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**Brady II Wind Energy Center**  
**Acoustic Assessment**  
**Hettinger County, North Dakota**

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Prepared for



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**TABLE OF CONTENTS**

**EXECUTIVE SUMMARY .....iv**

**1.0 INTRODUCTION ..... 1**

    1.1 Study Area ..... 1

    1.2 Existing Acoustic Environment ..... 2

    1.3 Acoustic Terminology ..... 2

**2.0 NOISE REGULATIONS AND GUIDELINES ..... 5**

    2.1 State of North Dakota Public Service Commission Noise Regulations..... 5

    2.2 Hettinger County Zoning Ordinance ..... 5

**3.0 ACOUSTIC MODELING METHODOLOGY and Results..... 6**

    3.1 Acoustic Modeling Software and Calculation Methods ..... 6

    3.2 Acoustic Modeling Input Parameters ..... 8

    3.3 Acoustic Modeling Results ..... 9

**4.0 OTHER SOUND CONSIDERATIONS .....21**

    4.1 Cumulative Impacts .....21

    4.2 Substation Noise .....28

    4.3 Construction Noise .....29

**5.0 CONCLUSIONS .....31**

**6.0 TECHNICAL REFERENCES .....32**

**TABLES**

Table 1. Sound Pressure Levels ( $L_p$ ) and Relative Loudness of Typical Noise Sources and Soundscapes .....3

Table 2. Acoustic Terms and Definitions.....4

Table 3. Broadband Sound Power Levels (dBA) Correlated with Wind Speed (GE 1.79-100) .....8

Table 4. Broadband Sound Power Levels (dBA) Correlated with Wind Speed (GE 2.3-116) .....9

Table 5. Sound Power Level by Octave Band Center Frequency .....9

Table 6. Summary of Acoustic Modeling Results - No Alternate WTG Locations..... 11

Table 7. Summary of Acoustic Modeling Results - With Alternate WTG Locations ..... 16

Table 8. Broadband Sound Power Levels (dBA) Correlated with Wind Speed .....21

Table 9. Sound Power Level by Octave Band Center Frequency .....21

Table 10. Summary of Acoustic Modeling Results - Cumulative .....23

Table 11. Transformer Sound Power Level .....28

Table 12. Estimated  $L_{max}$  Sound Pressure Levels from Construction Equipment .....30

**APPENDIX A**

**FIGURES**

Figure 1. Project Layout.....34

Figure 2. With Alternates: Received Sound Levels—Wind Turbines at Cut-In Wind Speed .....35

Figure 3. No Alternates: Received Sound Levels—Wind Turbines at Cut-In Wind Speed .....36

Figure 4. With Alternates: Received Sound Levels—Wind Turbines at Maximum Rotational Wind Speed .....37

Figure 5. No Alternates: Received Sound Levels—Wind Turbines at Maximum Rotational Wind Speed .....38

Figure 6. With Alternates: Received Sound Levels—Wind Turbines at Maximum Rotational Wind Speed, Anomalous Meteorological Conditions .....39

Figure 7. No Alternates: Received Sound Levels—Wind Turbines at Maximum Rotational Wind Speed, Anomalous Meteorological Conditions .....40

Figure 8. Cumulative: Received Sound Levels—Wind Turbines at Cut-In Wind Speed.....41

Figure 9. Cumulative: Received Sound Levels—Wind Turbines at Maximum Rotational Wind Speed .....42

Figure 10. Cumulative: Received Sound Levels—Wind Turbines at Maximum Rotational Wind Speed, Anomalous Meteorological Conditions .....43

**ACRONYMS AND ABBREVIATIONS**

AGL	above ground level
CadnaA	Computer-Aided Noise Abatement Program
dB	decibel
dBA	A-weighted decibel
dBL	unweighted decibel
GE	General Electric
HH	hub height
Hz	Hertz
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
KHz	kilohertz
L <sub>eq</sub>	equivalent sound level
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 ampere
MW	megawatt
NEER	NextEra Energy Resources, LLC
NEMA	National Electrical Manufacturers Association
Project	Brady II Wind Energy Center
PSC	Public Service Commission
pW	picowatt
RD	rotor diameter
Tetra Tech	Tetra Tech, Inc.
μPa	microPascal
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
W	watt
WTG	wind turbine generator

## EXECUTIVE SUMMARY

Tetra Tech, Inc. (Tetra Tech) has completed an acoustic assessment for the proposed Brady II Wind Energy Center located in Hettinger County, North Dakota. A screening-level analysis was completed to evaluate the expected sound levels resulting from the Project wind turbine generators (WTGs) and substation. Although the Project would consist of up to 72 WTGs, 5 alternate WTG locations are included in the layout. Acoustic analyses were completed for the Project "With Alternates" and with "No Alternates" for three different modeling scenarios, for wind turbine operation at cut-in wind speed and at maximum rotational wind speed under both moderate downwind and anomalous meteorological conditions. Analysis of the Project "With Alternates" should be considered conservative, since only 72 WTGs will be built as part of the Project. The overall objective of this study was to determine the feasibility of the Project to operate in compliance with the applicable North Dakota Public Service Commission (PSC) 50 dBA noise limit. Finally, a cumulative impacts assessment was analyzed, which included both the proposed Project WTGs and the proposed Brady Wind Energy Center WTGs north of this Project.

Wind turbine sound source data was obtained from General Electric (GE), the manufacturer of the GE 2.1-116 (2.1 MW) as documented in the turbine noise specification section (GE 2015). Substation data were obtained Brady Wind II, LLC (Brady Wind II) based on a 170 megavolt ampere (MVA) transformer. It is expected that the GE WTGs and substation equipment installed will have similar sound profiles to what was used in the acoustic modeling analysis; however, it is possible that the final warranty sound power levels may vary slightly. Sound propagation modeling was conducted using the Computer-Aided Noise Abatement (CadnaA) program (version 4.6.153), a comprehensive 3-dimensional acoustic modeling computer simulation software, with calculations made in accordance with the International Organization for Standardization (ISO) standard 9613-2 "Attenuation of Sound during Propagation Outdoors". This acoustic modeling software is widely used by acoustical engineers due to its adaptability to evaluate complex acoustic scenarios.

The results of the acoustic modeling analysis were compared to the North Dakota PSC 50 dBA noise limit within 100 feet of an occupied residence. Acoustic modeling results showed that the Project will not generate exceedances of the North Dakota PSC noise limit at any occupied receptor locations.

## 1.0 INTRODUCTION

Brady Wind II, LLC (Brady Wind II), a wholly-owned, indirect subsidiary of NextEra Resources, LLC (NEER), proposes to construct and operate the Brady II Wind Energy Center (Project) in Stark and Hettinger Counties, North Dakota. Brady Wind II is proposing to construct up to 72 wind turbine generators (WTGs). The site layout dated April 22, 2016 includes 65 GE 2.1-116 WTGs, seven GE 1.79-100 WTGs, and five alternate GE 2.1-116 WTG locations. While no more than 72 WTGs will be built, one or more of the alternate WTG locations could be activated in the event that any of the primary WTG locations were eliminated. The rotor diameter of the GE 2.1-116 is 381 feet (116 meters) and it has a hub height (HH) of 262 feet (80 meters). The proposed Project infrastructure also includes a collection substation to enable interconnection to Basin Electric Power Cooperative's transmission system. The substation, which will serve both the proposed Brady Wind Energy Center and the proposed Project, would be located outside of the Brady II Study Area adjacent to 109<sup>th</sup> Avenue SW near its intersection with 52<sup>nd</sup> Street SW. Substation data were obtained from Brady Wind II based on a 170 megavolt ampere (MVA) transformer similar to the HICO 170 MVA transformer in use at other NEER energy facilities.

Acoustic analyses were completed for the Project "With Alternates" and with "No Alternates" for three different modeling scenarios, for wind turbine operation at cut-in wind speed and at maximum rotational wind speed under both moderate downwind and anomalous meteorological conditions. Analysis of the Project "With Alternates" should be considered conservative since only 72 WTGs will be built as part of the Project. Operational sounds levels resulting from the Project were analyzed at existing noise-sensitive receptors (e.g., residential structures) and compliance was assessed relative to the North Dakota Public Service Commission (PSC) noise limit. The results of this analysis are presented in section 3.3. Noise impacts in association with the proposed Brady Wind Energy Center, which is adjacent to the Project, were also modeled in the "Cumulative" assessment. The results of this analysis are presented in Section 4.1.

### 1.1 Study Area

The Brady II Study Area encompasses approximately 27,264 acres (43 square miles) in northern Hettinger County and southern Stark County, although all WTGs will be located in Hettinger County. County and township (section line) roads characterize the existing roadway infrastructure in and around the Study Area. The Study Area is accessed via I-94, U.S. Highway 85, State Highway 22, State Highway 8, and other local two-lane paved and gravel county roads. The land within the Study Area is primarily agricultural with scattered farmstead residences. The turbines will be located on privately-owned land in northern Hettinger County, approximately 15 miles south of Dickinson. This region of North Dakota has topography that can be described as level to rolling plains with isolated sandstone buttes or badlands formations to the west of the Study Area. Gentle slopes characterize most of the Study Area and local relief ranges from less than 2,670 to over 2,920 feet. Current land use within the Study Area is primarily agricultural, supporting both crops and livestock grazing.

Occupied and unoccupied structures are scattered throughout the Study Area. Potential noise sensitive receptor locations within the Study Area and in the vicinity of proposed turbine locations

were included in the acoustical analysis. Of these 175 receptors identified, 114 are occupied structures and 61 are unoccupied. Brady Wind II designed the Project using a minimum turbine setback of 2,000 feet from occupied residences, which exceeds Hettinger County's setback requirement of 1,320 feet. Figure 1 (Appendix A) presents the proposed Brady II WTGs, as well as the noise sensitive receptor locations.

## 1.2 Existing Acoustic Environment

Northern Hettinger County would generally be considered a rural agricultural area. Existing ambient sound levels are expected to be relatively low, although sound levels would be higher near roadways such as I-94, U.S. Highway 85, State Highway 22, State Highway 8. Other human activity such as agricultural operations would seasonally contribute to sound levels in the area associated with crop harvests. Background sound levels are expected to vary both spatially and temporally depending on proximity to area sound sources such as roadways and natural sounds. Typically, background sound levels are quieter during the night than during the daytime, except during periods when evening and nighttime insect noise may contribute to the soundscape, predominantly in the warmer seasons.

## 1.3 Acoustic Terminology

Airborne sound is described as the rapid fluctuation or oscillation of air pressure above and below atmospheric pressure, creating a sound wave. Sound is characterized by properties of the sound waves, which are frequency, wavelength, period, amplitude, and velocity. Noise is defined as unwanted sound. A sound source is defined by a sound power level ( $L_w$ ), which is independent of any external factors. The acoustic 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 and can be directly determined with a microphone or calculated from information about the source sound power level and the surrounding environment through predictive acoustic modeling. While the sound power of a source is strictly a function of the total amount of acoustic energy being radiated by the source, the sound pressure levels produced by a source are a function of the distance from the source and the effective radiating area or physical size of the source. In general, the magnitude of a source's sound power level is always considerably higher than the observed sound pressure level near a source due to the fact that the acoustic energy is being radiated in various directions.

Sound levels are presented on a logarithmic scale to account for the large pressure response range of the human ear, and are expressed in units of decibels (dB). A dB 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 commonly referenced to 1 picowatt (pW), which is one trillionth of a watt. Broadband sound includes sound energy summed across the frequency spectrum. In addition to broadband sound pressure levels, analysis of the various frequency components of the sound spectrum is often completed to determine tonal characteristics. The unit of frequency is Hertz (Hz), which corresponds to the rate in cycles per second that sound pressure waves are generated. Typically, a sound frequency

analysis examines 11 octave (or 33 1/3 octave) bands ranging from 20 Hz (low) to 20,000 Hz (high). This range encompasses the entire human audible frequency range. Since the human ear does not perceive every frequency with equal loudness, spectrally varying 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. Sound exposure in acoustic assessments is commonly measured and calculated as A-weighted dB (dBA). Unweighted sound levels are referred to as linear. Linear dB are used to determine a sound's tonality and to engineer solutions to reduce or control noise as techniques are different for low and high frequency noise. Sound levels that are linear in this report are presented as dBL.

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 in the State of North Dakota. Estimates of noise sources and outdoor acoustic environments, and the comparison of relative loudness are presented in Table 1. Table 2 provides additional reference information on acoustic terminology.

**Table 1. Sound Pressure Levels ( $L_p$ ) and Relative Loudness of Typical Noise Sources and Soundscapes**

Noise Source or Activity	Sound Level (dBA)	Subjective Impression	Relative Loudness (perception of different sound levels)
Jet aircraft takeoff from carrier (50 ft)	140	Threshold of pain	64 times as loud
50-hp siren (100 ft)	130		32 times as loud
Loud rock concert near stage or Jet takeoff (200 ft)	120	Uncomfortably loud	16 times as loud
Float plane takeoff (100 ft)	110		8 times as loud
Jet takeoff (2,000 ft)	100	Very loud	4 times as loud
Heavy truck or motorcycle (25 ft)	90		2 times as loud
Garbage disposal, food blender (2 ft), or Pneumatic drill	80	Loud	Reference loudness
Vacuum cleaner (10 ft)	70		1/2 as loud
Passenger car at 65 mph (25 ft)	65	Moderate	
Large store air-conditioning unit (20 ft)	60		1/4 as loud
Light auto traffic (100 ft)	50	Quiet	1/8 as loud
Quiet rural residential area with no activity	45		
Bedroom or quiet living room or Bird calls	40	Faint	1/16 as loud
Typical wilderness area	35		
Quiet library, soft whisper (15 ft)	30	Very quiet	1/32 as loud
Wilderness with no wind or animal activity	25	Extremely quiet	
High-quality recording studio	20		1/64 as loud
Acoustic test chamber	10	Just audible	
	0	Threshold of hearing	

Adapted from: Beranek 1988; EPA 1971

**Table 2. Acoustic Terms and Definitions**

<b>Term</b>	<b>Definition</b>
Noise	Typically defined as unwanted sound. This word adds the subjective response of humans to the physical phenomenon of sound. It is commonly used 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 1,000 Hz.
Sound Power Level (L <sub>w</sub> )	The total acoustic power of a noise source measured in decibels referenced to picowatts (one trillionth of a watt). Noise specifications are provided by equipment manufacturers as sound power as it is independent of the environment in which it is located. A sound level meter does not directly measure sound power.
A-Weighted Decibel (dBA)	Environmental sound is typically composed of acoustic energy across all frequencies. 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.
Unweighted Decibels (dBL)	Unweighted sound levels are referred to as linear. Linear decibels are used to determine a sound's tonality and to engineer solutions to reduce or control noise as techniques are different for low and high frequency noise. Sound levels that are linear are presented as dBL 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 Hz and is typically divided into center frequencies ranging from 31 to 8,000 Hz for noise modeling evaluations.
Broadband Sound	Noise which covers a wide range of frequencies within the audible spectrum, i.e., 200 to 2,000 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.
Frequency (Hz)	The rate of oscillation of a sound, measured in units of Hz or kilohertz (kHz). One hundred Hz is a rate of one hundred times (or cycles) 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.

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

## 2.0 NOISE REGULATIONS AND GUIDELINES

A review was conducted of noise regulations applicable to the Project at the federal, state, county, and local levels. There are no federal environmental noise requirements specific to this Project. At the state level, the PSC has established regulations applicable to wind energy facilities. Hettinger County also provides noise limits applicable to the Project via their land use regulations. The controlling regulation for the Project is the PSC's noise limit, which is more stringent than the requirements prescribed by Hettinger County. Both the State's and County's noise regulations are summarized in the subsections that follow.

### 2.1 State of North Dakota Public Service Commission Noise Regulations

North Dakota adopted noise regulations for wind energy facilities under the PSC Chapter 69-06-08-01(4) as follows:

*A wind energy conversion facility site must not include a geographic area where, due to operation of the facility, the sound levels within one hundred feet of an inhabited residence or a community building will exceed fifty dBA. The sound level avoidance area criteria may be waived in writing by the owner of the occupied residence or the community building.*

Sound levels resulting from the Project within 100 feet of all identified receptors located in the vicinity of the Project were assessed against the 50 dBA limit to determine whether compliance was achieved. The PSC noise limit is absolute and independent of the existing acoustic environment; therefore, a baseline sound survey is not required to assess conformity.

### 2.2 Hettinger County Zoning Ordinance

The Hettinger County land use regulations include maximum day and night sound level limits in Section 6.7 that are applicable to the Project, specifically:

*Section 6.7—Sustained noise of over 75 decibels (dB) during the day and 65 dB at night is prohibited.*

The 65 dB nighttime limit prescribed by Hettinger County is less conservative than that prescribed by the PSC, so by achieving compliance with the PSC requirements, compliance with the Hettinger County Land Use Regulations is also obtained.

### 3.0 ACOUSTIC MODELING METHODOLOGY AND RESULTS

Sound generated by an operating WTG is comprised of both aerodynamic and mechanical sound with the dominant sound component from modern utility scale WTGs being largely aerodynamic. Aerodynamic sound refers to the sound produced from air flow and the interaction with the WTG tower structure and moving rotor blades. 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 minimized. Sound reduction elements designed as a part of the WTGs include impact noise insulation of the gearbox and generator, sound reduced gearbox, sound reduced nacelle, and rotor blades designed to minimize noise generation.

Wind energy facilities, in comparison to other energy-related facilities, are somewhat unique in that the sound generated by each individual WTG will increase as the wind speed across the site increases. 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 maximum rotational speed are achieved. Under this condition, the WTG maximum sound power level will be reached at approximately 7 meters per second [m/s], according to the GE specifications. It is important to recognize as wind speeds increase, the background ambient sound level will generally increase as well, resulting in acoustic masking effects; however, this trend is also affected by local contributing sound sources. The net result is that during periods of elevated wind speeds when higher WTG sound emissions occur, the sound produced from a WTG operating at maximum rotational speed may be largely or fully masked due to wind generated sound in foliage or vegetation. In practical terms, this means a nearby receptor would tend to hear leaves or vegetation rustling rather than WTG noise. This relationship is expected to further minimize the potential for any adverse noise effects of the Project. Conversely, these acoustic masking effects may be limited during periods of unusually high wind shear or at receiver locations that are sheltered from the prevailing wind direction.

#### 3.1 Acoustic Modeling Software and Calculation Methods

The operational acoustic assessment was performed using the proposed Project WTG layout dated April 22, 2016 which includes 65 GE 2.1-116 WTGs, seven GE 1.79-100 WTGs, and five alternate GE 2.1-116 WTG locations. The operational acoustic assessment included an evaluation "With Alternates" consisting of 77 WTG locations (72 planned WTG locations and an additional 5 alternate locations), and an evaluation with "No Alternates" consisting of 72 WTG locations. The Project would use the GE 2.1-116 WTG model, which has a rotor diameter of 381 feet (116 meters) and a hub height of 262 feet (80 meters), and the GE 1.79-100 WTG model, which has a rotor diameter of 328 feet (100 meters) and a hub height of 262 feet (80 meters). The Project would also include a collection substation with a 170 MVA transformer. WTG sound source data were obtained from GE (GE 2013, 2014, and 2015) and substation transformer data were obtained from Brady Wind II.

The acoustic modeling analysis was conducted using the most recent version of DataKustic GmbH's computer-aided noise abatement program or CadnaA (v 4.6.153). CadnaA is a comprehensive 3-dimensional acoustic software model that conforms to the International Organization for Standardization (ISO) standard ISO 9613-2 "Attenuation of Sound during Propagation Outdoors." The engineering methods specified in this standard consist of full (1/1) octave band algorithms that incorporate geometric spreading due to wave divergence, reflection from surfaces, atmospheric absorption, screening by topography and obstacles, ground effects, source directivity, heights of both sources and receptors, seasonal foliage effects, and meteorological conditions. 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  $G=0$  for acoustically hard, reflective surfaces and  $G=1$  for absorptive surfaces and soft ground. If the ground is hard-packed dirt, typically found in industrial complexes, pavement, bare rock or for sound traveling over water, the absorption coefficient is defined as  $G=0$  to account for reduced sound attenuation and higher reflectivity. In contrast, ground covered in 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.,  $G=1.0$ ). A mixed (semi-reflective) ground factor of  $G=0.5$  was used in the Project acoustic modeling analysis. In addition to geometrical divergence, attenuation factors include topographical features, terrain coverage, and/or other natural or anthropogenic obstacles that can affect sound attenuation and result in acoustical screening. To be conservative, sound attenuation through foliage and diffraction around and over existing anthropogenic structures such as buildings was not included in the model.

Sound attenuation by the atmosphere is not strongly dependent on temperature and humidity; however, the temperature of 10°Celsius (50°Fahrenheit) and 70 percent relative humidity parameters were selected as reasonably representative of conditions favorable to sound propagation. Atmospheric absorption depends on temperature and humidity and is most important at higher frequencies. Over short distances, the effects of atmospheric absorption are minimal. The ISO 9613-2 standard calculates attenuation for meteorological conditions favorable to propagation, i.e., downwind sound propagation or what might occur typically during a moderate atmospheric ground level inversion. Though a physical impracticality, the ISO 9613-2 standard simulates omnidirectional downwind propagation. For receivers located between discrete WTG locations or WTG groupings, the acoustic model may result in over-prediction. In addition, 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. These anomalous meteorological conditions may include well-

developed moderate ground-based temperature inversions and Low Level Jets (LLJs). While the North Dakota PSC does not specifically require or suggest that these meteorological conditions be explicitly addressed in modeling assessments, ISO 9613-2 includes a methodology to account for effects produced under these conditions and so they were addressed to ensure a conservative assessment.

**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 per International Electrotechnical Commission (IEC) standard IEC 61400-11:2006 Wind Turbine Generator Systems—Part 11: Acoustic Noise Measurement Techniques. This accepted IEC standard was developed to ensure consistent and comparable sound emission data of utility-scale WTGs between manufacturers. Tables 3 and 4 present a summary of sound power data for the GE 1.79-100 and GE 2.1-116 WTGs during normal operations correlated to 10 meter height integer wind speeds 10 meter above ground level (AGL) with a stated roughness length<sup>1</sup> of 0.05 meters, which is representative of level grass-covered terrain (GE 2015). The sound power data for the GE 2.1-116 WTG is not yet available, so data for the GE 2.3-116 WTG was used. GE stated that the sound power profile for the GE 2.3-116 WTG is effectively the same as the profile for the GE 2.1-116 WTG, and therefore this data substitution should not impact results.

The specification for the WTGs includes an expected warranty confidence interval, or k-factor, of 2 dB, which was added to the nominal sound power level in the acoustic model. This confidence interval incorporates the uncertainty in independent sound power level measurements conducted, the applied probability level and standard deviation for test measurement reproducibility, and product variability.

**Table 3. Broadband Sound Power Levels (dBA) Correlated with Wind Speed (GE 1.79-100)**

10-meter AGL Wind Speed	WTG L <sub>max</sub> Sound Power Level (L <sub>w</sub> ) at Reference Wind Speed							
	11.2 mph (5 m/s)	12.3 mph (5.5 m/s)	13.4 mph (6 m/s)	14.5 mph (6.5 m/s)	15.7 mph (7 m/s)	17.9 mph (8 m/s)	20.1 mph (9 m/s)	22.4 mph (10 m/s)
GE 1.79-100	98.6	101.0	103.2	105.5	107.2	107.5	107.5	107.5

<sup>1</sup> The roughness length describes the vertical wind profile per IEC specification in a neutral atmosphere with the wind profile following a logarithmic curve.

**Table 4. Broadband Sound Power Levels (dBA) Correlated with Wind Speed (GE 2.3-116)**

Wind Speed	WTG L <sub>max</sub> Sound Power Level (L <sub>w</sub> ) at Reference Wind Speed									
	8.9	11.2	13.4	15.7	17.9	14.5	20.1	24.6	26.7	29.1
	mph (4.0 m/s)	mph (5.0 m/s)	mph (6.0 m/s)	mph (7.0 m/s)	mph (8.0 m/s)	mph (9.0 m/s)	mph (10.0 m/s)	mph (11.0 m/s)	mph (12.0 m/s)	mph (13.0 m/s)
GE 2.3-116	95.0	95.8	98.2	101.6	104.5	105.8	107.5	107.5	107.5	107.5

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, it is assumed that WTG directivity and sound generating efficiencies are inherently incorporated in the sound source data and used in acoustic model development. A summary of sound power data by octave band center frequency for both WTGs operating at maximum rotation are presented in Table 5 (1/1 octave band frequency data provided with stated intended use limited for informational purposes only).

**Table 5. 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 1.79-100	91.0	96.1	98.0	100.8	103.3	100.0	90.3	70.6	107.5
GE 2.3-116	89.0	95.1	99.6	102.8	102.5	97.6	87.4	66.8	107.5

### 3.3 Acoustic Modeling Results

Acoustic modeling was completed for WTG cut-in and maximum rotational operating conditions, thereby describing resultant sound pressure levels over the entire operational range of the Project "With Alternates" and with "No Alternates". In addition, sound energy contribution from the Project substation was included in the acoustic modeling analysis. When calculating received sound levels, it was assumed that the Project substation and all WTGs were operating concurrently at the given operating condition. Sound contour plots displaying Project operational sound levels in color-coded isopleths are provided in Figures 2 through 8, in Appendix A. Figures 2 and 3 display the broadband operational sound levels under low-level wind speeds sufficient for the WTGs to operate at initial cut-in rotational speeds. Figures 4 and 5 display broadband operational sound levels at wind speeds sufficient to sustain WTG operation at maximum rotational speeds for moderate downwind propagation. Figures 6 and 7 display broadband operational sound levels at wind speeds sufficient to sustain WTG operation at maximum rotational speeds under anomalous meteorological conditions.

Tables 6 and 7 present the results of the Brady II Wind Energy Center acoustic modeling analysis and includes the ID, Universal Transverse Mercator (UTM) coordinates, receptor status and the received sound levels at each receptor. Table 6 presents results for the Project with "No

Alternates” and Table 7 presents the results for the Project “With Alternates”. Received sound levels are rounded to the nearest whole decimal for consistency with the State of North Dakota noise limit absolute value of 50 dBA. In addition, a 100-foot buffer was included around the receptors, corresponding to the point of compliance identified in the PSC 50 dBA noise limit.

The acoustic modeling results shown in Tables 6 and 7 demonstrate that received sound levels are all below the PSC 50 dBA noise limit at all occupied receptors.

Table 6. Summary of Acoustic Modeling Results - No Alternate WTG Locations

Receptor ID	Receptor Status		UTM Coordinates (NAD83 UTM Zone 13 meters)		Nearest Wind Turbine	Distance to Nearest Wind Turbine (m)	Received Sound Level		
	Occupied/Unoccupied	Participant/Non-participant	Easting (m)	Northing (m)			Cut-in Rotation (dBA)	Maximum Rotation (dBA)	Maximum Rotation under Anomalous (dBA)
401	Occupied	Non-participant*	681106	5162818	67	2,819	20	32	34
404	Occupied	Non-participant*	681064	5162775	67	2,768	19	31	34
390009	Unoccupied	Participant	673486	5163982	50	319	41	50	51
400006	Unoccupied	Non-participant	680072	5176797	53	11,734	1	12	15
400037	Unoccupied	Non-participant	681527	5177443	53	12,895	<1	11	14
420002	Occupied	Non-participant	688875	5171095	25	5,033	17	28	31
420023	Occupied	Non-participant	668410	5170735	25	4,764	16	28	31
420029	Occupied	Non-participant	668316	5170507	24	4,557	16	28	31
420039	Occupied	Non-participant	667891	5171580	24	5,689	16	28	30
420047	Occupied	Non-participant	667886	5171532	24	5,642	12	24	26
420051	Occupied	Non-participant	664044	5171213	19	5,361	16	28	31
420065	Occupied	Non-participant	664088	5171360	19	5,505	16	28	31
420069	Occupied	Non-participant	663975	5171244	19	5,398	16	28	31
420076	Occupied	Non-participant	663894	5171299	19	5,482	15	27	30
420089	Occupied	Non-participant	663065	5171180	18	5,492	16	28	31
420090	Occupied	Non-participant	662974	5171187	18	5,516	16	28	29
420100	Occupied	Non-participant	662342	5170932	5	5,299	16	28	31
420108	Occupied	Non-participant	662543	5170920	5	5,316	16	28	31
420116	Occupied	Non-participant	662765	5170601	18	4,992	16	29	31
420117	Occupied	Non-participant	654920	5169153	2	6,501	6	18	21
420119	Occupied	Non-participant	660825	5167514	5	2,013	24	36	38
450548	Occupied	Non-participant	681287	5160073	71	2,935	16	29	31
450554	Unoccupied	Non-participant	681307	5160130	71	2,946	17	30	32
450562	Unoccupied	Non-participant	679454	5163350	67	1,577	23	36	38
450563	Unoccupied	Non-participant	679450	5164236	59	2,001	23	35	37
500002	Occupied	Non-participant	680617	5158589	71	2,988	17	30	32
500006	Occupied	Non-participant	679633	5157936	71	2,927	18	31	33
500012	Occupied	Non-participant	679628	5157991	71	2,875	19	31	33
500016	Unoccupied	Non-participant	679508	5163376	67	1,633	22	35	36
500018	Unoccupied	Non-participant	679256	5165366	59	2,275	21	33	36
500022	Occupied	Non-participant	677510	5165047	56	924	28	41	41
500028	Occupied	Non-participant	677401	5165136	56	870	28	41	42
500032	Unoccupied	Participant	677690	5161966	66	587	35	47	47
500033	Unoccupied	Non-participant	674884	5159598	65	870	28	41	42
500035	Occupied	Non-participant*	673147	5158516	63	2,489	21	33	35

Table 6. Summary of Acoustic Modeling Results - No Alternate WTG Locations

Receptor ID	Receptor Status		UTM Coordinates (NAD83 UTM Zone 13 meters)		Nearest Wind Turbine	Distance to Nearest Wind Turbine (m)	Received Sound Level		
	Occupied/Unoccupied	Participant/Non-participant	Easting (m)	Northing (m)			Cut-in Rotation (dBA)	Maximum Rotation (dBA)	Maximum Rotation under Anomalous (dBA)
500039	Occupied	Non-participant	671766	5158494	46	3,356	19	31	33
500053	Occupied	Non-participant	672221	5159146	63	2,638	22	34	36
500054	Unoccupied	Non-participant	671612	5161365	57	2,390	22	34	36
500055	Unoccupied	Non-participant	670870	5158304	49	2,556	22	34	36
500059	Occupied	Non-participant*	669892	5159454	46	1,261	29	39	41
500064	Occupied	Non-participant*	669899	5159550	46	1,213	29	40	42
500068	Unoccupied	Non-participant	669196	5158847	48	867	30	41	42
500076	Unoccupied	Non-participant	666743	5158531	36	951	28	40	42
501000	Occupied	Non-participant	684105	5172245	53	10,357	2	14	16
501012	Occupied	Non-participant	681646	5173097	53	9,231	9	20	23
501019	Occupied	Non-participant	680468	5175745	53	10,909	1	13	16
501022	Occupied	Non-participant	680563	5175382	53	10,620	2	13	16
501030	Occupied	Non-participant	679723	5174632	53	9,592	3	15	17
501037	Occupied	Non-participant	679731	5171167	53	6,541	7	19	22
501040	Occupied	Non-participant	678406	5173332	53	7,915	5	17	20
501050	Occupied	Non-participant	678419	5173433	53	8,015	5	17	19
501053	Unoccupied	Non-participant	678555	5173259	53	7,893	5	17	20
501059	Occupied	Non-participant	678568	5173250	53	7,888	5	17	20
501065	Occupied	Non-participant	678822	5170399	53	5,401	14	26	28
501068	Occupied	Non-participant	677851	5169797	53	4,411	15	26	28
501073	Occupied	Non-participant	681345	5169634	53	6,580	7	19	21
501081	Occupied	Non-participant	681279	5169706	53	6,568	7	19	21
501082	Occupied	Non-participant	675433	5171946	53	6,182	13	24	27
501083	Unoccupied	Non-participant	666768	5166374	23	473	34	46	47
501085	Occupied	Non-participant	672965	5164410	50	901	33	42	43
501096	Occupied	Non-participant	672947	5164396	50	899	33	42	43
501097	Unoccupied	Non-participant	667485	5163313	30	1,299	28	40	42
501099	Occupied	Participant	675017	5163411	54	856	31	42	44
501104	Occupied	Participant	675027	5163439	54	828	31	42	44
501108	Occupied	Non-participant	670613	5160034	46	1,742	26	37	39
501118	Occupied	Non-participant	659777	5163091	11	1,123	28	40	41
501122	Unoccupied	Non-participant	661117	5163653	11	340	38	51	51
501126	Occupied	Non-participant	663477	5163902	16	1,049	29	42	43
501131	Occupied	Non-participant	664747	5163175	22	2,051	24	36	38
501138	Occupied	Participant	664349	5164755	17	680	33	45	46
501141	Occupied	Non-participant	665127	5163747	22	1,382	27	39	41

Table 6. Summary of Acoustic Modeling Results - No Alternate WTG Locations

Receptor ID	Receptor Status		UTM Coordinates (NAD83 UTM Zone 13 meters)		Nearest Wind Turbine	Distance to Nearest Wind Turbine (m)	Received Sound Level		
	Occupied/Unoccupied	Participant/Non-participant	Easting (m)	Northing (m)			Cut-in Rotation (dBA)	Maximum Rotation (dBA)	Maximum Rotation under Anomalous (dBA)
501147	Occupied	Non-participant	665442	5161863	30	1,855	22	35	36
501156	Occupied	Participant	674657	5162748	58	717	32	44	45
501162	Occupied	Non-participant	666164	5171091	23	5,054	13	25	28
501165	Occupied	Non-participant	668751	5170669	25	4,630	17	29	32
501168	Occupied	Non-participant	666562	5170280	23	4,237	14	26	29
501172	Occupied	Non-participant	662856	5171199	18	5,552	16	28	31
501173	Occupied	Non-participant	661884	5171096	5	5,422	15	28	30
501174	Occupied	Non-participant	661893	5171077	5	5,404	15	28	30
501175	Occupied	Non-participant	661018	5169979	5	4,347	17	30	32
501176	Occupied	Non-participant	660668	5170916	5	5,329	15	27	30
610001	Occupied	Non-participant	657943	5169457	2	4,918	15	28	30
610009	Occupied	Non-participant*	657243	5168249	2	4,229	16	28	31
610014	Occupied	Non-participant*	657329	5168365	2	4,270	16	28	31
610018	Unoccupied	Non-participant	657481	5167671	2	3,632	16	29	31
610021	Occupied	Non-participant	658588	5168791	2	4,068	12	25	27
610025	Occupied	Non-participant	659083	5169071	4	4,125	17	30	32
610031	Occupied	Non-participant	660171	5167459	4	2,186	23	35	37
610042	Occupied	Non-participant	662190	5167946	5	2,330	20	33	35
610045	Occupied	Non-participant	662204	5167951	5	2,338	20	33	35
610049	Occupied	Non-participant	662204	5167996	5	2,382	19	32	34
610053	Occupied	Non-participant	660882	5167398	5	1,884	24	37	39
610057	Occupied	Non-participant	660875	5167437	5	1,922	24	37	39
610059	Unoccupied	Non-participant	662665	5165804	10	394	39	51	51
610063	Unoccupied	Non-participant	661981	5166658	5	1,033	30	42	44
610079	Unoccupied	Non-participant	661982	5163992	12	436	37	49	50
610084	Occupied	Non-participant*	666867	5164930	23	1,197	27	39	41
610089	Occupied	Non-participant*	668413	5169125	24	3,179	20	32	34
610091	Unoccupied	Non-participant	668196	5169582	24	3,671	19	30	33
610094	Occupied	Non-participant	663473	5168761	18	3,040	21	33	35
610098	Occupied	Non-participant	664446	5167109	19	1,239	27	40	41
610102	Occupied	Non-participant*	669505	5169577	25	3,472	18	29	31
610108	Occupied	Non-participant*	669518	5169514	25	3,409	19	31	34
610111	Occupied	Non-participant	670742	5169632	25	3,729	20	32	34
610116	Unoccupied	Non-participant	671898	5169600	42	3,504	31	43	46
610118	Unoccupied	Non-participant	671916	5169648	42	3,545	30	43	46
610121	Occupied	Participant	672258	5168851	42	2,694	27	39	42

Table 6. Summary of Acoustic Modeling Results - No Alternate WTG Locations

Receptor ID	Receptor Status		UTM Coordinates (NAD83 UTM Zone 13 meters)		Nearest Wind Turbine	Distance to Nearest Wind Turbine (m)	Received Sound Level		
	Occupied/Unoccupied	Participant/Non-participant	Easting (m)	Northing (m)			Cut-in Rotation (dBA)	Maximum Rotation (dBA)	Maximum Rotation under Anomalous (dBA)
610125	Unoccupied	Non-participant	672486	5168786	42	3,593	32	44	47
610130	Unoccupied	Non-participant	673973	5169036	42	3,085	18	30	33
610134	Unoccupied	Non-participant	674002	5169040	42	3,100	18	30	33
610139	Occupied	Non-participant	675879	5170362	53	4,572	14	25	28
610144	Unoccupied	Non-participant	675675	5169238	53	3,464	19	31	33
610145	Unoccupied	Non-participant	675358	5166322	53	838	29	41	42
610149	Occupied	Non-participant	674773	5165354	52	1,050	31	43	44
610155	Unoccupied	Non-participant	669844	5164888	28	653	33	46	46
610164	Unoccupied	Non-participant	669893	5164876	28	693	33	46	46
610170	Occupied	Participant	667574	5164565	26	1,627	27	39	41
610181	Occupied	Participant	670466	5167264	25	1,490	23	34	38
610185	Occupied	Participant	670516	5167245	25	1,507	23	34	36
610188	Unoccupied	Non-participant	668519	5166787	24	925	28	41	42
610190	Unoccupied	Non-participant	669313	5167829	25	1,737	22	34	37
610194	Unoccupied	Non-participant	669326	5167878	25	1,785	21	33	35
610197	Unoccupied	Non-participant	673253	5168730	42	2,576	21	33	36
610203	Unoccupied	Non-participant	670759	5168861	25	3,018	21	32	35
706192	Unoccupied	Non-participant	656694	5166353	1	3,456	17	30	32
800288	Unoccupied	Non-participant	670007	5160023	46	1,142	29	40	41
800288	Unoccupied	Non-participant	664145	5164372	17	1,003	31	43	44
800292	Unoccupied	Non-participant	664102	5164281	17	1,090	30	43	44
800304	Unoccupied	Non-participant	670346	5166290	25	837	29	41	42
800308	Occupied	Participant	667354	5158391	36	861	30	42	43
800311	Occupied	Participant	667332	5158349	36	903	28	40	41
800317	Occupied	Non-participant	662260	5158285	36	5,195	13	25	28
800342	Unoccupied	Non-participant	670035	5161380	40	993	30	41	43
800364	Unoccupied	Non-participant	669001	5162054	40	279	39	52	52
811069	Unoccupied	Non-participant	682736	5175254	53	11,613	1	12	15
811201	Occupied	Non-participant	680019	5177169	53	12,066	0	12	15
811205	Occupied	Non-participant	679691	5178020	53	12,773	<1	12	14
811210	Occupied	Non-participant	680887	5178421	53	13,541	<1	11	14
811214	Unoccupied	Non-participant	680759	5178424	53	13,498	<1	11	14
811217	Unoccupied	Non-participant	680753	5178482	53	13,551	<1	11	14
811224	Unoccupied	Non-participant	680747	5178483	53	13,549	<1	11	14
811228	Unoccupied	Non-participant	682023	5174120	53	10,276	2	14	16
811231	Unoccupied	Non-participant	682042	5174165	53	10,324	2	14	16

Table 6. Summary of Acoustic Modeling Results - No Alternate WTG Locations

Receptor ID	Receptor Status		UTM Coordinates (NAD83 UTM Zone 13 meters)		Nearest Wind Turbine	Distance to Nearest Wind Turbine (m)	Cut-in Rotation (dBA)		Received Sound Level	
	Occupied/Unoccupied	Participant/Non-participant	Easting (m)	Northing (m)			Maximum Rotation	Maximum Rotation Anomalous (dBA)		
811236	Unoccupied	Non-participant	682274	5174639	53	10,844	1	13	16	
811237	Unoccupied	Non-participant	679990	5178775	53	13,592	<1	11	14	
811285	Unoccupied	Non-participant	657284	5169323	2	5,095	15	27	30	
811287	Occupied	Non-participant	655467	5168218	2	5,489	8	20	23	
811290	Occupied	Non-participant	650090	5167200	1	9,782	1	13	16	
880001	Occupied	Non-participant	680270	5173773	53	9,051	8	20	23	
900002	Occupied	Participant	661988	5161930	11	2,051	23	35	37	
900007	Occupied	Participant	662323	5161469	11	2,621	21	33	36	
900011	Occupied	Non-participant	662065	5161089	11	2,810	20	32	34	
900015	Occupied	Non-participant	658130	5161120	1	3,339	18	30	33	
900019	Occupied	Non-participant	658166	5161105	1	3,340	18	30	33	
900025	Unoccupied	Non-participant	666717	5161478	31	754	32	44	45	
900027	Occupied	Non-participant	664500	5161670	30	2,813	23	35	38	
900031	Occupied	Non-participant	665522	5158935	36	1,869	24	36	38	
900035	Occupied	Non-participant*	665494	5159171	36	1,872	24	36	38	
900039	Occupied	Non-participant*	665496	5159110	36	1,873	24	36	38	
900042	Unoccupied	Non-participant	666233	5158189	36	1,552	25	37	39	
900047	Occupied	Non-participant	663971	5160025	37	3,418	16	29	31	
900053	Occupied	Non-participant	664011	5160036	37	3,379	19	31	33	
900056	Unoccupied	Non-participant	664009	5160071	37	3,386	19	31	34	
900059	Occupied	Non-participant	665090	5160153	37	2,331	23	35	38	
900063	Unoccupied	Non-participant	665463	5160848	31	1,838	24	37	39	
900068	Unoccupied	Non-participant	665093	5160747	31	2,217	22	34	37	
900070	Occupied	Non-participant	679567	5171280	53	6,543	10	22	23	
900537	Unoccupied	Non-participant	662248	5160947	11	3,021	20	32	34	
900539	Unoccupied	Non-participant	659745	5159757	11	3,971	14	27	29	
900542	Occupied	Non-participant	664710	5156553	36	3,785	10	22	24	
900543	Unoccupied	Non-participant	664547	5156573	36	3,887	12	24	27	
900546	Occupied	Non-participant	664516	5156546	36	3,929	10	22	23	
900547	Occupied	Non-participant	665655	5157082	36	2,782	16	29	31	
900548	Occupied	Non-participant	665667	5156254	49	3,165	2	14	13	
900549	Unoccupied	Non-participant	667277	5156374	49	1,900	4	16	18	

\* Denotes receptors categorized as Non-Participating because the receptor is located on land that is not covered by an easement. However, the landowners at these receptors are participants of the Project on property located elsewhere in the Project Area.

Table 7. Summary of Acoustic Modeling Results - With Alternate WTG Locations

Receptor ID	Receptor Status	UTM Coordinates (NAD83 UTM Zone 13 meters)		Nearest Wind Turbine	Distance to Nearest Wind Turbine (m)	Received Sound Level				
		Occupied/Unoccupied	Participant/Non-participant			Easting (m)	Northing (m)	Cut-in Rotation (dBA)	Maximum Rotation (dBA)	Maximum Rotation under Anomalous (dBA)
401	Occupied	Non-participant*	681106	5162818	67	2,819	20	32	34	
404	Occupied	Non-participant*	681064	5162775	67	2,768	19	31	34	
390009	Unoccupied	Participant	673486	5163982	50	319	41	50	51	
400006	Unoccupied	Non-participant	680072	5176797	53	11,734	1	13	15	
400037	Unoccupied	Non-participant	681527	5177443	53	12,895	<1	11	14	
420002	Occupied	Non-participant	668875	5171095	25	5,033	17	28	31	
420023	Occupied	Non-participant	668410	5170735	25	4,764	16	28	31	
420029	Occupied	Non-participant	668316	5170507	24	4,557	16	28	31	
420039	Occupied	Non-participant	667891	5171580	24	5,689	16	28	30	
420047	Occupied	Non-participant	667886	5171532	24	5,642	12	24	26	
420051	Occupied	Non-participant	664044	5171213	19	5,361	16	29	31	
420065	Occupied	Non-participant	664088	5171360	19	5,505	16	28	31	
420069	Occupied	Non-participant	663975	5171244	19	5,398	16	29	31	
420076	Occupied	Non-participant	663894	5171299	19	5,462	15	27	30	
420089	Occupied	Non-participant	663065	5171180	18	5,492	16	28	31	
420090	Occupied	Non-participant	662974	5171187	18	5,516	16	28	29	
420100	Occupied	Non-participant	662342	5170932	5	5,299	16	29	31	
420108	Occupied	Non-participant	662543	5170920	5	5,316	16	29	31	
420116	Occupied	Non-participant	662765	5170601	18	4,992	16	29	31	
420117	Occupied	Non-participant	654920	5169153	2	6,501	7	19	22	
420119	Occupied	Non-participant	660825	5167514	5	2,013	24	36	39	
450548	Occupied	Non-participant	681287	5160073	71	2,935	16	29	31	
450554	Unoccupied	Non-participant	681307	5160130	71	2,946	17	30	32	
450562	Unoccupied	Non-participant	679454	5163350	67	1,577	23	36	38	
450563	Unoccupied	Non-participant	679450	5164236	59	2,001	23	35	37	
500002	Occupied	Non-participant	680617	5158589	71	2,988	17	30	32	
500006	Occupied	Non-participant	679633	5157936	71	2,927	18	31	33	
500012	Occupied	Non-participant	679628	5157991	71	2,875	19	31	33	
500016	Unoccupied	Non-participant	679508	5163376	67	1,633	22	35	38	
500018	Occupied	Non-participant	679256	5165366	59	2,275	21	33	36	
500022	Occupied	Non-participant	677510	5165047	56	924	28	41	41	
500028	Occupied	Non-participant	677401	5165136	56	870	28	41	42	
500032	Unoccupied	Participant	677690	5161966	66	587	35	47	47	
500033	Unoccupied	Non-participant	674884	5159598	65	870	28	41	42	
500035	Occupied	Non-participant*	673147	5158516	63	2,489	21	33	35	

Table 7. Summary of Acoustic Modeling Results - With Alternate WTG Locations

Receptor ID	Receptor Status	UTM Coordinates (NAD83 UTM Zone 13 meters)		Nearest Wind Turbine	Distance to Nearest Wind Turbine (m)	Received Sound Level			
		Occupied/Unoccupied	Participant/Non-participant			Cut-in Rotation (dBA)	Maximum Rotation (dBA)	Maximum Rotation under Anomalous (dBA)	
									Eastings (m)
500039	Occupied	Non-participant	671766	5158494	46	3,356	19	31	33
500053	Occupied	Non-participant	672221	5159146	63	2,638	22	34	36
500054	Unoccupied	Non-participant	671612	5161365	57	2,390	22	34	36
500055	Unoccupied	Non-participant	670870	5158304	49	2,556	22	34	36
500059	Occupied	Non-participant*	669892	5159454	46	1,261	29	39	41
500064	Occupied	Non-participant*	669899	5159550	46	1,213	29	40	42
500068	Unoccupied	Non-participant	669196	5158847	48	867	30	41	42
500076	Unoccupied	Non-participant	666743	5158531	36	951	28	40	42
501000	Occupied	Non-participant	684105	5172245	53	10,357	2	14	16
501012	Occupied	Non-participant	681646	5173097	53	9,231	9	20	23
501019	Occupied	Non-participant	680468	5175745	53	10,909	2	13	16
501022	Occupied	Non-participant	680563	5175382	53	10,620	2	13	16
501030	Occupied	Non-participant	679723	5174632	53	9,592	3	15	17
501037	Occupied	Non-participant	679731	5171167	53	6,541	7	19	22
501040	Occupied	Non-participant	678406	5173332	53	7,915	5	17	20
501050	Occupied	Non-participant	678419	5173433	53	8,015	5	17	20
501053	Unoccupied	Non-participant	678555	5173259	53	7,893	5	17	20
501059	Occupied	Non-participant	678568	5173250	53	7,888	5	17	20
501065	Occupied	Non-participant	678822	5170399	53	5,401	14	26	28
501068	Occupied	Non-participant	677851	5169797	53	4,411	15	26	28
501073	Occupied	Non-participant	681345	5169634	53	6,580	7	19	21
501081	Occupied	Non-participant	681279	5169706	53	6,568	7	19	21
501082	Occupied	Non-participant	675433	5171946	53	6,182	13	24	27
501083	Unoccupied	Non-participant	666768	5166374	23	473	34	46	47
501085	Occupied	Non-participant	672965	5164410	50	901	33	42	43
501086	Occupied	Non-participant	672947	5164396	50	899	33	42	43
501097	Unoccupied	Non-participant	667485	5163313	30	1,299	28	40	42
501099	Occupied	Participant	675017	5163411	54	856	31	42	44
501104	Occupied	Participant	675027	5163439	54	828	31	42	44
501108	Occupied	Non-participant	670613	5160034	46	1,742	26	37	39
501118	Occupied	Non-participant	659777	5163091	11	1,123	30	43	44
501122	Unoccupied	Non-participant	661117	5163653	11	340	39	51	51
501126	Occupied	Non-participant	663477	5163902	16	1,049	29	42	43
501131	Occupied	Non-participant	664747	5163175	22	2,051	24	36	39
501138	Occupied	Participant	664349	5164755	17	690	33	45	46
501141	Occupied	Non-participant	665127	5163747	22	1,382	27	39	41

Table 7. Summary of Acoustic Modeling Results - With Alternate WTG Locations

Receptor ID	Occupied/Unoccupied	Receptor Status	UTM Coordinates (NAD83 UTM Zone 13 meters)		Nearest Wind Turbine	Distance to Nearest Wind Turbine (m)	Received Sound Level		
			Easting (m)	Northing (m)			Cut-in Rotation (dBA)	Maximum Rotation (dBA)	Maximum Rotation under Anomalous (dBA)
501147	Occupied	Non-participant	665442	5161863	30	1,855	23	35	36
501156	Occupied	Participant	674657	5162748	58	717	32	44	45
501162	Occupied	Non-participant	666164	5171091	23	5,054	13	25	28
501165	Occupied	Non-participant	668751	5170669	25	4,630	17	29	32
501168	Occupied	Non-participant	666562	5170280	23	4,237	14	27	29
501172	Occupied	Non-participant	662856	5171199	18	5,552	16	28	31
501173	Occupied	Non-participant	661884	5171096	5	5,422	15	28	30
501174	Occupied	Non-participant	661893	5171077	5	5,404	15	28	30
501175	Occupied	Non-participant	661018	5169979	5	4,347	17	30	32
501176	Occupied	Non-participant	660668	5170916	5	5,329	15	28	30
610001	Occupied	Non-participant	657943	5169457	2	4,918	16	28	31
610009	Occupied	Non-participant*	657243	5168249	2	4,229	16	29	31
610014	Occupied	Non-participant*	657329	5168365	2	4,270	16	29	31
610018	Unoccupied	Non-participant	657481	5167671	2	3,632	16	29	31
610021	Occupied	Non-participant	658588	5168791	2	4,068	13	25	28
610025	Occupied	Non-participant	659083	5169071	4	4,125	17	30	32
610031	Occupied	Non-participant	660171	5167459	4	2,186	23	35	37
610042	Occupied	Non-participant	662190	5167946	5	2,330	20	33	35
610045	Occupied	Non-participant	662204	5167951	5	2,338	20	33	35
610049	Occupied	Non-participant	662204	5167996	5	2,382	20	32	34
610053	Occupied	Non-participant	660882	5167398	5	1,884	24	37	39
610057	Occupied	Non-participant	660875	5167437	5	1,922	24	37	39
610059	Unoccupied	Non-participant	662665	5165804	10	394	39	51	51
610063	Unoccupied	Non-participant	661981	5166658	5	1,033	30	42	44
610079	Unoccupied	Non-participant	661962	5163992	12	436	37	50	50
610084	Occupied	Non-participant*	668867	5164930	23	1,197	27	39	41
610089	Occupied	Non-participant*	668413	5169125	24	3,179	20	32	34
610091	Unoccupied	Non-participant	668196	5169582	24	3,671	19	30	33
610094	Occupied	Non-participant	663473	5168761	18	3,040	21	33	36
610098	Occupied	Non-participant	664446	5167109	19	1,239	27	40	41
610102	Occupied	Non-participant*	669505	5169577	25	3,472	18	29	31
610108	Occupied	Non-participant*	669518	5169514	25	3,409	19	31	34
610111	Occupied	Non-participant	670742	5169632	25	3,729	20	32	34
610116	Unoccupied	Non-participant	671898	5169600	42	3,504	31	43	46
610118	Unoccupied	Non-participant	671916	5169648	42	3,545	30	43	46
610121	Occupied	Participant	672258	5168851	42	2,694	27	39	42

Table 7. Summary of Acoustic Modeling Results - With Alternate WTG Locations

Receptor ID	Occupied/Unoccupied	Receptor Status	UTM Coordinates (NAD83 UTM Zone 13 meters)		Nearest Wind Turbine	Distance to Nearest Wind Turbine (m)	Received Sound Level		
			Easting (m)	Northing (m)			Curtain Rotation (dBA)	Maximum Rotation (dBA)	Maximum Rotation under Anomalous (dBA)
610125	Unoccupied	Non-participant	672486	5169786	42	3,583	32	44	47
610130	Unoccupied	Non-participant	673973	5169036	42	3,085	18	30	33
610134	Unoccupied	Non-participant	674002	5169040	42	3,100	18	30	33
610138	Unoccupied	Non-participant	675979	5170362	53	4,572	14	25	28
610144	Unoccupied	Non-participant	675675	5169238	53	3,464	19	31	33
610145	Unoccupied	Non-participant	675358	5166322	53	838	29	41	42
610149	Occupied	Non-participant	674773	5165354	52	1,050	31	43	44
610155	Unoccupied	Non-participant	669944	5164888	28	653	34	46	46
610164	Unoccupied	Non-participant	669983	5164876	28	693	33	46	46
610170	Occupied	Participant	667574	5164565	26	1,627	27	39	41
610181	Occupied	Participant	670466	5167264	25	1,480	23	34	38
610185	Occupied	Participant	670516	5167245	25	1,507	23	34	36
610188	Unoccupied	Non-participant	668519	5166787	24	925	28	41	42
610190	Unoccupied	Non-participant	668313	5167829	25	1,737	22	34	37
610194	Unoccupied	Non-participant	669326	5167878	25	1,785	21	33	35
610197	Unoccupied	Non-participant	673253	5168730	42	2,576	21	33	36
610203	Unoccupied	Non-participant	670759	5168861	25	3,018	21	32	35
706192	Unoccupied	Non-participant	656694	5166353	All3	3,341	18	31	33
800268	Unoccupied	Non-participant	670007	5160023	46	1,142	29	40	41
800288	Unoccupied	Non-participant	664145	5164372	17	1,003	31	43	44
800292	Unoccupied	Non-participant	664102	5164281	17	1,090	30	43	44
800304	Unoccupied	Non-participant	670346	5166290	25	837	29	41	42
800308	Occupied	Participant	667354	5158391	36	861	30	42	43
800311	Occupied	Participant	667332	5158349	36	903	28	40	41
800317	Occupied	Non-participant	662260	5158285	All4	4,253	15	28	30
800342	Unoccupied	Non-participant	670035	5161380	40	993	30	41	43
800364	Unoccupied	Non-participant	669001	5162054	40	279	39	52	52
811069	Unoccupied	Non-participant	682736	5175254	53	11,613	1	12	15
811201	Occupied	Non-participant	680019	5177169	53	12,066	1	12	15
811205	Occupied	Non-participant	679691	5178020	53	12,773	<1	12	15
811210	Occupied	Non-participant	680887	5178421	53	13,541	<1	11	14
811214	Unoccupied	Non-participant	680759	5178424	53	13,498	<1	11	14
811217	Unoccupied	Non-participant	680753	5178482	53	13,551	<1	11	14
811224	Unoccupied	Non-participant	680747	5178483	53	13,549	<1	11	14
811228	Unoccupied	Non-participant	682023	5174120	53	10,276	2	14	16
811231	Unoccupied	Non-participant	682042	5174165	53	10,324	2	14	16

Table 7. Summary of Acoustic Modeling Results - With Alternate WTG Locations

Receptor ID	Receptor Status	UTM Coordinates (NAD83 UTM Zone 13 meters)		Nearest Wind Turbine	Distance to Nearest Wind Turbine (m)	Received Sound Level				
		Occupied/Unoccupied	Participant/Non-participant			Easting (m)	Northing (m)	Cut-in Rotation (dBA)	Maximum Rotation (dBA)	Maximum Rotation under Anomalous (dBA)
811236	Unoccupied	Non-participant	682274	5174639	53	10,844	1	13	16	
811237	Unoccupied	Non-participant	679990	5178775	53	13,582	<1	11	14	
811285	Unoccupied	Non-participant	657284	5169323	2	5,095	15	27	30	
811287	Occupied	Non-participant	655467	5168218	2	5,489	8	21	23	
811290	Occupied	Non-participant	650090	5167200	Alt3	9,500	1	14	17	
880001	Occupied	Non-participant	680270	5173773	53	9,051	8	20	23	
900002	Occupied	Participant	661988	5161930	Alt4	670	30	42	43	
900007	Occupied	Participant	662323	5161469	Alt4	1,240	25	38	39	
900011	Occupied	Non-participant	662065	5161089	Alt4	1,469	24	36	38	
900015	Occupied	Non-participant	658130	5161120	Alt2	1,388	24	36	38	
900019	Occupied	Non-participant	658166	5161105	Alt2	1,361	24	36	38	
900025	Unoccupied	Non-participant	666717	5161478	31	754	32	44	45	
900027	Occupied	Non-participant	664500	5161670	30	2,813	23	36	38	
900031	Occupied	Non-participant	665522	5158935	36	1,869	24	36	38	
900035	Occupied	Non-participant*	665494	5159171	36	1,872	24	36	38	
900039	Occupied	Non-participant*	665496	5159110	36	1,873	24	36	38	
900042	Unoccupied	Non-participant	666233	5158189	36	1,552	25	37	39	
900047	Occupied	Non-participant	663971	5160025	Alt4	3,407	17	29	32	
900053	Occupied	Non-participant	664011	5160036	37	3,379	19	32	34	
900056	Unoccupied	Non-participant	664009	5160071	37	3,386	20	32	34	
900059	Occupied	Non-participant	665090	5160153	37	2,331	23	36	38	
900063	Unoccupied	Non-participant	665463	5160848	31	1,838	25	37	39	
900068	Unoccupied	Non-participant	665083	5160747	31	2,217	22	35	37	
900070	Occupied	Non-participant	679567	5171280	53	6,543	10	22	23	
900537	Unoccupied	Non-participant	662248	5160947	Alt4	1,666	23	36	38	
900539	Unoccupied	Non-participant	659745	5159757	Alt2	1,871	20	33	35	
900542	Occupied	Non-participant	664710	5156553	36	3,785	10	22	24	
900543	Unoccupied	Non-participant	664547	5156573	36	3,887	12	25	27	
900546	Occupied	Non-participant	664516	5156546	36	3,929	10	22	23	
900547	Occupied	Non-participant	665655	5157082	36	2,762	17	29	31	
900548	Occupied	Non-participant	665667	5156254	49	3,165	3	14	13	
900549	Unoccupied	Non-participant	667277	5156374	49	1,900	5	17	19	

\* Denotes receptors categorized as Non-Participating because the receptor is located on land that is not covered by an easement. However, the landowners at these receptors are participants of the Project on property located elsewhere in the Project Area.

## 4.0 OTHER SOUND CONSIDERATIONS

### 4.1 Cumulative Impacts

An assessment of cumulative environmental impacts considers the potential impact of a proposed Project in the context of past, present, and reasonably foreseeable 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. For the purpose of this analysis, cumulative impacts are restricted to noise impacts from wind energy developments. A wind energy facility would need to be located within approximately 2 to 3 km of the Project in order to present a potential cumulative noise impact.

Cumulative wind energy noise impacts from the Project were considered in association the Brady Wind Energy Center, an adjacent facility in southern Stark County that has yet to be built. The Brady Wind Energy Center would have a total of 87 WTGs, consisting of 80 GE 1.7-103 WTGs and 7 GE 1.79-100 WTGs. Table 8 below provides summary sound power data for the GE 1.7-103 WTGs and the GE1.79-100 (GE 2014, 2015). A confidence interval of k=2 was incorporated into the acoustic modeling analysis per the manufacturer specification.

**Table 8. 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							
	11.2 mph (5 m/s)	12.3 mph (5.5 m/s)	13.4 mph (6 m/s)	14.5 mph (6.5 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 1.7-103	100.3	102.6	104.9	106.9	107.0	107.0	107.0	107.0
GE 1.79-100	98.6	101.0	103.2	105.5	107.2	107.5	107.5	107.5

A summary of sound power data for the GE 1.7-103 WTG and 1.79-100 WTG by octave band center frequency is presented in Table 9.

**Table 9. 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 1.7-103	90.5	95.7	97.7	100.3	102.6	99.6	91.4	74.1	107.0
GE 1.79-100	91.0	96.1	98.0	100.8	103.3	100.0	90.3	70.6	107.5

Brady and Brady II would sometimes operate concurrently; therefore a cumulative wind energy noise impact assessment was completed. Cumulative effects were assessed for all WTGs, assuming "No Alternates" for both facilities, in conjunction with operation of the on-site substation servicing both of the facilities.

Acoustic modeling these two projects was completed for concurrent WTG cut-in and maximum rotational operating conditions. Table 10 presents the results of the cumulative acoustic modeling analysis and includes the ID, status, UTM coordinates, receptor status and the received sound levels at each receptor. The receptor status is based on the most recent receptor status

information provided by NEER. Sound contour plots displaying Project operational sound levels in color-coded isopleths are provided in Figures 8 through 10 (Appendix A) and are also rounded to the nearest whole decimal for consistency with the State of North Dakota noise limit absolute value of 50 dBA. These values reflect all WTGs operating under the cut-in rotational speed, maximum rotational speed, and maximum rotational speed under anomalous meteorological conditions, respectively. A 100-foot buffer was included around the receptors, corresponding to the point of compliance identified in the PSC noise standard. The results of the cumulative analysis are presented in Table 10.

The acoustic modeling results demonstrate that received sound levels are all below the 50 dBA State noise standard at occupied receptors.

Table 10. Summary of Acoustic Modeling Results - Cumulative

Receptor ID	Receptor Status	UTM Coordinates (NAD83 UTM Zone 13 meters)		Nearest Wind Turbine	Project	Distance to Nearest Wind Turbine (m)	Received Sound Level		
		Eastings (m)	Northing (m)				Cut-in Rotation (dBA)	Maximum Rotation (dBA)	Maximum Rotation under Anomalous (dBA)
401	Occupied	681106	5162818	67	Brady II	2,819	24	34	36
404	Occupied	681064	5162775	67	Brady II	2,768	22	32	35
390009	Unoccupied	673486	5163982	50	Brady II	319	41	50	51
400006	Unoccupied	680072	5176797	77	Brady I	2,497	26	33	35
400037	Unoccupied	681527	5177443	77	Brady I	1,226	30	36	38
420002	Occupied	668875	5171095	24	Brady I	3,314	26	33	36
420023	Occupied	668410	5170735	24	Brady I	2,728	26	34	36
420029	Occupied	668316	5170507	24	Brady I	2,528	26	34	36
420039	Occupied	667891	5171580	24	Brady I	2,927	25	33	35
420047	Occupied	667886	5171532	24	Brady I	2,885	25	32	34
420051	Occupied	664044	5171213	23	Brady I	2,595	28	35	37
420065	Occupied	664088	5171360	23	Brady I	2,690	27	35	37
420069	Occupied	663975	5171244	23	Brady I	2,661	27	35	37
420076	Occupied	663894	5171299	23	Brady I	2,755	25	33	36
420089	Occupied	663065	5171180	22	Brady I	3,050	27	34	37
420090	Occupied	662974	5171187	20	Brady I	3,096	27	33	36
420100	Occupied	662342	5170932	14	Brady I	2,690	27	35	37
420108	Occupied	662543	5170920	14	Brady I	2,737	27	35	37
420116	Occupied	662765	5170601	20	Brady I	2,516	28	35	38
420117	Occupied	654920	5169153	1	Brady I	2,694	20	27	30
420119	Occupied	660825	5167514	15	Brady I	712	38	45	46
450548	Occupied	681287	5160073	71	Brady II	2,935	17	29	31
450554	Unoccupied	681307	5160130	71	Brady II	2,946	18	30	33
450562	Unoccupied	679454	5163350	67	Brady II	1,577	26	37	39
450563	Unoccupied	679450	5164236	59	Brady II	2,001	27	37	39
500002	Occupied	680617	5158589	71	Brady II	2,988	18	30	32
500006	Occupied	679633	5157936	71	Brady II	2,927	19	31	33
500012	Occupied	679628	5157891	71	Brady II	2,875	19	31	34
500016	Unoccupied	679508	5163376	67	Brady II	1,633	25	35	38
500018	Occupied	679256	5165366	59	Brady I	1,742	29	38	40
500022	Occupied	677510	5165047	56	Brady II	924	31	41	42
500028	Occupied	677401	5165136	56	Brady II	870	31	42	43
500032	Unoccupied	677690	5161966	66	Brady II	587	35	47	47
500033	Unoccupied	674884	5159598	65	Brady II	870	28	41	42
500035	Occupied	673147	5158516	63	Brady II	2,489	21	33	35

Table 10. Summary of Acoustic Modeling Results - Cumulative

Receptor ID	Receptor Status		UTM Coordinates (NAD83 UTM Zone 13 meters)		Nearest Wind Turbine	Project	Distance to Nearest Wind Turbine (m)	Received Sound Level		
	Occupied/Unoccupied	Participant/Non-participant	Easting (m)	Northing (m)				Cut-in Rotation (dBA)	Maximum Rotation (dBA)	Maximum Rotation under Anomalous (dBA)
500039	Occupied	Non-participant	671766	5158464	46	Brady II	3,356	20	31	34
500053	Occupied	Non-participant	672221	5159146	63	Brady II	2,638	22	34	36
500054	Unoccupied	Non-participant	671612	5161365	57	Brady II	2,390	22	34	36
500055	Unoccupied	Non-participant	670870	5158304	49	Brady II	2,556	22	34	36
500059	Occupied	Non-participant*	669892	5159454	46	Brady II	1,261	29	39	41
500064	Occupied	Non-participant*	669889	5159550	46	Brady II	1,213	29	40	42
500068	Unoccupied	Non-participant	669196	5158847	48	Brady II	867	30	41	42
500076	Unoccupied	Non-participant	666743	5158531	36	Brady II	951	28	40	42
501000	Occupied	Non-participant	684105	5172245	87	Brady I	2,509	24	31	33
501012	Occupied	Non-participant	681646	5173097	79	Brady I	907	38	44	45
501019	Occupied	Non-participant	680468	5175745	70	Brady I	1,699	30	37	39
501022	Occupied	Non-participant	680563	5175382	70	Brady I	1,324	32	39	40
501030	Occupied	Non-participant	679723	5174632	70	Brady I	1,290	32	39	41
501037	Occupied	Non-participant	679731	5171167	82	Brady I	838	37	44	45
501040	Occupied	Non-participant	678406	5173332	64	Brady I	676	38	45	45
501050	Occupied	Non-participant	678419	5173433	64	Brady I	766	37	44	45
501053	Unoccupied	Non-participant	678555	5173259	64	Brady I	726	38	45	45
501059	Occupied	Non-participant	678568	5173250	64	Brady I	730	38	45	45
501065	Occupied	Non-participant	678822	5170399	82	Brady I	909	37	44	45
501068	Occupied	Non-participant	677851	5169797	48	Brady I	630	39	47	48
501073	Occupied	Non-participant	681345	5169634	86	Brady I	820	34	41	42
501081	Occupied	Non-participant	681279	5169706	86	Brady I	769	34	41	41
501082	Occupied	Non-participant	675433	5171946	61	Brady I	1,933	30	37	39
501083	Unoccupied	Non-participant	666768	5166374	23	Brady II	473	35	47	47
501085	Occupied	Non-participant	672965	5164410	50	Brady II	901	33	42	44
501086	Occupied	Non-participant	672947	5164396	50	Brady II	899	33	42	44
501097	Unoccupied	Non-participant	667485	5163313	30	Brady II	1,299	28	40	42
501099	Occupied	Participant	675017	5163411	54	Brady II	856	32	43	44
501104	Occupied	Participant	675027	5163439	54	Brady II	828	32	43	44
501108	Occupied	Non-participant	670613	5160034	46	Brady II	1,742	26	37	39
501118	Occupied	Non-participant	669777	5163091	11	Brady II	1,123	29	41	42
501122	Unoccupied	Non-participant	661117	5163653	11	Brady II	340	38	51	51
501126	Occupied	Non-participant	663477	5163902	16	Brady II	1,049	30	42	43
501131	Occupied	Non-participant	664747	5163175	22	Brady II	2,051	25	36	39
501138	Occupied	Participant	664349	5164755	17	Brady II	690	33	46	46
501141	Occupied	Non-participant	665127	5163747	22	Brady II	1,382	27	39	41

Table 10. Summary of Acoustic Modeling Results - Cumulative

Receptor ID	Receptor Status		UTM Coordinates (NAD83 UTM Zone 13 meters)				Nearest Wind Turbine	Project	Distance to Nearest Wind Turbine (m)	Received Sound Level		
	Occupied/Unoccupied	Participant/Non-participant	Easting (m)	Northing (m)	Maximum Rotation (dBA)	Maximum Rotation (dBA)				Maximum Rotation under Anomalous (dBA)		
501147	Occupied	Non-participant	665442	5161863	30	Brady II	1,855	23	34	36		
501156	Occupied	Participant	674657	5162748	58	Brady II	717	32	44	45		
501162	Occupied	Non-participant	666164	5171091	24	Brady I	1,846	26	33	35		
501165	Occupied	Non-participant	668751	5170669	24	Brady I	2,987	27	34	37		
501168	Occupied	Non-participant	666562	5170280	24	Brady I	1,123	31	38	40		
501172	Occupied	Non-participant	662856	5171189	20	Brady I	3,109	27	34	37		
501173	Occupied	Non-participant	661884	5171096	14	Brady I	2,774	27	34	37		
501174	Occupied	Non-participant	661883	5171077	14	Brady I	2,756	27	34	37		
501175	Occupied	Non-participant	661018	5169979	14	Brady I	1,764	30	38	40		
501176	Occupied	Non-participant	660668	5170916	9	Brady I	2,621	27	35	37		
610001	Occupied	Non-participant	657943	5169457	4	Brady I	1,524	31	38	40		
610009	Occupied	Non-participant*	657243	5168249	2	Brady I	1,099	35	41	43		
610014	Occupied	Non-participant*	657329	5168365	4	Brady I	1,097	34	41	42		
610018	Unoccupied	Non-participant	657481	5167671	2	Brady I	535	40	46	47		
610021	Occupied	Non-participant	658588	5168791	5	Brady I	657	37	44	45		
610025	Occupied	Non-participant	659083	5169071	5	Brady I	922	35	42	43		
610031	Occupied	Non-participant	660171	5167459	8	Brady I	667	39	46	47		
610042	Occupied	Non-participant	662190	5167946	14	Brady I	664	39	46	46		
610045	Occupied	Non-participant	662204	5167951	14	Brady I	673	39	45	46		
610049	Occupied	Non-participant	662204	5167996	14	Brady I	648	39	45	46		
610053	Occupied	Non-participant	660882	5167398	15	Brady I	671	38	45	46		
610057	Occupied	Non-participant	660875	5167437	15	Brady I	671	38	45	46		
610059	Unoccupied	Non-participant	662665	5165804	10	Brady II	394	41	52	52		
610063	Unoccupied	Non-participant	661981	5166658	17	Brady I	464	41	49	49		
610079	Unoccupied	Non-participant	661982	5163982	12	Brady II	436	37	50	50		
610084	Occupied	Non-participant*	666867	5164930	23	Brady II	1,197	29	40	41		
610089	Occupied	Non-participant*	668413	5169125	29	Brady I	2,185	29	37	39		
610091	Unoccupied	Non-participant	668196	5169582	24	Brady I	2,098	28	36	38		
610094	Occupied	Non-participant	663473	5168761	21	Brady I	660	38	44	45		
610098	Occupied	Non-participant	664446	5167109	25	Brady I	637	39	46	47		
610102	Occupied	Non-participant*	669505	5169577	33	Brady I	1,970	29	36	38		
610108	Occupied	Non-participant*	669518	5169514	33	Brady I	1,920	29	36	39		
610111	Occupied	Non-participant	670742	5169632	32	Brady I	1,040	33	40	41		
610116	Unoccupied	Non-participant	671898	5169600	32	Brady I	574	39	46	48		
610118	Unoccupied	Non-participant	671916	5169648	32	Brady I	624	39	46	47		
610121	Occupied	Participant	672258	5168851	32	Brady I	672	38	45	46		

Table 10. Summary of Acoustic Modeling Results - Cumulative

Receptor ID	Receptor Status	UTM Coordinates (NAD83 UTM Zone 13 meters)				Nearest Wind Turbine	Project	Distance to Nearest Wind Turbine (m)	Received Sound Level		
		Occupied/Unoccupied	Participant/Non-participant	Easting (m)	Northing (m)				Cut-in Rotation (dBA)	Maximum Rotation (dBA)	Maximum Rotation under Anomalous (dBA)
610125	Unoccupied	Non-participant		672486	5168786	32	Brady I	1,101	38	45	47
610130	Unoccupied	Non-participant		673973	5169036	35	Brady I	653	35	42	43
610134	Unoccupied	Non-participant		674002	5169040	35	Brady I	673	35	42	43
610139	Occupied	Non-participant		675979	5170362	44	Brady I	1,214	33	40	42
610144	Unoccupied	Non-participant		675675	5169238	44	Brady I	931	34	41	43
610145	Unoccupied	Non-participant		675358	5166322	50	Brady I	816	34	43	44
610149	Occupied	Non-participant		674773	5165354	52	Brady II	1,050	34	44	45
610155	Unoccupied	Non-participant		669944	5164888	28	Brady II	653	34	46	47
610164	Unoccupied	Non-participant		669993	5164876	28	Brady II	693	34	46	47
610170	Occupied	Participant		667574	5164565	26	Brady II	1,627	28	39	41
610181	Occupied	Participant		670466	5167264	36	Brady I	729	36	44	44
610185	Occupied	Participant		670516	5167245	36	Brady I	696	37	44	44
610188	Unoccupied	Non-participant		668519	5166787	24	Brady II	925	31	41	43
610190	Unoccupied	Non-participant		669313	5167829	25	Brady II	1,737	30	38	40
610194	Unoccupied	Non-participant		669326	5167878	33	Brady I	1,747	30	38	40
610197	Unoccupied	Non-participant		673253	5168730	35	Brady I	407	40	47	47
610203	Unoccupied	Non-participant		670759	5168861	33	Brady I	605	37	44	45
706192	Unoccupied	Non-participant		656694	5166353	1	Brady I	704	36	43	44
800288	Unoccupied	Non-participant		670007	5160023	46	Brady II	1,142	29	40	41
800292	Unoccupied	Non-participant		664145	5164372	17	Brady II	1,003	31	43	44
800304	Unoccupied	Non-participant		664102	5164281	17	Brady II	1,090	31	43	44
800308	Unoccupied	Non-participant		670346	5166290	25	Brady II	837	34	43	44
800311	Occupied	Participant		667354	5158391	36	Brady II	861	30	42	43
800317	Occupied	Participant		667332	5158349	36	Brady II	903	28	41	41
800342	Unoccupied	Non-participant		662260	5158285	36	Brady II	5,195	15	26	28
800364	Unoccupied	Non-participant		670035	5161380	40	Brady II	993	30	41	43
811069	Unoccupied	Non-participant		689001	5162054	40	Brady II	279	39	52	52
811201	Occupied	Non-participant		682736	5175254	74	Brady I	404	42	49	49
811205	Occupied	Non-participant		680019	5177169	77	Brady I	2,577	25	32	34
811210	Occupied	Non-participant		679691	5178020	77	Brady I	3,127	21	28	30
811214	Occupied	Non-participant		680887	5178421	77	Brady I	2,338	24	31	33
811217	Unoccupied	Non-participant		680759	5178424	77	Brady I	2,433	24	31	33
811224	Unoccupied	Non-participant		680753	5178482	77	Brady I	2,477	24	31	33
811228	Unoccupied	Non-participant		680747	5178483	77	Brady I	2,482	24	31	33
811231	Unoccupied	Non-participant		682023	5174120	72	Brady I	187	48	55	55
811231	Unoccupied	Non-participant		682042	5174165	72	Brady I	139	50	57	57

Table 10. Summary of Acoustic Modeling Results - Cumulative

Receptor ID	Receptor Status		UTM Coordinates (NAD83 UTM Zone 13 meters)				Nearest Wind Turbine	Project	Distance to Nearest Wind Turbine (m)	Received Sound Level		
	Occupied/Unoccupied	Participant/Non-participant	Easting (m)	Northing (m)	Northing (m)	Cut-in Rotation (dBA)				Maximum Rotation (dBA)	Maximum Rotation under Anomalous (dBA)	
811236	Unoccupied	Non-participant	682274	5174639	72	Brady I	398	43	49	50		
811237	Unoccupied	Non-participant	679990	5178775	77	Brady I	3,250	21	27	30		
811285	Unoccupied	Non-participant	657284	5169323	4	Brady I	1,712	30	37	39		
811287	Occupied	Non-participant	655467	5168218	1	Brady I	1,630	23	30	32		
811290	Occupied	Non-participant	650090	5167200	1	Brady I	6,518	10	18	21		
880001	Occupied	Non-participant	680270	5173773	68	Brady I	649	40	47	47		
900002	Occupied	Participant	661988	5161930	11	Brady II	2,051	24	36	38		
900007	Occupied	Participant	662323	5161469	11	Brady II	2,621	23	34	36		
900011	Occupied	Non-participant	662085	5161089	11	Brady II	2,810	21	33	35		
900015	Occupied	Non-participant	658130	5161120	1	Brady II	3,339	22	32	34		
900019	Occupied	Non-participant	658166	5161105	1	Brady II	3,340	22	32	34		
900025	Unoccupied	Non-participant	666717	5161478	31	Brady II	754	32	44	45		
900027	Occupied	Non-participant	664500	5161670	30	Brady II	2,813	24	36	38		
900031	Occupied	Non-participant	665522	5158935	36	Brady II	1,869	24	36	38		
900035	Occupied	Non-participant*	665494	5159171	36	Brady II	1,872	24	36	38		
900039	Occupied	Non-participant*	665498	5159110	36	Brady II	1,873	25	36	38		
900042	Unoccupied	Non-participant	666233	5158189	36	Brady II	1,552	25	37	39		
900047	Occupied	Non-participant	663971	5160025	37	Brady II	3,418	18	29	32		
900053	Occupied	Non-participant	664011	5160036	37	Brady II	3,379	20	31	34		
900056	Unoccupied	Non-participant	664009	5160071	37	Brady II	3,386	20	32	34		
900059	Occupied	Non-participant	665090	5160153	37	Brady II	2,331	24	36	38		
900063	Unoccupied	Non-participant	665463	5160848	31	Brady II	1,838	25	37	39		
900068	Unoccupied	Non-participant	665093	5160747	31	Brady II	2,217	23	35	37		
900070	Occupied	Non-participant	679567	5171280	82	Brady I	663	39	46	46		
900537	Unoccupied	Non-participant	662248	5160947	11	Brady II	3,021	21	32	35		
900539	Unoccupied	Non-participant	659745	5159757	11	Brady II	3,971	17	27	30		
900542	Occupied	Non-participant	664710	5156553	36	Brady II	3,785	12	23	27		
900543	Unoccupied	Non-participant	664547	5156573	36	Brady II	3,887	14	25	27		
900546	Occupied	Non-participant	664516	5156546	36	Brady II	3,929	12	23	27		
900547	Occupied	Non-participant	665655	5157082	36	Brady II	2,762	18	29	32		
900548	Occupied	Non-participant	665667	5156254	49	Brady II	3,165	7	16	21		
900549	Unoccupied	Non-participant	667277	5156374	49	Brady II	1,900	8	18	23		

\* Denotes receptors categorized as Non-Participating because the receptor is located on land that is not covered by an easement. However, the landowners at these receptors are participants of the Project on property located elsewhere in the Project Area.  
 Note: The cumulative noise assessment was analyzed using Brady Wind Energy Center and Brady II Wind Energy Center site layouts dated November 6, 2015, and April 22, 2016, respectively. If either facility site layout is modified, potential noise impacts will be reanalyzed to ensure consistency with the PSC's noise requirement.

**4.2 Substation Noise**

Substations have switching, protection and control equipment and typically 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 vibrational noise is the principal noise source and does not vary significantly with electrical load. Transformers are designed and catalogued by MVA ratings. Just as horsepower ratings designate the power capacity of an electric motor, a transformer’s MVA rating indicates its maximum power output capacity. The National Electrical Manufacturers Association (NEMA) published NEMA Standards TR1-1993 (R2000), which establish the maximum noise level allowed for transformers, voltage regulators, and shunt reactors based on the equipment’s method of cooling its dielectric fluid (air-cooled vs. oil-cooled) and the electric power rating.

Transformer noise is generated and will attenuate with distance at different rates depending on the transformer dimensions, voltage rating, and design. The noise produced by substation transformers 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. The characteristic humming sound consists of tonal components generated at harmonics of 120 Hz. Most of the acoustical energy resides in the fundamental tone (120 Hz) and the first 3 or 4 harmonics (240, 360, 480, 600 Hz). In addition to core vibration noise, transformer cooling fans may generate broadband noise, limited to periods when high heat loads require additional cooling capacity. The resulting audible sound is a combination of core noise and the broadband fan noise. Circuit-breaker operations may also cause audible noise, particularly the operation of air-blast breakers which is characterized as an impulsive sound event of very short duration. This is expected to occur only a few times throughout the year, and was therefore not considered in this analysis.

The proposed collection substation would be located approximately 600 feet (183 meters) south of 52nd Street SW and immediately adjacent to 109th Avenue SW. The transformer at this substation location was modeled using the latest version of CadnaA implementing ISO 9613-2. Transformer sound source levels were provided based on a 170 MVA transformer similar to the HICO 170 MVA transformer in use at other NEER energy facilities. Table 11 presents the transformer sound source data by octave band center frequency calculated based on the estimated transformer NEMA and MVA ratings using standardized engineering guidelines.

**Table 11. Transformer Sound Power Level**

Frequency (Hz)	Octave Band Sound Power Level (dB)								Broadband (dBA)
	63	125	250	500	1000	2000	4000	8000	
170 MVA Transformer	93	99	101	94	90	85	80	73	97

Transformers the size of the one proposed for the Project can present a noise concern if the separation distance is less than a few hundred feet between the transformer and noise-sensitive

receptors. The proposed transformer location is approximately 1,050 feet (320 meters) from the nearest noise sensitive receptor and poses little concern from a noise perspective. That being said, transformer noise may be periodically audible at nearby receptors on occasions when background sound levels are very low.

#### 4.3 Construction Noise

The development of Brady II Wind Energy Center will involve construction to establish access roads, excavate and form WTG foundations, prepare the site for crane-lifting and assemble and commission the WTGs. Work on large-scale wind projects such as Brady II 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. *Grading*: This phase would begin with the grading 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. *WTG 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 WTGs will be erected in small groupings. Each grouping may undergo periodic testing and commissioning prior to commencement of full commercial operation. Other construction activities include those for the supporting infrastructure such as the substation, maintenance building, and the overhead transmission line.

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. The list of construction equipment that may be used on the Project and estimates of near and far sound source levels are presented in Table 12.

**Table 12. Estimated L<sub>max</sub> 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

Source: FHWA 2006; Bolt et al. 1977

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 specified 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 normally notifies the community via public notice or alternative method of the 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 will 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 equipping internal combustion engines with appropriate sized muffler systems to minimize noise excessive emissions.

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.

## 5.0 CONCLUSIONS

Project operational sound has been calculated and compared to the 50 dBA PSC noise limit. Acoustic modeling analysis per ISO 9613-2 and inclusive of a number of conservative assumptions under operational conditions demonstrates the Project will not generate exceedances of the PSC noise limit at any occupied receptor location under either "With Alternates" or with "No Alternates". In addition, predicted noise impacts of the Project "With Alternates" should be considered conservative since only 72 WTGs will actually be built as part of the Project.

It is expected that received sound levels at noise-sensitive receptors will be consistent with sound generated at similar wind energy projects successfully sited throughout the state of North Dakota employing the same or similar criteria. However, while the Project has demonstrated compliance with the requirements, the Project may result in periodically audible sound within adjacent areas under certain operational and meteorological conditions.

## 6.0 TECHNICAL REFERENCES

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- Technical Documentation: Wind Turbine Generator Systems GE 1.79-100—50Hz and 60Hz, Noise emission characteristics Normal operation according to IEC, GE Wind Energy GmbH, 2013.
- Technical Documentation: Wind Turbine Generator Systems GE 1.7-103—50Hz and 60Hz, Noise emission characteristics Normal operation according to IEC, GE Wind Energy GmbH, 2014.
- Technical Documentation: Wind Turbine Generator Systems GE 2.3-116 1-2 MW, Noise emission characteristics Normal operation according to IEC, GE Wind Energy GmbH, 2015.

**APPENDIX A**  
**Figures**

NEXTERA ENERGY  
RESOURCES, LLC  
BRADY II WIND PROJECT  
HETTINGER COUNTY  
NORTH DAKOTA

FIGURE 1  
PROJECT LAYOUT  
MAY 2016

Brady II Proposed Turbine Array (4/22/2016)

- GE Xle 2.1-116 Turbine
- GE Xle 2.1-116 Turbine (Alt)
- GE Xle 1.79-100 Turbine

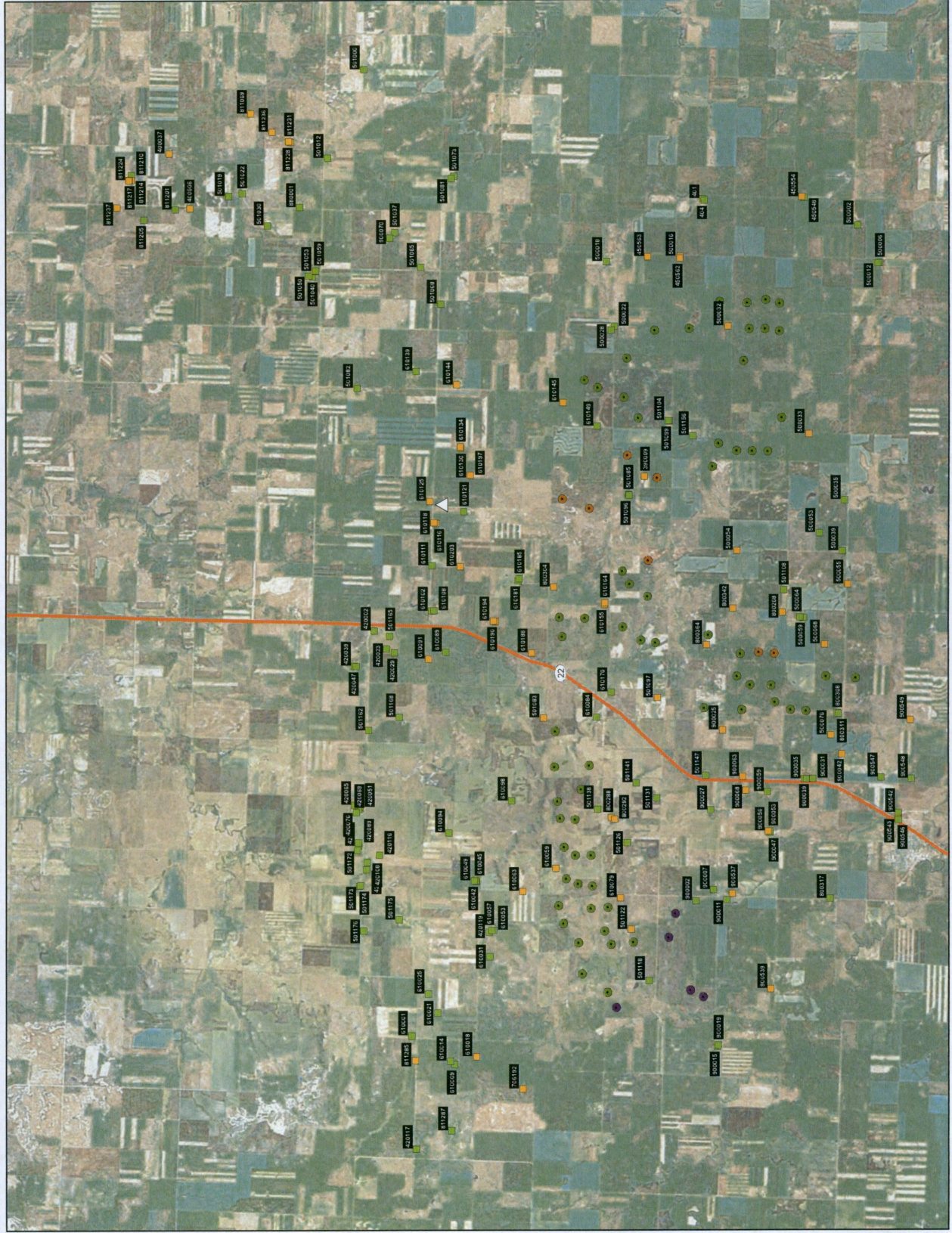
Receptors

- Occupied
- Not Occupied
- △ Substation
- Major Road



0 0.5 1 1.5 2 MILES

REFERENCE MAP



NEXTERA ENERGY  
 RESOURCES, LLC  
 BRADY II WIND PROJECT  
 HETTINGER COUNTY  
 NORTH DAKOTA

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

MAY 2016

Brady II Proposed Turbine Array (4/22/2016)

- GE Xle 2.1-116 Turbine
- GE Xle 2.1-116 Turbine (Alt)
- GE Xle 1.79-100 Turbine

Receptors

- Occupied
- Not Occupied
- △ Substation

Sound Level Contour Ranges (dBA)

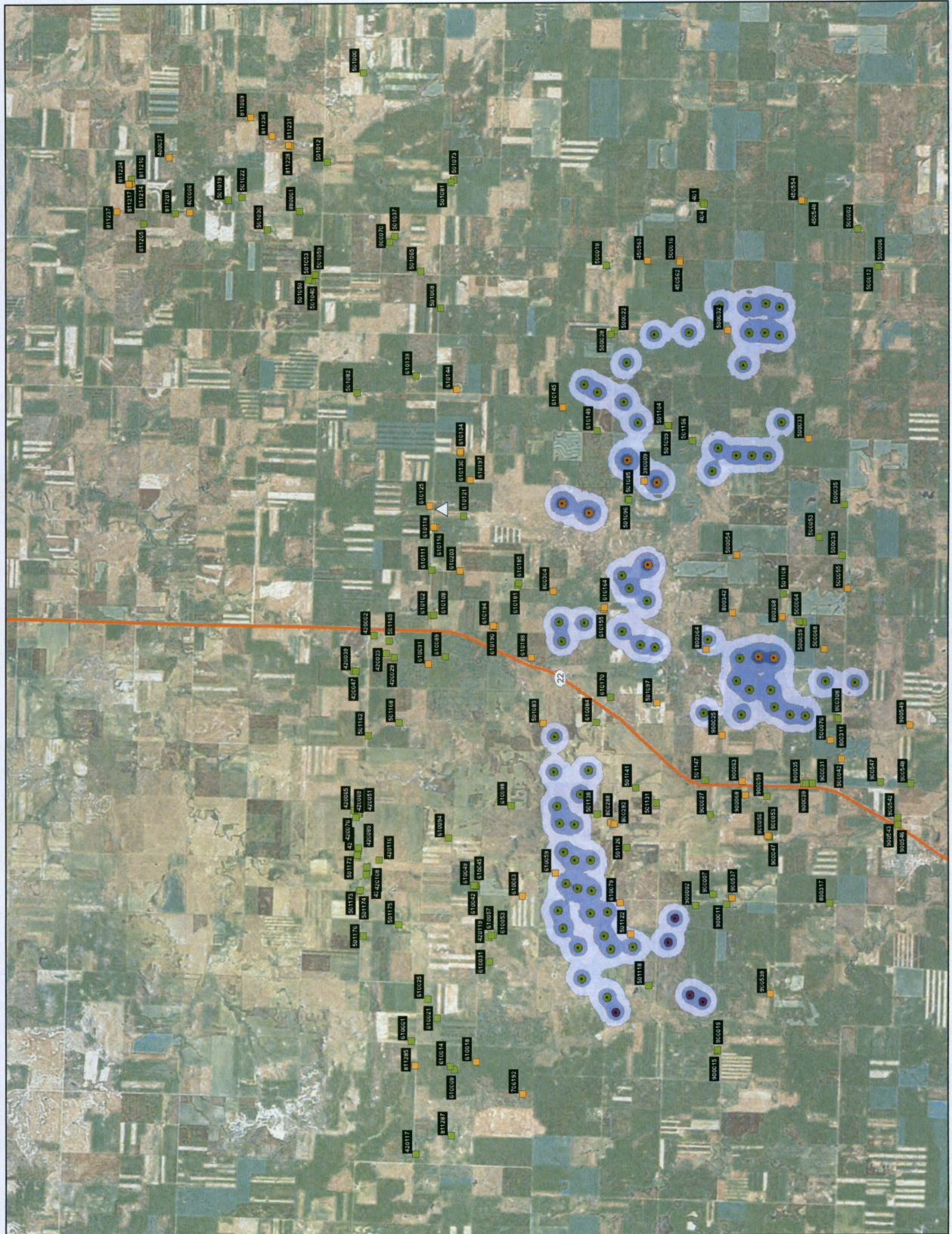
- 35-40
- >40-45
- >45-50
- >50

- Interstate Highway
- Major Road



0 0.5 1 1.5 2 MILES

REFERENCE MAP



NEXTERA ENERGY  
 RESOURCES, LLC  
 BRADY II WIND PROJECT  
 HETTINGER COUNTY  
 NORTH DAKOTA

FIGURE 3  
 NO ALTERNATES:  
 RECEIVED SOUND LEVELS -  
 WIND TURBINES AT CUT-IN  
 WIND SPEED

MAY 2016

Brady II Proposed Turbine Array (4/22/2016)

- GE Xle 2.1-116 Turbine
- GE Xle 1.79-100 Turbine

Receptors

- Occupied
- Not Occupied
- △ Substation

Sound Level Contour Ranges (dBA)

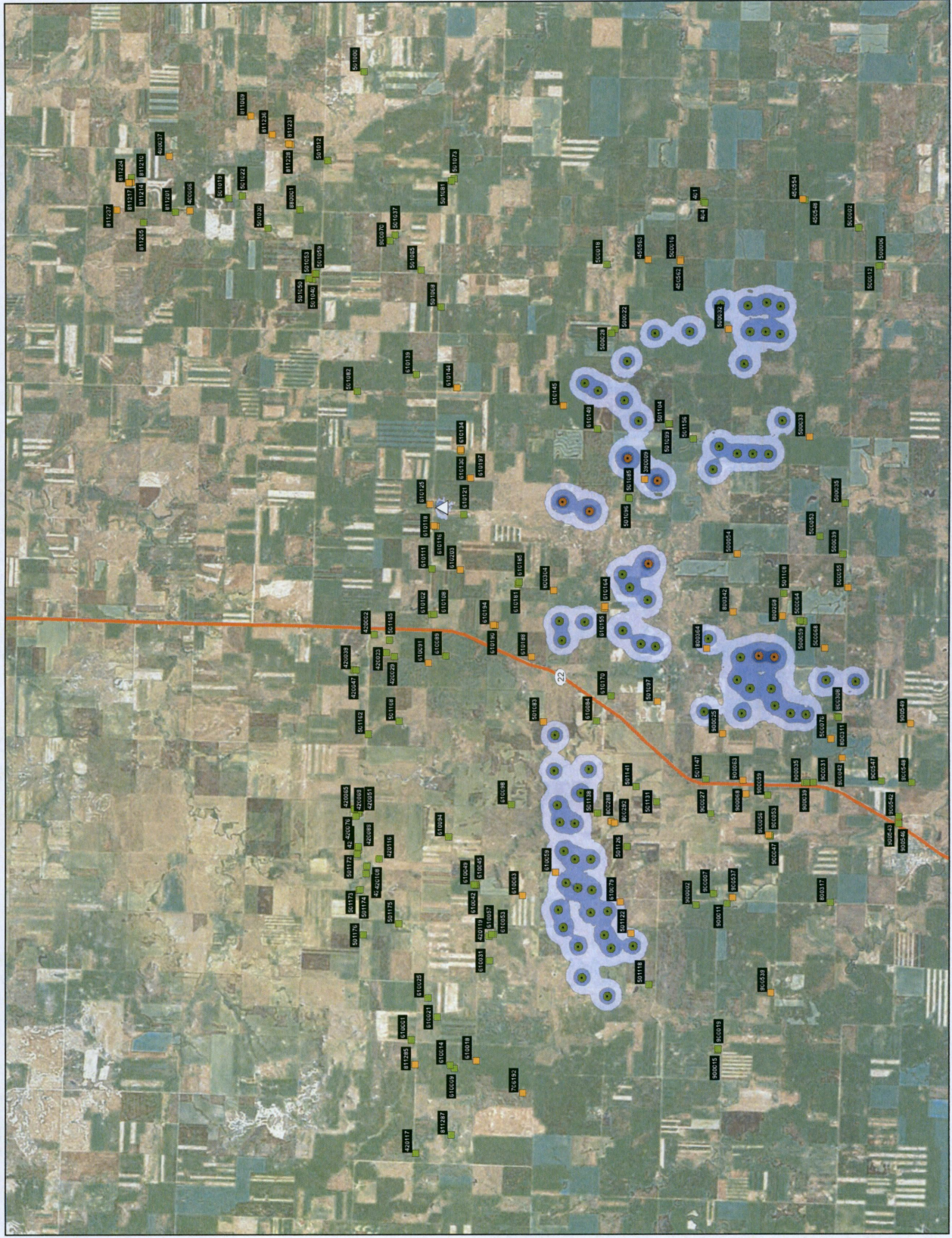
- 35-40
- >40-45
- >45-50
- >50

- Interstate Highway
- Major Road



0 0.5 1 1.5 2 MILES

REFERENCE MAP



NEXTERA ENERGY  
 RESOURCES, LLC  
 BRADY II WIND PROJECT  
 HETTINGER COUNTY  
 NORTH DAKOTA

FIGURE 4  
 WITH ALTERNATES:  
 RECEIVED SOUND LEVELS -  
 WIND TURBINES AT MAXIMUM  
 ROTATIONAL WIND SPEED

MAY 2016

Brady II Proposed Turbine Array (4/22/2016)

- GE Xle 2.1-116 Turbine
- GE Xle 2.1-116 Turbine (Alt)
- GE Xle 1.79-100 Turbine

- Receptors
- Occupied
  - Not Occupied
  - △ Substation

Sound Level Contour Ranges (dBA)

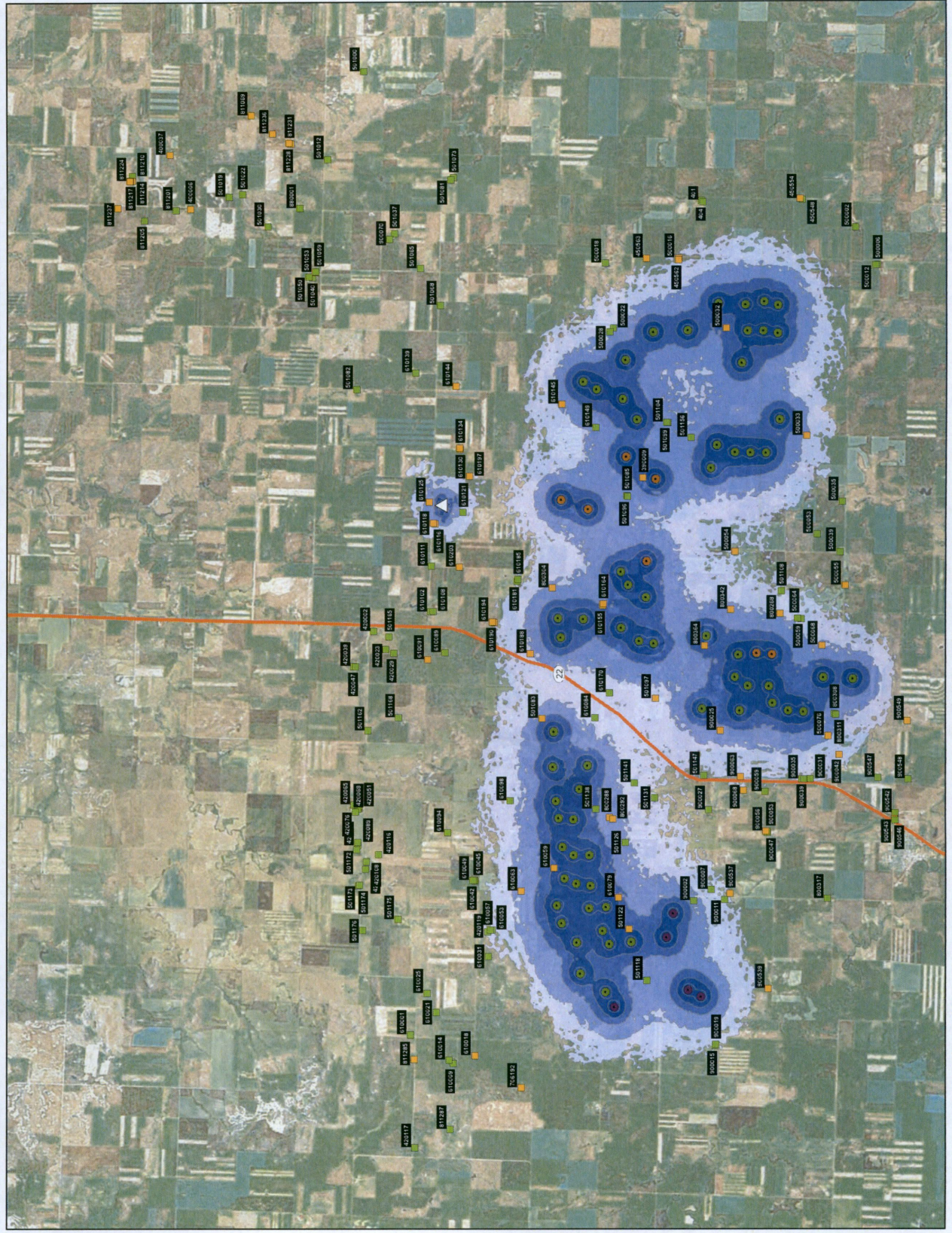
- 35-40
- >40-45
- >45-50
- >50

- Interstate Highway
- Major Road



0 0.5 1 1.5 2 MILES

REFERENCE MAP



NEXTERA ENERGY  
RESOURCES, LLC  
BRADY II WIND PROJECT  
HETTINGER COUNTY  
NORTH DAKOTA

FIGURE 5  
NO ALTERNATES:  
RECEIVED SOUND LEVELS -  
WIND TURBINES AT MAXIMUM  
ROTATIONAL WIND SPEED  
MAY 2016

Brady II Proposed Turbine Array (4/22/2016)

- GE Xle 2.1-116 Turbine
- GE Xle 1.79-100 Turbine

Receptors

- Occupied
- Not Occupied
- △ Substation

Sound Level Contour Ranges (dBA)

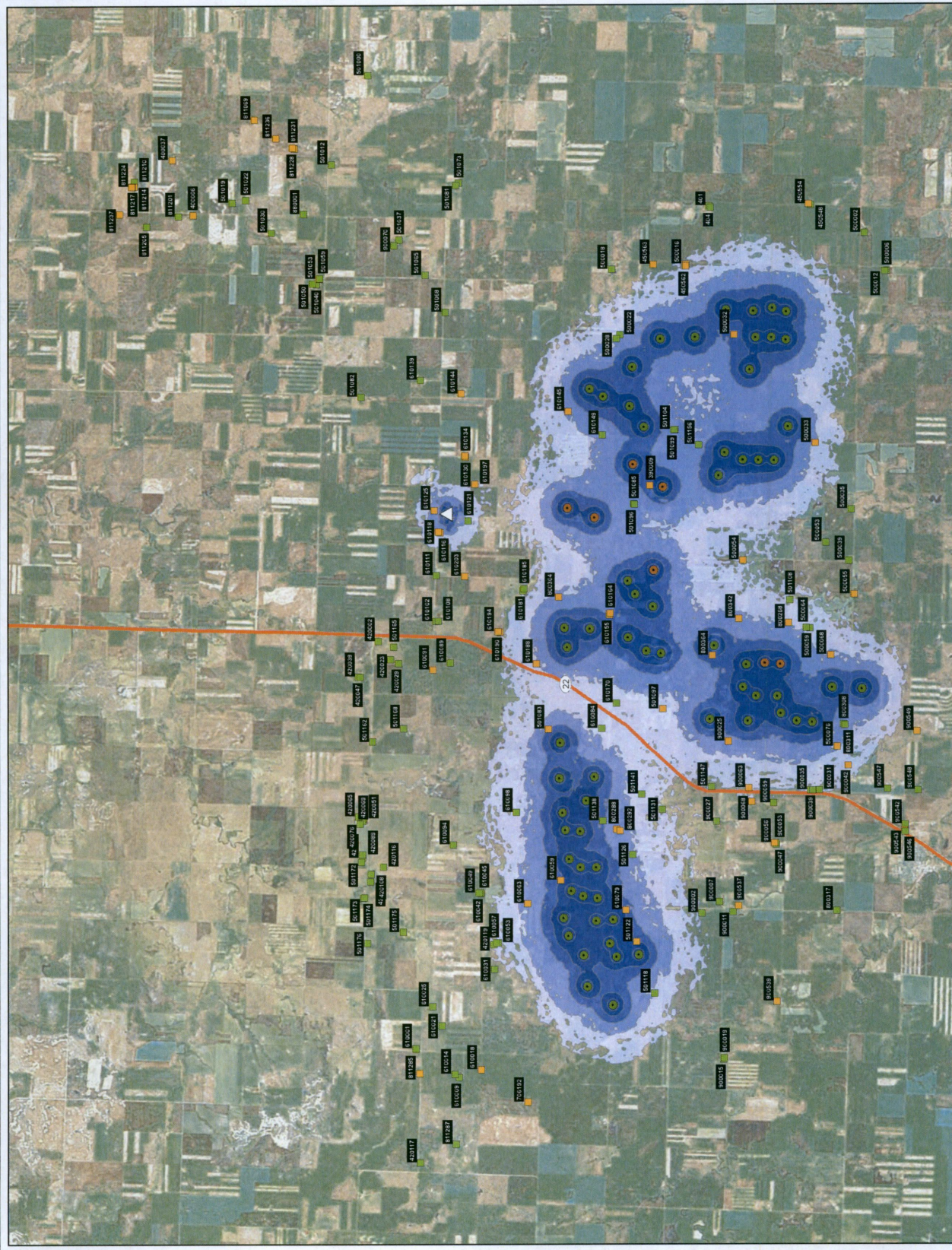
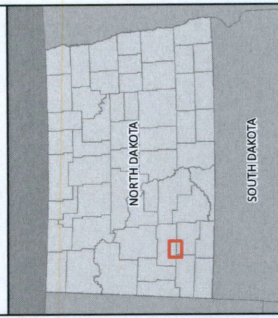
- 35-40
- >40-45
- >45-50
- >50

- Interstate Highway
- Major Road



0 0.5 1 1.5 2 MILES

REFERENCE MAP



NEXTERA ENERGY  
 RESOURCES, LLC  
 BRADY II WIND PROJECT  
 HETTINGER COUNTY  
 NORTH DAKOTA

**FIGURE 6**  
 WITH ALTERNATES:  
 RECEIVED SOUND LEVELS -  
 WIND TURBINES AT MAXIMUM  
 ROTATIONAL WIND SPEED  
 ANOMALOUS METEOROLOGICAL  
 CONDITIONS

MAY 2016

Brady II Proposed Turbine Array (4/22/2016)

- GE Xle 2.1-116 Turbine
- GE Xle 2.1-116 Turbine (Alt)
- GE Xle 1.79-100 Turbine

**Receptors**

- Occupied
- Not Occupied
- △ Substation

**Sound Level Contour Ranges (dba)**

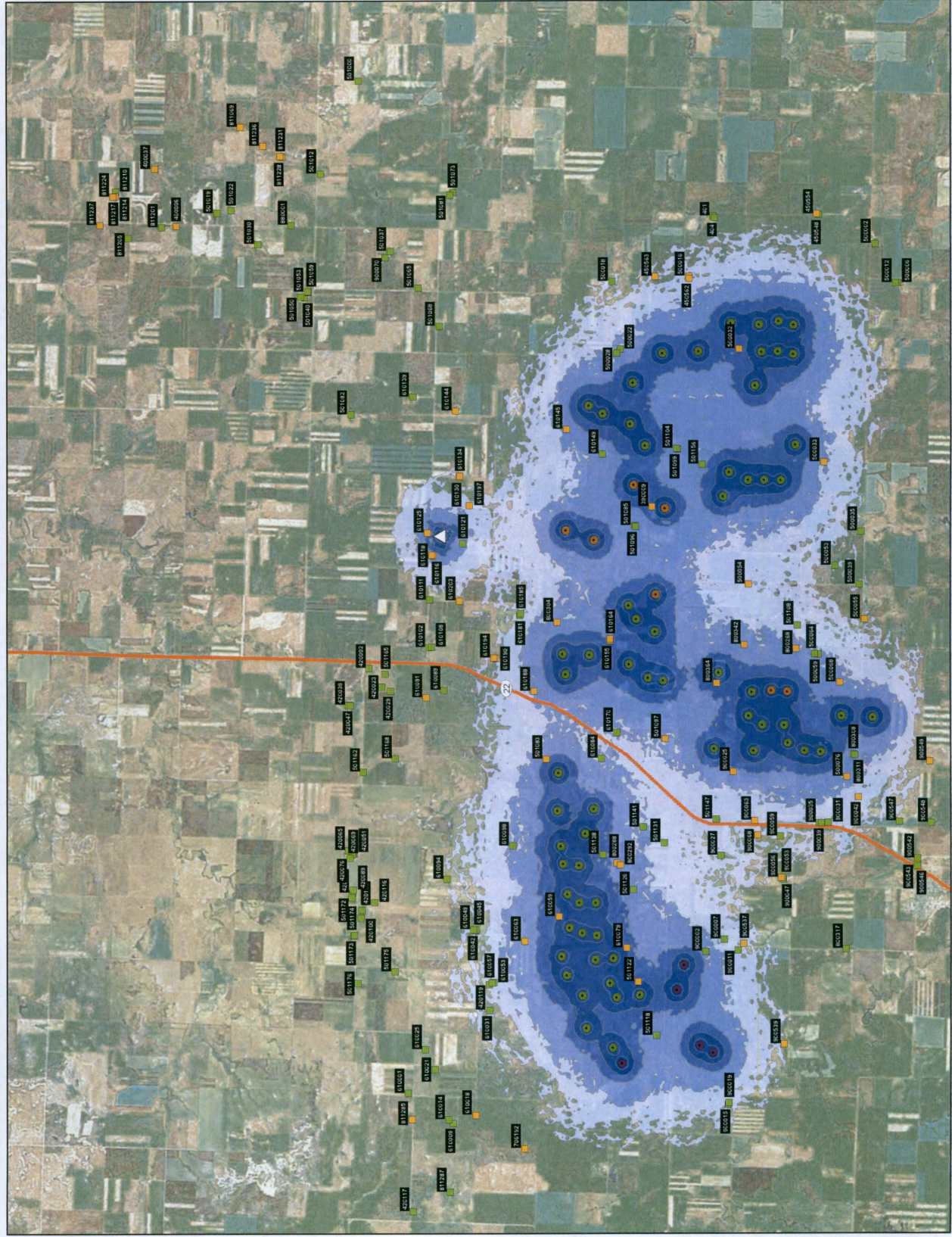
- 35-40
- >40-45
- >45-50
- >50

- Interstate Highway
- Major Road

0 0.5 1 1.5 2 MILES



**REFERENCE MAP**



NEXTERA ENERGY  
 RESOURCES, LLC  
 BRADY II WIND PROJECT  
 HETTINGER COUNTY  
 NORTH DAKOTA

FIGURE 7  
 NO ALTERNATES  
 RECEIVED SOUND LEVELS -  
 WIND TURBINES AT MAXIMUM  
 ROTATIONAL WIND SPEED  
 ANOMALOUS METEOROLOGICAL  
 CONDITIONS

MAY 2016

Brady II Proposed Turbine Array (4/22/2016)

- GE Xle 2.1-116 Turbine
- GE Xle 1.79-100 Turbine

Receptors

- Occupied
- Not Occupied
- △ Substation

Sound Level Contour Ranges (dBA)

- 35-40
- >40-45
- >45-50
- >50

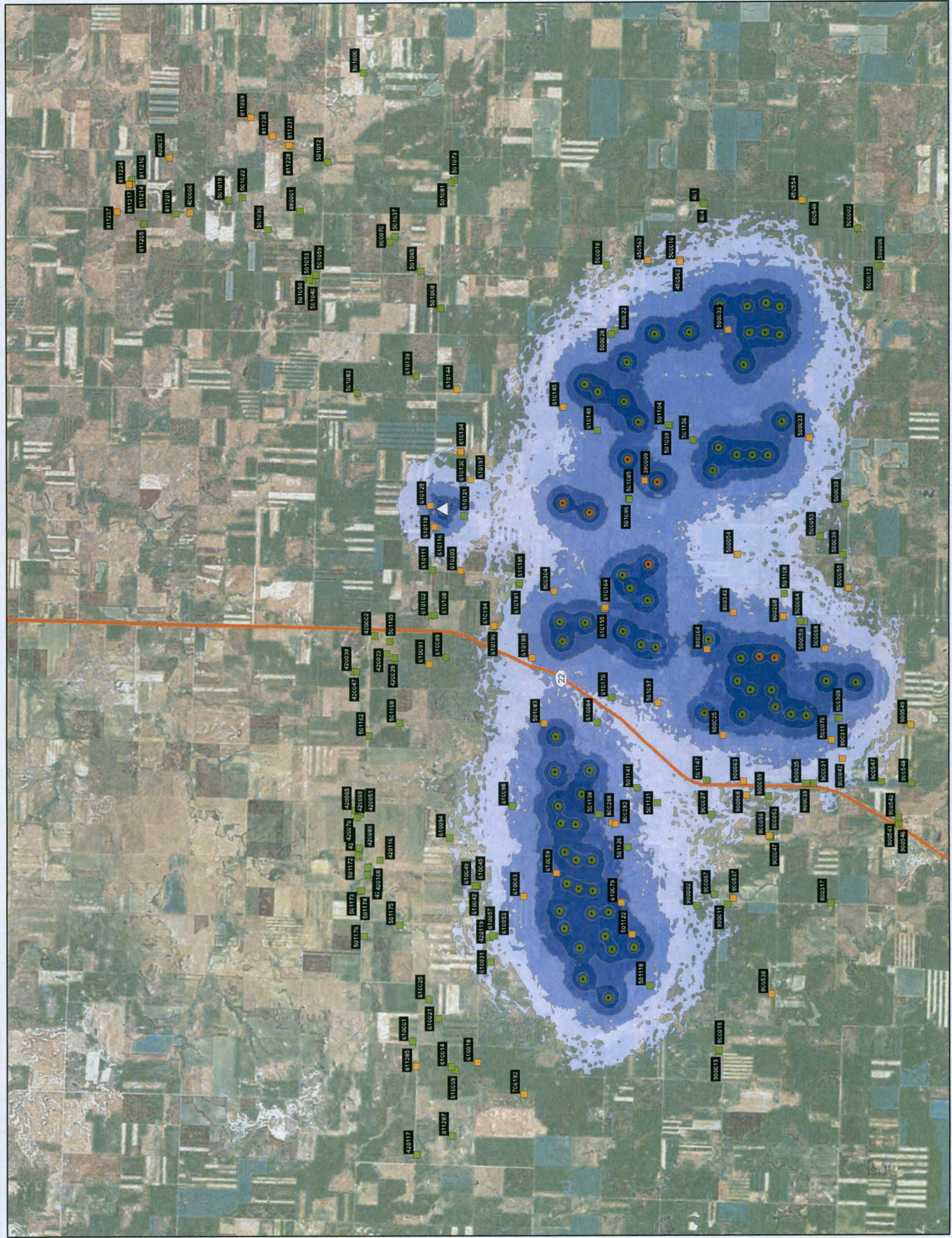
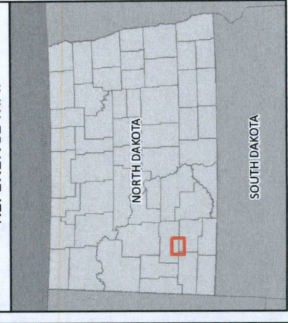
Interstate Highway

Major Road



0 0.5 1 1.5 2 MILES

REFERENCE MAP



NEXTERA ENERGY  
 RESOURCES, LLC  
 BRADY II WIND PROJECT  
 HETTINGER COUNTY  
 NORTH DAKOTA

FIGURE 8  
 CUMULATIVE EFFECTS (NO ALTS):  
 RECEIVED SOUND LEVELS -  
 WIND TURBINES AT CUT-IN  
 WIND SPEED

MAY 2016

Brady I Proposed Turbine Array (11/6/2015)

- GE 1.7 MW Turbine
- GE 1.79 MW Turbine

Brady II Proposed Turbine Array (4/22/2016)

- GE Xle 2.1-1.16 Turbine
- GE Xle 1.79-1.00 Turbine

Receptors

- Occupied
- Not Occupied
- △ Substation

Sound Level Contour Ranges (dBA)

35-40

>40-45

>45-50

>50

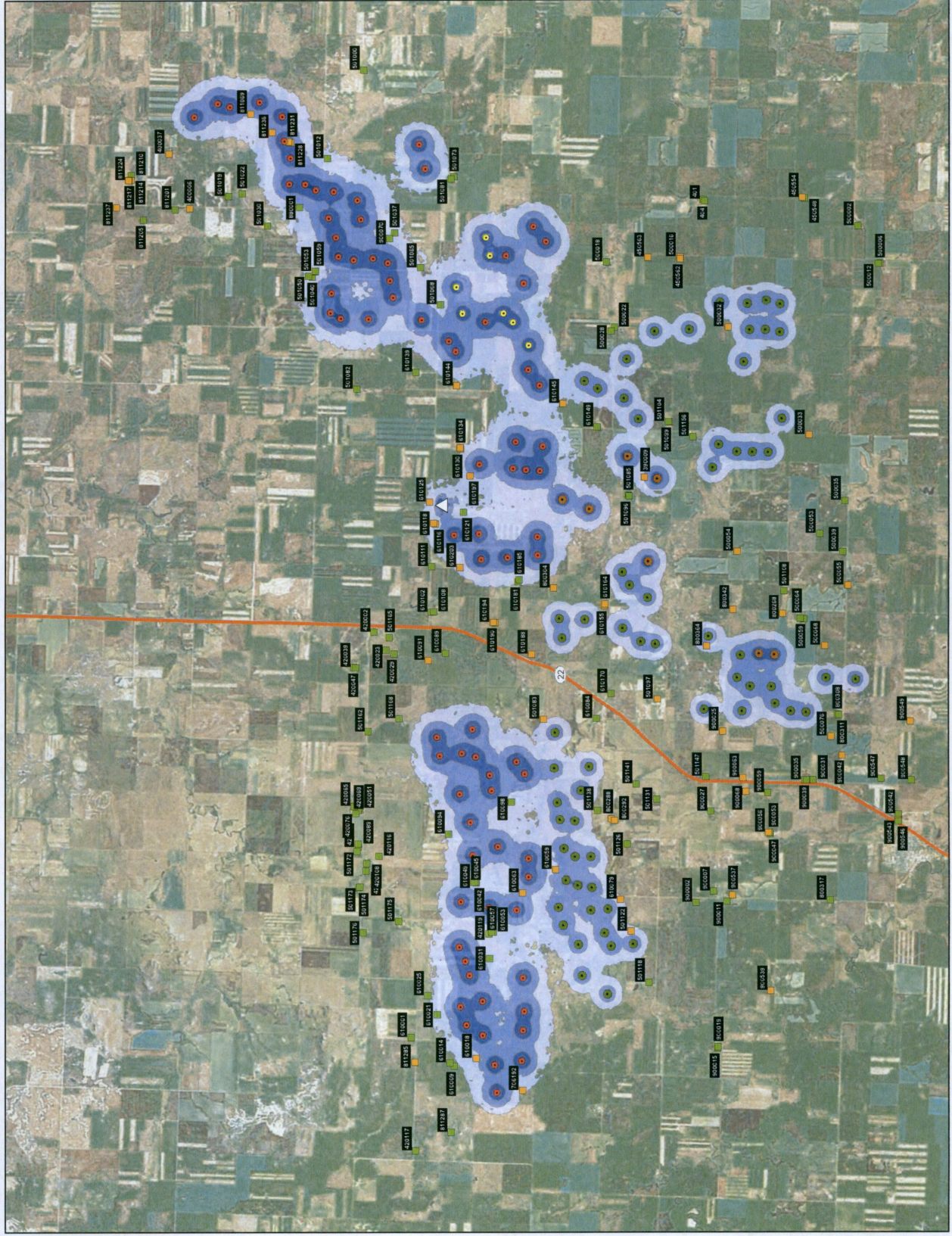
Interstate Highway

Major Road

0 0.5 1 1.5 2 MILES



REFERENCE MAP



NEXTERA ENERGY  
 RESOURCES, LLC  
 BRADY II WIND PROJECT  
 HETTINGER COUNTY  
 NORTH DAKOTA

FIGURE 9  
 CUMULATIVE EFFECTS (NO ALTS):  
 RECEIVED SOUND LEVELS -  
 WIND TURBINES AT  
 MAXIMUM ROTATIONAL  
 WIND SPEED

MAY 2016

Brady I Proposed Turbine Array (11/16/2015)

- GE 1.7 MW Turbine
- GE 1.79 MW Turbine
- GE Xle 2.1-1.16 Turbine
- GE Xle 1.79-100 Turbine

Receptors

- Occupied
- Not Occupied
- △ Substation

Sound Level Contour Ranges (dBA)

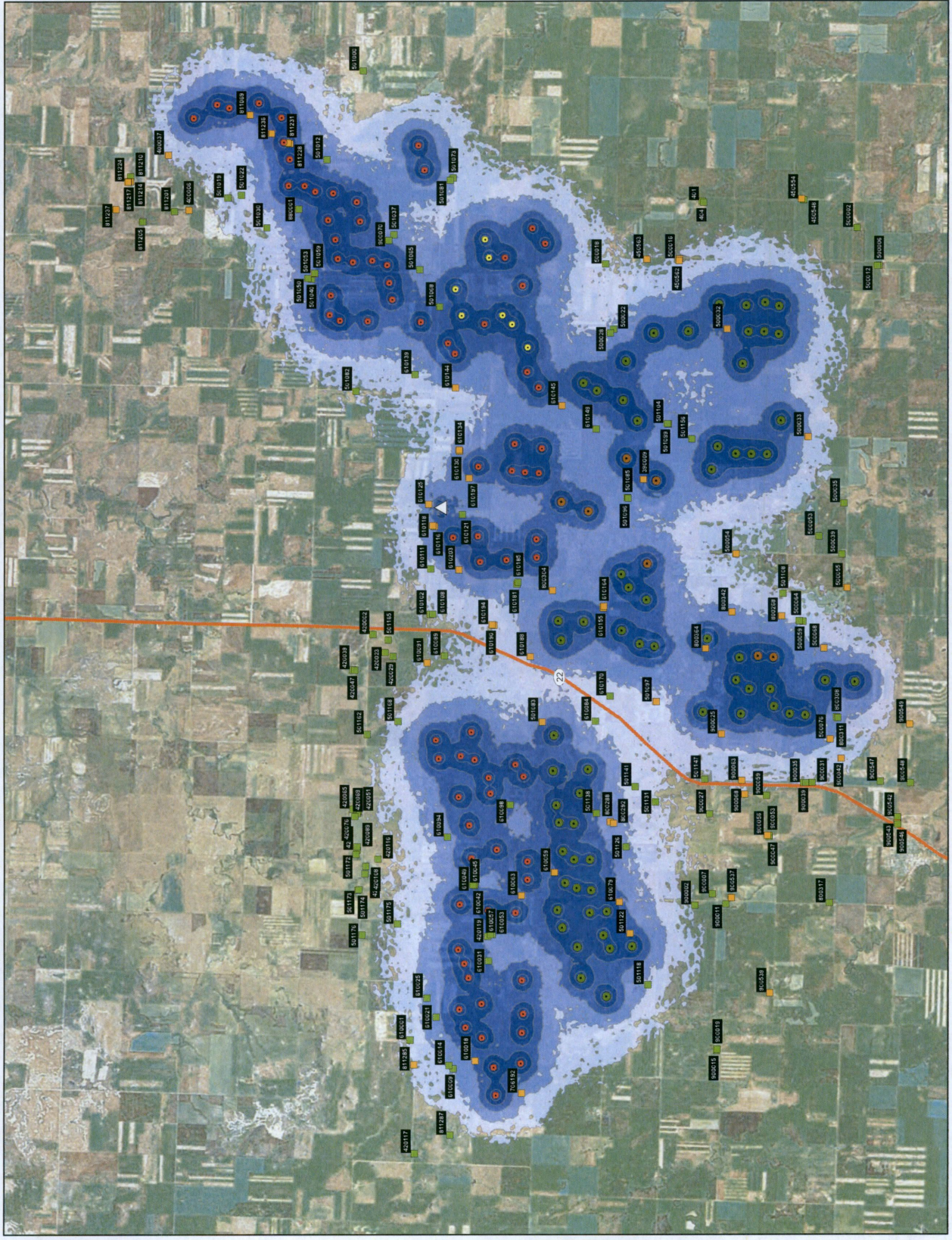
- 35-40
- >40-45
- >45-50
- >50

- Interstate Highway
- Major Road

0 0.5 1 1.5 2 MILES



REFERENCE MAP



NEXTERA ENERGY  
 RESOURCES, LLC  
 BRADY II WIND PROJECT  
 HETTINGER COUNTY  
 NORTH DAKOTA

FIGURE 10  
 CUMULATIVE EFFECTS (NO ALTS):  
 RECEIVED SOUND LEVELS -  
 WIND TURBINES AT MAXIMUM  
 ROTATIONAL WIND SPEED  
 ANOMALOUS METEOROLOGICAL  
 CONDITIONS

MAY 2016

- Brady I Proposed Turbine Array (11/6/2015)
- GE 1.7 MW Turbine
  - GE 1.79 MW Turbine
- Brady II Proposed Turbine Array (4/22/2016)
- GE Xie 2.1-1.16 Turbine
  - GE Xie 1.79-100 Turbine

- Receptors
- Occupied
  - Not Occupied
  - △ Substation

Sound Level Contour Ranges (dBA)

- 35-40
- >40-45
- >45-50
- >50

- Interstate Highway
- Major Road



0 0.5 1 1.5 2 MILES

REFERENCE MAP

