Saddleback Ridge Wind, LLC // Natural Resource Protection Act (NRPA) and Site Location of Development Act applications

- Appellants' Citations to the Record as Set Forth in the Appeal Document - "excerpts"

Saddleback Ridge Wind, LLC // Natural Resource Protection Act (NRPA) and Site Location of Development Act applications

- December 10, 2010 letter to Eric Ham re: Saddleback Ridge Wind Project – Request of Friends of Maine's Mountains and Other Aggrieved parties for Public Hearing
- *Exhibit 1: Affidavit of Michael A.Nissenbaum, M.D.*
- *Exhibit 2: Report by Richard James (E-Coustic Solutions) dated December 9, 2010*

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RUFUS E. BROWN
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December 10, 2010

VIA E-Mail and U.S. Mail

Eric Ham
Project Manger
Maine Department of Environmental Protection
17 State House Station
Augusta, ME 04333

Re: Saddleback Ridge Wind Project (the "Project") - Request of Friends of Maine's Mountains and Other Aggrieved Parties for a Public Hearing

Dear Eric:

On behalf of Friends of Maine's Mountains ("FMM") and the other parties listed below (the "Aggrieved Parties"), and pursuant to 06-096- CMR Ch. 2, Section 7 (the "DEP Procedural Rules"), I hereby request that the Maine Department of Environmental Protection ("DEP" or the "Department") hold a public hearing on the application of Saddleback Ridge Wind, LLC for permits under the Maine Site Location of Development Act and the Natural Resource Protection Act on the subjects of noise and visual impact.

I. THE AGGRIEVED PARTIES.

FMM is a non-profit organization dedicated to protecting the mountain regions of Maine from various threats to their natural and human environments. At this time, FMM believes that the most pressing threat to both natural and human values in the area is the inadequately controlled development of wind power plants on mountains, their ridges and in small towns that

embody the qualities of life in rural Maine that the State should protect. The principal activities of FMM have been efforts to educate the public about industrial wind power, and to support grass roots opposition to inappropriately sited projects. FMM objects to the Saddleback Ridge Wind Project based on the likelihood that it will generate excessive noise and on the grounds that it will have an unreasonable visual impact on the surrounding environment, including Mount Blue State Park and on the mountains popular with climbers that lie north and east of the site. FMM is supported by those individuals who reside near the proposed turbines for the Project and will be affected by noise generated from the Project as well as those who hike and engage in other recreational activities in and around Mount Blue State Park. In addition, FMM has title to property that abuts the proposed Project site, consisting of 3290 acres including the summit of Saddleback Mountain.

In addition to Friends of Maine's Mountains, 24 of the 34 individuals who own property at the Receiver Points used in the *Noise Impact Study* submitted by the Applicant join in the request for a public hearing. They are: William F. Kremer, Basin Road, Carthage ME (Receiver ID# 02); Dennis and Denise McAllister, Basin Road, Carthage ME 04224 (Receiver ID# 3); Will and Teresa Deane, Basin Road, Carthage ME 04224 (Receiver ID# 4); David C. Manca, Basin Road Carthage, ME 04224 (Receiver ID# 6&7); Kathy and Alan Ackley, 196 Basin Road, Carthage, ME 04224 (Receiver ID# 8&9); Richard Carson, Basin Road, Carthage ME 04224 (Receiver ID# 10); Alice Barnett, 1 Pit Road, Carthage, ME 04224 (Receiver ID # 11); Patrick Gorham, 1 Pit Road, Carthage, ME 04224 (Receiver ID# 12); Joseph Beggs, 2 Pit Road, Carthage, ME 04224 (Receiver ID# 13); Paula Kazarosian, 57 Earthway, Carthage, ME 04224 (Receiver # 14&15); Maynard and Joyce Elliot, 72 Winter Hill Road, Carthage, ME 04224 (Receiver ID# 17); Dennis Lecourse, 120 Winter Hill Road, Carthage, ME 04224 (Receiver ID#

18); Lee Paul and Janet Alfieri, Alfieri Drive, Carthage, ME 04224 (Receiver ID# 19); Dustin Maynard (formerly Smith), Winter Hill Road, Carthage, ME 04224 (Receiver ID# 20); Douglas Geis, Alfieri Drive, Carthage, ME 04224 (Receiver ID# 22); David Jackson, Winter Hill Road, Carthage, ME 04224 (Receiver ID# 27, 28 & 29); Louis, Eric, Mary and Patricia Francis, Winter Hill Road, Carthage, ME 04224 (Receiver # 30); John Steele, Winter Hill Road, Carthage, ME 04224 (Receiver # 32); Gene Casey, Winter Hill Road, Carthage, ME 04224 (Receiver ID# 34).

II. PETITIONS FOR A PUBLIC HEARING.

Accompanying this Request for Public Hearing is a paper petition and also a PDF of an on-line petition to hold a public hearing in this case. These petitions are submitted to demonstrate the broad public interest in holding a *public hearing*, where testimony can be presented and experts can be cross-examined, not just a public meeting as has been the DEP's practice in the past.

III. OBJECTIONS TO LIMITATIONS ON REQUESTING A PUBLIC HEARING.

The Aggrieved Parties claim a Property Interest in their peaceful use and enjoyment of their property near the proposed Project and a Liberty Interest in being free from exposure to adverse health risks from the proposed Project, both protected by the Due Process Clause of the Maine and United States Constitutions. As such the Aggrieved Parties have a right to a hearing on the application of Saddleback Ridge Wind, LLC that conforms to basic principles of Administrative Due Process. A "public hearing" held in accordance with Section 7 of the DEP Procedural Rules would satisfy the Administrative Due Process rights of the Aggrieved Parties.

The Aggrieved Parties object to the limitations in Section 7 of the DEP Procedural Rules on their right to a public hearing. To the extent that the DEP Procedural Rules make it discretionary with the Commissioner whether or not to hold a public hearing, the rule violates

Due Process if discretion is exercised in favor of not holding a hearing. In addition the 20 day deadline from the date the application is complete for requesting a public hearing in Section 7.A of the DEP Procedural Rules violates Procedural Due Process, even with the 4 day extension granted by the DEP, given the requirement that within those 20 days the aggrieved parties are required to justify their request for a hearing with credible technical information (that is, expert opinions) in conflict with the expert reports of the applicant regarding licensing criteria. An applicant has months to prepare its application and the DEP has months to review the application after it is filed. To require aggrieved parties to prepare and submit expert opinions in the narrow 20 day window commencing with the completion of the applications is unreasonable and denies the aggrieved parties a constitutionally protected opportunity for a hearing in accordance with the Due Process Clause.

The 20 day requirement is so short that not even the DEP's consultant, EnRad Consulting, has rendered an evaluation of the Project yet. Nor have there been any agency comments on public health or visual impacts related to the Project. The Department has informed the undersigned that Dr. Mills will not give her views on the health aspects of the Project until a much later stage, months from now when the draft order is being prepared. This practice effectively deprives the Aggrieved Parties of the opportunity to request a public hearing on health issues. The undersigned asked the Department for the Applicant's sound expert to clarify certain aspects of his *Noise Impact Study*, but have not received full responses within the time allowed for this Request. Further, the Department informed the undersigned by e-mail on December 8, 2010 that the Department would not accept supplemental comments from the Aggrieved Parties after clarifying information is received from the Applicant's sound expert. This position places severe limits on the ability of the Aggrieved Parties to adequately address

the Applicant's *Noise Impact Study*.

Accordingly, while we proceed with the request for a hearing, we do so under protest that the procedural restrictions and the time frame allowed for the request violates Due Process. In addition, the application of the Procedural Rules in this case, apart from violating Due Process, is arbitrary and capricious within the meaning of Section 11007.4.B(6) of the Maine Administrative Procedure Act, 5 M.R.S.A. §8001, et seq.

IV. A PUBLIC HEARING SHOULD BE HELD ON THE SUBJECT OF NOISE.

The Project as proposed is to be sited on a ridge, Saddleback Ridge, with existing residences located to the East, the South and the West of a string of 12 GE 2.75 MW wind turbines. The *Noise Impact Study* presented with Section 5 of the Site Law Application by RSG concludes that the Project can meet the nighttime quiet area Sound Level Limits of Section 10.C of 06-096 CMR. ch. 375.10 (the "DEP Noise Rule") of 45 dBA only by operating 5 turbines in Noise Reduced Operation ("NRO mode"). Even in these conditions, there is substantial risk, indeed a certainty, that nearby residents will be exposed to excessive noise.

A. A Public Hearing is Necessary to Examine Conflicts in Technical Information Concerning the Predictive Modeling of the Project.

The Aggrieved Parties raise technical objections to the modeling of sound predicted for the Project by RSG in its N*oise Impact Study* on several grounds.

1. *The Limitations of the Models Used to Measure Noise.*

The *Noise Impact Study* explains that the prediction modeling software used by RSG for its sound level assessment was the Cadna/A operating in ISO 9613-2. *Noise Impact Study*, Section 9.1 at 19. This prediction modeling software is not designed for wind turbines, it is not

designed for (1) sound sources at a height of a ridgeline, such as that proposed for the Project, or (2) for receiver points more distant than 1000 meters, or (3) for wind speeds above what ISO 9613-2 recommends, or (4) for sound sources that are in a string of turbines making "line source" measurements necessary. Report of Richard James, *Exhibit 2* at 2.

The author of the *Noise Impact Study*, Kenneth Kaliski, acknowledges most of these limitations of Cadna/A operating in ISO-9613-2 mode in his article, "Propagation Modeling for Wind Turbine Projects, *Exhibit 32*. In his article, Kaliski purports to have made adjustments to account for the inadequacies of ISO 9613-12, but it stretches credulity that his adjustments can result in prediction level accuracies within a 3-5 dBA range given the number of deficiencies that are required to be compensated for.

The problems with using Cadna/A (operating in ISO 9613-2) were also acknowledged by the DEP's own consultant, Warren Brown of EnRad Consulting, in an internal conference call in March 2009 on the subject of noise in wind power applications pending before the DEP. In the *Notes of March 5, 2009 DEP Conference Call* between Warren Brown, Dora Mills, Maine Center for Disease Control ("MCDC"), and others, *Exhibit 5*, Warren Brown stated that he "has issues with [the] model being used. Currently it's based on industrial noise, not wind power noise. ***We haven't been able to determine whether this model is accurate for wind turbines."*** [Emphasis added.] Later in the Notes he states that RSE predicts compliance with 45 dBA nighttime noise, "but [he] still [has] questions regarding the model – [it is] based on industrial noise." He states "wind turbine noise needs more investigation. 1. Need to be able to predict stable atmospheric conditions .... 2. Set up protocol for acoustic measurements with DEP staff member on site. ... Questions RSE's assumption – due to model. ... There is a period when turbines are loud. ***Not sure how to predict this yet. Need to figure out stable atmospheric***

conditions." [Emphasis added.]

The concerns expressed by Warren Brown in the conference call are also reflected in credible scientific literature on the subject in addition to Kenneth Kaliski. For example, Frank H. Brittain & Marlund E. Hale, in their article, "Some Limitations of Ray-Tracing Software for Predicting Community Noise from Industrial Facilities," NOISE-CON, Dearborn, Michigan (July 28-30, 2008), *Exhibit 9*, states that ISO 9613-2 estimates the accuracy of A-weighted sound propagation noise for distances only up to 1 km, but it is routinely used for distances greater than that. *See also,* Palmer, "A new Explanation for Wind Turbine Whoosh- Wind Shear," Third International Meeting on Wind Turbine Noise, Denmark (2009), *Exhibit 34,* pointing out that IEC 61400-11 does not provide for atmospheric stability, increasing sound levels and creating pulsation from wind shear, as discussed below.

2. The Failure to Factor in Atmospheric Stability.

The prediction modeling of RSG in the *Noise Impact Study* is also flawed because it does not sufficiently take into effect "atmospheric stability." The effect of "atmospheric stability" on the accuracy of sound assessments using the ISO 9613 algorithms that Warren Brown referred to in the DEP meeting is the focus of a study by Clifford Schneider, "Accuracy of Model Predictions and the Effects of Atmospheric Stability on Wind Turbine Noise at Maple Ridge Wind Power Facility, Lowville, NY- 2007," *Exhibit 14.* Atmospheric stability occurs at night when the land cools and vertical air movement disappears, and where wind can be calm on the ground but continue to blow at hub-height, creating wind shear. When this occurs, Schneider explains, "[w]ind turbine sounds are more noticeable, since there is little masking of background noise, and more importantly, because atmospheric stability can amplify noise levels significantly." *Id* at 6. Schneider states that most wind assessments never mention atmospheric

stability. *Id.* at 7. *See also*, Schneider, "Measuring Background Noise with Attended, Mobile Survey During Nights with Stable Atmospheric Conditions," INTERNOISE 2009 (stable atmospheric conditions are common), *Exhibit 38*. The flaws in wind turbine predictions that do not take into account atmospheric stability have been recognized at least since 2003, in the peer reviewed study of G.P. van den Berg, "Effects of Wind Profile at Night on Wind Turbine Noise", *Exhibit 10*. van den Berg estimates that atmospheric stability can add 15 dBA to the sound levels modeled. *See also*, comments of Rick James, *Exhibit 2* at 4 and, Palmer, *supra, Exhibit 34*; R Kochanow & N. Mackenzie, "Atmospheric Stability Specific Noise Criteria and Noise Predictions for Wind Farms", Acoustics 2008, *Exhibit 13*.

The *Noise Impact Study* acknowledges that "worst-case conditions for wind turbines tend to occur under moderate nighttime temperature inversions. Therefore, this is the default condition for modeling wind turbine sound." Section 8.2 at 18. However, as pointed out by Rick James, *Exhibit 2* at 4, the *Noise Impact Study* does not describe how atmospheric stability was taken into account in the modeling, if at all.

3. *The Failure to Use Line Source Calculations.*

The *Noise Impact Study* for the Project acknowledges that sound propagation from wind turbines occurs partially as a "point source," causing sound levels to attenuate at the rate of 6 dBA for every doubling of distance from the source, and partially as a "line source," where attenuation occurs at half that rate, at 3 dBA per doubling. *Id.* Section 3.4 at 5. There is clear scientific consensus on this issue. *See* NASA, Hubbard & Shepherd, "Applied Acoustics Handbook," *Exhibit 7* at 27 and C.E. Ebbing, "Applied Acoustics Handbook," *Exhibit 6,* at 2-8 through 2-10. The NASA study, *Exhibit 7, supra,* at 27 explains that the line source and point source produce similar results only at distances that exceed the length of the line. As pointed out

above, the modeling software used by RSG in its *Noise Impact Study* does not take into account line sources and the report does not explain whether it used line source, point source or a combination and if it used line sources at all how it did so.

Rick James points out in his Report, *Exhibit* 2 at 2-3 that the *Noise Impact Study* fails to reveal how its author calculated line source propagation in addition to the point source propagation, if at all. However, he provides his own calculations on two receiver points to show that the *Noise Impact Study* modeling sound pressure levels are too low by up to 5 dBA. Mr. James underscores the point that predictive modeling of the type done by RSE is not as precise as it claims.

4. The Failure to Apply the 5 dBA Penalty for SDRS.

RSG did not include the effects of Short Term Duration Repetitive Sounds ("SDRS") in its modeling of the Project. The DEP Noise Rule, Section 10.D. 19, defines SDRS as a "sequence of repetitive sounds which occur more than once within an hour, each clearly discernible as an event and causing an increase in the sound level of at least 6 dBA on the fast meter response above the sound level observed immediately before and after the event, each typically less than 10 seconds in duration, and which are inherent to the process or operation of the development and are foreseeable." Section 10.C.1 (e) (i) imposes a 5 dBA penalty when SDRS is present for purposes of measuring sound level limits. If SDRS had been included in the model predictions, the Project would not comply with the nighttime Sound Level Limits of the DEP Noise Rule.

The *Noise Impact Study* states that turbulence, such as wind shear during conditions of atmospheric stability, can cause increased sound pressure levels as well as SDRS or amplitude modulation. *Id.* at Section 10.0. Nevertheless, The *Noise Impact Study* states that RSG did not

include SDRS in its modeling of the Project because the "site characteristics are not conducive to common occurrences of SDRS." *Noise Impact Study,* Section 10.0 at 25.

Rick James, in his Report, *Exhibit 2* at 5-6, explains that RSE only looked at one source for turbulence creating amplitude modulation, that there are other sources for such turbulence including updrafts, cross drafts and wake interference, and that SDRS of 5-6 dBA is common for wind turbines, with SDRS of 10 to 15 dBA or more observed as a less frequent maximum, especially during periods of turbulence due to weather fronts or topography and during temperature inversions where the wind shear does not follow a simple gradient from ground to heights above the upper reach of the turbine blades, and that these conditions have been documented and reported in research papers by Hubbard and Shepherd in the 1990's ("Wind Turbine Acoustics", *Exhibit 7, supra*) and more recently by Dr. van den Berg. He opines that it cannot be assumed that the Saddleback Ridge Project wind turbines will not exhibit SDRS. Blade swish and thump, also referred to as amplitude modulation, is discussed in papers at annual conferences all around the world. He asks, if this is a condition that were infrequent or limited to a few makes and models of wind turbines, why are there so many research papers published investigating it? *Id.* at 5-6. H. *See also*, Dr. Christopher Hanning, "Wind Turbine Noise, Sleep and Health" (April 2010), *Exhibit 28,* at §3.6.

5. Turbulence from Turbine Configuration.

As RSE recognizes in its *Noise Impact Study*, Section 10 at 25, turbulence leading to SDRS can be caused by inter turbine placement, resulting in SDRS. Apparently RSE concluded that the turbines for the Saddleback Ridge Project were appropriately placed. Rick James disagrees. In his Report, *Exhibit 2* at 6, he explains "there is reason to be concerned that the current layout of turbines will result in this type of noise, especially during periods when the

winds are from the north or south such that the direction of the wind parallels the line of wind turbines. In discussions [he] had during a teleconference with GE management in charge of land and offshore wind turbines, it was stated that GE designs their projects to have 5 rotor diameters of distance between wind turbines in the non-dominant wind direction and 7 to 10 rotor diameters in the direction of prevailing winds. Review of the distances between turbines along Saddleback Ridge shows that the inter-turbine spacing is approximately 3 rotor diameters for the GE models. This is significantly less than GE's 5 rotor diameters and should be considered a likely cause of wake induced turbulence and increased wind turbine noise and amplitude modulation."

6. Problems with Modeling for NRO.

In its *Noise Impact Study*, RSE acknowledges that it can meet the DEP Noise Rule Sound Level Limits only by operating Turbines 6 trough 10 in NRO mode. *Id.* at 5.0 at 5-1. Rick James explains that RSE's reliance on the NRO modes to work is not backed by experience. *Exhibit 2* at 6-7. Based upon his observations at many locations where wind turbines are operating at similar distances from residences, the sound levels at the residential properties adjacent to the ridge will be higher than predicted. *Id.* Surface level winds at the residential properties will frequently not be sufficient to create sufficient wind induced noise from leaf rustle, etc. on many nights when the turbines will be operating at nominal power or higher. *Id.* A reduction of only 1 to 3 dBA by use of NRO mode operation will not protect those properties. *Id.* There is even a strong likelihood that there will be an increase in noise due to turbulence and wind shear that NRO modes cannot reduce. *Id.* His experience with wind turbines located on the island of Vinalhaven has shown that NRO modes do not reduce the sound levels under real world conditions when turbulence or wind shear is present. *Id. See also,* Exhibits 30 and 31. *See also,*

Report of Robert Rand and Stephen Ambrose, *Exhibit 3*, at 1-2.

5. Conclusion about the Applicant's Predictive Measurements

Given the limitations and flaws in the modeling of this Project, coupled with the necessity of requiring 5 turbines to operate in NRO mode to meet the DEP Noise Rule Sound Level Limits, never tested for accuracy in the real world, the *Noise Impact Study* should not be accepted by the Department as showing compliance of the Project with the Noise Rule or at least the Commissioner should grant the Aggrieved Parties' request for a public hearing on the issue. If allowances were made for the limitations and flaws of the sound propagation models the nighttime noise limits specified by the DEP Noise Rule would be exceeded for the Project. The Department should heed the lessons from Mars Hill, Liberty and Vinalhaven that projects sited so close to residences in the real world conditions result in serious noise complaints from routine operations. A greater cushion should be required to protect the local population. The fact that 5 turbines have to operate in NRO mode, should be a clear warning that excessive noise will be generated at this location. Until the Department has more experience with the efficacy of wind projects operating in NRO mode, which to date has been limited and, in the case of Vinalhaven unsuccessful, a project like this should not be permitted based on this issue alone. It should be borne in mind when evaluating the risks of modeling errors that sound level increases "approaching 10 dB result in a perceived doubling of SPL" because "SPLs are measured on a logarithmic scale". New York State Department of Environmental Protection, "Assessing and Mitigating Noise Impacts" (2001) at 14, *Exhibit 40*.

B. A Public Hearing is Necessary to Examine Conflicts In Technical Information Concerning the Health Risks of the Project.

The *Noise Impact Study* claims or at least implies that sound generated by the Project will

be insufficient to cause any health concerns. *See, Noise Impact Study* at Section 8.4 at 19 and Section 9.2.2 at 23. Dr. Eja Pederson, the world renowned Swedish expert on the subject of wind turbine noise recently warned that "the public concern regarding the possible health risks among people living in the vicinity of wind turbines should be treated seriously". E. Pederson, "Effects of Wind Turbine Noise on Humans", Third International Meeting on Wind Turbine Noise, June 17-19, 2009, *Exhibit 21*, at 2. The Aggrieved Parties ask the Department to do this by holding a public hearing on the risks of adverse health effects to neighboring residents of the proposed Projects.

1. Noise from the Project will Create Adverse Health Effects.

Dr. Michael Nissenbaum, who is an expert in the medical effects of exposure to excessive wind turbine noise, after reviewing the materials in the Saddleback Ridge Wind Project on noise, and based on his studies of other wind projects, has concluded that residents of Carthage and its surrounds will suffer adverse health effects from the Project. Affidavit of Michael Nissenbaum, *Exhibit 1,* at ¶s4-7 and 8. He opines that in his "opinion, the turbines proposed for the Saddleback Ridge Wind Project will be located too close to many of the residents living in the proximity of the project. Of the 34 residences indicated on Figure 18 of the RSG Saddleback Ridge Noise Impact Study, 20 will lie at or within 1400 meters of a wind turbine. Of these, 14 will lie downwind of the commonly prevailing winds. I further note that the turbines proposed for the Saddleback Ridge Wind Project are GE 2.75 MWs, larger than those installed in Mars Hill and Vinalhaven. Based on this information, I would expect that the residents at a minimum of 14 receptor sites will experience the same or similar adverse health effects, including and especially sleep disturbance, in the same proportions as the affected residents living within 1400 meters of the turbine installations at Mars Hill and Vinalhaven, and that other more distant

receptor sites will be exposed to an as yet unknown quantity of risk of adverse health effects. *Id.* at ¶8. The health impacts he anticipates are:

a) Sleep disturbances/sleep deprivation and the multiple illnesses that cascade from chronic sleep disturbance. These include cardiovascular diseases mediated by chronically increased levels of stress hormones, weight changes, and metabolic disturbances, including the continuum of impaired glucose tolerance up to diabetes.

b) Psychological stresses which can result in additional effects including cardiovascular disease, chronic depression, anger, and other psychiatric symptomatology.

c) Increased headaches.

d) Unintentional adverse changes in weight.

e) Auditory and vestibular system disturbances.

f) Increased requirement for and use of prescription medication.

Id. at ¶6.

Dr. Nina Pierpont in her book published in 2009, *Wind Turbine Syndrome, Exhibit 23,* at 26 "documents a consistent and often debilitating complex of symptoms experienced by adults and children living near [1000 to 4900 feet] large industrial wind turbines (1.5 – 3 MW)," such as the proposed Saddleback Ridge Wind Project. The symptoms found by Dr. Pierpont include "*sleep disturbance,* headache, tinnitus, ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia, irritability, problems with concentration and memory, and panic episodes associated with sensations of internal pulsation or quivering that arise while awake or asleep." *Id.* at 26. [Emphasis added.]

Dr. Christopher Hanning, a sleep disturbance expert, in his report, "Wind Turbine Noise" *Exhibit 28, supra,* reviewed and approved by a panel of professionals, concludes that "[t]here can be no doubt that ....industrial wind turbines ('wind farms') generate sufficient noise to disturb

the sleep and impair the health of those living nearby." *Id.* at 2.1.1. He explains that "[s]leep disturbance and impairment of the ability to return to sleep is not trivial as almost all of us can testify. In the short term, the resulting deprivation of sleep results in daytime fatigue and sleepiness, poor concentration and memory function. Accidents increase. In the longer term, sleep deprivation is linked to depression, weight gain, diabetes, high blood pressure and heart disease." *Id.* at 2.2.9.

Most recently, in a peer reviewed National Institute of Health funded study by Dr. Alec Salt and Timothy Hullar, "Responses of the Ear to Low Frequency Sounds, Infrasound and Wind Turbines, 268 *Hearing Research* 12 (June 2010)," *Exhibit 36*, the authors point out that symptoms reported by some people close to wind turbines "include sleep disturbance, headaches, difficulty concentrating, irritability and fatigue, but also include a number of otologic symptoms including dizziness or vertigo, tinnitus and sensation of aural pain or pressure." *Id.* at 12.

There is substantial amount of additional evidence in the record to support these findings and why they occur for wind turbine noise more than other kinds of noise and at what dB levels.

Recently the peer reviewed World Health Organization ("WHO") *Night Time Noise Guidelines for Europe* (2009), *Exhibit 26*, concluded that "[t]here is plenty of evidence that sleep is a biological necessity, and disturbed sleep is associated with a number of health problems". *Id.* at XI. Also, it concludes that "noise induced sleep disturbance is viewed as a health problem in itself (environmental insomnia)". *Id.* at XII. It also concludes that sleep disturbance also leads to further consequences for health and well-being". *Id.* In Section 2 of the *Guidelines* the consequences of sleep deprivation are summarized. *Id.* at 23 (Table 2.4). Some of the short term consequences are sleepiness, mood changes, irritability and nervousness, impairment of function, increased metabolic rate and thyroid activity, and immune function impairment. Some of the

long term consequences are depression/mania, violence, difficulty learning new skills, increased sensitivity to pain and susceptibility to viral illnesses. Based on the extensive research done, the 2009 WHO *Guidelines* concludes that sleep disturbance from noise occurs between 30 to 40 dB. *Id.* at XIII (table 1) and XVI-XVII (including Tables 3 and 4). Based on these findings, the 2009 WHO *Guidelines* recommend that noise levels at night should not exceed 40 dB during the night "[f]or the primary prevention of subclinical adverse health effects". *Id.* at XVIII.

The WHO *Guidelines* do not address wind turbine noise. However, that fact does not detract from the significance of its findings. To the contrary, it makes the report especially relevant because wind power noise poses a *greater risk factor* than other sources of industrial noise addressed in the WHO *Guidelines.*

An illustration of how the Saddleback Ridge Wind Project fits into the WHO 2009 Guidelines is set forth as Figure 4 in the Report of Robert Rand and Stephen Ambrose, *Exhibit 3*, at 11.

2. *The DEP Noise Rule Sound Level Limits Do Not Provide Adequate Protection Against Noise Generated from the Project.*

a. Wind Power Noise Is Different from Noises from Other Sources.

It is universally recognized today that noise generated by wind turbine facilities is more annoying than other sources of industrial noise. *See*, Report of Rick James, *Exhibit 2* at 8; Nissenbaum's Affidavit, *Exhibit 1*, at ¶18. The internationally renowned expert, Dr. Eja Pederson from Sweden, is most often cited for this proposition. In her peer reviewed article, E. Pederson & K. Waye, "Perception and Annoyance Due to Wind Turbine Noise – A Dose-Response Relationship," 116 J. *Acoust Soc. Am.* 3460, 3467 (2004), *Exhibit 17*, the authors state that "the results [of their study] suggest that the proportions of respondents annoyed by wind

turbine noise are higher than for other noise sources *at the same A-weighted SPL* and that the proportion annoyed increases more rapidly". [Emphasis added.] The conclusions were graphed as follows:

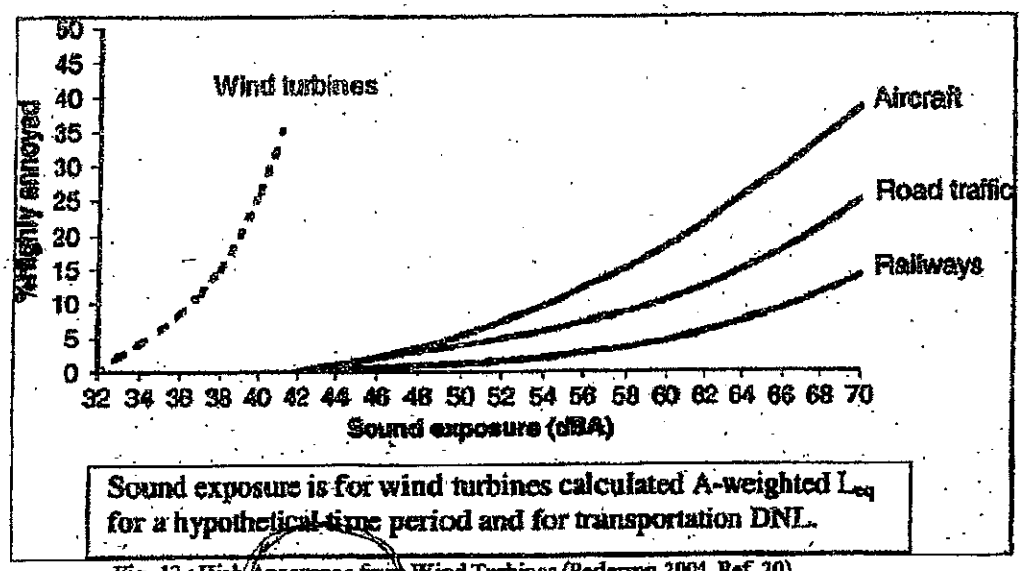


Fig. 13 : High Annoyance from Wind Turbines (Pederson 2004, Ref. 20)

Id. at 3468. This graph shows support for the DEP Noise Rule limit for night time noise in quiet areas at 45 dBA for industrial noise from aircraft, roads and railways, but shows the inadequacy of the sound limit for wind turbine noise as it causes annoyance at much lower limits. The conclusions of Dr. Pederson are reaffirmed in an EU financed study, G.P. van den Berg, Eja Pedersen, Jelte Bouma & Roel Bakker, " WINDFARMperception - Visual and Acoustic Impact of Wind Turbine Farms on Residents," June 3, 2008 , *Exhibit 22,* at 61 ("Perhaps the main finding is that wind turbine sound is relatively annoying, more so than equally loud sound from aircraft or road traffic."). The Pederson chart and her findings are frequently cited by others, including Dr. Christopher Hanning, "Wind Turbine Noise", *Exhibit 28.*

The most common explanation of why wind turbine noise is regarded as more annoying

than other industrial sources at the same sound pressure levels is that wind turbine noise is so often characterized by a pulsating, throbbing noise blade swish called "amplitude modulation". *See,* Pederson & Waye, *Exhibit 17, supra,* at 3468 ("Wind turbine noise was perceived by about 85% of the respondents *even when the calculated A-weighted SPL were as low as 35.0 - 37.5 dB.* This could be due to the presence of amplitude modulation in the noise, making it easier to detect and difficult to mask by ambient noise. This is also confirmed by the fact that the aerodynamic sounds were perceived at a longer distance than machinery noise."). [Emphasis added.] *See also,* G.P. van den Berg, "Low Frequency Noise and Vibration Control," 11th International Meeting on Low Frequency Noise and Vibration and its Control, "Do Wind Turbines Produce Significant Low Frequency Noise?" (2004), *Exhibit 11* at 8; G.P. van den Berg, et als, "WINDFARMperception, *Exhibit 22, supra,* at 57, 60, 61; Maine State Planning Office, Technical Assistance Bulletin #4, *Exhibit 16.* at 10 ("repetitive sounds are more annoying than multiband, constant noises".); George Kamperman & Richard James, "The 'How To' Guide to Siting Wind Turbine," *Exhibit 8,* at 12 (amplitude modulation is a "characteristic of wind turbine sound that increases sleep disturbance potential above that of other long-term sources".); Eja Pedersen and Kerstin Waye, "Wind Turbines-Low Level Noise Sources Interfering With Restoration?" *Environmental Res. Lett.* 3 (2008), *Exhibit 18;* Eja Pedersen, G.P. van den Berg, Roel Bakker & Jelte Bouma. "Response to Noise from Modern Wind Farms in the Netherlands", 126 *J Acoust. Soc. Am.* 634, 635 (2009), *Exhibit 19* ("Amplitude – modulated sound is more easily perceived than is a constant – level sound and has been found to be more annoying."); Kerstin Waye. "Perception and Environmental Impact of Wind Turbine Noise," Inter-Noise 2009, *Exhibit 24;* Geoff Leventhall, "Low Frequency Noise. What We Know, What We do not Know and What We would Like to Know," 28, *J. of Low Frequency Noise, Vibration and*

Active Control, 79, 97 (2009), *Exhibit 15,;* and C. Hanning, "Wind Turbine Noise," *Exhibit 28, supra,* at ¶2.2.4; Dr. Nissenbaum's Affidavit, *Exhibit 1*, at ¶18.

A second explanation as to why wind turbine noise is more annoying than other sources of industrial noise is that wind farms are often located in quiet, rural settings where pre-existing ambient noise levels are low. Pederson & Waye, *Exhibit 17, supra,* at 3468: "[a]nother factor that could be of importance for explaining the seemingly different dose-response relationships is that the wind turbine study was performed in a rural background, where a low background level allows perception of noise sources even if the A-weighted SPL are low." *See also*, Waye, *Exhibit 24* at 2-3 (ambient sound needs to be about 10 dB above that of wind turbine sound to mask it); Pederson & Waye, *Exhibit 17, supra,* at 2; E. Pederson, et als., "Wind Turbine Low Level Noise," *Exhibit 18, supra,* at 4; and Kamperman & James, *Exhibit 8, supra,* at 13-14; Dr. Nissenbaum's Affidavit, *Exhibit 1*, at ¶18; Rick James Report, *Exhibit 2* at 8.

A third reason why wind turbine noise is considered more annoying than other industrial sources is because of its low frequency content. Low frequency noise is typically in the range of 10 Hz to 100 Hz, although it can be extended an octave at each end of this to 5 Hz to 200 Hz. Geoff Leventhall, "Low Frequency Noise," *Exhibit 15, supra,* at 79. Wind turbines contain a significant amount of low frequency noise. Kamperman & James, "The 'How To' Guide," *Exhibit 8, supra,* at 4-5; Rick James Report, *Exhibit 2* at 7 and references therein. This was recognized by the DEP in a Memorandum from Andrew Fisk to Commissioner David Littell, dated January 10, 2008, made part of the *Report of the Governor's Task Force on Wind Power Development* as Exhibit I ("Noise generated from wind turbines does have attributes that warrant particular focus in the review of projects, including low frequency modulating noises generated as turbine blades pass by towers."). It is even recognized by Dr. Dora Mills, in her report, "Wind

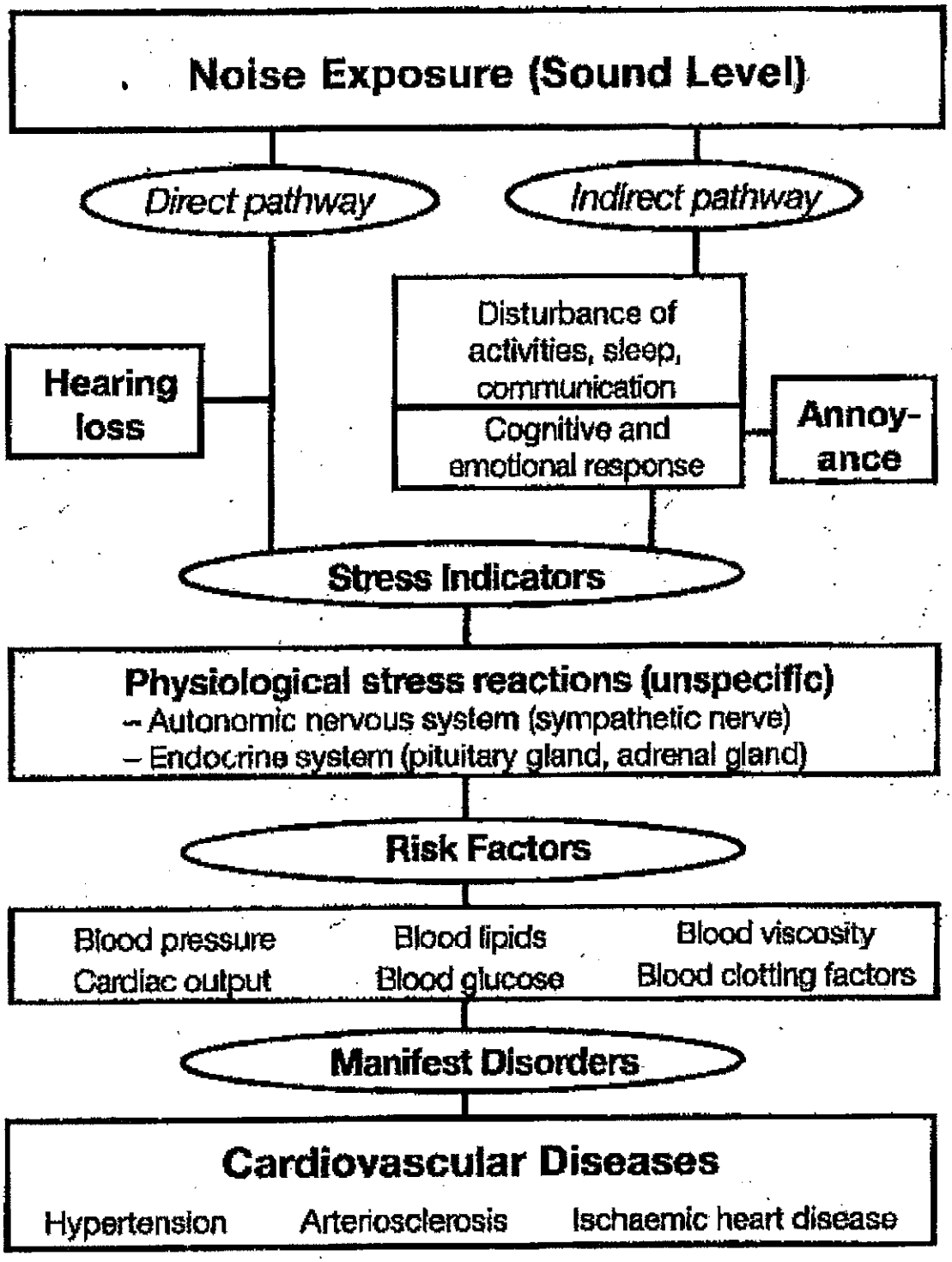
Turbine Neuro-Acoustical Issues" (June 2009), published on the Maine CDC website:

> Some have pointed to LFN [low frequency noise] emitted from
>
> > wind turbines as a possible source of adverse health effects. The reasons LFN are focused on include: LFN encounter less absorption as they travel through the air than higher frequency sound, so they persist for a longer distance; the amount of sound transmitted from outside to the inside of a building is higher with LFN; and some models for assessing impact of noise do not adequately include LFN.

Id. at 3. [Emphasis added.] *See also,* Dr. Nissenbaum's Affidavit, *Exhibit 1*, at ¶18. Even Geoff Leventhall, a prominent supporter of wind power, in his peer reviewed article, "Low Frequency Noise," *Exhibit 15, supra*, stresses that "annoyance from the low frequency noise [is] greater than that from higher frequency noise at the same A – weighted level", and that "[a]t equal A-weighted levels, *the noise dominated by the low frequency component was perceived as 4-7dB louder and 5-8dB more annoying.*"*Id.* at 86. [Emphasis added.]

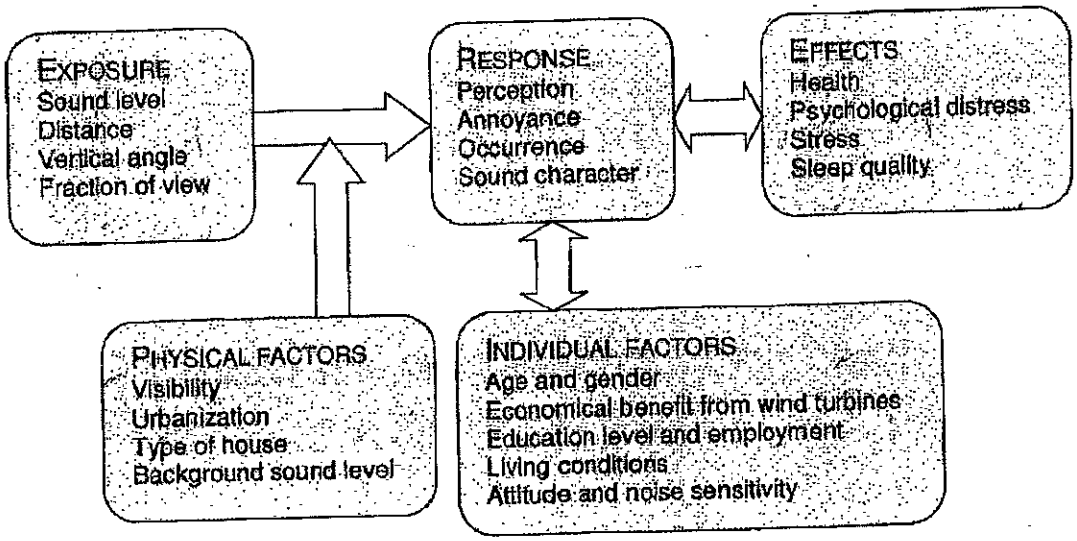
The significance of low frequency noise was also addressed by the WHO, *Guidelines on Community Noise* (1999). *Exhibit 27.* The 1999 *Guidelines* point out that "[h]ealth effects due to low-frequency components in noise are estimated to be more severe than for community noises in general" and this risk "is sufficiently strong to warrant immediate concern". *Id.* at 35. The 1999 *Guidelines* state that "*[n]oise with low-frequency components require lower guideline values..*" Id. at xiii. [Emphasis added.] *See also,* Kamperman & James, "The 'How To' Guide," *Exhibit 9. supra..*

The 2009 WHO *Guidelines, Exhibit 26, supra*, 62, while not addressing wind turbine noise, does explain the general principle that annoyance plays a prominent role in the indirect pathways to adverse health effects from noise, as illustrated in the following chart:



A similar chart showing the role of annoyance from wind turbines in relation to adverse health effects was prepared by van den Berg, et als. in the EU financed

study,"WINDFARMperception, " *Exhibit 22, supra*, at 23:



The same authors point out that "the stress scores, difficulties to fall asleep and sleep interruption were associated with annoyance due to wind turbines ..." *id.* at 55, *see also id.* at 57 ("wind turbine sound leads to annoyance for some people; annoyance that in turn possibly hinders psycho-physiological restoration and increases the level of stress.") and Pederson & Waye, "Wind Turbine – Low Level Noise," *Exhibit 18, supra* at 1 ("the prevalence of noise annoyance [is], apart from the sound pressure level, strongly related to disturbed rest" and "[i]nhibited restoration or hindrance of psychological stress recovery due to disturbance from noise sources is today believed to have an important impact on not only mood but more long term health consequences.") and E. Pederson, "Effects of Wind Turbine Noise, *Exhibit 21, supra*, at 10 ("Stress was in these studies not directly associated with A-weighted sound pressure levels, but with noise annoyance. There was a remarkable consistency among the studies for the relationship between feeling tense or stressed and annoyance.") It has also been recognized that annoyance on its own is an adverse health effect. Pederson & Waye, "Wind Turbine Low Level Noise," *Exhibit 18, supra* at 20.

This Board of Environmental Protection has stated in the last two appeals of wind turbine approvals by the DEP -- in the Record Hill Board Order dated March 18, 2010 at 11 and in the Oakfield Board Order dated June 11, 2010 -- that it "recognizes that noise emitted from the proposed project[s] has a potential to be heard at an audible level from protected locations and the noise generated by the Record Hill Wind Project [and the Oakfield Wind Project] may be deemed as an annoyance depending on a person's level of intensity." The turbines in Saddleback Ridge are sited in approximately the same distance from protected residential locations as in Oakfield and closer than Record Hill, but based on the extent of NRO mandated as a condition of the license in this case, it is logically more likely that the Saddleback Ridge Wind Project will cause more annoyance, sleep disturbance and secondary adverse health effects than either Record Hill or Oakfield. Therefore, the Department should make the same finding in this case and, based on that finding, in conjunction with the expert opinions and studies and reports reviewed above, should take additional steps to assure that the Project will not cause adverse health effects because of excessive noise.

b. The DEP Noise Rule Sound Level Limits Do Not Provide Adequate Protection Against the Unique Features of Wind Turbine Noise.

The DEP Noise Rule was last amended 21 years ago in 1989. The Rule makes no reference to noise propagated from industrial grade wind power projects. Back in 1989 the issue of wind power was not raised when the rule was amended, presumably because no one was approaching the DEP to license a wind turbine project under the Site Law in 1989. The existing DEP Noise Rule does not adequately protect against adverse health effects from noise, given its unique characteristics, for the reasons to be explained below. It has failed to protect the citizens of Mars Hill, Freedom and Vinalhaven. Because of this, Petitioners ask that the Department

exercise its authority under Section 375.10.E of the DEP Noise Rule. This provision allows the Department to establish, "as a term or condition of approval, any reasonable requirement to ensure that the developer has made adequate provision for the control of noise from the development and to reduce the impact of noise on protected locations. Such conditions may include, but are not limited to, imposing limits on hours of operation....".

i. High Frequency Sound Level Limits are Too High for Wind Turbine Noise.

The high frequency Sound Level Limits of 45 dBA set forth in Section 375.10.C(1) (a)(v) of the DEP Noise Rule for quiet area night time noise is too loud for wind turbine noise. Nissenbaum Affidavit, *Exhibit 1, supra,* at ¶27.a. As explained above, the 2009 WHO *Guidelines* finds that sleep disturbance occurs at dBA levels of 30-40 dBA and that is for general transportation noise, not wind turbine noise, which produces annoyance leading to health effects in the lower end of that range. For wind power noise, Dr. Nissenbaum states that the 2009 WHO *Guidelines* range should be used; more specifically he recommends 35 dBA. Nissenbaum Affidavit, *Exhibit 1, supra,* ¶s 6 and 26. Kamperman & James, "The 'How To' Guide", *Exhibit 8, supra,* at 15 also recommends 35 dBA. Dr. Hanning, in "Wind Turbine Noise," *Exhibit 28, supra,* at 4.4.2 agrees. The Pederson studies and the others cited above measuring significant annoyance levels below 40 dBA are further support for the need to protect against wind turbine noise below the 45 dBA set by the DEP Noise Rule and below 40 dBA. *Also see* Nissenbaum Affidavit, *Exhibit 1, supra,* ¶23a.

ii. The Absence of Setbacks.

The DEP Noise Rule does not set any setback limits to protect against the adverse health effects of noise. Dr. Pierpont recommends a setback of 1.24 miles and 2.0 miles for ridge mounted turbines. *Wind Turbine Syndrome, Exhibit 23, supra,* at 20. Dr. Nissenbaum

recommends 2000 meters, *Exhibit 1, supra,* at 7. Dr. Hanning recommends 1.5 km. *Exhibit 28, supra,* at ¶4.3.3. Dr. Salt recommends 2 kilometers. Alec Salt, PhD, "Infrasound: "Your Ears Hear It But They Cannot Tell Your Brain" (2010), *Exhibit 37*, Conclusions and Recommendations.

iii. No Measurements of Low Frequency Noise.

As explained above, low frequency noise emitted by wind turbines is more annoying and travels further and penetrates homes more and is more threatening to human health than higher frequency noise. Yet under the DEP Noise Rule low frequency noise is filtered out of the A-weighted measurement requirements in the Rule. *Also see,* Leventhall, "Low Frequency Noise", *Exhibit 15, supra* at 95. If, as Leventhall concludes, low frequency dominated noise is 5-8 dBA more annoying than high frequency noise at the same sound pressure level, *supra* at 20,, the DEP Noise Levels are too high by at least that amount, providing additional support for the 35 dBA limit discussed above. According to Leventhall, "[t]he absence of measurement requirement for … low frequency noise ... leads to long term stress effects….". *Id.* He adds, that "chronic psychophysiological damage may result from long-term exposure to an audible, low level frequency noise, which is left uncontrolled, despite complaints". *Id. Also see, Nissenbaum Affidavit, Exhibit 1, supra,* ¶23b.

iv. Inadequate Control of Amplitude Modulation.

The DEP Noise Rule takes amplitude modulation into account but only for noise that qualifies as SDRS and even noise so qualified is folded into an hour long measurement, rendering a finding of SDRS irrelevant as a practical matter for protection purposes. As Leventhall explains, when the government averages amplitude modulation into an average noise level over a period of time, an important feature of the noise (amplitude modulation) becomes

lost. *Id.* at 97. *Also see,* Nissenbaum Affidavit, *Exhibit 1, supra,* ¶23d.

v. Lack of Limits Related to Background Ambient Noise.

Finally, the DEP Noise Rule does not create limits for wind turbine noise by a defined increase over pre-development ambient background noise. Nissenbaum Affidavit, *Exhibit 1, supra,* ¶23.a. All that it does is set quiet time limits of 45 dBA when the ambient pre-development noise is 35 dBA. However, that allows a 45 dBA level of noise in the nighttime in rural areas where it is common to have ambient noise as low as 20 dBA. SPO Bulletin # 4, *Exhibit 16, supra,* at 1; Rick James Report, *Exhibit 2* at 8; Report of Robert Rand and Stephen Ambrose, *Exhibit 3* at 3 and 6. That would be impermissible in states such as Massachusetts that limit wind turbine noise to 10 dBA over pre-development ambient noise.[1] *See*, the MCDC *Wind Turbine Neuro-Acoustical Issues* dated June 2009 (the "Q&A") at 4, ("Basic Wind Turbine Noise Related Resources"), 310 CMR 7.10 and the New York Department of Environmental Conservation Guidelines for "Assessing and Mitigating Noise Impacts," *Exhibit 40* and the intent of the DEP Noise Rule. *See*, Basis Statement, *Exhibit 33,* Comment 12 ("We believe that areas with the low background levels need to be regulated differently since *an increase of 20 decibels would have a significant impact on existing noise levels and to individuals living near a development.*") [Emphasis added.] P. Kamperman & James, "The 'How To' Guide," *Exhibit 8, supra* at 14 recommend a limit of 5 dBA over background ambient noise.

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1. The Basis Statement for the 1989 amendments to the Noise Rule points out that the rule was amended "so that developments will produce, in most cases, no more than 15 dBA increase in ambient sound levels at protected locations" given that a higher increase "would have a significant impact on existing noise levels and to individuals living near a development". *Id.* Response to Comments 14 and 12. The Basis Statement further states that the amendment allows sound levels to increase more than 15 dBA over pre-development ambient noise in very quiet rural areas "based on the premise that relatively few inhabitated areas of the state would have background levels lower than 30 dBA at night and 40 dBA during the day." *Id.* Response to Comment 14. [Emphasis original.] Woodstock is inhabited and the pre-development ambient noise levels were measured by Tetra tech ---- as low as ---- -dBA, which is 19 dBA lower than the 45 dBA Sound Level Limits allowed for nighttime in quiet area under the DEP Noise Rule. RSE, *Sound Level Assessment, supra,* at 12, Table 6-1.

c. The Saddleback Ridge Wind Project will Generate Widespread Complaints, Strong Appeals to Stop Noise and Vigorous Community Action.

In the Report of Robert Rand and Stephen Ambrose, *Exhibit 3* attached to this Request, 2 acoustical engineers who have devoted themselves to studying wind power noise issues in this State in the past few years, the authors undertake a Community Impact Assessment of the Saddleback Ridge Wind Project. This analysis has at its foundation a methodology of assessing community reactions to noise created by the United States Environmental Protection Agency in 1974 pursuant to the Noise Control Act of 1972. The methodology is contained in a document entitled "Protected Noise Levels" made part of the rulemaking record when the DEP Noise Rule was last amended in 1989. *Exhibit 33*, Amended Index, Document Nos. 1 and 16. The second of these two documents (Document 16), "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," sets forth a model for assessing the cumulative effects of environmental noise on people by making adjustments to predicted or actual sound level measurements and plotting the results against a scale of community reactions. It is remarkable that the adjustments set forth in Table D-7 of the EPA document, *Exhibit 3* at 19, to a large extent, address the very same factors that make wind power a unique source of noise, namely, adjustments for introducing a new sound source into a community, adjustments for the pre-construction ambient noise level of that community, and adjustments for impulsive sound (amplitude modulation). The only factor important to the uniqueness of wind power not addressed in the EPA model was low frequency noise, which can increase the annoyance of sound by 5-8 dBA. *See supra at 20,* Rand and Ambrose in their Report took these adjustments and applied them to a large EPA noise study scaled against community reactions that did not contain the adjustments necessary for wind power projects just

described, and came up with a community reaction assessment matrix remarkably similar to the Pederson chart set forth at 17 *supra,* showing the annoyance levels for wind power noise in comparison to other sources of community noise. Then the Report overlaid the predictive sound levels done by RSE in the *Noise Impact Study*. The results are set forth in Figure 1, Community Impact Assessment, *Exhibit 3,* at 7. The community reaction would be even greater if one adds in the low frequency factor of 5-8 dBA. These results show that the community surrounding the Project will be severely impacted by the Project using RSE's own modeling. *See also*, Figure 2 and Figure 3, *Exhibit 3* at 9 and 10, with accompanying narrative showing the results of the analysis in alternative formats.

C. Conclusions

Based on the foregoing, it is clear that there is an urgent need for a public hearing on the noise to be generated by Saddleback Ridge Wind Project. The hearing is necessary to address the multiple conflicts in the record on the predictive modeling done by RSE in the *Noise Impact Study* for purposes of determining whether noise from the Project will exceed the Sound Level Limits in the DEP Noise Rule. Moreover, a public hearing is necessary to assess the risks that noise from the Project, even if it meets the limits of the DEP Noise Rule, will nevertheless cause an unreasonable risk to nearby residents of adverse health effects because of the unique features of wind power noise not addressed by the DEP Noise Rule. If the health issues addressed in this request are not adequately dispelled by the Applicant in a public hearing, the Department will then be in a position to exercise the authority given it in Section 10E. of the Noise Rule to impose additional measures, such as requiring the Project to stop operating at night, to protect the citizens in the vicinity of the Project.

V. A PUBLIC HEARING SHOULD BE HELD ON THE SUBJECT OF VISUAL IMPACT.

The Aggrieved Parties also request a public hearing on the visual impact of the Saddleback Ridge Wind Project. Public Law Chapter 661, the Wind Power Development Act, made special provisions for the assessment of visual impact of wind turbine projects under the Site Location of Development Act. For wind power projects, the applicable standard is whether the wind project "significantly compromises views from a scenic resource of state or national significance such that the development has an unreasonable adverse effect on the scenic character or existing uses related to scenic character of the scenic resource of state or national significance." 34-A M.R.S.A. §3452.1. Section 3452.3 sets forth evaluation criteria for making the visual impact assessment, and Section 3452.4 sets forth presumptions with regard to visual impact assessments depending on whether the area to be assessed is with a 3 mile or an 8 mile radius of the proposed project.

Following this regulatory scheme, the Applicant submitted a Visual Impact Assessment prepared by Terrence J. DeWan & Associates which concludes that the Project will not have an unreasonable adverse effect on the qualified scenic resources. The Aggrieved Parties attached hereto as *Exhibit 4* the Report of Michael Lawrence Associates, Landscape Architects & Site Planning Consultants, which concludes that the Project will have such an adverse impact. The primary difference between the two assessments is the failure of the Applicant's study to adequately assess the impact of the Project on Mount Blue State Park, a scenic resource of State significance within the meaning of the Wind Power Development Act. Based on this conflict among the experts on licensing criteria, the Aggrieved Parties request a public hearing on the subject of visual impact in addition to noise.

VI. PROPOSED TESTIMONY AT THE PUBLIC HEARING.

The DEP Procedural Rules do not require a person requesting the Commissioner to hold a

public hearing to summarize the proposed testimony of the requesting party. Compare Section 24.B.5 of the Procedural Rules for requests for the Board to hold a hearing. Nevertheless, the Aggrieved Parties state that at a public hearing they will present their principal findings consistent with the reports attached hereto, and address any agency or expert disagreements to these reports and submit additional rebuttal testimony consistent with the reports following cross examination of the noise and visual impact experts of the Applicant or the Department.

Respectfully Submitted.

Rufus E. Brown
Attorney for Friends of Maine's Mountains and Other Aggrieved Partie.

STATE OF MAINE
DEPARTMENT OF ENVIRONMENTAL PROTECTION
In re: SADDLEBACK RIDGE WIND PROJECT

AFFIDAVIT OF MICHAEL A. NISSENBAUM MD

I, Michael Nissenbaum, M.D., being first duly sworn, do depose and say as follows:

1. I am a graduate from the University of Toronto Medical School with post-graduate training at McGill University and the University of California.

2. I am a specialist in diagnostic imaging, whose training and work involves developing and utilizing an understanding of the effects of energy deposition, including sound on human tissues. I am a former Associate Director of MRI at a major Harvard Hospital, a former faculty member (junior) at Harvard University, and a published author. A copy of my CV is attached to this Affidavit as *Exhibit A.*

3. I give this Affidavit in support of citizens of Carthage, Maine who are concerned about potential adverse health effects from the proposed Saddleback Ridge Wind Project.

4. I have reviewed the documents in the Saddleback Ridge Wind Project file at the Maine DEP related to noise.

5. I developed an interest in the health effects of wind turbine projects after becoming aware of complaints related to an industrial wind turbine project in Mars Hill, Maine and subsequently investigating the widespread and serious health effects suffered by most of the residents of Mars Hill within 1400 meters or so of a linear arrangement of 28 GE 1.5 MW industrial wind turbines. Following a small pilot study in 2009 at Mars Hill, I undertook a larger, standardized study in 2010 in the towns of Mars Hill and Vinalhaven (Fox Island Wind Project) Maine using validated questionnaires regarding sleep disorders and physical and mental health,

in addition to attitudinal questions in 2010. The study followed a strict protocol including subject and control selection criteria, with raw data segregated from and not handled by the principal investigator. Data analysis was carried out by a professional epidemiologist, who did not interact with either subjects or controls and who used, in part, analysis software provided by Quality Metrics, developers and licensors of the SF-36v2 questionnaire, one of the validated questionnaires utilized in the study. Other validated questionnaires included the Epworth Sleep Scale and the Pittsburgh Sleep Quality Index, which evaluated effects upon sleep and resultant dysfunction. The material is being prepared for publication in a peer reviewed journal. Preliminary findings indicate that subjects at Mars Hill and Vinalhaven living within 1400 meters had worse sleep quality, were more sleepy, and worse SF-36v2 mental health summary scores than those living 3000-6000 meters away. Psychiatric symptom scores (irritability, stress, anger, hopelessness and anxiety) were significantly greater in the group living closer to the turbines, as was a composite mental health score. They were also more likely to report headaches), nausea and to wish to move away (73.7% v 0%). There were no differences between the Mars Hill and Vinalhaven sites. Dose response curves of PSQI, ESS and SF-36v2 scores against distance from the turbines were plotted and were significantly related even after controlling for gender, age and household clustering. In all cases, there was a sharp increase in effect between 1 and 2km. However, the scores were still declining and had not reached steady values at 6000m. From the foregoing, it is logical to conclude that industrial wind turbines adversely affect health, in particular sleep, at distances of at least 2000m and probably beyond.

6. Based on my studies and my medical background and experience, it is my professional opinion that there is a high probability of significant adverse health effects for

a) Sleep disturbances/sleep deprivation and the multiple illnesses that cascade from chronic sleep disturbance. These include cardiovascular diseases mediated by chronically increased levels of stress hormones, weight changes, and metabolic disturbances, including the continuum of impaired glucose tolerance up to diabetes.

b) Psychological stresses which can result in additional effects including cardiovascular disease, chronic depression, anger, and other psychiatric symptomatology.

c) Increased headaches.

d) Unintentional adverse changes in weight.

e) Auditory and vestibular system disturbances.

f) Increased requirement for and use of prescription medication.

7. Based on my studies and medical background and experience, it is my further professional opinion that any future industrial wind projects should build in an additional margin of safety to avoid the adverse health effects experienced at Mars Hill and Vinalhaven. I recommend a setback distance of at least 2000 meters, or a distance determined by an appropriately designed preconstruction sound modeling targeting a nighttime sound levels of 35dBA at the building façade or property line – whichever is greater. The 2000 meter minimum recommendation is also based upon the fact that preconstruction sound modeling is imprecise and has been, in Maine, a poor predictor of actual noise as measured. It is my further opinion that there is a high risk of adverse health effects from industrial wind turbines placed upwind from homes within distances of 1400 meters and thus adequate setbacks need to be required to avoid these effects. There is no reason to believe that larger turbines such as those planned for Saddleback will result in noise levels at property lines/homes less than obtained in Mars Hill and Vinalhaven at similar distances, regardless of what the current preconstruction sound modeling predicts.

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Saddleback will result in noise levels at property lines/homes less than obtained in Mars Hill and Vinalhaven at similar distances, regardless of what the current preconstruction sound modeling predicts.

8. In my opinion, the turbines proposed for the Saddleback Ridge Wind Project will be located too close to many of residents living in the proximity of the project. Of the 34 residences indicated on Figure 18 of the RSG Saddleback Ridge Noise Impact Study, 20 will lie at or within 1400 meters of a wind turbine. Of these, 14 will lie downwind of the commonly prevailing winds. I further note that the turbines proposed for the Saddleback Ridge Wind Project are GE 2.75 MWs, larger than those installed in Mars Hill and Vinalhaven. Based on this information, I would expect that the residents at a minimum of 14 receptor sites will experience the same or similar adverse health effects, including and especially sleep disturbance, in the same proportions as the affected residents living within 1400 meters of the turbine installations at Mars Hill and Vinalhaven, and that other more distant receptor sites will be exposed to an as yet unknown quantity of risk of adverse health effects.

9. There is not a single, non-industry funded study or any peer reviewed literature that states that wind turbine noise is harmless to human health. To the contrary, there is an emerging body of literature, some of which is peer reviewed, informing us that under certain circumstances wind turbine noise can have substantial physiological and psychological impact on a community. In support of this statement, I attach as *Exhibit B* a summary of some of the literature on this subject composed by Daniel Sheppard, PhD from the Auckland University of Technology in New Zealand.

10. At this point in time, the industrial wind industry does not appreciate or fails to acknowledge the progression of how new environmental toxins are evaluated by the medical community.

11. To quote Dr. Shepherd:

> Wind turbines are a new source of community noise, and as such their effects on public health are only beginning to emerge in the literature. The recognition of a new disease, disorder, or threat to health usually follows a set pathway. First, doctors and practitioners attempt to fit symptoms into pre-defined diagnostic categories or to classify the complaints as psychosomatic. Second, as evidence accumulates, case studies begin to appear in the literature, and exploratory research is undertaken to obtain better descriptions of the symptoms/complaints. Third, intensive research is undertaken examining the distribution and prevalence of those reporting symptoms, the factors correlating with the distribution and prevalence of those symptoms, and ultimately to cause-and-effect explanations of why those reporting symptoms may be doing so.
>
> In my reading of the literature the health effects of wind turbines are only beginning to be elucidated, and is caught somewhere between the first and second stage described in 2.3. The important point to note is that case studies (e.g., Harry, 2007; Pierpont, 2009) and correlation studies (e.g., Pedersen et al., 2007; van den berg, 2008) have already emerged in relation to the health effects of wind turbine noise, and so the possibility of detrimental health effects due to wind turbine noise must be taken with utmost seriousness.

12. The wind turbine industry acknowledges that wind turbine facilities can create annoyance for nearby residents, but then seeks to belittle the significance of this fact. While the word "annoyance" has been used in European studies relating to this turbine noise, the term has been misinterpreted by the wind industry and the MCDC to mean an inconsequential disturbance, whereas the authors define the word 'annoyance' as a state of diminished well being and diminished health. A reading of the original papers upon which proponents of the wind

industry base their opinions that "annoyance only" may occur quickly reveals that a more appropriate word in American English would be "disturbance." It further becomes clear that wind energy proponents appear to be exploiting the colloquial American English understanding of the word "annoyance" as an inconsequential "bother" of minor significance. In fact, the lead author of many of these studies (Eja Pedersen, PhD), erroneously quoted and interpreted by the wind proponents, stated to me in a personal communication that:

> "Annoyance is a response, rather than an effect. However, to be annoyed means a lowered well-being and annoyance should therefore be avoided. The relationship between annoyance and symptoms of lowered health goes, from what I have found in my studies, two ways.
>
> People who have lowered physical or mental health are more vulnerable and therefore get annoyed.
>
> People who get annoyed may not get the physiological and psychological restoration that they need and annoyance could hence increase the risk for impaired health."

13. A review of the Mars Hill and Vinalhaven findings suggests that this "annoyance" is one of the root causes of the sleep disturbances and secondary adverse health effects suffered. Mechanisms for how intrusive noise affects health are summarized in the diagram, from the WHO *Guidelines for Nighttime Noise in Europe* (2009), attached as *Exhibit C* hereto which reflects longstanding and non-controversial, settled medical knowledge.

14. "Annoyance" in the context of industrial wind energy facilties is not only a critical physiologic stressor and resultant symptoms and medical disorders, but it causes sleep disturbance. When sleep disturbance is chronic, which will happen when turbines are sited too close to residents because turbine noise at night is in fact chronic (it is there much of the time, week after week, month after month, year after year), it results in sleep deprivation. Sleep deprivation will result, as surely as day follows night, in a host of adverse symptoms and, over

time, diagnoses of real medical conditions. This includes headaches, changes in weight, psychiatric symptoms, cognitive dysfunction, possible increases in blood pressure, and the like in the near and medium term. Chronic effects, which have yet to be seen (it is early, yet) may include, in the fullness of time, effects such as diabetes and heart disease.

This progression of ill health related to sleep disturbance is not conjecture. This is simple, known, medical fact.

15. Annoyance, in addition to being addressed in the WHO *Night Noise Guidelines for Europe 2009 and Guidelines for Community Noise 1999*, has been studied extensively by Swedish wind noise expert, Dr. Eja Pederson, and her colleagues in the following publications:

a. Eja Pederson and Kerstin Wayne. "Perception and Annoyance Due to Wind Turbine - a Dose – Response Relationship," J. Acoust. Soc. Am. 116 (2004). **Peer reviewed.**

b. Eja Pedersen and Kerstin Waye, "Wind Turbines-Low Level Noise Sources Interfering With Restoration?" Environmental Res. Lett. 3 (2008).

c. Frits van den Berg, Eja Pedersen, Jelte Bouma & Roel Bakker. " WINDFARMperception, Visual and Acoustic Impact of Wind Turbine Farms on Residents," June 3, 2008

d. Eja Pedersen, Frits van den Berg, Roel Bakker & Jelte Bouma. "Response to Noise from Modern Wind Farms in the Netherlands," J Acoust. Soc. Am 126 (2), August 2009. **Peer reviewed.**

e. Eja Pedersen. "Third International Meeting on Wind Turbine Noise," Aalborg Denmark 17-19 June 2009."

f. Kerstin Waye. "Perception and Environmental Impact of Wind Turbine Noise," Inter-Noise 2009 (August 23-26,2009).

In the third of these articles, the authors state that since 2005 it has been known that "the prevalence of noise annoyance [is], apart from the sound pressure level, strongly related to disturbed rest" and "[i]nhibited restoration or hindrance of psychological stress recovery due to

disturbance from noise sources is today believed to have an important impact on not only mood but more long term health consequences." In the fifth article, the authors state that the "need for guidelines for maximum exposure to wind turbine noise is urgent .... To avoid possible health effects.

17. It is well established today that noise generated from the operation of wind turbine projects is unique and significantly different from noise generated from other common industrial and commercial operations, including traffic, rail and air transportation, as illustrated by the graph published by Eja Pederson in 2004 attached hereto as *Exhibit D*.

18. The reasons for this difference include: (a) amplitude modulation of audible sounds, which is pulsating (or 'impulsive') in nature and therefore more "annoying", or, more properly, more "disturbing" than other kinds of noise. (b) a dominance of dynamically modulated infrasonic and low frequency acoustic energy, which can more easily penetrate facades of buildings and can convert through building resonance sound that is otherwise inaudible into noise that is audible, intrusive and disturbing to most people, (c) noise being emitted from high above the ground resulting in a pervasive and omnipresent character that dominates the soundscape, and (d), noise which is often a new source of disturbance compared to noise from more common sources such as railroads and airports, and has therefore an increased potential to casue adverse effects on the adjacent community's health and welfare than sounds generated from other sources for which the current regulatory scheme for noise in Maine was developed.

19. Scientific literature that supports the statements made in paragraphs 17 and 18 of my affidavit, in addition to those articles cited in paragraph 10, include the following:

.a. Keith Stelling & Carmen Krogh. "Summary of Recent Research on Adverse Health Effects of Wind Turbines" 20 October 2009.

b. Dr. Christopher Hanning, "Wind Turbine Noise, Sleep and Health," April 2010.

c. "Wind Energy Industry Acknowledgement of Adverse Health Effects", prepared by the Society for Wind Vigilance (January 2010).

d. Geoff Leventhall, "Low Frequency Noise. What We Know, What We do not Know and What We would Like to Know," 28 Journal of Low Frequency Noise, Vibration and Active Control No. 2 (2009).

e. Hubbard, H.H., "Noise Induced House Vibrations and Human Perception," *Noise Control Engineering J.*, **19**, 49-55 (1982).

20. The WHO *Guidelines for Community Noise (1999),* indicate that particular attention should be given to assessing sources of noise with low frequency components because "[h]ealth effects due to low frequency components in noise are estimated to be more severe than community noise in general." In addition, the peer reviewed WHO *Night Noise Guidelines for Europe* (2009) includes a chart, attached hereto as *Exhibit E*, showing that 30 dBA outside the façade of a home is safe, with no observed effect level, and that 40 dBA outside the façade results in unequivocal adverse health effects, with a grey area in between 30-40.dBA.

21. There is no statement in the WHO *Guidelines* that the disease thresholds summarized in the foregoing charts are dependent on exposure for a year to observe all of the listed effects and there is nothing in the scientific literature that requires such a long exposure. Adverse health effects can be observed after only a few days of sleep disturbance. They are not dependent on exposure for a year and there is nothing in the scientific literature that requires such exposure. Chronically impaired sleep over a period of time, much shorter than one year, results in adverse health effects.

22. Therefore, if one is to look to the WHO *Guidelines* in order to determine what levels of noise would generally be safe, those limits would be set somewhere between 30 dBA and 40dBA, with a margin of safety from the lower threshold.

23. Finally, I disagree with the assertions that compliance with the Sound Level Limits of the DEP Noise Rule of 45 dBA at nighttime in a quiet, rural environment adequately protects against exposure to excessive noise from wind turbine projects for the following reasons:

a. The current 45 dBA limit specified in the DEP Noise Rule is too high for rural and wilderness communities. The DEP Noise Rule does not address the higher annoyance and disturbance effects caused by the unique and pervasive noise of wind turbines. It does not take into consideration the impact on rural and wilderness communities with naturally low background sound levels, especially at nightime, which results in a level of noise, when measured in decibel level, significantly over and above the pre-development community noise levels in these rural communities, and of sufficient amplitude, when sited in close proximity to homes (such as has occurred at Mars Hill), to result in adverse health effects.

b. The DEP Noise Rule does not require any measurement or control of infrasonic and low frequency noise propagated by wind turbine projects which can cause adverse public health consequences even at levels that are not audible to many people.

d. The DEP Noise Rule does not take into account amplitude modulation, a feature of wind power noise that is an important component of its uniquely disturbing quality.

e. It is possible for a noise emitter to produce continuous noise during a night that results in sound levels between 40 and 45 dBA that exceed WHO's 40 dB ($L_{night-outside}$) thresholds, where observable adverse health effects are known to occur, yet be in compliance with the DEP Noise Rules.

Dated: December 8 , 2010

Michael Nissenbaum, M.D.

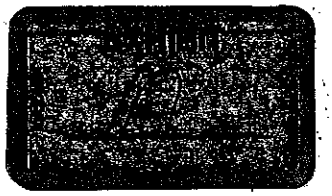
STATE OF MAINE
Aroostook, ss.

December 8, 2010

Personally appeared the above-named Michael Nissenbaum, M.D., and being sworn, made oath that the foregoing statements by him described are upon his own knowledge, information and belief and that, so far as upon information and belief, that he believes this information to be true.

Before me,

Notary Public/Attorney-at-Law
My commission expires: 10-27-2011



Curriculum Vitae - Michael A. Nissenbaum, MD

Address: 194 E. Main St., Fort Kent, ME 04743

Citizenship: Canadian / American

Positions Held:

1998-current:	Solo Radiologist, Northern Maine Medical Center, Fort Kent, ME
1994-1998	Chief, MRI Clinical Services, MRI Scan Center, Ft. Lauderdale. FL
1992-1994	Associate Director to Bob Edelman, MRI, Beth Israel Hospital, Boston, MA, (Harvard Medical School)

Education:

1979	McGill University, Faculty of Arts and Science (Honours Anthropology)
1983 M.D.	University of Toronto, Faculty of Medicine

Postdoctoral Training:

Internships, Residencies, Clinical Fellowships:

1984-1988	Resident, Radiology, McGill University Faculty of Medicine, Montreal, Canada
1983	Intern, Internal Medicine, Mount Sinai Hospital, Toronto, Canada
1988	Armed Forces Institute of Pathology, Washington, DC
1991-1992	MRI Clinical Fellow, Long Beach Memorial Medical Center, Long Beach, CA Supervisor: William G. Bradley, Jr., M.D., Ph. D.

Research Fellowship:

1990-1991	Interventional Research Fellow, University of California at San Diego, CA

Licensures and Certifications:

1984	Quebec License Registration
1986	Ontario License Registration
1989	California License Registration
1991	Massachusetts License Registration
1994	Florida License Registration
1988	Fellow, Royal College of Physicians of Canada
1988	Diplomate, American Board of Radiology
1988	Diplomate, Quebec Board of Medical Specialists (Radiology)
1998	Maine Medical License

Academic Appointments:

1992-94	Harvard Medical School, Boston, MA.

Hospital Appointments:

1989-1990	Attending Radiologist, Alexandra Hospital, Ingersoll, Ontario.
1991-1992	Clinical Fellow, Memorial Medical Center, Long Beach, CA.
1992- 1994	Attending Radiologist, Associate Director of MRI, Beth Israel Hospital, Boston, MA
1998-present	Attending Radiologist, Northern Maine Medical Center

Awards and Honours:

1977, 1978, 1979	McGill Scholar –McGill University
1977, 1978, 1979	James McGill Award – McGill University
1988	Chief Resident, Royal Victoria Hospital

Memberships, Offices and Committee Assignments in Professional Societies:

American Roentgen Ray Society -L
Canadian Medical Association
American College of Radiology - L
Radiological Society of North America - L
Associate Member, American Society of Neuroradiology -L

Teaching Experience:

1990	Percutaneous Ethanol Ablation of Hepatic Neoplasia: Tissue Responses, Physiological Effects, and Imaging Characteristics in the Normal Liver, Dept. of Rad. Research Conference, Univ. of CA at San Diego
1991	Interventional Radiology, University of California at San Diego
1991-1992	Monthly Lecturer MR Visiting Fellowship, MRI Instruction to Radiology Residents, University at Irvine Memorial MRI Educational Institute
1992	Lecture: MRA- Current State-of-the-Art. To: Grand Surgical Rounds, Department of Surgery, Beth Israel Hospital, Harvard Medical School. Nov 1992
1993	Lecture: MRI Update: New Diagnostic Applications. To: Internal Medicine Group, Beth Israel Hospital, Harvard Medical School. October 1993
1993	Lecture: Optimization of Magnetic Resonance Angiography. To: Brigham and Womens' Hospital MRI and CT Update: October 1993, Harvard Medical School
1994	Lecture: Advanced MRI Techniques. To: Department of Radiology, Chinese University Hong Kong. December 1994
1995	Ongoing Lectures: Topics in Neurological and Body MRI and MRA (AMA category 1 credits) monthly at MRI Scan Center, Ft. Lauderdale, FL

Editorial Responsibilities:

1992-98	Reviewer, MRI related topics. American Journal of Roentgenology

Principal Clinical and Hospital Service Responsibilities:

1992-94	Associate Director, MRI, Beth Israel Hospital, Boston, MA.
1994-98	Chief, MRI Clinical Services and Advanced MR Applications MRI Scan Centers, Ft. Lauderdale, FL

Grant Support:

Seed grant for Tumor Ablation Research, Canadian Radiological Foundation Research Award (1988-1989).

Imaging Guided Tumor Ablation Project, Academic Senate of the University of California (1990-1991).

Principle Investigator: AMI-25, Superparamagnetic Iron Oxide Contrast Agent for use in Assessment of Hepatic Malignancy. 1991-1992 at Long Beach Memorial Medical Center
(Corporate-sponsored, non-peer reviewed)

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3. Muller MF, Prasad P, Siewert B, **Nissenbaum MA,** Raptopoulos V, Edelman RR. Abdominal Diffusion- Mapping Using a Whole Body Echo Planar System. Radiology, August 1993.

4. Ros PR, Freeny PC, Harms SE, Seltzer SE, Davis PL, Chan TW, Stillman AE, Muroff LR, Runge VM, **Nissenbaum, MA.** Hepatic MR Imaging with Ferumoxides: A Multicenter Clinical Trial. Radiology, August 1995.

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1. **Nissenbaum MA,** vanSonnenberg E, D'Agostino HB. Interventional Radiology in the Liver, Biliary Tract, and Gallbladder. In: Schiff E, ed. Diseases of the Liver. J.B. Lippincott Company, 1993. pp 279-298.

2. **Nissenbaum MA,** Adamis MK. Magnetic Resonance Imaging in Rheumatology- An Overview. In: Rheumarology Clinics of North America. Trentham, ed. May 1994.

3. **Nissenbaum MA.** MRI of Bone Marrow Disease, In Magnetic Resonance Imaging, Edelman and Hesselink, 1995.

Abstracts:

1. **Nissenbaum MA,** Atkinson DJ, Song SJ, Brown SM, Yan K, Widoff BE, Blitzer J, Bradley WG. Metastic Lesion Detection in the Liver; Increased Sensitivity of Dynamic Ultrafast MRI. Society for MRI in Med. 1992;

2. **Nissenbaum MA,** Margossian P, Song SJ, Brown SM, Widoff BE, Yan K, Amster JL, Bradley WG. Increases Sensitivity of Black Blood MRA: A Role for Optimized Sequences? Society for MRI in Med. 1992;

3. **Nissenbaum MA,** Palmer N, Widoff BE, Song SJ, Brown SM, Yan K, Amster JL, Bradley WG. MRI of the Post Operative Lumbar Spine: The Value of Gadolinium Enhanced Multiplanar Reconstruction Using 3D Acquired Datasets Yielding 1MM Isotropic Resolution. Society for MRI in Med. 1992;

4. Brown SM, **Nissenbaum MA,** Atkinson DJ, Song SJ, Widoff BE, Yan K, Kurzweil PR, Jackson D, Bradley WG. MR Arthrography with Contrast Enhancement (MR ACE): Evaluation of Articular Cartilage in the Knee. Society for MRI in Med. 1992;

5. Brown SM, Atkinson DJ, **Nissenbaum MA,** Song SJ, Widoff BE, Yan K, Kurzweil PR, Jackson D, Bradley WG. Kinematic MRI of the Knee with Biplane Acquisition. Society for MRI in Med. 1992;

6. Bradley WG, Atkinson DJ, Nitz WR, **Nissenbaum MA,** Song SJ, Widoff BE, Yan K, Brown SM. Quantitative CSF Velocity Imaging: Comparison of Normals and Patients with Shunt-Responsive NPH. Society for MRI in Med. 1992;

7. Bradley WG, Brown SM, Widoff BE, Yan K, Song SJ, **Nissenbaum MA.** Analysis of Aneurysms and AVM's Missed on Routine MR Images which are Detected by MR Angiography. Society for MRI in Med. 1992;

8. **Nissenbaum MA,** Atkinson DJ, Brown SM, Song SJ, Widoff BE, Yan K, Bradley WG. Avoiding T1 Contrast Variability in IR Prepped Ultrafast Imaging Using Breath Holding. Society for MRI in Med. (1992).

9. **Nissenbaum MA,** Palmer N, Widoff BE, Brown SM, Song SJ, Yan K, Amster JL, Bradley WG. Assessments of the Lumbar Spine Using 3D Acquisition Sequences Providing 1mm Isotropic Resolution: The Value of Multiplanar Reconstruction. Society for MRI in Med. (1992).

10. **Nissenbaum MA,** Brown SM, Song SJ, Widoff BE, Yan K, Bradley WG. Decreased Intensity of Pathology in the Left Lobe of the Liver on T2 Weighted Imaging Related to Pulsation Induced Intravoxel Dephasing: Implications for Clinical Imaging. Society for MRI in Med. (1992).

Appendix C

A SUMMARY OF RESEARCH UNDERTAKEN ON WIND TURBINE NOISE*

Preamble

There are now a number of studies showing that turbine noise is annoying, and that there is a link between annoyance to turbine noise and health as defined by the WHO. A brief description of this evidence is now listed, and where possible, technical jargon has been omitted or minimised. It should be noted that, without exception, all of these studies have shortcomings, and indeed, research of this type is vulnerable to inherent limitations that serve to dampen its impact. However, the studies selected represent credible researchers undertaking difficult research.

Harry (2007)

Dr Amanda Harry, a British General Practitioner, conducted surveys of 42 residents living near several different turbine sites and reported a similar constellation of symptoms from all sites. Of the 42 respondents, 81% felt their health had been affected, in 76% it was sufficiently severe to consult a doctor and 73% felt their quality of life had been adversely impacted. This study is open to criticism for a design that invited symptom reporting and was not controlled. While the proportion of those affected may be questioned it nevertheless indicates strongly that some members of the public are severely affected by wind turbine noise at distances thought by governments and industry to be safe.

Harry, A. (2007), Wind Turbines, Noise and Health. Retrieved from: http://www.flat-group.co.uk/pdf/wtnoise_health_2007_a_barry.pdf

Pederson et al., (2003, 2004, 2007, 2008 and 2009)

Pedersen and co-investigators have undertaken a series of investigations examining the relationship between turbine noise and health. In a 2004 paper (n=351) Pedersen reports the importance of individual and contextual factors alongside noise parameters, and the danger in generalising findings from other sources of community noise (e.g., road, rail, aircraft) to the wind turbine context (see Figure 3.0, mainbody). In a 2007 paper (n=754), Pederson further explores these individual and contextual influences. They noted that those living in rural areas are more likely to be annoyed than those from suburban areas, and that those living in complex terrain (e.g., hills or rocky terrain) were more likely to be annoyed than those living on flat ground. The study found a strong association between annoyance and both lowered sleep quality and negative emotions. A paper

published in 2008 (n=1822) reanalysed pre-existing turbine noise and annoyance data and concluded that turbine noise can impede health, especially for susceptible individuals. The paper also discussed the dangers of using noise level as a sole predictor of annoyance, and the strength of noise sensitivity indices in predicting annoyance.

Pedersen and others (2009) reported that annoyance increased with increasing sound levels, both indoors and outdoors (see Table 1). The proportions who were rather and very annoyed at different sound levels are shown in Table I. In summary, when outside, 18% were rather or very annoyed at sound levels of 35-40 and 40-45 dB(A) compared to 7% at 30-35 dB(A) and 2% at <30 dB(A). When inside, the equivalent figures were 1% at <30 dB(A), 4% at 30-35 dB(A), 8% at 35-40 dB(A) and 18% at 40-45 dB(A). Those respondents who had an economic interest in the turbines had lower levels of annoyance while negative views of the visual impact of turbines increased the likelihood of annoyance.

Although the authors do not seek to recommend minimum sound levels, they do note that turbine noise was more annoying than other sources, with the possible exception of railway shunting yards and was more noticeable at night. Reported associations between annoyance and symptoms of stress (headache, tiredness, tension and irritability) confirmed that "annoyance" is more than irritation and is a marker of impaired health. They conclude that (Pedersen et al, 2009):

"...night time conditions should be treated as crucial in recommendations for wind turbine noise limits."

Nevertheless, it is clear from this analysis that external predicted turbine sound levels should be less than 35 dB(A), considerably less than those permitted by European noise standards, in order to reduce effects on nearby residents to acceptable levels.

Table 1: Percent responding to level of annoyance towards outdoor and indoor wind turbine noise levels for five categories of level in 5-dB(A) sound level intervals. Parentheses present 95% confidence intervals. (From Pedersen 2009)

	Predicted *A*-weighted sound pressure levels dB(A)				
	<30	30–35	35–40	40–45	>45
Outdoors	n=178	n=213	n=159	n=93	n=65
Do not notice	75 (68–81)	46(40–53)	21(16–28)	13 (8–21)	8(3–17)
Notice, but not annoyed	20 (15–27)	36(30–43)	41(34–49)	46 (36–56)	58(46–70)
Slightly annoyed	2 (1–6)	10(7–15)	20 (15–27)	23 (15–32)	22(13–33)
Rather annoyed	1 (0–4)	6(4–10)	12 (8–18)	6 (3–13)	6(2–15)
Very annoyed	1 (0–4)	1(0–4)	6 (3–10)	12 (7–20)	6(2–15)
Indoors	n=178	n=203	n=159	n=94	n=65
Do not notice	87 (81–91)	73(67–79)	61(53–68)	37 (28–47)	46(35–58)
Notice, but not annoyed	11(7–17)	15(11–20)	22 (16–29)	31(22–31)	38(28–51)

Slightly annoyed	1 (0–4)	8(5–12)	9 (6–15)	16 (10–25)	9(4–19)
Rather annoyed	0 (0–2)	3(1–6)	4 (2–8)	6 (3–13)	5(2–13)
Very annoyed	1 (0–4)	1(0–4)	4 (2–8)	10 (5–17)	2(0–8)

Pedersen, Hallberg, and Waye (2007) conducted in-depth interviews with 15 people living within close vicinity of wind turbines. A qualitative method known as grounded theory was selected to inform both data collection and data analysis. Respondents opinions of the turbines and the turbine noise was largely determined by their personal values about the living environment. The feeling of intrusion was associated with feeling a lack of control, subjected to injustice, a lack of influence, and not being believed. Various coping strategies were engaged, such as rebuilding their houses or complaining. Most however displayed learned helplessness and simply tried to ignore wind turbine noise.

Pedersen, E., Hallberg, L.R.M., and Persson Waye, K. P. (2007). Living in the Vicinity of Wind Turbines - A Grounded Theory Study. Qualitative Research in Psychology, 4: 1, 49 – 63.

Pedersen, E., and Nielsen, K.S. (1994). Annoyance due to noise from wind turbines. Delta Acoustic and Vibration Ltd. Report 150, Copenhagen, Denmark.

Pederson, E. W. (2005). Human Response to Wind turbine Noise – Annoyance and moderating factors. Wind Turbine Noise: Perspectives for control, Berlin, INCE/European Conference.

Pedersen, E., and Persson Waye, K. P. (2004). Perception and annoyance due to wind turbine noise: a dose-response relationship. Journal of the Acoustical Society of America, 116(6), p3460-3470.

Pedersen, E., and Persson Waye, K. (2007). Wind turbine noise, annoyance and self-reported health and well-being in different living conditions. Occupational Environmental Medicine, 64, p480-486.

Pedersen, E., and Waye, K. P. (2008). Wind Turbines – low level noise sources interfering with restoration? Environmental Research Letters, 3, 1-5.

Pedersen, E., van den Berg, F., Bakker, R., and Bouma, J. (2009). Response to noise from modern wind farms in The Netherlands. Journal of the Acoustical Society of America. 126:634-643.

van Der Berg (2008)

van den Berg and colleagues (2008) from the University of Groningen in the Netherlands have recently published a major questionnaire study of residents living within 2.5km from wind turbines. A random selection of 1948 residents were sent a similar questionnaire to that used by Pedersen in her studies in Sweden (2003, 2004, 2007 and 2008), questions on health, based on the validated General Heath Questionnaire (GHQ), were added. 725 (37%) replied which is good for a survey of this type but, nevertheless may be a weakness. Non-respondents were asked to complete a shortened questionnaire. Their responses did not differ from full respondents suggesting the latter are representative of the population as a whole.

Questions on wind turbine noise were interspersed with questions on other environmental factors to avoid bias. The sound level at the residents' dwellings was calculated, knowing the turbine type and distance, according to the international ISO standard for sound propagation, the almost identical Dutch legal model and a simple (non spectral) calculation model. The indicative sound level used was the sound level when the wind turbines operate at 8 m/s in daytime, that is, at high, but not maximum power. Noise exposure ranged between 24 and 54 dB(A). It is worth noting that the industry was approached for assistance in the research but refused. Complaints such as annoyance, waking from sleep, difficulty in returning to sleep and other health complaints were related to the calculated noise levels.

The research team concluded that *"Sound was the most annoying aspect of wind turbines"* and was more of an annoyance at night. Interrupted sleep and difficulty in returning to sleep increased with calculated noise level as did annoyance, both indoors and outdoors. Even at the lowest noise levels, 20% of respondents reported disturbed sleep at least one night per month. At a calculated noise level of 30-35 dB(A), 10% were rather or very annoyed at wind turbine sound, 20% at 35-40 dB(A) and 25% at 40-43 dB(A). van den Berg concluded also that, contrary to industry belief, road noise does not adequately mask turbine noise and reduce annoyance and disturbance. Bolin (2009) has shown that vegetation noise does not mask turbine noise as well as expected. With regard to health it was concluded that:

"There is no indication that the sound from wind turbines had an effect on respondents' health, except for the interruption of sleep. At high levels of wind turbine sound (more than 45 dB(A)) interruption of sleep was more likely than at low levels. Higher levels of background sound from road traffic also increased the odds for interrupted sleep. Annoyance from wind turbine sound was related to difficulties with falling asleep and to higher stress scores. From this study it cannot be concluded whether these health effects are caused by annoyance or vice versa or whether both are related to another factor."

Though the conclusion appears to contradict itself, and the assertion that only sleep is a factor cannot be concluded from their data as they did in fact find a relationship between annoyance and stress, but they could not conclude which one caused the other.

van den Berg, F., Pedersen, E., Bouma, J., and Bakker, R. (2008). Visual and Acoustic impact of wind turbine farms on residents. FP6-2005-Science and Society-20, Project no. 044628. A report financed by the European Union.

Thorne (2009)

As part of his research into the perception of low amplitude intrusive sound Thorne has found that there are significant differences in response between people living in rural areas near wind farms and people living in urban communities. Based on a series of sound simulations he found that the rural people interviewed found the sound of the turbines 'unpleasant, annoying and disturbing' whereas the urban community, who had not seen the wind farms or turbines, found the sounds 'pleasant and gentle'. A series of

noise sensitivity questionnaires also indicated a statistically significant difference between the two communities with the rural community more sensitive. Further research at two different locales near wind farms show that individuals initially accepting of wind farms can become increasingly sensitised to very low levels (outdoor LAeq 30 dB or less) of sound from wind farms due to the visual dominance of the turbines themselves and to noise that causes sleep disturbance or perceived adverse health effects. Sleep disturbance is caused by the varying nature of the wind farm noise; the 'rumble-thump' or 'swishing' sound heard inside the home at levels of LAeq 15 to 20 dB or less and cannot be avoided. The work of Thorne (2009) was to establish a practical methodology to integrate human perception of sound, personal sensitivity and relevant sound character analysis.

Thorne. R. (2008). Assessing intrusive noise and low amplitude sound. PhD thesis available online from Massey University, Palmerston North, New Zealand.

Jabben (2009)

Jabben and colleagues (2009) from RIVM, the Dutch National Institute for Public Health and Environment, were commissioned by the Dutch Government to examine the impact of different values of loudness on the ability to meet targets for onshore wind power generation. They reviewed current evidence and noted that, at present, 440,000 inhabitants (2.5% of the population) were *"receiving significant noise contribution from wind turbine noise of which 1,500 are expected to suffer severe annoyance. It is remarkable that almost half of this number already occurs within the range Lden 30-40db(A)"*.

Jabben J, -Verheijen E and Schreurs E. 2009. Impact of wind turbine noise in the Netherlands. Third International Meeting on Wind Turbine Noise, Aalborg 17-19 June 2009.

Pierpont (2009)

Pierpont (2009) has recently completed a very detailed case-series study of ten families around the world who have been so affected by wind turbine noise that they have had to leave their homes, nine of them permanently. The turbines ranged from 1.5 to 3MW capacity at distances between 305 to 1500m. The group comprised 21 adults, 7 teenagers and 10 children of whom 23 were interviewed. While this is a highly selected group, the ability to examine symptoms before, during and after exposure to turbine noise gives it a strength rarely found in similar case-series studies. The subjects described the symptoms of wind turbine syndrome outlined above and confirmed that they were not present before the turbines started operation and resolved once exposure ceased. There was a clear relationship between the symptoms, even in children, and the noise exposure. Pierpont reports also that all (actually 14 of 21) adult subjects reported *"feeling jittery inside"* or *"internal quivering"*, often accompanied by anxiety, fearfulness, sleep disturbance and irritability. Pierpont hypothesises that these symptoms are related to low frequency sound and suggests physiological mechanisms to explain the link between turbine exposure and the symptoms.

Of particular concern were the observed effects on children, include toddlers and school and college aged children. Changes in sleep pattern, behaviour and academic performance were noted. Seven of the ten children had a decline in their school performance while exposed to wind turbine noise which recovered after exposure ceased. In total, 20 of 34 study subjects reported problems with concentration or memory.

Pierpont's study mostly addresses the mechanism for the health problems associated with exposure to wind turbine noise rather than the likelihood of an individual developing symptoms. Nevertheless, it convincingly shows that wind turbine noise is strongly associated with the symptoms she describes, including sleep disturbance. She concludes by calling for further research, particularly in children, and a two-kilometre setback distance. A recent paper (Todd et al, 2008) has shown that the vestibular system in the human ear, the part concerned with detection of movement and balance, is exquisitely sensitive to vibration at frequencies of around 100 Hz. Pierpont claims that these findings support her hypotheses.

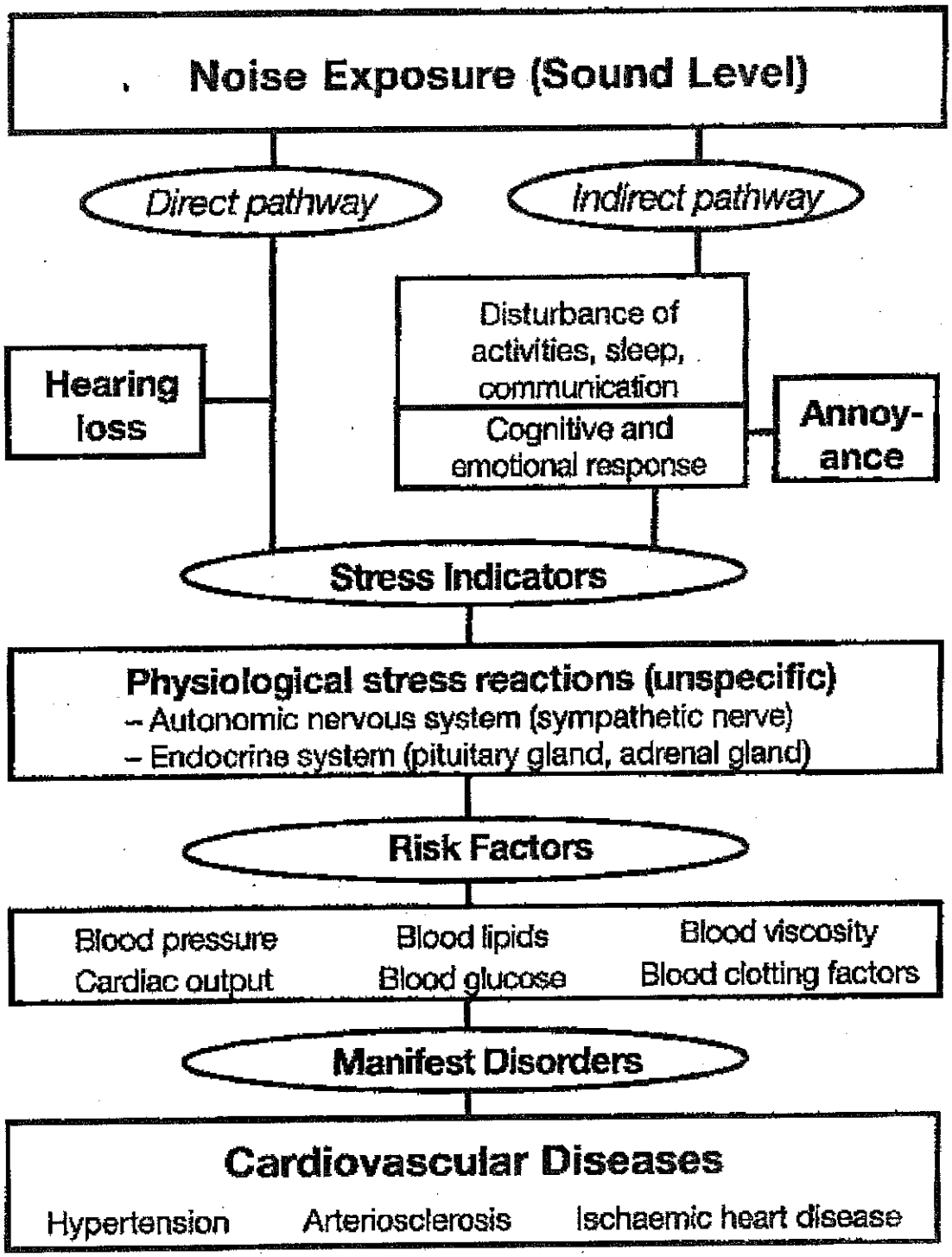
Pierpont N. (2009). Wind Turbine Syndrome: A Report on a Natural Experiment. K Selected Publications. Santa Fe, New Mexico.

Nissenbaum (2010)

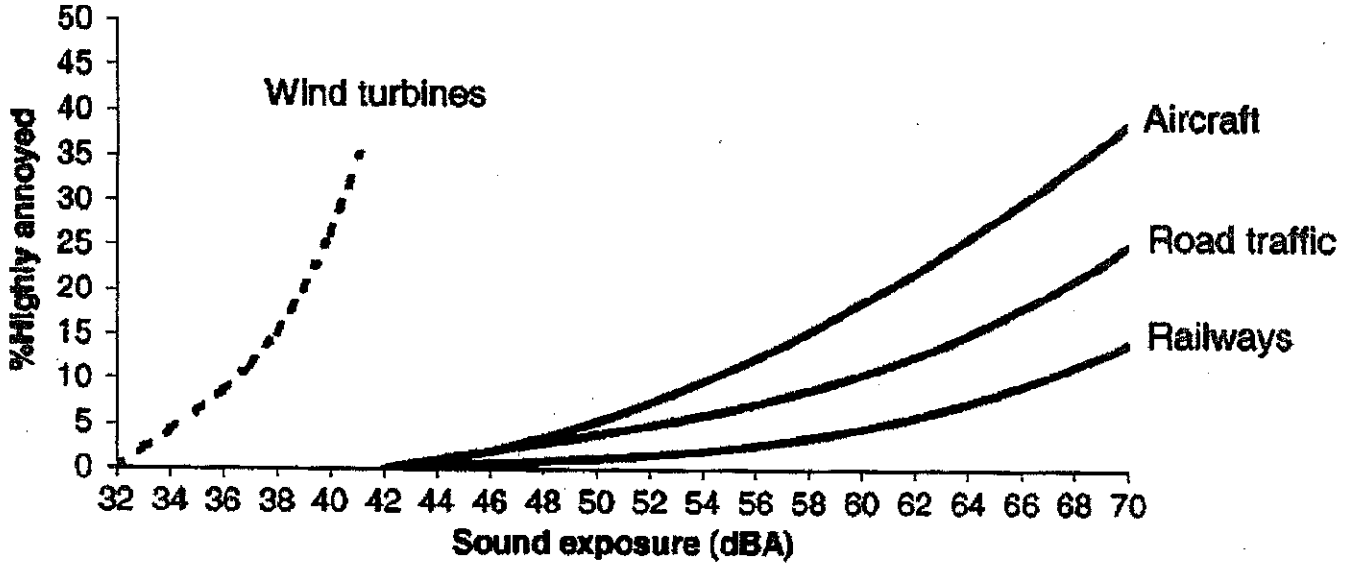
Nissenbaum (2010) has presented the preliminary results of a study of residents living downwind and within 300-1100m (mean 800m) of a wind farm at Mars Hill, Maine, USA. The 28 1.5MW turbines are sited on a 200m high ridge overlooking the homes. Thus far 22 of about 35 adult residents have been interviewed and compared with a randomly selected control group living approximately six kilometres away. Of the 22, 18 report new or worsened sleep onset disturbance at least twice a week, for 9 at least 5 times per week (controls 1/28). A further eight of the 22 report new or worsened headaches (controls 1/28) and 18/22 reported new or worsened mental health symptoms (stress 12/22; anger 18/22; anxiety 8/22; hopelessness 12/22; depression 10/22; controls 0/28).

The 22 subjects received 15 new or increased prescriptions from their physicians in the 18 months between the start of turbine operation and the study, the majority for psychoactive medication (control group: 4 prescriptions, none for psychoactive medication). All but one of the 22 participants have reported reduced quality of life and 20 are consider moving away (controls: 0/28 for both). The study may be criticised for it's relatively small numbers of subjects but the presence of a control group, well matched for age and gender, adds considerable power. All differences between the groups are statistically highly significant. The turbine noise levels at this site may be enhanced by the high concentration of turbines and the geography but the severe sleep disturbance, psychiatric symptomatology and increased medication requirement in the study group confirms the potential of wind turbine noise to adversely affect health at distances claimed to be safe.

Nissenbaum, M. A. (2010). Industrial Wind Turbines and Health Effects in Mars Hill, Maine, A Retrospective Controlled Study – Preliminary Findings as of November, 2009. Personal Communication.


Noise Exposure (Sound Level)
Direct pathway
Indirect pathway
Hearing loss
Disturbance of activities, sleep, communication
Cognitive and emotional response
Annoy-ance
Stress Indicators
Physiological stress reactions (unspecific)
– Autonomic nervous system (sympathetic nerve)
– Endocrine system (pituitary gland, adrenal gland)
Risk Factors
Blood pressure
Cardiac output
Blood lipids
Blood glucose
Blood viscosity
Blood clotting factors
Manifest Disorders
Cardiovascular Diseases
Hypertension
Arteriosclerosis
Ischaemic heart disease

Percent of Community Highly Annoyed



E. Pedersen and K. P. Waye, Perception and annoyance due to wind turbine noise—a dose–response relationship. J. Acoustical. Soc. Am. 116 (6), December 2004, pp. 3460–3470.

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Table 3
Effects of different levels of night noise on the population's health

Average night noise level over a year $L_{night,outside}$	Health effects observed in the population
Up to 30 dB	Although individual sensitivities and circumstances may differ, it appears that up to this level no substantial biological effects are observed. $L_{night,outside}$ of 30 dB is equivalent to the no observed effect level (NOEL) for night noise.
30 to 40 dB	A number of effects on sleep are observed from this range: body movements, awakening, self-reported sleep disturbance, arousals. The intensity of the effect depends on the nature of the source and the number of events. Vulnerable groups (for example children, the chronically ill and the elderly) are more susceptible. However, even in the worst cases the effects seem modest. $L_{night,outside}$ of 40 dB is equivalent to the lowest observed adverse effect level (LOAEL) for night noise.
40 to 55 dB	Adverse health effects are observed among the exposed population. Many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected.
Above 55 dB	The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a sizeable proportion of the population is highly annoyed and sleep-disturbed. There is evidence that the risk of cardiovascular disease increases.

A number of instantaneous effects are connected to threshold levels expressed in L_{Amax}. The health relevance of these effects cannot be easily established. It can be safely assumed, however, that an increase in the number of such events over the baseline may constitute a subclinical adverse health effect by itself leading to significant clinical health outcomes.

Based on the exposure-effects relationship summarized in Table 3, the night noise guideline values are recommended for the protection of public health from night noise as below.

Table 4
Recommended night noise guidelines for Europe

Night noise guideline (NNG)	$L_{night,outside}$ = 40 dB
Interim target (IT)	$L_{night,outside}$ = 55 dB

[1] $L_{night,outside}$ is the night-time noise indicator (L_{night}) of Directive 2002/49/EC of 25 June 2002: the A-weighted long-term average sound level as defined in ISO 1996-2: 1987, determined over all the night periods of a year; in which: the night is eight hours (usually 23.00 – 07.00 local time), a year is a relevant year as regards the emission of sound and an average year as regards the meteorological circumstances, the incident sound is considered, the assessment point is the same as for L_{den}. See *Official Journal of the European Communities*, 18.7.2002, for more details.

THRESHOLDS FOR OBSERVED EFFECTS

The no observed adverse effect level (NOAEL) is a concept from toxicology, and is defined as the greatest concentration which causes no detectable adverse alteration of morphology, functional capacity, growth, development or lifespan of the target organism. For the topic of night noise (where the adversity of effects is not always clear) this concept is less useful. Instead, the observed effect thresholds are provided: the level above which an effect starts to occur or shows itself to be dependent on the exposure level. It can also be a serious pathological effect, such as myocardial infarctions, or a changed physiological effect, such as increased body movement.

Threshold levels of noise exposure are important milestones in the process of evaluating the health consequences of environmental exposure. The threshold levels also delimit the study area, which may lead to a better insight into overall consequences. In Tables 1 and 2, all effects are summarized for which *sufficient and limited evidence* exists. For these effects, the threshold levels are usually well known, and for some the dose-effect relations over a range of exposures could also be established.

Table 1 Summary of effects and threshold levels for effects where *sufficient* evidence is available

Effect		Indicator	Threshold, dB
Biological effects	Change in cardiovascular activity	*	*
	EEG awakening	$L_{Amax,inside}$	35
	Motility, onset of motility	$L_{Amax,inside}$	32
	Changes in duration of various stages of sleep, in sleep structure and fragmentation of sleep	$L_{Amax,inside}$	35
	Waking up in the night and/or too early in the morning	$L_{Amax,inside}$	42
Sleep quality	Prolongation of the sleep inception period, difficulty getting to sleep	*	*
	Sleep fragmentation, reduced sleeping time	*	*
	Increased average motility when sleeping	$L_{night,outside}$	42
Well-being	Self-reported sleep disturbance	$L_{night,outside}$	42
	Use of somnifacient drugs and sedatives	$L_{night,outside}$	40
Medical conditions	Environmental insomnia**	$L_{night,outside}$	42

* *Although the effect has been shown to occur or a plausible biological pathway could be constructed, indicators or threshold levels could not be determined.*

***Note that "environmental insomnia" is the result of diagnosis by a medical professional whilst "self-reported sleep disturbance" is essentially the same, but reported in the context of a social survey. Number of questions and exact wording may differ.*

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December 9, 2010

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Portland, ME 04112-7530

Subject: Critical Issues in the Patriot Renewables "Noise Impact Study of the Saddleback Ridge Wind Project"

Dear Mr. Brown:

Per your request I have reviewed the Noise Impact Study for Saddleback Ridge Wind Farm, Carthage, Maine prepared by Resource Systems Group, Inc. (RSG) for Patriot Renewables, LLC..

My comments address the following topics:

1) Problems with Cadna/A (Limitations on Use of ISO 9613-2 Algorithms)
2) Line vs. point source models.
3) Atmospheric Stability
4) Amplitude modulation/SDRS
5) Turbulence from Turbine Configuration
6) Problems with NRO modes
7) Problems with Low Frequency Noise
8) Wind Turbine Annoyance

PROBLEMS WITH CADNA/A (LIMITATIONS ON USE OF ISO 9613-2 ALGORITHMS)

The sound propagation modeling presented by RSG and used as the basis for conclusions about the Impact of the Saddle Ridge Wind Project on nearby properties and residences by Mr. Kaliski underestimates the sound levels that will be received on the properties and homes adjacent to the wind turbine utility. The sound propagation modeling software used for the sound models is a general-purpose commercial package for use in modeling noise from noise sources like industrial plants, roads, and railways, not wind turbines. Although this does not completely preclude the use of the Cadna/A software package, it does call into question the implied assertion by RSG that the predicted values can be assumed to be precision values. What is called for is the use of reasonable safety factors and consideration of the known tolerances and limits to the accuracy of the procedures. Further, it must be understood that there are other computational methods and algorithms that can be used to model wind turbines other than the ISO method that produce different results.

RSG includes the two (2) decibel tolerance associated with instrumentation error from the IEC 61400 - 11 test protocol for measuring the sound power produced by wind turbines. However, RSG does not include the three (3) dB tolerance associated with errors when applying the ISO-methodology (See Figure 1). In addition, it is my understanding that the MDEP specifies that this tolerance be included in modeling.

If RSG had included the three (3) dB tolerance for the ISO methodology, the results of the models for daytime and nighttime operating modes would have shown many of the homes to the East, South, and Southwest of the project as being exposed to sound levels of 45 dBA or higher. Table 5, Section 9, Accuracy and limits of the method (Figure 1), of the ISO standard shows the tolerance is plus/minus 3 dB for predictions when the noise source is at a height greater than 5m and less than 30 m above the receiver and the receiver is within 1000 m. of the noise source. Inspection of Table 5 shows that the ISO standard is limited to receivers within 1000 m also limits it to situations where the noise source is no more than 30 m above the receiver.

Table 5 — Estimated accuracy for broadband noise of L_{AT}(DW) calculated using equations (1) to (10)

Height, h [a]	Distance, d [a]	
	$0 < d < 100$ m	$100 \text{ m} < d < 1\,000$ m
$0 < h < 5$ m	±3 dB	±3 dB
$5 \text{ m} < h < 30$ m	±1 dB	±3 dB
[a] h is the mean height of the source and receiver. d is the distance between the source and receiver.		
NOTE — These estimates have been made from situations where there are no effects due to reflection or attenuation due to screening.		

Figure 1- Table 5, Section 9 Accuracy and Limitations of Model

For the case of Saddleback Ridge Wind the closest nonparticipating residence to the East is at approximately 3500 feet, while the closest nonparticipating residence to the Southwest is approximately 2500 feet. These distances are at the far limit of the model's stated maximum distance between receiver and source. Many of the homes are beyond this limit.

The uncertainties related to RSG model are:

1) A 3 dB increase in the wind turbine's sound power levels is not used in the model.
2) The models have not been independently validated for predicting wind turbine noise from ridge mounted turbines,
3) It is used with noise sources located on a ridge while the residences (receivers) are at much lower elevations (approximately 300 m. below the bridge mounted turbines), and
4) The important locations for the models predictions are near or beyond the 1,000 m. distance limitation.
5) The presence of winds at higher speeds than contemplated by ISO 9613-2.
6) The model does not address the effects of line source sound propagation.

It essential to include the three (3) dB tolerance in the predictions. Further, the predicted values should be viewed as estimates, not precise values.

LINE VS. POINT SOURCE MODELS

RSG presents a discussion about the issues related to models that replicate spherical spreading (e.g. point source) vs. those that replicate cylindrical spreading (e.g. line source). However, there is no indication of how the models developed for Saddleback Ridge and presented in the RSG report address these issues.

(5) *At grazing angles greater than 20°*, which can commonly occur at short ranges or in the case of elevated sources, soft ground becomes a good reflector of sound and can be considered *hard ground*. Very soft ground is less predictable and measurements of sound pressure levels above very soft ground should be avoided.

Figure 2 ANSI S12.18 A.3.2 Classification of Ground Surfaces

This reviewer developed a model representing turbine sound levels for daytime operating mode. Receiving locations 003 and receiving locations 023 were selected for review. The model was constructed using the formula provided in Prof. John Harrison's paper "SOUND PROPAGATION FROM OFF-SHORE WIND TURBINE ARRAYS." This model can also be used for land based noise sources by changing the denominator

of the expression (r/200) to a value of (r/750) for noise over acoustically hard land. The formula as presented by Dr. Harrison is:

$$L = L_s - 20\log(r) - 11 + 3 - \Delta L_a + 10\log(\frac{r}{200})$$

Where: L is the sound pressure level at the observer, L_s is the turbine sound power (e.g. 105 dBA), 11 is 10 log (4π), 3 is 3 dBA of ground reflection, ΔL_a is the integrated frequency dependent absorption coefficient, a function of r, and r is the distance from turbine hub to the observer. The second term on the right gives the spherical spreading and the final term corrects for cylindrical spreading beyond 200 metres. For this reviewer's model a value of 750 m was used to represent the point where spherical spreading transitions to cylindrical spreading instead of the 200 m. distance found in the Harrison paper. The assumption is that the ground between the turbines and receivers is considered 'hard' because the elevation of the turbines is above a 20 degree inclination (see ANSI S12.18 A.3.2 Classification of Ground Surfaces.)

RSG's model representing nighttime conditions could not be evaluated because sound power data for the NRO mode was not provided in the report. Thus, this comparison considers the daytime condition.

The table below shows RSG's Cadna/A model prediction for locations 003 (east side of ridge) and 023 (south side of ridge). The first column shows the results of the RSG model derived from inspection of the contour maps for the daytime model. This does not include the 3 dB tolerance (ISO 9613-2, Table 5). The second column shows the RSG model predictions with the 3 dB tolerance added. The two columns on the right present the results of the combination spherical and cylindrical spreading model algorithm presented above. The third column is the estimated level in dBA and the fourth column is the estimated level in dBC.

The sound levels at both receiving locations predicted by the model using the spherical and cylindrical spreading formula are always higher than RSG's Cadna/A predictions. That difference increases as the distance between the receiver and turbines increases. Thus, this reviewer's model predicted sound levels at residential sites 003 and 023 are about 2 dBA higher than the Cadna/A model predicts. When the ISO tolerances are used reviewer's model results are about 5 dB greater than the model results shown in the RSG report contour maps.

Receiver	Cadna/A Model (day) w/o ISO 3 dB error offset dBA	Cadna/A Model (day) with the ISO 3 dB offset dBA	E-CS model (daytime Lw values) dBA	E-CS model (daytime Lw values) dBC
003	45	48 (45+3)	50	64
003 plus 1000m to east	40	43 (40+3)	47	62
023	44	47 (44+3)	49	64
023 plus 1000m to south	40	43 (40+3)	48	63

If the receiving location is moved away from the turbines another 1000 meters to the east for 003 and the south for 023 the difference between the RSG and reviewer's models increase to 4 and 5 dBA respectively (e.g. using the second column's levels). The last column shows the predicted dBC readings for the combined spherical and cylindrical spreading model. RSG does not give us any prediction for the dBC levels but it can be assumed that the differences seen in the dBA readings are paralleled in the dBC predictions.

Given the current state of understanding about modeling wind turbines in complex topographies it is not possible to tell which model is more accurate. One model predicts that the 45 dBA criteria will be met at all properties and the other implies it will exceed those limits. This uncertainty should alert reviewers that one should not put any faith in either model being so accurate that its predictions can be trusted to the decibel level.

Sound propagation models are at best an approximation to the real processes that produce sound and affect its propagation between the source and receiver. We should not expect precision predictions. Even the best Type 1 sound meters have tolerances of +/- 1 dB for measurements. We must accept that models are even less precise than direct measurements of a sound and apply the known tolerances and limitations in a manner that recognizes that imprecision. This uncertainty should justify the use of an additional safety factor over and above the 3 dB (ISO) and 2 dB (IEC) tolerance offsets.

ATMOSPHERIC STABILITY

RSG admits in section 8.2 that the effect of temperature inversions, which increase the noise received at distant properties by modifying the propagation path are the worst-case situation for creating noise. Temperature inversions are associated with high wind shear (e.g. large wind speed gradients) according to RSG in Section 8.2. RSG concludes that this condition is the "default condition for modeling wind turbine sound." However, we do not know how RSG considers the effect of temperature inversions in the Cadna/A models.

It is well established that when wind turbines operate during such conditions amplitude modulation (blade swish) is often a problem. In a paper by Clifford P. Schneider presented at the 2009 Inter-noise conference in Ottawa, Canada titled: " Measuring Background Noise With An Attended, Mobile Instrumentation During Nights With Stable Atmospheric Conditions" it is shown that these conditions are present as much as 40% of the nights during warm summer months and 30% of the time during other months. This is not an infrequent situation. Yet, RSG implies in its report in Section 10, that amplitude modulation is not likely to be a problem at Saddleback Ridge. "In turbine locations such as those found along the Saddleback Ridge, there tends to be fewer instances of excessive wind shear." From this I conclude that the RSG model does not consider the effect of the extra noise from turbines operating under these meteorological conditions in their model. This means that one of the primary causes of turbine noise that produces complaints is not addressed in the RSG study.

One might argue that conditions on ridges in Maine are different from what Mr. Schneider found in New York but there are other mechanisms that can achieve the same effect as a temperature inversion for ridge mounted turbines. When the winds are coming from the West the homes on the downwind side of the bridge are sheltered. Review of the wind-rose diagrams provided by Patriot Renewables for the period from January 2009 through December 2009 shows that winds from the west are dominant. With the exception of the month of June 2009 west winds are present for at least 25% of the time. To a lesser extent winds from the east are present between 5 to 15% of the time.

Winds from that direction would shelter the properties to the southwest of the ridge. This results in the same effect as a temperature inversion would produce on flat land. That is, winds at the height of the turbines are more than adequate for powering the turbines while at the same time winds at the ground level near the residences below the bridge are calm or low. For winds from the west, the sheltered condition of the homes on the downwind side of the ridge may be more frequent than the weather conditions that lead to temperature inversions.

Under these conditions wind turbines will operate at maximum or close to maximum sound output and there will be no wind at the ground level to induce leaf rustle or other types of masking sounds that might offset the noise from the wind turbines. It is often the cause of complaints about wind turbine noise reported by residents.

In a report titled: "Effects of the wind profile at night on wind turbine sound" by G. P. Van den Berg it is noted that: "*...measurements show that the wind speed at hub height at night is up to 2.6 times higher than expected, causing a higher rotational speed of the wind turbines and consequentially up to 15 dB higher sound levels, relative to the same reference wind speed in daytime.*" RSG should not discount the potential for these conditions to result in high levels of annoyance and complaints.

Amplitude Modulation/ Short Duration Repetitive Sounds (SDRS)

As stated in the prior section, RSG asserts in Section 10 of their report that Short Duration Repetitive Sounds (SDRS) from wind turbines are not expected to be a problem for the Saddleback Ridge Wind project. In support of this assertion they provide an analysis of windspeed variations as a measure of turbulence based on historical weather information from Patriot Renewables meteorological towers. While this analysis is interesting it is by no means an exhaustive review of all of the causes of turbulence for ridge mounted turbines. RSG admits to this in the discussion in Section 10 about other causes of amplitude modulation. Yet, RSG focuses only on their weather data analysis to claim that site characteristics are not conducive to common occurrences of SDRS. This statement ignores other causes of turbulence that can cause amplitude modulation such as updrafts, cross drafts and wake interference. It also ignores the consistent complaints about amplitude modulation that are made by people living near operating wind projects with turbines mounted on ridges above their homes.

SDRS's of 5-6 dBA are common for wind turbines with SDRS of 10 to 15 dBA or more observed as a less frequent maximum. During periods of turbulence due to weather fronts, winds interacting with local topography, and during temperature inversions turbulence induced amplitude modulation (blade swish) is likely. These conditions should trigger the 5 dB penalty in MDEP's rules for all wind turbines near homes. The 5 dBA penalty does not have to occur on a "regular basis" or "commonly" to be applied under the MDEP Noise Rules. These conditions have been documented and reported in research papers by Hubbard and Shepherd in the 1990's (Wind Turbine Acoustics) and more recently by Dr. Van den Berg.

It cannot be assumed that the Saddleback Ridge project wind turbines will not exhibit SDRS based on an analysis of only one potential cause of amplitude modulation. Amplitude modulation, also referred to as blade swish and thump, is discussed in papers at annual conferences all around the world. RSG's report lists just a few of the many papers on this noise problem. One must accept that amplitude modulation is a characteristic of all wind turbine projects. The cause of it at each site may be different but amplitude modulation is still the result. Blade swish and thump, also referred to as amplitude modulation, is discussed in papers at annual conferences all around the world.

If this were a condition that is infrequent, or limited to a few makes and models of wind turbines, then why are there so many research papers published investigating it? Amplitude modulation is one of the most common causes of complaints from people living near wind projects whether ridge mounted or located on flat farmland. It should not be discounted either by RSG or Maine's Department of Environmental Protection.

TURBULENCE FROM TURBINE CONFIGURATION

The RSG Report states at Section 10, page 25, that "Inflow turbulence between turbines in a turbine string can also affect noise from the wind farm. Proper turbine siting minimizes this type of turbine wake impact." Wake induced turbulence and the increased noise associated with it is often a result of providing insufficient distances between turbines for the wake of the upwind turbine to dissipate before it reaches the next downwind turbine's blades. There is reason to be concerned that the current layout of turbines will result in this type of noise, especially during periods when the winds are from the north or south such that the direction of the wind parallels the line of wind turbines. In discussions this reviewer had during a teleconference with GE management in charge of land and offshore wind turbines it was stated that GE designs their projects to have 5 rotor diameters of distance between wind turbines in the non-dominant wind direction and 7 to 10 rotor diameters in the direction of prevailing winds. Review of the distances between turbines along Saddleback Ridge shows that the inter-turbine spacing is approximately 3 rotor diameters for the GE models. This is significantly less than GE's 5 rotor diameters and should be considered a likely cause of wake induced turbulence and increased wind turbine noise and amplitude modulation. This effect was not included in the model and is not reflected in the findings and conclusions.

In summary, turbulence from any of a number of causes should be expected, not ignored as it is by RSG's report. It can be a result of updrafts, cross drafts, wake interference, and any other condition where the air stream entering the plane of rotation of the turbine's blades is not within a narrow range of wind speeds from the tip of the blade at the top of the rotation to the bottom of the rotation with motion perpendicular to the plane of blade rotation. All forms of turbulence will induce higher noise emissions and increased amplitude modulation.

PROBLEMS ASSOCIATED WITH NRO MODES

A brief description of the input values for the daytime model is presented in the appendix of the RSG report, but there is no similar data describing the input values for the nighttime mode of operation using the noise reduction operating modes(NRO) of the turbine. Thus it is impossible for an independent reviewer to assess whether the nighttime model represents a realistic estimate of the impact of these turbines on the extremely quiet rural soundscape. RSG may accept that the NRO modes will reduce nighttime noise but we do not agree. In our experience the NRO modes have not been successful in addressing nighttime noise complaints.

Information is provided by RSG in Figure "A4: Modeled Residences and 500 foot Buffer Locations" showing the daytime sound level dBA and nighttime sound levels with some "NRO" mode. Comparing the difference in sound level between the day and night models shows that there is only a 1 to 3 decibel difference. In consideration of the discussion above about the inherent limitations and accuracy of the modeling algorithms this small the difference should be given no weight in determining the impact of the turbines on nighttime sound levels and the potential for sleep disturbance.

This reviewer agrees with RSG that the sound levels predicted for the turbines in the daytime will most likely cause exceedances of the MDEP rules and complaints from the residents during the night. This reviewer does not agree that operating those turbines in Noise Reduced Operating Modes will be sufficient to prevent those complaints or exceedances. The alleged conservative predictions of noise at the residential properties implied by RSG in its report are not supported by independent research or experience at other wind projects. Based upon this reviewer's observations at many locations there were wind turbines are operating at similar distances from residences the sound levels at the residential properties adjacent the ridge will be higher than predicted. Surface level winds at the residential properties will frequently not be sufficient to create sufficient wind induced noise from leaf rustle, etc. on many nights when the turbines will be operating at nominal power or higher. A reduction of only 1 to 3 dBA by use of NRO mode operation will not protect those properties. There is even a strong likelihood that there will be an increase in noise due to turbulence and wind shear that NRO modes cannot reduce.

Our experience with wind turbines located on the island of Vinalhaven has shown that NRO modes do not reduce the sound levels under real world conditions when turbulence or wind shear is present. At Vinalhaven, the presence of turbulence at the blade height combined with a temperature inversion that causes the wind shear to be high results in the sound levels being up to 5-8 dBA higher than the sound level of the wind turbines operating during the daytime when there is less turbulence, no temperature inversion, and NRO modes are not required. This situation should be given strong consideration by MDEP. There are limits to the utility of NRO modes. They do not work to reduce the blade swish noises associated with turbulence and unstable wind shear.

PROBLEMS WITH LOW FREQUENCY NOISE

Wind turbines emit high levels of low frequency sound and it is significant.[1,2,3,4] This reviewer's research and personal observations of sound from operating wind projects has shown that low frequency sound is the dominant component of the acoustic energy emitted by wind turbines. This reviewer is convinced that the low frequency noise is a significant contributor to the problems associated with wind turbine noise and that it is necessary for the effects of low frequency noise to be considered in evaluating whether a community is compatible with wind turbine noise.

The RSG report does provide any detail on the predicted low frequency sound pressure levels. In section 8.4 the 65 dB level (for the 16 Hz one-third octave band) is identified as the threshold of structural response. RSG used the ANSI S12.2 method for evaluating whether a low frequency sound will cause structural vibration. There are two points that need to be made about this section of RSG's report. First, the RSG models did not include any data for the 16 Hz frequency range. Given the absence of data for the frequencies below 31.5 Hz in the RSG model how can RSG conclude that there will not be a problem in that frequency range? Second, the ANSI S12.2 method is considered by many to underestimate the potential for structural response and human perception. Many of those who do not feel ANSI S12.2 is useful in predicting human response to low frequency

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[1] Van den Berg, G. P., "Do wind turbines produce significant low frequency sound levels?," 11th International Meeting on Low Frequency Noise and Vibration and Its Control, 2004

[2] Leventhall, G., "A Review of Published Research on Low Frequency Noise and its Effects." for the Department for Environment, Food and Rural Affairs (DEFRA), U.K., 2003

[3] Swinbanks, M. A., "Wind Turbines: Low-Frequency Noise and Infrasound Revisited," Environmental Protection U.K. Workshop "Where now with Wind Turbine Assessment?, Birmingham, Sept. 9, 2010

4 Bray, W.R., "Measurement and sound quality issues concerning low-frequency noise," Noise-Con 2007

sound are those acoustical engineers who follow ASHRAE's guidelines for preventing excessive rumble in office and other buildings due to HVAC systems. This is because buildings with excessive 'rumble' from heating and cooling systems that are either poorly designed or installed have been a source of many complaints about worker productivity and health in high rise offices used by knowledge workers. The methods in the ASHRAE Guide (see Chapter 46 of the 2002 edition) are designed to address problems related to inaudible modulated low frequency noise which has many similarities to the modulated infra and low frequency sounds emitted by wind turbines. There is insufficient information in the RSG report to do a direct comparison between these methods. It is this reviewer's opinion there will be low frequency sounds that penetrate through the walls and roofs to become a noise problem inside homes near the wind utility. It is also likely that window vibration and other forms of structural response from resonance will be a problem from this project. This is based on the high dBC levels predicted in this reviewer's model and experience from other wind utility projects where there are complaints of structural vibrations.

Wind Turbine Noise and Annoyance

It is widely recognized that wind turbines are more annoying than other common community noise sources. Wind turbine noise is more annoying because it includes amplitude modulation of audible frequencies and the dominance of low frequency components.

It is also accepted that when a new noise is introduced into a quiet residential setting where nighttime background noise is very quiet like Saddleback Ridge that there will be problems with acceptance. Both the ANSI S12.9 and EPA Levels document assign a penalty for new noise sources introduced into a community that has no prior experience with noise of that type.

Background sound levels (L_{A90}) in this community are in the low 20 dBA range (See Noise study by Les Blomberg). That means that the wind turbines which will raise these quiet nighttime levels to 40 dBA or higher will cause an increase of 20 to 25 dBA to the nighttime background noise soundscape.

The higher sound levels reported in the RSG study for existing community noise levels are too high to be credible for a quiet rural community, especially during the night. Based on this reviewer's experience in conducting pre-operational noise studies in similar rural communities the high sound levels reported by RSG for Saddleback Ridge can only be explained by the inclusion of some unnatural noise source, defects in the testing procedure, or improper test site selection.

If RSG seriously thinks that an increase of 20 to 25 dBA in the community at night will not cause a strong negative community reaction then they are not exercising professional common sense.

Sincerely,

Richard R. James

Richard R. James, INCE