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July 6, 2017

Dan Wolf
Executive Secretary
Public Utilities Commission
121 – 7th Place East, Suite 350
St. Paul, MN 55101

RE: Freeborn Wind, LLC
MPCU Docket: IP-6946/WS-17-410

Dear Mr. Wolf:

On behalf of Association of Freeborn County Landowners, enclosed please find Notice of Appearance; Petition for Contested Case and Comments on Material Issues of Fact; and Comments on Completeness and exhibits.

Please let me know if you have any questions or require anything further.

Very truly yours,

Carol A. Overland
Attorney at Law

Enclosures

cc: Association of Freeborn County Landowners

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Service List Member Information

Electronic Service Member(s)

Last Name	First Name	Email	Company Name	Delivery Method	View Trade Secret
Anderson	Julia	Julia.Anderson@ag.state.mn.us	Office of the Attorney General-DOC	Electronic Service	No
Brusven	Christina	cbrusven@fredlaw.com	Fredrikson Byron	Electronic Service	No
Dobson	Ian	Residential.Utilities@ag.state.mn.us	Office of the Attorney General-RUD	Electronic Service	No
Ferguson	Sharon	sharon.ferguson@state.mn.us	Department of Commerce	Electronic Service	No
Litchfield	Dan	DLitchfield@invenergyllc.com	Invenergy LLC	Electronic Service	No
Wolf	Daniel P	dan.wolf@state.mn.us	Public Utilities Commission	Electronic Service	No

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STATE OF MINNESOTA
BEFORE THE
MINNESOTA PUBLIC UTILITIES COMMISSION

Nancy Lange	**Chair**
Dan Lipschultz	**Commissioner**
Matt Schuerger	**Commissioner**
Katie Sieben	**Commissioner**
John A. Tuma	**Commissioner**

In the Matter of the Application of Freeborn Wind Farm, LLC for a Large Wind Energy Conversion System Site Permit for the 84 MW Freeborn Wind Farm in Freeborn County.

PUC Docket No. IP-6946/WS-17-410

NOTICE OF APPEARANCE

NAME OF PARTY: Association of Freeborn County Landowners
Dorenne Hansen, Landowner Representative
12174 840th Ave., Glenville MN 56036

You are advised that the party above named will appear in this matter before the Commission:

PARTY'S ATTORNEY:

Carol A. Overland, Attorney at Law
Legalectric
1110 West Avenue
Red Wing, MN 55066
(612) 227-8638
overland@legalectric.org

DATE: July 6, 2017

Carol A Overland

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PETITION FOR CONTESTED CASE

COMMENT ON CONTESTED MATERIAL ISSUES OF FACT

The Association of Freeborn County Landowners is an informal association of landowners in and adjacent to the site footprint of the above-captioned Freeborn Wind Farm (hereinafter "Freeborn Wind"). The Association of Freeborn County Landowners hereby submit this Petition for a Contested Case, outlining contested material facts at issue, and also offer Comments regarding completeness of the Freeborn Wind Farm application. As landowners directly affected by this project, the members of the Association of Freeborn County Landowners have a direct interest in these proceedings. The Association of Freeborn County Landowners requests that the Commission consider these contested material facts at issue and refer this docket to the Office of Administrative Hearings for a Contested Case proceeding.

The Association of Freeborn County Landowners requests that this docket be tabled, and

that no further action be taken, until notice of this application has been provided to landowners within and adjacent to the project area. Applicants have detailed information about the landowners in the project area, and have been actively and intensely soliciting them to participate in this project, yet as of this date, no notice to landowners has been provided. This is a fundamental due process issue.

The Association of Freeborn County Landowners requests that the Commission take official notice of the record developed in the separate but connected docket for Freeborn Wind transmission[1] and that that record be incorporated into this docket as a connected action, and that the impacts considered regarding that project be considered in this siting docket. The Association of Freeborn County Landowners also requests joining these dockets together in the above-captioned docket to assure full consideration of the project in its totality.

The Association of Freeborn County Landowners requests that the Commission take official notice of the record developed in Xcel Energy's separate but connected " In the Matter of Petition of Xcel Energy's Petition for Approval of the Acquisition of 1,550 MW of Wind Generation"[2] regarding the 200 MW "Freeborn Wind Project" in Freeborn County, Minnesota, and Worth and Mitchell Counties, Iowa, and that the Freeborn Wind information be incorporated into this docket as if fully related herein. There is little information regarding the Iowa portion of this project in the Siting docket, and there is information in the "Acquisition" docket that, as part of the same "Freeborn Wind Project," should be included in the Siting docket should be considered by the Commission, including, but not limited to, the connected nature and scale of the projects and the impacts of the project as a whole.

[1] See PUC Docket IP-6946/TL-17-322.
[2] See PUC Docket E002/M-16-777.

The Association of Freeborn County Landowners also requests that the Xcel Energy acquisition docket, which supplants Certificate of Need, be put on hold until landowners associated with all the wind projects in that docket receive notice and ample time to weigh in regarding this acquisition. Notice has not been provided to Freeborn Wind landowners and landowners of all the other projects in that docket.

PETITION FOR CONTESTED CASE – ISSUES OF MATERIAL FACT

In its notice of June 21, 2017, the Commission requested comments on whether there are "contested issues of fact with respect to the representations made in the applications," and whether "the applications be referred to the Office of Administrative Hearings for a contested case proceeding"[3]. The Association of Freeborn County Landowners has identified several contested material issues of fact, and hereby Petition the Commission for referral of this docket to the Office of Administrative Hearings and a contested case proceeding. There are issues of contested material fact that require development of the record, and which require a full contested case proceeding to adequately inform the record, prior to consideration by the Commission. The Association of Freeeborn County Landowners raises the following issues of contested material fact for Commission consideration:

I. <u>WITH THREE SEPARATE DOCKETS BEFORE THE COMMISSION, AND FLAWED OR ABSENT NOTICE TO AFFECTED LANDOWNERS, HAS THE PUBLIC BEEN DENIED DUE PROCESS AND OPPORTUNITIES FOR PARTICIPATION?</u>

Whether landowners and affected parties have received notice, and have had an opportunity to participate is a material issue of fact.

No notice was given to landowners on any of the projects at issue in Xcel Energy's acquisition docket (E002/M-16-777). No notice has been given to landowners in the Freeborn

[3] The Notice states "applications" but it is not apparent that more than one application has been filed in this docket despite use of the plural.

transmission docket (IP6946/TL-17-322), although only Notification of Pending Route Permit has been filed in this docket.

No affidavits or certificates of service have been filed showing any notice to landowners. No notice was given to landowners within the Freeborn Wind project area of the application in the siting docket (IP6946/WS-17-410) when it was filed.[4] No notice was given to landowners of this public comment period.[5] No notice has been given to landowners, no notice whatsoever.

Further, Freeborn Wind has operated in bad faith. On May 5, 2016, a meeting was held Between the Freeborn Wind developers, its consultants, and a staffer from USFWS, after which the developer stated in a report:

The goal of the meeting was to address agency feedback to limit public comment. Application, Appendix A, Agency Comments, p. 8 of 78, Freeborn Wind report on 5/5/2016 meeting.

It appears public notice and participation has been intentionally suppressed and denied. Whether landowners have been provided notice is a material issue of fact.

II. IS INVENERGY/FREEBORN WIND, LLC, A UTILITY?

Whether Invenergy/Freeborn Wind, LLC, is a utility is a material fact issue, a mixed question of law and fact. If Invenergy/Freeborn Wind, LLC, is not a utility, it will have trouble getting a transmission routing permit, and would not have access to Freeborn County's right of way for the collector system and transmission, and this question has been raised by Sue Miller,

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20176-132805-01	17-410	WS	FREEBORN WIND ENERGY LLC	INITIAL FILING--COVER LETTER, AFFIDAVIT OF SERVICE, AND SERVICE LIST	06/15/2017

5

20176-132986-02	17-410	WS	PUC	NOTICE OF COMMENT PERIOD--CERTIFICATE OF SERVICE AND SERVICE LISTS	06/21/2017

the Freeborn County engineer. Freeborn claims that "will obtain an RPA from the Commission for the proposed transmission line," and "Freeborn Wind proposes to construct the Project O&M facility, Project Substation, and 161 kV transmission line between the Project Substation and the POI in Minnesota." Application, p. 16, 15. Can a non-utility obtain a route permit and construct a transmission line?

Invenergy and Freeborn Wind, LLC are not public service corporations as defined in Minnesota. These facts are easily discovered in Secretary of State filings, yet are not part of the record. Whether Invenergy/Freeborn Wind, LLC is a utility is a material issue of fact.

III. WHAT ARE THE PROJECT PLANS IN IOWA AND WHAT ARE THE IMPACTS OF THE IOWA PORTION OF THIS PROJECT?

The project plans in Iowa and impacts of Iowa portion of the Freeborn Wind project, in Worth and Mitchell Counties, are material issues of fact. The specifics of this project as a whole have not been disclosed, and the balance of this project is a "connected action" for the purposes of environmental review, and the Commission's consideration of this siting permit. Xcel Energy's acquisition docket (E002/M-16-777) is another connected action regarding the full project. Although the fact that part of the project in Iowa has been stated, the details are unknown. Xcel originally stated the project was in Freeborn County, and that has changed:

Table 1: 1,550 MW Wind Portfolio

Project Name	Size	Type	Location
Blazing Star I	200 MW	Self-Build	Lincoln County, MN
Blazing Star II	200 MW	Self-Build	Lincoln County, MN
Foxtail	150 MW	Self-Build	Dickey County, ND
Freeborn	200 MW	Self-Build	Freeborn County, MN and Worth and Mitchell Counties, IA

Xcel Energy Supplement, filed 3/15/2017.[6] See Exhibit A , Xcel Energy Project Description.

6

20173-129927-06	PUBLIC	16-777		M	XCEL ENERGY	OTHER--SUPPLEMENT-PART 1 OF 1-PUBLIC	03/15/2017

The collector system map shows that electricity generated in Iowa will move north through at least two collector lines at Raven Avenue at the border and another just west of Raven Avenue, and east of that one collector may drop down into Iowa and then back up at Raven Avenue. There may also be another collector system link south of turbine 45. See collector system on Figure 7, Topographic Map; Figure 11, Land Cover; Figure 16, Wetlands Inventory.

Impacts are not stopped by a jurisdictional border, particularly for a project on both sides of the border. See Figure 6, Sound/Noise; Figure 8, Shadow Flicker; Figure 9, Microwave Beam Paths, Figure 10, Unique Natural Features; Figure 11, Land Cover; Figure 12, Soils, Figure 13, Site Geology and Depth to Bedrock. In addition, "The temporary batch plant and staging/laydown areas needed during construction of the project will be located within Iowa."[7]

Collection and transmission is also laid out in two application sections, where it states that there will be one "project substation," and all the collectors will be gathered into one 161 kV line, and then to the point of interconnection southeast of Glenville, Minnesota.[8] Application, §6.0' 6.1' and 6.2.

It appears that many aspects of this project, economics, physical, electrical, and impacts, are interwoven, and all impacts of the entire project in both states should be considered.

IV. MISO QUEUE J407 WILL ALLOW ONLY 150 MW AFTER NETWORK UPGRADES, NOT 200 MW NAMEPLATE FOR FREEBORN WIND PROJECT. WHAT IS COST OF NETWORK UPGRADES? IS THIS A REASONABLE COST FOR 150MW, 25% LESS THAN PROJECT MW? IS PERMIT FOR 200 MW PROJECT APPROPRIATE FOR 150 MW GENERATION INTERCONNECTION?

The designation of the Freeborn Wind Project as a 200MW wind project is misleading. A material issue of fact exists as to whether this project can be designed, built, and operated as a

[7] Application, p. 15, fn. 6.
[8] There is no explanation why the proposed transmission line would not utilize shared structures and right of way.

200 MW project, and evidence suggests that it cannot. This may be best resolved in the Xcel Energy acquisition docket, but that docket is before the Commission July 6, 2017, and the Freeborn Landowners have had not notice nor have they had opportunity to weigh in.

Applicant states that up to 200 MW of wind will be developed for this project, of which 84 MW will be sited in Freeborn County, Minnesota, and in this application, the balance of the project is in Worth County, IA. Application, p. x (As above, Xcel Energy states that it is also in Mitchell County, Iowa.) The project is claimed to be a 200 MW project, yet only 150MW will be granted by MISO after network upgrades. Freeborn's MISO queue number as J407. Xcel Energy states in its acquisition docket Petition:

> **The MISO System Impact studies show that the project will be granted 150 MW of NRIS upon completion of all required network upgrades.**

Xcel Energy Petition, filed 10-/24/2016 (emphasis added).[9] What will happen with the other 50 MW of nameplate capacity? How are costs of the network upgrades apportioned, and at 150MW, is it a reasonable cost for a project with a planned 200MW output?

Xcel claims the MISO cost and interconnection information is Trade Secret, but in fact it is public information on the MISO site, and the network upgrades are expected to cost $11,740,365 as of July, 2016.[10] But there are several cost calculations in this MISO report, accessible with a simple search of the MISO reports available online.

The Freeborn Wind project, J407, will be assessed a share of network upgrades, in this case, the 2nd highest, at $58,702/MW, for the 2025 scenario:

[9] PUC Docket E002/M-16-777, online:

201610-125953-02	PUBLIC	16-777		M	XCEL ENERGY	OTHER--WIND GENERATION ACQUISITION	10/24/2016

[10] See MISO online: https://www.misoenergy.org/_layouts/MISO/ECM/Redirect.aspx?ID=225484

Table 9-10: Summary of Total NU Costs Allocated to Each Generation Project for 2025 Scenario

Project	Max Output (MW)	Total Cost of NU per Project ($)	$/MW	Share %
G736	200	$2,206,197	$11,031	4.08%
J299	73	$0	$0	0.00%
J385	100	$2,498,000	$24,980	4.62%
J391	50	$476,000	$9,520	0.88%
J400	62.5	$1,271,000	$20,336	2.35%
J405	40	$614,540	$15,364	1.14%
J407	200	$11,740,365	$58,702	21.72%
J411	300	$10,022,000	$33,407	18.54%
J416	200	$19,989,054	$99,945	36.99%
J426	100	$5,229,000	$52,290	9.68%
Total/Average	**1325.5**	**$54,046,156**	**$32,557**	**100.00%**

Id., p. 9-5.

For the 2018 scenario, the cost for J407 is even higher, $92,077/MW:

Table L-16: Summary of Total NU Costs Allocated to Each Generation Project for 2018 Scenario

Project	Max Output (MW)	Total Cost of NU per Project ($)	$/MW	Share %
G736	200	$2,206,197	$11,031	3.63%
J299	73	$0	$0	0.00%
J385	100	$2,498,000	$24,980	4.11%
J391	50	$476,000	$9,520	0.78%
J400	62.5	$1,271,000	$20,336	2.09%
J405	40	$614,540	$15,364	1.01%
J407	200	$18,415,365	$92,077	30.33%
J411	300	$10,022,000	$33,407	16.50%
J416	200	$19,989,054	$99,945	32.92%
J426	100	$5,229,000	$52,290	8.61%
Total/Average	**1325.5**	**$60,721,156**	**$35,895**	**100.00%**

Id., p. L17

Whether the 2018 or 2025 scenario, the J407 Freeborn project's dollar amount per MW for the network upgrades is high. Xcel Energy will recover this amount through its rates, ratepayers will have to pay it, but Xcel Energy does not disclose what this amount is in the acquisition docket. We have no idea whether this is a reasonable amount for this 150 or 200 MW addition.

The Commission should consider in this docket the 150-200 MW disparity; determine the MW of this project, in theory and in fact; determine how many MW are to be sited in Minnesota and in Iowa; ascertain which of the turbines would be built, and where, if 150 MW is the output constraint or if the project is being built for 200 MW. These are material issues of fact.

V. IS A 1,000 FOOT SETBACK SUFFICIENT? SHOULD A SETBACK OF ½ MILE BE UTILIZED?

Whether the residential setback distance is sufficient is a material issue of fact. Whether the concern is physical safety of residents due to a falling tower or blades spinning off, or a rotor/nacelle fire, or shadow flicker, or infrasound coming through the walls of landowners' homes, or the constant "woosh" of nearby turbines, or all of the above, having a zone of sufficient setback is the key to reduction of complaints, and more importantly, the key to respectful siting of wind projects.

Freeborn Wind claims that if there are varying setbacks between the County Ordinance and state "General Permit Standards," it "used the most stringent setback distance." Application, Section 5.1, p. 6-10. However, the Commission has been setting setbacks on a case by case basis, and for example, for the Goodhue Wind Project, setbacks of 1,500 feet from a residence. See App. E, Market, p. 8. The MPUC's 500 feet has not been utilized as a setback distance for over a decade, instead with setbacks increased over time, and ordered at up to 1,500 feet. Exhibit B, Standards, Notice of Commission Investigation and Request for Comments, p. 2, 7/21/2009, PUC Docket E-999/CI-09-845. A 500 foot setback from a residence, for a turbine with a total height of 442.9 – 452.8 feet, is absurd enough for the even developers to reject that notion out of hand. Application, p. 13, Table 5.1-4. The minimum setback considered should be 1,500 feet.

There are other safety considerations that go into setting a setback. Minnesota Dept. of Health has issued its report, "Public Health Impacts of Wind Turbines," which described sound

issues triggering noise complaints:

> Noise complaints are usually a reasonable measure of annoyance with low frequency environmental noise. Leventhall (2004) has reviewed noise complaints and offers the following conclusions:
>
> " The problems arose in quiet rural or suburban environments
> The noise was often close to inaudibility and heard by a minority of people
> The noise was typically audible indoors and not outdoors
> The noise was more audible at night than day
> The noise had a throb or rumble characteristic
> The main complaints came from the 55-70 years age group
> The complainants had normal hearing.
> Medical examination excluded tinnitus.
>
> " These are now recognised as classic descriptors of low frequency noise problems."
>
> These observations are consistent with what we know about the propagation of low intensity, low frequency noise. Some people are more sensitive to low frequency noise. The difference, in dB, between soft (acceptable) and loud (annoying) noise is much less at low frequency (see Figure 4 audible range compression). Furthermore, during the daytime, and especially outdoors, annoying low frequency noise can be masked by high frequency noise.
>
> The observation that "the noise was typically audible indoors and not outdoors" is not particularly intuitive. However, as noted in a previous section, low frequencies are not well attenuated when they pass through walls and windows. Higher frequencies (especially above 1000 Hz) can be efficiently attenuated by walls and windows. In addition, low frequency sounds may be amplified by resonance within rooms and halls of a building. Resonance is often characterized by a throbbing or a rumbling, which has also been associated with many low frequency noise complaints.
>
> Low frequency noise, unlike higher frequency noise, can also be accompanied by shaking, vibration and rattling. In addition, throbbing and rumbling may be apparent in some low frequency noise. While these noise features may not be easily characterized, numerous studies have shown that their presence dramatically lowers tolerance for low frequency noise (Berglund et al., 1996).

Exhibit C, Public Health Impacts of Wind Turbines, MN Dept. of Health, p. 16.[11]

Complaints increase where noise is above 35 dBA:

> The most common complaint in various studies of wind turbine effects on people is annoyance or an impact on quality of life. Sleeplessness and headache are the most common health complaints and are highly correlated (but not perfectly correlated) with annoyance complaints. Complaints are more likely when turbines are visible or when shadow flicker occurs. Most available evidence suggests that reported health effects are related to audible low frequency noise. Complaints appear to rise with increasing outside noise levels above 35 dB(A). It has been hypothesized that direct activation of the vestibular and autonomic nervous system may be responsible for less common complaints, but evidence is scant.

[11] Public Health Impacts of Wind Turbines, online at https://legalectric.org/f/2009/06/mndepthealth-windwhitepaper.pdf (inexplicably, this primary document was not filed in the PUC docket it triggered, only a link in the notice!).

Id., p. 25. This report states that a setback distance of one-half mile rom residences would limit noise and shadow flicker complaints, because "Low frequency noise from a wind turbine is generally not easily perceived beyond ½ mile." Id.

The character of infrasound, its measurements, and its impacts, are a material issue of fact, address by Rick James, INCE, E-Coustic Solutions, in his testimony for Goodhue Wind Truth, and which should be considered here.[12] Exhibit D, Direct Testimony of Rick James, INCE, with exhibits linked below. This testimony of James, INCE, is supported by the Dept. of Health recommendation that "Isopleths for dB(C) - dB(A) greater than 10 dB should also be determined to evaluate the low frequency noise component." Id., p. 26.

At this time, a setback of 1,000 feet is not reasonable, and whether it is sufficiently protective of residents, and protective of the developer against complaints, and whether a setback of ½ mile should be utilized, is a material issue of fact.

VI. DOES PROJECT HAVE RIGHTS TO LAND SUFFICIENT TO BUILD PROJECT? WERE CONTRACTS SIGNED FREE OF COERCION AND/OR MISREPRESENTATION?

[12] Youtube, Testimony of Rick James: https://youtu.be/Ds6UUNT3VKY ; see PUC Docket 08-1233 for exhibits:

20107-52680-01	GOODHUE WIND TRUTH	DIRECT TESTIMONY OF RICHARD R JAMES INCE	07/19/2010
20107-52680-15	GOODHUE WIND TRUTH	TESTIMONY--EXHIBITS RJ 1-5	07/19/2010
20107-52680-13	GOODHUE WIND TRUTH	TESTIMONY--EXHIBITS RJ 6-7	07/19/2010
20107-52680-05	GOODHUE WIND TRUTH	TESTIMONY--EXHIBITS RJ 8 TO 14	07/19/2010
20107-52680-07	GOODHUE WIND TRUTH	TESTIMONY--EXHIBIT RJ 11	07/19/2010
20107-52680-09	GOODHUE WIND TRUTH	TESTIMONY--EXHIBIT RJ 14	07/19/2010
20107-52680-11	GOODHUE WIND TRUTH	TESTIMONY--EXHIBIT RJ 15	07/19/2010
20107-52680-03	GOODHUE WIND TRUTH	TESTIMONY--EXHIBITS RJ 16 TO 23	07/19/2010

Freeborn Wind states that land rights have been acquired sufficient to build the project, but the information in the application regarding land is not correct, and not reliable. Whether the project has legitimate land rights is a material issue of fact, and developer claims of land rights must be verified.

A Freeborn Wind land agent was found to be lying to landowners and was fired. In the section entitled "Stakeholder Outreach Efforts" – Freeborn includes a sample letter sent to local government officials responding to Comment requests that notes that a company land agent including the following paragraph:

> 9. We hire experienced and trustworthy professionals to spend the time at kitchen tables and in the field negotiating our land agreements. Unfortunately, a land agent working on our project in 2015 did not live up to this standard and was exposed to be blatantly lying to some landowners. He was fired as soon as we found out, as we deem this behavior completely unacceptable. I don't know what else to say about this – I'm sorry for those who were lied to. It is not ok. We are doing the best we can do rebuild trust.

Application, Appendix A, Letters.

In addition, landowners were frequently told by this agent, Howard Krueger, and other land agents as well, that all their neighbors had signed up, and some were induced to sign by such claims. The land agents were very aggressive, approaching landowners frequently, intruding in their homes, claiming "everyone has signed" when in fact they had not. See Comments filed July 5, 2017 of Clark Erickson, Mike and Christine Lau, Dorenne Hansen, and Brad Struck ("I would never have signed anything for wind turbines if he had not deceived me). See Exhibit E, Letters regarding Misrepresentation by Freeborn Land Agents.

All contracts should be filed with the County and verified by the Commission. Those contracts signed by landowners through Freeborn's land agent Howard Krueger, and by others misrepresenting signing status of neighbors, should not be regarded as "participants" without

independent verification that they were willing and informed signers. Otherwise, these agreements could be contracts of mistake or fraud. Landowners coerced into signing should be offered the opportunity to affirm their intent to sign the contract or to terminate their contracts, without penalty, and thus remove uncertainty about the status of these agreements and confirm the land to which Freeborn has an interest. At that point, the Commission will know whether there is land sufficient to build this project.

VII. CAN TURBINES BE SITED AS PROPOSED BY APPLICANTS? ALTERNATE TURBINE LOCATIONS HAVE NOT BEEN DECLARED.

The ability to site turbines at the specific siting locations is a material issue of fact. The applicants have now declared tentative turbine locations, but a review of the application does not reveal alternate turbine site locations as requested more than once by the DNR. Application, Appendix A, Agency Comments. Because siting locations have not been approved, and agency comments on the siting layout are not part of the Agency Comments, it is unknown whether turbines can indeed be placed as proposed by Applicants. Alternative sites are needed for review so that they may be considered if all proposed turbine locations are not satisfactory.

VIII. ARE TIMING AND METHODS OF BAT MONITORING SUFFICIENT DURING BAT ACTIVITY AND MIGRATION SEASON?

Whether bat monitoring is adequate is a material issue of fact. The DNR recommended Increased bat monitoring, as did USFWS, recommending additional detectors "to collect a more robust data set for a project that encompasses a very large area." DNR Letter, 3/18/2015, Application, Appendix A, p. 4 of 78. The DNR also noted "a higher failure rate of acoustic detectors in late July and August which is when you typically have higher BPDN [bat passes per detector night]" and the DNR urged "the collection of additional bat acoustic data in 2017." DNR Letter, 2/21/2017, Application, Appendix A, p. 13 of 78.

The DNR's most recent email was May 17, 2017, just prior to filing, requesting project information, and has not reviewed the project after developer made significant changes to the site, including project boundary changes and proposed turbine locations. There are no DNR or USFWS comments regarding adequacy of monitoring or specific recommendations to review.

Whether monitoring has been performed as recommended, and the results, are material issues of fact.

IX. CAN PROJECT COMPLY WITH SHADOW FLICKER LIMIT OF LESS THAN 30 HOURS ANNUALLY?

Whether the project can meet claims of limiting shadow flicker to less than 30 hours annually is a material issue of fact. From the shadow flicker modeling, that limitation looks doubtful due to the locations of homes, and that at least eleven homes are missing from the map.

The shadow flicker modeling map for this projects calls into question the ability of the project to limit shadow flicker to less than 30 hours annually, a promise repeatedly made by project developers. Figure 8, Shadow Flicker, Initial Application, Figures 1-17. Many residences are located on the yellow 30 hour lines, and some are up against the 50 hour orange/tan lines. Further, many residences are not shown on the maps, 11 homes on the shadow flicker map. Given the customary range of error in modeling, residences could easily be within the 50 hour per year range for shadow flicker, and because homes are not on the map, we do not know the extent of impacts of shadow flicker, a material issue of fact.

X. DOES USFWS RECOMMEND AN EAGLE TAKE PERMIT?

The application reports that there are two eagle nests within the project boundary and one outside the boundary to the west. See Draft ABPP, p. 25-26. The location of eagle nests is a material issue of fact. Upon information and belief, there are at least three more eagle nests that are not disclosed in the application. Those eagle nests are located at:

- North of 110th St 1/2 mile and west of 840th Ave, Glenville MN
- 140th St and 1/2 miles west of 830th Ave, Glenville MN
- 52717 173rd St, Austin -outside footprint, ~6 miles, within 10 mile area of concern

At this time, there is no Comment letter from USFWS regarding whether or not an eagle take permit will be recommended. There is also no verification that USFWS knows about these eagle nests, and whether they have been considered in relation to the Freeborn Wind Project. The existence of eagle nests in and near the project, and the potential for impacts on these eagles, is a material issue of fact.

XI. HAS FREEBORN WIND ACCURATELY ASSESSED IMPACT ON PROPERTY VALUES AND TAX PAYMENTS?

The extent of impact of a wind project on property values, and the collateral impact on property tax revenue, and whether the decreased property tax revenue is offset by production tax payments to local units of government in the estimated amount of $397,000 annually if all 42 turbines are constructed. Application, §8.12.2, p. 66-68. Is that estimate of level of revenue to local governments accurate? Is the purpose of that revenue to be an offset for impacts on property tax revenue, compensation for hosting turbines, or other purpose? These are material issues of fact.

Freeborn Wind claims the project will have little impact, stating, "As all Project facilities will be located on leased lands it is anticipated that there will be no unmitigated impacts to the property values of participating landowners. Id., p. 67. There is no explanation of the relation between "leased lands" and mitigation. Freeborn further claims, citing just one study, that property values for non-participating landowners would not be impacted . Id. Other studies show the opposite – studies can be found to support any position.

Going to a primary source rather than a commissioned study, a landowner within the Freeborn Wind footprint collected data from public records regarding valuation of property by

the county, and found that while land outside of the footprint increased in value, land within the footprint decreased in value.

Property Values Within Bent Tree Wind Farm and 5 Miles Away (East and West)
Near Manchester & Hartland, Freeborn County, MN.

The figures below are taken from the Beacon-Schneider website. They reflect the actual property values from 2014 to 2017.

Within Wind farm	2014	2015	2016	2017	Value Up/Down?
25725 690th Ave	$444,900	413,700	412,100	393,200	Down
26823 690th Ave	$399,200	282,300	304,400	302,600	Down
25971 690th Ave	$846,500	782,500	761,500	721,000	Down
25886 708th Ave	$764,200	699,400	624,800	585,100	Down
26777 708th Ave	$289,100	261,700	243,000	226,500	Down
5 Miles Away					
26093 640th Ave	115,900	124,500	127,200	127,200	Up
26504 640th Ave	155,700	154,000	158,400	156,500	Up
25895 739th Ave	113,300	113,000	124700	142,300	Up
25889 739th Ave	89,100	87,800	91,500	118,100	Up

Comment, Stephanie Richter.[13] The applicants' claim that the project would have no impact on property valuation is suspect, and should be carefully reviewed and documented.

CONCLUSION -- FORWARD TO OAH FOR CONTESTED CASE

The Association of Freeborn County Landowners requests that the Commission consider each of the contested material issues of fact above, and refer this application docket to the Office of Administrative Hearings for a contested case proceeding.

July 6, 2017

Carol A. Overland MN #254617
Attorney for Association of Freeborn County Landowners
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[13] Comment, eFiled, available online: **20177-133473-01**

STATE OF MINNESOTA
BEFORE THE
MINNESOTA PUBLIC UTILITIES COMMISSION

Nancy Lange	**Chair**
Dan Lipschultz	**Commissioner**
Matt Schuerger	**Commissioner**
Katie Sieben	**Commissioner**
John A. Tuma	**Commissioner**

In the Matter of the Application of Freeborn Wind Farm, LLC for a Large Wind Energy Conversion System Site Permit for the 84 MW Freeborn Wind Farm in Freeborn County.	**PUC Docket No. IP-6946/WS-17-410**

COMMENT ON COMPLETENESS OF APPLICATION

The Association of Freeborn County Landowners is an informal association of landowners in and adjacent to the site footprint of the above-captioned Freeborn Wind Farm (hereinafter "Freeborn Wind"). The Association of Freeborn County Landowners hereby submit this Comment on completeness of this application.

Although "Freeborn Wind proposes to develop this Project to meet state policies of locating energy facilities in an orderly manner compatible with environmental preservation and the efficient use of resources," it is impossible to determine whether this is occurring without a complete application. There are many substantive omissions. The Freeborn Wind Project application is incomplete, and should be held in abeyance until the content requirements and the following matters have been addressed.

The Association of Freeborn County Landowners raises these completeness issues – this

list is not all-inclusive, and incorporates other landowner comments herein.

1. It is difficult to review the project and consider impacts without an "all-in-one" map overview, for example, a google earth kmz file, showing the many layers of information, including:

    - Layout and constraints
    - Project area and facilities (collectors, roads, transmission line, etc.)
    - Land Ownership
    - Public Land Ownership & Recreation
    - Sound Noise at 40, 45 and 50 dBA
    - Topographic map
    - Shadow Flicker
    - Microwave Beam Paths
    - Unique Natural Features
    - Land Cover
    - Soils
    - Geology & Depth to Bedrock
    - Surface Waters
    - FEMA Floodplains
    - Wetlands Inventory
    - Existing Turbine Locations (shows Iowa turbines)

2. The application is not complete because there is not a single affidavit or certificate of service showing landowners in the project area have received notice of this application. This is a substantive flaw, and the application should not go forward without notice.

3. It is unclear why this permit is for up to 84 MW, with an unknown number of MW in Iowa. The project is a claimed 200 MW in Xcel Energy's acquisition docket, and yet only up to 150 MW granted for MISO interconnection. Full information on Minnesota, Iowa, MISO and acquisition megawatts must be provided.
4. This project "began development in 2008" and many changes have occurred since that time, and it is unclear why this project has not yet been constructed, 9 years later. Application, p. 1. This project is also not scheduled to begin construction until the 2nd quarter of 2020. Id. The delays of this project should be explained in sufficient detail to be considered by the Commission and a feasibility/constructability determination made.

5. The application is not complete -- turbines 1-2, 5, 10, and 15 are missing with no explanation

6. The Route Permit Application for project transmission has not yet been filed. The reasons for separating out this seven mile long section from this siting permit

should be explained, whether due to the length thresholds for transmission, the private one-customer nature, presumed, for this transmission line, before the application may be deemed complete.

7. A wind project application must identify all projects owned and/or operated by the applying entity. The application states that "Freeborn Wind and Invenergy do not own or operate, or have financial interest in any other LWECS in Minnesota." The "and" in this sentence should be "or" and financial interests and ownership should be separately disclosed. As above, in the acquisition docket, this project is held out as a 200MW, and has pending interconnection from MISO for up to 150 MW.

8. "Stakeholder Outreach Efforts" – Notice to the "General Public" and directly affected non-participant landowners has been poor to non-existent. App. p. 5. The gatherings listed in Public Outreach §4.2 have been for participant landowners only, and the meeting at Riverland was to offer pay to students to collect signatures. Freeborn has also listed non-participating landowners incorrectly as "supporters" on social media. See Comment letter of Dorenne Hansen regarding "Public Outreach." No notice has been provided to landowners of this application.

9. "Stakeholder Outreach Efforts" – The Xcel Energy acquisition docket provided notice to only the Commission's general service list, and no notice whatsoever was provided to landowners of the acquisition docket. Freeborn Wind has contact information for landowners and did nothing to inform them. App. p. 5. See PUC Docket 16-777. Freeborn Wind's statement that it "is using information obtained with this outreach to optimize and refine Project design, identify and resolve issues, and address concerns brought forward by stakeholders prior to submitting this SPA" is not correct in light of failure to provide notice to landowners of this acquisition docket.

10. "Stakeholder Outreach Efforts" – Wind on the Wires, formerly a project and revenue stream of Izaak Walton League, is an industry lobbying group, not "General Public." App. p. 5.

11. "Stakeholder Outreach Efforts" – Freeborn includes a sample letter sent to local government officials responding to Comment requests that notes that a company land agent including the following paragraph:

> 9. We hire experienced and trustworthy professionals to spend the time at kitchen tables and in the field negotiating our land agreements. Unfortunately, a land agent working on our project in 2015 did not live up to this standard and was exposed to be blatantly lying to some landowners. He was fired as soon as we found out, as we deem this behavior completely unacceptable. I don't know what else to say about this – I'm sorry for those who were lied to. It is not ok. We are doing the best we can do rebuild trust.

Any participant who signed via this land agent must be offered an opportunity to terminate the contract without penalty. The application is not complete without independent verification of land rights acquisition without coercion, and those who signed under pressure or misrepresentations must be offered the opportunity to terminate the contracts without penalty.

12. Layout of project was not provided to agency commentors sufficient for them to offer comments to include in this application. There has been no pre-application agency review of the full project layout included in the application for the public to review prior to making public comments. See Agency Comments, Appendix A, requesting full layout information.

13. On May 5, 2016, Freeborn Wind and consultants met with USFWS Mags Rheude, and in Freeborn Wind's words:

> The objective of the meeting was to get Rheude's feedback on Freeborn's proposed eagle strategy and how it will be incorporated into its Avian and Bat Protection Plan (ABPP)(MNDOC prefers "ABPP" over "BBCS"). **The goal of the meeting was to address agency feedback to limit public comment.**

Application, Appendix A, p. 8 of 78 (emphasis added). Although this attempt to limit public comment is often perceived in utility proceedings, that the applicant would put this in writing, and then offer it in a filing appendix, is shocking. The application should be rejected as incomplete, and Freeborn be required to demonstrate good faith and sincere public outreach and documentation in a subsequent filing.

14. The application is incomplete because, although the noise modeling was performed for 50, 45, and 40 dBA, it does not depict impacts of sound at 35 dBA levels, a threshold noted in the Dept. of Health's "Public Health Impacts of Wind Turbines" report, as above.

> The most common complaint in various studies of wind turbine effects on people is annoyance or an impact on quality of life. Sleeplessness and headache are the most common health complaints and are highly correlated (but not perfectly correlated) with annoyance complaints. Complaints are more likely when turbines are visible or when shadow flicker occurs. Most available evidence suggests that reported health effects are related to audible low frequency noise. Complaints appear to rise with increasing outside noise levels above 35 dB(A). It has been hypothesized that direct activation of the vestibular and autonomic nervous system may be responsible for less common complaints, but evidence is scant.
>
> The Minnesota nighttime standard of 50 dB(A) not to be exceeded more than 50% of the time in a given hour, appears to underweight penetration of low frequency noise into dwellings. Different schemes for evaluating low frequency noise, and/or lower noise standards, have been developed in a number of countries.

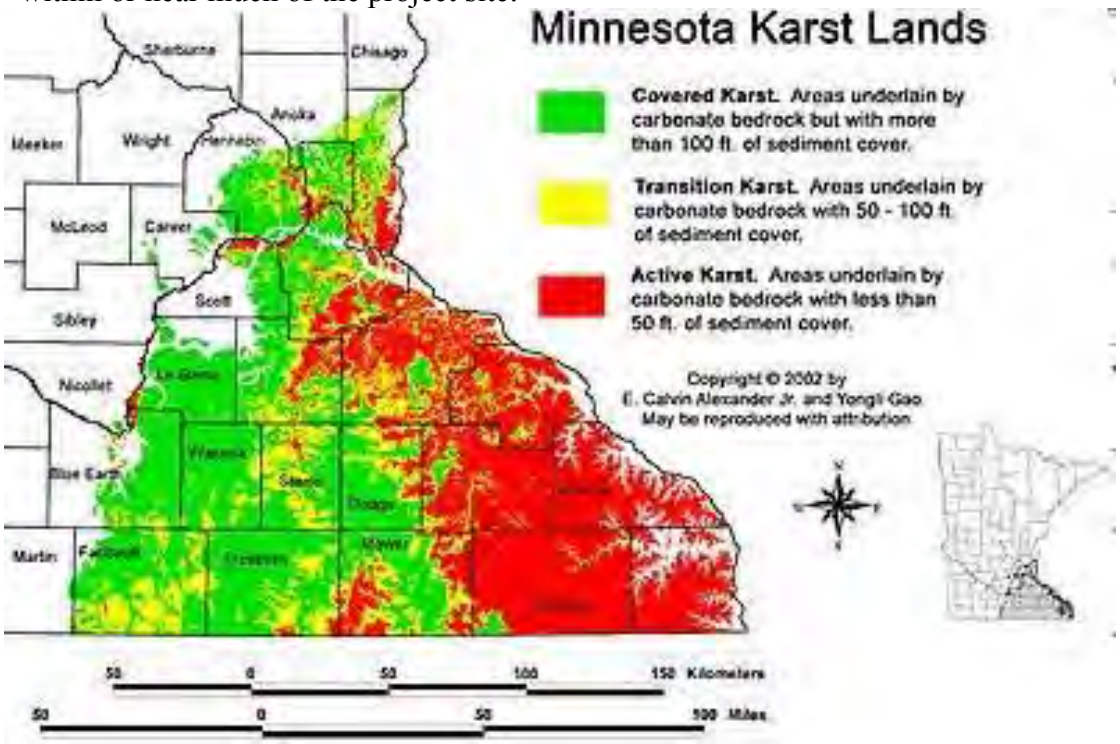
"Low frequency noise from a wind turbine is generally not easily perceived beyond ½ mile." Id., p. 25.

16. The Application and the Avian and Bat Protection Plan (Draft) are incomplete because they do not document or consider impacts of the project on three additional bald eagle nests, two within the project area, and one outside the footprint but within the 10 mile area of concern:

    - North of 110th St 1/2 mile and west of 840th Ave, Glenville MN
    - 140th St and 1/2 miles west of 830th Ave, Glenville MN
    - 52717 173rd St, Austin, outside footprint, ~6 miles, within 10 mile area of concern

    These bald eagle nests must be incorporated into the project Application, the DNR and USFWS must be notified, and impacts of the project on these bald eagle nests and the eagles within them must be considered.

17. The Application is incomplete, because the Application and Figure 13, Site Geology and Depth to Bedrock, is not labeled showing geology, only differing shades of blue, and does not show the transition Karst or active Karst documented within or near much of the project site:



Geospatial Information Office, online at
http://www.mngeo.state.mn.us/chouse/geology/county_regional.html

From another source:

> A field-verified karst feature, such as a sinkhole, is direct evidence that karst processes are active both on the surface and in a karst aquifer in the subsurface. However, the absence of karst features on the land surface does not imply the absence of karst processes on the land surface or karst hydrology in the subsurface.

Minnesota Regions Prone to Surface Karst Feature Development.[1] The Application must identify Transition and Active Karst areas within the project area.

CONCLUSION

Though these comments are not all-inclusive, there are many areas where the application is not complete. This application should be held in abeyance, and the clock should not start ticking, until Freeborn Wind provides the information and the Commission declares the application complete and accepts it for further consideration.

July 6, 2017

Carol A. Overland MN #254617
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[1] Minnesota Regions Prone to Surface Karst Feature Development, online at: http://files.dnr.state.mn.us/waters/groundwater_section/mapping/gw/gw01_report.pdf
Shapefiles available online: https://gisdata.mn.gov/dataset/geos-surface-karst-feature-devel

STATE OF MINNESOTA

BEFORE THE

MINNESOTA PUBLIC UTILITIES COMMISSION

Nancy Lange	**Chair**
Dan Lipschultz	**Commissioner**
Matt Schuerger	**Commissioner**
Katie Sieben	**Commissioner**
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In the Matter of the Application of Freeborn Wind Farm, LLC for a Large Wind EnergyConversion System Site Permit for the 84 MW Freeborn Wind Farm in Freeborn County.

PUC Docket No. IP-6946/WS-17-410

AFFIDAVIT OF CAROL A. OVERLAND

STATE OF MINNESOTA)
) ss.
COUNTY OF GOODHUE)

Carol A. Overland, after duly affirming on oath, states and deposes as follows:

1. I am an attorney in good standing, licensed in the State of Minnesota, Lic. No. 254617, and have extensive experience in utility regulatory proceedings in many venues.

2. I am working with the Association of Freeborn County Landowners drafting Comments as requested by the Commission in its June 21, 2017 Notice of Comment Period.

3. Attached as Exhibit A is a true and correct copy of Xcel Energy's project description of Freeborn Wind from its Petition, Docket E002/M-16-777.

4. Attached as Exhibit B is a true and correct cop of PUC Wind Siting Standards, from Notice of Comment Period, 7/21/2009, "Public Health Impacts of Wind Turbines" docket CI-09-845.

5. Attached as Exhibit C is a true and correct copy of the Dept. of Health's report "Public Health Impacts of Wind Turbines.

6. Attached as Exhibit D is a true and correct copy of the Direct Testimony of Rick James, PUC Docket IP-6701/WS-08-1233.

7. Attached as Exhibit E are true and correct copies of letters filed by landowners with personal experience of misrepresentations on the part of agents of Freeborn Wind.

Further your affiant sayeth naught.

Dated: July 6, 2017

Carol A. Overland MN Lic. 254617
Attorney for Association of Freeborn County Landowners
Legalectric
1110 West Avenue
Red Wing, MN 55066
(612) 227-8638
overland@legalectric.org

Signed and sworn to before me this
6th day of July, 2017

Notary Public

EMILY GROETSCH
NOTARY PUBLIC - MINNESOTA
My Commission Expires Jan. 31, 2020

EXHIBIT A

Xcel Energy's project description of Freeborn Wind

from Petition, Docket E002/M-16-777

interconnection process with MISO is fully complete. We are currently working with MISO and Geronimo regarding completion of the studies discussed above.

4. Freeborn

a. Project Description

The Freeborn Wind Project is being developed by an affiliate of Invenergy Wind Development LLC, and is located on an approximately 40,000 acre site East of Glenville, Minnesota. The Project will consist of a blend of **[TRADE SECRET BEGINS TRADE SECRET ENDS]** wind turbines and **[TRADE SECRET BEGINS TRADE SECRET ENDS]** wind turbines, resulting in 200 MW of nameplate wind power capacity. In addition to wind turbines, the Project will consist of an electrical collection system, access roads, substation and interconnection facilities, an operation and maintenance facility, and other infrastructure typical of a wind farm.

The Freeborn Wind Project is in Freeborn County in the southeast part of Minnesota – and is similarly-situated ecologically to our Pleasant Valley Wind Project, which is in adjacent Mower and Dodge counties. The site is predominately active crop land. Invenergy applied to interconnect the Freeborn Wind Project to ITC Midwest's transmission system in November 2014. The Project qualified for MISO's February 2015 DPP Study Cycle. All System Impact Studies have been completed and Facility Studies are ongoing. While final interconnection and transmission upgrade costs will not be known until the Facility Studies are complete and the GIA is executed, upgrades identified to-date include: (1) upgrading the Glenworth 161 kV substation to allow interconnection of the project; (2) rebuilding the 7.6 mile North Iowa Wind – Colby 161 kV line; (3) replacing the Glenworth 161 – 69 kV transformer; and (4) upgrading the PJM Wilton 3M– 4M 345 kV transmission lines. Invenergy is responsible for pursuing the necessary approvals to interconnect the Freeborn Project with the upper Midwest transmission system.

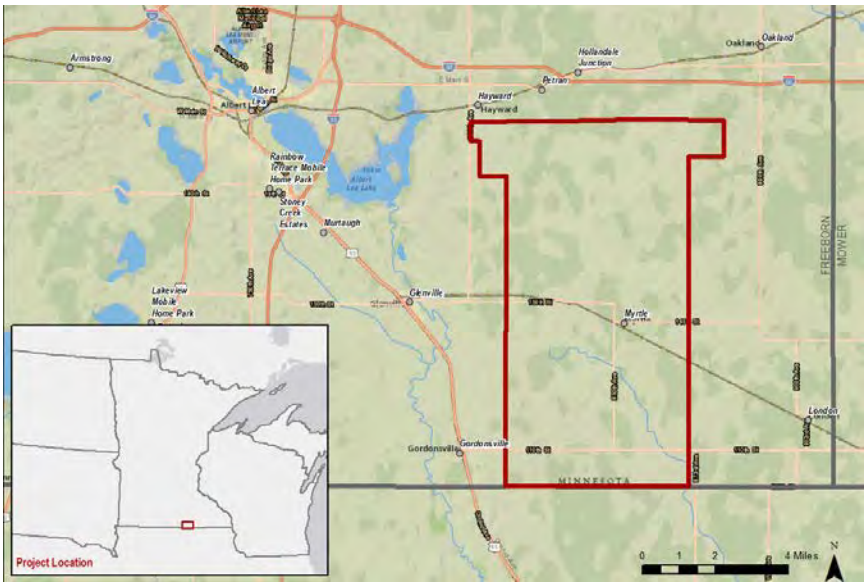
The MISO System Impact studies show that the project will be granted 150 MW of NRIS upon completion of all required network upgrades. Invenergy is responsible for pursuing the necessary approvals to interconnect the Freeborn Project with the MISO transmission system.

We have estimated the costs of transmission network upgrades and interconnection costs for the Freeborn Wind Project identified through the MISO studies process, and included them in our project costs. We have estimated the network upgrades at approximately **[TRADE SECRET BEGINS TRADE SECRET**

ENDS] and interconnection costs at approximately **[TRADE SECRET BEGINS TRADE SECRET ENDS]**, based on our knowledge and review of the facilities involved and included this cost in our estimate.

Figure 4 below shows the location of the Freeborn Wind Project.

Figure 4: Freeborn Project Location



Our analysis predicted a net capacity factor of approximately **[TRADE SECRET BEGINS TRADE SECRET ENDS]** percent. We additionally project average AEP of approximately **[TRADE SECRET BEGINS TRADE SECRET ENDS]** MWh, depending on final layout and turbine selection.

Total capital costs for the Freeborn Project are currently estimated at approximately **[TRADE SECRET BEGINS TRADE SECRET ENDS]**, which includes the estimated transmission upgrades and interconnection costs discussed above as well as anticipated siting and permitting costs. The projected LCOE for the Freeborn Project is **[TRADE SECRET BEGINS TRADE SECRET ENDS].**

b. Implementation Schedule

We expect our primary construction activities on the Freeborn Project will occur in 2020. However, engineering and some procurement will occur in 2018 and 2019. The current schedule indicates that wind turbine generators will be delivered to the project site starting in time to begin turbine erection in 2020. Under the current

estimated schedule, we anticipate that commercial operation will be achieved by early December 2020.

Key variables that may influence the estimated project schedule include the approval of this filing, weather-related delays, and the timeliness with which the interconnection process with MISO is fully complete. We are currently working with MISO and Invenergy regarding the remaining studies as discussed above.

F. Balance of Plant Construction Contracts

In addition to the contracts previously discussed, as part of our development of these projects, we will enter into BOP construction contracts with third party construction companies experienced in wind project construction. The BOP contracts will be fixed price contracts, which will minimize schedule and cost risk.

The scope of the BOP contracts will include installation of the wind turbines and construction of the site infrastructure. Site infrastructure includes access roads, turbine foundations, electrical cable collection system, collection substations, and operations and maintenance building. We have initiated discussions with established BOP contractors who have extensive experience building wind projects in the region, to evaluate our Wind Portfolio project plan and develop reasonable cost estimates for the relevant scope of work.

If our Wind Portfolio is approved by the Commission – and after the completion of our preliminary engineering including site/turbine design optimization – we will issue a firm price RFP for BOP construction to qualified contractors in order to support the completion of all proposed projects before the 2020 PTC deadline.

G. Contingency & Communication Plan

In its September 12, 2016 Supplemental Comments to our IRP, the Department of Commerce recommended that the Company "file a contingency plan early in the [wind acquisition] process to address the potential for the bidding process to fail." The Commission adopted this recommendation during deliberations, and we expect the Commission's upcoming written Order in the IRP to require a contingency plan. We propose the following measures to address the concerns the Department raised in comments.

First, we propose to make an informational filing in December 2016 in this Docket to update the Commission as to the bids received in response to our pending RFP. This filing will include a list of all bids received in response to the RFP. This will allow the

Commission and Department to confirm the robustness of our RFP process, and ensure that we will have a sufficient number of competitive bids to move forward with the RFP and to demonstrate the competitiveness of our Wind Portfolio.

Second, in January 2018 after the Commission has approved a package of wind projects and the successful projects are underway, we propose to make an informational filing to inform the Commission on project progress. This will allow the Company to raise any viability concerns that arise with any of the projects, and will give the Company and Commission the opportunity to address those concerns in a timely fashion.

We believe touch-points between the Company, Commission, and Department will ensure that our overall acquisition process continues to be transparent and moves forward constructively.

VI. EFFECT OF CHANGE UPON XCEL ENERGY REVENUE

This petition results in no change in revenue for the Company. We will separately file for approval for cost recovery of the final package of wind projects the Commission selects from this process.

CONCLUSION

The Company's goal is to reduce carbon emissions at a reasonable cost, and this proposal to build, own, and operate a 750 MW Wind Portfolio is an important part of accomplishing this goal. Our four projects are the result of a thorough due diligence process, and they are cost-competitive when compared to recent market data for wind and other renewable projects. On this basis alone, we believe the Commission could approve this petition, but we are also committed to the acquisition process outlined in our IRP Reply comments. To that end, we put forth our projects and pricing before we received the RFP bids for transparency. We will be back to the Commission in early 2017 with a comprehensive proposal that incorporates the results of our RFP process and self-build proposals.

Dated: October 24, 2016

Northern States Power Company

EXHIBIT B

PUC Wind Siting Standards

from Notice of Comment Period, 7/21/2009

"Public Health Impacts of Wind Turbines" docket CI-09-845

Typical Wind Turbine Permit Setback Conditions for Large Wind Energy Conversion Systems in Minnesota

Resource Category	General Permit Setback	Minimum Setback
Wind Access Buffer (setback from lands and/or wind rights not under permittee's control)	Wind turbine towers shall not be placed less than 5 rotor diameters (RD) from all boundaries of developer's site control area (wind and land rights) on the predominant wind axis (typically north-south access) and 3 rotor diameters (RD) on the secondary wind axis (typically east-west axis), without the approval of the permitting authority. This setback applies to all parcels for which the permittee does not control land and wind rights, including all public lands.	3 RD (763-985 ft) on east-west axis and 5 RD (1280-1640 ft) on north-south using turbines with 78-100 meter rotor diameters.
Internal Turbine Spacing	The turbine towers shall be spaced no closer than 3 rotor diameters (RD) for crosswind spacing (distance between towers) and 5 RD downwind spacing (distance between strings of towers). If required during final micro siting of the turbine towers to account for topographic conditions, up to 20 percent of the towers may be sited closer to the above spacing but the permittee shall minimize the need to site the turbine towers closer.	5 RD downwind spacing 3 RD apart for crosswind spacing
Noise Standard	Project must meet Minnesota Noise Standards, Minnesota Rules Chapter 7030, at all residential receivers (homes). Residential noise standard NAC 1, L50 50 dBA during overnight hours. Setback distances calculated on site layout and turbine for each residential receiver.	Typically 750 - 1500 ft is required to meet noise standards depending on turbine model, layout, site specific conditions.
Homes	At least 500 ft <u>and</u> sufficient distance to meet state noise standard.	500 feet + distance required to meet state noise standard.
Public Roads and Recreational Trails	The turbine towers shall be placed no closer than 250 feet from the edge of public road rights-of-way. Setbacks from state trails and other recreational trails shall be considered on a case-by-case basis.	Minimum 250 feet
Meteorological Towers	Meteorological towers shall be placed no closer than 250 feet from the edge of road rights-of-way and from the boundaries of developer's site control (wind and land rights). Setbacks from state trails and other recreational trails shall be considered on a case-by-case basis.	Minimum 250 feet

EXHIBIT C

"Public Health Impacts of Wind Turbines"

Minnesota Department of Health

PUC Docket CI-09-845

Public Health Impacts
of
Wind Turbines

Prepared by:
Minnesota Department of Health
Environmental Health Division

In response to a request from:
Minnesota Department of Commerce
Office of Energy Security

May 22, 2009

Table of Contents

Tables

Figures

I. Introduction

In late February 2009 the Minnesota Department of Health (MDH) received a request from the Office of Energy Security (OES) in the Minnesota Department of Commerce, for a "white paper" evaluating possible health effects associated with low frequency vibrations and sound arising from large wind energy conversion systems (LWECS). The OES noted that there was a request for a Contested Case Hearing before the Minnesota Public Utilities Commission (PUC) on the proposed Bent Tree Wind Project in Freeborn County Minnesota; further, the OES had received a long comment letter from a citizen regarding a second project proposal, the Lakeswind Wind Power Plant in Clay, Becker and Ottertail Counties, Minnesota. This same commenter also wrote to the Commissioner of MDH to ask for an evaluation of health issues related to exposure to low frequency sound energy generated by wind turbines. The OES informed MDH that a white paper would have more general application and usefulness in guiding decision-making for future wind projects than a Contested Case Hearing on a particular project. (Note: A Contested Case Hearing is an evidentiary hearing before an Administrative Law Judge, and may be ordered by regulatory authorities, in this case the PUC, in order to make a determination on disputed issues of material fact. The OES advises the PUC on need and permitting issues related to large energy facilities.)

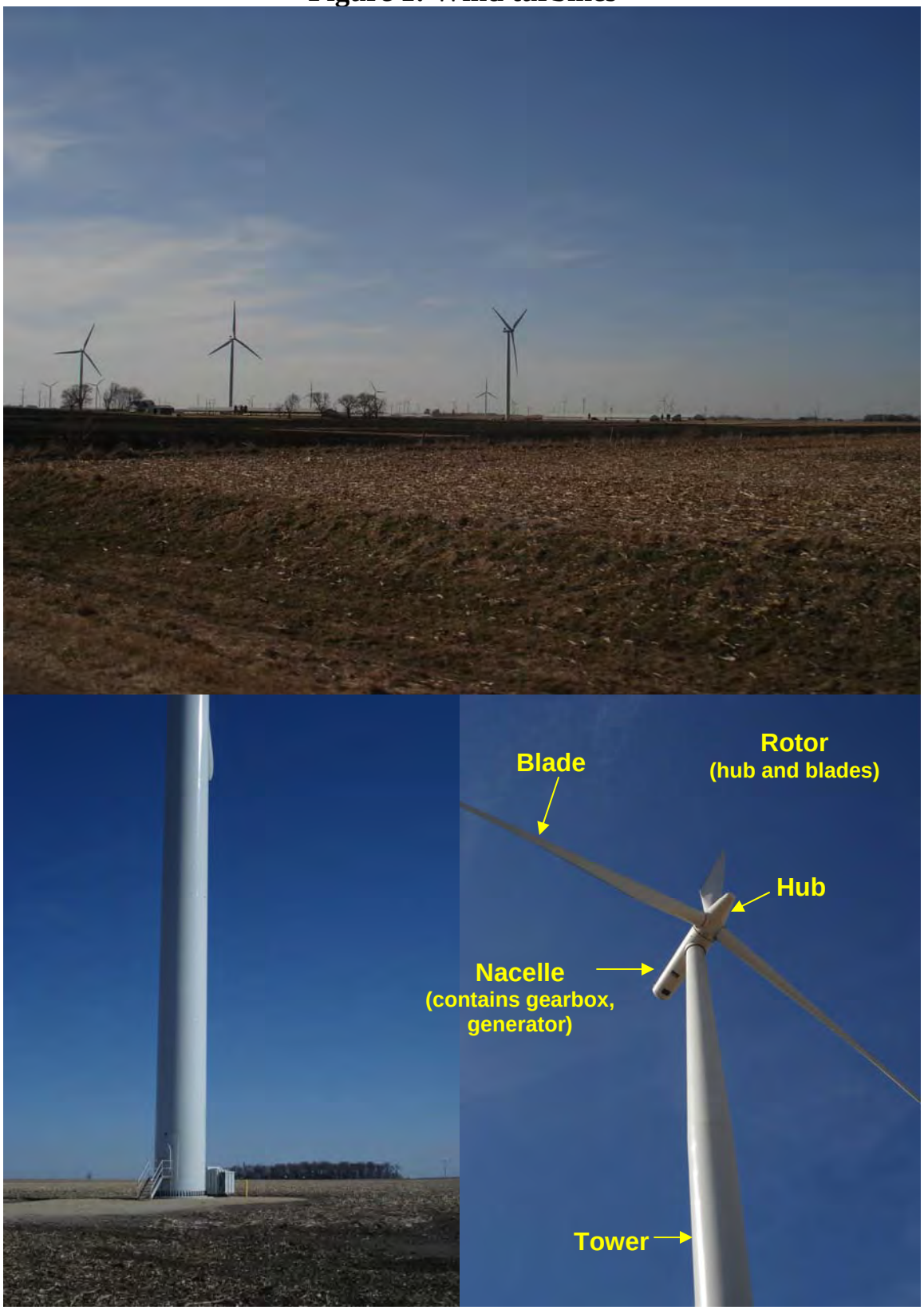
In early March 2009, MDH agreed to evaluate health impacts from wind turbine noise and low frequency vibrations. In discussion with OES, MDH also proposed to examine experiences and policies of other states and countries. MDH staff appeared at a hearing before the PUC on March 19, 2009, and explained the purpose and use of the health evaluation. The Commissioner replied to the citizen letter, affirming that MDH would perform the requested review.

A brief description of the two proposed wind power projects, and a brief discussion of health issues to be addressed in this report appear below.

A. Site Proposals

Wind turbines are huge and expensive machines requiring large capitol investment. Figure 1 shows some existing wind turbines in Minnesota. Large projects require control of extensive land area in order to optimize spacing of turbines to minimize turbulence at downwind turbines. Towers range up to 80 to 100 meters (260 to 325 feet), and blades can be up to 50 meters long (160 feet) (see Tetra Tech, 2008; WPL, 2008). Turbines are expected to be in place for 25-30 years.

Figure 1: Wind turbines



1. Bent Tree Wind Project in Freeborn County

This is a proposal by the Wisconsin Power and Light Company (WPL) for a 400 megawatt (MW) project in two phases of 200 MW each (requiring between 80 and 130 wind turbines). The cost of the first phase is estimated at $497 million. The project site area would occupy approximately 40 square miles located 4 miles north and west of the city of Albert Lea, approximately 95 miles south of Minneapolis (Figure 2) (WPL, 2008). The Project is a LWECS and a Certificate of Need (CON) from the PUC is required (*Minnesota Statutes 216B.243)*. The PUC uses the CON process to determine the basic type of facility (if any) to be constructed, the size of the facility, and when the project will be in service. The CON process involves a public hearing and preparation of an Environmental Report by the OES. The CON process generally takes a year, and is required before a facility can be permitted.

WPL is required to develop a site layout that optimizes wind resources. Accordingly, project developers are required to control areas at least 5 rotor diameters in the prevailing (north-south) wind directions (between about 1300 and 1700 feet for the 1.5 to 2.5 MW turbines under consideration for the project) and 3 rotor diameters in the crosswind (east-west) directions (between about 800 and 1000 feet). Thus, these are minimum setback distances from properties in the area for which easements have not been obtained. Further, noise rules promulgated by the Minnesota Pollution Control Agency (MPCA; *Minnesota Rules* Section 7030), specify a maximum nighttime noise in residential areas of 50 A-weighted decibels (dB(A). WPL has proposed a minimum setback of 1,000 feet from occupied structures in order to comply with the noise rule.

2. Noble Flat Hill Wind Park in Clay, Becker and Ottertail Counties

This is a LWECS proposed by Noble Flat Hill Windpark I (Noble), a subsidiary of Noble Environmental Power, based in Connecticut. The proposal is for a 201 MW project located 12 miles east of the City of Moorhead, about 230 miles northwest of Minneapolis (Figure 3) (Tetra Tech, 2008). The cost of the project is estimated to be between $382 million and $442 million. One hundred thirty-four GE 1.5 MW wind turbines are planned for an area of 11,000 acres (about 17 square miles); the site boundary encompasses approximately 20,000 acres. Setback distances of a minimum of 700 feet are planned to comply with the 50 dB(A) noise limit. However, rotor diameters will be 77 meters (250 feet). Therefore, setback distances in the prevailing wind direction of 1,300 feet are planned for properties where owners have not granted easements. Setbacks of 800 feet are planned in the crosswind direction.

Figure 2: Bent Tree Wind Project, Freeborn County

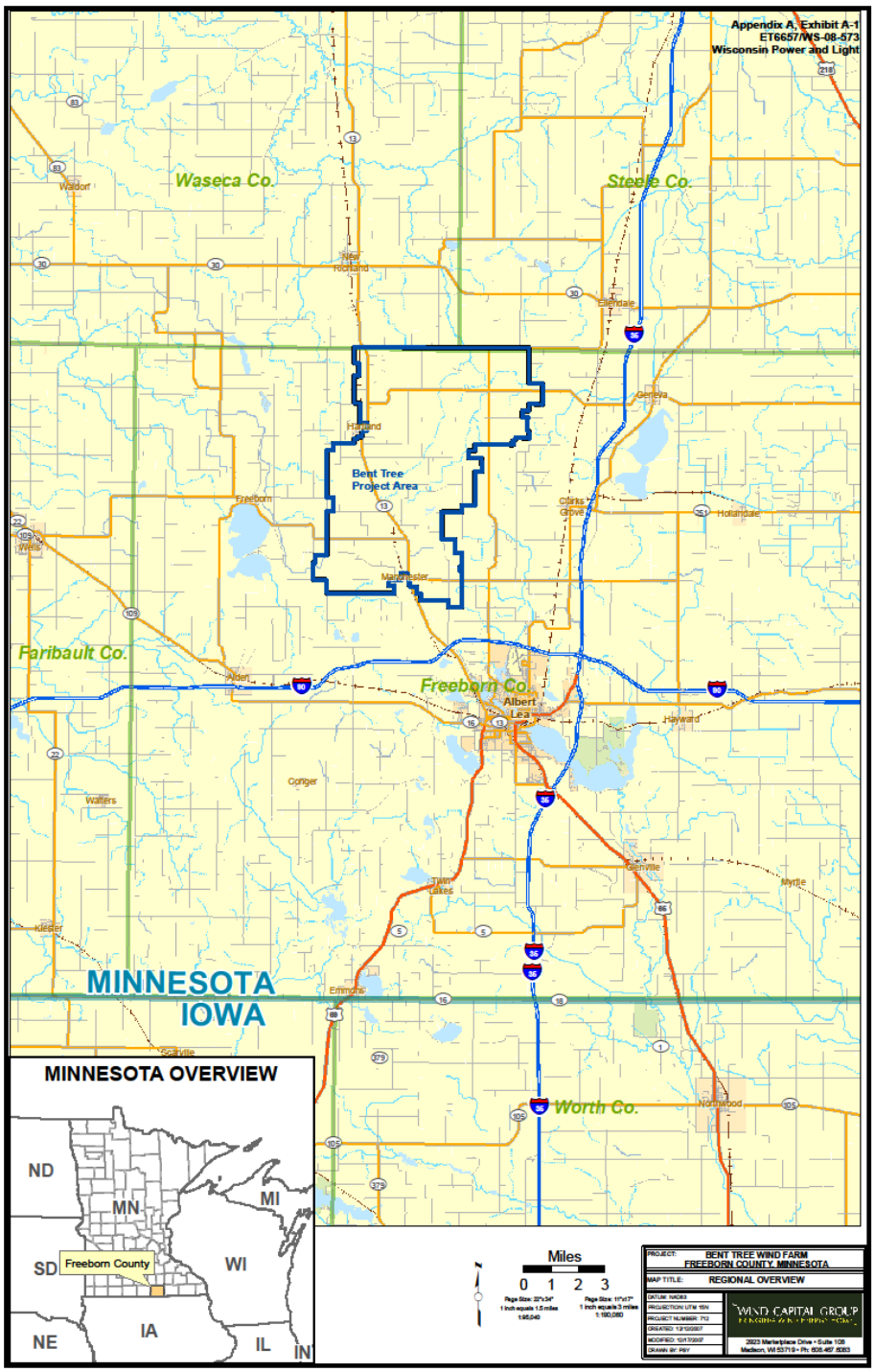
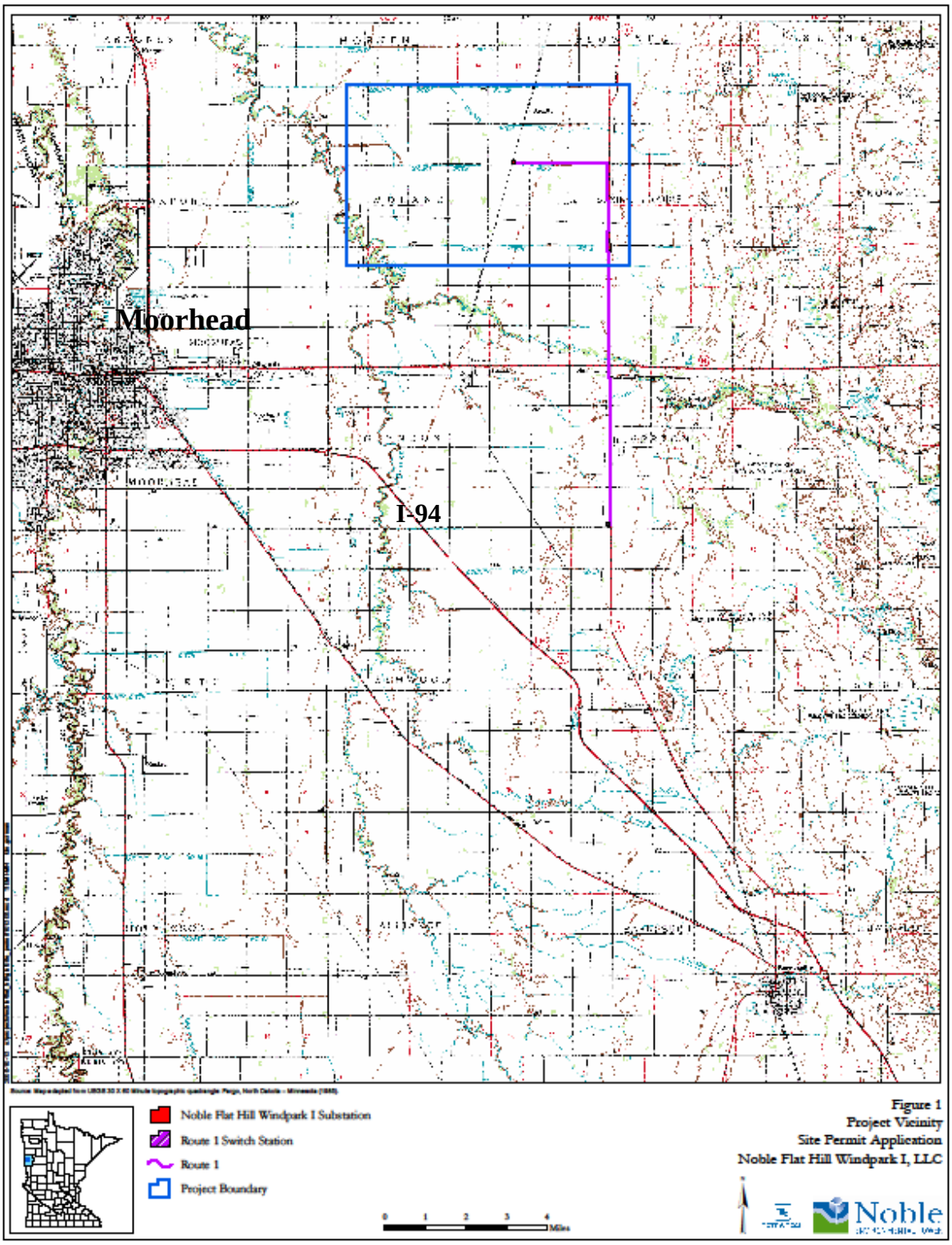


Figure 3: Noble Flat Hill Wind Park, Clay, Becker, Ottertail Counties



B. Health Issues

The National Research Council of the National Academies (NRC, 2007) has reviewed impacts of wind energy projects on human health and well-being. The NRC begins by observing that wind projects, just as other projects, create benefits and burdens, and that concern about impacts is natural when the source is near one's home. Further, the NRC notes that different people have different values and levels of sensitivity. Impacts noted by the NRC that may have the most effect on health include noise and low frequency vibration, and shadow flicker. While noise and vibration are the main focus of this paper, shadow flicker (casting of moving shadows on the ground as wind turbine blades rotate) will also be briefly discussed.

Noise originates from mechanical equipment inside the nacelles of the turbines (gears, generators, etc.) and from interaction of turbine blades with wind. Newer wind turbines generate minimal noise from mechanical equipment. The most problematic wind turbine noise is a broadband "whooshing" sound produced by interaction of turbine blades with the wind. Newer turbines have upwind rotor blades, minimizing low frequency "infrasound" (i.e., air pressure changes at frequencies below 20-100 Hz that are inaudible). However, the NRC notes that during quiet conditions at night, low frequency modulation of higher frequency sounds, such as are produced by turbine blades, is possible. The NRC also notes that effects of low frequency (infrasound) vibration (less than 20 Hz) on humans are not well understood, but have been asserted to disturb some people.

Finally, the NRC concludes that noise produced by wind turbines is generally not a major concern beyond a half mile. Issues raised by the NRC report and factors that may affect distances within which wind turbine noise may be problematic are discussed more extensively below.

II. Elementary Characteristics of Sensory Systems and Sound

A. Sensory Systems

1. Hearing

Sensory systems respond to a huge dynamic range of physical stimuli within a relatively narrow dynamic range of mechanical, chemical and/or neuronal (electrophysiological) output. Compression of the dynamic range is accomplished by systems that respond to logarithmic increases in intensity of physical stimuli with arithmetically increasing sensory responses. This general property is true for hearing, and has been recognized since at least the mid-19th century (see e.g., Woodworth and Schlosberg, 1964). "Loudness" is the sensory/perceptual correlate of the physical intensity of air pressure changes to which the electro-mechanical transducers in the ear and associated neuronal pathways are sensitive. Loudness increases as the logarithm of air pressure, and it is convenient to relate loudness to a reference air pressure (in dyne/cm^2 or pascals) in tenths of logarithmic units (decibels; dB). Further, the ear is sensitive to only a relatively narrow frequency range of air pressure changes: those between approximately 20 and 20,000 cycles per second or Herz (Hz). In fact, sensitivity varies within this range, so that the sound pressure level relative to a reference value that is audible in the middle of the range

(near 1,000 Hz) is about 4 orders of magnitude smaller than it is at 20 Hz and about 2 orders of magnitude smaller than at 20,000 Hz (Fig. 3). Accordingly, measurements of loudness in dB generally employ filters to equalize the loudness of sounds at different frequencies or "pitch." To approximate the sensitivity of the ear, A-weighted filters weigh sound pressure changes at frequencies in the mid-range more than those at higher or lower frequencies. When an A-weighted filter is used, loudness is measured in dB(A). This is explained in greater detail in Section B below.

The ear accomplishes transduction of sound through a series of complex mechanisms (Guyton, 1991). Briefly, sound waves move the eardrum (tympanic membrane), which is in turn connected to 2 small bones (ossicles) in the middle ear (the malleus and incus). A muscle connected to the malleus keeps the tympanic membrane tensed, allowing efficient transmission to the malleus of vibrations on the membrane. Ossicle muscles can also relax tension and attenuate transmission. Relaxation of muscle tension on the tympanic membrane protects the ear from very loud sounds and also masks low frequency sounds, or much background noise. The malleus and incus move a third bone (stapes). The stapes in turn applies pressure to the fluid of the cochlea, a snail-shaped structure imbedded in temporal bone. The cochlea is a complex structure, but for present purposes it is sufficient to note that pressure changes or waves of different frequencies in cochlear fluid result in bending of specialized hair cells in regions of the cochlea most sensitive to different frequencies or pitch. Hair cells are directly connected to nerve fibers in the vestibulocochlear nerve (VIII cranial nerve).

Transmission of sound can also occur directly through bone to the cochlea. This is a very inefficient means of sound transmission, unless a device (e.g. a tuning fork or hearing aid) is directly applied to bone (Guyton, 1991).

2. Vestibular System

The vestibular system reacts to changes in head and body orientation in space, and is necessary for maintenance of equilibrium and postural reflexes, for performance of rapid and intricate body movements, and for stabilizing visual images (via the vestibulo-ocular reflex) as the direction of movement changes (Guyton, 1991).

The vestibular apparatus, like the cochlea, is imbedded in temporal bone, and also like the cochlea, hair cells, bathed in vestibular gels, react to pressure changes and transmit signals to nerve fibers in the vestibulocochlear nerve. Two organs, the utricle and saccule, called otolith organs, integrate information about the orientation of the head with respect to gravity. Otoliths are tiny stone-like crystals, embedded in the gels of the utricle and saccule, that float as the head changes position within the gravitational field. This movement is translated to hair cells. Three semi-circular canals, oriented at right angles to each other, detect head rotation. Stimulation of the vestibular apparatus is not directly detected, but results in activation of motor reflexes as noted above (Guyton, 1991).

Like the cochlea, the vestibular apparatus reacts to pressure changes at a range of frequencies; optimal frequencies are lower than for hearing. These pressure changes can be caused by body movements, or by direct bone conduction (as for hearing, above) when vibration is applied directly to the temporal bone (Todd et al., 2008). These investigators

found maximal sensitivity at 100 Hz, with some sensitivity down to 12.5 Hz. The saccule, located in temporal bone just under the footplate of the stapes, is the most sound-sensitive of the vestibular organs (Halmagyi et al., 2004). It is known that brief loud clicks (90-95 dB) are detected by the vestibular system, even in deaf people. However, we do not know what the sensitivity of this system is through the entire range of sound stimuli.

While vestibular system activation is not directly felt, activation may give rise to a variety of sensations: vertigo, as the eye muscles make compensatory adjustments to rapid angular motion, and a variety of unpleasant sensations related to internal organs. In fact, the vestibular system interacts extensively with the "autonomic" nervous system, which regulates internal body organs (Balaban and Yates, 2004). Sensations and effects correlated with intense vestibular activation include nausea and vomiting and cardiac arrhythmia, blood pressure changes and breathing changes.

While these effects are induced by relatively intense stimulation, it is also true that A-weighted sound measurements attuned to auditory sensitivity, will underweight low frequencies for which the vestibular system is much more sensitive (Todd et al., 2008). Nevertheless, activation of the vestibular system *per se* obviously need not give rise to unpleasant sensations. It is not known what stimulus intensities are generally required for for autonomic activation at relatively low frequencies, and it is likely that there is considerable human variability and capacity to adapt to vestibular challenges.

B. Sound

1. Introduction

Sound is carried through air in compression waves of measurable frequency and amplitude. Sound can be tonal, predominating at a few frequencies, or it can contain a random mix of a broad range of frequencies and lack any tonal quality (white noise). Sound that is unwanted is called noise.

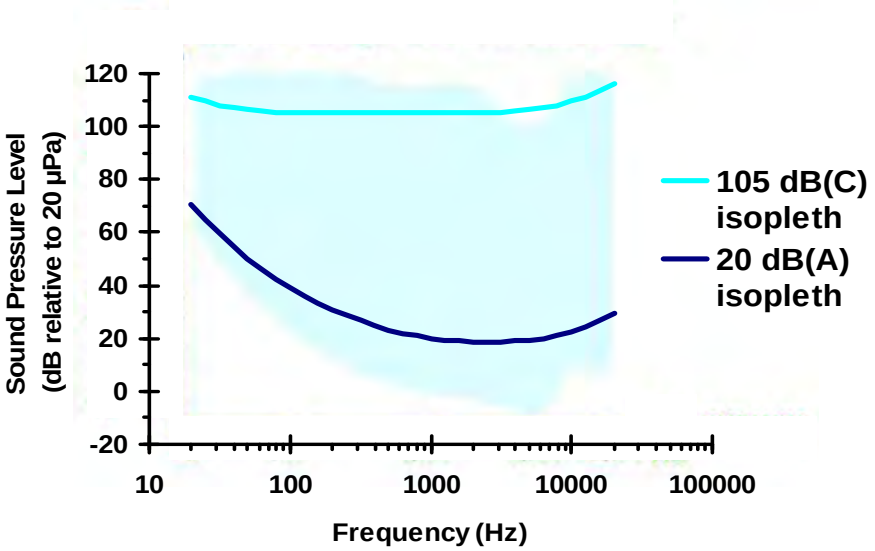
Audible Frequency Sound

Besides frequency sensitivity (between 20 and 20,000 Hz), humans are also sensitive to changes in the amplitude of the signal (compression waves) within this audible range of frequencies. Increasing amplitude, or increasing sound pressure, is perceived as increasing volume or loudness. The sound pressure level in air (SPL) is measured in micro Pascals (μPa). SPLs are typically converted in measuring instruments and reported as decibels (dB) which is a log scale, relative unit (see above). When used as the unit for sound, dBs are reported relative to a SPL of 20 μPa. Twenty μPa is used because it is the approximate threshold of human hearing sensitivity at about 1000 Hz. Decibels relative to 20 μPa are calculated from the following equation:

$$\text{Loudness (dB)} = \text{Log}\left(\left(\text{SPL} / 20\ \mu\text{Pa}\right)^2\right) * 10$$

Figure 4 shows the audible range of normal human hearing. Note that while the threshold sensitivity varies over the frequency range, at high SPLs sensitivity is relatively consistent over audible frequencies.

Figure 4: Audible Range of Human Hearing



Equivalence curves for different frequencies, when sound meter readings in dB are taken with A or C-weighting filters. (Adapted from EPD Hong Kong SAR, 2009)

Sub-Audible Frequency Sound

Sub-audible frequency sound is often called infrasound. It may be sensed by people, similar to audible sound, in the cochlear apparatus in the ear; it may be sensed by the vestibular system which is responsible for balance and physical equilibrium; or it may be sensed as vibration.

Resonance and modulation

Sound can be attenuated as it passes through a physical structure. However, because the wavelength of low frequency sound is very long (the wavelength of 40 Hz in air at sea level and room temperature is 8.6 meters or 28 ft), low frequencies are not effectively attenuated by walls and windows of most homes or vehicles. (For example, one can typically hear the bass, low frequency music from a neighboring car at a stoplight, but not the higher frequencies.) In fact, it is possible that there are rooms within buildings exposed to low frequency sound or noise where some frequencies may be amplified by resonance (e.g. ½ wavelength, ¼ wavelength) within the structure. In addition, low frequency sound can cause vibrations within a building at higher, more audible frequencies as well as throbbing or rumbling.

Sounds that we hear generally are a mixture of different frequencies. In most instances these frequencies are added together. However, if the source of the sound is not constant, but changes over time, the effect can be re-occurring pulses of sound or low frequency modulation of sound. This is the type of sound that occurs from a steam engine, a jack hammer, music and motor vehicle traffic. Rhythmic, low frequency pulsing of higher frequency noise (like the sound of an amplified heart beat) is one type of sound that can be caused by wind turbine blades under some conditions.

2. Human Response to Low Frequency Stimulation

There is no consensus whether sensitivity below 20 Hz is by a similar or different mechanism than sensitivity and hearing above 20 Hz (Reviewed by Møller and Pedersen, 2004). Possible mechanisms of sensation caused by low frequencies include bone conduction at the applied frequencies, as well as amplification of the base frequency and/or harmonics by the auditory apparatus (eardrum and ossicles) in the ear. Sensory thresholds are relatively continuous, suggesting (but not proving) a similar mechanism above and below 20 Hz. However, it is clear that cochlear sensitivity to infrasound (< 20 Hz) is considerably less than cochlear sensitivity to audible frequencies.

Møller and Pedersen (2004) reviewed human sensitivity at low and infrasonic frequencies. The following findings are of interest:

- When whole-body pressure-field sensitivity is compared with ear-only (earphone) sensitivity, the results are very similar. These data suggest that the threshold sensitivity for low frequency is through the ear and not vestibular.
- Some individuals have extraordinary sensitivity at low frequencies, up to 25 dB more sensitive than the presumed thresholds at some low frequencies.
- While population average sensitivity over the low frequency range is smooth, sound pressure thresholds of response for individuals do not vary smoothly but are inconsistent, with peaks and valleys or "microstructures". Therefore the sensitivity response of individuals to different low frequency stimulation may be difficult to predict.
- Studies of equal-loudness-levels demonstrate that as stimulus frequency decreases through the low frequencies, equal-loudness lines compress in the dB scale. (See Figure 4 as an example of the relatively small difference in auditory SPL range between soft and loud sound at low frequencies).
- The hearing threshold for pure tones is different than the hearing threshold for white noise at the same total sound pressure.

3. Sound Measurements

Sound measurements are taken by instruments that record sound pressure or the pressure of the compression wave in the air. Because the loudness of a sound to people is usually the primary interest in measuring sound, normalization schemes or filters have been applied to absolute measurements. dB(A) scaling of sound pressure measurements was intended to normalize readings to equal loudness over the audible range of frequencies at low loudness. For example, a 5,000 Hz (5 kHz) and 20 dB(A) tone is expected to have the same intensity or loudness as a 100 Hz, 20 dB(A) tone. However, note that the absolute sound pressures would be about 20,000 μPa and 40,000 μPa, respectively, or about a difference of 20 dB (relative to 20 μPa), or as it is sometimes written 20 dB(linear).

Most sound is not a single tone, but is a mixture of frequencies within the audible range. A sound meter can add the total SPLs for all frequencies; in other words, the dB readings over the entire spectrum of audible sound can be added to give a single loudness metric. If sound is reported as A-weighted, or dB(A), it is a summation of the dB(A) scaled sound pressure from 20 Hz to 20 kHz.

In conjunction with the dB(A) scale, the dB(B) scale was developed to approximate equal loudness to people across audible frequencies at medium loudness, and dB(C) was developed to approximate equal-loudness for loud environments. Figure 4 shows isopleths for 20 dB(A) and 105 dB(C). While dB(A), dB(B), dB(C) were developed from empirical data at the middle frequencies, at the ends of the curves these scales were extrapolated, or sketched in, and are not based on experimental or observational data (Berglund et al., 1996). As a result, data in the low frequency range (and probably the highest audible frequencies as well) cannot be reliably interpreted using these scales. The World Health Organization (WHO, 1999) suggests that A-weighting noise that has a large low frequency component is not reliable assessment of loudness.

The source of the noise, or the noise signature, may be important in developing equal-loudness schemes at low frequencies. C-weighting has been recommended for artillery noise, but a linear, unweighted scale may be even better at predicting a reaction (Berglund et al., 1996). A linear or equal energy rating also appears to be the most effective predictor of reaction to low frequency noise in other situations, including blast noise from mining. The implication of the analysis presented by Berglund et al. (1996) is that annoyance from non-tonal noise should not be estimated from a dB(A) scale, but may be better evaluated using dB(C), or a linear non-transformed scale.

However, as will be discussed below, a number of schemes use a modified dB(A) scale to evaluate low frequency noise. These schemes differ from a typical use of the dB(A) scale by addressing a limited frequency range below 250 Hz, where auditory sensitivity is rapidly changing as a function of frequency (see Figure 4).

III. Exposures of Interest

A. Noise From Wind Turbines

1. Mechanical noise

Mechanical noise from a wind turbine is sound that originates in the generator, gearbox, yaw motors (that intermittently turn the nacelle and blades to face the wind), tower ventilation system and transformer. Generally, these sounds are controlled in newer wind turbines so that they are a fraction of the aerodynamic noise. Mechanical noise from the turbine or gearbox should only be heard above aerodynamic noise when they are not functioning properly.

2. Aerodynamic noise

Aerodynamic noise is caused by wind passing over the blade of the wind turbine. The tip of a 40-50 meter blade travels at speeds of over 140 miles per hour under normal operating conditions. As the wind passes over the moving blade, the blade interrupts the laminar flow of air, causing turbulence and noise. Current blade designs minimize the amount of turbulence and noise caused by wind, but it is not possible to eliminate turbulence or noise.

Aerodynamic noise from a wind turbine may be underestimated during planning. One source of error is that most meteorological wind speed measurements noted in wind farm literature are taken at 10 meters above the ground. Wind speed above this elevation, in

the area of the wind turbine rotor, is then calculated using established modeling relationships. In one study (van den Berg, 2004) it was determined that the wind speeds at the hub at night were up to 2.6 times higher than modeled. Subsequently, it was found that noise levels were 15 dB higher than anticipated.

Unexpectedly high aerodynamic noise can also be caused by improper blade angle or improper alignment of the rotor to the wind. These are correctable and are usually adjusted during the turbine break-in period.

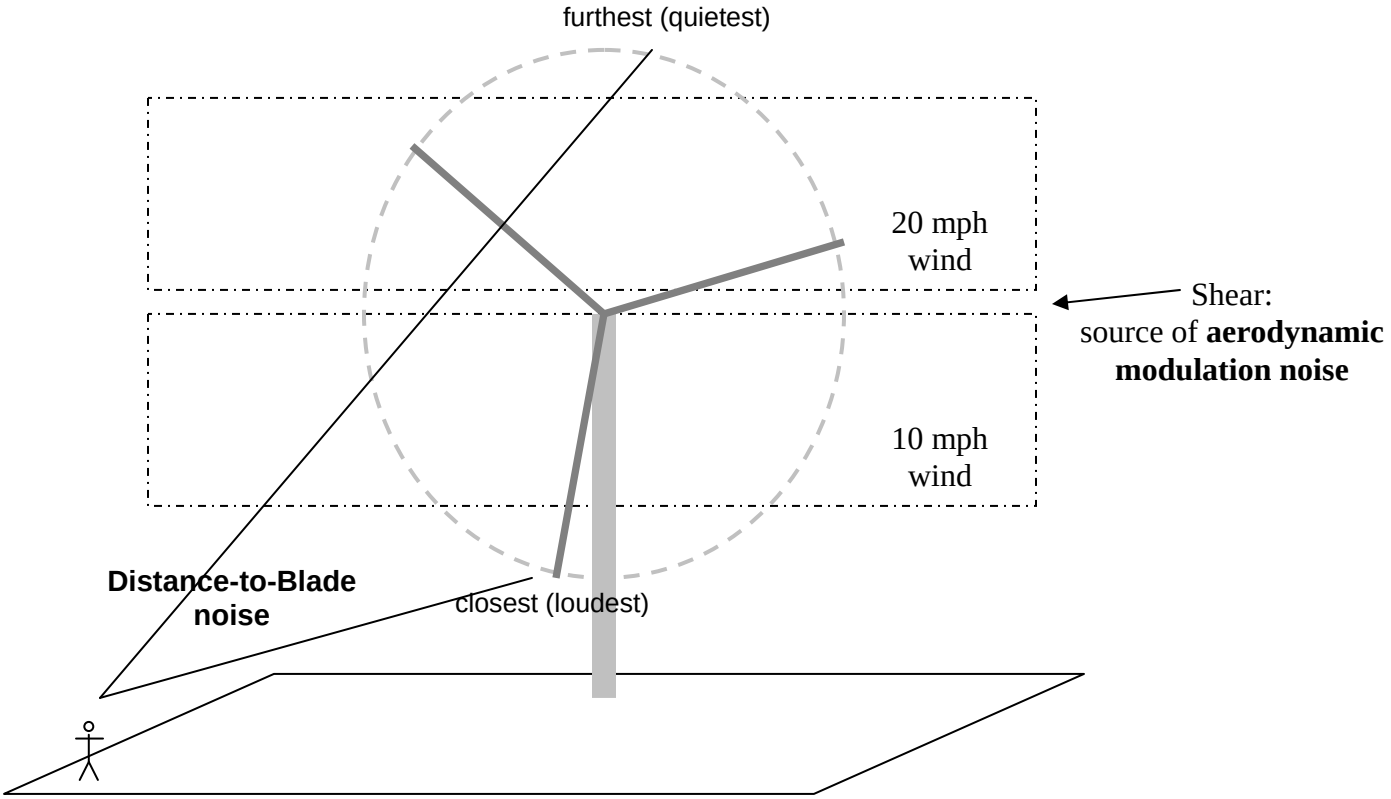
3. Modulation of aerodynamic noise

Rhythmic modulation of noise, especially low frequency noise, has been found to be more annoying than steady noise (Bradley, 1994; Holmberg et al., 1997). One form of rhythmic modulation of aerodynamic noise that can be noticeable very near to a wind turbine is a distance-to-blade effect. To a receptor on the ground in front of the wind turbine, the detected blade noise is loudest as the blade passes, and quietest when the blade is at the top of its rotation. For a modern 3-blade turbine, this distance-to-blade effect can cause a pulsing of the blade noise at about once per second (1 Hz). On the ground, about 500 feet directly downwind from the turbine, the distance-to-blade can cause a difference in sound pressure of about 2 dB between the *tip* of the blade at its farthest point and the *tip* of the blade at its nearest point (48 meter blades, 70 meter tower). Figure 5 demonstrates why the loudness of blade noise (aerodynamic noise) pulses as the distance-to-blade varies for individuals close to a turbine.

If the receptor is 500 feet from the turbine base, in line with the blade rotation or up to 60° off line, the difference in sound pressure from the *tip* of the blade at its farthest and nearest point can be about 4-5 dB, an audible difference. The tip travels faster than the rest of the blade and is closer to (and then farther away from) the receptor than other parts of the blade. As a result, noise from other parts of the blade will be modulated less than noise from the tip. Further, blade design can also affect the noise signature of a blade. The distance-to-blade effect diminishes as receptor distance increases because the relative difference in distance from the receptor to the top or to the bottom of the blade becomes smaller. Thus, moving away from the tower, distance-to-blade noise gradually appears to be more steady.

Another source of rhythmic modulation may occur if the wind through the rotor is not uniform. Blade angle, or pitch, is adjusted for different wind speeds to maximize power and to minimize noise. A blade angle that is not properly tuned to the wind speed (or wind direction) will make more noise than a properly tuned blade. Horizontal layers with different wind speeds or directions can form in the atmosphere. This wind condition is called shear. If the winds at the top and bottom of the blade rotation are different, blade noise will vary between the top and bottom of blade rotation, causing modulation of aerodynamic noise. This noise, associated with the blades passing through areas of different air-wind speeds, has been called aerodynamic modulation and is demonstrated in Figure 5.

Figure 5: Sources of noise modulation or pulsing



In some terrains and under some atmospheric conditions wind aloft, near the top of the wind turbine, can be moving faster than wind near the ground. Wind turbulence or even wakes from adjacent turbines can create non-uniform wind conditions as well. As a result of aerodynamic modulation a rhythmic noise pattern or pulsing will occur as each blade passes through areas with different wind speed. Furthermore, additional noise, or thumping, may occur as each blade passes through the transition between different wind speed (or wind direction) areas.

Wind shear caused by terrain or structures on the ground (e.g. trees, buildings) can be modeled relatively easily. Wind shear in areas of flat terrain is not as easily understood. During the daytime wind in the lower atmosphere is strongly affected by thermal convection which causes mixing of layers. Distinct layers do not easily form. However, in the nighttime the atmosphere can stabilize (vertically), and layers form. A paper by G.P. van den Berg (2008) included data from a study on wind shear at Cabauw, The Netherlands (flat terrain). Annual average wind speeds at different elevations above ground was reported. The annual average wind speed at noon was about 5.75 meters per second (m/s; approximately 12.9 miles per hour(mph)) at 20 m above ground, and about 7.6 m/s (17 mph) at 140 m. At midnight, the annual averages were about 4.3 m/s (9.6 mph) and 8.8 m/s (19.7 mph) for 20m and 140 m, respectively, above ground. The data show that while the average windspeed (between 20m and 140m) is very similar at noon and midnight at Cabauw, the windspeed difference between elevations during the day is

much less than the difference at night (1.85 m/s (4.1 mph) and 4.5 m/s (10 mph), respectively). As a result one would expect that the blade angle can be better tuned to the wind speed during the daytime. Consequently, blade noise would be greater at night.

A number of reports have included discussion of aerodynamic modulation (van den Berg, 2005; UK Department of Transport and Industry, 2006; UK Department for Business Enterprise and Regulatory Reform, 2007; van den Berg, 2008). They suggest that aerodynamic modulation is typically underestimated when noise estimates are calculated. In addition, they suggest that detailed modeling of wind, terrain, land use and structures may be used to predict whether modulation of aerodynamic noise will be a problem at a proposed wind turbine site.

4. Wind farm noise

The noise from multiple turbines similarly distant from a residence can be noticeably louder than a lone turbine simply through the addition of multiple noise sources. Under steady wind conditions noise from a wind turbine farm may be greater than noise from the nearest turbine due to synchrony between noise from more than one turbine (van den Berg, 2005). Furthermore, if the dominant frequencies (including aerodynamic modulation) of different turbines vary by small amounts, an audible beat or dissonance may be heard when wind conditions are stable.

B. Shadow Flicker

Rhythmic light flicker from the blades of a wind turbine casting intermittent shadows has been reported to be annoying in many locations (NRC, 2007; Large Wind Turbine Citizens Committee, 2008). (Note: Flashing light at frequencies around 1 Hz is too slow to trigger an epileptic response.)

Modeling conducted by the Minnesota Department of Health suggests that a receptor 300 meters perpendicular to, and in the shadow of the blades of a wind turbine, can be in the flicker shadow of the rotating blade for almost 1½ hour a day. At this distance a blade may completely obscure the sun each time it passes between the receptor and the sun. With current wind turbine designs, flicker should not be an issue at distances over 10 rotational diameters (~1000 meters or 1 km (0.6 mi) for most current wind turbines). This distance has been recommended by the Wind Energy Handbook (Burton et al., 2001) as a minimum setback distance in directions that flicker may occur, and has been noted in the Bent Tree Permit Application (WPL, 2008).

Shadow flicker is a potential issue in the mornings and evenings, when turbine noise may be masked by ambient sounds. While low frequency noise is typically an issue indoors, shadow flicker can be an issue both indoors and outdoors when the sun is low in the sky. Therefore, shadow flicker may be an issue in locations other than the home.

Ireland recommends wind turbines setbacks of at least 300 meters from a road to decrease driver distraction (Michigan State University, 2004). The NRC (2007) recommends that shadow flicker is addressed during the preliminary planning stages of a wind turbine project.

IV. Impacts of Wind Turbine Noise

A. Potential Adverse Reaction to Sound

Human sensitivity to sound, especially to low frequency sound, is variable. Individuals have different ranges of frequency sensitivity to audible sound; different thresholds for each frequency of audible sound; different vestibular sensitivities and reactions to vestibular activation; and different sensitivity to vibration.

Further, sounds, such as repetitive but low intensity noise, can evoke different responses from individuals. People will exhibit variable levels of annoyance and tolerance for different frequencies. Some people can dismiss and ignore the signal, while for others, the signal will grow and become more apparent and unpleasant over time (Moreira and Bryan, 1972; Bryan and Tempest, 1973). These reactions may have little relationship to will or intent, and more to do with previous exposure history and personality.

Stress and annoyance from noise often do not correlate with loudness. This may suggest, in some circumstances, other factors impact an individual's reaction to noise. A number of reports, cited in Staples (1997), suggest that individuals with an interest in a project and individuals who have some control over an environmental noise are less likely to find a noise annoying or stressful.

Berglund et al. (1996) reviewed reported health effects from low frequency noise. Loud noise from any source can interfere with verbal communication and possibly with the development of language skills. Noise may also impact mental health. However, there are no studies that have looked specifically at the impact of low frequency noise on communication, development of language skills and mental health. Cardiovascular and endocrine effects have been demonstrated in studies that have looked at exposures to airplane and highway noise. In addition, possible effects of noise on performance and cognition have also been investigated, but these health studies have not generally looked at impacts specifically from low frequency noise. Noise has also been shown to impact sleep and sleep patterns, and one study demonstrated impacts from low frequency noise in the range of 72 to 85 dB(A) on chronic insomnia (Nagai et al., 1989 as reported in Berglund et al., 1996).

Case studies have suggested that health can be impacted by relatively low levels of low frequency noise. But it is difficult to draw general conclusions from case studies. Feldmann and Pitten (2004)) describe a family exposed during the winter to low frequency noise from a nearby heating plant. Reported health impacts were: "indisposition, decrease in performance, sleep disturbance, headache, ear pressure, crawl parästhesy [crawling, tingling or numbness sensation on the skin] or shortness of breath."

Annoyance, unpleasant sounds, and complaints

Reported health effects from low frequency stimulation are closely associated with annoyance from audible noise. "There is no reliable evidence that infrasounds below the hearing threshold produce physiological or psychological effects" (WHO, 1999). It has not been shown whether annoyance is a symptom or an accessory in the causation of

health impacts from low frequency noise. Studies have been conducted on some aspects of low frequency noise that can cause annoyance.

Noise complaints are usually a reasonable measure of annoyance with low frequency environmental noise. Leventhall (2004) has reviewed noise complaints and offers the following conclusions:

> " The problems arose in quiet rural or suburban environments
> The noise was often close to inaudibility and heard by a minority of people
> The noise was typically audible indoors and not outdoors
> The noise was more audible at night than day
> The noise had a throb or rumble characteristic
> The main complaints came from the 55-70 years age group
> The complainants had normal hearing.
> Medical examination excluded tinnitus.
>
> " These are now recognised as classic descriptors of low frequency noise problems."

These observations are consistent with what we know about the propagation of low intensity, low frequency noise. Some people are more sensitive to low frequency noise. The difference, in dB, between soft (acceptable) and loud (annoying) noise is much less at low frequency (see Figure 4 audible range compression). Furthermore, during the daytime, and especially outdoors, annoying low frequency noise can be masked by high frequency noise.

The observation that "the noise was typically audible indoors and not outdoors" is not particularly intuitive. However, as noted in a previous section, low frequencies are not well attenuated when they pass through walls and windows. Higher frequencies (especially above 1000 Hz) can be efficiently attenuated by walls and windows. In addition, low frequency sounds may be amplified by resonance within rooms and halls of a building. Resonance is often characterized by a throbbing or a rumbling, which has also been associated with many low frequency noise complaints.

Low frequency noise, unlike higher frequency noise, can also be accompanied by shaking, vibration and rattling. In addition, throbbing and rumbling may be apparent in some low frequency noise. While these noise features may not be easily characterized, numerous studies have shown that their presence dramatically lowers tolerance for low frequency noise (Berglund et al., 1996).

As reviewed in Leventhall (2003), a study of industrial exposure to low frequency noise found that fluctuations in total noise averaged over 0.5, 1.0 and 2.0 seconds correlated with annoyance (Holmberg et al., 1997). This association was noted elsewhere and led (Broner and Leventhall, 1983) to propose a 3dB "penalty" be added to evaluations of annoyance in cases where low frequency noise fluctuated.

In another laboratory study with test subjects controlling loudness, 0.5 – 4 Hz modulation of low frequency noise was found to be more annoying than non-modulated low

frequency noise. On average test subjects found modulated noise to be similarly annoying as a constant tone 12.9 dB louder (Bradley, 1994).

B. Studies of Wind Turbine Noise Impacts on People

1. Swedish Studies

Two studies in Sweden collected information by questionnaires from 341 and 754 individuals (representing response rates of 68% and 58%, respectively), and correlated responses to calculated exposure to noise from wind farms (Pedersen and Waye, 2004; Pedersen, 2007; Pedersen and Persson, 2007). Both studies showed that the number of respondents perceiving the noise from the wind turbines increased as the calculated noise levels at their homes increased from less than 32.5 dB(A) to greater than 40 dB(A). Annoyance appeared to correlate or trend with calculated noise levels. Combining the data from the two studies, when noise measurements were greater than 40 dB(A), about 50% of the people surveyed (22 of 45 people) reported annoyance. When noise measurements were between 35 and 40 dB(A) about 24% reported annoyance (67 of 276 people). Noise annoyance was more likely in areas that were rated as quiet and in areas where turbines were visible. In one of the studies, 64% respondents who reported noise annoyance also reported sleep disturbance; 15% of respondents reported sleep disturbance without annoyance.

2. United Kingdom Study

Moorhouse et al. (UK Department for Business Enterprise and Regulatory Reform, 2007) evaluated complaints about wind farms. They found that 27 of 133 operating wind farms in the UK received formal complaints between 1991 and 2007. There were a total of 53 complainants for 16 of the sites for which good records were available. The authors of the report considered that many complaints in the early years were for generator and gearbox noise. However, subjective analyses of reports about noise ("like a train that never gets there", "distant helicopter", "thumping", "thudding", "pulsating", "thumping", "rhythmical beating", and "beating") suggested that aerodynamic modulation was the likely cause of complaints at 4 wind farms. The complaints from 8 other wind farms may have had "marginal" association with aerodynamic modulation noise.

Four wind farms that generated complaints possibly associated with aerodynamic modulation were evaluated further. These wind farms were commissioned between 1999 and 2002. Wind direction, speed and times of complaints were associated for 2 of the sites and suggested that aerodynamic modulation noise may be a problem between 7% and 25% of the time. Complaints at 2 of the farms have stopped and at one farm steps to mitigate aerodynamic modulation (operational shutdown under certain meteorological conditions) have been instituted.

3. Netherlands Study

F. van den Berg et al. (2008) conducted a postal survey of a group selected from all residents in the Netherlands within 2.5 kilometers (km) of a wind turbine. In all, 725 residents responded (37%). Respondents were exposed to sound between 24 and 54 dB(A). The percentage of respondents annoyed by sound increased from 2% at levels of 30 dB(A) or less, up to 25% at between 40 and 45 dB. Annoyance decreased above 45 dB. Most residents exposed above 45 dB(A) reported economic benefits from the

turbines. However, at greater than 45 dB(A) more respondents reported sleep interruption. Respondents tended to report more annoyance when they also noted a negative effect on landscape, and ability to see the turbines was strongly related to the probability of annoyance.

4. Case Reports

A number of un-reviewed reports have catalogued complaints of annoyance and some more severe health impacts associated with wind farms. These reports do not contain measurements of noise levels, and do not represent random samples of people living near wind turbines, so they cannot assess prevalence of complaints. They do generally show that in the people surveyed, complaints are more likely the closer people are to the turbines. The most common complaint is decreased quality of life, followed by sleep loss and headache. Complaints seem to be either from individuals with homes quite close to turbines, or individuals who live in areas subject to aerodynamic modulation and, possibly, enhanced sound propagation which can occur in hilly or mountainous terrain. In some of the cases described, people with noise complaints also mention aesthetic issues, concern for ecological effects, and shadow flicker concerns. Not all complaints are primarily about health.

Harry (2007) describes a meeting with a couple in Cornwall, U.K. who live 400 meters from a wind turbine, and complained of poor sleep, headaches, stress and anxiety. Harry subsequently investigated 42 people in various locations in the U.K. living between 300 meters and 2 kilometers (1000 feet to 1.2 miles) from the nearest wind turbine. The most frequent complaint (39 of 42 people) was that their quality of life was affected. Headaches were reported by 27 people and sleep disturbance by 28 people. Some people complained of palpitations, migraines, tinnitus, anxiety and depression. She also mentions correspondence and complaints from people in New Zealand, Australia, France, Germany, Netherlands and the U.S.

Phipps (2007) discusses a survey of 619 households living up to 10 kilometers (km; 6 miles) from wind farms in mountainous areas of New Zealand. Most respondents lived between 2 and 2.5 km from the turbines (over 350 households). Most respondents (519) said they could see the turbines from their homes, and 80% of these considered the turbines intrusive, and 73% considered them unattractive. Nine percent said they were affected by flicker. Over 50% of households located between 2 and 2.5 km and between 5 and 9.5 km reported being able to hear the turbines. In contrast, fewer people living between 3 and 4.5 km away could hear the turbines. Ninety-two households said that their quality of life was affected by turbine noise. Sixty-eight households reported sleep disturbances: 42 of the households reported occasional sleep disturbances, 21 reported frequent sleep disturbances and 5 reported sleep disturbances most of the time.

The Large Wind Turbine Citizens Committee for the Town of Union (2008) documents complaints from people living near wind turbines in Wisconsin communities and other places in the U.S. and U.K. Contained in this report is an older report prepared by the Wisconsin Public Service Corporation in 2001 in response to complaints in Lincoln County, Wisconsin. The report found essentially no exceedances of the 50 dB(A) requirement in the conditional use permit. The report did measure spectral data

accumulated over very short intervals (1 minute) in 1/3 octave bands at several sites while the wind turbines were functioning, and it is of interest that at these sites the sound pressure level at the lower frequencies (below 125 Hz) were at or near 50 dB(A).

Pierpont (2009) postulates wind turbine syndrome, consisting of a constellation of symptoms including headache, tinnitus, ear pressure, vertigo, nausea, visual blurring, tachycardia, irritability, cognitive problems and panic episodes associated with sensations of internal pulsation. She studied 38 people in 10 families living between 1000 feet and slightly under 1 mile from newer wind turbines. She proposes that the mechanism for these effects is disturbance of balance due to "discordant" stimulation of the vestibular system, along with visceral sensations, sensations of vibration in the chest and other locations in the body, and stimulation of the visual system by moving shadows. Pierpont does report that her study subjects maintain that their problems are caused by noise and vibration, and the most common symptoms reported are sleep disturbances and headache. However, 16 of the people she studied report symptoms consistent with (but not necessarily caused by) disturbance of equilibrium.

V. Noise Assessment and Regulation

1. Minnesota noise regulation

The Minnesota Noise Pollution Control Rule is accessible online at: https://www.revisor.leg.state.mn.us/rules/?id=7030 . A summary of the Minnesota Pollution Control Agency (MPCA) noise guidance can be found online at: http://www.pca.state.mn.us/programs/noise.html . The MPCA standards require A-weighting measurements of noise; background noise must be at least 10 dB lower than the noise source being measured. Different standards are specified for day and night, as well as standards that may not be exceeded for more than 10 percent of the time during any hour (L10) and 50 percent of the time during any hour (L50). Household units, including farm houses, are Classification 1 land use. The following are the Class 1 noise limits:

Table 1: Minnesota Class 1 Land Use Noise Limits

Daytime		Nighttime	
L50	L10	L50	L10
60 dB(A)	65 dB(A)	50 dB(A)	55 dB(A)

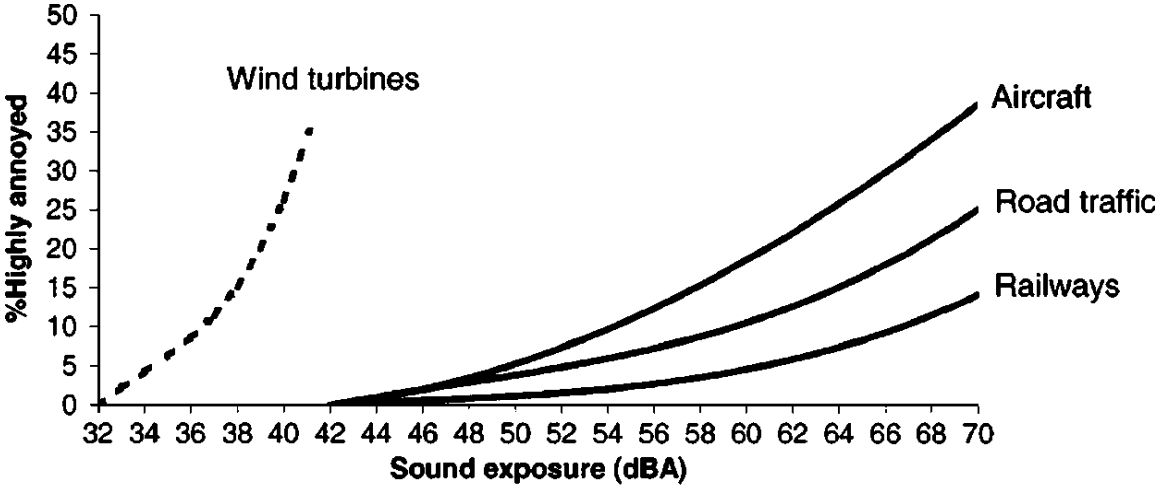
These noise limits are single number limits that rely on the measuring instrument to apply an A-weighting filter over the entire presumed audible spectrum of frequencies (20 Hz to 20 KHz) and then integrating that signal. The result is a single number that characterizes the audible spectrum noise intensity.

2. Low frequency noise assessment and regulation

Pedersen and Waye (2004) looked at the relationship between total dB(A) sound pressure and the annoyance of those who are environmentally exposed to noise from different sources. Figure 6 demonstrates the difficulty in using total dB(A) to evaluate annoyance. Note how lower noise levels (dB(A)) from wind turbines engenders annoyance similar to

much higher levels of noise exposure from aircraft, road traffic and railroads. Sound impulsiveness, low frequency noise and persistence of the noise, as well as demographic characteristics may explain some of the difference.

Figure 6: Annoyance associated with exposure to different environmental noises



Reprinted with permission from Pedersen, E. and K.P. Waye (2004). Perception and annoyance due to wind turbine noise—a dose–response relationship. The Journal of the Acoustical Society of America 116: 3460. Copyright 2004, Acoustical Society of America.

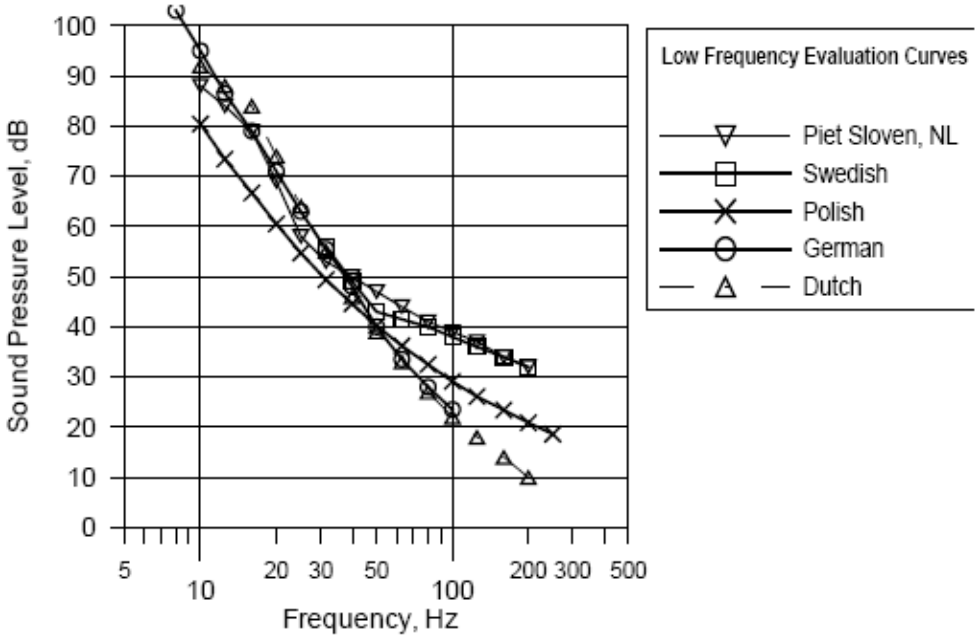
Kjellberg et al. (1997) looked at the ability of different full spectrum weighting schemes to predict annoyance caused by low frequency audio noise. They found that dB(A) is the worst predictor of annoyance of available scales. However, if 6 dB ("penalty") is added to dB(A) when dB(C) – dB(A) is greater than 15 dB, about 71% of the predictions of annoyance are correct. It is important to remember that integrated, transformed measurements of SPL (e.g. dB(A), dB(C)) do not measure frequencies below 20 Hz. While people detect stimuli below 20 Hz, as discussed in above sections, these frequencies are not measured using an A-weighted or C-weighted meter.

The World Health Organization (WHO) recommends that if dB(C) is greater than 10 dB more than dB(A), the low frequency components of the noise may be important and should be evaluated separately. In addition, WHO says "[i]t should be noted that a large proportion of low-frequency components in noise may increase considerably the adverse effects on health." (WHO, 1999)

Many governments that regulate low frequency noise look at noise within bands of frequencies instead of summing the entire spectrum. A study by Poulsen and Mortensen (Danish Environmental Protection Agency, 2002) included a summary of low frequency noise guidelines. German, Swedish, Polish, and Dutch low frequency evaluation curves were compared (see Figure 7). While there are distinctions in how the evaluation curves are described, generally, these curves are sound pressure criterion levels for 1/3 octaves from about 8 Hz to 250 Hz. Exceedance in any 1/3 octave measurement suggests that the noise may be annoying. However, note that regulations associated with low frequency

noise can be quite complex and the regulatory evaluations associated with individual curves can be somewhat different.

Figure 7: 1/3 Octave Sound Pressure Level Low frequency Noise Evaluation Curves



(Danish Environmental Protection Agency, 2002)

The Danish low frequency evaluation requires measuring noise indoors with windows closed; SPL measurements are obtained in 1/3 octave bands and transformed using the A-weighting algorithm for all frequencies between 10 and 160 Hz. These values are then summed into a single metric called $L_{pA,LF}$. A 5 dB "penalty" is added to any noise that is "impulsive". Danish regulations require that 20 dB $L_{pA,LF}$ is not exceeded during the evening and night, and that 25 dB $L_{pA,LF}$ is not exceeded during the day.

Swedish guidance recommends analyzing 1/3 octave bands between 31.5 and 200 Hz inside a home, and comparing the values to a Swedish assessment curve. The Swedish curve is equal to the United Kingdom (UK) Department of Environment, Food and Rural Affairs (DEFRA) low frequency noise criterion curve for overlapping frequencies (31.5 – 160 Hz).

The German "A-level" method sums the A-weighted equivalent levels of 1/3 octave bands that exceed the hearing threshold from 10 – 80 Hz. If the noise is not tonal, the measurements are added. The total cannot exceed 25 dB at night and 35 dB during the day. A frequency-dependent adjustment is applied if the noise is tonal.

In the Poulsen and Mortensen, Danish EPA study (2002), 18 individuals reported annoyance levels when they were exposed through earphones in a controlled environment to a wide range of low frequency environmental noises, all attenuated down to 35 dB, as depicted in Table 2. Noise was simulated as if being heard indoors, filtering out noise at

higher frequencies and effectively eliminating all frequencies above 1600 Hz. Noise levels in 1/3 octave SPLs from 8 Hz to 1600 Hz were measured and low frequencies (below 250 Hz) were used to predict annoyance using 7 different methods (Danish, German A-level, German tonal, Swedish, Polish, Sloven, and C-level). Predictions of annoyance were compared with the subjective annoyance evaluations. Correlation coefficients for these analyses ranged from 0.64 to 0.94, with the best correlation in comparison with the Danish low frequency noise evaluation methods.

As would be expected, at 35 dB nominal (full spectrum) loudness, every low frequency noise source tested exceeded all of the regulatory standards noted in the Danish EPA report. Table 2 shows the Danish and Swedish regulatory exceedances of the different 35 dB nominal (full spectrum) noise.

Table 2: 35 dB(A) (nominal, 8 Hz-20KHz) Indoor Noise from Various Outdoor Environmental Sources

	Traffic Noise	Drop Forge	Gas Turbine	Fast Ferry	Steel Factory	Generator	Cooling Compressor	Discotheque
Noise	67.6 dB(lin)	71.1 dB(lin)	78.4 dB(lin)	64.5 dB(lin)	72.7 dB(lin)	60.2 dB(lin)	60.3 dB(lin)	67.0 dB(lin)
Noise ≥ 20 Hz	35.2 dB(A)	36.6 dB(A)	35.0 dB(A)	35.1 dB(A)	33.6 dB(A)	36.2 dB(A)	36.6 dB(A)	33.6 dB(A)
	62.9 dB(C)	67.3 dB(C)	73.7 dB(C)	61.7 dB(C)	66.0 dB(C)	58.6 dB(C)	59.0 dB(C)	57.8 dB(C)
Danish Environmental Protection Agency	14.5 dB	21.5 dB *	14.8 dB	15.0 dB	13.1 dB	16.1 dB	14.0 dB	18.0 dB *
Swedish National Board of Health and Welfare	14.1 dB	19.7 dB	15.9 dB	16.8 dB	15.5 dB	18.3 dB	16.0 dB	10.0 dB
* includes 5 dB "penalty"								

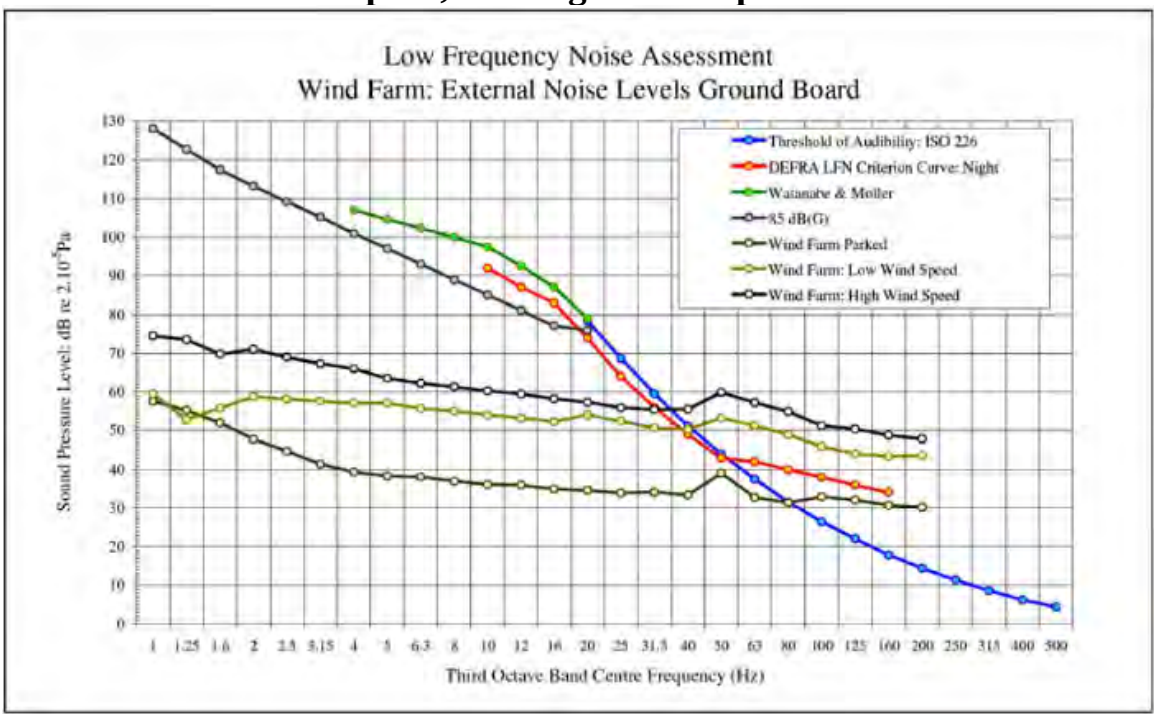
Noise adjusted to dB(lin), dB(A), dB(C) scales. Calculated exceedances of Danish and Swedish indoor criteria. (data from Danish Environmental Protection Agency, 2002)

In their noise guidance, the WHO (1999) recommends 30 dB(A) as a limit for “a good night’s sleep”. However, they also suggest that guidance for noise with predominating low frequencies be less than 30 dB(A).

3. Wind turbine sound measurements

Figure 8 shows examples of the SPLs at different frequencies from a representative wind turbine in the United Kingdom. Sound pressure level measurements are reported for a Nordex N-80 turbine at 200 meters (UK Department of Transport and Industry, 2006) when parked, at low wind speeds, and at high wind speeds. Figure 8 also includes, for reference, 3 sound threshold curves (ISO 226, Watanabe & Moller, 85 dB(G)) and the DEFRA Low Frequency Noise Criterion Curve (nighttime).

Figure 8: Low Frequency Noise from Wind Farm: Parked, Low Wind Speed, and High Wind Speed

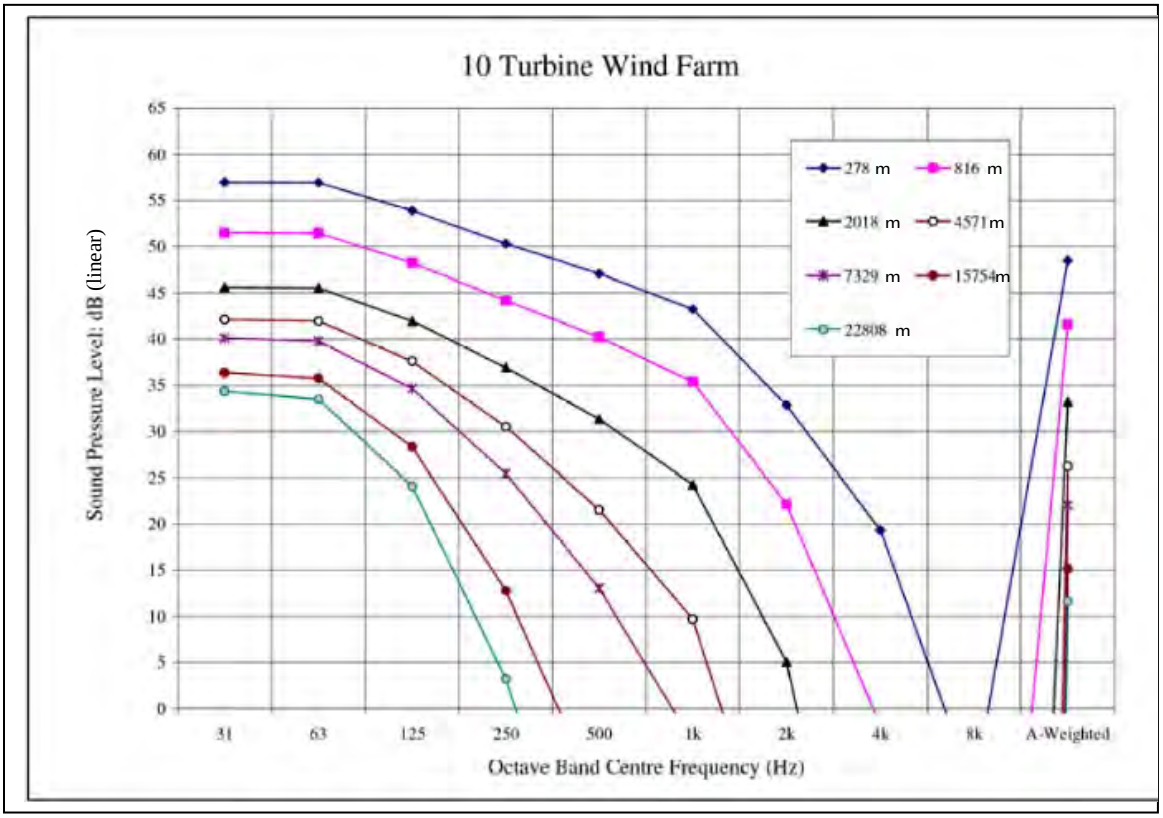


(UK Department of Transport and Industry, 2006)

In general, sound tends to propagate as if by spherical dispersion. This creates amplitude decay at a rate of about -6 dB per doubling of distance. However, low frequency noise from a wind turbine has been shown to follow more of a cylindrical decay at long distances, about -3 dB per doubling of distance in the downwind direction (Shepherd and Hubbard, 1991). This is thought to be the result of the lack of attenuation of low frequency sound waves by air and the atmospheric refraction of the low frequency sound waves over medium to long distances (Hawkins, 1987).

Figure 9 shows the calculated change in spectrum for a wind farm from 278 meters to 22,808 meters distant. As one moves away from the noise source, loudness at higher frequencies decreases more rapidly (and extinguishes faster) than at lower frequencies. Measurement of A-weighted decibels, shown at the right of the figure, obscures this finding.

Figure 9: Change in Noise Spectrum as Distance from Wind Farm Changes



(UK Department of Transport and Industry, 2006)

Thus, although noise from an upwind blade wind turbine is generally broad spectrum, without a tonal quality, high frequencies are efficiently attenuated by both the atmosphere, and by walls and windows of structures, as noted above. As a result, as one moves away from a wind turbine, the low frequency component of the noise becomes more pronounced.

Kamperman and James (2008) modeled indoor noise from outdoor wind turbine noise measurements, assuming a typical vinyl siding covered 2X4 wood frame construction. The wind turbine noise inside was calculated to be 5 dB less than the noise outside. Model data suggested that the sound of a single 2.5 MW wind turbine at 1000 feet will likely be heard in a house with the windows sealed. They note that models used for siting turbines often incorporate structure attenuation of 15dB. In addition, Kamperman and James demonstrate that sound from 10 2.5 MW turbines (acoustically) centered 2 km (1¼ mile) away and with the nearest turbine 1 mile away will only be 6.3 dB below the sound of a single turbine at 1000 feet (0.19 mile).

4. Wind turbine regulatory noise limits

Ramakrishnan (2007) has reported different noise criteria developed for wind farm planning. These criteria include common practices (if available) within each jurisdiction for estimating background SPLs, turbine SPLs, minimum setbacks and methods used to

assess impacts. Reported US wind turbine noise criteria range from: ambient + 10 dB(A) where ambient is assumed to be 26 dB(A) (Oregon); to 55 dB(A) or “background” + 5 dB(A) (Michigan). European criteria range from 35 dB(A) to 45 dB(A), at the property. US setbacks range from 1.1 times the full height of the turbine (consenting) and 5 times the hub height (non-consenting; Pennsylvania); to 350 m (consenting) and 1000 m (non-consenting; Oregon). European minimum setbacks are not noted.

VI. Conclusions

Wind turbines generate a broad spectrum of low-intensity noise. At typical setback distances higher frequencies are attenuated. In addition, walls and windows of homes attenuate high frequencies, but their effect on low frequencies is limited. Low frequency noise is primarily a problem that may affect some people in their homes, especially at night. It is not generally a problem for businesses, public buildings, or for people outdoors.

The most common complaint in various studies of wind turbine effects on people is annoyance or an impact on quality of life. Sleeplessness and headache are the most common health complaints and are highly correlated (but not perfectly correlated) with annoyance complaints. Complaints are more likely when turbines are visible or when shadow flicker occurs. Most available evidence suggests that reported health effects are related to audible low frequency noise. Complaints appear to rise with increasing outside noise levels above 35 dB(A). It has been hypothesized that direct activation of the vestibular and autonomic nervous system may be responsible for less common complaints, but evidence is scant.

The Minnesota nighttime standard of 50 dB(A) not to be exceeded more than 50% of the time in a given hour, appears to underweight penetration of low frequency noise into dwellings. Different schemes for evaluating low frequency noise, and/or lower noise standards, have been developed in a number of countries.

For some projects, wind velocity for a wind turbine project is measured at 10 m and then modeled to the height of the rotor. These models may under-predict wind speed that will be encountered when the turbine is erected. Higher wind speed will result in noise exceeding model predictions.

Low frequency noise from a wind turbine is generally not easily perceived beyond ½ mile. However, if a turbine is subject to aerodynamic modulation because of shear caused by terrain (mountains, trees, buildings) or different wind conditions through the rotor plane, turbine noise may be heard at greater distances.

Unlike low frequency noise, shadow flicker can affect individuals outdoors as well as indoors, and may be noticeable inside any building. Flicker can be eliminated by placement of wind turbines outside of the path of the sun as viewed from areas of concern, or by appropriate setbacks.

Prediction of complaint likelihood during project planning depends on: 1) good noise modeling including characterization of potential sources of aerodynamic modulation noise and characterization of nighttime wind conditions and noise; 2) shadow flicker modeling; 3) visibility of the wind turbines; and 4) interests of nearby residents and community.

VII. Recommendations

To assure informed decisions:

- Wind turbine noise estimates should include cumulative impacts (40-50 dB(A) isopleths) of all wind turbines.
- Isopleths for dB(C) - dB(A) greater than 10 dB should also be determined to evaluate the low frequency noise component.
- Potential impacts from shadow flicker and turbine visibility should be evaluated.

Any noise criteria beyond current state standards used for placement of wind turbines should reflect priorities and attitudes of the community.

VIII. Preparers of the Report:

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EXHIBIT D

Direct Testimony of Rick James, INCE
for Goodhue Wind Truth

PUC Docket IP-6701/WS-08-1233

STATE OF MINNESOTA

OFFICE OF ADMINISTRATIVE HEARINGS

FOR THE

PUBLIC UTILITIES COMMISSION

In the Matter of the Application of Goodhue Wind, LLC	Dockets: IP-6701/WS-08-1233
For a Certificate of Need for a 78 MW Wind Project	IP-6701/CN-09-1186
(Goodhue Wind Project) and Associated Facilities in	
Goodhue County, Minnesota	

GOODHUE WIND TRUTH

TESTIMONY OF RICHARD JAMES, INCE

EXHIBIT RJ-01

I. INTRODUCTION

Q: **Would you please summarize the testimony you are presenting?**

A: Yes. My name is Richard R. James, and I have been asked to prepare comments on the setbacks under consideration by the PUC on behalf of Goodhue Wind Truth.

For the past three years I have been working with local communities and citizens groups around the Midwest to address questions of how to integrate industrial wind turbines into rural communities. I would like to share with you my concerns about siting criteria for modern industrial scale wind turbines.

Over the past two years I have visited sites throughout the Midwest from western Iowa to the coast of Maine and Ontario to West Virginia with wind turbines. I have also reviewed the noise criteria and setbacks proposed by States, Provinces and local government bodies for wind farms. I find three sections have a particular importance for my testimony.

In my testimony, I focus on several points:

First, setbacks, from property lines to the nearest turbine of 1500 feet are clearly inadequate. Wind turbine noise is distinctively annoying. The Environmental Report does not correctly or adequately describe the impact of the proposed project on the host community and the residents whose homes and properties are close to or within the footprint of the project. People living at distances up to 1 mile or further from wind turbines are experiencing adverse health effects from sleep disturbance at night and from other aspects of wind turbine sound emissions that are currently believed to be caused by vestibular disturbances from infra and low frequency sound.

Second, background sound levels submitted on behalf of background sound levels

which include a ‘wind noise’ component result in a biased assessment of background sound levels. Further, the original Background Sound studies do not adequately define the background sound levels and characteristics of wind turbine noise for purposes of making decisions on location with respect to homes and properties.

Third, computer model estimates of operational sound levels from the proposed projects understate the impact of the turbines on the community.

Fourth, information provided by AWA Goodhue Wind in their application and as Comments, Appendices, and Figures, and references to studies and opinion papers on topics of health risks, infra and low frequency noise, noise limits and setbacks, background sounds in rural communitiesand computer modeling studies by Dr. Geoff Leventhal and others is misleading. Their assertions that there is no research supporting a causal link between wind turbine sound emissions at receiving properties and homes and health effects do not reflect current understanding of thresholds of perception and mechanisms whereby such perception can occur by experts who are not working for the wind industry.

The combination of the above negative factors related to wind turbine noise emissions will result in sleep disturbance for a significant fraction of those who live within a mile away and chronic sleep disturbance results in serious health effects.

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

I have reviewed the application of AWA Goodhue Wind and the Draft Permit proposed by the Office of Energy Security. I have also given cursory review to the Applicant’s prefiled

Comments, Appendices and Figures filed Friday, July 16, 2010, in particular the HDR report, and will have additional comments specific to those documents at the hearing. My experience with industrial wind projects leads me to conclude that siting criteria more lenient than those recommended by WHO's 40 dBA limit for avoiding health risks, such as the 45 to 55 dBA typically suggested by Applicants, and those used by the Minnesota Public Utilities Commission, will result in a high level of community complaints of both noise pollution and nuisance. In addition, there is mounting evidence that for the more sensitive members of your community, especially children under six, people with pre-existing medical conditions, particularly diseases of the vestibular system, the organs of balance, and seniors will be likely to experience serious health risks. The Minnesota Public Utilities Commission reviews Large Wind Energy Conversion Systems on a case by case basis and often attach conditions to permits. I will propose conditions in modification of the Draft Permit that would help alleviate these problems.

II. BACKGROUND AND C.V.

Q: **What is your professional background and training?**

A: I am a noise control consultant and an acoustical consultant, and I have been since 1971. I have a background in mechanical engineering. My Degree is from General Motors Institute, which is an accredited engineering college. As background, when I was going to college, that was at the ime when the EPA and a lot of the other noise issues were coming to a head. General Motors wanted to educate a limited number of engineers in the necessary issues, and that was the curriculum that I took. There were about ten of us. I graduated in 1971, with a Bachelor's in Mechanical Engineering with a focus on noise control engineering. Please see my C.V. attached.

Since 1973. after about six (6) years working for Chevrolet as Noise Control Engineer, I left GM to form my own company, Total Environmental Systems. Later, my partner in the first firm and I changed the name to James, Anderson and Associates, Inc. Currently, I'm working as an independent consultant under the name E-coustic Solutions.

Q: Do you have any teaching experience?

A: For the last 20 years or so, I have been teaching both at Michigan State University in their Speech and Communicative Disorders Department on the issues of noise and how it relates to speech Sciences. I've also taught at General Motors University. There, Itaught noise control and safety and health issues to almost all of my clients' Health and Safety Engineers. Noise control relating both to community noise issues and in-plant noise issues. Also have been an instructor for the American Industrial Hygiene Association, Michigan Department of Public Health, and a number of other groups on the issues of noise.

Q: **You use the abbreviation "INCE" after your name. What does that mean?**

A: Institute of Noise Control Engineer

Q. **On how many occasions have you testified as an expert in administrative hearings concerning noise?**

A. I have testified in over 15 administrative hearings as an expert in acoustical engineering on behalf of such companies as General Motors, Ford, and Chrysler held by the Occupational Safety and Health Administration. The purpose of my testimony in these cases was directed towards the limits of feasibility of engineering controls and to establish that my clients were taking the necessary administrative and medical/safety precautions to protect their employees from the adverse health effects of occupational noise exposure. I have also testified in approximately 10 to 12 administrative hearings considering applications by wind power

companies to install wind powered electrical generating utilities. The subject matter of my testimony in these cases was to review and comment upon the noise studies conducted on behalf of the wind developer by its acoustical consultants, to present my research and recommendations for whether the wind project would result in nighttime sleep disturbance and other adverse health effects from the turbine's noise emissions, and to state my recommendations for criteria that would limit wind turbine noise to a level that would not be likely to cause adverse health effects.

Q: **Are you a medical doctor?**

A: I am not a medical doctor. Acoustical engineers must understand enough to read and use medical research related to noise and health, but that does not make us medical doctors. That is why I review these issues with other Doctors, such as Doctors Nina Pierpont, Robert McMurtry, Michael Nissenbaum, Jerry Punch, and Alec Salt, to determine what a medical doctor would understand about the health impacts of noise issues related to wind turbines. Because I am not a medical doctor, I rely on the international standards and other international documents from groups such as the World Health Organization. This is common in my profession, for example, Dr.Geoff Leventhall, who is often quoted on health issues related to wind turbines on behalf of the wind industry, has no more medical training than do I!

Q: **What work experience do you have with noise-related issues?**

A: I have focused on noise and health since 1971. As President of James, Anderson & Assoc., we were the tier one supplier of noise control engineer services for General Motors, John Deere, Navistar….. almost all of the large companies. We did all of their noise work, including all their community noise work for the period from about 1976 forward to the present. I have been involved in a lot of issues, siting of new plants, doing the studies to identify whether communities are compatible, and I also started out with a very strong interest in computer

modeling, which has been applied to my clients' project. During some peak periods, we had a staff of 45 working on only noise related issues for our client's facilities not only in the U.S. but also in Canada and Mexico.

Q: **Please tell us about your computer noise-modeling experience?**

A: When I was a young engineer, computers were not yet one of the tools that we used for applied engineering. They were research tools, but I saw their use in modeling as an opportunity to apply them to practical problems. My graduation thesis was on the formulas and methods that are used for computer modeling for industrial facilities. At that time there were no standards, so we really had to rely on some very preliminary work. Models I developed were used in federal hearings on engineering feasibility of noise controls in 1976, in OSHA and EPA cases, and in the design of many manufacturing facilities. I have continued my interests on uses for computers for in-plant modeling and community noise modeling throughout my career.

Q: **Have you ever been retained to evaluate and testify regarding noise and health related issues associated with wind turbines?**

A: Since 2005, I have worked almost exclusively on wind turbines. In addition to working for community groups such as Goodhue Wind Truth, I've also worked with the Herron Zoning Board, Calumet Zoning Board, and a number of other communities around the country for setting up guidelines for the wind turbines. I'm also involved in about five cases in litigation at this point as the expert for the community.

Q: **Have you written any articles regarding wind related noise issues?**

A: Yes, I have written and co-written a number of articles. One in particular stands out – an article that I have written was co-written with one of my partners, George W. Kamperman. George Kamperman is the father of the Illinois EPA noise criteria. He was the person who

helped establish those criterion, and he has monitored them over the years. He has been practicing since 1952. At this time he's in semi-retirement.

Some time ago, he and I were talking about the confusion in the industry and the fact that almost all the articles that we saw were coming from only one side of the argument. At that time, we decided that we should present an overview and conclusions of the field, and to do that, we would do a review of all of the literature and data that we could get our hands on, everything, basically, on noise studies, before and after studies, what's good, what's bad about turbines, health issues, and so forth. Then, based upon our combined almost 80 years of experience, we planned to sort that out into a set of guidelines the communities could use that would allow them to site wind turbines without having the problems we see in the different parts of the United States at this time. Exhibit RJ-02, The "how to" guide to siting wind turbines to prevent health risks from sound, George W. Kamperman, P.E., and Richard R. James, INCE, October, 2008.

This paper was first presented in Detroit at a meeting and has since been published. We have essentially completed a review of primary scientific studies and anecdotal information, categorized and analyzed it and drawn our conclusions as to what it really means.

Q: In your professional work, have you had an opportunity to discuss certain health related issues with Dr. Nina Pierpont?

A: Yes, I have.

Q: Why is Dr. Pierpont's work important to you?

A: In our work, we found it important to get right to the sources of a lot of the information, so, yes, I've carried on a number of discussions with Dr. Pierpont, and she has shared some of her insights with us. Her work coincides and overlaps with ours and what her study is finding is that we do have a valid concern about health related to

improperly sited wind turbines -- and please note, we are referring to improperly sited wind turbines. I relied on her work, in part, for my testimony today.

One of the things that Dr. Pierpont noted is that all of her studies are for the newer models of wind turbines. A lot of the questions raised are asking why aren't we having problems in the other countries; and the answer is that other countries are using smaller wind turbines in many cases. But where they have put in the larger wind turbines, those problems are cropping up there, overseas, as well.

Q: Did you rely on Dr. Pierpont's studies and information in forming your conclusions with respect to the paper that you have recently authored?

A Yes, in part. Her studies and information were helpful in confirming aspects of our work and conclusions, and we put in a cautionary statement that that is still preliminary. There is plenty of scientific and health evidence already from the World Health Organization, and other studies not specific to wind turbines but specific to noise sources, that they can cause disturbances with sleep, that they do have an impact on health, not just a psychological impact, it's physiological changes as a result of long-term sleep deprivation.

Those symptoms and impacts of noise are well-recognized within the field whether it be railroad yards, airports, just about any type of noise sources. If the noise is such that it can wake people up, it does have a physiological effect. The bulk of the study put the weight on that because it is peer reviewed and is well established and is used by people all around the world in making the decision for land use planning with regard to noise sources.

Q: Have you published anything else recently?

A: Yes, recently I co-authored an article for Audiology today with Jerry Punch, Ph.D. Aud. Of MSU's Department of Communicative Science and Disorders. See attached Exhibit RJ-03.

I participated in writing the Society for Wind Vigilance issued in January. Exhibit RJ-04, Wind Energy Industry Acknowledgement of Adverse Health Effects, Part I & Part 2 (detailed analysis), January 2010.

Q: Are there any additional studies that you have relied on in drafting this testimony?

A: There are many important studies, some referenced specifically within or at the end of this testimony, and others referenced here. Ones particularly important in my review of the AWA Goodhue wind project are Exhibits RJ-05 – RJ-16:

- Exhibit RJ-05 - Low frequency noise from large wind turbines, Henrik Moller & Christian Sejer Pederson, June 11, 2010 (+ original in Danish)
- Exhibit RJ-06 - Research Plans for Improving Understanding of Effects of Very Low-Frequency Noise of Heavy Lift Rotorcraft, Fidell, Horonjeff, Schmitz, NASA, February 2010.
- Exhibit RJ-07 - Wind Turbine Acoustics, Hubbard, Shepherd, NASA December 1990
- Exhibit RJ-08 - Application of Ray Theory to Propagation of Low Frequency Noise from Wind Turbines, NASA, July 1987
- Exhibit RJ-09 - Potential Health Impact of Wind Turbines, CMOH Report, May 2010
- Exhibit RJ-10 - Summary of Recent Research on Adverse Health Effects of Wind Turbines, Sterling with Krogh, October 2009
- Exhibit RJ-11 - Measurement and sound quality issues concerning low-frequency noise, Bray, October 2007
- Exhibit RJ-12 - Comments of Swinbanks on AWEA/CANWEA White Paper "Wind Turbine Sound & Health Effects" April 14, 2010
- Exhibit RJ-13 -Rebuttal of MJWagner's statement to Huron County Planning Commission, April 14, 2010
- Exhibit RJ-14 - Swinbanks Comments to MPSC on Setbacks & Noise, December 9, 2009 (for PSC-MI docket U-15899)
- Exhibit RJ-15 - CV of Dr. Swinbanks

- Exhibit RJ-16 - An Analysis of the Epidemiology and Related Evidence on the Health Effects of Wind Turbines on Local Residents, Carl Phillips, July 3, 2010 (for PSC-WI docket 1-AC-231)

Q: **Have you reviewed the application presented by AWA Goodhue Wind?**

A: Yes, I have reviewed the Amended Application, filed on October 19, 2009, and in particular, the noise section found on page 25-28. I have also reviewed their July 16, 2010 filings, in particular, the new map, and the HDR and Exponent reports.

Q: **Have you reviewed a site map?**

A: Yes, but I have not seen the most detailed version. The map filed was labeled "Trade Secret" and neither my clients nor myself have any idea what is presented on this map. Because of the substantive errors on the previous map filed, we need to review the "Trade Secret" map to be able to fairly comment on this project.

Q: **Are you familiar with the Minnesota Pollution Control Noise Standards?**

A: Yes, I have reviewed Minnesota's Noise Standards, Minn. R. Ch. 7030. [1]

Q **Would you please comment on these rules?**

A: The permitted sound levels for Class 1 property are not sufficiently restrictive to protect rural properties. These day and night limits are for urban and suburban communities where there is "urban hum" from distant manmade activities. The standards also focus only on dBA limits. This might work acceptably well for common urban and suburban community noise sources, but it does not work for wind turbines in rural communities. Minimally, the daytime limits should be an LA50 of 35dBA and at night an LA50 limit of 25 would more appropriately reflect and protect the extremely quiet nature of rural communities, especially at night. In no case should the average sound level be permitted to exceed 40dBA (Leq) at night since that is the threshold for adverse health effects set by WHO in their new 2007-2009 Nighttime Noise Guidelines.

[1] Online at www.revisor.mn.gov/rules/?id=7030

Exhibit RJ-17, WHO 2007/2009 Night Noise Guidelines, excerpt. Further, dBC limits are needed for wind turbines because they are predominantly emitters of infra and low frequency sound which is not measured when using A-Weighting. See Exhibit RJ-03, The "how to" guide to siting wind turbines to prevent health risks from sound, for our recommended nighttime dBC limits; see also Exhibit RJ-19, Proposed criteria in residential communities for low-frequency noise emissions from industrial sources, Hessler, 2004.(on criteria for gas turbine plants in rural areas). In our siting paper, we are more restrictive than Hessler, who works for the utilities so he may want more lenient standards, but even his lenient limits are better than no limits. Kamperman/James set the limits at this point to reflect the very quiet nature of rural areas. Note that George Hessler's table of limits in his paper references L90 of 40dB. Since the rural nighttime noise levels in communities like Goodhue are 20 to 25 dB, we felt it was appropriate to use limits lower than Hessler.

Q: **Do these rules adequately address wind turbine noise?**

A: The limits set in the Minnesota Pollution Control Agency rules are questionable. As I noted above, they really apply more for a suburban environment. When the standards were written they were never intended to apply to very rural areas like Goodhue County and wind turbines were not an issue. The standards are what they are, but at this time there is a serious question as to whether they're really applicable for rural community wind turbine siting and whether they will protect that community in the way that the standard was intended to be protective. Based on my research, these rules require updating, because they do not address the different weighting scales necessary for measuring different types of noise, in particular, the types of noise made by wind turbines.

Q: **How are these standards used?**

A: One point, the standards were intended to be accessed by use of a sound level meter. However, they were not -- they were not designable standards, so-to-speak. Instead, they were standards used to propose tests for enforcement after a company has built a new facility. This might be a factory, or a wind turbine. And I think that leads to some very serious concerns about the report because what we see here is the use of computer modeling to replace measurement. Models may predict something is acceptable while measurements and/or community response to the project do not.

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

In preparation for this testimony, the materials provided by the Applicant have been reviewed. This includes the background noise study and computer model estimates of operating sound levels prepared by HDR, submitted July 16, 2010, and other supplemental materials by others.

Q: Have you noticed similarities between AWA Goodhue's plan and others?

There is considerable similarity between AWA Goodhue's documents, and similar documents filed in other states on behalf of wind utility developers requesting permits for their projects. The arguments presented in these documents appear on the surface to be well-crafted technical statements regarding wind turbine noise, community and land-use compatibility, and public health risks. However, despite the similarities in presentation, methodologies, and conclusions between the various authors in these documents there are serious flaws in the arguments and information used to support those conclusions. These studies present one-sided

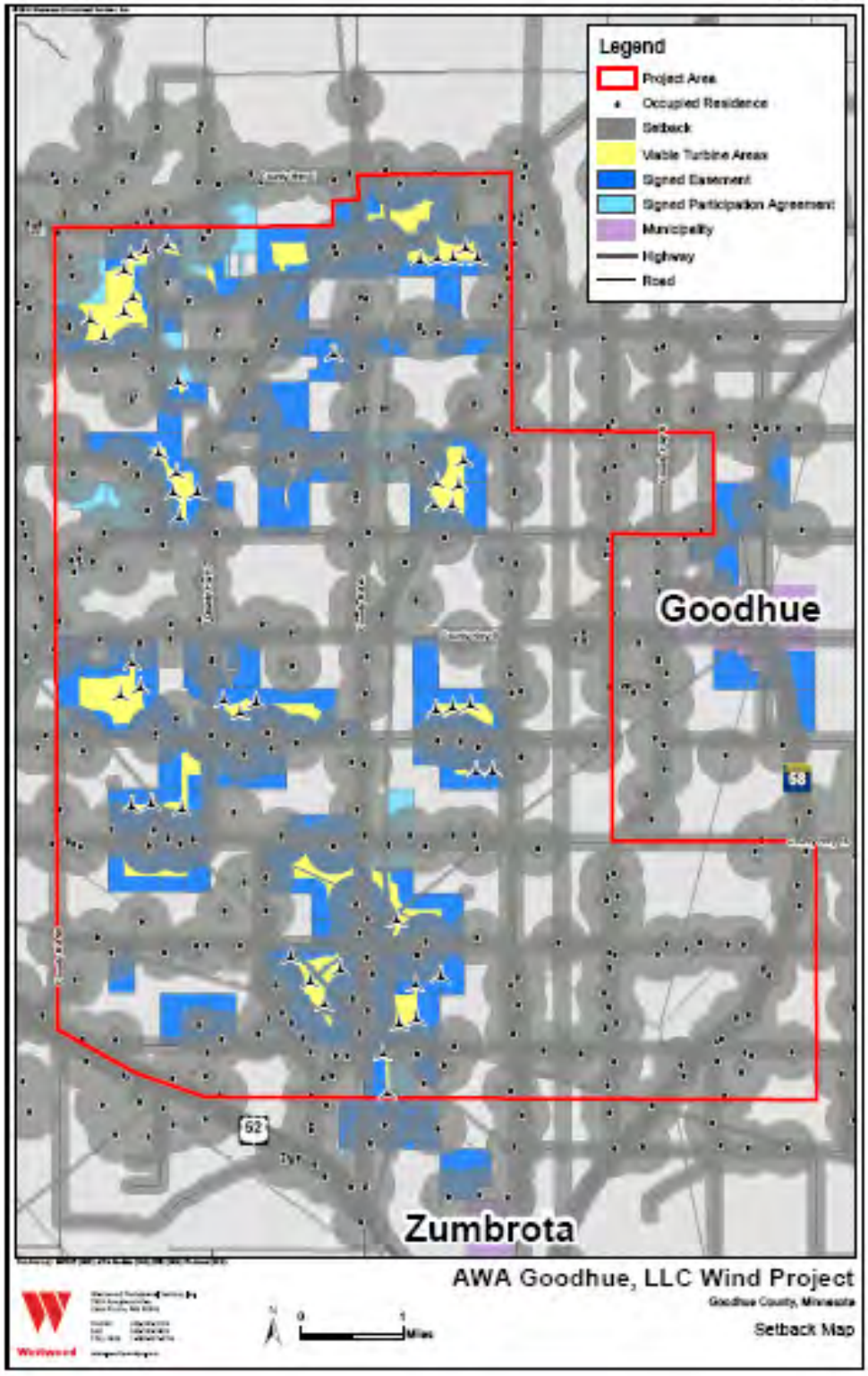
information to support the development of wind utilities in locations where people will be expected to live within 1000 to 1500 feet of industrial scale wind turbines.

It is the goal and focus of my testimony to present an expert analysis and critical review, and to provide the Minnesota Public Utilities Commission with the references to foundational research, papers, and presentations needed to understand that what is not disclosed in the wind utility application reports and supporting documents is critical. Given the opportunity for the Public Utilities Commission to review the information provided in this report and its attached references, it is hoped that the Commission will understand why wind utility projects from Iowa to Maine, Ontario to West Virginia are now the locus of numerous complaints and lawsuits. These complaints and lawsuits detail the problems experienced with wind turbines causing sleep disturbance, adverse health effects, and other related problems. At the time of these problematic projects' permit applications, the developer for each of these projects assured the permitting agency that none of these problems would occur. This report is intended to provide information such that the Public Utilities Commission will not find itself permitting similar problematic situations.

Q: Have you reviewed the proposed project footprint and sound contours?

A: Yes. The Applicants Setback Map, Figure 3, on the next page, was filed July 16, 2010, and illustrates the extent to which the proposed footprint of the wind utility will encroach on residential homes:

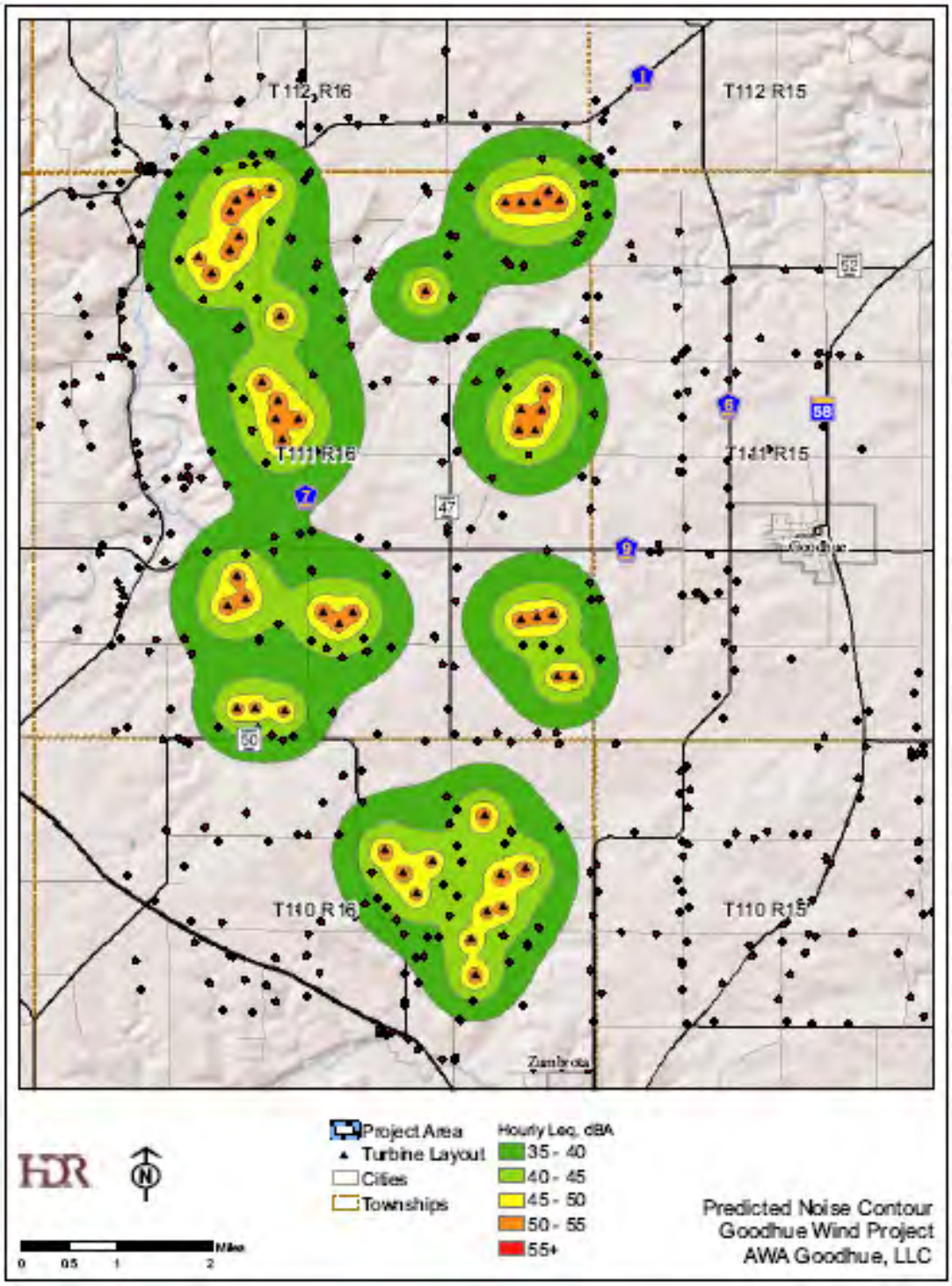
Figure 3


Legend
Project Area
Occupied Residence
Setback
Viable Turbine Areas
Signed Easement
Signed Participation Agreement
Municipality
Highway
Road
Goodhue
Zumbrota
58
52
AWA Goodhue, LLC Wind Project
Goodhue County, Minnesota
Setback Map
Miles

1

Q: Have you reviewed the Applicants Predicted Noise Contour, Figure 9, represents estimated noise?

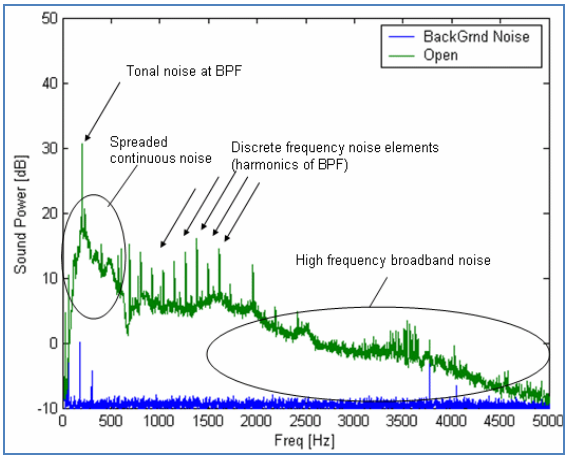
Figure 9



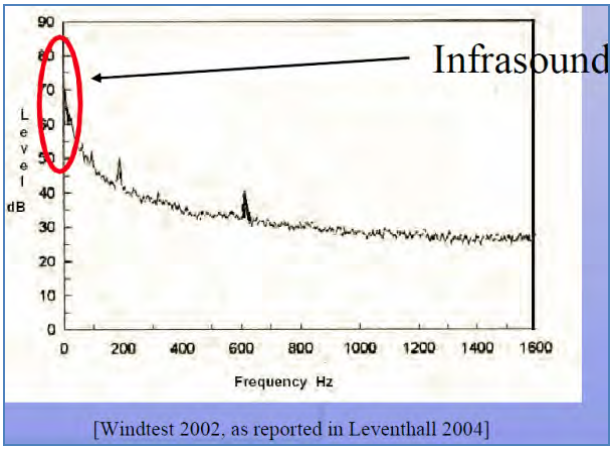
A: Yes, I have reviewed the Applicants Predicted Noise Contour Figure 9 – using 1,500 foot setbacks from homes.

Q: Are there particular ways of looking at turbine noise that are helpful to understand the cause of annoying noise?

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



Graph 2-Typical Fan Noise Spectrum



Graph 3-Vestas V-52 Spectrum (from NREL Presentation)

In Graph 3, the wind turbine spectrum for a Vestas V-52, shows some of the same spectral characteristics. For a wind turbine, the blade passage frequency is usually between 1 and 2 Hz and the primary harmonics occur usually below 10 Hz. Because this is a difficult range

of frequencies to measure, especially in field test situations, most information about the spectral characteristics do not show the infrasound range (0-20Hz) sound pressure levels (SPL). This is further obscured by the practice of wind industry acoustical consultants to present data using only A-weighting (dBA). No specific dBC data was provided. The practice masks the spectrum shape by creating a visual impression of minimal low-frequency sound content. Even when octave band (1/1 or 1/3) Sound Pressure Levels (SPLs) are presented, the reports normally ignore frequencies below 31.5 or 63 Hz. The wind industry and its consultants often say that there is no infra or low frequency content. If that is true then the customary reporting practices are understandable. But, if those assumptions are not accurate, then these practices mask a potential source of significant problems.

The graphic to the right (Graph 4) shows a wind turbine's spectrum for the frequency range of 0-10 Hz. Note the tones and harmonics and the correlation of the frequency of the tones to rotational speed. This graph is from a study conducted by the Federal Institute for Geosciences and Natural Resources, Hannover, Germany, titled: "The Inaudible Noise of Wind Turbines" presented at the Infrasound work shop in 2005 (Tahiti).

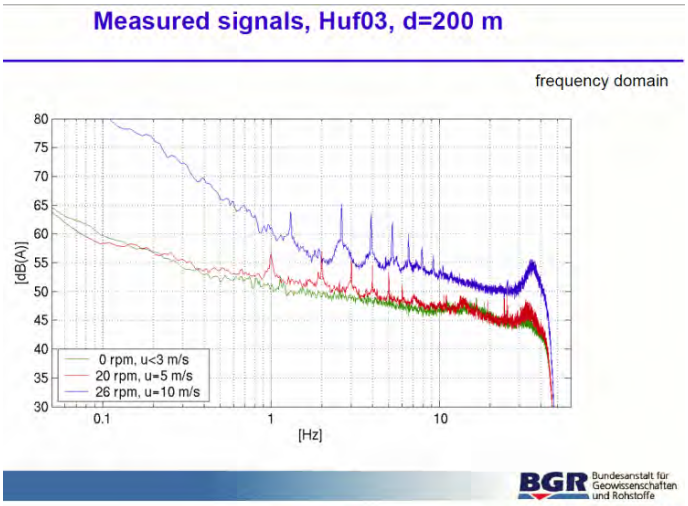


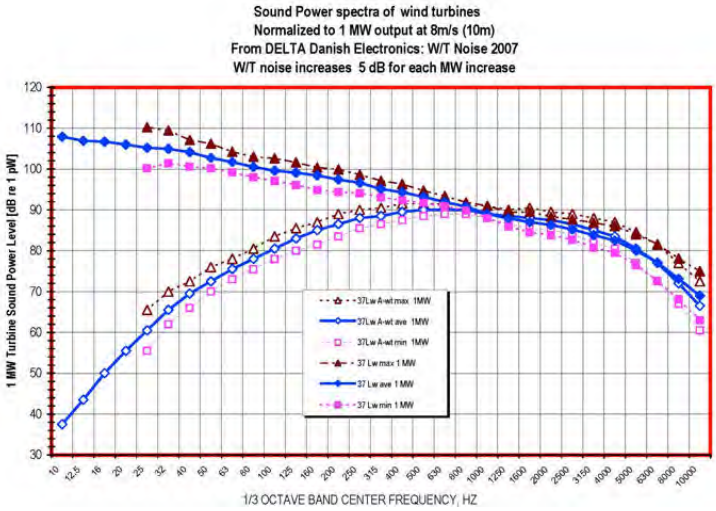
Figure 4-Wind Turbine Infrasound

Q: Are the sound emission characteristics similar or different for different models and makes of wind turbines?

A: Yes. Graph 5, below, shows the general spectrum shape of 37 modern upwind turbines of the type and sizes being located in the Midwest. This graph shows the sound power data after

normalizing the data for each turbine to 1 MW of power output.[2] It is clear that there is little deviation in spectral shape between any of the various models that is not related to power produced. In fact, the study shows that for each increase of 1 MW in power output the graph there may be a shift upward by approximately 5 dB. Given that power to sound level relationship and the constant increase in the power rating of turbines being installed we could see the wind turbine sound levels increase another 25 dB by the time 5 MW turbines are commercially available.

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



Q: Is wind turbine noise is distinctively annoying

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

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

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

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

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

Q: Explain what you mean by "character of the noise?

A: For example, wind turbines have a characteristic "Amplitude Modulation", also referred to as an "Audible Blade Swish." It is not clear whether it is:

1) the distinctive rhythmic, impulsive or modulating character of wind turbine noise, which are all synonyms for "thump" or "swoosh" or "beating" sounds);
2) its characteristic low frequency energy (both audible and inaudible, and also impulsive), health effects of chronic exposure to wind turbine noise (especially at night);
3) in-phase modulation among several turbines in a wind farm (this can triple the impulse sound level when impulses of three or more turbines become synchronized); or
4) some combination of all of these factors best explains the annoyance.

One or more of these characteristics are likely present depending on atmospheric and topographic conditions, (especially at night)[6] as is the individual susceptibility of each person to them.

Q: What is the relation between Amplitude Modulation, noise levels and annoyance or problems?

A: Reports based on surveys of those living near wind farms consistently find that, when compared to surveys of those living near other sources of industrial noise, annoyance is significantly higher for comparable sound levels among wind utility footprint residents. In most cases, where relationships between sound level and annoyance have been determined, annoyance starts at sound levels 10 dBA or more <u>below the sound level</u> that would cause equivalent

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

annoyance from the other common community noise sources. Whereas one would expect that people would be annoyed by 45 dBA nighttime sound levels outside their homes in an urban area, rural residents are equally annoyed by wind turbines when the sound levels are 35 dBA independent of the time of day. Given that wind turbine utilities are often permitted to cause sound levels of 40 to 50 dBA at the outside of homes adjacent to or inside the footprint of wind utilities in the states east of the Mississippi the negative reactions to wind turbines from many of those people is understandable. Their reactions provide objective evidence in support of an expectation that a substantial number of people who live near the Glacier Hills Wind project will complain that the noise level they experience is both causing nighttime sleep disturbance and creating other problems once operation commences.[7] [8]

Q: What causes amplitude modulation?

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

Q: Is sound modeling a reasonable predictor of turbine noise for a given project?

A: I have noted that consultants for wind utility developers often claim that wind turbine sound emissions inside and adjacent to the project footprint estimated by the sound propagation

[7] Pedersen (2007); Kamperman and James (2008); James (2009b); Minnesota Department of Health (2009), pp. 19-20.
[8] Bajdek, Christopher J. (2007). *Communicating the Noise Effects of Wind Farms to Stakeholders*, Proceedings of NOISE-CON (Reno, Nevada), available at http://www.hmmh.com/cmsdocuments/ Bajdek_NC07.pdf
[9] Van den Berg (2006, pp. 35-36); Bowdler (2008), Palmer (2009) and Oerlemans/Schepers (2009).
[10] Bowdler (2008)

model's represent worst-case conditions. However, it is only true that the input data used for the turbine's acoustic energy represents the turbine's sound emissions at or above its nominal operating wind speeds under standardized weather and wind conditions. That is reasonable given that the purpose of these tests is to produce standardized data to permit a prospective buyer of turbines to compare the sound emissions from various makes and models. However, this needs to be understood as being similar to the US EPA's standardized gasoline mileage tests. You do not get the mileage posted on the vehicle sticker since your driving habits are different. The same is true for wind turbines and the environments in which they operate. The IEC test data does not account for the increased noise from turbulence or other weather conditions that cause higher sound emissions.

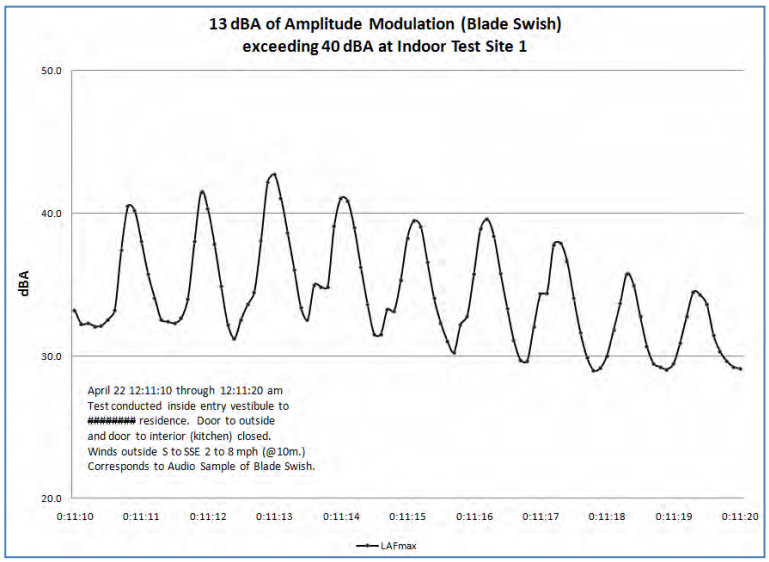
Q: Are guidelines for measurement helpful?

A: A review of the IEC 61400-11, Wind Turbine Systems-Part 11: Acoustic Noise Measurement Techniques' assumptions in the body and appendices (esp. Appendix A) show that the IEC test data reported to turbine manufacturers is not 'worst case' for real world operations. Independent of the effect of weather and wind on the turbine's noise emissions, ANSI standards for outdoor noise specifically caution that turbulence in the air can increase the downwind sound levels by 6-7 dB or more. 6-7dB represents about a doubling of loudness, – a significant increase. Any assertions by the acoustical modeler that the models represent worst case sound level estimates rely on careful phrasing and/or ignorance of the underlying standards and methods by the reviewers.

Q: Please explain "impulsive sound" and the advances made to reduce impulsive sound levels.

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

I have confirmed amplitude modulation (blade swish) at every wind project I've investigated. During periods of high turbulence I have measured levels of blade swish of 10-13 dBA. Graph 6, to the right shows the rise and fall of the A-weighted sound levels from blade swish measured inside a closed entry vestibule to a home. This test site is approximately 1500 feet from two (2) GE 1.5 MW turbines



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

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

with sound emission characteristics similar to the turbines proposed for the AWA Goodhue project. It should be noted that the sound levels exceed 40 dBA inside the home in the rooms facing the turbines with a window partly open.

Q: How is this "annoyance factor" addressed in modeling?

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

Frequency of Conditions that Cause Blade Swish

Q: How common is "Blade Swish" in today's wind turbines?

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

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

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

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

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

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

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

Infra and Low Frequency Sounds

Q: Please explain "infra" and "low" frequency sounds.

A: Sound measured as dBA is biased toward 1,000 Hz, the center of the most audible frequency range of sound pressure. Low frequency sound is in the range below 200 Hz and is

---

[18] (Van den Berg 2006, p. 90)
[19] *Id.*, p. 60
[20] *Id.*, p. 61. *Cf. also* Minnesota Department of Public Health (2009), pp. 12-13 and Fig. 5.
[21] Van den Berg 2006, p. 96

more appropriately measured as dBC, using a "C" weighted scale, using instrumentation that can provide 1/3 octave band resolution of the spectrum sound pressure levels. Sound below 20 Hz, termed **infrasound**, is generally presumed to not be audible to most people. *See* Leventhall (2003, pp. 31-37); Minnesota Department of Public Health (2009, p. 10); Kamperman and James (2008, pp. 23-24). For many years, it has been presumed, without inquiry or verification, that only infra and low frequency sounds that reached the threshold of audibility for people posed any health risks. Many acoustical engineers were taught that if you cannot hear a sound, it cannot harm you. The sensitivity and annoyance produced by a noise source increases substantially for increases in **low frequency sound,** once it is perceived, than the more readily audible mid-frequency sounds.

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

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

Q: Would you explain the World Health Organization's guidelines for noise?

A: While on the topic of nighttime sound levels and the impacts of noise, it should be noted that the World Health Organization (WHO) revised its guidelines for nighttime noise in 2007, noting the following effects of sleep disturbance:

> The review of available evidence leads to the following conclusions.
>
> • Sleep is a biological necessity, and disturbed sleep is associated with a number of adverse impacts on health.
>
> • There is sufficient evidence for biological effects of noise during sleep: increase in heart rate, arousals, sleep stage changes, hormone level changes and awakening.
>
> • There is sufficient evidence that night noise exposure causes self-reported sleep disturbance, increase in medicine use, increase in body movements and (environmental) insomnia.
>
> • While noise-induced sleep disturbance is viewed as a health problem in itself (environmental insomnia) it also leads to further consequences for health and well-being.
>
> • There is limited evidence that disturbed sleep causes fatigue, accidents and reduced performance.
>
> • There is limited evidence that noise at night causes clinical conditions such as cardiovascular illness, depression and other mental illness. It should be stressed that a plausible biological model is available with sufficient evidence for the elements of the causal chain

Van den Berg (2006), p. 106; Minnesota Department of Public Health (2009), p. 21. *See also* Pedersen (2007, p. 24).

Amplitude-modulated sound has also been found to be more annoying than sound without modulations." The revised guidelines supersede the guidelines commonly referenced

from 1999 and before.[23] These guidelines provide the definition of what is required for a causal link to be established between a exterior forcing agent like noise and health. They state:

> ***Sufficient evidence:*** *A causal relation has been established between exposure to night noise and a health effect. In studies where coincidence, bias and distortion could reasonably be excluded, the relation could be observed. The biological plausibility of the noise leading to the health effect is also well established.*
>
> ***Limited evidence:*** *A relation between the noise and the health effect has not been observed directly, but there is available evidence of good quality supporting the causal association. Indirect evidence is often abundant, linking noise exposure to an intermediate effect of physiological changes which lead to the adverse health effects.*

In Table 3 of the 2007 Guidelines, WHO presents the maximum sound levels that should be permitted outside the walls of a home to prevent adverse health effects:

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

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

End of WHO 2007 Guideline Excerpts

[23] WHO Night Noise Guidelines (2007)

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

Q: Does this provide a different understanding of impacts of sound?

A: Yes. Essentially, our understanding is outdated, and until recently, viewed with blinders because of our failure to utilize cross-disciplinary inquiry. To get a idea of just how outdated our understanding is of the way our bodies interact with the energies and forces around us, I would like to share a short piece that was sent to me by Eileen Mulvihill, a genetic biologist who received her Ph.D. in Molecular Biology from the Université Louis Pasteur, Strasbourg, France. She holds six patents for discoveries she made during her career.

Dr. Mulvihill's point is to demonstrate how our body's cells and molecules function as sensory receptors that augment the sensory organs, like our auditory and vestibular organs. Most of us learned that we have primary sensory organs and they perform all the needed functions for sensing the world around us, especially those who have not remained current with research in the field of molecular and cellular biology. It is this now outdated view-point that leads some of the wind industry acoustical experts to still claim that 'If you can't hear it, it can't hurt you." In other words, they believe that because the average person's auditory function, the outer, middle, and inner ear, is not as sensitive to infra and low frequency sounds, such as rumble, as it is to mid and high frequency sounds, such as those where speech occurs; and, that

the infra and low frequency sounds from wind turbines are not loud enough to be heard by most people, there is no potential for adverse health effects. Dr. Mulvihill recently provided a good example of research that shows how our body can sense external forces. In other words, she describes other ways we sense acoustic energy, like low frequency sounds, through cellular level mechanisms not related to dedicated sensory organs. Dr. Mulvihill offered the following example using a paper by Dr. D. Ingber:

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

Prog Biophys Mol Biol. 2008 Jun-Jul;97(2-3):163-79. Epub 2008 Feb 13

What Dr. Mulvihill describes is the process by which low levels of energy can affect hormone production which by their actions result in adverse health effects. There are many more and smaller receptors for sensory input that than just our dedicated organs. Because these receptors are so small they may be far more sensitive to low amplitude, low frequency sound than the studies conducted focusing on the auditory and vestibular organs only would reveal.

Also, remember that low frequency sound penetrates into our body with little attenuation in the same way that it passes through the walls and roofs of our homes.

Q: What other significant research has been published regarding sensitivity to and impacts of noise?

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

> Mechanoreceptive hair-cells of the vertebrate inner ear have a remarkable sensitivity to displacement, whether excited by sound, whole-body acceleration or substrate-borne vibration. In response to seismic or substrate-borne vibration, thresholds for vestibular afferent fibre activation have been reported in anamniotes (fish and frogs) in the range −120 to −90 dB re 1 g. In this article, we demonstrate for the first time that **the human vestibular system is also extremely sensitive to low-frequency and infrasound vibrations** by making use of a new technique for measuring vestibular activation, via the vestibulo-ocular reflex (VOR). We found a highly tuned response to whole-head vibration in the transmastoid plane with a best frequency of about 100 Hz. At the best frequency we obtained VOR responses at intensities of less than −70 dB re 1 g, which was **15 dB lower than the threshold of hearing** for bone-conducted sound in humans at this frequency. Given the likely synaptic attenuation of the VOR pathway, human receptor sensitivity is probably an order of magnitude lower, thus approaching the seismic sensitivity of the frog ear. These results extend our knowledge of vibration-sensitivity of vestibular afferents but also are remarkable as they indicate that the **seismic sensitivity of the human vestibular system exceeds that of the cochlea for low-frequencies.**" (Emphasis added)

These examples are provided to demonstrate that there is significant evidence to support a hypothesis of a causal link between ILFN and adverse health effects. The typical acoustician has not caught up on these biophysiological understandings of how our bodies respond to infra

and low frequency sound levels -- these levels were only a few years ago considered too low to cause any physical response. Once we understand that what you cannot hear, can hurt you; we will be in a better position to develop the procedures and criteria to use wind turbines as a renewable energy resource but until the time when the necessary studies have been completed it is appropriate to follow the precautionary principle and not expose the public to a potential health risk.

Q: Please explain "low frequency" in relation to typical wind turbine noise.

A: Wind turbine noise includes a significant low-frequency component, including inaudible infrasound as shown in Figures 3 through 5. For example, according to the manufacturer, under ideal test conditions at a distance of 200 meters (656 feet), a single 2.5 MW Nordex N80 wind turbine generates 95 decibels at 10 Hz[24]. This is at the threshold of human hearing for the average person and above the threshold for the most sensitive individuals.[25] The Nordex study also showed that sound pressure levels were highest at the blade passage frequency (between 1 and 2 Hz) and dropped off with increasing frequency. Thus, we can expect that below 10Hz sound pressure levels were higher than 95 dB. What does this say about infrasound during "non-ideal" conditions which increase infra sound emissions?

Although low frequency sound is in the less-audible or inaudible range, it is often felt rather than heard. Unlike the mid and higher frequency A-weighted components, the low-frequency components of wind turbine noise "*can penetrate the home's walls and roof with very little low frequency noise reduction.*[26]" Acoustic modeling for low frequency sound emissions of ten 2.5 MW turbines indicated "*that the one mile low frequency results are only 6.3 dB below the*

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

1,000 foot one turbine example.[27]" This makes the infra and low frequency sound emissions from wind turbines a potential problem over an even larger area than the audible sounds, such as, blade swish and other wind turbine noises in the mid to high frequency range.

Background Sound Levels

Q: How are background sound levels measured and considered, and why is this important?

A**:** Apart from the distinctive characteristics of wind turbine noise, including its low frequency component, the quiet soundscapes found in rural and semi-wilderness areas accentuate the perceived annoyance and potential for sleep disturbance. The Minnesota Public Utilities Commission has procedures for how to assess the pre-operational background sound levels that were designed for the types of communities in which the more traditional power generating utilities are located. Whether these are adequate for wind utilities located in quiet communities remains to be determined. It is not in the scope of this report to anticipate any needed changes, but the discussion above relative to the potential issues related to infra and low frequency sound does imply that some method of assessing and controlling the lower frequency sounds is warranted.[28]

Q: What sound information has been presented in the AWA Goodhue Application?

A: The sound information presented in the AWA Goodhue application was sparse, consisting of just three pages in the October, 2009 application[29] and ExhibitA-7, Noise Footprint GE 1.5 MW sle/xle Turbine. This section states:

> GE provided the sound power level at the turbine hub for the GE 1.5 MW xle turbine is 104 dBA. The term "sound power level" means a logarithmic measure of the sound power in comparison to a specified reference level. The sound power level of a source is

[27] *Id.*, p. 12
[28] Hessler,/gas turbine paper
[29] AWA Goodhue Application, p. 25-29.

> expressed in decibels (dB) and is equal to 10 times the logarithm to the base 10 of the ratio of the sound power of the source to a reference sound power. The reference sound power in air is normally taken to be 10^{-12} watt.

Application, p.26.

This paragraph is missing critical information, specifically

1) octave band level of detail for sound emissions at various wind speeds for frequencies from 6 Hz through 10,000 Hz;
2) Explanation that test results do not consider weather/wind condition producing highest levels of blade swish.
3) Information of all average sound levels while wind turbine sounds vary by as much as 15 dB above the steady sound emissions.

Providing a few more specifics, the application goes on to note:

> Goodhue Wind analyzed the noise footprint of the Project from the proposed GE 1.5 MW xle wind turbine model using the WindPRO version 2.6.1.252 module Decibel for Noise Impact Calculation (see **Exhibit A-7**). According to the manufacturer's noise data, the sound power level of the GE 1.5 MW xle wind turbine at a 10 meter height for an 80 meter hub height ranges from less than 96 dB (at 3 m/s wind speed) to less than or equal to 104.0 dB (at 9 m/s wind speed to the cut out speed). Using the highest sound power level of 104.0 dB, the distance to the 50 dBA noise setback distance from a single GE 1.5 MW xle wind turbine averages 531 feet (162 meters). As shown in **Exhibit A-7**, no residences are located within the 50 dBA setback area.

Id.

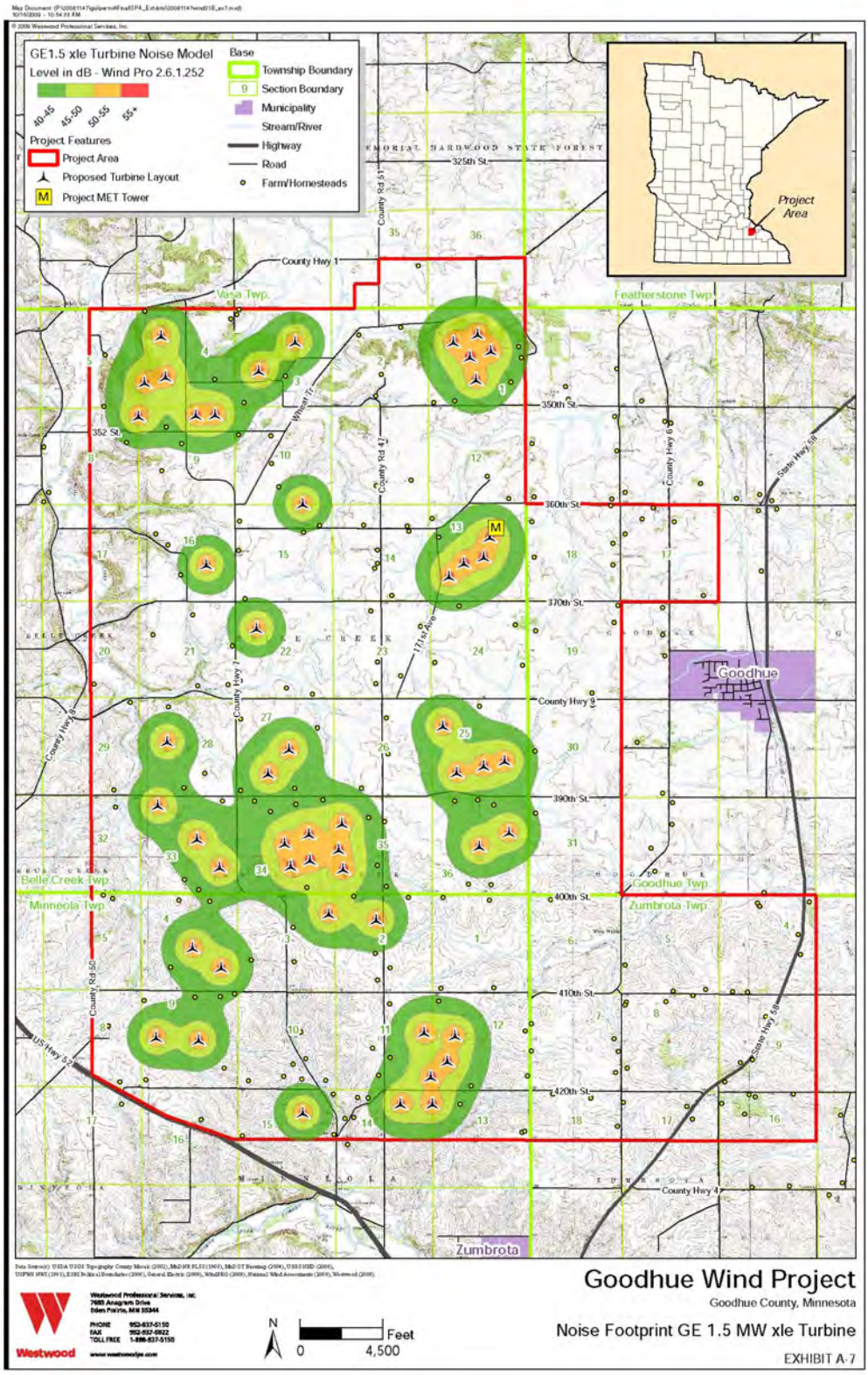
This methodology is flawed for several reasons.

1) No details of the input data was provided, only the results of modeling as an energy averaged dBA Leq;
2) No details showing the sound energy in each frequency band at homes and properties;
3) Assumed ground was 70% absorptive which is only possible during early summer with heavy ground cover and loose soil. Winter and when ground is hard-packed and has 0% absorption.

4) Assumes low frequency sound propagates at a similar rate to mid and high frequency sound. However, Infra and low frequency sound spreads at one-half or less the rate of mid and high frequency sound. Where a high frequency sound might decay at the rate of 6 dB per doubling of distance (point source) the lower frequencies will decay at rates more like 3 dB per doubling of distance. Thus, the rumble and roar are heard at much greater distances that the higher frequency sounds. Yet, use of dBA criteria would ignore that component of the wind turbine noise emissions.

5) No accommodation for blade swish and other noises normally associated with complaints. Averages can hide the dynamic sound swings. We need to know the maximum sound levels that will occur from any operation mode in all weather situations. We also need to know how much atmospheric conditions can lead to focusing sounds down to the ground that might otherwise have escaped into the atmosphere. These variables are not trivial. They can add as much as 15 dB to the average level the models predict.

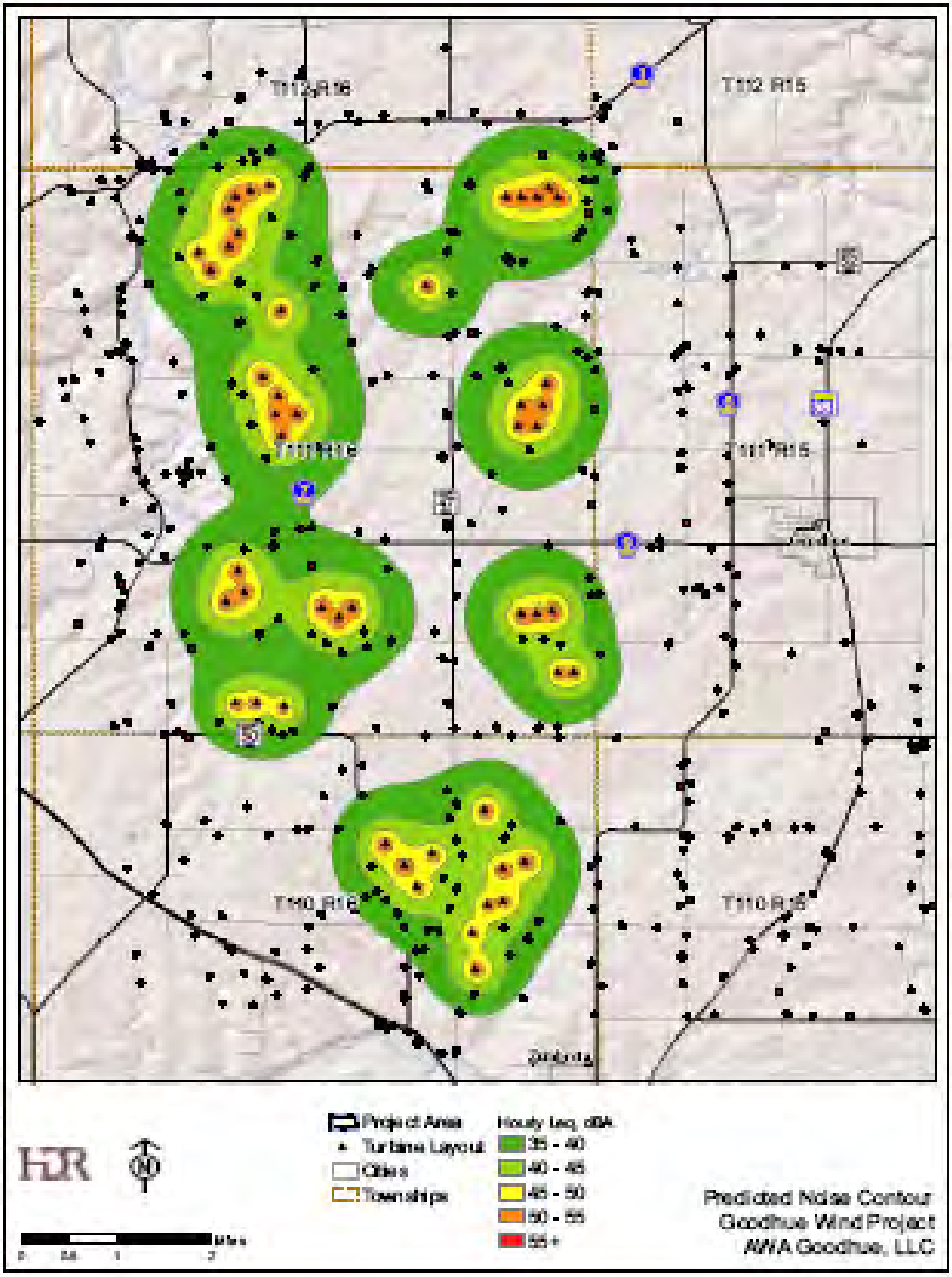
This methodology resulted the graphic representation in Exhibit A-7, Noise Footprint GE 1.5 M sle/xle Turbine, and is the methodology upon which the Environmental Report and the Environmental Impact Statement are based – the Environmental Impact Scoping Decision was issued May 28, 2010:


GE1.5 xle Turbine Noise Model
Level in dB - Wind Pro 2.6.1.252
40-45
45-50
50-55
55+
Project Features
Project Area
Proposed Turbine Layout
Project MET Tower
Base
Township Boundary
Section Boundary
Municipality
Stream/River
Highway
Road
Farm/Homesteads
Project Area
County Hwy 1
Vasa Twp.
Featherstone Twp
Goodhue
Belle Creek Twp
Minneola Twp
Goodhue Twp
Zumbrota Twp
Zumbrota
Goodhue Wind Project
Goodhue County, Minnesota
Noise Footprint GE 1.5 MW xle Turbine
EXHIBIT A-7
Westwood
N
0
4,500
Feet

1

The recent prefiled Figure 9 shows a much changed footprint and distribution:

Figure 9



The prefiled Appendices include Appendix D, a Memo from HDR, a noise analysis and modeling and "24-hour noise measurements at five locations that are representative of the rural portions of the project area." I have reviewed this Memo and note the following problems, reiterating those listed above:

1) Octave band level of detail for sound emissions at various wind speeds for frequencies from 6 Hz through 10,000 Hz;

2) Explanation that test results do not consider weather/wind condition producing highest levels of blade swish.

3) Information of all average sound levels while wind turbine sounds vary by as much as 15 dB above the steady sound emissions.

4) No details of the input data was provided, only the results of modeling as an average dBA log;

5) No details showing the sound energy in each frequency band at homes and properties;

6) Assumed ground was 70% absorptive which is only possible during early summer with heavy ground cover and loose soil. Winter and when ground is hard-packed has 0% absorbtion.

7) Assumes low frequency sound propagates at a similar rule to mid and high frequency sound. Infra and low frequency sound spreads at one-half or less the rate of mid and high frequency sound.

8) No accommodation for blade swish and other noises normally associated with complaints.

9) Misconception about how wind may or may not mask wind turbine sounds.

10) No tolerances for known errors in algorithms. These tolerances should add4dBto predicted model results.

Computer Model Predictions

Q: Is the computer modeling by HDR reliable?

A: Computer modeling is always based on assumptions, and so the assumptions used in the base case determine the outcome. Studies on behalf of AWA Goodhue presenting computer

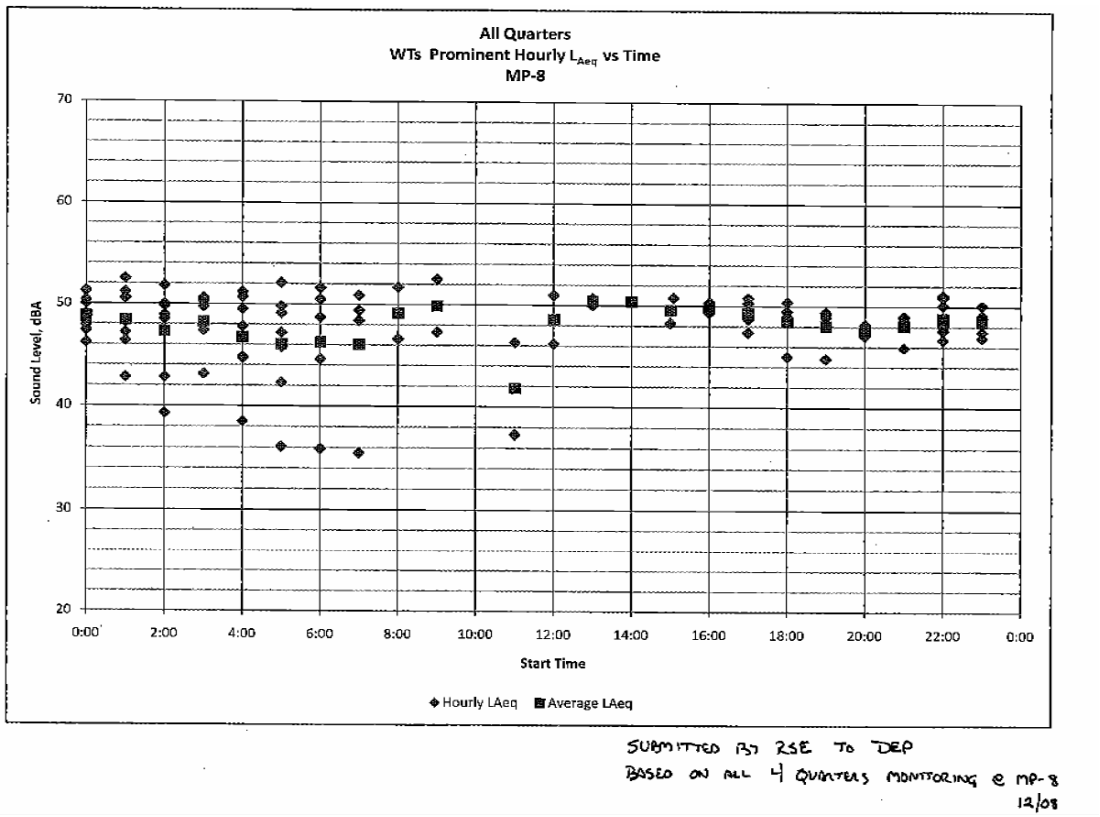
simulations that purportedly estimate the "worst-case" sound levels that will be received in the community should be viewed with serious skepticism. Models are representations and simplifications of complex interactions between noise emitters, and their surrounding environment. Models are not precise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

Q: Why is there such a broad range of levels?

A: This range of levels is understandable, given the discussion earlier in this report about the assumptions in the modeling process and also in the input data used to replicate the more important interactions as the wind turbine's sound propagates into the community. First, the model estimates a single number at a receiving site. This is an average value, representing for the input data and assumptions a yearly estimate of the sound emissions at the receiving site. It also does not reflect all of the conditions that can lead to higher sound emissions from blade swish and other weather induced effects on the turbine's noise.[30] Sometimes it is easier to understand this variability visually.

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

The chart in Graph 7, below, was presented to the citizens of Mars Hill, Maine in December of 2008 by the Director of the Maine Bureau of Land and Water Quality which includes the Dept. of Environmental Protection.



Maine's MDEP commissioned a four quarter study of the sound levels under various operating conditions and seasonal variations. This chart shows the 'best' of the data that was hand selected to represent only sound levels when wind turbines were operating and clearly audible. The test site is over 2000 feet from the nearest wind turbine, a 1.5MW upwind model. Note that the sound levels range from a low of about 35 dBA to a high of just over 52 dBA. All of these represent wind turbine sounds and not wind or other artifacts. The initial model estimated that the sound levels at this site would be 47.5 dBA. Sound levels higher than 52 dBA were observed but ground level winds above 5m/sec prevented accurate measurement.

Q: Why are these assumptions problematic, producing an inaccurate result?

A: Assuming that wind and other factors can result in a 17 dB range of sound levels for this operating wind utility, and that measurements during the highest noise conditions were precluded by wind speeds at the microphone exceeding the limits of the wind screen, how can any study of a operating wind utility claim that the levels estimated by the model adequately characterize the impact on the community. If the model reflects 'worst-case' wind speeds for the turbine, why are there so many complaints from people near turbines? The truth of the matter is that when the person who constructs the model is permitted to assess its accuracy the results should be viewed with suspicion. It is in that light that we must view the results of the HDR model presented. Goodhue Wind Truth asks that the Minnesota Public Utilities Commission view the estimates of sound propagation in the same way. It is at best a guide to estimate how the sound will affect the community, but to imply that the results have a high degree of accuracy is to stretch the credulity of the reviewer.

Q: Is there information about assumptions and models that is missing?

A: Yes. Studies that use models normally disclose the strengths and weaknesses of the models and also disclose the input data and other important assumptions. They give appropriate cautions and disclose error tolerances for all possible known conditions that the model does not consider. This is not done in the HDR modeling for AWA Goodhue. The model is poorly documented and missing important data if the study is to be critically reviewed by others competent to do so. Much could be said again about the flaws in computer modeling of sound in complex situations but that evidence has been previously submitted. The arguments are academic and not something that most non-engineers would not care to review. However, the

use and accuracy of CADNA and similar models are debated every year atnoise conferences with only wind turbine consultants claiming high levels of accuracy.

Q: How can we establish the validity of the assumptions and modeling?

A: The easiest way to establish that wind turbine models underestimate sounds at properties adjacent wind utilities is to look at existing wind projects. Since most, if not all, follow-up sound studies on various wind projects are conducted by acoustical consultants with strong ties to the wind utility developers, it is reasonable to look at other studies for projects. This review has conducted studies of operating wind utilities in many different states, and in Ontario. In all cases the projects were granted permits based on sound studies claiming the community had high background sound levels, came with discussions of how wind noise masks turbine noise, and presented wind turbine sound models estimating levels in the low to mid 40 dBA range at the nearest properties.

Other studies of background sound levels in rural communities confirm the results of the Kamperman-James study. For example, similarly low background sound levels were also reported in the study by Mr. Clifford Schneider[31]. Schneider reported that the median L_{A90} sound level for approximately 20 test locations in northern New York was 25.5 to 26.7 dBA. This reviewer has also found that in rural areas background sound levels are typically less than 30 L_{A90}. When sampling is conducted during the evening hours when community activities are at a minimum the L_{Aeq} and the L_{A90} are usually within 5 dB of each other. It is during this time that the sounds from the wind turbines will be most apparent and it is against those low background sound levels that land-use compatibility should be assessed.

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

The background sound study Hessler and Associates conducted for a wind developer in the upper New York area near Cape Vincent was questioned by members of that community. The complete Cape Vincent study by the wind developer's consultant Hessler & Associates is attached as Exhibit RJ-20. They commissioned an independent study by Dr. Paul Schomer, who is the Chair of the Acoustical Society of America's Standards Committee and is highly respected for impeccable work by his peers.[32] Dr. Schomer concluded that:

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

Rebuttal by Dr. Paul Schomer, attached as Exhibit RJ-21, Background sound measurements and analysis in the vicinity of Cape Vincent, New York, Schomer, May 2009; Exhibit RJ-22, Background sound measurements and analysis in the vicinity of Cape Vincent, New York, Schomer, May 2009; and Exhibit RJ-23, Letter to Supervisor Hirschey, Town of Cape Vincent, Schomer, April 23, 2010.

The review by Dr. Schomer should be reviewed by the Public Utilities Commission to determine whether the AWA Goodhue sound study was free from similar bias. Given that HDR is a Canadian firm accustomed to Ontario's rules which follow the Hessler approach, there is reason for caution.

Q: Why should we look at past noise studies and modeling in relation to the current noise information provided in this docket?

A: Historically, there is a pattern of overly optimistic and inaccurate modeling results based on inadequate refinement of base case assumptions.

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

Note the similarities in these studies to what AWA Goodhue has presented for the AWA Goodhue wind project under consideration. And consider what has happened at those locations that the Public Service Commission should take into consideration. The project developers made promises based on their submitted studies and modeling:

- The promises of compatibility with existing community sound levels;
- Promises of no potential for nighttime sleep disturbance or low frequency 'vibrations'

These promises have been followed by numerous complaints from the public, affected nearby residents, about noise and health, complaints to the local Boards and state Commissions that issued the site permits. In some cases this has escalated to threats of litigation and lawsuits.

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

Q: Have you reviewed the Exponent report provided by AWA Goodhue?

A: Yes, The prefiled Appendices also includes Appendix E, by Exponent, entitled "Evaluation of the Scientific Literature on the Health Effects Associated with Wind Turbines and Low Frequency Sound." I have reviewed this literature survey and note that there are substantive errors and omissions. Recent studies link low frequency noise impacts to impairment of the vestibular system or other organs.[33] This new link between health and noise should be considered along with studies showing that wind utility noise from turbines operating at distances of up to one mile is a cause of sleep disturbance for a vulnerable minority, and chronic sleeplessness results in adverse health effects.

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

An article in Noise and Health by Dr. Levanthall addresses these coping mechanisms for people exposed to noise.[34] It deserves careful reading by the Minnesota Public Utilities Commission. This study describes the coping mechanisms and other adaptations to life style that people adopt when exposed to infra low frequency noise (ILFN) over long periods of time. It is interesting to note that many of the coping mechanisms in that article are used by people who are now living in the footprint of wind utilities like the one proposed for Goodhue Wind. Indeed, there has been an ongoing debate between Dr. Leventhall and Dr. Pierpont about the risks of exposure to wind turbine sounds that seem to be contradicted by the statements of Dr. Leventhall in this article. If it can be assumed that the causal link between wind turbine noise exposure and the ILFN from wind turbines is established by the new medical research referenced earlier, and the levels of ILFN required to initiate a response from our bodies is lower than previously thought, then the disagreement between them appears to resolve in favor of Dr. Pierpont's research.

The supplemental reports provided by AWA Goodhue written by Dr. Leventhal and others take issue with this position. Leventhal's critique of the Kamperman/James paper shows there are two primary issues that he felt requires a response.

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

Information provided earlier in this testimony demonstrated that wind turbines do produce ILFN, including one chart showing infra sound from an early study of turbines by Leventhal, and that new research, not well known by acoustical engineers, show that the levels of acoustical energy are in the range of perception, above 90dB, for at least a small segment of the exposed

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

population. One chart in this shows infra and is referenced from an early study of turbines by Leventhal. With respect to whether wind turbines emit ILFN, consider that if one totals the acoustic energy of a wind turbine across the entire frequency spectrum from 16Hz up to the speech frequencies, the difference in the sum of the energy below 200 Hz is often 10-15 dB higher than the sum of the energy at 200 Hz and above. It is clear that wind turbines are primarily producers of noise in the ILFN range. Use of dBA criteria for this type of noise is non-sensical.

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

Even if only 5-10% of the people living in the footprint of an operating wind utility are susceptible, that is still a large number and given the fast rate at which wind utilities are being constructed this number will continue to increase. The Kamperman/James manuscript is written

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

Dr. Leventhal's critique of Kamperman/James's use of C-A demonstrates that he did not conduct a careful review of the manuscript. If he had done so, he would have noticed that the subscripts for the C-A criteria are: LCeq $_{(immission)}$ minus (LA90 $_{(background)}$ +5) $\leq$ 20 dB. This formulation is again an application of the precautionary principle. Given that we do not know how much increase in ILFN is needed to trigger an adverse health effect, the criteria was established to limit the additional ILFN from the operating turbines to no more than a small increase over the pre-operational background sound levels. In addition, the Kamperman/James paper suggests that the L_{Ceq} when the turbines are operating be limited to LCeq (emmision)= L_{C90}(background) +5 dB and not exceed 55dBC LCeq. In both cases, the justification is precaution. Until the extent of the links between nighttime sleep disturbance from audible sounds; and vestibular and cardio pathologies from audible sound or ILFN are known, it is best to error on the side of safety and health.

Dr. Nina Pierpont's work

Q: Please address the work of Dr. Nina Pierpont.

A: The symptoms reported by Dr. Pierpont for people exposed to dynamically modulated ILFN from wind turbines are not that different from the symptoms reported by Kirsten Persson Waye in collaboration with Dr. Leventhal in their 1997 paper "*Effects On Performance And Work Quality Due To Low Frequency Ventilation Noise*,"[35] This study compared the performance and other factors for a work group that was exposed to dynamically modulated low frequency sound to that of a work group exposed to more normal HVAC system sound spectrum with lower levels of LFN and no modulation. This study reported that the group exposed to LFN reported:

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

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

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

4. The effects seemed to appear over time

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

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

1. Mental tiredness,

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

2. Lack of concentration and

3. Headache related symptoms.

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

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

Persson-Waye 1995.

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

Q: Would you please summarize position of the World Health Organization?

A: Certainly. The World Health Organization (WHO) has a long established position that considers sleep disturbance to be an adverse health effect and to lead to secondary adverse health effects[36]. Dr. Leventhal did not seem to think this was important enough to include in his critique of Kamperman/James or of Dr. Pierpont. Nothing about these guidelines was mentioned in either of Mr. Hessler's reports. Chronic sleeplessness, in turn, causes a variety of health effects, including:

> *[P]rimary physiological effects . . . induced by noise during sleep, including increased blood pressure; increased heart rate; increased finger pulse amplitude; vasoconstriction; changes in respiration; cardiac arrhythmia; and an increase in body movements.*[37]"
> "*Exposure to night-time noise also induces secondary effects, or so-called after effects . . . including reduced perceived sleep quality; increased fatigue; depressed mood or well-being; and decreased performance.*[38]

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

Waking up in response to nighttime noise decreases as people get habituated to the noise; however, "*habituation has been shown for awakenings, but not for heart rate and after effects such as perceived sleep quality, mood and performance*."[39]

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

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

[39] Id., p. 45.

the turbines. WHO's descriptions of the health effects on the exposed populations closely parallel the experiences of people in other communities where wind utilities are currently operating.

Q: Hast the World Health Organization's position triggered further regional and local analysis of the impacts of wind turbines?

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

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

Minnesota's medical community, outside the Public Health Inquiry Regarding Health Impacts of Wind Turbines (PUC Docket 09-845), has yet to address the health controversy with a call for regulatory changes, but the situation in Minnesota is similar to that in Maine and elsewhere. Public officials with a duty to protect the public health and welfare should seriously

consider whether it is a wise decision to grant permits to a utility operator that, by its own admission, will expose the public to unsafe conditions 24 hours a day and 365 days a year.

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

Q: Do you have any words of conclusion regarding this project?

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

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

Background sound levels obtained by an independent acoustical consultant (Kamperman) shows that existing conditions at the Glacier Hills project in Wisconsin are often below 30 dBA. My own findings regarding the Goodhue site, just completed, are similar. Operation of wind turbines will increase sound levels on a routine basis to 40-45 dBA for many local residents and above that for conditions not accounted for in the models. For AWA Goodhue to meet WHO's guidelines the limits for sound at affected properties would need to be set at 35 dBA or lower. The studies and representations by AWA Goodhue show that estimated sound levels at properties adjacent to and inside the footprint of the proposed utility will exceed the nighttime sound levels WHO has identified as a health risk even without applying 5dB for tolerances and 10-15 dB for blade swish. Experience with other wind utilities with operating turbines having similar sound emission characteristics shows that wind turbine noise levels at distances of 1500 feet can exceed 50 dBA and that sound levels inside homes can easily exceed 30 dBA. Based on the above, the AWA Goodhue project, as proposed, will, with a high degree of certainty, have noise and health impacts that are "significant."

Q: Does this conclude your testimony?

A: Yes, it does.

Citations to references relied upon but not provided as Exhibits:

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

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

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

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

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

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

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

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

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

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

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

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

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

EXHIBIT E

Landowner Letters regarding misrepresentations by agents of Freeborn Wind

PUC Docket IP-6946/WS-17-410

STATE OF MINNESOTA
PUBLIC UTILITIES COMMISSION

July 3, 2017

Nancy Lange, Chair
Dan Lipschultz, Vice-Chair
John Tuma, Commissioner
Matt Schuerger, Commissioner
Katie Sieben, Commissioner

In the Matter of the Application of Freeborn Wind Farm, LLC for a Large Wind Energy Conversion System Site Permit for the 84 MW Freeborn Wind Farm in Freeborn County. PUC Docket Number: IP-6946/ WS-17-410

Honorable Commissioners,

I have reviewed the site permit application and wish to draw the Commission's attention to the following representation made by Invenergy in their application.

Public Outreach 4.2

Since the purchase of our property and the subsequent construction of our home, we have had limited interactions with Invenergy regarding the development of wind turbines near our home.

My family's first interaction with Invenergy was our attempt in the fall of 2015 to get clearance from Invenergy to move forward with our construction loan. Our title company attempted numerous times to connect with Invenergy without any communication back from the company. With a closing time table to get our title cleared, we had to fall back on communications from my in-laws with Invenergy to get acceptance from the title company.

In December 2015, I received a call from a worker telling me that I needed to meet with him to complete an W-9 form. Because I had no previous arrangement with Invenergy, I asked for clarification on the purpose and was told by the employee that I needed to meet with him and complete the form or face consequences from the IRS. At the meeting, the employee had me sign the W-9 and then pushed me to sign a "Good Neighbor Agreement" which I declined.

For the next year and half, neither my wife nor myself received any communication from Invenergy despite their decision to place seven turbines within one mile of our home. I attempted to communicate with Mr. Litchfield on 4/24/17 with some questions. My email was ignored. To follow up, I placed a call to the Glenville office in May 2017. My phone call was non-productive after I refused overtures to sign an agreement with Invenergy. Even a face-to-face meeting with Mr. Litchfield resulted in no cooperation besides giving me a schedule of shadow flicker times when I might want to avoid being at home.

I request that the Commission reject the site permit application until Invenergy provides accurate and complete information.

I request that the Commission reject the site permit application because Invenergy provided misleading information to the Commission.

Sincerely,
Sean Gaston
11133 850th Avenue
Glenville MN 56036

STATE OF MINNESOTA
PUBLIC UTILITIES COMMISSION

July 3, 2017

Nancy Lange, Chair
Dan Lipschultz, Vice-Chair
John Tuma, Commissioner
Matt Schuerger, Commissioner
Katie Sieben, Commissioner

In the Matter of the Application of Freeborn Wind Farm, LLC for a Large Wind Energy Conversion System Site Permit for the 84 MW Freeborn Wind Farm in Freeborn County. PUC Docket Number: IP-6946/ WS-17-410

Honorable Commissioners,

I have reviewed the site permit application and wish to draw the Commission's attention to the following representation made by Invenergy in their application.

Public Outreach 4.2

I had contacted Mr Litchfield after I saw an orange flag directly out my east window from my bedroom. The only open spot on my 11 acre farm. I have a windbreak to the west and north and a tree line to the south. I could spot this tiny orange flag directly out my 2nd story bedroom window.

I called Mr Litchfield to see if there was any way the wind turbine could be moved. He told me on the phone that why yes, it could be moved if I convinced my neighbors to the north to sign a Good Neighbor agreement and he could move the turbine to the north a bit. I asked why it couldn't go further to the east and he said that it couldn't be closer to the Davis family, but they have already signed their farmland up for turbines.

I just don't understand why the people that signed up for turbines on their farm land do not have a turbine directly out their front window like I do. My biggest concern is my 9 year old son with autism. He tells me that he gets dizzy watching kids play baseball. What is a giant wind turbine going to do to him when he is outside every day?

Dan said that he understand and he has kids of his own. He told me that I could get that turbine moved, as you will see in the email below, if I signed the Good Neighbor agreement. I was advised that if I did they could move it closer to my property and who is to say they would keep their word and move the turbine from the east (#30, as you will see on the map below).

The land owners that own the field directly to the east of my property live in Twin Lakes, MN and they said they would have never agreed to sign up for the turbine if they knew it was going directly out my front door. They would like to see if moved too. Mr Litchfield keeps telling me it can't be moved in any direction without getting others to sign up.

We live in the country to peace and quiet. It is sad how Invenergy operates. I wish everyone would have known the truth about these turbines before signing up.

I request that the Commission reject the site permit application until Invenergy provides accurate and complete information.

Sincerely,
Michelle Severtson
12047 870th Avenue
Glenville, MN 56036

STATE OF MINNESOTA
PUBLIC UTILITIES COMMISSION

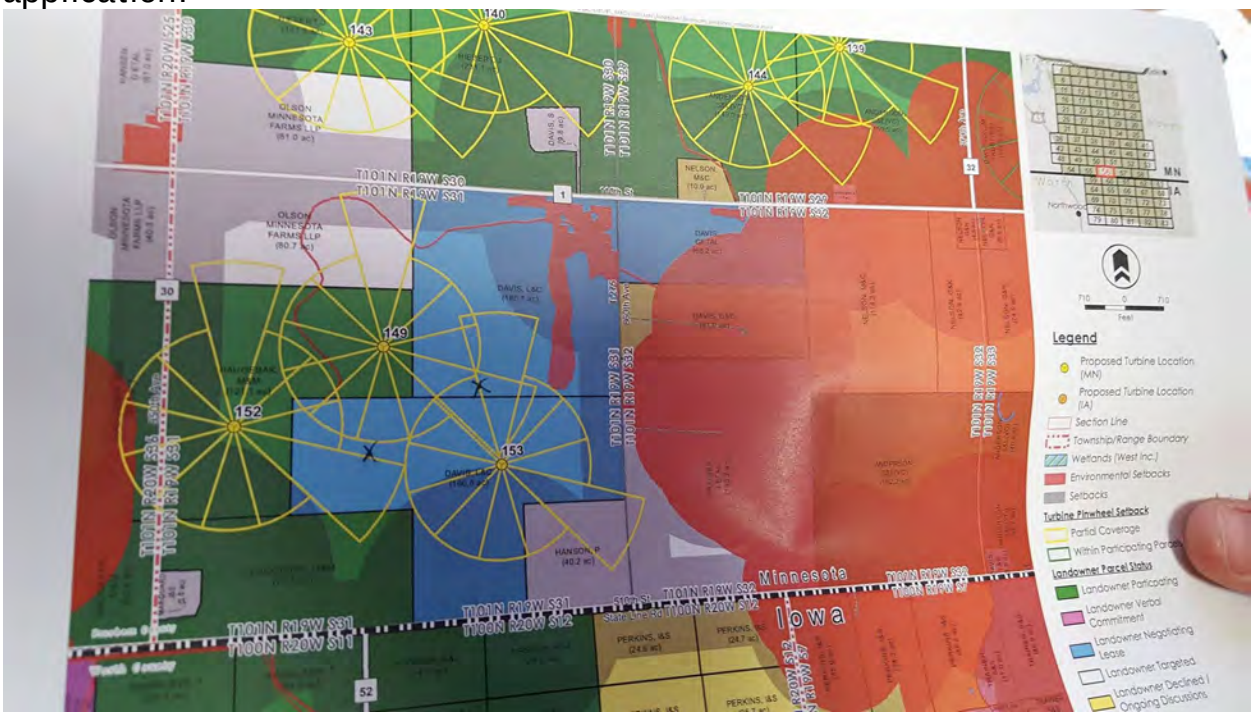
July 3, 2017

Nancy Lange, Chair
Dan Lipschultz, Vice-Chair
John Tuma, Commissioner
Matt Schuerger, Commissioner
Katie Sieben, Commissioner

In the Matter of the Application of Freeborn Wind Farm, LLC for a Large Wind Energy Conversion System Site Permit for the 84 MW Freeborn Wind Farm in Freeborn County. PUC Docket Number: IP-6946/WS-17-410

Honorable Commissioners,

I have reviewed the site permit application and wish to draw the Commission's attention to the following representation made by Invenergy in their application.



This map is from the Invenergy Office from February 1, 2017. The agent's name was Brett. The red shaded area (section 32) is considered "environmental concern area." He (Brett) assured me there would be NO wind turbines in

section 32 of the London Township. However, in the latest proposed maps, there is a proposed turbine in the southwest quarter of section 32. I am concerned about the setbacks toward the wetland and environmentally concerned area to the East of the proposed turbine.

Another thing to note is the invalid documentation of owner property. Davis, L & C should only own 200 acres total, however on this map, it shows that Davis, L & C owns 320 acres. Property ownership was incorrect at the initial planning of the proposed turbine placement.

I request that the Commission reject the site permit application until Invenergy provides accurate and complete information.

I request that the Commission reject the site permit application because Invenergy provided factually incorrect/ misleading information to the Commission.

Thank you

Lance Davis
87002 State Line Road
Glenville MN 56036

STATE OF MINNESOTA
PUBLIC UTILITIES COMMISSION

July 4, 2017

Nancy Lange, Chair
Dan Lipschultz, Vice-Chair
John Tuma, Commissioner
Matt Schuerger, Commissioner
Katie Sieben, Commissioner

Daniel P Wolf, Executive Secretary
Michale Kaluzniak, staff

In the Matter of the Application of Freeborn Wind Farm, LLC for a Large Wind Energy Conversion System Site Permit for the 84 MW Freeborn Wind Farm in Freeborn County. PUC Docket Number: IP-6946/WS-17-410

Honorable Commissioners,

I have had several neighbors including Mike and Dorenne Hansen and Raymond and Lydia Mittag tell me that Invenergy land agents have told them we had signed easements for our land. Nothing could be further from the truth. We have never signed our land to an Invenergy easement.

I request that the Commission reject the site permit application because Invenergy provided factually incorrect/ misleading information to the Commission.

Sincerely,

Mike and Christine Lau
84428 120th St
Glenville MN 56036

Christine Lau

Michael Lau

STATE OF MINNESOTA
PUBLIC UTILITIES COMMISSION

July 4, 2017

Nancy Lange, Chair
Dan Lipschultz, Vice-Chair
John Tuma, Commissioner
Matt Schuerger, Commissioner
Katie Sieben, Commissioner

Daniel P Wolf, Executive Secretary
Michale Kaluzniak, staff

In the Matter of the Application of Freeborn Wind Farm, LLC for a Large Wind Energy Conversion System Site Permit for the 84 MW Freeborn Wind Farm in Freeborn County. PUC Docket Number: IP-6946/WS-17-410

Honorable Commissioners,

I had an Invenergy representative come to my home in late 2009/early 2010. He had a presentation about wind energy. I don't recall his name but I do remember that he said he'd built a turbine on his parents land.
I wasn't in favor of signing an easement at that time but then he told us that all the neighbors had signed easements so even if we (I and my siblings) didn't sign an easement we would be surrounded by turbines. He was also said we would have up to 3 turbines on our land.
I and my siblings signed with an effective date of 3-22-2010.

Later we discovered that all our neighbors had NOT signed easements.

My family did not re-sign in 2017 due to the numerous problems we have learned about since 2010. Invenergy has admitted that they fired an agent due to his lying and deception to citizens of the Freeborn Wind Farm footprint.

Howard Krueger asked me to host a meteorological tower. I told him I had three siblings to contact. He came back a week later and the he came back again a few days later and again a few days after that. At the third meeting he suggested I sign and he could get "the tower business going" and I could get signatures later. I asked him to leave and not come back.

I had land representatives, coming to my home frequently, at times several times a week from the summer of 2015 until March of 2017 requesting that I resign my easement agreement. Some of the names I recall along with Howard Krueger are Steve Harvey and Tom Spitzer. There were others that I do not recall their names.

I request that the Commissioners reject the site permit application because it provided factually misleading information to the commission.

Dorenne Hansen

Dorenne Hansen
12174 840th Ave, Glenville MN 56036

STATE OF MINNESOTA
PUBLIC UTILITIES COMMISSION

July 3, 2017

Nancy Lange, Chair
Dan Lipschultz, Vice-Chair
John Tuma, Commissioner
Matt Schuerger, Commissioner
Katie Sieben, Commissioner

Daniel P Wolf, Executive Secretary
Michale Kaluzniak, staff

In the Matter of the Application of Freeborn Wind Farm, LLC for a Large Wind Energy Conversion System Site Permit for the 84 MW Freeborn Wind Farm in Freeborn County. PUC Docket Number: IP-6946/WS-17-410

Honorable Commissioners,

I am one of the "good neighbor" agreement holders who was tricked by Howard Krueger, an Invenergy land agent, into believing all my neighbors had signed for turbines or good neighbor agreements.

I would never have signed anything for wind turbines if he had not deceived me.

Brad Struck
84538 130th St
Glenville MN 56036

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TO; MINNESOTA PUBLIC UTILITIES COMMISION

I am a resident of Freeborn County. My wife and I reside in the parameters of the proposed wind farm. We are on an acreage (10.58 Ac.). Two years ago we were approached by a representative of the Freeborn wind farm or Invenergy. We were asked to sign a ' Good Neighbor Agreement ' . In the language of that we couldn't attend any hearings in the future against the wind farm. We would also give up our set back from the proposed towers. This was in exchange for $1000.00 per year.

Invenergy has told so many people so many different things to get their access point they need. They have pitted nieghbors against each by lying to everyone. No wonder they need everyone else to be a good nieghbor because they sure aren't . Invenergy is only interested in selling off this project once permitted and never to be seen again.

I worked in the Pleasant Valley wind farm located by Sargent MN two years ago. I hauled rock to the portable cement plant for the project. I saw first hand how the project people treated non participating people in that project. It was terrible and continues to be that way. Anyone that came with a concern was either told they should have read the 'fine' print or 'we never promised any of you anything'. Acreages are a hard sell there and anywhere else there are wind farms. There are over 100 acreages in the proposed wind farm that stand to lose 30 to 50% percent of their value.

Also many of us live on gravel roads and are not close to together , when we lose our cell phone reception, Dish TV , and our Internet is intermittent, we probably won' t get fiber optic line to provide us our service we stand to lose.

Our way of life here is at stake. If I wanted to live near 50 story structures I would live in Minneapolis not here. Please don't let the financial gain of a few hurt the rest of us.

Sincerely,
Clark Ericksen

Clark Ericksen
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