BEFORE THE MINNESOTA PUBLIC UTILITIES COMMISSION

David Boyd	Chair
J. Dennis O'Brien	Commissioner
Phyllis Reha	Commissioner
Thomas Pugh	Commissioner
Betsy Wergin	Commissioner

Adam Sokolski
Elm Creek Wind II, LLC
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Minneapolis, MN 55415

SERVICE DATE: March 14, 2011

DOCKET NO. IP-6728/WS-09-553

In the Matter of the Site Permit issued to Elm Creek Wind II, LLC for a Large Wind Energy Conversion System in Jackson and Martin Counties

The above entitled matter has been considered by the Commission and the following disposition made:

> **Approved the Sound Monitoring Protocol as proposed for the 148.8 MW Elm Creek II Wind Project in Jackson and Martin counties.**
>
> **Upon completion of the study, survey results must be reported to the Commission.**
>
> **The Permittee shall make a compliance filing once the four monitoring locations are determined, citing the monitoring locations and the rationale for selecting the locations.**

The Commission agrees with and adopts the recommendations of the Office of Energy Security which are attached and hereby incorporated in the Order.

BY ORDER OF THE COMMISSION

Burl W. Haar
Executive Secretary

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BEFORE THE MINNESOTA PUBLIC UTILITIES COMMISSION

COMMENTS AND RECOMMENDATIONS OF THE MINNESOTA OFFICE OF ENERGY SECURITY ENERGY FACILITY PERMITTING STAFF

DOCKET NO. IP-6728/WS-09-553

Meeting Date: March 10, 2011…..…….……..Agenda Item # __11___

Company: Elm Creek Wind II, LLC (subsidiary of Iberdrola Renewables, Inc.)

Docket No. **PUC Docket Number: IP-6728/WS-09-553**

In the Matter of the Site Permit issued to Elm Creek Wind II, LLC for a Large Wind Energy Conversion System in Jackson and Martin Counties.

Issue(s): Should the Commission approve the proposed noise monitoring protocol submitted by Elm Creek Wind II, LLC, for the 148.8 MW Elm Creek II Wind Project?

OES EFP Staff: Matthew A. Langan.....651-296-2096

Relevant Documents

Site Permit Application (Noise Level Modeling)...….……May 19, 2009
Commission Order for Elm Creek II Wind Farm……...……..February 25, 2010
Commission Order for Elm Creek II Wind Farm – Erratum Notice……...……...March 8, 2010
Sound Monitoring Protocol……...…….…….June 11, 2010
Sound Monitoring Protocol – Revised February 23, 2011….……..February 28, 2011

The enclosed materials are work papers of the Office of Energy Security (OES) Energy Facility Permitting (EFP) Staff. They are intended for use by the Public Utilities Commission and are based on information already in the record unless otherwise noted. This document can be made available in alternative formats (i.e., large print or audio) by calling 651-296-0391 (voice). Persons with hearing or speech disabilities may call us through Minnesota Relay at 1-800-627-3529 or by dialing 711.

Documents Attached:
1. Project Area Map
2. Project Facilities Map as built
3. State of Wisconsin's "Measurement Protocol for Sound and Vibration Assessment of Proposed and Existing Electric Power Plants" [November 2008, as adapted May 2010]
4. Minnesota Pollution Control Agency Memo

(Note: see eDockets (09-553) or the PUC Facilities Permitting website for additional documents: http://energyfacilities.puc.state.mn.us/Docket.html?Id=20051.

Statement of the Issue

Should the Commission approve the proposed noise monitoring protocol submitted by Elm Creek II Wind, LLC, for the 148.8 MW Elm Creek II Wind Project in Jackson and Martin Counties?

Introduction and Background

Iberdrola Renewables, Inc., applied to the Commission for a LWECS site permit on May 19, 2009, to develop the 150 MW Elm Creek II Wind Farm in Jackson and Martin counties. On February 25, 2010, a Commission Order issued a site permit to Iberdrola Renewables, Inc. subsidiary Elm Creek Wind II, LLC, consisting of 62 Mitsubishi 2.4 MW wind turbines. The project, built in 2010 on a 30,339-acre site, went into commercial operation on December 31, 2010.

In some projects recently permitted by the Commission, the public has raised concerns about the noise levels produced by wind turbines when in operation. In order to address this issue, some of the recently issued Commission site permits for large wind energy conversion systems have required post-construction noise surveys in order to gather base line information on wind turbine noise, compare modeled noise limits with actual noise measurements for verification purposes and insure compliance with Minnesota Pollution Control Agency (MPCA) state noise standards.

Project Location
The Elm Creek II Wind Project is located in Jackson and Martin counties, Minnesota, as shown on the accompanying map (Attachment 1) The Project is located within Enterprise and Wisconsin townships, Jackson County, and Cedar, Elm Creek and Jay townships, Martin County. The project site, approximately 30,339 acres in size, is comprised primarily of agricultural lands. Site terrain is relatively flat, with a variation in elevation between 1,245 and 1,451 feet above mean sea level. At the time of permit application, the Permittee controlled approximately 10,000 acres of land and wind rights within the 30,339-acre Project Area.

Elm Creek II Wind Project
The Elm Creek II Wind Project is comprised of 62 Mitsubishi 2.4 megawatt wind turbines, mounted on 80-meter (262 feet) high freestanding tubular steel towers. The blades on the Mitsubishi wind turbines are 47.5 meters (156 feet) long. The rotor diameter is 95 meters (312

feet). The generator cut in speed is 6.7 mph (3.0 meters per second m/s) and the cut out is 56 mph (25 m/s).

The project also includes an underground automated supervisory control and data acquisition system (SCADA) for communication purposes. One permanent free standing 80 meter meteorological tower is used to measure on-site meteorological conditions and is connected to the SCADA system. Other components of the project include a concrete and steel foundation for each tower, pad-mounted switchgears and grounding transformers at the ends of circuits, approximately 17 miles of all weather gravel roads, approximately 25 miles of underground energy collector lines and 10 miles of overhead energy collector lines, expansion of the Trimont Wind Electrical Substation, and a project operation and maintenance building. All of the proposed wind turbines and associated facilities are located in Jackson and Martin counties.

Wind Turbine Noise

Noise produced by wind turbines, when operating, has been one of the most studied environmental impacts of this technology.

The more contemporary (upwind) wind turbines produce two types of noise: mechanical noise from gearboxes and generators, and aerodynamic noise from blades. Current wind turbine design has eliminated much of the mechanical noise through design improvements and more use of insulating material in the nacelle, leaving aerodynamic noise as the biggest contributor. The aerodynamic noise is produced by the rotation of the blades generating broad-band swishing sound and is also a function of tip speed. By optimizing wind turbine airfoil design and tip speed, aerodynamic noise can be reduced in one of two ways: 1) decreasing rotational speeds to less than 65 meters per second (m/s) or 145.6 miles per hour; and 2) using pitch control on upwind turbines, which permit the rotation of the blades along their long axis.

At any given location, the noise within or around a wind farm can vary considerably depending on a number of factors including the distance of the receptor to the turbine, the model of turbine installed, topography, the speed and direction of the wind, background noise, time of year, and atmospheric conditions as well as other factors. The factors with the most influence on noise propagation are the distance between the observer and the source and the sound power level of the source.

The sound emissions of a wind turbine do increase as the wind speed increases before leveling off. However, the background noise will typically increase faster than the sound of the wind turbine, which tends to mask the wind turbine noise in higher winds. Sound levels decrease as the distance from the wind turbine increases.

Noise levels can be measured and predicted, but public attitude toward noise depends heavily on perception. Sound emissions can be accurately measured using standardized acoustic equipment and methodologies (International Organization for Standardization – ISO Standards, International Electrotechnical Commission – IEC Standards and other). Levels of sound are most commonly expressed in decibels (dB). The predictions of sound levels are of importance in order to insure compliance with existing standards.

When there are people living near a wind farm noise levels are factored into the design and layout of a project. Rural areas are quieter than cities, so the background noise is usually lower. However, there also are noisy activities in rural areas associated with agricultural operations, transportation, and industrial activities. Wind farms are located in windy areas, where background noise is higher, and as the wind speeds increase, ambient background noise levels also increase. As wind speeds increase, the wind itself tends to mask the noise produced by the turbines.

Because of the wide variation in the levels of individual tolerance for noise, there is no completely satisfactory way to measure its subjective effects or the corresponding reactions of annoyance and dissatisfaction. The individual annoyance for noise is a very complicated and complex topic, but dose-response relationship studies have demonstrated a correlation between noise annoyance with visual interference and the presence of intrusive sound characteristics.

Site permits for wind farms in Minnesota, authorized by the Environmental Quality Board or the Commission, have always required that projects be designed to comply with Minnesota Pollution Control Agency noise standards in Minn. Rule Chapter 7030, as contained in site permit condition III.E.2. (See Site Permit Requirements below).

In the 1990s, operation noise surveys were carried out on at least two wind projects in the Lake Benton area on Buffalo Ridge in Lincoln County. Those surveys, done by Hersh Acoustical Engineering, concluded that the turbines were in compliance with Minnesota's noise standards.

However, those turbines – tower height, rotor diameter –were considerably smaller than the commercial turbines now available. Considerable research has been and continues to be incorporated into blade design in order to improve operating efficiency, while at the same time reducing noise levels.

Nonetheless, the topic of turbine noise is often an issue that comes up in review of wind projects, in Minnesota and elsewhere. The Commission, in its review of the record in recent LWECS site permit proceedings, has included requirements for noise surveys, in part to address public concerns about wind turbine noise, but also to provide baseline information that allows for review of modeled sound emission levels against actual field measurements for correlation, to help determine compliance with MPCA noise standards, and to provide decision-makers with objective information that will assist them in evaluating noise levels.

Site Permit Requirements [Noise]

For the Elm Creek II Wind Project, wind turbine noise is addressed in the Commission-issued site permit (February 25, 2010) in two separate locations:

Site permit condition III.E.3 [Noise] addresses compliance with the MPCA noise standards (Minn. Rule Chapter 7030) and reads as follows:

> The wind turbine towers shall be placed such that the Permittee shall comply with noise standards established as of the date of this Permit by the Minnesota Pollution Control Agency at all times at all appropriate locations. The noise

> standards are found in Minnesota Rules Chapter 7030. Turbine operation shall be modified or turbines shall be removed from service if necessary to comply with this condition. The Permittee or its contractor may install and operate turbines, as close as the minimum setback required in this permit but in all cases shall comply with PCA noise standards. The Permittee shall be required to comply with this condition with respect to all homes or other receptors in place as of the time of construction, but not with respect to such receptors built after construction of the towers.

Site Permit condition III.F.2 [Studies/Noise] is the requirement for a post-construction noise survey and reads as follows:

> The Permittee shall submit a proposal to the Commission for the conduct of a noise study. Upon the approval of the Commission, the Permittee shall carryout the study. The study shall be designed to determine the noise levels at different frequencies and at various distances from the turbines at various wind directions and speeds.

Elm Creek Wind II, LLC, did not locate any of the 62 turbines within 1,000 feet of a residence, pursuant to site permit condition III.C.2.

Site Permit Application − Noise Information

The topic of wind turbine noise was included in Elm Creek Wind II, LLC's, site permit application (See Relevant Documents, pages 5-2 to 5-4, and Figure 5-1). Information in the application indicated that background noise levels in the Project Area are typical of those in rural settings, where existing noise levels are commonly in the low to mid-30 dBA range. The dBA scale represents A-weighted decibels based on the range of human hearing. Low to mid-30 dBA are relatively low background levels and are generally representative of the site. Higher levels exist near roads and other areas of human activity.

Sound Monitoring Protocol [February 2011]

As noted above, condition III.F.2 in the Elm Creek II Wind Site Permit requires the Permittee to submit a proposal to the Commission for the conduct of a noise study and, upon approval of the Commission, the Permittee shall carryout the study. To comply with this requirement, Elm Creek Wind II, LLC, submitted a Sound Monitoring Protocol dated May 14, 2010, revised February 23, 2011 (see Relevant Documents), prepared by its noise consultant at CH2MHILL, summarizing the field test procedures to be used in evaluating sound emissions from the Elm Creek II Wind Project relative to applicable regulatory noise limits once the project is fully operational. The aim of the study is to verify compliance with the MPCA Noise Standards and to determine the noise levels at different frequencies and at various distances from the turbines at various wind directions and speeds. The proposed protocol is comprised of the following components:

A qualified acoustical professional (Professional Engineer or Board Certified by the Institute of Noise Control Engineering) will conduct the operational noise study of the Elm Creek II Wind Project. ANSI S1.4 Type 1 (precision) sound level meters with 1/3-octave band capabilities will

be used to determine the noise levels at varying frequencies to compute the overall A- and C-weighted sound levels. Each meter will be equipped with a windscreen for conducting noise measurements in windy environments (oversize or secondary windscreens reflect the current state of the art). Average and statistical sound level metrics will be reported in 10-minute intervals to correlate with meteorological and operational data collection efforts as well as hourly intervals consistent with the MPCA noise measurement standards. Four on-site meters will be located at varying distances and directions from the turbines that are selected to be representative of the surrounding residences. An additional, an off-site meter will be located approximately two miles away to serve as a background location. The sound level meter locations have not been determined at this point. The outdoor monitoring sites will be determined by evaluating the locations of the turbines, residences and other noise sources (such as Interstate Highway 90). The locations will be selected to reflect varying distances from a turbine and will be located at least 20 feet from any structure to minimize error from reflections. The wind speed and direction at microphone height will be collected at the background location and one of the four project locations. The monitoring period is anticipated to be approximately 7-days, but may be extended if no significant wind events are monitored. The protocol requires the use of oversize windscreens to reduce wind induced noise on the microphone to nominal levels (the 7" ACO Model WS7-80T is envisioned)."

The proposed survey, if approved by the Commission, is expected to be carried out during the second or third quarter of 2011.

OES EFP Staff Comments and Analysis

Elm Creek Wind II, LLC, modeled potential noise impacts during the planning stages of the Elm Creek II Wind Project to make informed decisions about turbine placement. As discussed above, permit condition III.E.3. for the Elm Creek II Wind Project requires the Permittee to comply with noise standards established by the MPCA. The site permit (III.F.2.) also requires the Permittee to submit a proposal to the Commission for the conduct of a noise study.

While the current MPCA Noise Survey Protocols provide some applicable guidance on designing a noise study and reporting the results, they are not specifically designed to account for wind turbine noise at different frequencies. In reviewing various other noise studies, OES EFP staff became aware of requirements for noise studies adopted by the Wisconsin Public Service Commission. While these standards were initially designed to measure noise from more traditional electrical generating sources, they were amended to account for noise from wind turbine generators on November 17, 2008, and adapted on May 26, 2010 (See Attachment 3 in Commissioner's packet). The Wisconsin Public Service Commission "Measurement Protocol for Sound and Vibration Assessment of Proposed and Existing Wind Electric Generation" specifically addresses wind electric generation plants. This protocol contains five sections:

I. Objectives
II. PSC Staff Contacts
III. Introduction
IV. Measurements of the Existing Sound and Vibration Environment
    A. Sites With No Existing Generation

B. Sites With Existing Wind Electric Generation Facilities
C. Sound Level Estimates for proposed Wind Turbine (s)

V. Post Construction Measurements

As the focus of the site permit in this instance is on post-construction noise surveys, staff draws the Commission's attention to the following specific Wisconsin Public Service Commission "Post-Construction Measurements" requirements:

V. Post-Construction Measurements

1. Within twelve months of the date when the project is fully operational, and within two weeks of the anniversary date of the pre-construction ambient noise measurements, repeat the existing sound and vibration environmental measures taken before project approval.

2. Post-construction sound level measurement should be taken under two wind conditions:

   a. Under calm conditions without the wind turbine rotors rotating. These measurements shall be taken with the entire wind generating development offline.
   b. Under wind conditions just above the cut-in speed for the wind turbines with as many of the wind turbines in the development operating as possible.

3. Notes regarding post-construction sound level measurements for wind project developments:

   i. Measurements taken as required under section V.2b may be taken prior to measurements taken under section V.2.a.
   ii. Because of the variability of wind speeds, post-construction measurement may be taken outside of the measurement periods listed in section IV.B3.* However, measurements taken under section V.2.a, above, must be taken during the same time of day as the corresponding measurements taken under item V.2.b.
   iii. For each MP at which pre-construction noise measurements were taken, a minimum of three sets of measurements shall be taken under sections V.2.a and 2.b. The three sets of measurements should correspond to at least two different times of day. Any or all of the measurements may be taken outside of the measurement periods listed in Section IV.B.3.
   iv. Measurements taken to fulfill the requirements of sections V.2.a and 2.b must be taken within as few consecutive days as practicable.
   v. Measurements taken under sections V.2.a and 2.b must include a measurement of the 16 Hz octave band, as described in section IV.B.4.a.**

4. The post construction sound level measurements must include an evaluation of whether the wind development meets any and all state and local sound level requirements.

5. File a copy of the post-construction noise measurement report with the Public Service Commission including pre- and post-construction measurement data and using the same report format as used for the pre-construction sound land vibration study reports.

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* Section IV.B.3 specifies that measurements should be for a minimum of ten continuous minutes for each criterion (see section IV.B.4 below) at each location. Times of day recommended for measurements are as follows: Morning (6 – 8 a.m.); Midday (12 noon – 2 p.m.); Evenings (6 – 8 p.m.); and Night (10 p.m. – 12 midnight).

** For each measurement point and for each measurement period, provide each of the following measurement criteria: (a) At a minimum, unweighted octave-band analysis (16, 31.5, 63, 125, 250, 500, 1K, 2K, 4K, & 8K Hz), one-third octave band analysis is encouraged. PSC staff acknowledges that few sound level meters are capable of measurement of the 16 Hz center frequency octave band. However, because noise complaints from the public most likely involve low frequency noise associated with proposed plants, we encourage applicants to pursue the collection of this important ambient noise data.

The Elm Creek Wind II, LLC, Sound Monitoring Protocol, Wisconsin Power and Light's "Operational Sound Level Survey Test Protocol," and a copy of the State of Wisconsin's "Measurement Protocol for Sound and Vibration Assessment of Proposed and Existing Electric Power Plants" [November 2008, and adapted May 2010], (See Attachment 3) were sent by OES EFP staff to MPCA staff (Anne Claflin) for review and comment. Ms. Claflin's comments are provided in Attachment 4.

The MPCA staff comments noted that: "The work you have from Hessler is really well done. Their methods make a better protocol than the (Wisconsin) methods, but (Wisconsin) wouldn't be a bad place to start. If Hessler agrees, I would share their work as an example of what you are looking for." And, "it appears (Elm Creek Wind II, LLC) will be collecting data under a similar scheme to the Hessler analysis, so I would assume that their analytical methods would also be similar."

Ms. Claflin refers to Elm Creek Wind II, LLC, collecting data under a similar scheme to the Hessler protocol. This is in reference to multiple monitoring sites, an off-site control, and equipment used to collect the data. Ms. Claflin also makes the assumption that analytical methods will be similar between the two proposed protocols. Elm Creek Wind II, LLC, will use similar analytical (data reporting) methods in reporting the data for various frequencies, at different distances and locations, and will base the locations of the sound monitoring sites on the collection of this data.

As noted above, Wisconsin's Measurement Protocol calls for a pre-construction/operation survey of noise levels. As the Elm Creek II Wind Project is already operating, the Elm Creek Wind II, LLC, protocol addresses this element of the Wisconsin Protocol by including an off-site monitor to measure noise levels without the project present. MPCA found this to be an acceptable

approach, stating "Collecting ~1000 measurements from each of 4 sites over the course of a week and being able to compare to a simultaneous background sample and meteorological data will provide a lot of data from which to derive a profile of noise against wind speed for the state standards and for frequency analysis." OES EFP agrees with this assessment.

It should be pointed out that much of the concern regarding noise is about "low frequency noise." MPCA's memo indicated that "If the equipment is capable of measuring A and C weighting simultaneous, having that information can only help." However, low frequency noise (16 Hz) is very difficult to measure, as also acknowledged by footnote number 2 in the Wisconsin protocol. Elm Creek Wind II, LLC, proposes that more detailed 1/3 octave band data will be collected consistent with the Site Permit condition to measure "at different frequencies." The 1/3 octave band data can be used to calculate the C-weighting. The Permittee will report data gathered on A-weighted and C-weighted measurements in L_{10}, L_{50} and L_{90} levels

MPCA's memo points out that "using four locations on site and one off site is a smaller sample than used by Hessler, but may be representative of the project and an appropriate scale for the project." Elm Creek Wind II, LLC, submits that four monitoring locations is representative and appropriate to the project scale when compared to the Bent Tree project, which operates nearly twice the number of wind turbines than the Elm Creek II Wind Project. OES EFP agrees that the number of sites proposed for the Elm Creek Wind II Project is appropriate, but suggests the Commission require the Permittee make a compliance filing once these four locations are determined, citing the monitoring locations and the rationale for selecting the locations.

OES EFP staff sought out standards for noise protocol surveys for wind turbines. In this instance, the State of Wisconsin's noise survey protocol for wind turbines was reviewed by OES EFP and MPCA staff as a backdrop for evaluating noise survey protocols submitted for Commission approval. OES EFP staff finds that elements of the Wisconsin Public Service Commission Sound and Vibration Assessment Protocol Standards serve to augment the Minnesota Noise Monitoring Guidelines, which were not specifically designed for monitoring sound created by the operation of wind farms, and together provide an acceptable base for designing a protocol to address the Commission's permit condition. As noted in MPCA's comments, the noise protocol submitted for the Elm Creek II Wind Project was found to be a satisfactory approach for ensuring compliance with the State of Minnesota's Noise Standards and for determining noise levels at different frequencies, at various distances and wind speeds.

Therefore, OES EFP staff recommends that the Commission approve of the Sound Monitoring Protocol proposed by Elm Creek Wind II, LLC, for the Elm Creek II Wind Project to fulfill the requirement of site permit condition III.F.2. The survey results and report will be submitted to the Commission and e-filed for docket number 09-553.

Commission Decision Options

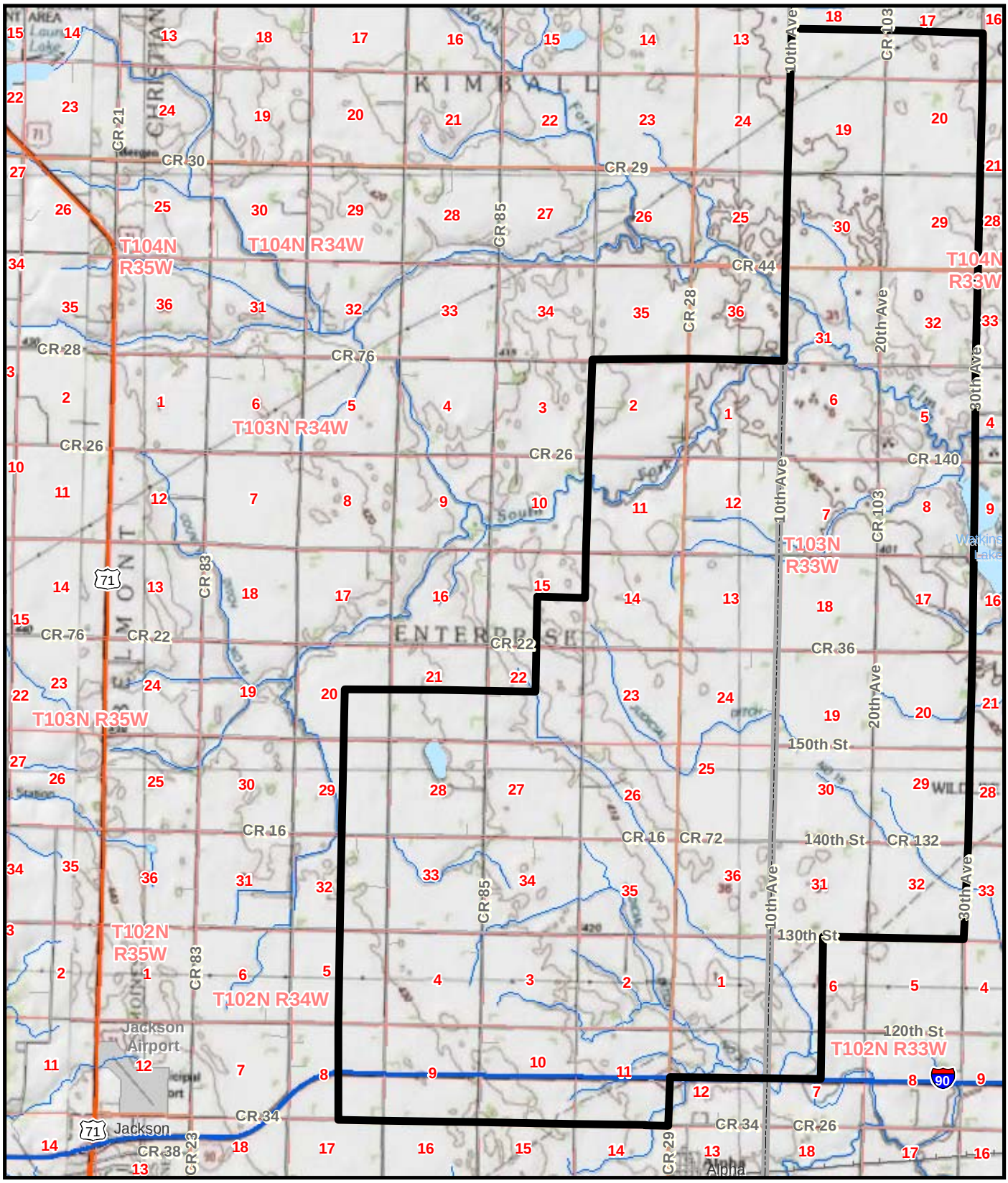
A. Approve the Sound Monitoring Protocol as proposed for the 148.8 MW Elm Creek II Wind Project in Jackson and Martin counties. Upon completion of the study, survey results will be reported to the Commission

B. Approve the Sound Monitoring Protocol with modifications.

C. Make some other decision deemed more appropriate.

D. Require the Permittee make a compliance filing once the four monitoring locations are determined, citing the monitoring locations and the rationale for selecting the locations.

OES EFP Staff Recommendation: The staff recommends Options A and D.



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- Interstate Highway
- US/State Highway
- County Highway
- Local Roads
- Project Area
- Section Lines

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Figure 1-2
Project Location Map
Elm Creek II Wind Project
Jackson & Martin Counties, MN

Modify Date: 5/14/2009

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Project Facilities Map
Elm Creek II Wind Project

Modify Date: 1/5/2011

Legend

- Turbine
- Permanent Met Tower
- Homes
- Turbine Access Road
- Overhead 34.5-kV Collector Line
- Underground 34.5-kV Collector Line
- Underground Fiber
- Interstate Freeway
- US/State/County Highways
- Local Roads
- Existing Transmission Line
- Existing Gas Pipelines
- O&M Facility
- Project Substation
- Contours (5-ft)
- Site Boundary
- Property Line
- County Line

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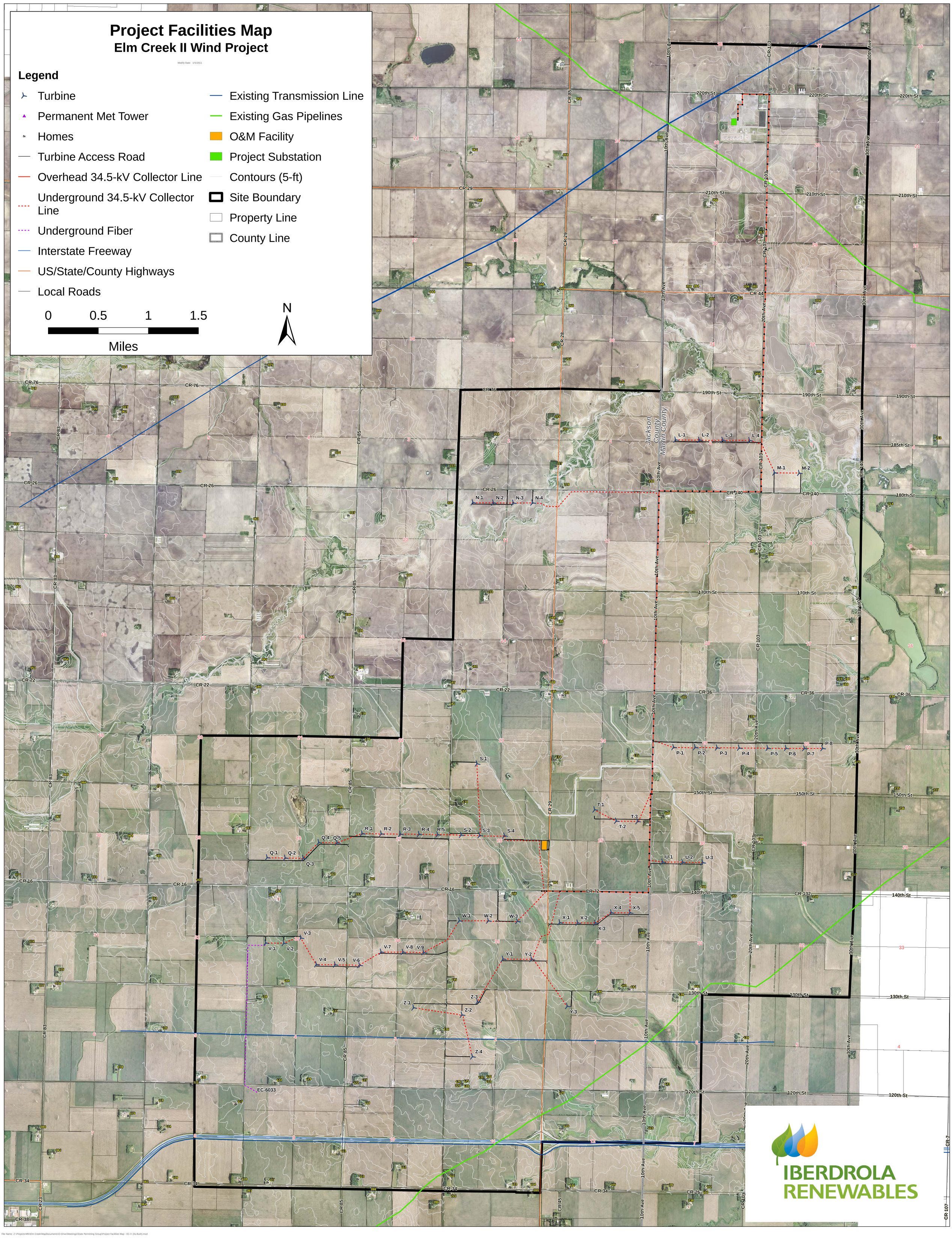

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MEASUREMENT PROTOCOL FOR SOUND AND VIBRATION ASSESSMENT OF PROPOSED AND EXISTING WIND ELECTRIC GENERATION PLANTS

May, 2010

Note: Consult with Commission staff prior to conducting any sound and vibration measurements.

I. Objectives

The primary objectives of this protocol include:

1. To measure and characterize the existing sound and vibration environment in the area of the proposed development.
2. To predict the incremental increase in sound and vibration levels that would occur as a result of operation of the proposed development.
3. To verify that the predicted incremental increase in sound and vibration levels is reasonable by taking post-construction sound level measurements.
4. To verify compliance with applicable sound and vibration level limitations by taking post-construction sound level measurements.

II. PSC Staff Contacts

Jim Lepinski, P.E. Public Service Commission of Wisconsin 610 N. Whitney Way PO Box 7854 Madison, Wisconsin 53707-7854 (608) 266-0478 jim.lepinski@wisconsin.gov	William Fannucchi Public Service Commission of Wisconsin 610 N. Whitney Way PO Box 7854 Madison, Wisconsin 53707-7854 (608) 267-3594 william.fannucchi@wisconsin.gov

III. Introduction

The potential sound and vibration impact associated with the operation of wind electric generation developments is often a primary concern for citizens living in the areas of the developments. This is especially true of projects located near homes, residential neighborhoods, schools, and hospitals. Determining the likely sound and vibration impacts is a highly technical undertaking and requires a serious effort in order to collect reliable and meaningful data for both the public and decision-makers.

This protocol is based, in part, on criteria published in the Standard Guide for Selection of Environmental Noise Measurements and Criteria.[i] The purpose of this protocol is to establish a consistent and scientifically sound procedure for estimating existing sound and vibration levels in a project area.

The layout of the proposed development and the features of the surrounding environment will influence the design of the sound and vibration study. Site layout and the existence of significant local sound and vibration sources and sensitive receptors must be taken into consideration when designing a sound and vibration study. It may be necessary to hire a qualified consultant to conduct the sound and vibration study.

Note: Consult with Commission staff prior to conducting any sound and vibration measurements.

These guidelines are meant to be general in nature and may need to be modified to accommodate unique site characteristics. Consult with Commission staff assigned to the project for guidance on study design before you begin the sound and vibration study. During consultation, good quality maps and diagrams of the site will be necessary. Maps and diagrams should show the site layout on an aerial photogragh base and identify important landscape features as well as significant local sound and vibration sources and sensitive receptors.

IV. Measurement of the Existing Sound and Vibration Environment

An estimate of the project area's existing sound and vibration environment is necessary in order to predict the likely impact resulting from a proposed project. The following guidelines must be used in developing a reasonable estimate of an area's existing sound and vibration environment.

A. Sites With No Existing Generation

1. At a minimum, sound level measurements should be taken at three locations or measurement points (MPs). Because each site is unique, more than three MPs may be necessary. **Consult with Commission staff regarding the quantity and location of the MPs.**

   MPs selected in consultation with Commission staff will generally be selected to provide information on the range of noise environments in a wind project area. Some examples of areas commonly selected for measurements include: areas with residences, areas with industrial noises, quiet areas, and public areas.

   All MPs should be located so that no significant obstruction (building etc.) blocks sound and vibration from existing wind facilities.

2. Duration of measurements should be a minimum of ten continuous minutes for each criterion (See item 4 below) at each location. Measurements should be taken during each of the following four periods:
   a. Morning (6 - 8 a.m.)
   b. Midday (12 noon – 2 p.m.)
   c. Evening (6 - 8 p.m.)
   d. Night (10 p.m. – 12 midnight)

The use of unattended continuous sound level measurement devices is encouraged. If these measurements are collected, qualitative sound recordings of the ambient noise environment should be collected for the duration of the measurements.

Sound level measurements must be made on a weekday of a non-holiday week.

3. For each MP and for each measurement period, provide each of the following measurement criteria:
    a. At a minimum, unweighted octave-band analysis (16,[ii] 31.5, 63, 125, 250, 500, 1K, 2K, 4K, & 8K Hz), one-third octave band analysis is encouraged
    b. L_{ave}, L_{10}, L_{50}, and L_{90}, in dBA
    c. L_{ave}, L_{10}, L_{50}, and L_{90}, in dBC
    d. A narrative description of sounds audible during each measurement

4. Identify all major sources of sound and vibration (i.e. highways, factories etc.) and where they are located in relation to MPs.

5. Provide a map on an aerial photo base clearly showing:
    a. the layout of the site
    b. the location of MPs
    c. the distance between MPs and the nearest proposed wind turbine generators
    d. the location of significant local sound and vibration sources
    e. the distance between all MPs and significant local sound and vibration sources
    f. the location of all sensitive receptors (schools, day-care centers, hospitals, and residences or residential neighborhoods) within the project area
    g. the distance to all major infrastructure (major roads, transmission lines, gas pipelines) in project area

B. Sites With Existing Wind Electric Generation Facilities

1. Two complete sets of sound level measurements must be taken under two wind conditions:
    a. Under calm conditions without the existing wind turbine rotors rotating. These measurements shall be taken with the entire wind generating development off line.
    b. Under wind conditions just above the cut-in speed for the wind turbines with as many of the wind turbines in the development operating as possible.

2. At a minimum, sound level measurements should be taken at three MPs. Because each site is unique, more than three MPs may be necessary. **Consult with Commission staff regarding the quantity and location of the MPs.**

    MPs selected in consultation with Commission staff will generally be selected to provide information on the range of noise environments in a wind project area. Some examples of areas commonly selected for measurements include: areas with residences, areas with industrial noises, quiet areas, and public areas.

    All MPs should be located so that no significant obstruction (building etc.) blocks sound and vibration from existing wind facilities.

3. Duration of measurements should be a minimum of ten continuous minutes for each criterion (see section IV.B.4 below) at each location. Measurements should be taken during each of the following four periods:
    a. Morning (6 - 8 a.m.)
    b. Midday (12 noon – 2 p.m.)
    c. Evening (6 - 8 p.m.)
    d. Night (10 p.m. – 12 midnight)

    The use of unattended continuous sound level measurement devices is encouraged. If these measurements are collected, qualitative sound recordings of the ambient noise environment should be collected for the duration of the measurements.

    Sound level measurements must be taken on a weekday of a non-holiday week.

4. For each MP and for each measurement period, provide each of the following measurement criteria:
    a. At a minimum, unweighted octave-band analysis (16,[ii] 31.5, 63, 125, 250, 500, 1K, 2K, 4K, & 8K Hz), one-third octave band analysis is encouraged
    b. L_{ave}, L_{10}, L_{50}, and L_{90}, in dBA
    c. L_{ave}, L_{10}, L_{50}, and L_{90}, in dBC
    d. A narrative description of sounds audible during each measurement

5. Identify all major sources of sound and vibration (e.g. highways, factories etc.) and where they are located in relation to each MP.

6. Provide a map or diagram clearly showing:
    a. the layout of the site
    b. the location of MPs
    c. the distance between MPs and the nearest existing wind turbine generators
    d. the location of significant local sound and vibration sources
    e. the distance between all MPs and significant local sound and vibration sources
    f. the location of all sensitive receptors (schools, day-care centers, hospitals, and residences or residential neighborhoods) within the project area
    g. the distance to all major infrastructure (major roads, transmission lines, gas pipelines) in project area

C. Sound Level Estimates for Proposed Wind Turbine(s)

In order to estimate the sound and vibration impact of the proposed wind development on the existing environment, an estimate of the sound and vibration produced by the proposed turbine(s) must be provided.

1. Provide the manufacturer's sound level characteristics for the proposed turbine model operating at full capacity. Include an **unweighted** octave band (16,[ii] 31.5, 63, 125, 250, 500, 1K, 2K, 4K, & 8K Hz) analysis for the unit at full capacity.

2. Provide a contour map of the expected sound levels from the wind energy development, in 5dBA increments, extending out to the 30 dBA contour.

3. Determine the impact of the new sound and vibration source on the existing environment. For each MP used in the ambient study:
    a. Report expected changes to existing sound levels for L_{ave}, L_{10}, L_{50}, and L_{90}, in dBA.
    b. Report expected changes to existing sound levels for L_{ave}, L_{10}, L_{50}, and L_{90}, in dBC.

    At least one MP should be located at the nearest sensitive receptors, as required by sections IV.A.1 and IV.B.2.

4. Clearly report all assumptions made in arriving at the estimates of impact and any conclusions reached regarding the potential effects on people living in the project area.

V. Post-Construction Measurements

1. Within twelve months of the date when the project is fully operational, and within two weeks of the anniversary date of the pre-construction ambient noise measurements, repeat the existing sound and vibration environment measurements taken before project approval.

2. Post-construction sound level measurements should be taken under two wind conditions:
    a. Under calm conditions without the wind turbine rotors rotating. These measurements shall be taken with the entire wind generating development off line.
    b. Under wind conditions just above the cut-in speed for the wind turbines with as many of the wind turbines in the development operating as possible.

3. Notes regarding post-construction sound level measurements for wind project developments:
    a. Measurements taken as required under section V.2.b may be taken prior to measurements taken under section V.2.a.
    b. Because of the variability of wind speeds, post-construction measurements may be taken outside of the measurement periods listed in section IV.B.3. However, measurements taken under section V.2.a, above, must be taken during the same time of day as the corresponding measurements taken under section V.2.b.
    c. For each MP at which pre-construction noise measurements were taken, a minimum of three sets of measurements shall be taken under sections V.2.a and 2.b. The three sets of measurements should correspond to at least two different times of day. Any or all of the measurements may be taken outside of the measurement periods listed in section IV.B.3.
    d. Measurements taken to fulfill the requirements of items sections V.2.a and 2.b must be taken within as few consecutive days as practicable.
    e. Measurements taken under sections V.2.a and 2.b must include a measurement of the 16 Hz octave band, as described in section IV.B.4.a.

4. The post-construction sound level measurement analysis must include an evaluation of whether the wind development meets any and all state and local sound level requirements.

5. File a copy of the post-construction noise measurement report with the Public Service Commission including pre- and post-construction measurement data and using the same report format as used for the pre-construction sound and vibration study reports.

Revision History

Revisions of May 26, 2010:

- Adapted the November 17, 2008, version of the PSC Noise Protocol to apply specifically to wind energy developments.

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[i] Standard Guide for Selection of Environmental Noise Measurements and Criteria (Designation E 1686-96). July 1996. American Society for Testing and Measurements.

[ii] PSC staff acknowledges that few sound level meters are capable of measurement of the 16 Hz center frequency octave band. However, because noise complaints from the public most likely involve low frequency noise associated with proposed plants, we encourage applicants to pursue the collection of this important ambient noise data.

If obtaining the 16 Hz data is beyond the capabilities of the sound level measurement apparatus, contact PSC staff prior to collection of any field ambient measurement data.

MPCA comments on State of Wisconsin's "Measurement Protocol for Sound and Vibration Assessment of Proposed and Existing Electric Power Plants" and the Bent Tree (WPL) Post-construction Sound Monitoring Protocol proposal (Hessler & Associates)

The work you have from Hessler is really well done. Their methods make a better protocol than the WI methods, but WI wouldn't be a bad place to start. If Hessler agrees, I would share their work as an example of what you are looking for.

Measurements with and without the turbines operating is a good practice to establish the background sound and the contribution to increased noise from the turbines. To avoid including noise from the wind itself, both sessions should be under similar conditions, and wind speed should be low (<~11 mph), if possible. Because noise and wind are not independent, there will be interference. The Hessler protocol that sets up separate off-site monitoring and correction based on many measurements is the most thorough I have seen. I was actually a bit surprised not to see higher wind speeds in the Hessler results.

Multiple locations are generally a good idea, but might be used differently than the WI methods in this case. Multiple homes will give a better description of the impact of such a dispersed project, rather than multiple location around a given turbine. Also, our standards are for areas receiving normal outdoor use, which is not necessarily the property line. Land is classified based on how it is used, so it would be inappropriate to apply the residential standards to agricultural land. I would recommend choosing locations near the homes, rather than property lines, so that you get measurements where the neighbors would be most affected, except where access is an issue, of course. Hessler seems to balance this well with representative sites.

I don't know that the multiple times of day are as necessary, but given different wind patterns, sensitivities, and standards, a day time and a night time session would be appropriate.

Hessler's seasonal recommendation is valuable – I have had interference from corn rustling.

We do not have frequency based standards, but the information may be very useful to the project managers, especially for answering questions about low frequency noise. If the equipment is capable of measuring A and C weighting simultaneously, having that information also can only help. L(ave) is often referred to as the L(eq), and along with the L90 helps describe the sound, and an L5 can help if there are complaints about short term noise. The more information like this that you can gather, the better, but I would recommend asking an AG about what you can require beyond showing compliance with the standards. I would strongly recommend doing full hour measurements, even if a few show compliance with the standards and they want to do shorter spot checks. Spot checks might help for noise from specific actions, like rotating the nacelles, but the concern is more about the constant drone type of noise. When noise is constant, you can sometimes shorten monitoring, but you want good information and evidence of compliance.

Not all consultants may be able to do the 14-day studies, and will have to do shorter monitoring. The information that Hessler was able to gather, though, doing 10-minute increments for 14 days straight, is really great for setting up a regression to remove some of the variability. The equipment I have doesn't come close to being able to do that.

I didn’t see frequency analysis from Hessler, but their C-weighted measurements do indicate lower frequency noise that is getting discounted in the A-weighting network. It might have been too much information to gather in 2000+ periods.

MN PCA comments on ECII Post-construction Sound Monitoring Protocol proposal

It looks like they will be collecting data under a similar scheme to the Hessler analysis, so I would assume that their analytical methods would also be similar.

Collecting ~1000 measurements from each of 4 sites over the course of a week and being able to compare to a simultaneous background sample and meteorological data will provide a lot of data from which to derive a profile of noise against wind speed for the state standards and for frequency analysis. This proposal includes an octave band analysis to capture measurements of noise at various frequencies, which will help to answer some of the questions posed about noise impacts from wind projects. They do not specifically say that they will include a C-weighted result, which might be desirable given concerns about appropriate weighting networks, but the information would be captured in the frequency analysis.

Again, what they need to show as evidence of compliance with the state standards doesn’t necessarily match up with the additional data desired, or the recommended monitoring protocols. As long as they can balance these needs against the constraints of a complicated system, they should be able to provide useful information about noise impacts from wind energy projects.

Using four locations on site and one off site is a smaller sample than used by Hessler, but may be representative of the project and an appropriate scale for the project. The locations chosen should represent sound levels heard at homes.