The Senate Select Committee on Wind Turbines

I, Steven Edwin Cooper, provide this submission to the Senate Select committee on Wind Turbines as a public submission.

I make this submission as Steven Cooper from The Acoustic Group.

I am the author of the Cape Bridgewater wind farm noise study released earlier this year.

This submission is not made on behalf of, with or for Pacific Hydro.

I do not intend to provide aural evidence to the Committee as such but will make myself available at a time to suit the Committee to answer any questions.

I request the Secretariat to download the Cape Bridgewater Report with the appendices and the two PowerPoint Presentations provided at Portland (links provided in Appendix A) so that they may be included into the Senate committee's considerations for the benefit of the public.

NB This submission is an amended version of the original submission. The amendments came about as a result of Pacific Hydro indicating they would grant me approval to reproduce any part of the study report and appendices. The provision of a copyright licence alters my testimony and my original submission.

The Senate Select Committee on Wind Turbines

On 20th January 2015, I received by email advice, a formal invitation to provide a submission in relation to the Select Committee on Wind Turbines.

I am advised that the full terms of reference are:

(a) the effect on household power prices, particularly households which receive no benefit from rooftop solar panels, and the merits of consumer subsidies for operators;
(b) how effective the Clean Energy Regulator is in performing its legislative responsibilities and whether there is a need to broaden those responsibilities;
(c) the role and capacity of the National Health and Medical Research Council in providing guidance to state and territory authorities;
(d) the implementation of planning processes in relation to wind farms, including the level of information available to prospective wind farm hosts;
(e) the adequacy of monitoring and compliance governance of wind farms;
(f) the application integrity of national wind farm guidelines;
(g) the effect that wind towers have on fauna and aerial operations around turbines, including firefighting and crop management;
(h) the energy and emission input and output equations from whole-of-life operation of wind turbines; and
a) any related matter.

In response to the invitation, this submission is provided, being a submission from Steven Cooper of The Acoustic Group.

The submission is not on behalf of any residential organisations or wind farm entities.

I am an acoustical and vibration engineer working in the areas of noise and vibration investigations for 37 years. I am the Principal of The Acoustic Group Pty Ltd based in Sydney.

I have a B.Sc. (Electrical) from the University of NSW and a M.Sc. (Architecture) in acoustics from the University of Sydney. My M.Sc. was a research degree, not coursework. I have also undertaken research work in relation to helicopter and aircraft noise as part of a PhD degree at Sydney University.

DISCLOSURE STATEMENT

When the preparation of an Australian Standard for wind farms was proposed, it came before the sub-committee on railway noise of which I was a member of that sub-committee. I was not interested in wind farms nor was I undertaking any work in that area so I did not move over to a working group established to develop a wind farm guideline. I was on the railway noise sub-committee (and other full committees in Australia and in the USA) in relation to the work I was undertaking and the experience I had in the relevant areas of noise and vibration.

Over the last 3½ years, I have undertaken noise monitoring in proximity to the Capital, Gullen, Cullerin and Woodlawn wind farms in NSW, the various Hallett wind farms and the Waterloo wind farm in South Australia and the Waubra, Cape Bridgewater and Glen Thompson wind farms in Victoria. All of the above wind farms have been the subject of monitoring by me at residential locations with the exception of the Waterloo wind farm where monitoring was also conducted on roads passing through the wind farm.

I have undertaken noise monitoring at residential locations in proximity to the (then) proposed wind farms of Flyers Creek, Gullen, Bocco Road, Collector and Bodangora wind farms in NSW.

For some of the above wind farms/project, I have been retained and received funding from residents to undertake the work. As identified in the previous Senate Inquiry (on Excessive Noise from Wind Farms), I received some funding from the Waubra Foundation to assist in travel expenses to Burra in South Australia for initial investigations of the Hallett wind farms and funding to undertake assessments of proposed wind farms in NSW and South Australia, but that the majority of the investigations have been funded by my company.

In late 2013, I was approach by Pacific Hydro to undertake noise monitoring at the Cape Bridgewater Wind Farm in an effort to identify the basis of complaints from residents that were related to “a compliant wind farm”.

Before undertaking the work, based on my previous experience with that organisation, I required convincing that Pacific Hydro were genuine in their statements of seeking to get to the bottom of the “noise” issue and were not simply “engaging me” to lock me out of appearing against the wind farm as a result of Stage 4 works at Cape Bridgewater and other wind farm projects in South Australia proposed by Pacific Hydro.

Following a meeting with the 6 affected residents in their homes (with representatives of Pacific Hydro present) in December 2013 and attending a meeting of the Cape Bridgewater Community Consultative Committee, I provided my concept of undertaking a study that would involve all parties, be transparent, and required the full cooperation of both the residents and the wind farm operator. I did not expect to be given the job to undertake the work.

However, Pacific Hydro came back to me in early 2014 and on reducing the proposed Scope-of-Work, engaged my firm under a very specific contract with specific controls and restrictions in relation to the content of the work.

The funding provided by Pacific Hydro covered the field work, some of the analysis of the data and some of the report.

The majority of the analysis and the preparation of the report was funded by me as the funding from Pacific Hydro could not complete the second part of the brief and extensions to the funding were rejected by Pacific Hydro.

INTRODUCTION

As a result of my investigations, I wish to provide material in relation to items c-f inclusive in the Terms of Reference.

I provided submissions to and appeared before the Senate Inquiry into Excessive Noise from Wind Farms and note that there is material in submissions to that Inquiry that are also relevant to this Committee.

I am the author of an acoustic study in relation to the Cape Bridgewater wind farm in south-west Victoria [1].

The results are presented in a 218 page report supplemented by 22 Appendices that provided sufficient detail of the study for all to see and examine. The method of the study and the results (including problems/errors) are provided so as to be totally transparent, which was the requirement for the study from the outset.

That study was released to the public in mid-January 2015 and has received both complimentary and adverse comments in the media concerning the study. The study report is a technical report with a very restricted brief.

It has been said by some acousticians that the brief from Pacific Hydro was deliberately set up for me to fail. I tend to agree with that perspective, particularly in light of the conduct of Pacific Hydro prior to and after the release of the study report.

However, the actual report (that was largely unfunded) that arose from the measurements that were fully funded by Pacific Hydro has been found to be significance with a number of matters never before identified and data from testing undertaken with the co-operation of a wind farm that to my knowledge, has never been carried out before.

The Cape Bridgewater Wind Farm Noise Study – An Overview

The study itself came about as a result of the windfarm operator, Pacific Hydro, identifying receipt of complaints for a period in excess of six years concerning the operation of the wind farm from six residents.

The windfarm operator has claimed that the windfarm is a “compliant windfarm” with respect to noise criteria contained on the permit conditions yet still receives complaints concerning disturbance from the windfarm including that of noise.

Contrary to statements by Pacific Hydro that I agree that the wind farm is a compliant wind farm, those statements area not correct. Pacific Hydro specifically instructed me not to undertake a compliance assessment and also provided advice to the Consultative Committee of those instructions.

The permit conditions use dB(A) and a New Zealand Standard for the assessment of noise with an analysis obtained by a regression curve that from my testing, measures the wind not the noise from the wind farm.

The study that I was commissioned to undertake had a very specific brief issued by Pacific Hydro requiring me to conduct sound and vibration measurements **to determine certain wind speeds and certain sound levels that related to disturbances identified by specific local residents.**

As such the study:

- was not the sort of study that would occur for a wind farm application,
- was not the sort of study that would occur for an acoustic compliance test of a wind farm,
- was not a study restricted to being just one of noise complaints,

- was not a scientific study in the form of a research project that may be undertaken by universities, and
- more importantly was not a health study.

The study involved noise and vibration monitoring over an eight week period utilising three houses at Cape Bridgewater being the designated houses of the “specific local residents”.

Included in the study was a period of approximately two weeks that covered a planned shutdown of the entire wind farm for the purpose of high-voltage cabling work at a main substation. Monitoring occurred during the shutdown period so as to identify the existing acoustic and vibration environment at the nominated houses when the wind farm was not operating but wind was occurring as part of the natural environment.

Prior to the conduct of the actual study, the residents were requested to participate in a trial using a diary format that was proposed for the subject study and based upon the diary format utilised by the South Australian EPA for testing at the Waterloo wind farm [2].

The residents indicated there was ambiguity in terms of the EPA's instructions versus what they experienced at Cape Bridgewater requiring modification of the questionnaire. However of importance, which has now been found to be a significantly important fact, is that the descriptions supplied for the matter of noise did not relate to what the residents were experiencing.

The introduction of vibration as a descriptor for impacts associated with the operation of the wind farm assisted some residents. However, it was not until the concept of “sensation”, being something that the residents neither heard nor felt through the floor of the building but was something that they experienced in their body, that there was a descriptor that could better relate to their complaints

The concept of introducing sensation to our windfarm study found that there was a new descriptor to better explain it in a very clear format what residents were receiving that simply would not be addressed by noise. The outcome of using the concept of sensation found that it was the major descriptor applicable to the disturbance obtained by the residents and that concept has been repeated by residents involved in the South Australian Waterloo wind farm study and other residents around the world who have provided similar comments following release of the report.

The severity ranking method and the questionnaire used in the study are set out in Appendix C of the study report. The survey is in a relatively simple format that can be replicated for any wind farm around the world.

The initial stages of the survey found that residents were actually reporting (in their diaries) changes into what they perceived which gave an indication of a relationship between the wind farm and the daily observations. This reporting led to the basis of identifying the first part of the brief “**certain wind speeds”**.

However, for the purpose of reporting and looking for links between the windfarm and the resident's observations, the diary format was modified so as to request the residents when at their dwellings (and where possible) to provide regular updates in the order of one or two hours.

The examination of the resident’s observations versus the data from the wind farm found that there was a link between the operation of the wind farm and the high levels of sensation, with severity 5 being equivalent to creating a physical harm to the residents and/or their perspective the sensation was of such an extent and magnitude that required them to leave their homes (or wishing to leave their homes).

The link between the wind farm operation and sensation 5 was found to relate to specific modes of the windfarm, being:

- turbines commencing to start operations,
- turbines at maximum power such that as the wind speed increased the turbines would be de-powered, and

- when the power output of the windfarm increased or decreased by more than 20%.

The above power output/change in power that generated sensation 5 could be related to "certain wind speeds" and simply by way of the resident's diaries and the output of the windfarm, a definite link could be established as a cause-and-effect **without** involving any acoustical assessment.

This result satisfied the first part of the brief.

If one considers in isolation sensation 5 as defined by the residents and look to the power output of the windfarm, then under the four modes of power described above we found the basis of a hypothesis for disturbance.

If one groups those four specific operations together and only looks to the high severity sensation observation, there is a relationship between the wind farm which gives a causal link between the wind farm and those observation of disturbance, i**.e. the study proved a cause and effect**.

On the basis that Pacific Hydro had identified these persons were affected and had been complaining for in excess of six years, then there is a link between persons sensitised to the wind farm and its operation.

Because the study was not a health study then whilst there is a causal link between the wind farm and sensation 5, it is correct to state that the study did not find any causal link between the wind farm and health.

If one seeks to ascertain a causal relationship between each of the four modes that gave rise to high severity of sensation than there is insufficient data for a causal link of each of the modes.

In relation to the brief, we were not required to establish a link between the wind farm and the disturbances, but to determine certain wind speeds and certain noise levels related to the disturbances.

However, following the release of the study, the executive manager of external affairs at Pacific Hydro (Andrew Richards) stated in the Business Spectator on 27 January 2015 [3] (http://www.businessspectator.com.au/article/2015/1/27/wind-power/why-pacific-hydro-commissioned-cape-bridgewater-wind-farm-acoustic) :

> The brief to Steven Cooper was to see whether any links could be established between certain wind speeds or sound levels at Cape Bridgewater and the concerns of the six individuals involved in the study. Beyond this, Steven Cooper determined the methodology and also had a fair amount of latitude in terms of the scope of the study.

Mr Richards's article then identifies some of the findings of the study and why Pacific Hydro undertook the study. However, the purpose of referring to the article issued by Mr Richards is to identify in the above statement as to links, which is different to the brief. The study report did not refer to any links because it was not in the brief. There is no mention of links in the study report. Whilst it is obvious a link (cause and effect) was established, so as to provide clarification to the Committee that in fact a link was established I refer to the review by the Director of the Standards Board of the Acoustical Society of America, Dr P Schomer in Appendix B10.

At this point it is relevant to identify the last two paragraphs of the Business Spectator article from Mr Richards:

> It is important to note this study is simply a broader program that we are continuing with our local communities. We will continue to work with the Cape Bridgewater community and other local communities in which we operate.
>
> We continue to welcome the discussion that the report has generated, as we believe no company or industry is above reproach and we should always strive for standards that are publicly acceptable. Pursuing a better understanding of the impacts of all human activities on both our environment and our communities is one we should never relinquish. We hope others can look beyond some of the inaccurate reporting so that a mature, informed discussion can occur.

I will come back to those two paragraphs later as history has now shown that in less than 6 weeks, Pacific Hydro reversed their position on the above statements.

The most difficult challenge of the study (assumed to be the part where I would fail) was to satisfy the second part of the brief to determine “certain sound levels” that related to the disturbances reported by the residents. The report presents the different “standard” types of acoustic descriptors that may be used for the assessment of wind farms. For those parameters, there was no relationship in terms of the operation of the wind farm and the noise levels. The investigation found that there was a high correlation (>0.9) between the noise levels and the wind speed.

On undertaking finer resolution of the acoustic signature recorded during the survey, it was found that on restricting the analysis to 1/3 octave bands there was also no relationship to the noise in the operation of the windfarm.

This finding is important to the Committee’s terms of reference in that, if one restricts an assessment of disturbance from a wind farm to 1/3 octave bands, dB(A) or dB(G), such as in the case of the SA EPA Waterloo wind farm study [2] or the recent paper from Prof Leventhall “Health based audible noise guidelines account for infrasound and low-frequency noise produced by the wind” (http://www.ncbi.nlm.nih.gov/pubmed/25759808) [4], those measurement **parameters cannot identify** the wind turbine signature and **will automatically produce an incorrect finding**. If the acousticians involved in such studies have the appropriate knowledge and understanding it is relatively easy to carry out narrow band analysis in that NASA some 30 years ago proved wind turbines generate a distinct signature that can only be seen using narrow band analysis, **one has to question the basis of preparing papers restricting the data to 1/3 octave bands and in some cases, not even going below 10 Hz.**

On undertaking further resolution to obtain the narrowband analysis, the high ranking of disturbance provided by the residents was found to be related to what I have described for a number years as Wind Turbine Signature (WTS).

The testing for the wind farm being ON, and shortly thereafter the wind farm being OFF, clearly identified the presence of the WTS. The WTS is nothing new in terms of measurements of wind farms, it is simply a term I have used that comes from an assessment in terms of narrowband signals provides a pattern that is based upon the blade pass frequency of the turbine (number of blades times the number of revolutions per minute divided by 60) and multiples of that blade pass frequency, typically up to the sixth or seventh harmonic. The wind turbine signature (WTS) has been found at other windfarms here in Australia and overseas with slightly different blade pass frequencies depending upon the operating speed of the turbine.

The measurements obtained with the wind farm OFF had no such WTS which has also been found elsewhere. Obtaining multiple on-off measurements at a set location where each set of ON-OFF would occur under the same weather conditions is considered by many acousticians around the world to be the exact set of data that is required to confirm the impact of turbines.

Having such a short period of time between ON and OFF and a complete shutdown of the wind farm (not just stopping the blades turning) overcomes criticism of wind farm advocates [5] of just having operating data whilst the turbines were operating, or even a comparison for ON and OFF separated by two weeks.

Using the link of severe disturbance under sensation 5 with the operation of the wind farm that fitted the concept of the four specific modes identified, the signature in the frequency domain was then plotted with respect to different sensation levels to develop a trend line upon which an equation could be developed with respect to the WTS. On the basis that sensation 5 is clearly an unacceptable limit where residents seek to actually leave their dwellings, then for the worst-case scenario, totally unacceptable, an infrasound limit can be used as a determining factor for the operation of the wind farm.

I then took the WTS peaks for sensation 5 (being a worst case scenario) and found a line of best fit when plotting the dB level versus frequency. Noting that sensation 5 was a level for which the residents either left or wanted to leave their homes because of the operation of the wind farm. Such a level would be well above the standard concept in acoustic assessments as “unacceptable”. Under Excel this line of best fit is described as a “trend line”.

The lower level of sensation (2) had from a small dataset a similar slope of trend line but with a lower magnitude.

From the “trend line” I created a weighting curve to apply to what I called dB(WTS) being the trend line normalised to a level at 10 Hz. dB(WTS) is a new parameter and the concept agrees with the slope of other measurements including the Shirley wind farm study and the infrasound data from a Canada Health study into turbines.

On the basis of the infrasound dB(WTS) one then can determine a separation distance for a lower level of sensation that could be taken as an acceptable level. Using the results from Cape Bridgewater for house 87 on the basis of a sensation 2 as identified to the Public Meeting in Portland (in response to a written question submitted before the meeting), the separation distance from the Cape Bridgewater turbines for house 87 should be in the order of 7 km, not the current 1.6 km.

The generation of discrete infrasound frequencies is not limited to wind turbines. There are other industrial sources that can generate infrasound that propagates for large distances.

Recently I have been investigating noise emission for a large ventilation fan serving a coal mine that has been nominated as the source of disturbance to residents. The impacts described by the residents are similar to that described by residents subject to wind farm noise. Whilst the fan was found to generate low frequency noise that is audible kilometres from the fan I have found the signature at residential properties to be from a large coal-fired power station some 10 – 15 kilometres from the receptor locations. The levels of infrasound are below the audibility threshold but by using the Cape Bridgewater diary format for sensation, the variation of wind direction and combination of generators in use has from the resident’s perspective confirmed the source of disturbance.

The use of dB(WTS) as a measurement tool that can be used for further studies such as medical studies has been hailed by acousticians around the world as a new step forward. However there are restrictions on the use of dB(WTS) because it is the property of Pacific Hydro.

With the copyright restrictions impose on reproduction of the study and with Pacific Hydro having ownership of dB(WTS), such that nobody else can use the descriptor without a license or permission from Pacific Hydro, I propose for the benefit of other researchers that “sensation” be termed dB(S) with different subsets to cover different types of (sources) signals.

At present there is discussion amongst researchers of the narrow band infrasound signals that the impact of wind turbines may be a vector summation of the individual peak levels rather than the logarithmic addition of the rms values as being part of future investigations.

Therefore I propose that dB(S-WT) be the descriptor for wind turbine signature instead of dB(WTS), with the curve derived/stated for the weighting and the value described as an rms or a peak value (the Kelley work used peak values).

For gas turbines the sensation could be dB(S-GT), for air conditioning noise (sometimes expressed as sick building syndrome) dB(S-AC), and for power stations dB(S-PS) etc.

Technically, if one is to be pedantic about terminology (as suggested by Professor Dickinson) if one is to follow the method of measurement used in New Zealand the metric we use is the decibel, abbreviated as dB. Therefore dBA may be considered a corruption in that the correct terminology should be to say L_{Aeq} is so many dB. A number of environmental Standards containing acoustic criteria have been changed to reflect the correct terminology.

As such it could be said dB(WTS) whilst fitting in with general convention of acoustics expressed in wind farm permits is incorrect and the correct term for acousticians is L_{WTS} is so many XXX dB, or $L_{S\text{-}WT}$ is so many XXX dB, therefore that terminology would not be Pacific Hydro's IP.

In relation to the second part of the brief (to determine certain sound levels related to the disturbance) the issue of permit conditions in terms of dB(A) becomes important for this Inquiry.

An outcome of the study which was agreed to by the windfarm operator (Pacific Hydro) issued in a public statement presented to the public meeting at Portland [6] was that:

> The study clearly states that no correlation has been found with standard acoustic parameters versus the wind farm but the report suggests a correlation of some parameters versus wind speed.

The principal acoustic parameter of dB(A) was examined in detail in the report. The wind farm operator (Pacific Hydro) agreed that the use of the dB(A) parameter nominated in the various standards and guidelines has no correlation with the wind farm and therefore cannot reflect the acoustic impact residents receive from such operations of the windfarm.

Furthermore, the methodology for determining the A-weighted level is on the basis of a regression line utilising data over two weeks, the A-weighted value had higher correlation with the actual wind speed, one is left with the situation that the current criteria utilised for windfarms will not protect the community.

The Public Meeting at Portland

The Cape Bridgewater windfarm noise study at the time of the preparation of this submission was still available on the Pacific Hydro website at the following locations. Also contained on the website were a series of two power points that relate to my presentations provided in Portland on 16th of February, 2015. The first presentation was a review of the study, with the second presentation being a response to questions that have been submitted by residents and organisations in response to the study.

Because I was the person giving the presentation and answering the questions, the following material has to be presented in the first person.

There were more questions provided which answers were available for in the presentation but there was a restriction in time on the presentation (apparently due to the venue, not the audience) and not all questions were answered (although I had an answer to all of the questions that related to me).

After my presentations to the audience were shut down, Mr Crockett (of Pacific Hydro) provided concluding remarks.

Mr Crockett in his first response to the investigations referred to the wind farm being compliant and noise compliance testing was not part of the brief. There is a comment I was supplied a copy of "the compliance report" and did not raise any issue with that (report).

I do not agree with the comment attributed to me. However, under the Consultancy Services Agreement with Pacific Hydro there is a gag clause prohibiting me from identifying how I have been misrepresented.

The second response identified the study was conducted "with the single intention of trying to better understand acoustic conditions at the wind farm and whether a link could be established between any such conditions and resident concerns".

The brief did not require me to identify links but both Mr Richards and Mr Crockett (after the release of the study of which they reviewed before the release) have identified the purpose of the study was to obtain links.

Mr Crockett then referred to the concept of sensation introduced into the study and stated it is a relatively new concept and has not been assessed as a scientifically robust measure.

Sensation is not a new concept. Sensation as to what people may feel in terms of whole-body vibration has been in existence for some time in that we in Australia and other countries around the world have standards referring to vibration levels based on comfort, sensation, motion sickness and occupational exposure levels. I am aware of such matters having been on the Australian Standards committee responsible for such standards in excess of 20 years.

If the intent is to mean sensation in terms of wind farms then Mr Crockett is again incorrect. One can go back to the late 1970's/early 1980's to find the work of NASA and Dr Kelley for the US Department of Energy used the term sensation in relation to experimental wind turbines both in terms of the data and detection of vibration in buildings.

As to the mechanism of how sensation is perceived in humans as a result of turbines it is correct that more scientific research is required. I have no dispute with that portion of the statement because it agrees with part of the conclusions in the study.

Of concern to the community and to the basis upon which Pacific Hydro convinced me that they had a genuine desire to address the complaints and despite the undertaking to the Community Consultative Committee by Pacific Hydro of a transparent study to look into the complaints, to address the resident's concerns and work with the community, and despite the report found links of significant disturbance to the wind farm, the Senate Committee should take heed of Mr Crockett's words:

> As the report indicates, it is beyond the scope of Pacific Hydro to conduct further research or investigations into this matter and we will now close all complaints that led to the commissioning of the report.
>
> We are also satisfied that we have gone as far as we can in attempting to find a pathway to resolving the residents' concerns at the Cape Bridgewater Wind Farm. This means that we won't be modifying the wind farm operations at Cape Bridgewater and, as a result of feedback received; we will be disbanding the Cape Bridgewater Community Consultative Committee.

> Finally, there is nothing in this report to justify any form of compensation. The Cape Bridgewater wind farm is a fully compliant wind farm. However, we do not want this to be the end of our engagement with the Cape Bridgewater community. Rather, we hope it is the beginning of a new journey based on transparency and trust.

The above advice clearly contradicts the position expressed by Mr Richards as to ongoing community relations and "we should always strive for standards that are publicly acceptable".

Mr Crockett states disbanding the Cape Bridgewater CCC and in the next paragraph says it is not the end of our engagement with the Cape Bridgewater community, and then states a beginning of a new journey based on transparency and trust.

Apart from what Pacific Hydro have done to the community at Cape Bridgewater and the concept of having further discussions of a technical nature based upon the results of the study, I have an issue in accepting anything Pacific Hydro say.

Copyright and Use of the Report

The contract for the study is very complex and required a significant expenditure on legal advice to get a contract that could actually work.

There is a Background IP that I brought to the study. Then there is the Principal's IP that relates to data from the wind farm and Pacific Hydro. The Project IP is material or findings that came about as a result of the study or in connection with my services.

The Background IP is mine. The Principal IP and the Project IP are Pacific Hydro's.

Both I and my lawyer were of the view that with the study and the Portland presentations being placed in the public domain that I and other researchers could reference the figures and the material in the study and reproduce that material (with the appropriate acknowledgement to Pacific Hydro).

The contract requires me to obtain permission from Pacific Hydro for any use or reference to project IP.

I requested a form of release be provided (back in December 2014) so that I could use the phrase dB(WTS) and the material in the study that would be placed in the public domain. I also provided three peer reviewed papers to Pacific Hydro that were ready for publication; one on sensation, one on infrasound propagation and one on the difference between 1/3 octave band and narrow band analysis of the turbines to obtain WTS (my IP).

The study report is of some length and contains a number of separate findings that of significance in the quest for investigating the basis of impacts created by wind turbines. The purpose of the papers was to provide separate technical papers on each specific/separate finding. The intent was to prepare more papers as there are more than three separate findings of importance

Pacific Hydro provided advice prior to the presentation of evidence that prohibits me (the author of the report) to use or reproduce any of the material from the study, other than the Background IP which I brought to the project (data from other studies, WTS and my method of presenting noise level versus wind and power output of the wind farm that have been presented before).

Again as part of the contract (gag clauses), I am not permitted to provide the details of the advice in this submission.

As a result of the direct advice from Pacific Hydro that as the study has now finished and the services are completed, the gag clauses still exist and I can no longer reproduce graphs and materials from the study to enable me to answer questions to the participants in the study as to their observations (and how it fits into my report) to support their submissions to this Inquiry.

As a result of that advice I was required to significantly amend my submission to the Inquiry.

As the survey for residents was developed during the project, that survey is the property of Pacific Hydro and even though it is available to be read, it cannot be reproduced by me without approval from Pacific Hydro.

I am instructed that the peer reviewed papers supplied to Pacific Hydro cannot be issued as they contain the graphs I produced for the study report that contains what is classified as Project IP (even though they are my graphs of wind data and wind farm data), thus owned and to be used only by Pacific Hydro.

I have not received any licence or release to issue the three peer reviewed papers, although I understand some of those peer reviewers may have referred to those papers in their submission to this Inquiry.

Such a situation completely stops any documented evidence based elucidation or reference by me of the study particularly, as Pacific Hydro are aware, that I have been invited to the Acoustical Society of America's May conference and Internoise 2015 in August to **specifically talk** about the Cape Bridgewater study.

Prior to the presentation of evidence to the Inquiry no release or licence has been supplied by Pacific Hydro to permit the preparation of papers to permit further discussion of the report.

Use of the Study

The study has generated comments from around the world as a result of showing a link between the wind farm and disturbance.

In 1984 Nussbaum and Reinis [7] in a laboratory study investigated by way of a pretest using an 8 Hz signal at 100dB for 30 minutes and a main test of 8 Hz at 130 dB with both nigh and low distortion variations found some of the subjects reported episodes of dizziness, nausea, headache and fatigue a few hours after the end of the experimental sessions.

Schomer [8] considers the Nussbaum & Rinis study and the Cape Bridgewater Study together complement each other leading to his opinion that the "Preponderance of the Evidence" to the position where it must be acknowledged that wind turbine emissions will affect some people at some wind turbine installations. I understand that Dr Schomer has provided a submission to the Committee.

What is of importance to researchers around the world is that the 6 residents in the study are people already affected or sensitised to the wind farm. That means the study was able to go directly to sensitised people and relate the impact of the wind farm on a self-reporting basis. For researchers looking to find the source/mechanism there is obvious benefit in starting with those people who have identified the level of sensation at which they leave their homes.

My study was not a laboratory study, it was with real people in their homes in the actual environment created by a wind farm for a number of years. It is the worst case scenario in terms of a dose response because whilst traffic noise leads to people becoming used to that noise over time and therefore more acceptable to the traffic noise, for wind farm noise the disturbance becomes worse over time.

Professor Brigette Schulte-Fortkamp (Appendix B20) has invited me to Internoise 2015 in August (the biggest acoustical conference in the world) and Dr Schomer has invited me to the Acoustical Society of America's conference in May to continue the dialogue of wind farm research.

Acoustic researchers in this area understand the importance of the study.

As to Mr Crockett's comments of a new beginning based on transparency and trust, the Senate Committee can determine for itself (from the residents) whether Pacific Hydro can be trusted.

As to Mr Richards comments of "*Pursuing a better understanding of the impacts of all human activities on both our environment and our communities is one we should never relinquish. We hope others can look beyond some of the inaccurate reporting so that a mature, informed discussion can occur*" just simply cannot occur from me, in light of the gag clause on the contract.

Furthermore, under the IP provisions (gag clauses) I am unable to defend myself over defamatory comments made in the press by persons who have no acoustical or scientific expertise to base such comments as discussed below, without 48 hours prior notice and permission from Pacific Hydro.

As a result of the provision of evidence to the Inquiry, Pacific Hydro has indicated their intent to grant a copyright client for me to reproduce or publish the graphs in the report.

Inaccurate Reporting on the Study

There has been some criticism in relation to the study with a number of media releases being issued shortly after the release of the study that presented a significant degree of misleading information and indicated that the author of those media releases had not read or comprehended the study.

As the study has over 200 pages of text and just fewer than 500 pages of appendices, it is not something that can be simply comprehended in a matter of a few hours.

A number of adverse comments refer to the lack of subjects in the study, the lack of a control group, lack of peer reviews, etc. I say that those comments automatically reveal the authors of the comments had not read the report, or if they had then they did not comprehend the report or intentionally presented misleading information.

Pacific Hydro in a joint statement with me issued at the Portland Public meeting confirmed the limitations of the study.

If the Senators view the Acknowledgment, the Executive Summary and the Conclusions of the study the brief for the study is clearly set out:

- Take measurements "to determine whether certain wind conditions or certain sound levels give rise to disturbances experienced by specific local residents at Cape Bridgewater."
- The local residents numbered only 6 (the three houses)

In the Portland meeting I provided under a heading of Clarification of the Study:

The study that was undertaken was from the outset, a totally different concept to undertaking an assessment of a wind farm.

In light of various comments in the media following the release of the report, it is necessary to note that the Brief was specific as to:

- No requirement for more people. (Pacific Hydro have identified the report was commissioned at the request of 6 residents in an attempt to better understand their specific issues. It was an investigation to see what we could find, not a formal scientific study.)
- No requirement for a control group
- No requirement to undertake compliance testing - specifically instructed not to do so. (Pacific Hydro advised that wind farm compliance had already been demonstrated and a compliance review was not part of the scope of the investigation.)
- No requirement to look at health impacts. It was agreed health impacts is not our area of expertise.
- No requirement to look at impacts on quality of life. If considered as a medical concept outside of our expertise. If considered as a socio-acoustic concept also outside of our expertise.
- No external peer review permitted, unless a sub-contractor subject to the same contract. Draft report was reviewed by both Pacific Hydro and the residents before release.

The findings of the report identified measurements and analysis not included in the current permit conditions and indicated more work was required to obtain supplementary criteria to be used for wind farms. The author's opinion was that the use of the WTS as a tool to positively identify the operation of the turbine could assist in medical studies.

There are acousticians around the world (including those in Australia and New Zealand) that have been studying the report, typically taking up to 2 weeks to get through the content of the report and then have had discussions to seek additional information on understanding the technical content in the report and what was undertaken.

Appendix A provides a link to the Pacific Hydro website [1] for the entire report (and appendices) and the 2 PowerPoint Portland Presentations. However, as Pacific Hydro has closed down the Cape Bridgewater Consultative Community Committee, the continuation of the data being available is unknown. Alternatively, better websites are available where I can expect the report to remain for a while being that of Wind Watch [9], the Waubra Foundation [10].

Can I request the Secretariat to include the full report, appendices and the two PowerPoint presentations (at Portland) into the Senate committee's considerations for the benefit of the public?

Appendix B provides communication from acousticians around the world in response to the study and also directly in response to some adverse comments provided in the Australian press. These comments are not subject to gag clauses.

The contents of the study has created interest around the world with a request for me to attend two major acoustic conferences in the US this year to present papers in relation to the study and participate in workshop/panels specifically looking at research that is to occur, or should occur, with respect to windfarm noise. However, without a licence or a release Pacific Hydro's gag clauses limits what I can actually present to acousticians overseas who are very interested in the results.

I note that to help other acousticians of the unique data, I strongly recommended to Pacific Hydro that with the permission of the residents, WAVE files of the on-off testing could be provided with the release of the report but was denied that opportunity. It would appear that the ownership of the WAVE files could be disputed by the residents who understood there was to be co-operation of Pacific Hydro in resolving the situation that is clearly not the case now after the public meeting in Portland. The residents have confirmed no WAVE files are to be provided to Pacific Hydro.

The response from acousticians in Appendix B and the provision of WAVE files is relevant to the committee in that to date, there have been no medical studies undertaken in relation to wind farm noise although there are a number reports to recommend such studies be undertaken. The problem is that before medical studies can be undertaken, it is necessary to have an appropriate acoustic signal that is directly identified to wind farm noise that can then be used as the basis of the study.

Dr Bruce Walker has looked at the FFT data in my report and attempted to create a synthesised wave file signal (see Appendices B1- B3) but is unable to check his signal with the actual data because I am unable to supply WAVE files, recorded during the study.

I make reference to an acoustic report issued in America in relation to the Shirley windfarm [9] that was a collaborative effort by 4 different acoustic consulting firms (including Dr Bruce Walker and Dr Paul Schomer cited above) and pointed out the narrowband signal of windfarms in the infrasound region to which I have described as the Wind Turbine Signature.

The Shirley windfarm report identifies a similar slope in terms of the measurement data when using narrowband parameters just as I have experienced at the Cape Bridgewater wind farm and other wind farms in Australia.

The importance of the Shirley wind farm study in relation to the Cape Bridgewater study is the fact that there are three recommendations from the Shirley windfarm:

1. To undertake a comprehensive literature review of windfarm noise,
2. To undertake on-off testing of operational windfarms, and
3. To undertake testing to determine the threshold of perception in relation to infrasound generated by windfarms.

Whilst I have an extensive literature review and database in relation to wind farms, I did not purposely conduct a literature review with respect to the first recommendation.

With respect to the second recommendation, I specifically included on-off testing in the test program at Cape Bridgewater, that occurred on a repeatable basis where monitoring continued for an extended period of time (in the order of two weeks) during which there were shutdowns and start-ups.

The authors of the Shirley wind farm report were critical that for their study the windfarm operator would not assist by undertaking shutdowns. Therefore the Cape Bridgewater noise study is, to my knowledge, the only study in the world where there has been cooperation between the residents and the wind farm operator to carry out observations and measurements including the critical on-off testing, not just stopping the turbines from turning for a short period of time but a complete shutdown (as described in the report).

With respect to recommendation 3, I had actually conducted work in my anechoic room on tones and then conducted work using turbine noise in May 2013 during monitoring that I conducted at Waterloo whilst the EPA Waterloo windfarm study was being undertaken. Local residents, where I was staying at their houses, provided information to me as to when they could perceive the operation of the turbines or not. This was carried out with different sets of residents in different locations which ascertained the general concept in narrowband analysis that the threshold of perception level was about 50 dB in the 4 - 5 Hz region where below that, these sensitised residents were unable to perceive the operation of the wind farm.

I note that the number of residents is a small sample.

In May 2013, I communicated that concept to a number of acousticians around the world working independently on the investigation of wind farms and using that concept, who had found a threshold for sensation and the same time were also investigating a distance concept at which the threshold disappeared.

The work that has been undertaken at Cape Bridgewater completed a majority of the recommendations from the Shirley windfarm report. The consultants involved in that study have been in communication with me as to my work with a number of those not only congratulating me on the work but supporting the need for more research following the signature, observations, and the thresholds that came about from the Cape Bridgewater wind farm noise study.

Appendix B provides copies of the correspondence and indicates to the committee the importance of the work that has been carried out at Cape Bridgewater and that I am not a fringe acoustic and/or generate unsupported analysis. Some of the world's leading acousticians have commented on the work in favourable terms and wish me to keep on conducting such research.

The acousticians in Appendix B have encouraged me to continue publication of the work.

In my original submission I provided a copy of two of the peer reviewed papers that were amended to address the Pacific Hydro gag clauses. As a result of the first day of the hearings I was advised a copyright licence would be provided but it has not yet been provided. Without a copyright release, in a technical sense the papers are completely useless and of no benefit to anybody, whereas the insertion of the graphs from the study provide technical benefit to people's understanding of the noise issues surrounding wind farms.

The relevance and the terms of reference versus the Cape Bridgewater windfarm noise study and the previous Senate Inquiry into excessive noise from windfarms.

Being an acoustician and not a medically trained person involved in health research I am unable to respond to questions in relation to wind turbines and health impacts. However, I do have first-hand knowledge of residents experiencing ongoing sleep deprivation when at their homes and when the turbines are operating.

As a result of the Cape Bridgewater wind farm noise study, there is now a tool available for future medical research that permits identification of the operation of a wind farm. By reason of the study using a limited number of persons, being persons who are sensitised to windfarms, is an important factor for any medical research.

The Senate Inquiry into Excessive Noise from Wind Farms proposed a limit of 10 dB(A) above the background and therefore was only concerned with dB(A) and the provision of monitoring data. However there were submission concerning sleep disturbance and the impact of infrasound.

There are submissions to that Inquiry that are relevant to a number of the terms of reference to this Inquiry.

I note that in my oral evidence (to the Excessive Nosie Inquiry) I was subject to a number of questions concerning infrasound and concerns about a report on infrasound at Cape Bridgewater prepared for Pacific Hydro by the firm Sonus [12].

Having been to Cape Bridgewater in 2012 I knew that the diagram contained in the Sonus report as to turbine 27 misrepresented what was in fact the situation when the testing was carried out. This was a report issued by Pacific Hydro who therefore had to know that the turbine diagram was incorrect, yet issued the report.

I identified to the Excessive Nosie Inquiry there were significant errors in the Sonus report and was invited to provide a supplementary submission [15] to my primary submission [14] to the Excessive Noise Inquiry.

This is one reason I used turbine 27 as a test turbine in the study. My data shows an entirely different result to the Sonus report. Noise from that turbine is not just restricted to bands of 1/3 octaves as shown by Sonus. I have proved there are narrow band components in the actual signature of that very turbine (just as there are narrow band components for all the other turbines at Cape Bridgewater wind farm.

As a matter of correction to the report of that Inquiry Appendix C provides a Statutory Declaration as to false evidence provided to the Inquiry (by writing) from an officer of the NSW Department of Planning in relation to Cullerin wind farm.

The conduct of acousticians in the reporting of wind farm noise was the subject of a technical article in the journal of the Australian Acoustical Society (presented in Appendix D) that is a matter for the Committee to review with respect to acoustic compliance monitoring and assessment of wind farms.

The Excessive Noise Inquiry received information that persons being sleep deprived was considered to be a health impact and that the provision of real time monitoring of noise emissions and wind data from a wind farm should be implemented. Whilst the Excessive Noise Inquiry was about dB(A) the importance of the WTS has been found in my study and other studies around the world that real time monitoring should also include infrasound.

(a) the role and capacity of the National Health and Medical Research Council in providing guidance to state and territory authorities;

To date, the results from the National Health and Medical Research Council, in terms of its reviews concerning wind farms, from a technical perspective have been disappointing and have exhibited a bias in that the nature of selecting research and investigations of wind farms prohibits a number of items of fine work that have been undertaken by a professionals all around the world.

There have been conflicts of interest in terms of the provision of "acoustic" advice from persons involved in the "reviewing" of acoustic material with such conflicts not being declared.

The concept of looking into the health impacts of wind farms has generally been based on literature reviews from persons not involved "at the coal face" in investigating wind farm noise.

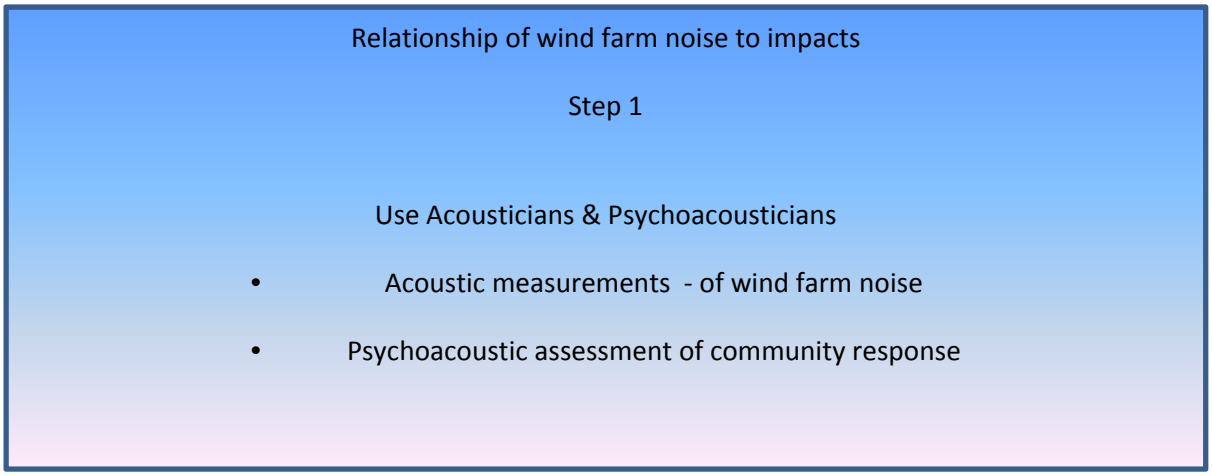
A literature review from a comfortable office is not the same as undertaking measurements in the field, meeting residents and even staying in their houses. For example, there are many administrators in public authorities who have never done field work.

It can be seen in other literature reviews for wind farm noise there is different material in the body of the report compared to the executive summary. Many of the reviews identify the absence of actual studies and the need for such studies but when reinterpreted by others the conclusion appears to say there are no issues with wind farms.

In June 2012, after undertaken measurements at wind farms, I attended a public meeting in Portland and presented my concept as to how the investigation of wind farms needed to be undertaken to get to the bottom of the problem.

Having undertaken measurements at wind farms, stayed at dwellings and having extensive discussions with residents who identified issues since the commencement of windfarms, I was of the view that before the research work could occur, it was necessary to determine what was going on from an acoustic perspective.

A few years ago I prepared a paper "Are windfarms too close to communities" [15] (see Appendix E) in which I gave my concept as a two-step approach.



I proposed to have socio-acoustic surveys being undertaken to quantify the relationship of the community to the noise of the wind farms and then to determine the acoustic characteristics of wind farms separate from the natural environment.

There is acknowledgement that the psycho-acoustic component of the first step has been undertaken by Dr Bob Thorne, whilst the acoustic research work has been undertaken by a number of acousticians in Australia involving a research group from Adelaide University led by Prof Colin Hansen, Dr Bob Thorne and his team, Les Huston and his organisation, and The Acoustic Group. All of those acousticians identified the infrasound components associated with the operation of the turbine and whilst not using my terminology WTS, have found the same signatures that I have called the WTS.

With the material undertaken by those organisations and the critical on-off testing from Cape Bridgewater, we now have the acoustic signature and material that identifies that there is an acoustic impact on residents to proceed to the medical research (step 2).

Relationship of wind farm noise to impacts

Step 2

Following Step 1 + On site Sleep Studies (with acoustic measurements)

Multidisciplinary research involving acousticians and psychoacousticians, together with experienced medical practitioners, researchers and clinicians, including but not limited to the following speciality areas:

- Sleep Physicians & physiologists
- Ear Nose & throat physicians and physiologists
- Neuroscientists
- Psychiatrists & Psychologists
- Cardiologists and cardiac physiologists
- Endocrinologists
- Epidemiologists
- Rural General Practitioners
- Occupational Health Physicians

In my view what I have called step 2 is a multi-disciplinary approach that needs research covering different areas of what can be described as medical monitoring for residents.

It needs to occur in their homes, not in a sleep unit, as there would be the need for a significant amount of field work to substantiate the acoustic climate (in the real world) as the buildings themselves interact with the infrasound and low frequency energy.

Despite years of apparently looking at wind farms (in the concept of desk top assessments – not in the real world) the National Health and Medical Research Council is not considering any such material and is basically presenting a position based upon literature reviews without looking at real fieldwork to see what is going on.

From the community's perspective and for those in proximity to wind farms, residents have advised me they have absolutely no confidence in the NHMRC and its nature of dismissing there being an actual impact. Examining the material in the report provided by the NHMRC in relation to acoustic aspects finds that the investigations have limited themselves to studies that clearly from the outset by using inappropriate measurement parameters (i.e. ignoring narrow band data) could not find that there is an issue.

In looking at the qualifying factors the NHMRC have taken for accepting material from a report, it would appear that whilst the Cape Bridgewater wind farm study that has been accepted by eminent acousticians around the world, being of much higher standing than anybody in Australia, the NHMRC would reject my study.

If one considers the possibility that the NHMRC is exhibiting any bias in terms of its investigation of wind farms, which is a common opinion held by the community, it would seem that the role and capacity of the NHMRC in providing guidance to state and territory authorities in relation to wind farm impacts would, at the present time, have no vote of confidence from communities that have been so impacted.

The select committee should be recommending a different organisation to undertake or supervise medical research into wind farms.

It is essential that any organisation overseeing this critical role must have absolute transparency and have the support of the community.

One of the major issues that came at the commencement of the Cape Bridgewater wind farm noise study was my insistence that the only way I would be involved in the work was on the basis there was transparency and that all that data was available. From that position, I was able to obtain the cooperation of the residents to permit the monitoring to occur and the wind farm company to participate in the study with the full release of the information necessary to investigate the issue.

However as discussed above the conduct of Pacific Hydro when faced with a report that satisfied the brief that doesn't suit them is a matter that must be considered for the organisation overseeing any research into wind farm impacts.

(d) The implementation of planning processes in relation to windfarms, including level of information available to prospective windfarm hosts.

From an acoustic perspective, the planning processes in Australia are inadequate to protect the amenity of residents in proximity to wind farms.

An essential ingredient in the planning process is to have appropriate acoustic/infrasound criteria to protect the amenity of people. If the wind farm is sufficiently removed from residents then there should be no impact.

To data there are no studies by Regulatory Authorities to ascertain the appropriate distances to ensure there are no adverse noise or health impacts. Without such studies the planning process is automatically set to fail the community to which it is obliged to protect.

From a noise perspective, guidelines that are based upon dB(A) are inappropriate. Independent acousticians undertaking investigations into wind farms will find that determining the dB(A) level of a wind farm by excluding the wind noise is a difficult process and that the dB(A) wind farm contribution is insignificant.

The current concept of using a regression line analysis that is more aligned to measuring the wind rather than the wind farm has a fundamental problem. The concept of regression line analysis in the New Zealand standard, the South Australian EPA guidelines and draft guideline by the New South Wales Department of Planning, does not agree with the general concept for industrial noise and in actual fact, is a concept that is doomed to automatically fail (to the disadvantage of the residents).

The New Zealand Standard

New Zealand standard is the guideline used in Victoria with the permit for Cape Bridgewater wind farm being based on the 1998 version of the Standard [16].

The Standard provides noise criteria with reference to a preliminary document issued by the World Health Organisation that purports to be based on sleep disturbance (clause 4.4.1).

The problem with the Standard and the referenced base document is that there was no investigation in terms of sleep disturbance from wind farms. The major investigations in the reference document related to noise from traffic in Europe. More importantly the disturbance in terms of traffic was not in rural areas but was in urban areas.

As such, the level of disturbance as a result of wind turbines that occurs in rural areas, which are the places where wind farms tend to be located, is not scientifically based on sleep disturbance from turbines. This would appear to be a fundamental problem with the NZ Standard.

If as Pacific Hydro claim the wind farm is compliant with the permit conditions (i.e. the NZ Standard), yet the residents in the study reported sleep disturbance it must follow there is a problem with the criteria in the NZ Standard. A similar situation is found with the SA EPA criteria for wind farms.

The use of the dB(A) parameter has a filter curve that excludes low-frequency energy and therefore dB(A) in the concept of noise disturbance is basically looking at mid and high frequency noise which dissipates over distance such that residents impacted by windfarms, when describing the noise, often talk about a droning sound as “the plane that never lands”.

The dB(A) parameter has no relationship to the infrasound components that are generated by wind turbines that have been found to have a link between sensitised people at Cape Bridgewater and the operation of that wind farm.

Clause 5.4 of the NZ Standard determines compliance of a wind farm by comparing “the best fit regression line of the background sound level and the regression curve of the operational windfarm corrected for any special audible characteristics”.

If however the regression curve is from results determined by use of wind farm noise with wind, or possibly only wind noise, it would seem difficult to determine compliance with a noise emission limit nominated as being from just the wind farm.

The regression curve method makes no allowance for the direction of the wind nor does it use the normal convention of background level that applies to industry.

In a general concept, industry in Australia is related to the repeatable minimum background (or the L90 level) with a typical limit of background + 5 dB(A). Where the wind speed exceeds 5 m/s at the microphone the background level is considered to be affected by the wind.

It is correct in terms of wind farm assessment that the noise from the turbines is dependent upon the wind at the turbines with regression curves normally expressed in terms of hub height wind speed (or in some case 10m above ground level at the wind farm).

It is obvious that if background levels are to be obtained in the presence of wind then the background level will increase as the wind increases. However actual wind noise is significantly lower than noise generated by the effect of wind on leaves and foliage. The placement of noise loggers in proximity to

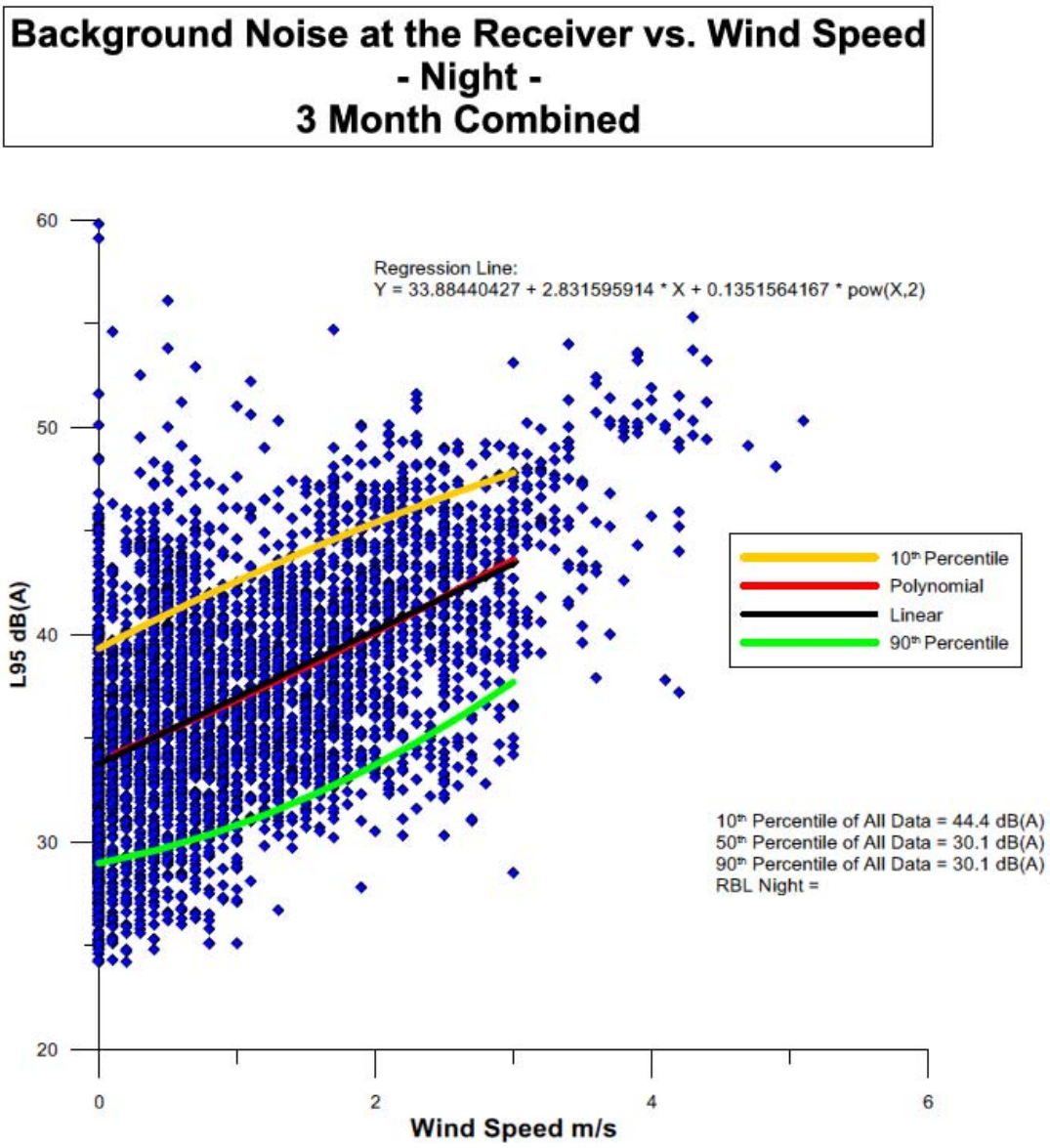
bushes and tall trees (as in the case of the SA EPA testing at Waterloo) can give rise to increases in the "wind background" levels in the order of 10 dB.

The regression line is a line of best fit through the data set. Then by definition the regression line without the wind farm cannot be the background level. One can from sufficient measurements determine the background level of the wind by taking the range of level in increments of the wind speed and determining a line of best fit though that data.

The following graph is from 3 months of measurements near the Waubra wind farm and shows the 90th percentile of the background levels versus wind at the site, together with the "normal" regression line and the line representing the 10th percentile.

The regression line is wind + wind farm noise that is in the order of background + 5 dB(A).

The wind speed in the following graph is at the microphone as the wind farm operator will not release the hub height wind data. Without hub height wind speed data the graph below cannot be compared with the Standard, or the cut-in (or cut-out) speed of the turbines.



However, clause 4.4.2 of the NZ Standard nominates a limit of 40 dB(A) or background (from the regression line) + 5 dB(A), whichever is the greater.

If the permit is in terms of noise from the wind farm and the resultant measured level is wind farm + wind then the permitted level can be significantly greater than suggested in the permit or the Standard where the limit is identified as just noise from the wind farm.

The above graph reveals the average level (regression line) will, on the basis of an attenuation of 10 dB(A) from outside to inside for an open window, have ambient background level less than 30 dB(A), with minimum internal background levels well below 20 dB(A).

By using instrumentation that is unable to measure the real background level (due to the noise floor of the meter) the regression lines present an incorrect picture of the acoustic environment.

A question often posed by residents is why does the NZ Standard consider sleep disturbance averaged over 14 days and what actually constitutes sleep disturbance from wind farms on a dB(A) basis?

The New Zealand Standard, that is based on a regression line using dB(A), is an inappropriate method for addressing sleep disturbance on three fundamental bases:

1. As confirmed by Pacific Hydro in their public statement there is no correlation of noise with the wind farm.
2. The dB(A) parameter attributed to wind farms cannot actually be determined as a contribution , because the measurement in the regression analysis includes wind.
3. There is no information available to identify noise (or infrasound) levels from wind turbines that gives rise to sleep disturbance.

The principal issue of concern in relation to the planning process must be setting the correct criteria for wind farms. If the limit is for protecting sleep (as in the case on the NZ Standard for Victoria) then there is the need to determine the sleep disturbance limits for wind farms – not road traffic in urban areas.

If the planning principles are to ensure the health and well-being of the community is not affected by the operation of wind farms then criteria should be based on health studies.

If the operation of a "compliant" wind farm creates sleep disturbance the dB(A) limit is incorrect. Similarly if the disturbances reported by the Cape Bridgewater residents have a link to the Wind Turbine Signature then the current permit conditions that are expressed in dB(A) will not address sensation.

At the present time the permit conditions are in dBA, On the basis the NZ Standard's "acceptable limit" is based on road traffic noise disturbing sleep **there is clearly a planning issue with what constitutes an unacceptable limit.**

Even though the regression method doesn't determine the level of noise from the wind farm, Section 4.4.2 nominates a level (of the wind farm) not to be exceeded. It does not say an average level not to be exceeded.

Clause 4.4.2 of the Standard is headed “Acceptable limit” and states:

> *As guide to the limits of acceptability, the sound level from the WTG (or windfarm) should not exceed, at any residential site, and at any of the nominated wind speeds, the background sound level (L_{95}) by more than 5 dBA, or a level of 40 dBA L_{95}, whichever is the greater*.
>
> *NOTE –*
> *(1) The level predicted (L_R) is based on the L_{eq} source level of the turbines under consideration and hence the predicted level is also an L_{eq} level. This predicted level needs to be assessed against a recommended acceptable level and possibly a measured background level, both determined using an L_{95} descriptor.*
> *(2) Overseas studies on windfarm sound (refer ETSU-R-97), have shown that L95 is typically 1.5dB – 2.5 dB lower than L_{eq} measured over the same period. Similarly L_{eq}, is typically 1.5 dB – 2.5 dB lower than L_{10}, assuming a normal distribution of sound levels. Hence L_{95} is typically 5 dB lower than L_{10}. For this reason, a 5 dB only margin should be applied above the L_{95} results, rather than the “background plus 10” approach which, subject to specified reservations, is taken in NZS 6802*

There are a number of problems with Clause 4.4.2 in relation to compliance with the permit conditions for the Cape Bridgewater wind farm.

The relevant background level for considering the NZ Standard cannot be the level for 50% of the time.

The clause states “should not exceed”. The clause does not state “should not exceed on average”, nor does it state “should not exceed for ten percent of the time”.

The sound limit is expressed as an L_{eq}. If the L_{eq} is say 2 dB above the L_{95} and the regression method is based on the average of the L_{95} levels it must follow that the limit should be shown as 38 dB(A) or 3 dB above the background level.

The concept of a nominal 2 dB difference between L_{eq} and L_{95} has not been established for the type of turbines used in Australia. Measurements I have conducted near turbines where the turbines are clearly the source noise (and wind noise is insignificant) reveals a much greater difference, particularly for infrasound and low frequencies.

It is correct that variation in the wind strength can create L_{eq} levels greater than the L_{95} level and is dependent upon the wind screen (over the microphone) that is used, but as discussed earlier, more importantly the foliage that is subject to wind near the monitoring location.

The case of the SA EPA for Waterloo placing their logger directly under a set of large gum trees resulted in a significant difference in the Leq and background level for a location of my logger (and that of Adelaide University) about 100 metres from the SA EPA logger.

I have conducted extended monitoring on an open hillside, in long grass, and near trees with respect to a proposed wind farm at Hallett in South Australia that is removed from traffic or any other extraneous noises. The background level versus the wind speed for the various situations can be plotted. A similar exercise was undertaken for a US wind farm noise standard and shows the wind contribution until the noise floor of the meters was reached [17]. If one knows what the instrumentation provides then provided the ambient noise is not being affected by foliage then the compliance testing of wind + turbine can logarithmic extract the wind contribution.

If the level is supposed to be the L_{eq} level of the source then the methodology should look to determine the source without the wind contributing to the overall level.

The more logical method for compliance testing (if restricted to dBA) is to undertake monitoring near the outside edge of the wind farm with a reasonable view of the wind farm and then extrapolate the result to residential receivers.

Whilst the NZ Standard makes no mention of infrasound it is easier to measure the infrasound contribution at residential receivers than the dB(A) contribution, because there is a much lower rate of attenuation for infrasound when compared to normal audible noise.

The NZ Standard, that is restricted to dB(A) allocates adjustments where special audible characteristics are present. However if the regression method is based upon unattended logging that provided a dB(A) result how can the monitoring determine the presence of special audible characteristics?

The determination of special audible characteristics at residential locations cannot be done with dB(A) measurements that are averaged over a ten minute sample. Yet at the present time that is the method on the permit condition, with the use of a regression method.

Whilst this is a compliance issue it is relevant in a planning sense to determine from the outset just what do the planning guidelines require and how can the limits be checked.

All of the above reveals the inadequacy of the planning concept of using the NZ Standard when the mechanism is not in place to determine the wind farm contribution or what is required in Australia to protect sleep from wind turbines.

The Senate Committee should make enquiries with the planning authorities in Victoria as to how compliance reports for wind farms in Victoria have ascertained:

- the contribution of the wind farms?
- the adjustment for special audible characteristics?
- the degree of exceedance that constitutes non-compliance?
- how does a regression method protect sleep?
- what limit is used for sleep disturbance in rural areas from wind turbines?
- where is the testing for Waubra wind farm that requires assessment at night?

The Senate Committee should make enquiries with the planning authorities in Victoria as to how the NZ Standard came to be used in Victoria and what due diligence was undertaken to ensure the community was not adversely affected by wind farms that satisfied the NZ Standard, in particular to sleep.

The Senate Committee should make enquiries with the planning authorities in Victoria as to how the fundamental basis of the NZ Standard (protecting from sleep disturbance) was validated for Victoria.

The above questions are relevant in that Mr Upson (from Infigen) in his evidence to the NSW Upper House Inquiry (2009) [18]:

> **Mr UPSON:** The noise standard in New South Wales utilises a South Australian standard. I think most people feel that standard is slightly stricter than the New Zealand standard, which is used in Victoria and some other States. It is basically a standard written around not disturbing sleep. The kind of headline noise level is 35 decibels from outside the house. That is quite a low decibel level. I feel that any wind farm that complies with that standard should not provide any disruption or annoyance. That is what it is written for. That is how the standard was developed.

The Cape Bridgewater study showed disruption and annoyance by reason of the brief requiring me to determine certain wind speeds and certain sound levels that related to disturbances from specific local residents. Pacific Hydro claim the subject wind farm complies with the acoustic criteria specified on the permit (being the NZ Standard).

SA EPA Wind Farm Guidelines

In South Australia the planning concept in terms of noise from wind farms falls to the SA EPA Guidelines. The SA EPA Guidelines use the more common L90 level as the background level, not the L95 level used in the first version of the NZ Standard. At present the SA EPA Guideline is the document used for wind farms in NSW.

Many of the technical concepts/issues identified above in relation to the NZ Standard also apply to the SA EPA guidelines.

However the basis of the EPA guideline is not as clear as the NZ Standard.

In the third paragraph of the introduction to the 2009 SA EPA wind farm guidelines it is stated:

> **The core objective of the guidelines is to balance the advantage of developing wind energy projects in South Australia with protecting the amenity of the surrounding community from adverse impacts**.

An examination of the guideline does not identify what is the amenity of the surrounding community, nor upon what basis the amenity is protected.

The SA EPA Waterloo wind farm study [3] (that restricted itself to only noise complaints) shows that the acoustic environment around Waterloo typically goes below 25 dB(A).

If one adopts a 35 or 40 dBA limit and the background + 5 dB, whichever is greater, where residents regularly experience background levels around 20 or 25 dB(A) then permitting a level of 35 dB(A) or 40 dB(A) present a significant level of intrusive noise.

It appears there is no material available from the SA EPA to identify studies in South Australia to establish what is the existing “amenity of the surrounding community” (to a wind farm).

I do not see how a 35 dB(A) or 40 dB(A) limit permitted by the EPA achieves the core objective.

The SA EPA Guideline treats hosts differently to normal rural residents (non-hosts). It seems for hosts (for people receiving money from the wind farm) that sleep disturbance is an adverse impact. However I cannot find in the document a definition of what is an adverse impact for rural residents.

As in the case for Victoria there is no material to identify what levels relate to sleep disturbance from wind farms in South Australia.

The matter of responsibility for permitting/creating an adverse to rural residents in South Australia lies directly with the SA EPA.

In the Stony Gap Appeal before the ERD Court in SA, the joint report of the two acoustic experts identified the Applicant’s acoustic expert was aware of complaints from residents in proximity to the Waterloo wind farm, and that residents have abandoned their homes since the wind farm came into operation. Despite that knowledge and what would appear to be both an ethical or moral obligation of that consultant to take into account the health and well-being of the community that would be impacted as a result of the wind farm, the entire responsibility/basis upon which he formed the view there would be no adverse impact fell to the SA EPA and their guidelines.

Of further concern with the SA EPA Guidelines is the claim in Section 4.7:

> Infrasound was a characteristic of some wind turbine models that has been attributed to early designs in which turbine blades were downwind of the main tower. The effect was generated as the blades cur through the turbulence generated around the downwind side of the tower.
>
> Modern designs generally have the blades upwind of the tower. Wind conditions around the blades and improved blade design minimise the generation of the effect. The EPA has consulted the working group and completed an extensive literature search but is not aware of infrasound being present at any modern wind farm site.

The concept of there being no infrasound present **at any modern wind farm site** (my emphasis) is so blatantly wrong, by reason of the work carried out here in Australia and overseas to show the Wind Turbine Signature.

The SA EPA issue a report [19] some time ago identifying that infrasound emitted from wind farms was not different to that of the natural environment. However, there is a problem with the report in that it utilised 1/3 octave band and dB(G) measurements as the basis of obtaining their conclusion.

However persons who are experienced in measurement of wind farms are aware that restricting assessments to the used of dB(A), dB(G), or even 1/3 octave bands will not reveal the Wind Turbine Signature. For the authors of the EPA report [19] to restrict an assessment of infrasound to at the highest resolution of 1/3 octaves is a matter that should be investigated by the Senate Committee as the EPA is an authority that is charged with protecting the community.

Chapter 9 of my Cape Bridgewater report shows clearly the difference between a 1/3 octave band analysis and narrow band analysis of the infrasound. If restricted to 1/3 octave bands there is no difference between a wind farm affected environment and the natural environment. However when viewing the same data in terms of narrow band results the difference between the two environments is very clear for all to see. If the SA EPA had conducted narrow band analysis of the infrasound from the natural environment versus a wind farm affected environment (assuming the wind turbines were operating) the conclusion to the report would have been different. See chapter 9 of my report that clearly shows the difference.

In the ERD Court matter re the Stony Gap wind farm the Court identified that despite there being issues raised by residents of disturbances from the Waterloo and Hallett wind farms and there were important findings emerging from the (then) Cape Bridgewater study the Court was required to adopt the SA EPA Guidelines, i.e. they are the planning guidelines in South Australia with respect to noise.

This single matter shows the problem with the SA EPA wind farm guidelines are a planning issue.

The Senate Committee should require the SA EPA to explain how their guidelines protect the community from adverse impacts and as for Cape Bridgewater how a compliant wind farm creates sleep disturbance.

(c) the adequacy of monitoring and compliance governance of wind farms and (d) the application integrity of national wind farm guidelines;

The discussion in the preceding sections concerning the NZ Standard used in Victoria and the SA EPA Guidelines used in South Australian and NSW have identified the flaws in the “acceptable limits” that do not protect the community from adverse noise impacts.

If the guidelines start from the wrong basis then the criteria, monitoring and compliance also must fail.

The Cape Bridgewater study applied to a “compliant” wind farm, yet the company acknowledges they were subject to ongoing complaints for six years.

The Cape Bridgewater study showed infrasound to be an issue yet there are no guidelines incorporating infrasound or for that matter low-frequency noise. Therefore monitoring and compliance governance of wind farms under the current guidelines will not address those issues.

The concept of sensation that originated from the residents of Waterloo in South Australia, who are adversely affected by a compliant wind farm, was used in the Cape Bridgewater study and became the link for determining the majority of the disturbances are from the wind farm as reported by the residents. The concept of sensation as a descriptor addressed the majority of the disturbance from the wind farm but noting that there were still noise and vibration issues.

In the South Australian EPA Waterloo ”study” the questionnaire ignored anything other than noise. An analysis of the resident’s logs available to community representatives revealed there a significant number of reported disturbances that were not related to noise.

Therefore if there are inadequate guidelines to protect the amenity of residents in proximity to windfarms one only can only obtain the conclusion that adopting either the New Zealand Standard, the South Australian EPA wind farm guidelines or the draft New South Wales wind farm guidelines to a National wind farm guideline has very little integrity as none of them are addressing infrasound.

The material from the Cape Bridgewater study found that there was a clear signature that occurs in the infrasound region, noting that it is not unique or the first time that such signature has been determined.

The difference with the Cape Bridgewater study was that it had extensive monitoring and observations from residents, together with all the turbine and wind speed data to permit the analysis to be undertaken.

The Cape Bridgewater study found that it is extremely difficult to determine the noise contribution from the wind farm when using the dB(A) parameter at residential receivers.

I consider for the purpose of monitoring, as discussed above, that the appropriate mechanism, which has been adopted by the New South Wales EPA for industrial sites, is to undertake monitoring at an intermediate position between the noise source and the receiver, where noise from the source can be easily measured above the background level from which calculations of the predicted noise contribution at the receiver location can be determined.

There is instrumentation and computerised systems that will allow such an exercise to be undertaken, which was in fact was an outcome in the previous Excessive Noise from Wind Farms inquiry that there was agreement in terms of the provision of monitoring.

The provision of monitoring and compliance governance of wind farms requires that exercise to be undertaken with transparency and with all the relevant material being available.

For the purpose of undertaking my investigation the only basis of doing the work was on the basis of transparency in terms of the information I collected and that of the wind farm data. That material was provided.

The concept of not being able to get hub height wind data has presented extreme difficulty for various researchers undertaking measurements on behalf of residents, when the criteria is expressed in terms of a noise level versus a hub height wind speed.

There would not appear to be any restriction in the provision of hub height wind speed data and turbine power output data after the event, with excuses previously provided by wind farm operators that the material was proprietary.

The Cape Bridgewater study clearly showed the relationship between the wind speed and noise levels obtained at residential locations and it is essential that the wind speed information is provided.

There is benefit in providing real-time monitoring of noise emission from the wind farm (on-site) together with the predicted noise levels that would occur at residential reference locations as the technology and the method of processing of the data is available at the present point in time.

The concept of adequacy of monitoring /compliance with respect to infrasound is a matter that in the first instance requires noise targets for that region of sound, noting that the issue of infrasound is one that is normally applied inside a dwelling.

Work undertaken by Dr Kelley and his team in the early 1980s confirms the investigations I carried out in Waterloo in 2013 (without being aware of the Dr Kelley information) and found that on a narrowband basis in the region of 4 to 5 Hz 50 dB was a threshold of perception.

The Cape Bridgewater study has identified by utilising the slope of the infrasound components a weighting curve that may be applied to determine a level in the first instance of unacceptable infrasound impacts with the appropriate limit to be derived and the a lower level for compliance to be at a lower level.

In view of the Pacific Hydro's gag clauses in relation to the use of the dB(WTS) I have proposed the concept of dB(S – WT), or to use the technically more correct version (as suggested by Professor Dickenson) of L_{S-WT} of xx dB as a limit.

At the present point in time the use of a dB(A) noise level by way of a regression analysis concept has absolutely no integrity if one is considering the protection of the community. As a result of the Cape Bridgewater study, work undertaken by Adelaide University, the Shirley wind farm study and the infrasound measurements in relation to Health Canada all reveal that the current guidelines for wind farms in Australia utilise incorrect criteria.

If dB(A) continues to be used for wind farm assessments in Australia then the noise limits contained in guidelines or used by authorities need to be modified to address the fundamental concept of sleep disturbance.

If the appropriate field studies are undertaken to determine what constitutes sleep disturbance as a result of turbines it may be possible to determine a dB(A) sleep disturbance level that occurs inside houses.

However, the Cape Bridgewater study would suggest those A-weighted levels may be extremely low and possibly not able to be measured on a consistent basis. The concept of L_{S-WS} (or some other similar format) may very well be the appropriate descriptor to be incorporated into guidelines to address adverse impacts.

There have been a number of Senate Inquiries in relation to wind farms that have all pointed to the need for research into what is creating adverse impacts on communities in proximity to wind farms.

In my view the Cape Bridgewater study has provided a mechanism that permits the medical research to be undertaken clearly on a dB(A) basis that work could not commence.

In looking to determining National wind farm guidelines, and the adequacy of monitoring and compliance governance of wind farms one needs to have the right criteria established to protect communities from adverse impact .

If this involves a greater separation distance to provide adequate protection then the research work will identify the appropriate distances that are required.

In my opinion the research work needs to be conducted primarily in the field, not a sleep laboratory, in that in the first instance one needs to identify the sound level that is audible (?) and the infrasound levels that impact upon residents. That can only be determined in existing houses.

There is merit in utilising people who have become sensitised to the noise over a period of time for the purpose of determining the appropriate limits to protect people's health.

It needs to be acknowledged that not all people are impacted by wind turbines and that over time more people become affected. It is expected there will be a dose response curve the relates to the levels of noise/infrasound that are received, but there will be a different dose response dependent upon the cumulative period of exposure (over years).

When undertaking aircraft noise assessments the concept has been adopted in the past is to only consider residents that are being subject to the aircraft noise for a period not less than two years. That may be an appropriate time period of exposure threshold for looking at persons who experience infrasound in the real world.

Moving into laboratory studies will experience difficulty in reproducing the sound fields that occur in dwellings where residents are exposed to the subject noise. It would be necessary to establish a three-dimensional sound field in receiver locations and then ascertain a mechanism that can generate in a sleep laboratory the same sound fields so as to have valid research.

This would appear to be difficult in that in many cases the building elements of dwellings in rural areas interact with the sound field and provide amplification inside the dwelling to that recorded externally.

The concept of integrity in terms of national wind farm guidelines is a matter that needs to be raised in addition to integrity of those administering the guidelines and those persons undertaking the measurements with respect to the guidelines. Concepts as to compliance with Uniform Civil Rules applied in courts of law is a matter that should be strongly considered.

STEVEN E. COOPER

References

1. The Acoustic Group, “The Results of an Acoustic Testing Program, Cape Bridgewater Wind Farm”, Dec 2014 http://www.pacifichydro.com.au/english/our-communities/communities/cape-bridgewater-acoustic-study-report/
2. Richards A, “Why Pacific Hydro commissioned the Cape Bridgewater wind farm acoustic study”, The Business Spectator http://www.businessspectator.com.au/article/2015/1/27/wind-power/why-pacific-hydro-commissioned-cape-bridgewater-wind-farm-acoustic , Jan 27 2015
3. SA EPA, “Waterloo Wind Farm Environmental noise study”, November 2013
4. Berger RG, Ashtiani P, Ollson CA, Whitfield Aslund M, McCallum LC, Leventhall G & Knopper LD “Health based audible noise guidelines account for infrasound and low-frequency noise produced by the wind” http://www.ncbi.nlm.nih.gov/pubmed/25759808
5. Mackie R, “Wind turbine infrasound: What’s all the noise about?” RE new economy, http://reneweconomy.com.au/2012/wind-turbine-infrasound-whats-all-the-noise-about-28735, December 2012
6. Joint Statement – Pacific Hydro & The Acoustic Group, 16 February 2015 https://www.wind-watch.org/documents/results-of-an-acoustic-testing-program-cape-bridgewater-wind-farm/
7. Nussbaum D. S. & Reinis S, “Some Individual Differences in Human Response to Infrasound” Institute for Aerospace Studies, University of Toronto, January 1985
8. Schomer P, Erdreich J , Pamidighantam PV & Boyle JH, “A theory to explain some physiological effects of the infrasonic emission at some wind farm sites”, Journal of the Acoustical Society of America **137** (3) March 2015
9. The Acoustic Group, “The Results of an Acoustic Testing Program, Cape Bridgewater Wind Farm”, Dec 2014 The Acoustic Group, https://www.wind-watch.org/documents/results-of-an-acoustic-testing-program-cape-bridgewater-wind-farm/
10. “The Results of an Acoustic Testing Program, Cape Bridgewater Wind Farm”, Dec 2014 http://waubrafoundation.org.au/resources/cooper-s-acoustic-group-results-cape-bridgewater-acoustic-investigation/
11. Walker B, Hessler DM, Hessler GF, Rand R & Schomer P, “ A Cooperative Measurement Survey and Analysis of Low Frequency and Infrasound at the Shirley Wind Farm in Brown County, Wisconsin”, Report Number 122412-1, December 2012
12. Sonus Pty Ltd, “Infrasound Measurements from Wind Farms and Other Sources, Pacific Hydro, November 2010
13. Supplementary Submission in the matter of Renewable Energy (Electricity) Amendment (Excessive Noise from Wind Farms) Bill 2012, 42.5006.R4
14. Submission to the Senate Environment and Communications/Legislation Committee in the matter of Renewable Energy (Electricity) Amendment (Excessive Noise from Wind Farms) Bill 2012, 42.5006.R2
15. Supplementary Submission in the matter of Renewable Energy (Electricity) Amendment (Excessive Noise from Wind Farms) Bill 2012, 42.5006.R4
16. New Zealand Standard, “Acoustics – The assessment and measurement of sound from wind turbine generators”, NZS 6808:1998
17. American National Standards Institute, “Draft American ANSI National Standard, ANSI S12.9 – Part 7: Measurement of Low Frequency Nosie and Infrasound Outdoors in the Presence of Wind and Indoors in Occupied Spaces”, December 2014
18. Hearing Transcript (Uncorrected), “Report of Proceedings before General Purpose Standing committee No. 5, Inquiry into Rural Wind Farms”, page 32, Friday 11 September 2009
19. Evans T, Cooper J & Lenchine V, “Infrasound level near wind farms and in other environments:, SA EPA, January 2013

APPENDIX A: Cape Bridgewater Noise Study

Due to restrictions imposed by Pacific Hydro on using the data contained in the Cape Bridgewater Study the reader of this submission needs to go to the Pacific Hydro website (if the report is still available) to obtain the report and presentations at Portland on 16th February 2015.

http://www.pacifichydro.com.au/english/our-communities/communities/cape-bridgewater-acoustic-study-report/

Alternative sites where the report, the presentations and comments by acousticians are available are:

https://www.wind-watch.org/documents/results-of-an-acoustic-testing-program-cape-bridgewater-wind-farm/

http://waubrafoundation.org.au/resources/cooper-s-acoustic-group-results-cape-bridgewater-acoustic-investigation/

APPENDIX B: Comments re CBW Study from Acousticians

Dr Bruce Walker

Thanks for the info. I was just looking at the Appendix Part 6 and wish I'd seen it before writing up some modulation and spectral analyis stuff for WTN2015. I could have saved a lot of work by just referencing your thorough presentation.

Toward the end of the Appendix you have another spectrum and synthesized wave that looks a lot like what I got from Fig 55 but about 20 dB lower. I was just going to run some subjective exposure tests based on the Fig 55 spectrum but wanted to be sure I'm not misinterpreting it first.

I had a chance to do single turbine measurements in 2012 and did a cursory report at WTN2013. At least at 100 meters distance, wind direction affected pulse waveshape, apparently by changing the phase of the BPF relative to the higher harmonics. My belief is that the BPF is a combination of the blades in stratified flow and blade/tower interaction and the upper harmonics are more dominated by the interaction. That test was great because we had 1x and 40x tachometer signals from the turbine recorded along with the acoustic data, which made it possible to recover the waves in time domain. Microphones were stationed at 10 degree increments all around the turbine and recorded simultaneously, but unfortunately only the three that I provided recorded anything below 10 Hz.

Best wishes,

Bruce

Bruce Walker, Ph.D., INCE Bd. Cert.

On Jan 26, 2015, at 10:35 PM, Steven Cooper <drnoise@acoustics.com.au> wrote:

Bruce,

House 89 is on the side of a hill at 1600 metres from the nearest turbine. The front door is level with the base of the tower so the dwelling has full exposure to the swept path of the turbine.

House 88 is below the base of the nearest turbine (1000 m) and has a different view of the swept path.

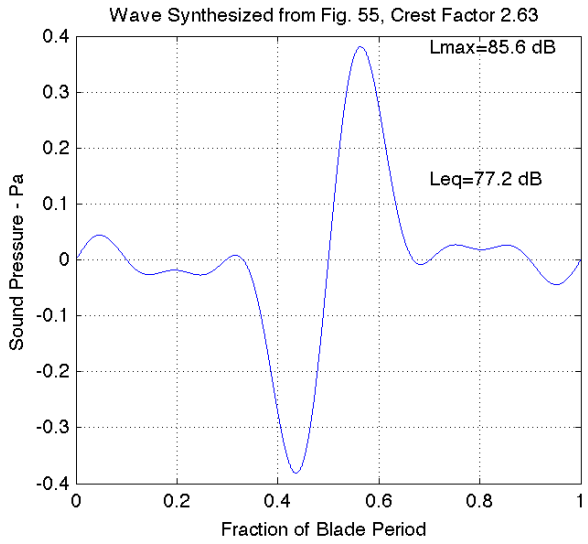
From: Bruce Walker |
Sent: Tuesday, 27 January 2015 9:23 AM
To: Bruce Walker
Subject: Bridgewater Wave Synthesis

Here is the thump wave I synthesize from Bridgewater Figure 55 spectrum.
This is akin to what I've measured outdoors at 150 meters. This distance is about 1650 meters. Interesting.

Note that the spectrum is in PSD. Subtract about 18 dB to get SPL.

Bruce

Bruce Walker



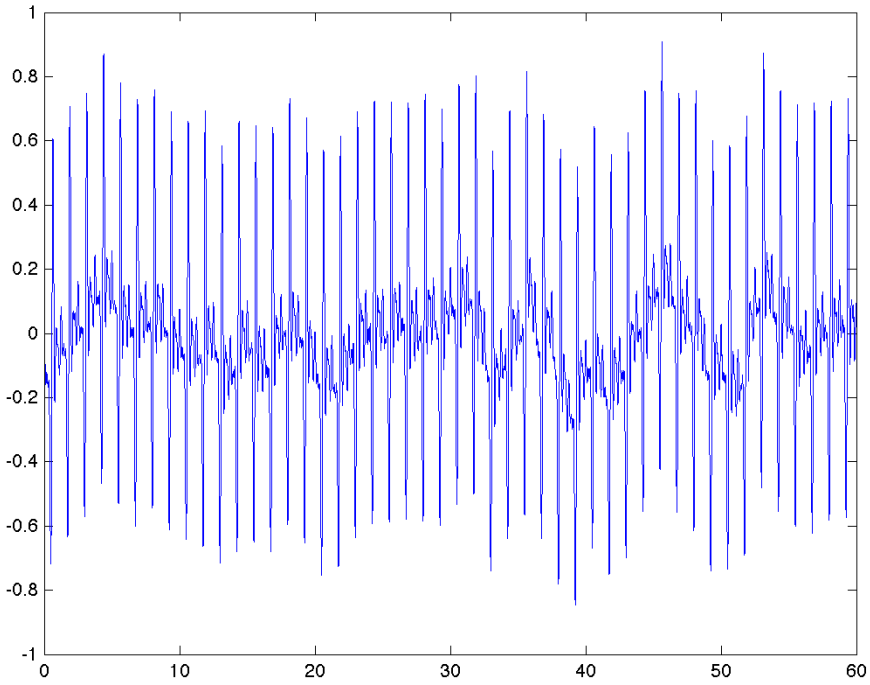
Here is the result of loudspeaker play of the Fig 55 wave. I actually hit it a little too hard by about 4 dB and got a little distortion. Plots are the ensemble average of 4 minutes of pulses and the SPL spectrum, measured with a 4193 microphone just above the listener's head. I just used my standard 0.8 Hz BPF to avoid a lot of program tinkering. Also shown is the first minute of raw data. This is a pretty calm day, so the atmospheric infrasound isn't too bad.

The normal-hearing human evaluator and I had zero reaction to ten minutes of this. The hyper-sensitive evaluator will be in for an audition later this evening

Bruce

Submission from Steven Cooper

APPENDIX B3



Dr Bob Thorne

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21 January 2014

Mr Steven Cooper
The Acoustics Group
Sydney
Em. drnoise@acoustics.com.au

Dear Steven

Cape Bridgewater Wind Farm Acoustic Study

Congratulations on the release of your benchmark research into the effects of wind farm activity and the measurable effects on persons living in the locale. At 235 pages for the report and 6 technical annexures (491 pages) the study cannot be matched by any previous wind farm study in Australia. The research is a unique contribution to science and is remarkable and ground-breaking:

1. The determination of the actual physical parameters involved in the measurement, interpretation and assessment of wind farm noise (audible and infrasound) on persons is formalised and supported by extensive documentation.
2. The development and determination of the concept of 'sensation' as distinct from 'noise' due to infrasound, low frequency sound, audible sound or vibration is ground-breaking and unique. The concept has an important place alongside standard measures such as 'quality of life' and psychoacoustical correlates.
3. The obvious support from both PacificHydro and the residents is the stand-out feature of the study and it is clear from the text that the outcomes were not envisaged by yourself or the study participants at the commencement of the study. The approach taken is highly professional and supportive to both your client (PacificHydro) and sympathetic to the residents who provided you with their assistance.

The study is extremely comprehensive. Outcomes immediately apparent from an overview of the study that should become a vital part of any present and future wind farm study are:

1. Measurement and analysis methodologies for instrumentation and uncertainty derived from the study are now the benchmark for all acoustic consultants, scientists and engineers involved in the field;
2. The determination of a wind turbine signature at two different frequency 'sets' related to sensation is unique. The sensation frequencies are grouped in the infrasound 1Hz to 5Hz and low frequency 30Hz to 35Hz bands for the Repower 88 turbines. Different turbines will have

different centre frequencies and sidebands at the blade pass frequency. The methodologies for determining sensation are the link-points for many other studies that did not have the access to the acoustical data and human response questionnaires developed by you for this study.

3. Infrasound is firmly identified as a standard and normal part of the emissions of a wind farm. The character of the infrasonic emissions is identified as being measurably different from 'ordinary' wind; that is, infrasound generated by/from turbines consists of trains of pressure pulses and must be measured through narrow-band analysis and interpreted accordingly. Standard measures with third-octave bands and G-weighting are found to be not valid identifiers/measures of wind turbine affected wind noise;
4. The determination of a wind turbine signature consisting of the nominal blade pass frequency and first 5 or 6 harmonics is a significant outcome from the study as these frequencies are present and measurable even in high winds.
5. The study provides significant 'food for thought' for power station managers and regulators with respect to the anecdotal issues /questions / complaints of adverse health effects and sleep disturbance, annoyance and loss of amenity and wellbeing experienced by persons living near a wind farm.

The most intriguing part of your study is the set of conclusions dealing with the 'pattern of high severity of disturbance' experienced by the residents with the wind farm in operation. Therefore, the obvious question, based on the detail in your study, is:

Can the operation of the wind farm be modified to reduce or mitigate the disturbances experienced by the residents?

The present situation cannot continue without change. The report has raised hard questions for PacificHydro to discuss with the residents. It is to be hoped - and expected - that support is given for the next steps of resolving the issue of adverse effects and restoring individual amenity and wellbeing to its original status prior to the operation of the wind farm.

Best Regards

Dr Bob Thorne PhD, MAAS, MIOA, FRSPH
Principal

Reference source:
http://www.pacifichydro.com.au/english/our-communities/communities/cape-bridgewater-acoustic-study-report/?language=en

Carmen Krough

Mr. Steven Cooper
The Acoustics Group
Sydney, Australia
drnoise@acoustics.com.au

February 6, 2015

Dear Steven,

Re: Cape Bridgewater Wind Farm Acoustic Study

I have reviewed the results of your acoustical study conducted at the Cape Bridgewater Wind Farm.

Congratulations on your investigation of those reporting adverse health effects.

It is evident this study would not have been possible without the commitment of the families who participated. They are to be commended for carrying out this enormous effort. As well, Pacific Hydro merits recognition for sponsoring the study and being responsive to those reporting adverse health effects.

Through the study design, your exhaustive infrasound measurements, the detailed diaries kept by the families, and Pacific Hydro's cooperation, this study has advanced the understanding of the role of infrasound and human responses associated with industrial wind turbines. Such collaborative efforts have set a new standard for conducting future research.

The study applied the term "sensation" which includes "headache, pressure in the head, ears or chest, ringing in the ears, heart racing or a sensation of heaviness". Based on reports of affected neighbours in Ontario, sensation is an appropriate term for describing human responses to infrasound. In medicine and physiology the term sensation can be more informative than the commonly used term of "perception". In addition, severity rankings should be included in future study designs when recording perceived noise and vibration impacts and other disturbances.

This important effort on the part of all parties is expected to benefit future research and inform knowledge on the risk of human exposure to industrial wind turbines.

Congratulations to all those who were involved.

Yours truly,

Carmen Krogh, BScPharm
Independent researcher, Ontario, Canada

Submission from Steven Cooper APPENDIX B7

Professor Dickinson

From: Philip Dickinson
Sent: Thursday, 22 January 2015 4:02 PM
To: Steven Cooper

Dear Steve
That's a remarkable piece of work you have done. It is indeed ground-breaking and seminal, in the sense that it will lead to an entirely new set of research topics that can lead to great public health benefits. The clue is that someone bending over had increased sensation. This could be a very good Ph.D., subject if you want to go that way. It is the otolith organs that are more affected by low frequency and infrasound than the cochlea.

Kind regards Philip D

From: Philip Dickinson
Sent: Tuesday, 27 January 2015 1:37 PM
To: Steven Cooper

Dear Steve
Thank you for emailing me a copy of your draft sensation report. Again that is another excellent piece of work – albeit still a little long. Again it is almost a dissertation rather than a paper suitable for a journal, which is where I expect you really would like it to go. You should aim for a maximum of about 8 pages if you want the world to sit up and take notice – which it really should about the work you have done for at the very least you deserve that.

Dr Malcolm Swinbanks

Steven,

It is clear that you have established a direct correlation between specific complaints and the infrasound associated with certain modes of operation of the wind-turbines. No matter how Pacific Hydro choose to spin this, they will inevitably have been placed on the back foot.

The important requirement is to compile similar, independently acquired evidence from other windfarms, so that your results cannot be dismissed as being the coincidental result of a flawed technique.

I believe that such evidence is accumulating. The reality of competent science is that once a clear process of cause and effect becomes established, it is impossible to turn back the clock and unlearn that process.

Best Wishes,

Malcolm

Robert Rand

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January 21, 2015

Mr. Steven Cooper
The Acoustics Group
Sydney
E-mail: drnoise@acoustics.com.au

Dear Steven,

Re: Cape Bridgewater Wind Farm Acoustic Study

Congratulations on this superlative work investigating the neighbor reports and correlating (unintended) adverse effects of the facility. The scope and detail of your report is sure to assist acoustic investigators, planners, utilities, and the public to understand without any further doubt or dismissal what wind turbine neighbors have been saying for years, as you so clearly sum up,

"What we found was that previously they were complaining about the noise, but it wasn't really the noise, it was sensations."

The report's establishing of tonal energy at the blade pass and harmonics along with higher frequencies with sidebands as the wind turbine signature, puts to rest any further tendency by acoustic professionals to rely on constant-percentage bands to attempt to assess neighbor impacts from wind turbine signals.

The correlation of sensation level to WTS tone level in the infrasonic and audible bands brings wind turbine acoustics right to the door of medical science. Medical tests in the homes, long overdue, can now be correlated directly to WTS. May the medical testing in homes begin without further delay.

I would like to express my deep appreciation to Pacific Hydro for sponsoring the study and providing turbine on/off conditions for evaluation.

Best Regards,

Robert W. Rand, ASA, INCE

Stephen Ambrose

Tel: 207-892-6691 S.E. Ambrose & Associates Email; sea@myfairpoint.net
15 Great Falls Road, Windham, ME 04062
Acoustics, Environmental Sound & Industrial

January 22, 2015

Mr. Steven Cooper, INCE, AAS, ASA
The Acoustics Group Pty Ltd
20-22 Fred Street
Lilyfield, 2040, NSW, Australia

Ref: Cape Bridgewater Wind Farm Acoustic Study

Congratulations, I commend you for pursuing scientific truth by investigating the human response to large wind-turbines in the acoustic environment. Your correlation of human response journal entries with scientific waveform analysis clearly shows hearing is not limited to audible sounds. Research continues to reveal that the ear has multiple functions and capabilities. This study merits recognition by acoustic and public health professionals for more research.

Your study goes far beyond the 1980s Neil Kelley et al. studies that identified operating wind-turbines can produce airborne transmissions that humans detect as "sensations". Bray/James research showed that one-third octave band filters could not measure the low-frequency peaks produced wind-turbines.

Neighbors' complaints were ignored by the majority. Acoustic experts failed to understand the limitations of their instruments and analysis methods. The Cape Bridgewater Wind Farm Analysis Study should end blaming the neighbor. Neighbors deserve respect. Experts earn respect.

Before wind turbines, the highest negative community reaction was "vigorous community action to stop the noise". Wind turbines have raised the bar to "home abandonment". This life-saving option is not affordable; most experience diminished quality of life, degradation of health, and loss of wellbeing. The population majority remains unknowing and unaffected by wind turbines because they live far away or genetically protected from "sensations". I was surprised to learn that I should not live near a wind turbine neighbor. I have no sympathy; I have real empathy.

Thank you and best wishes.

Respectfully,

Stephen E. Ambrose, ASA, INCE, *Board Certified*
Principal Consultant

PO Box 290
WOODEND
VIC 3442
AUSTRALIA

Email:
OFFICE@LHUSON.COM

Fax: 03 5427 1443

LHUSON & ASSOCIATES
Consultant Scientists in Acoustics

27 February 2015

Mr Steven Cooper
The Acoustics Group
20-22 Fred Street
Lilyfield
NSW 2040

Our Reference: LHA365/TAG1

Dear Steven

Firstly, I want to congratulate you on your recent work at the Cape Bridgewater Wind Farm. I fully understand the amount of effort required in analysing many gigabytes of data, which, in part, explains the delay in sending this letter since I must balance my efforts between research and consulting obligations.

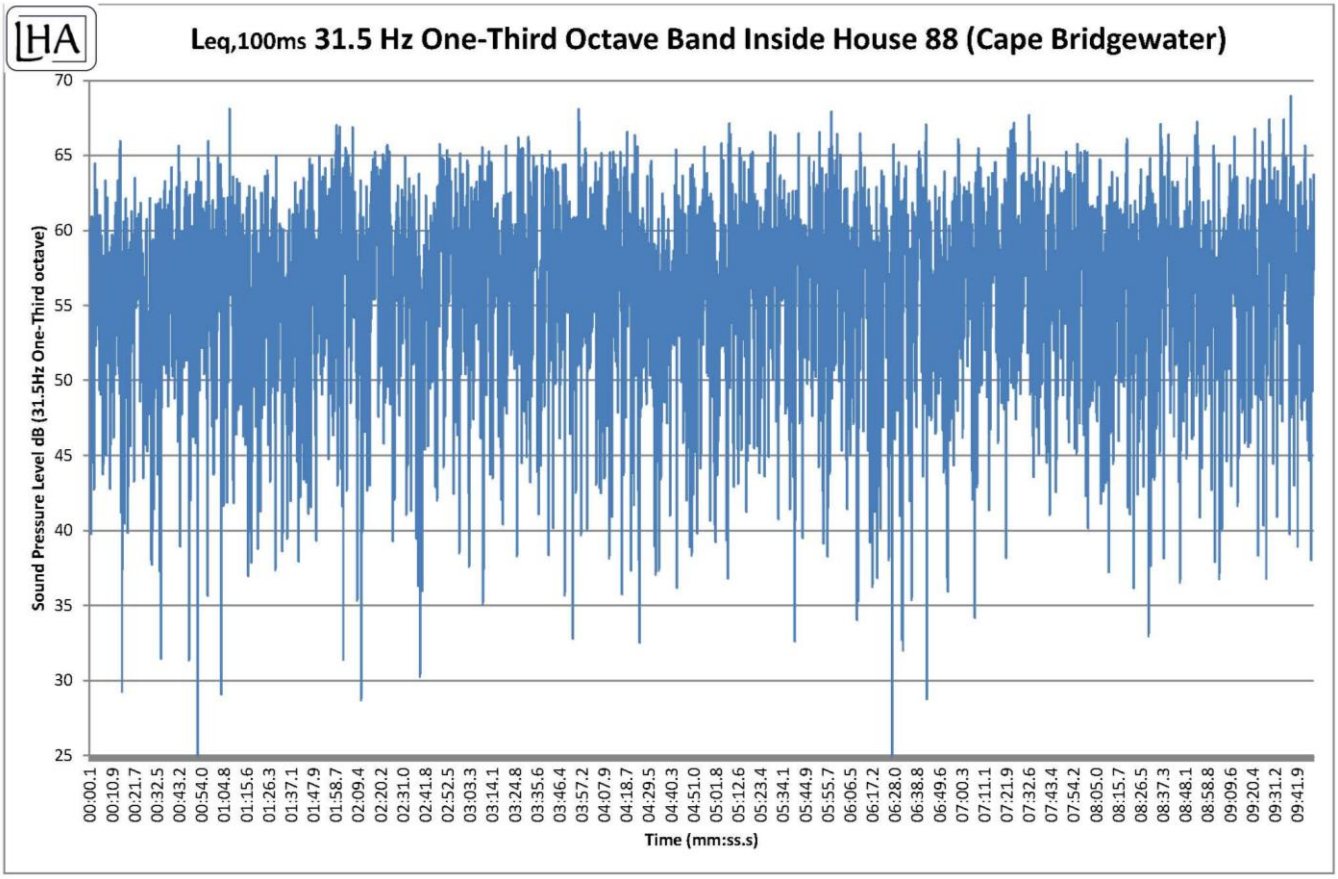
I have been independently gathering sound data in the audible and infrasound parts of the acoustic spectrum at numerous wind farms in Australia, the UK and Ireland over the past three years. Some of my data was recorded inside residences near to the Cape Bridgewater Wind Farm and I would like to corroborate your findings of a 31 Hz tonal signal, with sidebands, at that location. I have recorded audible and infrasound data inside house 88 that you refer to in your report and note from your work that long term monitoring indoors at this property was not part of your study. Perhaps you will find the results of my own work complimentary to your findings.

At the end of 2012 and the beginning of 2013 I completed long term audio recordings in an unoccupied bedroom of house 88 using a Type 1 sound level meter and digital recording equipment. Subsequently, I completed infrasound measurements at the same location at the end of 2013 and the early part of 2014, during which time I too observed a start-up of the wind farm. That information is included in a paper to be presented at the INCE/EUROPE Wind Turbine Noise Conference at the end of April 2015 in the UK.

I have now completed analysis of some of my recordings from 2012/2013 inside house 88 and can inform you of the results.

I have used the DEFRA funded UK research, NANR45 'Proposed criteria for the assessment of low frequency noise disturbance' Feb 2005 as a guide to determine the severity of the 31 Hz tone, and sidebands, that are found in the 31.5 Hz one-third octave band. The DEFRA research recommends a maximum indoor unweighted 31.5 Hz one-third octave band sound level of 56 dB.

The following chart is typical of many 10-minute samples I recorded that presents 100ms Leq values in the 31.5 Hz one-third octave band. The data for this chart was measured inside house 88 around 4am on 19 December 2012.



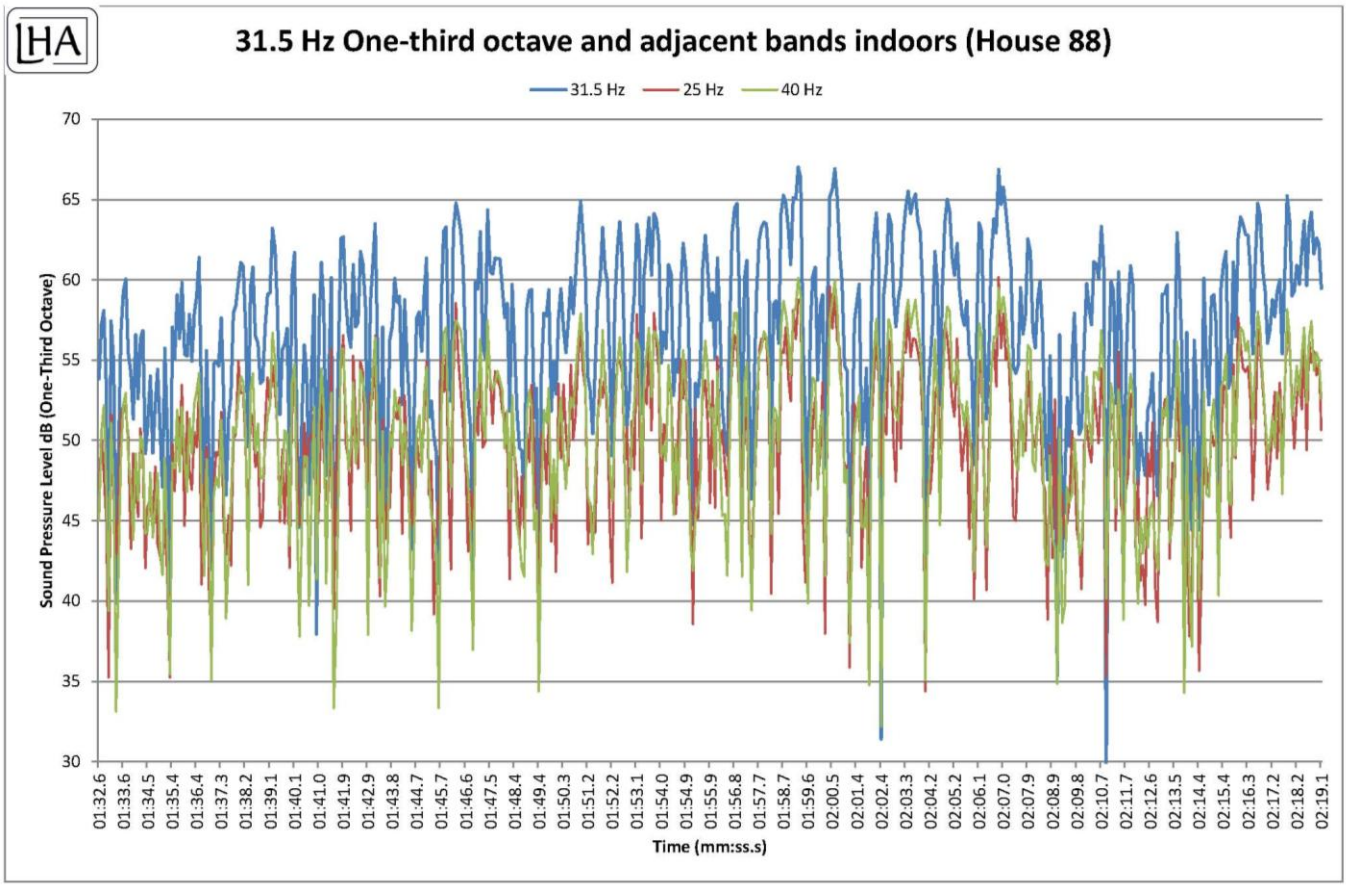
The next chart shows a 'zoomed-in' part of the same data showing the amplitude variation more clearly (amplitude modulation, AM) and the adjoining one-third octave bands that show the prominence of the 31.5 Hz band. It would appear from the randomness of the AM that the tone(s) is (are) formed from multiple sound sources operating with different phase (multiple wind turbines).

I have also completed audio recordings near to the Leonards Hill Wind Farm in Victoria that has two MM82 wind turbines. Data from those recordings were part of a paper prepared in March 2014 on AM.

A key finding from comparing the data at Cape Bridgewater to that from Leonards Hill is that the 31 Hz tones are absent at Leonards Hill, despite the turbines being of the same MM82 nameplate as those at Cape Bridgewater. It may be that the 31 Hz tone (which I believe to be a resonance associated with the Cape Bridgewater wind turbines) may have been identified by the manufacturer and fixed prior to the construction of the Leonards Hill Wind Farm in 2012. Alternatively, it may be that the wind turbines may be of different 'flavours' since there is a low speed and high speed option available, for example.

My measurements at Deeping St Nicholas (UK) in 2014, that also has MM82 wind turbines, did not show signs of the 31 Hz family of tones, despite that wind farm being completed in 2006. However, my measurements at the Earls Hall Wind Farm (UK) in 2014, that uses MM92 wind turbines and was constructed in 2012, does show the family of tones around 31 Hz.

It would obviously pay dividends in such research if the turbine manufacturers would be willing to assist by sharing information from their dynamic analyses of these machines.



Steven, you will see that the proposed acceptable sound level (56 dB) in the 31.5 Hz one-third octave band is exceeded by up to 10 dB.

Notwithstanding the findings of 'sensations' attributable to the wind turbine signature in your report for Cape Bridgewater it is also apparent that indoor audible sounds far exceed, the widely accepted, UK limits in house 88.

The residents of house 88 reported to me regular feelings of vibration. Although I have not taken any vibration measurements at Cape Bridgewater I have listened to the audio samples recorded and can understand why the 31.5 Hz tone could be classed as a 'vibration' by the lay person.

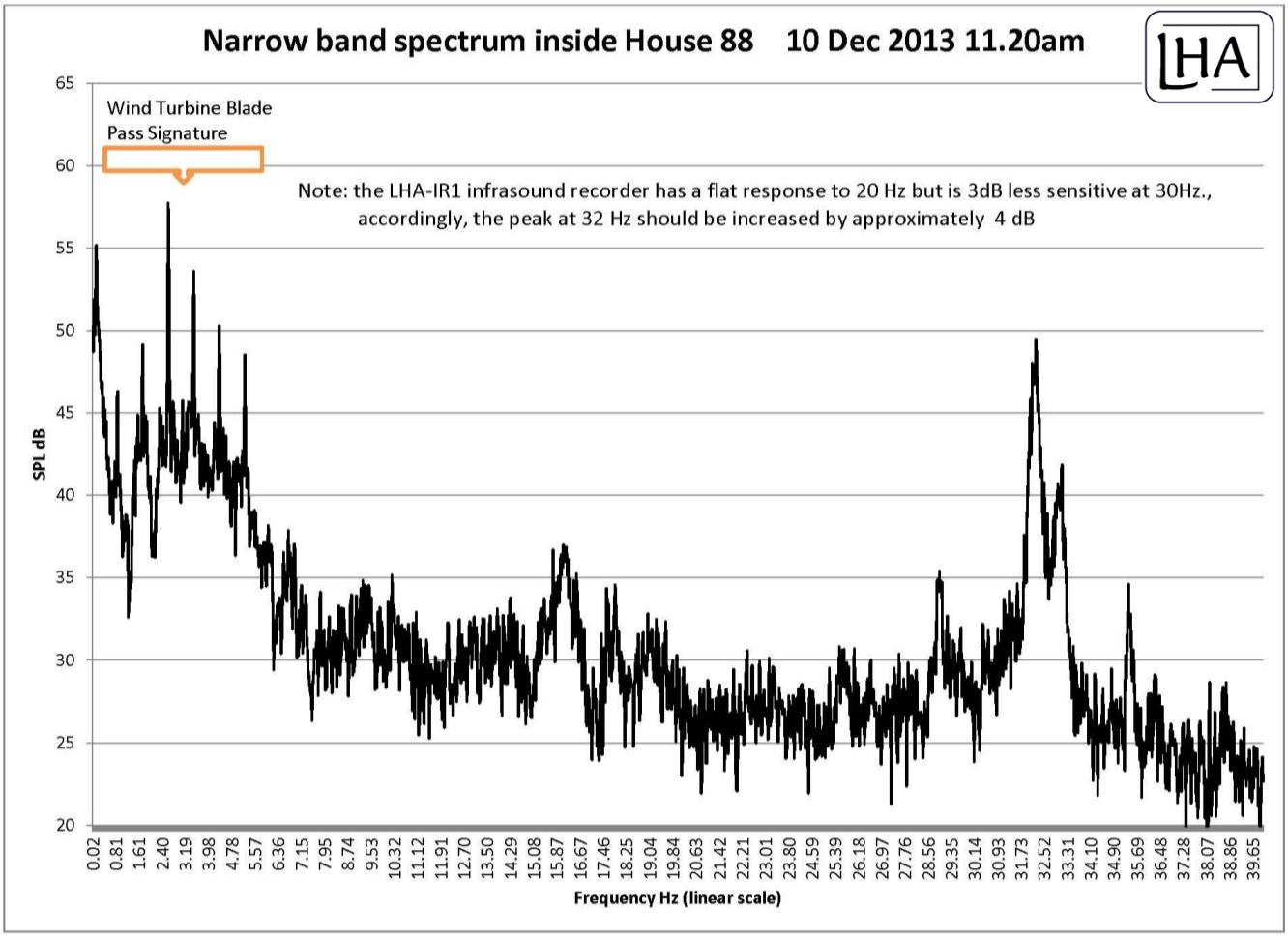
This data and more will form part of another paper that I intend to publish later in 2015.

I have also recorded infrasound levels in house 88 at the end of 2013 through to the beginning of 2014 using a microbarometer based LHA-IR1 infrasound recorder. This recorder captures infrasound signals faithfully up to 20 Hz but also records the lower audible frequencies with slightly reduced sensitivity.

The following chart is a sample of the LHA-IR1 results which typically show the blade pass frequency and harmonics you describe in your report as WTS and extends to include frequencies above 20 Hz.

The peaks in this chart (11.20am 10 Dec 2013) show narrow band spectrum results around 32 Hz consistent with measurements from the year before.

It is clear that the audible spectrum peaks in the 31.5 Hz one-third octave band have been present for a number of years and that the infrasound blade pass frequencies match those from your study.



I have no issue with my results being shared and hope that you find the above of interest.

If you wish to discuss any of my findings, please call.

Yours sincerely,

W Les Huson BSc(Hons) MSc CPhys MInstP MIoA MAAS MEIANZ

Dr Paul Schomer

Steve

Your study is great. Congratulations

Attached is my review of the study and its implications. If its OK, feel free to send it to anyone you want to have it

Paul

--
Paul Schomer
Standards Director, Acoustical Society of America
Schomer and Associates, Inc.
2117 Robert Drive

Champaign, IL 62821

Dr Paul Schomer and George Hessler

The Results of an Acoustic Testing Program, Cape Bridgewater Wind Farm Prepared for Energy Pacific by Steve Cooper, The Acoustic Group

A Review of this Study and Where It Is Leading

Paul D. Schomer, Ph.D., P.E.;
Schomer and Associates, Inc.*;* Standards Director, Acoustical Society of America
George Hessler, Hessler Associates, Inc.
10 February 2015

Recently Cooper has completed a first of its kind test regarding the acoustical emissions of wind turbines. His is the first study of effects on people that includes a cooperating windfarm operator in conjunction with a researcher that does not work exclusively for windfarms. This study makes three very simple points:

1. There is at least one non-visual, non-audible pathway for wind turbine emissions to reach, enter, and affect some people
2. This is a longitudinal study wherein the subjects record in a diary regularly as a function of time the level of the effects they are experiencing at that time
3. This periodic recording allows for responses as the wind-turbine power changes up and down, changes not known by the subject

The results are presented in a 218 page report augmented by 22 appendices spread over 6 volumes so that every single detail in the study has been documented for all to see and examine. The methods and results are totally transparent. The 22 appendices and the main text exhaustively document everything involved with this study.

Six subjects, 3 couples from different homes are the participants in this study. They do not represent the average resident in the vicinity of a wind farm. Rather, they are self-selected as being particularly sensitive and susceptible to wind farm acoustic emissions, so much so that one couple has abandoned their house. Cooper finds that these six subjects are able to sense attributes of the wind turbine emissions without there being an audible or visual stimulus present. More specifically, he finds that the subject responses correlate with the wind turbine power being generated but not with either the sound or vibration.

Although the very nature of a longitudinal study provides for a finding of cause and effect, some will undoubtedly argue that a correlation does not show cause and effect. In this case they must postulate some other thing like an unknown “force” that simultaneously causes the wind turbine power being generated and symptoms such as nausea, vertigo, and headaches to change up and down together. But that is the kind of “creative” logic it takes to say that this correlation does not represent cause-and-effect. So, rather than making such groundless arguments, perhaps something like an “expert statistical analysis” can be expected “proving” this is not a “valid sample” of the public at large, or proving the study does not do something else it was *never* intended to do.

So it is important to sort out what, by design, this study was intended to do and does do, and what, by design, it was not intended to do and does not do. This study is not in any way a sample of the general population nor is it in any way a sample of the general population in the vicinity of windfarms. According to Cooper’s report, this study was intended to address the issue of complaints from residents in the vicinity of Pacific Hydro’s Cape Bridgewater Wind Farm. Pacific Hydro requested the conduct of an acoustic study at 3 residential properties to ascertain any identifiable noise impacts of the wind farm operations or certain wind conditions that could relate to the complaints that had been received. The study was to incorporate three houses that are located between 650 m and 1600 m from the nearest turbine. This research represents a case study at 3 houses, each with one couple, 6 people. This is one sample, and only one sample, of a small group of people who are all self-selected as being very or extremely sensitive to wind turbine acoustic emissions. A similar group could be assembled elsewhere such as in Shirley Wisconsin, USA or Ontario Canada.

This study finds that these 6 people sense the operation of the turbine(s) via other pathways than hearing or seeing, and that the adverse reactions to the operations of the wind turbine(s) correlates directly with the power output of the wind turbine{s} and fairly large changes in power output.

Attempts may be made to obviscate these simple points with such arguments as it cannot be proved that infra-sound is the cause of the discomfort. But that again is a specious argument. The important point here is that something is coming from the wind turbines to affect these people and that something increases or decreases as the power output of the turbine increases or decreases. Denying infra-sound as the agent accomplishes nothing. It really does not matter what the pathway is, whether it is infra-sound or some new form of rays or electro-magnetic field coming off the turbine blades. If the turbines are the cause, then the windfarm is responsible and needs to fix it. Anyone who truly doubts the results should want to replicate this study using *independent* [1]acoustical consultants at some other wind farm, such as Shirley Wisconsin, USA, where there are residents who are self-selected as being very or extremely sensitive to wind turbine acoustic emissions[2].

Some may ask, this is only 6 people, why is it so important? The answer is that up until now windfarm operators have said there are no known cause and effect relations between windfarm emissions and the response of people living in the vicinity of the windfarm other than those related to visual and/or audible stimuli, and these lead to some flicker which is treated, and "some annoyance with noise." This study proves that there are other pathways that affect some people, at least 6. The windfarm operator simply cannot say there are no known effects and no known people affected. One person affected is a lot more than none; the existence of just one cause-and-effect pathway is a lot more than none. It only takes one example to prove that a broad assertion is not true, and that is the case here. Windfarms will be in the position where they must say: "We may affect some people." And regulators charged with protecting the health and welfare of the citizenry will not be able to say they know of no adverse effects. Rather, if they choose to support the windfarm, they will do so knowing that they may not be protecting the health and welfare of all the citizenry.

http://www.pacifichydro.com.au/pacific-hydro-releases-cape-bridgewater-wind-farm-acoustic-study/

http://www.pacifichydro.com.au/english/our-communities/communities/cape-bridgewater-acoustic-study-report/?language=en

[1] Independent Consultants are those who have worked for both industry and communities, and or have espoused the need for research to sort out the issues of people reacting to non-audible non-visual stimuli.

[2] Cooper's test shows cause and effect for at least one non-visual, no-audible pathway to affect people. If one only wanted to test for the ability to sense the turning on of wind turbines, and not replicate the cause and effect portion of Cooper's study, this reduced test could be accomplished in one to two months with a cooperative windfarm where there are residents who are self-selected as being very or extremely sensitive to wind turbine acoustic emissions and who also assert that they have this sensing ability. This study, a subset of the full Cooper tests, would only prove, again, that non-visual, non-auditory pathways exist by which wind turbine emissions may affect the body and "signal" the brain.

Further comments on the Cape Bridgewater Wind Farm Study--Muddying the waters

The Cooper report on the Cape Bridgewater Wind Farm is well-documented and states exactl y what it does,

but, as predicted, there are those who seek to obviscate what the report is with specious ar guments

Paul D. Schomer, Ph.D., P.E.;

Schomer and Associates, Inc.*;* Standards Director, Acoustical Society of America

George Hessler, Hessler Associates, Inc.

20 February 2015

On 10 February 2 015 George Hessler and I warned that rather than making patently groundless arguments, something like an "expert statistical analysis" could be expected "proving" this was not a "valid sample" of the public at large, or proving the study did not do something else it was *never* intended to do. Now we see the assertion that this was a "medical study" and that Steven Cooper, George and I are not qualified to make medical judgements. And of course we are not medical researchers, but it is the predicate that is wrong. This is not a medical study, and these are not medical conclusions. As predicted, this study is being made to be something that is not.

To explain this we offer the following analogy. Part of the condition of being a human is we get gas. And certainly many if not most have observed the cause-and-effect relation between eating beans and a certain aromatic condition. We ask each reader to reflect on this. Does it take a medical researcher to tell you that eating beans causes gas in some people? Certainly not. The medical research may say why or how the gas is produced in the body. But anyone can make the simple observation of the relation between eating beans and the aromatic condition, cause-and-effect, literally the input to and the output from the system.

The Cooper study is a variation of how one "discovers" the relationship: beans in – gas out. Cooper examines three possible inputs: sound level of the receivers (six subjects), the vibration levels at the receivers, and the power output of nearby turbines. Cooper's outputs are the periodic observations by each subject as to the degree by which they feel they are being affected by wind turbines, specifically at the time they are giving these observations. The cause and effect is found between the input, the turbine power, and the outputs, subject's judgements as to the degree they are being affected at the time. As with the beans in – gas out example, the processes inside the body are not explained; nothing "medical" is dealt with. Just the inputs to and the outputs from the body are dealt with. The result is as the wind turbines affect these 6 subjects and that the greater the turbine power, the greater the degree of effect. And, of course, the subjects had no knowledge as to the power output of any of the wind turbines

The results are that there is a cause and effect relationship between turbine power output and subject response, and, at the same time there is no correlation between subject response and either sound level or vibration level. These results show that there is a non-visual, non-audible pathway by which wind turbine emissions can cause some specific effects in some people. These results say nothing about the nature of these effects. Nothing internal to the body is

discussed. We again reiterate to government and to wind farm operators, if you don't believe the results, replicate the study using clearly independent consultants[1.]

Some may ask, this is only 6 people, why is it so important? The answer is that up until now windfarm operators have said there are no known cause and effect relations between windfarm emissions and the response of people living in the vicinity of the windfarm other than those related to visual and/or audible stimuli, and these lead to some flicker which is treated, and "some annoyance with noise." This study proves that there are other pathways that affect some people, at least 6. The windfarm operator simply cannot say there are no known effects and no known people affected. One person affected is a lot more than none; the existence of just one cause-and-effect pathway is a lot more than none. It only takes one example to prove that a broad assertion is not true, and that is the case here. Windfarms will be in the position where they must say: "We may affect some people." And regulators charged with protecting the health and welfare of the citizenry will not be able to say they know of no adverse effects. Rather, if they choose to support the windfarm, they will do so knowing that they may not be protecting the health and welfare of all the citizenry.

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http://www.pacifichydro.com.au/english/our-communities/communities/cape-bridgewater-acoustic-study-report/?language=en

[1] Cooper's test shows cause and effect for at least one non-visual, no-audible pathway to affect people. If one only wanted to test for the ability to sense the turning on of wind turbines, and not replicate the cause and effect portion of Cooper's study, this reduced test could be accomplished in one to two months with a cooperative windfarm where there are residents who are self-selected as being very or extremely sensitive to wind turbine acoustic emissions and who also assert that they have this sensing ability. This study, a subset of the full Cooper tests, would only prove, again, that non-visual, non-auditory pathways exist by which wind turbine emissions may affect the body and "signal" the brain.

George Hessler

Hessler Associates, Inc.
Consultants in Engineering Acoustics

Comments on the Cooper Study at the Cape Bridgewater Wind Farm and Wind Turbine Infrasound by George Hessler, 3/9/2015

I agree with and have endorsed my colleague Paul Schomer's review of the subject Cooper report except possibly that there is an *unseen and unheard* path to the receivers since this could not be controlled in any way and it appears both paths can be observed, at least at the closer residences. Even so, Paul and I, for years now, have done all we could possibly do to encourage and promote objective scientific research into this most perplexing issue and the Cooper Study is undeniably an important step.

It is a pity and it is apparent that such an important issue cannot be debated civilly and objectively. In my opinion, Pacific Hydro should be commended for making the Cooper Study possible. Instead, they are vilified for doing nothing more than their charter to create clean energy in accordance with all the substantial applicable regulations imposed by permitting authorities. Likewise, wind turbine proponents should acknowledge the study has merit and join the call for additional research to get to a solution that all can accept and move on.

In my opinion, the only solution is a field or laboratory simulation of wind-turbine specific and broadband infrasound in general played to large unbiased subject groups all over the globe. This is technically challenging to say the least, but the results could establish a Threshold of Perception and a Threshold of Annoyance for both types of infrasound sources (broadband and tonal). There is also a Threshold of Pain that can be experienced simply by lowering the rear windows of a typical automobile at highway speed to experience very high levels of infrasound. Just as important, the simulation testing may show that there are a small percentage of subjects that are extremely or acutely sensitive to wind-turbine infrasound. If this is known and it can be documented for individuals, wind turbine sites could still be permitted economically, but with just consideration for acutely sensitive neighbors that may elect to uproot their homes. Another colleague, Dr. Bruce Walker is at the forefront of the simulation approach.

I understand the passion and acknowledge the suffering of some at wind-farms. At one home occupied by a young couple and baby, the baby awakened screaming on windy nights, but never away from home. The home was mistakenly (50 dBA target) sited much too close to wind-turbines. The wife was seriously annoyed while the husband was not annoyed at all. This one case demonstrates the complexity and seriousness of the wind-turbine health effects issue. The couple solved the issue by relocating at their great personal expense.

Probably naïve and preachy to say, but if we all lower the rhetoric a little, maybe we could all start finding a solution.

Professor Brigette Schulte-Fortkamp

Dear Steven Cooper,

I was so pleased to hear of your initial research into low frequency sound in the environment, as measuring and protecting our natural soundscape is a major interest and the subject of much ongoing research. I consider your study "THE RESULTS OF AN ACOUSTIC TESTING PROGRAM CAPE BRIDGEWATER WIND FARM 44.5100.R7:MSC as most important regarding environmental planning and quality of life. We hope to hear more in the future!!

Steven, I would like to invite you into the current discussion within ASA on this topic. Moreover, please feel invited to Inter Noise 2015 in San Francisco in my structured session on Soundscape. You might know that Internoise 2015 does have a new concept- there will be a special focus on case studies to learn about the approaches that were used, and moreover: to learn about new procedures in environmental acoustics, also focusing on Soundscape approaches. Your work does fit perfectly here. If you agree, I would like to introduce your work to the Soundscape community, but also to the group that works currently on such research like you: to understand people's reaction to noise of windfarms. Paul Schomer et al will shortly publish a study within JASA which should mee t your interest.

I am looking forward to hear from you soon! Please send me your contact data that I can send you the official invitation for Internoise 2015.

With my very best regards
Brigitte Schulte-Fortkamp

Prof. Dr. Brigitte Schulte-Fortkamp
Technical University Berlin
ASA Vice President 2011-2012
Co Chair COST Action Soundscape
Receiver European Soundscape Award

From: Brigitte Schulte-Fortkamp
Date: March 18, 2015 at 12:12:44 PM GMT+1
To: Steven Cooper <drnoise@acoustics.com.au>
Subject: Re: International standards and measurement difficulties my message to Steven

Steven,

Thanks so much for your reply!!!

Sorry to be so late with my reply, but I am currently at the yearly conference of the German Acoustical Society, a bit loaded with all things relevant for me as a board member. But, just now I am listing to a great Keynote here on windturbine by Dominic Von Terci et al talking about Sound Mitigation : Source Reduction.

I am looking forward to meet you soon in Pittsbourgh. Today you will receive my invitation to present your work at Internoise 2015 in San Francisco.

44th Inter-Noise Congress & Exposition on Noise Control Engineering

Implementing Noise Control Technology

http://internoise2015.com
Secretariat: Cathy Vail | cathy@inceusa.org

Dear Steven Cooper,

InterNoise 2015 will be held in the Marriot Marquis Hotel in downtown San Francisco on 9-12 August 2015. The conference is being organized by the Institute of Noise Control Engineering/USA (INCE/USA), the Korean Society of Noise & Vibration Engineering (KSNVE), ASME Noise Control and Acoustic Division (NCAD) and ADC 40 Noise & Vibration Committed of the Transportation Research Board (TRB). With all of these players and this venue, InterNoise 2015 promises to be an exciting, rewarding and fun conference.

I am pleased to be an organizer of a core technical session on ***Soundscape.*** I am hoping that you can be part of this session at InterNoise 2015. **Please consider this an invitation to submit a paper for this session and focusing on your recent work on wind turbines and focusing on the "sensation" observations by the residents.**

Your abstract may be submitted online at the 'InterNoise2105' under 'Abstract Submission'. First enter a User Name and Password and then registration information. Then look for the title of the session **Soundscape under 'Core Technical Sessions'.** The title, authors and abstract for your paper may then be entered under the tab 'Submit Abstract' on the right.

Thank you for considering this invitation to submit a paper to InterNoise 2015. I look forward to hearing from you soon and to your participation in what I am sure will be a great conference.

Sincerely,
Brigitte

Prof. Dr. Brigitte Schulte-Fortkamp
TU Berlin Germany

Emails of support to continue the research from:

Dr Gilles Digle –	Past President of the Canadian Acoustical Society, Past President of the Acoustical Society of America , Head of the National Research Council of Canada.
Dr Truls Gjestland –	Former Chief Scientist at Sintef (Norway's equivalent of Australian's CSIRO)
Dr William Lang	Founder and Former President of Institute of Noise Control Engineering, Former President of the Acoustical Society of America, Chief Scientist for IBM
Dr Lou Sutherland	Past President of the Acoustical Society of America, Former Chief Scientist for Wylie Laboratories
Professor Tor Kihlman	Former Head of Department of Engineering at Chalmers University and Past President of the International Institute of Noise Control Engineering.

Mr Cooper: In my report I have provided the two papers, which I have had peer-reviewed, and the technical article that appeared in the August edition of the Australian Acoustical Society's journal. It appears as an attachment. And the second paper, 'Are wind farms too close to communities?' also appears already in my submission, and I can give you a list of the other peer reviews that I have conducted that have been reviewed by other acousticians before they went out.

CHAIR: Thank you. Have you had discussions with the acoustic engineers working for the New South Wales government Department of Planning and/or the EPA with regard to your wind farm studies?

Mr Cooper: There was only one engineer in the Department of Planning. His name is Jeff Parnell. The answer is: yes and no, in that I had discussions with him prior to my undertaking the work, and at a recent meeting that was at Cullerin he refused to talk to me. As to the EPA, the EPA had said that they are not involved in it at the present time. I have had some informal discussions with two officers of the EPA who have asked me about the technical aspect of my measurements because I have used equipment that they do not have; it is more sophisticated. I had to explain to them about the frequency responsive microphones so that they could understand my data and do the corrections.

CHAIR: So the New South Wales department would not talk to you?

Mr Cooper: The one officer who is handling noise, at a meeting which was part of an audit process for Cullerin, refused to talk to me and had his back to me for the entire two hours.

CHAIR: Was there any other state government reaction to your studies?

Mr Cooper: No. There was actually a deafening silence.

CHAIR: It is like that on the wind farm!

Mr Cooper: There was an extensive submission that went in in relation to the wind farm draft guidelines issued by the department. There were only four technical submissions in acoustic terms. Mine had detailed information, and it actually had where I had tried to do compliance testing and came up with the problems of not having the information. I gave the examples and there has been no response, but there were some discussions with the aforementioned New South Wales EPA officers about my methodology and measurements.

CHAIR: Are you aware of a company called Sonus?

Mr Cooper: Yes, I am.

CHAIR: Are they a reputable company in sound engineering?

Mr Cooper: To some people, yes; to some people, no.

CHAIR: To you?

Mr Cooper: No—not on the work that I have seen they have done.

CHAIR: So they are not reputable?

Mr Cooper: I have found problems with their work and misrepresentation in terms of what they have reported about wind farms.

CHAIR: Are you aware that they have been working on wind farm noise issues since 2002?

Mr Cooper: Yes.

CHAIR: So they are not competent?

Mr Cooper: One of the persons I have spoken to is competent. I have had lengthy discussions with him.

CHAIR: What happened to his input? One of them is competent. Are there other incompetent people at Sonus?

Mr Cooper: I have not discussed with the other people. I had the opportunity when I was at a public meeting at Wellington to talk to one of the authors of the reports and we discussed some of my findings. He was most interested in my work and that I had uncovered new areas of research that had not been looked at before. He advised me that he would also like to investigate that, but there was no funding to look into the areas that I had exposed.

CHAIR: Who is funding your analysis?

Mr Cooper: Regarding my analysis—you are looking at it—I have had some funding from some communities where I have done some peer reviews. The Goyder regional council did a peer review on Stony Gap, but 95 per cent of the work that I have done with consulting fees comes to probably a quarter of a million in the last 12 months.

Commonwealth of Australia

STATUTORY DECLARATION

Statutory Declarations Act 1959

1 *Insert the name, address and occupation of person making the declaration*

I,[1] Steven Edwin Cooper of 22 Fred Street, Lilyfield NSW 2040 being a professional Acoustical & Vibration Consulting Engineer.

make the following declaration under the *Statutory Declarations Act 1959:*

2 *Set out matter declared to in numbered paragraphs*

[2]

1. The Senate Environment and Communications Legislation Committee issued a report dated November 2012 in relation to the Renewable Energy (Electricity) Amendment (Excessive Noise from Wind Farms) Bill 2012 ("the report").

2. On page 1 of the report there is reference to evidence that I provided during the hearing for the Inquiry as set out on page 32 of Hansard for 14 November 2012.

3. On page 2 of the report under paragraphs 1.6 and 1.7 there are statements attributed to Mr Jeff Parnell who is identified in the report as a scientist with NSW government agencies.

4. The matters set out in paragraphs 1.6 and 1.7 relate to a meeting that was held on Monday 2nd of July 2012 at the home of Mr and Mrs B Edwards at Cullerin.

5. The material set out in paragraph 1.6 is identified in a footnote on page 2 as being correspondence to the committee (from Mr Parnell) received on 28 November 2012.

6. I say the material set out in paragraph 1.6 is incorrect and misrepresents the facts of the matter.

7. I do not have a copy of the correspondence provided to the committee and therefore can only provide a response to what has been printed in the report and placed in the public domain.

8. Mr Parnell claims that I was present as an observer and did not sit around the coffee table with everyone but sat a metre or so, not behind him but to the side. Mr Parnell also claims that I was not part of the meeting and did not contribute or speak to him until we were shaking hands after the meeting when he was leaving.

9. The facts of the matter are that I attended the meeting at the invitation of Mr and Mrs Edwards to be on hand to take note of technical information provided at the meeting. Mrs Edwards identified at the commencement of the meeting that I was there to provide technical advice to the Edwards and explain what was presented in that they had ticked a box to speak with the auditor of a noise audit that had been carried out in relation to the Cullerin wind farm and expected that person to be present.

10. In addition to my attendance to provide technical advice to Mr and Mrs Edwards there was also present Mr C Arnott (from the Boorowa) and one of my staff (Mr L Rhodes) to act as observers.

11. Two officers from the Department of Planning (Mr R Sherry and Mr J Sparkes) were in attendance at the designated time. The start of the meeting was delayed as Mr Parnell was not on time. It was not until some 25 minutes after the meeting had commenced, that Mr Parnell arrived. Contrary to the expectations of Mr and Mrs Edwards the auditor of the noise audit did not attend the meeting.

12. In relation to paragraph 1.6 the table that I and others were sitting at was not a coffee table but was the dining table in a room immediately off the kitchen of the residence. The table is oval in shape and I was seated at the northern end of the table that I understand in that household is normally identified as the head of the table.

13. I was seated at the table and not a metre or so away from the table as stated by Mr Parnell.

14. To my left along the larger axis of the table were the three Department of Planning officers on which in the chair to my left and closest to me was Mr Parnell. On the right-hand side of the table was situated Mr and Mrs Edwards and Mr Arnott whilst set back from the table was Mr Rhodes.

15. Whereas all the other people at the meeting were sitting at the table and facing directly to the table, Mr Parnell was seated at 90° to the table and as such had his back to me for the entire time that he was seated at the table. From my position all I could see of Mr Parnell was his back and his right side.

16. From my notes there was nothing of substance provided by Mr Parnell or the Department of Planning Officers that required input or a contribution from me in that no technical information concerning the results of the audit was presented during the meeting.

17. At the end of the meeting and whilst we still seated I attempted to talk to Mr Parnell to find that he ignored me completely. As such I got up and left the table.

18. Whilst people were having refreshments I attempted to talk to Mr Parnell but he remained talking with other persons.

19. As the officers were leaving and shaking hands (with all persons present) I asked Mr Parnell if he had received the email containing a letter to the editor of the SE Times. He replied "I did". The letter contained a number of defamatory comments and also a statement that the NSW Government "noise experts also conclude that the Cooper report is without merit".

20. I asked Mr Parnell if he had replied to the email. He answered "I didn't".

21. I then asked Mr Parnell if he was the NSW government noise expert mentioned in the article. He replied yes.

22. He then said words to the effect "This is not the right place to talk about it". He then left.

23. Mr Parnell did not say anything else to me.

24. Mr Parnell did not say any words to the effect "but I am happy to do so at another time" as stated in the Senate report.

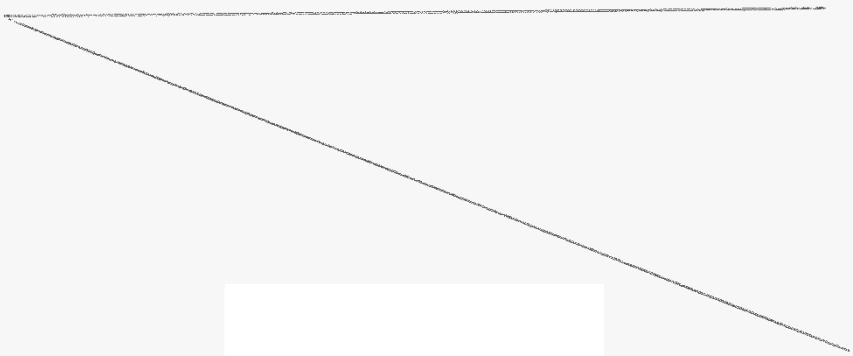
25. Accordingly Mr Parnell has not provided the full extent of his conversation with me as stated in paragraph 1.7 of the Senate report.

26. Paragraph 1.8 of the Senate report refers to information that I had provided as a submission to the Department of Planning and that there had been no response (Hansard page 32 Senate 14 November 2012).

27. In paragraph 1.9 Mr Parnell provides a response to the Committee that he had not responded to my submission because it would not be appropriate to do so under the relevant planning process and specifically refers to the Flyers Creek submission report had not been completed.

28. I say that paragraph 1.9 is both incorrect and deliberately misleading in that on checking page 32 of Hansard it can be seen that my statement as to no response from the Department was specifically in relation to wind farm draft guidelines issued by the Department. I made no statement nor implied that I had sought a response from my submission in relation to the Flyers Creek wind farm.

29. The response in paragraph 1.9 therefore is incorrect.



I understand that a person who intentionally makes a false statement in a statutory declaration is guilty of an offence under section 11 of the *Statutory Declarations Act 1959*, and I believe that the statements in this declaration are true in every particular.

3 *Signature of person making the declaration*

3 [signature]

4 *Place*
5 *Day*
6 *Month and year*

Declared at [4] BALMAIN on [5] 5th of [6] JUNE 2013

Before me,

7 *Signature of person before whom the declaration is made (see over)*

7 [signature]

8 *Full name, qualification and address of person before whom the declaration is made (in printed letters)*

8 MARGARET Miss JONES
Justice of the Peace Reg No 104793
BALMAIN Local Court. Balmain.

Note 1 A person who intentionally makes a false statement in a statutory declaration is guilty of an offence, the punishment for which is imprisonment for a term of 4 years — see section 11 of the *Statutory Declarations Act 1959*.

Note 2 Chapter 2 of the *Criminal Code* applies to all offences against the *Statutory Declarations Act 1959* — see section 5A of the *Statutory Declarations Act 1959*.

Technical Note

Note: Technical notes are aimed at promoting discussion. The views expressed are not necessarily those of the editors or the Australian Acoustical Society. Contributions are not formally peer-reviewed.

WIND FARM NOISE – AN ETHICAL DILEMMA FOR THE AUSTRALIAN ACOUSTICAL SOCIETY?

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Not since the opening of the Third Runway at Sydney Airport has there been so much publicity in Australia concerning noise – in this case wind farms. Putting aside the issue of noise versus inaudible noise there is a question being raised as to Members of the Society breaching the Code of Ethics. This is not the old question of Professional versus Learned Society. Reliance upon criteria contained in Guidelines or Standards may be an excuse by consultants that in turn places the "fault" on the SA EPA and the New Zealand Standard. However, if people making complaints to no avail and leave their homes because of the wind farm "noise" what is the responsibility of Members of the AAS to the community?

INTRODUCTION

The April 2012 edition of the Australian Acoustical Society's journal (Acoustics Australia – Vol 40, No. 1) provided a series of papers and technical notes relating to wind farm noise [1]. However, the articles supporting wind farms did not discuss the acoustic impact of the wind farms. The articles referred to criteria and compliance with the criteria. The articles did not identify the basis of the criteria or the acoustic impact of wind farms even when they complied with the nominated criteria.

It is evident from the recent public forums conducted by Senators Madigan and Xenophon in South Australia, Victoria and New South Wales that wind farm "noise" is an issue in the community [2,3]. The degree of claims for and against wind farm noise is reminiscent of the aircraft noise debate (with the introduction of jet aircraft to Australia) [4] and the third runway at Sydney Airport [5].

Examination of the aircraft noise debate finds acoustic and socio-acoustic research undertaken in Australia by Members of the Society. Examination of the wind farm noise issue finds a different position.

Members of the Society had been at the forefront of preparing acoustic and vibration Guidelines and Standards in Australia [6] to protect the community from a wide range of noise sources and invariably rely upon overseas experience/standards that are then compared or evaluated with Australian situations.

For example with respect to road traffic noise, we had Standards/Guidelines that originally followed the UK Department of Environment [7] recommendations (rather than US Department of Transport criteria). Work undertaken by the ARRB and Dr Stephen Samuels (and others) lead to a modification of the British criteria to account for Australian road conditions.

AIRCRAFT NOISE IMPACTS IN AUSTRALIA

In the initial stages for aircraft noise assessment Australia adopted the US NEF system [8]. As a result of community concerns about aircraft noise, and a Commonwealth government inquiry (HORSCAN report) [4] led to the noise study by the National Acoustics Laboratory [9] to then result in the ANEF system used for aircraft noise assessments in Australia. Changes have been proposed to the aircraft noise standard, citing the community's response to aircraft noise and the need for supplementary acoustic metrics. However the use of the N60, N70 or N80 descriptor [10] has not been presented in terms of any socio-acoustic surveys and therefore there is a fundamental problem of implementing N60/N80 criteria without any basis to support that criteria.

In the original NAL report on aircraft noise there is the dose response curve for ANEF versus affected people which is slightly different to the curve in Australian Standard AS 2021 [11]. Contained in the NAL report is a dose response for the N70 that can be placed in the context of the unacceptable/acceptable limits for the ANEF system and in turn the building site acceptability tables in AS 2021.

The NAL report does not provide any regression curves showing a basis for N60 or N80. Therefore, as presented previously [12-15], there are issues as to substantiating the number of events that may be applied to the N60 and N80 for an acceptable aircraft noise impact.

In undertaking research work with Fergus Fricke at Sydney University [16] most postgraduate students became aware that Fergus pulled/pushed you sideways to look into different aspects of your subject which required further investigation and a broadening of the material that was the subject of the research. It is such an approach that students of acoustics (of which all members of the Society can still said to be students) can benefit in their daily use of acoustics to have in the back of their mind when there is a problem the quote of Professor Julius Summer Miller "Why is it so?".

This is the exact situation when faced with the challenge of measurements from helicopter operations not agreeing with the international computer modelling led to investigating the matter of lateral attenuation. Investigation found that the attenuation

algorithms in the computer model [8] were wrong, had been wrong for many years, and people were unaware of that fact. Investigations, including going back to the original reference documents [17,18] to uncover the problem, which was verified with additional testing leading to that material being presented to the US Aircraft Standards Committee in 2003 [19], accepted and two years later INM was amended to overcome that issue.

Similarly in seeking to validate military aircraft operations with the computer model we kept on getting incorrect results for high frequency noise which under the same investigative concept lead to querying the results. Testing over a number of years led to identification that the original model for determining atmospheric attenuation coefficient per hundred metres was not carried out in any vast chamber or airfields, ovals or similar. The attenuation coefficients were determined from a stainless steel sphere of 1.68 m diameter on a theoretical basis [20].

Utilising measurement data for aircraft operations under different atmospheric conditions found the universal attenuation coefficients [8,21] did not agree with field measurement for aircraft [22] and monitoring at industrial sites.

These results revealed that if one utilises the atmospheric attenuation contained in various International and American standards in computer models there can be errors. And in particular there can be significant errors if one is dealing with high frequency noise, particularly with respect to the discharge of high velocity steam where there is a significant component of the noise source occurring above 2000 Hz.

It is in light of the above background material and the fact that throughout Australia there are hundreds of residents in proximity to wind farms who claim to be adversely affected, and in some cases so affected that they leave their properties, that must be of concern to members of the Society where there are repeated responses that these people are imagining the problem.

It would appear that the reaction of the community to wind farms is not that dissimilar to communities that were subject to the aircraft noise following the introduction of the jet engine that ultimately led to the famous NAL study. The number of people affected by wind farms is not as great as that affected by airports simply because wind farms are not located in suburban areas. However, in taking into account the percentage of people affected in the area covered by the nominated noise level criteria it would seem to be more than 10% of the population are seriously affected.

MEASUREMENT OF WIND FARM NOISE FOR THE COMMUNITY

I and a number of acousticians in Australia have been requested to undertake reviews of wind farm applications and/or conduct measurements of wind farms. This is not dissimilar to requests for peer reviews of acoustic reports for Development Applications or Compliance Tests for a range of typical noise sources, domestic, road, rail, air traffic, and industrial developments.

These reviews and testing have raised a number of issues as to the adequacy of the original assessments, the accuracy of the measurements and question the acceptability of noise limits which are simply matters that an appropriately qualified and experienced acoustic engineer/consultant would undertake.

Such investigations and assessments have raised concerns as to the adequacy of the guidelines and also the results of compliance testing undertaken by various organisations that include Members of the Australian Acoustical Society.

As a result of undertaking the assessments and providing those reports in the public domain I and other consultants have been labelled by wind farm power entities as being "anti-wind farm" or having close ties to "anti-wind farm lobby groups".

Having discussed this very fact with other Members of the Society who have been so labelled and do not accept such accusations, I have stated a number of times that I am not anti-wind farm but have been simply presenting the facts as to what has been generated by such installations that requires further investigation.

If one is to be labelled as anti-wind farm when simply presenting the facts of what is occurring as a result of undertaking work for the community, then it must be the case that the acoustic consultant/engineer who undertakes work for wind farm applicants should equally be labelled by the wind farm industry as "pro-wind farm".

Both the "anti-wind farm" and "pro-wind farm" acousticians who are Members of the Society would undoubtedly disagree with such labelling and should identify the fact that they are truly independent in carrying out such assessments. Furthermore, if those persons are Members of the Society then they could bring to their defence that there is an obligation to abide by the Code of Ethics of the Australian Acoustical Society [23].

So how can persons undertaking assessments "for or against" wind farms of the noise impact of wind farms be a dilemma for the Australian Acoustical Society you may ask.

CODE OF ETHICS

From the Code of Ethics, that appears on the Society's website, one can see there is the Responsibility for the members of the Society:

The welfare, health and safety of the community shall at all times take precedence over sectional, professional and private interests.

The explanatory notes in the Code of Ethics in referring to Responsibility requires members of the Society to:

- conform to acceptable professional standard and procedures, and not act in any manner that may knowingly jeopardise the public welfare, health, or safety.
- endeavour to promote the well-being of the community, and, if over-ruled in their judgement on this, inform their clients or employers of the possible consequences.
- contribute to public discussion on matters within their competence when by so doing the well-being of the community can be advanced.

The explanatory notes in the Code of Ethics in referring to Work within Areas of Competence requires members of the Society to:

- report, make statements, give evidence or advice in an objective and truthful manner and only on the basis of adequate knowledge

- reveal the existence of any interest, pecuniary or otherwise, that could be taken to affect their judgement in technical matters.

NOISE IMPACT

A significant number of wind farm assessments follow a generic format. Whether there is identification of primarily the South Australian EPA Wind Farm Guidelines [24,25] or the New Zealand Wind Farm Standard [26,27], the assessment in terms of those guidelines uses the ambient noise level to provide regression line curves, use of a criterion of 35, or 40 dBA and background +5 dB, whichever is the greater value.

The acoustic assessment generally provides the results of computer predictions using the A-weighted value to then indicate compliance with the criteria contained in Guidelines/ Standard.

The noise assessment in relation to the application provides predicted levels in terms of the substation and construction activities that are related to relevant guidelines, and may include an assessment of noise from power lines to indicate significant separation distance to residence to not present at an issue. In some cases there is identification of the acoustic impact of the substation, construction activities, and power lines [28-31].

However in the generic wind farm assessments there is no actual noise assessment of the wind farm, i.e. the assessment simply states compliance with the relevant guidelines and that is it.

The generic wind farm "noise assessment" considers the noise outside residences and does not identify to the community the audibility of the wind farm, the relationship of the guideline criteria with respect to the acoustic environment of the area, the percentage of time in which there will be audible noise as a result of weather conditions, or conversely a reduction in noise as a result of weather conditions.

The generic wind farm "noise assessment" does not report the situation of residents hearing the noise inside their homes or having sleep being disturbed or that some residents experience disturbance even when there is compliance with the guidelines noise limit. The "noise assessment" does not indicate situations in Australia where residents (host and non-hosts) leave their homes to live elsewhere.

The question is now being asked in the community, and invariably will be asked in courts of law, whether the absence of that material in the "noise assessment" is a Breach of Code of Ethics.

The Association of Australian Acoustical Consultants (AAAC), of which firms become members of that Association, have a Code of Professional Conduct [32] which goes one step further than the AAS in the section on Professional Standards:

- To maintain the standards of business and personal conduct reasonably expected of a professional
- To act with professional responsibility and integrity in my dealings with the community and clients, employers, employees and students
- To provide professional opinions in an objective and truthful manner, avoiding statements that may be demeaning, misleading or unethical
- Not to misrepresent one's skills and experience
- To undertake work only in areas of competence, unless the client is informed of the member's limitations
- To maintain a proper sense of responsibility to the client, broader community, employees, the profession and the environment.

In attending various rural dwellings to undertake wind farm noise measurements questions have been raised by the occupants as to the conduct of members of the AAAC and the AAS in relation to monitoring and reporting of the results/impact.

RURAL NOISE ENVIRONMENTS

Acousticians in Australia that are aware of the origins of Australian Standard AS 1055 [33,34] will be well aware that it follows that the general scenario outlined for other standards and its primary function as per its original title was "Noise Assessment in Residential Areas".

Accordingly AS 1055 is not really a document that is appropriate for rural areas and the background levels that were suggested for various categories may be appropriate in suburban areas. However for areas removed from traffic the lowest background level in AS 1055 would not necessarily apply in such areas.

Rural areas removed from main roads and the like, and being areas nominated for wind farm developments can experience background levels less than 20 dBA in the day and night, and can also experience ambient L_{eq} levels less than 30 dBA during the day and less than 25 dBA at night.

A fundamental question that communities exposed to wind farms raise is how can the guidelines substantiate 35, or 40 dBA as an acceptable base level at night in rural areas?

The SA EPA Guidelines refer to an indoor sleep disturbance level of 30 dBA by reference to a WHO Guideline [35]. However there is a failure to correctly identify that the WHO guidelines were referring to suburban areas impacted by traffic noise and did not provide criteria for rural areas or consider wind farm noise. The draft New South Wales Wind Farm Guidelines [36] specifically clarified the WHO guideline sleep arousal related to noise in suburban areas from traffic [37].

The situation of background levels in residential bedrooms which are between 10 dBA and 20 dBA, even with turbines operating, must be a fundamental issue of concern for the Members of the Society for a guideline that suggests 40 dBA is an acceptable level at night (as an external level) or 30 dBA as an internal level.

If the "pro-wind farm" acoustician's defence to inadequate reporting assessment or consideration of the community's health relies upon Guidelines or Standards that have been issued for wind farms, then apparently blame may be to the authors of the Guidelines or the Standards committees which include Members of the Society.

It could well be argued that when the first version of the guidelines were prepared by the South Australian EPA they did not have the benefit of an existing wind farm to undertake measurements and determine the appropriateness of the draft guideline and then the guideline.

It would appear historically that the original SA EPA guidelines were based upon overseas material in part. However, there does not appear to be any reference in the document to identify where the base criteria have been substantiated for use in Australian rural communities, i.e. socio-acoustic study to support the limits.

OUTCOMES

The current public debate as to noise impact from wind farms would appear to be more complex than just the "Learned Society of Professional Institution" question raised by Fergus Fricke [38] in the same 1982 AAS Bulletin that reported on the NAL 1982 Aircraft Noise Report.

If further work finds there is a health issue as a result of "noise" generated by wind farms and there are "acoustic assessments" that state there are no health impact no sleep impacts, and no infrasound, then what happens?

REFERENCES

[1] *Acoustics Australia*, Special Issue: Wind Turbine Noise, 40(1), 1-96 (2012)

[2] The Mid North Broadcaster, *Mr X's message for the Mid North ... 'Push the envelope'*, 4 April 2012

[3] Senator John Madigan, *One year on but no progress made*, Media Press Release, Parliament House, Canberra, 22 June 2012 http://www.wind-watch.org/news/2012/06/22/one-year-on-but-no-progress-made/

[4] Report to the House of Representatives Select Committee on Aircraft Noise, *Aircraft Operations and the Australian Community*, 1970 http://www.aph.gov.au/Parliamentary_Business/Committees/House_of_Representatives_Committees?url=report_register/bycomlist.asp?id=127

[5] Report of the Senate Select Committee on Aircraft Noise in Sydney, *Falling on Deaf Ears?*, Commonwealth of Australia, Canberra, 1995

[6] R. Mearns, "Acoustics in the Standards Association of Australia", *The Bulletin of the Australian Acoustical Society*, 1(2), 11–14 (1972)

[7] UK Department of Transport, Welsh Office, *Calculation of Road Traffic Noise (CoRTN)*, 1988, http://www.noiseni.co.uk/calculation_of_road_traffic_noise.pdf

[8] *Integrated Noise Model (INM)*, U.S. Department of Transportation, Federal Aviation Administration, http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/inm_model/

[9] A.J. Hede and R.B. Bullen, *Aircraft noise in Australia: A survey of community reaction*, National Acoustic Laboratories, NAL Report No. 88, 1982, http://www.infrastructure.gov.au/aviation/environmental/transparent_noise/expanding/pdf/88_hede_bullen_NAL_Report_Feb1982.pdf

[10] National Airports Safeguarding Advisory Group, *Principles for a National Land Use Planning Regime near Airports, Military Airfields and Flight Paths (Working Draft)*, November 2011

[11] Australian Standard AS 2021-2000 *Acoustics – Aircraft Noise Intrusion – Building Siting and Construction*

[12] S. Cooper, "Problems with the INM: Part 1 – Lateral attenuation", *Proceedings of Acoustics 2006, The First Australasian Acoustical Societies' Conference*, Christchurch, New Zealand, 20-22 November 2006, pp. 91–97

[13] S. Cooper and J. Maung, "Problems with the INM: Part 2 – Atmospheric attenuation", Acoustics 2006, Christchurch, NZ, *Proceedings of Acoustics 2006, The First Australasian Acoustical Societies' Conference*, Christchurch, New Zealand, 20-22 November 2006, pp. 99–104

[14] S. Cooper, "INM – Getting it to work acoustically", *Proceedings of the 20th International Congress on Acoustics (ICA2010)*, Sydney, Australia, 23-27 August 2010

[15] S. Cooper, "Alternative aircraft metrics – Useful or like moving the deck chairs on the Titanic?", *Proceedings of the 20th International Congress on Acoustics (ICA2010)*, Sydney, Australia, 23-27 August 2010

[16] S. Cooper, *Community Response to Aircraft & Helicopter Noise – Proposed PhD Research*, Technical Meeting of the Australian Acoustical Society, NSW Division, May 1991

[17] P.H. Parkin and W.E. Scholes, "The horizontal propagation of sound from a jet engine close to the ground, at Hatfield", *Journal of Sound and Vibration* 2(4), 353–374 (1965)

[18] Society of Automotive Engineers, *Prediction method for lateral attenuation of airplane noise during takeoff and landing*, SAE Aerospace Information Report (AIR) 1751, March 1981

[19] S. Cooper, *The INM program is a much better program than HNM for helicopter modelling, but....* SAE-A21 Helicopter Noise Working Group, Las Vegas 2004

[20] C. Harris, "Absorption of sound in air in the audio-frequency range", *Journal of the Acoustical Society of America* 35(1), 11–17 (1963)

[21] International Civil Aviation Organization, *Environmental Protection, Annex 16 to the Convention on International Civil Aviation*, Volume 1, Third Edition, 1993

[22] S. Cooper, *INM Problems, Military Operations and AS2021 and the JSF*, Technical Meeting of the Australian Acoustical Society, Victorian Division, September 2011

[23] Australian Acoustical Society, *Code of Ethics*, http://www.acoustics.asn.au/joomla/codeethics.html

[24] South Australia Environment Protection Authority, *Environmental noise guidelines: Wind farms*, 2003

[25] South Australia Environment Protection Authority, *Wind farms environmental noise guidelines*, 2009 http://www.epa.sa.gov.au/xstd_files/Noise/Guideline/windfarms.pdf

[26] New Zealand Standard NZS 6808:1998 *Acoustics – The assessment and measurement of sound from wind turbine generators*

[27] New Zealand Standard NZS 6808:2010 *Acoustics – Wind farm noise*

[28] Vipac Engineers & Scientists Ltd, *Capital II Wind Farm – Noise Impact Assessment*, Document No. 50B-10-0075-TRP-773565-2 December 2010, prepared for Infigen Energy

[29] Vipac Engineers & Scientists Ltd, *Flyers Creek Wind Farm, Noise Impact Assessment*, Document No. 50B-08-0089-TRP-773906-2, December 2010, prepared for Aurecon Australia Pty Ltd

[30] Marshall Day Acoustics, *Stony Gap Wind Farm, Noise Impact Assessment*, Report No. 002 R07 2008241, March 2011

[31] Heggies Pty Ltd, *Boco Rock Wind Farm Noise Impact Assessment*, Report No. 40-1738-R1 (Revision 3), November 2009

[32] Association of Australian Acoustical Consultants (AAAC), *Code of Professional Conduct*, http://www.aaac.org.au/au/aaac/ethics.aspx (Last accessed 22 July 2012)

[33] Australian Standard AS 1055-1978 *Code of Practice for Noise Assessment in Residential Areas*

[34] Australian Standard AS 1055.2-1997 *Acoustics – Description and measurement of environmental noise, Part 2: Application to specific situations*

[35] B. Berglund, T. Lindvall and D. Schwela (eds), *Guidelines for community noise*, World Health Organization, Geneva, 1999

[36] NSW Department of Planning and Infrastructure, *Draft NSW Planning Guidelines: Wind Farms*, 2011

[37] World Health Organization, *Night Noise Guidelines for Europe*, 2009

[38] F. Fricke, "Learned Society or professional institution?", *The Bulletin of the Australian Acoustical Society*, 10(3), 114–116 (1982)

ARE WIND FARMS TOO CLOSE TO COMMUNITIES?

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Currently, state planning legislation in Australia suggests separation distances of 1-2km from wind farms. Noise limits incorporated in the various State guidelines and used for assessment purposes have no scientific studies to support the basis of the limits. The use of a dB(A) limit set well above the natural ambient background level does not protect the health and well-being of the community. The noise concepts used for wind farms in NSW ignore the fundamental premise of not creating 'offensive noise' as defined in The Protection of the Environment Operations Act. Examination of 'noise levels' received by residents in proximity to wind farms reveals the presence of audible and inaudible sound that extends well past the nominal separation distances of 1-2km. The silence of the individual state Environmental Protection Authorities in addressing these issues is deafening.

Some twelve months ago I was requested to undertake a peer review of an acoustic assessment in relation to a proposed wind farm in central New South Wales. The process of reviewing an acoustic assessment report is relatively straight forward. Examination of the acoustic report found a number of significant technical omissions with respect to the project's specifications issued by the NSW Department of Planning and Infrastructure for the preparation of the Environmental Assessment.

Examination of the 'acoustic assessment' found there was a numerical analysis of potential noise emission levels of the wind farm, but no actual assessment of the impact to advise residents what they would experience.

In the process of reviewing the assessment it was identified that there are a number of wind farms in Australia that are subject to complaints from residents on the basis of noise disturbance and that in some cases some residents have left their homes to obtain relief.

Initial Assessment

As part of the peer review there was a request to attend a number of residential properties in proximity to the Capital Wind Farm to quantify the extent and magnitude of noise emitted from that wind farm. The result of that investigation has led to further attendances at residential properties in proximity to wind farms in both Victoria and South Australia and as such has identified a number of pertinent issues.

Going back to the original attendance at the first residential property, because it appeared the major issue was related to disturbance at night, there was a concentration of monitoring during that period. On the first night of testing there was negligible wind in the area and therefore there was no noise disturbance and measurements of the ambient noise revealed a relatively quiet environment.

The following night presented a different situation, in that the turbines were operating, although there was no apparent wind at the residential property. The noise from the turbines was audible outside the residence and not considered to be excessive and did not appear to correlate with the claims of disturbance.

Inside the dwelling there was some noise detected, but again on a subjective basis I did not consider the noise to be significant. However the resident was able to clearly detect the noise by reason of being sensitised to the noise. Instrumentation was set up to monitor inside and outside the dwelling.

The resident identified that since the operation of the wind farm her sleep was regularly disturbed, she experienced headaches and at times would be woken up as though being startled, but not knowing what caused the event, and at other times would wake up in an extreme state of panic.

The monitoring revealed there to be the presence of low frequencies in the audible range and also frequencies below the audible range. The monitoring suggested a periodic pattern which is associated with the operating speed of the turbine multiplied by the number of blades (which is identified as the blade pass frequency) and then harmonics (multiples) of that frequency. Attendance at other dwellings some 2 – 3 km from the wind farm found similar measurement results and varying levels of disturbance reported by residents.

Measurement Difficulties

The typical approach in dealing with general noise in the environment is to utilise in the first instance the A-weighted value which covers the audible spectrum of sound and utilises a curve that approximates the response of the human ear (see Figures 1 & 2).

The nature of the A-weighting curve reduces the impact of low frequency noise such that low frequency noise or frequencies below what the ear can hear in the frequency domain (identified as infrasound) do not get picked up in the A-weighted value.

Figure 3 shows noise emission levels for turbines (as sound power levels in 1/3 octave bands) with the A-weighting filter applied versus the same data without the A-weighting filter.

In general acoustic terms when one refers to dB(A) guidelines they seek to set criteria based upon a level that satisfies 90% of the people for 90% of the time. For typical noise sources one considers a noise threshold for disturbance to be around 5 dB (decibels) above the background level, and therefore it is not uncommon to find specifications written in terms of background plus 5dB(A).

Noise criteria used for wind farms in Australia tend to be based on a set of guidelines issued in 2003 by the South Australian EPA which only consider the noise in terms of the A-weighted value.

Normally, any measurements that occur in an area where the wind speed is greater than 5 metres per second are ignored for the purpose of background level measurements.

However, the operation of wind turbines requires wind. The presence of wind creates a noise across the microphone and therefore one can have a different background level dependent on the wind at the receiver location. For wind farm assessments there are two criteria utilised in the guidelines, the first one being background plus 5 dB(A), and the second one being a base level of 35 or 40 dB(A). The criteria normally expressed are the greater of the base level or background + 5 dB(A).

Therefore to determine the criteria to be applied to the subject development the procedure to date has been to determine the ambient background level at residential receivers versus the wind that would occur at either a height of 10 metres above ground level at the wind farm or at the hub height of the turbines. The guidelines require one to plot the background level versus the turbine wind speed and then to provide a regression curve of background level versus wind speed.

There are a number of issues with that procedure in that the regression analysis looks to obtain an average noise level versus the wind speed at the subject turbine that is reported to be relevant to the receiver location.

However on attending residential properties in proximity to wind farms it is obvious that due to the topography of the area the wind at the turbine under certain directions would produce a different impact at the residential receivers than for other directions.

As the regression graph that is obtained prior to the construction of the wind farm becomes the determining criteria for compliance purposes the community has some issues as to the relevance of the use of the regression line in view of different wind directions and the resultant noise that occurs at residential receivers. For example, compliance testing in relation to the Capital Wind Farm found the background level with the wind farm turned off to be lower than the regression line background level determined at the application stage.

The second issue of concern in relation to the relevance of the regression lines is that in many cases the instrumentation used for monitoring cannot measure low enough, and therefore the data that is obtained by the monitoring is automatically skewed away from the actual background levels and gives a false average.

Figure 4 shows the results of measurements on the side of a hill in rural South Australia with no trees for 500 metres and no wind farms for 20 kms. The regression line is of the background level versus the wind at 1.5 metres above ground. In this case instrumentation that can measure below 20 dB(A) was used with a standard 100mm windscreen. Because the graph relates to the wind speed at the microphone it shows a different relationship to the typical regression graphs for a location versus the hub height wind speed.

The third issue in terms of wind farm noise that is different from other industrial premises, is the use of a regression line of the data automatically places that curve above a level that would satisfy 90% of the population for 90% of the time.

A fourth issue of concern is the criteria obtained from the guidelines. It becomes obvious when one looks at the regression curves, that for relevantly low wind speeds when the turbines operate, the real background level at residential receivers is significantly below the base line criteria of 35 or 40 dB(A). Therefore the generation of noise levels permitted by the guidelines would be clearly audible in the rural environment.

A fifth issue of concern is whether the windscreen used for measurements is appropriate for the task in hand in that the passage of wind across the windscreen generates a noise other than that created by the wind and therefore leads to erroneous baseline data. In this regard the need for secondary windscreens and ground plane microphones has been raised with suggestions for the current procedure there is a deliberate use of microphone placement to provide an advantage to the wind farm, by elevating the background level.

Acoustic Criteria

One of the principle issues in terms of wind farm noise, is utilising limits typically encountered in suburban areas that do not reflect the acoustic environment in rural areas removed from traffic and industrial sources. Two social surveys in Sweden and one in the Netherlands for relatively small turbines have clearly shown for the same level of noise emission a greater disturbance in rural communities than in suburban communities.

Another issue is that wind turbines are getting bigger and more powerful over time. Measurements indicate stronger low frequency components from larger turbines. Therefore reference to previous wind farms as not being an issue to communities is not an appropriate response if one does not identify the size of the turbines in both physical size and capacity. For example, studies related to one or two 700 kW turbines that create an impact, cannot be taken as equivalent to a wind farm having 30 to 100 turbines with a generating capacity of 3000 kW for each turbine.

The noise levels set out in the guidelines permit a clearly audible noise at rural residential receivers, even when one uses the A-weighted concept that for general noise assessment throughout the state would be levels that are considered unacceptable for residential receivers.

The above issues of concern relate to the use of the A-weighted values which as set out above and shown by the weighting curves in Figures 2 & 3, do not address the low frequency and infrasound components generated by turbines. This becomes an issue in that there are instances of residential dwellings being subject to noise levels that clearly comply with the guidelines yet the persons who occupy those dwellings are adversely affected by the operation of the turbines.

Therefore if residents are subject to noise that interferes with their rest and repose, gives rise to headaches, and makes the occupancy of their residence unsuitable to the extent that some people leave, sometimes on medical advice, then clearly the A-weighted concept is incorrect. However the Environmental Protections and Health Authorities ignore such complaints.

It is in this regard that emphasis has been placed by acoustic researchers around the world to look at other components that exist in the acoustic signature of turbines that is not necessarily picked up in the A-weighted concept.

Figures 5 & 6 show 1/3 octave band noise levels recorded in relatively close proximity to operational turbines in South Australia where there are no interfering noises from wind, road traffic, residential or agricultural activities. In proximity to the turbine there are low frequency components and also infrasound components evident in the acoustic signature. The figures show the difference between a position to the side and in front of the turbine by breaking the sound into spectrum components by way of 1/3 octaves rather than just the dB(A) value.

However a better presentation to identify the unique characteristics of turbines is to analyse across sections of the frequency spectrum when expressed in a linear (i.e. no weighting) relationship.

Low Frequency and Infrasound

It is by use of the linear relationship and narrow band analysis that the unique spectral (frequency distribution) characteristics associated with turbines become evident. There are frequencies that occur below the range of sounds audible to the human ear, and are signals that are readily detected if one has the instrumentation capable of measuring down to such frequencies and measures in a linear format rather than A-weighted format.

The narrow band spectrum recorded in proximity to the turbines shown in Figure 7 clearly indicates the blade pass frequency and multiple harmonics of the blade pass frequency.

One can also look at the variation in the overall noise level to determine a modulation in the signal that is received by the microphone.

Measurements conducted at residential receivers removed from the wind farm have found the presence of the discreet signature of the turbines with those components being detected both outside and inside the dwellings (see Figures 8 & 9).

The resistance to sound provided by the building envelope is much greater at high frequencies than low frequencies, and presents a problem with buildings being unable to adequately attenuate these low frequency components. Furthermore in some cases the building itself may be subject to vibration or the rooms can have natural resonances that can give an enhancement of the infrasound signals, and/or the physical vibration of the building generates such internal noise levels.

The relevance of the low frequency noise, in acoustic terms is significant when one considers that the propagation of sound over distance varies dependent upon the characteristics of the sound source and the frequencies of concern.

Figure 10 provides the measurements recorded external to a dwelling 8km from the Waterloo Wind Farm expressed in 1/3 octave bands. There are some low frequency and infrasound levels but no distinct pattern. However, at this location, a low frequency rumble was clearly audible and to the residents completely out of character to the natural environment.

If one assumes a turbine has a sound power level of say 103 dB(A) then on a 6 dB attenuation per doubling of distance (without allocating any additional loss for topography) then the typical figure quoted of 35 dB(A) at 1 km would become 17 dB(A) at 8 km.

In a background level of 27 dB(A) shown in Figure 10 under normal dB(A) noise assessment one would expect the turbines to be barely audible/inaudible external to the residence and inaudible inside the residence. However this was not the case.

Figure 11 shows the narrow band levels simultaneously recorded inside (blue) and outside (red) using the narrow band technique to reveal the turbine blade pass frequency and multiple harmonics. Using the measurements near the turbine at the frequency of 4 Hz (80 dB at 150 metres) to achieve only a 20 dB reduction over 8 kms shows that 6 dB per doubling of distance cannot be applied to these frequencies.

The general approach by the use of the dB(A) parameter is to consider individual turbines as a hemispherical radiation point source where the attenuation (reduction in sound) is taken at 6 dB per doubling of the distance. However when one examines the flow characteristic of turbines with respect to the low frequency and infrasound components, measurements reveal the radiation does not occur as a hemispherical source but as a line source which leads to a lower rate of attenuation.

There are a number of facilities around the world that are used for the monitoring of nuclear explosions and seismic activity that concentrate on the low frequency/infrasound components in both an airborne noise and ground vibration. Staff at these facilities have significant expertise in monitoring such levels and a number of these establishments have conducted work in relation to wind turbines. They have found that if turbines are within 30km of such establishments then the operation of those facilities can be compromised. Clearly the sensitive nature of those facilities is different to that of residential dwellings and accordingly a lower separation distance would apply.

However work undertaken by the Federal Institute for Geosciences and Natural Resources specifically into the propagation of low frequency noise, by persons having a significant degree of experience in such measurements, has clearly demonstrated that the propagation characteristics of the infrasound measurements are entirely different to the general A-weighted propagation assumed for turbines (see Figure 12).

Therefore in terms of acoustic criteria applicable to the low frequency and infrasound components associated with turbines the use of dB(A) is entirely inappropriate and, as the guidelines used in South Australia or the New Zealand Standard ignore such components, then the absence of an appropriate criteria for low frequency and infrasound presents some difficulty for the Environmental Authorities fulfilling their role to protect the community from adverse impacts.

In fact the South Australian guideline claims that a well maintained modern wind farm does not produce infrasound. This would appear to be an incorrect statement by reference to the results in proximity to the turbines and the presence of those frequencies in the acoustic signature detected at a residential dwelling out to 8km from the Waterloo Wind Farm.

Some researchers have referred to the use of the dB(G) curve for evaluation of infrasound. The G-weighting is shown in Figure 13 in both a linear and a logarithmic presentation. However as the blade pass frequency of turbines is below 1 Hz, the dB(G) curve may not be appropriate. Alternatively the use of Linear (no weighting) over a restricted bandwidth may be appropriate.

This issue in terms of different propagation rates and the resultant level detected at residence becomes important in that the recent research of Salt and Lichtenhan (2011) and Salt Kaltenbach (2011) as reported by Richard James[1] has confirmed that there is physiological response to modulated infrasound at levels below the threshold of perception (for pure tones) that may start at amplitudes as low as 60dB(G). Similarly Dr Swinbanks (UK researcher) has identified that a modulation of the signal stimulates the auditory system at levels much lower than that normally attributed to pure tone assessment.

In his paper, R. James has identified that investigations many years ago in relation to low frequency and infrasound noise impacts in industry which were well known with respect to diesel generators, power stations and engine rooms on ships and that in the 1970's and early 1980's considerable investigation occurred into low frequency and infrasound that would now fall under the classification of noise-induced sick building syndrome.

Of recent times there have been claims that infrasound produced by wind farms is similar to or less than that obtained in the natural environment. One report used by the wind industry in Australia to support such a claim finds reliance upon 1/3 octave band results, that on a closer examination, leads one to question the results that have been provided.

Figure 14 shows a 10 minute time splice of the dB(A) level for an exposed location near Collector. 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.

Figure 15 compares the narrow band spectra for 0 – 50 Hz (upper graph) with the 1/3 octave spectrum (lower graph). As the comparison shows while 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.

When one considers the low frequency and infrasound noise and the reduced capacity of a building to attenuate such noise, then the issue of concern with respect to wind turbines becomes more of an indoor problem than an outdoor problem. Accordingly, if the acoustic criteria only consider external noise levels, then the obvious deficiency in terms of the appropriate criteria for wind turbines becomes clearly obvious.

The application of noise criteria applied in suburban areas verses utilising the same criteria in rural areas is easily understood to be an unsuitable situation when one considers the obvious difference in the acoustic environments. Reference is often made to guidelines produced by the World Health Organisation that refer to noise levels suitable for protecting persons sleeping without identifying that those guidelines relate to traffic noise impact in suburban areas.

Typically reference to the WHO guideline fails to identify the nature at low frequency characteristics give rise to a difference in the subjective impact of a noise, or the fact that the WHO guidelines do not discuss wind turbines or alternative criteria for quiet rural areas.

If residents across Australia in proximity to wind farms identify sleep and health issues as a result of turbines and yet other members of the household are not affected in such situations, then this is not dissimilar to an individual's response to other types of noise. If one considers the appreciation or enjoyment of music then a discussion with your family or colleagues will reveal different tastes of music and in some instances an extreme degree of annoyance when persons experience different types of music.

For example lovers of opera may not necessarily enjoy or even accept any music associated with rap music and it is not uncommon for young people to demand opera music to be turned off.

I have met with residents in proximity to various wind farms where one person is able to detect when the wind farm is operational by either a presence in the head or body, whilst the partner is unable to detect any such effects. The difference response/reaction of individuals must be taken into account.

Furthermore the length of exposure to the turbines must also be taken into account.

Adverse Impacts

The SA EPA Guidelines indicate that for residential receivers that have a financial relationship with the wind farm that adverse impact occurs if the occupants of the dwelling experience sleep disturbance. Interestingly there is no actual definition of an adverse noise or health impact contained in the guideline.

There is a common response to the objection to wind farms on the basis of noise by drawing attention to the lack of scientific evidence linking wind farm operations with health impacts. However there is also a lack of scientific evidence to prove that wind farm operations do not create health impacts.

The reason for the lack of scientific evidence for both scenarios is simply because the appropriate scientific studies have not been undertaken. There are a number of "peer reviews" quoted in relation to wind farm impacts. However, examination of those reviews find that in general they are simply literature reviews and not actual scientific studies that incorporate real-world data as to the operation of a wind farm, the physiological and medical response of the community with appropriate analysis.

On my review of the material unless one has the raw acoustic data to identify what the residents are exposed to as a result of the operation of the wind farm that is then being followed by the appropriate sleep studies, questionnaires and then medical studies of the persons so affected, then one cannot causally link the said noise source to that the reaction.

From an acousticians viewpoint it seems to me that there are two distinct steps to be undertaken is establishing the **Relationship of wind farm noise to impacts**.

Step 1

Use Acousticians and Psychoacousticians

- **Acoustic measurements - of wind farm noise**
- **Psychoacoustic assessment of community response**

Step 2 (Following Step 1 + on site sleep studies, with acoustic measurements)

This involves multidisciplinary research involving acousticians and psychoacousticians, together with experienced medical practitioners, researchers and clinicians, including but not limited to the following speciality areas:

- **Sleep Physicians & physiologists**
- **Ear Nose & throat physicians and physiologists**
- **Neuroscientists**
- **Psychiatrists & Psychologists**
- **Cardiologists and cardiac physiologists**
- **Endocrinologists**
- **Rural General Practitioners**
- **Occupational Health Physicians**

With the results of such studies then an answer to the question of the Relationship of wind farm noise impacts can be obtained.

Separation Distances

Clearly from the measurement results discussed above, separation distance from wind farms must be greater than the nominal 1 to 2 km. Obviously a separation distance of 100 km would ensure that there would be no impact. The answer lies somewhere in between.

As noted above in acoustic terms socio-acoustic surveys take samples of the population impacted to varying degrees by a noise and determine a level at which 10% of the population are seriously/highly affected.

The results of such surveys may indicate that there are other factors (other than noise) that may influence the response of the community. For example, the socio-acoustic study conducted in the late 1970s in relation to aircraft noise in Australia found only a 17% correlation associated with noise and that there were other factors such as fear of the aircraft crashing and interference with television reception that influenced the community's response to aircraft operations. The results of that study led to the development of noise criteria for residential occupancies in proximity to airports.

Neither the SA EPA guidelines nor the New Zealand Standard for wind farms identifies any socio-acoustic studies to support the base criteria set out in those documents. Furthermore whilst the

nominated criteria may be suitable for suburban environments communities in proximity to wind farms do not accept such levels for rural environments.

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

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

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

The Mary Morris conference sent 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 noticed the above affects and/or that the effects varied, but they were not affected. The remaining respondents said they were not affected.

The extent of the population living within 10km of the Waterloo Wind Farm that is affected by the operation of the wind farm 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 seriously 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.

If one utilised either of the two studies then under a socio-acoustic basis the separation distance from wind farms of the size of the Waterloo wind farm must be greater than 5 km. On a dB(A) basis the noise limit that would relate to such a separation distance is below 25 dB(A) and, is significantly lower than either the SA EPA guideline or the New Zealand Standard.

If one cannot, at the present time, nominate a separation distance then the appropriate mechanism to protect the community is to require, under the current methodology a noise limit of 25 dB(A) or background +5 dB(A) **whichever is the lower**.

Clearly a secondary criterion that addresses the low frequency and infrasound impacts needs to be identified and the appropriate place for consideration of those impacts is inside dwellings. The provision of an internal noise criterion presents difficulty in light of the different types of construction that is encountered in rural environments. The use of a linear value, a dB(C) value or dB(G) value, and whether such values are full range or limited in the frequency domain, is a matter that is subject to further investigation and should be incorporated in part of the scientific studies discussed in the previous section.

Conclusion

There are communities around Australia that are impacted by wind farms.

In some instances there are residents who leave their dwellings, and when they are relocated to dwellings removed from the wind farms they identify they are no longer adversely impacted and their sleeping patterns return to normal.

The provision of wind farms in rural Australia has generated significant conflict in the communities and it is often stated to me by residents that the wind farms are destroying communities.

Therefore at the present point in time the separation distances that exist from wind farms, that are generally based upon a dB(A) noise level are clearly inadequate.

Accordingly the answer to the question of wind farms being too close to communities is in the affirmative.

The responsibility of the environmental and health authorities in Australia must be to protect the community from adverse health effects. The most common complaint from the community concerning wind farms is related to sleep disturbance. With continual sleep disturbance then other health effects come into play.

At the present point in time wind farm operators rely upon criteria nominated by the regulatory authorities with the fall-back position that if their wind farm complies with the nominated criteria then it is no longer their issue.

So as to guarantee that there are no adverse impacts from wind farms then the separation distances must be increased.

In the absence of any scientific studies to identify the appropriate separation distance then an applicant/wind farm operator 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 do 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 the wind farm complied with the noise limits nominated by the Authority for the environmental assessment, and health impacts were found to occur then the Authority (not the applicant) would be liable.

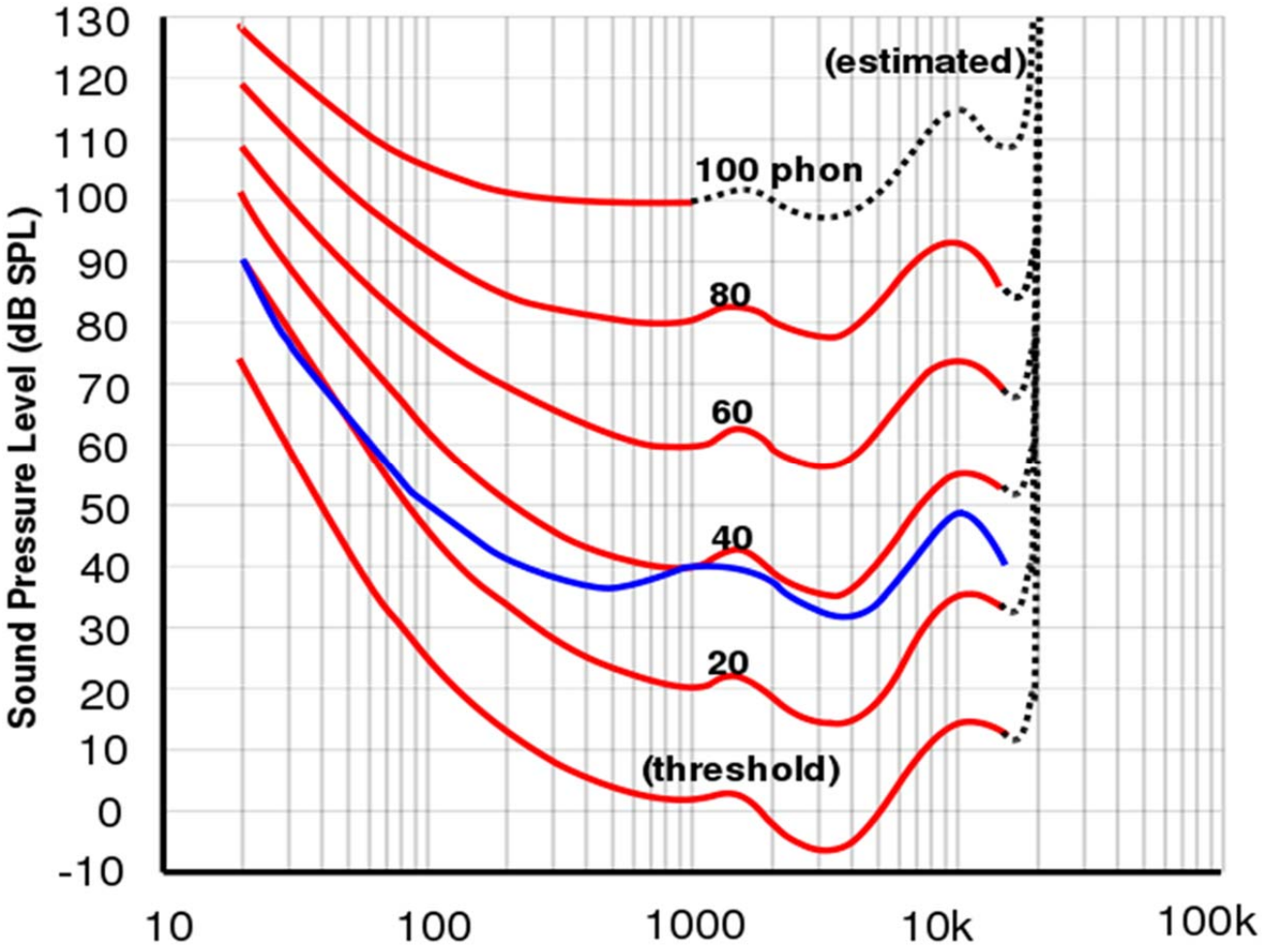


FIGURE 1 Equal-loudness contours (red) (from ISO 226: 2003 revision) and Original ISO Standard (blue) for 40 phons

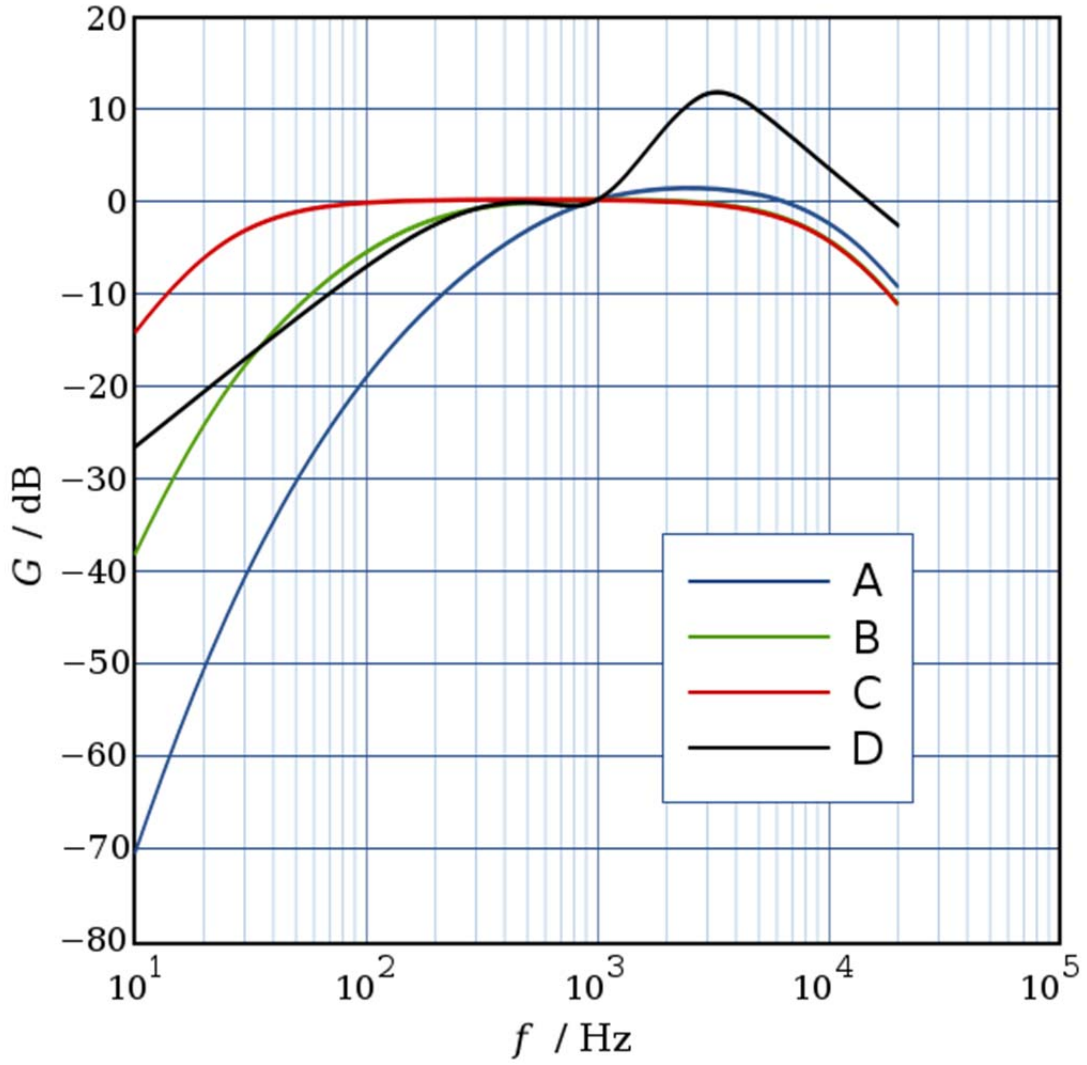


FIGURE 2 Normal Frequency Weighting curves

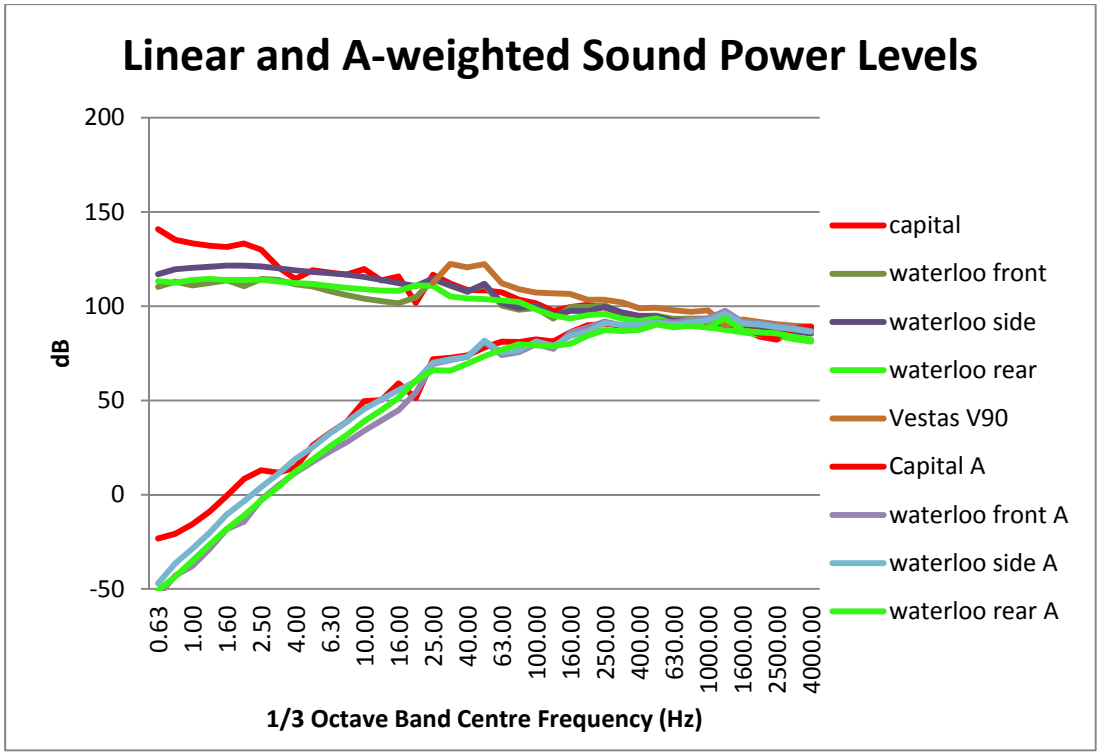


FIGURE 3 Turbine Sound Power Levels (Linear versus A-weighted)

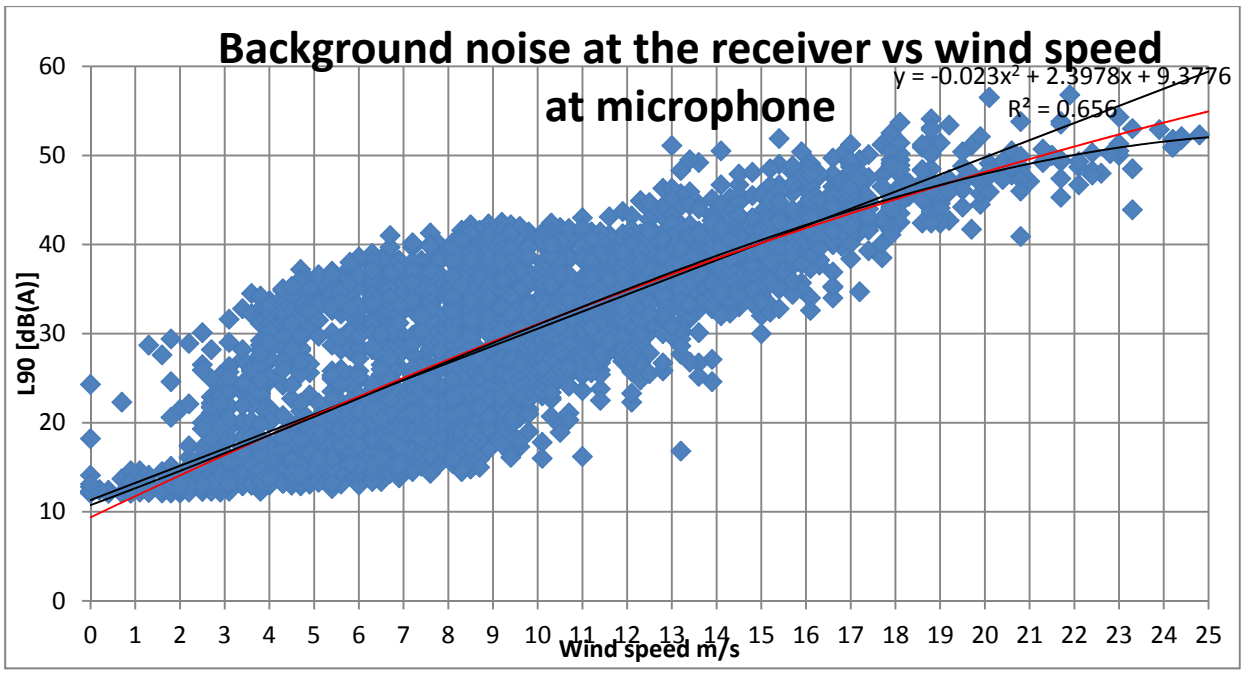


FIGURE 4 Exposed Hillside (furrowed ground) – No Turbines, No Trees within 500 metres

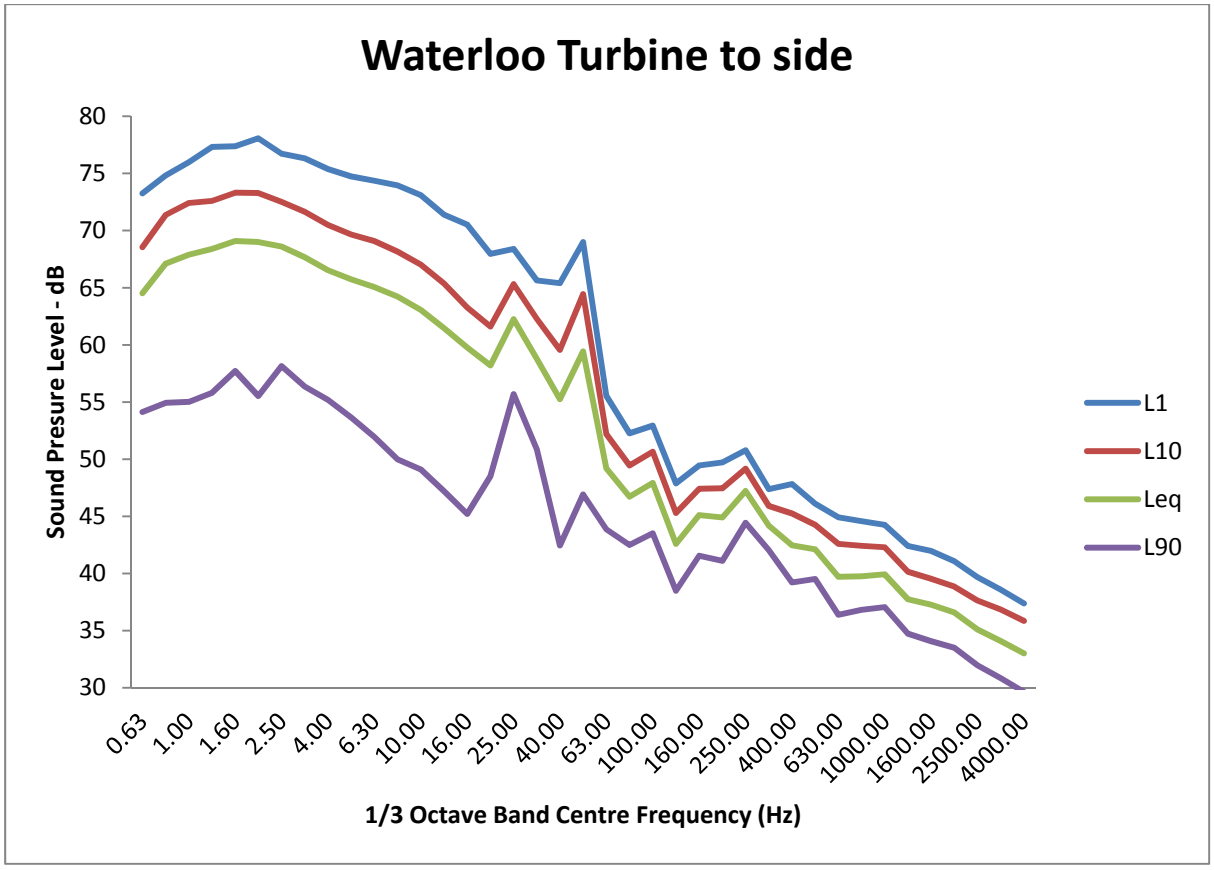


FIGURE 5 At 150 metres from tower

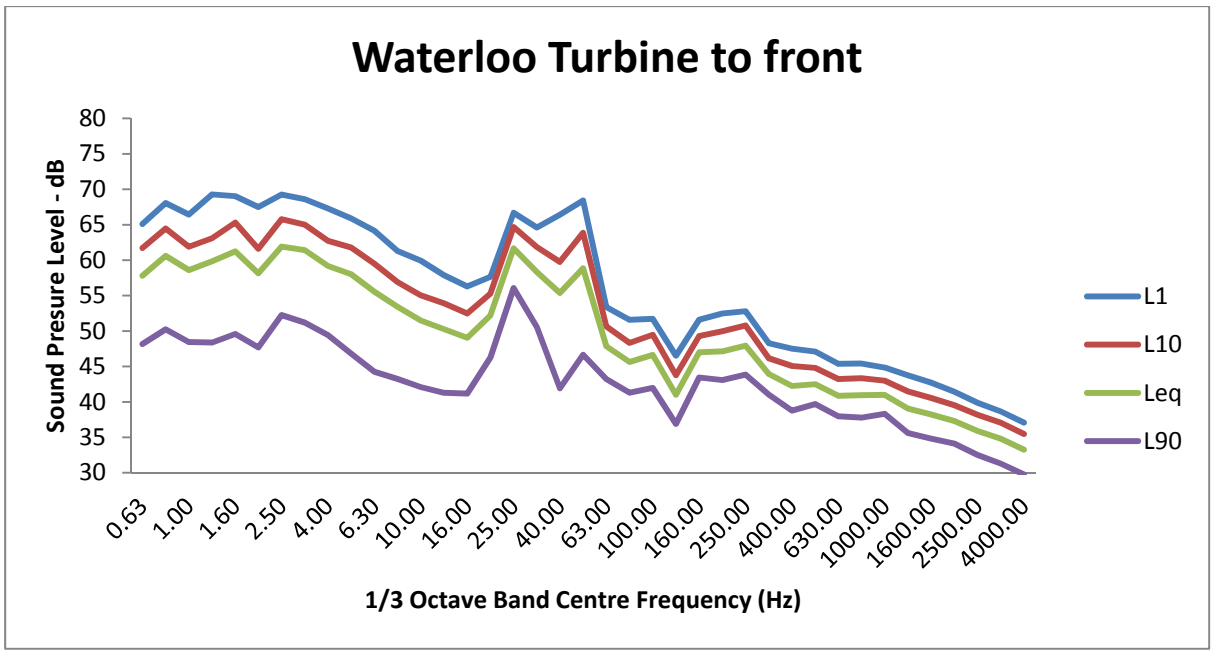


FIGURE 6 At 150 metres from tower

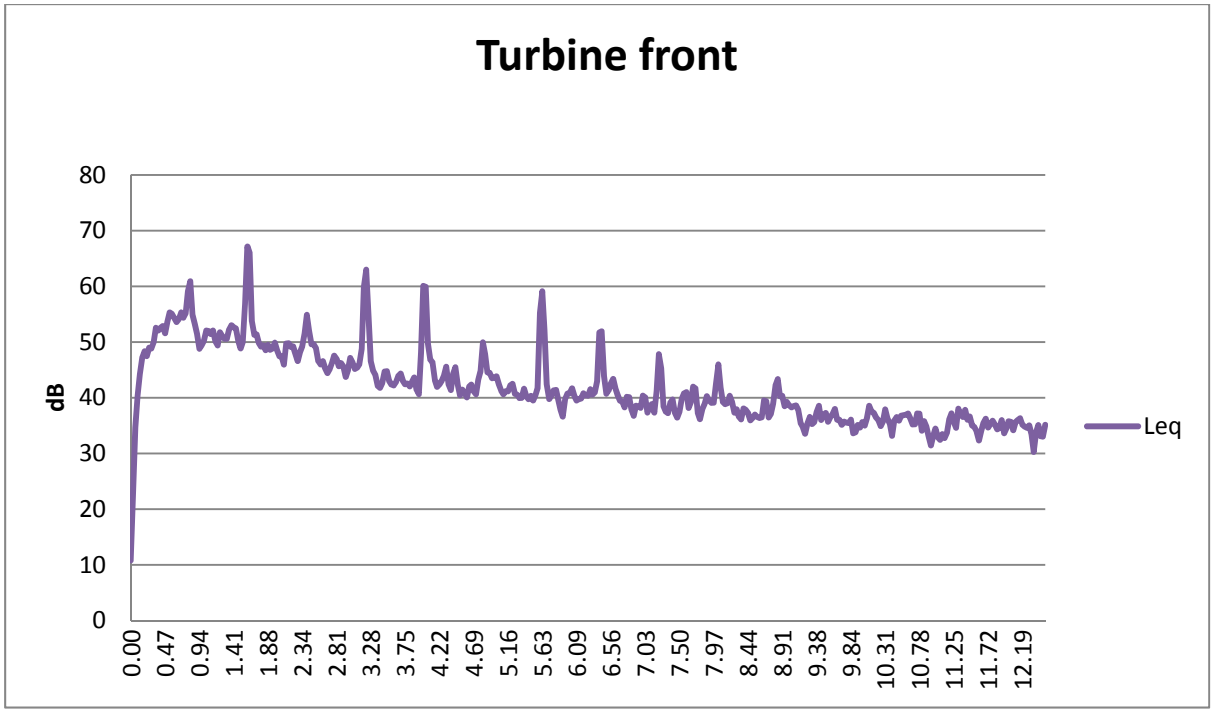


FIGURE 7: 0 – 12.5 Hz at 150 metres from tower

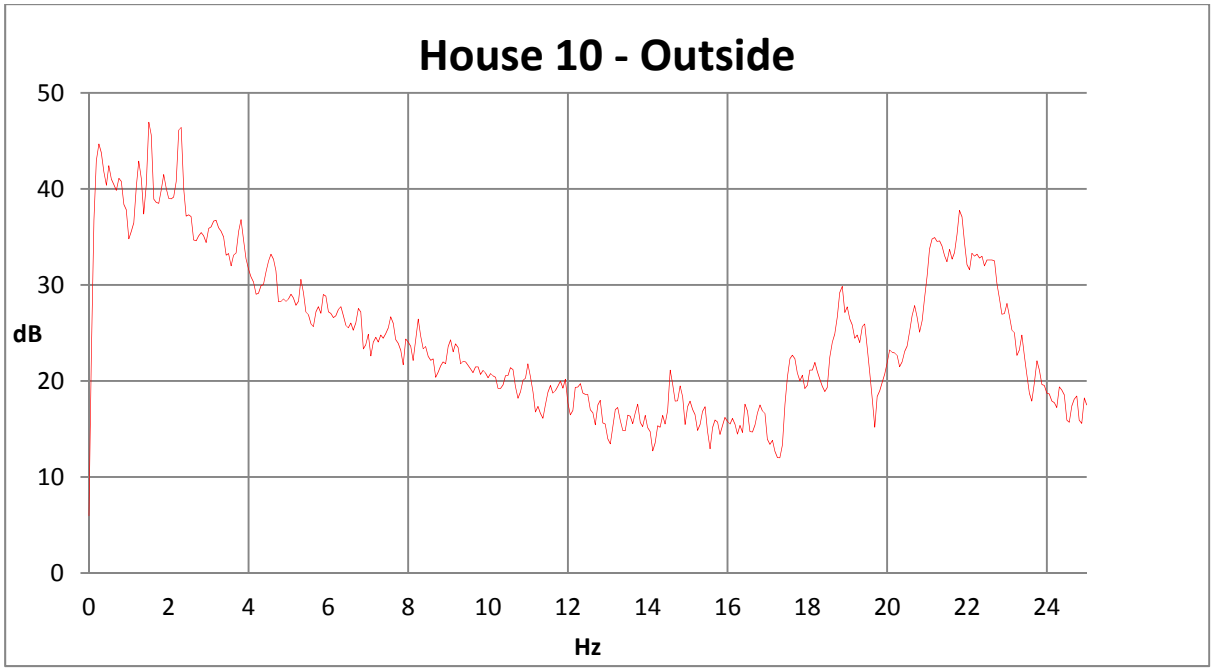


FIGURE 8 External Measurements approximately 1300 metres from nearest turbine

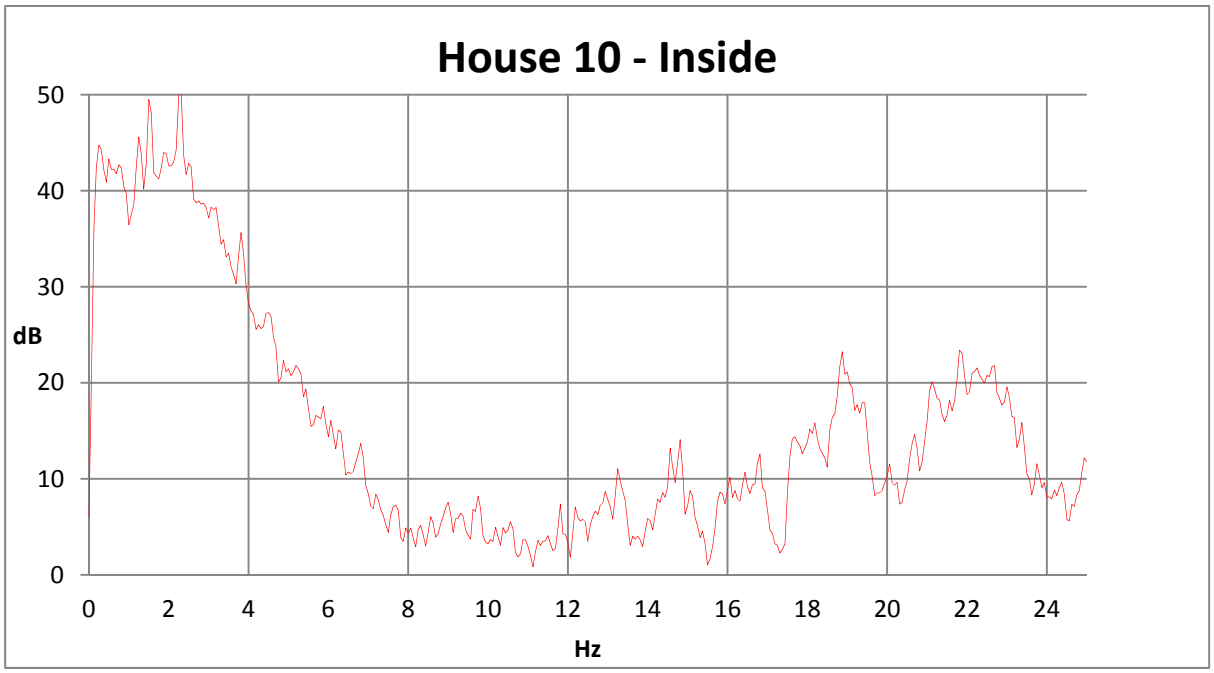


FIGURE 9 Internal Measurements approximately 1300 metres from nearest turbine

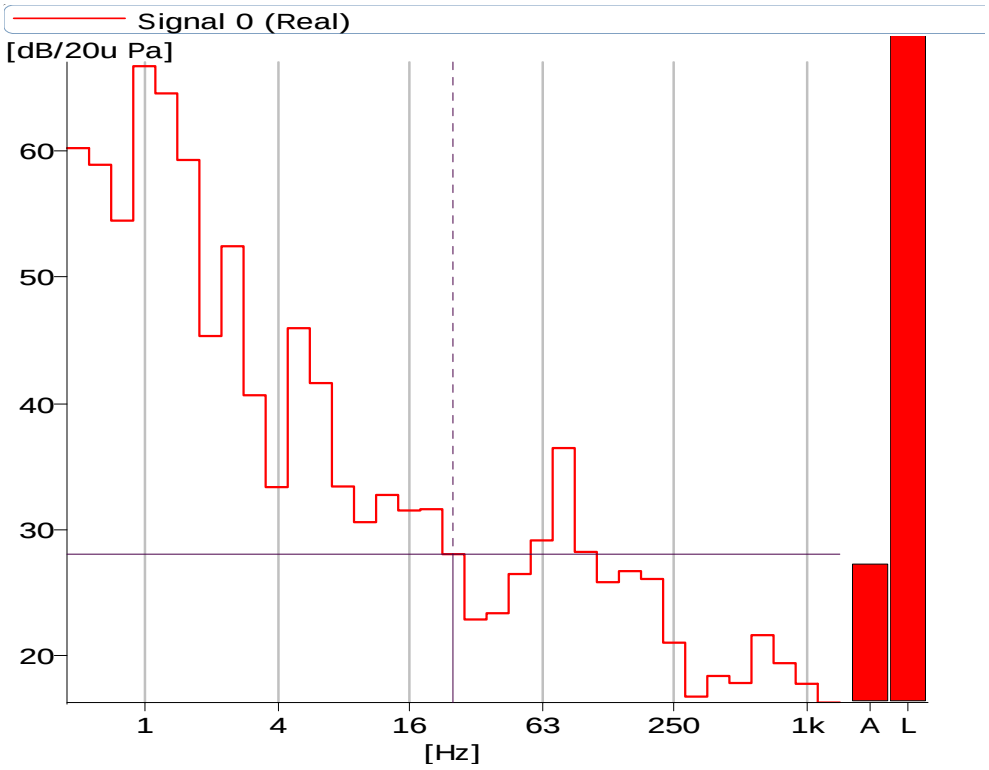


FIGURE 10 External Measurements approximately 8000 metres from nearest turbine

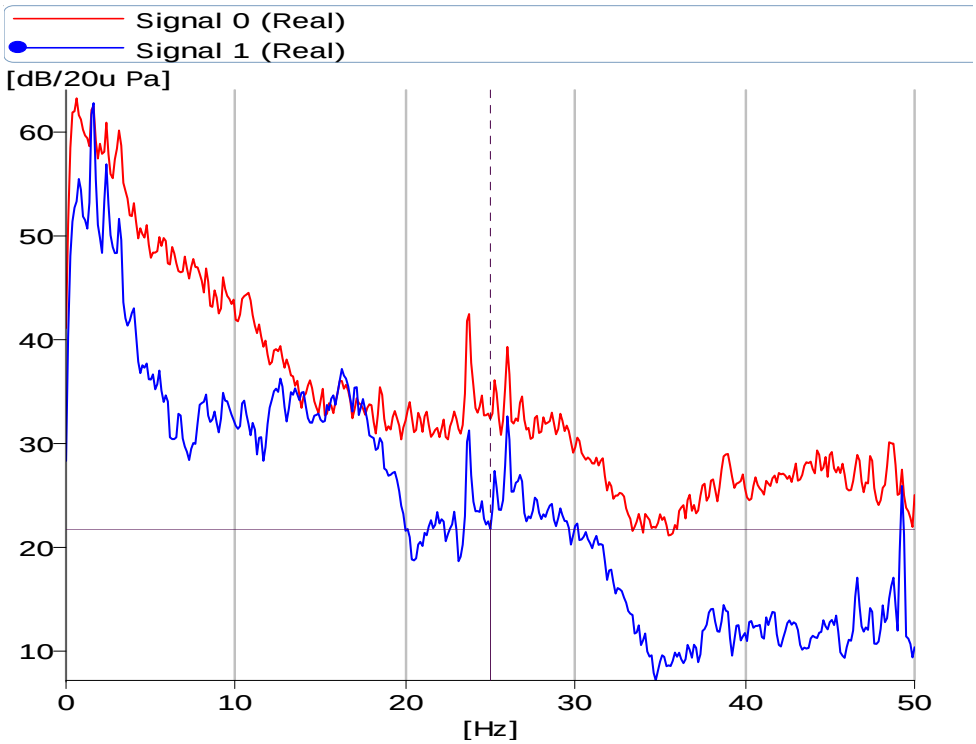
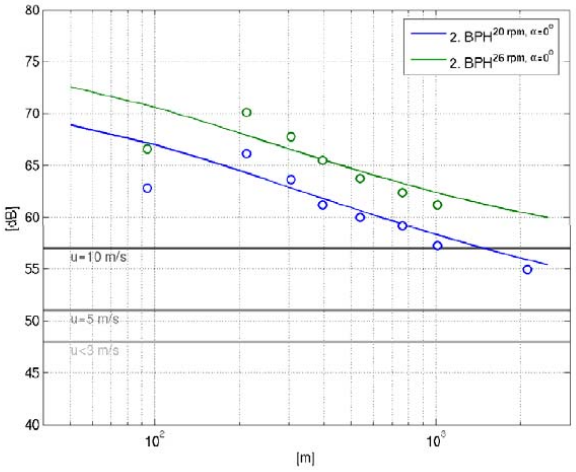


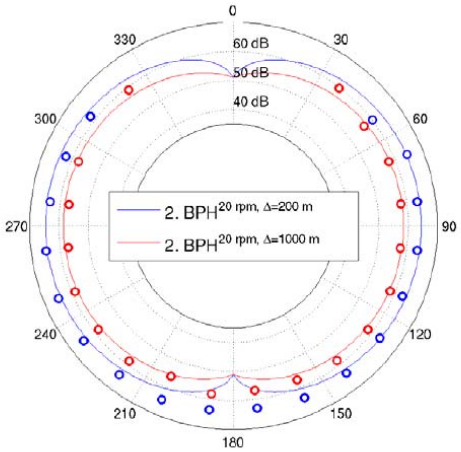
FIGURE 11 External and Internal Measurements approximately 8000 metres from nearest turbine

Comparison between measured and estimated SPL

SPL as a function of distance



SPL as a function of azimuth



account for surface effects (e.g. reflections) by adding 3 dB to the estimated curves

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Measured signals, Huf03, d=200 m

frequency domain

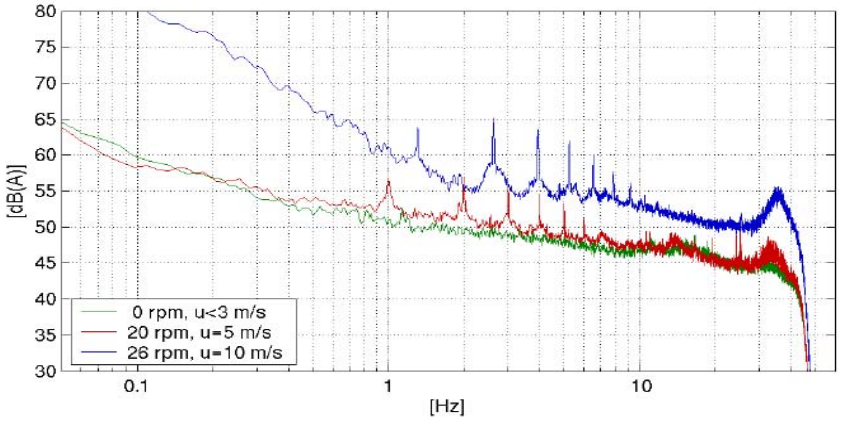

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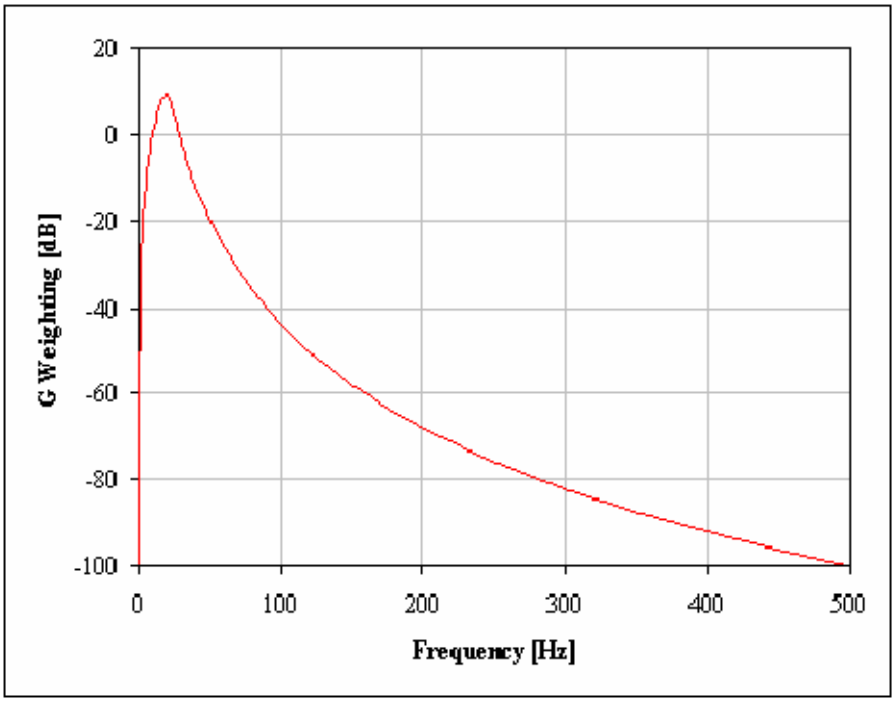
FIGURE 12 The inaudible noise of wind turbines, Ceranna, Hartmann and Henger, Federal Institute for Geosciences and Natural Resources (Hannover, Germany)
Infrasound Workshop Nov 28 , 2005 Tahiti

G weighting purportedly reflects human response to infrasound. The curve is defined to have a gain of zero dB at 10Hz. Between 1Hz & 20Hz the slope is approximately 12dB per octave. The cut-off below 1Hz has a slope of 24dB per octave, and above 20Hz the slope is -24 dB per octave.



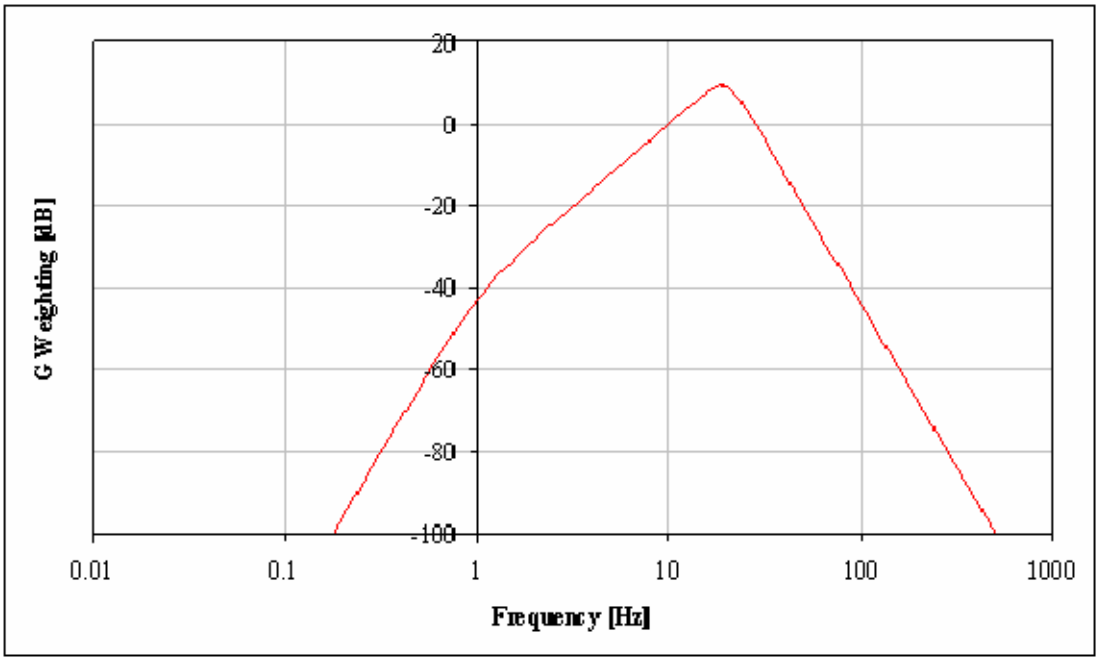


FIGURE 13 G-Weighted Overall Level

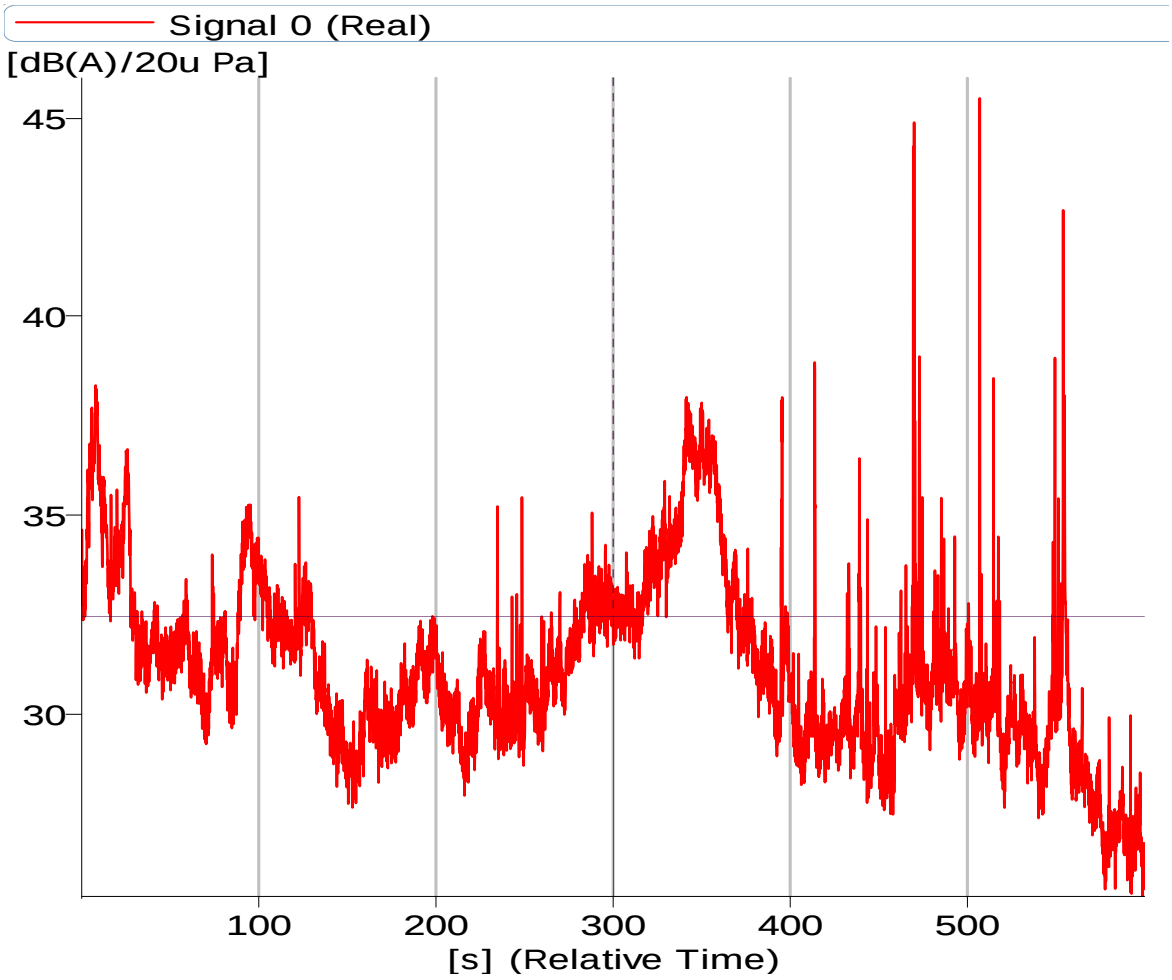
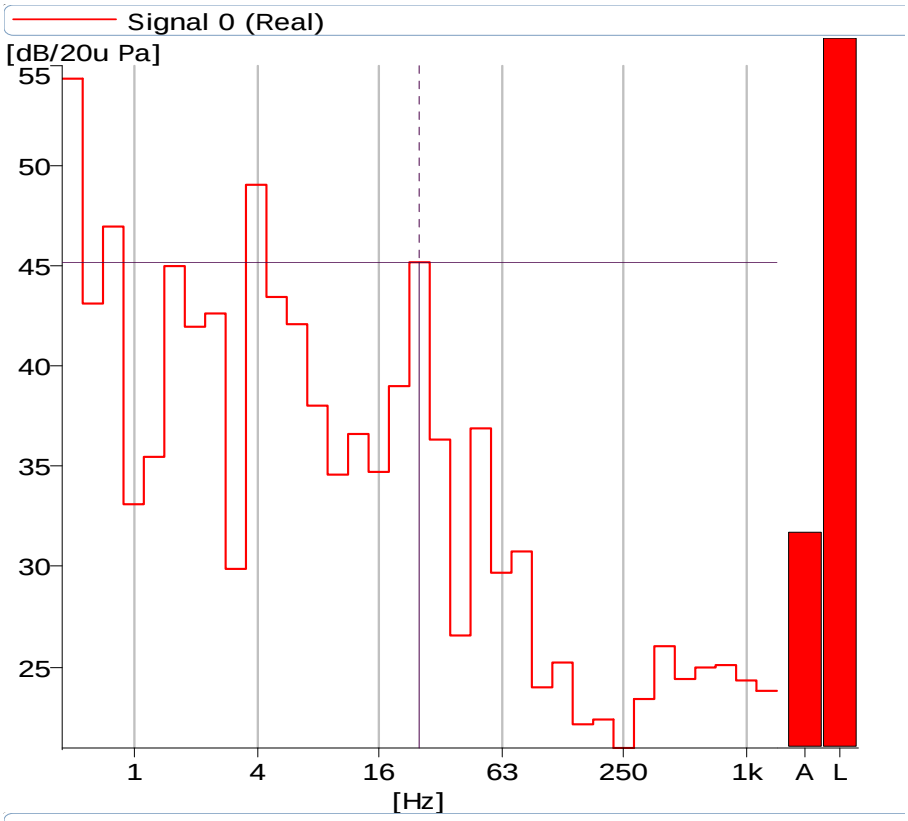


FIGURE 14: Ambient Noise Level for varying wind (up to 7m/s gusts) + birds



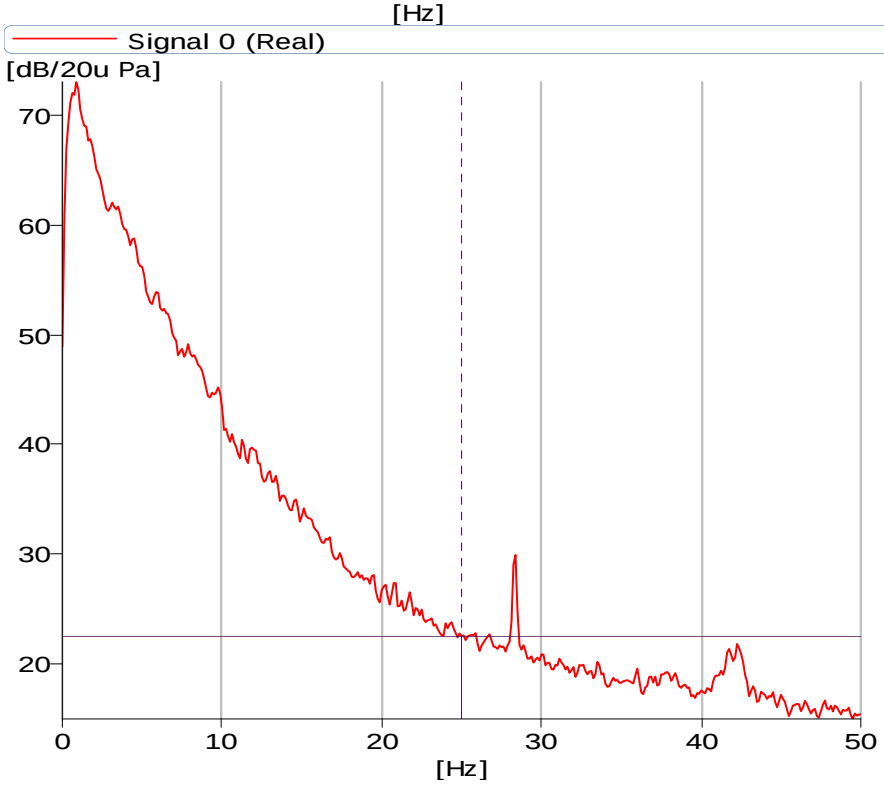


FIGURE 15 : 1/3 Octave and Low frequency FFT for 10 minute sample in Figure 14