houses L, Q, Z and AA reveal a higher noise floor.

Examination of the graph for House M on page I-3 would suggest that there should be two regression lines if one considered night versus day and that that the actual background level at night would be below 23 dB(A). Page I-13 shows the background level at the cut in speed to be less than 23 dB(A). However the noise floor limit of meter reveals that the regression curve should be lower.

If, for example, the ambient background level used for the assessment of industrial noise looks to wind speeds less than 5 m/s at the microphone and selects the lowest 10 percentile of the background levels. The lowest 10 percentile of the background levels will obtain a lower value than the average line in the regression analysis used for the operational "background" level.

Accordingly, one has a "background" level for the area different to the "background" level for the assessment of the operation of a wind farm.

The graphs in Appendix I of the Marshall Day Acoustics report reveal background levels below the regression line. A substantial number of data points are shown at the noise floor of the meter. This means that one can have background levels below the noise floor of the meter.

If the regression lines are extrapolated to identify the background level (for the area) prior to the cut in speed then one would expect a lower background level to prevail. Similarly if the data was presented just for the night time measurements, which tend to be the critical time of concern to residents, then one would automatically expect a different regression curve.

To this end unattended noise logging was carried out at three residential locations in the vicinity of the proposed wind farm.

Appendix D provides a summary table of background levels determine in accordance with the NSW EPA's Industrial Noise Policy (but using 10 minute samples and no exclusion of excessive wind) for a position east of House K. The table of results reveal night time background levels to be down to 18.5 dB(A), being the A-weighted noise floor of the SVAN 957 meter.

Appendix D includes a chart of the A-weighted levels over a 24 hour period and a regression chart obtained from wind data recorded at the microphone height using a Rainwise wind data logger.

Appendix E provides results for a location to the north of residence V to reveal similar results to Appendix D. The measurement results go down to the noise floor of the meter. If the true ambient background level is below that of the noise floor then the regression line either on the total data points or just the night time data points must also be lower.

If one assumes that the wind farm ambient background level of the area from the regression analysis is around 20 dB(A) at the cut-out speed, then it is an undeniable fact that wind farm noise at the nominal limit of 35 dB(A), would be clearly audible both inside and outside residential dwellings and would represent a significant impact in terms of the existing environment.

Similarly even a contribution from the wind farm of 30 dB(A) would be clearly audible both outside and inside residential dwellings when one considers that the noise level detected by residents in proximity to wind farms is that of a low frequency noise which is not necessarily identified in the dB(A) value.

Normally wind farm acoustic assessments identify the logger locations with respect to the surrounding area so as to identify the relevance of the logger results. The Marshall Day Acoustics report fails to provide such information.

The report does not provide wind data at the microphone (separately to, or supplementary to the 80m high wind data at the wind farm site). This is relevant for compliance testing as normally the wind farm operator does not provide operational information as to turbine output and hub wind speed and direction to permit the community to independently ascertain the noise contribution from the wind farm.

If one was to identify to the community there would be no impact/an impact /an adverse impact or severe impact from the proposed wind farm it would be appropriate for the report to discuss the relevance of the predicted noise levels versus the regression curve and/or the minimum background levels that relate to the various wind speeds.

For example Table 15 in the Environmental Assessment report (not provided in the acoustic report) provides a range of levels for comparison purposes. A level of 30 dB(A) is suggested for inside a bedroom with 20 dB(A) identified as in an unoccupied recording studio with a subjective evaluation as “almost silent”.

With the external background levels in the subject area at night being below 30 dB(A), and at times below 20 dB(A), there must therefore be even lower noise levels inside bedrooms of residences in rural areas.

Utilising Table 15 on page 78 of the Environmental Assessment the external acoustic environment of the area at night must therefore be almost silent, is clearly a situation that should have been identified by Marshall Day Acoustics.

Bearing in mind that the Marshall Day Acoustics report does not discuss the actual acoustic impact of the proposed wind farm and has not identified the acoustic amenity that residents currently experience then it would appear the predicted noise levels provided in the acoustic report will result in a loss of acoustic amenity.

The acoustic assessment purports at times to indicate that a conservative approach has been adopted in assessing the predicted noise emission levels but would not appear to identify the variation in noise levels that would occur as the result of weather conditions when compared to a worst-case scenario of propagation.

For example, one can have the turbines operating whilst at residential receivers there is absolutely no wind, which is not a situation identified in the acoustic assessment.

The Marshall Day Acoustics report has not identified the relationship between the wind speeds at the nominal hub height versus the wind speed at receiver locations. There is no correlation with the predicted noise levels under the wind scenarios that have been assessed, nor identification of the difference in propagation for different wind directions. Nor is there identification of the frequency of the occurrence of adverse meteorological effects which could be identified in a generic term as temperature inversions, separately to the more detailed and complex analysis attributed to the van den Berg effect.

It is quite likely that such an analysis could show a range of noise levels and identify to the community that for a certain percentage of the time the wind farm would be inaudible/barely audible/clearly audible. Such an analysis would provide a clearer interpretation as to the acoustic impact of the proposed wind farm.

For example the Marshall Day Acoustics report could have identified that for some operating wind speeds in their opinion the audible characteristics of the wind farm would result in inaudibility or barely audible at residential properties. Whilst at other locations the wind farm would be clearly audible. Such a description would assist the community in comprehending the impact of the proposed wind farm.

The predicted noise levels must have some degree of tolerance by reason of the noise source data and the variability in the assumptions made for propagation and local effects that could alter the predicted noise levels.

The assessment report has failed to identify the potential audibility of turbine noise outside or inside residential dwellings, which therefore is a significant failure of the report in providing appropriate advice to the community as to the likely acoustic impact. The community could understand the concept of hearing a noise versus not hearing a noise, yet the Marshall Day Acoustics report has not identified the audible impact of the proposed wind farm external to dwellings.

The Marshall Day Acoustics report has failed to identify the potential audibility of turbine noise inside residential dwellings, or the spectral content of the wind farm sound at residential properties. The attenuation of building elements provides a greater degree of attenuation at high frequencies to that at low frequencies. Therefore the spectral balance of noise detected outside a dwelling is different to that inside a dwelling.

There would appear to be an assumption that the noise from the wind farm would not exhibit modulation or tonality at residential receivers thereby not requiring an adjustment to the predicted noise levels.

4.0 DIRECTOR GENERAL's REQUIREMENTS

Section 3.1 of the Marshall Day Acoustics provides the Key Assessment Requirements of the DGRs.

Under the General Requirements section of the DGRs the Environmental Assessment was required to consider any relevant statutory provisions including the consistency of the project with the objects of the Environmental Planning and Assessment Act 1979. This requirement is not identified by Marshall Day Acoustics.

Under Key Assessment Requirements in relation to noise, the Environmental Assessment is to determine the noise impacts of the wind turbine operation under operating meteorological conditions, including impacts under meteorological conditions that exacerbate the impacts. The probability of such occurrences must be quantified.

The Marshall Day Acoustics report does not identify noise impacts. The report nominates noise levels not impacts. The Marshall Day Acoustics report does not provide noise levels under normal weather conditions only worst case scenarios. The Marshall Day Acoustics report does not quantify the probability of worst case occurrences as required by the DGRs.

As identified above, the Marshall Day Acoustics report does not adequately address the actual noise impact of the proposed wind farm at all. The report is silent on what would constitute a negative or adverse impact or considering "offensive noise" as defined in the *Protection of the Environment Operations Act*.

From an acoustic perspective one may consider an adverse impact to occur at a noise level of greater than what may be considered a significant impact, which for an A-weighted value may be assigned background + 5 dB(A) on the following basis. Under previous versions of Australian Standard AS 1055, noise level that exceeds the background may be considered to be annoying. Noise levels up to 5 dBA above the background were considered to be of marginal significance.

Offensive noise is a noise that is harmful to a person or a noise that interferes with the rest and repose of a person. Noise from a wind farm that gives rise to sleep disturbance clearly interferes with the rest and repose of a person. There are a significant number of residents in proximity to wind farms who regularly complain of sleep disturbance, headaches and nausea when the wind farm is operating. In some cases people have had to abandon their homes due to ongoing sleep disturbance and adverse health effects, which have not been acknowledged in the Marshall Day Acoustics report.

5.0 SA EPA GUIDELINES, NOISE IMPACTS

The DGRs for the subject application specifically identifies the Environmental Assessment is to be assessed against the 2003 SA EPA Guidelines (not the 2009 version of the SA EPA Guidelines).

The Marshall Day Acoustics report presents data which it asserts is sufficient to establish compliance with EPA guidelines. It then relies upon the concept that the EPA guidelines have determined comprehensively an acceptable noise level for rural environments that will apply to the assessment of wind farms. On this basis, the EPA guidelines "cover the field" and no further examination of noise impacts is undertaken, either generally or specifically in relation to the concept of offensive noise that appears in the NSW Protection of the Environment Operations Act. The report does not identify for the community the actual noise impact which will occur.

I have outlined at Section 3 above, a variety of concerns which I believe should be addressed in relation to the Marshall Day Acoustics report.

The Guidelines introduce two "core" principles - protecting the amenity of the community from adverse noise impacts and taking all reasonable and practicable measures to prevent or minimise environmental harm. These are contained in the Introduction section and its explanatory content:

The core objective of the guidelines is to balance the advantage of developing wind energy projects in this State with protecting the amenity of the surrounding community from adverse noise impacts.

Guidelines

The *Environment Protection Act 1993* requires a duty of care for the environment. This is specified under Section 25 of the Act and states:

A person must not undertake an activity that pollutes or might pollute, the environment unless the person takes all reasonable and practicable measures to prevent or minimise any resulting environmental harm.

Guidelines published by the EPA indicate the standard of care that is likely to be required to secure compliance with the general environmental duty as outlined in d.25 of the Act.

They have the advantage of flexibility and can be adapted to a range of circumstances.

Neither the body of the document nor the glossary defines "adverse noise impacts". As such the Guidelines do not assist the community by defining "adverse noise". Similarly whilst Section 4.6 of the Guidelines is headed "Excessive noise," there is no definition of excessive noise.

If one assumes the EPA has a responsibility to protect the community from unreasonable disturbance and to prevent or minimise any resulting environmental harm then it is not unreasonable to expect the noise criteria to reflect that situation.

Section 2 identifies that the concept is to set a base noise level typically 5 dB(A) lower than the level considered to reflect the amenity of the receiving environment. The Guidelines correctly identify that as the wind increases so can the noise in the environment such that a varying noise limit (dependent upon the wind strength) must apply.

In the 2003 version of the Guidelines the noise criteria for a new wind farm development is:

> **The predicted equivalent noise level (L_{Aeq10}), adjusted for tonality in accordance with these guidelines, should not exceed:**
>
> - **35 dB(A) or**
> - **The background noise (L_{Aeq10}) by more than 5 dB(A)**
>
> **whichever is the greater, at all relevant receivers for each integer wind speed from cut-in to rated power of the WTG.**
>
> **The background noise should be as determined by the data collection and regression analysis procedure recommended under these guidelines (Section 3). It should be read from the resultant graph at the relevant integer wind speed.**

If a rural living area has relatively quiet amenity and background levels in the day and night that can be around 20 – 25 dBA (or lower), then there would appear to be a conflict between the noise criteria set by the Guidelines and what residents who reside in such zones would consider is an acceptable acoustic amenity level.

There is a fundamental problem with the selection of the base criteria if they are 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.

There is no material in either the 2003 version (or the 2009 version) of the Guidelines identifying the basis of the base level of 40 dB(A) for a rural area. The bibliography towards the end of the Guidelines does not reference any reports or studies as to the acoustic amenity of rural areas in Australia (or in fact anywhere) nor any evaluation of acceptable amenity levels for rural areas.

There is a reference in the Bibliography to World Health Organisation 1999 *Guidelines for Community Noise*.

However, examination of the WHO 1999 Guidelines reveals an indoor limit of 30 dBA is associated with urban areas impacted by road traffic. There is no mention of wind farms or criteria for sleep disturbance in rural areas in the WHO Guidelines. In some cases there is a suggestion the WHO 1999 Guideline limit of 30 dB(A) is appropriate for rural areas which clearly becomes inappropriate if ambient background level in rural dwellings is less than 20 dB(A).

Social surveys in Scandinavia (Sweden 2000, Sweden 2005 and Netherlands 2007) for turbines significantly smaller than proposed for the subject wind farm clearly demonstrated rural communities had a greater degree of annoyance when compared to the same noise level in suburban environments (Pederson and Waye). These surveys came after the WHO 1999 Guidelines.

Section 2.3 of the Guidelines discusses 'Agreements with wind farm developers" being stakeholders, i.e. residents who receive a financial interest from the wind farm. The last paragraph on page 3 states:

> **If it is shown that a development is having an 'adverse effect on an amenity value of an area that...unreasonably interferes with...the enjoyment of the area' then appropriate action can be taken under the Act.**

But as discussed above the Guidelines do not specifically define adverse effect in numerical terms, the Guidelines do identify sleep disturbance as an adverse impact. The Guidelines identify on page 4 that if stakeholders experience sleep disturbance then that must be an adverse health impact:

> **However, the existence of an agreement will affect the consideration of whether the interference is unreasonable in a given situation. It is unlikely that there will be unreasonable interference if:**
>
> - **a formal agreement is documented between the parties.**
> - **the agreement clearly outlines to the landowner the expected impact of the noise from the wind farm and its effect upon the landowner's amenity, and**

- **the likely impact of exposure will not result in adverse health impacts (e.g. the level does not result in sleep disturbance).**

As the Guidelines do not specifically define or quantify excessive noise or adverse impact in terms of any measurable impact, the identification of sleep disturbance as an adverse impact agrees in part with the definition of "offensive noise" in the NSW Protection of the Environment Operations Act.

If as identified in the Guidelines the stake holder dwelling is permitted a higher level of noise then does it not mean that for non-stake holders where the external limit for rural living is 35 dB(A), the corresponding internal limit should be 25 dB(A) so as to ensure there is no adverse health impact under an open windows situation or 15 dB(A) for a closed window situation?

The Marshall Day Acoustics report has not identified the existing acoustic amenity that the residents receive.

If one utilises the predicted noise levels set out in Table 8 and compared with the background levels nominated as being the lowest measured night time background level at any of the non-host dwellings that were the subject of ambient monitoring, then for example at house V the maximum the predicted level is 30-31 dB(A) whereas the range of background levels shown in Appendix I-13 can for the regression line vary between 23 and 28 dB(A), but could simply be 23 dB(A).

The use of a generic regression curve to provide an averaging technique is not a methodology used by the EPA in determining a background level to protect 90% of the people for 90% of the time.

As location V can experience background levels less than that predicted for the wind farm at the hub height it must follow that the wind farm at times would be audible and cause an increase in the background level. The background level would increase and therefore there would be a loss of amenity.

At times the noise from the wind farm would exceed the general annoyance criterion of background + 5 dB(A). If the predicted dB(A) has a low frequency characteristic at the residence (not addressed by Marshall Day Acoustics) then a penalty could be required to the predicted level.

From an acoustic perspective one may consider an adverse impact to occur at a noise level of greater than what may be considered a significant impact, which an A-weighted value may be assigned background + 5 dB(A) on the following basis. Under previous versions of Australian Standard AS 1055, noise level that exceeds the background may be considered to be annoying. Noise levels up to 5 dBA above the background were considered to be of marginal significance.

In NSW "offensive noise" is a noise that is harmful to a person or a noise that interferes with the rest and repose of a person. Noise from a wind farm that gives rise to sleep disturbance clearly interferes with the rest and repose of a person. There are a significant number of residents in proximity to wind farms who regularly complain of sleep disturbance, headaches and nausea when the wind farm is operating. In some cases people have had to abandon their homes due to ongoing sleep disturbance and adverse health effects, which have not be acknowledged in the Marshall Day Acoustics report.

Of relevance to the Marshall Day Acoustics assessment for the Collector Wind Farm in terms of the application of the Guidelines is a decision before the New Zealand Environment Court (Decision No [2012] NZEnvC 133) between Palmerston North City Council and New Zealand Windfarms issued on the 4 July 2012.

The case related to a wind farm called Te Rere Hau that is situated in the rural hinterland of Palmerston North pursuant to a consent issued by the Council in February 2005.

The turbines are relatively small turbines when compared with the subject application but the operation the wind farm gave rise to complaints with paragraph 29 of the decision identifying a number of acoustic reports that had been undertaken for the Applicant and the Council.

The decision identifies errors in the original source levels and errors in the computer modelling that was used, and more relevant for the subject application was that there were a significant number of complaints when by use of the criteria nominated in the NZ Standard that there would be no loss of acoustic amenity.

Referring to paragraphs 115 and 116 of the decision cast doubt on the suitability of the SA Guideline to achieve the objective of the Guideline; namely "protecting the amenity of the surrounding community from adverse noise impacts".

> [115] NZWL accepted that it is … apparent that the initial Noise AEE predictions contained inaccuracies in relation to both the sound power level and sound progagation. To the extent that NZWL might imply by use of the word predictions, that the statements in the AEE as to these matters were predictive only and were not intended to be binding, we disagree. The information as to these aspects of turbine performance was presented in the NIAR as statements of fact based on assessment of the Gebbies Pass turbine. In any event, we refer to our discussion on modelled predictions contained in paras (103)-(105)(above).
>
> [116] The two conceded inaccuracies led to the following further inaccuracies in NZWL's description and evaluation of effects:
>
> - Miscalculation of the wind farm noise contours;
> - The conclusion that only three local residential locations were likely to be affected by sounds from the wind farm at levels of 30 dB(A) or more;
> - The statement that there would be nil noise effects from TRH on residences further away than the three identified residences. (We accept NZWL'S contention that the term nil noise effects was intended to indicate that other residential locations would not receive noise above 30 dB(A) not that they would hear no noise from TRH at all);
> - The conclusion that due to the restricted extent of noise effects there needed to be only one monitoring point for assessment of wind noise compliance.

We consider that all of these inaccuracies are relevant to consideration of Declaration 1.8.

If as in the New Zealand case that residents in proximity to the proposed wind farm have a relatively quiet amenity and background levels in the day and night can be around 20 – 25 dBA (or lower), then there would appear to be a conflict between the noise criteria set by the Guideline and what residents who reside in such zones would consider is an acceptable acoustic amenity level.

There is a fundamental problem with the selection of the base criteria if they are 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.

In the case of the South Australian wind farm guidelines there is no material in either the 2003 version (or the 2009 version) of the Guidelines identifying the basis of a base level of 40 dB(A) for a rural area. The bibliography towards the end of the Guidelines does not reference any reports or studies as to the acoustic amenity of rural areas in Australia (or in fact anywhere) nor any evaluation of acceptable amenity levels for rural areas.

The EPA Guideline references World Health Organisation 1999 *Guidelines for Community Noise*.

However, examination of the WHO 1999 Guidelines reveals an indoor limit of 30 dBA is associated with urban areas impacted by road traffic. There is no mention of wind farms or criteria for sleep disturbance in rural areas in the WHO Guidelines. In some cases there is a suggestion the WHO 1999 Guideline limit of 30 dB(A) is appropriate for rural areas which clearly becomes inappropriate if ambient background level in rural dwellings is less than 20 dB(A).

Social surveys in Scandinavia (Sweden 2000, Sweden 2005 and Netherlands 2007) for turbines significantly smaller than proposed for the subject wind farm clearly demonstrated rural communities had a greater degree of annoyance when compared to the same noise level in suburban environments (Pederson and Waye). These surveys came after the WHO 1999 Guidelines.

Section 2.3 of the SA Guidelines may assist in that is discusses 'Agreements with wind farm developers" being stakeholders, i.e. residents who receive a financial interest from the wind farm. The last paragraph on page 3 states:

If it is shown that a development is having an 'adverse effect on an amenity value of an area that…unreasonably interferes with…the enjoyment of the area' then appropriate action can be taken under the Act.

As the SA Guidelines do not specifically define adverse effect in numerical terms, the Guidelines do identify sleep disturbance as an adverse impact. The Guidelines identify on page 4 that if stakeholders experience sleep disturbance then that must be an adverse health impact:

> **However, the existence of an agreement will affect the consideration of whether the interference is unreasonable in a given situation. It is unlikely that there will be unreasonable interference if:**
>
> - **a formal agreement is documented between the parties.**
> - **the agreement clearly outlines to the landowner the expected impact of the noise from the wind farm and its effect upon the landowner's amenity, and**
> - **the likely impact of exposure will not result in adverse health impacts (e.g. the level does not result in sleep disturbance).**

If as identified in the SA Guidelines the stake holder dwelling is permitted a higher level of noise then does it not mean that for non-stake holders where the external limit for rural living is 35 dB(A), the corresponding internal limit should be 25 dB(A) so as to ensure there is no adverse health impact under an open windows situation or 15 dB(A) for a closed window situation?

The issue of sleep disturbance as an adverse health impact must lead to an examination of what noise causes sleep disturbance and to the use of dBA as the assessment parameter. Whilst identifying the sleep disturbance as an adverse health impact the SA Guidelines do not identify what level of noise from wind farms generates sleep disturbance.

Noise generated from wind turbines covers the entire audio spectrum and includes infrasound. Where monitoring reveals compliance with the nominated dBA noise criteria residents still hear the wind farm noise and complain about sleep disturbance.

The A-weighted filter curve significantly attenuates low frequencies (see Appendix F) and cannot provide a true indication of potential low frequency noise issues, which is a common source of complaint concerning wind farms. Furthermore if one considers noise that is below the frequency range of human hearing (i.e. less than 20 Hz which is normally referred to as Infrasound) the A-weighted value for such frequencies is insignificant.

The Marshall Day Acoustics report refers to a number of papers re noise associated with the wind farms. One of the reference authors H. G. Leventhall published a paper in Noise & Health 6.23 (April 2004) "Low frequency noise and annoyance" where the abstract states:

> *Low frequency noise, the frequency range from about 10Hz to 200Hz, has been recognised as a special environmental noise problem, particularly to sensitive people in their homes. Conventional methods of assessing annoyance, typically based on A-weighted equivalent level, are inadequate for low frequency noise and lead to incorrect decisions by regulatory authorities. There have been a large number of laboratory measurements of annoyance by low frequency noise, each with different spectra and levels, making comparisons difficult, but the main conclusions are that annoyance of low frequencies increases rapidly with level. Additionally the A-weighted level underestimates the effects of low frequency noises. There is a possibility of learned aversion to low frequency noise, leading to annoyance and stress which may receive unsympathetic treatment from regulatory authorities. In particular, problems of the Hum often remain unresolved. An approximate estimate is that about 2.5% of the population may have a low frequency threshold which is at least 12dB more sensitive than the average threshold, corresponding to nearly 1,000,000 persons in the 50-59 year old age group in the EU-15 countries. This is the group which generates many complaints. Low frequency noise specific criteria have been introduced in some countries, but do not deal adequately with fluctuations. Validation of the criteria has been for a limited range of noises and subjects.*

In the paper Leventhall specifically cites the World Health Organization as recognising low frequency noise as an environmental problem. He references the WHO publication on Community Noise and provides the following in relation to rest, sleep and adverse effects:

> *"It should be noted that low frequency noise, for example, from ventilation systems can disturb rest and sleep even at low sound levels"*
>
> *"When prominent low frequency components are present, noise measures based on A-weighting are inappropriate"*
>
> *"Since A-weighting underestimates the sound pressure level of noise with low frequency components, a better assessment of health effects would be to use C-weighting"*
>
> *"It should be noted that a large proportion of low frequency components in a noise may increase considerably the adverse effects on health"*
>
> *"The evidence on low frequency noise is sufficiently strong to warrant immediate concern"*
>
> *"For noise with a large proportion of low frequency sounds a still lower guideline (than 30dBA) is recommended"*

In 2009 Leventhall provided another paper in the Journal of Low Frequency Noise, Vibration and Active Control Low Frequency Noise, "What we know, what we do not know, and what we would like to know". He defines low frequency noise as in the range of 10 Hz to 100Hz, but could be extended an octave each end to give 5 Hz to 200Hz.

Whilst the 2009 paper contains the majority of the 2004 information he highlights significant issues concerning low frequency noise that cannot be detected using A-weighting.

> *Although we know a great deal about low frequency noise, there are aspects which we cannot yet explain. We know about how people hear low frequency noise and that some have a low tolerance to it. We believe that low frequency noise may, in general, be more annoying than higher frequency noise, but do not know why this is so. We do not know why*

> *some people complain of a low frequency noise which cannot be measured separately from the background noise.*
> *It is also possible that there are subtle effects of low frequency noise on the body, which we do not yet understand.*

Leventhall provides standardised threshold levels over a frequency range assigned for human hearing, including levels for part of the range described as Infrasound. He provides a series of questions that are clearly relevant to the proposed wind farm if it is shown that low frequency noise is likely to be produced:

> ***SOME FINAL QUESTIONS***
>
> *This review of low frequency noise and its effects leaves some unanswered questions, towards which future work might be directed.*
>
> - *Is the ear the most sensitive receptor to low frequency sound in the body?*
> - *Alternatively, is there a receptor mechanism in the body which is more sensitive than the ear at low frequencies? If so, what is the mechanism?*
> - *Are levels of infrasound below hearing threshold potentially harmful? If this is true, are there safe levels?*
> - *When people complain about noise which cannot be measured, is it because they are disturbed by fluctuations in the background noise?*
> - *Can fluctuations in the background noise level turn a noise, which has an average level below the hearing threshold of a listener, into a nuisance?*
> - *If fluctuations are combined with the lowest sensitivity of the hearing threshold (e.g. three standard deviations below the median) can people hear noises which have a measured average value so far below the hearing threshold that we might consider them inaudible?*
> - *Does the way in which we measure low frequency noise hide some of its disturbing characteristics?*
> - *Considering the normal distribution of the hearing threshold, why are there not more complaints of low frequency noise?*

Barbara Griefahn (Institute of Occupational Physiology at the University of Dortmund, Germany) is a well-known researcher on sleep disturbance due to noise. In Noise & Health Vol 4, 15 (2002) the abstract to "Sleep disturbance related to environmental noise" identifies that the ear still hears even when asleep:

> *The permanently open auditory channel and the ability of the brain to process incoming acoustical stimuli even while asleep and to respond adequately is the essential precondition for noise-induced sleep*

> *disturbances which are regarded as the most deleterious effects of noise. In the past, research was mainly focused on the detection and description of the various effects of noise, on the influence of personal and environmental factors, on the determination of dose response relations and the definition of critical noise loads, above which noise becomes intolerable. These limits are, however, as yet only tentative or applicable for a very few situations and need to be verified or revised.*

This material was available prior to the 2003 SA EPA Guideline and gives an explanation as to potential sleep disturbance impacts from wind farms that may operate continuously or intermittently at night.

The Marshall Day Acoustics report refers to computer predictions in accordance with ISO 9613-2. Computer models for acoustic purposes are designed to deal with general noise sources not wind farms with low frequency noise.

In a submission on the Draft NSW Wind Farm Guideline document issued for public comment last year, Vestas Australian Wind Technology Pty Ltd (available on NSW Department of Planning Website) states:

> Low frequency noise
>
> The Draft Guidelines state that "Analysis of wind turbine spectra shows that low frequency noise is typically not a significant feature of modern wind turbine noise and is generally less than that of other industrial and environmental sources."
>
> It is therefore unnecessary to require the prediction and monitoring of low frequency noise emissions from wind turbines. This is especially so, given the absence of regulation or limits upon the low frequency noise from "other industrial and environmental sources" as mentioned in the above statement from the Draft Guidelines. This is a further example of the way in which the Draft Guidelines discriminate against wind farms.

> **In addition, the existing and well validated industry standard models for acoustic propagation are not designed to deal with frequencies at the low end of the audible spectrum, specifically because noise emissions in this band are not considered to pose issues likely to affect the surrounding environment. Accordingly, Vestas suggests the removal of the requirement to measure low frequency noise from the Draft Guidelines.**

The above comment on low frequency noise from a local subsidiary of Vestas Wind Systems A/S (identifying themselves as the world's largest manufacturer of wind turbines and being supplier of the turbines currently proposed) confirms the computer models (including the computational standard used by Marshall Day Acoustics) are not designed to deal with the low frequencies.

Use of the A-weighting as an assessment criterion in the SA Guidelines overcomes the inadequacy of the computer models (because it ignores low frequency) and does not deal with the presence and impact of low frequency noise received at dwellings from wind farms.

One result of considering the potential adverse impact of sleep disturbance is that as there is an assumption people sleep at night, the assessment should differentiate between day and night.

In addition to low frequency noise, the operation of wind farms produces noise characteristics that do not get picked up in an average A-weighted measurement. For example there are modulations in the noise signature, tonal characteristics and infrasound, apparently dismissed by Marshall Day Acoustics for the subject application.

Noise data in relation to wind farms in the Goyder region (of South Australia) are discussed in the following section and show amplitude modulation, tones and infrasound exist for wind farms in proximity to the proposed wind farm. These characteristics, when present, can also be said to be adverse noise impacts from which the surrounding community is required to be protected.

Finally, there are those matters (outlined in preceding sections) in relation to which clear identification of the range of expected higher noise levels and the frequency of occurrence of the same needs to be made.

The predicted noise levels for a wind farm will be expected to vary as a result of different weather conditions. When there is no wind in the area, the wind farm will not create an acoustic impact.

However different wind strengths (at the wind farm turbine height) will generate different noise levels. Similarly different wind directions will also change the level of noise at receiver locations.

Similarly, temperature inversions can alter the propagation of noise that can significantly increase the noise levels.

The community will experience a range of noise levels over time depending upon the prevailing weather conditions. It would seem appropriate to clearly identify the range of noise levels and the frequency of occurrence of the higher noise levels

6.0 TESTING OF WINDFARM NOISE - WATERLOO AND HALLETT

Any appropriately qualified and experienced acoustic engineer will be aware that when there are vigorous complaints from residents as to noise disturbance then there is likely to be some form of noise impact occurring with respect to the relevant noise source. There may very well be a heightened sensitivity of residents who are continuously exposed to the subject noise and who can become "tuned into" the noise.

As part of my ongoing research into the actual or perceived impacts associated with wind farms, when the opportunity arises it is appropriate to undertake sound level measurements.

This section provides the results of measurements taken by the author near turbines in the region of the Waterloo Wind Farm to identify noise levels associated with the source and noise measurements at residential receivers. The results assist in placing the perceived noise impact in the existing environment and are relevant to the acceptability concept identified in the SA Guidelines. This material provides context to the subject application with respect to the topography and acoustic environment of the area.

These measurements may also provide an opportunity for residential receivers potentially impacted by the proposed wind farms to attend various locations in proximity to existing wind farms to ascertain for themselves the external acoustic environment that they could receive as a result of the subject proposal.

By use of noise contour graphs that identify the A-weighted level to be emitted from the Wind Farm, residents can find locations that would approximate their residence with respect to the proposed development to gauge first-hand the impact. For example, such a practical method permits residents who may be subject to a major road upgrade to experience the predicted noise levels as a result of that upgrade and thereby ascertain the likely impact.

Some caution should be applied to this suggestion as noise levels will depend on weather conditions and the perceived noise will relate to external noise, and not the noise levels obtained inside a dwelling.

Attendance at a number of residential dwellings in South Australia, Victoria, and New South Wales found that residents related having experienced varying degrees of disturbance/impacts when the turbines are operating compared to the situation prior to the construction of the relevant wind farm. Measurements were conducted both external to various dwellings, and in some cases simultaneous measurements both external to an inside the dwelling were undertaken.

During the course of attending various residences where either complaints have been registered with the local Council, or compliance monitoring has been conducted by the wind farm operators, an opportunity was also presented to conduct measurements on public roads in proximity to turbines in situations where noise was not influenced by either vehicular activity (i.e. no vehicles) or activities associated with rural properties. On attending a number of residences noise from the wind farms varied ranging from barely audible, clearly audible or not audible outside the residence. Measurements inside residences found differing degrees of audibility.

Some residents near Mt Bryan advised of sleep disturbance, whilst for periods when the turbines were not operating at night, they experienced no disturbance.

Some residents did not want their property specifically identified and therefore have been excluded from the material contained in this peer review. Residences referred to in this peer review are identified by a house code (house 7 – 12 are in the vicinity of Hallett and Waterloo Wind Farms).

Marshall Day Acoustics indicate the SA Guidelines claim there is no issue in terms of low frequency noise and that infrasound is only generated in poorly maintained wind farms. However, testing has revealed otherwise.

Towards the northern end of the Waterloo Wind Farm there is one public road that passes through the Wind Farm (Quinns Gap Road) and another that runs along the northern side of the current Wind Farm (Mollers Gap Road). These public roads permit access to positions relatively close to the turbines from which measurements may be undertaken.

One set of measurements were conducted on the top of Quinns Gap Road where one microphone was located directly in front of the turbine at a position 142 m from the base, or 168 m slant distance to the hub. A second microphone was located at a similar distance but perpendicular to the side of the hub so as to be in line with the rotating plane of the turbine blades.

A second set of measurements were conducted on the top and eastern side of Mollers Gap Road where one microphone was located to the side of the turbine at a position 152 m from the base or 172 m slant distance to the rear housing.

The response curves in Appendix F show the response of the ear is non-linear across the frequency bands. The general community assessment uses the A-weighted curve (the blue curve in the lower graph of Appendix F) and as identified previously attenuates the low frequency components.

Typically wind turbine noise spectra are also presented in A-weighting curves that show the maxima to be in the mid frequencies.

The upper graph in Appendix G presents the turbine power levels measured for a distance of 800 metres for Capital Wind Farm (NSW) and Waterloo Wind Farm (slant distances noted above) on the assumption of hemispherical radiation and 6 dB per doubling of distance. These results are Linear results (without the A-weighting filter).

The lower graph in Appendix G reproduces the Linear results and also the same results when presented as A-weighted levels. The difference in the identification of low frequency becomes obvious.

Appendix H presents the 1/3 octave band results of the Quinns Gap Road measurements over the Guideline standard 10 minute sample. The results show the spectrum information on a statistical basis in a linear format (not A-weighted) and show the statistical variation in the noise level.

There were no other intrusive noises at the site, only turbine noise. The results clearly identify distinct frequency peaks rather than a broadband noise.

The measurement results show different frequency characteristics for noise off the front of the turbines versus to the side.

The A-weighted level was not constant and exhibited a variation in level, which as nominated in the Guideline is identified as modulation. The modulation occurs over the entire audio spectrum. Whilst not showing a significant variation in the A-weighted level the modulation is most obvious in the upper frequency bands as shown by comparison of the A-weighted level versus the 2500 Hz 1/3 octave band in Appendix I.

Appendix J presents a number of FFT analyses that show the sound spectrum in a linear format (rather than constant percentage bandwidth – 1/3 octave bands) to permit identification of narrowband tones. Appendix H1 shows the statistical variation in the frequency display with the remaining graphs being the energy average (Leq) of each 2 minute sample.

The FFT analyses progressively reduce the bandwidth of each analysis to permit identification of specific tones that occur in the frequency area nominated as covering low-frequency sound and infrasound. The bottom axes are frequencies in Hz (i.e. Appendix H1 and H2 show 0 – 1 kHz, Appendix H3 shows 0 – 100 Hz and Appendix H4 shows 0 – 12.5 Hz).

The frequency graphs clearly show that there are low frequency and infrasound components generated by the turbine.

The results set out in Appendices G – J for the measurements of the turbine reveal modulation, low frequency noise and infrasound components.

The Marshall Day Acoustics report identifies ambient background levels below 40 dBA for residential receivers in proximity to the proposed Collector Wind Farm.

Earlier in this report I identified the results of ambient measurements near dwellings recorded over a two week period that indicate a range of background noise levels. The provision of a lengthy monitoring period in a quiet area permits determination of a regression line of noise versus wind.

Appendix K provides measurements using a SVAN 957 Sound Level Meter at a location approximately 2km south of the proposed Hallett 3 in South Australia. The location is well removed from any main roads. The proposed Hallet 3 Wind Farm was the subject of an Appeal in the South Australian ERD Court.

The background levels (shown in Appendix K) during the day are below 20 dB(A) – except for 40 minutes in the day, whilst the evening and night time background level are below 15 dB(A). How much below 15 dB(A) cannot be ascertained as the background is less than the electrical noise floor of the sound level meter.

The daytime (7am – 6pm) Leq, is 31 dB(A) whilst the Leq for the entire 23 hour period shown in Appendix K is 28 dB(A).

As to the background level as a result of the wind at the microphone, that becomes relevant in terms of independent compliance testing when the wind farm weather data is not provided, the regression graphs in Appendix K2 show the same instrumentation in open field, one with grass and one with furrowed ground. There is no difference for low wind speeds at the microphone but above 10 metres per second the grassed field produce higher background levels.

As noted previously the Marshall Day Acoustics report does not provide information to identify the wind at the microphone versus the wind farm weather monitoring station so as to clarify the relationship between the wind farm wind and the wind at residential receivers.

This matter becomes important in that residents in proximity to operational wind farms have been critical of noise audits conducted by the operator when turbines have been observed to be not operating and claims of restricting or controlling the pitch of the blades during testing have been made in Australia and in other countries.

Truly independent testing without the knowledge of the wind farm operator and subsequent supply of wind farm operating data (including turbine SCADA) can address these issues, as can obtaining wind corrections for wind induced aerodynamic noise on microphones as per the results in Appendix K2 and/or provision of supplementary wind screens (over the primary microphone wind screen).

The Marshall Day Acoustics claims there is no significant infrasound at residential dwelling with reference SA EPA Guideline statement as to no infrasound for a well maintained wind farm.

Appendix J shows the Waterloo turbine to generate infrasound, contrary to the SA Guideline. Appendix L provides a series of measurements conducted at House 10 which is approximately 1300 metres from the northern end of the Waterloo Wind Farm. The measurements include simultaneous inside and outside measurements where the internal location was in the centre of the master bedroom and the external location was located at a position 15 metres in front of the dwelling towards the wind farm.

The measurements in Appendix L were recorded during the night time period. The turbines were audible both outside and inside the dwelling. The external background level was found to be 27 dB(A) and the background in the bedroom (windows closed) was 16 dB(A).

The modulation of the turbine noise external to the dwelling becomes obvious in the 2 minute sample of the A-weighted level over time. However the attenuation of the building eliminates the high frequency modulation inside the building, which becomes obvious in comparing the results.

Similarly the presence of both low-frequency sound and infrasound inside the dwelling and outside the dwelling is shown in the frequency spectra.

Moller (for Maastricht City Council) identifies the use of A-weighted measurements and in relation to audibility states:

> **The level of the infrasound produced by modern wind turbines is so low that the sound cannot be perceived by humans even close to the turbines[6]. Much higher levels occur elsewhere in our daily environment, e.g. in transportation.**

> **Low-frequency wind turbine noise is usually described as humming or rumbling. It may have a more or less pronounced tonal character, e.g. in terms of tones that fluctuates and vary in level and/or pitch, or of tone-like pulses excited with regular or random intervals. The feeling of pressure at the eardrums is also reported. It is characteristic that the noise varies a lot in time and with wind and other atmospheric conditions.**
>
> **The rate of modulation of the low-frequency noise from wind turbines (and higher frequencies as well) is often in the infrasonic frequency range, e.g. the blade passage frequency, and the noise may thus be mistaken as infrasound, even when there is little or virtually no infrasound present.**

The measurements in proximity to the Waterloo turbines identifies the blade pass frequency of the turbines and the harmonics of that frequency to be present and those frequencies are also present outside and inside houses. The turbine measurements reveal the presence of infrasound components. Use of narrow band analysis, rather than 1/3 octave bands, reveals the pattern of the noise emitted from turbines exhibits a distinct signature. The signature can shift in frequency for higher turbine speeds but still exhibits a pattern, which also appears at residential premises.

The measurement of infrasound inside houses is similar to that obtained in Falmouth by Rand and Ambrose.

The Marshall Day Acoustics report seeks to dismiss the presence of infrasound from wind farms and refers to a report from Sonus (ref 9 cited on page 35 of the Marshall Day Acoustics report) as an authoritative report to demonstrate that infrasound and low frequency sound produced by regularly encountered natural and man-made sources is comparable to that of modern wind turbines. The conclusions of the Sonus report are questioned when one examines that document and the material so provided.

The Sonus report claims to have identified noise from the Cape Bridgewater Wind Farm for comparison with infrasound generated in the natural environment. However examination of the material in that report is not exactly definitive of what was measured, when the noise was measured, the source of the noise, and the prevailing weather conditions at the time.

Appendix M provides a graph of the claimed 1/3 octave spectra for various noise sources being a direct extract from the report. The Marshall Day Acoustics report identifies the Sonus report to be dated November 2010. The upper figure in Appendix M2 has been extracted from the Sonus report that suggests the circumstances of noise monitoring in relation to the Blowhole at Cape Bridgewater was only influenced by one turbine. The report suggests that measurements were conducted in June of that year.

The lower figure on Appendix M2 is a Google map that is identified as related to the situation in March 2010 that shows a greater number of turbines than indicated in the Sonus report. Advice from residents in proximity to the wind farm was at the situation of the turbines shown in the lower figure in Appendix M2 was a situation that existed in 2008.

In relation to the Sonus claim of infrasound at the beach at Cape Bridgewater, the report does not indicate the weather conditions at the time, the height of the surf, or the distance from the monitoring position to the surf. Furthermore on my inspection there did not appear to be any residential dwellings 25 m from the high watermark as suggested in the report.

As discussed above there is an issue in using 1/3 octave band measurements to describe infrasound energy from turbines in that the blade pass frequency and multiple harmonics of that frequency become grouped into a number of one third octave bands and therefore the distinct turbine pattern that can be seen in narrow band measurements does not appear in the 1/3 octave spectra.

Therefore without comparison of the narrow band spectra then the conclusion as to infrasound in the natural environment being comparable to that of modern wind turbines as claimed by Marshall Day Acoustics is incorrect.

The upper graph on Appendix M3 provides a narrow band graph for a house 8 km from the Waterloo turbines. The upper graph in red represents the external noise levels whilst the blue graph represents levels recorded inside the dwelling with doors and windows closed. External to the house a low frequency hum can be detected which the residents identify as a distinct and separate sound than that of the natural environment.

The lower graph in Appendix M3 is the 1/3 octave spectra for the external location in which there is no distinct pattern associated with the turbines.

Both graphs relate to a three minute sample.

A similar exercise was conducted in proximity to House K (re the Collector Wind Farm assessment) where there is no turbine noise and therefore represents the natural environment. At the time of the monitoring there was a wind blowing from the south that over the 10 minute average was found to have a mean wind speed of 3 m/s with peaks gusting up to 7.2 m/s.

The A-weighted variation in level over the 10 minute sample is shown in Appendix M4. Appendix M5 compares the narrow band FFT spectra for 0 – 50 Hz (upper graph) with the 1/3 octave spectrum (lower graph). As can be seen by the comparison whilst there may be designated frequencies in the 1/3 octave bands that fall in the infrasound region there is no harmonic or distinct pattern in the narrow band spectra.

Hence it can be seen that utilising 1/3 octave band material as a crux for comparison of wind farm environments versus natural environments is an incorrect methodology.

It is noted that the difference from outside to inside with respect to the low frequency sound and infrasound components is relatively small, and in some cases there is a negative difference in that there are higher levels inside the dwelling than outside (see Appendices L7 and M3).

When one is dealing with low frequency or infrasound noise associated with gas fired power stations it has been found that the energy emitted from the power station can excite the building elements into resonant modes or physical vibration that leads to the internal surfaces of the room in question vibrating and radiating noise.

The fact that there are discrete frequencies detected inside the dwelling that fall into the frequencies typically associated with different levels of sleep states is a matter that should be noted. The assessment of sleep disturbance is outside my field of expertise but the material provided in Appendix L is informative.

It is noted that in viewing the frequency graphs contained in this report, the measurement results are those obtained directly from the Bruel & Kjaer Pulse system with a low pass filter of 7 Hz (rather than the standard 22 Hz) and utilising Bruel & Kjaer Type 4189 microphones that have a frequency response that falls off below 10Hz.

If one is looking to accurately define the sound levels occurring in the infrasound region then one needs to adjust the measurement results appended to this review which will result in higher sound pressure levels for frequencies below 7 Hz.

Similarly, in view of the low ambient noise levels recorded both inside and outside the dwellings (at Waterloo) the measurement results are approaching the electrical noise floor of the microphones. More detailed investigations require specialised microphones to accurately record such levels.

During the course of monitoring at house H10, the occupants related that on the night upon which the measurement results appended to this review were obtained, they experienced disturbed sleep.

Residents at houses 10 and 12 advised the author that testing has been conducted by independent consultants to reveal that both of these properties comply with the SA Guidelines. Yet the occupants of both of these properties experience sleep disturbance and at times complained of excessive noise intrusion. I was advised that at house H10 monitoring conducted by one set of independent consultants placed the microphone approximately 1.5 m from the bedroom window of that residence.

Attendance at House H12 also suggested that monitoring which had been conducted by independent consultants was not in accordance with the SA Guidelines. The occupant identified that the monitoring position was to the side of the residence in relatively close proximity to large trees, rather than the complying with the requirement to be between the residence and the wind farm which would have placed the monitor in an open paddock.

Residents indicated that there are significant differences in noise received at their property dependent upon the weather conditions and cited both light and strong winds giving rise to different noise effects. Cloud cover was also cited by the residents as altering the noise propagation.

For the purposes of this peer review, the attached Appendices are sufficiently detailed to reveal that even when wind farms in the Goyder area are apparently able to comply with the SA Guidelines, they are still generating adverse impacts at residential properties. These impacts can be detected and measured when one looks to the use of non-A-weighted measurement results. The measurement data appended to this review identifies that there are both low frequency and infrasound components generated by the turbines that are currently located in the region.

A recent Application for the Stony Gap Wind Farm that came before the Goyder Development Assessment Panel on 1st August 2012. The panel heard testimony from people at Waterloo (3MW Vestas V90 wind turbines on the next range over from the proposed Stony Gap wind development) who live out to 8 – 10km away from wind turbines (including the resident from the house in Appendix M3) who claimed their lives have been significantly affected by the wind farm.

The Applicant (Stony Gap Wind Farm) was requested by DAP to give a guarantee there would be no adverse health impacts. The Applicant was unable to confirm the proposed wind farm would not give rise to noise or health impacts.

The grounds of refusal were:

It is considered that the nature of the proposed wind farm development will adversely and unreasonable impact on the health and amenity of the locality through noise and vibration caused by the operation and hours of operation of the proposed wind farm development.

The proposed wind farm development is at odds with the following Regional Council of Goyder Development Plan Objectives and Principles of Development Control:

2.1. Council Wide – Interface Between Land Uses

Objective 1

Development located and designed to prevent adverse impact and conflict between land uses

Objective 2

Protect Community health and amenity and support the operation of all desired land uses

Principles of Development Control

1. Development should not detrimentally affect the amenity of the locality or cause unreasonable interference through any of the following:

   (b) noise

   (c) vibration

   (g) hours of operation

2. Development should be designed and sited to minimise negative impact on existing and potential future land uses considered appropriate in the locality.

6. Sensitive uses likely to conflict with the continuation of lawfully existing developments and land uses considered appropriate for the zone should not be developed or should be designed to minimize negative impacts.

7. Developments should be designed, constructed and sited to minimize negative impacts of noise and to avoid unreasonable interference.

2.2 Council Wide – Orderly Sustainable Development

Objective 1. Orderly and economical development that creates a safe, convenient and pleasant environment in which to live.

It is relevant to note that the proposed Stony Gap Wind Farm was predicted to comply with a 35 dB(A) or background + 5 dB(A) limit – being similar to the noise limits for Waterloo and Hallett wind farms that were experienced by the residents.

Residents around the Waterloo Wind Farm have been the subject of two community surveys.

The first survey was conducted by an Adelaide University last a student in 2011 and the second by community member Mary Morris.

The university student Frank Wang's, original survey showed that of the study participants, who all live within 5 km of the Waterloo Wind Farm, 50% of them, were moderately to severely impacted by the noise.

The survey conducted by Mary Morris set out 230 surveys to every household within 10 km of the turbines and received a 40% response rate. 49% of the respondents were negatively affected by some or all of: noise, shallow flicker, sleep deprivation, interference. Another 17 respondents indicated they notice the above affects and/or that the effects varied with whether but they were not affected. The remaining respondents said they were not affected.

The extent of the population around the Waterloo Wind Farm that is affected by the operation of the wind farm when taken out to 10 km indicates a significantly higher proportion of the population than the nominal concept in socio-acoustic surveys of setting benchmark criteria for 10% of the persons seriously affected.

The results of the two surveys question the appropriateness of the SA EPA Guideline base noise limit to avoid adverse noise effects on people caused by the operation of wind farms.

7.0 CONCLUSIONS

Marshall Day Acoustics has relied upon the SA EPA base level criterion of 35 dB(A) and has ignored the acoustic characteristics that residents will actually receive as a result of the Collector Farm. They have not addressed the actual acoustic impact of the wind farm on the community.

The Marshall Day Acoustics acoustic assessment provides a set of predicted noise levels in terms of the A-weighted values set out in the EPA Guideline and concludes that there are no tonal or modulation characteristics requiring modification to the predicted noise levels.

In relation to background levels, the Marshall Day Acoustics measurement results confirm (as expected) that ambient background levels outside rural properties are significantly lower than 30 dB(A). As such, the noise generated by the wind farm is likely to be significantly greater than background +5dB(A) and therefore to have an impact significantly greater than for an "annoyance."

The issue of low frequency noise and infrasound has been raised and discussed above. Documentation from the world's leading supplier of turbines has identified that computer models are inadequate for low-frequency noise propagation. As high frequencies are rapidly attenuated over distance (when compared to low frequencies) audible characteristics of the turbines may be reduced to a low frequency hum and can also include frequencies below the normal range of human hearing.

The SA EPA Guidelines identify that infrasound is not generated on a well-maintained wind farm yet the measurement results contained in this report prove otherwise. The measurement data appended to this review identifies that there are both low frequency and infrasound components generated by operational modern day turbines, including those that are currently located in the region.

A proper assessment of community impact cannot ignore low frequency noise and "infrasound." To the extent that it does, when these have been issues of specific complaint with other wind farms, the Marshall Day Acoustics report falls short of its responsibility to the community as required by the Code of Ethics of the Australian Acoustical Society and the Code of Conduct of the AAAC.

The SA Guidelines identify that for host stakeholders, sleep disturbance is an adverse health effect.

It is not unreasonable for the community to assume that if sleep disturbance gives rise to an adverse health effect for persons in South Australia who are obtaining a financial gain from hosting turbines, then sleep disturbance that impacts upon the general community (i.e. non-host stakeholders) must also give rise to an adverse health effect. It is not unreasonable to expect people in New South Wales to experience similar impacts as those in South Australia,

This peer-review has identified two eminent acousticians who, in 2002/2004, identified that there are issues with low frequency and infrasound and that the ear still continues to work and receive signals even when people are asleep. The mechanism causing sleep disturbance (for example, whether individuals are able to detect the infrasound components) is an issue outside my expertise.

But it is clear that use of the A-weighted value for assessment or compliance purposes does not address all of the noise impact issues associated with wind farms.

The current application has not satisfactorily addressed all of the matters to determine the current acoustic amenity, and has not actually assessed the noise or the impact of the subject development.

As a result of the various matters raised and outlined above, there can be no confidence that the community will not be adversely impacted by the proposed Collector Wind Farm. It is recommended that Friends of Collector should request further particulars from the Applicant to address the individual matters raised above with a view to identifying the actual noise impact that will be generated by the proposed wind farm.

The Applicant should be required to guarantee that there will be no adverse noise effects, no offensive noise, no sleep disturbance and no adverse health effects if the subject wind farm was to proceed.

Similarly there is an issue for the determining authority to provide a similar guarantee, particularly if the authority was to approve the application based on unsubstantiated acoustic criteria which has no technical basis of guaranteeing there will be no impacts. As there is no material provided by an operating wind farm to prove that the operations to not generate adverse noise effects, do not generate offensive noise, do not generate sleep disturbance and have no adverse health effects, then it would appear that if the authority was to grant approval and that the wind farm complied with the noise limits nominated by the Department for the environmental assessment and such impacts were found to occur then the authority (not the applicant) would be liable.

Yours faithfully,

THE ACOUSTIC GROUP PTY LTD

STEVEN E. COOPER

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