

# Ashtabula III Wind Energy Center Acoustic Assessment Barnes County, North Dakota

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Prepared for



Prepared by



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**ACRONYMS AND ABBREVIATIONS**

AGL	above ground level
Applicant	NextEra Energy Resources, LLC
BIL	basic impulse level
BLM	Bureau of Land Management
CadnaA	Computer-Aided Noise Abatement Program
dB	decibel
dba	A-weighted decibel
dB	unweighted decibel
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information System
GE	General Electric
Hz	Hertz
HPD	hearing protection devices
IEC	International Electrotechnical Commission
ISO	Organization for International Standardization
kHz	kilohertz
kV	kilovolt
L <sub>dn</sub>	day-night averaged sound level
L <sub>eq</sub>	equivalent sound level
LFN	low frequency noise
L <sub>max</sub>	maximum sound level
L <sub>p</sub>	sound pressure level
L <sub>w</sub>	sound power level
m/s	meters per second
mph	miles per hour
MVA	megavolt amperes
MW	megawatt
NEMA	National Electrical Manufacturers Association
OSHA	Occupational Safety and Health Administration
PEIS	Programmatic Environmental Impact Statement
Project	Ashtabula III Wind Energy Center
pW	picowatt
Tetra Tech	Tetra Tech EC, Inc.
μPa	microPascal
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
W	watt
WTG	wind turbine generator



## EXECUTIVE SUMMARY

Tetra Tech EC, Inc. (Tetra Tech) has completed the acoustic assessment for the proposed Ashtabula III Wind Energy Center (Project) located in Barnes County, North Dakota. An engineering analysis was developed to address sound levels resulting from wind turbine generator (WTG) operations, as well as the consideration of sound from the electrical substation and sound generated during Project construction and maintenance activities. The overall objectives of this study were to: (1) determine Project sound sources and site-specific sound propagation characteristics incorporating terrain effects; (2) computer simulate WTG sound levels over a range of expected future Project operational and meteorological conditions using internationally accepted calculation standards; and (3) determine the feasibility of the Project to operate in compliance with applicable noise standards and guidelines. A cumulative sound impact assessment of the Project in conjunction with the Ashtabula I and II Wind Energy Centers was also completed.

Wind turbine sound source data was obtained from General Electric (GE), the manufacturer of the GE xle 1.6 megawatt (MW) wind turbine model. Sound propagation modeling was conducted using the Computer-Aided Noise Abatement (CadnaA) software program (version 4.0.136), a comprehensive 3-dimensional acoustic modeling computer simulation software specifically developed for the power generation industry, with calculations made in accordance with the Organization for International Standardization (ISO) 9613-2 “Attenuation of Sound during Propagation Outdoors”. The industry standard CadnaA acoustic modeling software is widely used by sound engineers due to its adaptability to describe complex acoustic scenarios. The results of the acoustic modeling results were compared to U.S. Environmental Protection Agency (EPA) environmental noise guidelines and Occupational Safety and Health Administration (OSHA) regulatory limits for worker exposure and public safety.

The overall conclusions of the acoustic assessment are as follows:

1. Acoustic modeling results show that the Project has been adequately designed, inclusive of a number of conservative model input assumptions, to operate in compliance with EPA noise guidelines at all existing inhabited structures considered to be noise sensitive receptors. The Project will also be constructed and operated in adherence to all applicable OSHA Regulation safety standards. The results of the cumulative sound impact assessment showed that there is the potential for an exceedance at one participating landowner. Further mitigation measures may be warranted to address this potential exceedance condition
2. The proposed turbine model will not produce an audible steady state pure tone or apparent tonal conditions at any existing receptors, as defined per International Electrotechnical Commission (IEC) standards for normal WTG operation.
3. Operation of the Project may result in periodically audible sound at noise sensitive receptors under certain operational and meteorological conditions. Specifically, the Project will be audible at the closest receptors relative to the Project, when background sound levels are low, and wind speeds high enough for WTG operation. Residents outside their houses and with a direct line of sight to an operating WTG may hear a gentle swooshing sound characteristic of wind energy projects. During meteorological conditions favorable to sound propagation and very quiet background ambient sound conditions, WTGs may be periodically audible at more distant receptor locations but will be consistent with recommended guideline limits to avoid the potential for adverse noise impacts on public health and safety.



## 1.0 INTRODUCTION

NextEra Energy Resources, LLC (NextEra; the Applicant) proposes to construct wind energy facility in Barnes County, North Dakota, referred to as the Ashtabula III Wind Energy Center (the Project). The Project consists of a total of 43 1.6 megawatt (MW) GE xle wind turbine generators (WTGs) with a rotor diameter of 271 feet (82.5 meters) and an effective hub height of 262.5 feet (80 meters) above grade. An electrical substation, which transforms the power generated from the WTGs to a higher voltage suitable for the local distribution system, will also be constructed. The acoustic assessment analyzed the total potential Project power production output of approximately 69 MW; however, further analysis was conducted including a cumulative assessment of sound resulting from Project in conjunction with the adjacent Ashtabula I and II Wind Energy Centers, which are both currently operational (see Section 5.1).

In support of environmental permitting efforts, Tetra Tech EC, Inc. (Tetra Tech) was retained to perform the acoustic assessment of several iterative Project layouts. This document presents the findings of the assessment, including calculated future sound levels resulting from Project operation and provides an evaluation of the feasibility of the Project to operate in compliance with applicable noise regulations and guidelines. Sound associated with Project substation, construction and maintenance activities has also been addressed. While construction is required to erect the Project WTGs and supporting electrical substation, no transmission line construction is anticipated in support of this Project.

### 1.1 Project Area

The Ashtabula III Wind Energy Center is located within the Northwestern Great Plains. The landscape includes the western mixed-grass prairie, short-grass prairie, and associated wetlands of the Missouri Slope and River Breaks regions. This semiarid region of North Dakota has topography that can be described as level to rolling plains with isolated sandstone buttes or badlands formations. Native grasslands persist in areas of steep or broken topography, but they have been largely replaced by spring and winter wheat, barley, sunflowers, corn, alfalfa, interspersed with cattle grazing.

The Project is located on privately owned lands in central North Dakota, consists of 31,028 acres (48 square miles) with the city of Valley City located approximately 25 miles south of the property. The Project area is located in the prairie pothole region of North Dakota and the Sheyenne River runs parallel to the west boundary of the Project area. Drainages, overhead power lines, underground power lines, and primary and secondary roads pass through the property. A railroad right-of-way passes through the northeast corner of the property. The Project area is characteristic of the upland portion of this region, with the majority of the land surface currently covered by agriculture and rangelands. Residences and abandoned farmsteads are widely scattered throughout the Project area. Patches of trees and shrubs exist throughout the Project area and are found primarily between agricultural fields, in drainages, and as shelter belts around homesteads.

A total of 142 receptor locations were identified within the designated acoustic study area using data provided by NextEra in the April 9, 2010 Farmstead Report; however, a further review of these data revealed that of those 142, only 103 appear to be existing occupied permanent or seasonal residences. Figure 1 presents the Barnes County acoustic study area, the locations of the proposed WTGs and receptor locations. Though all identified receptors were included in the acoustic modeling analysis, only those considered as noise sensitive receptors were considered for the purposes of the compliance demonstration. Figure 1 presents the land status of the receptor locations incorporated in the Acoustic Assessment.

## 1.2 Existing Acoustic Environment

Barnes County would generally be characterized as a rural agricultural land use area. Existing ambient sound levels are expected to be relatively low, although sound levels may be sporadically elevated in localized areas due to roadway noise or periods of human activity. Background sound levels will vary both spatially and temporally depending on proximity to area sound sources, roadways and natural sounds. Principal contributors to the existing acoustic environment likely include motor vehicle traffic, mobile farming equipment, farming activities such as plowing and irrigation, all-terrain vehicles, local roadways, periodic aircraft flyovers, and natural sounds such as birds, insects, and leaf or vegetation rustle during elevated wind conditions in areas with established tree stands or established crops. Diurnal effects result in sound levels that are typically quieter during the night than during the daytime, except during periods when evening and nighttime insect noise may dominate the soundscape, in warmer seasons.

In areas with elevated background sound levels, sound may be obscured through a mechanism referred to as acoustic masking. Seasonal effects such as cricket chirping, certain farming activities, as well as wind-generated ambient noise as ground level airflow interacts with foliage and cropland, contribute to this masking effect. The latter is most prevalent in rural and suburban areas with established tree stands. Wintertime defoliate conditions typically have lower background sound levels due to lower wind masking effects and reduced outdoor activities in colder climates. During colder seasons, people typically exhibit lower sensitivities to outdoor sound levels, particularly in this geographical region of the United States, as windows are closed further enhancing outdoor to indoor transmission losses, and increasingly limited amount of time is spent outdoors.

## 1.3 Acoustic Terminology

All sounds originate with a source whether it is a human voice, motor vehicles on a roadway, or a wind turbine generator. Sound energy propagates through a medium where it is sensed and then interpreted by a receiver. A sound source is defined by a sound power level ( $L_w$ ), which is independent of any external factors. By definition, sound power is the rate at which acoustical energy is radiated outward and is expressed in units of watts (W). Sound energy travels in the form of a wave, a rapid fluctuation or oscillation of air pressure above and below atmospheric pressure. A sound pressure level ( $L_p$ ) is a measure of this fluctuation at a given receiver location and can be obtained through the use of a microphone or calculated from information about the source sound power level and the surrounding environment. Sound power, however, cannot be measured directly. It is calculated from measurements of sound intensity or sound pressure at a given distance from the source.

Sound levels are described on a logarithmic scale to account for the large range of pressure that the human ear can perceive, and is expressed in units of decibels (dB). A decibel is defined as the ratio between a measured value and a reference value usually corresponding to the lower threshold of human hearing defined as 20 micropascals ( $\mu\text{Pa}$ ). Conversely, sound power is referenced to 1 picowatt (pW). Since the human ear does not perceive every frequency with equal loudness, spectrally complex sounds are often adjusted with a weighting filter. The A-weighted filter is applied to compensate for the frequency response of the human auditory system and sound exposure in acoustic assessments is commonly reported in A-weighted decibels (dBA).

An inherent property of the logarithmic decibel scale is that the sound pressure levels of two separate sources are not directly additive. For example, if a sound of 50 dBA is added to another sound of 50 dBA,

the result is a 3-decibel increase (or 53 dBA), not an arithmetic doubling of 100 dBA. The human ear does not sense changes in the sound pressure level as equal changes in perceived loudness. Scientific research demonstrates that the following general relationships hold between sound level and human perception for two broadband sound levels with the same or similar frequency characteristics:

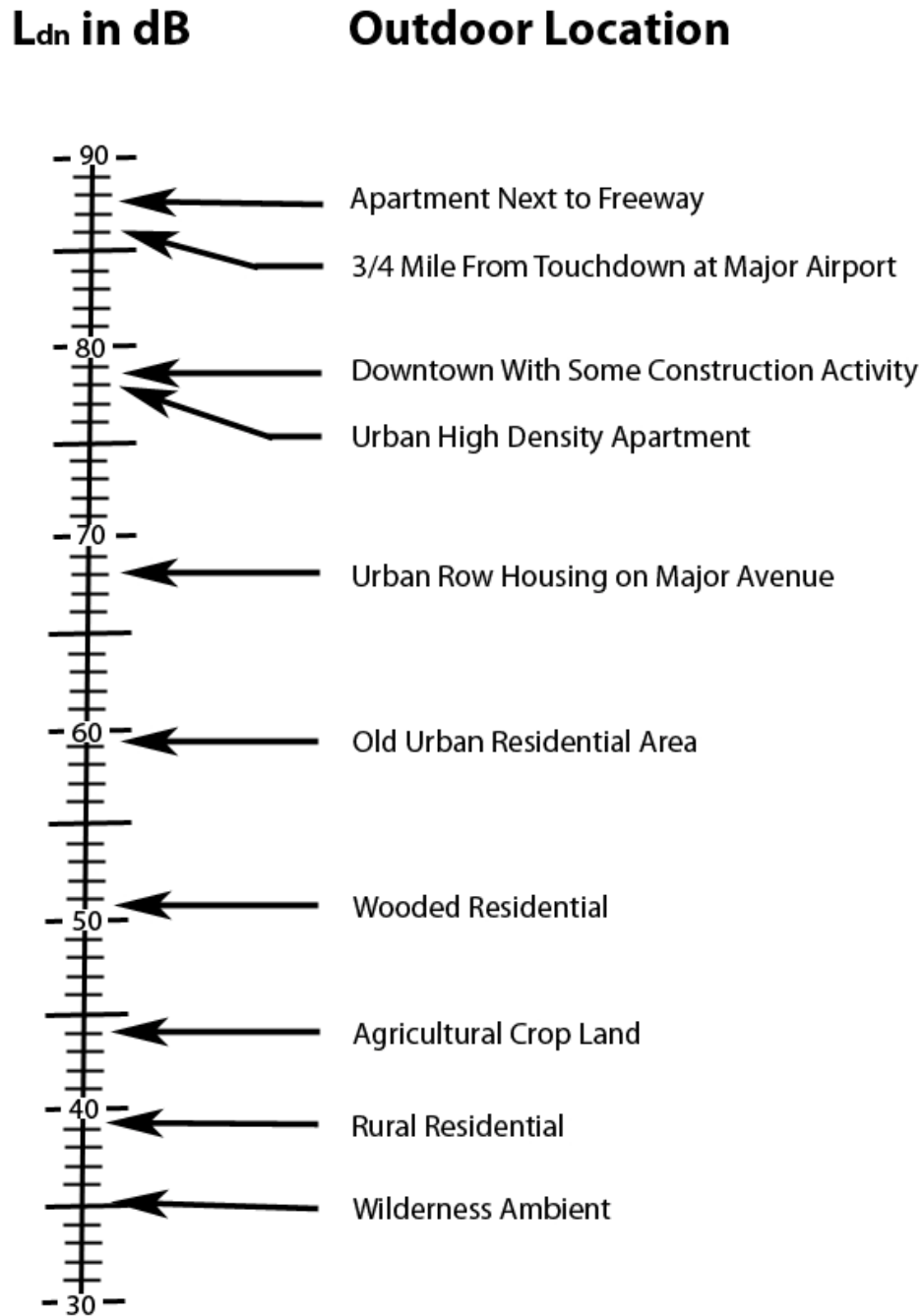
- 1 dBA is the practically achievable limit of the accuracy of sound measurement systems and corresponds to an approximate 10 percent variation in sound pressure. A 1 dBA increase or decrease is a non-perceptible change in sound.
- 3 dBA increase or decrease is a doubling (or halving) of acoustic energy and it corresponds to the threshold of perceptibility of change in a laboratory environment. In practice, the average person is not able to distinguish a 3 dBA difference in environmental sound outdoors.
- 5 dBA increase or decrease is described as a perceptible change in sound level and is a discernable change in an outdoor environment.
- 10 dBA increase or decrease is a tenfold increase or decrease in acoustic energy but is perceived as a doubling or halving in sound (i.e., the average person will judge a 10 dBA change in sound level to be twice or half as loud).

While the concept of sound is defined by the laws of physics, the term ‘noise’ has further qualities of being excessive or loud. The perception of sound as noise is influenced by technical factors as intensity, sound quality, tonality, duration, and the existing background levels. The effects of noise on people can be classified into three general categories: (1) subjective responses such as annoyance, nuisance, and dissatisfaction; (2) activity interference, e.g., speech, sleep, and learning; and (3) physiological effects such as anxiety or hearing loss. According to the United States Department of the Interior Bureau of Land Management (BLM), “Final Programmatic Environmental Impact Statement on Wind Energy Development on BLM-Administered Lands in the Western United States,” the sound levels associated with environmental noise have been found to generally produce effects only in the first two categories. At typically employed wind turbine setback distances, the comparatively low level sound generated by wind energy projects are expected to similarly fall principally within the subjective category, dependant on both technical and non-technical factors.

Sound can be measured, modeled, and presented in various formats, with the most common metric being the equivalent sound level ( $L_{eq}$ ). The equivalent sound level has been shown to provide both an effective and uniform method for comparing time-varying sound levels and is widely used in acoustic assessments of wind energy projects. Community sound levels are also often described in terms of the day-night averaged sound level ( $L_{dn}$ ), which accounts for the increased potential for annoyance that comes with elevated sound levels at night. In addition, the maximum sound level ( $L_{max}$ ) can be used to quantify the maximum instantaneous sound pressure level generated by a source and is often used in establishing regulatory noise limits. Broadband sound includes sound energy summed across the frequency spectrum. In addition to broadband sound pressure levels, data may also include the analysis of the various frequency components of the sound spectrum to determine tonal characteristics. The unit of frequency is Hertz (Hz), measuring the cycles per second of the sound pressure waves, and typically the frequency analysis examines 11 octave (or 33 1/3 octave) bands ranging from 16 Hz (low) to 16,000 Hz (high), encompassing the entire human audible frequency range.

The EPA estimates of various outdoor sound pressure levels and acoustic environments are presented in the day-night averaged sound level ( $L_{dn}$ ) in Table 1. Table 2 presents additional reference information on terminology used in the acoustic assessment.

**Table 1. Various Outdoor Sound Pressure ( $L_p$ ) Levels**



**Notes:**

$\mu$ Pa - Micropascals describe sound pressure levels (force/area).

dBA - A-weighted decibels describe sound pressure on a logarithmic scale referenced to 20  $\mu$ Pa.

Reference: USEPA, Protective Noise Levels. Condensed Version of EPA Levels Document. Publication EPA-550/9-79-100, November 1978.

**Table 2. Acoustic Terms and Definitions**

<b>Term</b>	<b>Definition</b>
Noise	Unwanted sound dependant on level, character, frequency or pitch, time of day, and sensitivity and perception of the listener. This word adds the subjective response of humans to the physical phenomenon of sound. Its use is limited to when negative effects on people are known to occur.
Sound Pressure Level (L <sub>p</sub> )	Pressure fluctuations in a medium. Sound pressure is measured in decibels referenced to 20 micropascals, the approximate threshold of human perception to sound at 1000 Hz.
Sound Power Level (L <sub>w</sub> )	<p>Sound power level is not the equivalent to a sound pressure level. While both are reported in decibels, the L<sub>w</sub> a noise source measured in decibels referenced to 10<sup>-12</sup> watts. Sound power is independent of the environment, for this reason wind turbine manufacturer noise specifications are provided in these terms.</p> <p>A sound power level is a function of both the sound pressure level produced by a source with distance and the effective radiating area or physical size of the source. In general, the ostensible magnitude of a sound power level is always considerably higher than the received sound pressure level near a source because of the area term, which for a wind turbine is effectively the entire rotor swept area.</p>
Frequency (Hz)	<p>The rate of oscillation of a sound, measured in units of Hertz (Hz) or kilohertz (kHz). One hundred Hz is a rate of one hundred times per second. The frequency of a sound is the property perceived as pitch: a low-frequency sound (such as a bass note) oscillates at a relatively slow rate, and a high-frequency sound (such as a treble note) oscillates at a relatively high rate. For comparative purposes, the lowest note on a full range piano is approximately 32 Hz and middle C is 261 Hz.</p>
A-Weighted Decibel (dBA)	Environmental sound is typically composed of acoustic energy across all frequencies (Hz). To compensate for the auditory frequency response of the human ear, an A-weighting filter is commonly used for describing environmental sound levels. Sound levels that are A-weighted are presented as dBA in this report.
Propagation and Attenuation	Propagation is the decrease in amplitude of an acoustic signal due to geometric spreading losses with increased distance from the source. Additional sound attenuation factors include air absorption, terrain effects, sound interaction with the ground, diffraction of sound around objects and topographical features, foliage, and meteorological conditions including wind velocity, temperature, humidity and atmospheric conditions.
Octave Bands	The audible range of humans spans from 20 to 20,000 Hertz and is typically divided into octave band center frequencies (Hz) ranging from 31 to 8,000 Hz.
Broadband Sound	Noise which covers a wide range of frequencies within the audible spectrum, i.e. 200 to 2000 Hz.
Masking	Interference in the perception of one sound by the presence of another sound. At elevated wind speeds, leaf rustle and noise made by the wind itself can mask wind turbine sound levels, which remain relatively constant.
Low Frequency Noise (LFN)	The frequency range of 20 to 200 Hz is typically defined as low frequency noise. At sufficiently high levels, low frequency noise can cause vibrations in structures and physiological effects in humans. Low frequency noise is generally associated with older wind turbines that have downwind rotor configurations.
Infrasound	The frequency range of infrasound is normally defined as below 20 Hz. Infrasound from wind turbines are significantly below recognized thresholds for both human perceptibility and standardized health.

Note: Compiled by Tetra Tech from multiple technical and engineering resources.

## 2.0 NOISE REGULATIONS AND GUIDELINES

This section presents information on the criteria used to evaluate the effects of noise from the Project. With the exception of the EPA environmental noise guidelines and the United States Occupational Health and Safety Administration's (OSHA) regulations that describe health and safety limits for noise exposure, there are no overarching state, county, or federal noise requirements specific to this Project or wind energy facilities in the state of North Dakota. Barnes County does not have an ordinance with numerical decibel limits.

### 2.1 Environmental Protection Agency Environmental Noise Guidelines

While the EPA has no regulation governing environmental noise, the agency has conducted several extensive studies to identify the effects of sound level on public health and welfare. In 1974, the EPA published a landmark document entitled "Information on Levels of Environmental Noise Requisite to Protect the Public Health and Welfare with an Adequate Margin of Safety." This publication remains the authoritative study based on a large sampling of community reaction to noise. The EPA sound level guidelines do not provide an absolute measure of noise impact, but rather a consensus on potential activity interference, human health and welfare effects, and annoyance. For outdoor residential areas, the recommended EPA guideline is an  $L_{dn}$  of 55 dBA (equivalent to an  $L_{eq}$  (1-hour) of 48.6 dBA assuming continuous 24-hour operation). The EPA sound level guidelines also suggest an  $L_{eq}$  of 70 dBA (24-hour) limit to avoid adverse effects on health and safety at publicly accessible property lines or work areas. Since these protective levels were derived without concern for technical or economic feasibility, and contain a margin of safety to ensure their protective value, they must not be viewed as standards, criteria, regulations, or goals. Rather, they should be viewed as levels below which there is no reason to suspect that the general population will be at risk from any of the identified effects of noise. The EPA criteria limits are summarized in Table 3.

**Table 3. Summary of EPA Cause and Effect Noise Levels**

Location	Level	Effect
All public accessible areas with prolonged exposure	70 dBA $L_{eq(24)}$	Safety / hearing loss concerns
Outdoor at residential structure and other noise sensitive receptors where a large amount of time is spent	55 dBA $L_{dn}$	
Outdoor areas where limited amounts of time are spent, e.g., park areas, school yards, golf courses, etc.	55 dBA $L_{eq(24)}$	Protection against annoyance and activity interference
Indoor residential	45 dBA $L_{dn}$	
Indoor non-residential	55 dBA $L_{eq(24)}$	

The EPA sound level guidelines state that the levels identified are low enough to be protective with an adequate margin of safety. The EPA sound level guidelines do not impose arbitrary federal decisions about the appropriateness of noise environments upon any level of government, nor are they a source of instructions for solving local noise problems, but best viewed as a technical aid for local decision makers who seek to balance scientific information about effects of noise on people, and to reconcile local economic and political realities such as cost and technical feasibility. The relationship between physical acoustic relationships and human response is not linear and depends on factors and cannot be precisely predicted. In any environment, a small portion of the general population may be somewhat annoyed depending on the person's subjective response due to the presence of any level of recurring audible sound, regardless of the actual or perceived loudness.

## 2.2 Bureau of Land Management Guidance

In June 2005, the United States Department of the Interior Bureau of Land Management (BLM) published the Final Programmatic Environmental Impact Statement (PEIS) to address the potential impacts of wind energy projects on BLM Lands in the Western United States. One of the issues identified was the siting of wind energy projects in areas that do not have applicable noise standards. Section 4.5.4 of that document states, “The EPA guideline recommends an  $L_{dn}$  of 55 dBA to protect the public from the effects of broadband environmental noise in typically quiet outdoor and residential areas. The EPA limit is not a regulatory limit but “intentionally conservative to protect the most sensitive portion of the American population” with “an additional margin of safety”. The BLM PEIS findings are not directly applicable to the Ashtabula III Wind Energy Center as it will be entirely sited on private land; however, the BLM restatement of the EPA guideline provides insight on how one governmental agency is addressing the potential for noise impacts produced by wind energy projects in areas with no state or local noise regulation.

## 2.3 Occupational Safety and Health Administration Noise Safety Standards

The federal government has long recognized the potential hazards caused by noise to work health and safety. Onsite noise levels are regulated by the Occupational Safety and Health of 1970 (29 Code of Federal Regulations [CFR] 1910.95). This regulation establishes standards for permissible noise exposure in the workplace to guard against the risk of hearing loss. The standards shown in Table 4 establish a sliding scale of permissible noise levels by duration of exposure. The exposure level is raised 5 dB for every halving of exposure duration. OSHA permits noise levels up to 90 dBA, over a time-weighted average eight-hour shift ( $TWA_{8-hr}$ ), measured on the A-scale of a sound level meter set at slow response. If there are workers exposed to a  $TWA_{8-hr}$  above 85 dBA, then the regulations call for a worker hearing protection program that includes baseline and periodic hearing testing, availability of hearing protection devices, and training in hearing damage protection.

When employees are subjected to noise doses exceeding those shown in Table 4, feasible administrative or engineering controls will be identified and implemented to lower employee noise exposure. If controls fail to reduce sound to these acceptable levels, personal protective equipment must be provided and used to reduce noise exposure. In compliance with OSHA, Project contractors will be required to readily provide construction workers with OSHA-approved hearing protection devices (HPD) and to identify high noise areas and activities where hearing protection Operational sound generated from the Project will not approach OSHA noise exposure limits even in very close proximity to individual WTG locations.

## 2.4 Summary of Acoustic Criteria

A summary of the pertinent acoustic criteria used to assess sound levels at existing receptors during Project operation is provided below:

- EPA 70 dBA  $L_{eq}$  (24) at publicly accessible project property lines or extents of work areas where extended public exposure is possible;

**Table 4. OSHA Permissible Daily Noise Exposure Limits**

Duration of Exposure Per Day (Hours)	Sound Level (dBA)
8	90
6	92
4	95
3	97
2	100
1 ½	102
1	105
½	110
¼ or less	115

- EPA 55 dBA  $L_{eq(24)}$  in outdoor areas where limited time is spent;
- 55 dBA  $L_{dn(24)}$  outdoors at all residential receptor locations where extended periods of time are spent outdoors, residential structures and areas in close proximity to the residential structure, e.g., yards. Wind turbines operate intermittently depending on wind conditions at hub height. Assuming the wind turbine is operating as a continuous steady state sound source and is the dominant contributor of environmental sound level at the receiver location, the  $L_{dn}$  is approximately 6.4 dB above the measured  $L_{eq}$ . Consequently, an  $L_{dn}$  of 55 dBA corresponds to a maximum instantaneous  $L_{eq}$  of 48.6 dBA; and
- OSHA regulatory limits for the protection of worker exposure and public safety.

The application of the EPA noise guidelines is a common noise assessment compliance approach and used to ensure adequate protection of human health and welfare. While the EPA criteria limits cannot be used to infer audibility thresholds, compliance with EPA guidelines would likely result in the reduced probability of dissatisfaction. Inaudibility under all operating conditions is an unrealistic expectation, and one that is not required under any other industrial, commercial, or agricultural activity in the state of North Dakota. OSHA noise safety standards are mandatory requirements at all times. Guideline limits identified are absolute and independent of the existing acoustic environment; therefore, no baseline sound survey is required to assess conformity.

### 3.0 ACOUSTIC MODELING METHODOLOGY

With the construction of wind energy projects in North Dakota and throughout the United States, a better understanding of the generation, propagation and attenuation of WTG sound in the natural environment has been gained. While sound generated by an operating WTG is comprised of both aerodynamic and mechanical sound, the dominant sound component from utility scale WTGs is largely aerodynamic. Aerodynamic sound refers to the sound produced from air flow and its interaction with the WTG's tower structure and rotor blades when they're in motion. Mechanical sound is generated at the gearbox, generator, and cooling fan, and is radiated from the surfaces of the nacelle and machinery enclosure and by openings in the nacelle casing. Due to the improved design of WTG mechanical components and the use of improved noise damping materials within the nacelle, including elastomeric elements supporting the generator and gearbox, mechanical noise emissions have been further minimized. The GE 1.6 MW xle WTG is an upwind variable speed-type wind turbine with an active yaw and pitch regulated with power/torque control capability and an asynchronous generator. Sound reduction elements designed into the GE 1.6 MW xle include impact noise insulation of the gearbox and generator, sound reduced gearbox, noise reduced nacelle, and rotor blades with minimized noise level.

Wind energy projects, in comparison to conventional energy projects, are somewhat unique in that the sound generated by each individual WTG will increase as the wind speed across the site increases, up to a certain maximum sound level under elevated wind conditions (i.e., greater than approximately 9 meters per second [m/s]) per manufacturer's specifications. Wind turbine sound is negligible when the rotor is at rest, increases as the rotor tip speed increases, and is generally constant once rated power output and full rotational speed is achieved. As an offset, as wind speeds increase, the background ambient sound levels likely will continue to increase, resulting in acoustic masking effects.

#### 3.1 Acoustic Modeling Software and Calculation Methods

The operational acoustic assessment was performed using the Project design layout dated May 13, 2010. The acoustic modeling analysis employed the most recent version of DataKustic GmbH's CadnaA, the computer-aided noise abatement program (v 4.0.136). CadnaA is a comprehensive 3-dimensional acoustic software model that conforms to the Organization for International Standardization (ISO) standard ISO 9613-2 "Attenuation of Sound during Propagation Outdoors." The engineering methods specified in this standard consist of 1/1 octave band algorithms that incorporate the following:

- Geometric spreading wave divergence
- Reflection from surfaces
- Atmospheric absorption
- Screening by topography and obstacles
- Terrain complexity and ground effects
- Source directivity factors
- Height of both sources and receptors
- Seasonal foliage effects
- Meteorological conditions including the effects of wind and atmospheric inversions

Topographical information was imported into the acoustic model using the official United States Geological Survey (USGS) digital elevation dataset to accurately represent terrain in three dimensions. Terrain conditions, vegetation type, ground cover, and the density and height of foliage can also influence the absorption that takes place when sound waves travel over land. The ISO 9613-2 standard accounts for

ground absorption rates by assigning a numerical coefficient of 0 for acoustically hard, reflective surfaces and 1 for absorptive surfaces and soft ground. If the ground is hard-packed dirt, typically found in industrial complexes, pavement, or for sound traveling over bodies of water, the absorption coefficient is defined as  $G=0$  to account for reduced sound attenuation. In contrast, ground covered in snow (common in this particular area during the winter season), vegetation, including suburban lawns, livestock and agricultural fields (both fallow with bare soil and planted with crops), will be acoustically absorptive and aid in sound attenuation, i.e.,  $G=1.0$ . For the acoustic modeling analysis, a conservative ground absorption rate was selected for a semi-reflective ground surface. This ground absorption coefficient was further reduced for receiver locations in close proximity to WTGs to account for decreased ground attenuation effects associated with an elevated sound source relative to receiver height. For this model, each WTG was modeled as an elevated point source at the position of the hub of 80 meters, an approach which is valid when the distance from the source to receiver is large compared to the dimensions of the source. For idealized point sources, sound levels will attenuate with increased distance from the source in accordance with the “inverse square law” due to geometric divergence that occurs as the sound energy is spread across a sphere of greater dimensions. The equivalent continuous downwind octave band sound pressure level at a receiver location is calculated for each individual WTG source and its image sources on both a broadband and frequency dependent basis from 31 Hz to 8 kHz. Geometrical divergence accounts for spherical spreading in the free field from a point sound source according to the equation below:

$$L_p = L_w + DI_\theta - 10 \log \left( \frac{1}{2} \pi R^2 \right) - A \text{ in dBA or dBL}$$

Where:

- $L_p$  = calculated sound pressure level at receiver location
- $L_w$  = reference sound power level by octave band center frequency
- $DI_\theta$  = directivity index correction to account for the variation in sound intensity with orientation relative to the noise source
- $R$  = linear (slant) distance of  $L_p$  from source in meters (or feet multiplied by 3.28) to calculate geometrical divergence with distance
- $A$  = extraneous attenuation factors that may occur during propagation from the point sound source to the receiver

The ISO 9613-2 standard calculates received sound pressure levels for meteorological conditions favorable to propagation, i.e., downwind sound propagation or what might occur typically during a moderate atmospheric ground level inversion, which is assumed to be regulatory worst case. At large distances from a sound source when the influences of wind or temperature gradients are present, atmospheric effects may cause fluctuations in received sound levels over long distances, but will typically attenuate noise to levels below those predicted. Rarely will these effects cause levels to be significantly above those predicted. First, the acoustic modeling algorithms essentially assume laminar atmospheric conditions, in which neighboring layers of air do not mix. This conservative assumption does not take into consideration turbulent eddies and micrometeorological inhomogeneities that may form when winds change speed or direction, which can interfere with the sound wave propagation path and increase attenuation effects. Conversely, there may be meteorological conditions from time to time that will aid in the long range propagation of sound, specifically at points of reception located at extended distances from WTGs. The presence of anomalous meteorological conditions can cause sound waves to curve downward

towards the ground and then reflect upwards towards the gradient, which is then repeated leading to a trapped sound wave. The wave refraction effects due to wind and temperature gradients during downwind conditions result into the convergence of modified cylindrical wave spreading, which has a reduced rate of sound attenuation. These anomalous meteorological conditions may include well-developed moderate ground-based temperature inversions, such as commonly occurs at nighttime and during early morning hours, and wind gradients which can bend sound downwards, which may occur at anytime depending on predominant weather conditions. Though somewhat infrequent according the ISO 9613-2 procedures, Project operational sound levels resulting from periodic anomalous meteorological conditions were also considered in the modeling analysis.

In addition to geometrical divergence, attenuation factors (A) include topographical features, terrain coverage, and/or other natural or anthropogenic obstacles that can affect sound attenuation and result in acoustical screening. Atmospheric absorption depends on temperature and humidity and is most important at higher frequencies. Over short distances, the effects of atmospheric absorption are minimal. Though a physical impracticality, the ISO 9613-2 standard simulates omnidirectional downwind propagation and maximum WTG source directivities. For receptors located between discrete WTG locations or WTG groupings, the acoustic model will result in over-predicted received sound level results. Additional sound attenuation through foliage and diffraction around and over existing anthropogenic structures such as buildings were ignored under all acoustic modeling scenarios. The results are therefore representative of defoliate winter time. The acoustic model assumes that all WTGs are operating continuously and concurrently at the maximum manufacturer-rated sound level at the given operational condition and sound energy is summed using the following equation in accordance with ISO 9613-2:

$$L_{PA} (DW) = 10 \log \left\{ \sum_{i=1}^n \left[ \sum_{j=1}^9 10^{0.1[L_{T(ij)} + f(A-wtd)(j)]} \right] \right\}$$

Where:

- n = the number of contributions i (sources and paths)
- j = an index indicating the nine standard octave band center frequencies spanning from 31 Hz to 8 kHz

The above equation determines the equivalent continuous A-weighted downwind sound pressure level at a point of reception (i.e., noise sensitive receptors), taking into account the contributing sound pressure levels produced by all Project WTGs. Calculations were completed using an 131-foot (40 meters) by 131-foot grid and also completed at discrete noise sensitive receptor locations.

### 3.2 Acoustic Modeling Input Parameters

In order to assist project developers and acoustical engineers, wind turbine manufacturers report WTG sound power data at integer wind speeds referenced to the effective hub height, ranging from cut-in to full rated power. This internationally accepted International Electrotechnical Commission (IEC) standard was developed to ensure consistent and comparable sound emission data of utility-scale wind turbines between manufacturers. These data are inclusive of both mechanical and aerodynamic source components. Wind turbines can be somewhat directional, radiating more sound in some directions than others. The IEC test measurement protocol requires that sound measurements are made for the maximum downwind directional location when reporting apparent sound power levels. Thus, worst-case WTG

directivity and sound generating efficiencies are reported in the sound source data and used in the acoustic model calibration.

A summary of sound power data for the selected GE 1.6 MW xle WTG correlated by wind speed at the rotor hub height of 262.4 feet (80 meters) are presented in Table 5. The GE 1.6 MW xle specification reports a confidence interval of K=2 dB to account for the manufacturer's warranty clause, which was incorporated into the acoustic model to ensure a conservative acoustic modeling assessment.

**Table 5. Broadband Sound Power Levels (dBA) Correlated with Wind Speed**

10-meter AGL Wind Speed	WTG L <sub>max</sub> Sound Power Level (L <sub>w</sub> ) at Reference Wind Speed						
	9 mph (4 m/s)	11.2 mph (5 m/s)	13.4 mph (6 m/s)	15.9 mph (7 m/s)	17.9 mph (8 m/s)	20.1 mph (9 m/s)	22.4 mph (10 m/s)
GE 1.6 MW xle	<96	<96	<99	<102	<104	≤106	≤106

A summary of sound power data for the GE 1.6 MW xle by octave band center frequency is presented in Table 6.

**Table 6. GE 1.6 MW xle Sound Power Level by Octave Band Center Frequency**

Frequency (Hz)	Octave Band Sound Power Level (dBA)								Broadband (dBA)
	63	125	250	500	1000	2000	4000	8000	
GE 1.6 MW xle	84.8	93.6	99.2	100.8	100.1	97.3	89.1	86.2	106.0

## 4.0 MODELING RESULTS AND COMPLIANCE DETERMINATION

Operational broadband (dBA) sound pressure levels were calculated throughout the Project area. Acoustic modeling results and the overall analysis conclusions are given in the following sections.

### 4.1 Acoustic Modeling Results

Acoustic modeling for the final Project layout was completed for WTG cut-in and full rotational operating conditions, thereby describing sound pressure levels over the entire range of future Project operational conditions. A list of receptors, unique number identifier, Universal Transverse Mercator (UTM) coordinates, and received sound levels are provided in Table 7. Results are presented to tenths of decibels for a more relevant comparison with the EPA criterion, which is given to one decimal place; however, the generally accepted level of accuracy for this calculation procedure is expected to be somewhat than this reporting format implies. Sound levels are typically reported to whole decibels.

Sound contour plots displaying Project operational sound levels in color-coded isopleths are provided in Figures 2 through 4. Figure 2 shows broadband (dBA) operational sound levels under low-level wind speeds sufficient for WTGs to operate at initial cut-in rotational speeds. Figure 3 shows broadband (dBA) operational sound levels at wind speeds sufficient to sustain WTG operation at maximum rotational speeds for moderate downwind propagation. Figure 4 shows broadband (dBA) operational sound levels at wind speeds sufficient to sustain WTG operation at maximum rotational speeds under anomalous meteorological conditions. The acoustic modeling was completed for all WTGs operating concurrently. The resultant sound contour plots are independent of the existing acoustic environment, i.e., the plots and tabulated results represent Project-generated sound levels only.

**Table 7. Summary of WTG Acoustic Model Output at Receptors (dBA)**

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substation
		Easting	Northing				
1200	Uninhabited Bin Site	580550	5227542	31.9	41.9	42.4	42.4
1201	Inhabited Active Farmstead	580142	5222727	11.2	21.2	23.8	23.9
1202	Inhabited Active Farmstead	580174	5222682	11.2	21.2	23.8	23.8
1203	Inhabited Active Farmstead	578609	5224306	11.0	21.0	23.6	23.6
1204	Uninhabited Abandoned Farm	582984	5227692	37.5	47.5	47.7	47.7
1205	Inhabited Active Farmstead	585112	5227553	33.0	43.0	43.5	43.5
1206	Uninhabited Active Farm	582255	5226427	26.5	36.5	38.4	38.4
1208	Inhabited Active Farmstead	583479	5225107	21.4	31.4	33.8	33.8
1209	Uninhabited Active Farm	583452	5224891	20.6	30.6	32.9	32.9
1210	Uninhabited Abandoned Farm	584213	5224515	15.5	25.5	29.4	29.4
1211	Uninhabited Active Farm	583711	5222922	12.0	22.0	24.6	24.8
1212	Uninhabited Active Farm	582720	5222812	13.4	23.4	26.3	26.5
1213	Inhabited Active Farmstead	582065	5222720	11.0	21.0	24.3	24.5
1214	Inhabited Active Farmstead	583685	5220947	11.0	21.0	23.6	29.1
1215	Inhabited Active Farmstead	583702	5220874	9.9	19.9	23.5	26.4
1216	Uninhabited Active Farm	585599	5219562	0.9	10.9	17.6	22.0
1217	Uninhabited Active Bin	585575	5219664	2.3	12.3	13.4	21.0
1218	Uninhabited Active Farm	585566	5219542	4.2	14.2	16.8	21.9
1219	Inhabited Active Farmstead	582973	5219659	9.3	19.3	21.6	29.3
1221	Uninhabited Active Bin	580613	5221365	16.5	26.5	28.9	29.0
1222	Inhabited Active Farmstead	579442	5221153	18.5	28.5	30.6	30.6

**Table 7. Summary of WTG Acoustic Model Output at Receptors (dBA)**

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substation
		Easting	Northing				
1223	Inhabited Active Farmstead	579281	5218105	31.1	41.1	41.3	41.3
1224	Inhabited Active Farmstead	582065	5218050	16.0	26.0	25.8	26.4
1225	Uninhabited Active Public building (Grand Prairie Community Center)	583675	5218098	8.3	18.3	20.6	25.0
1226	Uninhabited Abandoned Farm	583688	5217946	8.4	18.4	20.9	27.9
1227	Inhabited Active Farmstead	584346	5216926	9.5	19.5	22.4	23.2
1228	Inhabited Active Farmstead	583623	5215544	8.5	18.5	21.0	21.4
1229	Inhabited Active Farmstead	584703	5214840	4.7	14.7	17.3	17.7
1230	Inhabited Active Farmstead	581932	5214743	15.2	25.2	27.4	27.4
1231	Inhabited Active Farmstead	579412	5214742	24.2	34.2	36.0	36.0
1232	Inhabited Active Farmstead	578990	5213918	24.4	34.4	36.3	36.3
1233	Inhabited Active Farmstead	578911	5213927	24.7	34.7	36.7	36.7
1234	Uninhabited Inactive Farm	583866	5214102	7.1	17.1	19.8	19.9
1235	Uninhabited Active Bin	583860	5213618	6.6	16.6	19.3	19.4
1236	Inhabited Active Farmstead	583887	5212028	3.6	13.6	16.3	16.4
1237	Inhabited Active Farmstead	585678	5211517	0	0	0	0
1238	Uninhabited Active Bin	587097	5211492	0	0	0	0
1239	Uninhabited Active Bin	586985	5211550	0	0	0	0
1240	Inhabited Active Farmstead	582004	5211346	12.6	22.6	25.3	25.3
1241	Inhabited Active Farmstead	579021	5212612	20.8	30.8	33.1	33.1
1242	Inhabited Active Farmstead	579850	5211611	16.8	26.8	27.9	27.9
1243	Inhabited Active Farmstead	580342	5209916	9.7	19.7	20.4	20.4
1244	Inhabited Active Farmstead	581744	5209967	10.2	20.2	18.2	18.2
1245	Uninhabited Abandoned Farm	584824	5210115	0	0	0	0
1246	Uninhabited Active Farm	587242	5209967	0	0	0	0
1247	Uninhabited Active Farm	586041	5213209	0	0	0	2.3
1248	Inhabited Active Farmstead	586878	5213679	0	0	0	2.5
1249	Uninhabited Active Farm	587057	5213929	0	0	0	2.8
1250	Uninhabited Active Farm	586510	5214794	0	0	0	5.4
1251	Inhabited Active Farmstead	587146	5216309	0	0	0	7.8
1252	Inhabited Active Farmstead	585124	5217306	8.5	18.5	21.1	23.9
1253	Inhabited Active Farmstead	587410	5222861	11.2	21.2	24.1	24.2
1254	Uninhabited Active Farm	586123	5224611	17.9	27.9	30.6	30.6
1255	Inhabited Active Farmstead	587516	5225147	17.1	27.1	29.7	29.8
1256	Uninhabited Active Farm	583481	5212919	6.9	16.9	19.6	19.7
1257	Uninhabited Abandoned Farm	581183	5213115	15.7	25.7	28.8	28.8
1258	Uninhabited Abandoned Farm	582358	5213729	13.5	23.5	23.3	23.4
2504	Occupied House	580329	5232283	21.1	31.1	33.2	33.2
2511	Unoccupied Active Farm	580167	5230913	25.1	35.1	37.4	37.4
2512	Occupied House	580352	5229261	32.9	42.9	43.3	43.3
2523	Occupied House	581033	5230798	28.9	38.9	40.7	40.7
2532a	Occupied House	581751	5230201	36.4	46.4	46.7	46.7
2541	Occupied House	581032	5229560	34.2	44.2	44.5	44.5
2552	Occupied House	575315	5216300	29.1	39.1	39.9	39.9
2555	Commercial Building - Bayshore Resort & Marina	575014	5216280	23.2	33.2	34.8	34.8
2556	Seasonal Cabin	575062	5216274	24.2	34.2	35.1	35.1
2558	Seasonal Cabin	575072	5216320	23.5	33.5	35.0	35.0
2560	Seasonal Cabin	575071	5216337	23.4	33.4	35.0	35.0
2562	Occupied Cabin	575021	5216206	26.0	36.0	35.9	35.9

**Table 7. Summary of WTG Acoustic Model Output at Receptors (dBA)**

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substation
		Easting	Northing				
2564	Seasonal Cabin	575008	5216179	24.9	34.9	37.3	37.3
2567	Seasonal Cabin	574990	5216164	24.8	34.8	36.3	36.3
2568	Seasonal Cabin	575025	5216147	25.1	35.1	36.5	36.5
2570	Seasonal Cabin	574984	5216134	24.8	34.8	36.3	36.3
2572	Seasonal Cabin	575016	5216111	25.1	35.1	36.5	36.5
2575	Seasonal Cabin	574985	5216123	24.9	34.9	36.3	36.3
2578	Seasonal Cabin	574978	5216090	25.5	35.5	36.3	36.3
2579	Seasonal Cabin	574980	5216082	25.5	35.5	37.0	37.0
2582	Seasonal Cabin	574982	5216050	25.0	35.0	36.4	36.4
2584	Seasonal Cabin	574988	5216024	25.6	35.6	37.0	37.0
2585	Seasonal Cabin	574992	5216020	25.7	35.7	37.1	37.1
2588	Seasonal Cabin	574997	5215981	26.1	36.1	37.2	37.2
2589	Seasonal Cabin	575003	5215974	26.4	36.4	37.3	37.3
2592	Seasonal Cabin	574986	5215925	23.6	33.6	35.8	35.8
2594	Seasonal Cabin	574976	5215917	23.5	33.5	35.1	35.1
2596	Seasonal Cabin	574959	5215909	23.5	33.5	35.1	35.1
2598	Seasonal Cabin	574939	5215898	23.4	33.4	35.0	35.0
2600	Seasonal Cabin	574914	5215892	24.4	34.4	34.9	34.9
2602	Seasonal Cabin	574909	5215871	23.2	33.2	36.1	36.1
2608	Seasonal Cabin	574910	5215827	23.2	33.2	34.9	34.9
2611	Building - Church	574866	5215691	23.1	33.1	34.8	34.8
2614	Occupied House	574921	5215625	23.5	33.5	35.7	35.7
2616	Occupied House	574916	5215672	24.7	34.7	35.0	35.0
2618	Occupied House	574991	5215657	25.3	35.3	35.4	35.4
2619	Occupied Trailer	574933	5215709	23.5	33.5	35.1	35.1
2622	Occupied House	575012	5215797	23.9	33.9	35.5	35.5
2624	Occupied Trailer	575025	5215851	23.9	33.9	35.7	35.7
2626	Occupied Trailer	575064	5215887	25.7	35.7	37.2	37.2
2627	Building - Storage Garage	575052	5216092	25.4	35.4	35.9	35.9
2631	Seasonal Camper	575174	5216204	26.8	36.8	39.2	39.2
2632	Seasonal Camper	575149	5216203	25.4	35.4	35.9	35.9
2633	Seasonal Camper	575136	5216206	25.2	35.2	36.2	36.2
2634	Seasonal Camper	575123	5216202	25.1	35.1	36.4	36.4
2635	Seasonal Camper	575112	5216192	26.3	36.3	36.3	36.3
2636	Seasonal Camper	575111	5216170	24.1	34.1	36.6	36.6
2637	Seasonal Camper	575092	5216166	24.0	34.0	37.5	37.5
2638	Seasonal Camper	575081	5216167	25.5	35.5	37.5	37.5
2639	Seasonal Camper	575081	5216187	26.1	36.1	37.4	37.4
2640	Seasonal Camper	575076	5216199	26.0	36.0	36.2	36.2
2641	Seasonal Camper	575041	5216181	25.2	35.2	37.2	37.2
2642	Seasonal Camper	575047	5216188	25.8	35.8	37.2	37.2
2643	Seasonal Camper	575053	5216204	25.8	35.8	37.0	37.0
2644	Seasonal Camper	574921	5215729	23.4	33.4	35.0	35.0
2645	Seasonal Camper	574896	5215744	23.2	33.2	34.9	34.9
2646	Seasonal Camper	574914	5215752	23.3	33.3	35.0	35.0
2647	Abandoned Farmyard	585869	5228361	34.7	44.7	45.5	45.5
20001	Unoccupied Active Farm	586797	5228499	32.2	42.2	42.5	42.5
20004	Occupied House	586700	5228506	33.6	43.6	43.9	43.9
20015	Occupied House	584944	5230556	30.6	40.6	41.7	41.7
20017	Occupied House	584151	5229447	33.2	43.2	44.2	44.2

**Table 7. Summary of WTG Acoustic Model Output at Receptors (dBA)**

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substation
		Easting	Northing				
20025a	Unoccupied Active Farm	583499	5231233	37.2	47.2	47.1	47.1
20031a	Occupied House	583396	5231195	37.4	47.4	47.3	47.3
20033a	Uninhabited Active Farm	583394	5231641	33.1	43.1	43.3	43.3
20034	Uninhabited Active Farm	582746	5231810	35.4	45.4	45.3	45.3
20040	Occupied House	583758	5233087	24.6	34.6	36.5	36.5
20043	Occupied House	581353	5229137	35.2	45.2	45.7	45.7
20046	Occupied House	581828	5228336	36.6	46.6	46.8	46.8
20061	Occupied House	577437	5217759	30.3	40.3	41.6	41.6
20063	Occupied House	577279	5218296	27.8	37.8	39.4	39.4
20065	Unoccupied Active Farmyard	577200	5218382	27.3	37.3	38.9	38.9
20073	Occupied House	578543	5216011	30.8	40.8	42.0	42.0
20085	Occupied House	575688	5212243	22.9	32.9	34.4	34.4
20092a	Occupied House	575047	5213822	28.8	38.8	39.9	39.9
20095	Unoccupied Active Farmyard	575821	5214562	35.0	45.0	45.2	45.2
20098a	Occupied House	575645	5214511	33.7	43.7	44.1	44.1
20103a	Abandoned Unoccupied House	577321	5213745	32.4	42.4	43.1	43.1
20107	Building - Old Schoolhouse	575670	5215379	33.9	43.9	44.5	44.5
20113a	Occupied House	575864	5215660	36.4	46.4	46.9	46.9
20114	Occupied House	575604	5215682	33.2	43.2	43.9	43.9
200123	Occupied House	574963	5217729	21.3	31.3	34.4	34.4
730009	Farmyard Granary	584152	5228183	38.4	48.4	48.9	48.9
730010	Farmyard Grain Bin	584153	5228099	37.7	47.7	48.1	48.1
<b>Number of Potential Exceedances of EPA Noise Guideline at Receptors (48.6 dBA)</b>				<b>None</b>	<b>None</b>	<b>1</b>	<b>1</b>

Reported sound pressure levels are representative of receptors located downwind of the WTGs; lower sound levels are expected in other directions dependent on wind velocities, speed, direction, and gustiness. The acoustic modeling results were compared to the broadband (dBA) guideline criteria as described in Section 2.0 of this report, specifically the EPA broadband guideline of 55 dBA  $L_{dn}$  (equivalent to a  $L_{eq}$  (1-hour) of 48.6 dBA assuming continuous 24-hour operation), which was used as a Project design goal.

The EPA guideline limits presented in Section 2.1 are based on the yearly  $L_{dn}$ . To calculate the yearly  $L_{dn}$ , knowledge of future atmospheric conditions across the entire site over an extended time period are required to determine the long term sound exposure. The conservative approach employed in the Ashtabula III Wind Energy Center acoustic assessment assumed a sustained wind speed in excess of 8 m/s (17.9 mph) at WTG hub height over a continuous one year period. Actual wind speeds and directions over the course of a year will vary.

The yearly  $L_{dn}$  is calculated using the following equation per the EPA guidance document:

$$\text{Yearly } L_{dn}(\text{exterior}) = 10 \cdot \log_{10} \left[ \frac{\left( 15 \cdot 10^{\left( \frac{Leq(1-hour)}{10} \right)} + 9 \cdot 10^{\left( \frac{(Leq(1-hour)+10)}{10} \right)} \right)}{24} \right] \text{ dBA}$$

To calculate yearly  $L_{dn}$ , the  $L_{eq(1-hour)}$  in the above equation was assigned the value of the Project-generated instantaneous maximum sound level for the WTG operating condition under analysis (cut-in or at full rotational speed). Under real world meteorological conditions wind speed and direction will be variable. Over the course of a year, the actual received sound pressure levels as a result of Project operations will fluctuate from periods of calm or low level wind speeds, to wind speeds ranging from cut-in up to maximum rotational. During periods of calm and low level wind speeds below the rated cut-in wind speeds when WTGs will not operate, the Project will generate negligible sound. For time-varying sources, including wind energy projects, assessing sound levels generated during maximum rotational will ensure compliance during all other WTG operational conditions. Though this worst-case continuous operating scenario is not a realistic scenario, the intention of employing this calculation methodology is to provide a further level of conservatism in the acoustic assessment approach.

## 4.2 Compliance Determination

Project operational sound has been calculated and compared to relevant environmental noise criteria as established by the EPA and OSHA. Table 8 summarizes sound modeling results for Project cut-in and maximum rotational speeds as may occur during moderate wind velocities and during certain anomalous meteorological conditions. Table 8 also summarizes results for the Project at maximum rotation speeds under anomalous meteorological conditions in conjunction with the Project substation

**Table 8. Summary of Modeling Results and Comparison to EPA Guidelines at Existing Occupied Residential Receptors**

Operating Scenario	Receptor IDs of Potential Exceedances of EPA and OSHA Criteria
Cut-in Operation – Standard Propagation	None
Maximum Rotational – Standard Propagation	None
Maximum Rotational – Anomalous Meteorological Conditions	ID 730009
Maximum Rotational – Anomalous Meteorological Conditions with Substation	ID 730009

Acoustic modeling analysis results showed potential exceedances of the 55 dBA  $L_{dn}$  EPA noise guideline at one receptor location (ID 730009) under all modeling scenarios considered. The exceedance condition occurs with and without including sound contribution from the substation (indicating the substation is not the chief sound source contribution). Receptor ID 730009 does not appear to be an existing occupied residential structure according to the most recent Farmstead Report and additional field verification done by NextEra Energy (it is a farm granary); therefore, this exceedance can be considered insignificant.

Results indicate that the Project has been adequately designed to operate in compliance with EPA noise guidelines at all remaining noise sensitive receptors.

The EPA guideline limits identified are not legally enforceable requirements, but serve as useful guidelines to determine the likelihood of adverse community noise impacts. The EPA guidelines do not require inaudibility of a sound source. In fact, even if a Project-generated received sound level is below ambient conditions, the spectral and temporal characteristics of the new sound may result in perceptibility. The results of the acoustic modeling analysis indicate that operation of the Project may result in periodically audible sound within the adjacent areas under certain operational and meteorological conditions. Individual response to low-level WTG sound is largely subjective and therefore not easily predictable and may depend on several technical and non-technical factors, including predetermined perceptions of the Project and wind energy in general, individual and community economic incentives, existing background sound levels, the proximity of the listener to a single or grouping of WTGs, among several others. Due to their support of Project development, Project participants have been found to be less likely to become annoyed by low-level WTG sound than non-participants. Non-participants that consider the development of renewable energy sources, and wind energy projects specifically, as beneficial will also be more likely to deem the low-level environmental noise as generally acceptable. Nonetheless, complaints about noise from wind energy projects may still occur, even when fixed standards or limits relative to existing ambient conditions are proposed and met.

In conclusion, the acoustic modeling analysis, inclusive of a number of conservative assumptions has been shown to be adequately designed to operate in compliance with EPA guideline limits. Sound from the Project when audible will likely not be deemed excessive or unusually loud at the setback distance in place and will be consistent with sound generated at similar wind energy projects successfully sited throughout the state of North Dakota employing similar criteria.

## 5.0 OTHER SOUND CONSIDERATIONS

### 5.1 Cumulative Effects

An assessment of cumulative environmental impacts considers the potential impact of the proposed Project in the context of existing developments to ensure that any potential environmental impacts are not considered in isolation. The cumulative effects can result from individually minor, but collectively more significant actions taking place over a given period of time. Cumulative impacts are impacts that result from the incremental consequences of a project when added to other existing wind energy developments. A wind energy development would need to be located within approximately 3 km (2 miles) of the proposed wind farm in order to present a possible cumulative influence on sound. The Project was considered in association the Ashtabula I and II Wind Energy Centers, located adjacent to and approximately 3 miles north of the Ashtabula III Project area in Griggs and Steele counties, respectively (Figure 5). The Ashtabula I Wind Energy Center consists of 131 GE sle 1.5 MW WTGs and Ashtabula II Wind Energy Center of 81 GE xle 1.5 MW WTGs. The Ashtabula I and II Wind Energy Centers have been constructed and are currently operational and generating electricity.

Table 9 provides a summary of sound power data for the GE xle 1.5 MW and GE sle 1.5 MW WTG correlated by wind speed at a height of 10 meters (32.8 ft) above grade. A confidence interval of K=2 dB was incorporated into the acoustic modeling analysis per manufacturer specifications

**Table 9. Broadband Sound Power Levels (dBA) Correlated with Wind Speed**

10-meter AGL Wind Speed	WTG L <sub>max</sub> Sound Power Level (L <sub>w</sub> ) at Reference Wind Speed						
	9 mph (4 m/s)	11.2 mph (5 m/s)	13.4 mph (6 m/s)	15.9 mph (7 m/s)	17.9 mph (8 m/s)	20.1 mph (9 m/s)	22.4 mph (10 m/s)
GE 1.5 MW xle	<96	<96	98.8	102.3	<104.0	<104.0	<104.0
GE 1.5 MW sle	<96	<96	96.6	99.8	102.7	≤104.0	≤104.0

A summary of sound power data for the GE xle 1.5 MW and GE sle 1.5 MW by octave band center frequency are presented in Table 10 (provided for informational purposes by the turbine manufacturer).

**Table 10. GE 1.5 MW xle Sound Power Level by Octave Band Center Frequency**

Frequency (Hz)	Octave Band Sound Power Level (dBA)								Broadband (dBA)
	63	125	250	500	1000	2000	4000	8000	
GE 1.5 MW xle	83.4	92.2	97.8	99.4	97.7	93.4	86.6	84.8	104.0
GE 1.5 MW sle	85.1	94.0	97.2	98.6	97.9	94.5	87.3	78.1	104.0

The existing Ashtabula I and II and proposed Ashtabula III wind energy centers would invariably operate concurrently; therefore a cumulative acoustic modeling assessment was completed. Received sound levels resulting from concurrent operation of the as-built Ashtabula I and II Wind Energy Centers and the Ashtabula III Wind Energy Center are presented at all noise sensitive receptors in Table 11 and are

inclusive of three on-site electrical substations servicing the Ashtabula I, II and future Ashtabula III Wind Energy Centers.

**Table 11. Cumulative Effects for Ashtabula I, II, and III WTGs (dBA)**

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substations
		Easting	Northing				
1200	Uninhabited Bin Site	580550	5227542	37.1	45.3	45.7	45.7
1201	Inhabited Active Farmstead	580142	5222727	36.4	43.4	44.1	44.1
1202	Inhabited Active Farmstead	580174	5222682	37.4	44.3	44.8	44.8
1203	Inhabited Active Farmstead	578609	5224306	28.9	36.6	38.2	38.2
1204	Uninhabited Abandoned Farm	582984	5227692	37.0	47.9	48.2	48.2
1205	Inhabited Active Farmstead	585112	5227553	35.5	44.6	45.1	45.1
1206	Uninhabited Active Farm	582255	5226427	32.4	40.9	42.6	42.6
1208	Inhabited Active Farmstead	583479	5225107	37.8	45.3	46.0	46.0
1209	Uninhabited Active Farm	583452	5224891	37.8	45.2	45.8	45.8
1210	Uninhabited Abandoned Farm	584213	5224515	39.4	47.5	47.8	47.8
1211	Uninhabited Active Farm	583711	5222922	34.6	42.3	43.6	43.6
1212	Uninhabited Active Farm	582720	5222812	37.5	45.5	46.2	46.2
1213	Inhabited Active Farmstead	582065	5222720	37.0	45.6	46.2	46.2
1214	Inhabited Active Farmstead	583685	5220947	32.8	41.0	42.6	42.9
1215	Inhabited Active Farmstead	583702	5220874	32.5	40.8	42.2	42.3
1216	Uninhabited Active Farm	585599	5219562	28.2	36.8	38.4	38.5
1217	Uninhabited Active Bin	585575	5219664	28.8	37.4	38.9	39.0
1218	Uninhabited Active Farm	585566	5219542	28.9	37.5	39.1	39.2
1219	Inhabited Active Farmstead	582973	5219659	40.5	48.2	48.6	48.7
1221	Uninhabited Active Bin	580613	5221365	38.1	46.2	46.8	46.8
1222	Inhabited Active Farmstead	579442	5221153	37.1	44.8	45.6	45.6
1223	Inhabited Active Farmstead	579281	5218105	36.3	44.3	45.1	45.1
1224	Inhabited Active Farmstead	582065	5218050	38.8	47.0	47.6	47.6
1225	Uninhabited Active Public building (Grand Prairie Community Center)	583675	5218098	34.3	42.8	43.7	43.7
1226	Uninhabited Abandoned Farm	583688	5217946	33.8	42.2	43.2	43.4
1227	Inhabited Active Farmstead	584346	5216926	30.1	38.4	40.3	40.4
1228	Inhabited Active Farmstead	583623	5215544	34.1	43.7	44.4	44.4
1229	Inhabited Active Farmstead	584703	5214840	30.8	38.9	40.5	40.5
1230	Inhabited Active Farmstead	581932	5214743	37.0	43.8	44.7	44.7
1231	Inhabited Active Farmstead	579412	5214742	35.6	43.2	44.1	44.1
1232	Inhabited Active Farmstead	578990	5213918	36.2	43.8	44.5	44.5
1233	Inhabited Active Farmstead	578911	5213927	35.2	42.8	43.7	43.7
1234	Uninhabited Inactive Farm	583866	5214102	37.7	44.7	45.2	45.2
1235	Uninhabited Active Bin	583860	5213618	37.6	45.1	45.6	45.6
1236	Inhabited Active Farmstead	583887	5212028	35.5	43.8	44.4	44.4
1237	Inhabited Active Farmstead	585678	5211517	38.7	46.5	46.7	46.7
1238	Uninhabited Active Bin	587097	5211492	35.2	43.6	43.9	43.9
1239	Uninhabited Active Bin	586985	5211550	37.0	45.4	45.6	45.6
1240	Inhabited Active Farmstead	582004	5211346	34.4	42.1	42.8	42.8
1241	Inhabited Active Farmstead	579021	5212612	35.9	43.1	43.7	43.7
1242	Inhabited Active Farmstead	579850	5211611	33.5	40.1	41.0	41.0

**Table 11. Cumulative Effects for Ashtabula I, II, and III WTGs (dBA)**

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substations
		Easting	Northing				
1243	Inhabited Active Farmstead	580342	5209916	25.5	32.8	34.9	34.9
1244	Inhabited Active Farmstead	581744	5209967	31.7	39.3	40.0	40.0
1245	Uninhabited Abandoned	584824	5210115	28.4	36.1	37.8	37.8
1246	Uninhabited Active Farm	587242	5209967	26.2	34.1	36.0	36.0
1247	Uninhabited Active Farm	586041	5213209	29.9	38.3	39.9	39.9
1248	Inhabited Active Farmstead	586878	5213679	27.1	35.3	37.3	37.3
1249	Uninhabited Active Farm	587057	5213929	25.9	34.1	36.2	36.2
1250	Uninhabited Active Farm	586510	5214794	24.9	33.1	35.3	35.3
1251	Inhabited Active Farmstead	587146	5216309	23.2	31.2	33.7	33.8
1252	Inhabited Active Farmstead	585124	5217306	28.0	36.1	38.4	38.6
1253	Inhabited Active Farmstead	587410	5222861	22.4	30.5	33.0	33.0
1254	Uninhabited Active Farm	586123	5224611	27.0	35.3	37.4	37.4
1255	Inhabited Active Farmstead	587516	5225147	21.9	30.4	32.8	32.8
1256	Uninhabited Active Farm	583481	5212919	37.6	45.9	46.2	46.2
1257	Uninhabited Abandoned	581183	5213115	35.5	42.5	43.5	43.5
1258	Uninhabited Abandoned	582358	5213729	38.8	46.1	46.6	46.6
2504	Occupied House	580329	5232283	25.0	33.8	36.1	36.1
2511	Unoccupied Active Farm	580167	5230913	26.7	35.9	38.0	38.0
2512	Occupied House	580352	5229261	33.4	43.0	43.6	43.6
2523	Occupied House	581033	5230798	29.5	39.1	40.5	40.5
2532a	Occupied House	581751	5230201	36.5	46.5	46.9	46.9
2541	Occupied House	581032	5229560	34.9	44.4	45.0	45.0
2552	Occupied House	575315	5216300	30.0	39.4	40.7	40.7
2555	Commercial Building - Bayshore Resort & Marina	575014	5216280	24.3	33.6	35.3	35.3
2556	Seasonal Cabin	575062	5216274	25.1	34.5	36.1	36.1
2558	Seasonal Cabin	575072	5216320	24.6	33.9	35.5	35.5
2560	Seasonal Cabin	575071	5216337	24.6	33.9	35.6	35.6
2562	Occupied Cabin	575021	5216206	26.9	36.2	37.7	37.7
2564	Seasonal Cabin	575008	5216179	25.7	35.2	36.7	36.7
2567	Seasonal Cabin	574990	5216164	25.6	35.1	36.6	36.6
2568	Seasonal Cabin	575025	5216147	25.9	35.4	36.8	36.8
2570	Seasonal Cabin	574984	5216134	25.6	35.1	36.6	36.6
2572	Seasonal Cabin	575016	5216111	25.9	35.4	36.8	36.8
2575	Seasonal Cabin	574985	5216123	25.7	35.1	36.6	36.6
2578	Seasonal Cabin	574978	5216090	26.7	35.7	37.2	37.2
2579	Seasonal Cabin	574980	5216082	26.7	35.7	37.2	37.2
2582	Seasonal Cabin	574982	5216050	25.8	35.2	36.7	36.7
2584	Seasonal Cabin	574988	5216024	26.8	35.9	37.3	37.3
2585	Seasonal Cabin	574992	5216020	26.8	35.9	37.4	37.4
2588	Seasonal Cabin	574997	5215981	27.0	36.3	37.8	37.8
2589	Seasonal Cabin	575003	5215974	27.2	36.6	38.1	38.1
2592	Seasonal Cabin	574986	5215925	24.7	34.0	35.6	35.6
2594	Seasonal Cabin	574976	5215917	24.6	33.9	35.5	35.5
2596	Seasonal Cabin	574959	5215909	24.6	33.8	35.5	35.5
2598	Seasonal Cabin	574939	5215898	24.5	33.7	35.4	35.4
2600	Seasonal Cabin	574914	5215892	25.3	34.7	36.3	36.3
2602	Seasonal Cabin	574909	5215871	24.3	33.6	35.3	35.3
2608	Seasonal Cabin	574910	5215827	24.4	33.6	35.3	35.3
2611	Building - Church	574866	5215691	24.2	33.4	35.1	35.1
2614	Occupied House	574921	5215625	24.6	33.8	35.5	35.5

Table 11. Cumulative Effects for Ashtabula I, II, and III WTGs (dBA)

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substations
		Easting	Northing				
2616	Occupied House	574916	5215672	25.9	35.0	36.5	36.5
2618	Occupied House	574991	5215657	26.1	35.5	37.0	37.0
2619	Occupied Trailer	574933	5215709	24.6	33.8	35.5	35.5
2622	Occupied House	575012	5215797	25.0	34.2	35.8	35.8
2624	Occupied Trailer	575025	5215851	25.0	34.3	35.9	35.9
2626	Occupied Trailer	575064	5215887	26.6	36.0	37.4	37.4
2627	Building - Storage Garage	575052	5216092	26.2	35.7	37.1	37.1
2631	Seasonal Camper	575174	5216204	27.4	37.0	38.2	38.2
2632	Seasonal Camper	575149	5216203	26.2	35.7	37.1	37.1
2633	Seasonal Camper	575136	5216206	26.0	35.4	36.9	36.9
2634	Seasonal Camper	575123	5216202	25.9	35.4	36.9	36.9
2635	Seasonal Camper	575112	5216192	27.0	36.5	37.9	37.9
2636	Seasonal Camper	575111	5216170	25.1	34.4	36.0	36.0
2637	Seasonal Camper	575092	5216166	25.0	34.3	35.9	35.9
2638	Seasonal Camper	575081	5216167	26.3	35.7	37.1	37.1
2639	Seasonal Camper	575081	5216187	26.8	36.3	37.7	37.7
2640	Seasonal Camper	575076	5216199	26.7	36.2	37.6	37.6
2641	Seasonal Camper	575041	5216181	26.0	35.4	36.9	36.9
2642	Seasonal Camper	575047	5216188	26.5	36.1	37.5	37.5
2643	Seasonal Camper	575053	5216204	26.5	36.1	37.5	37.5
2644	Seasonal Camper	574921	5215729	24.5	33.7	35.4	35.4
2645	Seasonal Camper	574896	5215744	24.3	33.6	35.3	35.3
2646	Seasonal Camper	574914	5215752	24.4	33.6	35.3	35.3
2647	Abandoned Farmyard	585869	5228361	36.2	44.9	45.3	45.3
20001	Unoccupied Active Farm	586797	5228499	34.5	42.3	42.7	42.7
20004	Occupied House	586700	5228506	35.9	43.7	44.0	44.0
20015	Occupied House	584944	5230556	30.9	40.7	41.8	41.8
20017	Occupied House	584151	5229447	33.7	43.5	44.5	44.5
20025a	Unoccupied Active Farm	583499	5231233	36.8	47.2	47.4	47.4
20031a	Occupied House	583396	5231195	36.6	47.5	47.7	47.7
20033a	Uninhabited Active Farm	583394	5231641	32.6	43.2	43.9	43.9
20034	Uninhabited Active Farm	582746	5231810	32.7	45.4	45.8	45.8
20040	Occupied House	583758	5233087	25.0	35.1	37.1	37.1
20043	Occupied House	581353	5229137	36.1	45.4	45.9	45.9
20046	Occupied House	581828	5228336	38.1	47.1	47.5	47.5
20061	Occupied House	577437	5217759	32.1	41.1	42.5	42.5
20063	Occupied House	577279	5218296	31.1	39.6	41.3	41.3
20065	Unoccupied Active Farmyard	577200	5218382	31.3	39.7	41.5	41.5
20073	Occupied House	578543	5216011	32.9	42.0	43.4	43.4
20085	Occupied House	575688	5212243	25.6	33.9	35.9	35.9
20092a	Occupied House	575047	5213822	31.0	39.0	40.1	40.1
20095	Unoccupied Active Farmyard	575821	5214562	36.5	45.1	45.5	45.5
20098a	Occupied House	575645	5214511	35.4	43.9	44.4	44.4
20103a	Abandoned Unoccupied	577321	5213745	32.9	42.9	43.6	43.6
20107	Building - Old Schoolhouse	575670	5215379	34.5	44.0	44.6	44.6
20113a	Occupied House	575864	5215660	36.9	46.4	46.7	46.7
20114	Occupied House	575604	5215682	33.8	43.3	43.9	43.9
200123	Occupied House	574963	5217729	23.0	32.2	34.4	34.4
730009	Farmyard Granary	584152	5228183	38.2	48.8	49.0	49.0
730010	Farmyard Grain Bin	584153	5228099	38.1	48.2	48.5	48.5

Table 11. Cumulative Effects for Ashtabula I, II, and III WTGs (dBA)

Receptor ID	Receptor Status	UTM Coordinates (m)		Cut-In	Maximum Rotation	Anomalous Meteorological Conditions	Anomalous Meteorological Conditions Plus Substations
		Easting	Northing				
1259	O&M Facility	583916	5219607	38.1	45.9	46.4	53.1
1	Occupied	577943	5234042	35.3	43.2	43.7	43.7
2	Occupied	580136	5234084	27.6	35.5	37.7	37.7
3	Abandoned	580172	5234823	29.2	37.1	39.2	39.2
4	Occupied	578058	5235452	37.6	46.1	46.6	46.6
5	Occupied	576452	5235674	34.2	41.6	42.5	42.5
6	Occupied	580955	5235593	32.5	40.4	41.6	41.6
7	Abandoned	576929	5236628	38.5	46.0	46.5	46.5
8	Occupied	580066	5236532	34.6	42.4	43.7	43.7
9	Occupied	583290	5236534	30.7	38.7	40.3	40.3
10	Abandoned	580797	5237298	37.1	44.5	45.3	45.3
11	Occupied	578959	5237317	40.0	47.4	47.9	47.9
12	Occupied	576824	5237783	30.9	38.6	39.8	39.8
13	Abandoned	583377	5238914	33.0	41.1	42.2	42.2
14	Abandoned	579780	5238925	40.3	47.1	47.7	47.7
15	Abandoned	580765	5239004	39.3	46.3	47.0	47.0
16	Abandoned	581799	5238934	37.3	44.7	45.4	45.5
17	Abandoned	578187	5239076	39.0	46.5	47.1	47.1
18	Abandoned	577480	5239221	41.3	48.8	49.0	49.0
19	Occupied	583396	5239372	32.7	40.3	41.7	41.7
20	Occupied	576426	5239877	31.0	38.2	39.5	39.5
21	Occupied	577050	5240101	34.8	42.4	42.9	42.9
22	Non-Residential Structure	580393	5240459	42.4	50.0	50.2	50.2
23	Occupied	581646	5240174	37.1	44.0	45.0	45.0
24	Occupied	576564	5240486	31.4	38.7	40.2	40.2
25	Occupied	583384	5240343	35.0	43.1	43.8	43.8
26	Occupied	578086	5240529	40.9	48.2	48.5	48.5
27	Occupied	583832	5240565	32.3	40.3	41.5	41.5
28	Occupied	577347	5240903	35.9	42.9	43.8	43.8
29	Occupied	581852	5241069	38.2	45.4	45.9	45.9
30	Abandoned	582369	5241959	38.1	44.9	45.3	45.4
31	Occupied	575932	5241880	25.3	32.5	34.7	34.7
32	Occupied	583294	5241769	36.4	44.0	44.5	44.7
33	Occupied	582990	5242031	36.6	43.9	44.4	44.7
34	Occupied	583409	5239245	32.8	40.4	41.9	41.9
35	Occupied (Not Confirmed)	578022	5242598	27.3	34.9	36.4	36.4
36	Occupied (Not Confirmed)	584309	5242025	27.8	35.5	37.3	37.8
37	Non-Residential Structure	580275	5240357	40.6	48.2	48.6	48.6
38	Occupied	579019	5237320	40.2	47.6	48.1	48.1
<b>Number of Potential Exceedances of EPA Noise Guideline at Receptors (48.6 dBA)</b>				<b>None</b>	<b>3</b>	<b>3</b>	<b>5</b>

Modeling results for the cumulative effects assessment are also presented in the form of sound contour level maps. Figures 5, 6, and 7 show the Ashtabula I and II WTGs with the proposed Ashtabula III WTGs at cut-in wind speeds, and maximum rotational wind speeds for moderate downwind meteorological conditions and during anomalous meteorological conditions. In addition, Table 12 summarizes the

findings of the cumulative effects assessment. Of the possible exceedance conditions identified in Table 12, it appears that only receptor ID 1219 is an existing inhabited active farmstead and participating landowner. Although this exceedance is anticipated only during anomalous meteorological conditions, consideration of further mitigation may be warranted.

**Table 12. Summary of Cumulative Modeling Results and Comparison to EPA Guidelines at Existing Occupied Residential Receptors**

Operating Scenario	Receptor IDs of Potential Exceedances of EPA Guideline Criteria
Cut-in Operation – Standard Propagation	None
Maximum Rotational – Standard Propagation	IDs 730009, 18, and 22
Maximum Rotational – Anomalous Meteorological Conditions	IDs 730009, 18, and 22
Maximum Rotational – Anomalous Meteorological Conditions with Substations	IDs 1219, 1259, 730009, 18, and 22

## 5.2 Electrical Substation

The substation is an integral part of the Project as it collects and increases the voltage produced by the WTGs to the higher voltage needed for transmission by the local grid system. Sound from the Project electrical substations was examined as part of the Acoustic Assessment. Substations have switching, protection and control equipment and one or more transformers, which generate the sound generally described as a low humming. There are three main sound sources associated with a transformer: core noise, load noise and noise generated by the operation of the cooling equipment. The core is the principal noise source, dominating in the intermediate frequency range between 100 and 600 Hz. The relative magnitudes of the noise at these different frequency components is dependent on the design of the transformer (i.e., core material, core geometry) and does not vary significantly with the load on the transformer, meaning that the noise generated is largely independent of the transformer load. The load noise is primarily caused by the load current in the transformer's conducting coils (or windings) and consequently the main frequency of this sound is twice the supply frequency; 100 Hz for 50 Hz transformers and 120 Hz for 60 Hz transformers. The cooling equipment (fans and pumps) noise typically dominates the very low and very high frequency ends of the sound spectrum; however, cooling equipment sound is comparatively lower and considered secondary to the sound produced by the core and load.

Transformers are designed and catalogued by kilovolt ampere (kVA) ratings. Just as horsepower ratings designate the power capacity of an electric motor, a transformer's kVA rating indicates its maximum power output capacity. The transformer industry uses the National Electrical Manufacturers Association (NEMA) sound level rating to designate the sound emitted from a transformer. This rating system requires the determination of the average A-weighted sound level at a distance of 0.3 meters (1 foot) from the wall surfaces of the transformer and is specified by the equipment manufacturer. The sound power radiated is a function of the NEMA rating and the total surface area of the four side walls.

The proposed Ashtabula III electrical substation and as-built substations servicing Ashtabula I and II Wind Energy Centers were modeled using CadnaA. To assess potential impacts of substation operation on nearby residential receptors, a screening level acoustic analysis was conducted using the CadnaA model incorporating site-specific topographic and terrain data and modeled cumulatively with WTG operational scenarios. Transformer sound source levels were estimated for a NEMA sound rating of 82

dBA and are presented in Table 13. The octave band center frequencies were calculated linearly based on the estimate transformer NEMA rating using standard engineering technical guidelines.

**Table 13. Transformer Sound Power Level (NEMA 82 dBA)**

	Unweighted Octave Band Sound Power Data (dBL)								
	31.5	63	125	250	500	1000	2000	4000	8000
NEMA Rating 82 dBA	100	106	108	103	103	97	92	87	80

Figures 2 through 7 include operational sound from both Project WTGs and substation(s) corresponding to the rated electrical output. Table 7 shows received sound levels resulting from the Ashtabula III substation in combination with the Project WTGs at maximum rotational wind speed, respectively. Table 11 shows received sound levels resulting from the Ashtabula I, II and II substations in combination with the Ashtabula I, II and III WTGs.

Few complaints from nearby residents are expected regarding substations with transformers less than 10 MVA capacities, except in urban areas with little or no buffer distance attenuation between source and receiver locations. Complaints are more likely at substations with transformer sizes of 10 to 150 MVA with separation distances of 500 to 600 feet or less. In very quiet rural areas where the nighttime ambient acoustic environment can reach levels of 20 to 25 dBA under calm wind conditions, the sound generated from transformers of this size may be periodically audible at distances of half a mile or greater.

### 5.3 Construction Noise

The development of the Ashtabula III Wind Energy Center will involve construction to establish access roads, excavate and form WTG foundations, works associated with preparing the site for crane-lifting and actual WTG assembly and commissioning. Work on large-scale wind projects such as the Ashtabula III Wind Energy Center is generally divided into four phases consisting of the following:

1. *Site Clearing:* The initial site mobilization phase includes the establishment of temporary site offices, workshops, stores, and other on-site facilities. Installation of erosion and sedimentation control measures will be completed as well as the preparation of initial haulage routes.
2. *Excavation:* This phase would begin with the excavation and formation of access roads and preparation of laydown areas. Excavation for the concrete turbine foundations would also be completed.
3. *Foundation Work:* Construction of the reinforced concrete turbine foundations would take place in addition to installation of the internal transmission network.
4. *Wind Turbine Installation:* Delivery of the turbine components would occur followed by their installation and commissioning.

Work on these construction activities is expected to overlap. It is likely that the wind turbines will be erected in small groupings. Each grouping may undergo testing and commissioning prior to commencement of full commercial operation. Other construction activities include those for the supporting infrastructure such as the substation.

The construction of the Project may cause short-term but unavoidable noise impacts. The sound levels resulting from construction activities vary significantly depending on several factors such as the type and age of equipment, the specific equipment manufacturer and model, the operations being performed, and the overall condition of the equipment and exhaust system mufflers. A list of representative construction equipment that may be used on the Project and estimates of near and far sound source levels are presented in Table 14.

Sounds generated by construction activities are typically exempt from state and local noise oversight provided that they occur within weekday, daytime periods as may be further stipulated under local zoning or legal codes. All reasonable efforts will be made to minimize the impact of noise resulting from construction activities. As the design of the Project progresses and construction scheduling is finalized, the construction engineer should notify the community via public notice or alternative method of expected Project construction commencement and duration to help minimize the effects of construction noise. In addition, the location of stationary equipment and the siting of construction laydown areas should be carefully selected to be as far removed from existing noise sensitive receptors as is practical. Candidate construction noise mitigation measures include scheduling louder construction activities during daytime hours and treating internal combustion engines with appropriate sized muffler systems to minimize noise excessive emissions. If blasting for foundation or other noisy activities are required during the construction period, nearby residents shall be notified in advance.

**Table 14. Estimated  $L_{max}$  Sound Pressure Levels from Construction Equipment**

Equipment*	Estimated Sound Pressure Level at 50 feet (dBA)	Estimated Sound Pressure Level at 2000 feet (dBA)
Crane	85	53
Forklift	80	48
Backhoe	80	48
Grader	85	53
Man basket	85	53
Dozer	83 - 88	51 - 56
Loader	83 - 88	51 - 56
Scissor Lift	85	53
Truck	84	52
Welder	73	41
Compressor	80	48
Concrete Pump	77	45

Data compiled in part from the following sources:

Federal Highway Administration, "Roadway Construction Noise Model User's Guide," Report FHWA-HEP-05-054 / DOT-VNTSC-FHWA-05-01, January 2006.

Power Plant Construction Noise Guide, Bolt Beranek and Newman, Inc. 1977.

Federal Highway Administration, "Procedures for Abatement of Highway Traffic Noise and Construction Noise." Code of Federal Regulations, Title 23, Part 772, 1992.

Construction activity will generate traffic having potential noise effects, such as trucks travelling to and from the site on public roads. At the early stage of the construction phase, equipment and materials will be delivered to the site, such as hydraulic excavators and associated spreading and compacting equipment needed to form access roads and foundation platforms for each turbine. Once the access roads are constructed, equipment for lifting the towers and turbine components will arrive. Traffic noise is categorized into two categories: (1) the noise that will occur during the initial temporary traffic

movements related to turbine delivery, haulage of components and remaining construction; and (2) maintenance and ongoing traffic from staff and contractors, which is expected to be minor.

Federal laws prohibit state and local governments from regulating off-site sound levels generated by trucks and automobiles operating on a private site or public roadways. This federal regulatory preemption is specified in the Federal Noise Control Act of 1972 and in the Surface Transportation Assistance Act of 1982, both of which prohibit states and local authorities from regulating the noise emitted by trucks engaged in interstate commerce, i.e., truck deliveries. A federal OSHA preemption also prohibits local and state governments from regulating safety signals on trucks and construction equipment.

## 6.0 TECHNICAL REFERENCES

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- Technical Documentation: Wind Turbine Generator Systems GE 1.6 xle – 50Hz and 60Hz, Noise emission characteristics Normal operation according to IEC, GE Wind Energy GmbH, 2009.
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- Wagner, S., Bareib, R. and Guidati, G. 1996. Wind Turbine Noise, Springer, Berlin.

# FIGURES



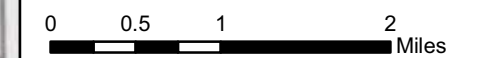
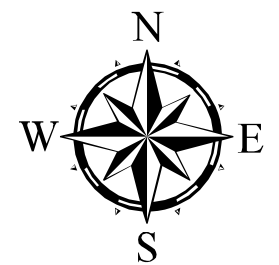
FIGURE 1  
PROJECT LAYOUT

JULY 2010



Legend

- Proposed Turbine Location
- Proposed Substation Location
- Receptor
  - Occupied
  - Unoccupied / Non-Residential



REFERENCE MAP

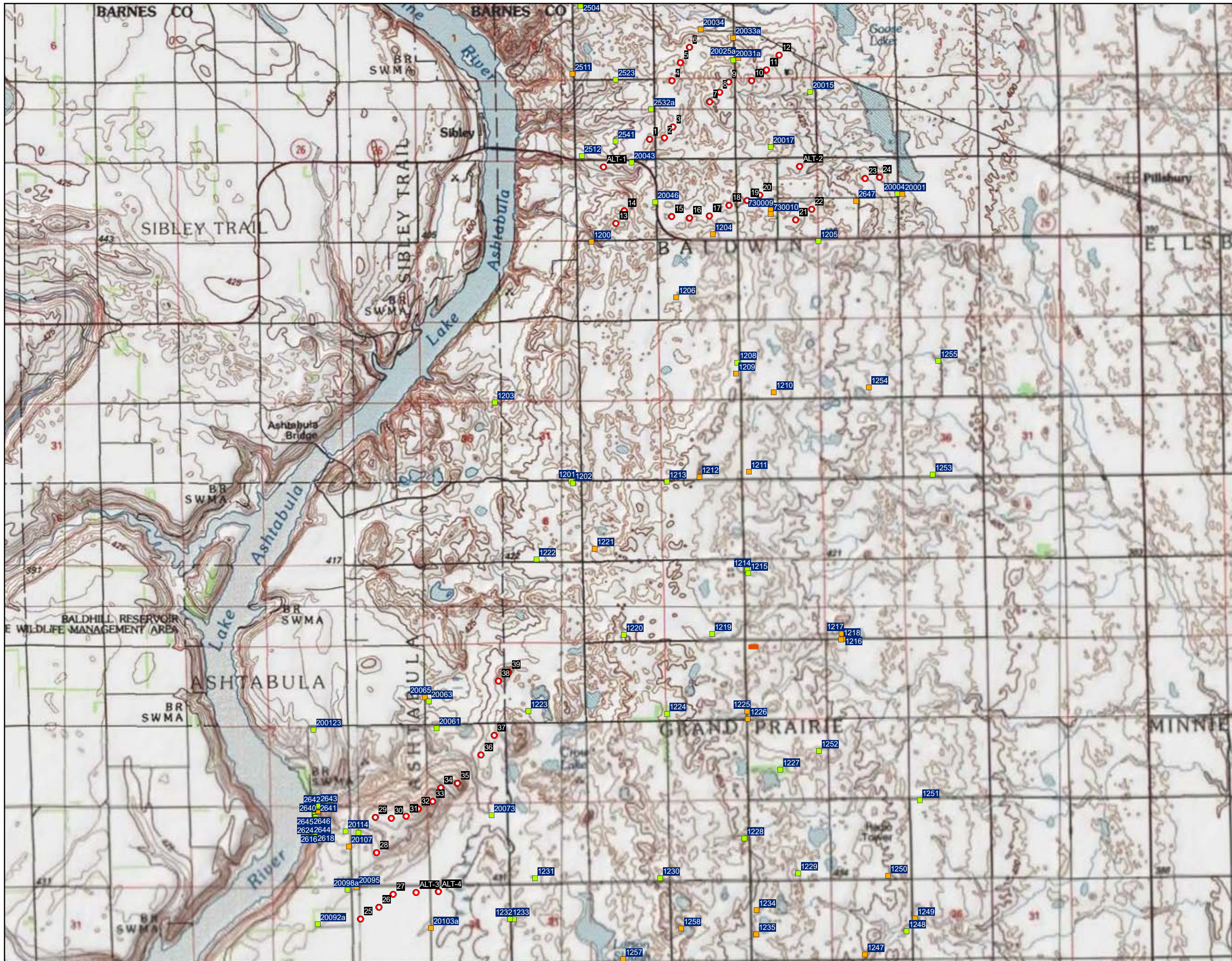


FIGURE 2  
RECEIVED SOUND LEVELS:  
WIND TURBINES AT CUT-IN

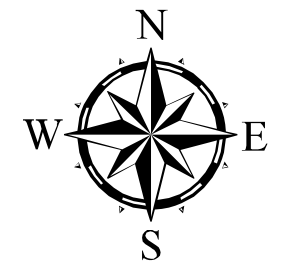
JULY 2010



TETRA TECH EC, INC.

Legend

- Proposed Turbine Location
- Proposed Substation Location
- Receptor**
- Occupied
- Unoccupied / Non-Residential
- Isopleth Ranges (dBA)**
- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)



REFERENCE MAP

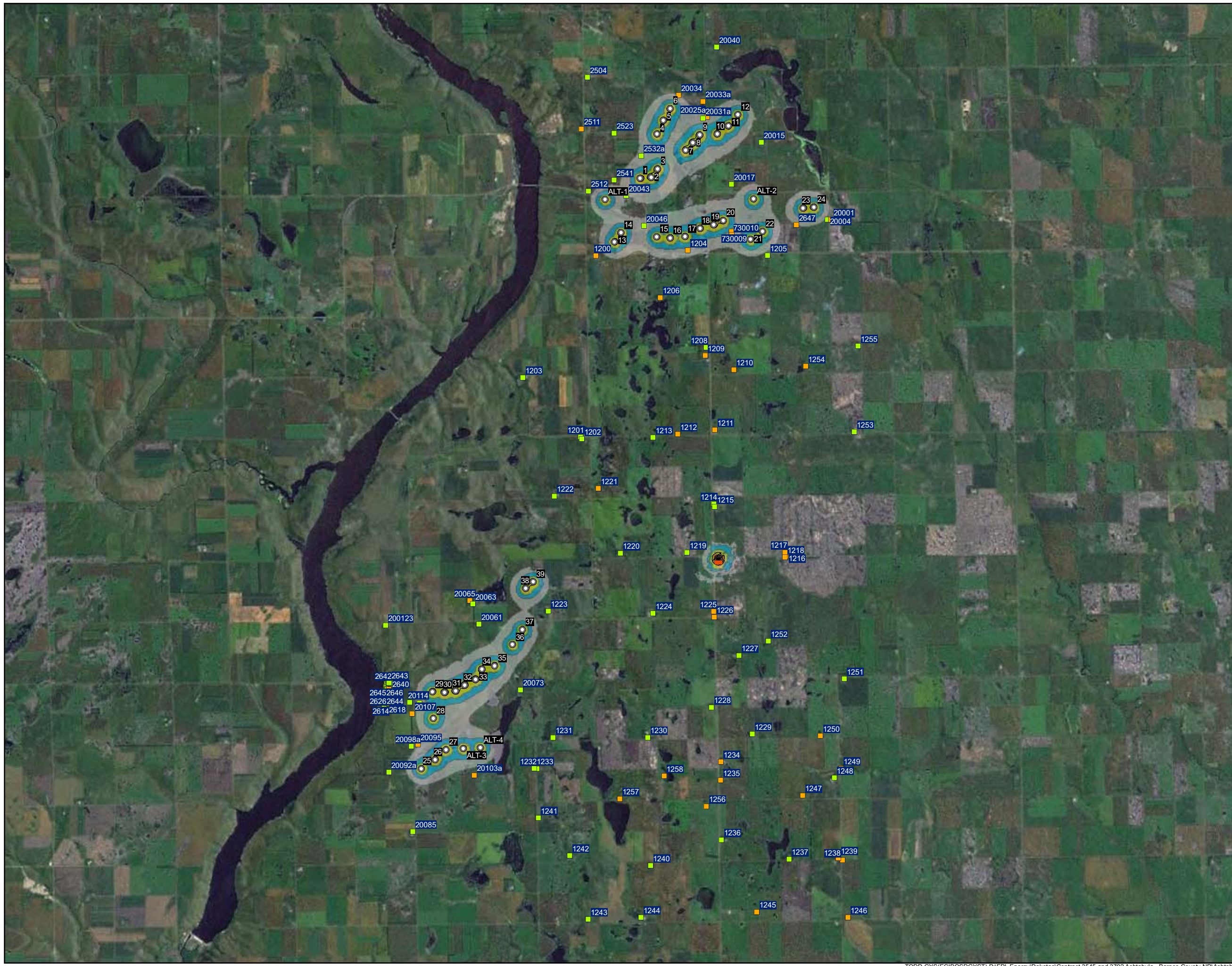


FIGURE 3  
 RECEIVED SOUND LEVELS:  
 WIND TURBINES AT MAXIMUM  
 ROTATION

JULY 2010



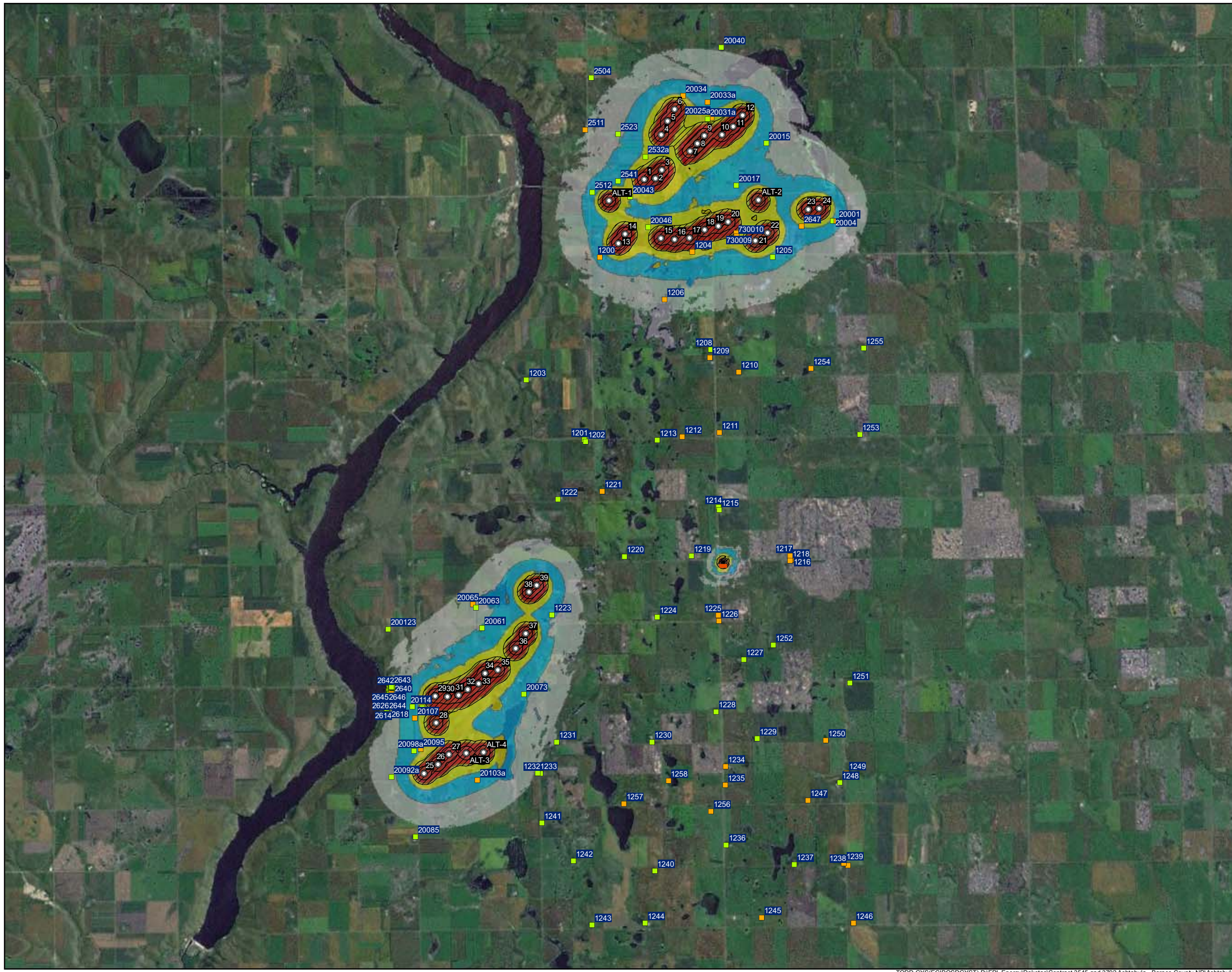
TETRA TECH EC, INC.

**Legend**

- Proposed Turbine Location
- Proposed Substation Location
- Receptor**
- Occupied
- Unoccupied / Non-Residential
- Isopleth Ranges (dBA)**
- 35 - 40
- 40 - 45
- 45 - 50
- >50
- Isopleth Range Exceeding EPA Guideline (>48.6 dBA)



**REFERENCE MAP**





NEXTERA ENERGY RESOURCES, LLC  
 ASHTABULA III WIND ENERGY CENTER  
 BARNES, GRIGGS, AND STEELE COUNTIES  
 NORTH DAKOTA

FIGURE 5  
 CUMULATIVE RECEIVED SOUND  
 LEVELS: WIND TURBINES AT CUT-IN

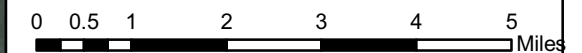
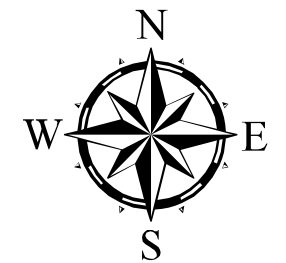
JULY 2010



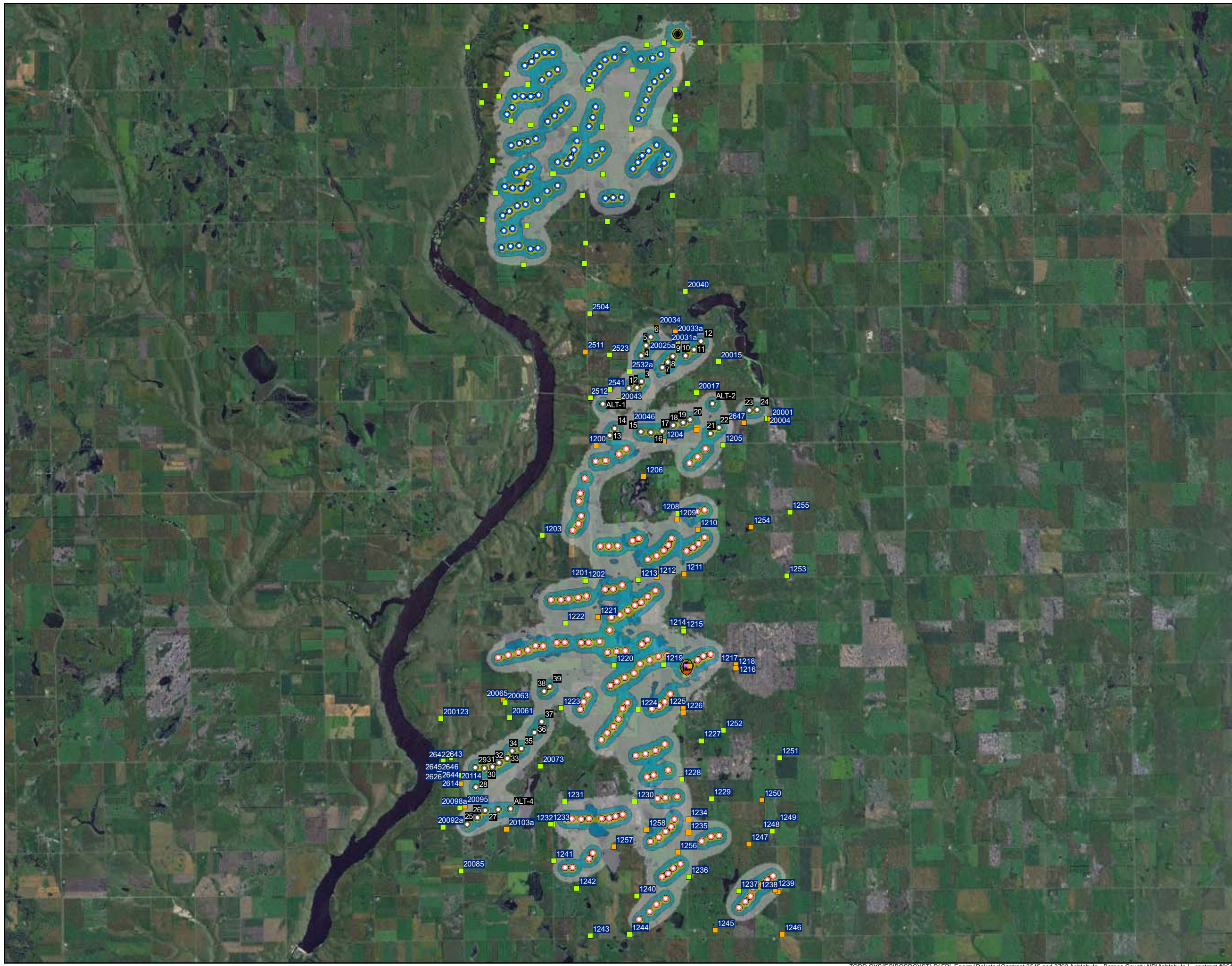
TETRA TECH EC, INC.

Legend

- Existing Ashtabula I GE 1.5 sle (dated January 26, 2010)
  - Existing Ashtabula II GE 1.5 xle (dated May 22, 2009)
  - Planned Ashtabula III GE 1.6 xle (dated May 13, 2010)
  - Existing Substation Location
  - Proposed Substation Location
- Receptor
- Occupied
  - Unoccupied / Non-Residential
- Cut-in Contours - 5 dB
- 35 - 40
  - 40 - 45
  - 45 - 50
  - >50
  - Isopleth Range Exceeding EPA Guideline (>48.6 dBA)



REFERENCE MAP



NEXTERA ENERGY RESOURCES, LLC  
 ASHTABULA III WIND ENERGY CENTER  
 BARNES, GRIGGS, AND STEELE COUNTIES  
 NORTH DAKOTA

FIGURE 6  
 CUMULATIVE RECEIVED SOUND  
 LEVELS: WIND TURBINES AT  
 MAXIMUM ROTATION

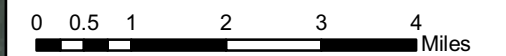
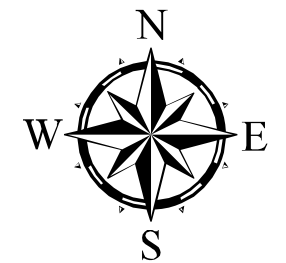
JULY 2010



TETRA TECH EC, INC.

Legend

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  - Existing Ashtabula II GE 1.5 xle (dated May 22, 2009)
  - Planned Ashtabula III GE 1.6 xle (dated May 13, 2010)
  - Existing Substation Location
  - Proposed Substation Location
- Receptor
- Occupied
  - Unoccupied / Non-Residential
- Isopleth Ranges (dBA)
- 35 - 40
  - 40 - 45
  - 45 - 50
  - >50
  - Isopleth Range Exceeding EPA Guideline (>48.6 dBA)



REFERENCE MAP

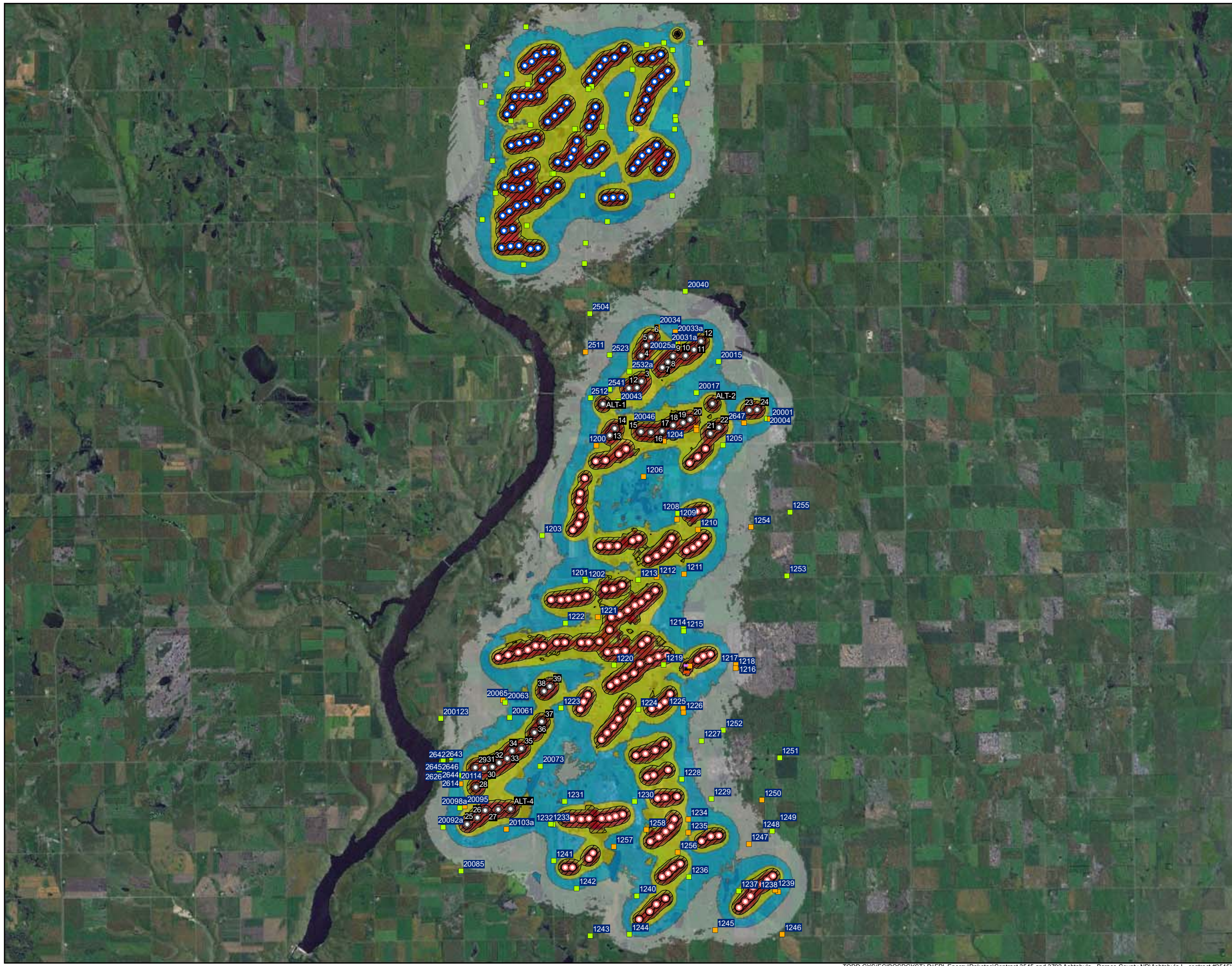


FIGURE 7  
 CUMULATIVE RECEIVED SOUND  
 LEVELS: WIND TURBINES AT MAXIMUM  
 ROTATION AND ANOMOLOUS  
 METEOROLOGICAL CONDITIONS

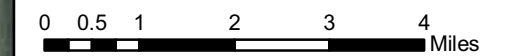
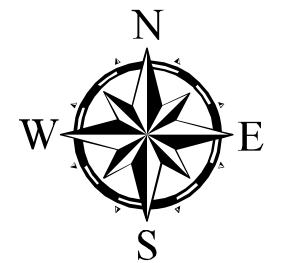


TETRA TECH EC, INC.

JULY 2010

Legend

- Existing Ashtabula I GE 1.5 sle (dated January 26, 2010)
  - Existing Ashtabula II GE 1.5 xle (dated May 22, 2009)
  - Planned Ashtabula III GE 1.6 xle (dated May 13, 2010)
  - Existing Substation Location
  - Proposed Substation Location
- Receptor
- Occupied
  - Unoccupied / Non-Residential
- Isopleth Ranges (dBA)
- 35 - 40
  - 40 - 45
  - 45 - 50
  - >50
  - Isopleth Range Exceeding EPA Guideline (>48.6 dBA)



REFERENCE MAP

