STATE OF NEW YORK
PUBLIC SERVICE COMMISSION

Application of Cassadaga Wind Project for a Certificate under Article 10 of the Public Service Law

Case No. 14-F-0490

REBUTTAL TESTIMONY OF:

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I. INTRODUCTION

Q: Please state your name, employer, and business address.

A: Robert J. McCunney, MD, MPH, MS and I currently hold a number of positions with respect to occupational and environmental medicine. I have an active clinical practice at Brigham and Women's Hospital; Pulmonary Division, 75 Francis Street, Boston, MA 02115. I also co-teach a course on epidemiology at Massachusetts Institute of Technology, Department of Biological Engineering, 77 Massachusetts Avenue 16-771, Cambridge, MA 02139.

Q: What positions do you currently hold?

A: I am a physician, board certified in occupational and environmental medicine, a research scientist at the Massachusetts Institute of Technology Department of Biological Engineering, a staff physician in occupational/environmental medicine at Brigham and Women's Hospital in Boston, a member of the clinical faculty of Harvard Medical School and a visiting scientist at the Harvard School of Public Health. I am also a co-author of a comprehensive review of the peer-reviewed scientific literature with respect to wind turbines and human health, entitled "Wind Turbine Sound and Health Effects: An Expert Panel Review." (Colby et al., 2009). I am also lead author of an article published in the *Journal of Occupational and Environmental Medicine*, entitled "Wind Turbines and Health: A Critical Review of the Scientific Literature." (McCunney et al., 2014) and the

lead author of a critical examination of a proposed case definition related to potential health effects of living near wind turbines. (McCunney et al., 2015).

Q: How long have you been practicing occupational and environmental medicine?

A: For the past 36 years, I have practiced Occupational and Environmental Medicine from a variety of perspectives, including research, clinical and educational dimensions. (See my *Curriculum Vitae* Exhibit RJM_1). I have been board certified since 1982 by the American Board of Preventive Medicine in Occupational and Environmental Medicine. Board certification requires completion of a three-year residency following graduation from medical school, a year of practical experience and successful passing of a comprehensive examination. As evidenced by my CV, I have published over 110 peer-reviewed articles, book chapters and related publications, including three editions of a major textbook and two other textbooks as well as a number of scientific monographs. I have also served as editor of three special issues of major academic journals. I have an active medical practice in Boston, Massachusetts where I evaluate and treat people exposed to potential occupational and environmental hazards. At the Massachusetts Institute of Technology (MIT), where I am a research scientist, I conduct environmental and occupational medical research and also co-teach a course in epidemiology. I regularly lecture

to graduate students and residents in occupational/environmental medicine at the Harvard School of Public Health on the subject of noise and hearing. I also lecture the pulmonary fellows of the Brigham and Women's Hospital of Harvard Medical School on occupational and environmental lung disease.

Q: What is your experience with health and noise exposure?

A: My professional interest in the health implications of noise exposure arose as a result of my responsibilities as an occupational physician in overseeing hearing conservation programs of workers in occupational settings. Occupational exposure to noise can adversely affect hearing, a finding noted and confirmed in the medical literature and summarized in three book chapters in which I was a co-author, including Meyer and McCunney; Environmental and Occupational Medicine; Rom, WN, (editor) Lippincott Williams and Wilkins; 2007. My involvement with potential noise implications on hearing has focused on (1) publishing: I have written three book chapters for two different textbooks; (2) clinical issues: in serving as Director of Environmental Medicine at MIT from 1994 to 2001, I was responsible for reviewing, interpreting and following up the results of audiometric tests conducted on MIT employees; and (3) lecturing: for the past 14 years, I have regularly lectured at the Harvard School of Public Health to graduate students on noise and hearing; the most recent lecture was this past April, 2017. In my testimony below, I discuss certain matters relating to

epidemiology, and specifically the epidemiology of health effects of noise emissions from wind turbines. My experience and training in epidemiology includes course work towards my MS in environmental health at the University of Minnesota (1972) and course work at the Harvard School of Public Health during my residency training (1979-1981) in occupational and environmental medicine. I have also taught and continue to teach occupational epidemiology at MIT. In addition, as noted in my CV, I have been a co-author of a number of epidemiology studies and am a participant in ongoing epidemiological research efforts. Finally, as part of my teaching responsibilities at MIT, I lecture on the critical interpretation of research studies, most notably epidemiology studies.

Q: Have you previously testified before the New York State Public Service Commission or Siting Board on Electric Generation and the Environment?

A: No.

Q: Have you previously served as an expert witness before any other court, agency, or other body on the subject you plan to offer testimony on today?

A: I have appeared before environmental tribune hearings in Ontario, Canada and the US. The focus of my testimony has exclusively pertained to potential health implications of living near wind turbines.

Q: What is the purpose and scope of your testimony in this proceeding?

A: My testimony is being submitted to rebut evidence presented by the direct testimony of Richard R. James ("James") and Jerry L. Punch ("Punch") submitted on behalf of the Concerned Citizens of the Cassadaga Wind Project ("CCCWP") which alleges that wind turbine noise can cause certain "adverse health effects". My testimony is also being submitted to rebut the direct testimony of Department of Public Service Staff ("DPS"), and the New York Department of Public Health Staff ("DOH") to the extent such testimony implies or otherwise indicates that turbine noise can result in potential health-related effects.

Q: What documents did you review in preparing your testimony?

A:

a) Submitted testimony and exhibits of Miguel Moreno-Caballero (DPS),

b) Submitted testimony and exhibits of Henry Spliethoff (DOH),

c) Submitted testimony and exhibits of Jerry L. Punch (CCCWP);

d) Submitted testimony and exhibits of Richard R. James (CCCWP);

e) CASE 14-F-0490 - Application of Cassadaga Wind LLC for a Certificate of Environmental Compatibility and Public Need Pursuant to Article 10 to Construct a Wind Energy Facility, Ruling on Schedule (Issued January 26, 2017) [including Exhibits 15 (public health and safety) and 19 (noise and vibration) and Appendix T (complaint resolution plan) and Appendix Z

(preconstruction noise impact assessment and post-construction monitoring protocol)].

Q: In your testimony, will you refer to, or otherwise rely upon, any studies, publications, data or documents produced by persons other than yourself. If so, please cite these sources. [These are independent studies, etc.]

A: Included with my testimony is a list of references to which I refer to or otherwise rely upon to reach my conclusions. (Exhibit RJM_2)

Q: Can you provide a summary of your testimony?

A: Wind turbines, just like other mechanical equipment, produce sound, both audible and inaudible (low-frequency and infrasound). There is no scientific evidence that the noise emitted from wind turbines is unique and should therefore be treated any differently from noise produced by other equipment. Sound can be minimized through proper siting design criteria and potential impacts to public health and safety can be effectively minimized, if not eliminated, with compliance with certain noise guidelines. In short, the assertions made by Punch and James that wind turbine sound causes "adverse health effects" are inconsistent with epidemiology studies, most notably the results of a major investigation conducted by Health Canada. Punch and James conclude that wind turbines may annoy some people, but this is not a recognized health condition as to be described in more detail later.

Q: What are the noise design goals for the Facility?

A: It is my understanding that the Facility has an audible noise design goal of 45 dBA L(8) for nighttime noise outside at non-participating residences and 55 dBA L(8) for nighttime noise outside at participating residences.

Q: What are the noise-induced vibration goals for the Facility?

A: The Facility has also established a design goal of 65 dB at the 16 Hz2 and 31.5 Hz octave bands and 70 dB at the 63 Hz octave band to avoid noise-induced vibrations.

Q: In your opinion, are these design standards consistent with guidelines or levels that are protective of public health?

A: Yes. According to the noise reports prepared by RSG, the sound consultant for the Facility, the audible noise design goals are in conform with the guidelines of the World Health Organization (WHO) and the National Association of Regulatory Utility Commissioners (NARUC). Repeated studies have shown that there is no direct causal link between wind turbine noise, at the levels proposed for this Facility, and actual health impacts (i.e. hearing loss). At the design levels proposed, the Facility will not cause harm to public health or safety.

Q: Can you summarize whether this is also true for low-frequency and infrasound?

A: Although wind turbines can generate infrasound and low-frequency sound, detectable levels of infrasound and low-frequency sound are not at harmful levels based on studies near wind farms in the United States, the United Kingdom, the Netherlands, Denmark and Australia. Moreover, there are no studies demonstrating harmful effects to humans as a result of exposure to infrasound or low-frequency sound at the noise levels measured in the vicinity of wind turbines or in experimental studies involving noise levels several orders of magnitude higher than those noted in the vicinity of wind turbines (such as in the astronaut studies described below).

Q: You mentioned that the testimonies of James and Punch identify "annoyance" as an "adverse health effect". Do you agree?

Concern has been raised that annoyance reported in the context of living near wind turbines may lead to stress and chronic stress can lead to sleep disturbance and a corresponding range of health effects. Annoyance, however, despite the erroneous assertions by Punch who is not a physician, is not considered an adverse health effect. In the International Classification of Diseases (ICD), in its most recent 10th edition, annoyance is not described as an illness. The ICD has been adopted worldwide and is routinely used in the USA and other countries for classifying disease, research and for health insurance purposes. Assertions by

Punch that the WHO considers "annoyance" an adverse health effect are not based on any reference material or scientific publications.

While guidelines of the WHO (1999 and 2009) and more recently NARUC identify design goals to limit reports of "annoyance" they do not conclude that annoyance causes harm to human health. Numerous studies have demonstrated that annoyance from wind turbines varies depending on a number of factors, not just sound, such as the visibility of the turbines and financial compensation, among others.

Q: How is your testimony structured?

A: I provide a brief literature review of the reports I have co-authored regarding wind turbine noise and health effects, and other reports as well, most notably the Health Canada study. A background on sound and its components, including infrasound and low-frequency sound from wind turbines follows. Finally I address conclusions drawn by Punch in his testimony.

II. LITERATURE REVIEW

Q: **Can you describe your involvement with the December 2009 report entitled "Wind Turbine Sound and Health Effects: An Expert Panel Review." (Colby et al., 2009)?**

A: In 2009, I was invited to be part of an expert panel assembled to provide a report on potential health implications of living near wind turbines. ("Wind Turbine

Sound and Health Effects: An Expert Panel Review." (Colby et al., 2009)). This report contains a comprehensive discussion of health issues that have been raised with respect to wind turbines, including infrasound, low-frequency sound and annoyance, among other matters, associated with living in proximity to wind turbines.

Q: What was the conclusion of the expert panel review?

A:

- The sounds emitted by wind turbines are not unique. There is no reason to believe, based on the levels and frequencies of the sounds and the panel's experience with sound exposures in occupational settings, that the sounds from wind turbines could plausibly have direct adverse health consequences.
- The body of accumulated knowledge about sound and health is substantial.
- The body of accumulated knowledge provides no evidence that the audible or inaudible sounds emitted by wind turbines have any direct adverse physiological effects.
- Over 125 references were cited as part of the report.

Q: Can you explain what you mean by "audible" or "inaudible"?

A: Audible means the ability to hear a sound whereas; inaudible means a sound is not heard.

Q: Have you recently confirmed these conclusions?

A: Yes. My co-authors and I re-confirmed these conclusions in a recently published peer reviewed article entitled "Wind Turbines and Health: A Critical Review of the Scientific Literature." (McCunney et al., 2014).

Q: Was this report peer-reviewed or published? [Same comment as above.]

A: Yes, by reviewers assembled by the editor of the Journal of Occupational and Environmental Medicine.

Q: What were the conclusions of this review?

A: In that article, we concluded:

- Measurements of low-frequency sound, infrasound, tonal sound emission and amplitude-modulated sound show wind turbines emit infrasound. The levels of infrasound are typically well below audibility thresholds.
- No cohort or case-control studies (which are of the highest value in assessing causality) were located, but among the cross-sectional studies of sufficient quality, no clear or consistent association is seen between wind turbine noise and any reported disease or other indicator of harm to human health.
- Components of wind turbine sound, including infrasound and low-frequency sound, have not been shown to present unique health risks to people living near wind turbines.
- Annoyance associated with living near wind turbines is a complex phenomenon related to personal factors. Noise from turbines plays a minor

role in comparison with other factors (such as visual impacts) in leading people to report annoyance in the context of wind turbines.

Q: In preparing your testimony today did you review whether there has been any additional scientific literature since 2014 questioning the conclusions from your previous work?

A: Yes, for the purpose of preparing this rebuttal testimony, I conducted an additional literature search to identify any new articles that may have been published since the MIT review, for which I was lead author, was published in October, 2014. There have been new studies and reports published as noted in the appendix of this report. In December, 2014, Schmidt et al. published a literature review titled "Health Effects Related to Wind Turbine Noise: A Systematic Review." That review does not contribute anything new to the scientific literature, and does not change my opinion with respect to the peer-reviewed literature regarding evaluations of potential health effects among people living in the vicinity of wind turbines. (See appendix for an updated list of published articles related to "wind turbines and health" obtained by a review of PubMed on March 13, 2017). In May, 2015 Onakoya et al. also published a literature review titled "[t]he effect of wind turbine noise on sleep and quality of life: A systemic review and meta-analysis of observational studies." The authors concluded that while there is some evidence that exposure to wind turbine noise is associated with

increased odds of annoyance and sleep problems individual attitudes could influence the type of response to noise from wind turbines. In addition, in May 2015, Mroczek et al. published a study titled "Evaluation of Quality of Life of Those Living Near a Wind Farm." The authors concluded: (1) age is the strongest contributor to QoL levels in wind-farm areas. It is possible that QoL is simultaneously influenced by several factors, such as chronic diseases and other health problems, adverse socioeconomic factors, and environmental stress factors; (2) the lowest scores for overall QoL and general health are noted among residents of places where projects are in the planning or construction phase. In order to find ways to reduce environmental stress and its adverse effects on health, it is necessary to conduct research among the residents of places where a wind-farm project is either being planned or is under construction or has just been completed; and (3) the presence of wind farms near residential areas has no negative influence on the QoL of residents. The highest QoL levels are noted in places where wind farms at various stages of development are located within one kilometer from the residence. These observations are consistent with the authors' earlier study (Mrozcek et al., 2012). Additional studies have also been conducted including an assessment of the role of psychological factors associated with sleep disturbance among people living near wind turbines. (Jalali et al., 2016). The authors concluded, ***"Participants reported poorer sleep quality if they had a***

***negative attitude to wind turbines, if they had concerns related to property devaluation or if they could see the turbines form their property*.**" (Jalali et al., 2016) The authors further concluded that it appears that self-reported sleep effects "may be associated with indirect effects of visual and attitudinal cue and concern about property devaluation rather than distance to the nearest turbine or noise itself." This was the first study "to use a repeated noise and sleep measurement before and after wind turbine (WT) operation to investigate the impacts of WT presence on self reported sleep quality and psychological factors, such as visibility of and attitude towards WTs and concern related to property devaluation. Contrary to expectations, changes in sleep variables were not associated with distance to WTs but "instead strongly associated with subjective factors, such as attitude to WTs, visual impact and concern about property values." (Jalali et al., 2016)

Q: Do these new reports and studies change any of your previous conclusions?

A: No. These studies further support the conclusion that noise associated with wind turbines, including infrasound and low-frequency sound, is not a health risk. The studies further support the conclusion that individual attitudes about wind projects contribute to whether the individual reports impacts (i.e. sleep disruption, annoyance) more than the actual sound generated by the turbines themselves.

III. SOUND

Q: Going back to your previous work in McCunney et. al., 2014, what are the concerns associated with wind turbine noise?

A: To understand the basis of the conclusions reached in the expert panel report, the 2014 MIT critical review of the scientific literature review and the conclusions I express in this testimony, it would be helpful to review general principles about sound. The fundamental environmental "exposure" of concern regarding potential health effects associated with the operation of wind turbines is sound. Sound, characterized primarily by its "loudness" is customarily measured in decibels dB (A) and its pitch or frequency measured in Hertz (Hz). Sounds can range from various combinations of low frequency to high frequency components. Nearly all environmental sources of noise include a range of frequencies. Low-frequency sounds can be associated with vibration and since they have longer wavelengths than high frequencies, can travel farther distances from the source of the sound in comparison to high frequency sounds.

Q: How are infrasound and low frequency sound defined?

A: Infrasound is defined as frequencies between 0 to 20 Hz. Low-frequency sound typically refers to frequencies between 20 to 250 Hz, although some authorities suggest that it may extend to 500 Hz. One internationally regarded acoustician stated: "*Over the past 40 years, infrasound and low-frequency sound have*

attracted a great deal of adverse publicity on their effects on health, based mainly on media exaggerations and misunderstandings." (Leventhall, 2007).

Q: At what levels are sounds perceptible?

The ability for people to recognize sound is dependent on the sound's intensity (*i.e.*, loudness) as well as its frequency (low, high, infra etc.). At infrasound frequencies (0-20 Hz) the loudness of the sound needs to be much higher than at higher frequencies in order to be "heard" (see Table 1 below). The lower the frequency, the higher the noise level necessary for the sound to be heard (Leventhall et al., 2003).

Table 1 – Hearing Thresholds in the Infrasonic and Low-frequency Range

Hz	4	8	10	16	20	25	50	100	200
SPL	107	100	97	88	79	69	44	27	14

Infrasound is very common in the natural and man-made environment and is not unique to wind turbine operations. Sea waves, the wind itself, bodily functions such as the heartbeat and lung sounds, and refrigerator compressors, among others, all produce infrasound. Health risks of infrasound are related to the intensity of the noise exposure as with other frequencies. For example, if an acute explosion generates a sound level of 140 dB (A), people nearby can suffer ruptured tympanic membranes (ear drum). This adverse effect is based on the

intensity of the noise exposure – not the frequency. A similar assessment of infrasound is used regarding potential health effects, that is, the sound has to be high enough not only to be heard but also sufficiently high to cause hearing damage. At low frequencies, a much higher level of sound is necessary for it to be heard in comparison to recognizing sounds at higher frequencies. For example, at 10 Hz, the sound must be at 97 dB to be audible (see Table 1 above). If this level occurred at the mid to high frequencies, which the ear detects effectively, it would be roughly equivalent to standing without hearing protection directly next to a power saw.

Q: Are there guidelines for infra and low-frequency sound?

A: Sound levels associated with infra or low-frequency sound are addressed in the criteria of the American National Standards Institute (ANSI)/Acoustical Society of America (ASA). The threshold for moderate acoustically induced vibration and rattles for the 31.5 and 63 Hz octave bands (low frequencies) is 65 dB, and for the 63 Hz octave band, it is 70 dB indoors (ANSI/ASA S12.2-2008). These thresholds are considerably higher than the sound levels associated with wind turbines.

Q: Punch and James both claim that infrasound and low-frequency noise produced by wind turbines can adversely affect human health. What is your response to this assertion?

A: There are no scientific studies demonstrating adverse health effects from sub-audible infrasound at the levels encountered near homes in the vicinity of wind turbines. Comprehensive reviews of low-frequency sound, its sources and measurement have been published (Berglund and Lindvall, 1996), including in specific relation to infrasound from wind turbines (Leventhall, 2006). The low levels of infrasound and low-frequency sound associated with wind turbine operations have been confirmed by others (Jakobsen, 2004; van den Berg, 2004). As described below, field studies in Texas (O'Neal, 2011) and Australia (Turnbull, 2012) have shown insignificant (*i.e.*, below natural background) levels of infrasound from wind turbines. In general, acousticians and other scientists have reached consensus that infrasound from wind turbines is not a significant risk to human health. (Leventhall, 2006). Studies conducted to assess wind turbine low-frequency noise have shown that wind turbine sound near residences is not audible below about 50 Hz (Hayes 2006). Recent work on evaluating a large number of noise sources between 10 Hz and 160 Hz suggests that wind turbine noise heard indoors at typical separation distances is modest (Pedersen, 2008).

Q: Can you provide more information on the low frequency and infrasound field studies conducted in Texas?

A: To address whether the operation of wind turbines may create unacceptable levels of low frequency noise and infrasound, a field study of noise measurements in the vicinity of wind turbines in Texas was conducted (O'Neal et al., 2011). Two types of wind turbines were studied (General Electric (GE) 1.5sle (1.5 MW) and Siemens SWT-2.3-93 (2.3 MW)). Measurements were collected from 15 operating wind turbines. The land around the wind turbines is rural and used for agriculture and cattle grazing. The siting of the sound level measurement locations was chosen to minimize local low frequency and infrasound sources aside from the wind turbines and the wind itself. Two distances from the nearest wind turbine were selected 305 meters (1000 feet) and 457 meters (1500 feet).

Q: What was the result of the Texas field study?

A: The results indicated that *infrasound is not audible to even the most sensitive people 305 meters (1,000 feet) from the wind turbines.* The authors concluded:

> The results show that all equivalent outdoor ANSI/ASA S12.2 [American National Standards Institute /American Standards Association] criteria for evaluating room noise and perceptible vibration criteria were met. The 31.5 and 63 Hz sound levels are below the level of 65 dB identified for minimal annoyance in ANSI S12.9 Part 4 [governing the quantities and procedures for description and

> measurement of environmental sound], and the 16 Hz sound level is within 1.5 dB of this level, which is an insignificant increase since the levels were not rapidly fluctuating. The low-frequency sound levels are below the ANSI S12.9 Part 4 thresholds for the beginning of rattles (the combined sound level in the 16, 31.5, 63 Hz bands are less than 70 dB). (O'Neal, 2011)

Results from the O'Neal study on infrasound and low-frequency sound also indicated that at distances of more than 305 meters from the nearest residence, the wind turbines:

(a) Did not pose a low-frequency noise or infrasound problem, in that they were less than the standards and criteria published by cited agencies, such as ANSI. At this distance the wind farms were below ANSI/ASA S12.2 indoor thresholds for low-frequency sound for bedrooms, classrooms and hospitals;

(b) Were below ANSI/ASA S12.2 indoor thresholds for moderately perceptible vibrations in lightweight walls and ceilings;

(c) Were below ANSI S12.9 Part 4 thresholds for annoyance and beginning of rattles; and

(d) Have no audible infrasound to the most sensitive listeners.

The results of the O'Neal study are similar to other field studies in the UK (Hayes, 2006), Denmark (Delta, 2008) and the Netherlands (van den Berg, 2008) in which low-frequency sound and infrasound were not considered a health risk to residents living in the vicinity of wind farms.

Q: You also mentioned a field study in Australia; can you provide more information in regards to that field study?

A: Infrasound was measured near two Australian wind farms, one comprising 27 wind turbines, each with a rated capacity of 2.1 MW, and another comprising 29 wind turbines, each with a rated capacity of 2.0 MW. Infrasound was also measured in the vicinity of a beach, a coastal cliff, the city of Adelaide and a power station using below ground methodology to minimize measuring low frequency and infrasound by the wind itself. (Turnball et al., 2012)

Q: And what were the conclusions of the Australia field study?

A: This Australian study showed that even at distances of 200 meters (approx. 650 feet), infrasound from wind turbines was insignificant in comparison to natural background sources. More recently, the Australian Environment Protection Authority, in conjunction with Resonate Acoustics, conducted a study into the level of infrasound in typical environments in South Australia, with a particular focus on comparing wind farm environments to urban and rural environments away from wind farms. (Evans, Cooper and Lenchine, 2013) Measurements were

undertaken over a period of approximately one week at seven locations in urban areas and four locations in rural areas including two residences approximately 1.5 kilometres away from the wind turbines. The authors found that infrasound levels of between 60 and 70 dB (G) **commonly** occur in the urban environment, and that in rural environments, infrasound levels at houses adjacent to wind farms (*e.g.*, 1.5 km away) were no higher, and in certain cases lower, than those at houses located a considerable distance (30 km) from wind farms.

The authors concluded:

> This study concludes that the level of infrasound at houses near the wind turbines assessed is no greater than that experienced in other urban and rural environments, and that the contribution of wind turbines to the measured infrasound levels is insignificant in comparison with the background level of infrasound in the environment. [(Evans, Cooper and Lenchine, 2013)]

Q: Have there been human experimental studies on effects from infrasound and low-frequency noise?

A: As noted above, infrasound is ubiquitous in the natural environment (*e.g.*, sea waves, wind) and is present in normal human physiology, such as heart tones. In experimentally designed studies to assess potential health effects of infrasound,

astronauts, who were part of the Apollo space program, were tested to determine potential adverse health effects of infrasound. Results suggested that 24-hour exposures to 120 to 130 dB are tolerable below 20 Hz, the upper limit of infrasound. Studies have also assessed physiological impacts of low-level sounds. Low-level sounds from outside of the body, however, do not cause a high enough excitation within the body to exceed the internal body sounds. In other words, body sounds themselves mask low-level sounds from outside the body. For example, when measuring chest resonant vibration caused by external sounds, the internal vibration of bodily functions masks resonance for external sounds below an 80 dB excitation level (Leventhall, 2006). Investigations at very low frequencies show a reduction of about 30 dB from external to internal sound in the body of a sheep (Peters et al., 1993). Similar findings have been noted in the protective effect of the uterus in attenuating noise exposure to the fetus at about 30 dB (A).

Q: What about the study by Dr. Alec Salt referenced by Punch in his testimony, which Punch claims shows a pathway to exist whereby infrasound can reach the brain through the outer cells (OHCs) in the cochlea which can then lead to health impacts?

A: The most important aspect of the Salt el al. work is that the results were conducted on guinea pigs-not humans and that no adverse effects were noted,

despite the neural connection reportedly observed in the guinea pigs. It has been claimed that sounds that contain low-frequency noise, most notably within the infrasonic level, can adversely affect human health even when the sound level is below the average person's ability to detect them (*e.g.*, Alves-Pereira and Branco, 2007; Salt et al., 2010). In September 2010, Salt et al., published a review article on experimental studies conducted in guinea pigs related to infrasound (Salt et al., 2010). This review article aroused interest among some people concerned about potential health implications of wind turbines. The authors stated:

> In most cases, **the inner ear's responses (that is, of the outer hair cells of guinea pigs) to infrasound can be considered normal,** but they ***could be*** [a very tentative comment] associated with unfamiliar sensations or subtle changes in physiology. This raises the *possibility* that exposure to the infrasound component of wind turbine noise *could* influence the physiology of the ear. [Emphases added] The phrases ***"could be"*** and ***"could influence"*** are vague, tentative, non definitive assertions, that, in my view, are inappropriate for public policy decisions.

The authors were appropriately tentative about their conclusions since they provided no scientific support that infrasound at levels encountered in the vicinity

of wind turbines could reasonably be expected to represent a threat to human health. In fact, the authors noted that they had simply introduced concepts about responses – and not harmful responses – of the outer hair cells of the inner ear of guinea pigs upon exposure to infrasound. Even if there was a response of outer hair cells (which is a hypothesis only) that does *not* mean that the response is detrimental or harmful.

It is also important to note that these hypotheses are based on investigations involving guinea pigs, *not humans*. These laboratory animals have a different anatomy of the inner ear in comparison to humans and, as a result, the corresponding implications of the results of many such animal studies to humans are unclear. Moreover, Salt et al., do not mention the ubiquitous nature of infrasound in the natural environment (*e.g.*, ocean waves, wind); the body itself (*e.g.*, heart tones are infrasound (2 Hz)); and the man-made environment (*e.g.*, refrigerator compressors, etc.). Infrasound is not a new phenomenon and is not unique to the operation of wind turbines. In sum, the Salt et al., review article of infrasound experiments with guinea pigs does not provide scientific support for the proposition that exposure to infrasound from wind turbines poses a risk to human health.

Q: Can you summarize whether infrasound from wind turbines cause harm to human health?

A: Although wind turbines can generate infrasound and low-frequency sound (Moeller, 2011), detectable levels of infrasound and low-frequency sound are not at harmful levels based on studies near wind farms in the United States, the United Kingdom, the Netherlands, Denmark and Australia. Moreover, there are no studies demonstrating harmful effects to humans as a result of exposure to infrasound or low-frequency sound at the noise levels measured in the vicinity of wind turbines or in experimental studies involving noise levels several orders of magnitude higher than those noted in the vicinity of wind turbines (such as in the astronaut studies described above).

IV. HEALTH CANADA

Q: Can you provide an overview of the 2016 Health Canada study?

A: Based on my research, publishing and educational experience, it is my view that the most appropriate health related research study for assessing potential health impacts of living near wind turbines is the recent effort conducted by Health Canada. (Michaud et al., 2016, A, B, C, D and Feder et al., 2015). In collaboration with Statistics Canada, and other external experts, this Canadian governmental health agency conducted the Community Noise and Health Study to better understand the impacts of wind turbine noise (WTN) on health and well-being. They performed a cross-sectional epidemiological study between May and September 2013 in southwestern Ontario and Prince Edward Island that involved

1238 randomly selected people (606 males, 632 females) aged 18-79 years, living between 0.25 and 11.22 km (approximately 820 ft. and 7 miles) from operational wind turbines. The approach of including only randomly selected participants reduced the potential for an epidemiological bias known as "selection bias" in which people who feel they have an issue participate, a phenomenon that skews the results. Prior to implementing the study, the investigators subjected their proposed methodology to extensive peer review, including: The Health Canada Science Advisory Board; a 27 member expert committee, the World Health Organization's (WHO) Noise Committee and the Health Canada's research ethics board. And finally, the investigators invited public comments about the proposed methodology, from which they received 950 submissions.

Q: How was the study conducted?

A: Health of participants was assessed by a questionnaire and objective measures of stress, sleep, blood pressure and others. Noise was assessed by internationally accepted protocols, sound recordings, including low frequency noise, inside and outside on a number of homes and infrasound measurements. The participation rate was excellent at 78.9%, and above the target of 70% set by Health Canada Statistics investigators. Although some participants reported some health issues, the extent and prevalence of the symptoms did not change in relation to noise levels, findings inconsistent with a causal link between symptoms and noise

exposure. The results of Health Canada study were published in five separate publications in the peer reviewed literature; it represents the largest group of people studied and also the first group of people studied in which objective measures of health, including stress, sleep and blood pressure, among others, were assessed.

Q: What do you recommend to the Siting Board with respect to the Health Canada Study?

A: I note the Health Canada Study was reviewed favorably in the DOH Testimony and given the significance of the study, I recommend that officials evaluating the Cassadaga Wind Project recognize the value of this study for public policy and give it serious consideration in the deliberative process. Moreover, the authors of this $2.1 million study developed an initial research plan that they subjected to peer review among scientists; they also invited public comment on their proposed evaluation prior to commencing the study. It is the largest epidemiology study to date that has addressed potential health implications of living near wind turbines; it is also the only study that included both objective and subjective measures of sleep, stress and blood pressure. The results were published in five separate peer reviewed journals. These reports included results related to the following:

1. General Health (Michaud et al., 2016 A)

2. Sleep (Michaud et al., 2016 B)
3. Stress (Michaud et al., 2016 C)
4. Personal and situational factors associated wind turbine annoyance (Michaud et al., 2016 D)
5. Quality of life (Feder et al. 2015)

These five publications and their implications to the Facility are discussed below. These five publications are discussed below by including comments taken directly from the abstracts of the papers, which represent the key conclusions of the authors.

Q: What does the Health Canada study say about reported health effects?

A: In general, the authors concluded that wind turbine noise was **not** associated with self-reported:

- Sleep disturbance or disorders (as also noted in the DOH Testimony);
- Illnesses and chronic health conditions;
- Perceived stress and quality of life.

The Health Canada Study: Perceptual responses and reported health effects (Michaud et al., 2016 a) states: **"**Self-reported health effects (e.g., migraines, tinnitus, dizziness, etc.), sleep disturbance, sleep disorders, quality of life, and perceived stress were **not** related to wind turbine noise (WTN) levels. Visual and

auditory perception of wind turbines as reported by respondents increased significantly with increasing WTN levels as did high annoyance toward several wind turbine features, including the following: noise, blinking lights, shadow flicker, visual impacts, and vibrations… Beyond annoyance, results do **not** support an association between exposure to WTN up to 46 dBA and the evaluated health-related endpoints." (Michaud et al., 2016 a). Again, I note that this study and its results were also identified in the DOH Testimony.

Note that wind turbine noise levels reached 46 dBA, yet no health problems were associated with these levels. According to the Health Canada report, the 46 dBA is equivalent to the WHO annual outdoor night time average of 40 dBA, which is consistent with the design goals for the Facility. As described in this testimony, annoyance is not a health effect; the International Classification of Diseases (ICD), in its most recent 10th edition, does not classify annoyance as an illness. The ICD has been adopted worldwide and is routinely used in the USA and other countries for classifying disease, research and for health insurance purposes.

Q: What does the Health Canada study say about sleep disturbance?

A: The authors concluded: **"results do not support an association between exposure to outdoor WTN up to 46 dB (A) and an increase in the prevalence of disturbed sleep.** Conclusions are based on WTN levels averaged over 1 year and, in some cases, may be strengthened with an analysis that examines sleep

quality in relation to WTN levels calculated during the precise sleep period time." The Health Canada group conducted the first study that evaluated potential implications on sleep as a result of living in proximity to wind turbines that included both subjective and objective measures of sleep. The authors concluded: *"There was **no** association between exposure to outdoor WTN **up to 46 dB** and an increase in the prevalence of disturbed sleep."* The Pittsburgh Sleep Quality Index (PSQI), a well-validated questionnaire to assess sleep, was used. The PSQI measures the subjective experience of sleep and is one of the most common methods used in sleep research. Although noise at certain levels can affect sleep, this study showed no adverse effects on sleep from wind turbine noise levels up to 46 dBA, which is consistent with the guidelines of the WHO in its Nighttime Noise Guidelines. (WHO, 2009) and demonstrated by the figure below from the 2009 WHO guidelines. As the curve below indicates, no adverse effects on sleep were expected at noise levels up to 46 dBA L_{night} and this was demonstrated by Health Canada.

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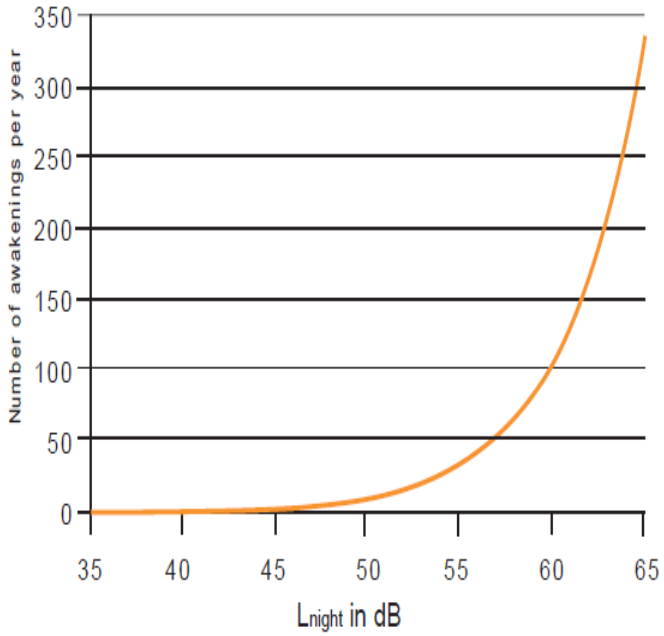

Fig. 3.1
Worst case prediction of noise-induced behavioural awakenings.
L_{night}, converted from inside relation with [3] on page 10.

Source: Miedema, Passchier-Vermeer and Vos, 2003

As shown above, the Health Canada study on sleep and wind turbines confirmed the findings of the 2009 World Health Organization report, in which noise induced awakenings, did not occur below 45 dB. The Health Canada authors concluded: ***"Study results do not support an association between exposure to outdoor wind turbine noise up to 46dB (A) and an increase in the prevalence of disturbed sleep."*** (Michaud et al., 2016, b) This study demonstrates the

fundamental principle of dose –response, that is, risk of noise induced health effects is based on the noise level and its duration. Although it is well acknowledged that noise at certain intensities can adversely affect sleep and lead to other health issues, risk of noise exposure on health and sleep is dependent on the intensity and duration of exposure to noise. In the case of wind turbine noise, at levels proposed for the Facility, it is not expected to result in adversely affecting nearby non-participant residences sleep.

Q: What does the Health Canada study say about stress?

A: Concern has been raised that annoyance reported in the context of living near wind turbines may lead to stress and chronic stress can lead to sleep disturbance and a corresponding range of health effects. As a result, the Health Canada study also focused on subjective and objective measures of stress. "The current study was the first to assess stress reactions associated with wind turbine noise (WTN) exposure using self-reported and objective measures. Multiple regression modeling left the great majority (77%-89%) of the variance in perceived stress scale (PSS) scores, hair cortisol concentrations, resting blood pressure, and heart rate unaccounted for, and WTN exposure had no apparent influence on any of these endpoints. Collectively, the **findings do not support an association between exposure to WTN up to 46 dBA and elevated self-reported and objectively defined measures of stress." (Michaud et al., 2016, C)** To sort out

the many variables associated with a person noting annoyance on a questionnaire, a multiple regression analysis is used. This statistical method used can differentiate the contributions of different factors in affecting the outcome of interest. This method was used to enable the investigators to conclude that wind turbine noise had no effect on self-reported or measured stress levels.

Q: What does the Health Canada study say about annoyance?

A: Some people living near wind turbines have reported annoyance. Health Canada assessed links between noise levels and annoyance and also evaluated other factors that led people to report annoyance on questionnaires. "The current analysis presents results related to WTN annoyance. WTN levels reached 46 dB, and for each 5 dB increase in WTN levels, the odds of reporting to be either very or extremely (i.e., highly) annoyed increased by 2.60 [95% confidence interval: (1.92, 3.58), $p < 0.0001$]. Multiple regression models had R(2)'s up to 58%, with **approximately 9% attributed to WTN** level. [Note: R(2) refers to a correlation coefficient, which will be discussed in more detail below.]Variables associated with WTN annoyance included, but were not limited to, other wind turbine-related annoyances, personal benefit, noise sensitivity, physical safety concerns, property ownership, and province. Annoyance was related to several reported measures of health and well-being, although these associations were statistically weak ($R(2) < 9\%$), <u>independent of WTN levels,</u> and not retained in multiple

regression models. The analysis suggests that communities are between 11 and 26 dB less tolerant of WTN than of other transportation noise sources." (Michaud et al., 2016 (c))

Q: Can you explain what is meant when the authors state "associations were statistically weak"?

A: These results show a very low correlation (~9%) between wind turbine noise and annoyance, based on the correlation coefficient of 0.09. The results indicate a very poor relationship between exposure to wind turbine noise and annoyance. In statistics, the correlation coefficient (R^2) measures the strength and direction of a linear relationship between two variables- in this case, noise and annoyance as assessed by the Health Canada investigators. A correlation coefficient (R^2) of 9% represents a very weak association between noise and annoyance in the context of wind turbines. As noted in many epidemiological studies, although noise can contribute to annoyance in the context of living near wind turbines, it is a minor factor in comparison to other factors associated with annoyance. This conclusion has also been drawn in other epidemiological studies, such as those performed in the Netherlands and Sweden. (Pedersen et al., 2004; 2007; 2009; 2011). Below is an example of various correlation coefficients and their corresponding significance. Recall the correlation coefficient of + 0.09, reported by Health Canada in its assessment of the potential link between WTN and annoyance.

- +0.30. A weak linear relationship
- +0.50. A moderate relationship
- +0.70. A strong linear relationship
- Exactly +1. A perfect linear relationship

In light of the very poor correlation (r=9%) between wind turbine noise and annoyance, it is important to note that annoyance associated with living near wind turbines is a complex phenomenon primarily related to personal factors. For example, numerous epidemiological studies have demonstrated that noise from turbines plays a minor role in comparison with other factors that lead people to report annoyance in the context of living near wind turbines. Annoyance associated with wind turbines tends to be a subjective phenomenon, which appears to be related primarily to attitudes to the visual impact of wind turbines, personal characteristics and whether economic benefit is associated with living near wind farms. (Pedersen et al., 2011; 2009; 2007; 2004)

Q: Does WHO classify annoyance an "adverse health effect"?

A: Annoyance associated with wind turbines is a subjective phenomenon, which appears to be related primarily to attitudes to the visual impact of wind turbines and economic benefit associated with wind farms. (Pedersen et al., 2011; 2009; 2007; 2004) Annoyance is not a health effect. I was also unable to locate "annoyance" as a disease entity in the 10th revision of the International

Classification of Diseases (ICD-10). As a result, claims that "annoyance" is an adverse health effect reflect individual opinions and not the consensus of the international medical community. Moreover, a review of the constitution of the WHO (1948) and its subsequent publications do not indicate that the WHO considers "annoyance" an adverse health effect.

Q: What does the Health Canada study say about quality of life?

A: The Health Canada study used a World Health Organization approach to assess quality of life among the Canadian participants. A summary of the results follows.

> *"Living within the vicinity of wind turbines may have adverse impacts on health measures associated with quality of life (QOL). There are few studies in this area and inconsistent findings preclude definitive conclusions regarding the impact that exposure to wind turbine noise (WTN) may have on QOL. In the current study, …questionnaires provided an evaluation of QOL in relation to WTN levels… In the multiple regression analyses, WTN levels were* ***not*** *related to scores on the Physical, Psychological, Social or Environment domains, or to rated QOL and Satisfaction with Health questions. However, some wind turbine-related variables were associated with scores on the WHOQOL-BREF,* ***irrespective of WTN levels****. Hearing wind turbines for less than one year (compared to not at all and greater than one year) was associated with*

improved (i.e. higher) scores on the Psychological domain (p=0.0108). Lower scores on both the Physical and Environment domains (p=0.0218 and p=0.0372, respectively), were observed among participants reporting high visual annoyance toward wind turbines. Personal benefit from having wind turbines in the area was related to higher scores on the Physical domain (p=0.0417). ***Collectively, results do not support an association between exposure to WTN up to 46 dBA and QOL assessed using the WHOQOL-BREF questionnaire****."*

Note that visual "annoyance" was a major feature that affected people's perception of quality of life but that noise from a turbine had no appreciable effect. In fact, numerous studies have demonstrated that annoyance associated with living near wind turbines is primarily affected by the visual aspects of the turbines and whether a person receives economic benefit from the turbines. Noise from the turbines plays a minor role in people reporting annoyance in the context of living near wind turbines, a conclusion also drawn in epidemiological studies conducted prior to Health Canada. (Pedersen et al., 2011; 2009; 2007; 2004). It is important to keep in mind that a subjective QoL assessment can depend on many factors, such as pre-existing happiness, socioeconomic status, marital or relationship status, health, and other factors rather than the introduction of one potentially unpopular component (such as a wind farm).

Q: Both Punch and James rely heavily on the recent 2016 Health Canada study in support of their conclusions in their testimony. Does the Health Canada study support Punch and James' assertion that wind turbine noise causes adverse health impacts, such as sleep disturbance?

A: In an attempt to ascribe health effects due to living near wind turbines based on the Health Canada study, Punch prepared a misleading table with an incorrect citation and a scientifically inappropriate use of a control group. See Table 1 on page 13 of Punch's testimony, where he prepared a table based on data from Health Canada and selected data supposedly from another publication to contrast the Health Canada results. Punch cites Wilson et al.; Canadian Journal of Public Health; Vol 98; no.2, p.154, although he did not cite the year of publication. First, it is entirely incorrect to take data from participants in one study in a different location and assume they can serve as controls for participants in another study at a different location. Secondly, Punch cited the wrong paper; he also has the title wrong and the table to which he refers is not in the paper he cited. When I reviewed the citation, the actual title of the paper is "Factors affecting change over time in self reported health"-not "Prevalence Rate for non exposed general population self reported health" as claimed by Punch. This type of careless scholarship is littered throughout the Punch testimony and renders his conclusions

about adverse health effects from the Health Canada study incorrect and misleading.

In contrast to Punch's incorrect assertions about a doubling of the prevalence of symptoms in the Health Canada study, the actual authors of the Health Canada study noted that wind turbine noise was **not** associated with:

(a) self-reported sleep disturbance or disorders;

(b) self-reported illnesses and chronic health conditions; and

(c) self-reported perceived stress and quality of life.

The authors noted no association between wind turbine noise and objectively measured results such as blood pressure, resting heart rate, sleep efficiency, the rate or awakenings, duration of awakenings, total sleep time or how long it took to fall asleep.

V. PUNCH TESTIMONY

Q: Punch links adverse health effects with wind turbine noise based on his knowledge of the functioning of the inner ear. Do you agree with Punch's assessment?

A: Knowledge of the functioning of the inner ear in the absence of medical training and expertise is not a persuasive qualification for assessing causality between exposure to a hazard and an adverse health effect. Moreover, Punch's assertions about the mechanism of health effects reported in the context of living near wind

turbines are unconfirmed conjectures, not supported by experimental evidence and primarily based on work performed on guinea pigs by Salt and colleagues. (Salt et al., 2010) Note that Dr. Salt has not demonstrated adverse health effects in humans by his proposed mechanism. It is unclear how an audiologist with no training, experience or credentials in medicine and in evaluating patients could possibly have the scientific background to conduct a differentials diagnosis, an essential step in assessing causality. A proper causality assessment includes a thorough review of symptoms and past medical history with appropriate diagnostic studies. The determination of causality is an important exercise in health care, but it is customarily only undertaken after diagnosis and treatment. A causality assessment where noise exposure may be a factor should also consist with a thorough review of noise measurements conducted in the vicinity of the individual's home along with a comparison of the symptoms, diagnosis and noise levels in light of what has been published in the peer-reviewed scientific literature. Punch does not conduct a proper causality assessment; instead he relies on self-reported studies, many of which are subject to recall bias that affects the outcome of the study.

Q: What is recall bias?

A: A patients' own self-assessments of causes of symptoms, although potentially helpful, can often be incorrect. Recall bias, a well-recognized factor in

epidemiological studies, can distort the results of case-control studies. This phenomenon of recall bias has been confirmed in studies of breast cancer, Parkinson's Disease and coronary artery disease (Rugbjerg et al., 2011 Zota et al., 2010 and Metcalfe et al., 2008). In fact, Zota et al. noted that their "results highlight the difficulty of distinguishing in retrospective self-report studies between valid associations and the influence of recall bias." Metcalfe et al. concluded, "Recall is likely to be influenced by present outcome" (Metcalfe et al., 2008). The point of the above commentary is to demonstrate the limited utility of recall when evaluating self-reported symptoms.

Q: Can you provide an example of where Punch relied on a flawed self-reported study?

A: Yes, on page 28 of his testimony Punch states that Nissenbaum et al. (2012) found that

residents living within 1.4 kilometers (0.87 mile) of an industrial wind turbine scored worse on measures of sleep quality and mental health when compared to those living further away, when controlling for gender, age, and household clustering.

Q: What is your understanding of the Nissenbaum study?

A: This study compared sleep and general health outcomes among 38 participants residing 375 to 1400 m from the nearest turbine with another group of 41

individuals residing 3.3 to 6.6 km from the nearest wind turbine. Participants completed questionnaires and in-person interviews on a range of health and attitudinal topics. Prevalence of self-reported symptoms was compared by distance from the wind turbines, statistically controlling for age, sex, site, and household cluster in some analyses. Participants living within 1.4 km of a wind turbine reported worse sleep, were sleepier during the day, and had worse SF-36 Mental Component Scores compared with those living farther than 3.3 km away. Statistically significant correlations were reported between Pittsburgh Sleep Quality Index, Epworth Sleepiness Scale, SF-36 Mental Component Score, and log-distance to the nearest wind turbine. The authors attributed the observed differences to the wind turbines, yet the results were within normal limits among the participants. (Nissenbaum et al., 2012)

Q: Besides being a self-reporting study are there other problems with this study?

A: There are significant methodological problems with this study. Notably, all of the "near" turbine groups were plaintiffs in a lawsuit against the wind turbine operators and had already been interviewed by the lead investigator prior to the study. All of the participants also knew the purpose of the study. About 50% of eligible people in the near group participated. The authors make no attempt at differentiating those who participated in the study from those who did not

participate in the study, a routine assessment expected to assess whether participants and non-participants differed in ways that may affect the results. None of the "far" group were interviewed; they were "cold called" by an assistant until enough people were assembled to use as a control group. This differential treatment of the two groups introduces bias (selection and reporting bias) in the integrity of the methods and corresponding results. Further, details of the far group, as well as participation rates, were not noted.

Some major shortcomings of this limited and small study are noted below.

(a) Sound power levels were not collected from the homes of those surveyed, but were derived *post-hoc* data obtained in public reports. This is not scientifically defensible and should not have been used to draw conclusions about the findings of the questionnaires with distance from turbine locations;

(b) The title of the paper "Effects of industrial wind turbine noise on sleep and health" is not supported by the data presented. No evidence with respect to sound level (noise) and its effect on sleep and health was statistically presented in this paper. The authors could have more appropriately focused the title with respect to the *distance* from the turbines, which is the variable that they actually investigated;

(c) The authors state that noise emitted by IWTs can affect sleep, however, their results do not support this statement. In fact, the authors state that *"The data on measured and estimated noise levels were not adequate to construct a dose-response curve…"* . No statistical analyses were conducted to assess this supposed relationship. Thus, any conclusions on distance from wind turbines and effect on sleep outcomes is not supported by the authors' statistical findings;

(d) The authors acknowledge that *"[t]here was no statistically significant difference in [physical component score] PCS (P = 0.9881)."* Thus, respondents reported no difference in their physical component summary score or physical well-being between the two groups. The findings of the PCS score appear to support the premise that there is nothing physically emitted from the turbines that affected health in this small sample.

Shortcomings of this small study (38 people) that limit its general applicability to other settings have been raised in two letters to the editor. (Olsen et al., 2012 and Barnard, 2012).

Olsen et al. noted the following about the Maine study:

(a) "Sound power levels were not collected from the homes of those surveyed, but were derived *post-hoc* from data obtained in public reports.

(b) The title of the paper *"Effects of industrial wind turbine **noise** on sleep and health"* is not supported by the data presented. No evidence with respect to sound level (noise) and its effect on sleep and health was statistically presented in this paper. The authors could have more appropriately focused the title with respect to the ***distance*** from the turbines, which is the variable that they actually investigated;

(c) The authors state that noise emitted by IWTs can affect sleep, however, their results do not support this statement. In fact, the authors state that *"The data on measured and estimated noise levels were not adequate to construct a dose-response curve…."* No statistical analyses were conducted to assess this supposed relationship. Thus, any conclusions on distance from wind turbines and effect on sleep outcomes is not supported by the authors' statistical findings."

In another letter to the editor of the journal *Noise and Health*, Barnard raises a number of issues with the study that limit widespread conclusions. (Barnard, 2013)

a. Dr. Nissenbaum had previously been active in investigating the Mars Hill and Vinalhaven wind farms. This is not disclosed, and therefore, it is possible that previous contact with the investigators and other anti-wind activists has primed the responses of participants, or biased the sample.

Analogous studies looking at electromagnetic radiation (EMR) rather than noise have shown that concern about EMR, rather than the EMR itself, can affect sleep quality (Danker-Hopfe et al., 2010);

b. The authors assert that there is a "strong" dose-response relationship. This is not justified, given the presented data. In contrast to the conclusions, [Figure 1] and [Figure 2] in the paper show a very weak dose-response, if there is one at all. The near horizontal "curve fits" and large amount of "data scatter" are indications of the weak relationship between sleep quality and turbine distance. The authors seem to use a low P value as a support for the hypothesis that sleep disturbance is related to turbine distance. A better interpretation of the P value related to a near horizontal line fit would be that it suggests a high probability of a weak-dose response. Correlation coefficients are not given, but should have been given, to indicate the quality of the curve fits;

c. There is insufficient evidence to suggest a causal relationship between wind turbine noise and sleep quality. Other potential causal factors such as resident sentiment toward wind turbines or the level of anti-wind farm lobbying have not been investigated; and

d. The Pittsburgh Sleep Quality Index material asserts that any score over 5 indicates a poor sleeper, and that both the control group and the group

closer to the wind generators had scores over 5 on average. The implication is that rural dwellers on average are poor sleepers. This is a more significant finding than any related to wind turbines. The Epworth scores confirm this finding, yet it goes unnoted by the authors.

Q: Punch claims the research literature indicates that a substantial proportion of people living in the vicinity of wind turbines experience a variety of adverse health effects. Are you aware of any research supporting this statement?

A: No, in fact, Punch's comment is directly refuted by the results of the Health Canada study I mentioned earlier in my testimony.

Q: What is your response to Punch's assertion that *"Those effects* [adverse health]*, which vary widely among affected individuals, are remarkably common worldwide and include sleep disturbance, annoyance, headaches, dizziness, vertigo, nausea, motion sickness, bodily sensations, fatigue, stress, depression, memory deficits, inability to concentrate, and reduced quality of life. In a given individual, each of these effects can occur alone or in combination with other effects."*

A: As noted above, the Health Canada study, the world's largest and most comprehensive research study that has evaluated potential links between health and living near wind turbines, has drawn dramatically different conclusions than

the Punch testimony. "*Self-reported health effects (e.g., migraines, tinnitus, dizziness, etc.), sleep disturbance, sleep disorders, quality of life, and perceived stress were* ***not*** [Emphasis added] *related to WTN levels."* (Michaud et al., 2016 A). For example, see Table 2 below, which is based on results from Table V of the Health Canada study, (Michaud et al., exposure to wind turbine noise: Perceptual responses and reported health effects. J Acoust Soc Am 2016; 139: 1443-1454). Table 2, which I prepared based on the original data in the Health Canada study refers to results that addressed symptoms based on sound levels. As the Table indicates, no statistically significant relationship was demonstrated between increasing noise levels and any of the following symptoms, despite the assertions in the Punch Testimony: migraines, dizziness, tinnitus, high blood pressure, highly disturbed sleep, or diabetes. Another key distinction in this table is the absence of a dose response relationship. If wind turbine noise were causing the health problems assessed, one would expect more symptoms in those exposed > 40 dB in comparison to those exposed to > 35dB, but as Table 2 below indicates, this was not the case.

Table 2:

Symptoms (% of study group) and corresponding Noise Levels reported in the Health Canada Study*

Symptom	**35-40 dB**	**40-45 dB**

Migraines	25.8	24.4
Dizziness	21.9	25.2
Tinnitus	24.8	23.2
High Blood Pressure	32.0	27.8
Meds for high blood pressure	31.3	27.0
Highly disturbed sleep **	14.5	10.3
Diabetes	8.8	8.2

* Abstracted from Michaud et al., "Exposure to wind turbine noise: Perceptual responses and reported health effects." J Acoust Soc Am 2016; 139: 1443-1454.

As Table 2 above indicates, there was no dose-response relationship between noise and health effects. Note that people exposed to noise levels > 40-45 dB did NOT have higher symptoms than those people exposed to 35-40 dB. These results argue against the proposition that noise from wind turbines caused the health problems investigated. Moreover, note that the only symptom that appeared to occur at a higher frequency among the 40-45 dB group in comparison to the 35-40 dB group was dizziness. (25.2 vs. 21.9) Health Canada, however, also noted that participants exposed to noise levels < 25 dB reported a 22.6% risk of dizziness; these results are inconsistent with a causal connection between WTN and adverse health effects at the noise levels assessed. It is further noteworthy that the group of people exposed to < 25 dB had the highest percentage of *"highly disturbed*

sleep" (15.7 % in contrast to 10.3 % of those people exposed to greater than 40 dB) These results from the largest and most comprehensive study of wind turbines and health effects to date do NOT indicate adverse health effects from living near wind turbines as claimed by the Punch Testimony. Punch's assertions about health effects are based primarily on anecdotal comments from wind turbine blogs, much smaller limited studies and reports unpublished in the peer-reviewed literature. His assertions are inconsistent with the results of the Health Canada study.

The authors of the Health Canada study emphasized their results as follows*: "Table V* [data from which I developed Table 2 above] *shows that subjectively reported sleep disturbances from any source while sleeping at home over the year, in addition to* ***a multitude of health effects, were found to be unrelated to WTN levels.*** *Similarly, medication use for high blood pressure, anxiety or depression was also found to be unrelated to WTN levels."* (Michaud et al., exposure to wind turbine noise: Perceptual responses and reported health effects. J Acoust Soc Am 2016; 139: 1443-1454)

Despite the firm conclusions drawn by the authors of the largest study of people living near wind turbines, the Punch Testimony concludes health related effects among people living near wind turbines without proper scientific citation. As noted below, every symptom aside from dizziness (25.2 @ 40-45 dB vs. 21.9 at

35-40 dB) occurred less frequently at greater than 40 dB than at 35-40 dB, which is inconsistent with causality. When a causal link between exposure to a hazard and a health effect exists, those exposed to higher levels of the hazard should have a higher percentage of health effects. The Punch Testimony appropriately noted the importance of dose repose in assessing causality, however, as the results above indicate, higher noise levels showed no higher risk of the symptoms assessed, results that are inconsistent with causality.

Q: What is your response to Punch's assertion that he is "*convinced that large-scale wind turbines indeed cause many unpleasant sensations and lead to substantial health problems in humans and that these problems are occurring widely in the U.S. and internationally.*"

A: Notwithstanding the gross embellishments in the Punch Testimony, based on the extensive investigation conducted as part of the Health Canada study, his assertion is unfounded based on research studies, especially his reference to "**substantial health problems**" [emphasis added]. If "substantial health problems" occur in the context of living near wind turbines, these problems would have been identified by the Health Canada investigators report, which is the world's largest epidemiology study that has evaluated potential health implications of living near wind turbines.

Q: What is your response to Punch's assertion that a "dose response" relationship is starting to emerge between wind turbine noise and health effects?

A: This assertion is not correct. As noted earlier, there is a very weak relationship (~9%) between WTN and annoyance and none in relation to WTN to health effects. (Michaud et al., 2016 D). His assertion that a dose response relationship is "beginning to emerge" (sic) is not based on any scientific study, but simply his own speculation.

Q: What is your response to Punch's assertion that "the health of a substantial number of people living within several miles of the project will be dramatically impacted."

A: These hyperbolic assertions are not supported by the results of the weight of scientific evidence on wind turbines and health (McCunney et al., 2014) and the Health Canada Study. Punch's assertions are inconsistent not only with the Health Canada study but also with the weight of the scientific evidence regarding wind turbines and human health.

Q: What is your response to Punch's assertion that the "Health Canada study, even 30-35 dBA results in a doubling of prevalence rates of some health symptoms."?

A: This comment is incorrect. Contrary to the Punch Testimony, the Health Canada

study did not conclude that populations exposed to noise that is 26 dBA or more is vulnerable to health problems. This assertion was made by Punch and described earlier in this report. Punch cited the wrong research paper and inappropriately applied results from another investigation that he did not properly cite to create the scientifically misleading impression of a doubling of risk of adverse health effects.

Q: What is your response to Punch's assertions that infrasound from large wind turbines negatively affects people?

A: As discussed above, infrasound is not some mysterious aspect of noise, but to the contrary, is ubiquitous in the environment, such as sea waves and heart tones, among others. For example, physicians need to use a stethoscope to assess heart sounds, since the tones are in the 1 to 2 Hz range, clearly infrasound. In essence, people are repeatedly exposed to infra sound as a result of the normal functioning of the heart.

Infrasound from wind turbines is not unique and has not been found to cause sleep disturbance, unpleasant bodily sensations, or other direct health impacts.

Q: Does the journal article entitled: "Wind Turbines and Health: A Critical review of the literature" as conducted by a team of professions including yourself assembled by the Massachusetts Institute of Technology (McCunney et al., 2014) review the reports cited by James and Punch?

A: The MIT report addressed peer reviewed studies. Many of the citations made by Punch include reports not in the peer-reviewed literature, unstructured comments in anti-wind turbine blogs and a self-published book by a vanity press by Pierpont, in which she described her telephone interviews with members of 10 families.

Q: Is infrasound, as claimed by the Punch Testimony, known to be a major cause of sleep disturbance?

A: No.

Q: Have you read the Punch Testimony regarding the NYSDEC Noise Guidelines, *Assessing and Mitigating Noise Impacts*, 2000?

A: Yes. Again, the Punch Testimony blatantly mischaracterizes the document. For example, the Punch Testimony claims that Table 2 of the NYSDEC noise guidelines reports that new sounds that exceed background levels by 5 dB or more will be "objectionable". However, this is simply not true. Table 2 of the NYSDEC noise guidelines indicates that an increase in sound pressure would have to be 15 dB to 20 dB to be "objectionable".

Q: Does the NYSDEC limit the increase over background sound levels to 6 dB as claimed by the Punch testimony?

A: No. The NYSDEC very clearly states that an increase over 6 dB "may require a closer analysis of impact potential depending on existing SPLs and the character

of surrounding land use and receptors." The NYSDEC does not contain a "limit", as claimed by the Punch Testimony.

Q: The Punch Testimony claims that low frequency noise has a wind turbine signature. Can you explain this?

A: Although I hesitate to discern the message of his jargon in using a term such as "signature" I assume that he is implying the LFN can be separately identified as originating from a wind turbine. Such a distinction, however, is irrelevant in evaluating real world settings, as conducted by Health Canada, to determine whether people experience adverse health effects from living near wind turbines.

Q: Do the Punch Testimony's biological explanations for adverse health affects associated with low frequency sound make sense (See e.g. P33)?

A: No.

Q: What are the "Bradford Hill criteria"?

A: The Bradford Hill criteria are used to evaluate the results of research studies to assess potential casual connections between a reported association and a potential health effect.

Q: Why does the Punch testimony refer to these?

A: He refers to these criteria to justify his erroneous conclusions about a causal connection between exposure to wind turbine noise and adverse health effects.

Q: Does this conclude your testimony?

A: Yes.