E-Coustic Solutions

Noise Control ▫ Sound Measurement ▫ Consultation
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February 19, 2009

Gary A. Abraham, Esq.
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Dear Mr. Abraham:

Thank you for the opportunity to respond to your request for preliminary comments on the appropriate method to assess background sound levels in rural Allegany, New York. The purpose of measuring background sound levels is to be able to predict potential impacts from noise emissions caused by a 32-turbine industrial wind farm proposed by Everpower Renewables. You have indicated that the Allegany Planning Board will be reviewing submissions from Everpower with the help of an independent consulting firm, as soon as the Board is satisfied the submissions are complete. EverPower's submissions should present the findings of their pre-construction background sound level measurements and their post-construction operational sound levels as estimated by computer modeling of the wind turbine's sound emissions' propagation into the adjacent community.

Reviewing this type of report requires an independent and thorough understanding of how wind turbines affect the potential for community annoyance, sleep disturbance, and possible health risks. There are specific differences between wind turbine sound emissions and those of other common community noise sources like roads, rail, aircraft and most industries. These differences require measurements to identify the times when the turbines are most clearly audible, which is typically when the ground level winds are calm and upper level winds are strong enough to power the wind turbine at full capacity and the man-made sounds of the community have quieted for the evening/night. This condition is typical of many summer evenings and nights so the opportunities to collect this information at night are not uncommon.

Modeling procedures for wind turbines also differ from the ones used to predict annoyance and land-use compatibility for the more common rail, road, air, and industrial sources of community noise. Wind turbines do not meet many of the requirements for accurate modeling of sound propagation under the ISO 9613-2 standard upon which all commercial modeling software's computational methods rely. The Planning Board's acoustical consultant will also need to understand the issues related to IEC 61400-11, the standard for measuring wind turbine noise under laboratory conditions. Thus, a thorough understanding of ANSI standards such as S12.9 parts 2 and 3, and S12.18; and ISO 9613-2 for sound propagation models, and IEC61400-11 for the input data to those models will be needed to adequately judge completeness, accuracy and implications of the Everpower noise study.

Limitations identified in each of the standards related to their intended use, limitations of the procedures; and conditions that could lead to higher sound emissions than the reported test results along with the theoretical limitations of the sound propagation algorithms will need to be disclosed in the report or else the reviewers will need to obtain this understanding independently. One example of this in-depth understanding is to know that the ISO 9613-2 prediction formulas and procedures are able to accurately address only the simplest of geometries between noise source and receiver. Another is that the formulas specified under ISO standards assume that the noise and receiver are under ideal weather conditions with low speed winds. Wind speeds sufficient to power wind turbines are not within the scope of the ISO standard's procedures. If the terrain is not flat, the models' ability to properly address the interactions of the terrain (as a barrier) between the source and receiver must also be carefully reviewed. Wind turbine models are not a good fit to the ISO standard's assumptions and pre-conditions used in constructing the models and computing the sound levels emitted into the adjacent properties. There is a long list of input data values that must be disclosed and reviewed for appropriateness on any particular project. If these are withheld and not disclosed in the report then the validity of the model cannot be independently verified.

Even with the above information, the model's results will not reflect the 'real world' conditions. First, the models can only consider average sound levels. They cannot, by themselves, provide any insight into the degree of fluctuating noise that will be heard outdoors on one's property, or whether the low frequency noise emissions will be a cause of problems inside adjacent homes. This later issue is especially important to know whether the wind project, when operating at night, may cause sleep disturbance.

One cannot blindly apply the results of a sound propagation model that was originally developed to predict noise levels of rail, road, and other industrial noise sources common to suburban and urban communities. Models of wind turbines on tall towers, located in rural communities, and sometimes operating under extreme weather and wind conditions have numerous opportunities for potential inaccuracy. For example:

1. Wind turbines do not operate at the low wind speeds for which the ISO based computer models assume,
2. The turbines' blades and other noise sources are located at a height that exceeds the upper limit for noise sources to be above the ground (limit is 30 meters), and
3. Because of the height, sound waves propagating from the turbine to the receiver do so at steep angles such that normal attenuation from vegetation and terrain do not occur.
4. For Wind turbine projects located in a long row along a ridge, the rate at which sound decays can be very different from what would occur if the turbines were scattered across flat terrain. If this is not accounted for in model construction serious underestimates of sound level in the community will occur. Unless the decay rates for sound from the turbines are disclosed, there will be no way to know if this and similar situations are handled properly.

Yet, given that the models are poor at replicating the way turbine sound emissions will propagate in the real world due to the poor fit between the ISO 9613-2 formulas and the way turbines are situated they are still often used in wind turbine company noise studies included in requests for permits and other necessary approvals. It is critical that those who will be reviewing the EverPower sound study understand the details of the model construction and the assumptions used in creating it. The study should also disclose all factors that could lead to higher noise levels than the model predicts to allow the reviewers to estimate the upper limit of noise impact.

I have reviewed Mr. Charles Ebbing's PowerPoint presentation given to the Planning Board on February 2, 2009. I fully support his estimate of about 25 dBA as representative of the community's nighttime background sound level. I base that support on my understanding that the Everpower project area is located in an area that would be considered rural or wilderness. I understand that this area does not bound urban areas where air, rail, and road noise set the long-term background sound levels. It is typical of rural areas 3-5 miles distant from any major artery that is heavily trafficked at night, not on flight/landing paths, not affected by industrial noise sources, and where rail and other man-made sounds are infrequent especially during late evening and nighttime hours.

I have conducted tests of background sound levels in many similar areas. Nighttime background sound levels of 25 dBA or even lower were commonly observed.

Mr. Ebbing is also correct to emphasize the common situation of stable atmospheric conditions, where calm air prevails at ground level, with little or no wind speed, but wind speeds at elevations of 100 feet or more above ground level are sufficient to operate turbines at maximum output. This condition is especially common for people who live below ridge line-sited wind turbines. People living at the foot of the ridge are often sheltered from the wind by the ridge. Under those conditions, the turbines are producing maximum sound emissions but there is no masking of wind turbine sounds in the valley because there the winds are calm and there is no 'wind' noise.

This condition, when the turbines are "clearly audible," is the one that should be used to assess whether a wind project meets the sound level criteria, not some other condition, such as, when surface winds are high and the sounds of wind interacting with objects and vegetation might provide some masking of the turbine sounds. The standards are intended to prevent complaints of noise. It would be absurd to judge the acceptability of wind turbines for conditions that represent situations when sounds in the valley are unusually high.

Generally accepted procedures for land use planning assess the new source against the quiet times of the community not the noisy times when complaints would be unlikely. Since wind turbines operate 24 hours a day, the likely complaint time would be at night, when man-made noises have stopped, the winds at the turbines on the ridges are at nominal or higher operating speeds, and the winds in the valley are shielded by the ridge or because of wind shear. Mr. George and Dave Hessler, in their paper titled: "*Baseline Environmental Sound Levels for Wind Turbine Projects*" say in the first paragraph of the Conclusion:

"Adverse impacts occur when the new noise from a project significantly exceeds the background level at sensitive receptors and becomes clearly audible.[1]"

It is puzzling that, immediately after this statement, the Hesslers continue by concluding that the time when wind turbines will be "clearly audible" is when the wind outside homes in the valley is blowing hard, e.g. at 10-20 mph, and the wind at the ridge is also high causing the turbines to operate at their maximum sound emission level.

This interpretation is contrary to the generally accepted understanding of a community's 'background sound level.' This is a defined term in acoustics. To alter its meaning to be the noisiest conditions and not the quiet conditions as generally accepted for land use planning and evaluating a community's reaction to a new noise source is truly novel. It is clearly at odds with ANSI standards and procedures for assessing background sound levels and for assessing the impact of a new noise source on a community.

Mr. D. Hessler's report for Everpower on pre-construction background noise uses this novel twist to the meaning of background sound level to substitute higher sound levels for the basis of compatibility conclusions than sound levels representing the quiet nighttime ambient. This substitution is not appropriate because using the 'worst case' wind induced noise sound level in place of the more appropriate 'quiet time' sound level gives the appearance that the wind project will be more compatible with the community than it will be in operation. There are many examples of wind developer sound studies that use this type of ruse to conclude that a wind project will be compatible or even not audible in a community when it requests a permit. Yet, those same projects cause frequent complaints of excessive noise once they start operating. The methods being applied in the EverPower study can easily lead to the same problems.

Because the methods used for the Everpower report do not follow generally accepted practices any statements about compatibility with the community should be ignored. The fact that the wind project may not be a noise 'problem' when the community is subjected to high noise from wind and weather has nothing to do with its compatibility when the community is quiet and the turbines remain in operation. The report's novel method of interpreting (or misinterpreting) the background sound level near the project area based on conditions when the turbines are the least audible (because it is already noisy outside from high winds) will always show wind turbines are more compatible with the community, compared to an interpretation based on generally accepted standards for determining background sound. Generally accepted standards dictate that background sound levels be determined under conditions when the turbines would be most clearly audible. Whether this is intentional biasing of the study in favor of the developer or not, the result is to bias the findings in favor of the developer's goals.

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[1] Hessler, George F., Hessler, David M., "Baseline Environmental Sound Levels for Wind Turbine Projects" published in Sound and Vibration Magazine, pages 10-13, Nov., 2006

Mr. Hessler may respond that this method is used by many other consultants who work for wind energy developers. But, as Mahatma Gandi said: *" An error does not become truth by reason of multiplied propagation, nor does truth become error because nobody sees it"*

Mr. Ebbing is also correct to distinguish the impact of low frequency sound from A-weighted sound levels generated by wind turbines. Low frequency sound is a significant component of wind turbine noise, it more easily passes through walls to home interiors where there is an expectation of privacy and quiet, and can be expected to be higher in amplitude (louder) than sound levels from the same source measured with the meter set to apply A-weighting to the measurement data (dBA). Since Hessler's model results are not presented with octave or 1/3 octave band level of detail nor in terms of over-all dBC sound levels the dominance of the energy in the lower frequency ranges common to most modern wind turbines is not apparent to a reviewer of the report who does not already know the spectral energy distribution of a wind turbine. Thus, without this information it is not possible to know if the wind turbine's sound emissions will result in excessive low frequency energy.

Mr. George Hessler understands the role low frequency sounds can play in community complaints and has written a paper on that topic in which he recommends strict limits for low frequency sound using dBC measurements to assess whether the low frequency sounds are excessive[2]. Yet, even with that knowledge available to him, Mr. D. Hessler presents no analysis of the operational low frequency noise emissions of the EverPower wind project. Is this oversight or intentional? To dismiss low frequency sound and its potential as a community annoyance or possible public health risk using an unsupported assertion that it is not 'significant' is not science, it is public relations. Complaints from people who live near operating wind projects often involve low frequency sound issues. It would have been appropriate for Mr. D. Hessler to present an analysis to show whether the low frequency sound emissions from this project might pose problems given the understanding of the issues of low frequency sound and complaints shown in Mr. G. Hessler's paper.

Based on my experience measuring community background sound levels, such rural areas are much quieter than acoustical experts have assumed for the last 30 years. This lack of information occurred because in the U.S., almost all of the major research on community noise was conducted in the 1970s under the auspices of EPA's Office of Noise Abatement and Control. These studies focused almost exclusively on urban, suburban and industrial areas. Those areas were the primary concern because those areas where undergoing the most rapid development. In 1980 the Office of Noise Abatement and Control was defunded and no administration since has renewed funding. Thus, all government-sponsored research came to a virtual halt. By the time acoustical engineers, as a profession, realized we had no understanding of long term background sound levels in rural/wilderness areas there were no funds to conduct the research.

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[2] Hessler, G. F. Jr., "Proposed criteria in residential communities for low-frequency noise emissions from industrial sources", Pages 179 to 185, Noise Control Eng. J. **52** (4), 2004 Jul–Aug

Mr. George Kamperman, PE, Bd. Cert. INCE (emeritus), who has been active in the community noise field since about 1950 and who participated directly or indirectly in many of the studies used to establish the guidelines now commonly used in community ordinances has stated in private conversations that the truly rural areas were not considered because they were not near sources like road/rail/air/industry. Developing noise criteria for the urban and suburban land-uses was the initial concern of the EPA. Once the office was defunded there was no way to fill in the gaps in our understanding of rural/wilderness land-uses.

This lack of data and the subsequent miscues created by committees who have adopted acoustical principles and rules created in the 1970s for road/rail/air/industrial noise sources for wind projects along with misdirection in marketing materials from wind advocacy groups like the trade lobbying organization American Wind Energy Association has resulted in disasters like the UPC/First Wind, Mars Hill utility in Maine. There and in other places the application of old rules for land-use planning has resulted in wind projects being "compliant" but the adjacent properties are subjected to constant sound levels over 50 dBA with high low frequency sound energy and the periodic "whoosh" of turbine blades every 1.5 seconds 24/7. This is part of a general phenomenon, where modeling by wind developers predicts low impacts, but many operating wind farms around the world, especially those using modern upwind industrial scale wind turbines located within a half mile of homes, have elicited unexpected levels of community complaints about noise.

The long-term background sound level (L_{90}) as defined and measured according to ANSI standards, is the proper starting point for assessing community response to a new noise source. My rule of thumb is that if one can hear sporadic traffic at distance of 1-2 miles at night when the air is calm and man-made sounds are not present near the listener, the L_{90} will be in the range of 25 dBA or lower. Some rural/wilderness areas I have tested have been 18 dBA and possibly lower where even the sound of distant traffic is not present.

The Acoustical Society of America is in the initial stages of establishing a new working group to review the issue of rural/wilderness long-term background sound levels and how to measure them. The measurement methods in the Kamperman and James manuscript reflect the current best understanding of how to make these measurements within the framework of current ANSI/ISO standards. I expect, based on Mr. Kamperman's relationship with Dr. Schomer, who is charged with the task, that our procedures will be part of the working group's starting point.

However, as explained above, consultants who regularly work for the wind industry use their own method. It does not meet any of the generally accepted acoustical standards and in many respects its methods are directly prohibited under the ANSI/ISO standards. For example, measuring community background sound levels when winds exceed 4.5 mph, or allowing transitory sounds such as sounds of a nearby brook to be taken into account in the measurement are both prohibited under the standards. This is because the standards require that the measurements capture only sounds that can be expected to be persistent over long periods; the standard directs that transitory sounds and wind noise be removed from the data set used to determine background sound level.

Based on my professional experience, I expect that the families living in the valley between the two ridges on which Everpower proposes to site industrial turbines in Allegany will be subjected to higher levels of annoyance, sleep disturbance and other negative impacts than would occur if the turbines were on relatively flat land. None of the computer-based acoustic models being applied for wind projects that I have reviewed to date properly address this difference. My research and that of others into the current models used by wind developers show that the attempts to make the models fit the ridge-to-valley situation can introduce errors that further under-predict the extent to which sound propagates into the valley. For this reason the models also under-predict the potential for annoyance and sleep disturbance. Computer model results need to be carefully reviewed to prevent such errors and, if needed, adjusted manually for the ridge-to-valley situation.

I have enclosed guidelines developed by myself and George Kamperman titled "Simple guidelines for siting wind turbines to prevent health risks," for your and the Planning Board's further reference.

Sincerely,

Richard R. James, INCE
For: E-Coustic Solutions

February 19, 2009

Attachment

E-Coustic Solutions

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February 22, 2010

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Subject: January 27, 2010- Environmental Sound Survey and Noise Impact Assessment for Allegany Wind Farm Project

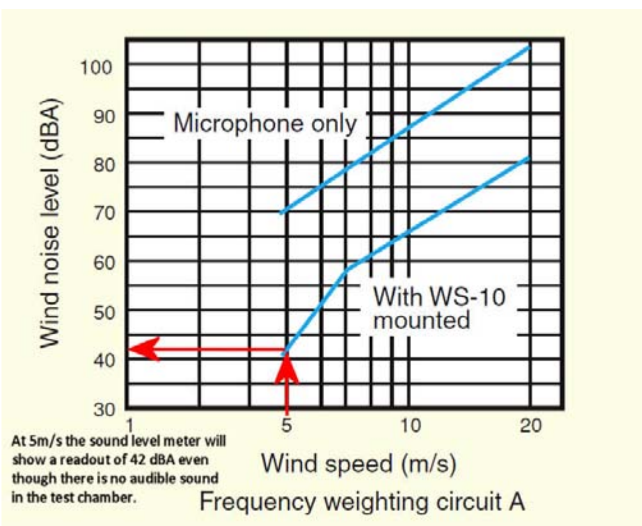
Dear Mr. Abraham:

Thank you for the opportunity to provide my opinion on behalf of the Concerned Citizens of Cattaraugus County (CCCC) regarding what fundamental flaws in the methods used by Hessler and Associates in conducting the background sound study for Everpower, LLC and in the methods used for estimating its impact using computer modeling.

There is no basis in any recognized peer-reviewed acoustic standards for considering the sounds that winds may produce as the basis for establishing the background sound levels. The basis for the approach used in the Hessler study for Allegany Wind is based instead on a procedure known as ETSU-R-97 which was developed in the U.K. by a group of wind industry attorneys, their consultants, and government agency staff working under the authority of a British Government agency tasked with expediting wind turbine implementation in the U.K. (See Item 1, on page v of the attached: "ETSU-R-97 summary" for the origin of the idea that wind turbines should be judged against the noise wind may produce when blowing through trees, shrubs and around objects.) This procedure is based on the desire to expedite development and justify locating turbines close to homes. It is not based upon recognized scientific and medical principles, nor did the authors consider such principles. (See attached paper "ETSU-R-97 Why it is Wrong" describing its genesis and flaws.) Hessler and Associates have been actively promoting this flawed procedure in their work for wind utility developers and it has also been adopted by many other consultants working for the wind utility developers, but that does not make it acceptable or correct.

I addressed some of my concerns about this method of establishing background sound levels in my letter of February 19, 2009 in the sections where I commented on Mr. Charles Ebbing's presentation. It appears that in spite of these forewarnings and advice on proper procedures the most recent study contains the same flawed methods. These methods result in reported background sound levels that do not reflect what would have been reported had the test protocols been conducted using proper procedures which exclude the effects of natural sounds like wind, water, short term events and other contaminating sounds. According to generally accepted acoustical engineering procedures in ANSI S12.9, Part 3 and S12.18 standards, such contaminating sounds are not considered part of a proper background sound test. One significant requirement of the ANSI procedures is that no measurement data may be taken when the wind speed at the measurement microphone exceed 5 meters per sec (m/s). ANSI S12.18 states at 4.4.1.1: "No sound level measurement shall be made when the average wind velocity exceeds 5 m/s….No attempt shall be made to adjust measured noise levels based on the wind data." (see excerpt below the windscreen graph.) The reason for this requirement is best understood by looking at the following graph which shows how a sound level meter outfitted with the manufacturer's recommended wind screen reacts to air movement during a measurement. In this graph the microphone is not subjected to any sound (the test area is quiet) but the air movement across the microphone begins to leak through the windscreen at wind speeds of below 5 m/s (about 11 mph). The air impinges on the microphone's diaphragm and at 5 m/s produces a false reading of 42 dBA. At 10 m/s the false reading has increased to 65 dBA. There are some specialized wind screens that improve on this performance but they only add a few decibels of extra protection. None can handle the strong winds at the ground level that are the 'goal' of the Hessler/ETSU method.

If we examine Figure 2.5.6 "Design Valley Sound Level Compared to Wind Speed" in the January 2101 report we see that the sound levels increase from below 30 dBA during periods without wind to as high as 45 dBA when winds are at 10 m/s. This is presented by the report's author as though it is the sound of winds in the community. But, using the chart below for windscreen failure induced noise we see that these sound levels can be easily explained as being the result of wind screen failure and not as any actual community noise.



The "Hessler Method" is novel in the sense that it is not based on established peer-reviewed procedures. In fact, it violates them. A new, proper background noise study, performed by an independent acoustical consultant should be required. Because Everpower, LLC. has not submitted a professionally defensible sound study, I would urge the Planning Board to insist they supplement the study before accepting the pre-draft EIS as complete.

Computer Modeling

The January 2010 study repeats the same errors in computer modeling that I warned about in my February 19, 2009 letter. On the first and second pages of that letter I described the proper methods for modeling of wind turbines under ridge and valley topographic conditions. Those warnings did not result in any changes to the models submitted by Mr. Hessler in the January 27, 2010 revised sound study for EverPower, LLC.

4.4.1.1 Wind, temperature and cloud cover

No sound level measurement shall be made when the average wind velocity exceeds 5 m/s when measured at a height of 2±0.2 m above the ground. No attempt shall be made to adjust measured noise levels based on the wind data.

Hessler's reliance on the sound power levels used in his model rely on the manufacturer's data as measured using the IEC 61400-11 standard. Mr. Hessler claims that this data represents a worst case situation, but that is far from accurate. It represents standardized measurements of wind turbine noise taken under optimum weather conditions for test repeatability. It does not attempt to reproduce the conditions that lead to worst-case sound emissions. It is a standardized test like the ones used for auto mileage estimates. It is not conservative and does not allow an evaluation of the worst case effect of wind turbine noise. If it did, the results of the model would have been between 5-15 dB higher than reported in this study.

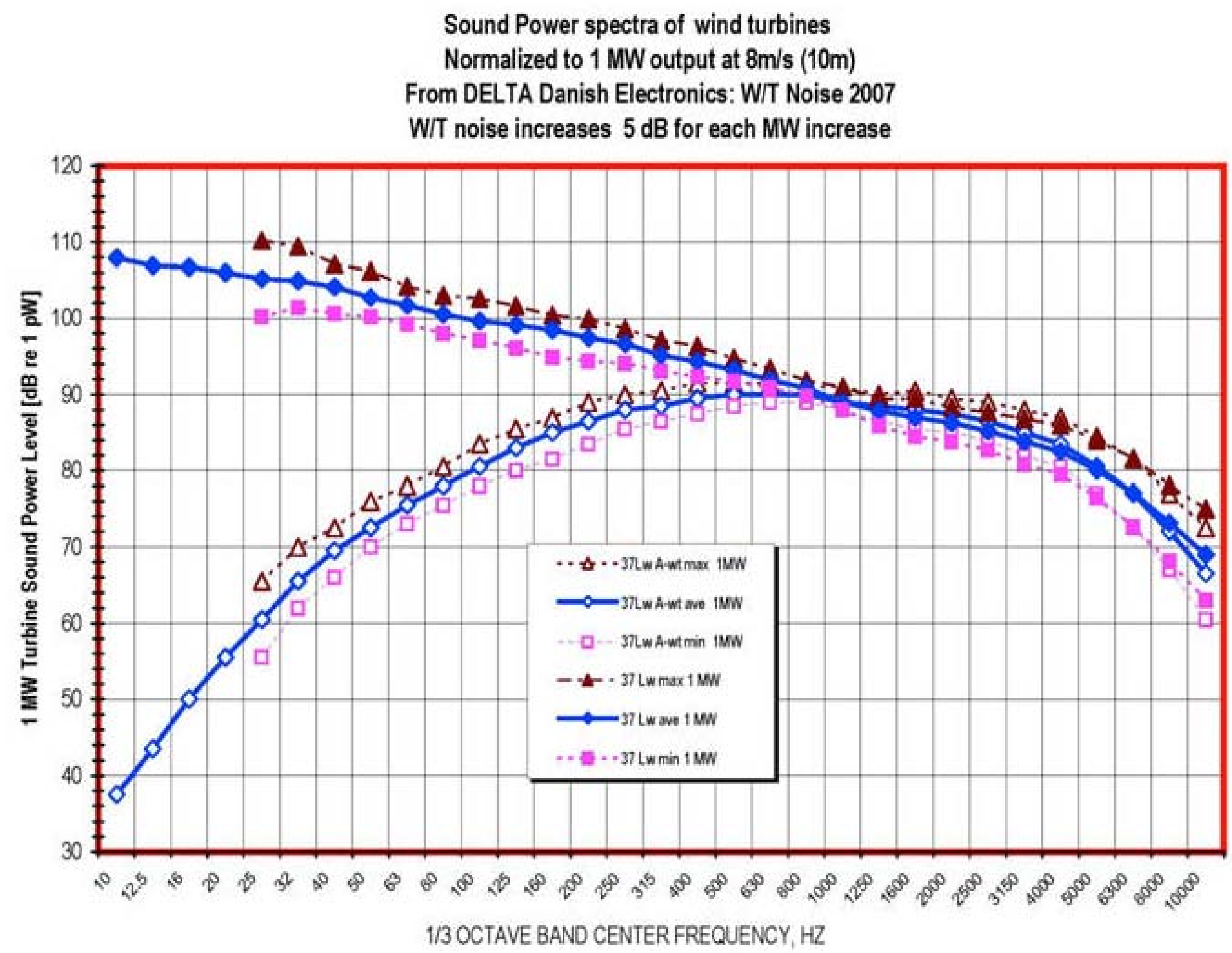
For, example, the standard does not include the sound emissions related to blade swish or other effects of turbulence in the air flowing into the turbine's blades. The standard does not include noise from inflow turbulence, especially up-thrust winds at the ridge's downwind side, wind eddies during storms, or high wind shears. Appendix A of the IEC standard explains that these conditions are known to increase sounds above those reported by the test and that they were not considered when developing the standardized data. Yet, it is these sounds that increase as the wind speeds increase and can add as much as 5-15 dBA to the maximum sound level received at a home. [Van den berg]

I have confirmed this many times while conducting tests for my clients. I found blade swish and thump sounds from turbines 1500 feet downwind that were over 50 dBA outdoors and exceeded 40 dBA inside the bedroom for a client living near the Noble Bliss wind project in Bliss, NY and similar levels in a home near turbines at the High Sheldon Wind Farm in Wyoming County, NY. These sounds exceed the 30 dBA outdoor nighttime sound levels recommended for safe sleep in the 2009 World Health Organization Guidelines for Night Time Noise. They also exceed the 40 dBA limit set in those guidelines at which adverse health effects from sleep disturbance can be expected. The Hessler report shows that sound levels will be above 30 dBA even for the optimum model conditions of the standardized IEC test data. This model does not reflect the real impact of the wind turbine project on the host community. The results do not reflect what the community will experience during normal operation of the wind project once it is installed and operating. This should not be a surprise. The same type of flawed modeling has been used to apply for operating and building permits at many wind projects in western New York and other places. The disconnect between the idealized 'models' and the real-world with its unpredictable weather conditions the models cannot address is the reason why after these projects start operation complaints start being filed as has been seen in Cohocton, NY, Mars Hill, ME, and many other places.

Low Frequency Sound

In section 3.6 of the January 2010 report, Mr. Hessler presents a chart and description of a study by Bo Sondergaard (of DELTA) that is purported to show: "***The results of this testing show that for a typical turbine its sound levels taper down steadily in magnitude towards the low end of the frequency spectrum and that the sound energy below about 40 Hz is actually comparable to or less than the sound energy in the natural rural environment where the measurements were made (Figure 3.6.1).***" This comment is based on an outright misrepresentation of the facts. The graph shown in the Hessler report depicts the spectrum of wind turbines as it appears after applying an A-weighting calculation on the true data that dramatically reduces the low frequency sound levels. Showing these modified spectrums in graph form makes the low frequency energy appear to have little impact compared to higher frequencies (a hump shaped graph) unless one remembers that it depicts data that has been manipulated by applying A-weighting filters. A-weighting reduces sound levels in the 10 Hz region by over 70 dB.

I have inserted a graph below showing the summarized data for all 37 of the turbines in the



Sondergaard study, not just the single turbine in the graph in Figure 3.6.1. For this example I have removed the artificial effect of A-weighting for the set of data that slopes down from left to right. This is the true shape of the energy spectrum for a modern upwind industrial scale wind turbine. It starts with most of the acoustic energy in the infra and low frequency range and the acoustic energy decreases as the frequency increases into the audible speech frequency range. To make the comparison easier I have also reproduced the original A-weighted data from the Sondergaard study. This data is shown in the hump shaped curves that start out appearing to be low in the lower frequency range only because A-weighting subtracts large values (over 70 dB at 10 Hz) from the true values shown in the top curves. These are similar to what Mr. Hessler shows in his example. But, just as the A-weighting gives a false impression about low frequency acoustic energy in my example of the 37 turbines in the DELTA study so it does in Mr. Hessler's example. When looking at Figure 3.6.1 in the January 2010 report it is important to remember that the real curve starts out high on the left side of the graph and slopes down to the left just as in my example.

Thus, Mr. Hessler's argument rests on his expectation that lay reviewers will not notice that he has played tricks with the data and is trying to convince the reader of his report that low frequency sound is not present based on the shape of his graph. Once this trick is removed it is easy to see that most of the sound energy for wind turbines is in the low frequency range. It is appropriate to say that this graph shows that wind turbine sound is primarily low frequency acoustic energy.

Given that Mr. Hessler is not being open and forthcoming on this issue, one must be wary of his other methods and conclusions. I have tried to identify these to you in this and my previous letters. I trust that you can use this information to explain my concerns to the Planning Board so that it understands why these reports are not only incomplete but also misleading. These studies should be repeated by an independent consultant.

Sincerely,
E-Coustic Solutions

Richard R. James

Richard R. James, INCE

Attachments ETSU-R-97 Why it is Wrong, by Dick Bowdler
ETSU-R-97 Executive Summary

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ETSU-R-97

Why it is Wrong

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July 2005

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ETSU-R-97

Why it is Wrong

1 INTRODUCTION

1.1 ETSU-R-97 is used throughout the UK to assess wind farm noise in planning applications. It has been incorporated into PAN45 in Scotland and PPS22 in England. Nevertheless it is a thoroughly flawed document and does not deserve the prominence it has been given.

1.2 The conclusions of ETSU-R-97 are so badly argued as to be laughable in parts (the daytime standard is based on the principle that it does not matter if people cannot get to sleep on their patio so long as they can get to sleep in their bedrooms). It is the only standard where the permissible night time level is higher than the permissible day time level.

1.3 ETSU-R-97 bears no resemblance to standards used for other industrial developments. Other renewable energy developments have to meet much stricter standards. Each time the Noise Working Group that drew up the document decide that a particular standard is appropriate, they follow it up by saying (without putting forward any evidence whatsoever) that such a standard would restrict development of wind farms and so find reasons to relax it further.

2 ASSESSMENT OF THE IMPACT OF ENVIRONMENTAL NOISE

2.1 It seems common sense that the impact of a new noise on existing residences is related in some way to the background noise. For example if the background noise level at present is 45dBA then a level of 35dB from a new industrial source would probably be inaudible. If the background noise level at present is 20dB then an industrial noise of 35dB will clearly be heard and would be very likely to produce complaints.

2.2 Indeed it is normal to set a noise limit relative to the pre-existing background noise when a new industrial noise is to be introduced into a residential area. Typical planning conditions imposed by rural local authorities (and sometimes urban ones) require that the new noise be no more than 5dB above the pre-existing background. This is based on the procedure set out in British Standard 4142.

2.3 In fact BS4142 does not purport to be a method of assessing nuisance or amenity. It was first published in 1967 and has since been revised twice though the general principles remain the same. It is simply a method of assessing the likelihood of complaints. Its origin is obscure and it has been the subject of endless criticism for a whole variety of reasons. But the fact is that it works. It has been and is still regularly used to assess noise impact and I do not know of one case where it has been suggested that BS4142 gave an anomalous result. Furthermore it was endorsed by DEFRA in September 1998, the department of government concerned with the environment at that time. They submitted their Noise and Nuisance Policy under Health Effect Based Noise Assessment Methods to the EU. This said that *BS4142:1997 provides a technical means of assessing whether or not 'complaints are likely'. The result of an assessment carried out to BS4142 would normally be relevant to the deliberations of any court considering whether or not a nuisance exists.*

2.4 BS4142 is not normally used to assess wind farms. This is done using the document ETSU-R-97 "The Assessment and Rating of Noise from Wind Farms".

2.5 ETSU-R-97 was written by a Noise Working Group (NWG) of developers, noise consultants, environmental health officers and others set up in 1995 by the Department of Trade and Industry through ETSU (the Energy Technology Support Unit). The DTI's mission is *prosperity for all by working to create the best environment for business success in the UK*. It has no brief for the protection of the environment or for the protection of the citizen from nuisance or loss of amenity. ETSU was the UK Government executive agency for energy technologies.

2.6 The status of ETSU-R-97 is perfectly clear. The preface says *The aim of the Working Group was to provide information and advice to developers and planners on the environmental assessment of noise from wind turbines. While the DTI facilitated the establishment of this Noise Working Group this report is not a report of Government and should not be thought of in any way as replacing the advice contained within relevant Government guidance. The report represents the consensus view of the group of experts listed below who between them have a breadth and depth of experience in assessing and controlling the environmental impact of noise from wind farms. This consensus view has been arrived at through negotiation and compromise and in recognition of the value of achieving a common approach to the assessment of noise from wind turbines.*

2.7 The first paragraph of the executive summary says *This document describes a framework for the measurement of wind farm noise and gives indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding unduly to the costs and administrative burdens on wind farm developers or local authorities.*

2.8 It is thus, by its own admission, not a method of assessing impact. What is more the compromise reached by the NWG is so lacking in basis, so full of unfounded assertions and so badly thought out and argued that it comes up with standards for wind farm noise that are quite unlike any other noise standards. I need to explain in some detail why this is the case so that my point can be fully understood.

3 THE NWG ARGUMENT IN ETSU

3.1 I have explained why the assessment method in ETSU-R-97 is not a measure of impact. I need to describe how the assessment method was developed by the NWG in order to explain how it relates to normal methods of measuring impact. The NWG starts by pointing out that the planning advice relating to noise says that the likelihood of complaints can be assessed, where the Standard is appropriate, using guidance in BS 4142: 1990. In examining whether BS4142 is appropriate for assessing wind turbine noise the NWG suggests that there are three reasons why it might not be. These are:

> *Wind farms are likely to be developed in largely rural areas and not in the areas to which the standard is principally addressed, namely mixed residential and industrial areas;*
>
> *the scope of BS 4142 specifically precludes situations where background noise levels are below 30dB(A);*
>
> *BS 4142 recommends that noise measurements should not be taken in extreme weather conditions such as high wind speed greater than 5 metres per second average ".*

3.2 In answer to the first point they say *Although the standard is intended for use in mixed residential and industrial areas as suggested by its title, there are no obvious reasons which prevent its application in more rural areas and indeed Members of the Noise Working Group have used it in such areas.* So BS4142 is not rejected for this reason.

3.3 To the second point they say, after some debate, *The question that arises is: if one intends to apply the principles of BS 4142 to the protection of external amenity, and the instrumentation is available to accurately measure noise levels below 30dB(A), should a margin above background approach be pursued in low noise environments or can an absolute level be justified in such circumstances?* They leave the question to be dealt with later. I should point out that since ETSU-R-97 was published BS4142 has been revised so that low noise levels are only excluded when both the background is less than 30dB and the turbine noise is less than 35dB.

3.4 Whatever the NWGs answer to the third reason, and it is not very clear what that answer is, it is obvious that they accept that there is no reason to reject BS4142 at higher wind speeds because ETSU itself says that background noise should be measured at all wind speeds up to 12m/s.

3.5 In summary, thus far the NWG seem to find no good reason to reject BS4142 except that it leaves open the possibility of whether to adopt a limiting absolute level to be dealt with later.

3.6 At this point it is necessary for me to explain L_{A90} and L_{Aeq}. Noise levels can be stated in different ways. For example if a noise is fluctuating we could talk about the minimum or the maximum or the average. BS4142, in accordance with international practice, uses the measure L_{Aeq} to describe the specific noise – that is the noise to be assessed. This is effectively an average. It is actually a logarithmic average but that is of no real significance here. Again in accordance with common practice BS4142 uses L_{A90} to define background noise. This is the level exceeded for 90% of the time, so in a ten minute period the noise level is more than the L_{A90} for an aggregate of 9 minutes. So the L_{A90} is usually close to the minimum noise level.

3.7 On the question of turbine noise the NWG put forward the suggestion that L_{A90} should be used to measure turbine noise. This is because the measure will eliminate other extraneous noise. For example, if a site is affected by an occasional passing car, the L_{Aeq} may be determined by the car whilst the L_{A90} may not. I have no objection to the principle of measuring turbine noise by the use of $L_{A90.}$ This is a method I often use where the difference between the L_{Aeq} and the L_{A90} is known and constant. However, it would be much better to measure as L_{A90} and then add back 2dB (the difference between the two) to get the L_{Aeq} value so that the units remain consistent with BS4142 and other normal practice. ETSU-R-97 carries on describing turbine noise as an L_{A90} which simply leads to confusion. BS7445 (Also ISO1996) *Description and Measurement of Environmental Noise* makes it clear that environmental noise is to be described as L_{Aeq}.

3.8 On Page 59 ETSU-R-97 says *It is proposed that the background noise levels upon which limits are based, and the noise limits themselves, are based upon typical rather than extreme values at any given wind speed. An approach based upon extreme values would be difficult to implement as the difference in measurements between turbine noise and background would depend upon the length of time one is prepared to take data. A more sensible approach is to base limits upon typical or average levels, but to appreciate that both turbine and background noise levels can vary over several dB for the same nominal conditions.* What they are saying is that, having measured background noise levels over a period of several weeks we should take the background noise level at each wind speed as the average of all the background noise levels at that wind speed. This is completely inconsistent with normal practice and suggesting it is "sensible" is merely an unfounded assertion. In using BS4142 in the field we are generally required by local authorities to measure at the quietest part of the period in question. It is not acceptable, where traffic noise predominates, to take an average of the L_{A90} values over, for example, a whole night time period. The local authority will require the background noise in the middle of the night when it is quietest. For example

> A letter from Renfrew Council in 2004 in connection with a planning application says that the impact of noise on nearby dwellings should be assessed by BS4142 and that *the background noise level for the most sensitive period that the source could operate should be used for this assessment*.
>
> At the Portree Co-Op development it was agreed that *In accordance with BS4142 the background noise should be measured as L_{A90} and the noise from the development as L_{Aeq}. Measurements of L_{A90} over any specific period should be carried out in wind speeds less than 5m/s and during a representative part of the period including the quietest part of the period. The measurements should be made in intervals of between 5 and 15 minutes. The average and standard deviation of all the measurements should be calculated and the*

background noise taken as the average less one standard deviation.
So the level required is more or less the quietest part of a quiet night.

3.9 In the case of background noise dominated by wind it has been my practice to take the average and the standard deviation of a group of 10 minute measurements and to define the period L_{A90} as the average less one standard deviation. Typically this is about 4dB less than the average. Statistically 15% of the time the background noise is below this level. Unless there is a large variation between day and night time background noise I will normally use the whole 24 hour data rather than separate day and night.

3.10 Returning to ETSU-R-97 on page 60, continuing discussion on background noise the NWG say*, Noise from the wind farm will be limited to 5dB(A) above background for both day- and night-time. When comparing the proposed margin with the complaints criteria suggested by BS 4142 it is important to bear in mind that the LA90 descriptor is also being proposed for the turbine noise. The Leq levels can be expected to be about 1.5-2.5dB greater. An addition of 1.5-2.5dB places the margin at the upper end of the range which can be considered to be of marginal significance ie around 5dB.* What they appear to be saying is that, because turbine noise is measured as L_{A90}, the margin above background noise that is proposed is actually 7dB in normal BS4142 terms rather than the 5dB normally adopted by local authorities. There is nothing in BS4142 that suggests that 7dB is *at the upper end of the range which can be considered to be of marginal significance.* This phrase is simply an invention of the NWG.

3.11 Further down page 60 it says that *On balance it is considered that a margin of 5dB(A)* (by which it means 7dB in BS4142 terms) *will offer a reasonable degree of protection to both the internal and external environment without unduly restricting the development of wind energy which itself has other environmental benefits.* There is no foundation whatsoever for this assertion. No evidence is brought forward or referred to.

3.12 So the position in the argument so far is this. The NWG has decided, without any foundation, that the 5dB “marginal significance” in BS4142 could be 7dB. It has decided, against all normal practice, that the background noise level for assessment purposes ought to be the average of background levels in any particular condition rather than the lowest level. In wind controlled background noise the average is likely to be at least 4dB more than a realistic background level. So the NWG consider that 11dB over background is appropriate for wind farms as against normal practice for industrial noise of 5dB over background noise. Of course I have to bear in mind that ETSU-R-97 does not purport to offer a method of assessment of impact. So the NWG is proposing that, for wind farms, a level of noise that is likely to give rise to complaints is appropriate because of the particular public benefits of wind farms. I cannot agree with this. As I exemplify elsewhere other projects of public benefit have to meet the stricter standard of 5dB above background.

3.13 Not content with establishing a margin above background noise far greater than normal, the NWG, at the bottom of page 60, continues *Applying the margin above background approach to some of the very quiet areas in the UK would imply setting noise limits down to say 25-30dB(A) based upon background levels perhaps as low as 20-25dB(A).* This is true in principle but in practice turbines generate less noise at low wind speeds and, at cut in, turbine noise might have to be limited in some areas to as little as 25dB. By the time wind speed was up to 6m/s the background noise level would be at least 25dB probably more like 30dB and so this would require turbine noise to be restricted to less than 30-35dB rather than 25-30dB. *Limits of this level would prove very restrictive on the development of wind energy.* This is simply a broad assertion. No evidence whatsoever has been adduced to demonstrate this.

3.14 Some measure of loss of amenity needs to be applied in low background noise levels and it is normal practice in rural Scotland (and sometimes in towns) to use BS4142 even in low background noise levels. For example:

> Co-Op Retail Store, Portree in 2002. *Noise of plant from the development should not exceed the background noise level by more than 5dBA or, if the noise is tonal, should not exceed the background noise at all at any noise sensitive property.* The background noise at Home Farm Road was measured at 28dB on a calm night and this was agreed as the background noise.
>
> New factory for Vestas at Machrihanish in 2001. At this new factory (ironically the factory that makes wind turbines) Argyll and Bute Council require that: *The rated noise level from the development shall not exceed the predetermined ambient noise level (the L90(A)) at the nearest noise sensitive properties at the former RAF housing, by more than 5dB(A). All measurements are to be taken in accordance with BS4142: 1997 with the measurement periods being 1 hour for the period 0800-2200 hours and 5 minutes for the period 2200-0800 hours*. The night time background noise was agreed at 27dB which was the lowest hourly level reached during a windless night. Earlier measurements when there was sea noise and the background was 32dB were not accepted by the council.
>
> In 2004, SEPA, at Roslin in Midlothian, asked for a BS4142 assessment for a landfill gas generator even though the background noise level was only 27dB.

3.15 On page 61 the NWG say *During the night one can reasonably expect most people to be indoors and it will not be necessary to control noise to levels below those required to ensure that the restorative process of sleep is not disturbed. A night-time absolute lower limit is therefore appropriate based upon sleep disturbance criteria.* What this says is that a turbine noise level inside peoples houses of just less than the World Health Organisation say is necessary to get back to sleep if you wake up in the night is satisfactory. It seems to me this must be the very upper limit of acceptability, not one that is well balanced. Since then, the WHO has revised its guidance 5dB lower. So the ETSU night standard is now higher than WHO say you need to get back to sleep.

3.16 When they come to day time, on Page 62 of ETSU-R-97, it says *It is also the opinion of the Noise Working Group that there is no need to restrict noise levels below a lower absolute limit of LA90,10min = 33dB(A); if an environment is quiet enough so as not to disturb the process of falling asleep or sleep itself then it ought to be quiet enough for the* *peaceful enjoyment of one's patio or garden.* This is a bizarre statement. It seems that the 33dBA is the 35dB sleep restoration level set out by the World Health Organisation for inside bedrooms at night. They seem to be saying that there is no need for noise levels during the day to be any lower than is necessary to allow you to go to sleep on your patio on a sunny afternoon.

3.17 Having suggested that 33dB would be satisfactory because people could get to sleep on their patio – they now say that *This level would however be a damaging constraint on the development of wind power in the UK as the large separation distances required to achieve such low noise levels would rule out most potential wind farm sites.* There is absolutely no evidence brought forward to justify this. A margin of 2km would normally easily achieve this even with the noisier modern turbines. They argue that *Wind farms have global environmental benefits which have to be weighed carefully against the local environmental impact.* So do many other things. They argue that *Wind farms do not operate on still days when the more inactive pastimes (eg sunbathing) are likely to take place.* The suggestion seems to be that the protection of people's amenity does not include protecting them whilst sunbathing in their gardens on a slightly windy day or sleeping on the patio.

3.18 Then, on page 63 there is another leap of credibility: *There is no evidence for or against the assertion that wind farm noise with no audible tones is acceptable up to and including LA90,10min levels of 40dB(A) even when background noise levels are 30dB or less.* This is just nonsense. There most certainly is evidence against this assertion. The 40dB is actually 42dB in BS4142 units. This is at least 12dB above background noise level of "30dB or less" and BS4142 says there are likely to be complaints at turbine levels of plus 10dB. Furthermore there is no argument that BS4142 is not applicable. Even BS 4142:1990 (which was current when ETSU-R-97 was written) might easily be applicable here. If the wind speed is 5m/s, the background noise 30dB and the turbine noise 42dB(LAeq) then there is no reason not to use BS4142, it does not exclude itself in these circumstances. This noise level is also 12dB more than (twice as loud as) the WHO considers necessary for you to be able to get to sleep.

3.19 They summarise this *For periods during the day the Noise Working Group has adopted the approach that external noise limits should lie somewhere between that required to avoid sleep disturbance even if the occupant is outside of the property and the higher level that would still prevent sleep disturbance inside the property.* In other words the lowest turbine noise level that they would adopt, during the day, would be high enough to prevent you getting to sleep on your patio. The highest level they adopt during the day would not quite stop you getting back to sleep in your bedroom. Presumably the principle is that, if it is too noisy to sleep outside on your patio you can be assured you will be able to get to sleep indoors.

4 CONCLUSION

4.1 ETSU-R-97 is so poor technically that its conclusions have to be queried. It is put together through a series of unfounded assertions and there has been no research drawn on to justify them.

4.2 Even if one were minded to accept the suggestion that you should use very low background noise levels and that there ought to be a level below which it would be appropriate to use an absolute noise level, the levels proposed by the NWG are not acceptable. The night time level is 45dB(L_{Aeq}) and the day time level is 37 to 42dB(L_{Aeq}). Most wind farm sites are in rural areas where background noise levels can easily be 20 to 25dBA when turbines are operating and so the margin above background could be up to 20dB or more.

ETSU-R-97

The Assessment & Rating of NOISE from Wind Farms

ETSU

for the

dti

Department of Trade and Industry

ETSU-R-97

THE ASSESSMENT AND RATING OF NOISE FROM WIND FARMS

The Working Group on Noise from Wind Turbines

Final Report
September 1996

PREFACE

This report describes the findings of a Working Group on Wind Turbine Noise. The aim of the Working Group was to provide information and advice to developers and planners on the environmental assessment of noise from wind turbines. While the DTI facilitated the establishment of this Noise Working Group this report is not a report of Government and should not be thought of in any way as replacing the advice contained within relevant Government guidance.

The report represents the consensus view of the group of experts listed below who between them have a breadth and depth of experience in assessing and controlling the environmental impact of noise from wind farms. This consensus view has been arrived at through negotiation and compromise and in recognition of the value of achieving a common approach to the assessment of noise from wind turbines.

Members of the Noise Working Group:

Mr R Meir, Chairman	DTI
Dr M L Legerton, Secretary	ETSU
Dr M B Anderson	Renewable Energy Systems
Mr B Berry	National Physical Laboratory
Dr A Bullmore	Hoare Lea and Partners
Mr M Hayes	The Hayes McKenzie Partnership
Mr M Jiggins	Carrick District Council
Mr E Leeming	The Natural Power Company Ltd
Dr P Musgrove	National Wind Power Ltd
Mr D J Spode	North Cornwall District Council
Mr H A Thomas	Isle of Anglesey County Council
Ms E Tomalin	EcoGen Ltd
Mr M Trinick	Bond Pearce Solicitors
Dr J Warren	National Wind Power Ltd

EXECUTIVE SUMMARY

INTRODUCTION

1. This document describes a framework for the measurement of wind farm noise and gives indicative noise levels thought to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding unduly to the costs and administrative burdens on wind farm developers or local authorities. The suggested noise limits and their reasonableness have been evaluated with regard to regulating the development of wind energy in the public interest. They have been presented in a manner that makes them a suitable basis for noise-related planning conditions or covenants within an agreement between a developer of a wind farm and the local authority.

2. The noise limits suggested have been derived with reference to:

- existing standards and guidance relating to noise emissions
- the need of society for renewable energy sources to reduce the emission of pollutants in pursuance of Government energy policy
- the ability of manufacturers and developers to meet these noise limits
- the researches of the Noise Working Group in the UK, Denmark, Holland and Germany
- the professional experience of members of the Working Group in regulating noise emissions from wind turbines and other noise sources
- the discussion of the issues at meetings of the Noise Working Group and with others with appropriate experience.

3. The Noise Working Group has sought to protect both the internal and external amenity of the wind farm neighbour. Wind farms are usually sited in the more rural areas of the UK where enjoyment of the external environment can be as important as the environment within the home.

4. The guidance contained within this report refers to the operation of the wind farm and is not appropriate to the construction phase.

NOISE LIMITS

5. The Noise Working Group recommends that the current practice on controlling wind farm noise by the application of noise limits at the nearest noise-sensitive properties is the most appropriate approach. This approach has the advantage that the limits can directly reflect the existing environment at the nearest properties and the impact that the wind farm may have on this environment.

6. Given that one of the aims of imposing noise limits is to protect the internal environment, one might consider it appropriate to set these limits and hence monitoring locations at positions within the building. There are, however, some practicalities to take into consideration which lead us to believe that the current practice of setting external limits on noise is the more sensible approach; these factors are described in detail in Chapter 6 of the full report.

7. The noise limits applied to protect the external amenity should only apply to those areas of the property which are frequently used for relaxation or activities for which a quiet environment is highly desirable.

8. The Noise Working Group considers that absolute noise limits applied at all wind speeds are not suited to wind farms in typical UK locations and that limits set relative to the background noise are more appropriate in the majority of cases.

9. Only by measuring the background noise over a range of wind speeds will it be possible to evaluate the impact of turbine noise, which also varies with wind speed, on the local environment.

10. The Noise Working Group is of the opinion that one should only seek to place limits on noise over a range of wind speeds up to 12m/s when measured at 10m height on the wind farm site. There are four reasons for restricting the noise limits to this range of wind speed:

- Wind speeds are not often measured at wind speeds greater than 12m/s at 10m height

- Reliable measurements of background noise levels and turbine noise will be difficult to make in high winds

- Turbine manufacturers are unlikely to be able to provide information on sound power levels at such high wind speeds for similar reasons

- If a wind farm meets noise limits at wind speeds lower than 12m/s it is most unlikely to cause any greater loss of amenity at higher wind speeds

11. The recommendation of the Noise Working Group is that, generally, the noise limits should be set relative to the existing background noise at nearest noise-sensitive properties and that the limits should reflect the variation in both turbine source noise and background noise with wind speed. We have also considered whether the low noise limits which this could imply in particularly quiet areas are appropriate and have concluded that it is not necessary to use a margin above background approach in such low-noise environments. This would be unduly restrictive on developments which are recognised as having wider national and global benefits. Such low limits are, in any event, not necessary in order to offer a reasonable degree of protection to the wind farm neighbour.

12. Separate noise limits should apply for day-time and for night-time. The reason for this is that during the night the protection of external amenity becomes less important and the emphasis should be on preventing sleep disturbance. Day-time noise limits will be derived

from background noise data taken during quiet periods of the day and similarly the night-time limits will be derived from background noise data collected during the night.

Quiet day-time periods are defined as:

All evenings from 6pm to 11pm,

plus Saturday afternoon from 1pm to 6pm,

plus all day Sunday, 7am to 6pm.

Night-time is defined as 11pm to 7am.

13. Consideration has also be given to circumstances where a more simplified approach, based on a fixed limit, may be appropriate.

14. The Noise Working Group is agreed that the $L_{A90,10min}$ descriptor should be used for both the background noise and the wind farm noise, and that when setting limits it should be borne in mind that the $L_{A90,10min}$ of the wind farm is likely to be about 1.5-2.5dB(A) less than the L_{Aeq} measured over the same period. The use of the $L_{A90,10min}$ descriptor for wind farm noise allows reliable measurements to be made without corruption from relatively loud, transitory noise events from other sources.

15. The limits to be proposed relate to free-field (except for ground reflections) measurements in the vicinity of noise-sensitive properties.

16. The Noise Working Group is of the opinion that absolute noise limits and margins above background should relate to the cumulative effect of all wind turbines in the area contributing to the noise received at the properties in question. It is clearly unreasonable to suggest that, because a wind farm has been constructed in the vicinity in the past which resulted in increased noise levels at some properties, the residents of those properties are now able to tolerate higher noise levels still. The existing wind farm should not be considered as part of the prevailing background noise.

17. Wind turbines operate day and night dependent upon wind speeds. It will be necessary to acquire background noise data for both day- and night-time periods because:

- the absolute lower limit is likely to be different for day- and night-time operation
- the noise limits are to be related to the background noise levels
- background noise levels may be different in the day than during the night.

18. It is proposed that the background noise levels upon which limits are based and the noise limits themselves are based upon typical rather than extreme values at any given wind speed. An approach based upon extreme values would be difficult to implement as the difference in measurements between turbine noise and background would depend upon the length of time one is prepared to take data. A more sensible approach is to base limits upon typical or average levels but to appreciate that both turbine and background noise levels can vary over several dB for the same nominal conditions.

19. The variation in background noise level with wind speed will be determined by correlating $L_{A90,10min}$ noise measurements taken over a period of time with the average wind speeds measured over the same 10-minute periods and then fitting a curve to these data.

20. The wind farm noise limits proposed below refer to rating levels in a similar manner to that proposed in BS 4142 in respect that additions are made to the measured noise to reflect the character of the noise.

21. Noise from the wind farm should be limited to 5dB(A) above background for both day- and night-time (with the exception of the lower limits and simplified method described below), remembering that the background level of each period may be different.

22. In low noise environments the day-time level of the $L_{A90,10min}$ of the wind farm noise should be limited to an absolute level within the range of 35-40dB(A). The actual value chosen within this range should depend upon a number of factors:

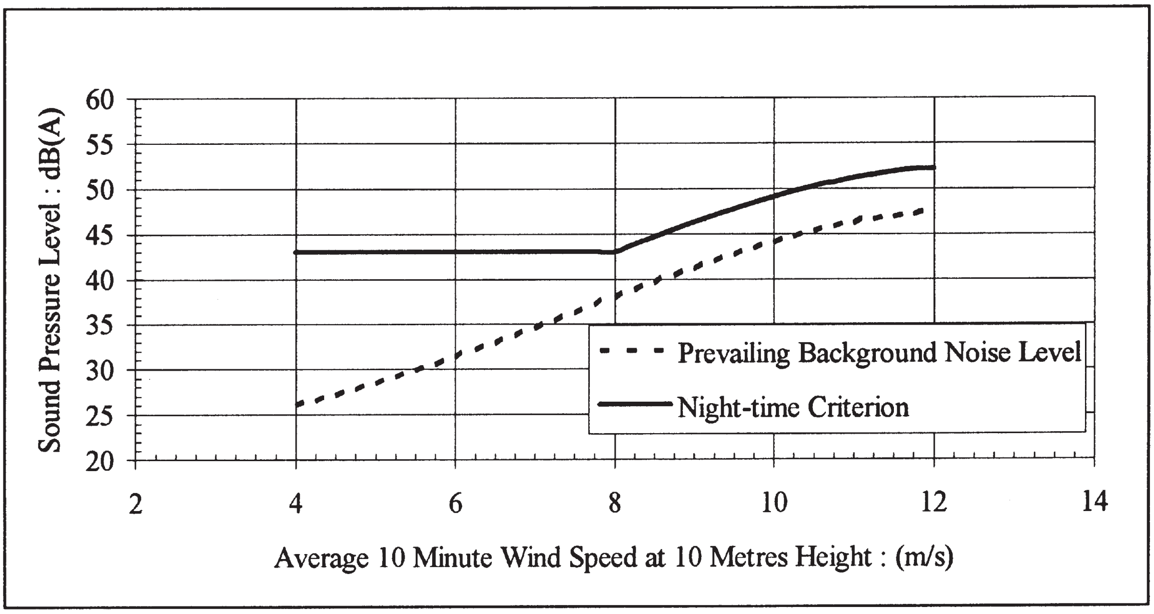
- the number of dwellings in the neighbourhood of the wind farm
- the effect of noise limits on the number of kWh generated
- the duration and level of exposure.

23. The Noise Working Group recommends that the fixed limit for night-time is 43dB(A). This limit is derived from the 35dB(A) sleep disturbance criteria referred to in Planning Policy Guidance Note 24 (PPG 24). An allowance of 10dB(A) has been made for attenuation through an open window (free-field to internal) and 2dB subtracted to account for the use of $L_{A90,10min}$ rather than $L_{Aeq,10min}$.

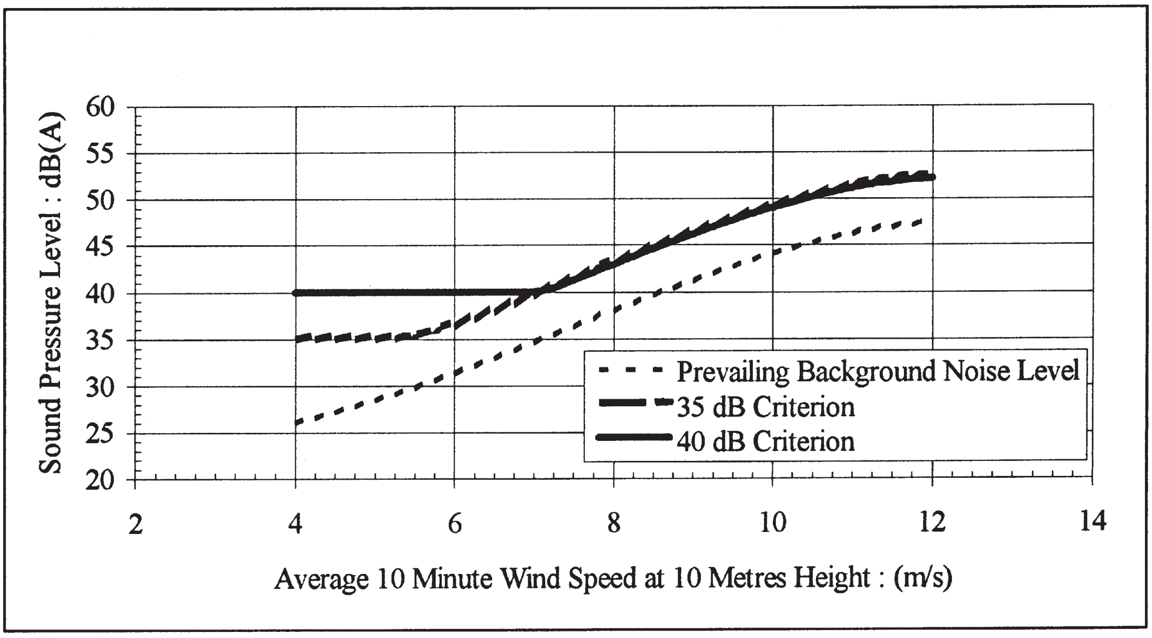
24. The Noise Working Group recommends that both day- and night-time lower fixed limits can be increased to 45dB(A) and that consideration should be given to increasing the permissible margin above background where the occupier of the property has some financial involvement in the wind farm.

25. For single turbines or wind farms with very large separation distances between the turbines and the nearest properties a simplified noise condition may be suitable. We are of the opinion that, if the noise is limited to an $L_{A90,10min}$ of 35dB(A) up to wind speeds of 10m/s at 10m height, then this condition alone would offer sufficient protection of amenity, and background noise surveys would be unnecessary. We feel that, even in sheltered areas when the wind speed exceeds 10m/s on the wind farm site, some additional background noise will be generated which will increase background levels at the property.

26. Graphical representations of the recommended limits appear in the figures overleaf based upon a fairly typical background noise curve. Both background levels and turbine noise are determined by best-fit curves through representative data.



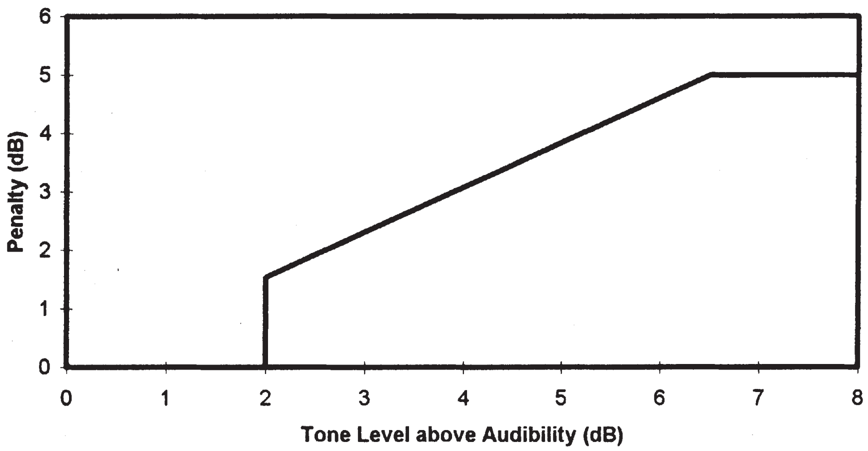
Example of night-time noise criterion



Example of day-time noise criterion

27. The noise levels recommended in this report take into account the character of noise described as blade swish. Given that all wind turbines exhibit blade swish to a certain extent we feel this is a common-sense approach given the current level of knowledge.

28. The Noise Working Group recommends that a tonal penalty is added to the measured noise levels in accordance with the figure below. The penalty incurred is related to the audibility of any tones produced by the wind turbines when measured using a prescribed method as represented graphically below.



Penalties for tonal noise

29. The Noise Working Group thought that it would be beneficial to present its recommendations in a form which might be useful to developers and planners. We therefore considered drafting planning conditions, but came to the conclusion that the necessary definitions of terms which would be required would make planning conditions too complicated. Therefore, it was decided to produce covenants for inclusion within an Agreement between a developer and a local authority. Conditions and Agreements (known as Planning Obligations) are discussed in Chapter 2. The Planning Obligation produced by the Noise Working Group is reproduced in Chapter 8 where it is supplemented by some Guidance Notes to which it refers. These Guidance Notes also serve as a useful summary of the proposed measurement procedure.

CONTENTS

LIST OF TABLES

EXHIBIT 808

E-Coustic Solutions

Noise Control Sound Measurement Consultation — *Richard R. James*
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Comments on WEPCO's Glacier Hills Application and Supporting Documents Regarding Wind Turbine Noise and Its Impact on the Community

Oct. 5, 2009

Please accept the following commentary and recommendations on behalf of the Coalition for Wisconsin Environmental Stewardship (CWESt) in support of the following assertions:

1) Wind turbine noise is distinctively annoying and the documents submitted to the Wisconsin Public Service Commission (WPSC) under Docket No: 6630-CE-302 do not correctly or adequately describe the impact of the proposed project on the host community and the residents whose homes and properties are close to or within the footprint of the project,
2) Background sound levels submitted on behalf of WEPCO which include a 'wind noise' component were obtained using a methodology that has been shown to result in a biased assessment of background sound levels. Further, the original and revised Background Sound studies do not adequately define the background sound levels and characteristics of wind turbine noise for purposes of making decisions on location with respect to homes and properties.
3) Computer model estimates of operational sound levels from the proposed projects understate the impact of the turbines on the community.
4) That information provided supplemental to the background sound and computer modeling studies by Dr. Geoff Leventhal, and others asserting that there is no research supporting a causal link between wind turbine sound immissions at receiving properties and homes and health effects do not reflect current understanding of thresholds of perception and mechanisms whereby such perception can occur.
5) That information provided supplemental to the background sound and computer modeling studies by Dr. Geoff Leventhal, asserting that there are errors in the manuscript titled: "The 'How to' Guide To Siting Wind Turbines to Prevent Health Risks from Sound" Version 2.1[1], does not reflect a proper understanding of the goals and criteria proposed in that document.
6) The combination of the above negative factors related to wind turbine noise emissions will result in sleep disturbance for a significant fraction of those who live within a mile away and chronic sleep disturbance results in serious health effects."

The result of these technical flaws along with an outdated understanding of how the human body responds to acoustical energy previously considered to be below the threshold of perception leads to a conclusion that if the WEPCO project, as proposed, is approved, it will, with a high degree of certainty, have negative noise impacts that are "significant."

In preparation for this report, the materials provided on the WPSC website for Docket 6630 - CE – 302 have been reviewed. This includes the background noise study and computer model estimates of operating sound levels prepared by Mr. George Hessler Jr., P.E., INCE Board

[1] Kamperman, George and Richard R. James (2008). Simple guidelines for siting wind turbines to prevent health risks, The Institute of Noise Control Engineering of the USA, 117 Proceedings of NOISE-CON 2008 1122-1128, Dearborn, Michigan, available at <http://www.inceusa.org/

Certified, submitted October 8, 2008 and its subsequent revisions; and the supplemental materials by Dr. Leventhal and others.

There is considerable similarity between WEPCO's documents, and similar documents filed in other states on behalf of wind utility developers requesting permits for their projects. The arguments presented in these documents appear on the surface to be well-crafted technical statements regarding wind turbine noise, community and land-use compatibility, and public health risks. However, despite the similarities in presentation, methodologies, and conclusions between the various authors in these documents there are serious flaws in the arguments and information used to support those conclusions. These studies present clearly one-sided information to support the development of wind utilities in locations where people will be expected to live within 1000 to 1500 feet of industrial scale wind turbines.

It is the goal and focus of this report to present the other side of this argument, and to provide the WPSC with the foundation research, papers, and presentations needed to understand that what is not disclosed in the wind utility application reports and supporting documents is critical. Given the opportunity for the WPSC to review the information provided in this report and its attached references, it is hoped that the WPSC will understand why wind utility projects from Iowa to Maine, Ontario to West Virginia are now the locus of numerous complaints and lawsuits. These complaints and lawsuits detail the complaint's problems with wind turbines causing sleep disturbance, adverse health effects, and other related problems. Yet, it must be remembered that at the time of the permit application, the developer for each of these projects assured the permitting agency that none of these problems would occur. This report is intended to provide information such that the WPSC will not find itself permitting similar situations.

The Glacier Hills Wind project will result in a large number of residences being within 1000 feet of one of more wind turbines. Figure 1 illustrates the extent to which the proposed footprint of the wind utility will encroach on residential homes.

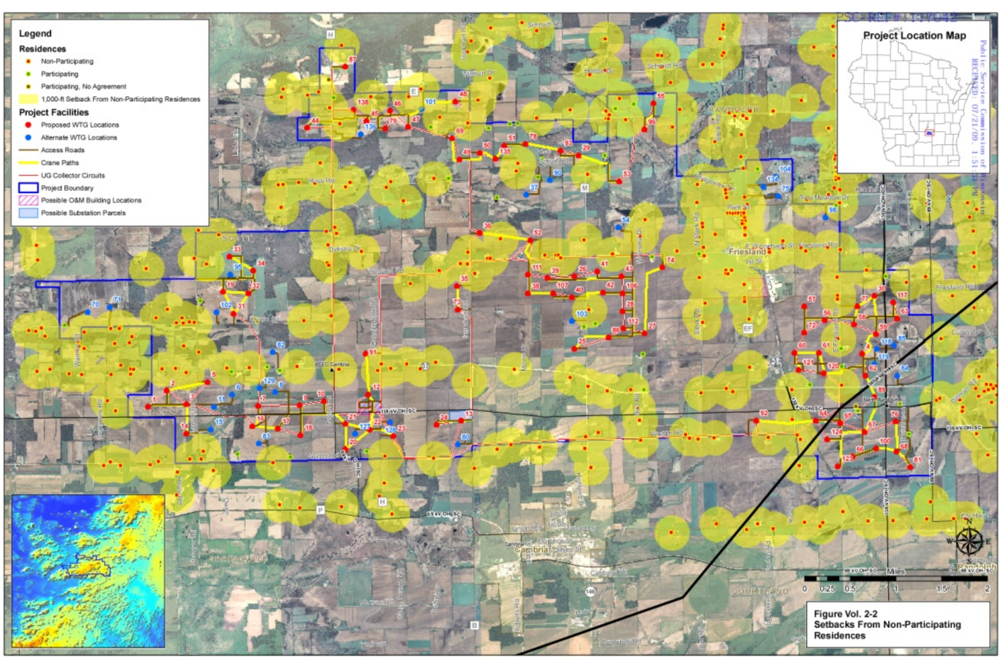

Figure 1-1000 foot setbacks from homes

It is common for people to look at wind turbines as a new type of noise source. However, some of the problems associated with them are easier to understand if we view wind turbines as a special case of large industrial fans. For example, if we take a look at the spectrum from a fan, as shown in Figure 2, there are certain characteristics that all fans have in common. There is maximum energy at the blade passage frequency, tones above the blade passage frequency, and broadband noise. The harmonics of that tone have somewhat lower energy content. The broadband spectrum starts above the range where the tones longer dominate. The energy is highest at the blade passage frequency and drops off as frequency increases.

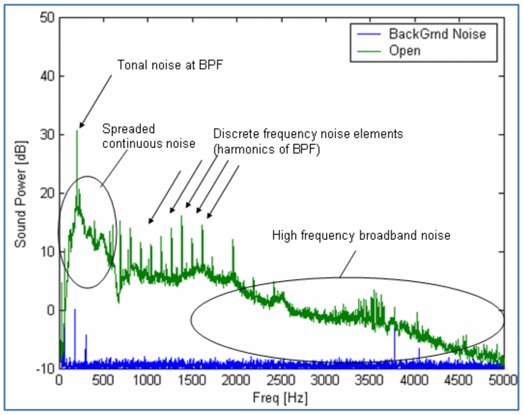

Figure 2-Typical Fan Noise Spectrum

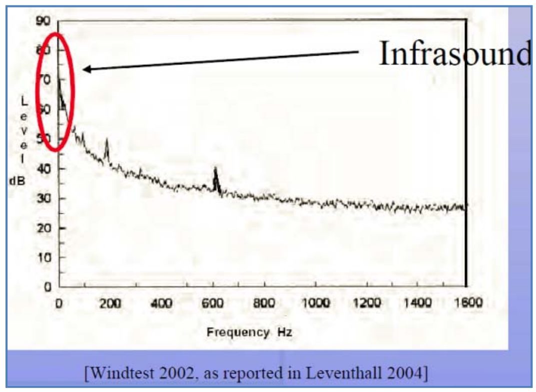

Figure 3-Vestas V-52 Spectrum (From NREL Presentation)

Figure 3, the wind turbine spectrum for a Vestas V-52, shows some of the same spectral characteristics. For a wind turbine the blade passage frequency is usually between 1 and 2 Hz and the harmonics occur usually below 10 Hz. Because this is a difficult range of frequencies to measure, especially in field test situations, most information about the spectral characteristics do not show the infrasound range (0-20Hz) sound pressure levels (SPL). This is further obscured by the practice of wind industry acoustical consultants to present data using of A-weighting (dBA). The practice masks the spectrum shape by creating a visual impression of minimal low-frequency sound content. Even when octave band (1/1 or 1/3) SPLs are presented the reports normally ignore frequencies below 31. 5 or 63 Hz. The wind industry and its consultants often say that there is no infra or low frequency content. If that is true then the customary reporting practices are understandable. But, if those assumptions are not accurate, then these practices mask a potential source of significant problems.

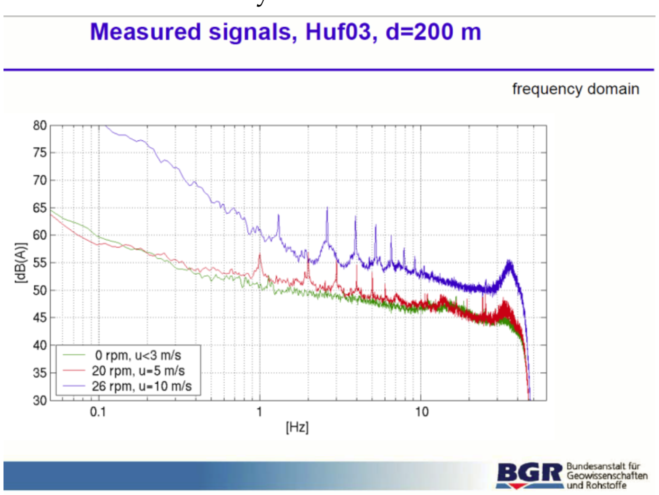

Figure 4-Wind Turbine Infrasound

The graphic to the left (Figure 4) shows a wind turbine's spectrum for the frequency range of 0-10 Hz. Note the tones and harmonics and the correlation of the frequency of the tones to rotational speed. This graph is from a study conducted by the Federal Institute for Geosciences and Natural Resources, Hannover, Germany, titled: "The Inaudible Noise of Wind

Turbines" presented at the Infrasound work shop in 2005 (Tahiti).

Are the sound emission characteristics similar or different for different models and makes of wind turbines? Figure 5 shows the general spectrum shape of 37 modern upwind turbines of the type and sizes being located in the Midwest. This graph shows the sound power data after normalizing the data for each turbine to 1 MW of power output.[2] It is clear that there is little deviation in spectral shape between any of the various models that is not related to power produced. In fact, the study concluded that for each increase of 1 MW in power output the graph would shift upward by approximately 5 dB.

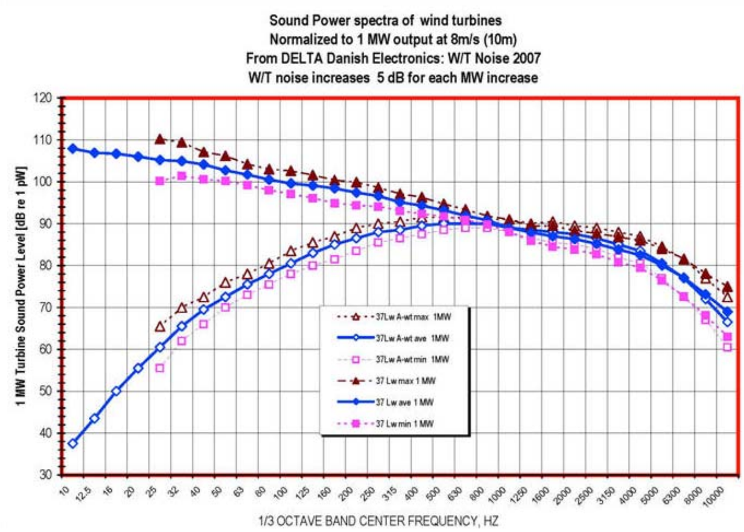

Figure 5-Sound Power Level of 37 Turbines Normalized to 1MW

Given that power to sound level relationship and the constant increase in the power rating of turbines being installed we could see the wind turbine sound levels increase another 25 dB by the time 5 MW turbines are commercially available.

1) Wind turbine noise is distinctively annoying

There have been several studies, primarily conducted in European countries with a long history of wind turbines, showing that at the same sound pressure (decibel) level or less, wind turbine noise is experienced as more annoying than airport, truck traffic or railroad noise[3][4][5]. There are several reasons why people respond more negatively to wind turbine noise that are directly a result of the character of the noise more than the absolute level of the sounds received.

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[2] DELTA, Danish Electronics, Light & Acoustics, "EFP-06 Project, Low Frequency Noise from Large Wind Turbines, Summary and Conclusions on Measurements and Methods," April 30, 2008

[3] Pedersen, E., Waye, K. P., "Human response to wind turbine noise – annoyance and moderating factors", Proceedings of the First international Meeting on Wind Turbine Noise: Perspectives for Control, Berlin, October 17-18, 2005.

[4] E. Pedersen and K. Persson Waye, "Perception and annoyance due to wind turbine noise: a dose–response relationship," J. Acoust. Soc. Am. 116, 3460–3470 (2004).
K. Persson Waye and E. Ohrstrom, "Psycho-acoustic characters of relevance for annoyance of wind turbine noise," Journal of Sound and Vibration 250(1), 65-73 (2002).
K. Persson Waye, E. Ohrstrom and M. Bjorkman, "Sounds from wind turbines – can they be made more pleasant?" In: N. Carter and R. F. S. Job (eds), 7th International congress on noise as a public health problem, pp 531-534 (22-26 Nov, Sydney, Australia 1998).
K. Persson Waye, A. Agge and M. Bjorkman, "Pleasant and unpleasant characteristics in wind turbine sounds," In: D. Cassereau (eds), Inter-Noise 2000, (August 27-30, Nice, France 2000).
K. Persson Waye and A. Agge, "Experimental quantification of annoyance unpleasant and pleasant wind turbine sounds," In: D. Cassereau (eds), Inter-Noise 2000, (August 27-30, Nice, France 2000).

[5] Vandenberg, G., Pedersen, E., Bouma. J., Bakker, R. "WINDFARMperception Visual and acoustic impact of wind turbine farms on residents" Final Report, June 3, 2008.

Amplitude Modulation (Audible Blade Swish)

It is not clear whether the distinctive **rhythmic, impulsive or modulating character of wind turbine noise** (all synonyms for "thump" or "swoosh" or "beating" sounds), its characteristic low frequency energy (both audible and inaudible, and also impulsive), health effects of chronic exposure to wind turbine noise (especially at night), in-phase modulation among several turbines in a wind farm (this can triple the impulse sound level when impulses of three or more turbines become synchronized), or some combination of all of these factors best explains the annoyance. One or more of these characteristics are likely present depending on atmospheric and topographic conditions, (especially at night)[6] as is the individual susceptibility of each person to them.

Nevertheless, reports based on surveys of those living near wind farms consistently find that, compared to surveys of those living near other sources of industrial noise, annoyance is significantly higher for comparable sound levels among wind utility footprint residents. In most cases, where relationships between sound level and annoyance have been determined, annoyance starts at sound levels 10 dBA or more <u>below the sound level</u> that would cause equivalent annoyance from the other common community noise sources. Whereas one would expect that people would be annoyed by 45 dBA nighttime sound levels outside their homes in an urban area, rural residents are equally annoyed by wind turbines when the sound levels are 35 dBA independent of the time of day. Given that wind turbine utilities are often permitted to cause sound levels of 40 to 50 dBA at the outside of homes adjacent to or inside the footprint of wind utilities in the states east of the Mississippi the negative reactions to wind turbines from many of those people is understandable. Their reactions provide objective evidence in support of an expectation that a substantial number of people who live near the Glacier Hills Wind project will complain that the noise level they experience is both causing nighttime sleep disturbance and creating other problems once operation commences.[7] [8]

Although there remain differences in opinions about what causes the amplitude modulation of audible wind turbine noise most of the explanations involve **air turbulence around the turbine blades**[9]. There are a number of explanations and more than one may apply at any specific wind farm site. For example, eddies in the wind, wind shear (different wind speeds at the higher reach of the blades compared to the lower reach), slightly different wind directions across the plane of the blades, and interaction among turbines, have each been identified as causes of modulating wind turbine noise from modern upwind turbines.[10]

It is noted that consultants for wind utility developers often claim that wind turbine sound emissions inside and adjacent to the project footprint estimated by the sound propagation model's represent worst-case conditions. However, it is only true that the input data used for the turbine's acoustic energy represents the turbine's sound emissions at or above its nominal operating wind speeds under standardized weather and wind conditions. That is reasonable

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[6] G.P. Van den Berg, "The beat is getting stronger: The effect of atmospheric stability on low frequency modulated sound on wind turbines," Noise notes 4(4), 15-40 (2005) and "The sound of high winds: the effect of atmospheric stability on wind turbine sound and microphone noise" Thesis (2006)

[7] Pedersen (2007); Kamperman and James (2008); James (2009b); Minnesota Department of Health (2009), pp. 19-20.

[8] Bajdek, Christopher J. (2007). *Communicating the Noise Effects of Wind Farms to Stakeholders*, Proceedings of NOISE-CON (Reno, Nevada), available at http://www.hmmh.com/cmsdocuments/ Bajdek_NC07.pdf

[9] Van den Berg (2006, pp. 35-36); Bowdler (2008), Palmer (2009) and Oerlemans/Schepers (2009).

[10] Bowdler (2008)

given that the purpose of these tests is to produce standardized data to permit a prospective buyer of turbines to compare the sound emissions from various makes and models. This needs to be understood as being similar to the US EPA's standardized gasoline mileage tests. You do not get the mileage posted on the vehicle sticker since your driving habits are different. The same is true for wind turbines and the environments in which they operate. The IEC test data does not account for the increased noise from turbulence or other weather conditions that cause higher sound emissions. A review of the IEC 61400-11, Wind Turbine Systems-Part 11: Acoustic Noise Measurement Techniques' assumptions in the body and appendices (esp. Appendix A) show that the IEC test data reported to turbine manufacturers is not 'worst case' for real world operations. Independent of the effect of weather and wind on the turbine's noise emissions, ANSI standards for outdoor noise caution that turbulence in the air can increase the downwind sound levels by 6-7 dB or more. It should be clear that any assertions by the acoustical modeler that the models represent worst case sound level estimates rely on careful phrasing and ignorance of the underlying standards and methods by the reviewers.

Impulsive sound was considered more problematic for older turbines that had rotors mounted downwind from the tower[11]. The sound was reduced by mounting the rotor upwind of the tower, common now on all modern turbines[12]. Initially, many presumed that the change from downwind to upwind turbine blades would eliminate amplitude modulated sounds (whooshes and thumps) being received on adjacent properties. However, in a landmark study by G. P. van den Berg now referred to in all serious discussions of wind turbine noise[13], it was shown that the impulsive swishing sound increases with size because larger modern turbines have blades located at higher elevations where they are subject to higher levels of "wind shear" during times of ground level "atmospheric stability." This results in sound fluctuating 3-5 dBA between beats under moderate conditions and 10 dBA or more during periods of higher turbulence[14].

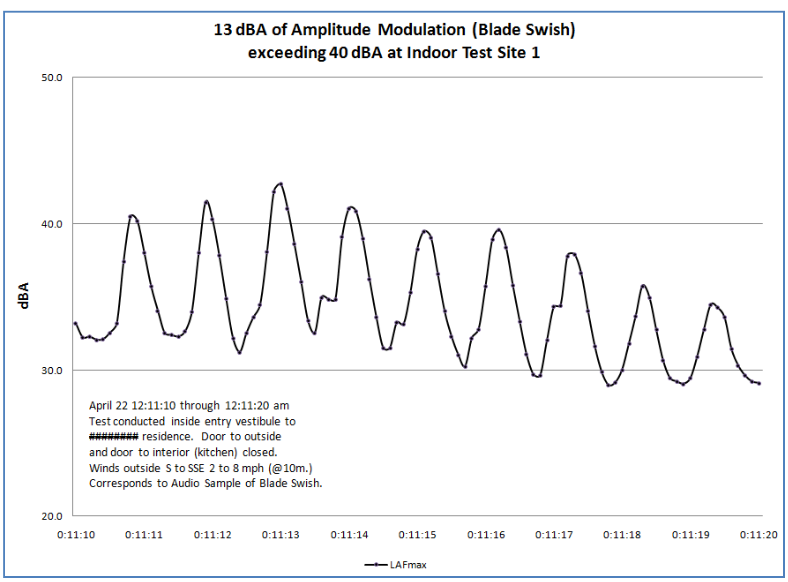

Figure 6-Audible Blade Swish inside home from New York Wind Utility

This author has confirmed amplitude modulation (blade swish) at every wind project he has investigated. During periods of high turbulence he has measured levels of blade swish of 10-13 dBA. Figure 6's graph shows the rise and fall of the A-weighted sound levels from blade swish measured inside a closed entry vestibule to a home. This test site is approximately 1500 feet from two (2) turbines with sound emission characteristics similar to the turbines proposed for the

[11] Rogers (2006, p. 10)
[12] *Id.*, pp. 13, 16; Van den Berg (2006), p. 36.
[13] Van den Berg (2006, p. 36)
[14] *Id.*,

WEPCO project. It should be noted that the sound levels exceed 40 dBA inside the home in the rooms facing the turbines with a window partly open.

To compensate for the added annoyance of fluctuating or impulsive sound, the convention is to add a penalty of 5 dBA to computer model estimates of average sound levels to account for the increased annoyance from sort term flucuations in sound levels.[15] In the Kamperman/James criteria, this penalty is already included in its recommendation for a maximum allowable sound level at the receiving property of 35 dBA.

Frequency of Conditions that Cause Blade Swish

The phenomenon of wind shear coupled with ground level atmospheric stability refers to the boundary between calm air at ground level and turbulent air at a higher altitude. "*A high wind shear at night is very common and must be regarded a standard feature of the night time atmosphere in the temperate zone and over land.*"[16] A recent paper presented at the 2009 Institute of Noise Control Engineers, Noise-Con 2009 conference in Ottawa, Canada on background noise assessment in New York's rural areas noted: "*Stable conditions occurred in 67% of nights and in 30% of those nights, wind velocities represented worst-case conditions where ground level winds were less than 2 m/s and hub-height winds were greater than wind turbine cut-in speed, 4 m/s.*"[17]

Based on a full year of measurements every half-hour at a wind farm in Germany, Van den Berg found:

> "*the wind velocity at 10 m[eters] follows the popular notion that wind picks up after sunrise and abates after sundown. This is obviously a 'near-ground' notion as the reverse is true at altitudes above 80 m. . . . after sunrise low altitude winds are coupled to high altitude winds due to the vertical air movements caused by the developing thermal turbulence. As a result low altitude winds are accelerated by high altitude winds that in turn are slowed down. At sunset this process is reversed.*[18]"

In other words, when ground-level wind speed calms after sunset, wind speed at typical hub height for large wind turbines (80 meters, or 262 feet) commonly increases. As a result, turbines can be expected to operate, generating noise, while there is no masking effect from wind-related noise where people live. "*The contrast between wind turbine and ambient sound levels is therefore at night more pronounced*.[19]" As the turbine's blades sweep from top to bottom under such conditions the blade encounters slightly different wind velocities creating unexpected turbulence that results in rhythmic swishing noise[20]. Such calm or stable atmosphere at near-ground altitude accompanied by wind shear near turbine hub height occurred in the Van den Berg measurements 47% of the time over the course a year on average, and most often at night[21].

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[15] Van den Berg (2006), p. 106; Minnesota Department of Public Health (2009), p. 21. *See also* Pedersen (2007, p. 24) ("Amplitude-modulated sound has also been found to be more annoying than sound without modulations."

[16] Van den Berg (2006, p. 104). *See also* Cummings (2009)

[17] Schneider, C. "Measuring background noise with an attended, mobile survey during nights with stable atmospheric conditions" Noise-Con 2009

[18] (Van den Berg 2006, p. 90)

[19] *Id.*, p. 60

[20] *Id.*, p. 61. *Cf. also* Minnesota Department of Public Health (2009), pp. 12-13 and Fig. 5.

[21] Van den Berg 2006, p. 96

Infra and Low Frequency Sounds

The level of annoyance produced by noise also increases substantially for **low frequency sound,** once it is perceived, than the more readily audible mid-frequency sounds. Sound measured as dBA is biased toward 1,000 Hz, the center of the most audible frequency range of sound pressure. Low frequency sound is in the range below 200 Hz and is more appropriately measured as dBC or using instrumentation that can provide 1/3 octave band resolution of the spectrum sound pressure levels. Sound below 20 Hz, termed **infrasound**, is generally presumed to not be audible to most people. *See* Leventhall (2003, pp. 31-37); Minnesota Department of Public Health (2009, p. 10); Kamperman and James (2008, pp. 23-24). For many years it has been presumed that only infra and low frequency sounds that reached the threshold of audibility for people posed any health risks. Many acoustical engineers were taught that if you cannot hear a sound, it cannot harm you.

Recent research has shown that the human body is more sensitive to infra and low frequency noise (ILFN) and that the organs of balance (vestibular) and cardio-vascular systems respond at levels of sound significantly lower than the thresholds of audibility. [22] Dr. Nina Pierpont has conducted a peer reviewed study of the effects of infra and low frequency sound on the organs of balance that establishes the causal link between wind turbine ILFN and medical pathologies. The new research is not from the traditional fields that have provided guidance for acoustical engineers and others when assessing compatibility of new noise sources and existing communities. This research is coming from the field of medical research into how our bodies respond to external energies at the cellular level. Numerous studies are now available showing how the body responds to extremely low levels of energy not through the traditional organs of auditory and balance, but at the level of cell activity.

To get a idea of just how outdated our understanding is of the way our bodies interact with the energies and forces around us I would like to share a short piece that was sent to me by Eileen Mulvihill, a genetic biologist who received her Ph.D. in Molecular Biology from the Université Louis Pasteur, Strasbourg, France. She holds six patents for discoveries she made during her career. Her point is to demonstrate how our body's cells and molecules function as sensory receptors that augment the sensory organs, like our auditory and vestibular organs. Most of us learned that we have primary sensory organs and they perform all the needed functions for sensing the world around us (especially those who have not remained current with research in the field of molecular and cellular biology). It is this, now outdated view-point that leads some of the wind industry acoustical experts to still claim that 'If you can't hear it, it can't hurt you." In other words, they believe that because our auditory function (outer, middle, and inner ear) is not as sensitive to infra and low frequency sounds (rumble) as it is to mid and high frequency sounds (where speech occurs); and, that the infra and low frequency sounds from wind turbines are not loud enough to be heard by <u>most</u> people, there is no potential for adverse health effects. She recently provided a good example of research that shows how our body can sense external forces. In other words, she describes other ways we sense acoustic energy, like low frequency

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[22] Alves-Pereira, Marianna and Nuno A. A. Branco (2007a). *Vibroacoustic disease: Biological effects of infrasound and low-frequency noise explained by mechanotransduction cellular signalling*, 93 PROGRESS IN BIOPHYSICS AND MOLECULAR BIOLOGY 256–279, available at http://www.ncbi.nlm.nih.gov/ pubmed/17014895><
and, Alves-Pereira, Marianna and Nuno A. A. Branco (2007b). *Public health and noise exposure: the importance of low frequency noise*, Institute of Acoustics, Proceedings of INTER-NOISE 2007,

sounds, through cellular level mechanisms not related to dedicated sensory organs. She offered the following example using a paper by Dr. D. Ingber:

> "Anyone who is skilled in the art of physical therapy knows that the mechanical properties, behavior and movement of our bodies are as important for human health as chemicals and genes. However, only recently have scientists and physicians begun to appreciate the key role which mechanical forces play in biological control at the molecular and cellular levels.
>
> "An article by Dr. D. Ingber, who first described the model of tensegrity, describes what his team has learned over the past 30 years as a result of their research focused on the molecular mechanisms by which cells sense mechanical forces and convert them into changes in intracellular biochemistry and gene expression-a process called "mechanotransduction".
>
> "Ingbers Prog Biophys Mol Biol. 2008 Jun-Jul;97(2-3):163-79. Epub 2008 Feb 13 work has revealed that molecules, cells, tissues, organs, and our entire bodies use "tensegrity" architecture to mechanically stabilize their shape, and to seamlessly integrate structure and function at all size scales. Through the use of this tension-dependent building system, mechanical forces applied at the macroscale produce changes in biochemistry and gene expression within individual living cells.
>
> "**This structure-based system provides a mechanistic basis to explain how application of physical impacts, such as low frequency sound, influences cell and tissue physiology.**" (Emphasis added)

What she is describing is the process by which low levels of energy can affect hormone production which by their actions result in adverse health effects. There are many more and smaller receptors for sensory input that than just our dedicated organs. Because these receptors are so small they may be far more sensitive to low amplitude, low frequency sound than the studies conducted focusing on the auditory and vestibular organs only would reveal. Also, remember that low frequency sound penetrates into our body with little attenuation in the same way that it passes through the walls and roofs of our homes.

We are also finding that new research tools not available to the researchers who are frequently quoted by wind developers in their defense are showing that our auditory and vestibular organs themselves are more sensitive than previously known. In Dr. Pierpont's forthcoming study, Wind Turbine Syndrome, she cites the research of Drs. Todd, Rosengrenm, and Colebatch in their paper "Tuning and sensitivity of the human vestibular system to low-frequency vibration" published in Neuroscience Letters 444 (2008) 36–41. In this paper they present the findings of a study in the abstract as:

> "Mechanoreceptive hair-cells of the vertebrate inner ear have a remarkable sensitivity to displacement, whether excited by sound, whole-body acceleration or substrate-borne vibration. In response to seismic or substrate-borne vibration, thresholds for vestibular afferent fibre activation have been reported in anamniotes (fish and frogs) in the range −120 to −90 dB re 1 g. In this article, we demonstrate for the first time that **the human vestibular system is also extremely sensitive to low-frequency and infrasound vibrations** by making use of a new technique for measuring vestibular activation, via the vestibulo-ocular reflex (VOR). We found a highly tuned response to whole-head vibration in the transmastoid plane with a best frequency of about 100 Hz. At the best frequency we obtained VOR responses at intensities of less than −70 dB re 1 g, which

was **15 dB lower than the threshold of hearing** for bone-conducted sound in humans at this frequency. Given the likely synaptic attenuation of the VOR pathway, human receptor sensitivity is probably an order of magnitude lower, thus approaching the seismic sensitivity of the frog ear. These results extend our knowledge of vibration-sensitivity of vestibular afferents but also are remarkable as they indicate that the **seismic sensitivity of the human vestibular system exceeds that of the cochlea for low-frequencies.**" (Emphasis added)

These examples are provided to demonstrate that there is sufficient evidence to present a causal link between ILFN and adverse health effects. The typical acoustician has not caught up on these new understandings of how our bodies respond to infra and low frequency sound levels. These levels were only a few years ago considered too low to cause any physical response. Once we understand that what you cannot hear, can hurt you; we will be in a better position to develop the procedures and criteria to use wind turbines as a renewable energy resource but until the time when the necessary studies have been completed it is appropriate to follow the precautionary principle and not expose the public to a potential health risk.

Wind turbine noise includes a significant low-frequency component, including inaudible infrasound as shown in Figures 3 through 5. For example, according to the manufacturer, under ideal test conditions at a distance of 200 meters (656 feet), a single 2.5 MW Nordex N80 wind turbine generates 95 decibels at 10 Hz[23]. This is at the threshold of human hearing for the average person and above the threshold for the most sensitive individuals.[24] The Nordex study also showed that sound pressure levels were highest at the blade passage frequency (between 1 and 2 Hz) and dropped off with increasing frequency. Thus, we can expect that below 10Hz sound pressure levels were higher than 95 dB.

Although low frequency sound is in the less-audible or inaudible range, it is often felt rather than heard. Unlike the A-weighted component, the low-frequency component of wind turbine noise "*can penetrate the home's walls and roof with very little low frequency noise reduction*.[25]" Acoustic modeling for low frequency sound emissions of ten 2.5 MW turbines indicated "*that the one mile low frequency results are only 6.3 dB below the 1,000 foot one turbine example*.[26]" This makes the infra and low frequency sound immissions from wind turbines a potential problem over an even larger area than the audible sounds, such as, blade swish and other wind turbine noises in the mid to high frequency range.

2) Background Sound Levels

Apart from the distinctive characteristics of wind turbine noise, including its low frequency component, the quiet soundscapes found in rural and semi-wilderness areas accentuate the perceived annoyance and potential for sleep disturbance. The WPSC has procedures for how to assess the pre-operational background sound levels that were designed for the types of communities in which the more traditional power generating utilities are located. Whether these are adequate for wind utilities located in quiet communities remains to be determined. It is not in the scope of this report to anticipate any needed changes, but the discussion above relative to the potential issues related to infra and low frequency sound does

[23] Nordex (2004, p. 4).
[24] Rogers et al. (2006, p. 9, table 5)
[25] Kamperman and James (2008), p. 3.
[26] *Id.*, p. 12

imply that some method of assessing and controlling the lower frequency sounds is warranted.

The first background sound assessment that was submitted was flawed by instrumentation setup errors. These errors were observed and reported by George Kamperman when he conducted an independent assessment of background sound levels.[27] Mr. Kamperman reported background sound levels at the four test sites ranging from 20 to 31 dBA (L_{A90}) and L_{A50} ranging from 23 to 35 dBA. The revised background sound study by Mr. Hessler (Aug. 9, 2009) reports the background sound levels as being between 28 and 35 L_{A90} and 51 to 60 L_{A50}. It is difficult to understand why there is such a discrepancy between the L_{A50} values if sites and conditions were equivalent.

In discussions with Mr. Kamperman regarding these differences it was noted that the Hessler test sites were not at the residents' homes, but instead, were located near wind monitors. Mr. Kamperman summarized his observations as follows:

> "Rick:
>
> "Your note reminded me of Hessler's four measurement locations at Glacier Hills. He did not select any locations near residents. He stated in his report that his measurements were near wind monitors. His measurements were on public roads near wind monitors and always on a hilltop. "Near" means approximate. Monitor A and B appeared to be about 1/4 mile (my guess not measured) east of the N-S road. Monitor A appeared to be equal distance from SR-33 and the N-S road to the west. Monitors C and D are a couple hundred feet west of Mon. 4 and 3 respectively. No Hessler microphone measurement locations appeared to be near residents except possibly Mon. 1. Traffic noise from SR-33 is the primary environment noise source in the Glacier Hills area.
>
> "I visited Glacier two consecutive evenings in June to measure background noise level at the Hessler Mon. 1-4 locations. The first evening had to be scrubbed because of high surface winds. Although a local resident farmer confirmed the Ethanol plant was operating normally I could barely hear the plant operation either night at position Mon. 1. Traffic noise from SR-33 (1/2 mile south) was dominant.

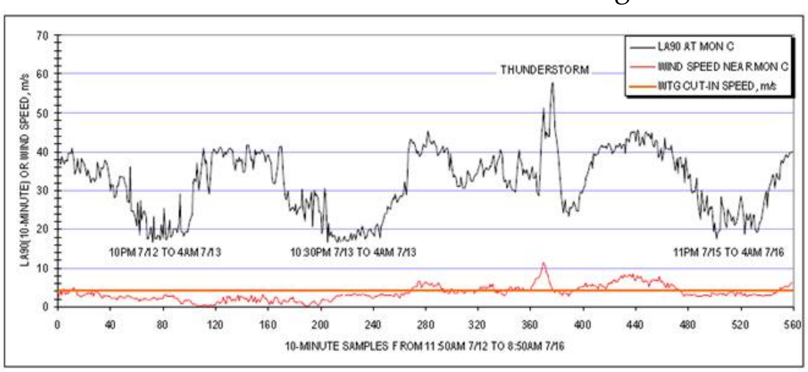

Figure 3: *Continuous LA90 sound level over a 4-day sampling period at Monitor C, Site 4 compared to measured wind speed at a height of 10 meters.*

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> "First look at the Glacier Hills new background noise data from Hessler. Figure 3 shows the background noise level 1/4 mile south of SR-33 with line-of-sight between the Mon 4 microphone and a long section of the highway. Here we see the lowest L_{A90} levels are about 17 dBA on three of the four nights. ANSI Std. integrating sound level meters

[27] Kamperman, G. W., P.E., INCE Bd. cert., "Critique of background sound measurements reported by Hessler Associates, Inc. "Noise Assessment Glacier Hills Wind Park" October 2008," Dated June 15, 2009

> typically exhibit a noise floor between 15 dBA and 17 dBA. Therefore I can presume the actual minimum ten minute L90 background noise level to be 14 dBA, or less, next to SR-33. When nighttime traffic noise is this quiet I would expect the nearest resident near Mon. 1 northeast (3/4 miles) of the Ethanol plant can clearly hear normal plant operations.
>
> "If we assume from Figure 3 daytime SR-33 traffic noise elevates the background to 40 dBA during daytime at Mon. 4 (C) 1/4 mile south we should expect the same traffic noise to be about 37 dBA at the near farmhouse 1/2 mile north near Mon. 1 (A). So our farmhouse may experience a daytime/nighttime ten minute background noise level of 37dBA/14 dBA a 23 dBA day/night variation. Now try to imagine the noise impact with the introduction of 50 dBA wind turbine noise 24/7."

Is this the explanation for the differences between the two 2009 studies? It may be that Mr. Hessler selects his test sites with the intention of biasing the test results. This is something that has been observed in other tests he and his firm have conducted for wind developers. The background sound study Hessler and Associates conducted for a wind developer in the upper New York area near Cape Vincent was questioned by members of that community. They commissioned an independent Study by Dr. Paul Schomer, who is the Chair of the Acoustical Society of America's Standards Committee and is highly respected for impeccable work by his peers.[28] Dr. Schomer concluded that:

> "Hessler's BP study for the Cape Vincent Wind Power Facility appears to have selected the noisiest sites, the noisiest time of year, and the noisiest positions at each measurement site. Collectively, these choices resulted in a substantial overestimate of the a-weighted ambient sound level, 45-50 dB according to Hessler."

The complete Cape Vincent study is provided with the references. If should be reviewed by the WPSC to determine if the WEPCO sound study was free from similar bias.

Other studies of background sound levels in rural communities confirm the results of Mr. Kamperman's study. For example, similarly low background sound levels were also reported in the study by Mr. Clifford Schneider[29]. Schneider reported that the median L_{A90} sound level for approximately 20 test locations in northern New York was 25.5 to 26.7 dBA. This reviewer has also found that in rural areas background sound levels are typically less than 30 L_{A90}. When sampling is conducted during the evening hours when community activities are at a minimum the L_{Aeq} and the L_{A90} are usually within 5 dB of each other. It is during this time that the sounds from the wind turbines will be most apparent and it is against those low background sound levels that land-use compatibility should be assessed.

While on the topic of nighttime sound levels it should be noted that the World Health Organization (WHO) revised its guidelines for nighttime noise in 2007. The revised guidelines supersede the guidelines commonly referenced from 1999 and before.[30] These guidelines provide the definition of what is required for a causal link to be established between a exterior forcing agent like noise and health. They state:

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[28] Schomer, P., PE, INCE Bd. Cert., "Cape Vincent Background Noise Study," May 11, 2009

[29] Schneider, C. "Measuring background noise with an attended, mobile survey during nights with stable atmospheric conditions" Noise-Con 2009

[30] WHO Night Noise Guidelines (2007)

"Sufficient evidence: *A causal relation has been established between exposure to night noise and a health effect. In studies where coincidence, bias and distortion could reasonably be excluded, the relation could be observed. The biological plausibility of the noise leading to the health effect is also well established.*

"Limited evidence: *A relation between the noise and the health effect has not been observed directly, but there is available evidence of good quality supporting the causal association. Indirect evidence is often abundant, linking noise exposure to an intermediate effect of physiological changes which lead to the adverse health effects."*

Table 3. Summary of the relation between night noise and health effects in the population

$L_{night-outside}$ **up to 30 dB**	Although individual sensitivities and circumstances differ, it appears that up to this level no substantial biological effects are observed.
$L_{night-outside}$ of **30 to 40 dB**	A number of effects are observed to increase: body movements, awakening, self-reported sleep disturbance, arousals. With the intensity of the effect depending on the nature of the source and on the number of events, even in the worst cases the effects seem modest. It cannot be ruled out that vulnerable groups (for example children, the chronically ill and the elderly) are affected to some degree.
$L_{night-outside}$ of **40 to 55 dB**	There is a sharp increase in adverse health effects, and many of the exposed population are now affected and have to adapt their lives to cope with the noise. Vulnerable groups are now severely affected.
$L_{night-outside}$ of **above 55 dB**	The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a high percentage of the population is highly annoyed and there is some limited evidence that the cardiovascular system is coming under stress.

End of WHO 2007 Guideline Excerpts

In Table 3 of the 2007 Guidelines, WHO presents the maximum sound levels that should be permitted outside the walls of a home to prevent adverse health effects. The new criteria are based on recent research into nighttime noise and health that was not available when the 1999 guidelines were published. The outdoor criteria ($L_{night-outside}$) represent the long term conditions, not a single night's exposure. Table 3 shows that nighttime sound levels of 30 dBA and under pose no health risks. However, nighttime sound levels of 40 to 50 dBA as projected for homes in the footprint of Glacier Hills would result in "a sharp increase in adverse health effects, and many of the exposed population are now affected and have to adapt their lives to cope with the noise.

An article in Noise and Health by Dr. Levanthall addresses these coping mechanisms for people exposed to noise.[31] It deserves careful reading by the WPSC. It describes the coping mechanisms and other adaptations to life style that people adopt when exposed to ILFN over long periods of time. It is interesting to note that many of the coping mechanisms in that article are used by people who are now living in the footprint of wind utilities like Glacier Hills. Indeed, there has been an ongoing debate between Dr. Leventhall and Dr. Pierpont about the risks of exposure to wind turbine sounds that seem to be contradicted by the statements of Dr. Leventhall in this article. If it can be assumed that the causal link between wind turbine noise exposure and the ILFN from wind turbines is established by the new medical research referenced earlier, and the levels of ILFN required to initiate a response from our bodies is lower than previously thought, then the disagreement between them appears to resolve in favor of Dr. Pierpont's research.

[31] Leventhall, H. G. "Low Frequency Noise and Annoyance," Noise and Health, Vol. 6, Issue 23, Page 59-72 (2004)

3) Computer Model Predictions

Studies on behalf of WEPCO presenting computer simulations that purportedly estimate the "worst-case" sound levels that will be received in the community should be viewed with serious skepticism. Models are representations and simplifications of complex interactions between noise emitters, and their surrounding environment. Models are not precise instruments, and are not any better than the input data used to represent the noise source and accuracy of the algorithms used to represent how sound decays with increasing distance from the location of each source. For specific situations of modeling wind turbines in complex terrain, such as ridges and valleys, acoustical models are seriously challenged. The ability of the model to accurately replicate how the sounds are blocked by terrain or reflected by terrain is especially weak. Errors in models of wind turbine noise propagation located on flat terrain have been shown to have errors of 5 to 10 dB or more when studied by independent acoustical engineers. It would be expected that errors of this magnitude or higher would be found in models of more complex terrain such as is found in the community near WEPCO's footprint.

This range of levels is understandable, given the discussion earlier in this report about the assumptions in the modeling process and also in the input data used to replicate the more important interactions as the wind turbine's sound propagates into the community. First, the model estimates a single number at a receiving site. This is an average value, representing for the input data and assumptions a yearly estimate of the sound immissions at the receiving site. It also does not reflect all of the conditions that can lead to higher sound immissions from blade swish and other weather induced effects on the turbine's noise.[32] Sometimes it is easier to understand this variability visually. The chart in Figure 7, was presented to the citizens of Mars Hill, Maine in December of 2008 by the Director of the Maine Bureau of Land and Water Quality which includes the Dept. of Environmental Protection. Maine's MDEP commissioned a four quarter study of the sound levels under various operating conditions and seasonal variations. This chart shows the 'best' of the data that was hand selected to represent only sound levels when wind turbines were operating and clearly audible. The test site is over 2000 feet

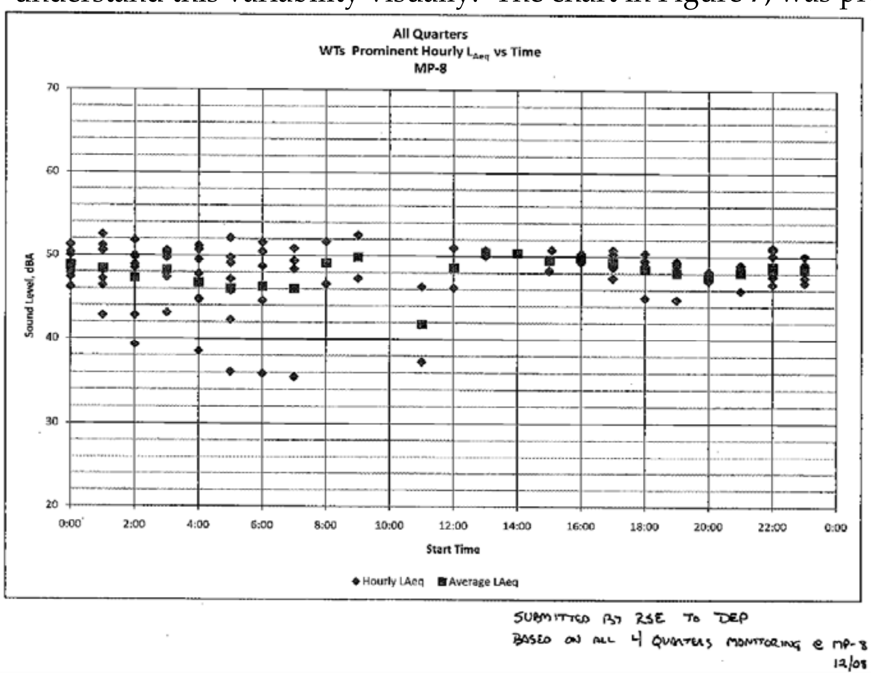

Figure 7-Chart showing range of sound levels at one Mars Hill test site from four quarterly sound studies

[32] Ebbing, C. E. Some Limitations and Errors in Current Turbine Noise Models, Report for Appeal of Record Hill Wind decision in Maine.

from the nearest wind turbine, a 1.5MW upwind model. Note that the sound levels range from a low of about 35 dBA to a high of just over 52 dBA. All of these represent wind turbine sounds and not wind or other artifacts. The initial model estimated that the sound levels at this site would be 47.5 dBA. Sound levels higher than 52 dBA were observed but winds prevented accurate measurement.

Assuming that wind and other factors can result in a 17 dB range of sound levels for this operating wind utility, and that measurements during the highest noise conditions were precluded by wind speeds at the microphone exceeding the limits of the wind screen, how can any study of a operating wind utility claim that the levels estimated by the model were found during a single series of field tests. If the model reflects 'worst-case' wind speeds for the turbine, how can the follow-up study claim that test results for operating conditions that were not part of the model's assumptions demonstrate the model is accurate? The truth of the matter is that when the person who constructs the model is permitted to assess its accuracy the results should be viewed with suspicion. It is in that light that this reviewer views the results of the model presented in the October 2008 study by Mr. Hessler. It is suggested that the WPSC view the estimates of sound propagation in the same way. It is at best a guide to estimate how the sound will affect the community, but to imply that the results have a high degree of accuracy is to stretch the credulity of the reviewer.

Furthermore, studies that use models normally disclose the strengths and weaknesses of the models and also disclose the input data and other important assumptions. They give appropriate cautions and disclose error tolerances for all possible known conditions that the model does not consider. This is not done in the WEPCO study. The model is poorly documented and missing important data if the study is to be critically reviewed by others competent to do so.

Much could be said again about the flaws in computer modeling of sound in complex situations but that evidence has been previously submitted. The arguments are academic and not something that most non-engineers would not care to review. Therefore, the easiest way to establish that wind turbine models underestimate sounds at properties adjacent wind utilities is to look at existing wind projects. Since most, if not all, follow-up sound studies in Wisconsin were conducted by acoustical consultants with strong ties to the wind utility developers it is reasonable to look at projects outside of Wisconsin. This review has conducted studies of operating wind utilities in many different states, and in Ontario. In all cases the projects were granted permits based on sound studies claiming the community had high background sound levels, came with discussions of how wind noise masks turbine noise, and presented wind turbine sound models estimating levels in the low to mid 40 dBA range at the nearest properties. Note how close the parallel is to what WEPCO has presented for the Glacier Hills wind utility under consideration. But, what has happened at those locations? The promises of compatibility with existing community sound levels, of no potential for nighttime sleep disturbance or low frequency 'vibrations' have been replaced with numerous complaints about noise and health to the local Boards. In some cases this has escalated to threats of litigation.

Given that track record, it is a safe assumption to consider the WEPCO models to be estimates of turbine noise under optimum operating conditions and nothing more.

4) Supplemental information provided by WEPCO (Leventhall et. al.)

Recent studies link low frequency noise impacts to impairment of the vestibular system or other organs.[33] This new link between health and noise should be considered along with studies showing that wind utility noise from turbines operating at distances of up to one mile is a cause of sleep disturbance for a vulnerable minority, and chronic sleeplessness results in adverse health effects. The supplemental reports provided by WEPCO written by Dr. Leventhal and others take issue with this position.

Kamperman/James

There are two primary issues that require a response to the comments on the K/J paper.

Dr. Leventhall's review of the Kamperman/James paper asserts that:

1. K/J are too focused on ILFN, and
2. The proposed criteria using the difference in a-weighted sound levels and c-weighted sound levels should not apply.

Information provided earlier in this report demonstrated that wind turbines do produce ILFN and that new research, not well known by acoustical engineers, show that the levels of acoustical energy are in the range of perception for at least a small segment of the exposed population. With respect to whether wind turbines emit ILFN, consider that if one totals the acoustic energy of a wind turbine across the entire frequency spectrum from 16Hz up to the speech frequencies, the difference in the sum of the energy below 200 Hz is often 10-15 dB higher than the sum of the energy at 200 Hz and above. It is clear that wind turbines are primarily producers of noise in the ILFN range.

Any critique of the K/J emphasis on ILFN must consider that the recommendations be seen as precautionary. At the time the manuscript was prepared there was less information about the nature of the sound immission in operating wind utilities. Based on information culled from studies of some of the first wind projects in the US and other countries, it was decided that there was a need for a limit to ILFN as a <u>precaution</u>. We did not know, at that time, if all wind turbines produced the same spectrums as those we saw in the sound tests conducted for many of the participants in Dr. Pierpont's study. But, based on the initial indications, and our experience with other large fans, and related problems in work areas subject to 'rumble' it was decided to include criteria that would severely limit any increases in the existing long term ILFN to which people in rural areas are typically exposed. Dr. Leventhall's critique misses this important point. The focus by K/J on ILFN was initially precautionary. Subsequent to the development of those criteria additional information has been accumulated that supports the need for that precaution.

Even if only 5-10% of the people living in the footprint of an operating wind utility are susceptible, that is still a large number and given the fast rate at which wind utilities are being constructed this number will continue to increase. The K/J manuscript is written to apply the Precautionary Principle to what we do and do not know about the causal links and the short

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[33] See Alves-Pereira and Branco, 2007; (linking the low-frequency component of wind turbine noise to abnormal growth of collagen and elastin in the blood vessels, cardiac structures, trachea, lungs, and kidneys of humans and animals exposed to infrasound (0–20 Hz) and low-frequency noise (20–500 Hz), in the absence of an inflammatory process). See also Pierpont "Wind Turbine Syndrome" study (2009) and Minnesota Department of Public Health (2009), pp. 7-8.

and long term health effects of wind turbine noise emissions. The criteria developed in that manuscript (which the reviewer encourages the WPSC to consider as a replacement for the current 50 dBA criteria) are based on that principle. When solving one problem, the need for clean energy, it is not appropriate to expose people to a second problem, a potential health risk. It is hoped that the discussion about the causal links between ILFN and adverse health effects can help the debate between those that are concerned about health effects and those who continue to deny need for such caution can now progress beyond the 'if you can't hear it, it can't hurt you' stage of argument. When, new information of the type disclosed by Dr. Pierpont and others is made available, wind turbine manufacturers and reasonable experts will try to understand these new concepts before rejecting them in favor of the former beliefs.

Dr. Leventhall's critique of K/J's use of C-A demonstrates that he did not conduct a careful review of the manuscript. If he had done so, he would have noticed that the subscripts for the C-A criteria are: $L_{Ceq\ (immission)}$ minus ($L_{A90\ (background)}$ +5) ≤ 20 dB. This formulation is again an application of the precautionary principle. Given that we do not know how much increase in ILFN is needed to trigger an adverse health effect, the criteria was established to limit the additional ILFN from the operating turbines to no more than a small increase over the pre-operational background sound levels. In addition, the K/J paper suggests that the L_{Ceq} when the turbines are operating $L_{Ceq\ (immision)}$= L_{C90}(background) +5 dB. In both cases, the justification is precaution. Until the extent of the links between nighttime sleep disturbance from audible sounds; and vestibular and cardio pathologies from audible sound or ILFN are known, it is best to error on the side of safety and health.

Pierpont

The symptoms reported by Dr. Pierpont for people exposed to dynamically modulated ILFN from wind turbines are not that different from the symptoms reported by Kirsten Persson Waye in collaboration with Dr. Leventhal in their 1997 paper "*Effects On Performance And Work Quality Due To Low Frequency Ventilation Noise*,"[34] This study compared the performance and other factors for a work group that was exposed to dynamically modulated low frequency sound to that of a work group exposed to more normal HVAC system sound spectrum with lower levels of LFN and no modulation. This study reported that the group exposed to LFN reported:

1. subjective estimations of noise interference with performance were higher for the low frequency noise (exposed group)

2. The exposure to low frequency noise resulted in lower social well-being ('96 words) "more disagreeable, less co-operative, helpful and a tendency to lower pleasantness "more bothered, less contented as compared to the mid frequency noise (exposed group)

3. Data may indicate that the response time during the last part of the test was longer in the low frequency noise exposure e.g. cognitive demands were less well coped with under the low freq. noise condition.

4. The effects seemed to appear over time

5. The hypothesis that cognitive demands are less well coped with under the low frequency noise condition needs to be further studied.

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[34] *Journal of Sound and Vibration (*1997), 205(4), 467-474

They also reported that a "few previous studies indicate that low frequency noise may reduce performance at levels that can occur in such occupational environments. Some of the symptoms that are related to exposure to low frequency noise such as

1. Mental tiredness,
2. Lack of concentration and
3. Headache related symptoms,

could be associated with a reduced performance and work satisfaction."

"The reported symptoms and effects on mood were apart from tiredness in accordance with earlier findings on effects after exposure low-frequency noise. The subjects reported a feeling of pressure on the head rather than headache and lower social orientation and pleasantness after low-frequency noise exposure (Persson-Waye 1995)."

Given that this study identified adverse health effects from dynamically modulated LFN that is similar in level to what is experienced inside the homes of people living near turbines, one might think that Dr. Leventhal would embrace the new medical studies and Dr. Pierpont's research as a possible answer to the HVAC study's findings. The symptoms listed in Dr. Pierpont's report are very similar to those reported in the HVAC study.

5) Conclusion

The World Health Organization (WHO) has a long established position that considers sleep disturbance to be an adverse health effect and to lead to secondary adverse health effects[35]. Dr. Leventhal did not seem to think this was important enough to include in his critique of K/J or of Dr. Pierpont. Nothing about these guidelines was mentioned in either of Mr. Hessler's reports. Chronic sleeplessness, in turn, causes a variety of health effects, including "*primary physiological effects . . . induced by noise during sleep, including increased blood pressure; increased heart rate; increased finger pulse amplitude; vasoconstriction; changes in respiration; cardiac arrhythmia; and an increase in body movements.*[36]" "*Exposure to night-time noise also induces secondary effects, or so-called after effects . . . including reduced perceived sleep quality; increased fatigue; depressed mood or well-being; and decreased performance.*[37]" Waking up in response to nighttime noise decreases as people get habituated to the noise; however, "*habituation has been shown for awakenings, but not for heart rate and after effects such as perceived sleep quality, mood and performance.*"[38]

WHO issued the 2007 Night Time Noise Guidelines (NNGL) as a replacement for the 1999 Guidelines. These guidelines are intended to replace all earlier guidelines with respect to sleep and noise. They supersede the prior guidelines that recommended that sleeping rooms be protected from outside sound that raises sound levels inside to above 30 dBA. Because the earlier guidelines provided a limit in terms of interior sound levels and also included special conditions when low frequency sounds were present outside the home WHO explains that it was decided there was too much room for interpretation of their research findings. Thus, in 2007, following several years of research by respected experts in health and noise and three major meetings to present their findings WHO issued the new guidelines. This time, they elected to establish the guidelines for the outside façade of the home and not the sleeping area.

[35] WHO (1999), pp. 44-46
[36] Id., p. 44.
[37] Id., pp. 44-45
[38] Id., p. 45.

This avoided issues such as whether windows are open and if so how much and also issues of various types of building construction that affect how low frequency sounds penetrate into the home. The focus was to establish science based guidelines that would promote healthful sleep.

The table excerpted from WHO's 2007 guideline clearly states that to avoid adverse health effects during sleeping hours that the sound levels at the outside wall of a home should not exceed 30 dBA at night. It also states that when sound levels outside a home are over 40 dBA there is a sharp increase in adverse health effects; that people would be attempting to adapt to cope with the high outdoor noises, and that the more vulnerable members of the exposed population would be severely affected. These are the same sound levels that WEPCO has claimed are compatible with the community and safe for the people living under and adjacent to the turbines. WHO's descriptions of the health effects on the exposed populations closely parallel the experiences of people in other communities where wind utilities are currently operating.

The new guidelines from WHO and other recent medical research have led several health organizations to call for serious research before more wind turbines are located near people's homes. Recently, Health Canada, which functions much as the US Center for Disease Control does in the US, issued a position statement calling for reconsideration of a wind utility project in Nova Scotia that would result in sound levels at homes similar to those projected for the WEPCO project. The basis for their statement includes the new medical research, Guidelines such as WHO's, and the existence of other projects in Nova Scotia where the studies submitted for permitting showed no potential for health risks or complaints but operation of the utilities resulted in them anyway. The Maine Medical Association, which has been evaluating new health research on residents of Maine's first wind utility at Mars Hill, issued a Resolution stating:

"*WHEREAS, there is a need for modification of the State's regulatory process for siting wind energy developments to reduce the potential for controversy regarding siting of grid-scale wind energy development and* ***to address health controversy with regulatory changes...***" (emphasis added)

Wisconsin's medical community has yet to address the health controversy with a call for regulatory changes, but the situation in Wisconsin is similar to that in Maine. Public officials with a duty to protect the public health and welfare should seriously consider whether it is a wise decision to grant permits to a utility operator that, by its own admission, will expose the public to unsafe conditions 24 hours a day and 365 days a year.

It should be of great significance to those who wish to be fair and impartial in making decisions that affect the public and its health that many of the complaints this author has been asked to evaluate for residents and local governments including wind utilities operating or proposed in New York and other states, Canada, the U.K., and, places as remote as New Zealand are all <u>directly related to noise resulting from operation of turbines during conditions excluded from the IEC test results and the sound propagation models</u>.

Has WEPCO in its reports, presentations, studies and recommendations to the WPSC discussed these negatives and uncertainties in an open manner or have they focused on defending themselves when these issues have arisen through public questions? Have they disclosed that there are operating wind utilities, possibly even some of their own, where complaints or lawsuits have been lodged?.

Finally, this caution is offered. If the data submitted by WEPCO has created the impression with the WPSC that there will be no future problems from noise they should consider that these same assertions were made to other government officials tasked with deciding on whether or not to issue permits. The local government officials of areas affected by WEPCO's plans for a wind utility will be in the same place as the officials of other communities where anger, complaints, and litigation are common. Those other officials, or their successors, are now facing complaints and threats of litigation from the people living in their wind utility's footprint.

The background sound levels obtained by an independent acoustical consultant (Kamperman) shows that existing conditions at Glacier Hills are often below 30 dBA. Operation of wind turbines will increase sound levels on a routine basis to 40-45 dBA for many local residents and above that for conditions not accounted for in the models. For WEPCO to meet WHO's guidelines the limits for sound at affected properties would need to be set at 35 dBA or lower. The studies and representations by WEPCO show that estimated sound levels at properties adjacent to and inside the footprint of the proposed utility will exceed the nighttime sound levels WHO has identified as a health risk. Experience with other wind utilities with operating turbines having similar sound emission characteristics shows that wind turbine noise levels at distances of 1500 feet can exceed 50 dBA and that sound levels inside homes can easily exceed 30 dBA.

Based on the above, the WEPCO project, as proposed, will, with a high degree of certainty, have noise and health impacts that are "significant."

End of Report Narrative

Richard R. James, INCE,
For E-Coustic Solutions

Richard R. James

Date: Oct. 5, 2009

Details on References not provided in Narrative:

1) Alves-Pereira, Marianna and Nuno A. A. Branco (2007a). *Vibroacoustic disease: Biological effects of infrasound and low-frequency noise explained by mechanotransduction cellular signaling*, 93 PROGRESS IN BIOPHYSICS AND MOLECULAR BIOLOGY 256–279, available at http://www.ncbi.nlm.nih.gov/ pubmed/17014895><

2) Alves-Pereira, Marianna and Nuno A. A. Branco (2007b). *Public health and noise exposure: the importance of low frequency noise*, Institute of Acoustics, Proceedings of INTER-NOISE 2007, http://www.bevarandmyran.com/publikasjoner/ILFN.pdf>Istanbul (Turkey),

3) Bajdek, Christopher J. (2007). *Communicating the Noise Effects of Wind Farms to Stakeholders*, Proceedings of NOISE-CON (Reno, Nevada), available at http://www.hmmh.com/cmsdocuments/ Bajdek_NC07.pdf

4) Bolton, R. H. (2006). EVALUATION OF ENVIRONMENTAL NOISE ANALYSIS FOR "JORDANVILLE WIND POWER PROJECT" (public comments).

5) Bowdler, Dick (2008). *Amplitude modulation of Wind Turbine Noise. A Review of the Evidence*. 33:4 INSTITUTE OF ACOUSTICS BULLETIN.

6) Cavanagh Tocci Assocs. (2008). CAPE VINCENT POWER PROJECT (report to Town of Cape Vincent, NY).

7) Cummings, Jim (2009). *AEI Special Report: Wind Turbine Noise Impacts* (Acoustic Ecology Institute, Santa Fe, NM), available at <AcousticEcology.org/srwind.html>

8) Davis, Julian and S. Jane Davis (2007). *Noise Pollution from Wind Turbines: Living with amplitude modulation, lower frequency emissions and sleep deprivation*, presented at Second International Meeting on Wind Turbine Noise, Lyon (France).

9) James, Richard R. (2009a). Letter to Gary A. Abraham, Esq. [re: Everpower Renewable wind project in Allegany, New York].

10) James, Richard R. (2009b). A REPORT ON LONG TERM BACKGROUND (AMBIENT) SOUND LEVELS AT SELECTED RESIDENTIAL PROPERTIES, MACHIAS, NY, June 2009.

11) Kamperman, George and Richard R. James (2008). Simple guidelines for siting wind turbines to prevent health risks, The Institute of Noise Control Engineering of the USA, 117 Proceedings of NOISE-CON 2008 1122-1128, Dearborn, Michigan, available at <http://www.inceusa.org/

12) Oerlemans, S., Schepers, G. "Prediction of wind turbine noise directivity and swish" Third International Meeting on Wind Turbine Noise Aalborg Denmark 17 – 19 June 2009

13) Palmer, P.Eng., K., "A New Explanation for Wind Turbine Whoosh – Wind Shear" Third International Meeting on Wind Turbine Noise Aalborg Denmark 17 – 19 June 2009

BEFORE THE
PUBLIC SERVICE COMMISSION OF WISCONSIN

Application of Wisconsin Electric Power Company for a Certificate of Public Convenience and Necessity to Construct a Wind Electric Generation Facility and Associated Electric Facilities to be known as the Glacier Hills Wind Park, Located in the Towns of Randolph and Scott, Columbia County, Wisconsin

Docket No.6630-CE-302

SURREBUTTAL TESTIMONY OF RICHARD R. JAMES ON BEHALF OF THE COALITION FOR WISCONSIN ENVIRONMENTAL STEWARDSHIP

Q. Please state your name and address.

A. Richard R. James.

Q. Are you the same Richard R. James who offered direct testimony in this case?

A. Yes.

Q. What is the purpose of your surrebuttal testimony?

A. I am testifying in response to the rebuttal testimony of George Hessler, Mark Roberts, and Geoff Leventhal, filed on behalf of Wisconsin Electric Power Company.

Q. Do you agree with Mr. Hessler's critique of your direct testimony?

A. No, I do not.

Q. How have you organized your responses to Mr. Hessler's rebuttal testimony?

A. I have organized my responses into three sections: Ambient Sound Measurements, Validity of Noise Modeling, and Sleep Interference.

Ambient Sound Measurements.

Mr. Hessler takes issue with criticisms raised in Mr. Kamperman's study (as summarized in my direct testimony) with respect to location of test sites and with other aspects of his 2009 testing for Glacier Hills. These criticisms were not rebutted by Mr. Hessler and remain as questions about whether the tests appropriately characterize the ambient conditions at residences in the project footprint.

In addition, Mr. Hessler takes umbrage at the question raised in my testimony that: "It may be that Mr. Hessler selects his test sites with the intention of biasing the test results." This question was prefatory to the discussion of the Cape Vincent Study by Paul Schomer, Ph.D. of work by Hessler and Associates, which stated:

> Hessler's BP study for the Cape Vincent Wind Power Facility appears to have selected the noisiest sites, the noisiest time of year, and the noisiest positions at each measurement site. Collectively, these choices resulted in a substantial overestimate of the a-weighted ambient sound level, 45-50 dB according to Hessler.

Given that Mr. Kamperman raised similar concerns about the test sites selected for Glacier Hills, it is not unreasonable to ask whether there is a similar explanation for findings at Glacier Hills.

Mr. Hessler confuses the questions that were raised by observations made at Glacier Hills and the Schomer Report. Kamperman and I made no assertion about motives. Any issue Mr. Hessler has on that aspect is between his firm and Dr. Schomer.

Mr. Hessler refers to a paper[1] he presented at the 2009 Inter-Noise Conference in Ottawa, Canada. This paper is included in my previously filed exhibit 809. In this paper, Mr. Hessler acknowledges the concerns about contamination of the background sound level tests by wind, insects, short duration events that are not part of the background soundscape, etc. He also acknowledges that background sound levels in rural communities would be expected to be 30 dBA and below. He states:

> The very quiet rural description range of 26 to 30 dBA is based on a survey of acoustical consultants representing some 180 plus years of experience. Levels in very remote wilderness areas may be lower than the ranges shown during calm and still measurement conditions but the ranges apply to occupied residential receptors."

Mr. Hessler concludes: "It is shown that L_{Aeq} is not a good metric for quantifying levels in quiet environments, at least if the data is to be used for noise impact studies. L_{A50} and L_{A90} are better metrics."

Table 1 – Glacier Hills Background Sound Levels from 2009 Tests

	Site 1		Site 2		Site 3		Site 4	
2009 Study By:	L_{A90}	L_{A50}	L_{A90}	L_{A50}	L_{A90}	L_{A50}	L_{A90}	L_{A50}
Hessler	27.6	30.6	20.4	24.4	21.0	23.2	20.6	25.2
Kamperman	20.8	22.6	26.0	29.6	21.8	23.1	30.9	35.0

Table 1 shows the data for these two metrics from the two 2009 studies at Glacier Hills by Mr. Hessler and Mr. Kamperman. This table supports the

[1] Hessler, G., "Measuring ambient sound levels in quiet environments," Inter-Noise 2009, Ottawa, Canada, August 23-26.

statements in Mr. Hessler's Ottawa presentation regarding typical sound levels in quiet rural communities quoted above. However, Mr. Hessler is unwilling to call these values the background sound for the community, arguing:

> Nevertheless, experience indicates the worst case for potential noise annoyance occurs when winds are light at ground level but sufficiently high to operate the wind turbines. It is unduly conservative to estimate the increase in level due to turbine operation based on minimum ambient levels when the turbines will not operate.

He then proceeds to reintroduce his regression analysis, which presumably shows that: "The LA90 baseline level is seen to be 33 dBA when wind turbine operation begins." This statement is based upon an assumption that wind turbines only produce noise when the wind speeds at the ground level are high enough to result in noise from vegetation and turbulence around ground structures and obstacles. Acoustical consultants for wind utility developers frequently make this assumption, but it is without basis in fact.

Numerous studies have shown that wind turbines can be operating at nominal or higher power production during conditions when the ground level winds are calm and there is no noise from vegetation and turbulence around ground structures to mask the wind turbines. I have conducted almost all of my studies of operating wind turbines under the condition of wind speeds at the ground level (not 10m measurement, but ground level measurements) where winds are less than 2.2 m/s (5 mph). I have also confirmed that many of the complaints made about excessive wind turbine noise by residents living in the footprint of operating wind generators are made when wind speeds at the ground level are calm.

The appropriate background sound levels against which the Glacier Hills project should be judged are those reported in Table 1 above, not the L_{A90} sound levels Mr. Hessler proposes to substitute under his assumption that ground level winds are required for operation of the turbines. This is explained in more detail in the reference paper submitted with my direct testimony by Mr. Clif Schneider[2] stating:

> Stable conditions occurred in 67% of nights and in 30% of those nights, wind velocities represented worst-case conditions where ground level winds were less than 2 m/s and hub-height winds were greater than wind turbine cut-in speed, 4 m/s.

There is no reason to believe that the stable weather conditions referred to for New York are any different in Wisconsin.

Validity of Noise Modeling

Mr. Hessler's faith in the estimates of wind turbine noise propagation models based on ISO 9613-2 as implemented in Cadna/A, demonstrates a lack of understanding of the limitations that the ISO 9613-2 document includes in the body of the Standard. However, I stand by the statements made in my direct testimony explaining how experience shows they are not accurate.

Contrary to Mr. Hessler's protestations, sound propagation models are not precise instruments, and are not any better than the input data used

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[2] Schneider, C. "Measuring background noise with an attended, mobile survey during nights with stable atmospheric conditions" Inter-Noise 2009 Ottawa

to represent the noise source and accuracy of the algorithms used to represent how sound decays with increasing distance from the location of each source. Errors in models of wind turbine noise propagation located on flat terrain have been shown to have errors of 5 to 10 dB or more when studied by independent acoustical engineers (See studies by Kaliski in exhibit 809)

In his paper, Mr. Kaliski notes that he produced four (4) different models of a simple wind turbine layout using the various options and settings provided in Cadna/A. He then goes on to state that his “real world data” matched only one of the four models' predicted sound levels. This does not prove that the model is accurate. It only proves that Mr. Kaliski found one of his four models produced sound levels that were close to the real world measurements.

Cadna/A has so many tweaks and options that there is no way its use can be calibrated unless numerous independent studies are done. For the example in Mr. Kaliski’s paper and in Mr. Hessler’s claim that these studies confirm the model’s accuracy, it is my opinion that any such "matching" of model to real world results are more likely a case of seeking the set of Cadna/A variables that support the conclusion than it is any sign that models are accurate.

It should be expected that errors of 5 dBA or higher would be found in models of more complex terrain such as is found in the community near Glacier Hills' footprint even if the follow up study was done by independent experts and the models' assumptions for the state of turbine power generation, wind speed and direction are carefully matched. The fact that Mr. Hessler finds no such errors when he checks his own models proves nothing about model accuracy. This is not independent validation.

There are independently validated models that are accepted as being accurate enough for planning purposes used by the Federal Highway Administration and the Federal Aviation Administration. Those models have undergone much development for specific noise sources and have been independently validated by experts not involved in creating the models.

When errors in models are identified by projects that do follow the models' predictions, the models are revised or cautions for the circumstances that lead to those errors are available. This is not true for wind turbine project models. Each wind project model is unique and validation attempts to date have been flawed by poor protocols and documentation.

Sleep Interference

Mr. Hessler asserts that the World Health Organization's most recent documents and criteria on nighttime noise and health support his position that sound levels above 40 dBA ($L_{night-outside}$) are acceptable. He states: "The final document from WHO[3] states in a crystal clear manner in

[3] World Health Organization 2009, Night Noise Guidelines For Europe, ISBN 978 92 890 4173 7

the Abstract and the report body that an “outside level of 40 dBA should be the target of the Night Noise Guidelines for Europe (NNG) to protect the public …” This is an incomplete representation of the 2007 and 2009 WHO statements. The 2007 document states:

> "Lnight,outside 30 dB is the ultimate target of Night Noise Guideline (NNGL) to protect the public, including the most vulnerable groups such as children, the chronically ill and the elderly, from the adverse health effects of night noise."

The 2009 document states:

> The LOAEL of night noise, 40 dB $_{\text{Lnight,outside}}$, can be considered a health-based limit value of the night noise guidelines (NNG) necessary to protect the public, including most of the vulnerable groups such as children, the chronically ill and the elderly, from the adverse health effects of night noise.

There is no conflict between the 2007 and 2009 documents; just a different goal. On the one hand, the 2007 WHO guidelines set 30 dBA as the target to protect the public, while on the other hand,, the 2009 WHO guidelines state that 40 dBA should be considered as the health-based limit value. Limit values are “limits,” not “targets.” A value of 40 dBA is a not-to-exceed-without-risk-of-harm limit.

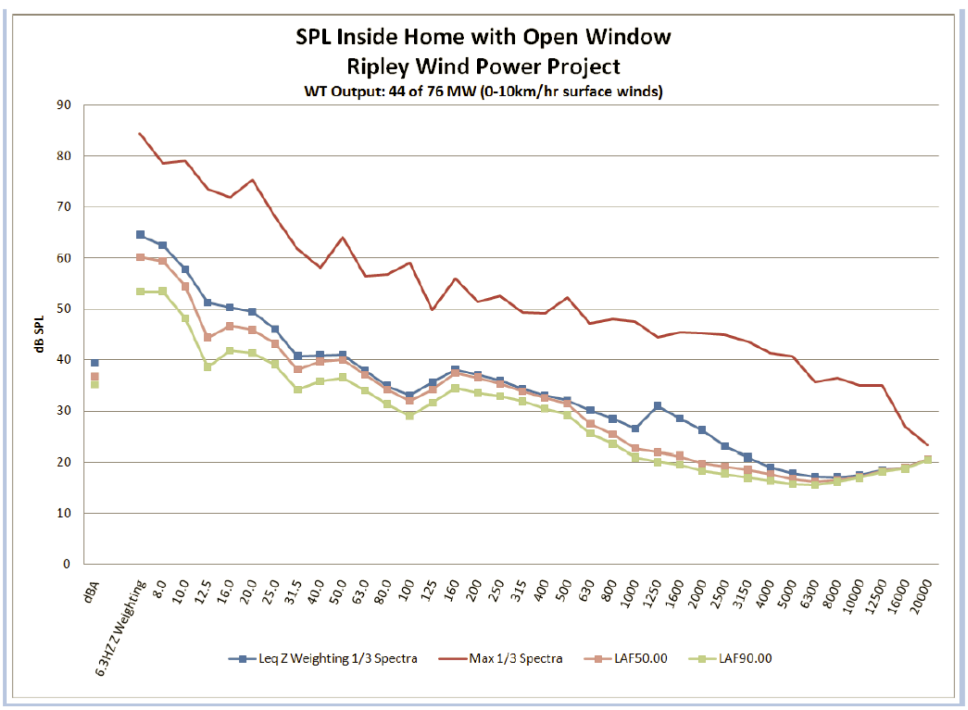
The two documents confirm that WHO’s post-2000 research shows that if the $L_{\text{night-outside}}$ is 30 dBA or lower, the environment can be considered as safe and healthful for sleep. When the $L_{\text{night-outside}}$ is 40 dBA or higher, the data is sufficient to establish that adverse health effects will be experienced by the vulnerable groups. Mr. Hessler’s confusion over what these values represent is apparent when he draws his conclusion (above) that WHO’s 2009 document sets 40 dBA as the target one should try for. A level of 30 dBA is reasonable in light of the current nighttime background sound levels of less than 30 dBA (L_{A90}). A level of 40 dBA or higher would clearly put the public's health and well being at risk.

Mr. Hessler's contention that the criteria should be even higher than 40 dBA is based on his incorrect assumption that wind turbines do not produce significant low frequency sound, and thus will not be an indoor noise problem. Given the information showing that low frequency sounds are the dominant form of sound emitted by wind turbines (as stated in my direct testimony), it seems unusual that Mr. Hessler would reintroduce his opinion that the walls of a home would be effective in reducing the low frequency rumble that is experienced inside homes, especially evident at night when the bedroom is quiet.

The subject of low frequency noise is addressed on pages 9-12 of the Kamperman-James "How to… Guide," which is included in exhibit 809. Low frequency noise was also highlighted in the 1990 NASA study[4] by Hubbard and Shepherd (See: Noise Exposure Inside Buildings, page 35-39) to the effect that low frequency turbine sounds can resonate inside a home leading to even higher levels of low frequency sound inside the home than outside. Mr. Hessler's focus on only dBA values, which do not include the low frequency sounds, discredits Mr. Hessler's contrary argument.

[4] Hubbard, H. H., Shepherd, K. P. "Wind Turbine Acoustics," NASA Technical Paper 3057 DOE/NASA/20320-77 (1990)

Mr. Hessler also comments on the need to limit low frequency sound to levels of 60 to 65 dBC is a valid upper limit. The criteria proposed in the Kamperman-James paper uses Mr. Hessler's paper on that topic as a source for its not-to-exceed limits. However, the reports of adverse health effects, especially those of the type described for Wind Turbine Syndrome also occur during the daytime when sleep disturbance is not an issue. Tests I have taken inside the homes of people reporting such effects found low frequency sound pressure levels exceeding 60 dB in the 6.3 Hz 1/3 Octave Band. The graph below illustrates this situation.



The slope of the spectrum increases as frequency decreases. Thus, the sound pressure levels in the infrasound region below 10 Hz may be higher yet. These measured levels are consistent with the sound emission spectrum of wind turbines. Although wind may play some role in raising the sound pressure level in the lower frequency, the wind turbines are by themselves significant contributors that should not be ignored by continued use of A-weighting to measure and display wind turbine sound data.

Adverse health effects are being reported that may be linked to vestibular and balance functions. Whether these are a result of the simple average sound pressure level or whether some other characteristic of the acoustic energy such as the dynamic modulation of the sound in these lower frequencies is responsible is not known. Following the precautionary principle, the K-J criteria proposed that in communities without significant man-made sources of low frequency sound to mask the ILFN sounds from the turbines that there also be limits to any increases in over-all ILFN. Thus, the recommendation for applying a second limitation for ILFN using the criteria of $L_{Ceq} = L_{C90}$ +5 for additional sound from wind turbines.

Q. Does this complete your response to the rebuttal testimony of George Hessler?

A. Yes.

Q. What is your response to the rebuttal testimony of Mark Roberts?

A. Dr. Roberts describes what he believes to be deficiencies in the work of Dr. Nina Pierpont. This position may be more understandable when one considers that epidemiological studies rely on exposed populations with adverse health effects. In this case the focus should be on preventing adverse health effects in the exposed population, not permitting it.

What is lost in Dr. Roberts's arguments is that Dr. Pierpont's work is the first step in bringing attention to the adverse health effects reported by people living near wind turbines. Today, there is no base of exposed population that would permit a study of the type Dr. Roberts would like to have conducted. Dr. Roberts claims an extensive knowledge of how such studies should be done in his field, but fails to acknowledge that studies of the type conducted by Dr. Pierpont are common and accepted in the medical community.

For example, the use of case studies and self-reported adverse health effects are the medical community's first line of defense against unexpected interactions between prescription drugs. There are reports in the news that this or that new drug has unanticipated side effects for a small portion of the people to whom it was prescribed. These are based on studies of the type conducted by Dr. Pierpont and others for wind turbine related health issues.

It is not clear which version of Dr. Pierpont's study Dr. Roberts reviewed. The study will not be available to the public in published form until November 6th, 2009, at the earliest. Since the second draft was released on the Internet in winter 2009, the study has changed significantly. Yet, no other complete copies have been made available. The references that I used in my direct testimony were taken from a small excerpt of the galley draft made available to a limited audience for the purpose of addressing Dr. Pierpont's concerns about papers published by others that claimed there were no adverse health effects. Dr. Pierpont's forthcoming study has been extensively and favorably peer-reviewed by some of the top experts in the fields of otolaryngology and otology.

Q. What is your response to the rebuttal testimony of Geoff Leventhall?

A. Dr. Leventhall states that "infrasound from wind turbines is of no consequence." Dr. Leventhall incorrectly lumps infrasound and low frequency noise together. They are two distinct noise categories. This is surprising since even Dr Leventhall's own earlier work is concerned with the mitigation of low frequency noise because it has been acknowledged to be disruptive to human activities.

Dr. Leventhall testifies that "any effect from wind turbine noise, or any other low level of noise, which might be produced within the body is 'lost' in the existing background noise and vibration." Human beings have adapted to disregard normal bodily noises. It is , therefore, seriously wrong of Dr. Leventhall to compare external, imposed, and unnatural fluctuating sounds with pressure levels of 40 -70 decibels to physiologic noises within the body.

Dr. Leventhall testifies that "higher frequency noise from wind turbines, if it is audible, can cause disturbance to some residents, but this effect is no different from that of noise from another source." On the contrary, wind turbine noise, by virtue of its constant presence (over hours or days), dynamic modulation of ILFN and audible frequencies, and frequent nocturnal exacerbation, is unlike other sources of community and industrial noise. Moreover, other sources of industrial noise are regulated in manners suitable to their nature. Given the demonstrated increased annoyance of turbine noise, and contribution of nighttime annoyance to sleep disturbance, regulations must be specially formulated to address their unique qualities and potentials for annoyance.

Q. Do you have any comments on Dr. Leventhall's discussion of the work of Dr. Inger and Dr. Mulvihill?

A. Yes. Dr. Leventhal correctly notes that Dr. Ingber’s research does not establish a link between ILFN and cellular response. The conclusion that research into mechanotransduction response supports a link to ILFN was drawn by Dr. Mulvihill based on her prior experience and on the research reported in peer-reviewed studies. Dr. Leventhall dismisses these studies as not meeting his standards or his understanding of this hypothesis for the causal link between ILFN and adverse health effects.

Dr. Leventhall contacted Dr. Ingber about Dr. Mulvihill’s linkage reported in the direct testimony and Dr. Ingber responded that his work was neutral on this topic. Dr. Mulvihill contacted Dr. Ingber in response to Dr. Leventhall’s rebuttal. The following is Dr. Ingber's email response to Dr. Mulvihill (provided to me by Dr. Mulvihill):

From: **Ingber, Donald** <Donald.Ingber@childrens.harvard.edu>

Date: Fri, Oct 23, 2009 at 9:54 AM

Subject: Re: Wind turbine controversy

To: Eileen Mulvihill <mulvier@gmail.com>

E/ Prof. Leventhall did not indicate that he would be using this for formal testimony, but I also was not aware you or others were referring to my work without first inquiring about the details.

In any case, that quote of mine is accurate, HOWEVER, I also wrote him:

"You can quote me as long as you do not make me seem to say there is no way that low frequency vibration can influence cells directly, because there probably is an effect; I just can't tell whether that effect is negative, positive or null physiologically without controlled experiments."

Feel free to use this quote, AS LONG AS you emphasize the need for controlled experiments to explore potential health dangers.

Best,

Don

It is clear that Dr. Ingber remains open to the possibility of the causal link in spite of Dr. Leventhall's assertion that no such link exists.

Q. Do you have any comments regarding Dr. Leventhall's discussion of VAD ?

A. Yes. There are others who support Dr. Mulvihill's conclusion about cellular level processes accounting for some of the reported adverse health effects. Dr. Leventhall not only dismisses the work of Dr. Pierpont, he also dismisses the work of the VAD Team headed by Dr. Nuno Branco, which has been investigating the linkage between ILFN and pathology for over 28 years in Portugal. The VAD Team's research has been published in peer-reviewed journals and also presented at conferences, yet Dr. Leventhall dismisses their conclusions regarding this causal hypothesis. While it may be true that many of their studies involved higher levels of ILFN than may be routinely present in homes near operating wind utilities, there is also research that shows effects at levels more typical of wind turbine noise.

There are also recent studies showing adverse health effects associated with living near airports and highways that may be an early indication that community standards which have focused on A-weighted sound levels may have failed to protect the public from adverse health effects of low frequency sound.

Q. Do you have any comments on Dr. Leventhall's discussion of mechanotransduction?

A. Yes. Dr. Leventhall pays great attention to rebutting any link between research on the mechanotransduction process and the adverse health effects reported for exposure to ILFN, claiming that sound pressure levels are not high enough to cause any such effects from wind turbines. Yet, in the VAD team's paper entitled: "*Vibro-acoustic disease: Biological effects of infrasound and low-frequency noise explained by Mechanotransduction cellular signaling,*" --reproduced in exhibit 810, filed with my testimony--it is just this link that is presented as the explanation for these health effects. It is clear that the sound pressure levels reported in this paper are not significantly different in the lowest frequency bands than the sound pressure levels inside homes during the operation of wind turbines documented by me.

Dr. Leventhall's fallback argument seems to be that, in his opinion, sound pressure levels of low frequency sound in people's yards and homes do not exceed the threshold of perception levels for the median population. He then asserts there can be no adverse health effect without audibility. Yet the adverse health effects, other than sleep disturbance, are being reported by a small sub-set of the people living near wind turbines. Not all people living near wind turbines are claiming any adverse health effects. The adverse health effects matching the symptoms of Wind Turbine Syndrome being reported do not affect large percentages of people living near wind turbines. The fact that it is a small portion of the exposed population that report adverse health effects may be supporting evidence that it is some more vulnerable subset of people who are responding to the wind turbine acoustic energy.

If we use the threshold of perception for the most sensitive people then the median threshold drops by approximately 12 dB. In Dr.

Leventhall's article in Noise and Health (part of exhibit 809) he discusses this issue and states that for the most sensitive people the threshold may be even lower than 12 dB. This is not far from the sound pressure levels that are being reported inside homes. It should also be remembered that the 1990 NASA study reported that in-home resonance can increase the amplitude of the lower frequency acoustic emissions above the levels found outside the home.

Q. Do you have anything else to add regarding exhibit 810.

A. Yes. A careful reading of the section of the VAD team's paper, in section "*2.2 What you can't hear, won't hurt you,*" supports my precautionary approach to the reports of adverse health effects, not the outright dismissal that is offered by Dr. Leventhall.

Q. Do you have any further comments on Dr. Leventhall's rebuttal testimony?

A. Yes. Dr. Leventhal finds flaws in my direct testimony regarding other research papers. His testimony demonstrates more about the frame of reference in which he positions his beliefs and opinions than it does about errors in using those references. It is true that reasonable people can differ in their interpretation of such research. There are many independent experts in acoustics, medicine, and other professions who support the positions taken in my direct testimony. It is the responsibility of all professionals to use their skills to protect the public health and welfare.

Some may disagree and say that we should proceed with allowing wind turbines to be located close to homes as do those who recommend distances of 1000 to 2000 feet. In my opinion, there should be at least a mile and ¼ between turbines and homes. I say this not to restrict wind energy as a source of renewable energy, but instead as a temporary condition until the questions of adverse health effects can be addressed in independent research that can be used as a future guide to either continue the large setbacks or to set new setbacks that are founded on knowledge and not speculation.

Q. Does this complete your testimony?

A. Yes.

SCHOMER AND ASSOCIATES, INC.

BACKGROUND SOUND MEASUREMENTS AND ANALYSIS IN THE VICINITY OF CAPE VINCENT, NEW YORK

May 11, 2009

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Table of Contents

List of Figures

Annex A

BACKGROUND SOUND MEASUREMENTS AND ANALYSIS IN THE VICINITY OF CAPE VINCENT, NEW YORK

Executive Summary

The acoustic consulting engineering firm Hessler Associates, Inc., Haymarket, Virginia produced two sound level assessment reports for two wind projects proposed for Cape Vincent, New York: the first report in 2007 for BP and the second report in 2009 for AES-Acciona. Because there were concerns early on among local citizens that the BP report was misleading, the Wind Power Ethics Group (WPEG) contracted with Schomer and Associates, Champaign, Illinois to conduct an independent background sound survey of Cape Vincent. Hessler's BP study for the Cape Vincent Wind Power Facility appears to have selected the noisiest sites, the noisiest time of year, and the noisiest positions at each measurement site. Collectively, these choices resulted in a substantial overestimate of the a-weighted ambient sound level, 45-50 dB according to Hessler.

This study was designed to address a number of flaws noted in Hessler's BP study. First, a summer survey was planned so it would not coincide with the emergence of vocal adult insects (e.g., fall crickets and cicadas on August 1). Two monitoring sites were selected within the Town of Cape Vincent. One site was a rural residence and the other a small dairy farm. At each of these sites, two sound level meters and a single small weather station were run for one week of continuous data collection. At each site one meter was set up close to the house or farm building and a road. This site was called the "Hessler" position, because it was typical of sites selected by Hessler for his studies in Cape Vincent. The other position was called the Community position and it was located back away from the noise influences of roads, houses and farm operations. The Community position also reflected guidelines adopted by the Cape Vincent Planning Board whereby sound levels were to be measured at the property lines, not residences.

The analysis of the spectral (frequency) content of the sound showed that much of the difference in sound levels between Hessler's study and this study was attributable to insect noise, sounds near 5000 Hz. Hessler failed to remove insect sound from his data and recalculate A-weighted sound levels, even though he previously (2006) recommended this procedure to other scientists and engineers in a professional journal publication. Had he

followed his own advice, ambient sound levels would have been more comparable to the results in this study.

Furthermore, and more importantly, wind turbine sound spectra are low frequency and mid-frequency phenomena; therefore, higher frequency insect noise will not mask wind turbine sounds. So even if insect noise was present year round instead of for a few weeks it should still not be included in the ambient because it provides little or no masking of the wind turbine sound.

Other examples of Hessler's misleading choices include arbitrarily discarding sound data from one of his sites because the levels were too low. Remarkably, the levels at that site were more comparable to this study. Also, Hessler described position 3 in the BP study as "representative of a typical residence along NYS Rte 12E." However, he failed to show that the trailer in the photograph was a field office for a construction company installing a new Town of Cape Vincent water district. Furthermore, at the back of the trailer, out of view, was a marshalling yard for trucks, supplies and heavy equipment. The choice of this site and suggesting it is a typical residence was very misleading.

The accurate measurement of spectrally-relevant ambient sound is important because these levels are used by wind developers to assess wind turbine noise impacts on nearby, non-participating residents. Local Cape Vincent Planning Board guidelines suggest these impacts should not exceed 5 dB above the A-weighted ambient at the property lines of non-participating residents. New York State noise assessment policy states any new sound that exceed 6 dB above the A-weighted ambient should undergo a detailed assessment and the developer is required to mitigate any excessive noise. Therefore, using an inaccurate, elevated A-weighted ambient level, such as 47 dB, allows wind developers to place wind turbines much closer to non-participating residents in such a way that the A-weighted wind turbine noise level will be 52 dB (e.g., 5 dB above Hessler's elevated ambient level). A much more accurate and typical ambient level is 30 dB, which is an average of both "Hessler" and Community positions during daytime, evening and nighttime periods from this study. Using 30 dB as a typical A-weighted ambient level would then require wind developers to plan a wind farm where predicted noise at non-participating property lines would not exceed 35 dB, or 5 dB above this study's A-weighted ambient level. In summary, to adequately protect rural residents that are not participants in proposed wind farms it is essential to have accurate, unbiased assessments of ambient sounds.

In conclusion:

1. The Hessler position at a measurement site systematically and significantly yields higher sound levels than does the Community position.
2. The sound levels measured in this study show Cape Vincent to be a quiet rural area, much as depicted by the data for Hessler's position 4.
3. Measurements, such as those conducted at Hessler's position 3, are not indicative of the noise environment of typical residences in the Cape Vincent area.
4. Failure to remove insect noise in Hessler's study violated his own recommended survey and analytical techniques and substantially misrepresented typical ambient sound levels.
5. In assessing potential noise impacts from wind turbine development, rather than using 45-50 dB A-weighted levels as suggested by Hessler, a more accurate level would be 30 dB, which is the average value for the daytime, evening and nighttime L90 sound levels observed at both the "Hessler" and Community positions for sites A and B in this study. Arguably, the level should be down at 20 to 25 dB, since an A-weighted L90 of 20 dB occurs during the quietest nighttime hours, and the A-weighted L90 for the whole 9-hour night is 25 dB.

I. Introduction

A wind farm has been proposed by BP Alternative Energy N. A., Inc. to be established in the Cape Vincent area. Hessler Associates, Inc. has produced an assessment of current Cape Vincent ambient sound levels in their report dated November 27, 2007 entitled: Environmental Sound Level Survey- Summertime Conditions.[1] This survey appears to have selected from among the noisiest sites, the noisiest time of year, and the noisiest positions at each measurement site.

a. **Hessler chooses noisy positions at the sites**. For example, figure 1 (top) is taken from the Hessler report and is of his site 2. This picture portrays a quiet, pastoral site. Figure 1 bottom shows that this position actually is right in the middle of noisy farm machinery and two sheds, and not as near to the house where people reside.

b. **Hessler chooses noisy sites.** For example, Hessler describes his site 3 by: "The objective of this position [site] was to measure sound levels representative of those experienced at the homes along Route 12E, such as the farm house in the background of Figure 2.2.5." The Hessler figures for his site 3 depict a rather serene, treed, rural site. Hessler neglects to tell the reader that this site is the marshalling yard for heavy construction equipment for a large water project and less than 100 ft from part of the construction site. Figure 2 shows one of Hessler's site photos and a picture of the marshalling yard. Imagine it filled with large, running, diesel powered construction equipment. This, according to Hessler is "representative of…homes along Route 12E." This is simply false.

c. **Hessler chooses the noisiest time of year.** Hessler measures in late August and early September, when insect noise reaches its maximum. This insect noise dominates the Hessler results. Hessler states: "Figure 2.6.2 clearly shows that insect noise peaking at 5000 Hz strongly affected the overall sound levels when they were at a maximum and, significantly, also when they were at a minimum." He goes on to state: "In general, the continual dominance of insect noise, which is clearly unrelated to wind or atmospheric conditions, explains why the site sound levels—during the summer at least—do not exhibit any real dependence on wind speed." Finally, at the end of his conclusions Hessler states: "An additional field survey is

[1] A second report by Hessler for a second wind farm to be built and run by AES Acciona's was just made available in March 2009. It is very similar to the first report in scope and approach, and it suffers from the same deficiencies.

> planned for this winter to measure project area sound levels without any leaves on the trees and without any of this insect activity. A subsequent noise impact assessment will be prepared based on the results of both the summer and winter background surveys."

But the winter measurements never occurred. Only the insect noise dominated data are used. And the underlying allegation to all of the Hessler analysis is that the background, if loud enough, will mask the wind turbine noise. However, as is well known, masking primarily takes place in one-third-octave bands. The high-frequency (e.g., 5000 Hz) insect noise masks little of the wind-turbine noise. The presence of insect noise does nothing to mitigate the wind turbine noise; the measurement of insect noise only masks and obviscates the truth.

The purpose of this study is to document the difference in background sound between the time of year, type of site, and the position within a site chosen by Hessler, and those more indicative of the quiet, rural nature of the Cape Vincent area.

Schomer and Associates, Inc. was retained by the Wind Power Ethics Group (WPEG) to conduct an independent study including development of the test plan, selection of measurement sites, setting up of the instrumentation, setting up the data collection procedures, examining the data for quality control, analyzing the data, and reporting on the results. I visited the Cape Vincent area on June 8-11, 2008 to perform all the on-site aspects of this study listed above. Data quality control, analysis, and reporting were conducted at the Schomer and Associates offices in Champaign, IL.

Figure 2.2.3 *Position 2 Looking West towards Church of St. Vincent de Paul*

Figure 1. Top: “Quiet” Hessler view of his site 2. Bottom: View from opposite direction showing monitor area was actually nearby to farm machinery and sheds, and not very near to the house.

Figure 2. Left - Hessler’s monitoring site #3 from the BP sound report with trailer on the left side of the image. Right – backside of trailer showing construction field office and marshalling yard.

II. Measurements

1. Site Selection and Layout

Two sites were selected in the Cape Vincent area based on their similarity to residential sites selected by Hessler for his study, the willingness of the owner to grant permission for this study, and the security of the equipment used for measurement. These two sites are within the project boundaries of BP's proposed Cape Vincent wind power facilities. One of the sites (site A) is a typical rural residence, and the other site (site B) is a working dairy farm. Two precision sound level meters were deployed for a week at site A, and subsequently for a week at site B. At each site, two positions were selected: the Hessler position which was near the road, and the Community position substantially farther from the road and more indicative of the area. The community positions were designed to provide data more compatible with the guideline adopted by the Cape Vincent Planning Board (e.g., noise measured at the property line). Figure 3 shows a map of the Cape Vincent area indicating the locations of site A and site B. Figures 4 and 5 show the general layouts of site A and site B, respectively. Figures 6 through 10 are photographs taken at site A, and figures 11 through 14 are photographs taken at site B.

2. Instrumentation

Measurements were conducted using two RION Model NA-28 precision integrating sound level meters (SLM) that meet the ANSI requirements for a Type 1 SLM and also meet the requirements of the recently-revised International Electrotechnical Commission (IEC) Standard (IEC 61672-1) for a Class 1 SLM. The SLMs were calibrated with a Norsonic Model 1251 calibrator that meets the Class 1 requirements of ANSI S1.40 for calibrators. Weather conditions were measured using a HOBO weather station that included sensors for wind speed, wind direction, temperature, and humidity. The HOBO weather station was always situated near the Community position. To further reduce the effects of low-frequency wind noise at the Community position, a special RION 8-inch windscreen was employed (see Figure 6). An ordinary 4-inch windscreen was used at the Hessler position.

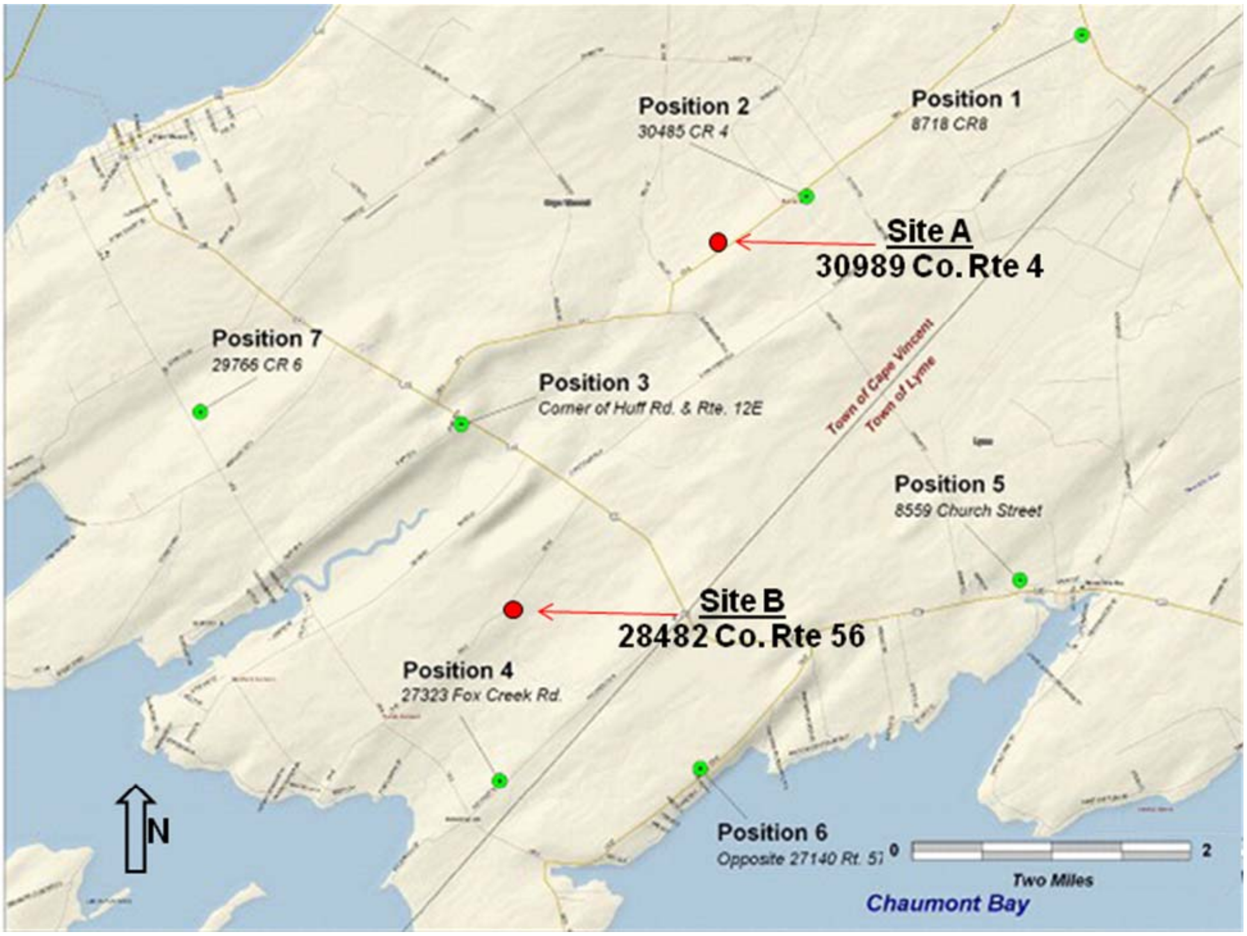

Figure 3. Map of the Cape Vincent area

Figure 4. Site A general layout

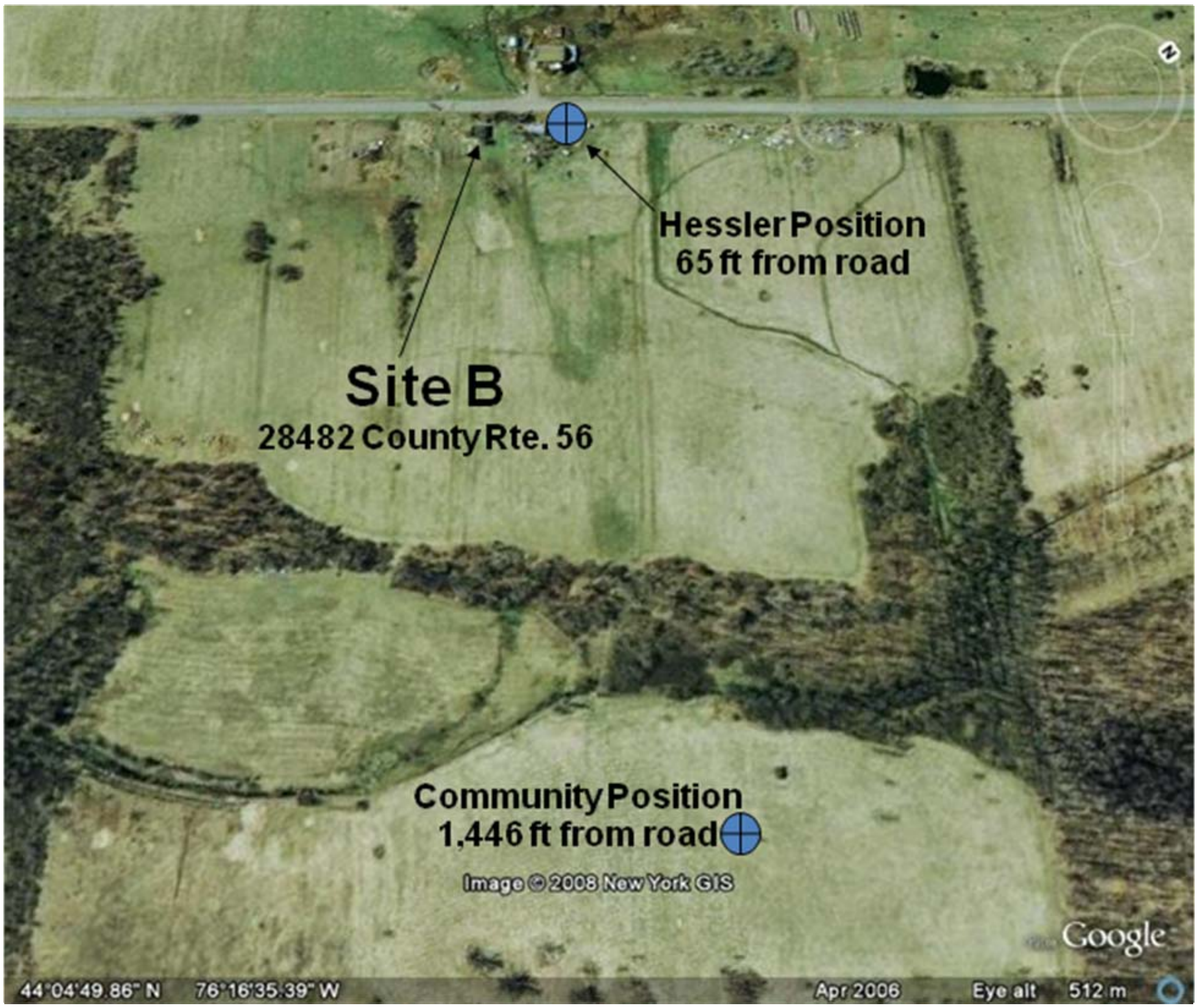

Figure 5. Site B general layout

Figure 6. Site A Community position - view looking west

Figure 7. Site A Community position - view looking east

Figure 8. Site A Hessler position - view looking north

Figure 9. View looking east

Figure 10. Site A Hessler position - view looking west

1. Operation

During the first week (June 10 – June 17, 2008), the two SLM's and the weather station were set up at site A. The SLMs were calibrated and all instruments were placed in operation. Data were collected daily from each instrument and batteries were replaced as required. Calibration was performed during the same servicing period. During the second week (June 17 – June 24, 2008), the same instrumentation was setup at site B. For two days after the second week (June 24 – June 26, 2008), both SLMs and the weather station were all co-located at the Community position of site B.

The RION SLMs were set to sequentially record one-third-octave-band, 1-second LEQ levels. The weather station was set to record data every 3 seconds, the shortest time interval available. Data were collected for the entire 24 hour day, except for the brief time required to collect data, calibrate, and replace batteries as required (typically 30 minutes).

Figure 11. Site B Community position - view looking south

Figure 12. Site B Community position - view looking north

Figure 13. Site B Hessler position - view looking east

Figure 14. Site B Hessler position - view looking west

The RION SLM has several built-in frequency weightings, including A, C, and the new Z-weighting.[2] The initial plan was to C-weight both RION SLMs because the C-weighting eliminates some of the low frequency wind noise. Inadvertently, one of the meters was set to Z-weighting for the first few days. For the last 2 days of the regular study, one unit was purposefully set to Z-weighting and both units were set to Z-weighting for the special 2-day wind study (that is the subject of a separate paper). Table 1 lists the weighting employed by monitor day and position.

Table 1. Weightings employed by the SLM's during the study

Date	Community Pos.	Hessler pos.
11-Jun	C	Z
12-Jun	C	Z
13-Jun	C	Z
14-Jun	C	C
15-Jun	C	C
16-Jun	C	C
17-Jun	C	C
18-Jun	C	C
19-Jun	C	C
20-Jun	C	C
21-Jun	C	C
22-Jun	C	C
23-Jun	Z	C
24-Jun	Z	C
25-Jun	Z	Z
26-Jun	Z	Z

[2] Z-weighting is defined in the new IEC SLM standard, IEC 61672-1. It gives a precise frequency weighting that takes the place of the undefined, so called "flat-weighting" or "un-weighted".

III. Data Analysis

As indicated above, this study had as its main purpose: comparing the sound levels measured by Hessler with the sound measured at sites and in positions that are more indicative of the Cape Vincent area. Hessler focuses on the L90 levels, and we concur with this focus. Since Hessler presents both LEQ and L90 data, we do also; but the focus is on the L90 data. For added information, Annex A contains figures analogous to the L90 data presented in the text but for the L50 metric.

Data collected from the SLMs were analyzed in 10 minute and 1 hour blocks of time. In both cases calculations were based on the original 1 second data. Calculations were performed to check that there were valid data from all three instruments (the two RION NA-28s and the HOBO weather station) for that second. Essentially the whole day had good data, except for the few minutes each day spent retrieving data, calibrating, and replacing batteries as required. Data collection took about 30 minutes so typically about three 10- minute blocks of data were lost each day. On very rare occasions a one hour block of data was lost. For each 10- minute or 1- hour block of data, 3 metrics were calculated: (1) LEQ, (2) L50 exceedance, (3) L90 exceedance. LEQ was calculated separately for the overall flat-weighted levels, the A-weighted levels, and all of the one-third-octave-band levels from 12.5 Hz to 20 kHz. The L50 and L90 exceedance levels were calculated solely on the basis of the 1-second A-weighted levels. The flat-weighted levels and the one-third-octave-band levels reported herein for L50 and L90 are those that occur in the second of time that contains the A-weighted L50 or L90, respectively. No separate calculations were performed to determine any L50 or L90 directly from the data except for the A-weighted data. Annex B, available only in soft form as an Excel file, contains the 10-minute LEQ, L90, and L50 data in separate tabs by day (from collection period to collection period). In each tab, LEQ is displayed first, while L90 and L50 are located to the right of LEQ, in that order). Hessler position and Community position data are located on the same tabs with Community position data at the top of the data sheet, and Hessler position data below. Annex C, also only available in soft form as an Excel file, contains the 1-hour LEQ, L90, and L50 data organized in the same way as Annex B.

The calculated 1 hour blocks of A- weighted LEQ's and L90's were plotted versus time for each week separately. Each of these four plots (Figure 15 through 18) compares the Hessler position with the Community position by site and by metric (LEQ or L90). Each of these four plots was converted into a “24-hour day plot” (Figure 19 through Figure 22) by averaging the data for the seven days of each week separately. In this averaging process, the L90 (and L50 of Annex A) averages were arithmetic, but the LEQ average was on an energy basis. In a similar fashion, the “24-hour day plot” data were converted into L_{day} (7 AM- 7 PM), $L_{evening}$ (7PM- 10 PM), and L_{night} (10 PM- 7 AM) data. These *day*, *evening,* and *night* levels are shown in Figures 23 through 26. As before, the L90 (and L50 of Annex A) data were averaged arithmetic plots, and the LEQ data were averaged on an energy basis.

Annex D, available only in soft form as an Excel file, contains the 1-hour A-weighted data portrayed in Figures 15 through 18 and Figures A1 and A2. The data are divided by date and by week (by site) into 14 tables. Annex E contains the “24-hour day plot” data portrayed in Figures 19 through 22 and Figures A3 and A4. The data are divided by week (by site) into 2 tables.

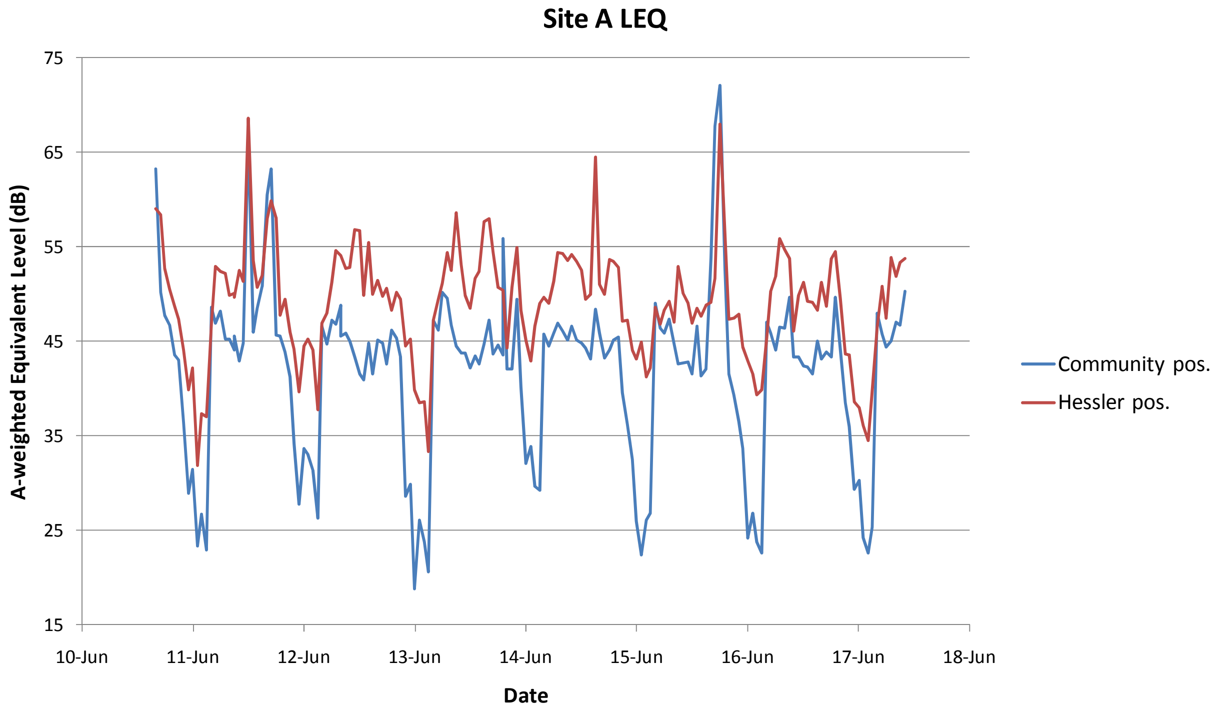

Figure 15. A-weighted LEQ for the week of site

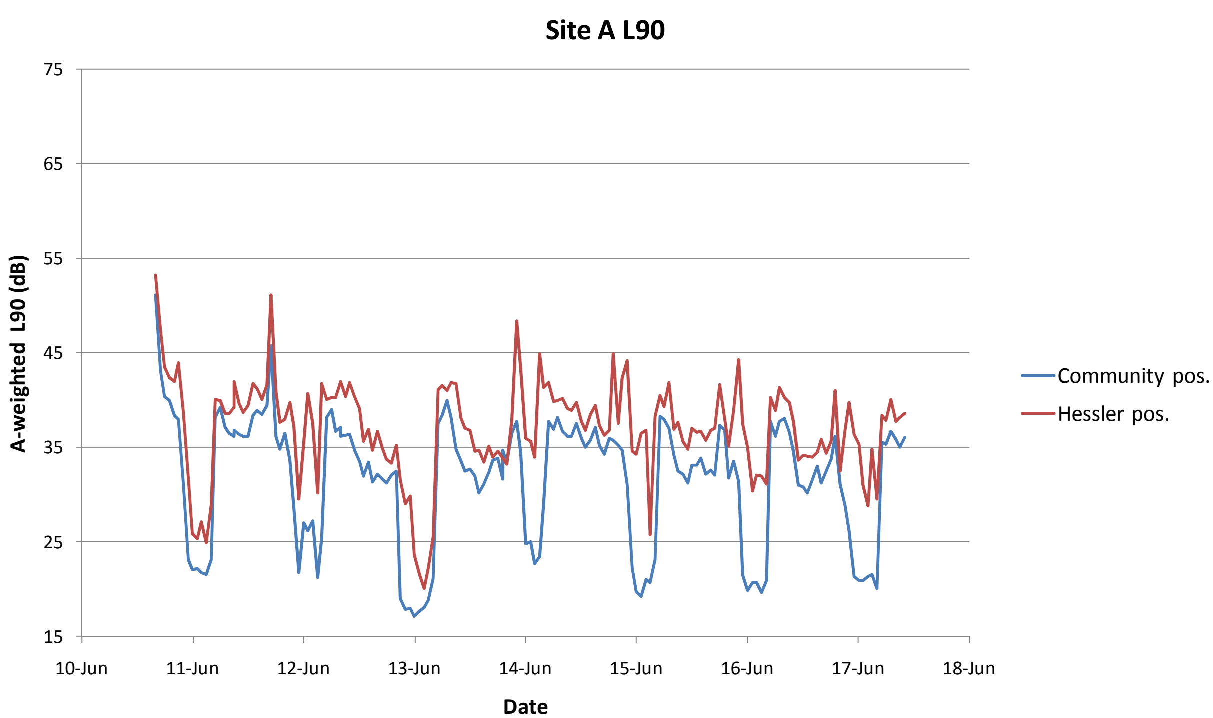

Figure 16. A-weighted L90 for week of site A

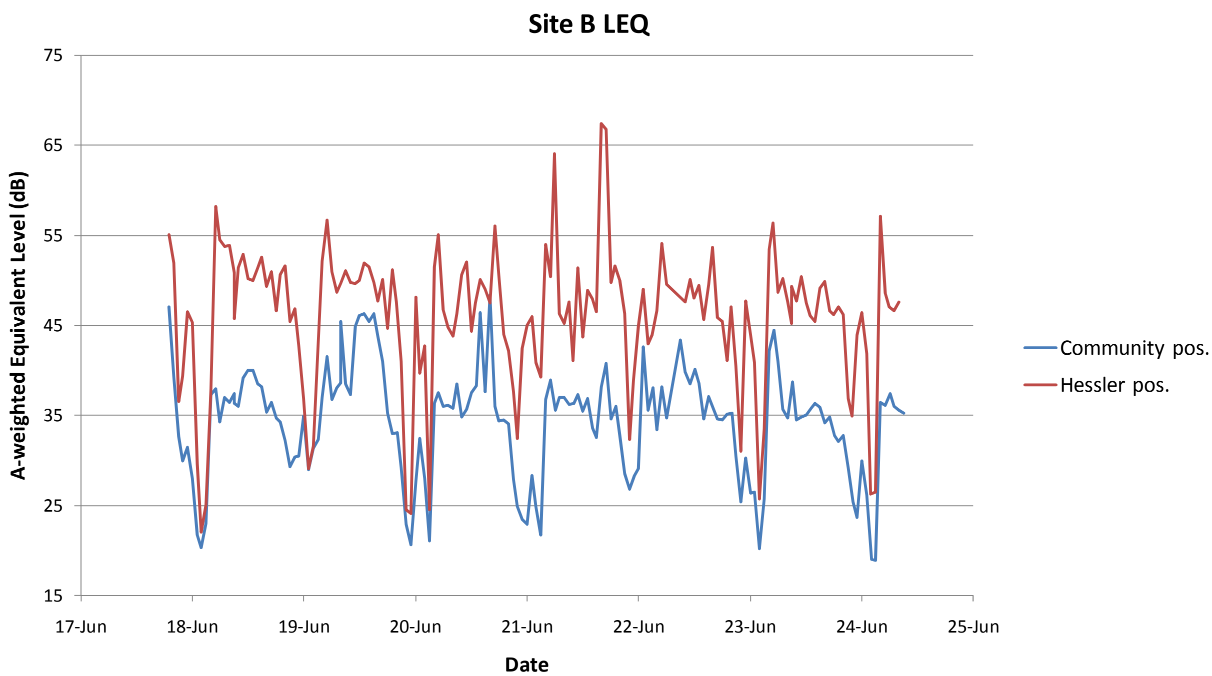

Figure 17. A-weighted LEQ for week of site B

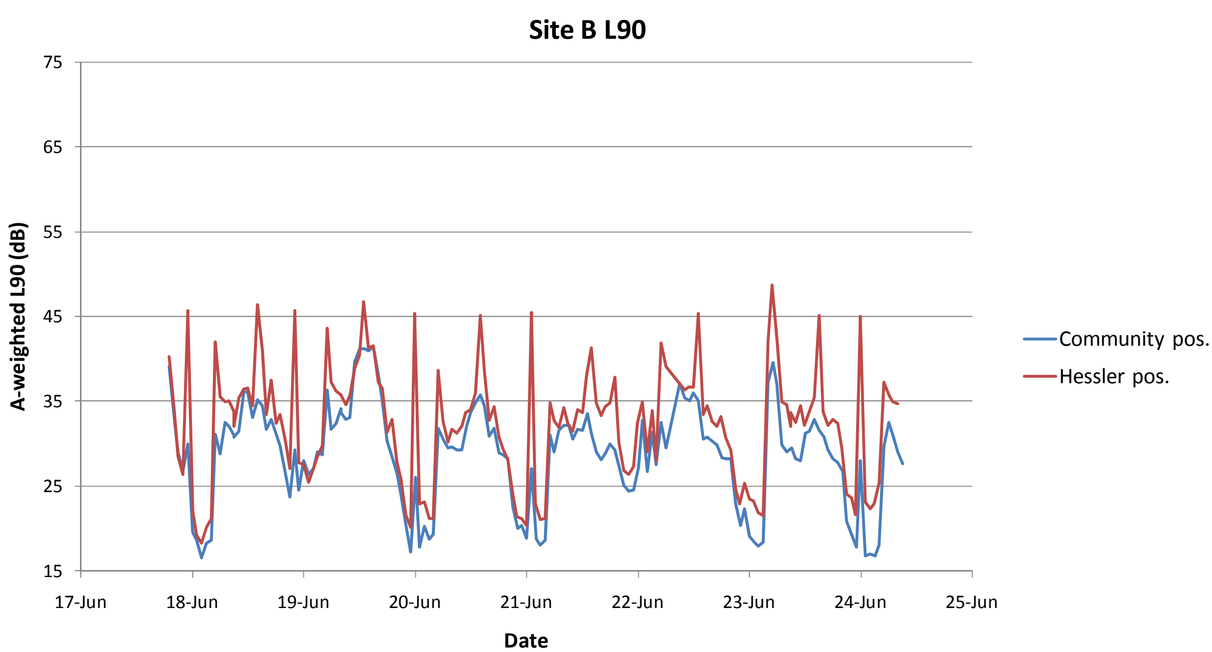

Figure 18. A-weighted L90 for week of site B

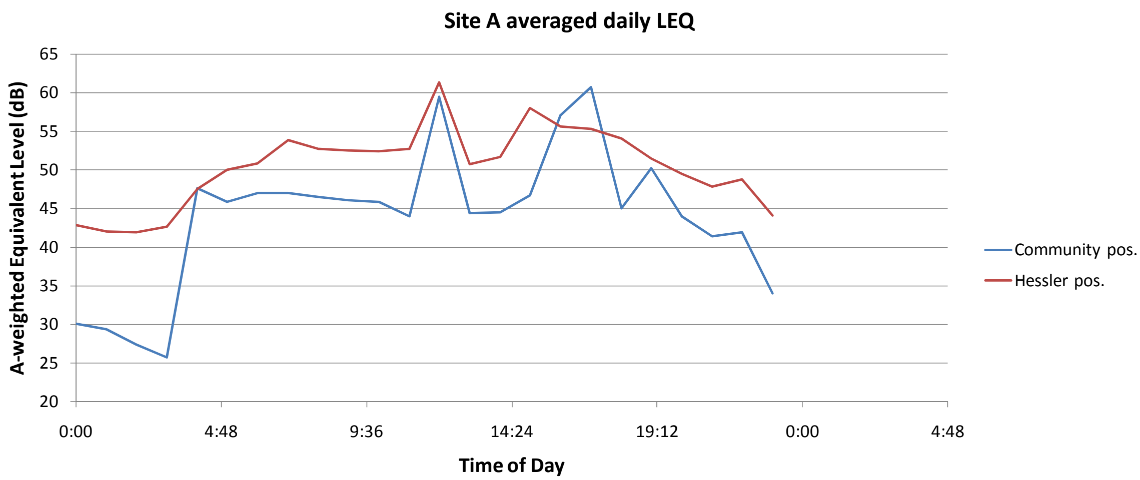

Figure 19. Averaged 24-hour A-weighted LEQ at site A

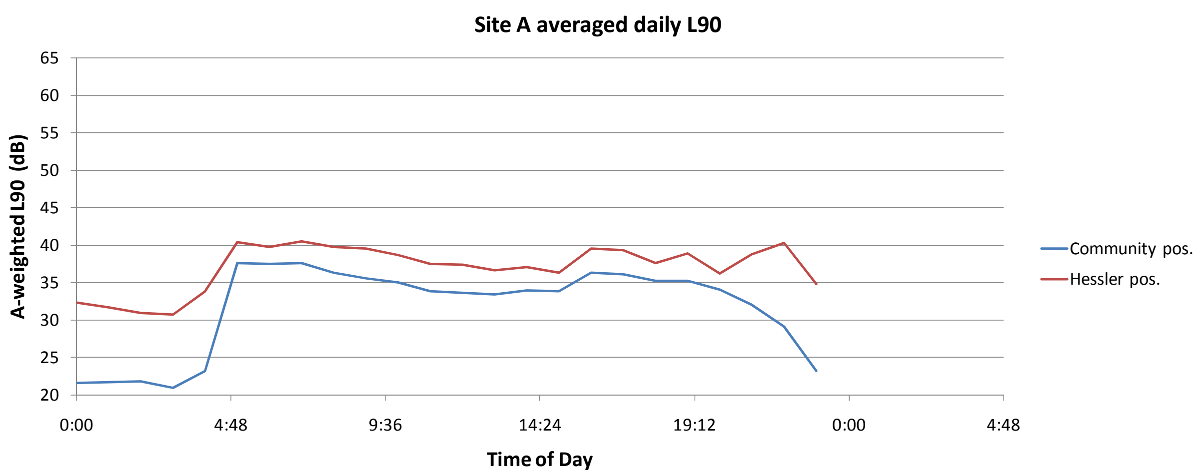

Figure 20. Averaged 24-hour A-weighted L90 at site A

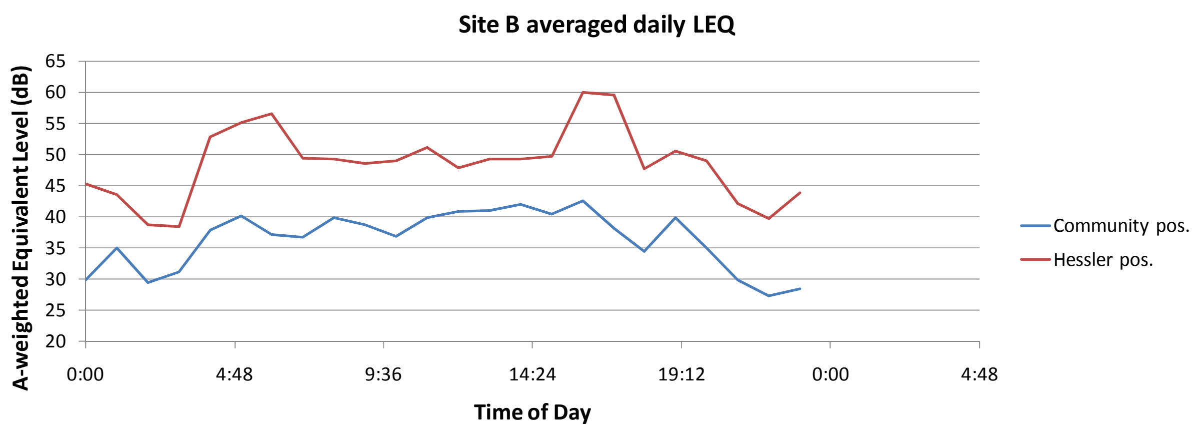

Figure 21. Averaged 24-hour A-weighted LEQ at site B

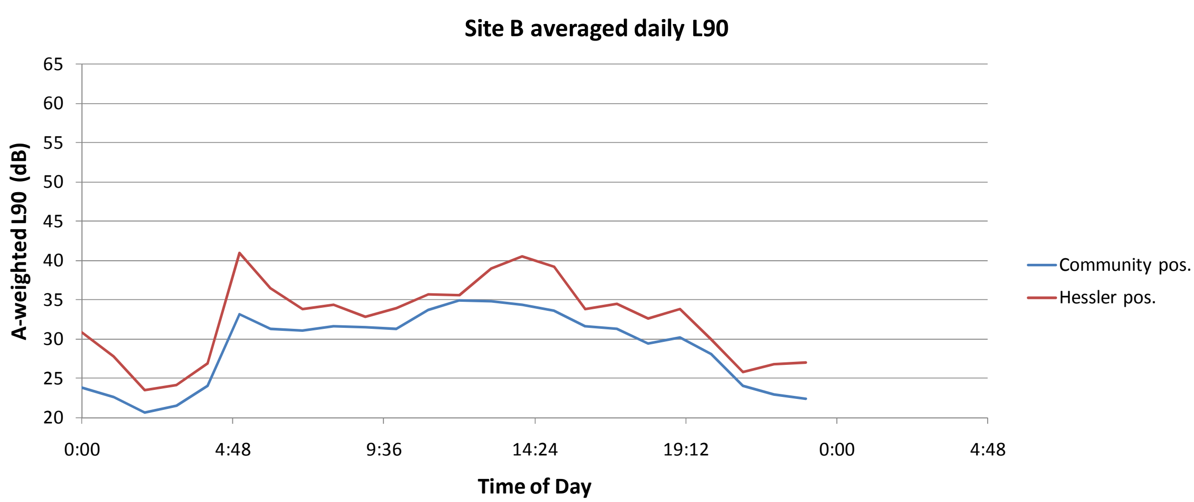

Figure 22. Averaged 24-hour A-weighted L90 at site B

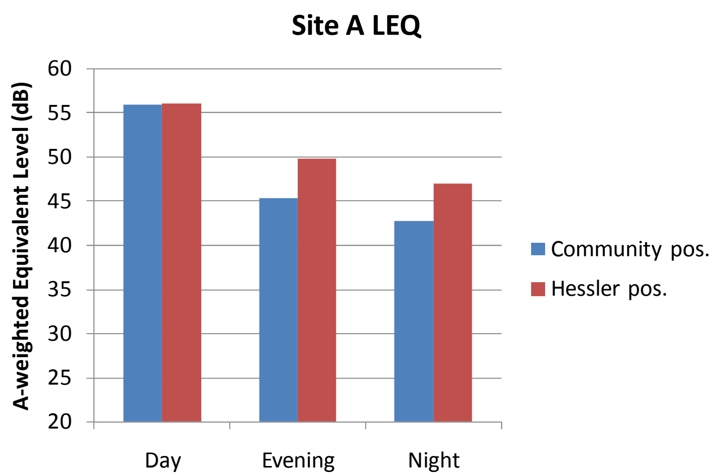

Figure 23. Site A comparison of A-weighted LEQ of day, evening, and night times

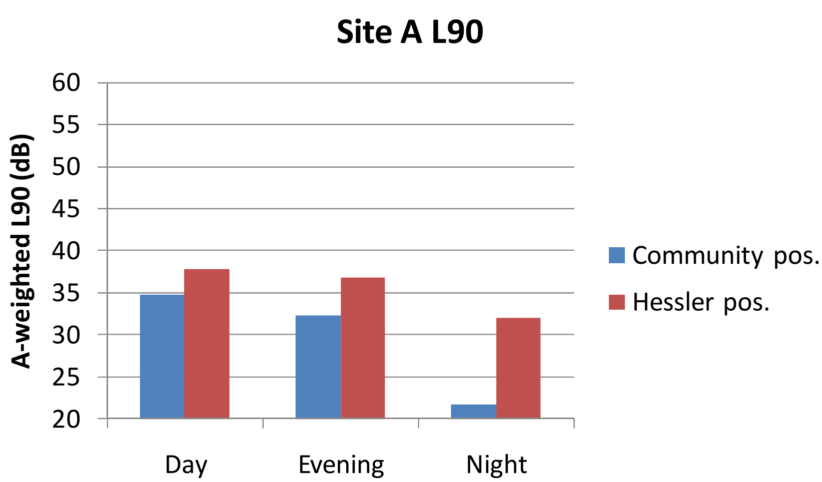

Figure 24. Site A comparison of A-weighted L90 of day, evening, and night times

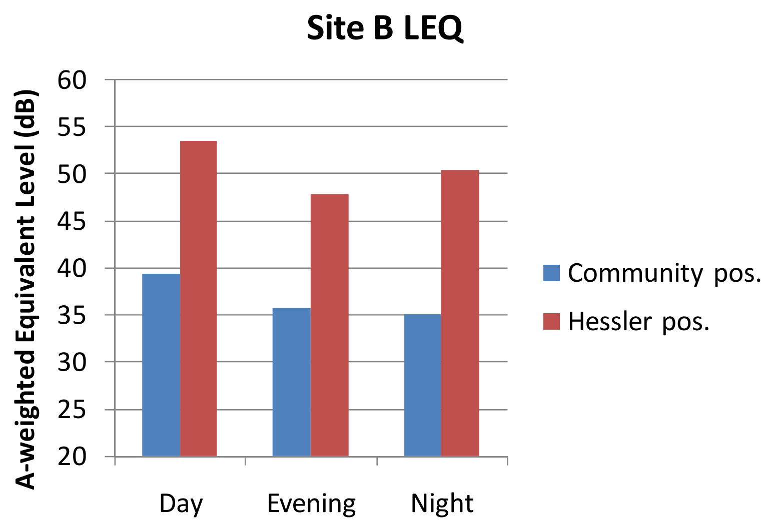

Figure 25. Site B comparison of A-weighted LEQ of day, evening, and night times

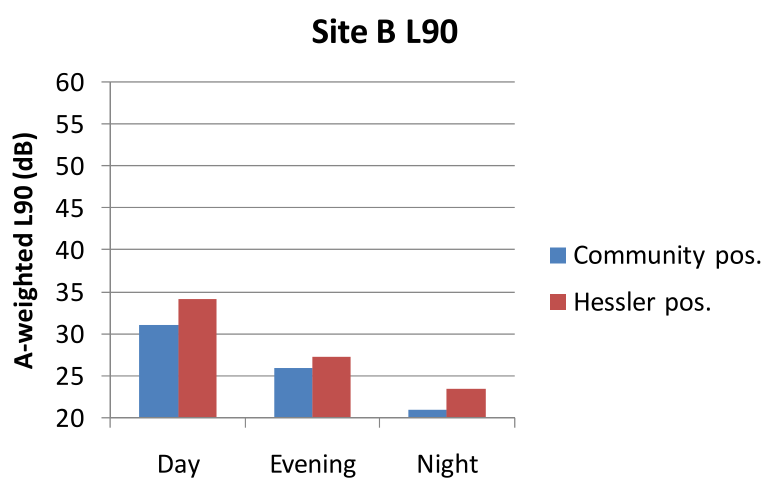

Figure 26. Site B comparison of A-weighted L90 of day, evening, and night times

Table 2 contains the time period data (*day, evening, night*) portrayed in Figures 23 through 26 and Figures A5 and A6. Table 2 contains 36 entries (3 time periods by 3 metrics by 2 positions by 2 sites). Figures 27 through 38 and Figures A7 through A12 contain the spectral data that correspond to the 36 entries in Table 2. Each of these 18 figures (3 time periods by 3 metrics by 2 sites) compares the Hessler position with the Community position[3]. The data for these 18 figures are contained in the 6 tables that comprise Annex F, which is also only available in soft form as an Excel file. The six tables are split out by the 3 time periods, and by the 2 sites, so each table contains 6 columns, LEQ for the Hessler and Community positions, L50 for the Hessler and Community positions, and L90 for the Hessler and Community positions. [4]

Table 2. Day, evening, and night sound values for site A and site B

		Day		Evening		Night	
		Community pos.	Hessler pos.	Community pos.	Hessler pos.	Community pos.	Hessler pos.
Site A	LEQ (dB)	55.9	56.0	45.3	49.7	42.7	47.0
	L50 (dB)	40.9	43.7	39.1	43.8	27.6	41.5
	L90 (dB)	34.8	37.8	32.3	36.9	21.7	32.1
Site B	LEQ (dB)	39.4	53.5	35.8	47.9	35.1	50.5
	L50 (dB)	35.7	43.0	31.1	36.1	27.0	32.8
	L90 (dB)	31.1	34.2	26.0	27.4	21.0	23.5

[3] Negative values were discarded for the bar graphs at high frequencies.
[4] Wind noise is a low frequency phenomenon such that Z-weighted wind noise data contains much more total sound energy than is contained in the energy sum of the one-third-octave-bands. In contrast, the C-weighted level is much closer to the energy sum of the one-third-octave-bands. Since they are so different, when assessing the wind noise phenomenon, it is not possible to meaningfully combine or compare C-weighted levels with Z-weighted levels. In order to complete the above analysis, the Z-weighted levels for the first 3 days of the Hessler position and the last 2 days of the Community position were replaced with the energy sum of the one-third-octave bands.

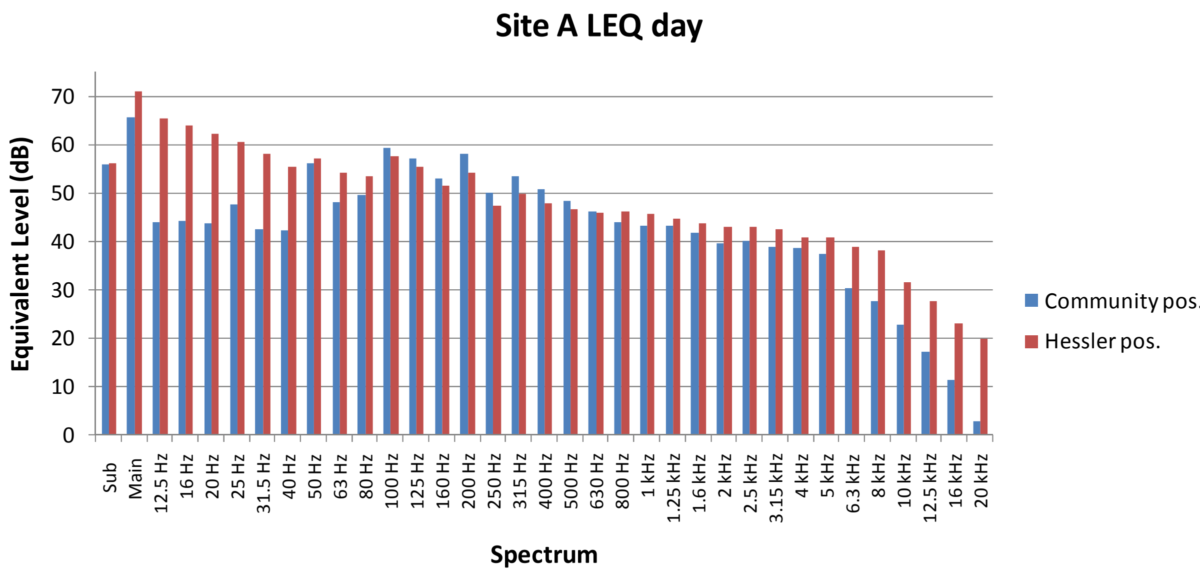

Figure 27. Site A averaged day-time LEQ spectrum

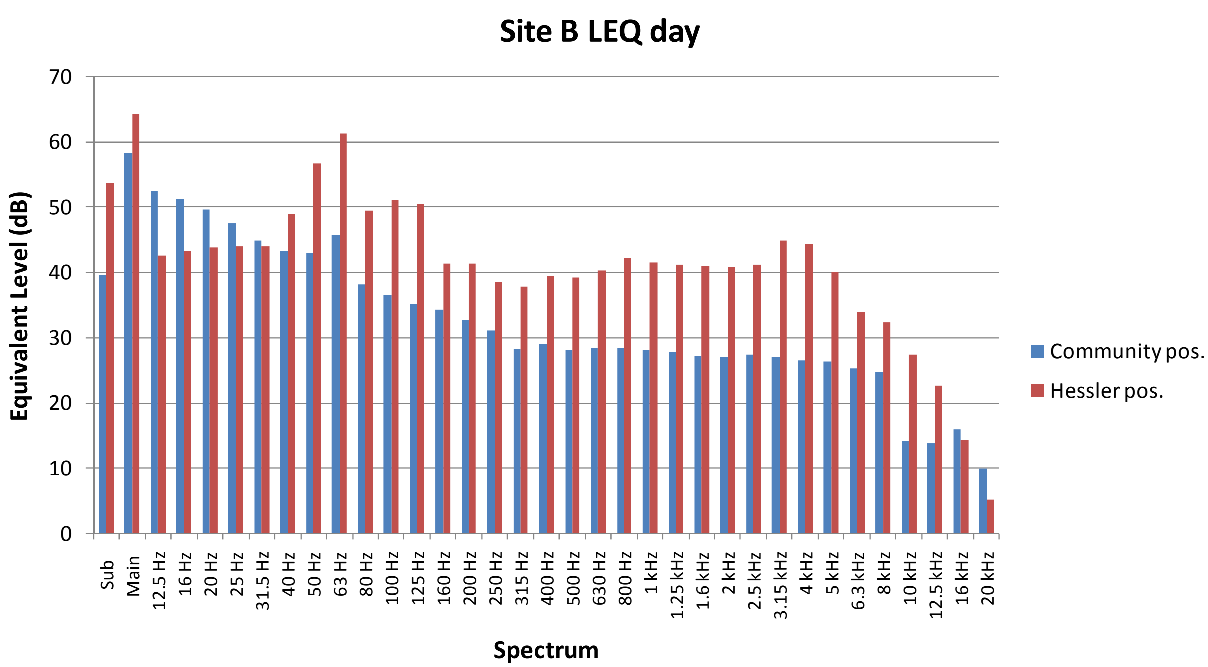

Figure 28. Site B averaged day-time LEQ spectrum

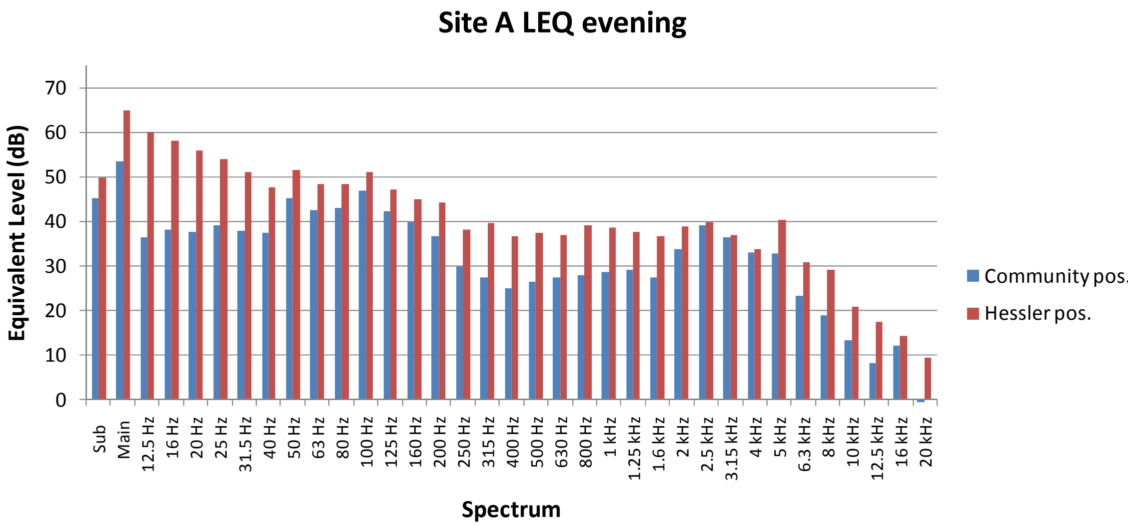

Figure 29. Site A averaged evening LEQ spectrum

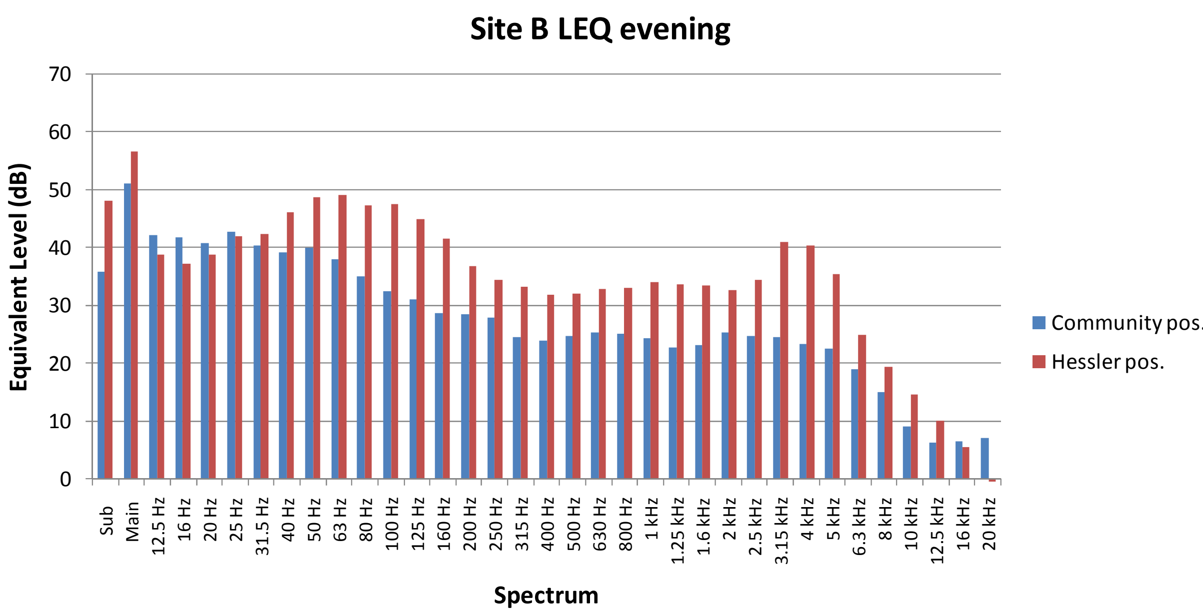

Figure 30. Site B averaged evening LEQ spectrum

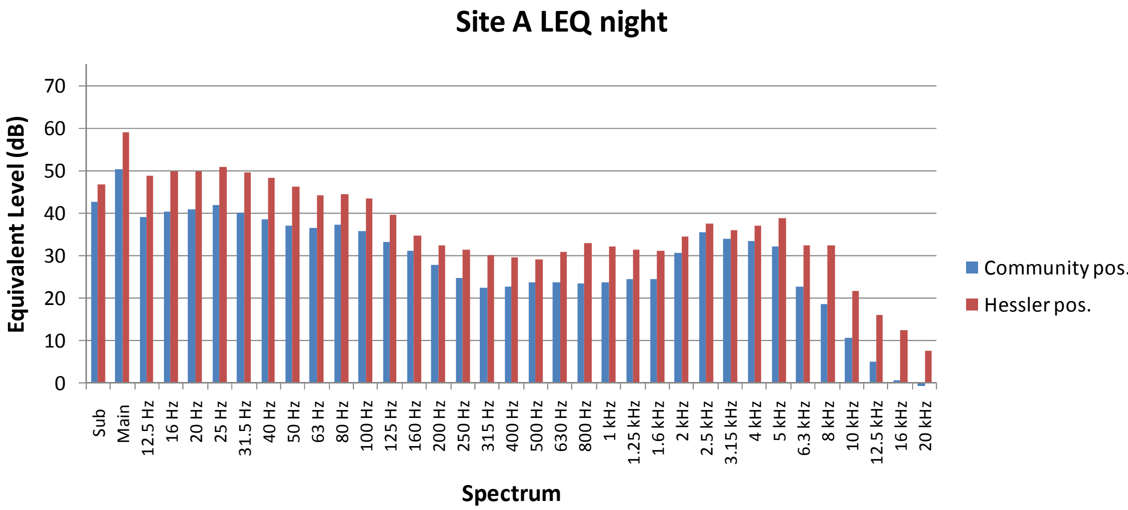

Figure 31. Site A averaged night-time LEQ spectrum

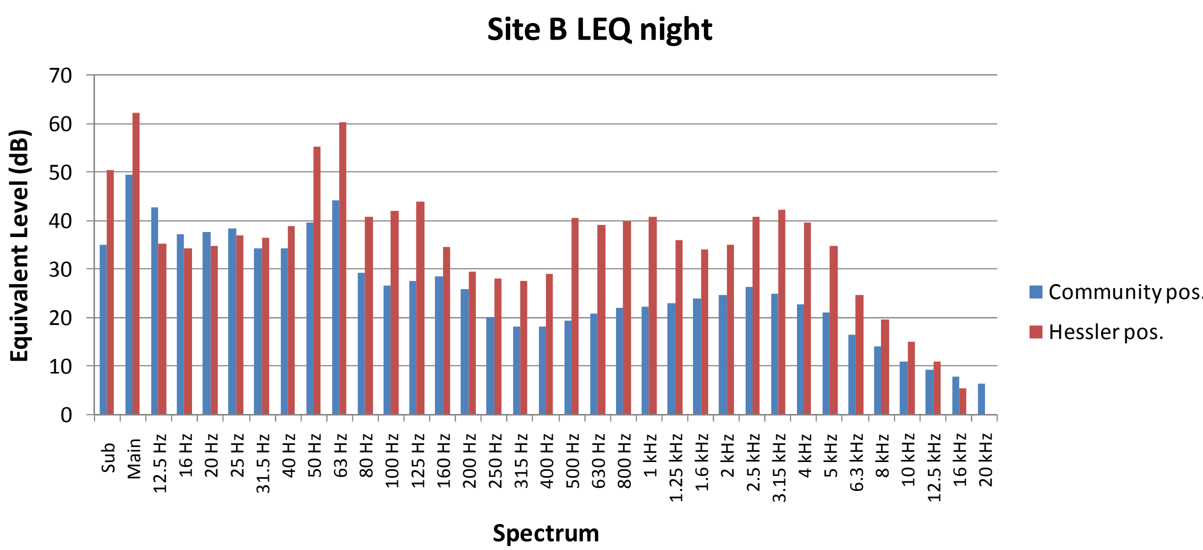

Figure 32. Site B averaged night-time LEQ spectrum

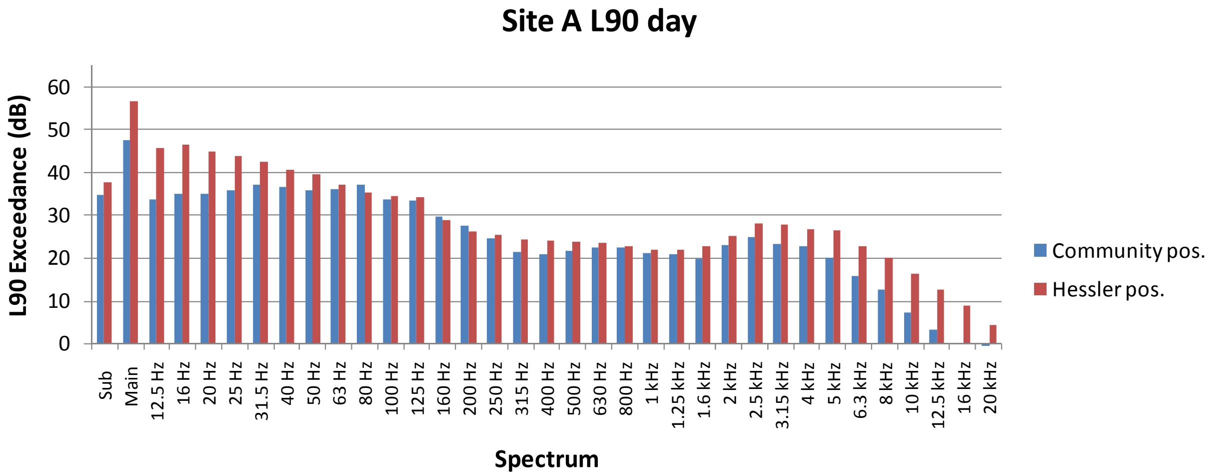

Figure 33. Site A averaged day-time L90 spectrum

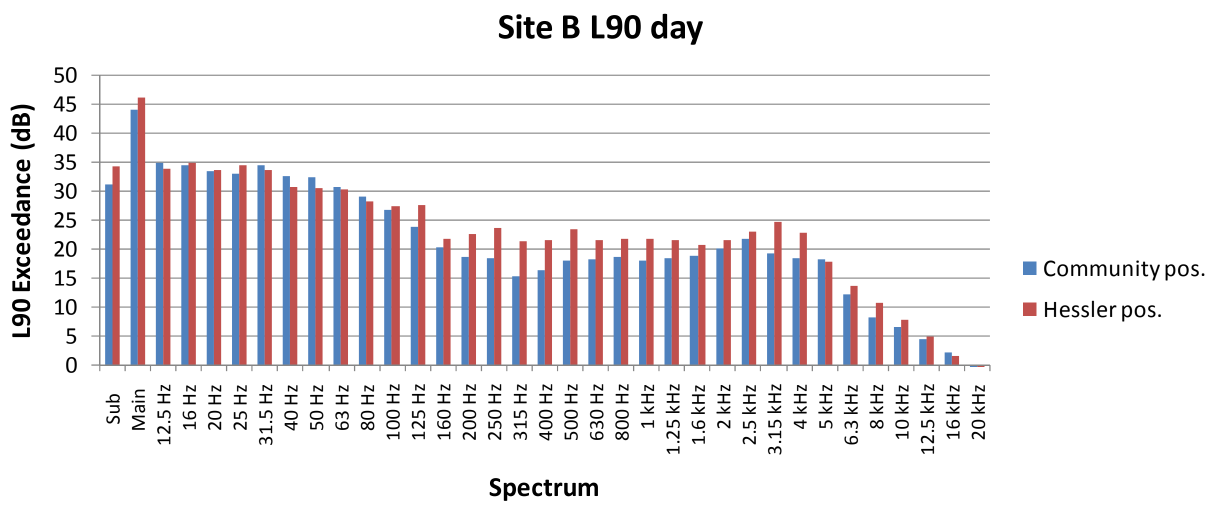

Figure 34. Site B averaged day-time L90 spectrum

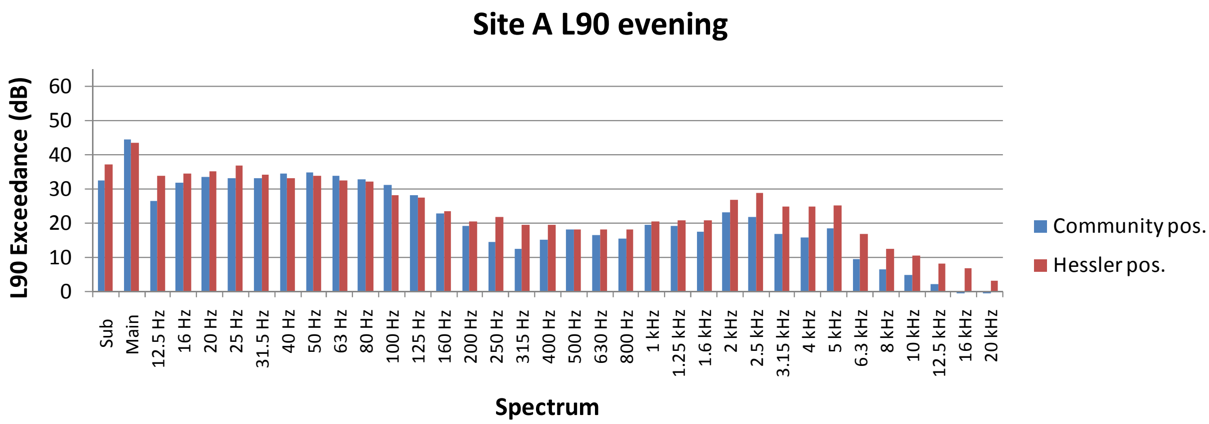

Figure 35. Site A averaged evening L90 spectrum

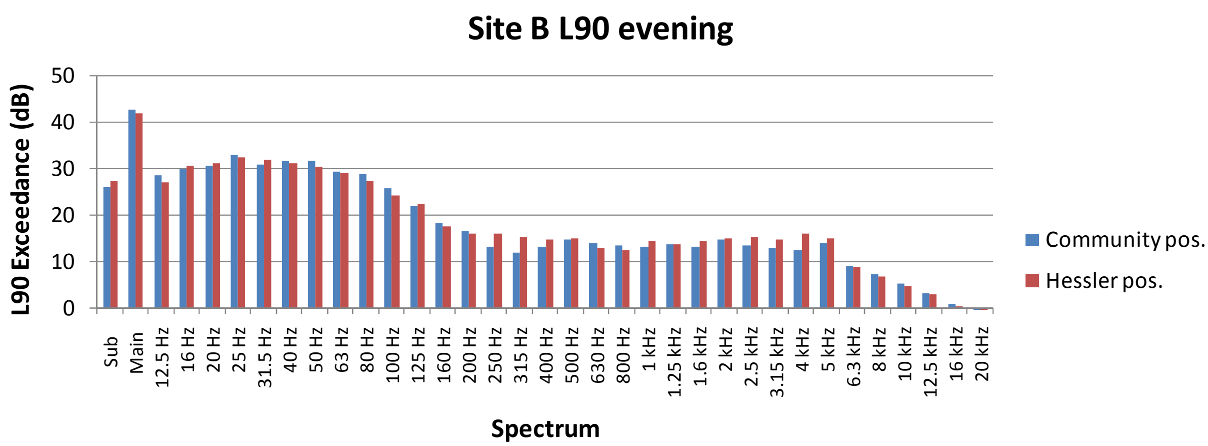

Figure 36. Site B averaged evening L90 spectrum

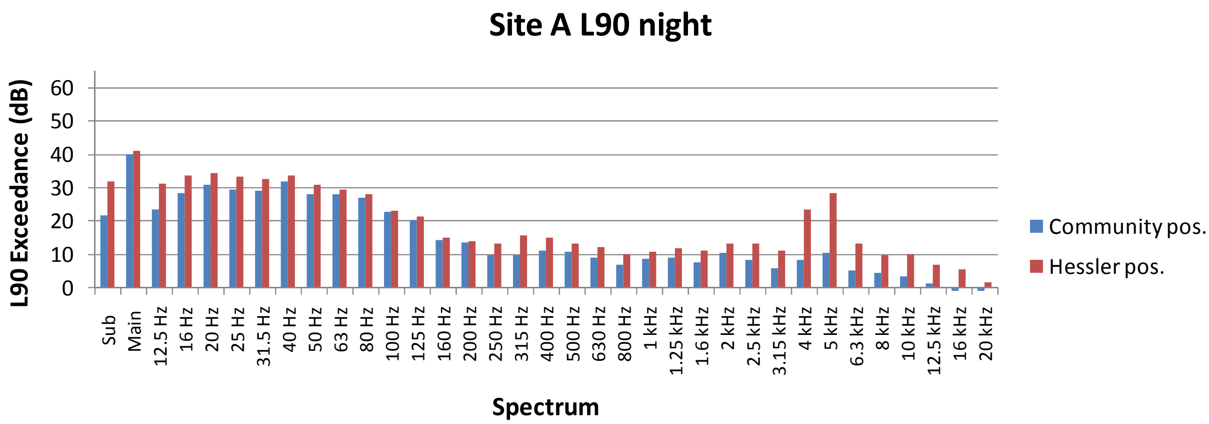

Figure 37. Site A averaged night-time L90 spectrum

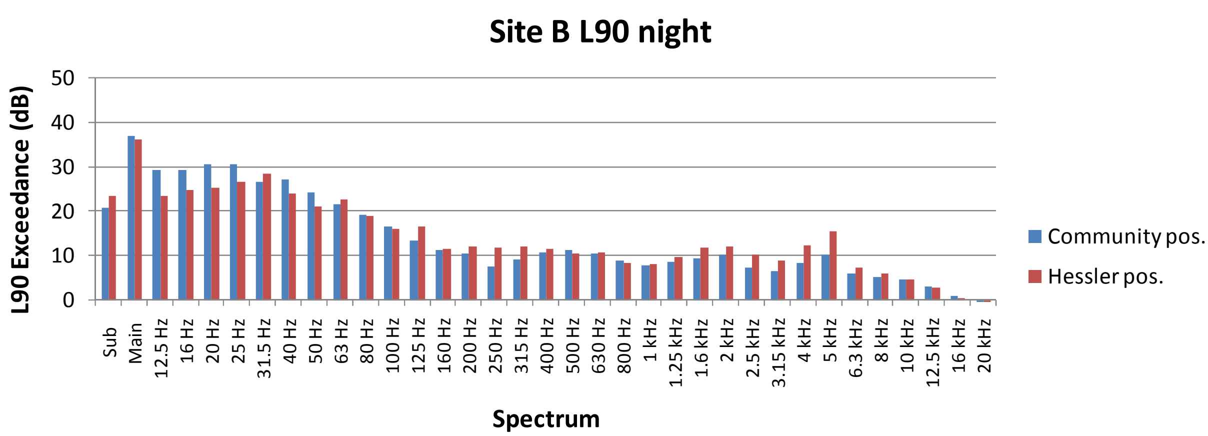

Figure 38. Site B averaged night-time L90 spectrum

IV. Discussion

At Site A there was a typical diurnal cycle with low sound levels at night and higher levels during the day (Fig. 16). A-weighted L90 ambient levels were below 25 dB at the Community position for all seven nights, and at the Hessler position for three nights. Site B had a similar daily pattern (Fig. 18). Nighttime A-weighted L90s were at or below 25 dB each night at the Community position and for 6 of 7 nights at the Hessler position. At both sites the upper range of the A-weighted L90s was approximately 45 dB.

At both sites A and B (see Figures 20 and 22), the A-weighted L90s were always higher at the Hessler positions. A-weighted L90 sound levels at the Hessler positions were 3 dB higher during daytime and up to 10 dB greater during nighttime. The A-weighted L90 sound levels increase around 5:00 AM, presumably from bird vocalizations, and then remain around 30-40 dB for the remainder of the day.

The day, evening and night ambient sound level data are summarized in Table 2 and, for L90 values, plotted in Figures 24 and 26. During the day, the A-weighted L90 sound levels were 3 dB greater at the Hessler position at both sites. The simple[5] daytime average A-weighted L90 for both sites and both positions was 35.5 dB. During the evening, the L90s at the Hessler position were 4.6 and 1.4 dB greater at sites A and B, respectively, and the simple-average A-weighted L90 for both positions and sites was 30.7 dB. During the night, the Community position was always quietest with A-weighted L90 levels averaging 21.7 and 21.0 dB for sites A and B, respectively (Table 2). The Hessler position was 10.4 and 2.5 dB louder at night at sites A and B, respectively. Combining both the Hessler and Community positions at both sites, the simple, A-weighted L90 average was 24.6 dB for nighttime ambient noise.

The results of the L90 sound spectrum analysis are displayed in Figures 33-38 for day, evening and nighttime. During all three time periods and at both sites, low frequency sound dominates the sound spectra. Of particular interest is the way insect noise, although not near its peak, is a factor in these spectra and the corresponding A-weighted levels. Insect noise is particularly evident in Figure 38, but it also is present in the data from Figures 33-37.

Data for the Community position at site A show that it is a quiet site, and data for the Community position at site B show that it is a very quiet site. Although the "Hessler" positions are noisier than the community positions, the Hessler position data are much quieter than the data reported by Hessler. In fact, these data are comparable only to the data for Hessler position 4, the data Hessler arbitrarily discarded because they were quieter than his other data. Overall, the data herein certainly support the contention that Hessler chose loud sites, loud positions within the sites, and the time-or-year when insect noise is loudest.

Overall, and especially Figures 24 and 26 taken together suggest that in Cape Vincent, daytime, evening, and nighttime A-weighted L90s average at 35.5, 30.7 and 24.6 dB, respectively. Thus, the overall day-evening-night simple arithmetic average is about 30 dB compared with Hessler's reported average of 45 to 50 dB—a range of levels that exceed the true ambient by 15 to 20 dB—a huge error.

The biggest factor responsible for Hessler's higher measure of ambient sound in Cape Vincent was the inclusion of insect sounds. Hessler stated, "..insect noise peaking at 5000 Hz strongly affected the overall sound levels when they were at a maximum and, significantly, also when they were at a minimum." In Figure 2.6.2 of his report insect sound levels (e.g. 4000 to 8000 Hz) were 35-55 dB compared to 10-25 dB in this study. Hessler's failure to remove insect noise contradicts what he recommends in his November 2006 article appearing in The Journal of Sound and Vibration entitled "Baseline Environmental Sound Levels for Wind Turbine Projects:"

> *"To exclude certain contaminating noise and to correct measured sound levels for self-induced wind noise, it is necessary to record not only the A-weighted sound level but also the octave-band frequency content of the background sound level. For example, this approach allows the mathematical subtraction of high-frequency insect noise from summertime survey results yielding a modified A-weighted sound level that can be used as a year-round design basis. Without this adjustment, one might easily overestimate the long-term background level, particularly the nighttime level, that is present at the site. It is the lowest sound level that is consistently present and available to mask project noise that is sought in every baseline ambient sound survey.*

---

[5] The simple average was calculated by taking the arithmetic average of the four levels (sites A and B by positions Hessler and Community).

In contrast to Hessler's BP study, the current study was designed to avoid insect noise by scheduling the survey period prior to the emergence of adult fall crickets and cicadas (e.g., August 1). Actually, the results in this report are more aligned with Hessler's journal recommendation to seek the lowest sound level that is consistently present.

Furthermore, and more importantly, wind turbine sound spectra are low frequency and mid-frequency phenomena; therefore, higher frequency insect noise will not mask wind turbine sounds. So even if insect noise was present year round instead of for a few weeks it should still not be included in the ambient because it provides little or no masking of the wind turbine sound.

In summary, Hessler's claim that A-weighted ambient sound levels of 45-50 dB are typical for Cape Vincent is incorrect and misleading. Results in this study showed A-weighted L90 ambient sound levels averaged: 24.6 dB at night, 30.7 dB for evenings and 35.5 dB during daytime; and the overall (arithmetic) average of these three A-weighted L90 levels is 30.3 dB. Importantly, these sound levels represent an average of both the "Hessler" and Community positions, not just the Community position averages. These results demonstrate that selection of monitoring sites, position within the site, and time of year all markedly affect the "measured" background sound in Cape Vincent.

V. Conclusions

1. The Hessler position at a measurement site systematically and significantly yields higher sound levels than does the Community position.
2. The sound levels measured in this study show Cape Vincent to be a quiet rural area, much as depicted by the data for Hessler's position 4.
3. Measurements, such as those conducted at Hessler's position 3, are not indicative of the noise environment of typical residences in the Cape Vincent area.
4. Failure to remove insect noise in Hessler's study violated his own recommended survey and analytical techniques and substantially misrepresented typical ambient sound levels.
5. In assessing potential noise impacts from wind turbine development, rather than using 45-50 dB A-weighted levels as suggested by Hessler, a more accurate level would be 30 dB, which is the average value for the day, evening and night L90 sound levels observed at both the "Hessler" and Community positions for sites A and B in this study. Arguably, the level should be down at 20 to 25 dB, since an A-weighted L90 of 20 dB occurs during the quietest nighttime hours, and the A-weighted L90 for the whole 9-hour night is 25 dB.

Paul Schomer

Paul Schomer, Ph.D., P.E.
Member, Board Certified, Institute of Noise Control Engineering

Annex A: L50 Data Summaries

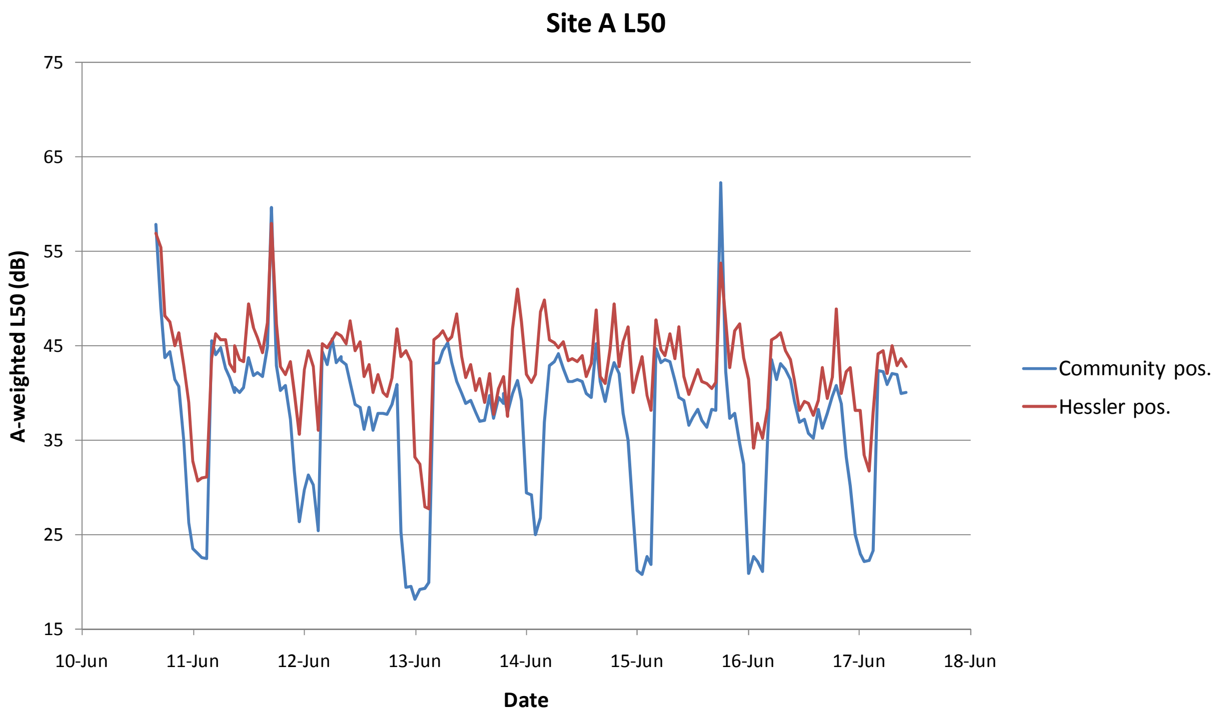

Figure 39. A-weighted L50 for week of site A

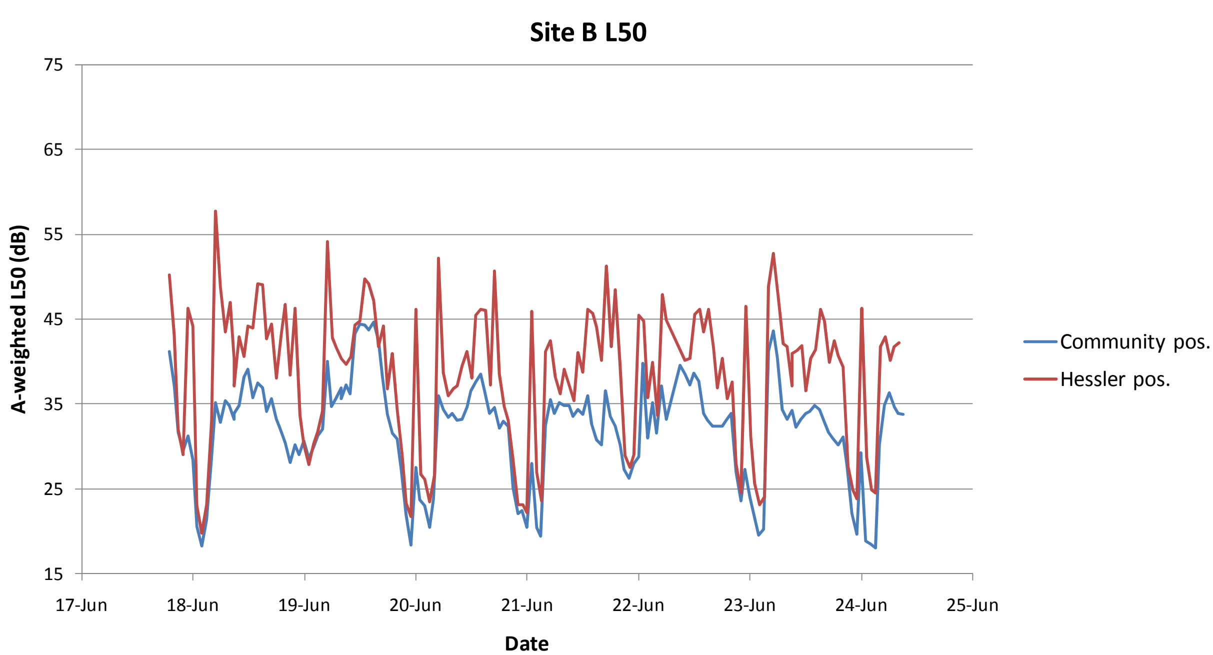

Figure 40. A-weighted L50 for week of site B

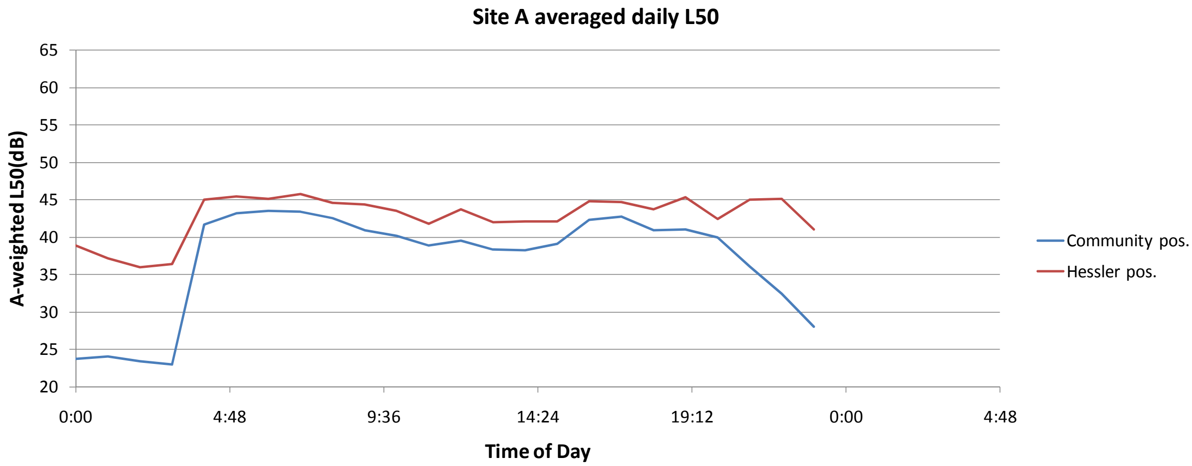

Figure 41. Averaged 24-hour A-weighted L50 at site A

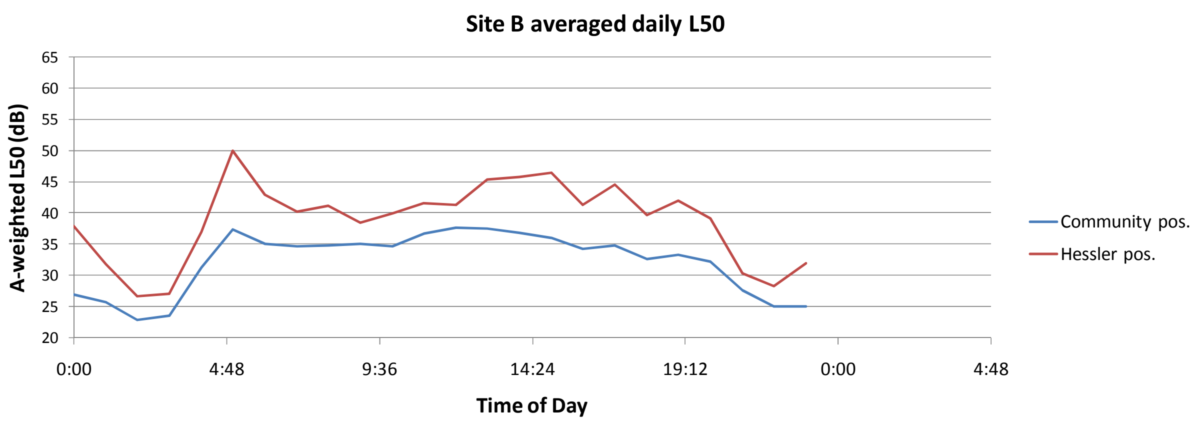

Figure 42. Averaged 24-hour A-weighted L50 at site B

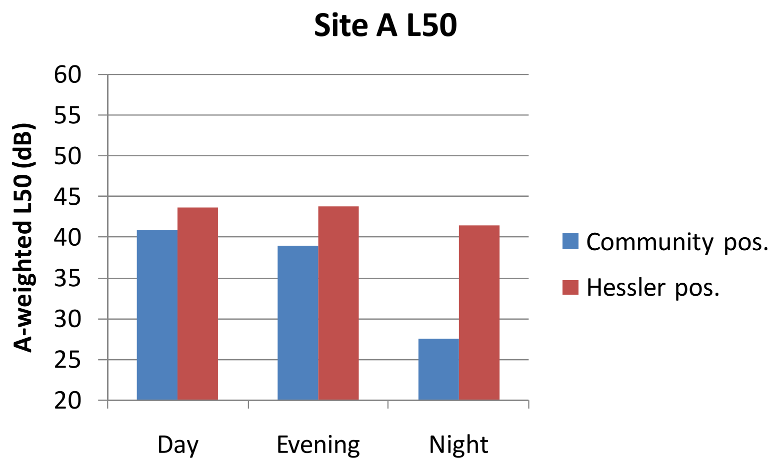

Figure 43. Site A comparison of A-weighted L50 of day, evening, and night times

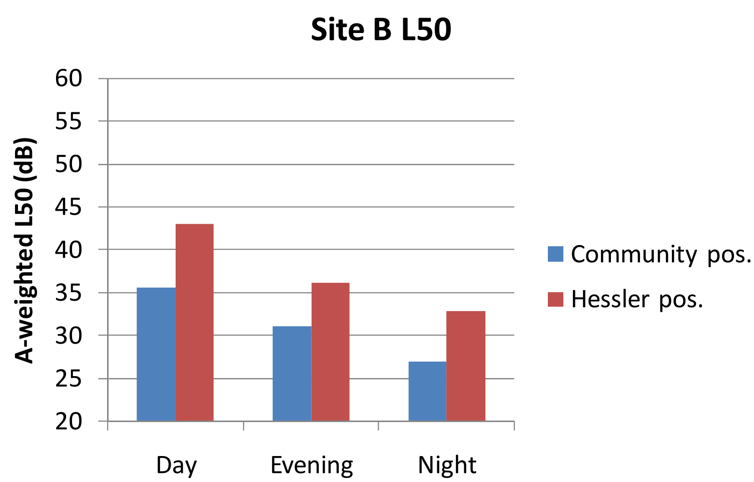

Figure 44. Site B comparison of A-weighted L50 of day, evening, and night times

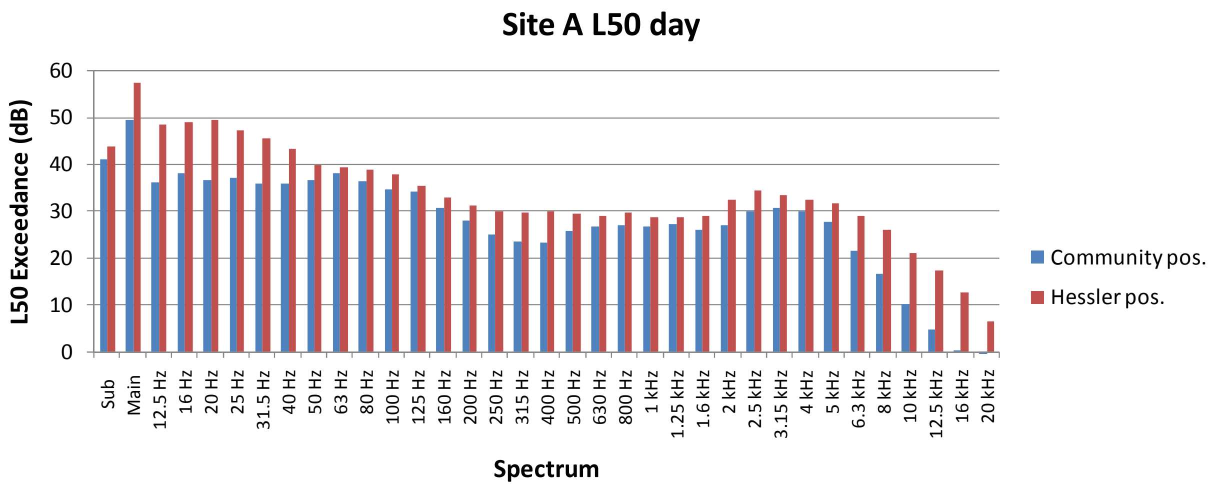

Figure 45. Site A averaged day-time L50 spectrum

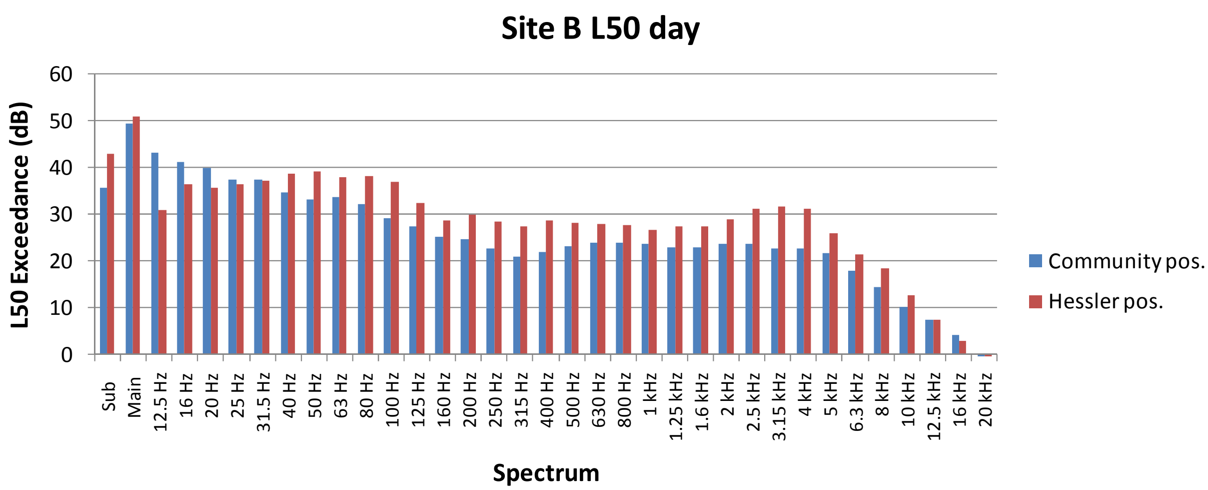

Figure 46. Site B averaged day-time L50 spectrum

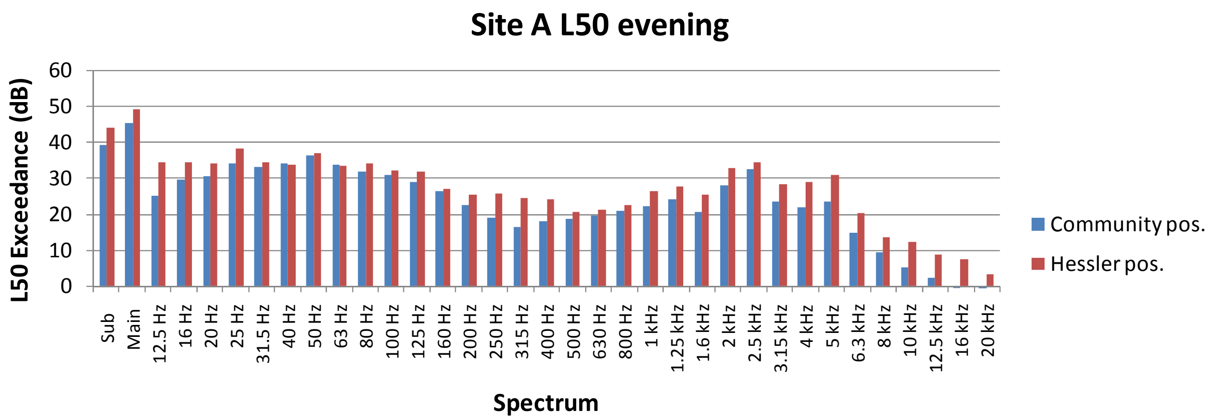

Figure 47. Site A averaged evening L50 spectrum

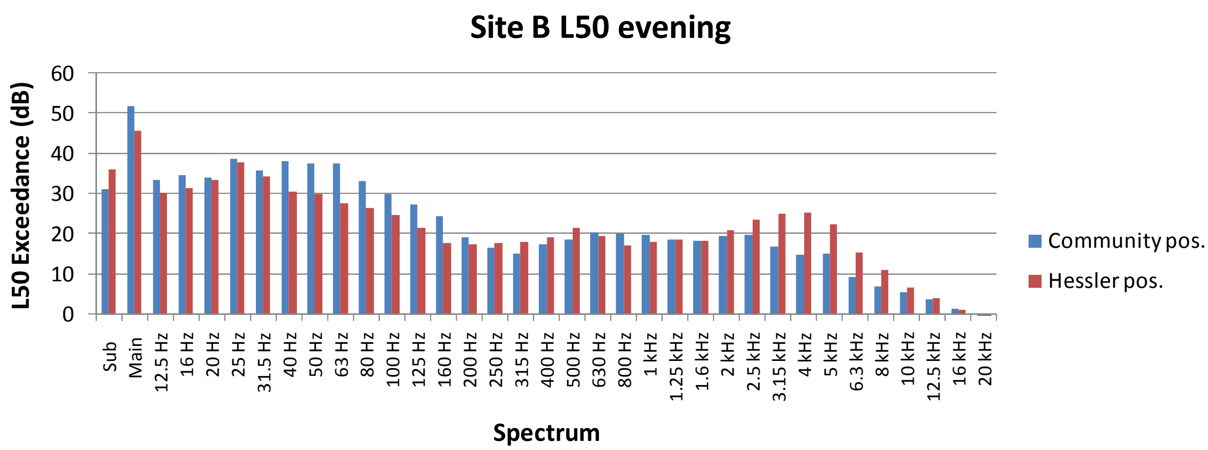

Figure 48. Site B averaged evening L50 spectrum

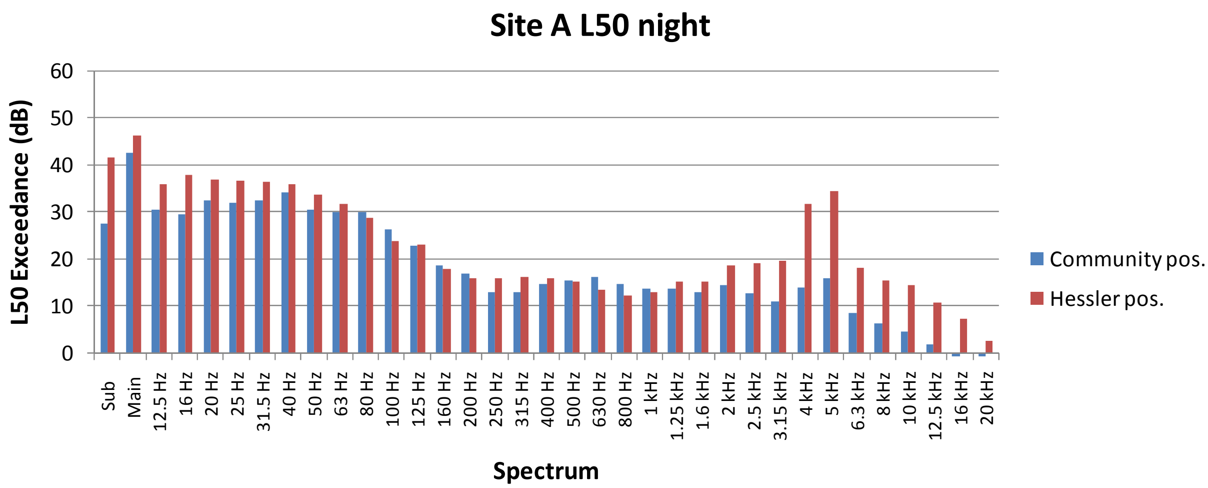

Figure 49. Site A averaged night-time L50 spectrum

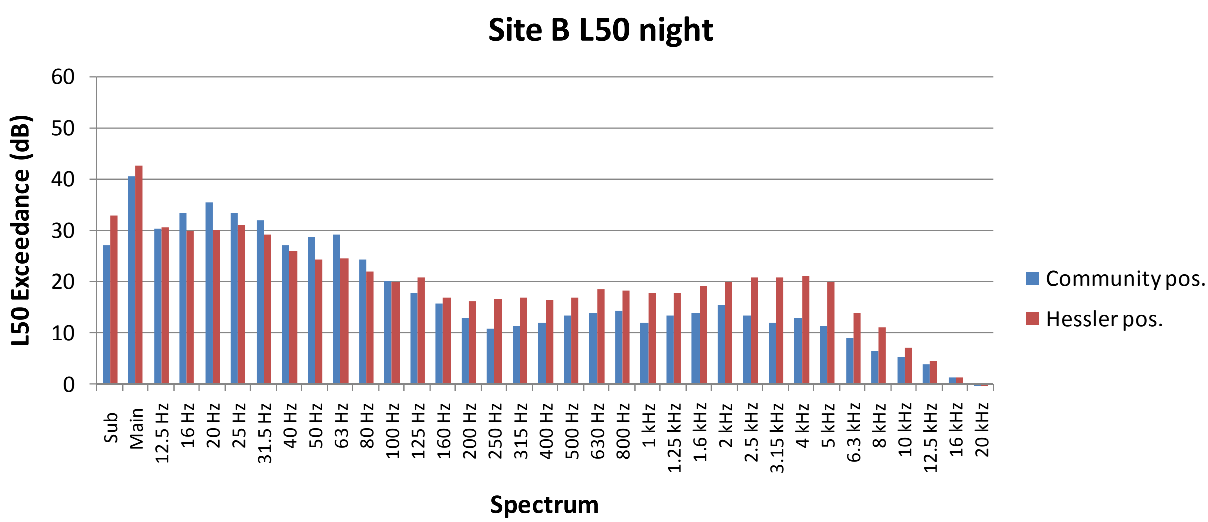

Figure 50. Site B averaged night-time L50 spectrum

Annex B: 10-minute LEQ, L90, L50 organized by date

(Data only available in soft form)

Annex C: 1-hour LEQ, L90, L50 organized by data

(Data only available in soft form)

Annex D: 1-hour A-Weighted data portrayed in figures 13-18

(Data only available in soft form)

Annex E: Averaged 24-hour sound levels portrayed in Figures 19 - 24

Table 3. Annex E - Site A averaged 24-hour sound levels portrayed in Figures 19-24

	LEQ (dB)		L50 (dB)		L90 (dB)	
Hour	Community pos.	Hessler pos.	Community pos.	Hessler pos.	Community pos.	Hessler pos.
0:00	30.1	42.8	23.8	38.8	21.6	32.2
1:00	29.4	42.0	24.1	37.2	21.7	31.6
2:00	27.4	41.9	23.5	36.0	21.8	30.9
3:00	25.7	42.6	23.0	36.4	21.0	30.7
4:00	47.6	47.5	41.7	45.0	23.2	33.8
5:00	45.9	50.0	43.2	45.4	37.6	40.3
6:00	47.1	50.8	43.5	45.0	37.5	39.7
7:00	47.0	53.9	43.4	45.7	37.6	40.5
8:00	46.4	52.7	42.5	44.5	36.3	39.7
9:00	46.0	52.5	40.9	44.3	35.6	39.5
10:00	45.8	52.4	40.1	43.5	35.0	38.7
11:00	44.0	52.7	38.9	41.8	33.8	37.4
12:00	59.5	61.3	39.6	43.7	33.7	37.4
13:00	44.4	50.7	38.4	42.0	33.4	36.6
14:00	44.5	51.7	38.3	42.1	33.9	37.0
15:00	46.7	58.0	39.2	42.1	33.9	36.3
16:00	57.1	55.6	42.3	44.8	36.3	39.5
17:00	60.7	55.3	42.7	44.7	36.1	39.3
18:00	45.0	54.0	40.9	43.7	35.2	37.6
19:00	50.3	51.5	41.1	45.3	35.2	38.9
20:00	43.9	49.5	39.9	42.4	34.1	36.2
21:00	41.4	47.9	36.1	45.0	32.0	38.8
22:00	41.9	48.7	32.5	45.1	29.1	40.2
23:00	34.1	44.1	28.0	41.0	23.2	34.7

Table 4. Annex E - Site B averaged 24-hour sound levels portrayed in Figures 19-24

	LEQ (dB)		L50 (dB)		L90 (dB)	
Hour	Community pos.	Hessler pos.	Community pos.	Hessler pos.	Community pos.	Hessler pos.
0:00	29.8	45.2	27.0	37.9	23.8	30.9
1:00	35.0	43.5	25.8	31.8	22.6	27.8
2:00	29.5	38.8	22.9	26.7	20.7	23.5
3:00	31.1	38.4	23.7	27.2	21.6	24.2
4:00	37.8	52.8	31.4	37.1	24.1	27.0
5:00	40.1	55.2	37.4	50.0	33.2	41.0
6:00	37.1	56.6	35.1	43.0	31.3	36.5
7:00	36.7	49.5	34.8	40.2	31.1	33.9
8:00	39.8	49.3	34.8	41.2	31.7	34.4
9:00	38.8	48.6	35.0	38.5	31.6	32.8
10:00	36.8	49.0	34.7	40.0	31.4	33.9
11:00	39.9	51.2	36.7	41.6	33.8	35.7
12:00	40.8	47.9	37.7	41.3	35.0	35.6
13:00	40.9	49.3	37.5	45.3	34.9	39.0
14:00	42.0	49.3	36.8	45.8	34.4	40.5
15:00	40.4	49.8	36.0	46.4	33.6	39.3
16:00	42.6	60.0	34.3	41.4	31.7	33.9
17:00	38.1	59.5	34.8	44.6	31.3	34.5
18:00	34.4	47.8	32.6	39.7	29.5	32.6
19:00	39.8	50.6	33.3	42.0	30.2	33.9
20:00	34.9	49.0	32.2	39.1	28.1	30.0
21:00	29.8	42.2	27.7	30.4	24.1	25.9
22:00	27.2	39.7	25.0	28.4	23.0	26.9
23:00	28.4	43.9	25.1	32.1	22.5	27.0

Annex F: Spectra for the data portrayed in Figures 31-48

(Data only available in soft form)

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April 23, 2010

Mr. Urban Hirschey – Supervisor
Town of Cape Vincent
1964 NYS Rte 12E
Cape Vincent, NY 13618

Dear Supervisor Hirschey:

This letter is my response to Mr. David Hessler's April 14, 2010 presentation to the Cape Vincent Planning Board regarding my report, "Background sound measurements and analysis in the vicinity of Cape Vincent, New York."

Mr. Hessler continues to ignore important facts. Specifically, he:

1. Mixes winter and summer wind speed versus ambient sound level together as if the same processes governed both seasons,
2. Continues to reject Site 4 data because they are "too quiet."

Consider winter. Mr. Hessler examines the ambient when the wind at 10 m is thought to be about 7 m/s and shows (Hessler's BP winter study Figure 2.5.5) that about 80 % of the ambient data are louder than 37 dB with few data that are greatly quieter.[1] This indicates that in winter when the winds (at 10 m) are about 7 m/s that the wind turbine can produce up to 43 dB at an affected property and be in compliance with the New York State guideline. But that is all it shows. It cannot necessarily be extrapolated to other wind speeds, and it definitely cannot be extrapolated to summer. Consider Figure 2.5.5 at 4 m/s. Here, about 80 % of the ambient data exceed 20 dB. So in winter, when the wind is 4 m/s, the turbine noise at an affected property must be less than 26 dB in order to comply with NYSDEC policy of 6 dB above background sound levels. Nowhere is this shown to be the case.

In summer, Hessler uses the winter ambient noise versus wind speed relation to predict the summer ambient even though, as Cavanaugh-Tocci has correctly noted, the summer data exhibit virtually no correlation between ambient sound level and wind speed. And, indeed, there is none. The summer data are dominated by insect noise, a high frequency noise that cannot and does not mask the low-frequency wind-turbine noise. Even more importantly, regularly and frequently, especially at night, the relation between wind speed and altitude cited by Hessler breaks down completely. It is simply wrong. This is not some idle theory; it is a well known and well documented fact, and Hessler acknowledges this phenomena in his presentation (see quote below). What actually happens is that the wind is strong at hub height but it is calm near the ground (10 m). So the wind turbine can easily operate and make

[1] Rightfully, Mr. Hessler chooses a wind speed and corresponding ambient sound level such that about 80% if the time the ambient is greater than 37 dB and 20% of the time it is quieter. This can be thought of as protecting 80% of the population or protecting 80% of the time, or some combination of these two. The important point is that the protection should be at least at the 80 to 90% level—not at 50%.

noise while at the same time there is no masking wind noise at ground level.

How often does this condition occur? At the InterNoise2009 conference last August, the one Hessler mentions in his presentation, I chaired a session in which a paper was presented that contained factual data showing that this condition, strong winds at hub height and zero winds at 10 m, occurs almost every other night during the warmer weather months at Cape Vincent—almost every other night.

How loud is it? As Hessler stated during the recent hearing:

> "*Now turbine sound level varies with wind and weather conditions and time of day, no question about that. In particular, at night, wind tends to blow up above while calmer near the ground; the curvature of the shear profile is pretty slanted, so the top of the blades are in high wind and the bottom of the blades are in lower wind. That causes them to make a kind of churning noise, most often it happens at night. So, levels are going to vary, some time it's going to be completely inaudible and other times temporarily rather loud, it's just the way wind turbines are.*"

"*Rather loud*" means louder than predicted; louder than the "permitted" 43 dB(A). How much louder? The wind turbine manufacturers do not measure it—perhaps 5 to 10 dB.

What is the bottom line? During warm-weather months, almost every other night, the ambient, as we and Hessler both measured, will be about 25 dB(A). At the same time the wind turbine can be producing on the order of 50 dB. Rather than the permitted 6 dB increase, the true increase will be about 25 dB, and this huge increase may occur almost every other night.

People will be very unhappy—and rightfully so.

Paul Schomer

Paul Schomer, Ph.D., P.E.
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Accuracy of Model Predictions and the Effects of Atmospheric Stability on Wind Turbine Noise at the Maple Ridge Wind Power Facility, Lowville, NY - 2007

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SUMMARY

New York State is currently on a "fast-track" for developing sources of renewable energy – the goal is renewable energy constituting 25% of all energy sold in New York by 2013. At present there are six commercial wind farms operating in New York State, with four more under construction. There are another 30 projects that are under some stage of environmental review, and there are undoubtedly more that are being considered. There are a number of important issues that confront developers in getting their projects approved; one of them is dealing with wind turbine noise.

Although wind farm noise may be low compared to a big municipal airport, in a quiet rural setting even low level noise can pose a significant problem. Wind power developers use mathematical models to predict the impact of wind turbine noise on nearby residents. However, no one knows if predicted noise impacts are high, low or on target. Developers, planning boards and residents are all assuming that model predictions are accurate and that they do not require any validation. Regrettably, there have been no compliance surveys done on any of the six operational wind farms in New York State.

The main objective of this study was to measure the noise levels at two sites within Atlantic Renewable Energy Corporation's Maple Ridge Wind Power Project located in Lewis County, New York, and compare actual levels with the model predictions that were available in the preconstruction Draft Environmental Impact Statement (DEIS). The second objective was to examine atmospheric stability at Maple Ridge. Atmospheric stability was identified as a significant problem at a wind farm on the Dutch-German border. Stability occurs when ground level winds, where people live and reside, are decoupled from those at wind turbine hub-height. This can occur at the end of the day when the land mass begins to cool. It affects wind turbine noise because wind turbines can be operating and making noise when ground level winds are calm and we expect quiet surroundings.

This study demonstrated that summer, night-time noise levels exceeded levels predicted for two sites within the Maple Ridge Wind Farm. For winds above generator cut-in speed (e.g., 3.0 m/s @ 80-m), the measured noise was 3-7 dBA above predicted levels. The decoupling of ground level winds from higher level winds, i.e., atmospheric stability, was apparent in the noise data at both sites during evening and night-time periods. At wind speeds below 3.0 m/s, when wind turbines were supposedly inoperative, noise levels were 18.9 and 22.6 dBA above the expected background levels for each of the sites and these conditions occurred a majority of the time. The same results were evident in the evening period. Furthermore, digital recordings revealed prominent wind turbine sounds below cut-in speeds.

The fact that nearly all measurements exceeded Atlantic Renewable's predicted impacts suggests there is a problem with the choice of a model and/or how the models are configured. The model protocol used by Atlantic Renewable is very common; most wind power developers in New York use the same protocol. However, different models used in wind farm noise assessments have been shown to produce different results, and the model used by Atlantic Renewable was not designed to model elevated sources of sound, i.e., wind turbines.

Several recommendations are suggested for planning boards, communities and the NYSDEC:

1. The first step should be a validation of the results in this study. A small study should be undertaken quickly to confirm or refute these results. The consultant hired to do the work should be independent of any developer, preferably accountable only to NYSDEC.
2. If the validation study confirms the conclusions in this study, the NYSDEC should make a strong recommendation in their comments to lead agencies to delay issuing any new permits (e.g., a moratorium) for wind farms until a more comprehensive assessment can be undertaken of all the operating wind farms in New York.

3. Because atmospheric stability can have such a profound effect on wind turbine noise, planning boards and regulatory agencies should require developers to submit wind velocity summaries to describe prevalence of atmospheric stability.
4. Wind power developers could do a much better job of predicting noise impacts if planning boards required noise compliance surveys, and if they imposed operation restrictions if actual noise exceeded predictions.
5. NYSDEC should take a more involved and active role in reviewing noise impacts, to date their comments on wind turbine noise are minimal to non-existent. NYSDEC needs to get more involved in reviewing wind farm noise impact assessments.
6. For those non-participating residents within the bounds of existing wind farms, depending on the results of the comprehensive review, it may be appropriate to find some means to mitigate excessive noise, i.e., additional payments and/or shutting down wind turbines during periods of stable atmospheric conditions.

INTRODUCTION

In New York State at the end of 2007 six commercial wind farms were operational, four were under construction and thirty others were under some stage of environmental review[2]. Two of these projects, totaling 236 wind turbines, are proposed for the Town of Cape Vincent, NY, where I currently reside. The New York State Environmental Quality Review Act (SEQR) requires a careful, comprehensive review of all the potential impacts from any policy or project that could affect the environment, including commercial wind power development. For the two projects in Cape Vincent, developers have submitted Draft Environmental Impact Statements (DEIS) and they are in the process of revising and supplementing these reports. One of the most important issues that developers have to consider is wind turbine noise, particularly as it affects those residents outside of the wind farm project boundaries (AWEA 2008). In Europe, where commercial wind projects have been operating for years, there have been a number of instances where wind turbine noise has become a problem with non-participating residents. As a result, scientists have begun to study and document wind turbine noise impacts on community health

Annoyance with wind turbine noise is the most common complaint, but more serious health problems have begun to emerge as well. In a number of Swedish studies of wind farm residents, researchers found annoyance was related to wind turbine noise, as well as other factors, e.g., visibility, urbanization and sensitivity (Pedersen and Waye 2007). They also determined that wind farm noise was much more annoying than aircraft, road traffic and railway noise at far lower sound levels (Pedersen and Waye 2004). Wind turbine noise is principally broadband, white noise, which in itself is not particularly annoying. The character of wind turbine noise many people find annoying is called amplitude modulation, which relates to the periodic increase in the level of the broadband noise. Amplitude modulated noise can be simulated by tuning an AM radio between two stations, where static is heard, and then increasing the volume every 1-2 seconds. This is not pleasant. For some living within a wind farm, annoyance has lead to sleep

[2] http://www.dec.ny.gov/energy/40966.html

disturbance (Pedersen 2003), which in turn can result in a low-level stress response and other potential health effects associated with stress.

The usual approach wind power developers use in assessing noise impacts is to: 1) conduct a background noise survey, 2) use noise propagation models to predict wind turbine noise impacts on non-participating residents, and 3) align these predictions to some local or state noise standards. In these noise assessments, wind power developers assert a cautious and conservative analysis, and assure us their models are configured so they produce conservative, worst-case scenarios. For example, in a recently completed noise study for the New Grange Wind Farm in Chautauqua County, New York there were thirty-six separate uses of the phrase "worst-case" (HWE 2008). The overall impression for anyone reviewing these reports is that developers use sophisticated, complex mathematical models to make very conservative estimates of noise impacts. The wind power industry, however, has overlooked the real worst-case scenario – the effect of atmospheric stability on wind turbine noise.

The Dutch environmental physicist, G.P. van den Berg, has published extensively on the relationship of atmospheric stability and wind turbine noise (2003, 2004, 2005 and 2006). During the day, the land is heated and the air rises and the near-ground atmosphere is considered unstable; winds that blow at ground level are even more intense at wind turbine hub-heights (e.g., 80m). At evening, the land begins to cool and vertical air movements disappear; wind can be calm near ground, but continue to blow strongly at hub-height. This is considered a stable atmosphere.

Atmospheric stability can have an acute effect on wind turbine noise, too. Wind turbine sounds are more noticeable, since there is little masking of background noise, and more importantly, because atmospheric stability can amplify noise levels significantl. Herein should be the developer's worst-case scenario for their wind turbine noise impact studies: A still evening on the back patio with motionless flowers and trees, but with nearby wind turbines operating near full power and noise – much more noise than would be expected from a similar rural setting elsewhere. From what I have observed locally, atmospheric stability is not a rare phenomenon, on the contrary, it is very common.

In most wind farm noise assessments, however, they never mentioned atmospheric stability. Although stability is ignored by consultants doing noise exposure assessments, atmospheric stability is extremely important to developers who are trying to optimize electric power production: *Choosing to ignore such diurnal effects* (stability) *would surely result in unreliable energy forecasts* (Van Lieshout 2004). The commercial wind industry knows the importance of atmospheric stability for commercial wind power production; however, the industry ignores the issue when assessing noise impacts on rural communities.

I became interested in wind turbine noise when I was faced with proposals for two wind farm projects in Cape Vincent. I was also concerned about the complaints I heard from residents of Maple Ridge as well as those from other parts of the world via the web. In addition, I was suspicious about some of the claims and forecasts made by developers in their modeling of noise impacts. From my experience as a biologist I understand that models are not infallible and that follow-up studies are needed to validate model predictions. Regrettably, in New York there have been no noise compliance surveys done to date on any operating wind farm, nor are there any plans in the future for these kinds of studies (Tomasik 2008).

For these reasons, and because of the proximity of Atlantic Renewable Energy Corporation's Maple Ridge Wind Power Project in Lowville, NY, I undertook a study of wind turbine noise in August and September of 2007. The objectives of my study were to 1) compare noise measurements during wind farm operation with model predictions outlined in the Maple Ridge DEIS[3], and 2) determine if the effects of atmospheric stability on wind turbine noise were as pronounced as that observed in Europe. I did not try to describe amplitude modulation and other characteristics of wind turbine noise, not because they are unimportant, but because I was limited in what I could do with my

[3] The DEIS for the Maple Ridge Wind Power Project was originally titled Flat Rock Wind Power Project DEIS.

electronic equipment. Hence, the focal point of my study is wind turbine noise as it relates to pre-construction model predictions by Atlantic Renewable for their Maple Ridge Wind Facility.

METHODS

Two landowners within the Maple Ridge Wind Farm allowed me to set up equipment in August-September, 2007. The site referred to as SW1 (Fig.1) is the property of a wind farm cooperator and was one of Atlantic Renewable's noise monitoring sites. SW1 is located on the Swernicki Road and there are six nearby wind turbines between 340 and 638 m (1,116-3,071 ft.). The other site, R14 (Fig. 1), is the residence of a non-participating landowner located near the Rector and Borkowski Roads, which has six wind turbines within 1,000 m; the closest two are both 382 m (1,250 ft.) away. These two sites were useful, because in the Maple Ridge DEIS (AREC 2003) noise predictions were tabulated for both sites and at five generator power settings associated with 80-m, hub-height wind speeds of 3.0, 6.4, 8.0, 9.5 and 12.0 m/s, respectively (Appendix B this report). In the subsequent methodology I tried to duplicate, as best I could, the locations, equipment, noise metrics and analytical approaches used by Atlantic Renewable in their noise report (AREC 2003).

Measurement Location : SW1

Figure 1. ***Two monitoring sites used for 2007 noise compliance study at Maple Ridge Wind Farm. Left is photo of R14 residence (keyed to Maple Ridge Wind Farm DEIS) and photo at the right SW1(2002***

photo from DEIS). The close proximity of the sound measuring equipment to the buildings at the SW1 site was chosen to exactly duplicate the location used by the developer for their background noise survey in December, 2002.

For the noise measurements I used a Quest Model 2900 Type II Integrated and Logging Sound Level Meter. The meter was purchased on April 18, 2007 from Quest Technologies at which time they completed a factory calibration (Appendix C). Noise measurements were recorded for 10-minute segments for L_{eq}, L_{max}, L_{min} an L_{90} metrics. The $L_{eq,\ 10\text{-}min}$ measurement was the principal metric used in study in order to be compatible with Atlantic Renewable's model forecasts. The limitations of the meter and microphone would not allow measurements below about 26 dBA, consequently, levels this low could have been even lower. The meter was fitted with a ½ inch electret microphone and a 75 mm diameter, closed-cell wind screen. Standard foam windscreens help reduce wind-induced microphone noise, but at moderate wind speeds they are not very effective.

Wind-induced microphone noise is a major problem in measuring noise levels associated with wind turbines, because wind not only drives wind turbine generators, but it can also contaminate noise measurements. Atlantic Renewable indicated that 5 m/s wind speeds at the microphone represented the upper limit for uncontaminated noise measurements in their background noise surveys (AREC 2003). Also, in their review of Australian wind farm assessment techniques, Teague and Foster (2006) recommend, "*Time intervals for which the wind speed exceeds 5m/s (11.2 mph) at the receiver microphone need to be excluded from the data-set.*" However, for the noise data collected in this study, I concluded that 5 m/s did not afford adequate protection, and assumed any noise measurements made in winds that exceeded 2 m/s were contaminated (see results section).

Due to a battery-life limitation, the time series for each session was limited to 35 hours of continuous operation. The night-time period was the main focus of these studies, because winds at night diminish and thereby make wind turbine noise more noticeable. In order to maximize night-time data collection, each session began in the evening of day-1 and was terminated the morning of day-3. For each set of batteries, two nights were sampled for each day. At the SW1 monitoring site the data collection periods were: Sept. 19-21: 18:30-06:36, Sept. 21-23: 19:46-06:35, and Sept. 23-25: 18:30-08:42 hrs. At the R14 residence sampling periods were: Aug. 27-29: 21:53-12:42, Aug. 29-31: 16:33-04:15. At each visit to setup equipment or replace batteries, nearby wind turbines were operating. At the beginning and completion of each of the surveys I conducted a field calibration of the sound level meter and none of the calibration tone levels varied by more than +/- 0.3 dBA.

Wind velocity data was collected using an Inspeed Vortex Anemometer[4] with a Madgetech Pulse data logger. The anemometer and logger were located at the same height as the sound level meter (e.g., 1-m above ground level, agl), but approximately 15 meters away. Wind velocity was collected and correlated for the same 10-minute segments as that used for noise data. Atlantic Renewable referenced all their wind speed data to 80-m height, which meant I had to convert the 1-m velocities. To convert wind speed collected at ground level to 80-m, hub-height equivalents, I used the formula described by van den Berg (2006):

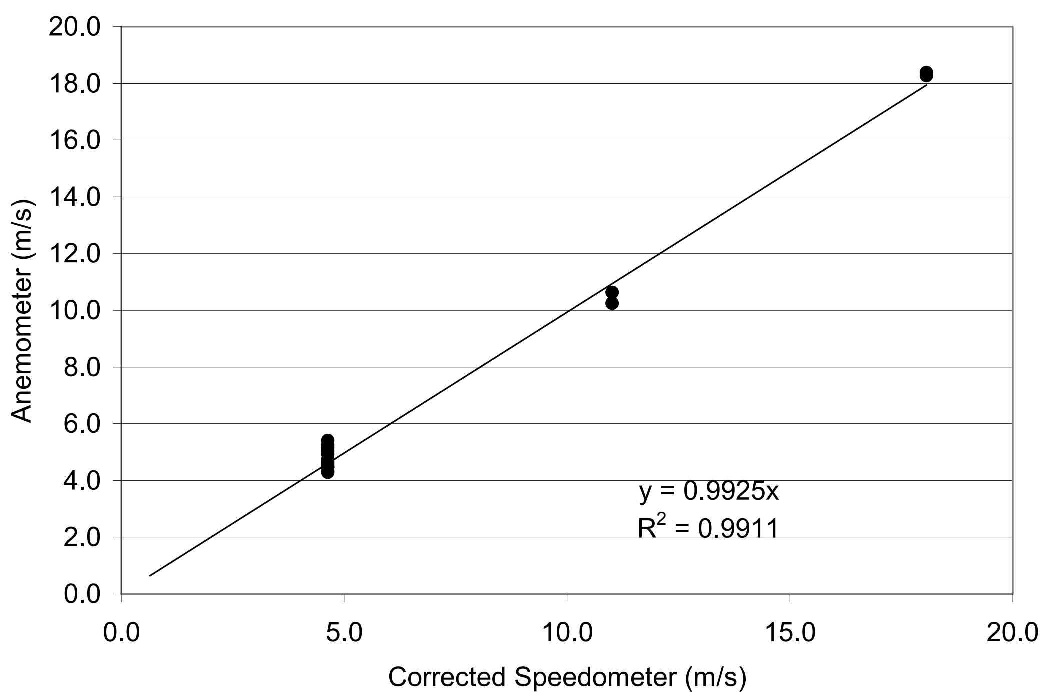
$$V_{80\text{-}m} / V_{1\text{-}m} = (h_{80\text{-}m} / h_{1\text{-}m})^m$$

Where velocity of the wind at 80-m is a power function of the ratio of hub and anemometer heights. The shear exponent *m* is an expression of atmospheric stability. Van den Berg (2006) indicated that shear exponents near 0.20 represented moderately unstable atmospheric conditions and 0.41 represented a very stable atmosphere. In my calculation of 80-m velocities I used m= 0.20, identical to that used by Atlantic Renewable in their discussion of microphone noise effects (Section 5.6 AREC 2003). To provide a better understanding of the velocity conversions, with m= 0.2 the resultant ratio of 1-m to 80-m wind velocity was 2.4 – the winds at hub-height were 2.4 times that measured at 1-m. For comparison, velocities during stable conditions (e.g., m= 0.41), would be six times greater at hub-height than at ground level.

[4] http://www.inspeed.com/anemometers/Vortex_Wind_Sensor.asp

To assess the accuracy of my anemometer, I conducted a simple field calibration on a windless morning with the anemometer attached to a 2-m pole stretched out the window of my van. I first checked the accuracy of the van's speedometer by measuring time and distance, and then compared a number of speeds from 4.6 – 18.1 m/s. There was close agreement between the anemometer and corrected speedometer (e.g., linear regression y= 9925x, r^2= 0.9925, Fig. 2).

Beginning on September 5, 2007 I used an Olympus D30 digital audio recorder in conjunction with the sound level meter. The recordings were conducted using the monaural SP mode with a 22 kHz sampling frequency and an overall frequency response of 100-8,000 Hz. Each recording file had an elapsed time provision that enabled portions of the recording to be coupled with the corresponding noise level data. I was able to listen to the recordings and establish if turbine sounds were prominent. I also used SEA Wave[5] sound spectrographic analysis software to examine the recordings and identify wind turbine, insects and other sound sources.



[5] SEA Wave – Sound Emission Analysis

Figure 2. ***Relationship of Vortex anemometer wind speed to corrected motor vehicle speed. The anemometer was attached to a 2-m pole extended from the vehicle. The field calibration was conducted when ground level winds were non-existent.***

At the completion of a survey, I downloaded both the noise and wind speed data and created a flat-file database with Microsoft Excel. I used the various plot and statistical functions of Excel to examine different aspects of the noise and wind speed data. The focus of the analysis was on evening and night-time, because these periods have lower background sounds and, consequently, wind turbine noise is potentially more noticeable.

RESULTS

Microphone Noise – All of the noise level data collected at during August-September, 2007 were plotted against wind speeds at 1-m, microphone height in Figure 3. Gross visual inspection shows a fairly flat response from 0-2 m/s, an inflexion point at approximately 2 m/s, and above this point noise increased with wind speed. For wind speeds above 2 m/s, the increases may be due to wind turbines, increased background noise or other sources, but undoubtedly also include wind-induced microphone noise. Without a more rigorous analysis than a gross inspection of the data and to be very cautious, I assumed noise data collected $\leq$ 2 m/s were not contaminated by microphone noise. This limit is markedly less than the general guideline of 5 m/s used by others (AREC 2003, SAEPA 2006, Teague and Foster 2006), but it permits a fairly safe assumption that microphone noise will be minimal. Aside from the noise-time plots for the SW1 and R14 sites, only noise data collected at wind speeds $\leq$ 2 m/s were included in the analyses of noise and wind speed. For subsequent noise/wind speed analyses, wind speeds of the selected data (e.g., $\leq$ 2 m/s @ 1/m) were converted to wind speeds at 80-m heights using a neutral atmosphere profile in order to conform with Atlantic Renewable's predictions (AREC 2003).

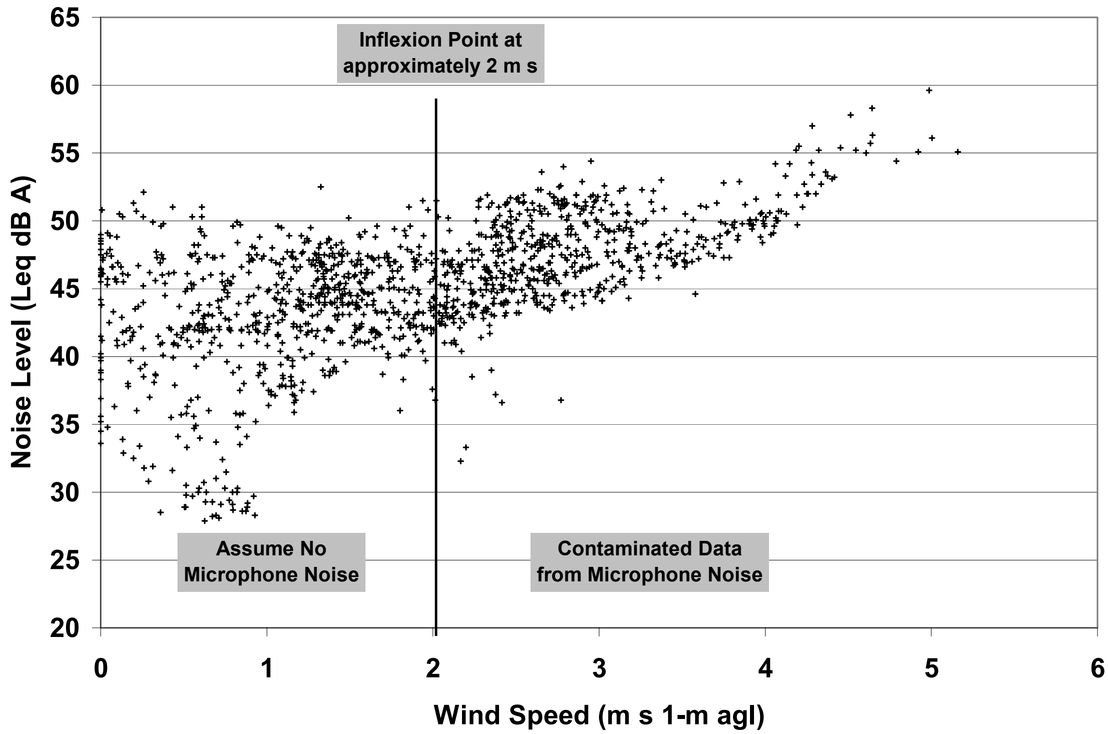


Figure 3. ***Noise levels ($L_{eq,\ 10\text{-}min}$) in relation to wind speeds at microphone level collected at SW1 and R14 monitoring sites at Maple Ridge Wind Farm, August-September, 2007 (n=1,325).***

SW1 Monitoring Site – Between September 19 through 25, 2007, noise levels ($L_{eq,\ 10\text{-}min}$) at SW1 ranged from roughly 30 to 60 dBA, and averaged 43.6 dBA (Figure 4). Wind speed ranged from 0-12 m/s and was generally greater during the day. For a brief period during the early morning of September 20, noise levels dropped below 30 dBA, near background levels, but were never as low for the remainder of the SW1 surveys.

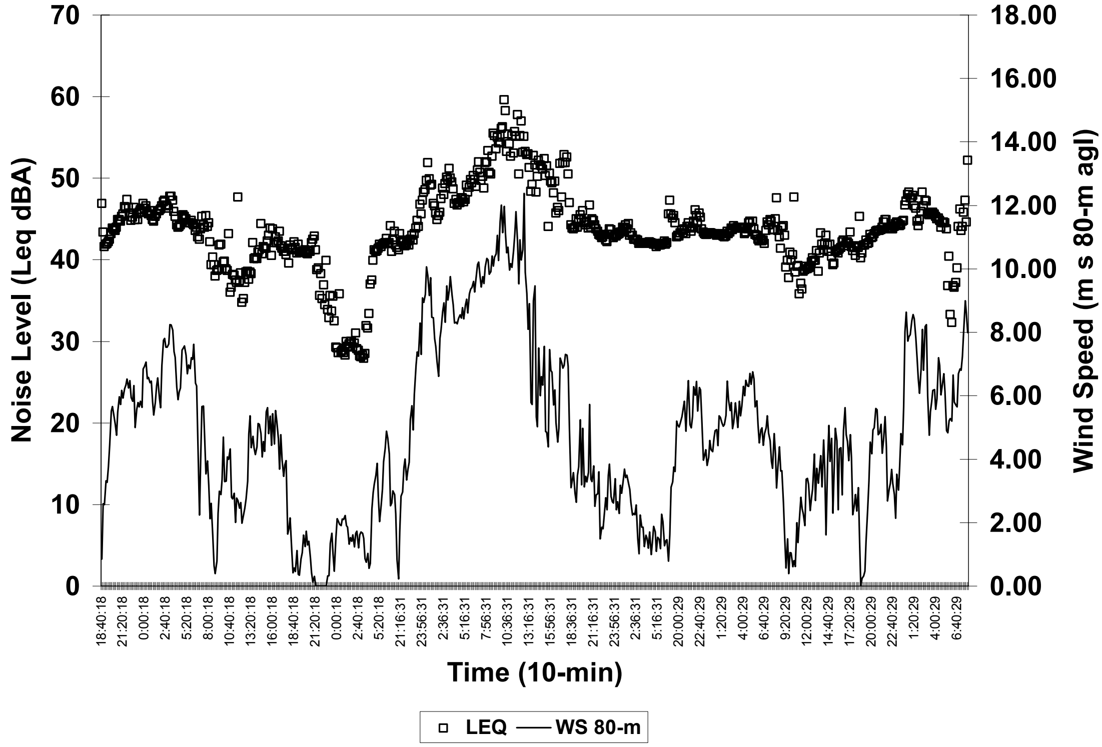


Figure 4. ***Noise ($L_{eq\ 10\text{-}min}$) and wind speed conditions at monitoring site SW1 at Maple Ridge Wind Farm from September 19-25, 2007.***

The noise levels ($L_{eq,\ 10\text{-}min}$) measured at night at SW1 were plotted against selected and converted wind speeds from September 19-25, 2007 (Fig. 5). Included in the plot are Atlantic Renewable's predicted noise impacts for the various 80-m wind speeds associated with cut-in and ¼ power settings (3.0 and 6.4 m/s) for the wind generators. The results are presented in a similar format as that used in their Maple Ridge DEIS (AREC 2003, Appendix C this report). In addition, the average night-time L_{90} background noise was calculated and plotted using the polynomial regressions provided in the Maple Ridge DEIS (AREC 2003).

Above cut-in speed (e.g., $\geq$3.0 m/s), noise estimates ($L_{eq,\ 10\text{-}min}$) were up to 5 dBA above predicted levels and averaged 43.3 dBA; 3.4 dBA above predictions. None fell below the line denoting predicted noise levels.

Below cut-in speed, when wind turbines were expected to be inoperable, there were three groupings of noise data: 1) 54% were above 40 dBA, 2) 25% were below 30 dBA, and 3) 23% were between 30-40 dBA. The dark squares in Figure 5 represent those segments where the digital recordings were examined for the presence of wind turbine sounds. Review of these recordings showed that those above 40 dBA were dominated by wind turbine noise, and averaged 42.5 dBA or 22.6 dBA above the expected background L_{90} level. There was no wind turbine noise for those segments where noise levels were at or below 30 dBA.

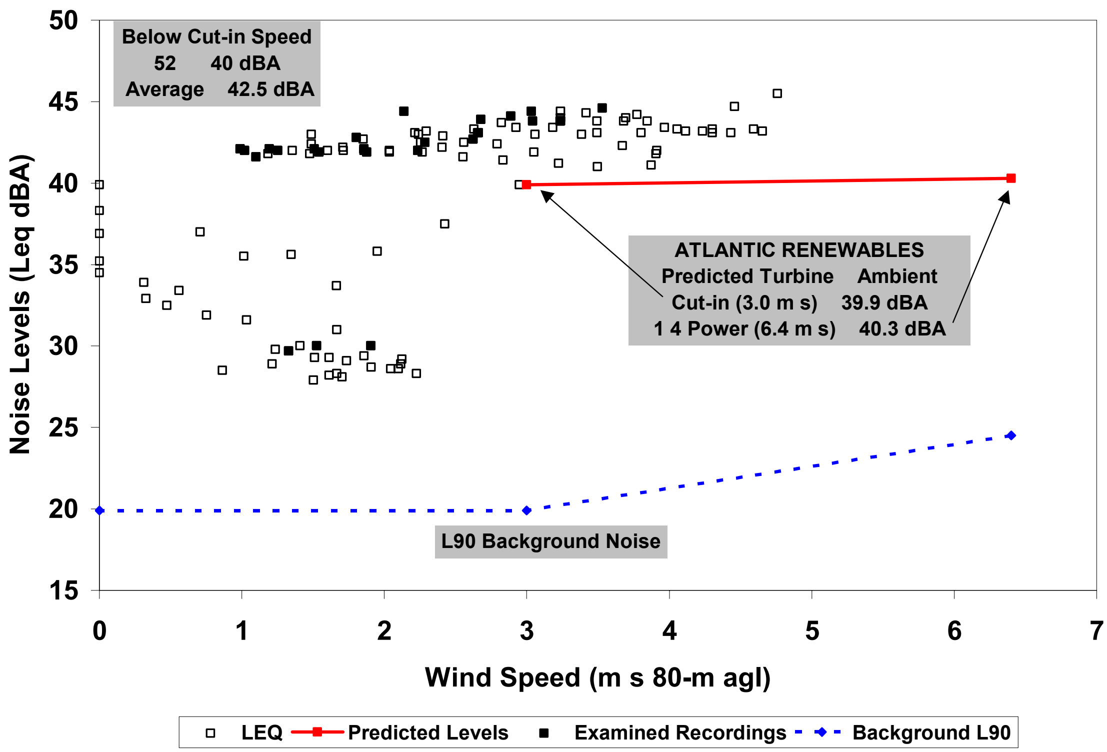


***Figure 5.** Night-time (22:00 – 06:00 hrs.) noise levels ($L_{eq\ 10\text{-}min}$) measured at SW1 monitoring site, Maple Ridge Wind Farm, September 19-25, 2007. Solid line represents the predicted noise from the Maple Ridge DEIS (AREC 2003). The dashed L_{90} background noise was calculated from Atlantic Renewable's regression formulas. Solid squares are those segments where companion digital recordings were examined to establish noise sources.*

R14 Residence – Shortly after this R14 survey was initiated, on the morning of August 27, the $L_{eq,\ 10\text{-}min}$ noise levels dropped to 28.9 dBA, which was presumably near background noise levels (Fig. 6). This level was also preceded by a period of diminished wind velocity, but aside from the drop in noise ($L_{eq,\ 10\text{-min}}$) in the beginning of this survey, noise levels were remarkably consistent, ranging from 40-50 dBA, averaging 46.8 dBA (Fig. 6). This consistency was maintained during both day and night periods and during substantial changes in wind velocity.

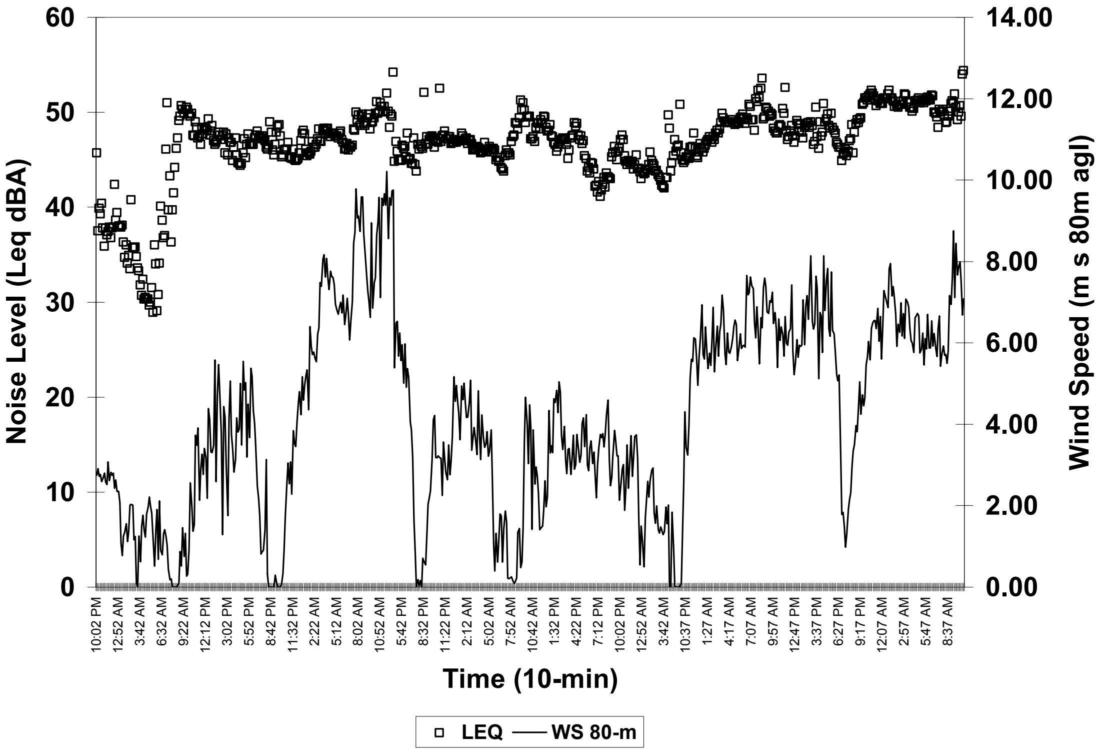


Figure 6. ***Noise ($L_{eq\ 10\text{-min}}$) levels(open squares) and wind speed (solid line) at monitoring site R14 at Maple Ridge Wind Farm from August 27-31, 2007.***

The plot of night-time noise levels on wind speed at R14 was similar to SW1, albeit measured noise exceeded predictions by an even greater amount (Fig 7). Above cut-in speeds noise levels averaged 46.1 dBA, exceeding predicted noise by more than 7 dBA; none of the observed noise values were close to predicted levels. Examination of the few available digital recordings (black squares)[6] showed that the noise above cut-in wind speeds was comprised of both wind turbine and insect noise. Higher noise at R14 compared to SW1 was likely attributable to insects, since insect sounds were not well-defined in the SW1 recordings.

[6] Use of the digital recorder began after most of the R14 survey was completed.

Below cut-in speed 54% of the noise segments were above 40 dBA (equivalent to the predicted noise at cut-in), 42% were between 30-40 dBA, and 4% were at or below 30 dBA. Fewer noise levels were less than 30 dBA compared to SW1 (25%), and again, this was most likely related to prominent insect noise at R14.

The Maple Ridge DEIS used background levels observed at the R3 monitoring site as a surrogate to measuring background levels at R14 (AREC 2003). Compared to the average R3 L_{90} background noise below cut-in speed (e.g., 25.8 dBA), wind turbine noise at R14 was 18.9 dBA louder than expected.

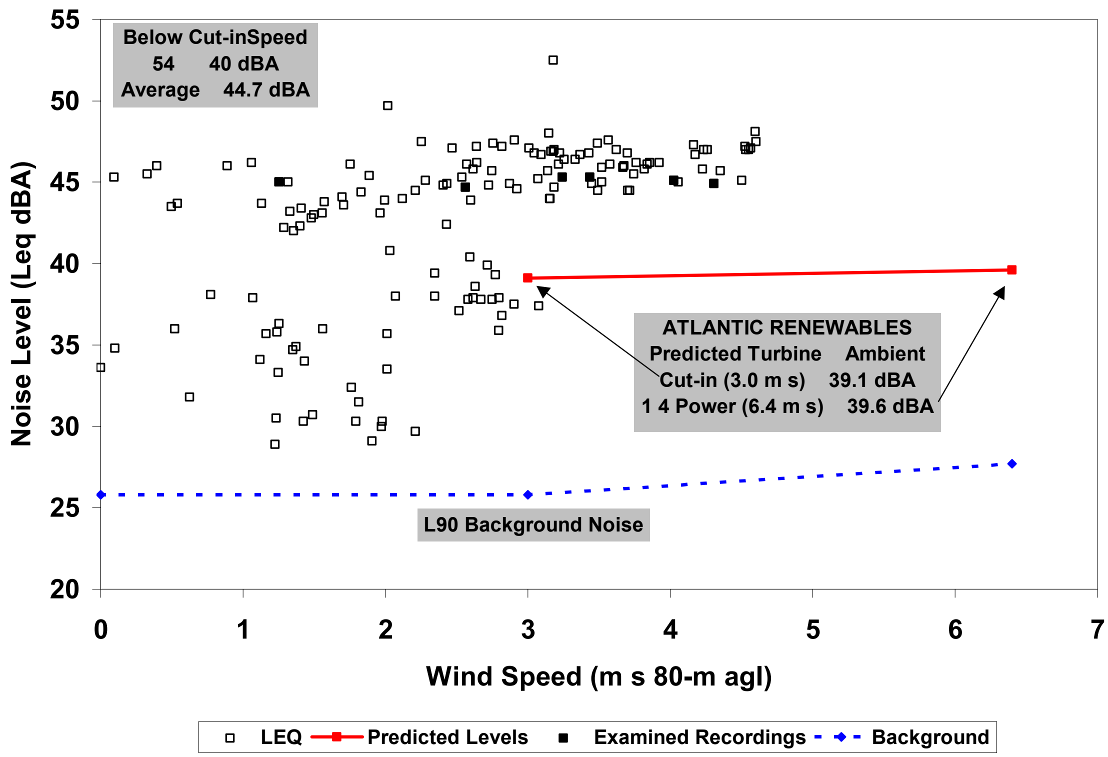


Figure 7. ***Night-time (22:00 – 06:00 hrs.) noise levels ($L_{eq\ 10\text{-}min}$) measured at R14 monitoring site, Maple Ridge Wind Farm, August 27-31, 2007. Solid line represents the predicted noise from the Maple Ridge DEIS (AREC 2003). The dashed L_{90} background noise was calculated from Atlantic Renewable's regression formulas. Solid squares are those segments where companion digital recordings were examined to establish noise sources.***

Evenings and Atmospheric Stability – During the evening at Maple Ridge, when I was setting up the equipment for the noise surveys, I noticed that ground conditions were very calm, yet nearby wind turbines were operating and their noise was very noticeable. I expected this example of stable atmospheric conditions at night, but was surprised it was so obvious late in the day, too. Consequently, I examined a subset of the daytime data from 17:00 to 22:00 hrs looking for evidence of atmospheric stability and elevated noise. The $L_{eq,\ 10\text{-min}}$ noise levels for the evening period of both SW1 and R14 surveys are plotted in Figure 8. Although Atlantic Renewable provided no noise predictions for wind turbines operating in evening, I used their daytime predicted noise levels for SW1 as a surrogate and reference (actually evening background levels and predictions would probably be lower because evenings seem quieter than daytime). Above cut-in speeds (e.g. 3 m/s) the observed noise exceeded daytime predictions for all segments, both at SW1 and R14, similar to what was observed during night-time. Again, elevated noise levels were prevalent below cut-in speeds, as well, i.e., all but three segments were above the 40 dBA level.

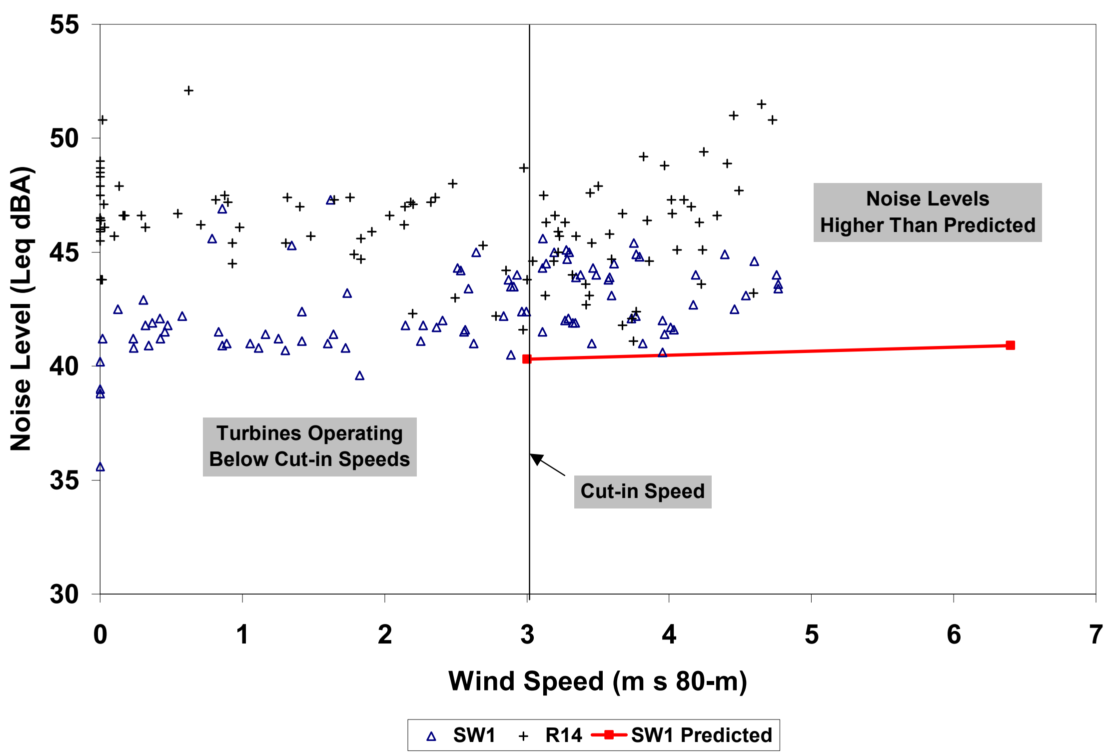


Figure 8. ***Relationship of noise level (Leq, 10-min) to wind speed for EVENING HOURS (17:00 – 22:00 hrs) at the SW1 and R14 sites at the Maple Ridge Wind Farm, August and September, 2007.***

DISCUSSION

Microphone noise contamination of background noise surveys is an issue that has received a lot of attention and criticism. It was a major concern in this study, as well. In an effort to remove any possibility of wind-induced microphone noise contamination, all of the data associated with wind speeds in excess of 2 m/s were purged -- 65% of the 1,325 noise and wind speed data were removed. The 2 m/s cut-off was far more restrictive than the 5 m/s upper limit used by Atlantic Renewable and recommended by others (Teague and Foster 2006). The effect of this more cautious approach, however, was to greatly reduce the potential for wind-induced contamination of the noise data, and thereby ensure better, more reliable noise data.

Atlantic Renewable stated in their DEIS (AREC 2003) that their impact assessment is "... likely a worst-case assessment of the noise impact from the proposed wind farm." This was clearly not the case, however. For winds above generator cut-in speed, average noise exceeded predicted impacts by 3.4 to 7.0 dBA for SW1 and R14, respectively. The decoupling of ground level winds from higher level winds, i.e., atmospheric stability, was apparent in the noise data at both sites during evening and night-time periods. Below cut-in speeds, when wind turbines were supposedly inoperative, noise levels were 18.9 and 22.6 dBA above the expected background levels for R14 and SW1, respectively. Moreover, below cut-in speed the majority of these observations (average 53%) exceeded the predicted noise for cut-in wind speed.

It is apparent that Atlantic Renewable missed or avoided a very important potential impact of wind farm noise. Although they went through the required second level analysis outlined in the NYSDEC noise policy (NYSDEC 2001), they failed to predict a 20+ dBA noise impact in calm conditions that is deemed by the NYSDEC as "very objectionable to intolerable." NYSDEC policy further states, *"When the above analyses indicate significant noise effects may or will occur, the applicant should evaluate options for implementation of mitigation measures that avoid, or diminish significant noise* *effects to acceptable levels."* Atlantic Renewable should have done more to mitigate the impacts of atmospheric stability.

Not only did Atlantic Renewable fail to consider noise impacts related to atmospheric stability, but also, they mislead when they stated, "*However when the wind speed is low, a wind turbine will not operate and as such, no noise impact will occur* [AREC 2003]. This is true at hub-height, since wind turbines need wind to operate, but it is not the case at ground level where people live. The results of this study refute any insinuation or suggestion by developers that noise will not be a problem when the wind is not blowing, and these results are also compatible with other studies documenting the effects of atmospheric stability (van den Berg 2003, 2004, 2005 and 2006). Contrary to the assertions of Atlantic Renewable, wind turbines can operate without wind. The key to this contradiction is to better understand atmospheric conditions.

The reason why wind turbines appeared to be operating below cut-in speeds is because estimates of hub-height (80-m) wind velocity were erroneous. Typically, developers use a neutral atmospheric profile to convert wind speeds from one height to another. I used the same neutral atmosphere wind profile as Atlantic Renewable to calculate 80-m wind speeds, but it was apparent the evening and night-time meteorological conditions at this time at Maple Ridge were typically stable; not neutral. Therefore, Atlantic Renewable's use of a neutral atmospheric profile to estimate microphone level noise from 80-m tower height winds would have substantially underestimated the actual wind velocity. This in turn would indicate that microphone noise contamination was a bigger problem in their original background noise study than they had previously thought, i.e., they overestimated background noise.

Therefore, because atmospheric stability is such a prevalent condition, in modeling noise impacts Atlantic Renewable and other developers need to consider stable atmospheric profiles and not limit their analysis to neutral conditions. Furthermore, with all the years of study of the winds at these proposed wind farm project sites, it is difficult to believe that developers do not fully understand the extent of atmospheric stability, temperature inversions and other meteorological phenomena. Also, these issues are far more important today, because modern wind turbines are considerably taller than earlier versions, and hence, there will be greater disparities between ground and hub-height wind speeds. The noise consultant to Atlantic Renewable at Maple Ridge recently completed a noise survey of a gas-fired electric generation facility in New South Wales Australia and noted: *The wind speed profile with height can also have an influence on the propagation of noise from the source to the receiver. When there is a significant increase in wind speed with height, the sound emitted to the atmosphere by the source undergoes refraction back towards the surface. This can cause a significant increase in the sound propagation to receptor locations downwind of the source* (Hayes McKenzie APW 2007). They went on to indicate the effects of atmospheric stability can increase noise by 5-10 dBA and that the direction of the wind had a substantial influence on the noise perceived at nearby residences. It is apparent developers know about the impact of atmospheric stability, and they undoubtedly know how frequently it occurs, too.

Given the inaccuracies of Atlantic-Renewable's predictions, the obvious question is how could their predictions be so far off the mark[7], especially when Atlantic Renewable's predictions supposedly represent a worst-case scenario? At first glance, we might wonder if the developer substituted a different wind generator from what was described in their DEIS, one that had a higher source level. Atlantic Renewable's noise predictions were based on an A-weighted source level of 103.3 dBA at rated power. Another make or model could increase source levels by about 3 dBA, enough to explain some of the discrepancies in their predictions. I also know there were some apparent problems with the tips of the wind turbine blades, and I saw technicians working on the wind turbine blade tips. Since most of the aerodynamic noise is generated at the blade tips, possibly modifying the blade tips could have altered the noise characteristics of the wind turbines, thereby increasing wind turbine aerodynamic noise. On the other hand, I did not see any maintenance activity associated with wind turbines close to SW1 or R14.

[7] The dBA difference between predicted and measured levels may seem small, but noise is measured in a logarithmic, not linear scale.

Another possible explanation might be the selection of an inappropriate noise propagation model. Teague and Foster (2006) noted: *The CONCAWE model overpredicted relative to the other models (by about 1 dB relative to Nord2000, by about 4 dB relative to GPM*[8] *and by up to 6 dB relative to ISO9613*." The ISO9613 model was used by Atlantic Renewable for Maple Ridge assessments, and compared to the others appears to underestimate predicted impacts. Furthermore, the accuracy of the ISO9613 protocol is +/-3 dBA, without considering reflected sounds, and it is not recommended for source levels higher than 30m (ISO 1996).

Using appropriate models properly configured is not only an issue for Atlantic Renewable, but it should be important for all wind power developers in New York State because they all use the same ISO9613 model to predict noise impacts. Teague and Foster (2006) warn, *The application of modeling software to specific situations needs to be carefully considered and, where possible, based on validations with actual measurement data to provide confidence and minimize associated inaccuracies.* As noted earlier, there have been no model validation studies for any of the New York wind farm projects to date, and it is obvious from the results of this study that compliance surveys represent a critical need.

Reviewing agencies, planning board members and the general public need to be aware of misleading claims that modeled noise predictions represent worst-case conditions. A true worst-case scenario should include winter, night-time L_{90} background levels modeled under stable atmospheric conditions, using a conservative, appropriate noise propagation model.

What about Cape Vincent and other communities that are now faced with evaluating environmental assessments by developers who may make many of the same assumptions, claims and predictions as Atlantic Renewable at Maple Ridge, what should they do? The following suggestions may help us all do a better job of assessing noise impacts from proposed wind farms in New York:

---

[8] General Prediction Model, Nordic.

- The first step should be a validation of the results in this study. I do not claim to be an acoustic consultant or engineer. Consequently, a small study should be undertaken quickly to confirm or refute these results. The consultant hired to do the work should be independent of any developer, preferably accountable only to NYSDEC.
- If the validation study confirms my results, the NYSDEC should make a strong recommendation in their comments to lead agencies to delay issuing any new permits (e.g., a moratorium) for wind farms until a more comprehensive assessment can be undertaken of all the operating wind farms in New York. Again, the comprehensive study should be done by professionals who are independent from commercial wind power developers, accountable only to the NYSDEC.
- Because atmospheric stability can have a profound effect on wind turbine noise, municipal planning boards should require developers to submit wind velocity data in order to establish the incidence of atmospheric stability at each proposed wind farm site. These summaries should include hourly averages of wind speed at different heights above ground level, along with ratios of velocity, e.g., 1-m:80-m. This should be completed for a recent calendar year.
- I was fortunate that atmospheric stability was such a common event at Maple Ridge. It allowed me to assess wind turbine noise impacts with little or no wind-induced microphone noise from ground-level winds. Because wind-induced noise is such a serious problem with assessing wind farm noise impacts, this approach of focusing on a compliance survey using night-time and evening periods minimizes potential microphone noise contamination. Van den Berg (2006) makes the same point, *...to reduce wind induced sound, it helps to measure over a low roughness surface and at night (stable atmosphere), as both factors help to reduce turbulence, even if the (average) wind velocity on the microphone does not change.*
- From my experience to date, I believe the wind power industry can do a better job predicting wind turbine noise impacts, in spite of the results from this study.

However, running models, predicting noise impacts and comparing them to standards is not sufficient. As any traffic cop knows, posting a speed limit does not guarantee all drivers will comply – you need enforcement, too. Wind power developers will do a much better job predicting impacts if they understand that post-operational noise surveys will be done, and if they exceed their predictions then operational restrictions will be imposed, such as a shut down of wind turbines during stable atmospheric conditions.

- NYSDEC should take a more involved and active role in reviewing noise impacts. Their comments to date focused primarily on bird and bat issues with few comments directed to wind turbine noise. NYSDEC needs to get more involved with noise issues.
- For those non-participating residents within the bounds of existing wind farms, depending on the results of the comprehensive review, it may be appropriate to find some means to mitigate excessive noise, i.e., additional payments and/or shutting down wind turbines during periods of stable atmospheric conditions.

Acknowledgements

I especially want to thank Judith and John Waligori and Rick Beyers for permitting me to use their property for my study. I also appreciate the helpful suggestions provided by Richard Bolton and Charles Ebbing.

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Appendix A Background Experience:

I graduated from Cornell University in 1965 and began work with the New York State Department of Environmental Conservation Department as a fishery biologist. Between 1967 and 1970 I served with the U.S. Marine Corps as an electronics technician. I completed over nine-months of technical schooling that included basic electronics, radio theory and repair, and cryptographic training. In addition, I also completed an intensive U.S. Air Force program in the calibration and repair of electronic test equipment. As a Marine electronics tech I worked in a calibration lab for over a year, and for the remainder of my service time I oversaw a radio repair facility at a Marine Airbase in Hawaii. After my service commitment was completed I returned to my job as a biologist working at the Cape Vincent Fisheries Station. In 1978, I completed a short-course on Hydroacoustic Fish Stock Assessment at the Applied Physics Lab at the University of Washington. During my work with hydroacoustics I became familiar with source levels, noise propagation losses and other acoustic principles. In 1980, I also attended a workshop at the University of British Columbia that focused on simulation modeling of biological systems, which provided some insight into the development and use models to help guide the management of fisheries resources. In the course of my 34 year career I have been an author in more than 25 peer-reviewed journal reports. The last task I completed for the NYSDEC was to lead an investigation of Double-crested Cormorant impacts on fish populations in Lake Ontario. I retired in 1999 as the Lake Ontario Unit Leader at NYSDEC's Cape Vincent Fisheries Station.

Appendix B Maple Ridge DEIS Data

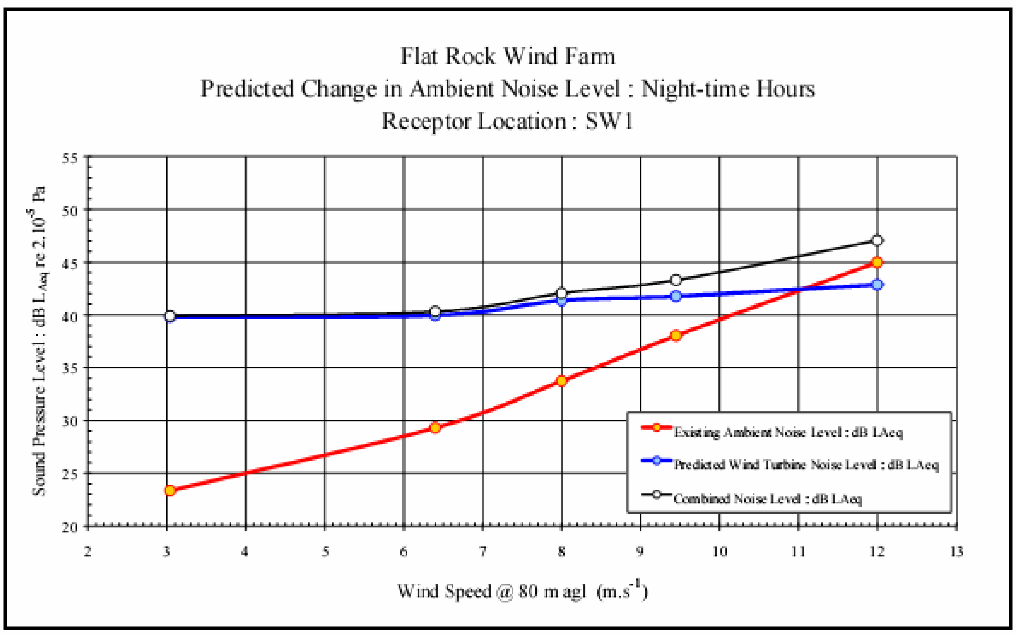
Flat Rock Wind Farm : Noise Impact Assessment

Appendix 7 : Predicted Change In Ambient Noise Levels

Night-time Predicted Change in Ambient Noise Levels			Predicted Wind Turbine LAeq					Source Measurement Location Background Noise Level ID	Existing Ambient Noise Level					Predicted New Ambient Noise Level					Predicted Change in Ambient Noise Level				
Dwelling Name	Dwelling Type	Participant	Cut-in	1/4 Power	1/2 Power	3/4 Power	Rated Power		Cut-in	1/4 Power	1/2 Power	3/4 Power	Rated Power	Cut-in	1/4 Power	1/2 Power	3/4 Power	Rated Power	Cut-in	1/4 Power	1/2 Power	3/4 Power	Rated Power
R12	Residence	Y	38.4	38.6	40.0	40.4	41.5	R3	28.2	31.1	34.7	38.8	46.7	38.8	39.3	41.1	42.7	47.9	10.7	8.2	6.4	3.9	1.1
R13	Residence	N	38.7	38.9	40.3	40.7	41.8	R3	28.2	31.1	34.7	38.8	46.7	39.1	39.5	41.3	42.9	47.9	10.9	8.4	6.6	4.0	1.2
R14	Residence	N	38.7	38.9	40.3	40.7	41.8	R3	28.2	31.1	34.7	38.8	46.7	39.1	39.6	41.4	42.9	48.0	11.0	8.5	6.7	4.1	1.2
R15	Residence	N	37.5	37.7	39.1	39.5	40.6	R3	28.2	31.1	34.7	38.8	46.7	37.9	38.5	40.4	42.2	47.7	9.8	7.4	5.7	3.3	0.9
R16	Garage	N	36.2	36.4	37.8	38.2	39.3	R3	28.2	31.1	34.7	38.8	46.7	36.8	37.5	39.5	41.5	47.5	8.6	6.4	4.8	2.7	0.7
R17	Residence	Y	35.1	35.3	36.7	37.1	38.2	R3	28.2	31.1	34.7	38.8	46.7	35.9	36.7	38.8	41.1	47.3	7.7	5.6	4.1	2.2	0.6
R18	Residence	Y	34.3	34.6	36.0	36.4	37.5	R3	28.2	31.1	34.7	38.8	46.7	35.2	36.2	38.4	40.8	47.2	7.1	5.1	3.7	2.0	0.5
R19	Seasonal	Y	34.5	34.7	36.1	36.5	37.6	R3	28.2	31.1	34.7	38.8	46.7	35.4	36.3	38.5	40.8	47.2	7.2	5.2	3.8	2.0	0.5
R20	Seasonal	N	33.2	33.6	35.0	35.4	36.5	R3	28.2	31.1	34.7	38.8	46.7	34.4	35.5	37.8	40.4	47.1	6.2	4.4	3.1	1.6	0.4
R21	Seasonal	Y	32.9	33.2	34.6	35.0	36.1	R3	28.2	31.1	34.7	38.8	46.7	34.1	35.3	37.7	40.3	47.1	6.0	4.2	2.9	1.5	0.4
R22	Seasonal	Y	36.4	36.6	38.0	38.4	39.5	R3	28.2	31.1	34.7	38.8	46.7	37.0	37.7	39.6	41.6	47.5	8.8	6.5	4.9	2.8	0.7
SW1	Rental	Y	39.8	40.0	41.4	41.8	42.9	SW1	23.4	29.3	33.7	38.0	45.0	39.9	40.3	42.0	43.3	47.1	16.5	11.0	8.3	5.3	2.1
SW2	Rental	Y	39.5	39.7	41.1	41.5	42.6	SW1	23.4	29.3	33.7	38.0	45.0	39.6	40.1	41.8	43.1	47.0	16.3	10.8	8.1	5.1	2.0
FR1	Residence	Y	37.7	37.9	39.3	39.7	40.8	FR2	21.4	30.1	36.1	41.3	48.6	37.8	38.6	41.0	43.6	49.3	16.4	8.5	4.9	2.3	0.7
FR2	Residence	N	39.9	40.0	41.4	41.8	42.9	FR2	21.4	30.1	36.1	41.3	48.6	40.0	40.5	42.5	44.6	49.6	18.5	10.4	6.5	3.3	1.0
FR3	Rental	Y	40.6	40.8	42.2	42.6	43.7	FR2	21.4	30.1	36.1	41.3	48.6	40.7	41.1	43.1	45.0	49.8	19.2	11.1	7.1	3.7	1.2
FR4	Rental	Y	39.7	39.9	41.3	41.7	42.8	FR2	21.4	30.1	36.1	41.3	48.6	39.8	40.3	42.4	44.5	49.6	18.4	10.2	6.4	3.2	1.0
FR5	Rental	Y	42.5	42.7	44.1	44.5	45.6	FR2	21.4	30.1	36.1	41.3	48.6	42.6	43.0	44.8	46.2	50.4	21.1	12.9	8.7	4.9	1.8
FR6	Seasonal	N	37.6	37.8	39.2	39.6	40.7	FR2	21.4	30.1	36.1	41.3	48.6	37.7	38.5	40.9	43.5	49.3	16.3	8.4	4.9	2.3	0.7
FR7	Bar/ Restaurant	N	35.7	35.9	37.3	37.7	38.8	FR2	21.4	30.1	36.1	41.3	48.6	35.8	36.9	39.7	42.9	49.0	14.4	6.8	3.7	1.6	0.4
RO1	Seasonal	N	37.7	37.9	39.3	39.7	40.8	R3	28.2	31.1	34.7	38.8	46.7	38.2	38.7	40.6	42.3	47.7	10.0	7.6	5.9	3.5	1.0
RO2	Seasonal	N	36.6	36.8	38.2	38.6	39.7	R3	28.2	31.1	34.7	38.8	46.7	37.2	37.8	39.8	41.7	47.5	9.0	6.7	5.1	2.9	0.8
RO3	Seasonal	N	34.0	34.3	35.7	36.1	37.2	R3	28.2	31.1	34.7	38.8	46.7	35.0	36.0	38.2	40.7	47.2	6.9	4.8	3.5	1.8	0.5
RO4	Seasonal	Y	37.4	37.6	39.0	39.4	40.5	R3	28.2	31.1	34.7	38.8	46.7	37.8	38.4	40.3	42.1	47.7	9.7	7.3	5.6	3.3	0.9
O1	Residence	Y	32.3	32.7	34.1	34.5	35.6	SW1	23.4	29.3	33.7	38.0	45.0	32.9	34.3	36.9	39.6	45.5	9.5	5.0	3.2	1.6	0.5
O2	Residence	Y	37.4	37.6	39.0	39.4	40.5	SW1	23.4	29.3	33.7	38.0	45.0	37.6	38.2	40.1	41.8	46.3	14.2	8.9	6.4	3.7	1.3

Flat Rock Wind Power LLC Page 14 of 16 / Appendix 7 Hayes McKenzie Partnership

Appendix 7 Flat Rock Wind Farm Change in Ambient Noise Levels.doc



Example of Maple Ridge DEIS predicted impacts for SW1 Receptor.

Appendix C

Page 1 of

Certificate of Calibration

Certificate No: CD8020047

Submitted By: CLIF SCHNEIDER
1560 VINCENT STREET
CAPE VINCENT, NY 13618

Serial Number: CD8020047
Customer ID:
Model: 2900 SLM
Test Conditions:
Temperature: 18°C to 29°C
Humidity: 20% to 80%
Barometric Pressure: 890 mbar to 1050 mbar

Date Received: 4/17/2007
Date Issued: 4/17/2007
Valid Until: 4/17/2008
Model Conditions:
As Found: IN TOLERANCE
As Left: IN TOLERANCE

SubAssemblies:
Description: MICROPHONE QE 7052 1/2 IN. ELECTRET
Serial Number: 12026

Calibrated per Procedure: 56V996

Reference Standard(s):

I.D. Number	Device	Last Calibration	Date Calibration Due
ET0000523	B&K / QUEST ENSEMBLE	6/15/2006	6/15/2007

Measurement Uncertainty:
+/- 3.6% ACOUSTIC (0.3DB) +/- 1.4% VAC +/- 0.1% VDC
Estimated at 95% Confidence Level (k=2)

Calibrated By: Paul M. Wegmann 4/17/2007
PAUL WEGMANN Service Technician

This report certifies that all calibration equipment used in the test is traceable to NIST, and applies only to the unit identified under equipment above. This report must not be reproduced except in its entirety without the written approval of Quest Technologies.

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