

August 15, 2018

VIA E-MAIL AND FEDERAL EXPRESS

Mr. Darrell Nitschke
Executive Secretary
North Dakota Public Service Commission
600 E. Boulevard, Dept. 408
Bismarck, ND 58505-0480

**RE: Meadowlark Wind I LLC's Application for a Certificate of Site Compatibility
for the New Frontier Wind Energy Project in McHenry County, North Dakota
Case No. PU-11-69**

Dear Mr. Nitschke:

In accordance with Certification Relating to Order Provisions ("Certification") attached to the North Dakota Public Service Commission's ("Commission") May 10, 2017 Order of Continuing Suitability for the New Frontier Wind Energy Project ("Project"), Meadowlark Wind I LLC ("Meadowlark") provides two (2) copies of the following documents:

1. Certification Regarding Layout Modifications, with Exhibits (per Certification Provision No. 38).

A copy of this letter is also enclosed. Electronic copies of this letter and the above-referenced documents were filed with the Commission today via e-mail.

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fax 612.492.7077	Minneapolis, Minnesota
fredlaw.com	55402-1425

Mr. Darrell Nitschke
August 15, 2018
Page 2

If you have any questions, please let me know.

Sincerely,

A handwritten signature in cursive script that reads "Mollie M. Smith".

MOLLIE M. SMITH

MMS/ms
Enclosures

cc: Jerry Lein (via e-mail – w/o encl.)
Todd Hartleben (via e-mail – w/o encl.)
Chad Tucker (via e-mail – w/o encl.)
Bill Behling (via e-mail – w/o encl.)
Joe Griffiths (via email – w/o encl.)

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regarding modifications to the Project layout, which incorporated the modifications submitted on July 3, 2018 (the “Modifications Certification”).

4. Since filing the Modifications Certification, Meadowlark has made additional minor modifications to the Project layout. A figure comparing the layout as submitted with the Modifications Certification to the current Project layout is attached hereto as **Exhibit A**.

5. The layout modifications include the following:

- a. A collection line has been added to the final design.
- b. Additional temporary workspace areas outside of previously surveyed areas have been identified.
- c. Five turbines have each been shifted less than 150 feet due to micrositing:
 - i. Turbine 9 was shifted to avoid a wetland within the area of turbine construction disturbance.
 - ii. Turbine 11 was shifted to avoid a wetland within the area of turbine construction disturbance.
 - iii. Turbine 24 was shifted in consultation with the Western Area Power Administration to avoid an existing microwave beam path.
 - iv. Turbine 39 was shifted due to constructability issues.
 - v. Turbine 43 was shifted to move permanent infrastructure away from the property line.

6. The Project layout complies with all requirements set forth in the Commission’s Order.

7. The five turbine modifications comply with the setback and shadow flicker commitments set forth in Order Paragraph No. 4(c) and (d), and the Commission’s sound

avoidance area criterion. In accordance with Order Paragraph Nos. 7 and 8, updated noise and shadow flicker analysis reports are attached as **Exhibits B** and **C**, respectively. Please note that while the modeling indicates that four participating residences (receptors 2, 3, 12, and 44) may experience shadow flicker levels above 30 hours per year, and four participating residences (receptors 1, 2, 3, and 12) may experience sound levels above 50 dBA within 100 feet of the residence, the owners of each of these residences previously executed shadow flicker acknowledgments and/or sound level waivers (*see* Appendix D to the Certification of Continuing Suitability Filing).

8. Approximately 10.73 acres within which proposed modifications are planned are outside of the areas previously surveyed for cultural resources and wetlands. In accordance with Order Paragraph Nos. 5 and 6, Meadowlark completed Class III cultural resource field surveys and wetland delineations of the previously unsurveyed areas that will be impacted by Project construction activities.


9. The Cultural Resources Addendum VI Report for the New Frontier Wind Energy Project, McHenry County, North Dakota is attached hereto as **Exhibit D**. No cultural resources were identified within the newly surveyed areas, and no cultural resources will be impacted by the layout modifications. The cultural resource reports have been reviewed by the North Dakota State Historical Society, and a copy of its response is attached as **Exhibit E**.

10. The Evaluation of Wetlands Within Previously Un-Surveyed Areas of Project Layout (report dated July 31, 2018) is attached hereto as **Exhibit F**. One U.S. Army Corps of Engineers jurisdictional wetland area was identified during the field survey. However, the modifications shown in **Exhibit A** avoid the wetland area.

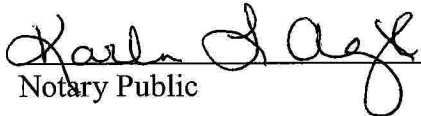
11. The Project layout modifications and associated construction activities will not affect any known exclusion or avoidance areas within the designated Project site.

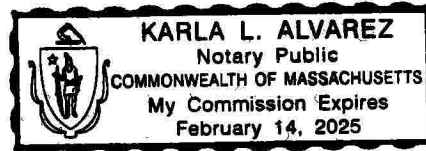
12. With respect to the Project, including the layout modifications, Meadowlark will comply with the Commission's Order, including applicable siting laws and rules.

FURTHER AFFIANT SAYETH NOT.

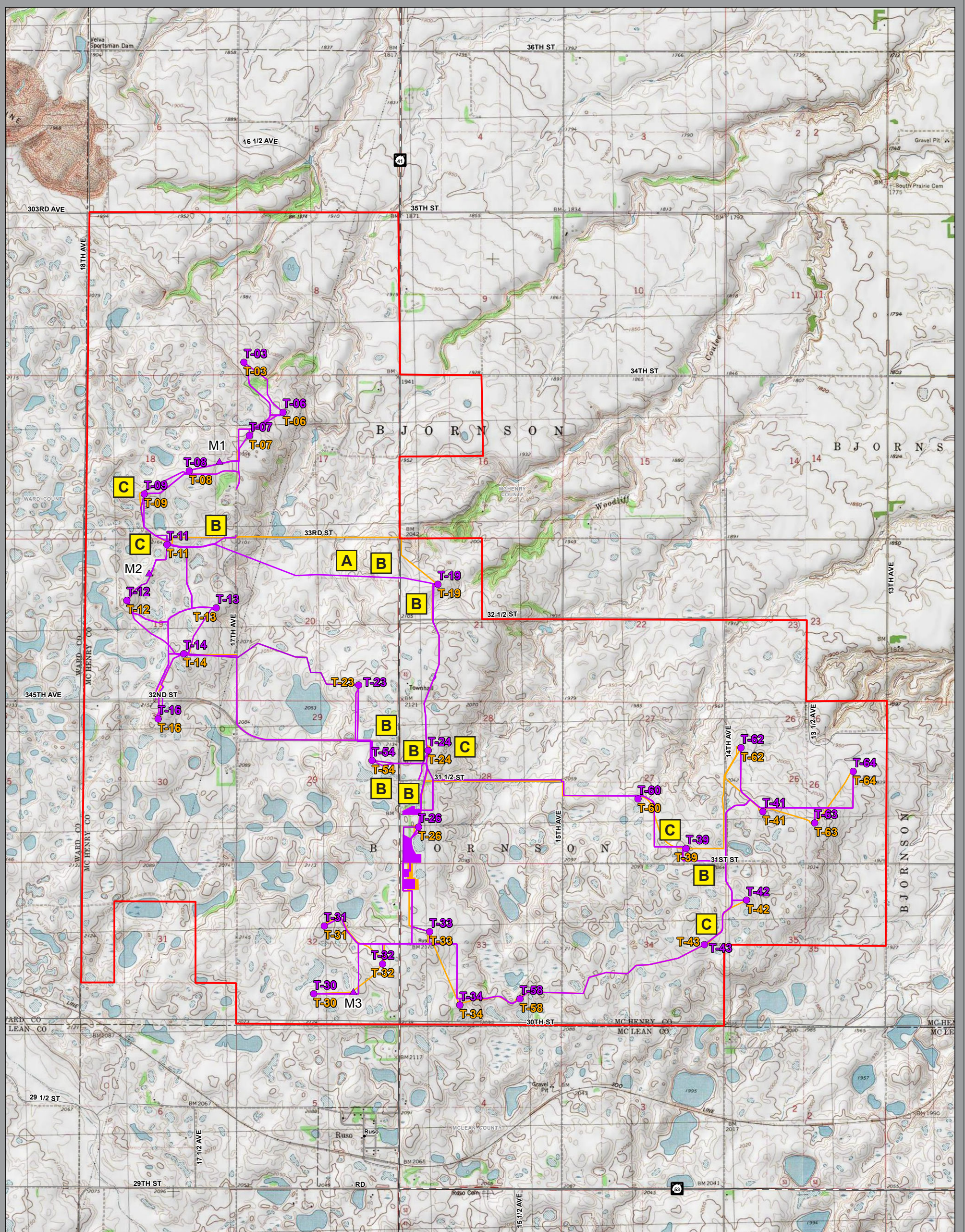

Paul F Wendelgass

Subscribed and sworn to before me
this 15th day of August, 2018.


Notary Public



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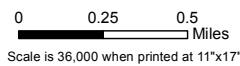


NEW FRONTIER WIND ENERGY PROJECT

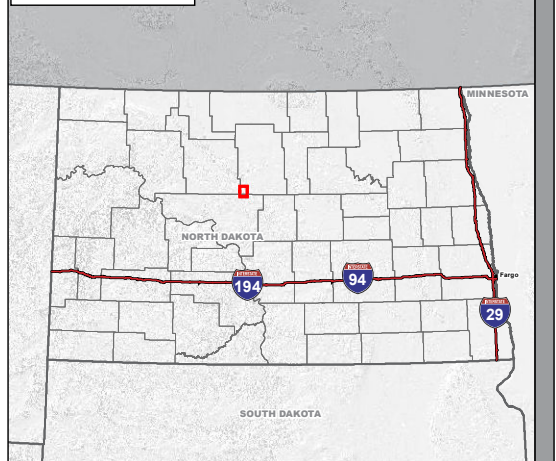
29-Turbine Layout (July 2018) and Updated 29-Turbine Layout (August 2018)

- | | |
|---|---|
| Project Area | 29-Turbine Layout (August 2018) Turbine |
| 29-Turbine Layout (July 2018) Turbine | 29-Turbine Layout (August 2018) Met Tower |
| 29-Turbine Layout (July 2018) Met Tower | 29-Turbine Layout (August 2018) Access Road |
| Access Road | 29-Turbine Layout (August 2018) Collector Line |
| Collector Line | 29-Turbine Layout (August 2018) O & M Building |
| O & M Building | 29-Turbine Layout (August 2018) Substation |
| Substation | 29-Turbine Layout (August 2018) Laydown/Batch Plant |
| Laydown/Batch Plant | 29-Turbine Layout (August 2018) Crane Walk/Path |
| Crane Walk/Path | |

Layout Modifications
 A – Collection line added to final design
 B – Additional temporary workspace areas outside of previously surveyed areas
 C – Minor turbine shifts



Vicinity Map



**Acoustic Assessment for the
New Frontier Wind Energy Project
McHenry County, North Dakota**

Prepared for



Prepared by



**November 2016
Updated January 2018
Updated May 2018
Updated August 2018**

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Acronyms and Abbreviations

CadnaA	Computer-Aided Noise Abatement Program
Capital Power	Capital Power Corporation
dB	decibel
dBA	A-weighted decibel
dB L	unweighted decibel
ft.	feet
Hz	Hertz
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
kHz	kilohertz
Leq	equivalent sound level
Lmax	maximum sound level
Lp	sound pressure level
Lw	sound power level
m	meters
Meadowlark	Meadowlark Wind I LLC
m/s	meters per second
mph	miles per hour
MVA	megavolt ampere
MW	megawatt
NEMA	National Electrical Manufacturers Association
NSR	Noise Sensitive Receptor
Project	New Frontier Wind Energy Project
PSC	North Dakota Public Service Commission
PSC Order	Order on Continuing Suitability PU-11-69
pW	picowatt
Tetra Tech	Tetra Tech, Inc.
μPa	microPascal
UTM	Universal Transverse Mercator

Executive Summary

Tetra Tech, Inc. (Tetra Tech) has completed an acoustic assessment for the proposed New Frontier Wind Energy Project (Project) under development in McHenry County, North Dakota. A screening-level analysis was completed to evaluate the expected sound levels resulting from the Project wind turbines and substation. Operational turbines were evaluated at the 29 potential locations from the July 31, 2018 Project layout. Acoustic analyses for three different modeling scenarios were performed. Scenarios included wind turbine operation at cut-in wind speed, as well as maximum rotational wind speed under both moderate downwind and anomalous meteorological conditions. The overall objective of this study was to determine the feasibility of the Project to operate in compliance with the North Dakota Public Service Commission (PSC) 50 dBA noise limit applicable within 100 feet of an occupied residence or community building, and to demonstrate continued compliance with the Order of Continuing Suitability PU-11-69 (PSC Order) issued by the PSC May 10, 2017 for the Project.

Wind turbine sound source data was obtained from Vestas for the Vestas V126-3.45 (Vestas 2016). Substation noise impacts were based on a projected 111 megavolt ampere (MVA) transformer. It is expected that the wind turbines 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 (Cadena) program (version 2018 MR1), 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. Several modeling assumptions inherent in the ISO 9613-2 calculation methodology, or selected as conditional inputs by the user, were implemented in the Cadena model to ensure conservative results.

The results of the acoustic assessment show that the Project will comply with the PSC 50 A-weighted decibel limit at all receptors, except for four participating landowner residences, which may experience sound levels above the applicable noise limit under certain operational and meteorological conditions. Meadowlark Wind I LLC (Meadowlark) has obtained written waivers of the sound level avoidance area criteria from those landowners. 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.

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1.0 OVERVIEW

On April 26, 2012, the North Dakota Public Service Commission (PSC) issued Certificate of Site Compatibility Number 29 to Meadowlark Wind I LLC (Meadowlark or Applicant) for the New Frontier Wind Energy Project (Project) in McHenry County, North Dakota (Figure 1). In December 2014, Capital Power Investments LLC, a subsidiary of Capital Power Corporation (Capital Power), completed the acquisition of Element Power US, LLC, which included Meadowlark and the Project. In February 2016, Capital Power contracted Tetra Tech to conduct the following acoustic assessment for the Project to support the Certification of Continuing Suitability Application for the Project. On May 10, 2017, the PSC issued Order on Continuing Suitability PU-11-69 (PSC Order) to Meadowlark for the Project. The acoustic analysis was updated in January 2018 to assess the Project's final selected turbine model and array layout and updated again in May 2018 and August 2018 to address minor turbine location adjustments, per the PSC Order Paragraph No. 7: In the event Project modifications occur that are not covered by its current sound analysis, Meadowlark shall conduct a sound analysis and file a report with the Commission to ensure that the Project complies with the Commission's Avoidance Area Sound Requirement.

Capital Power proposes to construct and operate the Project in McHenry County, North Dakota. The Project is expected to have an up to nominal 100.1 megawatt (MW) power output capacity using 29 wind turbine locations, which were previously permitted by the PSC. For the Project site layout, Capital Power has selected the Vestas V126-3.45 wind turbine model. The proposed Project infrastructure also includes underground collection lines and a substation. The substation transformer is rated at 111 megavolt ampere (MVA) and located along State Highway 41 north of State Highway 53.

This acoustic assessment included modeling analyses to predict future sound levels when the wind turbines are operational. Three different modeling scenarios were considered, one with wind turbines operating at cut-in wind speed and two others at maximum rotational wind speed, under moderate downwind and anomalous meteorological conditions. Operational sounds levels resulting from the Project were analyzed at existing noise-sensitive receptors (NSRs; e.g., residential structures) and compliance was assessed relative to the PSC noise limit.

1.1 Study Area

The Project Study Area encompasses approximately 10,530 acres (16.5 square miles) within McHenry County. County and township (section line) roads characterize the existing roadway infrastructure in and around the Study Area. The Study Area is accessed via State Highway 41, State Highway 53, 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 southwestern McHenry County. 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 1,712 to over 2,196 feet. There are also several waterbodies throughout the Study Area. Current land use within the Study Area is primarily agricultural, supporting both crops and livestock grazing. Potential NSR locations within the Study Area and in the vicinity of proposed turbine locations were included in the acoustic analysis. Noise sensitive receptor (NSR) 15 was identified as a military use facility. Figure 1 (Appendix A) presents the proposed wind turbine locations, as well as the noise sensitive receptor locations.

1.2 Existing Acoustic Environment

McHenry 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 State Highway 41 and State Highway 53. 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 natural sounds and proximity to area sound sources such as roadways. 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. 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 (LP) 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 since 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 (μPa). 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 bands (or 33 1/3 octave) 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 (Leq). 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 (50 ft.)	80	Loud	Reference loudness
Vacuum cleaner (10 ft.)	70	Moderate	1/2 as loud

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)
Passenger car at 65 mph (25 ft.)	65		
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	
Term	Definition
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_p)	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_w)	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.

Table 2. Acoustic Terms and Definitions

Term	Definition
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, county or local environmental noise requirements specific to this Project. At the state level, the PSC has established regulations applicable to wind energy facilities.

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.

3.0 ACOUSTIC MODELING METHODOLOGY AND RESULTS

Sound generated by an operating wind turbine is comprised of both aerodynamic and mechanical sound with the dominant sound component from modern utility scale wind turbines being largely aerodynamic. Aerodynamic sound refers to the sound produced from air flow and the interaction with the wind turbine 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 wind turbine 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 wind turbines 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 wind turbine 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. Wind turbine maximum sound power will generally be reached at wind speeds between 7 meters per second [m/s] and 11 m/s, depending on the candidate turbine selected. 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 wind turbine sound emissions occur, the sound produced from a wind turbine 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 wind turbine 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 July 31, 2018 layout with 29 wind turbine locations. The following wind turbine model was evaluated in this analysis:

- **Vestas V126-3.45** – Wind turbine that has a rotor diameter of 413 ft. (126 m) and a hub height of 285 ft. (87 m).

The acoustic modeling analysis was conducted using the most recent version of DataKustic GmbH's computer-aided noise abatement program or CadnaA (version 2018 MR1). CadnaA is a comprehensive 3-dimensional acoustic software model that conforms 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 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 degrees Celsius (50 degrees 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 wind turbine locations or wind turbine 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 variations 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. 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

To assist project developers and acoustical engineers, wind turbine manufacturers report wind turbine 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 wind turbines between manufacturers. Tables 3 and 4 present a summary of sound power data for the candidate wind turbine models during normal operations correlated to 10 meter height integer wind speeds 10 meter above ground level.

The specification for the wind turbines includes an expected warranty confidence interval, or k-factor which was added to the nominal sound power level in the acoustic model. As indicated in the manufacturer sound specification, the Vestas 126-3.45 wind turbines have a k-factor of 2 dB applied. 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. Vestas V126-3.45 Wind Turbine Broadband Sound Power Levels Correlated with Wind Speed									
Hub Height (m)	WTG Sound Power Level (dBA) at Reference Wind Speed (m/s)								
	3	4	5	6	7	8	9	10	11
87.0	92.5	92.6	94.3	97.8	101.4	104.7	107.7	109.8	110.1

Source: Vestas 2016.

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 wind turbines operating at maximum rotation are presented in Table 4 (1/1 octave band frequency data provided with stated intended use limited for informational purposes only).

Table 4. Vestas V126-3.45 Wind Turbine Broadband Sound Power Level by Octave Band Frequency										
K-Factor	Octave Band Sound Power Level (dBA) by Frequency (Hz)									Broadband (dBA)
	31.5	63	125	250	500	1000	2000	4000	8000	
2.0	79.5	90.0	96.5	100.1	102.2	105.4	104.4	98.3	84.6	110.1
Source: Vestas 2016.										

3.3 Acoustic Modeling Results

Acoustic modeling was completed for wind turbine cut-in and maximum rotational operating conditions, thereby describing resultant sound pressure levels over the entire operational range of the Project. 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 wind turbines 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 4, in Appendix A. Figure 2 shows received sound levels when all wind turbines are operating at cut-in wind speed. Figure 3 shows received sound levels when all wind turbines are operating at maximum rotational wind speed under moderate downwind propagation conditions. Figure 4 shows received sound levels conditions when all wind turbines are operating at maximum rotational wind speed under anomalous meteorological conditions.

Table 5 presents the results of the Project acoustic modeling analysis and includes the ID, Universal Transverse Mercator (UTM) coordinates, NSR status and the received sound levels at each NSR. 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.

Acoustic modeling results show that there are four occupied NSRs (NSR IDs 1, 2, 3, and 12) with received sound levels greater than 50 dBA. All these residences are owned by landowners that are participating in the Project. Received sound levels at all non-participating NSRs were determined to be below the PSC 50 dBA noise limit.

Table 5. Acoustic Modeling Results Summary						
NSR ID	NSR Status	UTM Coordinates (meters)		Vestas V126-3.45		
		Easting	Northing	Cut-in	Maximum Rotational	Anomalous Meteorological
R01	Participant	355605.0	5301329.0	32	50	50
R02	Participant	355661.0	5302441.0	34	52	52
R03	Participant	355702.0	5304238.0	35	53	53
R04	Participant	354027.0	5303759.0	26	44	45
R05	Participant	354097.0	5304134.0	28	45	46
R06	Participant	355606.0	5307543.0	24	42	43
R07	Participant	355126.0	5306945.0	29	47	47
R08	Non-participant	356588.0	5306315.0	23	41	41
R09	Participant	355290.0	5309265.0	18	36	38
R10	Non-participant	355229.0	5309343.0	18	35	37
R11	Non-participant	354397.0	5309449.0	18	36	38
R12	Participant	354123.0	5306615.0	34	52	52
R13	Participant	354129.0	5306370.0	32	49	49
R14	Participant	352764.0	5304471.0	28	46	46
R15	Non-participant	356024.0	5307978.0	21	38	40
R16	Non-participant	355935.0	5310392.0	13	30	33
R17	Non-participant	357493.0	5309065.0	14	31	34
R18	Non-participant	360751.0	5304944.0	20	38	40
R19	Non-participant	348671.0	5304722.0	5	23	25
R20	Non-participant	348189.0	5304543.0	4	21	24
R21	Non-participant	355635.0	5300982.0	28	46	46
R22	Non-participant	355940.0	5308365.0	20	37	39
R23	Non-participant	357655.0	5306178.0	20	37	39
R24	Non-participant	355731.0	5300486.0	24	42	43
R25	Non-participant	355619.0	5299997.0	20	38	40
R26	Non-participant	355445.0	5300002.0	20	38	40
R27	Non-participant	355401.0	5300005.0	20	38	40
R28	Non-participant	355289.0	5300130.0	21	38	40
R29	Non-participant	355309.0	5300409.0	22	40	41
R30	Non-participant	355799.0	5299704.0	19	36	38
R31	Non-participant	358962.0	5301030.0	24	41	42
R32	Non-participant	353241.0	5300543.0	18	35	37
R33	Non-participant	355840.0	5311882.0	9	26	29

Table 5. Acoustic Modeling Results Summary						
NSR ID	NSR Status	UTM Coordinates (meters)		Vestas V126-3.45		
		Easting	Northing	Cut-in	Maximum Rotational	Anomalous Meteorological
R34	Non-participant	357661.0	5310795.0	10	28	30
R35	Participant	355462.0	5309266.0	18	35	37
R36	Non-participant	360761.0	5306287.0	15	33	35
R37	Non-participant	358898.0	5299451.0	16	34	36
R38	Non-participant	354692.0	5299450.0	17	35	37
R39	Non-participant	355368.0	5299420.0	18	35	37
R40	Non-participant	355104.0	5300327.0	22	40	41
R41	Non-participant	352663.0	5299129.0	13	30	33
R42	Non-participant	354311.0	5309444.0	18	36	38
R43	Non-participant	355272.0	5309370.0	18	35	37
R44	Participant	355890.0	5305977.0	31	48	49
R45	Non-participant	361733.0	5299729.0	12	30	32
R46	Non-participant	362418.0	5300028.0	11	29	31
R47	Non-participant	357737.0	5299654.0	18	35	38

Tabulated sound levels are rounded values. Please note that sound levels greater than 50 dBA, and exceedances of the PSC noise criteria, are identified in **red**.

3.4 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 substation would be located along State Highway 41 approximately 15,000 feet (4,500 meters) north of State Highway 53, with the closest residence approximately 820 feet (250 meters) to the southwest. The transformer at this substation location was modeled using the latest version of CadnaA implementing ISO 9613-2. Table 6 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 6. 111 MVA Transformer Sound Power Level									
Octave Band Sound Power Level (dBA) by Frequency (Hz)									Broadband (dBA)
31.5	63	125	250	500	1000	2000	4000	8000	
54.0	73.3	85.4	87.9	93.3	90.6	86.8	81.5	72.4	97.0

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 NSRs. The proposed transformer location is approximately 500 feet (150 meters) from the nearest NSR and poses little concern from a noise perspective. Nevertheless, transformer noise may be periodically audible at nearby NSRs on occasions when background sound levels are very low.

3.5 Construction Noise

The development of the Project will involve construction to establish access roads, excavate and form wind turbine foundations, prepare the site for crane-lifting and assemble and commission the wind turbines. Work on large-scale wind projects such as the Project 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 wind turbines 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, operations and 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 7.

Table 7. Estimated L_{max} Sound Pressure Levels from Construction Equipment		
Equipment	Estimated Sound Pressure Level at 50 feet (dBA)	Estimated Sound Pressure Level at 2000 feet (dBA)
Crane	85	53
Forklift	80	48
Backhoe	80	48
Grader	85	53
Man basket	85	53
Dozer	83–88	51–56
Loader	83–88	51–56
Scissor Lift	85	53
Truck	84	52
Welder	73	41
Compressor	80	48
Concrete Pump	77	45
Concrete Batch Plant	83	51
Source: FHWA 2006; Bolt et al. 1977		

Sounds generated by construction activities are typically exempt from state and local noise oversight if 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 NSRs 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.

4.0 CONCLUSIONS

Project operational sound has been calculated and compared to the 50 dBA North Dakota PSC noise limit. Acoustic modeling analysis per ISO 9613-2 and inclusive of a number of conservative assumptions demonstrates the Project will comply with the PSC's sound level avoidance area criteria at all NSRs, except for four participating landowner residences, which may experience sound levels above the applicable noise limit under certain operational and meteorological conditions. Meadowlark has obtained written waivers of the sound level avoidance area criteria from those landowners, and copies are provided in Appendix D of the New Frontier Wind Energy Project Certification of Continuing Suitability Filing dated November 2016. The Project continues to comply with the PSC Order Paragraph 7. 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.

5.0 REFERENCES

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- Bonner, W. Climatology of the Low Level Jet. Monthly Weather Review, Volume 96, Number 12, December 1968.
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- V126-3.45 MW Loq Torque (LTq) Third octave noise emission. Vestas Wind Systems A/S 2016.

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Figures

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NEW FRONTIER WIND ENERGY PROJECT

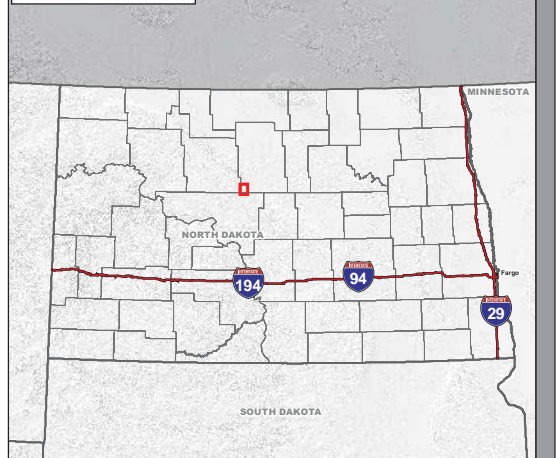
Figure 1: Project Layout

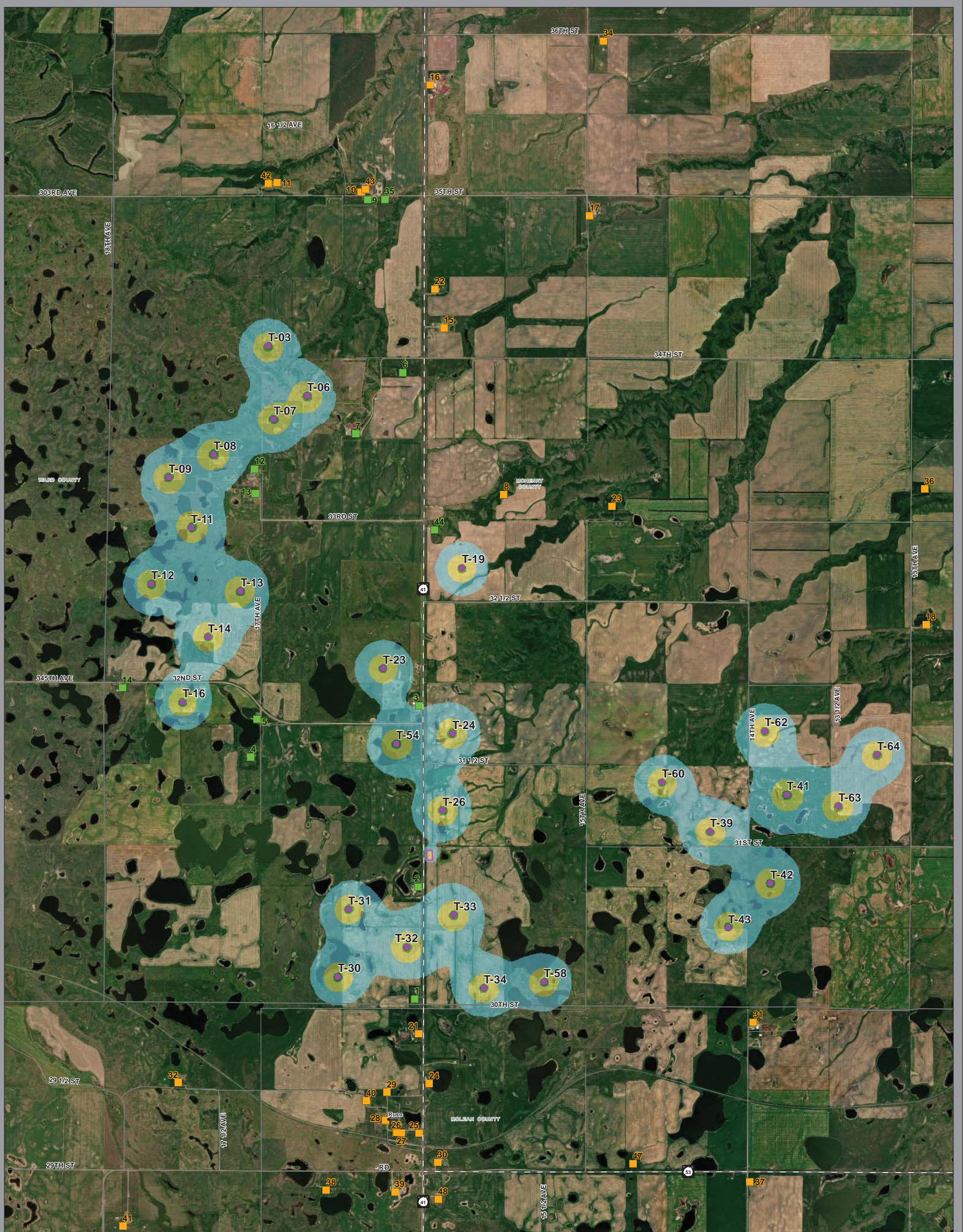
- Vestas V126-3.45 Wind Turbine (Project site layout dated July 31, 2018)
- Participant Receptor
- Non-Participant Receptor
- Substation

0 0.25 0.5 Miles
Scale is 1:36,000 when printed at 11x17"



Vicinity Map



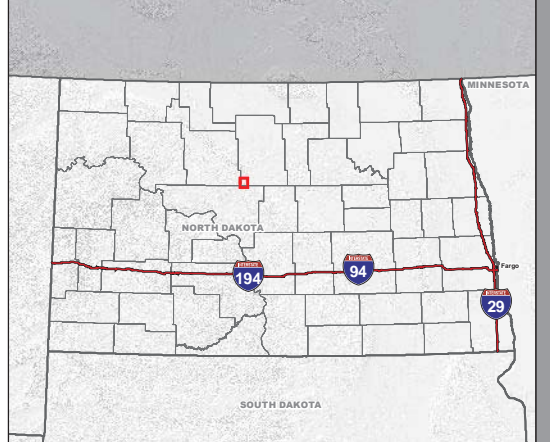


NEW FRONTIER WIND ENERGY PROJECT
Figure 2 – Vestas V126-3.45: Received Sound Levels
Wind Turbines at Cut-In Wind Speed

0 0.25 0.5 Miles
 Scale is 1:36,000 when printed at 11x17"



Vicinity Map



- Vestas V126-3.45 Wind Turbine (Project site layout dated July 31, 2018)
 - Participant Receptor
 - Non-Participant Receptor
 - Substation
- | Sound Level Contour Ranges (dBA) | |
|----------------------------------|-------------|
| | 35 - 40 dBA |
| | 40 - 45 dBA |
| | 45 - 50 dBA |





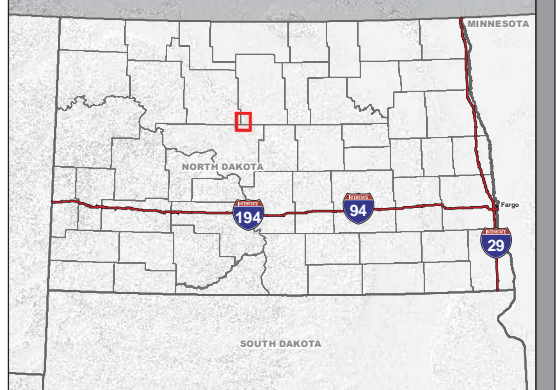
NEW FRONTIER WIND ENERGY PROJECT
Figure 3 – Vestas V126-3.45: Received Sound Levels
Wind Turbines at Maximum Rotational Wind Speed

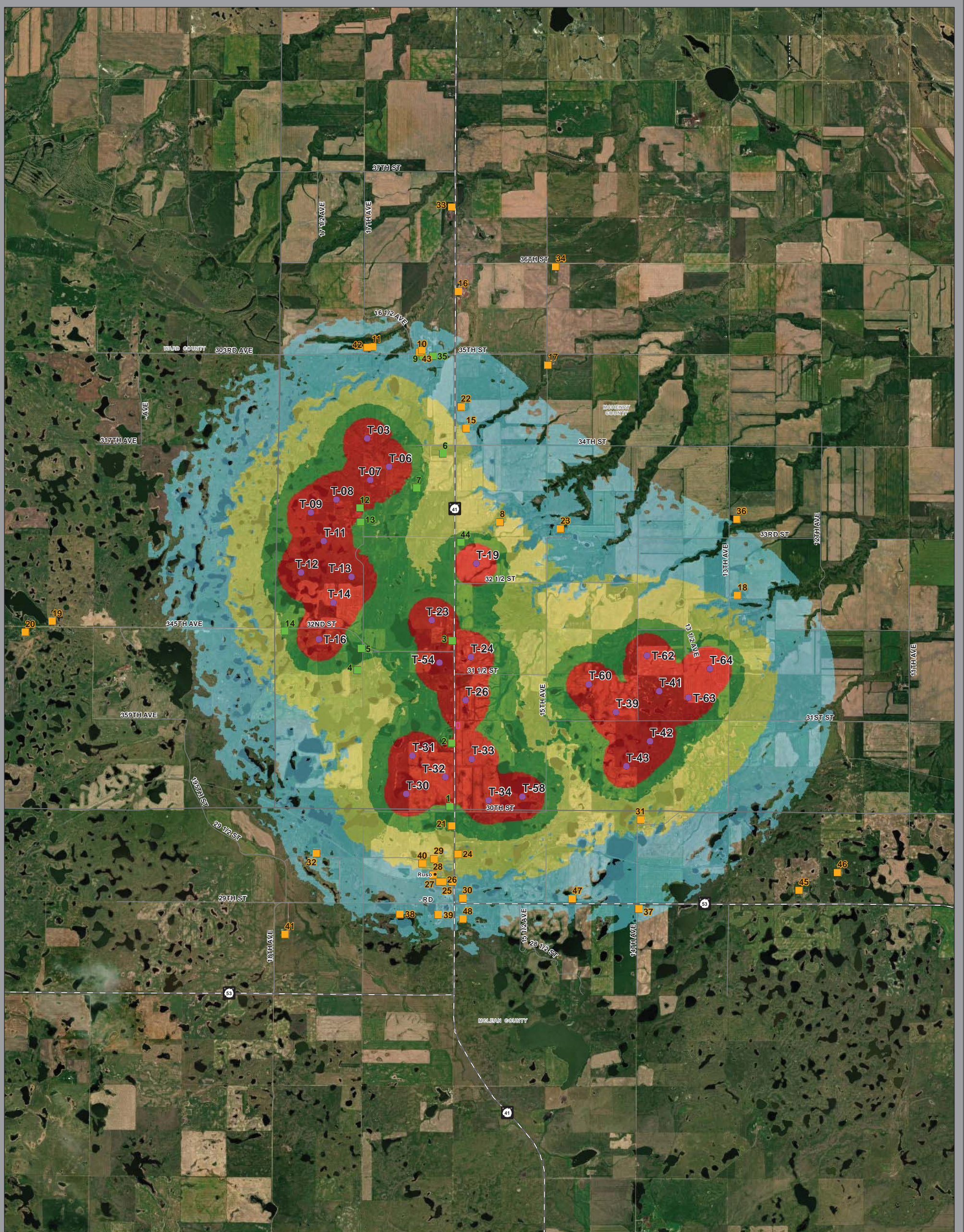
- Vestas V126-3.45 Wind Turbine (Project site layout dated July 31, 2018)
 - Participant Receptor
 - Non-Participant Receptor
 - Substation
- | Sound Level Contour Ranges (dBA) | |
|--|-------------|
| | 35 - 40 dBA |
| | 40 - 45 dBA |
| | 45 - 50 dBA |
| | > 50 dBA |

0 0.5 1 Miles
 Scale is 1:64,000 when printed at 11x17"



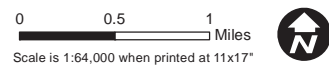
Vicinity Map





NEW FRONTIER WIND ENERGY PROJECT
Figure 4 – Vestas V126-3.45: Received Sound Levels
Wind Turbines at Maximum Rotational Wind Speed
Anomalous Meteorological Conditions

- Vestas V126-3.45 Wind Turbine (Project site layout dated July 31, 2018)
 - Participant Receptor
 - Non-Participant Receptor
 - Substation
- | Sound Level Contour Ranges (dBA) | |
|----------------------------------|-------------|
| | 35 - 40 dBA |
| | 40 - 45 dBA |
| | 45 - 50 dBA |
| | > 50 dBA |



Vicinity Map



Shadow Flicker Impact Analysis for the New Frontier Wind Energy Project McHenry County, North Dakota

Prepared for



Prepared by



**November 2016
Updated January 2018
Updated May 2018
Updated August 2018**

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- Attachment A. Detailed Summary of WindPro Shadow Flicker Analysis Results

Acronyms and Abbreviations

Capital Power	Capital Power Corporation
Hz	Hertz
Meadowlark	Meadowlark Wind I LLC
NCDC	National Climatic Data Center
Project	New Frontier Wind Energy Project
PSC	North Dakota Public Service Commission
PSC Order	Order on Continuing Suitability PU-11-69
rpm	rotations per minute
UTM	Universal Transverse Mercator

1.0 OVERVIEW

On April 26, 2012, the North Dakota Public Service Commission (PSC) issued Certificate of Site Compatibility Number 29 to Meadowlark Wind I LLC (Meadowlark) for the New Frontier Wind Energy Project (Project) in McHenry County, North Dakota (Figure 1). In December 2014, Capital Power Investments LLC, a subsidiary of Capital Power Corporation (Capital Power), completed the acquisition of Element Power US, LLC, which included Meadowlark and the Project. In February 2016, Capital Power contracted Tetra Tech to conduct the following shadow flicker analysis for the Project, to support the Certification of Continuing Suitability Application for the Project. On May 10, 2017, the PSC issued to Meadowlark the Order on Continuing Suitability PU-11-69 (PSC Order) for the Project. The shadow flicker analysis was updated in January 2018 to assess the Project's final selected turbine model and array layout and updated again in May 2018 and August 2018 to address minor turbine location adjustments, per the PSC Order Paragraph No. 8:

In the event Project modifications occur that are not covered by its current shadow flicker analysis, Meadowlark shall conduct a shadow flicker analysis and file a report with the Commission to ensure that the Project complies with the commitment in Order Paragraph No. 4(d) [Meadowlark shall site Project turbines so as to meet a shadow flicker goal of 30 hours per year or less at each currently occupied residence, considering site-specific conditions, unless a written acknowledgment is obtained from the landowner.]

2.0 PROJECT COMPONENTS

The Project will consist of up to 29 wind turbines. The turbine model selected for the Project is the Vestas V126-3.45 and has the following specifications:

- **Vestas V126-3.45:** Three-blade 126 m rotor diameter, with a hub height of 87 meters and generating capacity of 3.45 megawatts. The V126-3.45 has a normal high rotor speed of 12.8 rotations per minute (rpm), which translates to a blade pass frequency of 0.64 hertz (Hz; 0.64 alternations per second).

3.0 SHADOW FLICKER BACKGROUND

A wind turbine's moving blades can cast a moving shadow on locations within a certain distance of a turbine. These moving shadows are called shadow flicker, and can be a temporary phenomenon experienced at nearby residences or public gathering places. The impact area depends on the time of year and day (which determine the sun's azimuth and altitude angles) and the wind turbine's physical characteristics (height, rotor diameter, blade width, and orientation of the rotor blades). Shadow flicker impact to surrounding properties generally occurs during low angle sunlight conditions, typically during sunrise and sunset times of the day.

However, when the sun angle gets very low (less than three degrees), sunlight passes through more atmosphere and becomes too diffused to form a coherent shadow. Shadow flicker will not occur when the sun is obscured by clouds or fog, at night, or when the source turbine(s) are not operating. In addition, shadow flicker is only an issue when at least 20 percent of the sun's disc is covered by the turbine blades.

Shadow flicker intensity is defined as the difference in brightness at a given location in the presence and absence of a shadow. Shadow flicker intensity diminishes with greater receptor-to-turbine separation distance. Shadow flicker intensity for receptor-to-turbine distances beyond 2,500 meters (8,202 feet) is very low and generally considered imperceptible. In general, increasing proximity to turbines may make shadow flicker more noticeable, with the largest number of shadow flicker hours, along with greatest shadow flicker intensity, occurring nearest the wind turbines.

Shadow flicker frequency is related to the wind turbine's rotor blade speed and the number of blades on the rotor. From a health standpoint, the low flicker frequencies associated with wind turbines, are harmless, and public concerns that flickering light from wind turbines can have negative health effects, such as triggering seizures in people with epilepsy are unfounded. Epilepsy Action (working name for the British Epilepsy Foundation) states that there is no evidence that wind turbines can cause seizures (Epilepsy Action 2008). However, they recommend that wind turbine flicker frequency be limited to three Hz (for comparison, strobe lights used in discos have frequencies which range from about three Hz to 10 Hz (one Hz = one flash per second)). Since the proposed Project's wind turbine blade pass frequency is approximately 0.87 Hz (less than one alternation per second), no negative health effects to individuals with photosensitive epilepsy are anticipated.

As stated in Section 1, PSC Order Paragraph 8 requires that the project site the wind turbines so as to meet a shadow flicker goal of 30 hours per year or less at each currently occupied residence. Therefore, the 30 hours per year threshold has been used in this shadow flicker analysis.

4.0 WINDPRO SHADOW FLICKER ANALYSIS

An analysis of potential shadow flicker impacts from the Project was conducted using the WindPro software package. As described above, the Project will install up to 29 wind turbines.

The WindPro analysis was conducted to determine shadow flicker impacts under realistic impact conditions (actual expected shadow). This analysis calculated the total amount of time (hours and minutes per year) that shadow flicker could occur at receptors surrounding the Project turbines. The realistic impact condition scenario is based on the following:

- The elevation and position geometries of the wind turbines and surrounding receptors (potentially occupied residences). Elevations were determined using U.S. Geological Survey digital elevation model data. Positions geometries were determined using

geographic information system and referenced to Universal Transverse Mercator (UTM) Zone 14 (NAD83).

- The position of the sun and the incident sunlight relative to the wind turbine and receptors on a minute-by-minute basis over the course of a year.
- Historical sunshine availability (percent of total hours available). Historical sunshine rates for the area (as summarized by the National Climatic Data Center [NOAA 2015] for nearby Bismarck, North Dakota) used in this analysis are as follows:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
54%	52%	61%	58%	64%	67%	75%	72%	67%	53%	42%	45%

- Estimated wind turbine operations and orientation based on wind data (wind speed and direction) measured at meteorological towers located on the Project site.
- Receptor viewpoints (i.e., house windows) are assumed to always be directly facing turbine to sun line of sight (“greenhouse mode”).

WindPro incorporates terrain elevation contour information and the analysis accounts for terrain elevation differences. The sun’s path with respect to each turbine location is calculated by the software to determine the cast shadow paths every minute over a full year. Sun angles less than 3 degrees above the horizon were excluded for the reasons identified earlier in Section 3. Since shadow flicker is only an issue when at least 20 percent of the sun disc is covered by the blades, WindPro uses blade width dimension data to calculate the maximum distance from the turbine where shadow flicker must be calculated. Beyond this distance, the turbine will not contribute to the shadow flicker impact. It should be noted however, that WindPro provides a conservative estimate of shadow flicker as obstacles such as trees, haze, and visual obstructions (window facing, coverings) are not accounted for despite the likelihood of their reducing or eliminating shadow flicker impacts to receptors.

A total of 47 residential structures were identified within and near the Project Area as occupied or potentially occupied residences and are considered potential shadow-flicker receptors for the purpose of this analysis. A receptor in the model is defined as a one meter squared area (approximate size of a typical window), 3.28 feet (one meter) above ground level. Approximate eye level is set at 4.94 feet (1.5 meters). Figure 1 shows the locations of all 47 identified residential structures, along with the 29 potential turbine locations considered.

5.0 SHADOW FLICKER ANALYSIS RESULTS

As expected, WindPro predicts that shadow flicker impacts will be greatest at locations closer to the wind turbines. Figure 2 illustrate the WindPro predicted shadow flicker impact areas for each of the turbine model scenarios.

Table 1 presents the WindPro predicted shadow flicker impacts for the top ten worst case impacts receptors. Table 2 summarizes the shadow flicker impact prediction statistics. The predicted shadow flicker for all 47 receptors is presented in Appendix A. Because the Project is using a minimum turbine siting setback requirement of 1,400 feet to occupied residences as required by the PSC Order for the Project, the most sensitive receptors are generally not located in the high potential shadow flicker impact zones. The maximum predicted shadow flicker impact at any occupied residence receptor is 68 hours and 52 minutes per year (Receptor 12). This is approximately 1.54 percent of the potential available daylight hours. There are four occupied receptors (Receptors 2, 3, 12, and 44) with shadow flicker impacts greater than 30 hours per year. All of these residences are owned by landowners that are participating in the Project. The analysis results indicate substantial reduction of shadow flicker impact from what was presented in the November 2016 shadow flicker analysis report. This improvement is the result of the smaller number of wind turbines proposed in the current project design.

Table 1. WindPro Top Ten Expected Shadow Flicker Impacts			
Receptor ID	Receptor Type	Receptor Project Participation Status	Expected Shadow Flicker Hours per Year (Hours/Year)
			Vestas V126-3.45
12	Resident	Participant	70.50
3	Resident	Participant	61.65
2	Resident	Participant	42.82
44	Resident	Participant	31.02
1	Resident	Participant	25.12
13	Resident	Participant	22.68
14	Resident	Participant	21.58
5	Resident	Participant	19.90
7	Resident	Participant	13.40
6	Resident	Participant	10.87

Table 2. Statistical Summary of WindPro Expected Shadow Flicker Impacts – Number of Modeled Receptors	
Cumulative Shadow Flicker Time (Expected)	Vestas V126-3.45
Total	47
= 0 Hours	31
> 0 Hours < 10 Hours	6
≥ 10 Hours < 20 Hours	3
≥ 20 Hours < 30 Hours	3
≥ 30 Hours	4

6.0 CONCLUSION

The analysis of potential shadow flicker impacts from the Project on nearby receptors shows that shadow flicker impacts within the area of study are expected to be minor and within acceptable ranges for avoiding nuisance conditions. There are four occupied receptors with shadow flicker impacts greater than 30 hours per year, however all of these residences are owned by landowners that are participating in the Project. Meadowlark has communicated this information to the landowners, and the landowners have executed written acknowledgments, copies of which are provided in Appendix D of the New Frontier Wind Energy Project Certification of Continuing Suitability Filing dated November 2016. The Project continues to comply with the PSC Order Paragraphs 4(d) and 8. Shadow flicker is not expected to be a significant environmental impact.

The analysis was deliberately conservative and actual shadow flicker is expected to occur for less than the modeled durations. The analysis assumes that the receptors all have a direct in-line view of the incoming shadow flicker sunlight and does not account for trees or other obstructions which may block sunlight. In reality, the windows of many houses will not face the sun directly for the key shadow flicker impact times.

7.0 REFERENCES

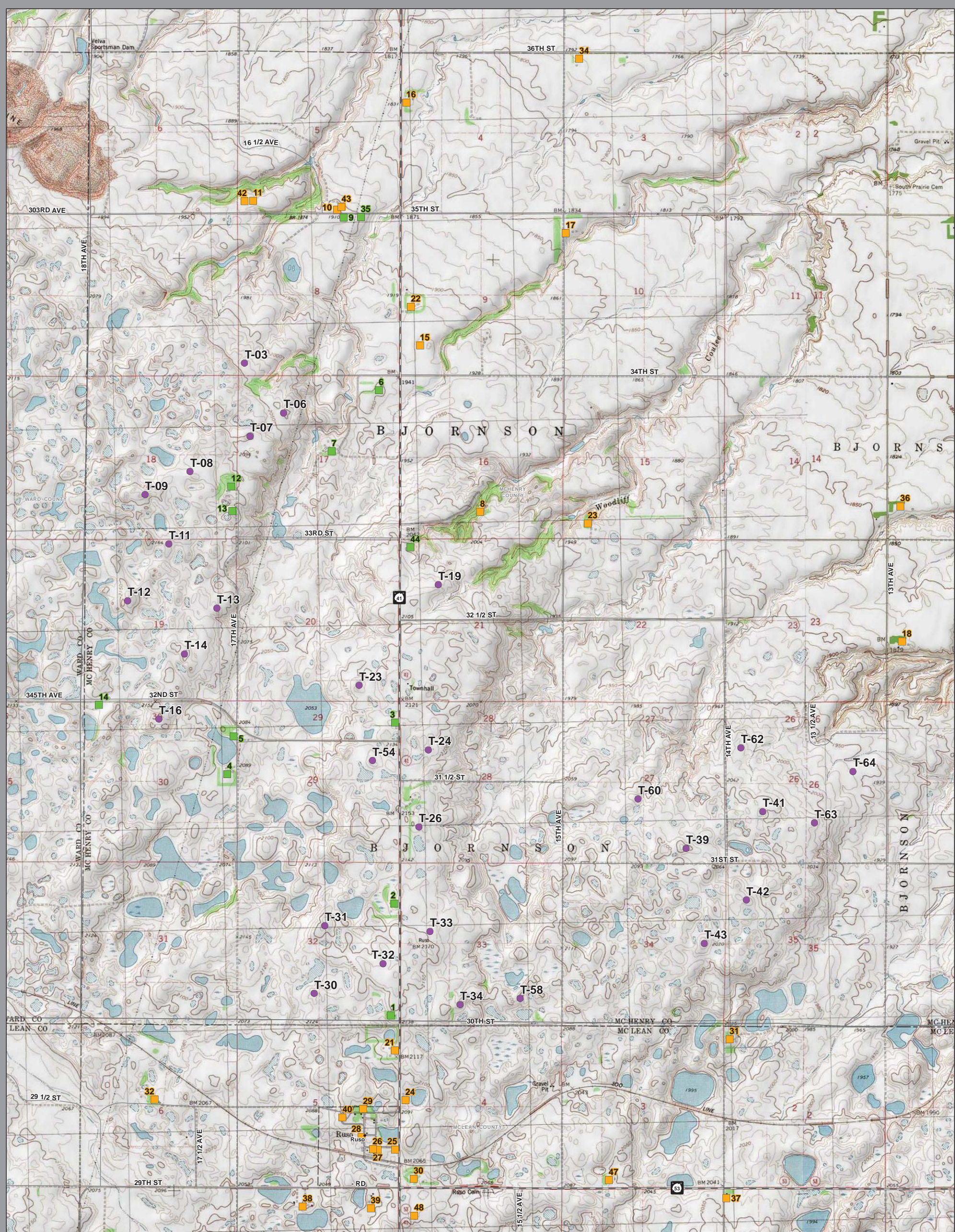
Epilepsy Action. 2008. Information Web Page on Photosensitive Epilepsy. British Epilepsy Association. http://www.epilepsy.org.uk/info/photo_other.html. Accessed November 2015.

NOAA (National Oceanic and Atmospheric Administration). 2015. Comparative Climatic Data for the United States Through 2015.

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Figures

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NEW FRONTIER WIND ENERGY PROJECT

Figure 1: Turbine and Receptor Locations

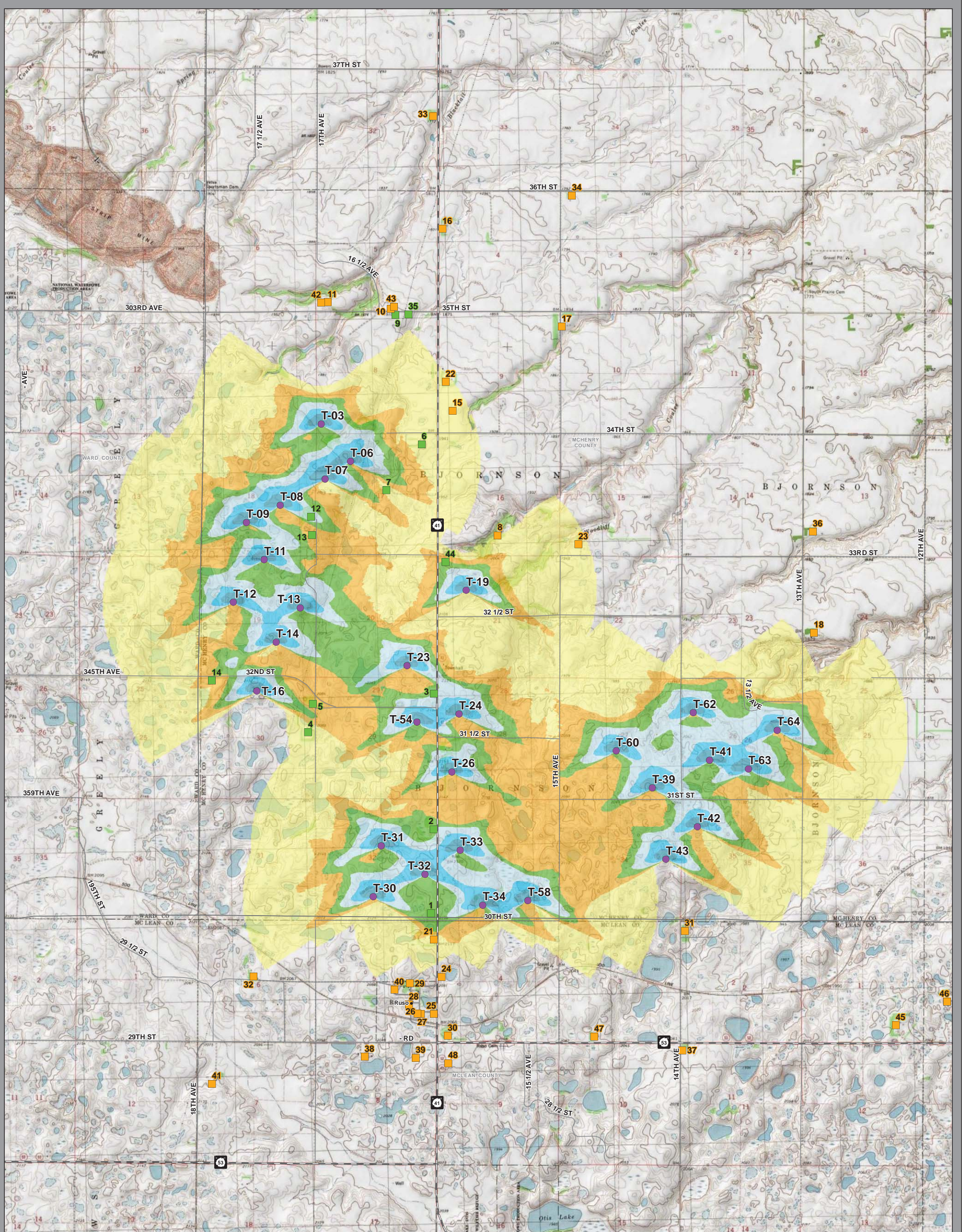
- Turbine
- Participant Receptor
- Non-Participant Receptor

0 0.25 0.5 Miles
Scale is 1:18,000 when printed at 22x34"



Vicinity Map





NEW FRONTIER WIND ENERGY PROJECT

Figure 2: Expected Shadow Flicker Impact Areas

Vestas V126 Array

- Vestas V126 Turbine Array
- Participant Receptor
- Non-Participant Receptor

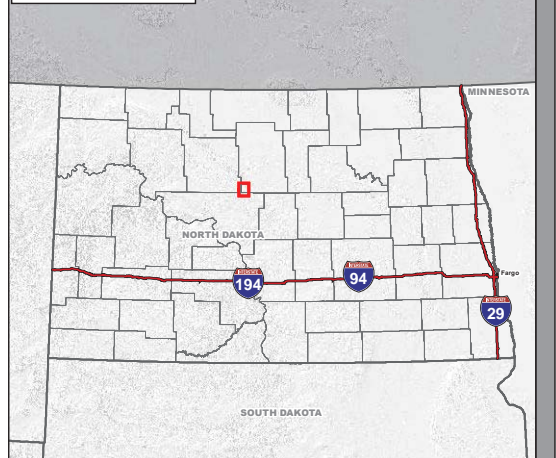
Shadow Flicker (hours per year)

	0 - 15
	>15 - 30
	>30 - 50
	>50 - 100
	>100 - 200
	>200

0 0.25 0.5 Miles
Scale is 1:24,000 when printed at 22x34"



Vicinity Map



**Attachment A:
Detailed Summary of WindPro Shadow Flicker Analysis Results**

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Detailed Summary of WindPro Shadow Flicker Analysis Results – Vestas V126-3.45

Capital Power New Frontier Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Status	Participation Status
1	355605.40	5301329.12	25.12	Resident	Participant
2	355661.04	5302441.06	42.82	Resident	Participant
3	355701.95	5304237.91	61.65	Resident	Participant
4	354027.18	5303758.70	2.22	Resident	Participant
5	354097.00	5304133.53	19.90	Resident	Participant
6	355606.23	5307543.03	10.87	Resident	Participant
7	355126.06	5306944.55	13.40	Resident	Participant
8	356588.12	5306314.94	0.60	Resident	Non-Participant
9	355289.86	5309264.74	0.00	Resident	Participant
10	355228.99	5309342.92	0.00	Resident	Non-Participant
11	354396.88	5309448.87	0.00	Resident	Non-Participant
12	354123.00	5306615.00	70.50	Resident	Participant
13	354128.83	5306369.78	22.68	Resident	Participant
14	352764.09	5304471.09	21.58	Resident	Participant
15	356023.92	5307978.07	1.95	Missile Site	Non-Participant
16	355934.85	5310391.99	0.00	Resident	Non-Participant
17	357492.91	5309064.75	0.00	Resident	Non-Participant
18	360751.46	5304943.70	0.00	Resident	Non-Participant
19	348671.06	5304721.90	0.00	Resident	Non-Participant
20	348189.46	5304542.92	0.00	Resident	Non-Participant
21	355635.43	5300982.28	3.30	Resident	Non-Participant
22	355939.73	5308365.07	3.72	Resident	Non-Participant
23	357655.42	5306177.53	1.67	Resident	Non-Participant
24	355731.47	5300485.94	0.00	Resident	Non-Participant
25	355618.73	5299997.13	0.00	Resident	Non-Participant
26	355445.39	5300001.72	0.00	Resident	Non-Participant
27	355400.62	5300005.16	0.00	Resident	Non-Participant
28	355289.26	5300129.61	0.00	Resident	Non-Participant
29	355309.24	5300408.57	0.00	Resident	Non-Participant
30	355798.51	5299703.70	0.00	Resident	Non-Participant
31	358962.39	5301029.91	0.00	Resident	Non-Participant
32	353241.16	5300542.53	0.00	Resident	Non-Participant
33	355840.17	5311882.33	0.00	Resident	Non-Participant
34	357660.51	5310795.29	0.00	Resident	Non-Participant
35	355462.08	5309266.00	0.00	Resident	Participant
36	360761.37	5306287.05	0.00	Resident	Non-Participant
37	358897.97	5299450.61	0.00	Resident	Non-Participant
38	354691.97	5299450.42	0.00	Resident	Non-Participant
39	355368.25	5299419.73	0.00	Resident	Non-Participant
40	355103.66	5300326.72	0.00	Resident	Non-Participant
41	352663.41	5299129.48	0.00	Resident	Non-Participant
42	354311.50	5309444.28	0.00	Resident	Non-Participant
43	355272.03	5309369.84	0.00	Resident	Non-Participant
44	355889.74	5305977.17	31.02	Resident	Participant
45	361732.60	5299729.17	0.00	Resident	Non-Participant
46	362417.60	5300028.31	0.00	Resident	Non-Participant
47	357737.12	5299653.55	0.00	Resident	Non-Participant

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August 3, 2018

Stephen Anderson
Principal Archaeologist
Tetra Tech, Inc.
350 Indiana Street, Suite 500
Golden, CO 80401

ND SHPO Ref: 11-2377H PSC, PU-11-069 "Cultural Resources Addendum VI Report for the New Frontier Wind Energy Project McHenry County, North Dakota"

Dear Mr. Anderson:

We reviewed ND SHPO Ref: 11-2377H PSC, PU-11-069 "Cultural Resources Addendum VI Report for the New Frontier Wind Energy Project McHenry County, North Dakota," and find it acceptable. It represents a good faith effort to identify and avoid impacts to "Significant Sites."

We concur with a "No Significant Sites Affected" determination provided the project is of the nature stated and it takes place in locations described in the project documentation.

Thank you for the opportunity to review this project and we look forward to further consultation on it. Please include the ND SHPO reference number listed above in any further correspondence for this specific project. If you have any questions, please contact Susan Quinnell at (701) 328-3574 or squinnell@nd.gov.

Sincerely,

Claudia J. Berg
Director, State Historical Society of North Dakota



Memorandum

To: Bill Behling, Joe Griffiths, Bob Evans, Capital Power Corporation, Inc.
From: Jeff Stone, Sarah McCall, Tetra Tech, Inc.
Date: July 31, 2018
Project: New Frontier Wind Energy Project
Subject: Evaluation of Wetlands within Previously Un-Surveyed Areas of Project Layout

Introduction

On May 10, 2017, the North Dakota Public Service Commission (PSC or Commission) issued the Order on Continuing Suitability (PSC Order) to Meadowlark Wind I, LLC (Meadowlark) for the New Frontier Wind Energy Project (Project) in McHenry County, North Dakota (Figure 1). Order Number 6 of the PSC Order states “If modifications are made to the Project layout, Meadowlark shall complete a wetland delineation of any previously un-surveyed areas affected by Project-related activities, as necessary, and file the report with the Commission”.

The Project layout was modified and Tetra Tech, Inc. (Tetra Tech), as requested by Meadowlark, has previously conducted follow-up wetlands and other waters of the United States (WOTUS) surveys to determine whether potential jurisdictional wetlands occurred within the portions of the revised Project layout that had not previously been surveyed:

- Project layout dated October 17, 2017, letter report was filed with the PSC on November 27, 2017.
- Project layout provided April 24th, 2018, letter report was filed with the PSC on May 2, 2018.
- Project layout provided June 13 - 18, 2018, letter report was filed with the PSC on July 3, 2018.
- Project layout provided June 18 – July 10, 2018, letter report was filed with the PSC on July 26, 2018.

Meadowlark made minor modifications to the Project layout again in July 2018, and Tetra Tech has completed a fifth survey for potential jurisdictional wetlands and other WOTUS in previously un-surveyed areas of the Project. These wetland surveys were conducted on July 24 and July 25, 2018. This memorandum documents WOTUS surveys conducted on July 24 and July 25, 2018 for the modifications to the Project layout, as requested in the PSC Order.

In October 2011, HDR Engineering, Inc. (HDR) performed wetland and other WOTUS surveys for the Project. The Wetland Delineation Report for those surveys (HDR 2011) was submitted to the U.S. Army Corps of Engineers (USACE) in November 2011 (HDR 2011). An approved jurisdictional determination (JD) from the USACE was received on February 24, 2012; this JD was set to expire February 24, 2017.

Meadowlark submitted a request to the USACE to re-verify the JD for an additional 5 years and the new JD from the USACE was received on December 8, 2016.

Methods

Prior to conducting the field surveys, Tetra Tech conducted a desktop analysis of the portions of the revised Project layout that had not previously been surveyed to identify potential jurisdictional wetlands and other WOTUS. The desktop analysis reviewed the following sources of information: results of the previous wetland delineation conducted for the project in 2011 by HDR 2011, aerial imagery, the U.S. Geological Survey (USGS) National Hydrography Dataset (NHD), the National Wetlands Inventory (NWI), and the data from the October 2017 and April 2018 survey efforts by Tetra Tech.

During this most current field survey (July 24-25, 2018), a Tetra Tech wetland scientist evaluated the previously un-surveyed areas of the most current Project layout and made one of three determinations:

- Upland—no wetland or other WOTUS present
- USACE Non-Jurisdictional wetland present
- USACE Jurisdictional wetland present

During the field survey, wetland boundaries were determined based on observations of dominant hydrophytic vegetation and the presence of characteristic wetland hydrology. A formal delineation of wetlands was conducted according to USACE methodology because a new potentially jurisdictional wetland was encountered. Observations of each wetland that was identified during the survey were documented through mapping of an observation point (NF-01, -02, etc.).

A geographic information specialist (GIS) specialist designed a Project-specific geodatabase that was used to capture wetland and non-wetland feature location data in the field with GPS technology. To complete the field surveys, the geodatabase was loaded onto ESRI's GIS Collector App.

Results

A total of three previously un-surveyed areas were evaluated during field surveys conducted on July 24 and 25, 2018 (Table 1). Locational data was collected using GPS at each observation point. Photographs were taken and notes were collected in a field logbook. Of these three observation points, two were identified as upland areas with no wetlands or other WOTUS present. The third observation point was identified as a potential jurisdictional wetland.

Observation Point NF-19

This previously un-surveyed area is located approximately 1,200 feet south of 33rd St N and contains a USACE jurisdictional wetland at latitude 47.888309, longitude -100.938329 (Figure Observation Point NF-19). The wetland boundary will be flagged prior to construction of the proposed collection line which will be bored under the wetland, thereby avoiding any impacts to the wetland feature.

Conclusions

A total of three previously un-surveyed areas were evaluated during field surveys conducted on July 24 and 25, 2018. Of the three observation points, two were identified as upland areas with no wetlands or other WOTUS present and one was identified as a USACE jurisdictional wetland.

Memorandum
New Frontier Wind Energy Project–Wetland Evaluation Report
Page 3

Other than Observation Point NF-19 noted above, there were no other wetlands or other WOTUS identified during the field survey that would likely be considered jurisdictional wetlands or other WOTUS.

References

HDR (HDR Engineering, Inc.). 2011. Wetland Delineation Report for New Frontier Wind Farm McHenry County, North Dakota. November 2011. Prepared for Meadowlark Wind I LLC.

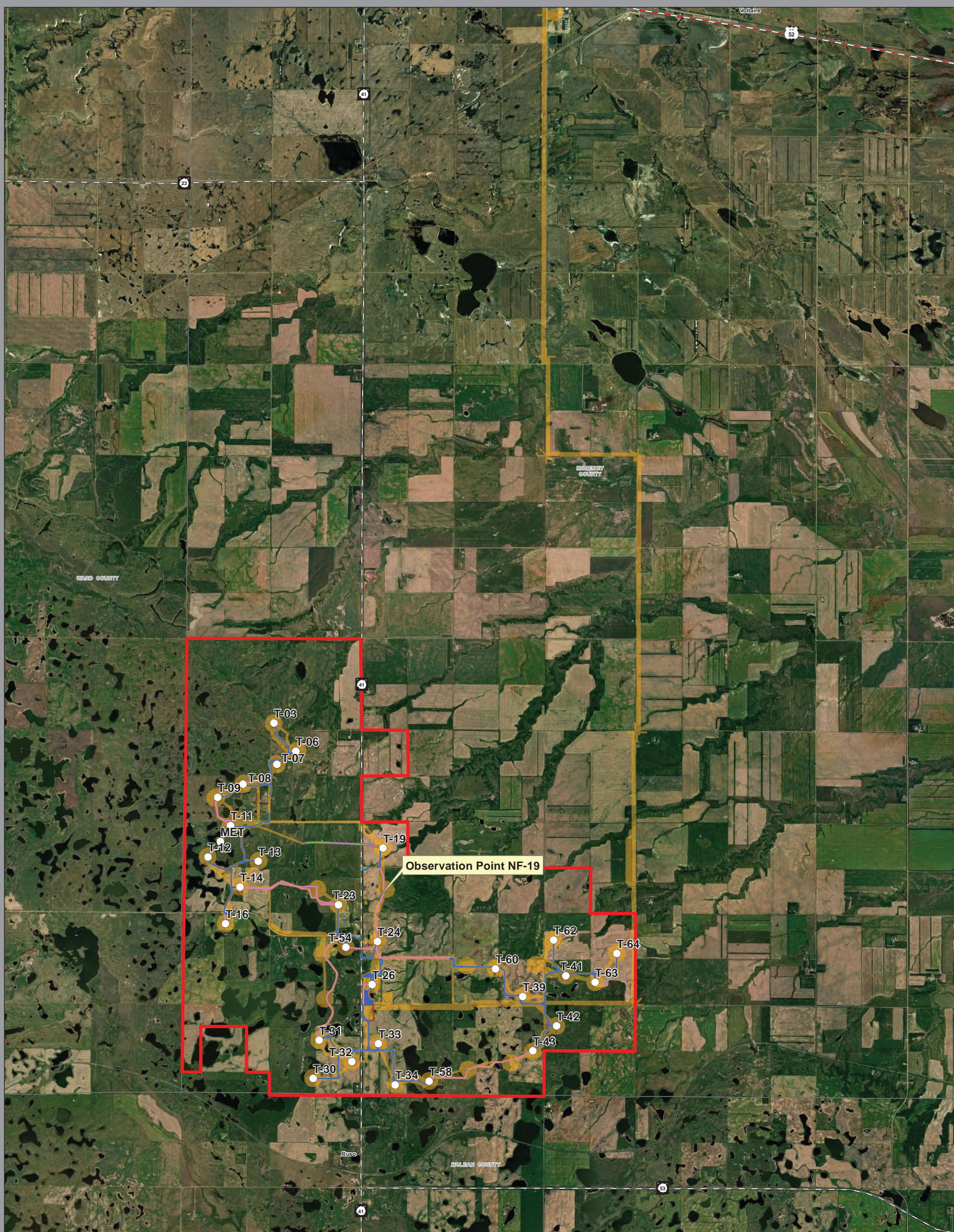
Memorandum
 New Frontier Wind Energy Project–Wetland Evaluation Report
 Page 4

Table 1:
 Field Observations for Wetlands in Previously Un-Surveyed Areas of the New Frontier Wind Energy Project

Observation Point ID	Upland—no wetland or other WOTUS present	USACE Non-Jurisdictional wetland present	USACE Jurisdictional wetland present	Notes
NF-19			X	USACE jurisdictional wetland will be flagged prior to construction.
NF-20	X			Portion of road ditch and non-crop land dominated by Bromus inermis, non-JD wetland to the west
NF-21	X			Wheat field, narrow non-JD wetland in road ditch between turning radius and 33 rd St.

Figures

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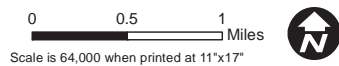
NEW FRONTIER WIND ENERGY PROJECT

Figure 1: Project Overview

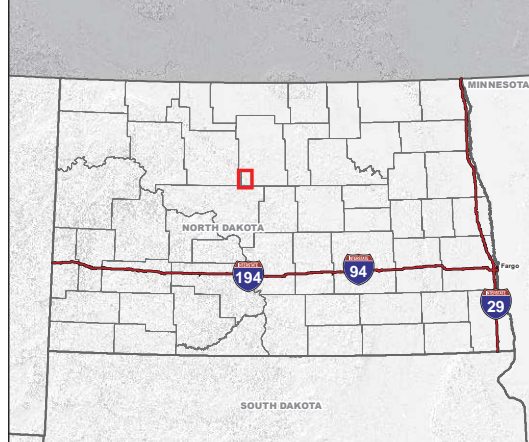
- Project Area
- Access Road
- Collector Line
- Crane Path
- Switchyard/O&M Leased Parcel

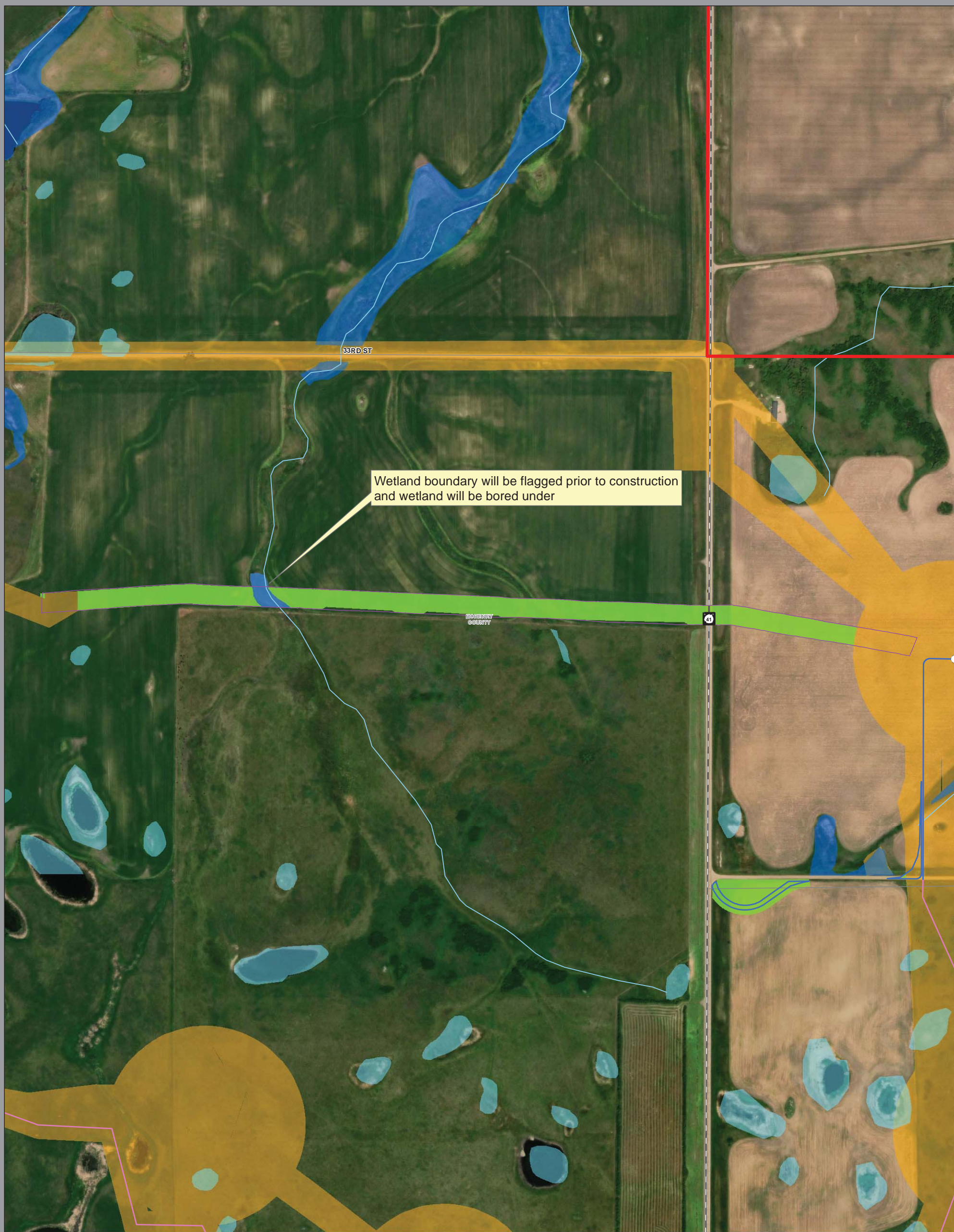
***Project layout provided June 18th – July 19th, 2018*

- Additional area to be surveyed week of 7/23/18
- Previous survey 7/31/18



Vicinity Map





NEW FRONTIER WIND ENERGY PROJECT

Observation Point NF-19

- Project Area
- Access Road
- Collector Line
- Crane Path

***Project layout provided June 18th – July 19th, 2018*

- Additional area to be surveyed week of 7/23/18
- Previous survey 7/31/18

Hydrology

- Perennial Stream
- Intermittent Stream
- Canal Ditch
- USACE Jurisdictional Wetland
- Non-Jurisdictional Wetland



Vicinity Map

