TOWN OF OAKFIELD
WIND ENERGY REVIEW COMMITTEE

P.O BOX 10
OAKFIELD, ME 04763

WIND ENERGY WORKSHOP SESSION:

FINAL REPORT

September 4, 2009

PROLOGUE

Presently, the Town of Oakfield does not have any local zoning or site review ordinances that address wind energy facility developments. Instead, the only regulatory review available is by the Maine Department of Environmental Protection ["Maine DEP"] under the Site Location of Development Act and Natural Resource Protection Act. This report was developed in order to (1) identify local concerns related to First Wind's proposed wind energy facility in the Town of Oakfield, Maine, (2) provide information about these local concerns to the Oakfield community, and (3) provide recommendations for how to address these local concerns.

Upon its establishment, the Town of Oakfield Wind Energy Review Committee ["Committee"] decided to conduct a due diligence process of First Wind's proposed wind energy facility. The Committee was charged with collecting information from the public, reviewing First Wind's applications to the Maine DEP, requesting and reviewing information from First Wind, and then reporting and making any recommendations to the Board of Selectmen. Specifically, these recommendations would include appropriate actions that would be forwarded to First Wind and the Maine DEP with requests for their inclusion in First Wind's current applications (as amendments) and any approval orders issued by the Maine DEP.

In furtherance of its charge, the Committee engaged three separate firms to assist in its due diligence process. To address sound and noise issues, the Committee engaged Ken Kaliski, P.E., of Resource Systems Group based out of White River Junction, Vermont. For general engineering issues, the Committee engaged Jonathan Edgerton, P.E., of Wright-Pierce, which is based out of Topsham, Maine. To address any legal issues, the Committee engaged Andrew Hamilton, Esq., and Jonathan Pottle, Esq., of Eaton Peabody based out of Bangor, Maine.

INTRODUCTION

I. Chronology of Events Before Establishment of the Wind Energy Review Committee

In 2003, Evergreen Wind Power II, LLC ["First Wind"] erected a meteorological tower ["MET"] in the Town of Oakfield ["Town"] to assess whether to pursue the development of a commercial wind energy facility. First Wind erected a second MET in 2007, and four additional METs in August of 2008 to further assess whether to continue pursuing a commercial wind energy facility in the Town. On July 21, 2008, First Wind presented a "project introduction" to the Maine DEP.

Throughout 2008, First Wind attended Board of Selectmen ["Selectmen"] meetings to discuss its proposed wind energy facility. In October of 2008, First Wind held an informational meeting to discuss its proposed project with the community of Oakfield. In the fall of 2008, the Town engaged Eaton Peabody Consulting Group to assist the Town with establishing a Tax Increment Finance ["TIF"] district. This allows all of the new tax revenues that are "captured" within the TIF district to be used for project costs and for other approved economic development purposes within the town.

In the fall and winter of 2008, the uncertainty surrounding the school consolidation initiative postponed any continued evaluation of a TIF district, due to discussions concerning the School Assessment Ratio. In January of 2009, after some of the uncertainties were resolved, the Selectmen held an informational meeting to explain how a TIF district works. The Selectmen continued to evaluate and negotiate the TIF district throughout the winter of 2009. Also during the winter of 2009, First Wind held another public informational meeting (in February of 2009) and proposed a Community Benefit Fund program designed to provide an additional benefit to the Town of Oakfield (in addition to any TIF benefits).

In March of 2009, a public hearing was held to review the need for a TIF district to "shelter" new tax dollars for the Town. The Selectmen placed the TIF district to a vote – but placed questions regarding the Credit Enhancement Agreement and the refund of tax dollars to a later vote. The voters of Oakfield approved the TIF district in March of 2009. The Selectmen continue to review and negotiate terms of the Credit Enhancement Agreement and the Community Benefit Fund up to the date of this report.

In April 2009, First Wind submitted Site Location of Development Act ["Site Law"] and Natural Resources Protection Act ["NRPA"] permit applications to the Maine DEP for a proposed wind energy facility consisting of 34 wind turbines in the Town. The

Maine DEP is currently reviewing these applications to determine whether or not they satisfy the requirements under the Site Law and NRPA.

On May 8, 2009, the Selectmen held a meeting in which a motion was passed to place a wind energy facility moratorium question to be voted upon at the next Town Meeting. On May 20, 2009, the Selectmen held another meeting to identify and discuss any local concerns with First Wind's proposed wind energy facility.

II. Establishment of the Wind Energy Review Committee

In response to concerns identified at the May 20, 2009 meeting, the Selectmen met in June of 2009 to discuss how to best address issues associated with First Wind's proposed commercial wind energy facility. At this meeting, the Selectmen decided to establish a committee to address these issues through a due diligence process that would be open to the public. The name of this committee is the "Town of Oakfield Wind Energy Review Committee" [the "Committee"].

III. The Committee Appointments

Table 1 below shows the names, addresses, and occupations of the members chosen by the Selectmen to serve on the Committee.

Table 1 – Committee Members.

Name	**Address**	**Occupation**
Jim Sholler –Selectmen	257 Thompson Settlement Road Oakfield, ME 04763	Retired B&A Railroad – Carmen
Linnwood Hersey – Selectmen	24 Norman Street Oakfield, ME 04763	Retired Maine State Trooper
Dennis Small –Selectmen	70 Brown Road Oakfield, ME 04763	Retired USAF Major
Anthony White – Planning Board Member	69 Ridge Road Oakfield, ME 04763	Katahdin Forest Products – Manager
Robin Crandall (Alternate) – Planning Board Member	216 Brown Road Oakfield, ME 04763	Retired Homemaker
Kirby Hardy – Planning Board Member	92 Spaulding Lake Oakfield, ME 04763	Independent Logging Contractor

IV. The Committee's Charge

The purpose of the Committee is to review local siting and environmental concerns related to the proposed First Wind commercial wind energy facility in Oakfield and to report and make recommendations to the Selectmen for appropriate actions with respect to these local concerns.

Specifically, the Committee was formed to:

(1) Receive input from Oakfield residents on project-related siting and environmental concerns;

(2) Review appropriate portions of First Wind's applications to the Maine DEP for permit approvals as they relate to local siting and environmental concerns;

(3) Request and review First Wind responses to local siting and environmental concerns;

(4) Consult with any 3rd party review consultant(s) engaged by the Town on specific project-related issues; and

(5) Report and make recommendations to the Selectmen for appropriate actions.

Consistent with the Committee's charge, it hired Ken Kaliski, P.E., of Resource Systems Group ["RSG"] to address sound and noise issues, Jonathan Edgerton, P.E., of Wright-Pierce to address other issues relating to the siting of wind turbines in Oakfield and Andrew Hamilton, Esq., and Jonathan Pottle, Esq., of Eaton Peabody to address legal matters. Collectively, these consultants provided technical and legal support for the Committee's due diligence review.

V. Meeting Schedule

In order to meet the Committee's Charge, a series of meetings were held that collectively make up the Wind Energy Workshop Session. Below is a summary of these meetings.

June 17, 2009	Introductory Meeting: Review Principles of Sound and Noise and the Framework of Site Law / NRPA
June 23, 2009	Review Construction, Natural Resources, and Miscellaneous Issues
July 1, 2009	Review Economic Considerations Associated with First Wind's Proposed Wind Energy Facility
July 16, 2009	Host the Maine DEP Informational Meeting
July 22, 2009	Review Sound Modeling, Sound Levels, Infrasound, Amplitude Modulation, and Mitigation
August 3, 2009	Review Issues for Draft Written Report
August 10, 2009	Continue to Review Issues for Draft Written Report
August 17, 2009	Discuss Schedule for Submitting Final Report
August 24, 2009	Finalize Draft Written Report; Prepare Final Report
September 4, 2009	Endorse and Submit Final Written Report to the Selectmen

PROJECT DESCRIPTION

First Wind is proposing to construct approximately 34 wind turbines within the Town of Oakfield, utilizing General Electric 1.5 megawatt ["MW"] wind turbine nacelles and a combination of LM Glasfiber and Tecsis turbine blades. Specifically, up to 18 wind turbine locations are proposed to the north and south of the South Oakfield Road (easterly of Red Bridge), and up to 18 wind turbine locations are proposed along the ridge line of Sam Drew Mountain (southerly of Spaulding Lake). Notably, there are two additional proposed wind turbine locations than proposed wind turbines. (*See* Appendix A for an aerial view of the proposed locations for each wind turbine – the "Project Area Map".) The capacity or potential power output of the proposed project is estimated to be up to 51 MW of electricity.

First Wind's proposed wind energy facility also includes the construction of about 12 miles of a collector system, up to 4 permanent MET towers, an electrical substation, an operations and maintenance building, and road construction for the construction of wind turbines and for operating and maintenance access (including a combination of new roads, road upgrades, and road maintenance).

First Wind anticipates that about 8,790 square feet (or 0.20 acres) of wetlands will be cleared for wind turbine construction, and about 2,440 square feet (or 0.06 acres) of wetlands will be filled with material due to road widening. One stream crossing is anticipated, where a culvert will be placed for continued drainage and flow.

RECOMMENDATIONS

The Committee has identified four main categories of concerns for its recommendations to the Selectmen: (I) Construction; (II) Health and Safety; (III) Environmental; and (IV) Miscellaneous.

I. Construction

Construction issues focus on safety, infrastructure investments, and adverse environmental effects. With respect to First Wind's proposed wind energy facility, the Committee has identified the following issues relating to construction:

(A) The construction schedule;
(B) Setbacks or buffers from wind turbines to maintain and promote safety;
(C) Blasting;
(D) Impacts to rights of way; and
(E) Wind energy facility operation and maintenance.

A. Construction Schedule

i. What is a Construction Schedule?

A construction schedule is the listing of specific construction activities that are anticipated to occur over estimated time frames. First Wind anticipates that the construction schedule for its proposed wind energy facility, if approved, will last for about nine (9) months.

Major construction activities include:

(1) preliminary layout for new road construction or road upgrades, turbine locations, an operating and maintenance ["O&M"] building site, and a substation site;
(2) clearing for roads, collection lines, an O&M building, and a substation;
(3) road construction;
(4) construction and assembly of wind turbines;
(5) construction of a substation and an O&M building; and
(6) commissioning and testing wind turbine generators and electrical connections.

A collection line is also proposed to be constructed. Major activities required to construct this collection line are:

(1) preliminary layout;
(2) wetland delineation (the practice of mapping wetlands);
(3) clearing;
(4) installation of utility poles;
(5) stringing of electrical wire (the collector line);
(6) energizing of a collector line; and
(7) cleanup and restoration of areas used for temporary construction activities.

ii. Why is the Construction Schedule a Consideration?

The construction schedule is important because, if not identified and properly followed, it could otherwise cause (1) unnecessary environmental damage; (2) interruption with customary transportation routes; and (3) interruption with public access.

iii. Construction Schedule Recommendations Including Appropriate Actions

The Committee recommends that First Wind provide the Town of Oakfield with a more detailed construction schedule, including specific dates, prior to commencing any construction of the proposed wind energy facility. At this juncture, the Committee recognizes that First Wind cannot provide a more specific construction schedule unless it receives all required regulatory approvals and finalizes project financing. However, as soon as practicable and with reasonably prompt notice, First Wind should provide a copy of its anticipated construction schedule to the Town.

APPROPRIATE ACTION: **First Wind shall submit its written construction schedule to the Town of Oakfield at least twenty-one (21) days prior to commencing any construction. The date of submittal shall be the date on which the written construction schedule is received by the Town of Oakfield.**

B. Setbacks & Safety

i. What are Setbacks?

Setbacks represent a specific distance (or a range of distances) from one object or activity to another.

ii. Why are Setbacks & Safety a Consideration?

Setbacks are important because they are designed to promote safety by preventing unnecessary injuries or property damage. Although catastrophic failures of wind turbines are rare events, they have been known to structurally fail with the potential to send turbine components a significant distance causing property damage and serious bodily injury. Lightning strikes, severe storms, damage to concrete foundations, metal fatigue, brake overloading, faulty welding, and normal wear and tear are potential factors that could result in the structural failure of a wind turbine. The safety setback is designed to avoid these risks and/or adverse effects.

iii. Setback and Safety Recommendation Including Appropriate Actions

Both the manufacturer of the proposed wind turbines and the Maine DEP agree that, in the absence of site specific safety assessments, a safety-related setback of 1.5 times the maximum height of a wind turbine (the highest point of any turbine rotor blade measured at the highest arc of the blade) or, in this case, 584 feet, is sufficient to prevent any adverse effects. This setback is further endorsed by agencies engaged in the certification of wind power installations (such as Germanischer Lloyd and the Deutsches Windenergie-Institut). This setback should be maintained between wind turbines and occupied structures, roads, trails or other public use areas. While several Committee members have made First Wind aware of the probable status of several roads, trails, and public rights of way, it is beyond the Committee's authority to determine their status in conjunction with the safety setback.

The proposed wind energy facility layout has been developed with the above criterion in mind, and the only identified area of concern relates to the relocation of several trails used for recreation. These recreational concerns are discussed later in Part IV.C "Recreation – Public Access" of this report.

C. Blasting

i. What is Blasting?

Blasting is the practice of breaking up material such as ledge, stone, or rock through the use of explosives. First Wind anticipates that blasting will be needed to construct the proposed 34 wind turbines in their planned locations. In addition, First Wind anticipates that blasting will be required for road construction and the placement of underground power lines.

ii. Why is Blasting a Consideration?

Blasting is an important consideration because it may cause:

(1) vibrations that affect the structural integrity of nearby buildings or wells;
(2) sound and noise that is annoying;
(3) flying debris that may cause serious bodily injury or property damage;
(4) negative effects on unique natural areas; and
(5) soil erosion and sedimentation.

iii. Blasting Recommendation Including Appropriate Actions

First Wind's application materials submitted to the Maine DEP indicate that all blasting will be done in conformance with guidelines published by the U.S. Department of the Interior and that a pre-blast survey will be completed for any structures within 2,000 feet of any blasting operations. However, only landowners within 1,000 feet must be given notice of any blasting under the Maine DEP regulations – even though pre-blast surveys must be completed for structures within 2,000 feet. In effect, since there are little or no structures within 1,000 feet of any anticipated blasting areas, it is unlikely that any notices will be required under the Maine DEP regulations. Therefore, the Committee recommends that any landowners with structures within 2,000 feet of any blasting operations (which must be part of the pre-blast survey) should receive notice prior to any blasting. In addition, the Committee recommends that the pre-blast survey include any bedrock wells.

APPROPRIATE ACTION: **First Wind shall ensure the pre-blast survey includes bedrock wells and shall provide a written notice to the Town and to all affected landowners with structures located within 2,000 feet of any blasting area at least three (3) days prior to commencing any blasting operations.**

D. Impacts to Town Ways

The transport of wind turbine components and equipment necessary for their construction will dictate uncharacteristic usage of several Town-owned ways, which may result in damage or impacts to Town roads and adjacent properties.

In anticipation of any such impacts, First Wind and the Selectmen have engaged in discussions relative to the estimated need for temporary improvements to support access, as well as the potential for damage to roadways and the responsibility for repairs. A separate document entitled "Road Authorization Agreement" has been drafted and is

currently under review by the Selectmen. This agreement is expected to include provisions for documentation of the current (pre-construction) conditions of affected roadways to ensure that any impacts can be objectively identified and mitigated.

The Committee's understanding is that the Road Authorization Agreement will be designed to address any adverse effects that could result from impacts to Town-owned ways, and recommends that the Selectmen continue their review to obtain a satisfactory agreement prior to any construction activities involving the proposed wind energy facility.

E. Wind Energy Facility Operation and Maintenance

i. What are the Considerations for Operating and Maintaining a Wind Energy Facility?

If approved, the operation of the wind energy facility will need to be monitored and maintained to ensure the continued operational and structural integrity of each wind turbine, which will have a bearing on the wind energy facility's potential to constitute a risk or nuisance to the inhabitants of the community.

ii. Wind Energy Facility Operation and Maintenance Recommendation Including Appropriate Actions

An on-site supervisory control and data acquisition ["SCADA"] system will be connected to each turbine's generator control system and linked to both First Wind's operational center and GE's customer support center. This system will track specific operating parameters for monitoring. The SCADA system uses automated mathematical algorithms to detect abnormal conditions and, if an abnormal condition should occur, First Wind and GE staff will be automatically notified, provided with information regarding the event, and can troubleshoot, stop, or reset turbines from their remote locations.

More specifically, each wind turbine will be equipped with vibration sensors designed to identify issues such as ice accumulation or blade damage. Each wind turbine will also be equipped with thermal sensors to identify unusual temperature rises in the windings of the generator and in the various lubricants (within the gearbox, for example). In addition to alarms when vibrations or temperatures reach pre-determined points, a variety of parameters will be tracked on the system computers by First Wind and GE that can identify trends before an issue results in damage to any wind turbines.

Based upon the above reasons, the Committee has concluded that the SCADA system described above currently provides the best practical technology to monitor and

maintain the proposed wind energy facility in order to prevent structural failures, ice throw, and any other risks or failures.

II. Health and Safety

Health and safety issues are important to address in order to protect the general welfare of the public. The Committee has identified three primary health and safety issues associated with First Wind's proposed wind energy facility:

(A) Sound and noise;
(B) Shadow flicker; and
(C) Ice throw.

A. Sound and Noise

i. What is Sound and Noise?

The terms "sound" and "noise" are often used interchangeably, but they have distinct differences. "Sound" is the quantity we can hear, feel, or measure. "Noise" is unwanted or undesirable sound. For example, we can say that a *noise* ordinance limits the level of *sound* that can be generated from a facility. Noise reflects a perception of sound.

Wind turbines produce sound and noise from both mechanical components (such as the gearbox), and the interaction between air, turbine blades, and the tower structure. Sound issues associated with wind turbines are typically categorized into four main areas:

1. **Broadband Sound**: Audible sound absent of any particular tones. Broadband sound is generally measured on an A-weighted scale to reflect the human ear's response along the entire audible frequency spectrum.

2. **Low-frequency Sound**: Sound below a frequency of about 200 Hz. Infrasound is sound below a frequency of 20 Hz and is considered inaudible to humans except at very high levels. High energy infrasound and low frequency (well above audible levels) sound can be felt as body resonances. The C-weighting scale is typically used to measure high energy sounds and does not reduce the contribution of low-frequency sounds to the extent the A-weighting scale does when estimating sound levels.

3. **Amplitude Modulation**: Sound that changes level on a noticeably rhythmic basis in relation to the rotor blade passage frequency. "Swishing," "whooshing," and

"thumping" noises from wind turbines are usually associated with varying degrees of amplitude modulation.

4. **Pure Tones:** Narrow frequency bands of sound that rise in level to the point that they are distinctly audible above the background broadband sound. (Example: a backup alarm typically emits a pure tone alarm at about 1,200 Hz.)

ii. Why is Sound and Noise a Consideration?

The primary adverse effect of wind turbine sound and noise is annoyance. Annoying sounds have the potential to interfere with the use and enjoyment of property and may cause adverse secondary effects, such as stress.

In a University of Gothenburg/University of Groningen study, "Project WINDFARMperception: Visual and acoustic impact of wind turbine farms on residents" (2008),[1] a survey of 725 residences living within 2.5 km (1.6 miles) of a wind energy facility found that annoyance is correlated with, in part, the level of visibility of the wind energy facility, the level of noise exposure, whether they are benefiting in some way, and their attitude toward wind energy facilities. Non-participating residents who were "rather" or "very" annoyed by wind turbines increased from 1% of the sample who were exposed to sound levels below 30 dBA to 28% of the sample who were exposed to sound levels above 45 dBA.

Overall, whether a wind energy facility generates noise complaints from annoyance depend upon a number of factors, such as:

- Sound emissions from wind turbines;
- Surrounding topography;
- Meteorological conditions;
- Whether turbine noise is masked by wind or other noise sources;
- The character of the perceived sound;
- The surrounding environment;
- The frequency of the observed sound; and
- The attitude of the listener.

The WINDFARMperception study found the only health effect that is statistically correlated with wind turbine noise is sleep disturbance. This occurs at a statistically significant level above 45 dBA at and outside the home. This is consistent with World Health Organization ["WHO"] guidelines recommending 45 dBA outside the home

[1] *Available at* http://www.rug.nl/wewi/deWetenschapswinkels/natuurkunde/publicaties/WFp-final-1.pdf.

(averaged over the night).[2] The WHO based their recommendations on the latest research on the levels of noise that created changes in sleep patterns. (*See* Appendix B for a copy of Section 4 "Guideline Values.")

While the WINDFARMperception study did not find adverse health effects from wind turbines other than those mentioned above, a vigorous public debate exists on whether noise from wind turbines may cause other adverse health effects. After a literature review, the Committee did not find any peer-reviewed medical or public health reports or journal articles that concluded sound and noise from modern wind turbines in a well-designed, properly sited, operated, and maintained wind energy facility can cause adverse health effects.

iii. How Does the Maine DEP Regulate Sound and Noise?

Presently, there is also a public debate in how to regulate sounds produced from wind energy facilities in order to prevent any adverse effects. The lack of uniform regulatory standards for wind energy facilities in the United States and throughout the world has added to this debate.

In the State of Maine, the Maine DEP has adopted noise standards that cover developments of any type within organized towns.[3] In other words, the Maine DEP has not created noise standards specific to any one type of development. To prevent annoyance and its secondary effects, the Maine DEP has adopted noise standards that regulate all types of developments, including First Wind's proposed wind energy facility in Oakfield. These standards are as follows:

1. Sound Regulated by the Maine DEP From Routine Operation of Developments

At any property line of the development or contiguous property owned by the developer:

75 dBA at any time of day

At any protected location in an area that <u>is not</u> predominantly commercial, transportation, or industrial:

60 dBA between 7:00 a.m. and 7:00 p.m. (the "daytime hourly limit")

50 dBA between 7:00 p.m. and 7:00 a.m. (the "nighttime hourly limit")

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[2] The WHO guidelines state that "sound pressure levels at the outside facades of the living spaces should not exceed 45 dB LAeq and 60 dB LAmax, so that people may sleep with bedroom windows open." (*See* Appendix B for a copy of Section 4 "Guideline Values.")

[3] In Maine, the Land Use Regulation Commission has jurisdiction in any unorganized towns.

At a protected location in an area that is predominantly commercial, transportation, or industrial:

70 dBA between 7:00 a.m. and 7:00 p.m. (the "daytime hourly limit")

60 dBA between 7:00 p.m. and 7:00 a.m. (the "nighttime hourly limit")

When a development is proposed to be located in an area that has a daytime average ambient (or background) sound level of equal to or less than 45 dBA and/or the pre-development average ambient (or background) sound level at nighttime is equal to or less than 35 dBA, the following sound standards apply:

55 dBA between 7:00 a.m. and 7:00 p.m. (the "daytime hourly limit")

45 dBA between 7:00 p.m. and 7:00 a.m. (the "nighttime hourly limit")

[The so-called "quiet level" noise standards.]

The quiet level noise standards for the overall A-weighted sound levels from a development are consistent with the WINDFARMperception findings that there are no statistically significant adverse health effects at or below an exposure level of 45 dBA. In addition, the quiet level noise standard is also consistent with the WHO guideline of 45 dBA, averaged over the night, as measured outside the bedroom window. The quiet level Maine DEP standards are somewhat more conservative because they are an hourly limit rather than the WHO's 8-hour limit,[4] and they are measured closer to the wind turbines either at the residential property line or 500 feet from the home, rather than WHO's bedroom window measurement location.

Notably, a development (in a location that is not predominantly commercial, transportation, or industrial) that produces sound levels greater than 45 dBA but less than 50 dBA during nighttime hours *will still comply* with the Maine DEP noise standards if the pre-development nighttime ambient (or background) sound levels are greater than 35 dBA. For daytime hours, a development (in a location that is not predominantly commercial, transportation, or industrial) that produces sound levels greater than 55 dBA but less than 60 dBA *will also still comply* with the Maine DEP noise standards if the daytime pre-development ambient (or background) sound levels are greater than 45 dBA.

In First Wind's applications to the Maine DEP, First Wind has represented that its proposed wind energy facility will meet the more restrictive 45 dBA nighttime and 55

[4] When sound levels are averaged over a shorter period of time, there is a greater tendency to estimate higher noise levels.

dBA daytime standards – the quiet level noise standards. Thus, sound levels from First Wind's proposed wind energy facility must meet the 45 dBA nighttime and 55 dBA daytime noise standards, even if the pre-development ambient (or background) sound levels are greater than 35 dBA or 45 dBA, respectively.

At the Committee's August 24, 2009 meeting, there was extensive discussion relating to the need or desirability of pre-development ambient sound monitoring. It should be noted that, although pre-development ambient monitoring is not required, it would provide some background information on existing sound levels to help understand the degree or magnitude of any local impacts upon the Town. The Committee recognizes, however, that this additional data would not be necessary for the Maine DEP regulatory review, and that ambient sound levels in Oakfield most likely vary season by season making it challenging to estimate the degree or magnitude of the impacts upon the Town. Based upon these circumstances, the Committee has deferred to First Wind's decision to accept the quiet limits in lieu of pre-development ambient sound monitoring.

Although variances are available under the Maine DEP standards, they must be applied for and granted. For the Mars Hill wind energy facility, a variance was sought and granted that allowed First Wind to apply a 50 dBA standard, 5 dBA higher than what would have been required if the pre-development ambient nighttime sound levels were less than 35 dBA (i.e., the quiet level nighttime noise standard of 45 dBA would have applied without a variance). In the Oakfield application materials, the Committee understands that no such variance has been or will be requested by First Wind. The Committee and its counsel and consultants interpret First Wind's application to commit the Phase I development to comply with the quiet level nighttime and daytime noise standards of 45 dBA and 55 dBA respectively, irrespective of the actual sound levels of ambient or background sounds or whether ambient or background sounds exceed the regulatory standards for application of these quiet level noise standards.

Further, the Committee understands that First Wind has committed that any future projects sited proximate to the Phase I Project that would contribute to cumulative sound levels in the Town of Oakfield will be sited and operated in a manner causing both Phase I and any future projects to comply with the quiet level noise standards of 45 dBA and 55 dBA for nighttime and daytime time periods, respectively, at the regulatory locations. The Committee understands that First Wind, its counsel, and consultants agree with these interpretations and understandings of the Committee.

2. Penalties for Tonal and Short Duration Repetitive Sounds

Penalties can be applied to the applicable noise standard for characteristic sound that is more annoying than steady-state broadband sound. A penalty is added to the measured or predicted sound before it is compared to the noise standard.

The Maine DEP has a 5 dBA penalty in their standard for "short duration repetitive sounds" which are defined as:

> A sequence of repetitive sounds which occur more than once within an hour, each clearly discernible as an event and causing an increase in the sound level of at least 6 dBA on the fast meter response above the sound level observed immediately before and after the event, each typically less than ten seconds in duration, and which are inherent to the process or operation of the development and are foreseeable.

Maine DEP Chapter 375.10.G(19).

In past wind energy facility siting permit reviews, such as Rollins and Mars Hill, the Maine DEP has defined the characteristic swishing or thumping of the blades to potentially qualify as short duration repetitive sounds if the characteristic 6 dBA swing in levels is met. The 5 dBA penalty is applied to the sound level of the short duration repetitive events for the time period or duration that they occur.

Tonal sounds also trigger a 5 dBA penalty. Tonal sounds are defined in the regulations as follows:

> For the purpose of this regulation, a tonal sound exists if, at a protected location, the one-third octave band sound pressure level in the band containing the tonal sound exceeds the arithmetic average of the sound pressure levels of the two contiguous one-third octave bands by 5 dB for center frequencies at or between 500 Hz and 10,000 Hz, by 8 dB for center frequencies at or between 160 and 400 Hz, and by 15 dB for center frequencies at or between 25 Hz and 125 Hz.

Maine DEP Chapter 375.10.G(24).

This Maine DEP definition of tonal sounds is consistent with "sounds with tonal content" defined in ANSI standard S12.9-2005/Part 4.[5] This ANSI standard is not specific to wind turbines and gives procedures for the "description and measurement of environmental sound." ANSI standard S12.9-2005/Part 4 applies a 5 dB penalty to the overall sound level. This penalty would be applied to the overall sound level for the

[5] ANSI S12.9-2005/Part 4 was first published in 1996, reaffirmed in 2002 and revised in 2005 and well after Maine DEP 375.10 was promulgated in 1989. The definition of "sounds with tonal content" traces its origin to ANSI standard S12.9-1987 Part 3 Annex C. Although Part 3 of ANSI S12.9 also contains guidance on the measurement of one-third octave-band sound pressure levels it does not contain any guidelines with respect to adjustment of sounds with tonal content. Further, ANSI 12.9/Part 4 states that "If sounds are not audible at the location of interest … the adjusted sound exposure for these sounds shall not be included in the total (ref. Table 2 Note 4)."

amount of time that the tonal sound occurs at a protected location. For example, with this approach, if the tonal sound occurred 100% of the time, then the overall A-weighted sound level would be increased by 5 dBA. Yet, if the tonal sound occurred for 50% of the time, the net increase would be 3 dBA.

The definition of tonal sounds is not the same as "tonal audibility," which is used in both the international standard IEC 61400-11 and IEC 61400-14. These latter standards are specifically used for wind turbines and, as such, may give a better measure for determining whether a tone may be audible from a wind energy facility. First Wind and its noise consultant have noted that the measurement distance set forth by IEC 61400-11 for the proposed GE turbines is approximately 400 feet and significantly less than distances to regulated protected locations in the vicinity of the proposed Oakfield project. The Committee's noise consultant points out that the measurement of tonality (i.e., tonal audibility) can be performed at a protected location and that nothing in the IEC standard prevents such a practice, although additional requirements (such as narrow band instrumentation, microphone position, measurement periods, and turbine shutdowns) may be needed to determine the tonality using the IEC standard. As a result, measurements in accordance with IEC 61400-11 can be used to provide measurements of tonality at protected locations as long as appropriate additional measures are utilized.

In a presentation at the Committee's July 22, 2009 meeting, First Wind's noise consultant stated that the 5 dBA penalty would only be added to the 1/3 octave band in which tonal sounds occurred. However, the Committee does not believe this interpretation of the 5 dBA penalty standard represents an approach that is adequately protective of the local community in Oakfield. ANSI S12.9-2005/Part 4 applies the 5 dB adjustment to the overall A-weighted sound level and not just to the 1/3 octave band where the tone occurs. If the Maine DEP standard were applied in the manner First Wind and its noise consultant are proposing, then the penalty for a tonal sound at 160 Hz (the most likely candidate for a sound with tonal content on a GE turbine) would be equivalent to only about 1.5 dBA on the overall A-weighted sound level.

First Wind has stated that its interpretation of how to apply the tonal penalty has been used and accepted by the Maine DEP since the noise regulation was adopted in 1989. A primary reason for this approach is that the application of the 5 dBA penalty to the sound level of the tonal frequency effectively factors in the audibility of the tonal sound at the protected location. Because the 160 Hz is a less prominent or audible frequency for the GE 1.5 sle, applying the penalty would likely have a lower net increase to the overall A-weighted sound level. Conversely, more prominent tones would result in a higher net penalty. Importantly, with this approach, the resultant net penalty is a function of the contribution of a particular component frequency to the overall broadband sound level.

In the case of the GE 1.5 sle, the 1.5 dBA net increase due to a less prominent

frequency is significantly lower than the 5 dBA that would be applied when using the ANSI S12.9-20085/Part 4 standard assuming a continuous and audible tonal sound. This could result in less protection for the community if pure tones are found.

For example, if the overall sound level measured at a protected location is 43 dBA and a 160 Hz tonal sound is found that just meets the threshold value, the Maine DEP's application of the standard, adding 1.5 dBA to the overall level, would not result in a violation of the Maine DEP noise standards. However, if the 160 Hz tonal sound substantially exceeds the threshold value and is more prominent, the penalty would increase and could cause an exceedance of the 45 dBA limit. Further, a 5 dBA penalty assuming a continuous tonal sound when added to the overall sound level (i.e. to bring the total broadband sound to 48 dBA) could also result in a violation.[6]

The Committee's noise consultant believes that the Maine DEP rule is not clear as to whether the tonal penalty applies to the overall sound or just to tonal sounds, and that First Wind's noise consultant's representation of past practices of the Maine DEP appears to be more precise than the rule itself concerning tonal penalties. Regardless, the important point is that tonal sounds from a well-operated wind energy facility should not occur, and if tonal sounds develop the best practice is to mitigate and eliminate these tones. As discussed below, the Committee understands from First Wind that there will be measures in place to minimize the likelihood that tonal sounds will occur and if they do occur, that they will be adequately addressed.

First, malfunctioning gears or damaged turbine blades are a potential cause of tonal sounds. The SCADA system and regular inspections by operating personnel would reveal the existence of these types of problems, which may also reduce overall turbine performance. Accordingly, First Wind's regular inspection and maintenance program for turbines will reduce the likelihood that tonal sounds will occur.

Second, in the event tonal sounds occur and cause an exceedance of the applicable DEP sound limits, they will have to be addressed to ensure that the proposed wind energy facility remains in compliance with the DEP noise standards. First Wind has represented that if tonal sounds cause an exceedance of the applicable DEP noise standards, they will promptly notify the Maine DEP and the Town of Oakfield. First Wind will then expedite an investigation of the sound level exceedance and the associated tonal sound and develop a mitigation plan and schedule to achieve compliance with the applicable sound

[6] DEP Chapter 375.10 H provides measurement procedures and methods for determination of compliance with the DEP Standards. Subsection (4.2)(c) states: "Identification of tonal sounds produced by routine operation of a development for the purpose of adding the 5 dBA penalty in accordance with subsection C(1)(d) requires aural perception by the measurer, followed by use of one-third octave band spectrum analysis instrumentation. If one or more of the sounds of routine operation of the development are found to be tonal sounds, the hourly sound level component for tonal sounds shall be computed by adding 5 dBA to the one-hour equivalent sound level for those sounds."

level limits. First Wind will provide copies of the mitigation plan to DEP and the Town, implement the mitigation plan, and provide a written report describing the action(s) taken and new measurement results that demonstrate compliance. Mitigation options could include reduction of the overall sound level and/or the tonal sound component. The presence of a tonal sound does not necessarily indicate non-compliance unless the adjusted overall sound level exceeds the Maine DEP quiet limits.

Finally, the Complaint Response and Resolution Protocol provides an additional level of protection against tonal sounds that either do not implicate the DEP tonal penalty and/or do not result in exceedances of any applicable noise limits, but nonetheless could be annoying.

In light of these considerations, the Committee concludes that the Maine DEP must address how tonal sounds are to be interpreted under its own regulation (Chapter 375.10). In addition, the Committee concludes there is agreement that (1) tonal sounds that implicate the Maine DEP policy will be mitigated, (2) the Oakfield Wind Project Sound Complaint Response and Resolution Protocol will help identify tonal sounds, and (3) with these understandings, there should be sufficient mechanisms in place to address potential tonal sounds from the proposed wind energy facility.

3. Low Frequency Sound

The Maine DEP has no specific standard for low frequency sound or for vibrations caused by low frequency sound. The WINDFARMperception study found that 4% of the respondents were rather or very annoyed by perceived vibrations, likely induced from low frequency sound. This fairly low percentage indicates that low frequency sound/vibrations issues are uncommon with wind energy facilities, and should not be an issue in a well-designed, properly sited, operated, and maintained wind energy facility.

Yet, low frequency noise, especially low frequency resulting in induced vibration, can be very annoying. The analysis of measured sound levels at the Stetson wind energy facility presented by First Wind's noise consultant at the July 22, 2009 Committee meeting indicates that sound levels from the Oakfield project are not projected to rise to the levels that generate sound-induced vibration inside the home.

If a low-frequency sound/vibration problem did occur, the current Maine DEP standards would <u>not</u> require First Wind or its successors to address the problem unless other Maine DEP standards were exceeded. For this reason, it would be sensible for First Wind to evaluate available low frequency data and compare it to the ANSI S12.2-2008 standard, "Criteria For Evaluating Room Noise," for the level of low frequency noise that would cause moderately noticeable acoustically induced vibration or rattles inside a building.

The levels should be measured in the 16 Hz, 31.5 Hz, and 63 Hz octave bands and with the guidelines levels specified by ANSI, which are 65 dB, 65 dB, and 70 dB, respectively. Sound levels should be measured as required by Maine DEP regulation Chapter 375.10 at representative protected locations. Notably, First Wind's noise consultant, in its July 22, 2009 evaluation of low frequency sound, also compared the sound from wind turbines against ANSI 12.2's interior Noise Criteria curves. The Committee does not believe that any Noise Criteria standard should be applied as these are not generally intended to be used as impact criteria for this type of project.

4. Cumulative Impacts

The applications before the Committee represent Phase I of a potentially two or more part development. Plans for Phase II have not been issued, but discussions and lease negotiations are apparently underway. The Committee believes that the cumulative impacts of both developments should be considered, and that the recommendations and standards developed should be applied to the combined impacts of both phases.

As explained above, the Committee understands that, although not required by existing sound regulations, First Wind has committed that any future projects sited proximate to the Phase I Project that would contribute to cumulative sound levels in the Town of Oakfield will be sited and operated in a manner that will cause Phase I and future projects to comply with the quiet level noise standards of 45 dBA and 55 dBA for nighttime and daytime time periods, respectively, at the regulatory locations.[7] As a result, the Committee recommends that First Wind's pledge on cumulative impacts be incorporated into the Maine DEP permit (if approved) for the proposed Oakfield project.

5. Summary Finding

The Committee appreciates the cooperative work between the Committee's and First Wind's noise consultants. Based on the above reasons, and with the inclusion of the applicable Committee recommendations in the Maine DEP application and permit, the Committee has concluded that the Maine DEP's quiet level noise standards should prevent adverse effects from sound and noise in a well-designed, properly sited, operated, and maintained wind energy facility. Under unusual cases of excess low frequency noise that causes building vibrations, the Maine DEP standard may not be sufficient, which is why the Committee has recommended that First Wind voluntarily evaluate wind turbine sound levels in accordance with the building vibration criteria as specified in ANSI S12.2-2008 standard, "Criteria For Evaluating Room Noise."

[7] The nighttime limit of 45 dBA applies within 500 feet of a residence on a protected location. At distances over 500 feet, the 55 dBA limit applies during all hours.

6. Sound Prediction Modeling

To satisfy the Maine DEP noise standards, First Wind must show that its proposed wind energy facility will not exceed the quiet level noise standards of 45 dBA and 55 dBA during nighttime and daytime time periods. First Wind has proposed to meet this burden through sound prediction modeling.

Sound prediction modeling for a wind energy facility is conducted to forecast sound levels at sensitive areas prior to construction. It is typically done using the international standard, ISO 9613, "Acoustics – Attenuation of Sound During Propagation Outdoors." The Committee notes that, at the time of writing, this standard was not calibrated to sources like wind energy facilities with high source heights and long propagation distances. However, experience applying the standard to wind energy facilities has led to adjustments to the methodology that makes it more accurate.

In this case, First Wind's noise consultant used standard modeling assumptions, but applied a +2 dB adjustment to the manufacturer's sound power to represent the error in estimating sound power, and a +3 dB adjustment to represent the error in estimating sound propagation. First Wind's noise consultant confirmed that this was an appropriate adjustment by comparing monitored sound levels to modeled sound levels at two existing wind energy facilities, Mars Hill and Stetson. In both cases, the model adjustments used in Oakfield were validated, or found to be conservative.

The Committee's noise consultant conducted a sensitivity analysis of the Oakfield sound model using other assumptions from published reports on wind energy facility modeling. In their paper, "Propagation Modeling Parameters for Wind Power Projects," (Sound & Vibration, December 2008), authors Kaliski and Duncan found that the ISO 9613 standard can be applied to both overestimate and underestimate wind energy facility impacts depending on what ground factors and meteorological adjustments are used.[8] (*See* Appendix C for a copy of this report.) This paper recommended several ground and/or meteorological adjustments that best correlated with their calibrated monitoring site 2,000 feet from a wind energy facility along flat farmland. The authors found that using a "non-spectral ground attenuation" method was accurate (if the manufacturer's +2 dB confidence interval was added) and a "spectral ground attenuation" method was slightly conservative if the ground factor was set to hard ground (G=0).

The Committee's noise consultant conducted another sensitivity analysis of the Oakfield sound model for the Oakfield Phase I array and found that the "non-spectral" method yielded lower sound levels from the turbines than the results presented in First Wind's Site Law application. The "spectral" results (with G=0) yielded results that were within about ±0.5 dB of the predicted sound. The Committee's noise consultant used a

[8] *Available at* http://www.sandv.com/downloads/0812kali.pdf.

+2 dB confidence interval compared to a +5 dB adjustment used by First Wind's noise consultant. Under all circumstances, the Committee consultant's modeling scenarios showed predicted sound levels of 45 dBA or lower from the wind turbines at each non-participating residence.[9]

By comparing the modeling results from the Mars Hill and Stetson wind energy facilities provided by First Wind's noise consultant, and by checking the modeling parameters for robustness in the sensitivity analysis conducted by the Committee's consultant, the Committee has concluded that the applicant's sound predictions and modeling are appropriate and may be conservative.

While a review of First Wind's modeling indicates the project can satisfy the Maine DEP noise standards, models are still only predictions of certain results. There are conditions that cannot presently be modeled that affect sound from wind energy facilities, including excessive turbulence, blade abnormalities, mechanical equipment aging, and upset conditions. In addition, the individual characteristics of a single wind energy facility will vary based upon the proposed location, proposed wind turbine equipment, and proposed configuration of the wind turbines.

Because of these local variations and the inherent uncertainties associated with sound modeling, the Committee has concluded that it is necessary to develop a monitoring protocol that sufficiently addresses and prevents any adverse effects from sound and noise that may not be prevented through the Maine DEP noise standards and review process. Indeed, in response to this request, First Wind and its noise consultant have developed the "Oakfield Wind Project Sound Complaint Response and Resolution Protocol" that includes provisions to identify sound issues and for refining or supplementing monitoring protocols. (*See* Appendix D for a copy of this protocol; *see also* Part II.A.iv.3, discussing this protocol.)

iv. Sound and Noise Recommendations Including Appropriate Actions

1. Low-Frequency Sound

The Committee recommends that First Wind gather low-frequency data during all sound level measurements consistent with the Maine DEP noise standards. This will provide sufficient data in the event low-frequency sound levels require further analysis. In addition, the Committee recommends that First Wind address the ANSI standard S12.2-2008 for moderately perceptible acoustically-induced vibration and rattle in the 16

[9] A "non-participating residence" is a property in which First Wind has not obtained an interest in real estate, such as a sound easement, ground lease, or fee acquisition.

Hz through 63 Hz whole octave bands. Sound levels exceeding ANSI specified levels will require further investigation to determine their cause.

APPROPRIATE ACTION: **First Wind should collect 1/3 octave band data during monitoring carried out in accordance with Chapter 375.10. 1/3 octave band data should extend at least to 20 Hz. 12 Hz is the lower third octave band limit in response to complaints of acoustically induced building vibration or rattle. For monitoring conducted in accordance with the Maine DEP noise standards, First Wind will report the C-weighted sound levels to the Town of Oakfield for informational purposes only.**

2. Post-Construction Monitoring

The Maine DEP quiet noise standards will be in place to protect Oakfield residences from undue adverse noise levels during operation of the proposed wind energy facility. However, because the Maine DEP noise standards were not specifically intended to address potential adverse effects from wind energy facilities, and due to inherent uncertainties with predictive sound modeling, there should be a monitoring plan to address the measurement of sound levels as part of assuring compliance with the Maine DEP noise standards. A monitoring plan should:

- Address both standard post-construction monitoring and complaint resolution;
- Address each of the components of wind energy facility noise that are in the standard, including overall sound levels, amplitude modulation, and tonal sound;
- Collect enough information on the sound spectrum to evaluate upset or other conditions that could lead to complaints;
- Require testing during times when the turbines are generating their maximum sound power;
- Require testing during meteorological conditions that are favorable to propagation or that are conducive to complaints by neighbors;
- Use industry standard practices for equipment sensitivity and accuracy;
- Include simultaneous monitoring of wind speed and wind direction representative of the sound measurement locations at each hub;
- Allow for reasonable forecasting of the proper conditions favorable for monitoring;
- Allow for appropriate flexibility within specified constraints;

- Be conducted under repeatable conditions; and
- Allow for appropriate response times in the case of complaints.

In the case of the Rollins wind energy facility monitoring protocol set forth as an example by First Wind, the Committee is concerned that those conditions would not be met in their entirety. In addition, the Rollins protocol does not address how complaints will be resolved or addressed. First Wind has committed, however, to implementation of the Oakfield Wind Project Sound Complaint Response and Resolution Protocol, which is designed to identify and develop responses to any noise issues (discussed below in Part II.A.iv.3). (*See* Appendix D for a copy of the Oakfield Wind Project Sound Complaint Response and Resolution Protocol.)

The Rollins monitoring protocol adequately defines meteorology favorable to propagation, but is confined to a very narrow set of conditions that may be difficult to forecast in advance, may occur infrequently if at all, and could prevent the timely collection of sound data. Implementation of the Maine DEP directed monitoring protocol (as modified below) coupled with the Oakfield Wind Project Sound Complaint Response and Resolution Protocol developed by First Wind should provide important means for ensuring that the proposed wind energy facility remains in compliance, and that complaints by the public are appropriately addressed.

APPROPRIATE ACTION: **First Wind should seek concurrence from the Maine DEP that any required post-construction monitoring protocol be consistent with the following (and if the Maine DEP does not require post-construction monitoring then First Wind should nonetheless implement a post-construction monitoring protocol consistent with the following): within 12 months from when the project commences operation, First Wind shall conduct sound monitoring at two (2) or more representative locations around the project. These locations shall be chosen in consultation with the Maine DEP and the Town of Oakfield based on how well they represent local meteorology and their relative noise impact from the wind turbines (highest potential to exceed the applicable noise standards). In addition, special consideration shall be given to landowners that have registered sound complaints. The April 6th Rollins protocol shall be followed except that the weather conditions in Section b of the protocol will be relaxed if:**

A. If the following conditions are met:

i. The difference between the LA90 and LA10 during any 10-minute period is less than 5 dB, and

ii. The surface wind speed (l0 meter height) is 6 mph or less for 80% of the measurement period and did not exceed 10 mph at any time; or the turbines are shut down during the monitoring period and the difference in the observed LA50 after shut down is equal to or greater than 6 dB, and

iii. Observer logs or recorded sound files clearly indicate the dominance of turbine sounds, or

OR

B. If the following condition is met:

iv. The overall 10-minute LAeq is 40 dBA or less.

To provide further clarification, Section b of the protocol will be relaxed in two separate cases: (A) conditions i, ii, and iii are met; OR (B) condition iv is met.

Sound levels (dB) from wind turbines will be compared to ANSI S12.2-2008 indoor acoustically-induced moderately perceptible vibration and rattle standard for octave band frequencies up to 63 Hz. C-weighted sound levels will be reported for information purposes only.

3. Complaint-Based Sound Measurement and The Process for Remedial Action

A major concern of the Committee is how any future noise issues will be identified and resolved in order to prevent any continuing adverse effects caused by sound and noise generated by the proposed wind energy facility. As previously discussed, the Rollins protocol did not include any provisions on how complaints would be addressed and resolved. In response to this concern, First Wind has developed the **"Oakfield Wind Project Sound Complaint Response and Resolution Protocol,"** which includes measures to document, analyze, and respond to complaints. (*See* Appendix D.) The purpose of this protocol is to:

(1) Provide a transparent process for reporting sound complaints to First Wind;
(2) Provide a consistent approach to documenting complaints and to inform subsequent monitoring efforts;
(3) Provide a process for informing the Town and the Maine DEP of sound complaints.

Once a complaint is received, First Wind will provide a response, which will depend upon the particular set of circumstances contained in the complaint. Responses may include:

(1) a site visit to the location of the complaint;
(2) an inspection of the wind turbines operating near the location of the complaint;
(3) informal sound monitoring and sound evaluation; or
(4) formal sound monitoring and sound evaluation.

In the event First Wind conducts formal sound monitoring at a complaint location, it will notify the Town ahead of time and will provide the results to the Town. If First Wind conducts a visit to the complainant, or informal sound monitoring at a complaint location, it will undertake best efforts to notify the Town Manager and allow him or her to observe. In any event, the results of the response to the sound complaint will be available for the Town's review.

The Maine DEP or First Wind may require sound monitoring as part of a protocol developed to address sound complaints. If sound monitoring is undertaken to determine if the Oakfield wind energy facility meets the quiet level noise standards, First Wind will first provide the appropriate protocol to both the Town and the Maine DEP for review

and comment and then report the results of the approved protocol. If the results indicate that the Oakfield wind energy facility is not in compliance, First Wind must submit a revised wind energy facility operation protocol to the Maine DEP[10] that will demonstrate compliance with the Maine DEP noise standards.

The Committee has concluded that the Oakfield Wind Project Sound Complaint Response and Resolution Protocol is designed to adequately identify and formulate a response to any future noise issues associated with the proposed wind energy facility. As a result, the Committee recommends that the Selectmen request this protocol to be incorporated into First Wind's current Site Law application and permit, if approved.

APPROPRIATE ACTION: **The Selectmen shall request that the Oakfield Wind Project Sound Complaint Response and Resolution Protocol be included in First Wind's current Site Law Application before the Maine DEP, or that the Maine DEP include the protocol as a condition for approval.**

4. Overall Sound Levels

The Committee believes that it is important for the proposed wind energy facility to adhere to the overall quiet level noise standards (45 dBA and 55 dbA during the nighttime and daytime, respectively), and that it is sensible for any overall sound level issues to be appropriately addressed.

APPROPRIATE ACTION: **Sound Emissions: The Committee recommends that First Wind take affirmative steps so that GE turbines will perform within stated limits on overall sound power. As reflected in its application, First Wind expects expects GE turbines to operate consistent with a maximum continuous sound power output of 104 dBA (+/- 2 dBA).**

Tonal Sound: The Committee and First Wind have different views on how to apply the Maine DEP tonal sound penalties. Regardless, prominent discrete tones should not occur in a well-operated wind energy facility and, if they do develop, the best practice is to mitigate and eliminate these tones. The Committee understands from First Wind that there will be measures in place to minimize the likelihood that tonal sounds will occur and if they do occur, that they will be adequately addressed. (*See* Part II.A.iii.2

[10] A copy of this protocol will be provided to the Town.

"Penalties for Tonal and Short Duration Repetitive Sounds" describing the measures to address tonal sounds.)

APPROPRIATE ACTION: **The Selectmen should request that if tonal sounds cause an exceedance of the applicable sound limits, First Wind will promptly notify the Maine DEP and the Town of Oakfield. First Wind will then expedite an investigation of the sound level exceedance and the associated tonal sound and develop a mitigation plan, and schedule to achieve compliance with the applicable sound level limits. First Wind will provide copies of the mitigation plan to DEP and the Town, implement the mitigation plan and provide a written report describing the action(s) taken and new measurement results that demonstrate compliance. Mitigation options could include reduction of the overall sound level and/or the tonal sound component.**

Applicable Nighttime Noise Standard: The Committee recommends that the proposed wind energy facility adhere to the more restrictive 45 dBA nighttime standard, even if the pre-development ambient (or background) sound levels are shown to be greater than 35 dBA.

APPROPRIATE ACTION: **First Wind shall specifically state in its applications to the Maine DEP that its proposed development will comply with the 45 dBA quiet limit during during nighttime hours, even if the pre-development ambient sound level is shown to be greater than 35 dBA.**

Applicable Daytime Noise Standard: The Committee recommends that the proposed wind energy facility adhere to the more restrictive 55 dBA daytime standard, even if the pre-development ambient (or background) sound levels are shown to be greater than 45 dBA.

APPROPRIATE ACTION: **First Wind shall specifically state in its applications to the Maine DEP that its proposed development will comply with the 55 dBA quiet limit during daytime hours, even if the pre-development ambient sound level is shown to be greater than 45 dBA.**

Cumulative Impacts: The Committee recommends that any future projects should incorporate the wind energy facility operations of Phase I.

APPROPRIATE ACTION: **The Committee understands that, although not required by applicable sound regulations to do so, First Wind has represented that any future projects sited proximate to the Phase I Project that would contribute to cumulative sound levels in the Town of Oakfield will be sited and operated in a manner to cause Phase I and future projects to comply with the quiet noise limits of 45 dBA and 55 dBA for nighttime and daytime limits, respectively, at any regulatory locations. Thus, the Selectmen should request that First Wind's pledge on cumulative impacts be incorporated into the Maine DEP application and permit for the Oakfield project.**

B. Shadow Flicker

i. What is Shadow Flicker?

Shadow flicker occurs when the angle of the sun aligns with rotating turbine blades causing a shadow to be cast. It can be described as the flickering effect of shadows cast by turbine blades passing between the sun and a given location called a receptor (the effect is similar to a strobe light). Shadow flicker depends upon 6 main conditions:

(1) The amount of sunlight;
(2) The wind direction (which affects the rotor orientation);
(3) The time of day;
(4) The geographical position of a wind turbine;
(5) The topographical position of a wind turbine; and
(6) The distance to habituated areas or other significant areas in the vicinity of a wind turbine.

ii. Why is Shadow Flicker a Consideration?

The shadow flicker effect is most pronounced when the blades of the turbine are perpendicular to the line between the sun and the receptor. While there is little or no documented potential for health impacts associated with shadow flicker, it can constitute an annoyance for those who are subjected to it and, accordingly, although Maine has not

set any specific regulatory limit, the Maine DEP has referenced 30 hours per year as a reasonable upper limit to reduce nuisance complaints on residential properties.

iii. Shadow Flicker Recommendation Including Appropriate Actions

First Wind's application to the Maine DEP includes the results of computer modeling that suggest approximately 40 residences will be subject to shadow flicker impacts. Approximately 20 of these 40 residences have entered into lease/easement agreements with First Wind that release First Wind from liability for impacts associated with Shadow Flicker. For the remaining cases, the anticipated annual duration of these impacts will be less than 30 hours in all cases, and likely on the order of 5 hours or less.

The Committee notes that, consistent with published guidelines for the estimation of shadow flicker, these projections are based on assumptions relative to a variety of meteorological conditions (cloud cover, wind direction, wind speed, etc.), which have a bearing on the potential for shadow flicker. These have been based on recorded meteorological conditions for the project area.

Due to the nature of the phenomenon known as shadow flicker, there are limited mechanisms available for mitigation, most of which (such as planting of screening vegetation) are limited in their application because they can only be practically implemented at the receptor location. Moreover, should it be found that shadow flicker occurs at unacceptable levels during certain times of the year, a wind turbine can be programmed until the sun moves to a position from which shadow flicker is no longer an annoyance.

C. Ice Throw

i. What is Ice Throw?

Ice throw consists of the shedding of accumulated ice from the blades of the turbine. The potential for ice throw is associated with freezing conditions and precipitation (generally in a liquid state). While studies of ice throw potential have been conducted in a number of locations, it is important to note that projections regarding the maximum size and distance for ice throw for a specific installation should be based on observations using the same or similar equipment.

ii. Why is Ice Throw a Consideration?

The combination of the height of a wind turbine and its location (usually at higher elevations with adjacent slopes) can cause ice to be thrown for a significant distance. This is a concern for several reasons. First, ice throw can cause serious bodily injury to

persons and animals that are in close proximity to wind turbines. Second, ice throw can cause property damage, such as tree damage. Third, ice throw can have negative impacts on the ability to access areas near wind turbines.

iii. Ice Throw Recommendation Including Appropriate Actions

While wind turbine manufacturers have researched coatings and other means to reduce the tendency for ice accumulation on turbine blades, the primary mechanism for avoiding and mitigating the risks associated with ice throw has been establishing appropriate setbacks to areas of public access.

First Wind has provided the Committee and its consultants with information from General Electric specific to ice throw potential associated with the proposed 1.5 sle model turbines, as well as safety-related setbacks that have been developed by GE. In general, the layout of the proposed wind energy facility in Oakfield, including buffer distances that will be under legal control of First Wind (via lease, easement, or acquisition) meet or exceed the recommended minimum setback distance of 584 feet. The exception to this relates to portions of several trails or roads that are primarily used for snowmobile and ATV recreation. Other types of recreation, such as hiking, cross-country skiing, hunting, and snowshoeing, also occur in these areas. These issues are discussed in Part IV.C "Recreation – Public Access" of the report.

Post-Construction Monitoring: The Maine DEP does not currently require any formal post-construction monitoring of ice throw incidents. While no formal program for monitoring ice throw is currently required in the Maine DEP process, the Committee believes it is sensible to identify and maintain records of any observed ice throw incidents near or beyond the recommended setback. Identifying and recording ice throw incidents (by First Wind, the community, and/or visitors to the community) will enable First Wind and the Town to make better informed decisions concerning the proposed wind energy facility operations, as well as areas of significant public use in close proximity to wind turbines, in order to prevent any personal injuries or property damage.

APPROPRIATE ACTION: **The Selectmen should request that any observed ice throw incidents at or beyond the designated setback within areas of significant public use be identified, recorded, and maintained by First Wind at its local office. When these ice throw incidents are observed by First Wind or observed and communicated to First Wind, records should be maintained that include the estimated time, date, and location of the incident. If feasible, First Wind should record the distance from the thrown ice to the nearest wind**

turbine. Copies of ice throw incidents shall be made available to the Town Manger.

III. Environmental

The Committee has identified three primary environmental issues associated with First Wind's proposed wind energy facility:

(A) Wildlife;
(B) Natural resources; and
(C) Stormwater.

A. Wildlife

The nature and size of First Wind's proposed wind energy facility presents a potential for adverse impacts to wildlife. First Wind's application to the Maine DEP includes an assessment of the potential impact to a variety of wildlife species associated with the construction of the proposed facility, including consultation with the Maine Department of Inland Fisheries and Wildlife with respect to the habitat of threatened or endangered species. Aside from limited impacts to wetland habitats (discussed below in Part III.B.i "Wetland Impacts"), the Committee has identified little in the way of potential permanent impacts. During the ensuing operational phase of the project, the primary area of potential impact relates to bird and bat mortality from encountering the wind turbine blades (i.e., avian strikes).

i. Bird and Bat Considerations

The application materials submitted to the Maine DEP include reports that discuss monitoring for bird and bat populations and their flight patterns within the project area, as well as anticipated mortality estimations when the proposed wind energy facility is operating. Based on visual and radar-based observations, coupled with observed mortality levels at other facilities, First Wind's consultants have projected that bird and bat strikes are not expected to reach significant levels of mortality, and that the project site is not located in an area of significant bird and bat migration.

ii. Post-Construction Monitoring

First Wind's applications to the Maine DEP states post-construction monitoring of bird and bat strikes will be conducted for a period of two (2) years after the proposed wind energy facility commences operation. The Committee has concluded that this post-construction monitoring protocol is appropriate.

B. Natural Resources

Given the presently undeveloped nature of the project area, the potential exists for adverse impacts to a variety of natural resources. First Wind's applications include an inventory of the natural resources that exist within the project area. This natural resources inventory includes wetlands (based on state and federal jurisdictional guidelines) and potential rare or threatened species of vegetation. The applications included the results from requests to the Natural Areas Program located within the Maine Department of Conservation.

Based upon these materials, First Wind's proposed wind energy facility is not expected to impact rare or endangered plant species, and the project layout has been developed to minimize impacts to jurisdictional wetlands and waterbodies. While two plant species of Special Concern were found within the overall project area, these two plant species were not found within the area designated for development.

i. Wetlands

While the layout for the proposed wind energy facility appears to have been developed to minimize impacts to jurisdictional wetlands, it appears that the construction of roadways to access the facilities will need to include one stream crossing. (*See* Appendix E, describing the areas where wetland impacts are anticipated.) First Wind has sited the proposed crossing to coincide with an existing crossing of a woods road and included other measures to minimize impacts to the associated wetland and aquatic habitats.

ii. Buffers

Based upon its review of the materials contained within First Wind's applications, the Committee has concluded the proposed facilities and activities of the project will include appropriate buffers to protect natural resources.

C. Stormwater

The nature and magnitude of the proposed wind energy facility has the potential for several types of stormwater-related impacts, including:

(1) sediment transport during and immediately following construction;
(2) increases in long-term erosion potential due to concentrating flows along new roadways; and
(3) increases in peak rates of stormwater runoff onto adjacent properties.

First Wind's applications include an evaluation of stormwater runoff quantities and patterns, as well as proposed measures to address soil erosion and sediment transport. In general, First Wind's proposal relies on the maintenance of vegetated buffers for compliance with the Maine DEP's Chapter 500 stormwater rules, although underdrained soil filters are proposed at two locations within the Spaulding Lake watershed. The proposal for erosion control is outlined based on the Basic Standards as set forth by the Maine DEP. The Committee has concluded that these standards, if properly implemented, will be adequate.

Post-Construction Monitoring: The Committee understands that the Maine DEP will require the provision of a "third-party inspector" during construction to ensure that stormwater and erosion control measures are constructed and maintained in accordance with the approved design materials. As a result, the Committee recommends that the Selectmen endorse and request the use of a third-party inspector.

APPROPRIATE ACTION: **The Selectmen shall request in writing that the Maine DEP use a third-party inspector to review and ensure the stormwater and erosion control measures are constructed and maintained in accordance with the approved design materials.**

IV. Miscellaneous

In addition to construction, health and safety, and environmental concerns, the Committee has identified a number of other issues associated with First Wind's proposed wind energy facility. These are:

(A) Decommissioning issues;
(B) Property values and visual and aesthetic impact issues;
(C) Recreation and public access issues;
(D) Legal issues involving indemnification;
(E) Legal issues involving sound easements; and
(F) Legal issues involving enforcement by the Maine DEP.

A. Decommissioning

i. What is Decommissioning?

Decommissioning is the process of disassembling a wind turbine or turbines and restoring the site to similar pre-development conditions.[11] The Governor's Advisory Committee on Wind Power has recently acknowledged the limited lifespan of these projects, as well as the negative impacts associated with allowing them to remain in place after their useful lifetime has lapsed.

To address these concerns, permitting under the Site Law requires developers of grid-scale wind energy facilities[12] to set aside funding to support removal of the facilities and restoration of the site. If a specific wind turbine does not operate for 12 months, it must be decommissioned unless the developer demonstrates that the proposed wind energy facility has not been abandoned and should not be decommissioned.

ii. Why is Decommissioning a Consideration?

The primary concern with decommissioning is financial – will the developer of a proposed wind energy facility have sufficient funds to properly decommission the project? If funds are not available, then wind turbines that are no longer operating may remain in place for a significant time period.

iii. Decommissioning Recommendation Including Appropriate Actions

The funding concern relates to the strength of the assumptions used in the computation of the reserve fund, given fairly significant fluctuations in both construction costs (associated with removal/restoration) and in the commodity values of copper and other components that will likely have a meaningful impact on the ultimate salvage value of the wind turbines - all key elements in the overall financial analysis.

Funding Projections: The application materials submitted by First Wind include computations relative to the projected net costs associated with removal and restoration of the proposed wind energy facility. The designated protocol includes a $50,000 annual contribution to the fund and allows for the basis for reserve funding to be revisited in year 15 and for adjustments to be made in the annual amount set aside at that time.

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[11] Notably, any underground collection lines that are buried more than 24 inches will be left in place and abandoned. First Wind has represented that these materials (cables and conduits) are not known to be harmful to the environment.

[12] First Wind's proposed wind energy facility in Oakfield falls within the definition of a grid-scale wind energy facility.

APPROPRIATE ACTION: **At such time as the Maine DEP provides for the computation of decommissioning costs to be revisited, First Wind or its successors shall simultaneously submit to the Town the relevant documents to substantiate both demolition costs and salvage values within the decommissioning analysis.**

B. Property Values; Visual and Scenic Impact

The value of property is a function of what a buyer is willing to pay for certain real estate. Due to the numerous uncertainties with the various factors that affect property value, the Committee believes that a case-by-case assessment is required to adequately estimate the effect a wind energy facility may have on property values. As a result, the Committee recommends that, if property owners in Oakfield have questions or concerns, these interested property owners should retain a qualified real estate appraiser to estimate the effect (either positive or negative) that the proposed wind energy facility may have on the value of their property.

APPROPRIATE ACTION: **The Selectmen shall establish and maintain a list of qualified real estate appraisers within the region at the Town Office, which shall be available upon request. The written list of appraisers shall be updated by July 1 of each calendar year.**

C. Recreation – Public Access

i. Public Access Concern: Maintaining Trail Infrastructure

Presently, ITS 83 and other snowmobile trails are located within setback areas of proposed wind turbine locations along the ridgeline of Sam Drew Mountain and in the area where ITS 83 crosses the South Oakfield Road. (*See* Appendix F, describing the proposed wind turbine sites, the currently located trails, and possible areas for relocation.) Because ice throw is a safety concern during the winter months for snowmobiling and other types of winter recreational activities (hiking, cross-country skiing, snowshoeing, hunting, etc.), certain trail sections located within 584 feet of a proposed wind turbine location pose a significant safety risk.

As a result, the Committee is concerned with the impact this will have on the trail infrastructure for the Town of Oakfield and the surrounding communities. In addition to potentially removing an aesthetically pleasing experience, there is a risk that snowmobile

ridership may drop and other winter recreationalist will decrease their visits to the Town of Oakfield, which are activities that provide significant economic benefit to the Town and surrounding communities.

ii. Public Access Recommendation Including Appropriate Actions

In response to the above concerns, First Wind is working to relocate portions of trails that are located within 584 feet of any proposed wind turbines. First Wind has indicated that it will continue to work with the local snowmobile club and landowners in order to relocate these at-risk trails (*See* Appendix F, describing the draft relocation plan.) The Committee encourages First Wind to continue these discussions and to promptly resolve the issue in a timely fashion. The Committee understands that First Wind has been and will continue pursuing best efforts to relocate these trails prior to commencing any construction of the proposed wind energy facility.

When First Wind, local clubs, and landowners agree on how and where to relocate affected trails, the Committee recommends that appropriate signage be placed in areas within or near the designated setback.

APPROPRIATE ACTION:

First Wind shall continue its best efforts to relocate any trails within the designated setback areas to ensure the integrity of the trail structure, to avoid and reasonably mitigate adverse effects due to relocation, and to maintain adequate safety setbecks.

In the event First Wind is not able to relocate all trail sections currently within 584 feet of a wind turine, it shall report back to the Town and the Committee, and identify the status of trail use at these locations. Thereafter, the Committee and First Wind shall discuss appropriate measures to be taken.

The Selectmen should recommend that appropriate signage be placed in areas within or near the 584 setback area from wind turbines. The Selectmen should make this request to local clubs and to First Wind.

D. Legal Issues –Indemnification

i. What is Indemnification?

Indemnification is the "action of compensating for loss or damage sustained." Black's Law Dictionary at p. 772 (7th ed. 1999). Under a simple *indemnification agreement,* one party ("party A") agrees to compensate or reimburse the other party ("party B") for damages or expenses incurred by party B, that arise out of particular events or actions that are specified in the agreement.

ii. Why is Indemnification a Consideration?

In the current setting, an indemnification agreement would protect the Town against expenses arising from possible future lawsuits that might be brought as a result of the permitting, construction, or operation of First Wind's proposed wind energy facility. The concern is that, without an indemnification agreement, the Town could incur significant legal fees or be subject to damage claims if the Town is named as a defendant in lawsuits filed against First Wind relating to the wind energy facility. In some circumstances, such claims or expenses could affect the Town's finances.

iii. Indemnification Recommendation Including Appropriate Actions

Although indemnification has been raised as an issue during the Committee's deliberations, the Committee recommends that indemnification should be addressed by the Selectmen.

E. Legal Issues – Sound Easements

A sound easement is an interest in real estate that exempts the holder of the easement from satisfying noise standard requirements in the Maine DEP regulations. The Maine DEP exemption specifically states:

> Sound associated with the following shall be exempt from regulation by the Board: Sounds from a regulated development received at a protected location when the generator of the sound has been conveyed a noise easement for that location. This exemption shall only be for the specific noise, land and term covered by the easement.

Maine DEP Chapter 375.10.C.5.s. (2009).

Sound easements are important because they may determine whether or not the Oakfield wind energy facility complies with the Maine DEP noise standards. If noise levels from the routine operation of First Wind's wind energy facility exceed the quiet level daytime or nighttime noise standards at a protected location, then the facility would not comply with those standards unless a sound easement is obtained from the property owner.

In this case, First Wind is the holder of numerous sound easements and has included eight (8) of these sound easements in their Site Law application that will allow the Oakfield wind energy facility to exceed any applicable noise standards at these locations.

F. Legal Issues – Maine DEP Enforcement

The Committee believes it is important for the Town to understand typical Maine DEP enforcement procedures in the event any issues develop with the proposed wind energy facility. The Maine DEP has set forth the following objectives for regulatory compliance:

- Encourage voluntary compliance with environmental statutes, regulations, licenses and permits;
- Provide incentives for regulated entities to go beyond compliance with source reduction and pollution prevention in order to achieve environmental excellence;
- Establish an appropriate and consistent approach to violations and violators;
- Ensure that appropriate corrective and future preventative actions are taken once a violation has occurred;
- Remove any incentives or opportunities gained by violating an environmental requirement; and
- Deter or prevent future violations.

One of the tools the Maine DEP uses to meet these objectives is enforcement. Enforcement involves regular inspections of a development to ensure it satisfies the environmental requirements. The Maine DEP prefers to resolve civil enforcement actions in order to: remediate environmental damage; restore natural resources to appropriate conditions; impose penalties that capture any economic benefit gained by a violator; and deter similar actions in the future.

The typical response from the Maine DEP upon discovering noncompliance is:

(1) a letter of warning that identifies the violation;
(2) a notice of violation describing the alleged violation with a clear deadline for corrective action;

(3) administrative consent agreements, which are voluntary agreements with the Maine DEP to perform corrective action that is a legally binding contract; and
(4) an "80K action," which is a court action brought by the Maine DEP against an alleged violator.

Yet, in order to initiate any enforcement actions, the Maine DEP must know, or have reason to know, that an entity is in noncompliance. As previously discussed in Part II.A "Sound and Noise," the Committee's view is that the Maine DEP post-construction monitoring protocol, which only requires one sound monitoring event, may be insufficient to protect the Oakfield community because this would be the only opportunity to know, or have reason to know, whether or not the proposed wind energy facility complies with the quiet level nighttime and daytime noise standards (45 dBA and 55 dBA, respectively).

For these reasons, the Committee recommends that the Selectmen endorse the Oakfield Wind Project Sound Complaint Response and Resolution Protocol, which allows for continued monitoring in order to identify noise issues. If circumstances arise when a bona fide noise issue exists and appropriate actions have not been taken in a timely manner, the Committee believes the Town should first take actions to inform First Wind or its successors and the Maine DEP of the unresolved complaint or complaints.

APPROPRIATE ACTION: **The Selectmen should request that the Maine DEP provide a copy of any report that results in a change in wind turbine operations.**

COMMITTEE UPDATE

In the event that First Wind's proposed wind energy facility receives approval from the Maine DEP and is subsequently constructed, there may be issues that require review by the Committee. For this reason, the Committee recommends that the Selectmen retain the Committee for at least one year after operations at the proposed wind energy facility commence. The Committee should be charged with maintaining a record of all issues related to construction and operation of the proposed wind energy facility, including any sound complaints or other issues should they occur. Further, the Committee should be charged with developing a report, or an addendum to this report, to update the Selectmen on the operations of the proposed wind energy facility.

APPROPRIATE ACTION: **The Committee shall remain in place for at least one year after commencement of operations of the proposed wind energy facility and, prior to**

sunsetting, the Committee shall issue a report to the Selectmen as an update.

Dated at Oakfield, Maine, this 4th day of September, 2009.

TOWN OF OAKFIELD WIND ENERGY REVIEW COMMITTEE

By: _____
Jim Sholler

By: _____
Dennis Small

By: _____
Linnwood Hersey

By: _____
Anthony White

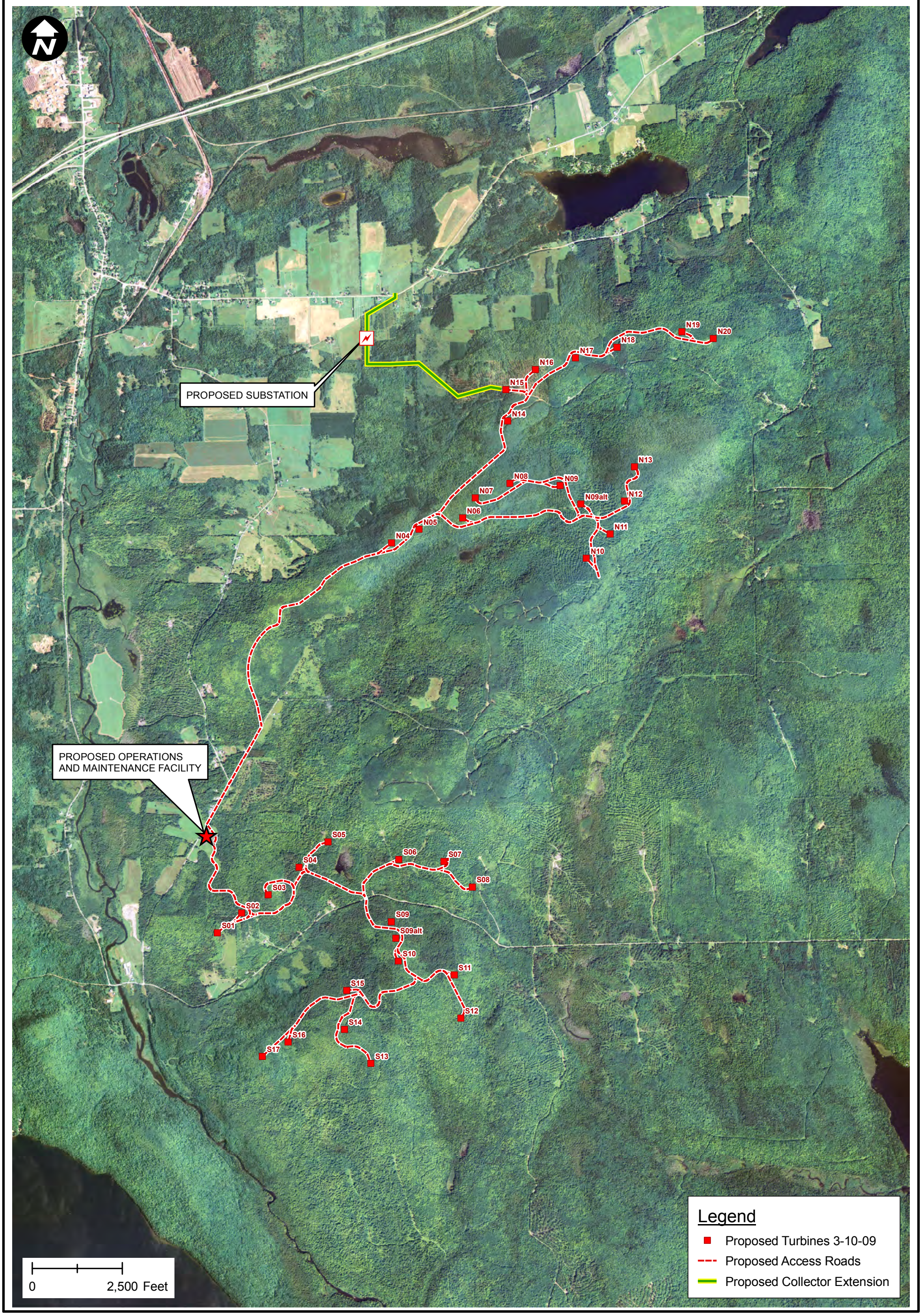
By: _____
Kirby Hardy

By: _____
Robin Crandall

APPENDICES

Appendix A:	Project Area Map
Appendix B:	World Health Organization Sound and Noise Guidelines
Appendix C:	Kenneth Kaliski and Eddie Duncan, Propagation Modeling Parameters for Wind Power Projects (Sound & Vibration, December 2008)
Appendix D:	Oakfield Wind Project Sound Complaint Response and Resolution Protocol proposed by Evergreen Wind Power II, LLC ["First Wind"]
Appendix E:	Wetland Impact Maps
Appendix F:	Draft Location Map of Trails and Proposed Wind Turbine Sites with Possible Trail Relocations

Appendix A:
Project Area Map



Prepared By: Stantec 195600152_0000_Location	Project: Oakfield Wind Project Oakfield, Maine	Sheet Title: Project Area Map	Date: March 26, 2009 Scale: 1"=2500' Proj. No.: 195600152 Figure: 1

Appendix B:
World Health Organization Sound and Noise Guidelines

4. Guideline Values

4.1. Introduction

The human ear and lower auditory system continuously receive stimuli from the world around us. However, this does not mean that all the acoustical inputs are necessarily disturbing or have harmful effects. This is because the auditory nerve provides activating impulses to the brain that enable us to regulate the vigilance and wakefulness necessary for optimal performance. On the other hand, there are scientific reports that a completely silent world can have harmful effects, because of sensory deprivation. Thus, both too little sound and too much sound can be harmful. For this reason, people should have the right to decide for themselves the quality of the acoustical environment they live in.

Exposure to noise from various sources is most commonly expressed as the average sound pressure level over a specific time period, such as 24 hours. This means that identical average sound levels for a given time period could be derived from either a large number of sound events with relatively low, almost inaudible levels, or from a few events with high sound levels. This technical concept does not fully agree with common experience on how environmental noise is experienced, or with the neurophysiological characteristics of the human receptor system.

Human perception of the environment through vision, hearing, touch, smell and taste is characterized by a good discrimination of stimulus intensity differences, and by a decaying response to a continuous stimulus (adaptation or habituation). Single sound events cannot be discriminated if the interval between events drops below a threshold value; if this occurs, the sound is interpreted as continuous. These characteristics are linked to survival, since new and different stimuli with low probability and high information value indicate warnings. Thus, when assessing the effects of environmental noise on people it is relevant to consider the importance of the background noise level, the number of events, and the noise exposure level independently.

Community noise studies have traditionally considered noise annoyance from single specific sources such as aircraft, road traffic or railways. In recent years, efforts have been made to compare the results from road traffic, aircraft and railway surveys. Data from a number of sources show that aircraft noise is more annoying than road traffic noise, which, in turn, is more annoying than railway noise. However, there is not a clear understanding of the mechanisms that create these differences. Some populations may also be at greater risk for the harmful effects of noise. Young children (especially during language acquisition), the blind, and perhaps fetuses are examples of such populations. There are no definite conclusions on this topic, but the reader should be alerted that guidelines in this report are developed for the population at large; guidelines for potentially more vulnerable groups are addressed only to a limited extent.

In the following, guideline values are summarized with regard to specific environments and effects. For each environment and situation, the guideline values take into consideration the identified health effects and are set, based on the lowest levels of noise that affect health (critical health effect). Guideline values typically correspond to the lowest effect level for general populations, such as those for indoor speech intelligibility. By contrast, guideline values for annoyance have been set at 50 or 55 dBA, representing daytime levels below which a majority of

the adult population will be protected from becoming moderately or seriously annoyed, respectively.

In these *Guidelines for Community Noise* only guideline values are presented. These are essentially values for the onset of health effects from noise exposure. It would have been preferred to establish guidelines for exposure-response relationships. Such relationships would indicate the effects to be expected if standards were set above the WHO guideline values and would facilitate the setting of standards for sound pressure levels (noise immission standards). However, exposure-response relationships could not be established as the scientific literature is very limited. The best-studied exposure-response relationship is that between L_{dn} and annoyance (WHO 1995a; Berglund & Lindvall 1995; Miedema & Vos 1998). Even the most recent relationships between integrated noise levels and the percentage of highly or moderately annoyed people are still being scrutinized. The results of a forthcoming meta-analysis are expected to be published in the near future (Miedema, personal communication).

4.2. Specific Effects

4.2.1. Interference with communication

Noise tends to interfere with auditory communication, in which speech is a most important signal. However, it is also vital to be able to hear alarming and informative signals such as door bells, telephone signals, alarm clocks, fire alarms etc., as well as sounds and signals involved in occupational tasks. The effects of noise on speech discrimination have been studied extensively and deal with this problem in lexical terms (mostly words but also sentences). For communication distances beyond a few metres, speech interference starts at sound pressure levels below 50 dB for octave bands centered on the main speech frequencies at 500, 1 000 and 2 000 Hz. It is usually possible to express the relationship between noise levels and speech intelligibility in a single diagram, based on the following assumptions and empirical observations, and for speaker-to-listener distance of about 1 m:

a. Speech in relaxed conversation is 100% intelligible in background noise levels of about 35 dBA, and can be understood fairly well in background levels of 45 dBA.

b. Speech with more vocal effort can be understood when the background sound pressure level is about 65 dBA.

A majority of the population belongs to groups sensitive to interference with speech perception. Most sensitive are the elderly and persons with impaired hearing. Even slight hearing impairments in the high-frequency range may cause problems with speech perception in a noisy environment. From about 40 years of age, people demonstrate impaired ability to interpret difficult, spoken messages with low linguistic redundancy, when compared to people aged 20–30 years. It has also been shown that children, before language acquisition has been completed, have more adverse effects than young adults to high noise levels and long reverberation times.

For speech outdoors and for moderate distances, the sound level drops by approximately 6 dB for a doubling of the distance between speaker and listener. This relationship is also applicable to

indoor conditions, but only up to a distance of about 2 m. Speech communication is affected also by the reverberation characteristics of the room, and reverberation times beyond 1 s can produce a loss in speech discrimination. A longer reverberation time combined with background noise makes speech perception still more difficult.

Speech signal perception is of paramount importance, for example, in classrooms or conference rooms. To ensure any speech communication, the signal-to-noise relationship should exceed zero dB. But when listening to complicated messages (at school, listening to foreign languages, telephone conversation) the signal-to-noise ratio should be at least 15 dB. With a voice level of 50 dBA (at 1 m distance this corresponds on average to a casual voice level in both women and men), the background level should not exceed 35 dBA. This means that in classrooms, for example, one should strive for as low background levels as possible. This is particularly true when listeners with impaired hearing are involved, for example, in homes for the elderly. Reverberation times below 1 s are necessary for good speech intelligibility in smaller rooms; and even in a quiet environment a reverberation time below 0.6 s is desirable for adequate speech intelligibility for sensitive groups.

4.2.2. Noise-induced hearing impairment

The ISO Standard 1999 (ISO 1990) gives a method of calculating noise-induced hearing impairment in populations exposed to all types of occupational noise (continuous, intermittent, impulse). However, noise-induced hearing impairment is by no means restricted to occupational situations alone. High noise levels can also occur in open-air concerts, discotheques, motor sports, shooting ranges, and from loudspeakers or other leisure activities in dwellings. Other loud noise sources, such as music played back in headphones and impulse noise from toys and fireworks, are also important. Evidence strongly suggests that the calculation method from ISO Standard 1999 for occupational noise (ISO 1990) should also be used for environmental and leisure time noise exposures. This implies that long term exposure to LAeq,24h of up to 70 dBA will not result in hearing impairment. However, given the limitations of the various underlying studies, care should be taken with respect to the following:

a. Data from animal experiments indicate that children may be more vulnerable in acquiring noise-induced hearing impairment than adults.

b. At very high instantaneous sound pressure levels mechanical damage to the ear may occur (Hanner & Axelsson 1988). Occupational limits are set at peak sound pressure levels of 140 dBA (EU 1986a). For adults, this same limit is assumed to be in order for exposure to environmental and leisure time noise. In the case of children, however, considering their habits while playing with noisy toys, peak sound pressure levels should never exceed 120 dBA.

c. For shooting noise with LAeq,24h over 80 dB, studies on temporary threshold shift suggest there is the possibility of an increased risk for noise-induced hearing impairment (Smoorenburg 1998).

d. The risk for noise-induced hearing impairment increases when noise exposure is combined with vibrations, ototoxic drugs or chemicals (Fechter 1999). In these circumstances, long-term exposure to LAeq,24h of 70 dB may induce small hearing impairments.

e. It is uncertain whether the relationships in ISO Standard 1999 (ISO 1990) are applicable to environmental sounds having a short rise time. For example, in the case of military low-altitude flying areas (75–300 m above ground) LAmax values of 110–130 dB occur within seconds after onset of the sound.

In conclusion, dose-response data are lacking for the general population. However, judging from the limited data for study groups (teenagers, young adults and women), and on the assumption that time of exposure can be equated with sound energy, the risk for hearing impairment would be negligible for LAeq,24h values of 70 dB over a lifetime. To avoid hearing impairment, impulse noise exposures should never exceed a peak sound pressure of 140 dB peak in adults, and 120 dB in children.

4.2.3. Sleep disturbance effects

Electrophysiological and behavioral methods have demonstrated that both continuous and intermittent noise indoors lead to sleep disturbance. The more intense the background noise, the more disturbing is its effect on sleep. Measurable effects on sleep start at background noise levels of about 30 dB LAeq. Physiological effects include changes in the pattern of sleep stages, especially a reduction in the proportion of REM sleep. Subjective effects have also been identified, such as difficulty in falling asleep, perceived sleep quality, and adverse after-effects such as headache and tiredness. Sensitive groups mainly include elderly persons, shift workers and persons with physical or mental disorders.
Where noise is continuous, the equivalent sound pressure level should not exceed 30 dBA indoors, if negative effects on sleep are to be avoided. When the noise is composed of a large proportion of low-frequency sounds a still lower guideline value is recommended, because low-frequency noise (e.g. from ventilation systems) can disturb rest and sleep even at low sound pressure levels. It should be noted that the adverse effect of noise partly depends on the nature of the source. A special situation is for newborns in incubators, for which the noise can cause sleep disturbance and other health effects.

If the noise is not continuous, LAmax or SEL are used to indicate the probability of noise-induced awakenings. Effects have been observed at individual LAmax exposures of 45 dB or less. Consequently, it is important to limit the number of noise events with a LAmax exceeding 45 dB. Therefore, the guidelines should be based on a combination of values of 30 dB LAeq,8h and 45 dB LAmax. To protect sensitive persons, a still lower guideline value would be preferred when the background level is low. Sleep disturbance from intermittent noise events increases with the maximum noise level. Even if the total equivalent noise level is fairly low, a small number of noise events with a high maximum sound pressure level will affect sleep.

Therefore, to avoid sleep disturbance, guidelines for community noise should be expressed in terms of equivalent sound pressure levels, as well as LAmax/SEL and the number of noise events. Measures reducing disturbance during the first part of the night are believed to be the most effective for reducing problems in falling asleep.

4.2.4. Cardiovascular and psychophysiological effects

Epidemiologial studies show that cardiovascular effects occur after long-term exposure to noise (aircraft and road traffic) with LAeq,24h values of 65–70 dB. However, the associations are weak. The association is somewhat stronger for ischaemic heart disease than for hypertension. Such small risks are important, however, because a large number of persons are currently exposed to these noise levels, or are likely to be exposed in the future. Other possible effects, such as changes in stress hormone levels and blood magnesium levels, and changes in the immune system and gastro-intestinal tract, are too inconsistent to draw conclusions. Thus, more research is required to estimate the long-term cardiovascular and psychophysiological risks due to noise. In view of the equivocal findings, no guideline values can be given.

4.2.5. Mental health effects

Studies that have examined the effects of noise on mental health are inconclusive and no guideline values can be given. However, in noisy areas, it has been observed that there is an increased use of prescription drugs such as tranquilizers and sleeping pills, and an increased frequency of psychiatric symptoms and mental hospital admissions. This strongly suggests that adverse mental health effects are associated with community noise.

4.2.6. Effects on performance

The effects of noise on task performance have mainly been studied in the laboratory and to some extent in work situations. But there have been few, if any, detailed studies on the effects of noise on human productivity in community situations. It is evident that when a task involves auditory signals of any kind, noise at an intensity sufficient to mask or interfere with the perception of these signals will also interfere with the performance of the task. A novel event, such as the start of an unfamiliar noise, will also cause distraction and interfere with many kinds of tasks. For example, impulsive noises such as sonic booms can produce disruptive effects as the result of startle responses; and these types of responses are more resistant to habituation.

Mental activities involving high load in working memory, such as sustained attention to multiple cues or complex analysis, are all directly sensitive to noise and performance suffers as a result. Some accidents may also be indicators of noise-related effects on performance. In addition to the direct effects on performance, noise also has consistent after-effects on cognitive performance with tasks such as proof-reading, and on persistence with challenging puzzles. In contrast, the performance of tasks involving either motor or monotonous activities is not always degraded by noise.

Chronic exposure to aircraft noise during early childhood appears to damage reading acquisition.

Evidence indicates that the longer the exposure, the greater the damage. Although there is insufficient information on these effects to set specific guideline values, it is clear that day-care centres and schools should not be located near major noise sources, such as highways, airports and industrial sites.

4.2.7. Annoyance responses

The capacity of a noise to induce annoyance depends upon many of its physical characteristics, including its sound pressure level and spectral characteristics, as well as the variations of these properties over time. However, annoyance reactions are sensitive to many non-acoustical factors of social, psychological or economic nature, and there are also considerable differences in individual reactions to the same noise. Dose-response relations for different types of traffic noise (air, road and railway) clearly demonstrate that these noises can cause different annoyance effects at equal LAeq,24h values. And the same type of noise, such as that found in residential areas around airports, can also produce different annoyance responses in different countries.

The annoyance response to noise is affected by several factors, including the equivalent sound pressure level and the highest sound pressure level of the noise, the number of such events, and the time of day. Methods for combining these effects have been extensively studied. The results are not inconsistent with the simple, physically based equivalent energy theory, which is represented by the LAeq noise index.

Annoyance to community noise varies with the type of activity producing the noise. Speech communication, relaxation, listening to radio and TV are all examples of noise-producing activities. During the daytime, few people are seriously annoyed by activities with LAeq levels below 55 dB; or moderately annoyed with LAeq levels below 50 dB. Sound pressure levels during the evening and night should be 5–10 dB lower than during the day. Noise with low-frequency components require even lower levels. It is emphasized that for intermittent noise it is necessary to take into account the maximum sound pressure level as well as the number of noise events. Guidelines or noise abatement measures should also take into account residential outdoor activities.

4.2.8. Effects on social behaviour

The effects of environmental noise may be evaluated by assessing the extent to which it interferes with different activities. For many community noises, interference with rest, recreation and watching television seem to be the most important issues. However, there is evidence that noise has other effects on social behaviour: helping behaviour is reduced by noise in excess of 80 dBA; and loud noise increases aggressive behavior in individuals predisposed to aggressiveness. There is concern that schoolchildren exposed to high levels of chronic noise could be more susceptible to helplessness. Guidelines on these issues must await further research.

4.3. Specific Environments

Noise measures based solely on LAeq values do not adequately characterize most noise environments and do not adequately assess the health impacts of noise on human well-being. It is also important to measure the maximum noise level and the number of noise events when deriving guideline values. If the noise includes a large proportion of low-frequency components, values even lower than the guideline values will be needed, because low-frequency components in noise may increase the adverse effects considerably. When prominent low-frequency components are present, measures based on A-weighting are inappropriate. However, the difference between dBC (or dBlin) and dBA will give crude information about the presence of low-frequency components in noise. If the difference is more than 10 dB, it is recommended that a frequency analysis of the noise be performed.

4.3.1. Dwellings

In dwellings, the critical effects of noise are on sleep, annoyance and speech interference. To avoid sleep disturbance, indoor guideline values for bedrooms are 30 dB LAeq for continuous noise and 45 dB LAmax for single sound events. Lower levels may be annoying, depending on the nature of the noise source. The maximum sound pressure level should be measured with the instrument set at "*Fast*".

To protect the majority of people from being seriously annoyed during the daytime, the sound pressure level on balconies, terraces and outdoor living areas should not exceed 55 dB LAeq for a steady, continuous noise. To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound pressure level should not exceed 50 dB LAeq. These values are based on annoyance studies, but most countries in Europe have adopted 40 dB LAeq as the maximum allowable level for new developments (Gottlob 1995). Indeed, the lower value should be considered the maximum allowable sound pressure level for all new developments whenever feasible.

At night, sound pressure levels at the outside façades of the living spaces should not exceed 45 dB LAeq and 60 dB LAmax, so that people may sleep with bedroom windows open. These values have been obtained by assuming that the noise reduction from outside to inside with the window partly open is 15 dB.

4.3.2. Schools and preschools

For schools, the critical effects of noise are on speech interference, disturbance of information extraction (e.g. comprehension and reading acquisition), message communication and annoyance. To be able to hear and understand spoken messages in classrooms, the background sound pressure level should not exceed 35 dB LAeq during teaching sessions. For hearing impaired children, an even lower sound pressure level may be needed. The reverberation time in the classroom should be about 0.6 s, and preferably lower for hearing-impaired children. For assembly halls and cafeterias in school buildings, the reverberation time should be less than 1 s. For outdoor playgrounds, the sound pressure level of the noise from external sources should not exceed 55 dB LAeq, the same value given for outdoor residential areas in daytime.

For preschools, the same critical effects and guideline values apply as for schools. In bedrooms in preschools during sleeping hours, the guideline values for bedrooms in dwellings should be used.

4.3.3. Hospitals

For most spaces in hospitals, the critical effects of noise are on sleep disturbance, annoyance and communication interference, including interference with warning signals. The LAmax of sound events during the night should not exceed 40 dB indoors. For wardrooms in hospitals, the guideline values indoors are 30 dB LAeq, together with 40 dB LAmax during the night. During the day and evening the guideline value indoors is 30 dB LAeq. The maximum level should be measured with the instrument set at *"Fast"*.

Since patients have less ability to cope with stress, the equivalent sound pressure level should not exceed 35 dB LAeq in most rooms in which patients are being treated or observed. Particular attention should be given to the sound pressure levels in intensive care units and operating theatres. Sound inside incubators may result in health problems, including sleep disturbance, and may lead to hearing impairment in neonates. Guideline values for sound pressure levels in incubators must await future research.

4.3.4. Ceremonies, festivals and entertainment events

In many countries, there are regular ceremonies, festivals and other entertainment to celebrate life events. Such events typically produce loud sounds including music and impulsive sounds. There is widespread concern about the effect of loud music and impulse sounds on young people who frequently attend concerts, discotheques, video arcades, cinemas, amusement parks and spectator events, etc. The sound pressure level is typically in excess of 100 dB LAeq. Such a noise exposure could lead to significant hearing impairment after frequent attendance.

Noise exposure for employees of these venues should be controlled by established occupational standards. As a minimum, the same standards should apply to the patrons of these premises. Patrons should not be exposed to sound pressure levels greater than 100 dB LAeq during a 4-h period, for at most four times per year. To avoid acute hearing impairment the LAmax should always be below 110 dB.

4.3.5. Sounds through headphones

To avoid hearing impairment in both adults and children from music and other sounds played back in headphones, the LAeq,24h should not exceed 70 dB. This implies that for a daily one-hour exposure the LAeq should not exceed 85 dB. The exposures are expressed in free-field equivalent sound pressure levels. To avoid acute hearing impairment, the LAmax should always be below 110 dB.

4.3.6. Impulsive sounds from toys, fireworks and firearms

To avoid acute mechanical damage to the inner ear, adults should never be exposed to more than 140 dB peak sound pressure. To account for the vulnerability in children, the peak sound pressure level produced by toys should not surpass 120 dB, measured close to the ears (100 mm). To avoid acute hearing impairment, LAmax should always be below 110 dB.

4.3.7. Parkland and conservation areas

Existing large quiet outdoor areas should be preserved and the signal-to-noise ratio kept low.

4.4. WHO Guideline Values

The WHO guideline values in Table 4.1 are organized according to specific environments. When multiple adverse health effects are identified for a given environment, the guideline values are set at the level of the lowest adverse health effect (the critical health effect). An adverse health effect of noise refers to any temporary or long-term deterioration in physical, psychological or social functioning that is associated with noise exposure. The guideline values represent the sound pressure levels that affect the most exposed receiver in the listed environment.

The time base for LAeq for "daytime" and "night-time" is 16 h and 8 h, respectively. No separate time base is given for evenings alone, but typically, guideline value should be 5 –10 dB lower than for a 12 h daytime period. Other time bases are recommended for schools, preschools and playgrounds, depending on activity.

The available knowledge of the adverse effects of noise on health is sufficient to propose guideline values for community noise for the following:

a. Annoyance.
b. Speech intelligibility and communication interference.
c. Disturbance of information extraction.
d. Sleep disturbance.
e. Hearing impairment.

The different critical health effects are relevant to specific environments, and guideline values for community noise are proposed for each environment. These are:

a. Dwellings, including bedrooms and outdoor living areas.
b. Schools and preschools, including rooms for sleeping and outdoor playgrounds.
c. Hospitals, including ward and treatment rooms.
d. Industrial, commercial shopping and traffic areas, including public addresses, indoors and outdoors.
e. Ceremonies, festivals and entertainment events, indoors and outdoors.
f. Music and other sounds through headphones.
g. Impulse sounds from toys, fireworks and firearms.
h. Outdoors in parkland and conservation areas.

It is not enough to characterize the noise environment in terms of noise measures or indices based only on energy summation (e.g. LAeq), because different critical health effects require different descriptions. Therefore, it is important to display the maximum values of the noise fluctuations, preferably combined with a measure of the number of noise events. A separate characterization of noise exposures during night-time would be required. For indoor environments, reverberation time is also an important factor. If the noise includes a large proportion of low frequency components, still lower guideline values should be applied.

Supplementary to the guideline values given in Table 4.1, precautionary recommendations are given in Section 4.2 and 4.3 for vulnerable groups, and for noise of a certain character (e.g. low-frequency components, low background noise), respectively. In Section 3.10, information is given regarding which critical effects and specific environments are considered relevant for vulnerable groups, and what precautionary noise protection would be needed in comparison to the general population.

Table 4.1: Guideline values for community noise in specific environments.

Specific environment	Critical health effect(s)	LAeq [dB]	Time base [hours]	LAmax, fast [dB]
Outdoor living area	Serious annoyance, daytime and evening Moderate annoyance, daytime and evening	55 50	16 16	- -
Dwelling, indoors Inside bedrooms	Speech intelligibility and moderate annoyance, daytime and evening Sleep disturbance, night-time	35 30	16 8	 45
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60
School class rooms and pre-schools, indoors	Speech intelligibility, disturbance of information extraction, message communication	35	during class	-
Pre-school Bedrooms, indoors	Sleep disturbance	30	sleeping -time	45
School, playground outdoor	Annoyance (external source)	55	during play	-
Hospital, ward rooms, indoors	Sleep disturbance, night-time Sleep disturbance, daytime and evenings	30 30	8 16	40 -
Hospitals, treatment rooms, indoors	Interference with rest and recovery	#1		
Industrial, commercial, shopping and traffic areas, indoors and Outdoors	Hearing impairment	70	24	110
Ceremonies, festivals and entertainment events	Hearing impairment (patrons:<5 times/year)	100	4	110
Public addresses, indoors and outdoors	Hearing impairment	85	1	110
Music through headphones/ Earphones	Hearing impairment (free-field value)	85 #4	1	110
Impulse sounds from toys, fireworks and firearms	Hearing impairment (adults) Hearing impairment (children)	- -	- -	140 #2 120 #2
Outdoors in parkland and conservation areas	Disruption of tranquillity	#3		

#1: as low as possible;
#2: peak sound pressure (not LAmax, fast), measured 100 mm from the ear;
#3: existing quiet outdoor areas should be preserved and the ratio of intruding noise to natural background sound should be kept low;
#4: under headphones, adapted to free-field values

Appendix C:
Kenneth Kaliski and Eddie Duncan,
Propagation Modeling Parameters for Wind Power Projects
(Sound & Vibration, December 2008)

Propagation Modeling Parameters for Wind Power Projects

Kenneth Kaliski and **Eddie Duncan**, Resource Systems Group, Inc., White River Junction, Vermont

Noise modeling of wind turbines can be problematic in that they generate sound over a large area, from a high elevation, and make the most noise in very high wind conditions. For ISO 9613, these factors directly relate to how ground attenuation and meteorology are accounted for.

To study how ground attenuation and wind speed affect the accuracy of propagation modeling for wind turbines, data were gathered at an existing industrial-scale wind farm, and propagation modeling was conducted using Cadna A modeling software by Datakustik, GmbH for the same site under the same operating conditions in which monitoring was carried out. By adjusting the type of ground attenuation used in the model and the meteorological conditions, the best combinations for modeling propagation for wind turbines were determined with comparisons to the monitored data.

Standards Background

ISO 9613-2 (1996)[1,2] provides two methods for calculating ground effect (A_{gr}). The first method, known as spectral ground attenuation, divides the ground area between the source and the receiver into three regions: a source region, a receiver region, and a middle region. The source region extends from the source toward the receiver at a distance equal to 30 times the height of the source. For a tall wind turbine, this can be up to 2 to 3 km. The receiver region extends from the receiver toward the source at a distance equal to 30 times the height of the receiver. If the source and receiver regions do not overlap, the distance between the two regions is defined as the middle region. The ISO standard goes on to define ground attenuation for each octave band utilizing a ground factor (G) for each region depending on how reflective or absorptive it is. For reflective, hard ground, G=0; and porous, absorptive ground suitable for vegetation, G=1. If the ground is a mixture of the two, G equals the fraction of the ground that is absorptive. The ISO standard states that "This method of calculating the ground effect is applicable only to ground that is approximately flat, either horizontally or with a constant slope."

The second method provided in ISO 9613-2, known as nonspectral ground attenuation, is for modeling A-weighted sound pressure level over absorptive or mostly absorptive ground; but the ground does not need to be flat. Using the alternative method also requires an additional factor (D_Ω) be added to the modeled sound power level to account for reflections from the ground near the source.

To show the effect of using spectral vs. nonspectral ground attenuation for a source at a reasonable wind turbine hub height of 80 m, the ground attenuation (A_{gr}) was calculated using both methods for a source height of 80 m and 1 m over a range of distances from 0 to 3.5 km with the ground factor, G, set to zero. In a third scenario, G was set to 1, and an 80-m source height was used. In each example, the receiver height was set at 1 meter. The results for spectral ground attenuation are shown in Figure 1, and nonspectral ground attenuation results are shown in Figure 2.

As shown in the graphs, over soft, porous, spectral ground, attenuation for an 80-meter source is approximately 2 dB less than a 1-meter source. For nonspectral ground attenuation, an 80-m source height actually has negative ground attenuation over the first 750 m due to reflections from the ground.

ISO 9613-2 is only valid for moderate nighttime inversions or downwind conditions. The valid range of wind speeds is 1 to 5 m/s at 3 to 11 m high. For wind turbines, it may be more accurate to consider adjustments such as those presented by CONCAWE[3] or HARMONOISE.[4] These adjustments account for propagation at various wind speed, wind directions, and atmospheric stability. The CONCAWE meteorological adjustments are built into Cadna A and were used in this study.

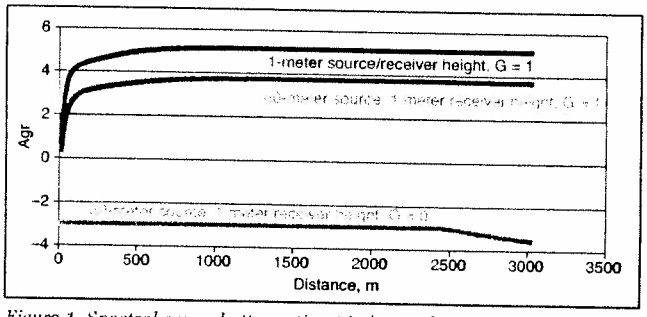


Figure 1. Spectral ground attenuation (A_{gr}) over distance for an 80-m and 1-m-high source; 1-m-high receiver and ground factor set to 1 (soft) and 0 (hard).

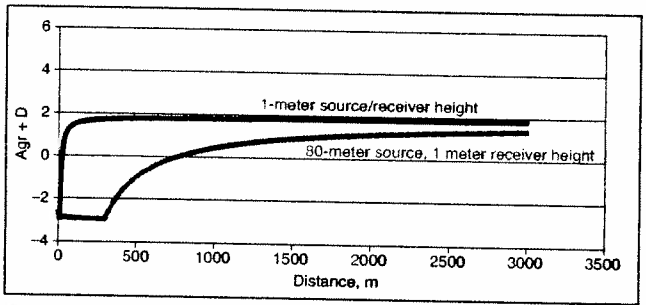


Figure 2. Nonspectral ground attenuation (A_{gr}) over distance for an 80-m and-1 m source and 1-m receiver height. Nonspectral ground attenuation is not a function of ground hardness.

Figure 3. Rural 100-MW wind farm used to study ground attenuation and meteorological modeling factors.

Wind Farm Background

The wind farm in this study is situated on nearly 8 square miles of flat farm land. There are a total of 67 wind turbines that are capable of producing about 100 megawatts of electricity. Each turbine hub is 80 m tall, and the rotation path of the three blades is 80 m in diameter. The turbines are roughly 1,000 ft apart, but there is a wide variation for individual pairs. An image of the terrain and some of the turbines is shown in Figure 3, and Figure 4 shows the layout of the wind farm.

Sound Monitoring

Two sound level meters were set up at 120 m and 610 m from the northern edge of the wind farm. Each sound level meter was an IEC Type I Cesva SC310 fitted with windscreens. The sound level meter at 120 m was placed flat on a 1-m-square ground board,

Based on a paper presented at Noise-Con 2007, Institute of Noise Control Engineering, Reno, NV, October, 2007.

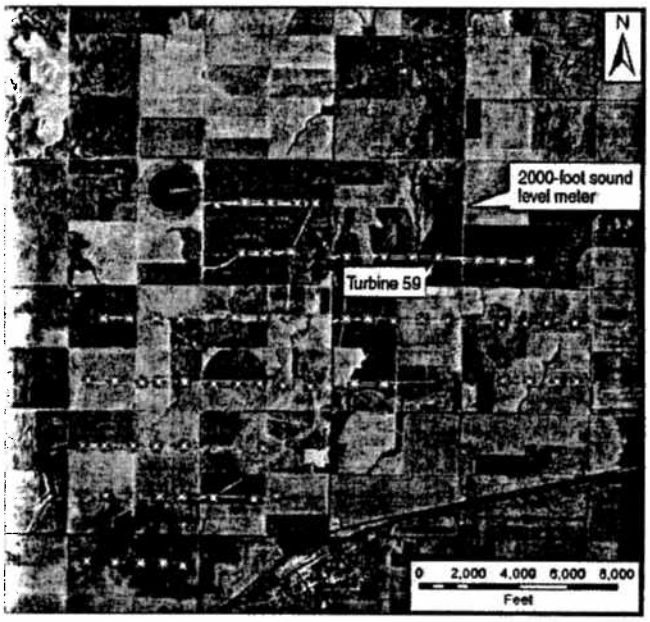


Figure 4. Map of wind farm used for study ; asterisks = wind turbines.

while the meter at 610 m was mounted on a stake at approximately 1 m off the ground.

The measurement period was at night from approximately 10 p.m. to 10 a.m. Each meter logged 1-minute equivalent average sound levels in 1/3-octave bands. In addition, recordings of WAV files were made at certain points.

At the same time, spot measurements of wind speed and direction at hub height, blade rotational frequency, and energy output for each wind turbine were made at 10-minute intervals.

Since we could not obtain background sound levels, we assumed that much of the localized noise from wind passing through the surrounding wheat field would be at and above 2,000 Hz. This was confirmed by listening to and analyzing the WAV file recordings. Therefore, to isolate the wind turbine sound, we created a virtual low-pass filter eliminating sound at frequencies above 2 kHz. In addition, assuming that the wind turbines operated within a narrow range of sound power over any one 10-minute period, we used the 90th-percentile, 1-minute equivalent average sound level for each 10-minute period for comparison to modeled results. This minimized the localized effects of noise from wind gusts.

Sound Monitoring

The Cadna A sound propagation model made by Datakustik GmbH was used to model sound levels from the wind farm. Cadna A can use several standards of modeling, including ISO 9613 with or without CONCAWE meteorological adjustments.

A model run was conducted for every 10-minute period of turbine operation during the monitoring period. This was done by running Cadna A for the following scenarios:

- Standard meteorology with spectral ground attenuation and G=1.
- Standard meteorology with spectral ground attenuation and G=0.
- Standard meteorology with nonspectral ground attenuation.
- Standard meteorology with no ground attenuation.
- CONCAWE adjustments for D/E stability with winds from the south at greater than 3 m/s and spectral ground attenuation, assuming G=1.
- CONCAWE adjustments for D/E stability with winds from the south at greater than 3 m/s and nonspectral ground attenuation.
- CONCAWE adjustments for D/E stability with winds from the south at greater than 3 m/s and no ground attenuation.

For each scenario, a "protocol" was run that listed the ISO 9613-2 attenuation and propagation factors by frequency between each turbine and receivers at 120 m and 610 m from the northern end of the wind farm; that is, the receivers represented by the sound

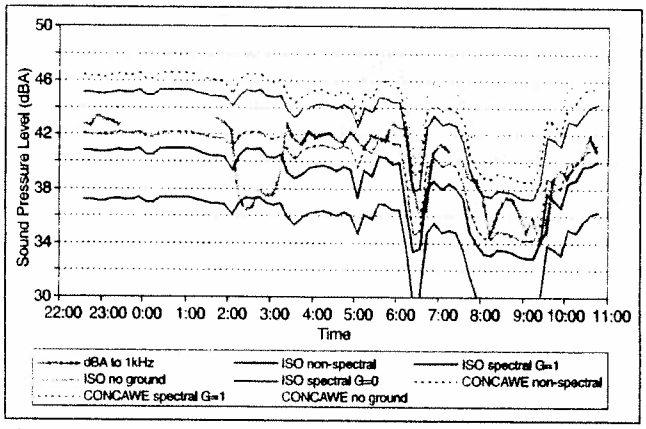


Figure 5. Comparison of monitored sound levels over time at 610 m (shown in orange) with modeled sound levels under various combinations of ground attenuation and meteorological factors.

monitoring locations. These attenuation factors were then put into a spreadsheet model that looked up the manufacturer sound power level for each turbine for each 10-minute period based on actual measured wind speeds at each turbine. The spreadsheet model then calculated the sound level from each turbine by subtracting the attenuation factors from the sound power levels and then combining each turbine to get an overall sound pressure level at the 610-m receiver.

Results

A comparison of the modeled results to monitored sound levels over time is shown in Figure 5. The orange line toward the middle is the actual monitored sound levels. As shown, these monitored levels ranged from about 34 dBA to 43 dBA. Except for the period between 2:00 and 3:00 a.m., the sound levels were highly correlated with wind speed.

We conducted further regression analyses to determine which method achieved the best fit to the modeled data. The results are shown in Figures 6 and 7. Starting with Figure 6a, we found that the CONCAWE meteorology combined with spectral ground attenuation had a coefficient close to 1.0 and, on average, underestimated sound levels by only 1%. The CONCAWE meteorology along with the nonspectral ground attenuation consistently overestimated monitored sound levels. The ISO meteorology with nonspectral ground attenuation yielded a good fit. The coefficient of 0.957 indicates that average modeled levels underestimated monitored levels by about 4%. On the opposite end of the scale, the ISO meteorology along with spectral ground attenuation and G=1 significantly underestimated modeled sound levels by an average of 13%.

Starting with Figure 7a, the CONCAWE meteorology with no ground attenuation overestimated monitored sound levels by approximately 13%, while the ISO meteorology with no ground attenuation provided the best fit of all the runs, with a coefficient of 0.9924. Finally, the ISO meteorology with spectral ground attenuation and G=0 yields moderately accurate results but overestimates by approximately 3%. All trend lines were statistically significant with probabilities greater than 99%.

Discussion and Conclusions

The results of the study indicate the modeling of wind turbines in flat and relatively porous terrain may yield results that underestimate actual sound levels when using the standard ISO 9613-2 algorithms with spectral ground attenuation and G=1. We found that the best fit between modeled and monitored sound levels for this case occurs when using ISO meteorology and no ground attenuation. The second-best model fit was with the CONCAWE adjustments for wind direction and speed along with spectral ground attenuation and G=1. Using the ISO methodology with nonspectral ground attenuation also yielded good results.

While the ISO 9613-2 methodology specifically recommends spectral ground attenuation for flat or constant-slope terrain with G=1, in this case, it underestimated the sound levels. This may be due to the height of the hub (80 m) as compared with typical noise

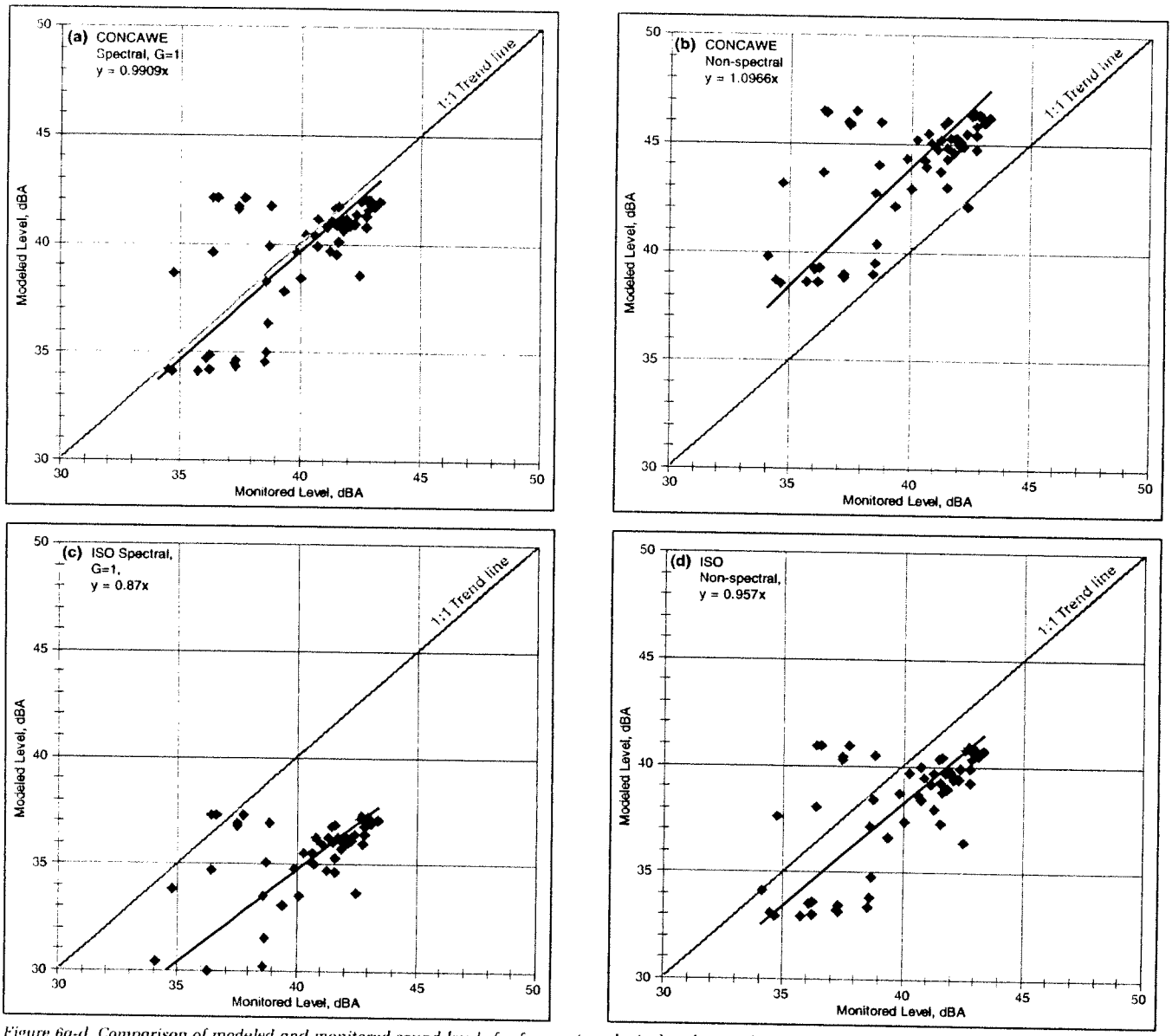


Figure 6a-d. Comparison of modeled and monitored sound levels for four meteorological and ground attenuation combinations. Regression coefficients are shown in the upper left-hand corner. Regression trendline shown in black; 1:1 trendline, indicating a match between monitored and modeled sound levels, is shown in red. N = 60.

sources. That is, the sound waves may not significantly interact with the ground over that distance. It may also be due to the fact that sound from wind turbines comes not from a single point – we assumed a single point at hub height – but is more likely to be similar to a circular area source. Finally, wind turbines often operate with wind speeds that are higher than ISO 9613-2 recommends. The combination of higher wind speeds and an elevated noise source may result in greater downward refraction.

To be more representative, a larger dataset should be obtained. Some improvements to the methodology and study would include:

- Improved accounting for background sound levels.
- Measurements of ground impedance so that the ISO 9613-2 G factor can be better estimated.
- Monitoring over a larger range of wind speeds.
- Using ground boards for the measurement microphone to minimize self-induced wind noise.
- Using larger wind screens.
- Measuring at distances greater than 610 m.
- Applying the methodology to other ground types and terrain.

Care should be taken in applying this methodology in other projects that are not similar. Overall, the ISO 9613-2 methodology is appropriate for propagation modeling of wind turbines, but modeling parameters should be adjusted appropriately to account for this source's unique characteristics.

Acknowledgments

We acknowledge gratefully the project sponsor, Iberdrola, its project manager, Krista Jo Gordon, and the wind farm operator, enXco, for funding and cooperation. We also thank all those who attended Noise-Con 2007 and Acoustics '08 who provided valuable feedback on our methodology and many suggestions for further study.

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2. International Standards Organization, "Acoustics – Attenuation of Sound During Propagation Outdoors, Part 1 – General Method of Calculation," ISO 9613-2, 1996.
3. Manning, C. J., The Propagation of Noise from Petroleum and Petrochemical Complexes to Neighboring Communities, Report 4/81, CONCAWE, 1981.
4. "Harmonized Accurate and Reliable Methods for the EU Directive on the Assessment and Management Of Environmental Noise, Final Technical Report," Information Society and Technology Program, European Commission, February 2005.

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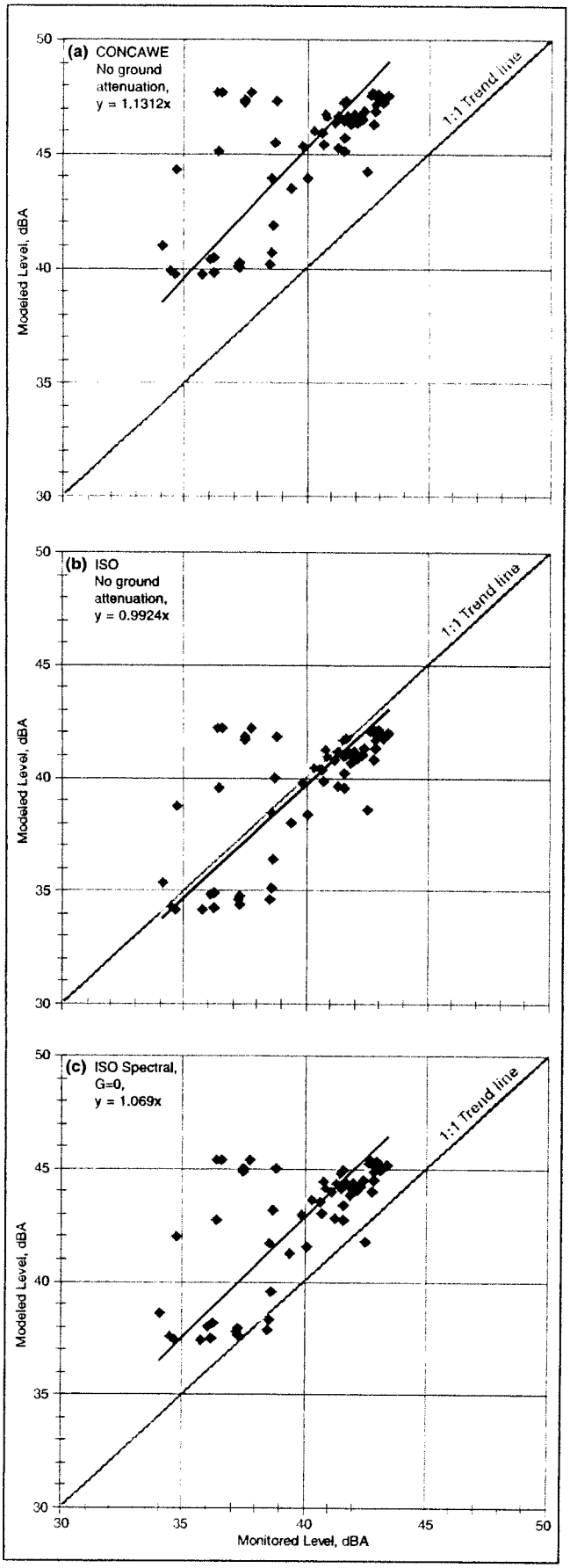

Figure 7a-c. Comparison of modeled and monitored sound levels for three meteorological and ground attenuation combinations. Regression coefficients shown in upper left-hand corner. Regression trend line shown in black; 1:1 trend line, indicating a match between monitored and modeled sound levels, is shown in red. N = 60.

Appendix D:
Oakfield Wind Project Sound Complaint Response and Resolution Protocol
proposed by Evergreen Wind Power II, LLC [“First Wind”]

Oakfield Wind Project Sound Complaint Response and Resolution Protocol

Evergreen Wind Power II, LLC (herein referred to as Evergreen) submitted a sound level study completed by RSE. The sound level study was conducted to model expected sound levels from the proposed Oakfield Wind Project (the "Project") and to compare model results to operation standards pursuant to the Site Location of Development Rules, Chapter 375 §10.

In recognition of the rural nature of the site, the applicant elected to apply quiet limits of the 55 dBA during daytime and 45 dBA at night at all nearby protected locations in accordance with Chapter 375 §10 (H) (3) (1). This is a conservative approach, because ambient sound levels under weather conditions suitable for wind turbine operation can exceed thresholds of 45 dBA daytime and 35 dBA nighttime. Conservative assumptions were also incorporated into the modeling of predicted sound levels from the project. Thus it is expected that sound levels from the operating Project will remain within predicted levels.

As an added measure, Evergreen will implement the following procedure for receiving input and responding to the public, in the event there are concerns regarding compliance with applicable sound level standards during operation of the Project. This procedure is in addition to the compliance testing protocol that will be implemented as part of the DEP Site Location Permit.

The intent of the sound complaint resolution protocol is to:

1. **provide a transparent process for reporting sound complaints to Evergreen;**
2. **provide a consistent approach to documenting complaints and to inform subsequent monitoring efforts; and**
3. **provide a process for informing the Town and DEP of sound complaints.**

Evergreen will provide a contact person and 24 hour "hotline" telephone number for complaints regarding sound from the Project. Contact information along with a copy of this protocol and a "Sound Complaint Record Form" will be mailed to all abutters, consistent with the definition of abutters set forth in Chapter 2 of the Maine DEP regulations, and provided to the Town and DEP.

Residents of Oakfield are encouraged to fill out the Sound Complaint Record Form but they are not required to do so in order to make a complaint on the hotline. The purpose of the form is to ensure that a standardized set of basic information is collected for each complaint in order to facilitate analysis. The following information will be required from the complainant in order to process the form:

- Name and address of complainant
- Date, time and duration or periods of sound event
- Description of sound event—relative amplitude, source of annoyance, steady or fluctuating, low/mid/high or mix of frequencies/pitch, noticeable vibration, indoor or outdoor and specific location
- Description of other audible sounds from sources outside and inside the dwelling of the complainant.

Oakfield Wind Project Sound Complaint Response and Resolution Protocol

Evergreen will complete the Sound Complaint Record Form by providing the following:

- Nearest turbine to complaint location
- Date and time call or form processed
- Power output (kW), wind speed and direction of closest turbines during sound event
- Local/surface weather conditions—cloud cover, precipitation, relative wind speed and direction, temperature, and relative humidity
- Ground conditions – field, wooded, snow, foliage, frozen/icing

A log of complaints will be kept and managed by the operational staff at the Project site. Evergreen will provide a copy of the complaint log to the Town and DEP on a quarterly basis or more frequently upon request by the Town or DEP.

The response to each complaint will depend on each situation, but may include, without limitation, a visit to the location of the complaint; inspection of the operating condition of the turbines closest to the complaint location to evaluate potential upset conditions that might increase sound levels; informal sound monitoring by Evergreen; an informal evaluation of the complaint by Evergreen's sound consultant; or formal sound monitoring. In the event that Evergreen conducts formal sound monitoring at a complaint location, it will notify the Town ahead of time, allow the Town Manager the opportunity to observe, and will provide the results to the Town. In addition, if Evergreen conducts a visit to a complainant or conducts informal sound monitoring at a complaint location, it will undertake best efforts to notify the Town Manager and allow him or her the opportunity to observe. In any event, a Sound Complaint Response Form and Follow-up Record will be completed by Evergreen staff.

Evergreen will use the information collected during the first three months of operation to assist in selecting compliance monitoring locations for testing in accordance with the DEP post-construction sound level compliance assessment plan, as well as timing to ensure monitoring is conducted under weather and operating conditions when sound from the project is most noticeable.

If Evergreen or the DEP determines that there is a consistent pattern of complaints that suggest sound levels from the Project may exceed applicable DEP sound level limits, Evergreen will develop and implement an appropriate protocol for ensuring that the Project continues to meet applicable sound level limits. Evergreen shall take reasonable steps to provide a copy of the protocol to the Town and DEP prior to its implementation, and will provide the results of testing undertaken as part of the protocol to the DEP and the Town. If the Project is not in compliance with the DEP standards, and as set forth in the DEP Site Law permit, Evergreen will submit a revised operation protocol to the DEP and provide a copy to the Town that demonstrates the Project will be in compliance at all the protected locations surrounding the Project.

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Protocol Implementation:

Evergreen Wind will hold an initial public information meeting in conjunction with the Town to explain the complaint response and resolution process, including how to properly file complaints and complete the form(s).

Forms will be mailed to project abutters and will be available at the Town Office and the DEP.

The 24/7 hotline number will be mailed to abutters and posted at the Town Office.

For the first year of operations, Evergreen will hold quarterly meetings in conjunction with the Town to discuss complaints and their resolution. This process can also be used to report the results of compliance testing per the DEP protocol.

Evergreen Wind will develop and schedule in consultation with the DEP compliance testing to occur sometime after commercial operations but during the first year of routine operations so that complainant locations can be incorporated as appropriate.

The proactive and innovative measures identified in this sound complaint response and resolution protocol will facilitate a more complete understanding and evaluation of potential sound complaints and will ensure that those complaints are appropriately addressed. Evergreen invites the public to participate in this process to ensure that the Oakfield Wind Project remains a positive contributor to the community.

Appendix E:
Wetland Impact Maps

PROPOSED SUBSTATION

AREA 5

AREA 4

AREA 3

AREA 2

AREA 1

PROPOSED OPERATIONS AND MAINTENANCE FACILITY

N01 N02 N03 N04 N05 N06 N07 N08 N09 N09alt N10 N11 N12 N13 N14 N15 N16 N17 N18 N19 N20

S01 S02 S03 S04 S05 S06 S07 S08 S09 S09alt S10 S11 S12 S13 S14 S15 S16 S17

Thomas Brook

Long Lake

Clark Pond

Spaulding Lake

Oakfield

Red Bridge

Oakfield Ridge

Oakfield Hills

Sam Drew Mountain

Higgins Brook

Downing Brook

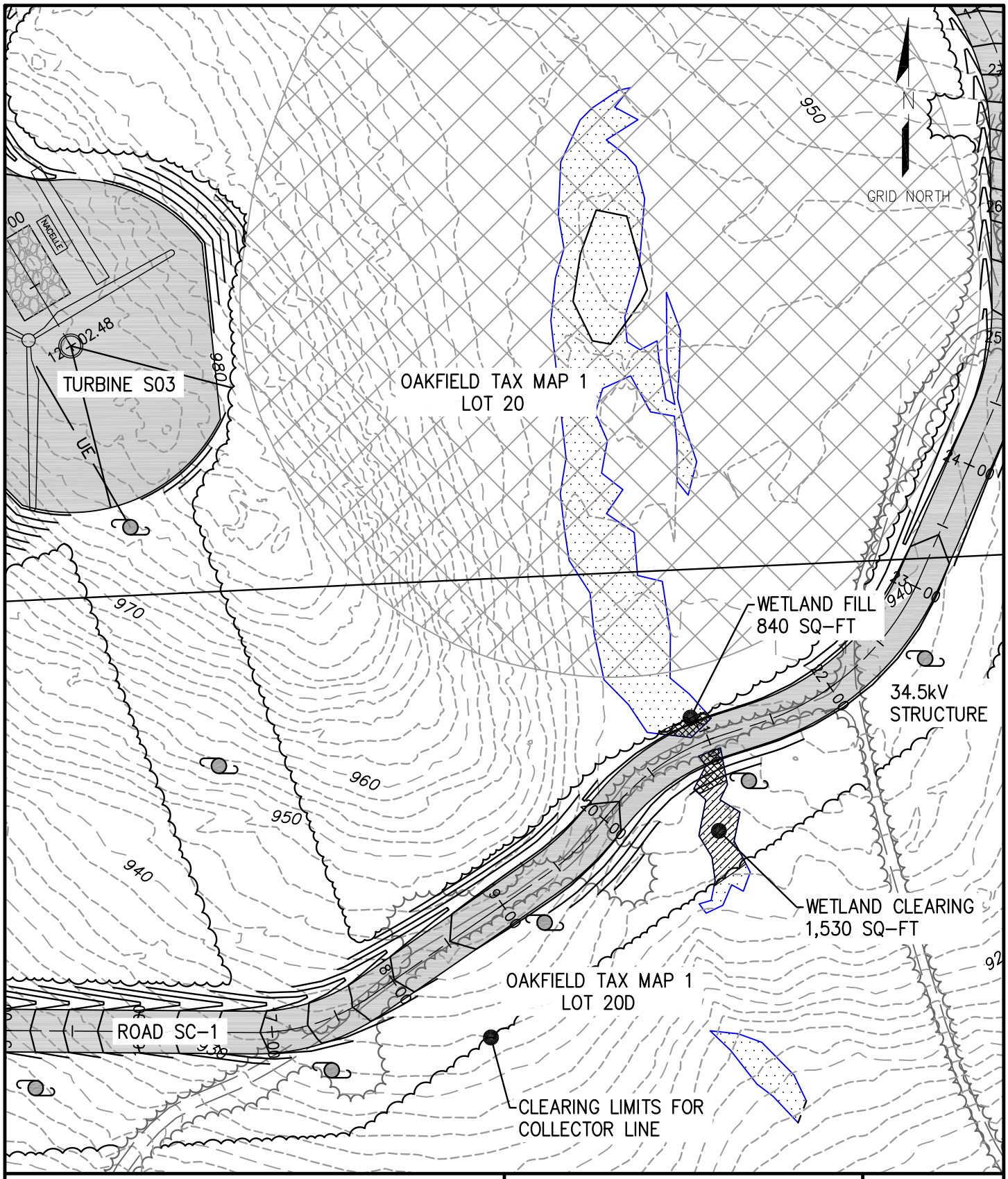
East Branch Mattawamkeag River

0 2,000 Feet

Legend

- Proposed Turbines
- Proposed Access Roads
- Proposed Collector Extension
- Proposed Wetland Impacts
- Delineated Stream
- Delineated Wetland

Prepared By: Stantec	00152_0000_Impact_Location
Project: Oakfield Wind Project, Oakfield, Maine	
Sheet Title: Wetland Impact Key Map	
Date: April 2, 2009	
Scale: 1"=2000'	
Proj. No.: 195600152	
Figure:	



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Fax: 207-866-6501

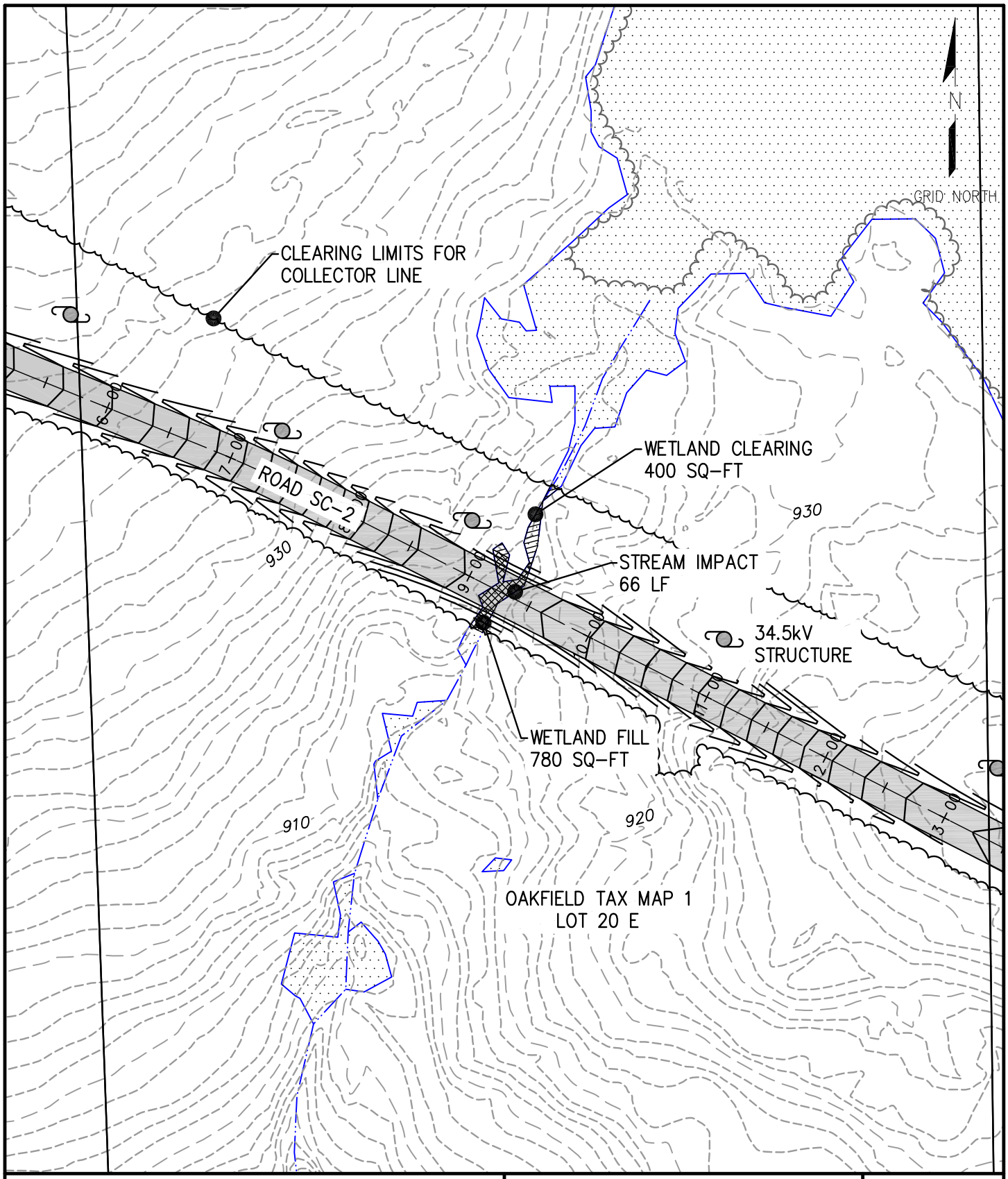
WETLAND IMPACT EXHIBIT
OAKFIELD WIND

AREA 1 OF 5

DATE: 03-31-09

0 100 200

SCALE: 1"=100'



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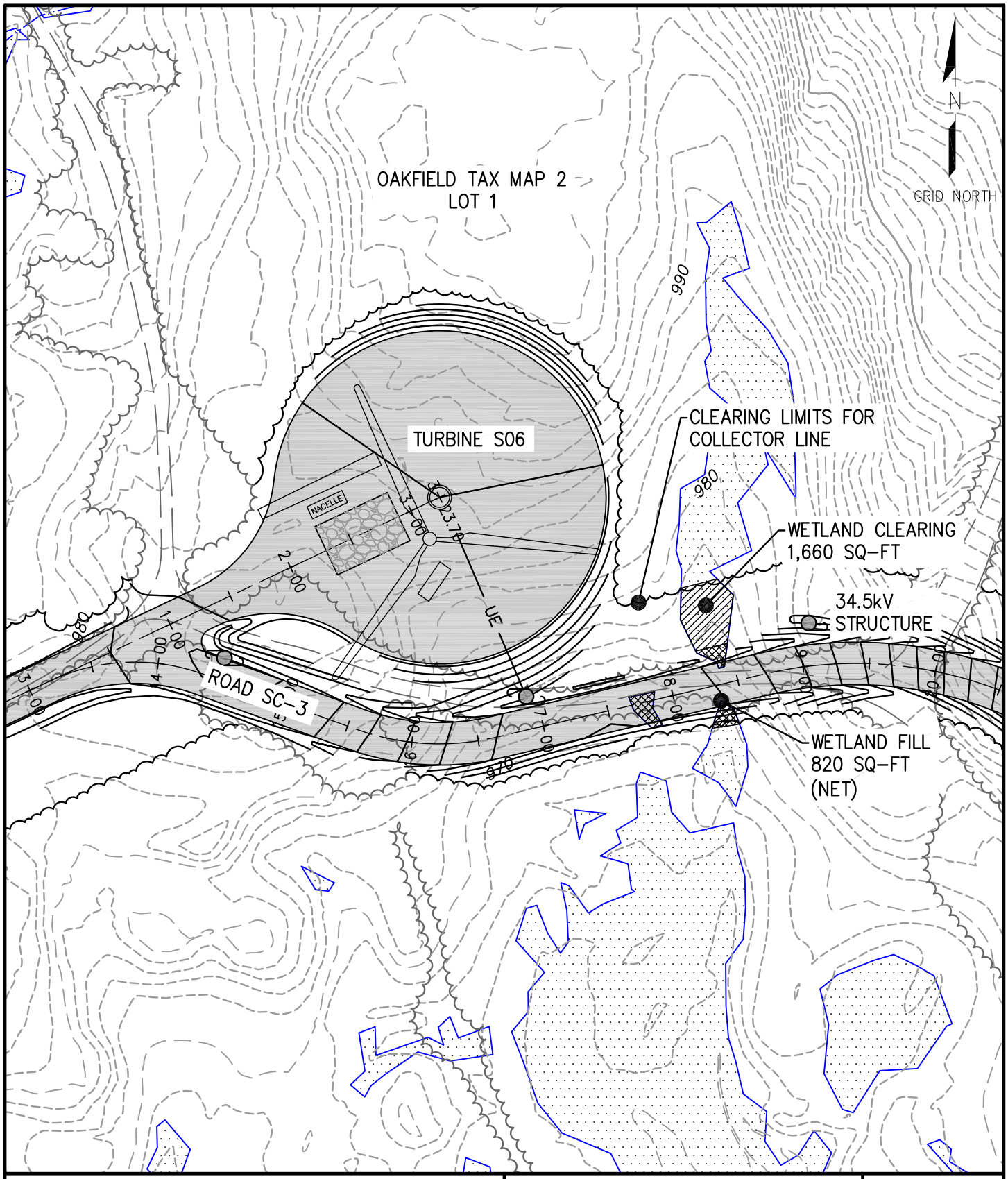
WETLAND IMPACT EXHIBIT
OAKFIELD WIND

AREA 2 OF 5

DATE: 03-31-09

0 100 200

SCALE: 1"=100'



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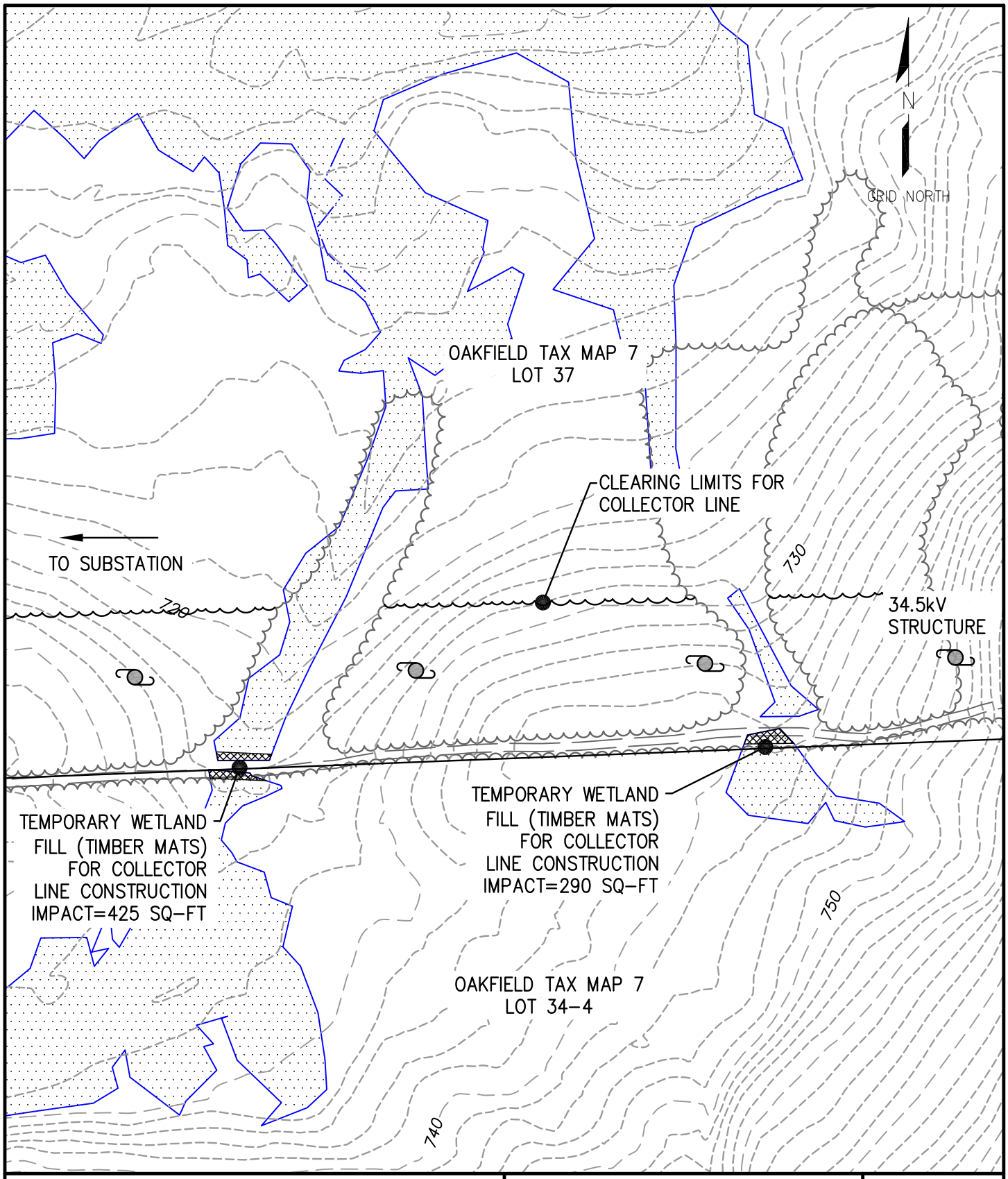
WETLAND IMPACT EXHIBIT
OAKFIELD WIND

AREA 3 OF 5

DATE: 03-31-09

0 100 200

SCALE: 1"=100'



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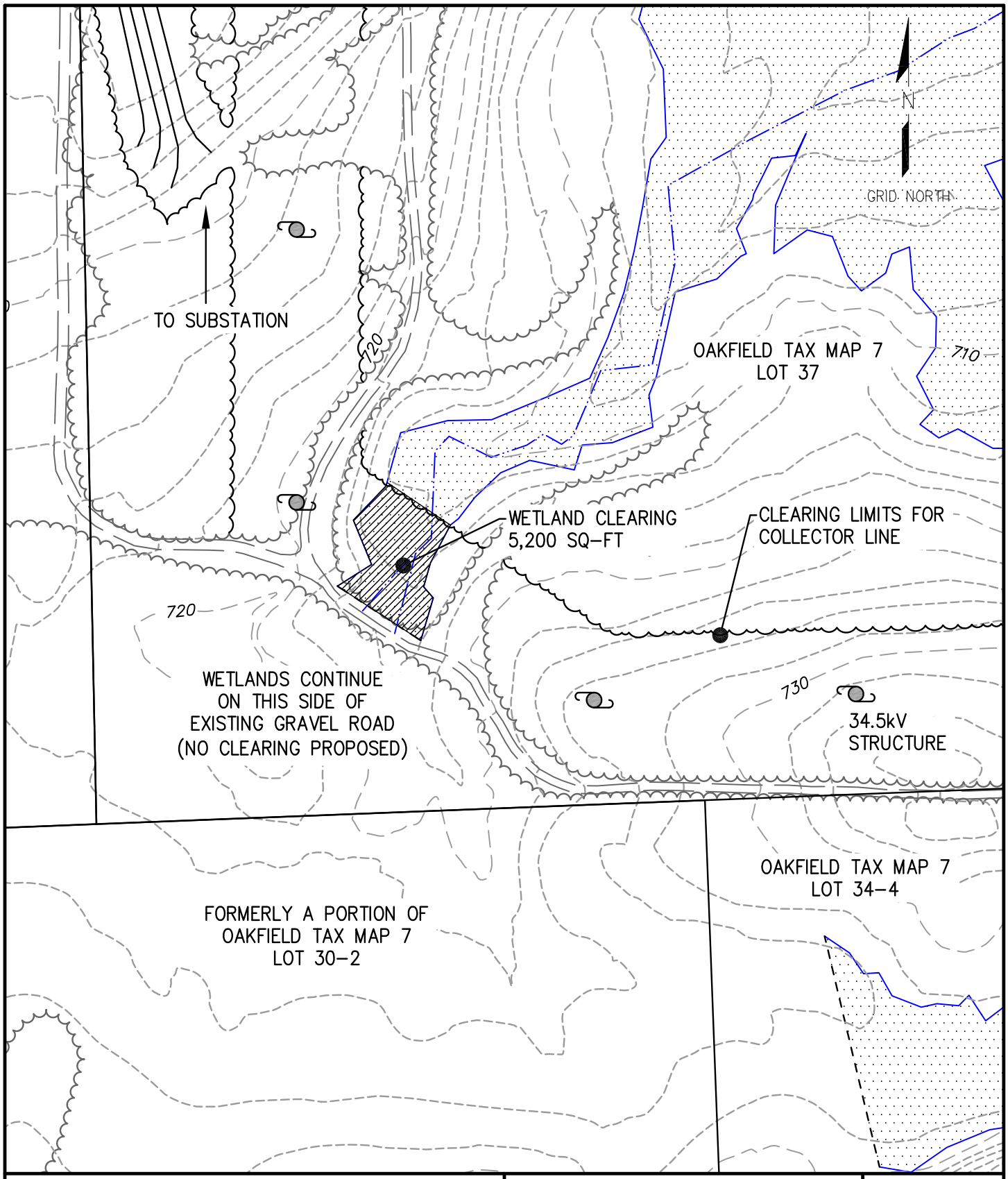
WETLAND IMPACT EXHIBIT
OAKFIELD WIND

AREA 4 OF 5

DATE: 03-31-09

0 100 200

SCALE: 1"=100'



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WETLAND IMPACT EXHIBIT
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AREA 5 OF 5

DATE: 03-31-09

0 100 200

SCALE: 1"=100'

Appendix F:
Draft Location Map of Trails and Proposed
Wind Turbine Sites with Possible Trail Relocations

Oakfield Wind
Project Area Map Draft

N
W E
S

Legend

- Permanent Met Towers
- O&M Building
- Substation Location
- Parcels
- Transmission Line
- Primary Transportation Route
- Potential Transportation Route
- Project Access Roads and Electrical Collector System
- Existing Maine Public Service Electrical Transmission Infrastructure
- 584 Ft. Safety Setback
- Snowmobile Club Trail
- Snowmobile Connector Trail
- Snowmobile ITS 83
- Concept Snowmobile Re-Route

0 1,000 2,000 4,000 6,000 8,000 10,000 Feet

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