STATE OF NEW HAMPSHIRE
SITE EVAULATION COMMITTEE

RE: Application of Antrim Wind, LLC for Certificate of site and facility to construct up to 28.8 MW of wind electric generation in the town of Antrim, Hillsborough County, New Hampshire and operate the same (SEC Docket 2015-02).

PREFILED TESTIMONY OF RICHARD R. JAMES
PREPARED ON BEHALF OF ANTRIM RESIDENT, JANICE LONGGOOD

1. Please state your name and business address.

My name is Richard R. James. My business address is E-Coustic Solutions, P.O. Box 1129, Okemos, Michigan, 48805, USA.

2. Who is your current employer and what position do you hold?

I am the Owner and Principal Consultant for E-Coustic Solutions LLC, of Okemos, Michigan, USA. I have been a practicing acoustical engineer for 45 years.

3. What is your background and qualifications?

Attached is a narrative of my career experience as it relates to acoustics, noise control engineering, and the application by Antrim Wind, LLC before the New Hampshire Site Evaluation Committee. A summary of my wind related projects and testimony is also provided in Exhibit JL-RJ-1.

I have been actively involved in acoustics, noise measurement and control, and with the Institute of Noise Control Engineers (INCE) since I started my career in the early 1970s. I currently have Member Emeritus status in INCE. My clients include, or have included, many large manufacturing firms, such as, General Motors, Ford, Goodyear Tire & Rubber, and others who have operations involving both community noise and worker noise exposure. This included facilities located in Canada, Mexico and Europe. In addition, I have worked for many small companies and private individuals.

My academic credentials include appointments as Adjunct Professor and Instructor to the Speech and Communication Science Departments at Michigan State University (through 2013) and Central Michigan University (through 2017). Specific to wind turbine noise, I have worked for clients in the U.S., Canada, and New Zealand and collaborated with other acousticians on projects in those and many other countries.

I have provided written and oral testimony in approximately 30 of those cases. I have authored or co-authored four papers covering topics from how to set criteria to protect public health, demonstrating that wind turbine sound emissions have both audible and inaudible characteristics and are predominantly comprised of infra and low frequency sound. One paper provides a historical review of other types of noise sources with similar sound emission characteristics to wind turbines that have known adverse health effects on people exposed to their sound.

The documents are current through January, 2016. No significant changes have occurred since that time. Copies of publications are available upon request.

4. Have you participated in proceedings in the State of New Hampshire before?

Yes. I appeared before the NH Site Evaluation Committee as a witness for Loranne and Richard Block in Docket 2012-01. At that time, the Committee was considering an earlier application submitted by Antrim Wind, LLC for the same project area. I was also active in the New Hampshire stakeholder process to develop draft rules for the safe siting of wind energy facilities in the state.

5. What is the purpose of your testimony?

I have been engaged by Ms. Janice Longgood, of 156 Salmon Brook Road in Antrim, NH to review all testimony relevant to the noise studies and predictive sound modeling conducted by the Applicant and provide oral and written testimony on those materials.

6. Can you explain the Daubert Standard and why it is relevant to your testimony?

Yes. During a court proceeding in the State of Michigan, I was engaged to provide expert testimony pertaining to wind turbine noise emissions and their impact on the plaintiffs . My qualifications to provide opinions on wind turbine noise measurement and its impact on people were challenged by the defendant's attorneys under the US Supreme Court's Daubert Rules. This process is intended to prevent what might be characterized as junk science being used as expert testimony. After an extensive hearing the Court found that I had satisfied the requirements under the Daubert Standard to provide expert testimony regarding acoustics, including measurement of wind turbine noise, and the health effects of wind turbine noise on the plaintiffs. While my testimony in this Docket focuses on concerns I have with the noise studies submitted for this project, I am prepared to answer questions related to health impacts based on my experience with people experiencing those impacts as an acoustician.

7. What material was consulted prior to this review?

I was provided a copy of the pre-filed sound report and updated pre-filed sound report prepared by Epsilon Associates, Inc. on behalf of the Applicant entitled "Sound Level Assessment Report, Antrim Wind Energy Project." The two documents are dated June 8, 2015 and February 17, 2016 respectively. It is my understanding that the February 17, 2016 updated sound report was prepared in response to the New Hampshire Site Evaluation Committee's newly adopted rules governing wind energy siting. In addition to reviewing the Epsilon reports, I also reviewed the prefiled testimony of Mr. Robert O'Neal, responses to written data requests pertaining to turbine noise emissions as well as Epsilon Associates sound report, and testimony filed with the Committee under Docket 2012-01. Finally, I also read the NH SEC rules pertaining to wind turbine noise standards.

8. Do you have any comments regarding the report and testimony of Mr. O'Neal and Epsilon Associates?

Yes, I found a number of deficiencies in the report and testimony presented by Mr. O'Neal and Epsilon Associates.

9. What are those deficiencies?

They are:

a. The background sound study conducted by Epsilon used improper locations for the test instruments and testing protocols that do not meet the requirements for outdoor testing required by the New Hampshire SEC regulations. These require that the tests conducted by Epsilon meet the requirements set by ANSI/ASA S12.9-2013 Part 3 for short-term attended measurements or ANSI S12.9-1992 (R2013) for long-term unattended monitoring.

   According to the Epsilon report, the sounds collected during the monitoring period included transient noises described as "traffic", "diesel powered equipment", "dogs barking", "birds chirping", "water noise", "wind noise", "rustling vegetation" and "guns shooting," which were not removed from the measured data as required by the

ANSI standard S12.9 Part 3 for determining background sound levels. Instead, all are mentioned as being included in the report's graphs and charts.

There is no information in the report regarding the location or direction of the sounds, the time when the sounds occurred, their duration, or the distance relative to the measuring equipment or homes. Such descriptive information should have been included with the report as required by the ANSI standards to validate the test protocols and resulting measurements. The particular improprieties result in mischaracterization and overstatement of the background sound levels for properties adjacent the wind turbine project's footprint.

b. Further, the sound propagation modeling presented by Epsilon used as the basis for conclusions by Mr. O'Neal under-estimates the sound levels that will be received on the properties and at homes adjacent to the wind turbine facility. The sound propagation modeling software used for the sound models is a general purpose model designed for modeling noise from common urban noise sources like industrial plants, roads, and railways that are located on flat land with the noise source close to the ground, not wind turbines located on ridges. The model also only represents how sound propagates during weather conditions that are essentially calm winds which do not represent the weather and wind conditions during which wind turbines produce the most noise and that noise propagates the furthest. The model has been used for predicting turbine noise propagation with some success provided the outputs appropriately consider the limitations of the model and apply necessary correction factors for tolerances. The model results presented by Epsilon do not include those corrections for tolerances or for weather conditions other than calm winds.

c. The Sound Power data used in the sound propagation models does not represent the noise produced by wind turbines during weather and operating conditions that are commonly associated with sleep disturbance and annoyance. The IEC 61400.11 test standard used as the source of Epsilon's modeling data represent wind turbine noise emissions for mild wind shear and turbulence conditions that do not cause these higher noise emissions.

That covers my primary concerns about these topics based on my review.

10. According to the NH Site rules 301.18(a)(1) and 301.18(a)(2) background noise studies are to be conducted in accordance with either ANSI/ASA S12.9-2013 Part

3 or ANSI S12.9-1992 Part 2 (R2013). Can you provide some examples of ANSI requirements that were not met by Epsilon's background noise study?

Yes, I will start with a general explanation to help put the standards in perspective.

First, the locations selected by Epsilon are not representative of the places that would be appropriate to assess for background sound levels representing the community's expectations of quiet property, such as, people's back yards. Photographs in the report show the instruments located near trees and vegetation which create localized high noise sites. Other information informs us that roads and other noise sources were near the test sites. These are not proper for evaluating background noise. The sites should represent the sounds in the vicinity of homes such as their backyards.

Second, the test data was not properly screened to remove artifacts that are specifically prohibited by ANSI test standards. Test locations were near reflecting objects, trees, shrubs and other vegetation, and/or situated near high noise areas such as roads, driveways or sites near human activity such as logging. Locations sites near vegetation also causes artifacts due to localized high noise from "leaf" rustle. Test data was collected during periods when transient background sounds were present and those samples were not excluded from the reported results. Test data was included from periods when weather conditions such as precipitation, or with wind sufficient to produce leaf rustle and other sounds, or to produce pseudo-noise due to wind screen limitations. All of this should have been excluded from reported results.

Third, much of the Epsilon report focuses on metrics other than the nighttime L_{90} test data. While the NH SEC rules require that metrics such as L10, and Leq are reported the formatting of the report does not make it clear that the continuous background sound levels were extremely low. Focusing on extraneous material obfuscates the findings that the continuous background sound levels (L_{A90}) at <u>all</u> test sites are less than 20 dBA. The focus should have been on the L_{A90} measurements as they are the basis for both the NH SEC rules and the ANSI/ASA standards assessment of pre-operational continuous background sound levels.

More specifically, standards for conducting background sound level tests are provided in ANSI S12.9 Part 3 and Part 2. They include requirements, such as:

a. ANSI/ASA S12.9 Pt. 3, Section 3.1 defines background sound as: "all-encompassing sound associated with a given environment without contributions from the source or sources of interest." For utility scale wind turbine projects the source or sources of interest are the proposed wind turbines whether operating or in the design and proposal stage of development. The standard then differentiates between the two types of background sounds:

i. "NOTE 1 In this standard, background sound is described as a combination of (1) continuous background sound, and (2) transient background sounds, with the durations for continuous and transient defined according to application and situation. Continuous relates to the constant nature of the background, not to any measurement duration."

A measure of the continuous background sound is the sound pressure level present 90% of the time specified as L_{90} for each frequency band, or overall sound level with the associated filter weighting as in L_{A90}. ANSI/ASA S12.9 Pt 3, Section 6.6 (3): "…use of the L_{90} will automatically remove transient background sounds from the result."

b. ANSI/ASA S12.9 Pt 3, Section 3.2 continuous (long term) background sound is the "background sound measured during a measurement period specified in this Standard, after excluding the contribution of transient background sounds in accordance with one of the methods specified in this standard."

c. ANSI/ASA S12.9 Pt. 3, Section 3.3 transient (short term) background sound level is defined as: "background sound associated with one or more sound events which occur infrequently during the basic measurement period, a measurement interval with or without the source operating, and measured in accordance with one of the methods in this standard." This is further explained in:

   i. NOTE The sound exposure level and time of occurrence of transient background sounds cannot be described statistically during the basic measurement period. Examples of transient background sounds include sounds from such sources as a nearby barking dog, accelerating motor vehicle, radio music, siren, or an aircraft flyover, etc.

d. ANSI/ASA S12.9 Pt. 3 Section 3.5, corrected measurement period equivalent-continuous sound pressure level is defined as: "Measurement period data which has been corrected for transient background sound by the transient sound having been inhibited from being collected with or having been removed from the measurement period data."

e. ANSI S12.9 Pt 3, Section 5. Background sound states: "The measurement procedures described herein provide a systematic method to remove the effects of transient background sounds and continuous background sound in the measurement of the noise emissions from a specific source or sources."

f. ANSI S12.9 Pt. 3, Section 6.1 Site Selection states:

   a. "NOTE Microphones shall be located at least 7.5 m from any surface where reflections may influence the measured sound pressure levels,"

   b. "NOTE 1 Reflecting objects with small dimensions (trees, posts, bushes, etc.) should not be within 1.5 m of the microphone position. If sound pressure levels are measured within 1.5 m of such objects, the effect, if any, on the measured data should be determined from measurements made at another location where the objects are at a greater distance, or by an equivalent procedure."

   c. "NOTE 4 Nearby reflecting objects also should be avoided since they may increase the level of the background sound (e.g., sound produced by the rustling of leaves).

g. ANSI/ASA S12.9 Pt 3, Section 6.3 Measurement site operation and checking instrument sensitivity states:
    a. "(a) Measurements shall not be made during periods of rain or ice that are heavy enough to significantly increase the ambient level and significantly increase background noise issues, or are heavy enough to adversely affect the electrical functioning of the meter or likely may damage the instruments or microphone."
    b. "(b) To minimize the effects of wind on the microphone, sound measurements should not be taken when the wind velocity is greater than 5 m/s (11 mph or 10 knots) at the microphone position when measured at a height of 2 m above the ground."
h. ANSI/ASA S12.9 Pt 3, Section 4.5 Windscreen puts the further condition on wind speed: "A windscreen shall be used when the wind-induced noise is within 10 dB of the source sound pressure level in any frequency band being measured." Wind at speeds over 2.2 m/s (approx.) produce pseudo-noise on microphones even when a wind screen is installed because of the performance limitations of the wind screen and low background sound levels. This establishes a lower wind speed threshold than 5.5 m/s for background sound measurements in quiet rural environments.

This is not an exhaustive list of requirements for testing that were not met by the study and reporting of Epsilon for Antrim Wind LLC. They are however significant.

My review of the Epsilon report concludes that the data used for the opinions and conclusions of Mr. O'Neal's testimony regarding current background sound conditions does not meet the thresholds set by the NH SEC regulations and reference standards.

11. Do you have any further comments on the Epsilon background noise study?

Yes. I want the Committee to understand why the concerns listed above are important. The Committee should take special care to make sure that the study and report by Epsilon is accurate and properly characterizes the Antrim community's existing soundscape. Antrim is a quieter rural community than many in which wind turbines projects are developed. The project has the potential to the project seriously degrade the area. Epsilon's model predictions show that the average sound levels with the wind turbines operating at homes are all above 25 dBA and a significant number of homes will be above 30 dBA. While the NH SEC 40 dBA limit for nighttime addresses preventing adverse health effects from sleep disturbance it must be recognized that increasing nighttime noise from the current under 20 dBA levels to those that are predicted will result in a significant loss in quality of life and increase in annoyance.

The most relevant background soundscape to define is the sound level during the time when the new noise sources are expected to be the most noticeable. Adverse impacts occur when the new noise from a project significantly exceeds the background level at sensitive receiver sites and becomes clearly audible. For wind turbines that operate 24/7 this target soundscape is the quiet time at night when surface level winds are low and winds at the blades are at or above nominal operating speeds. This condition occurs frequently during warm seasons. It is this condition that is lost when wind turbine noise is permitted to dominate the soundscape of quiet rural communities.

Table 5-4 of Epsilon's noise report gives us some understanding of the current character of the soundscape at night near Antrim. It shows that the L_{A90} nighttime background sound levels at each of the five monitored locations, L1 through L5, range from 14 dBA (Reed Carr Road) to 18 dBA (Keene Road). All of the sites have periods where the continuous background sound levels are below 20 dBA. These are very low sound levels. Much lower than in many other rural communities. These L_{A90} levels establish the sound level of the soundscape during those periods when there is an absence of short term sounds. The sounds of children playing, people talking loudly, barking dogs, traffic, insects, frogs, bird calls, leaf rustle and the sound that wind makes when it is strong enough to be heard are excluded. It is this long term continuous background soundscape that the ANSI standards are saying should be measured and protected from degradation by new noise sources.

The L_{A90} nighttime background sound levels at each of the five monitored locations are significantly lower than the L_{A90} sound levels reported by Epsilon in its June 8, 2015 report. It appears that the June 8, 2015 report only repeats the results of Epsilon's background sound survey from Docket 2012-01 which was conducted from September 16-October 4, 2011. In the prior proceeding, both Mr. Greg Tocci, sound expert for Counsel for the Public, and I were highly critical of Epsilon's methodology that allowed seasonal insect noise to contaminate the sound data collected. In the February 17, 2016 report, Epsilon's monitored data was collected from January 7-22, 2016 when there was no insect activity. This may account for the lower background sound levels even though Epsilon did not pro-actively remove artifacts.

Quiet, and especially very quiet, rural and wilderness communities are an increasingly rare asset. These communities have large listening distances. That is, the distance of the furthest sounds one hears on nights in the absence of human activity with calm or no winds. This characteristic of rural communities is what gives them a sense of connectedness that is lost in noisier suburban and urban neighborhoods. In these communities one can hear the sounds of activities at great distances. Increasing the long term background sound level results in the loss of the distant sounds.

In a community as quiet as Antrim it would be expected that on a calm warm season night a person outside their home can hear sounds from a mile or more away. Raising the background sound levels by introducing wind turbines will in practice, increase the background sounds to 35 dBA or more in the yards of homes outwards of a mile from the ridge on nights when quiet would have been expected. 35 dBA at night is typical of continuous background sound levels for suburban neighborhoods located within a mile of a major expressway with heavy nighttime traffic. For those who live closer to the wind turbines, the nighttime sound levels may be increased to as much as 40 dBA, a very noisy suburban condition. When people go outside at night in those communities they are often limited to hearing only the sounds from activities within 500 to a 1000 feet. This reduction in listening radius is a loss of an important characteristic of the existing community. One that should be given considerable weight.

12. Can nearby residents to the project site expect sound from wind turbine blades to be masked by wind noise at the downwind locations?

It is a myth that wind induced noise will mask the noise of wind turbines in high wind conditions. While it may be true that for some wind condition the sound of wind induced leaf rustle can be as high as that from the wind turbines, the repetitive nature of the wind turbine noise from blade rotation will make it a distinct pattern of sound distinct from the more random sounds of wind induced noises. These high wind noise conditions are not the ones that are to be protected. People accept that during windy, gusty days the sound of wind induced noise is high. That is one reason why those times are not optimum for outdoor parties or other activities and people close the windows to their homes. It is the periods with calm winds at the surface, such that there are no wind induced sounds while the wind speeds at the blades is high and the wind turbines are producing at nominal to full power output, that are critical for outdoor activities and open window nights. The relationship between winds at the heights of the turbine's blades to the winds that "ground dwellers" experience is not the same. There are many occasions when the winds will be more than adequate at the height of the blades to power the wind turbines but the surface wind speeds at the ground will be calm. This can be as much as 30% and more of the warm season nights. In that case, no wind noise at ground level will be present to mask the turbine noise.

In fact, it is precisely this condition that requires necessary limits on noise increases over background levels. During periods when winds at the ground level are sufficient to cause leaf rustle the noise from wind interacting with vegetation and other surface objects has entirely different frequency and temporal characteristics. When two sounds are different there is no masking of one by the other. Based on my experience with listening to wind turbine noise during moderate to high winds I find that the wind turbines are always clearly discernable.

In addition, masking does not have any effects on the sounds heard inside a home. This is especially true when low frequency sound is present outside homes and other occupied structures. This situation makes wind turbine noise especially from the larger, more slowly rotating models, often more of an indoor problem than an outdoor one. The usual assumption about wall and window attenuation being 15 dBA or more, which is valid for most sources of community noise, is not sufficiently protective given the relatively high amplitude of the wind turbines' low frequency emission spectra.

13. Do you have any further comments on the computer simulations presented by Epsilon?

Yes. The Cadna/A software used by Epsilon implements the procedures of the ISO 9613-2 standard for sound propagation estimates. This model is commonly used in the wind industry to assess turbine noise propagation. However, this model is a very simple one that only addresses sound propagation under limited noise source and receiver arrangements, calm wind and weather conditions, on flat ground for noise sources no more than 1km from the receiving location. Even if the noise sources, receivers, and weather conditions all meet the assumptions of the ISO model the model is not a precise tool for predictions. When one or more of the assumptions are not met, these tolerances will be higher.

ISO-9613, part 2, Section 9, Accuracy and Limitations of the method includes Table 5, *Estimated accuracy for broadband noise of LAT (DW) calculated using equations (1) to (10)*. It states the confidence limits are +/- 3 dB. But this can only be true if the model adheres to all assumptions and limitations specified in the standard.

The Epsilon model deviates from the assumptions and limitations in several significant ways. First, Epsilon's model does not include any adjustments to account for the ISO confidence limits. The requirement to follow ISO 9613-2 (*NH Site rule 301.18(c)*) carries with it a requirement to properly apply the confidence levels associated with the standard's algorithms. This is as important as the requirement to add the measurement uncertainty to the mean apparent sound power levels for the wind turbines from the IEC61400-11 tests.

That tolerance <u>was</u> included by Epsilon. It is not acceptable to pick and choose which tolerances one should include.

Scientific evidence, especially when used for decisions affecting the health and welfare of people, requires use of tolerances, and often safety factors on top of the tolerances, in decision making. This cannot be selective. All tolerances are important and models involving several cannot pick and choose which will be included and which will be excluded as Epsilon has argued is acceptable. Because the NH standard requires the model to represent "predictable worst case" conditions, it is appropriate to use the upper bound of the confidence limits as adjustment to input data for the sound propagation model. This would add 3 dB to the predicted values at all receptors in Epsilon's report independent of any corrections for measurement tolerances. Applying a 3dB correction to Epsilon's predicted levels shows that the project will operate above the permitted 40 dB(A) nighttime levels.

Epsilon asserts the model was run using conservative assumptions and parameters. Review of the information provided in the report shows this is not true. Saying the model is conservative does not alter the fact that the input variables do not include tolerances, that the wind turbine noise source exceeds the height above the receiver permitted for the model, that the wind turbines are ridge mounted and not on flat land, receivers are more than 1km from the wind turbines, or that the meteorological conditions defined for use of the ISO standard within the +/- 3dB tolerance assume wind turbines are operating in calm winds, not the wind conditions that lead to "representative worst case conditions." Rather, sound emissions from operating wind turbines are often irregular because the wind is not-steady, is turbulent, and has high wind shear when located along ridgelines. Wind gusts and turbulent in-flow air moving over the blades will cause noise levels to be significantly higher than the average levels Epsilon predicted.

14. **When asked whether there were any atmospheric conditions, temperature gradients or wind shear gradients that could cause sound levels at any given location to be higher than what his model predicted, Mr. O'Neal replied 'No' and explained that:**

> "The sound study was conducted consistent with the methodology required by the NH SEC in 301.18. As clearly discussed on page 7-3 of the Sound Study Report, the worst-case temperature and relative humidity were assumed to minimize atmospheric absorption, and thus increase modeled sound levels. The maximum sound level under any wind condition was used in the modeling. This occurs under strong hub-height winds, and as per the ISO 9613-2 standard, the meteorological conditions for these propagation calculations are under ground-level wind speeds

between 1 m/s and 5 m/s. Thus, this represents a strong shear situation although there is no wind shear exponent directly input to the ISO 9613-2 propagation standard."

Do you agree with Mr. O'Neal's response?

Mr. O'Neal is correct that the model does not provide for a wind shear exponent to be entered into the model but that does not mean shear is not a factor in the prediction. The ISO 9613-2 standard assumes a "well-developed moderate ground-based temperature inversion, such as commonly occurs on clear, calm nights." The model does not account for atmospheric conditions, temperature gradients or wind shear gradients that result in the turbines emitting noise levels that exceed the average predicted levels Epsilon cites in its report.

Over the past 10 years I have reviewed well over 50 noise impact statements for projects in North America, New Zealand, and Australia. I have observed that in almost all of these statements the acoustical contractor who developed the computer model for the project represents the results as being highly accurate for predicting sound propagation from wind turbines, often to the decimal place. Further, many of these studies claim that tolerances are not required to be included in the results because the "acoustician doing the model has made extremely conservative decisions that preclude the need for confidence limits." This is doubly specious. First, the ISO and ANSI standards specifically state that the models based upon the standards do not apply for noise sources elevated high above the ground, or that have significant low frequency content (the models only considers sound from the 63 Hz octave band and higher, while wind turbine sound is dominant in the frequencies from 0 Hz to the 31.5 Hz octave band), and only consider the simple weather condition of little or no wind under a temperature inversion.

Further, the data that is used as input to these models, is derived from a standardized test procedure under IEC 61400–11. This and other parts of the IEC61400 series of standards defines the weather conditions, test site, topography, measurement and analysis methods to be used in determining the <u>apparent</u> sound power level of a single wind turbine on a test stand. The weather conditions desired are those that produce the most efficient power production for the wind turbine being tested. Those being winds producing steady in-flow air with little or no intrinsic turbulence and a wind shear coefficient of less than 0.2 so that the angle of the blade is always optimum for power extraction. These conditions also result in the lowest noise emissions. Power extraction is maximized and noise is minimized by assuring that during the tests the wind speed over the area that the blades travel has little variation from the bottom to the top of the rotation path and there is little turbulence in the wind. These conditions do not represent what happens when the wind turbines are put in operation for ridge mounted projects as proposed by Antrim Wind LLC. Under these real-world conditions wind turbines produce considerably more noise and the relatively steady noise observed on the test stand on flat ground with optimum winds can become a whooshing and thumping noise that is even more disturbing.

Any use of computer models needs to acknowledge that the model algorithms are not validated for the type of noise and height of modern utility scale wind turbines. Yet, during my review of "industry standard practice" sound propagation models I have observed applicants claiming that their models are so accurate that they can be trusted to the 0.1 decimal place without the need for any adjustments to account for deviations from the assumptions of the ISO based models and the IEC based test procedures for Apparent Sound Power Level.

15. Would you expect Mr. O'Neal to be aware of these limitations in the model?

Yes. Many of these same points were presented in my testimony during the first hearing on Antrim Wind. Mr. O'Neal is fully aware of these criticisms from this and other hearings. He has also had his opinions challenged by other acousticians. In fact, during a recent hearing in Ontario for the White Pines Wind Project, Dr. Paul Schomer, Director Emeritus of the Acoustical Society of America's Technical and Standards Committee, who was a member of the ISO working group that developed the ISO 9613-2 standard, chastised Mr. O'Neal characterizing his views of sound propagation and weather as simplistic.

Dr. Paul Schomer's testimony stated:

> "ISO 9613-2 is totally based on empirical data and not theory. It was derived from a German standard on the same topic. It works reasonably well in the sound regimes it was designed for and works pretty well for medium or high frequency sources in situations that it wasn't designed for. But below 30 Hertz, and certainly below 10-15 Hertz, the physics are entirely different, and things people aren't expecting to happen will happen such as focusing and a complete change in the ground impedance from soft to hard." (*Schomer written Testimony for Ontario White Pines Project Hearing before the Ontario Environmental Tribunal*)

Dr. Schomer further opined that if the ISO model is used for wind turbine noise predictions (for the range from 63 Hz and above) adjustments on the order of 5 to 10 dB need to be applied for the additional uncertainties caused by use of a model outside of its defined assumptions. These additional uncertainties are separate from those defined under IEC 61400–11 and IEC 61400–14 and the ISO 9613-2 standards. I opined in the same White Pine hearing that a minimum of five dBA needs to be added to the predicted values, just to account for uncertainties in the model and determination of wind turbine apparent sound power levels. Dr Schomer argued for even greater safety margins.

I have also opined in that same proceeding that it is absurd to present the results of these models in terms of decimal place precision when even a precision sound level meter cannot make a measurement with that accuracy. Implying such a level of precision mischaracterizes the true uncertainty in sound propagation models.

16. Can the Siemens' accuracy factor of 1.5 dBA for the selected turbine model serve as a substitute for 3dB defined under ISA 9613-2?

No. These two factors represent confidence figures for two entirely different engineering procedures. One cannot be substituted for the other. Rather, both the 1.5 dBA and the 3 dBA should be added to Epsilon's predicted levels.

Real world operating conditions could result in the properties near the project site receiving sound from the wind turbines above the NH limit. In a report funded by the US DOE for the Minnesota Public Utility Commission, titled: "Assessing Sound Emissions from Proposed Wind Farms &Measuring the Performance of Completed Projects," October 11, 2011, pages 12-13, the author, Mr. David Hessler of Hessler Associates, Inc. states:

> "Extensive field experience measuring operational projects indicates that sound levels **commonly fluctuate by roughly +/- 5 dBA about the mean trend line** and that short-lived (10 to 20 minute) spikes on the order of 15 to 20 dBA above the mean are occasionally observed when atmospheric conditions strongly favor the generation and propagation of noise." (Emphasis added)

The point that Mr. Hessler makes in the Minnesota document is well known to acousticians working on wind turbine noise issues. Weather conditions and operating modes of wind turbines not accounted for in the model presented by Epsilon can increase the mean/average/Leq sound levels by 5 dBA or more. This should be expected given the combined tolerances for the IEC measurement data and ISO modeling protocols is approximately 4-5 dB and those tolerances are seldom included in wind turbine project sound models. This has been verified by myself as well as other acoustical consultants in the U.S., Ontario, New Zealand, Australia, and the U.K.

17. Mr. O'Neal points to the Wallace paper entitled *Wind turbine noise modeling and verification: two case studies – Mars Hill and Stetson Mountain I, Maine*, presented at NOISE-CON 2011 to show that predicted sound levels from pre-

construction modeling were conservative (higher) than measured sound levels under worst-case operating conditions for sound. Do you disagree?

Mr. O'Neal's assertion misrepresents the situation and mischaracterize the Wallace study's findings. Wallace's experiences at Mars Hill and Stetson clearly demonstrate what I've already stated in this testimony, that the corrective factors for turbine sound certainty and the ISO model must be applied to the predicted values. Wallace states this in his paper:

> "The Stetson Mountain I acoustic model was virtually identical to the Mars Hill Model with +2 dBA added to account for uncertainty in the GE specification of the apparent sound power level and another +3 dBA to reflect mathematical limitations inherent in ISO 9613-2. This conservative approach was also informed by the extensive measurement experiences at Mars Hill."

Mr. O'Neal's reliance on the Wallace report failed to take into consideration that the Wallace study included all of the tolerances while Mr. O'Neal only added the 1.5 dBA to his predicted numbers. His insistence that adding the 3 dBA to address uncertainties in the ISO model is not needed is based on a flawed understanding of the Wallace study and of the science of measurement and modelling in general. No measurement or model is precise. That is a fact that scientists and engineers are trained to understand and to accommodate in their work. To argue otherwise demonstrates a flawed understanding of scientific work. Further, there are much better studies comparing wind turbine sound immissions over flat farm land and model predictions that have shown that the ISO model under predicts the real world sound levels by 6 dB or more depending on how the model is programmed. Mr. O'Neal's reliance on poorly controlled studies that support his position may be a result of cherry picking studies to support his opinions.

18. **Antrim Wind LLC has confirmed that the wind shear exponent at the project site was measured, and greater than 0.2, at hub-height, when wind speeds were above 3 m/s, approximately 19% of the time during calendar year 2010. These periods during which the wind shear exponent was measured at these levels occurred during all hours of the day but with greater frequency during the hours between 8:00 PM and 8:00 AM. The average shear exponent was 0.13 and the maximum shear exponent was 1.19. How can this information be used when predicting whether the project will operate within the standard adopted by the Committee (not-to-exceed 40 dB(A) at night)?**

We know from this information that approximately 19% of the time, and usually at night, the turbines will be operating under atmospheric conditions that are more turbulent than those assumed in the standardized test procedure under IEC 61400–11 by a wide margin. According to Antrim Wind, LLC the mean shear coefficient in 2010 was only 0.13 but there were clearly many hours when the shear exceeded this average. The maximum wind shear of 1.19 is much higher than one will see for wind turbines on flat farm land. There nighttime wind shears of 0.4 and higher are common but they seldom exceed 1.0. The higher the wind shear value the more difference there is in wind speed between the bottom and top of the blade's travel path.

Wind speed is used to calculate the angle of the blade to extract optimum power. All blades are set to the same angle. This angle cannot be rapidly changed to account for wide variations in wind speed over the rotation area. It is fixed for a single wind speed generally based on the wind speed at the height of the hub. Thus, a large wind shear means that the angle of the blade that is optimum for extracting power, for example, at the bottom of the rotation, is not optimum as the wind turbine's blade rises to the top where the winds are much faster. This results in loss of lift, loss of efficiency, and more noise during the non-optimum parts of the rotation. This is also associated with the complaints of people who say the wind turbine noise starts to include whooshing and thumping sounds.

19. **Antrim Wind LLC has testified that the Siemens SWT-3.2-113 turbine is quieter than the Acciona AW3000/116 however, the difference in the maximum sound power levels is only 0.9 dB (108.4 dB – 107.5 dB). Would a 0.9 dB difference even be noticed?**

No. Recent designs of wind turbines have focused on longer blades to extract more power for each tower location. These longer blades must turn more slowly to avoid design limitations for tip speed. There have also been some improvements in blade designs that have shifted some of the mid and higher frequency sound emissions into lower frequencies that are de-emphasized in dBA measurements. That does not mean a person would judge the newer models to be quieter. They would have a lower frequency sound but that sound may be even more likely to cause disturbance because the low frequency sound enters homes with less attenuation than the mid and higher frequency sound of earlier models.

Even if the sound spectrum had not changed, a 0.9 dB difference is insignificant. For a listener it takes at least a 3 dBA difference in sound level to perceive a change. When one considers that precision sound level meters cannot make a measurement with such decimal-place accuracy, making such a claim is highly misleading. What Antrim Wind and Mr. O'Neal do not state is that the Siemens turbine model produces sound levels that are higher than the Acciona turbine at some frequencies, in particular at 63, 4000, and 8000 Hz.

20. Mr. O'Neal has stated that using a G-factor of 0.0 will increase predicted sound levels by 3 dBA. He also states that a G-factor of 0.5 would be inappropriate according to Section 7.3.1 of the ISO 9613-2 standard. Can you comment on this?

Yes. Mr. O'Neal is misreading or misunderstanding the ISO standard. Ground factor is important for noise sources close to the ground. Under that situation the sound traveling across the ground will interact with absorptive surfaces and be attenuated due to that interaction. If, hypothetically, the wind turbine's blades were much closer to the ground, the surface characteristics and ground factor would be important. In that case, the fact that for much of the year the ground is snow covered and is comprised of hard rock with a thin layer of dirt would focus the argument on whether the ground factor should be 0.5 or lower. However, the 113-meter diameter blades are elevated high above the ground on 80 to 90 meter towers on a ridge 200 to 300 meters or so above the Town of Antrim. The tops of some of the blades will be approximately 400 meters above the Town of Antrim. The sound wave from the blades will propagate to the homes below with little, if any, significant interaction with the ground.

In this case, how can ground absorption occur? It is likely significant sound energy will pass through the atmosphere and directly reach a home before it reflects off of the ground. There is no absorption occurring for the strongest elements of the sound wave that propagates to properties below.

This makes the use of <u>any</u> ground factor incorrect and arguments about what value to use specious. For a wind turbine blade located on a tower, on top of a ridge, this interaction with the ground is absent except possibly for the ground closest to the receiver. The model is not sophisticated enough to handle anything more than noise sources close to the ground on flat land. That is why ISO model limits source elevations to no more than 30 meters (approx.) above the receiver under the assumption that both are on flat ground to consider these effects. For a wind turbine on a ridge, the Cadna/A software's implementation of the ISO model applies the algorithms for ground absorption even though they do not apply. The workaround for this is to use a ground factor of 0.0 to eliminate this aspect of the sound propagation calculations and to apply appropriate safety factors. Mr. O'Neal either does not understand this limitation or chooses to ignore it in his arguments. Using a ground absorption of either 0.5 or 0.7 is inappropriate for a noise source that is positioned on a tower on top of a ridge well over the ISO 30 meter height limits.

Based on a proper interpretation of how ground factor applies to ridge mounted wind turbines with homes at elevations below the ridge top and using Mr. O'Neal's estimate that a 0.0 ground factor would increase the predicted sound levels by 3 dB shows that the Epsilon model is under-predicting the real world sound levels from the wind turbines on homes and properties. This would be on top of the 3 dBA associated with the missing tolerances for the ISO model calculations. Using this reasoning the Epsilon models are under predicting by 6 dBA.

21. According to Mr. O'Neal's June 2015 report, eighteen "receptors" are predicted to experience project sound emissions above 37 dBA? Given your review of Epsilon's sound report, what is the likelihood the project will produce sound levels in excess of the 40 dBA?

All of the receptors will experience sound levels that are at or above 40 dBA. Considering the ISO tolerance of +/- 3 dB, and the ground factor correction of 3 dBA from Mr. O'Neal's estimate for using a ground factor of 0.0, the eighteen homes are likely to be at 43 dBA. Further, given what is known about the limitations of the models, I would expect many more receptors to experience exceedances.

22. New Hampshire Site rule 301.18(h) states "Noise emissions shall be free of audible tones, and if the presence of a pure tone frequency is detected, a 5 dB penalty shall be added to the measured dBA sound level." Does this rule apply for the operating turbines or the substation?

As a general rule, the most recent designs of wind turbines are not likely to produce tones that are audible. That is not to say they do not produce tones, just that the tones are at frequencies where audibility is not the issue. When a wind turbine is producing an audible tone it is generally a result of a maintenance related issue such as worn gears, bearings causing grinding or similar sounds, or from failures on the surfaces of the blades leading to whistling sounds. These cannot be anticipate during the design and permitting phases but do rely on the developer/operator being responsive to complaints once the project is in operation.

On the other hand, equipment that is used in substations including transformers, inverters, fans and other electrical equipment are known to produce tones. This is considered so common that in projects I have reviewed the developer routinely applies the 5 dBA penalty to the sound emissions from the substation equipment and often designs a barrier (berm) around the substation to block this noise from affecting nearby homes. Tones related to substation equipment are tied to the 60 Hz frequency of the electrical system and other have a maximum in the 125 Hz octave band. The sound power data for the Antrim substation shows this peak in that frequency range.

Epsilon's model does not apply this penalty for substation equipment. The model should be re-run using the 5 dBA penalty applied to the apparent sound power level of substation equipment.

23. Do you have any opinions about how the issues describe affect use of the Epsilon model's predictions for this hearing?

Yes, the accumulated impact of the issues described above makes the results of the Epsilon model unreliable and unsuitable for use in making decisions under the NH SEC rules designed to protect public health and welfare. The model's results should be given no weight and rejected.

My review of the Epsilon model concludes that the data used for the opinions and conclusions of Mr. O'Neal's testimony regarding predicted operational sound levels at receiving properties do not meet the requirements set by the NH SEC regulations and reference standards.

24. Does this conclude your testimony?

Yes

Richard R. James, INCE
E-Coustic Solutions LLC
May 23, 2016