

1 In the late 1980s I was invited to apply for the post of Professor and Head of the,
2 then, Institute of Environmental Engineering in London, where I stayed for about
3 five years, also practicing part time as a consultant. Since that time I have been
4 in practice full time as a consultant.

5 Much of my work has been in relation to low frequency noise problems. I have
6 carried out work for the UK government department, DEFRA, on low frequency
7 noise and there is an ongoing DEFRA project to help people cope with insoluble
8 low frequency noise problems. I am also working with the US company Wyle
9 Laboratories on a NASA project related to low frequency noise from a new
10 concept heavy lift rotor, which may eventually replace short haul jets. Of course,
11 there is also short-term problem-solving work in low frequency noise.

12 I first became involved with wind turbine noise in the mid 1980s, before there
13 were any in the UK, looking at assessment methods for response to wind turbine
14 noise. This work continued into the early 1990s, but for much of the remainder of
15 the 1990s I spent more time on one of my other interests from my academic
16 days, active control of noise, and had a consultancy with Digisonix, from
17 Middleton near to Madison. This continued until 1997, about the time when
18 Digisonix's parent company, Nelson Industries, was sold to a company that did
19 not wish to continue with the active control work. I was then able to give more
20 time to my other work, including wind turbine noise. I am regularly consulted in
21 relation to the strange things which people say about infrasound and low
22 frequency noise from wind turbines. In fact, for nearly 40 years I have been
23 trying to educate the public and others in order to undo some of the harm which

1 was caused by media exaggerations in the 1970s and which have more recently
2 developed on the Internet.

3 I am a former President of the UK Institute of Acoustics and have been awarded
4 two medals by the Institute in recognition of my work.

5 I am, by invitation, a “Distinguished International Member” of the US Institute of
6 Noise Control Engineering.

7 I was the founding editor of the Journal of Low Frequency Noise and Vibration,
8 now in its 28th year and edited it for the first 18 years.

9 I have organized nine of the 13 international series of conferences on Low
10 Frequency Noise and Vibration its Control, which have been held to date, and
11 been advisor to the organisers of a further three. The 14th of these conferences
12 will be held in 2010 in Denmark. Again, I am advisor to the organisers.

13 I was the originator of the International Conference Series on Wind Turbine
14 Noise and organized the three which have been held so far. The fourth is
15 currently being arranged for 2011.

16 Over the past few years I have been a member of two UK committees concerned
17 with noise and health, both preparing reports on this topic, one of which has been
18 published. I am currently a member of the AWEA committee of independent
19 experts considering the effects of noise on health. This report is not yet
20 completed. My Curriculum Vitae is submitted as Exhibit 17.

21 **Q. On whose behalf are you testifying?**

1 A. Wisconsin Electric.

2 **Q. Please briefly summarize your testimony.**

3 A. Based on my experience of infrasound and low frequency noise, it is my belief
4 that the infrasound from wind turbines is of no consequence. Attempts to claim
5 that illnesses result from inaudible wind turbine noise do not stand up to simple
6 analyses of the very low forces and pressures produced by the sound from wind
7 turbines. Additionally, the body is full of sound and vibration at infrasonic and low
8 frequencies, originating in natural body processes. As an example, the beating
9 heart is an obvious source of infrasound within the body. Other sources of
10 background low frequency noise and vibration are blood flows, muscle vibrations,
11 breathing, fluids in the gut and so on. The result is that any effect from wind
12 turbine noise, or any other low level of noise, which might be produced within the
13 body is “lost” in the existing background noise and vibration. This is considered
14 in more detail in my Appraisal of Wind Turbine Syndrome, which is submitted as
15 Exhibit 18.

16 More broadly, my testimony establishes that the claims of health effects from the
17 low levels of infrasound and low frequency noise from wind turbines, as
18 described in the Wind Turbine Syndrome and Vibroacoustic Disease hypotheses,
19 fail. However, higher frequency noise from wind turbines, if it is audible, can
20 cause disturbance to some residents, but this effect is no different from that of
21 noise from another source.

1 My testimony also directly addresses Richard James’s submissions to the PSC,
2 which rely heavily on three hypotheses that do not withstand scrutiny: Wind
3 Turbine Syndrome, Vibroacoustic Disease, and, novelly “mechanotensegrity,”
4 which, as its principal proponent explained to me, has no known applicability in
5 this context. My testimony also briefly addresses James’s criticism of the work
6 done at Glacier Hills by George Hessler, and James’s own suggested criteria for
7 permitting wind developments. Finally, I also address James’s misplaced
8 reliance on my work.

9 **Q. What are your general reactions to the testimony submitted by Richard**
10 **James?**

11 A. Part of James’s testimony appears to be saying that it is impossible to model
12 wind turbine noise. If James is correct in his approach, where are all the
13 complaints from every wind farm? The problems which he says might occur do
14 not normally do so, and especially not at the important locations nearest to the
15 turbines.

16 He is incorrect to claim research showing a causal link between wind turbine low
17 frequency sound levels and effects on health. Additionally, the effects of higher
18 frequency wind turbine noise are no different from those of any other similar
19 noise source. There is nothing special or mysterious about wind turbine noise.

20 **DISCUSSION OF VARIOUS CLAIMED HEALTH EFFECTS DUE TO**
21 **INFRASOUND AND LOW FREQUENCY NOISE**

22 **Q. Let’s explore your criticisms of James’s testimony in more detail. James**
23 **claims in Exhibit 808 that new medical discoveries establish that low**

1 **frequency noise below the threshold of human hearing can have negative**
2 **impacts on human health. What is your reaction to that claim?**

3 A. I do not agree. The new discoveries to which he is referring appear to be:

4 Wind turbine Syndrome – put forward by Pierpont

5 Vibroacoustic disease – put forward by the Portuguese

6 Tensegrity – put forward by Mulvihill

7 **Q. Please explain your view of Wind Turbine Syndrome.**

8 A. Pierpont's hypothesis about a Wind Turbine Syndrome, as resulting from
9 disturbance to the vestibular systems by the low levels of infrasound from wind
10 turbines, does not stand up to scrutiny.¹ I believe that this part of her work is
11 now discredited and should be acknowledged as such. She has not made any
12 new discoveries but, in the review section of her book (which I have reviewed in
13 prepublication draft as its release date keeps being pushed back), has surveyed
14 what is already known. The wide range of symptoms which she associates with
15 Wind Turbine Syndrome are well known to others as the stress effects of audible
16 noise, to which a small number of persons are susceptible. Also, my medical
17 colleagues tell me that it is unusual to associate such a wide range of symptoms
18 with a single named syndrome, as this makes the syndrome too easy to find.

19 **Q. Please continue.**

20 A. Pierpont has a very poor understanding of acoustics, which continually lets her
21 down. Her work depends on two hypotheses, neither of which she is able to

¹ For a discussion of sound levels produced by wind turbines and perception thresholds, see pages 19-20 of my testimony.

1 support. Her first hypothesis relied, until recently, heavily on work by Todd et al.²
2 However, it was clear to me on reading Todd's paper that she has both
3 misunderstood and misrepresented it. She has incorrectly sought to insert noise
4 issues into a paper which is entirely about vibration through the skull. I asked
5 Todd about this some time ago but, at that time, he did not wish to become
6 involved with the "politics" of wind turbines. However, there was publicity on
7 Pierpont's work on 2nd August 2009 in a UK newspaper. As this article referred
8 to his work, Todd finally came out and repudiated Pierpont, and her use of his
9 research. In a letter to the newspaper (Exhibit 19), he said

10 *Our research is being cited to support the case that "wind turbine*
11 *syndrome" is related to a disturbance of vestibular apparatus produced by*
12 *low-frequency components of the acoustic radiations from wind turbines.*
13 *Our work does not provide the direct evidence suggested. We described a*
14 *sensitivity of the vestibular system to low-frequency vibration of the head,*
15 *at about 100Hz, and not air-conducted sound.*
16 *At present I do not believe that there is any direct evidence to show that*
17 *any of the above acoustico-physiological mechanisms are activated by the*
18 *radiations from wind turbines. Even if the vestibular system were activated*
19 *in a controlled acoustic environment, it is not necessarily the case that it*
20 *would produce pathological effects. Until such evidence is available I have*
21 *an open mind on "wind turbine syndrome".*

² Todd, N., Rosengren, S. M., and Colebatch, J. G. (2008): Tuning and sensitivity of the human vestibular system to low frequency vibration. *Neuroscience Letters* **444**, 36 - 41.

2 The response from Dr. Todd was published on 9th August and shortly after this
3 all references to him disappeared from Pierpont's web page
4 (www.windturbinesyndrome.com).

5 Throughout Pierpont's work there is no clear indication of the excitation levels
6 which she believes might cause a problem. While she must be aware of safe and
7 unsafe doses of medication, she continues to close her mind to the concept of
8 safe doses of sound, although "safe sound" is our everyday experience.
9 Thus, Pierpont's first hypothesis fails.

10 **Q. What is Pierpont's second hypothesis, and does it fare any better in your**
11 **estimation?**

12 A. Pierpont's second hypothesis is equally unfounded. She says that infrasound at 4
13 – 8Hz enters the lungs and vibrates the diaphragm and its attached liver, so
14 passing confusing messages on to the visceral graviceptors. She gives no
15 evidence to support this, but instead uses references to whole body vibration,
16 applied to the feet or seat, which is a completely different excitation to that from
17 sound. A simple order of magnitude calculation, using basic physics of the level
18 which will be known to a 16-year-old school pupil, shows that the movement of
19 the diaphragm under the forces which might result from wind turbine noise is less
20 than 10 micron. That is less than one hundredth of a millimetre or about one
21 tenth of the average thickness of human hair. During normal breathing, the

1 diaphragm moves several centimetres. Wind turbine effects will not be passed
2 by the diaphragm on to the visceral gravicaptors, as hypothesized by Pierpont.
3 There is no scientific merit in Pierpont's second hypothesis. In fact, in strictly
4 scientific terms I find little to distinguish this hypothesis from the following equally
5 fanciful Internet posting, which explains why the crew abandoned the Marie
6 Celeste:

7 *The mystery was unsolved for decades, until it became clear that*
8 *infrasound was the explanation of the phenomenon. As it turned out,*
9 *infrasound of seven hertz emitted by ocean waves under some definite*
10 *conditions was the reason of it. But infrasound of seven hertz is terrible*
11 *for people: they may go mad and throw themselves overboard to save*
12 *their lives. <http://ghosts.monstrous.com/infrasound.htm>*

13 Another part of Pierpont's second hypothesis states that infrasound from wind
14 turbines, at a frequency of 1 – 2Hz, vibrates the chest, so adding to the confusing
15 signals which upset the balance system. However, there is already a strong
16 source of infrasound inside the body, beating at 1 –2 Hz, giving far greater
17 magnitudes than might be produced by infrasound from wind turbines at these
18 frequencies: the human heart. The beating heart vibrates the surface of the
19 body at a high enough level to be picked up by a stethoscope, or even the ear.
20 The sound produced by wind turbines does not.

21 **Q. Please comment on James's continued reliance on the writings of Drs.**
22 **Todd, Rosengren, and Colebatch.**

1 A. I am surprised, and saddened, to find that as late as 5th October, two months
2 after Todd cleared the air by firmly repudiating Pierpont's use of his work, James
3 is still relying on Todd in his "Comments on WEPCO's Glacier Hills Application
4 and Supporting Documents regarding Wind Turbine Noise and Its Impact on the
5 Community" (Exhibit 808). On pages 9 –10 he uses Todd as an example to
6 "demonstrate that there is sufficient evidence to present a causal link between
7 ILFN and adverse health effects." What Todd actually showed was that, for a
8 vibration input through physical contact to the mastoid area at the back of the
9 head, certain reflexes, indicative of a vestibular response, continue to about
10 15dB lower than the level at which the hearing mechanism of the inner ear
11 ceases to respond to vibration in the skull. It takes only a little thinking to realise
12 that all of the people who use bone conduction hearing aids are receiving
13 vibration inputs to their vestibular system at levels well above the system's
14 perception threshold. This does not affect them, as one might expect from
15 Todd's penultimate sentence in his repudiation of Pierpont, where he is saying, in
16 effect: So what – vestibular excitation is not necessarily a problem.

17 **Q. James relies on Dr. Eileen Mulvihill's writings. What have you found out**
18 **about the source of these writings and what is your reaction to them?**

19 A. James did not give the details of the paper from which he took the quotation,
20 which he reproduces on page 9 of his Exhibit 808. I searched for the paper and
21 eventually found it on the web page of the New Mexico Citizens Alliance for
22 Responsible Energy and Sustainability
23 (<http://www.newmexicocare.org/1pages/vad.html>).

1 This Internet page includes the statement:

2 *The presentation below is a summary in response to reports suggesting*
3 *that identification of "Wind Turbine Syndrome" is unnecessarily alarming*
4 *and misleading to the general public and that VAD, or Vibroacoustic*
5 *Disease, is part of some conspiracy.*

6 This is then followed by reference to papers, amongst others, on

- 7 • Military, applications of infrasound as a non-lethal weapon;
- 8 • Work carried out in connection with the Apollo space program (i.e. levels
9 equivalent to exposure of astronauts during blast off);
- 10 • Echocardiography of aerospace workers (i.e. those working around
11 ground running aero engines); and
- 12 • Noise risks in military operations.

13 All the above relate to very, very high levels of infrasound and bear no
14 connection to the sound produced by wind turbines.

15 Dr. Mulvihill also reviews papers on aircraft and traffic noises and summarizes
16 papers on VAD, some of which describe experiments on rats, which have been
17 given continuous long term exposure (up to seven months) at levels around
18 100dB, or more, in the frequency range 80Hz to 500Hz. Another paper
19 describes effects on rats, which have been exposed for 3 months at levels of
20 about 100dB between 50Hz and 100Hz. These exposures would deafen us. It is
21 not surprising that the rats suffered adverse effects. However, the work is not
22 relevant to wind turbine noise, which has levels falling from about 50dB to 35dB

1 over this range. That is from about 50 to 65dB lower than that imposed on the
2 unfortunate rats.

3 It must be emphasized that, on a noise dose basis, which, as discussed below,
4 the VAD group adheres to, the noise dose received from 1 year at 100dB will
5 take 100,000 years to be received at 50dB.

6 And finally, at the end of this long web page of Dr. Mulvihill's, we find the
7 paragraph quoted wholesale by James. (This webpage is also the source of
8 pages 196 – 206 in James's supporting documents, submitted as Exhibit 809).

9 Let us be clear. This quotation is not from a refereed publication, but from a self-
10 published Internet page. However, James's extract does give a reference to a
11 paper by Prof. Ingber, which James has included in full at page 308 of his
12 supporting documents.

13 **Q Did you investigate any relevance Prof. Ingber's research might have to the**
14 **issue of adverse health effects attributable to low frequency sound or**
15 **infrasound from wind turbines?**

16 A. Yes. Prof. Ingber says on page 320 of Exhibit 809:

17 *All organs also use structural hierarchies to mediate the*
18 *mechanotransduction response. Contraction and dilation of the heart, for*
19 *example, results in deformation of its component ECMs [extra cellular*
20 *matrix] which distort cells and their integrin adhesion as well as focal*
21 *adhesions and the linked cytoskeletal and nuclear components. At every*
22 *size scale and level of organisation, the level of tone or prestress in these*

1 *discrete structural networks, governs their overall response to stress, both*
2 *mechanically and biomechanically. This is also true in sound sensation in*
3 *the ear, responsiveness to air movements in the lung, hemodynamic*
4 *stresses in blood vessels and the compression in bone and cartilage.*
5 *Thus, tensegrity helps to guide force retransmission and orchestrate*
6 *multimolecular responses to stress at all size of scale and in all organ*
7 *systems*

8 What Prof. Ingber is saying here is that his model of tensegrity, which shows how
9 cells respond to deformations and then return to their original shapes, applies to
10 all movement in the body. He gives the examples of hearing, breathing, stresses
11 caused to blood vessels by the flow of blood, and compressions in stiff structures
12 in the body. To these could be added movement and flow in any part of the
13 body. Cells respond to the stresses in accordance with their function. As this
14 contradicts the assumption that low frequency noise might be harmful, I made
15 contact with Prof. Ingber. His reply contained the following

16 *I was not aware that my work has been cited to support the concept that*
17 *low frequency noise will adversely influence cell activity, and there is no*
18 *evidence that I am aware of to support this idea. Moreover, mechanical*
19 *noise can sometimes have positive effects on cell activity and human*
20 *physiology. For example, you should read the work of James Collins at*
21 *Boston University and now at the Wyss Institute that I head*
22 *(www.wyss.harvard.edu) who has pioneered the use of 'stochastic*
23 *resonance', which involves applying a sub-threshold mechanical vibratory*

1 *signal and thereby increasing fidelity of control in elderly patients with gait*
2 *control problems, diabetics with peripheral neuropathy, etc.*

3 Thus, Prof. Ingber's research has no bearing on the issues in this case.

4 **Q. Do you agree with James's assertion that Vibro Acoustic Disease can be**
5 **caused by wind turbine sound?**

6 A. I do not agree. If this assertion was correct, every resident of Madison would be
7 equally at risk, not to mention most of the USA and other first world countries.

8 This is because the infrasonic and low frequency sound levels in urban areas,
9 below about 50Hz, are similar to wind turbine sound levels in this range.

10 It also seems that Pierpont herself has doubts about VAD. On page 58 of the
11 June 30th prepublication version of her book, she writes in reference to the
12 aeronautical workers who are exposed to very high levels:

13 *High intensities of low-frequency noise over prolonged time periods may*
14 *cause marked neurological damage as described by the Vibroacoustic*
15 *Disease group in Portugal. This is a provocative body of research, full of*
16 *interesting case descriptions and pathology studies, but compromised by*
17 *absence of specified study group criteria, absence of control groups and*
18 *lack of quantification.*

19 And this is in reference to the VAD group's main work at very high sound levels -
20 120dB. There is no merit in the assertions that the low levels of wind turbine
21 sound will cause a problem. From a noise dose point of view, as stated
22 elsewhere, it will take a 100,000 years to receive the same dose from a 50dB
23 noise as that received in one year from a 100dB noise.

1 Submitted as Exhibit 20 is my full assessment of VAD, which I believe further
2 demonstrates that whatever merit it may have at very high sound levels, it has no
3 applicability at sound levels produced by wind turbines.

4 **JAMES'S VIEWS ON MODELING AND PERMITTING STANDARDS ARE**
5 **BOTH UNREASONABLE, AND NOT SUPPORTED BY THE SCIENCE**

6 **Q. Please explain your view of James's critique of modelling methods used to**
7 **predict potential sound levels from wind turbines.**

8 A. Other experts have found that the widely-accepted modelling methods used by
9 Mr. Hessler do work satisfactorily. For example, a paper given at the Wind
10 Turbine Noise 2009 Conference, entitled "Wind farm noise predictions and
11 comparison with measurements," showed a good agreement over the three sites
12 investigated and at distances up to one kilometer. This paper is submitted as
13 Exhibit 21. It will be noted that the sites used in that study were either flat or
14 undulating, but an author of the paper tells me that:

15 *Over a hilly area the approach should hold fine. You may get a couple of*
16 *factors to take account of, one is barriers where line of sight to the tip of a*
17 *turbine is blocked we assume a 2 dB(A) reduction. The other is if the*
18 *ground falls away significantly between the source and receiver then you*
19 *can get a +3 dB(A) addition to noise levels .*

20 In general, accuracy is greatest over shorter distances, so that the nearest
21 residences, at about 300m, will be accurately predicted. These are the most
22 important positions for any analysis.

1 Q. Do you have reactions to James’s paper entitled “The ‘How To’ Guide to
2 Siting Wind Turbines to Prevent Health Risks from Sound?”

3 A. I considered this paper in some detail in my earlier comments, which are
4 submitted as Exhibit 22. It seems to me that the paper has two main problems.
5 First, there is undue emphasis on infrasound and low frequency noise. There
6 has been a great deal of irresponsible nonsense written about these, extending
7 over the past 40 years, initially in newspapers and other media, but now on the
8 Internet. Their paper gives me the impression that Kamperman and James may
9 have come to the subject already preconditioned to believe that there was an
10 infrasound problem from wind turbines, and determined to prove it.

11 Second, their reliance on the difference between the levels of the C-A weighting
12 as a criterion for a low frequency noise problems is not convincing. The
13 development of C – A as an *indicator* of low frequency noise was for tonal noise
14 at low frequencies, not for broadband wind turbine noise. Most low frequency
15 environmental noise problems have been tonal problems in which the A-
16 weighting does not give a proper assessment of the low frequency tone.
17 Consequently, their use of the C-A difference as a criterion is not safe.

18 Their attempt to carry this through to a criterion fails on a technical level for the
19 following reasons:

20 The C-A limit is not substantiated.

21 The comparison of an A-weighted level before installation with a C-
22 weighted level after installation takes no account of existing C-weighted
23 noise prior to installation.

1 Where, on page 17 of Exhibit 808, James writes his condition as

$$2 \quad L_{\text{Ceq(imission)}} \text{ minus } (L_{\text{A90(background)}} + 5) < 20\text{dB}$$

3 And states that

$$4 \quad L_{\text{Ceq(imission)}} = L_{\text{C90 (background)}} + 5\text{dB}$$

5 These can be combined to give

$$6 \quad L_{\text{C90 (background)}} \text{ minus } L_{\text{A90(background)}} < 20\text{dB}$$

7 Where the L_{C90} is with turbines operating and the L_{A90} is before installation.

8 In the EIS, Table 5.8.4, measurements are given at existing wind farms for both
9 L_{C90} and L_{A90} levels for turbines on and off. The L_{A90} , turbines off, can be
10 associated with the preconstruction levels. Inspection of the Table shows that
11 the difference between L_{Ceq} (turbines on) and L_{A90} (turbines off) is around 20dB,
12 but the difference between L_{C90} (turbines on) and L_{C90} (turbines off) is only a few
13 decibels. The proposed criterion is not only faulty in its proposed limit, but also
14 unfair in that it suppresses existing low frequency noise. An enlarged part of
15 Table 5.8-3 is included as Exhibit 23, illustrating this point.

16 **Q. James writes that the Glacier Hills Wind Park will “expose the public to**
17 **unsafe conditions 24 hours a day and 365 days a year.” Do you agree?**

18 A. I do not agree. Some opponents of wind turbine developments have, in the past,
19 said that wind turbines are of little benefit because they operate for only about
20 25% of the time. Nobody, except James, believes that they operate 24/365. The
21 correct figure is probably between 25% and 100%. However some of their
22 operational time is at low speed in low wind conditions, when their noise levels
23 are low. Further, as demonstrated in this testimony, there is simply no support

1 for the assertion that inaudible infrasound or low frequency sound from wind
2 turbines is harmful to human health.

3 **Q. James also states that sound from wind turbines is inherently more**
4 **annoying than sound from other industrial sources. What do you think?**

5 A. A fluctuating noise is normally more annoying than a steady sound of the same
6 average level. If the higher frequency wind turbine sound is fluctuating in level,
7 there will be this modulation effect. However, this does not occur all the time or
8 at every installation. Studies in the UK have shown that only four out of about
9 130 wind farms had a problem of fluctuation (amplitude modulation).³ The
10 response of the British Government to this work was to decide that amplitude
11 modulation was, in reality, not a significant enough problem to merit further work
12 on it.⁴

13 Other work in Denmark looked at a wide range of sounds evaluated by the
14 Danish method of assessing low frequency noise, which covers the range 10Hz
15 to 160Hz. Wind turbine noise, as heard indoors, was assessed for a 3.6MW
16 turbine at 600m and shown to be lower than all other sources except for a
17 refrigerator.⁵

18 **Q. What is your reaction to James's estimate of the amount of time that wind**
19 **turbine sound may be amplitude modulated?**

³ Moorhouse, A., Hayes, M., von Hunerbein, S., Piper, B., and Adams, M. (2007): Research into aerodynamic modulation of wind turbine noise. BERR Report URN 07/1235. <http://www.berr.gov.uk/files/file40570.pdf>.

⁴ www.berr.gov.uk/files/file40571.pdf

⁵ Pedersen, T. H. (2008): Low frequency noise from large wind turbines. *DELTA Report EFP - 06*.

1 A. On page 6 of his report (Exhibit 808) James says, “The author has confirmed
2 amplitude modulation (blade swish) at every project he has visited.” This is
3 possible, as he probably only visits installations where there have been
4 complaints, but some numbers would be useful. However, on page 7 of his
5 Exhibit 808, he quotes an assessment for New York rural areas. “Stable
6 conditions occurred for 67% of the time and that for 30% of those nights, wind
7 velocities represented worst case conditions where ground level winds were less
8 than 2m/s and hub height winds were greater than wind turbine cut in speeds,
9 4m/s”. 30% of 67% is 20%.

10 He also quotes van den Berg’s estimate of 47% of the time over a year for the
11 Rhede Wind Farm on the border between Germany and The Netherlands.
12 However, this is a very extensive flat area, such as is most prone to these
13 effects.

14 **Q. Please describe the levels of infrasound and low frequency noise emitted**
15 **by wind turbines similar to those proposed for the Glacier Hills Wind Park.**

16 A. I am willing to accept the spectrum given by Kamperman and James in their
17 “How to Site” paper, which can be found at both the beginning and the end of
18 their Exhibit 809, on Fig. 1, page 7 of their paper. This shows the level external
19 to a residence from a 2.5MW turbine at 305m (1000ft). From the graph given,
20 one can extract the low frequency levels in tabulated form as follows:

Freq	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315
Level	63	62	61	59	57	55	53	50	48	46	44	42	42	39	38	37

- 1
- 2 **Q. Please describe the average levels at which infrasound and low frequency**
- 3 **sound are audible.**
- 4 A. The best work on the audibility of infrasound and low frequency noise has been
- 5 by Watanabe and Moller in Denmark.⁶ Auditory threshold levels are

Freq Hz	4	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200
Level dB	107	100	97	92	88	79	69	60	51	44	38	32	27	22	18	14

- 6
- 7 This shows that the levels in the infrasound region start at 107dB at 4Hz and
- 8 gradually reduce into the audible region.
- 9 When one compares these two tables with each other one arrives at the
- 10 following in the low frequency region:

Freq Hz	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200
Threshold	97	92	88	79	69	60	51	44	38	32	27	22	18	14
WT sound	63	62	61	59	57	55	53	50	48	46	44	42	42	39
Difference	34	30	27	20	12	5	-2	-6	-10	-6	-17	-20	-24	-25

⁶ Watanabe, T., and Møller, H. (1990a): Hearing thresholds and equal loudness contours in free field at frequencies below 1kHz. *Jnl Low Freq Noise Vibration* **9**, 135-148.

1 In this comparison table, where the difference is positive, that is up to about 31.5
2 – 40Hz, the wind turbine sound is not audible to the average person. The low
3 infrasound frequencies are well below the hearing threshold.

4 This shows that while some low frequency noise produced by wind turbines may
5 be above the hearing threshold, it does not reach harmful levels, because the
6 sound pressure level is low.

7 **JAMES’S RELIANCE ON MY PRIOR ACADEMIC WORK IS MISPLACED.**

8 **Q. James relies on a paper you wrote entitled “Low Frequency Noise and**
9 **Annoyance.” What is your reaction to that?**

10 A. I was invited to write a paper on Low Frequency Noise and Annoyance for a
11 special Low Frequency Noise Issue of the Journal of Noise and Health. The
12 paper contains general material on annoyance by noise, and is angled towards
13 low frequency noise. Much of what is in the paper is applicable to any audible
14 noise, including the coping methods referred to by James at the bottom of page
15 13 of his report, Exhibit 808. They are not specific to low frequency noise. In
16 fact, similar methods are used to help people with high frequency tinnitus. There
17 is nothing mysterious about these methods. They involve learning to desensitize
18 oneself to the noise and its effects. In this, one’s attitude toward the noise is very
19 important.^{7 8} The constant propaganda that wind turbines are dangerous to
20 health has caused fear and concern amongst the public. It is well known that if

⁷ Jonsson, E., and Sorensen, S. (1970): Relation between annoyance reactions and attitude to source of annoyance. *Public Health Reports* **85**, 1070 - 1074.

⁸ Hatfield, J., Job, R., Carter, N., Peplow, P., Taylor, R., and Morrell, S. (2001): The influence of psychological factors on self-reported physiological effects of noise. *Noise and Health* **3**, 1-13.

1 there is fear of a noise source, or an antagonism to its creators, then the
2 responses are more negative than they would otherwise have been. This also
3 applies to wind turbines.⁹

4 I disagree with James's assertion in this section that I have been having an
5 "ongoing debate" with Pierpont. Some five years ago, when she was the leading
6 NIMBY in her locality, I criticised some of her statements about noise. The
7 response of her and her husband was to attempt to discredit me, instead of
8 replying to the points raised. We have never debated. Exhibit 24 shows the
9 response of Pierpont to my submission in this proceeding on Wind Turbine
10 Syndrome. Finally, as it has been shown that the claims of health effects through
11 direct physiological action by low levels of infrasound and low frequency noise
12 are untenable, James's final sentence on page 13 is not relevant.

13 **Q. James also relies on a paper you wrote entitled "Effects on Performance**
14 **and Work Quality Due to Low Frequency Ventilation Noise." What is your**
15 **reaction to that?**

16 A. The spectrum which was used for the low frequency element of the noise in that
17 study was vastly different from that of wind turbine noise in several respects. It
18 mirrored more closely the spectrum which is produced by tonal low frequency
19 noises in the environment. The low frequency component of the noise was an
20 amplitude modulated tone of around 35Hz, fluctuating in level about twice per
21 second to produce a rapid throbbing sound. The maximum tone level was about

⁹ Pedersen, E., van den Berg, F., Bakker, R., and Bouma, J. (2009): Response to noise from modern wind farms in The Netherlands. *J Acoust. Soc. Am* **126**, 634-643.

1 40dB above the surrounding noise levels and clearly audible. The spectrum is
2 submitted as Exhibit 25. Of course, this additional noise was noted by the
3 participants as a disturbing factor. Nevertheless, differences between
4 performance in this low frequency noise and in medium frequency noise were
5 small. Social orientation changed by about 7% and pleasantness by about 10%.
6 The change in annoyance was not statistically significant.

7 This work cannot be compared with the effects claimed to be attributable to wind
8 turbines. James is incorrect when, on page 18 of his Exhibit 808, he compares
9 the experimental levels of this work with those of wind turbines in homes. In our
10 work the level was about 75dB in the 31.5 Hz 1/3 octave band. The levels
11 outside residences given by Kamperman and James at 31.5Hz are 55dB, and
12 will be even lower inside.

13 **Q. In addition to relying on your work, James submitted several hundred**
14 **pages of supporting materials in Exhibit 809. Could you comment on those**
15 **materials?**

16 A. I found this to be a rather confusing collection of material, with only part of it
17 relevant to his testimony. I have addressed some of it in my testimony, but, like
18 James, I have not referred directly to most of it.

19 **APPLICATION OF THE PRECAUTIONARY PRINCIPLE IS UNWARRANTED**
20 **IN THIS CONTEXT**

21 **Q. James advocates application of the precautionary principle with regard to**
22 **wind turbine noise. Do you agree?**

1 A. This is related to the different approaches of Clinicians and Legislators. Clinicians
2 deal with individuals – their patients -- and are concerned for the well-being of
3 each one as a unique person. A legislator, or planner, considers people as a
4 group and develops criteria for protection of the majority. For noise sources, this
5 has normally been achieved by a social survey, which relates number annoyed to
6 a physical characteristic of the noise, such as dBA or L_{dn} . A decision is then
7 made on where to set the limiting level for a protection criterion. Criteria do not,
8 and never have been, designed to protect the most sensitive, although the
9 special problems of the sensitive may influence the criteria.

10 A difficult decision has to be made, balancing national needs against individual
11 needs. The approaches of both Clinicians and Legislators are valid within their
12 own spheres. However, problems may arise when one impinges on the field of
13 the other.

14 **Q. Does this conclude your testimony?**

15 A. Yes.

BEFORE THE
PUBLIC SERVICE COMMISSION OF WISCONSIN

Application for a Certificate of)
Public Convenience and Necessity)
to Construct and Place in Service a Wind) Docket No. 6630-CE-302
Turbine Electric Generation Facility)
Known as Glacier Hills Wind Park)
in Columbia County, Wisconsin)

**SUR-SURREBUTTAL TESTIMONY OF DR. GEOFF LEVENTHALL
ON BEHALF OF WISCONSIN ELECTRIC POWER COMPANY**

Q. Please state your name.

A. Dr. Geoff Leventhall.

Q. Did you previously provide rebuttal testimony in this case?

A. I did.

Q. What is the purpose of your sur-surrebuttal testimony?

A. To respond to certain statements made in the surrebuttal testimony of CWEST witness
Richard James.

**Q. On page SR9.16, Mr. James accuses you of “lumping together” low frequency sound
and infrasound. How do you respond?**

A. He is wrong. Mr. James correctly states my belief about infrasound from wind turbines,
which is that it is of no consequence. This is supported by the research of Jakobsen of
Denmark and van den Berg, of the Netherlands. There is, of course, a continuum from
infrasound to low frequency noise, but when the infrasound is negligible, as with wind
turbines, we need to consider only audible low frequency noise. In fact, whenever Mr.
James uses the abbreviation ILFN, which he does frequently, for infrasound and low
frequency noise, it is he who is lumping them together.

1 Mr. James mentions my earlier work on mitigation of low frequency noise, but
2 does not acknowledge that there are different sorts of low frequency noise. Most of the
3 environmental studies were done on disturbance from tonal noise - machines, fans etc. A
4 continuous low frequency noise, falling in level into higher frequencies, is less annoying
5 than one with high separate components. This is because it does not display a distinctive
6 character. As mentioned in earlier testimony, it has been shown that noise falling at
7 about 5 dB per octave, similar to wind turbine noise, is bland and unobtrusive.

8
9 **Q. Mr. James claims that it is not possible for effects from wind turbine noise to**
10 **become “lost” amongst the other internal noises of the human body because humans**
11 **have adapted to ignore normal bodily noises. What is your reaction to that**
12 **statement?**

13
14 A. Human beings have not adapted to disregard normal body sounds. We are not normally
15 aware of even the strongest of these sources – the heart, but may be concerned when the
16 heartbeat intrudes into our consciousness. Further, the fact that we are not normally
17 aware of internal sounds does not mean that they are not present. Similarly, those who
18 suffer from tinnitus have not adapted to it, but may be more or less attuned to it
19 depending on a number of factors.

20 What Mr. James is saying is contrary to all that we know about masking of a low
21 sensation by a higher sensation, such that the low sensation is not detected. How many
22 times have we not been able to hear what is said because of traffic noise, or some other
23 noise? Nevertheless, Mr. James appears to believe, like Dr. Pierpont, that low level
24 external infrasound from wind turbines at 1 – 2 Hz will have an effect internally above
25 the high internal sound and vibration of the heartbeat.

26

1 **Q. Please continue.**

2

3 A. The external sounds at 40-70 dB to which Mr. James refers on page SR9.16 must first
4 enter the body, a process which causes them to be attenuated to even lower internal
5 levels, before being compared with the existing internal sounds. Further, 40-70 dB are
6 very low levels. In my rebuttal testimony I have shown that a level of 54 dB exerts a
7 force on the body equivalent to that of a layer of water one micron thick (10^{-6} m), whilst
8 the skin is typically around 1mm thick, which is 1000 times that of the layer of water.
9 There is no effect without a mechanism. Mr. James offers no mechanism by which this
10 miniscule force penetrates the skin and then goes on to the other organs, which are
11 separate from the skin – not part of it.

12 But on the other hand, sound sources within the body cause sufficient vibration in
13 the body for the skin to radiate sounds externally. As an example, when we hear another
14 person's "tummy rumble," it is because the internal fluctuations have vibrated the outer
15 surface and transmitted sound.

16

17 **Q. Mr. James charges that you have "dismissed" the studies cited by Dr. Mulvihill. Is**
18 **he correct?**

19

20 A. No. I showed that those studies looked at very high levels of sound, well above levels
21 produced by wind turbines. They may well be perfectly good studies for what they
22 represent, but they are at levels of over 100 dB, that is 50 – 60 dB greater than the levels
23 from wind turbine noise.

24

25

26

1 **Q. Is it any more correct for Mr. James to say that you “dismiss” the work of the**
2 **vibroacoustic disease team?**

3
4 A. No. In my critique, there is a footnote at the end making clear that what I say about their
5 attempt to swing VAD onto wind turbines is not intended as a criticism of their work at
6 high levels on aircraft technicians. I leave that to others.

7 I note that on page SR9.19 at lines 9-12, Mr. James concedes that the VAD team’s
8 work involves higher sound levels, but claims that other research bridges the gap between
9 VAD levels and wind turbine levels. His failure to identify this “other research” is
10 telling. The VAD team’s opinions on wind turbine noise have not been published in
11 refereed journals. Two and a half years ago, they announced that they had made a
12 connection, but have not progressed further. One can only speculate on why they have
13 done nothing more on such a hot topic.

14 **Q. Mr. James implies that you have somehow misrepresented your e-mail**
15 **correspondence with Dr. Ingber regarding the applicability of his theories of**
16 **mechanotransduction to wind turbine noise. How do you respond?**

17
18 A. I was careful to ask Dr. Ingber’s permission to quote him and used only his own unedited
19 words.

20 Further, I would suggest that it is actually Mr. James who misrepresents the
21 correspondence with Dr. Ingber. As reflected in the e-mail excerpt on page SR9.18 of
22 Mr. James’s surrebuttal testimony, Dr. Ingber indicated that he did not know whether low
23 frequency vibration might have a positive, negative or null effect on the human body. Of
24 course, he is speaking like a cautious academic might be expected to. Obviously, though,
25 Dr. Ingber is not saying, as Mr. James originally indicated in Exhibit 807, that

1 mechanotransduction provides the “missing link” between wind turbine noise and
2 physiological effects on the human body.

3 **Q. Does Mr. James make any significant concessions in his surrebuttal testimony?**

4
5 A. I am delighted to see that Mr. James is now being more cautious about his claims of
6 numbers of people who might be affected by wind turbine sound. In the space of six
7 lines he uses phrases like “a small subset,” “not all people,” “do not affect large
8 percentages,” and “a small proportion.”

9 However, Mr. James’s focus on this “small subset” of especially sensitive people
10 may be misplaced. It is my experience, and that of other researchers, in investigating the
11 auditory threshold of complainants of low frequency noise, that they do not have
12 sensitive hearing thresholds. They scatter around the normal average. They complain,
13 and are stressed, simply because they can hear the noise, whilst others who can also hear
14 it do not complain.

15
16 **Q. Does this conclude your sur-surrebuttal testimony?**

17
18 A. Yes.
19