



Federal Aviation  
Administration

« OE,

## DoD Preliminary Screening Tool

[DoD Preliminary Screening Tool - Desk Reference Guide V\\_2014.2.0](#)

### Disclaimer:

- The DoD Preliminary Screening Tool enables developers to obtain a preliminary review of potential impacts to Long-Range and Weather Radar(s), Military Training Route(s) and Special Airspace(s) prior to official OE/AAA filing. This tool will produce a map relating the structure to any of the DoD/DHS and NOAA resources listed above. The use of this tool is **100 % optional** and will provide a first level of feedback and single points of contact within the DoD/DHS and NOAA to discuss impacts/mitigation efforts on the military training mission and NEXRAD Weather Radars. **The use of this tool does not in any way replace the official FAA processes/procedures.**

### Instructions:

- Select a screening type for your initial evaluation. Currently the system supports pre-screening on:
  - Air Defense and Homeland Security radars(Long Range Radar)
  - Weather Surveillance Radar-1988 Doppler radars(NEXRAD)
  - Military Operations
- Enter either a single point or a polygon and click submit to generate a long range radar analysis map.
- Military Operations is only available for a single point.
- At least three points are required for a polygon, with an optional fourth point.
- The largest polygon allowed has a maximum perimeter of 100 miles.

Screening Type:  Geometry Type:

Point	Latitude				Longitude			
	Deg	Min	Sec	Dir	Deg	Min	Sec	Dir

1	<input type="text" value="46"/>	<input type="text" value="55"/>	<input type="text" value="11.96"/>	<input type="text" value="N"/>	<input type="text" value="102"/>	<input type="text" value="33"/>	<input type="text" value="37.95"/>	<input type="text" value="W"/>
2	<input type="text" value="46"/>	<input type="text" value="56"/>	<input type="text" value="3.68"/>	<input type="text" value="N"/>	<input type="text" value="102"/>	<input type="text" value="22"/>	<input type="text" value="45.52"/>	<input type="text" value="W"/>
3	<input type="text" value="46"/>	<input type="text" value="49"/>	<input type="text" value="5.21"/>	<input type="text" value="N"/>	<input type="text" value="102"/>	<input type="text" value="29"/>	<input type="text" value="48.51"/>	<input type="text" value="W"/>
4	<input type="text" value="46"/>	<input type="text" value="50"/>	<input type="text" value="49.13"/>	<input type="text" value="N"/>	<input type="text" value="102"/>	<input type="text" value="15"/>	<input type="text" value="21.27"/>	<input type="text" value="W"/>

Horizontal Datum:

**Map Legend:**

- **Green:** No anticipated impact to Air Defense and Homeland Security radars. Aeronautical study required.
- **Yellow:** Impact likely to Air Defense and Homeland Security radars. Aeronautical study required.
- **Red:** Impact highly likely to Air Defense and Homeland Security radars. Aeronautical study required.





Federal Aviation  
Administration

« OE,

## DoD Preliminary Screening Tool

[DoD Preliminary Screening Tool - Desk Reference Guide V\\_2014.2.0](#)

### Disclaimer:

- The DoD Preliminary Screening Tool enables developers to obtain a preliminary review of potential impacts to Long-Range and Weather Radar(s), Military Training Route(s) and Special Airspace(s) prior to official OE/AAA filing. This tool will produce a map relating the structure to any of the DoD/DHS and NOAA resources listed above. The use of this tool is **100 % optional** and will provide a first level of feedback and single points of contact within the DoD/DHS and NOAA to discuss impacts/mitigation efforts on the military training mission and NEXRAD Weather Radars. **The use of this tool does not in any way replace the official FAA processes/procedures.**

### Instructions:

- Select a screening type for your initial evaluation. Currently the system supports pre-screening on:
  - Air Defense and Homeland Security radars(Long Range Radar)
  - Weather Surveillance Radar-1988 Doppler radars(NEXRAD)
  - Military Operations
- Enter either a single point or a polygon and click submit to generate a long range radar analysis map.
- Military Operations is only available for a single point.
- At least three points are required for a polygon, with an optional fourth point.
- The largest polygon allowed has a maximum perimeter of 100 miles.

Screening Type:	<input type="text" value="NEXRAD"/>	Geometry Type:	<input type="text" value="Polygon"/>
<b>Point</b>	<b>Latitude</b>	<b>Longitude</b>	
	Deg Min Sec Dir	Deg Min Sec Dir	

1	<input type="text" value="46"/>	<input type="text" value="55"/>	<input type="text" value="11.96"/>	<input type="text" value="N"/>	<input type="text" value="102"/>	<input type="text" value="33"/>	<input type="text" value="37.95"/>	<input type="text" value="W"/>
2	<input type="text" value="46"/>	<input type="text" value="56"/>	<input type="text" value="3.68"/>	<input type="text" value="N"/>	<input type="text" value="102"/>	<input type="text" value="22"/>	<input type="text" value="45.52"/>	<input type="text" value="W"/>
3	<input type="text" value="46"/>	<input type="text" value="49"/>	<input type="text" value="5.21"/>	<input type="text" value="N"/>	<input type="text" value="102"/>	<input type="text" value="29"/>	<input type="text" value="48.51"/>	<input type="text" value="W"/>
4	<input type="text" value="46"/>	<input type="text" value="50"/>	<input type="text" value="49.13"/>	<input type="text" value="N"/>	<input type="text" value="102"/>	<input type="text" value="15"/>	<input type="text" value="21.27"/>	<input type="text" value="W"/>

Horizontal Datum:

#### Map Legend:

- **Green: No Impact Zone.** Impacts not likely. NOAA will not perform a detailed analysis, but would still like to know about the project.
- **Dk Green: Notification Zone.** Some impacts possible. Consultation with NOAA is optional, but NOAA would still like to know about the project.
- **Yellow: Consultation Zone.** Significant impacts possible. NOAA requests consultation to discuss project details and to perform a detailed impact analysis. NOAA may request mitigation of significant impacts.
- **Orange: Mitigation Zone.** Significant impacts likely. NOAA will likely request mitigation if a detailed analysis indicates that the project will cause significant impacts.
- **Red: No-Build Zone.** Severe impacts likely. NOAA requests developers not build wind turbines within 3 km of the NEXRAD. Detailed impact analysis required.



Because the NEXRAD can detect wind turbines occasionally at great distance, NOAA like to know the location of all wind farm projects so that corrupted radar data can be Send project information directly to NOAA at [wind.energy.matters@noaa.gov](mailto:wind.energy.matters@noaa.gov) or thru National Telecommunications & Information Administration (NTIA) in the Dept. of Cor NOAA protects all wind project information as proprietary and sensitive.



Federal Aviation  
Administration

« OE,

## DoD Preliminary Screening Tool

[DoD Preliminary Screening Tool - Desk Reference Guide V\\_2014.2.0](#)

### Disclaimer:

- The DoD Preliminary Screening Tool enables developers to obtain a preliminary review of potential impacts to Long-Range and Weather Radar(s), Military Training Route(s) and Special Airspace(s) prior to official OE/AAA filing. This tool will produce a map relating the structure to any of the DoD/DHS and NOAA resources listed above. The use of this tool is **100 % optional** and will provide a first level of feedback and single points of contact within the DoD/DHS and NOAA to discuss impacts/mitigation efforts on the military training mission and NEXRAD Weather Radars. **The use of this tool does not in any way replace the official FAA processes/procedures.**

### Instructions:

- Select a screening type for your initial evaluation. Currently the system supports pre-screening on:
  - Air Defense and Homeland Security radars(Long Range Radar)
  - Weather Surveillance Radar-1988 Doppler radars(NEXRAD)
  - Military Operations
- Enter either a single point or a polygon and click submit to generate a long range radar analysis map.
- Military Operations is only available for a single point.
- At least three points are required for a polygon, with an optional fourth point.
- The largest polygon allowed has a maximum perimeter of 100 miles.

Screening Type:  Geometry Type:

Point	Latitude				Longitude			
	Deg	Min	Sec	Dir	Deg	Min	Sec	Dir

1    N    W

Horizontal Datum:

The preliminary review of your proposal does not return any likely impacts to military airspace. Please contact Dr. Thomas (Thom) H. Rennie at the USAF Regional Environmental Coordinator at (214)767-4678 for confirmation and documentation.

The preliminary review of your proposal does not return any likely impacts to military airspace. Please contact the US Navy Representative, FAA Central Service Area at the USN Regional Environmental Coordinator at (817) 222-5930 for confirmation and documentation.

The preliminary review of your proposal does not return any likely impacts to military airspace. Please contact LTC Owen B. Castlemain at the USA Regional Environmental Coordinator at (817) 222-5921 for confirmation and documentation.

The preliminary review of your proposal does not return any likely impacts to military airspace. Please contact the US Navy Representative, FAA Central Service Area at the USMC Regional Environmental Coordinator at (817) 222-5930 for confirmation and documentation.

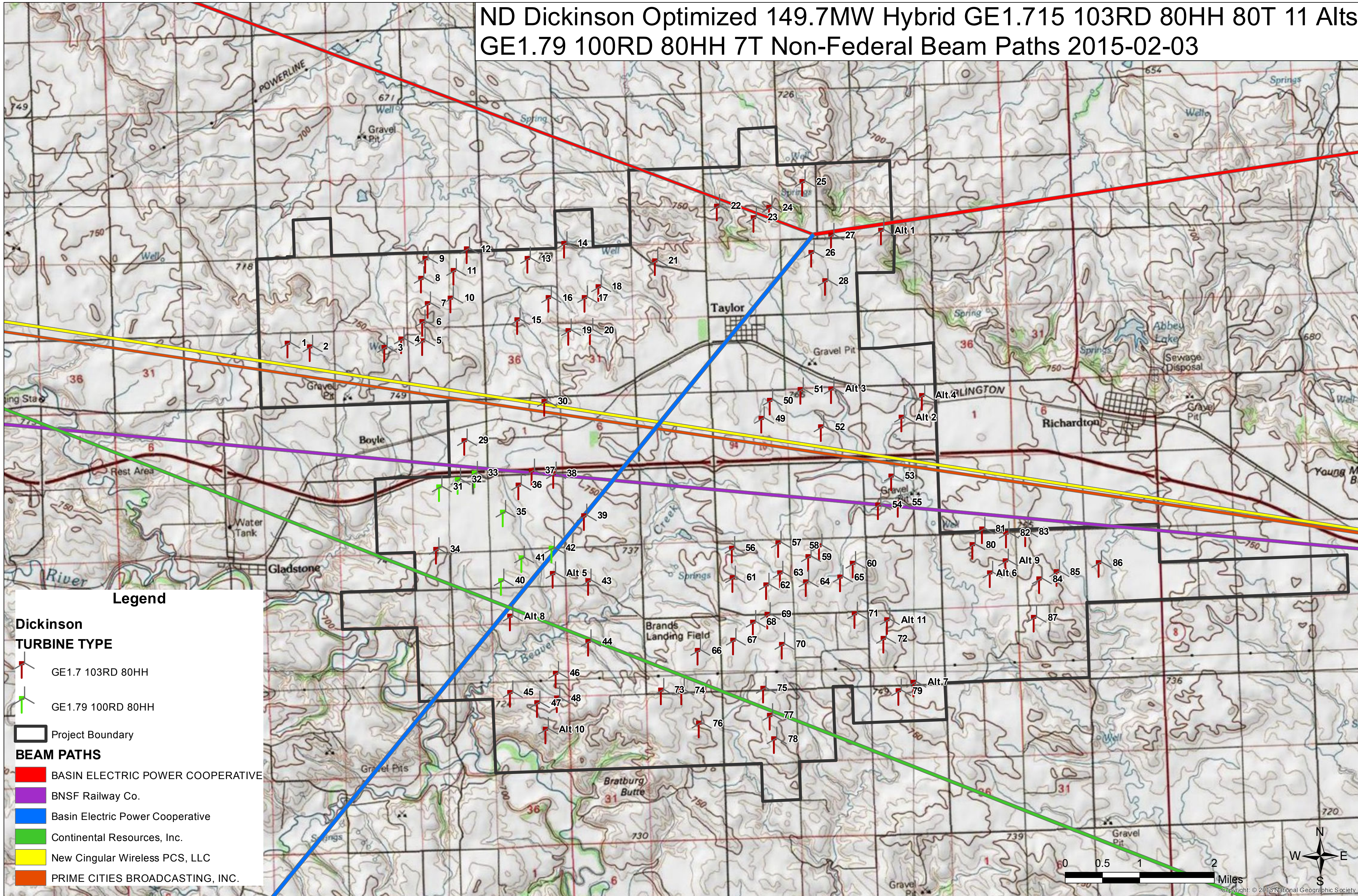
**This is a preliminary review of your proposal and does not preclude official FAA processes.**

Your search data is not retained and the privacy of all your searches is assured.



Any questions interpreting the map, please email Steve Sample with your question/s phone number at [steven.sample@pentagon.af.mil](mailto:steven.sample@pentagon.af.mil)



# ND Dickinson Optimized 149.7MW Hybrid GE1.715 103RD 80HH 80T 11 Alts GE1.79 100RD 80HH 7T Non-Federal Beam Paths 2015-02-03




**Legend**







**Dickinson**

**TURBINE TYPE**

-  GE1.7 103RD 80HH
-  GE1.79 100RD 80HH

 Project Boundary

**BEAM PATHS**

-  BASIN ELECTRIC POWER COOPERATIVE
-  BNSF Railway Co.
-  Basin Electric Power Cooperative
-  Continental Resources, Inc.
-  New Cingular Wireless PCS, LLC
-  PRIME CITIES BROADCASTING, INC.

0 0.5 1 2 Miles



Copyright © 2013 National Geographic Society

**Shadow Flicker Impact Analysis  
for the  
Dickinson Wind Energy Center  
Stark County, North Dakota**

*Prepared for*  
**Dickinson Wind, LLC**

*Prepared by*



**February 2015**

## Table of Contents

1.0	Overview .....	1
2.0	Project Components.....	1
3.0	Shadow Flicker Background .....	1
4.0	WindPro Shadow Flicker Analysis .....	3
5.0	Shadow Flicker Analysis Results .....	4
6.0	Conclusion .....	6
7.0	References.....	6

## List of Tables

Table 1.	WindPro Predicted Shadow Flicker Impacts for Receptors.....	4
Table 2.	Statistical Summary of WindPro Predicted Shadow Flicker Impacts at Modeled Receptor Locations.....	5

## List of Figures

- Figure 1. Turbine and Receptor Locations
- Figure 2. Expected Shadow Flicker Impact Areas

## List of Attachments

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

## Acronyms and Abbreviations

Dickenson	Dickinson Wind, LLC
GE	General Electric
Hz	Hertz
NCDC	National Climatic Data Center
NextEra	NextEra Energy Resources, LLC
Project	Dickinson Wind Energy Center Project
rpm	rotations per minute
UTM	Universal Transverse Mercator

## 1.0 OVERVIEW

NextEra Energy Resources, LLC (NextEra), is proposing to develop the Dickinson Wind Energy Project (Project) in Stark County, North Dakota. The Project would install up to 87 wind turbines with a maximum nameplate capacity of approximately 150 megawatts. Tetra Tech has conducted the following shadow flicker analysis for the Project to support the Project's application for a Certificate of Site Compatibility under the North Dakota Public Service Commission.

## 2.0 PROJECT COMPONENTS

The Project will consist of 87 wind turbines. Seven (7) of the turbines (numbers 31, 32, 33, 35, 40, 41, and 42) will be the GE 1.79-100 turbine model and the rest of turbines will be the General Electric (GE) 1.715-103 turbine model. The two wind turbine models being considered for the Project, and evaluated for potential shadow flicker impacts, have the following characteristics:

- **GE 1.79 100** – 3-blade 100-meter diameter rotor, with a hub height of 80 meters and generating capacity of 1.79 MW. The GE 1.79-100 has a normal high rotor speed of 17.5 rotations per minute (rpm) which translates to a blade pass frequency of 0.87 hertz (Hz) (less than 1 alternation per second). The Project plans to install up to 7 GE 1.79-100 turbines.
- **GE 1.715 103** – 3-blade 103-meter diameter rotor, with a hub height of 80 meters and generating capacity of 1.715 MW. The GE 1.715-103 has a normal high rotor speed of 17.5 rpm which translates to a blade pass frequency of 0.87 Hz (less than 1 alternation per second). The Project plans to install up to 80 GE 1.715-100 turbines.

## 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 3 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 3 Hz. (For comparison, strobe lights used in discotheques have frequencies which range from about 3 Hz to 10 Hz (1 Hz = 1 flash per second). Since the proposed Project's wind turbine blade pass frequency is approximately 0.87 Hz (less than 1 alternation per second), no negative health effects to individuals with photosensitive epilepsy are anticipated.

Shadow flicker impacts are not regulated in applicable state or federal law, and there is no permitting threshold with regard to hours per year of anticipated impacts to a receptor from a wind energy project.

## 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 earlier, the Project will install 87 wind turbines (7 GE 1.79-100 and the rest GE 1.715-103 model turbines). While only 87 turbines will be constructed, 98 turbines have been evaluated with WindPro so that the analysis includes assessment of up to eleven (11) alternative turbine locations.

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. The realistic impact condition scenario is based on the following assumptions:

- 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 13 (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 [NCDC 2008] for nearby Bismarck, North Dakota) used in this analysis are as follows:

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
53%	53%	58%	58%	61%	64%	73%	72%	65%	58%	43%	47%

- Estimated wind turbine operations and orientation (based on approximately 5 years of wind data (6/15/2006–10/19/2011), including wind speed/wind direction frequency distribution, measured at on-site meteorological towers).
- 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 this section. 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 79 structures were identified within a minimum buffer of approximately 1 mile of the proposed Project turbines; of these, 44 were determined to be occupied residences and are considered potential shadow-flicker receptors for the purpose of this analysis. A receptor in the model is defined as a 1 meter squared area (approximate size of a typical window), 3.28 feet (1 meter) above ground level. Approximate eye level is set at 4.94 feet (1.5 meters). Figure 1 shows the locations of all identified structures and the 44 shadow flicker receptors (occupied residences), along with the 98 potential turbine locations considered.

## 5.0 SHADOW FLICKER ANALYSIS RESULTS

As expected, WindPro predicts that shadow flicker impacts will be greatest at locations nearer to the wind turbines. Figures 2 illustrates the WindPro predicted shadow flicker impact areas. A detailed WindPro shadow flicker analysis summary, for each of the modeled receptor location, is provided in Attachment A.

Tables 1, 2, and 3 present the WindPro predicted shadow flicker impacts for the top ten worst case impacts for the 44 identified receptors (occupied residences). The predicted shadow flicker for all 44 occupied residential receptors is presented in Appendix A. Because the Project is using a minimum turbine siting setback requirement of 2,000 feet (609.6 meters) to occupied residences, 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 29 hours 7 minutes per year (Receptor 610073), which is approximately 0.7 percent of the potential available daylight hours. This structure is owned by a landowner that is participating in the Project.

<b>Table 1. WindPro Predicted Shadow Flicker Impacts for Receptors</b>			
<b>Receptor ID</b>	<b>Shadow Hours per Year (expected) [hh:mm / year]</b>	<b>Receptor Type</b>	<b>Receptor Occupation Status</b>
610073	29:07	house occupied	Yes
610201	26:38	house occupied	Yes
610336	22:32	house occupied	Yes
610981	19:51	house occupied	Yes
610219	19:20	house occupied	Yes
610185	17:16	house occupied	Yes
610433	17:15	travel trailer not known if occupied	Assumed Yes
610384	15:18	house occupied	Yes
710350	14:47	mobile home occupied	Yes
610605	14:00	house occupied	Yes

The shadow flicker impact prediction statistics are summarized in Table 2.

<b>Table 2. Statistical Summary of WindPro Predicted Shadow Flicker Impacts at Modeled Receptor Locations</b>	
<b>Cumulative Shadow Flicker Time (expected)</b>	<b>Number of Receptors</b>
Total	44
= 0 Hours	13
> 0 Hours < 10 Hours	15
≥ 10 Hours < 20 Hours	13
≥ 20 Hours < 30 Hours	3
≥ 30 Hours	0

## 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 well within acceptable ranges for avoiding nuisance conditions. 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. Adding to the analysis' conservatism, Dickinson will construct fewer wind turbines than were included in the modeled results.

## 7.0 REFERENCES

- Epilepsy Action. 2008. Information Web Page on Photosensitive Epilepsy. British Epilepsy Association. [http://www.epilepsy.org.uk/info/photo\\_other.html](http://www.epilepsy.org.uk/info/photo_other.html). Accessed 3/1/10.
- National Climatic Data Center (NCDC). 2008. Sunshine Average Percent of Possible. <http://www.ncdc.noaa.gov/oa/climate/online/ccd/pctpos.txt>. Accessed 3/1/10

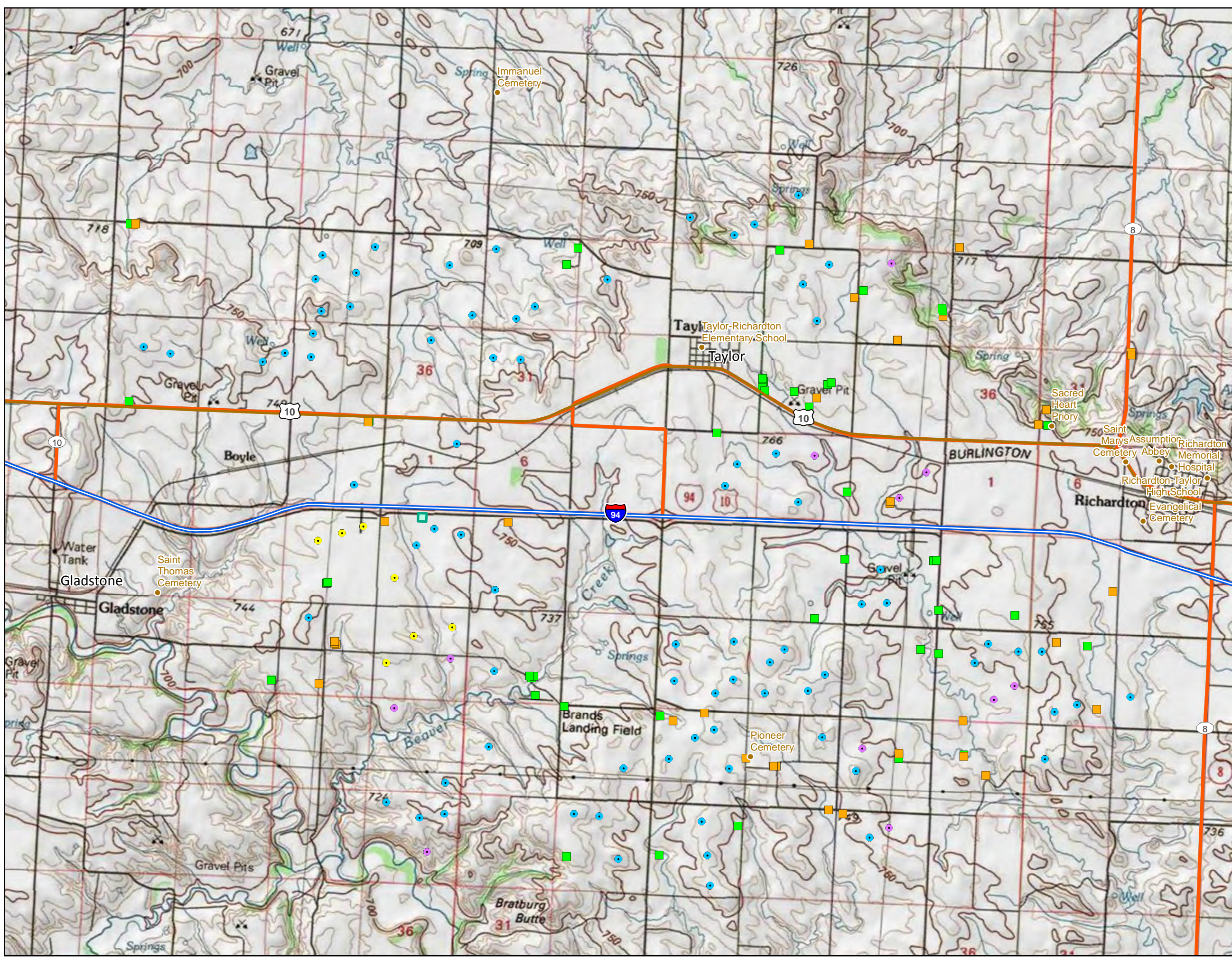
## Figures

NEXTERA ENERGY  
 RESOURCES, LLC  
 DICKINSON WIND ENERGY CENTER  
 STARK COUNTY, NORTH DAKOTA

FIGURE 1  
 TURBINE AND RECEPTOR  
 LOCATIONS

FEBRUARY 2015

- GE Xle 1.715-103 Turbine
- GE Xle 1.715-103 Turbine (Alt)
- GE Xle 1.79-100 Turbine
- Receptor - Occupied
- Structure - Unoccupied
- Substation



NEXTERA ENERGY  
 RESOURCES, LLC  
 DICKINSON WIND ENERGY CENTER  
 STARK COUNTY, NORTH DAKOTA

FIGURE 2  
 EXPECTED SHADOW FLICKER  
 IMPACT AREAS  
 FEBRUARY 2015

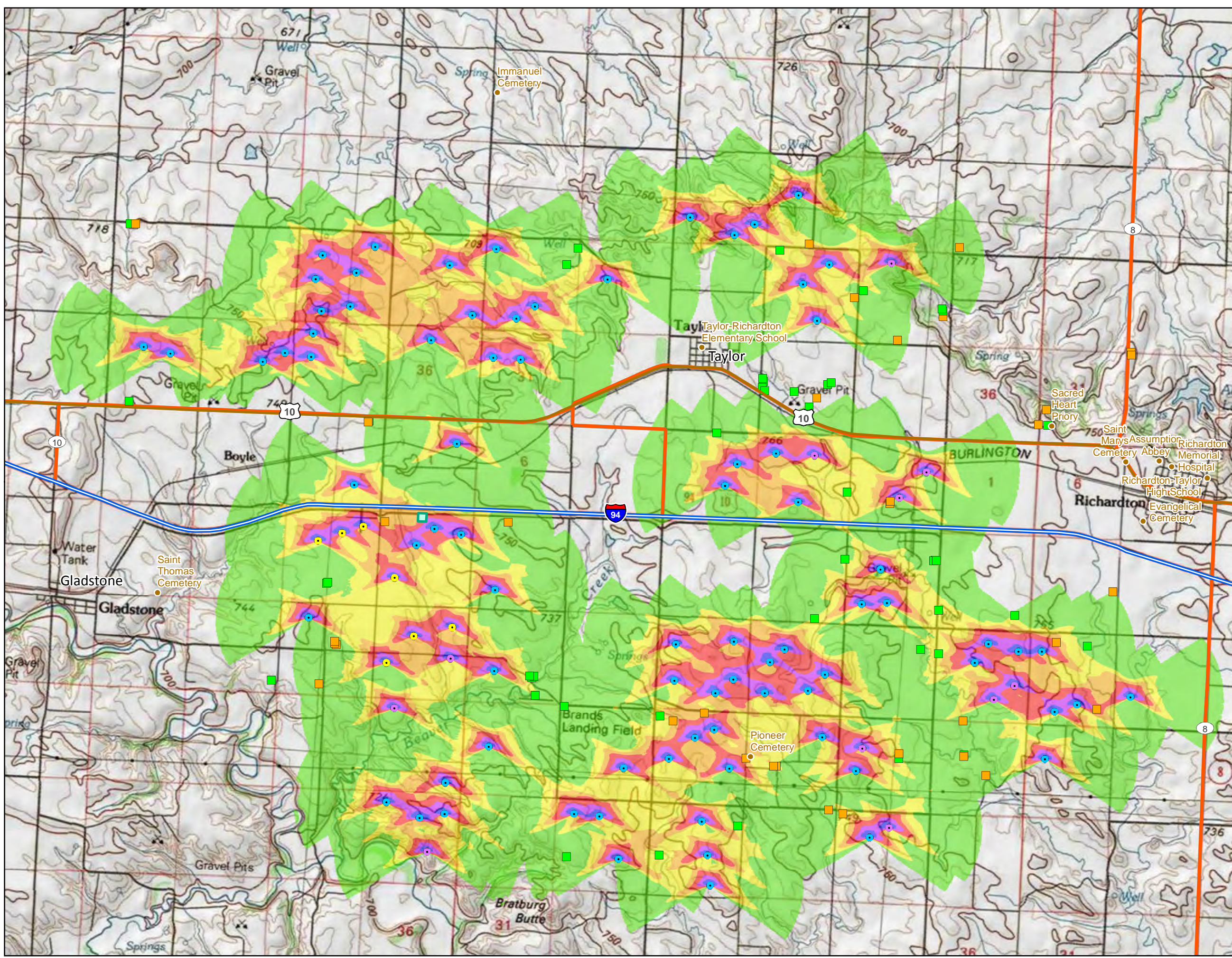
- GE Xle 1.715-103 Turbine
- GE Xle 1.715-103 Turbine (Alt)
- GE Xle 1.79-100 Turbine
- Receptor - Occupied
- Structure - Unoccupied
- Substation

Shadow Flicker (hours per year)

- 0 - 14
- 15 - 29
- 30 - 49
- 50 - 99
- 100 - 200
- > 200



REFERENCE MAP



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

**DICKINSON WIND ENERGY PROJECT  
SHADOW FLICKER IMPACT ANALYSIS**

**Dickinson Wind - Detailed Summary of WindPro Shadow Flicker Analysis Results**

WindPro Receptor ID	Dickinson Wind Receptor ID	UTM-E (m)	UTM-N (m)	WindPro Predicted Expected Shadow Flicker (Hours per Year)	Occupied Status
AA	610073	695,860	5,191,288	29:07:00	house occupied
AG	610201	700,580	5,192,724	26:38:00	house occupied
AK	610336	696,029	5,188,885	22:32:00	house occupied
BA	610981	697,349	5,189,492	19:51:00	house occupied
AH	610219	700,033	5,190,866	19:20:00	house occupied
AF	610185	698,395	5,193,168	17:16:00	house occupied
BY	610433	693,566	5,191,807	17:15:00	travel trailer not known if occupied
AO	610384	693,681	5,191,477	15:18:00	house occupied
BO	710350	693,834	5,199,236	14:47:00	mobile home occupied
AU	610605	698,790	5,195,387	14:00:00	house occupied
AE	610164	698,844	5,194,233	13:36:00	house occupied
AD	610131	700,520	5,193,472	12:38:00	house occupied
AP	610392	693,605	5,191,777	11:53:00	house occupied
AS	610557	697,313	5,199,467	10:35:00	house occupied
BV	610398	693,639	5,191,806	10:24:00	trailer home occupied
BE	710344	693,659	5,198,938	8:50:00	house occupied
AJ	610276	703,133	5,193,055	7:58:00	house occupied
AL	610347	700,263	5,192,777	7:57:00	house occupied
BU	610103	700,422	5,194,329	7:37:00	trailer home occupied
AT	610568	698,807	5,198,881	7:31:00	house occupied
AC	610107	700,372	5,194,322	7:20:00	house occupied
AB	610095	700,396	5,194,332	7:13:00	house occupied
AI	610250	701,840	5,193,484	5:53:00	house occupied
AN	610376	694,200	5,191,330	4:41:00	house occupied
AM	610369	694,434	5,188,738	3:31:00	house occupied
AV	610642	696,464	5,196,240	3:03:00	house occupied
W	610498	689,960	5,193,148	1:57:00	house 2 occupied
V	610496	689,939	5,193,130	1:51:00	house 1 occupied
BQ	610752	701,154	5,191,016	1:44:00	office active
AW	610727	698,026	5,196,804	1:30:00	house occupied
BD	710314	690,461	5,195,981	0:58:00	house occupied
AQ	610513	689,117	5,191,392	0:00:00	house occupied
AR	610532	697,203	5,197,185	0:00:00	house occupied
AX	610731	697,749	5,197,051	0:00:00	house occupied
AY	610738	697,190	5,197,081	0:00:00	house occupied
AZ	610743	697,236	5,197,030	0:00:00	house occupied
BB	710278	686,081	5,199,064	0:00:00	house occupied
BC	710300	686,301	5,196,009	0:00:00	house occupied
BK	610669	700,203	5,198,634	0:00:00	house1 occupied
BL	610745	698,316	5,197,214	0:00:00	house1 occupied
BM	610672	700,187	5,198,672	0:00:00	house2 occupied
BN	610750	698,374	5,197,253	0:00:00	house2 occupied
BP	610660	702,155	5,196,804	0:00:00	monastery active
BW	610551	697,188	5,197,235	0:00:00	trailer home occupied

**Dickinson Wind Energy Center  
Acoustic Assessment  
Stark County, North Dakota**

**February 2015**

**Prepared for**



**Prepared by**



**160 Federal Street  
Boston, MA 02110  
617-443-7500**

## TABLE OF CONTENTS

<b>EXECUTIVE SUMMARY .....</b>	<b>ES-1</b>
<b>1.0 INTRODUCTION.....</b>	<b>1</b>
1.1 Project Area .....	1
1.2 Existing Acoustic Environment .....	3
1.3 Acoustic Terminology .....	3
<b>2.0 NOISE REGULATIONS AND GUIDELINES .....</b>	<b>7</b>
2.1 State of North Dakota Public Service Commission Noise Standards .....	7
2.2 Stark County Zoning Ordinance .....	7
<b>3.0 ACOUSTIC MODELING METHODOLOGY.....</b>	<b>8</b>
3.1 Acoustic Modeling Software and Calculation Methods .....	8
3.2 Acoustic Modeling Input Parameters .....	10
<b>4.0 PROJECT OPERATING NOISE LEVELS.....</b>	<b>11</b>
4.1 Results .....	11
4.2 Substation Noise .....	17
4.3 Construction Noise .....	18
<b>5.0 CONCLUSIONS.....</b>	<b>20</b>
<b>6.0 TECHNICAL REFERENCES .....</b>	<b>21</b>

## TABLES

Table 1. Acoustic Terms and Definitions.....	6
Table 2. Broadband Sound Power Levels (dBA) Correlated with Wind Speed.....	10
Table 3. Sound Power Level by Octave Band Center Frequency .....	11
Table 4. Summary of Acoustic Modeling Results.....	11
Table 5. Transformer Sound Power Level .....	17
Table 6. Estimated $L_{max}$ Sound Pressure Levels from Construction Equipment .....	19

## FIGURES

Figure 1. Project Layout.....	2
Figure 2. Various Outdoor Sound Levels ( $L_{dn}$ ) .....	5
Figure 3. Received Sound Levels - Wind Turbines at Cut-In Wind Speed.....	14
Figure 4. Received Sound Levels - Wind Turbines at Maximum Rotational Wind Speed .....	15
Figure 5. Received Sound Levels - Wind Turbines at Maximum Rotational Wind Speed, Anomalous Meteorological Conditions .....	16

**ACRONYMS AND ABBREVIATIONS**

AGL	above ground level
Applicant	NextEra Energy Resources, LLC
CadnaA	Computer-Aided Noise Abatement Program
dB	decibel
dBA	A-weighted decibel
dBL	unweighted decibel
GE	General Electric
Hz	Hertz
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
kHz	kilohertz
L <sub>dn</sub>	day-night averaged sound level
L <sub>eq</sub>	equivalent sound level
LFN	low frequency noise
L <sub>max</sub>	maximum sound level
L <sub>p</sub>	sound pressure level
L <sub>w</sub>	sound power level
m/s	meters per second
mph	miles per hour
MVA	megavolt ampere
MW	megawatt
ND	North Dakota
NEMA	National Electrical Manufacturers Association
Project	Dickinson Wind Energy Center
PSC	Public Service Commission
pW	picowatt
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 Dickinson Wind Energy Center located in Stark 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. The overall objective of this study was to determine the feasibility of the Project to operate in compliance with applicable noise standards. The study also includes an assessment of sound generated during Project construction and maintenance.

Wind turbine sound source data was obtained from General Electric (GE), the manufacturer of the GE 1.7-103 (1.7 megawatts (MW)) and 1.79-100 (1.79 MW) WTGs as documented in each turbine's noise specification (GE 2013 and 2014). Substation data were obtained from NextEra Resources, LLC (NextEra) 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 (Cadena) program (version 4.5.147), 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 were compared to the North Dakota Public Service Commission (PSC) noise standards. Acoustic modeling results showed that the Project will not generate exceedances of the North Dakota PSC noise standards at any occupied receptor locations. Therefore, the Project is not expected to present an adverse noise impact to public welfare, health and safety.

## 1.0 INTRODUCTION

NextEra Resources, LLC (NextEra) proposes to construct and operate the Dickinson Wind Energy Center (Project) in Stark County, North Dakota. The Project wind turbine generator (WTG) layout, dated January 29, 2015, includes locations for 91 GE 1.7-103 WTGs and seven GE 1.79-100 WTGs. Eleven of the 91 GE 1.7-103 WTG locations are alternates. The rotor-diameters for the GE 1.7-103 and GE 1.79-100 WTGs are 338 feet (103 meters) and 328 feet (100 meters), respectively, and both WTG models have a hub height of 80 meters. The Project infrastructure also includes a collection substation to enable interconnection to Basin Electric Power Cooperative's transmission system. The substation would be located near the center of the Project Area and adjacent to the south side of Interstate 94 (I-94). Substation data were obtained from NextEra based on a 170 megavolt ampere (MVA) transformer similar to the HICO 170 MVA transformer in use at other NextEra energy facilities. 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 PSC noise standards.

### 1.1 Project Area

The Dickinson Project Area is shown in Figure 1 and is located on privately owned lands in Stark County, roughly spanning an area that includes the cities of Gladstone, Taylor, and Richardton, ND. This region of North Dakota has topography that can be described as level to rolling plains with isolated sandstone buttes or badlands formations. The majority of the Project Area is either grazing land or cropland. Most crop fields within the Project Area are wheat fields, although some corn, sunflower, and safflower crops are also. Patches of trees and shrubs exist throughout the Project Area and are found primarily between agricultural fields, in drainages, and as shelter belts around homesteads. There are a number of small water bodies such as ponds throughout the Project Area.

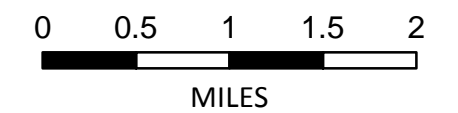
Occupied and unoccupied structures are widely scattered throughout the Dickinson Project Area. Structures that are not noise sensitive receptors, such as oil rigs and radio towers, were not included in the analysis. Of the 56 receptors included in the acoustical analysis, 44 are occupied structures and 12 are unoccupied (Swenson, Hagen & Co. 2015). NextEra intentionally designed the Project to be located away from the most densely populated areas. Additional developments in the Project Area include oil exploration and extraction areas, a landfill near Taylor, Interstate 94 (I-94), State Route 10 (SR 10), other roadways, the Burlington Northern Railway, and grass landing strips for aircraft. Additionally, there are two non-utility scale WTGs in the Project Area, approximately 1 mile northwest of Richardton, ND. Figure 1 is a map of the Dickinson Wind Energy Center Project Area, the locations of the proposed WTGs, and noise-sensitive receptor locations.

NEXTERA ENERGY  
RESOURCES, LLC  
DICKINSON WIND ENERGY CENTER  
STARK COUNTY, NORTH DAKOTA

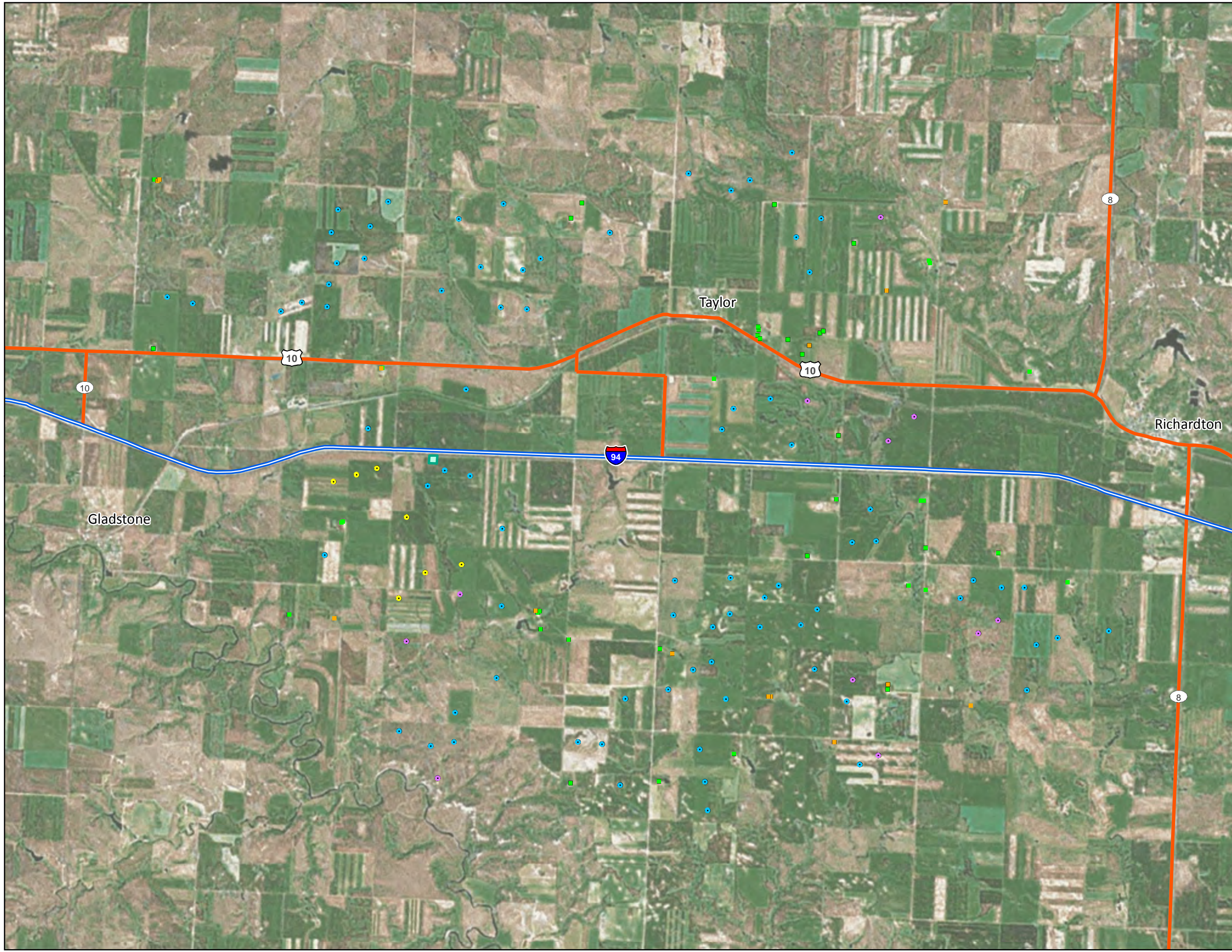
FIGURE 1  
PROJECT LAYOUT

FEBRUARY 2015

- GE 1.7 MW Xle Turbine
- GE 1.7 MW Xle Turbine (Alt)
- GE 1.719 MW Xle Turbine
- Receptor - Occupied
- Receptor - Unoccupied
- Substation



REFERENCE MAP



## 1.2 Existing Acoustic Environment

Stark 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 and SR 10 and near the railroad. Additional noise is likely a result of equipment and trucks associated with oil exploration in the area. 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.

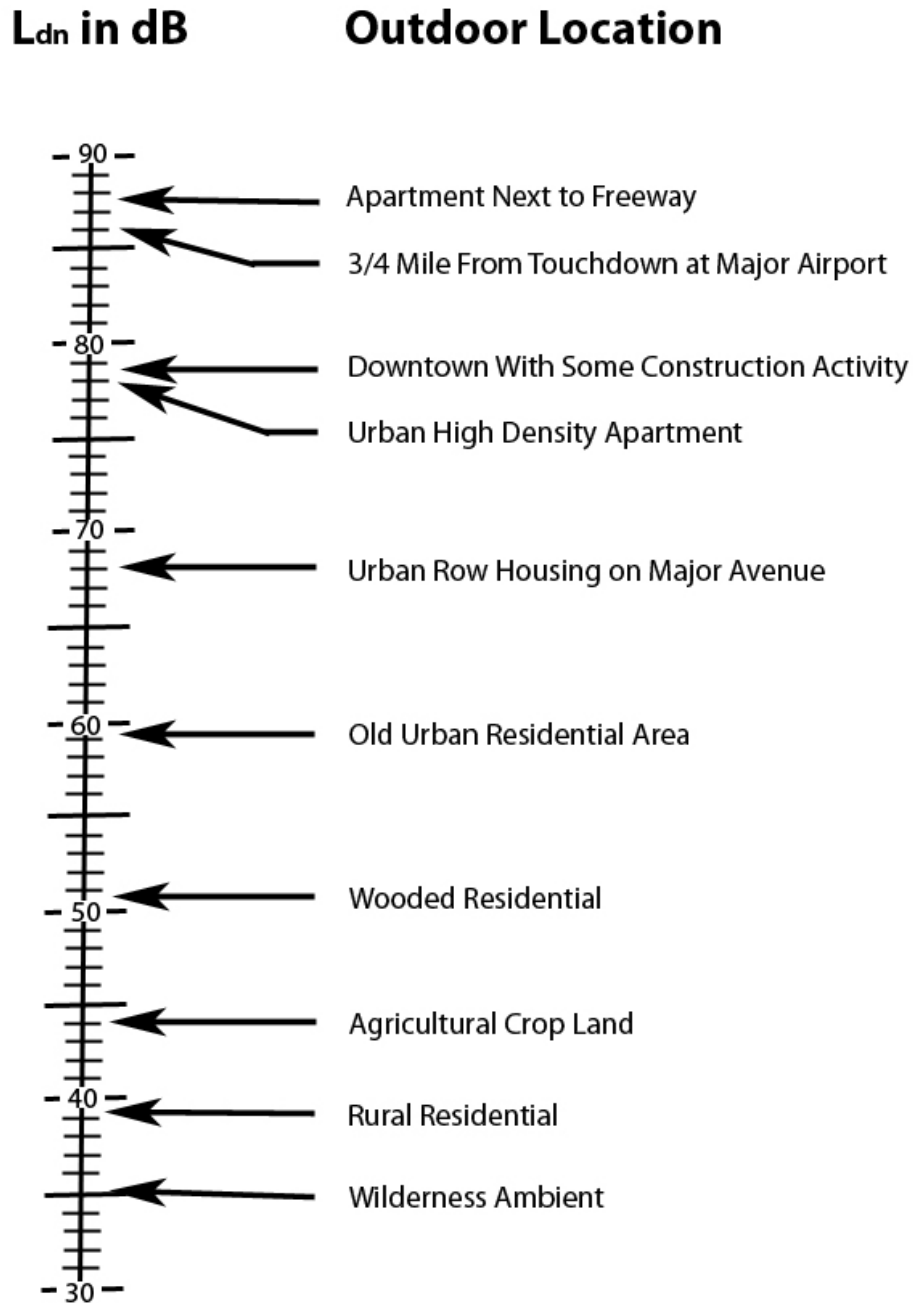
Sound levels are presented on a logarithmic scale to account for the large pressure response range of the human ear, and are expressed in units of decibels (dB). A dB is defined as the ratio between a measured value and a reference value usually corresponding to the lower threshold of human hearing defined 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 16 Hz (low) to 16,000 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.

An inherent property of the logarithmic decibel scale is that the sound pressure levels of two separate sources are not directly additive. For example, if a sound of 50 dBA is added to another sound of 50 dBA, the result is a 3-decibel increase (or 53 dBA), not an arithmetic doubling to 100 dBA. With respect to how the human ear perceives changes in sound pressure level relative to changes in "loudness", scientific research demonstrates that the following general relationships hold between sound level and human perception for two sound levels with the same or very similar frequency characteristics:

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

Sound can be measured, calculated, and presented in various formats, with a 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 environmental acoustic assessments. The  $L_{eq}$  is often further defined by the time period (T) it is measured over  $L_{eq(T)}$ , for instance  $L_{eq24}$  would indicate the equivalent sound level over a 24-hour period. Community sound levels are also often described in terms of the day-night averaged sound level ( $L_{dn}$ ), which accounts for the increased potential for annoyance that comes with elevated sound levels at night. In addition, the maximum sound level ( $L_{max}$ ) can be used to quantify the maximum instantaneous sound pressure level generated by a source. Estimates of noise sources and outdoor acoustic environments, and the comparison of relative loudness are presented in Figure 2. Table 1 provides additional reference information on acoustic terminology.

Figure 2. Various Outdoor Sound Levels ( $L_{dn}$ )**Notes:**

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

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

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

**Table 1. Acoustic Terms and Definitions**

<b>Term</b>	<b>Definition</b>
Noise	Unwanted sound dependent on level, character, frequency or pitch, time of day, and sensitivity and perception of the listener. This word adds the subjective response of humans to the physical phenomenon of sound. 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 1000 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). Equipment 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.
Frequency (Hz)	The rate of oscillation of a sound, measured in units of Hertz (Hz) or kilohertz (kHz). One hundred Hz is a rate of one hundred times (or cycles) per second. The frequency of a sound is the property perceived as pitch. For comparative purposes, the lowest note on a full range piano is approximately 32 Hz and middle C is 261 Hz.
A-Weighted Decibel (dBA)	Environmental sound is typically composed of acoustic energy across all frequencies (Hz). To compensate for the auditory frequency response of the human ear, an A-weighting filter is commonly used for describing environmental sound levels. Sound levels that are A-weighted are presented as dBA in this report.
Propagation and Attenuation	Propagation is the decrease in amplitude of an acoustic signal due to geometric spreading losses with increased distance from the source. Additional sound attenuation factors include air absorption, terrain effects, sound interaction with the ground, diffraction of sound around objects and topographical features, foliage, and meteorological conditions including wind velocity, temperature, humidity and atmospheric conditions.
Octave Bands	The audible range of humans spans from 20 to 20,000 Hertz and is typically divided into octave band center frequencies (Hz) ranging from 31 to 8,000 Hz.
Broadband Sound	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.
Masking	Interference in the perception of one sound by the presence of another sound. At elevated wind speeds, leaf rustle and noise made by the wind itself can mask wind turbine sound levels, which remain relatively constant.
Low Frequency Noise (LFN)	The frequency range of 20 to 200 Hz is typically defined as low frequency noise. Studies have shown that low frequency sound from modern wind turbines is generally below the threshold of human perception at standard setback distances.
Infrasound	The frequency range of infrasound is normally defined as below 20 Hz. Infrasound from wind turbines are significantly below recognized thresholds for both human perceptibility and standardized health.

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

## 2.0 NOISE REGULATIONS AND GUIDELINES

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 North Dakota Public Service Commission (PSC) has established standards applicable to wind energy facilities. Stark County also provides noise limits applicable to the Project via their zoning ordinance. The cities of Gladstone, Taylor, and Richardton, North Dakota have no known noise limits applicable to the Project. The controlling regulation for the Project is the PSC's noise standard, which is more stringent than the requirements prescribed by Stark 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 Standards

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 standard is absolute and independent of the existing acoustic environment; therefore, a baseline sound survey is not required to assess conformity.

### 2.2 Stark County Zoning Ordinance

The Stark County zoning ordinance includes 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 eighty (80) decibels (dB) during the day and seventy (70) decibels (dB) at night is prohibited.”*

The 70 dBA nighttime limit prescribed by Stark County is less than that prescribed by the North Dakota PSC so by achieving compliance with the PSC requirements, compliance with the Stark County Zoning Ordinance is also obtained.

### 3.0 ACOUSTIC MODELING METHODOLOGY

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 fossil fuel or nuclear power plants, 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 maximum rotational wind speed the specified maximum sound power level will be reached, which typically occurs around 7 to 10 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 likely increase as well, resulting in acoustic masking effects. 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 particularly sheltered from prevailing winds.

#### 3.1 Acoustic Modeling Software and Calculation Methods

The operational acoustic assessment was performed using the Project WTG layout dated January 29, 2015 consisting of 98 proposed WTG locations, 11 of which are alternate WTG locations. The Project would implement two WTG models, the GE 1.7-103 and the GE 1.79-100 with rotor diameters of 338 feet (103 meters) and 328 feet (100 meters), respectively, and both WTG models have a hub height of 80 meters. Both WTG models have hub heights of 262.5 feet (80 meters). The Project would also include a collection substation with a 170 MVA transformer to connect to the Western Area Power Administration's transmission system. WTG sound source data were obtained from GE (GE 2013 and 2014) and substation transformer data were obtained from NextEra.

The acoustic modeling analysis was conducted using the most recent version of DataKustic GmbH's computer-aided noise abatement program or CadnaA (v 4.5.147). 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 ignored.

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, such as commonly occurs at nighttime and during early morning hours, and wind gradients which can bend sound downwards, which may occur any time depending on weather conditions. Per ISO 9613-2, the effects of meteorological conditions on sound propagation are small for short distances, and also small for longer distances at greater source and receptor heights. Over extended distances when the influences of wind or temperature gradients are most prevalent, atmospheric effects may cause fluctuations in received sound levels, but will typically attenuate noise to levels below those predicted. Levels significantly above those predicted are defined as exceptional events

under the ISO 9613-2 standard. Propagation for anomalous meteorological conditions are presented to show that for comparatively short periods of time received sound levels may be higher than the mean.

### 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. Table 2 presents a summary of sound power data during normal operations correlated to 10 meter height integer wind speeds 10 meter above ground level (AGL) with a stated roughness length of 0.05 meters, which is representative of level grass-covered terrain (GE 2013 and 2014). The roughness length describes the vertical wind profile per IEC specification in a neutral atmosphere with the wind profile following a logarithmic curve.

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 2. 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

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 the acoustic model development. A summary of sound power data for the WTGs by octave band center frequency are presented in Table 3 (1/1 octave band frequency data provided with stated intended use limited for informational purposes only).

**Table 3. 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

## 4.0 PROJECT OPERATING NOISE LEVELS

Operational received sound levels (dBA) were calculated assuming that all WTGs and the substation transformer are operating concurrently at the maximum manufacturer-rated sound level.

### 4.1 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. In addition, sound energy contribution from the Project substation was included in the acoustic modeling analysis. Table 4 presents the results of the Dickinson 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.

Sound contour plots displaying Project operational sound levels in color-coded isopleths are provided in Figures 3 through 5 and are rounded to the nearest whole decimal for consistency with the State of North Dakota noise limit absolute value of 50 dBA. Therefore, the range of “45 – 50 dBA” includes values up to 50.0 and the range of “>50 dBA” includes all values over 50.0. The tabulated results and contour plots are independent of the existing acoustic environment and are representative of expected Project sound levels only. Figure 3 is a map of the operational sound levels under low-level wind speeds sufficient for the WTGs to operate at initial cut-in rotational speeds. Figure 4 is a map of the operational sound levels at wind speeds sufficient to sustain WTG operation at maximum rotational speeds for moderate downwind propagation. Figure 5 is a map of the operational sound levels at wind speeds sufficient to sustain WTG operation at maximum rotational speeds under anomalous meteorological conditions. A 100-foot buffer was included around the receptors, corresponding to the point of compliance identified in the PSC noise standard.

**Table 4. Summary of Acoustic Modeling Results**

Receptor ID	Receptor Status*	UTM Coordinates (m)		Received Sound Levels (dBA $L_{eq}$ )		
		Easting (X)	Northing (Y)	Cut-in Wind Speed	Maximum Wind Speed	Anomalous Meteorological Conditions
610073	Home (occupied)	695860	5191288	40	46	47
610090	Home (abandoned)	696092	5191217	42	49	49
610095	Home (occupied)	700396	5194332	36	42	44

**Table 4. Summary of Acoustic Modeling Results**

Receptor ID	Receptor Status*	UTM Coordinates (m)		Received Sound Levels (dBA L <sub>eq</sub> )		
		Easting (X)	Northing (Y)	Cut-in Wind Speed	Maximum Wind Speed	Anomalous Meteorological Conditions
610103	Trailer Home (occupied)	700422	5194329	35	42	43
610107	Home (occupied)	700372	5194322	36	42	44
610131	Home (occupied)	700520	5193472	36	43	44
610164	Home (occupied)	698844	5194233	38	45	46
610177	Home (abandoned)	699143	5189841	39	45	46
610185	Home (occupied)	698395	5193168	38	45	46
610201	Home (occupied)	700580	5192724	38	45	46
610219	Home (occupied)	700033	5190866	38	44	45
610243	Trailer Home (unknown if occupied)	700029	5190954	38	45	45
610250	Home (occupied)	701840	5193484	40	46	47
610276	Home (occupied)	703133	5193055	36	43	44
610305	Home (abandoned)	701555	5190691	33	40	41
610336	Home (occupied)	696029	5188885	38	44	45
610347	Home (occupied)	700263	5192777	37	43	44
610369	Home (occupied)	694434	5188738	37	43	44
610376	Home (occupied)	694200	5191330	34	41	43
610384	Home (occupied)	693681	5191477	36	42	44
610392	Home (occupied)	693605	5191777	36	43	44
610398	Trailer Home (occupied)	693639	5191806	35	42	43
610433	Trailer Home (unknown if occupied)	693566	5191807	37	43	44
610496	Home (occupied)	689939	5193130	38	45	46
610498	Home (occupied)	689960	5193148	38	45	46
610513	Home (occupied)	689117	5191392	30	37	39
610524	Home (abandoned)	689941	5191389	33	40	42
610532	Home (occupied)	697203	5197185	34	40	42
610551	Trailer Home (occupied)	697188	5197235	33	40	42
610557	Home (occupied)	697313	5199467	39	46	46
610568	Home (occupied)	698807	5198881	38	44	45
610603	Home (abandoned)	699459	5198072	32	38	40
610605	Home (occupied)	698790	5195387	37	44	45
610642	Home (occupied)	696464	5196240	37	44	44
610660	Monastery	702155	5196804	27	33	36

**Table 4. Summary of Acoustic Modeling Results**

Receptor ID	Receptor Status*	UTM Coordinates (m)		Received Sound Levels (dBA L <sub>eq</sub> )		
		Easting (X)	Northing (Y)	Cut-in Wind Speed	Maximum Wind Speed	Anomalous Meteorological Conditions
610669	Home (occupied)	700203	5198634	28	35	36
610672	Home (occupied)	700187	5198672	28	35	36
610685	Home (abandoned)	700406	5199751	28	34	36
610708	Home (abandoned)	698141	5196974	35	41	43
610727	Home (occupied)	698026	5196804	36	42	43
610731	Home (occupied)	697749	5197051	34	41	43
610738	Home (occupied)	697190	5197081	34	40	42
610743	Home (occupied)	697236	5197030	34	41	42
610745	Home (occupied)	698316	5197214	34	40	42
610750	Home (occupied)	698374	5197253	34	40	42
610774	Home (abandoned)	697933	5190578	38	44	45
610780	Home (abandoned)	697887	5190573	38	45	46
610981	Home (occupied)	697349	5189492	38	45	46
710278	Home (occupied)	686081	5199064	23	30	32
710294	Home (abandoned)	686145	5199050	23	30	32
710298	Trailer Home (abandoned)	686174	5199072	24	31	33
710300	Home (occupied)	686301	5196009	33	39	40
710314	Home (occupied)	690461	5195981	35	42	43
710318	Home (abandoned)	690446	5195968	35	42	43
710344	Home (occupied)	693659	5198938	36	43	44
710350	Trailer Home (occupied)	693834	5199236	35	42	43

\*Receptor status is based on the January 16, 2015 farmstead report prepared by Swenson, Hagen & Co. (2015).

The acoustic modeling results demonstrate that received sound levels are all below the PSC 50 dBA noise standard.

NEXTERA ENERGY  
RESOURCES, LLC  
DICKINSON WIND ENERGY CENTER  
STARK COUNTY, NORTH DAKOTA

FIGURE 3  
RECEIVED SOUND LEVELS:  
WIND TURBINES AT CUT-IN  
ROTATIONAL WIND SPEED

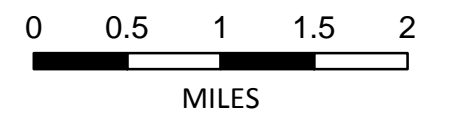
FEBRUARY 2015

- GE 1.7 MW Xle Turbine
- GE 1.7 MW Xle Turbine (Alt)
- GE 1.719 MW Xle Turbine
- Receptor - Occupied
- Receptor - Unoccupied

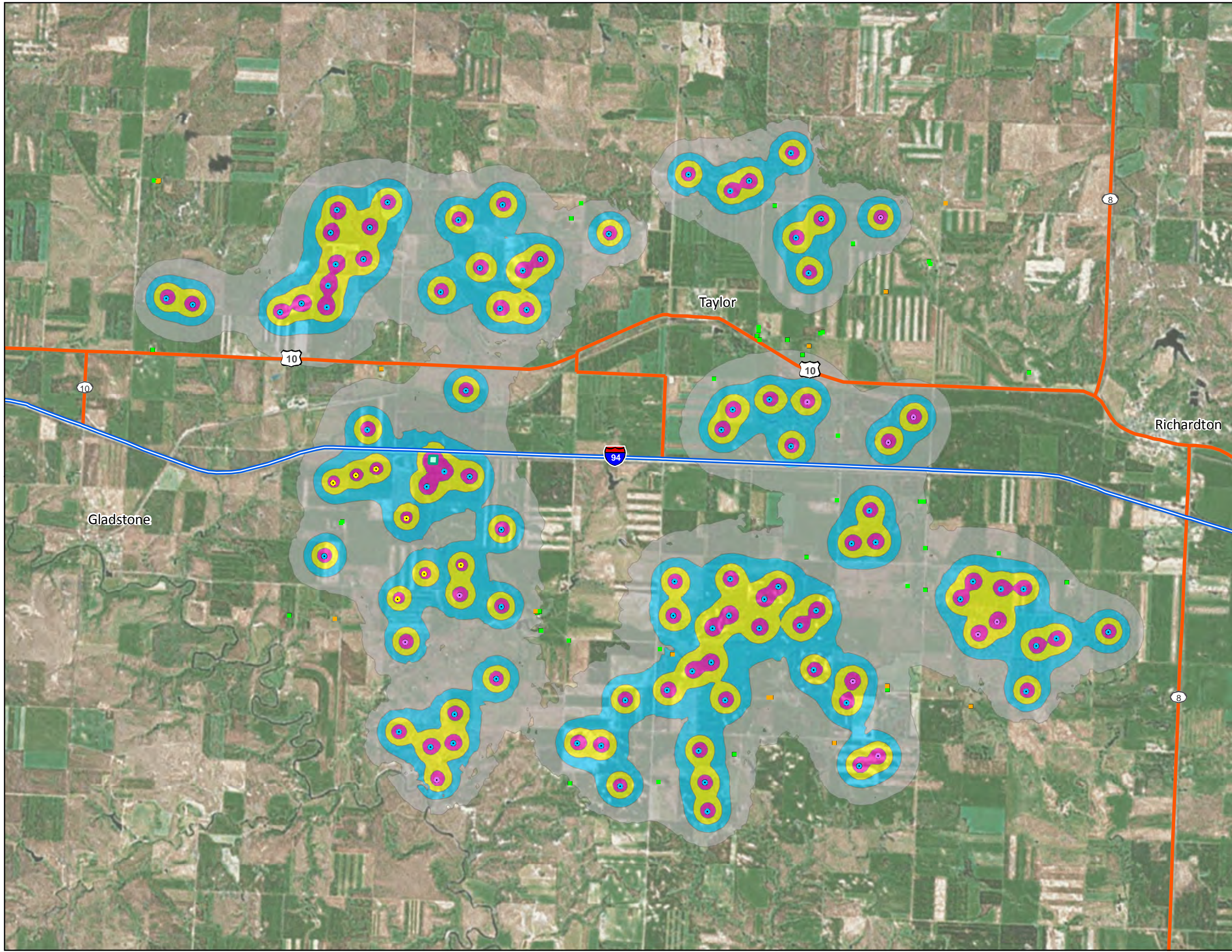
■ Substation

Sound Level Contour Ranges (dBA)

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









REFERENCE MAP



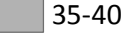
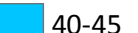


NEXTERA ENERGY  
 RESOURCES, LLC  
 DICKINSON WIND ENERGY CENTER  
 STARK COUNTY, NORTH DAKOTA

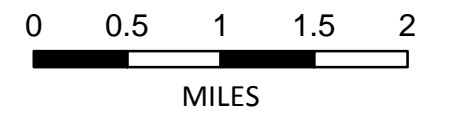
FIGURE 4  
 RECEIVED SOUND LEVELS:  
 WIND TURBINES AT MAXIMUM  
 ROTATIONAL WIND SPEED

FEBRUARY 2015

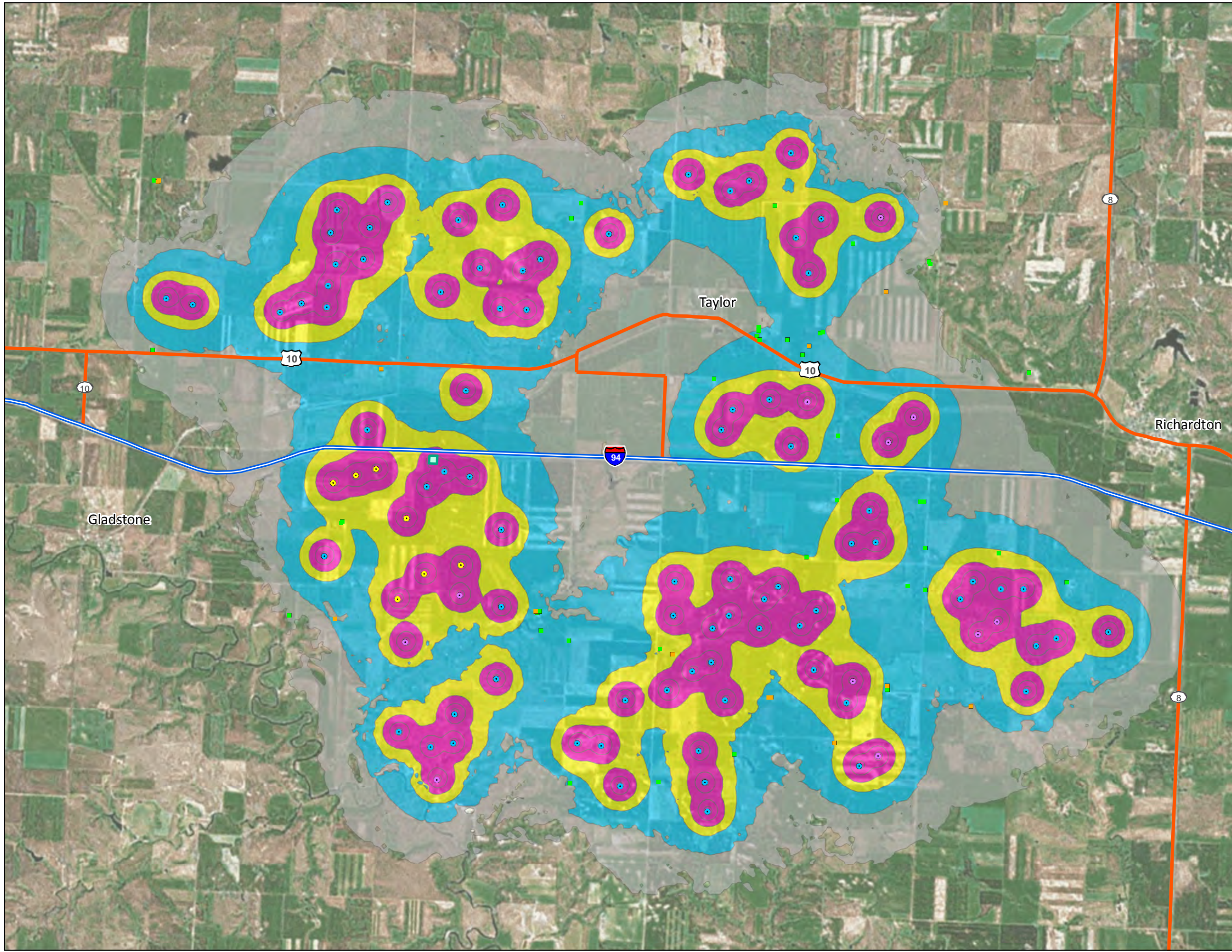
-  GE 1.7 MW Xle Turbine
-  GE 1.7 MW Xle Turbine (Alt)
-  GE 1.719 MW Xle Turbine
-  Receptor - Occupied
-  Receptor - Unoccupied
-  Substation

Sound Level Contour Ranges (dBA)

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









REFERENCE MAP







NEXTERA ENERGY  
 RESOURCES, LLC  
 DICKINSON WIND ENERGY CENTER  
 STARK COUNTY, NORTH DAKOTA

FIGURE 5  
 RECEIVED SOUND LEVELS:  
 WIND TURBINES AT MAXIMUM  
 ROTATIONAL WIND SPEED,  
 ANOMALOUS METEOROLOGICAL  
 CONDITIONS

FEBRUARY 2015

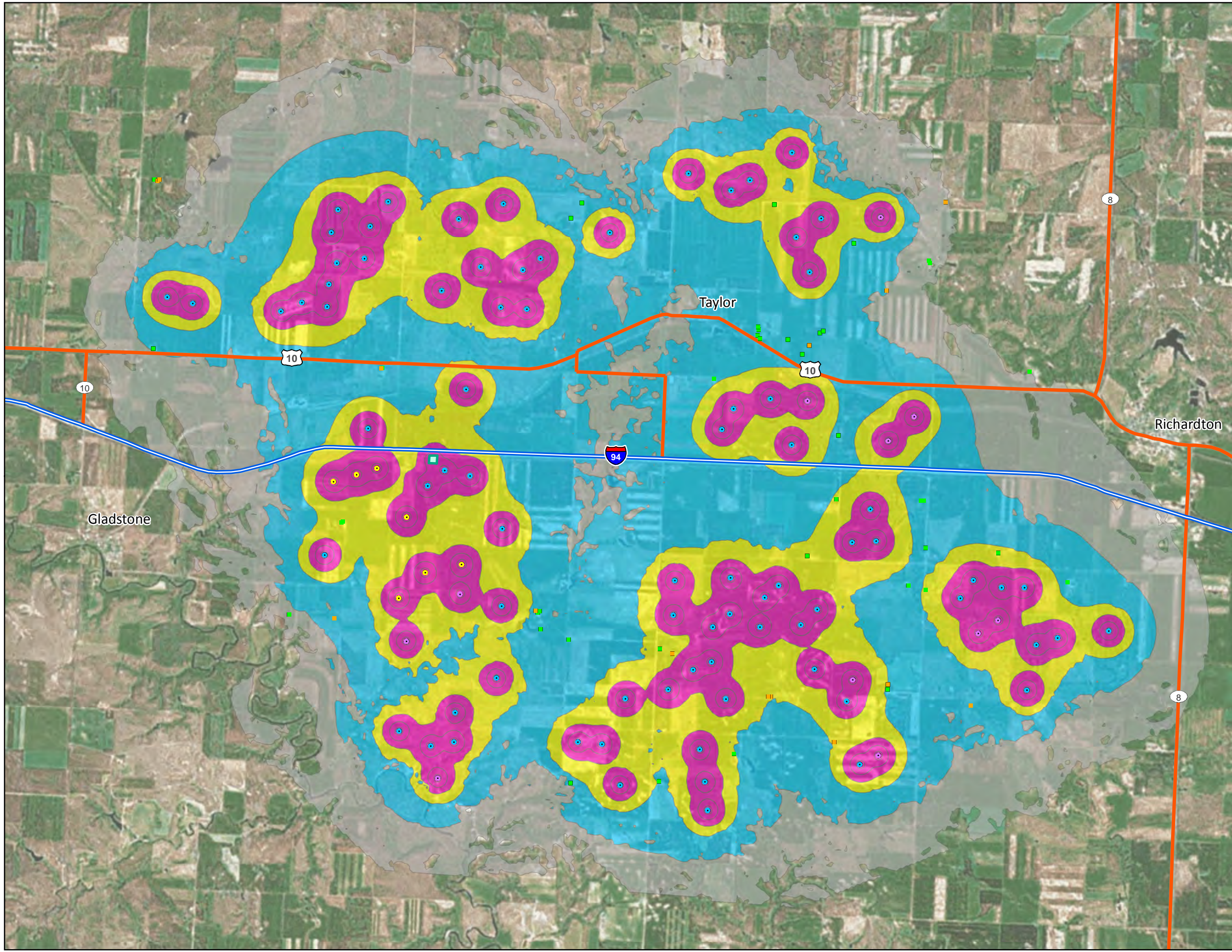
-  GE 1.7 MW Xle Turbine
-  GE 1.7 MW Xle Turbine (Alt)
-  GE 1.719 MW Xle Turbine
-  Receptor - Occupied
-  Receptor - Unoccupied
-  Substation

Sound Level Contour Ranges (dBA)

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



REFERENCE MAP



## 5.2 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 Dickinson electrical substation would be located 2,300 feet east of 97<sup>th</sup> Avenue and 450 feet south of I-94. The transformer at this substation was modeled using the latest version of CadnaA implementing ISO 9613-2. Transformer sound source levels for the Dickinson substation were provided based on a 170 MVA rating. Table 5 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 5. 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	93.3	99.3	101.3	96.3	90.3	85.3	80.3	73.3	96.7

Transformers the size of the Project's 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 Dickinson transformer location is approximately 2,000 feet (610 feet) from the nearest noise sensitive receptor and poses little concern from a noise perspective, especially given the location of the nearest sensitive receptor being within 1,000 feet (305 meters) of I-94. 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 Dickinson 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 Dickinson Wind Energy Center is generally divided into four phases consisting of the following:

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

Work on these construction activities is expected to overlap. It is likely that the 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 6.

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.

**Table 6. 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

Data compiled in part from the following sources:

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

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

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

Construction activity will generate traffic having potential noise effects, such as trucks travelling to and from the site on public roads. At the early stage of the construction phase, equipment and materials will be delivered to the site, such as hydraulic excavators and associated spreading and compacting equipment needed to form access roads and foundation platforms for each turbine. Once the access roads are constructed, equipment for lifting the towers and turbine components will arrive. Traffic noise is categorized into two categories: (1) the noise that will occur during the initial temporary traffic movements related to turbine delivery, haulage of components and remaining construction; and (2) maintenance and ongoing traffic from staff and contractors, which is expected to be minor.

## **5.0 CONCLUSIONS**

Project operational sound has been calculated and compared to the 50 dBA PSC noise standard. 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 standard. 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.

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

- Bolt, Beranek and Newman, Inc., Power Plant Construction Noise Guide, prepared for the Empire State Electric Energy Research Corporation, Report No. 3321, 1977.
- David Bies, Collin Hansen. "Engineering Noise Control: Theory and Practice", Pages 554-555, Published by Taylor & Francis, 2003.
- DataKustik GmbH. 2015. Computer-Aided Noise Abatement Model CadnaA, Version 4.5.147 Munich, Germany.
- Elliott, T. et al. Standard handbook of power plant engineering. McGraw-Hill: 1998, New York.
- Federal Highway Administration, FHWA Roadway Construction Noise Model User's Guide, FHWA-HEP-05-054, January 2006.
- Federal Highway Administration, "Procedures for Abatement of Highway Traffic Noise and Construction Noise". Code of Federal Regulations, Title 23, Part 772, 1992.
- IEC (International Electromechanical Commission). 61400-11:2002(E) Wind Turbine Generator Systems – Part 11: Acoustic Noise Measurement Techniques, Third Edition 2006-12.
- ISO (International Organization for Standardization). 1989. Standard ISO 9613-2 Acoustics – Attenuation of Sound During Propagation Outdoors. Part 2 General Method of Calculation. Geneva, Switzerland.
- Rogers, Anthony, James Manwell, Sally Wright. 2006. "Wind Turbine Noise – A White Paper," Renewable Energy Research Laboratory, University of Massachusetts at Amherst, June 2002, Amended January 2006.
- Swenson, Hagen & Co. 2015. P.C. Dickinson Wind Farm Farmstead Location Report. Revised January 16, 2015.
- 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.
- USEPA. 1978. Protective Noise Levels. Condensed Version of EPA Levels Document. Publication EPA-550/9-79-100, November.
- Wagner, S., Bareib, R. and Guidati, G. 1996. Wind Turbine Noise, Springer, Berlin.

**WHOOPING CRANE LIKELIHOOD OF  
OCCURRENCE REPORT**

**FOR**

**DICKINSON WIND ENERGY CENTER**

**STARK COUNTY, NORTH DAKOTA**

Prepared For:



RESOURCES

**NextEra Energy Resources, LLC**  
700 Universe Blvd.  
Juno Beach, Florida 33408

Prepared By:



**Tetra Tech, Inc.**  
350 Indiana St, Suite 500  
Golden, CO 80401

February 2015

*This page intentionally left blank*

## **EXECUTIVE SUMMARY**

NextEra Energy Resources, LLC (NextEra) contracted Tetra Tech, Inc. (Tetra Tech) to conduct a landscape-scale analysis to assess the potential occurrence of whooping cranes at the Dickinson Wind Energy Center (Project). The likelihood of whooping cranes occurring on land within the boundary of the Project (Project Area) is low, despite higher proportion of suitable wetlands within the Project Area compared to the surrounding area. The major factor that contributed to this low likelihood finding was the position of the Project Area in the western portion of the whooping crane migration corridor; the majority of whooping crane sightings occur farther east in central North Dakota. The two most likely impacts of wind development on whooping cranes are: 1) whooping cranes' avoidance of the area around the facility; or 2) direct mortality of whooping cranes due to collisions with transmission lines, turbines, or other facilities. Each Project site is unique with respect to the relationship of the facilities with potential whooping crane habitat. Overall, the higher proportion of wetlands within the Project Area compared to the Surrounding Area (35-miles outside of the Project Area) may potentially serve as an attractant, but, based on the location of the Project Area in the migration corridor, migrating cranes likelihood of occurrence is low.

## Table of Contents

1.0	INTRODUCTION.....	1
2.0	LEGAL STATUS OF THE WHOOPING CRANE IN THE UNITED STATES.....	1
3.0	ENVIRONMENTAL SETTING AND PROJECT AREA DESCRIPTION.....	2
3.1	Environmental Setting.....	2
3.2	Project Area Description.....	2
4.0	WHOOPING CRANE BIOLOGY .....	3
4.1	Reasons for the Population Decline.....	3
4.2	Threats to Whooping Cranes .....	4
5.0	WHOOPING CRANE MIGRATION .....	5
5.1	Fall Migration .....	5
5.2	Spring Migration.....	5
5.3	Migration Flight Behavior .....	6
5.4	Stop-over Habitat Characteristics.....	6
6.0	ASSESSMENT OF WHOOPING CRANE LIKELIHOOD OF OCCURENCE.....	7
6.1	Location of a Project Area in the Migration Corridor (L).....	8
6.2	Attractiveness of the Landscape (A).....	8
6.3	Presence of Foraging and Roosting Sites (W).....	9
6.4	Likelihood Index Formula (LI) .....	10
7.0	PROJECT AREA ASSESSMENT AND SUMMARY .....	11
8.0	LITERATURE CITED .....	12

## Tables

Table 1.	Summary of parameters used in the likelihood index calculation. ....	7
Table 2.	Likelihood index scores for the Dickinson Wind Energy Center. ....	11

## Figures

Figure 1.	Vicinity Map
Figure 2.	Whooping Crane Migration Corridor
Figure 3.	Whooping Crane Migration: North Dakota
Figure 4.	Whooping Crane Habitat Map

*This page intentionally left blank*

## **1.0 INTRODUCTION**

NextEra Energy Resources, LLC (NextEra), proposes to develop the Dickinson Wind Energy Center (Project) in Stark County, North Dakota (Figure 1). One concern when developing wind energy facilities in parts of the Great Plains is the federally endangered whooping crane (*Grus americana*). The whooping crane migrates through the western and central portions of North Dakota during spring and fall. Whooping cranes have been killed by collisions with power lines, and the whooping crane recovery plan lists construction of power lines, fences, and other structures in the migration corridor as a threat to the species (CWS and USFWS 2007). Thus, the construction of wind turbines may pose a risk to whooping cranes through avoidance of areas or direct mortality where turbines are located.

NextEra contracted Tetra Tech, Inc. (Tetra Tech) to conduct a landscape-scale analysis to assess the potential occurrence of whooping cranes within the lands of the Project and associated transmission line (Project Area). The objective of this likelihood of occurrence analysis is to evaluate the biological and landscape features within the Project Area to determine the potential for whooping cranes to occur during migration. Certain landscape features may increase the likelihood of whooping crane occurrence during migration. Thus, Tetra Tech developed a likelihood index to evaluate the Project Area based on its location in the migration corridor, the presence of feeding and roosting sites, and the availability of habitat within the Project Area compared to the surrounding landscape. The likelihood index does not predict how many whooping cranes may occur in the Project Area; rather, it scores the site based on a suite of variables that are related to whooping crane occurrence. Higher scores denote higher potential likelihood of occurrence. This assessment tool is not intended to replace field surveys. However, the low probability of detecting a whooping crane during field surveys minimizes the utility of field surveys in documenting presence in or absence from a given area. As a consequence, this assessment tool was designed to take advantage of available data, with an emphasis on habitat.

## **2.0 LEGAL STATUS OF THE WHOOPING CRANE IN THE UNITED STATES**

The whooping crane is protected by both federal and state laws in the United States. It was considered endangered in the United States in 1970 and the endangered listing was 'grandfathered' into the Endangered Species Act (ESA) of 1973, which prohibits "take" (CWS and USFWS 2007). "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (16 U.S.C. §1532(19)). "Incidental take" occurs when a fatality of an ESA-listed species occurs as an unintended consequence of an otherwise legal activity, as would be the case in the unlikely event of a fatality occurring at a wind farm. To Tetra Tech's knowledge, no whooping crane fatality has occurred at a wind energy facility. North Dakota does not have state endangered or threatened

species list, but instead defers to the USFWS federal listing of endangered and threatened species that occur within North Dakota (NDGF 2012).

The whooping crane population in North America sharply declined and disappeared from most of its historic range (CWS and USFWS 2007). The number of whooping cranes in North America prior to 1870 is estimated to have been between 500 and 1,400 individuals (Allen 1952, Banks 1978), but some biologists suggest that the population may have numbered as many as 10,000 individuals (CWS and USFWS 2007). Activities such as habitat destruction, hunting, and displacement due to anthropogenic activities likely led to widespread population declines (CWS and USFWS 2007). One self-sustaining wild population of whooping cranes currently exists in the world. Members of this population breed primarily within the boundaries of Wood Buffalo National Park in Canada and migrate through the central United States to wintering grounds at the Aransas National Wildlife Refuge along the Gulf Coast of Texas (Figure 2). This flock is referred to as the Aransas-Wood Buffalo National Park Population. Due to intensive management, this population has increased from 15 birds in 1941 to an estimated 304 birds (with a 95% probability of actual flock size being between 260–354 birds) as of the 2013/2014 winter whooping crane survey conducted by USFWS (USFWS 2014a). Aerial surveys for the winter of 2014/2015 have been completed but the results will likely not be released until March 2015 (USFWS 2014b).

### **3.0 ENVIRONMENTAL SETTING AND PROJECT AREA DESCRIPTION**

#### **3.1 Environmental Setting**

The Project Area is located in the Missouri Plateau subregion of the Northwestern Great Plains Ecoregion (Bryce et al. 1996). The region is mostly used for dryland farming and cattle grazing. The topography of the region is a semiarid rolling plain (Bryce et al. 1996). Vegetation in the region was historically mixed-grass prairie with blue grama (*Bouteloua gracilis*), little bluestem (*Schizachyrium scoparium*), prairie sandreed (*Calamovilfa longifolia*) and a wheatgrass-needlegrass association (Bryce et al. 1996). Native grasslands occur in areas of steep topography.

#### **3.2 Project Area Description**

The Project Area is located on privately-owned lands in southwest North Dakota and consists of 143,380 acres. The proposed Project turbines will be located approximately 11 miles east of Dickinson in eastern Stark County, and the associated 230-kilovolt (kV) overhead transmission line would run west from the Project Area south of Dickinson approximately 31 miles (Figure 1). The Project has a proposed nameplate capacity of approximately 150 megawatts (MW), consisting of 80 GE 1.7 MW Xle wind turbine generators and 7 GE 1.7 MW Xle wind turbine generators. Additional facilities include access roads, electrical collection systems and cabling, a collection substation, an operation and maintenance (O&M) building, a switchyard, and two

construction laydown areas. Three guyed temporary meteorological towers have been installed for the Project Area and up to three additional temporary towers are planned. Up to two of the towers may be converted to permanent meteorological towers, depending on offtaker requirements.

The existing land use in the Project Area is primarily cattle production and agriculture. The area contains numerous small wetlands that vary from shallow vegetated depressions, man-made cattle ponds, and intermittent creeks. There are few wetlands evident that are not associated with a stream system. Residences and a few abandoned farmsteads are scattered throughout the Project Area. The Project Area is a mix of cattle pastures, agriculture, and remnant native prairie. Whooping cranes have been documented to occur at Lake Sakakawea (approximately 45 miles to the north), Ilo National Wildlife Refuge (approximately 30 miles to the north), and Pretty Rock National Wildlife Refuge (approximately 43 miles to the southeast) during its annual migration periods (Figure 1; Austin and Richert 2001).

#### **4.0 WHOOPING CRANE BIOLOGY**

The whooping crane is a long-lived species that may reach 28 years old in the wild (Binkley and Miller 1983). Individuals reach sexual maturity at 3 to 5 years of age and form life-long breeding pairs while on the wintering grounds or during spring migration (Stehn 1997; CWS and USFWS 2007). Whooping cranes have low annual reproductive output. Females typically lay two eggs, but only 10 percent of families arrive on the winter grounds with two chicks because the smaller chick usually dies within the first two weeks after hatching (CWS and USFWS 2007). The juveniles become independent of the parents on the wintering ground prior to spring migration. Sexually immature individuals (i.e., subadults) return to the breeding grounds where they may remain solitary or congregate in small groups on the periphery of breeding pairs (CWS and USFWS 2007).

##### **4.1 Reasons for the Population Decline**

Populations of long-lived species with low annual reproductive output such as the whooping crane are sensitive to changes in adult survival (Stahl and Oli 2006). Hunting, especially during spring migration, from 1870 to 1930 resulted in 274 documented whooping crane fatalities (Allen 1952). In addition, Hahn (1963) tallied 309 mounts and 9 skeletons in museum collections throughout the world. Because many of these specimens do not contain information regarding the date and location of collection, it is unlikely that the majority were collected by museum personnel. It is possible that mortality from shooting exceeded annual production of juveniles during the early 1900s (CWS and USFWS 2007).

Degradation and loss of breeding habitat eliminated the whooping crane from much of its core breeding range in North America. Whooping cranes once bred from the southern edge of Lake

Michigan north through southern Minnesota to northeastern North Dakota through Manitoba, Saskatchewan, and Alberta (Allen 1952). Conversion of prairie and pothole ecosystems to agriculture and ranching made much of the breeding habitat unsuitable (CWS and USFWS 2007). Due to their high degree of site fidelity, members of the Aransas-Wood Buffalo Population are unlikely to naturally recolonize the historic whooping crane range in North America.

#### **4.2 Threats to Whooping Cranes**

Several factors threaten the whooping crane because of its small population size and concentration of all members of the Aransas-Wood Buffalo National Park population at single breeding and wintering locations. Threats to the whooping crane identified in the recovery plan that are related to wind power development include collision with power lines, fences, and other structures, and loss and degradation of stop-over and wintering habitat through avoidance (CWS and USFWS 2007; USFWS 2009).

Power lines pose a major threat to whooping cranes when they are located in the vicinity of foraging or roosting habitat because individuals often fly at low altitudes (33 to 49 feet above the ground) when moving among sites (CWS and USFWS 2007; Stehn and Wassenich 2008). The majority of documented fatalities during migration are due to collisions with power lines. Since 1956, 46 whooping cranes have been killed or seriously injured as a result of collisions with power lines (Stehn and Wassenich 2008). Collisions with power lines have resulted in fatalities of whooping cranes in other experimental populations that are maintained by the introduction of captive-reared young (Stehn and Wassenich 2008). Fourteen individuals from the Florida non-migratory population and one individual in the migratory Wisconsin population have died from colliding with power lines (Stehn and Wassenich 2008).

Although whooping crane mortality has not been attributed to wind turbines, the whooping crane recovery plan considers wind power development within the whooping crane migration corridor a threat because of the construction of power lines and associated structures (CWS and USFWS 2007). Both sandhill and whooping cranes have been seen in the vicinity of operational wind turbines, and Nagy et al. (2012) showed that the cranes either flew above or around the turbines, therefore minimizing the likelihood of turbine collision. Other studies have documented sandhill cranes gradually climbing as they approach marked power lines (Morkill and Anderson 1991, Murphy et al. 2009). The USFWS (2009) believes that whooping cranes will avoid stopping at areas with operational wind turbines. Thus, behavioral avoidance of wind farms by whooping cranes may reduce the probability of collision but may result in loss of stop-over habitat.

## **5.0 WHOOPING CRANE MIGRATION**

Whooping cranes undertake a 5,000-mile round-trip migration from the breeding area in Canada to the wintering area in Texas every year. Individuals depart the breeding ground in Canada and travel south through Alberta, Canada, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas to the wintering ground at Aransas National Wildlife Refuge on the Texas coast. The migration route is well-defined and 95 percent of all observations occur within a 200-mile wide corridor during spring and fall migration (USFWS 2010; Figure 2). Whooping cranes may occasionally travel with sandhill cranes during migration, and stop-over sites used by sandhill cranes may indicate potential whooping crane stop-over areas (CWS and USFWS 2007).

During migration, whooping cranes can occur where suitable habitat is available. Four sites in the migration corridor are used consistently by whooping cranes and have high annual use: the Platte River in Nebraska, Cheyenne Bottoms Wildlife Management Area and Quivira National Wildlife Refuge in Kansas, and the Salt Plains National Wildlife Refuge in Oklahoma. Additionally, Aransas National Wildlife Refuge in Texas is used yearly by whooping cranes as the wintering grounds. These five sites are designated as critical habitat under the Endangered Species Act (Figure 2; CWS and USFWS 2007). The Platte River is the closest of these four sites to the Project Area and is located over 450 miles to the south.

### **5.1 Fall Migration**

Whooping cranes depart the breeding grounds at Wood Buffalo National Park in mid-September and parents with young are usually the last to depart. Birds may travel alone, in pairs, in family groups, or in small flocks (Johns 1992). The birds first travel southeast about 300 miles to a major staging area in Saskatchewan, where they may remain for 2 to 4 weeks before resuming migration. During fall migration, birds may stay at traditional stop-over sites for 7 to 10 days, but stays as long as 6 weeks have been documented at Quivira National Wildlife Refuge (CWS and USFWS 2007). The majority of whooping cranes reach the wintering grounds by mid-November. In North Dakota, most sightings occur from late September to early November with peak migration occurring in mid-October (Austin and Richert 2001).

### **5.2 Spring Migration**

Whooping cranes depart the wintering grounds in late March; the last birds depart in May. Breeding pairs are typically first to depart and migration is facilitated by winds from the southeast. There is no known staging area in spring as there is in fall, and migration is completed in 2 to 4 weeks. Traditional stop-over sites that are used in fall are also used in spring. However, individuals spend fewer days at stop-over sites during spring migration. Whooping cranes travel through North Dakota from mid-April to early May with peak migration in late April (Austin and Richert 2001).

### **5.3 Migration Flight Behavior**

Whooping cranes are diurnal migrants and primarily fly by using static soaring, but low-level flapping flight may be used when conditions dictate. Migration is initiated after the air has warmed and thermal updrafts are present. Individuals spiral upwards on thermals of warm air to heights of 1,000 to 6,000 feet (Kyut 1992), then enter into long, descending glides. This process is repeated throughout the day until suitable habitat is reached. Static soaring is energy efficient as birds seldom flap after they are airborne. Whooping cranes may travel up to 500 miles per day in ideal conditions; during average conditions they may travel 250 miles per day (Stehn and Wassenich 2008). During the end of the migration flight, individuals will enter long descending glides and use flapping flight at lower altitudes until they reach suitable roosting and feeding habitat. Whooping cranes do not regularly migrate during unfavorable weather conditions such as a strong headwind, rain or other precipitation, or overcast conditions. When visibility is poor, individuals use flapping flight at lower altitudes until they reach suitable roosting or feeding habitat.

### **5.4 Stop-over Habitat Characteristics**

Whooping cranes require roosting habitat when they stop during migration. They often select sites with unobstructed visibility (Austin and Richert 2001). Palustrine wetlands (freshwater wetlands characterized by emergent vegetation) are most often used as roosting sites, but individuals have been found roosting at lacustrine wetlands (wetlands around a lake), and riverine wetlands (wetlands along a river). The size of wetlands used during spring and fall migration ranges from 0.4 hectare to over 500 hectares, and no seasonal use patterns are evident (Austin and Richert 2001); 75 percent of recorded roost wetlands were smaller than 4 hectares (10 acres). Although size of the wetlands used for roosting varies, water depth ranges 18 to 20 inches and little variability is found among sites.

Whooping cranes forage in wetlands and agricultural fields during migration and may commute between roosting and feeding areas. Palustrine wetlands are used most often when whooping cranes forage in wetlands, but lacustrine and riverine wetlands have also been used as feeding sites (Austin and Richert 2001). Among agricultural crops used as feeding sites, the use of winter wheat was higher than other crop types in the fall and the use of row-crop stubble (comprised mostly of corn) was higher in the spring than other crop types (Austin and Richert 2001). Whooping cranes have also been observed feeding in sorghum, sunflower, and soybean stubble (Austin and Richert 2001). Feeding sites are often located adjacent to roosting sites. For example, 94.9 and 72.9 percent of roosting sites were within 0.62 mile of feeding sites in spring and fall, respectively (Johns et al. 1997; USFWS 2009).

## 6.0 ASSESSMENT OF WHOOPING CRANE LIKELIHOOD OF OCCURENCE

The primary threats of wind energy development to whooping cranes are mortality due to collision with transmission lines, associated structures and loss of habitat due to avoidance. Because of the high level of concern regarding whooping cranes, the ability to evaluate the risk to whooping cranes at an individual Project Area and a 35-mile buffer of the Project Area excluding the Project Area (Surrounding Area; Figure 3) is a critical component to understanding the environmental impacts of a proposed wind energy facility. Here, Tetra Tech presents a method used to evaluate the likelihood of whooping cranes to occur at the Project Area located in southwest North Dakota. This evaluation method considers the location of the Project Area in the migration corridor, the presence of feeding and roosting sites, and the availability of habitat within the Project Area compared to the surrounding landscape (Table I). Tetra Tech expects whooping cranes to be more likely to occur over the life of a Project at Project Areas with high scores. For the purposes of this analysis, the scores calculated for each parameter were entered into a formula and the resulting score represented the likelihood of occurrence for whooping cranes in the Project Area which was ranked as: Low (less than 5); Moderate (5-10); High (greater than 10). This assessment tool is not intended to replace field surveys. However, the low probability of detecting a whooping crane during field surveys minimizes the utility of field surveys in documenting presence or absence from a given area. As a consequence, this assessment tool was designed to take advantage of available data. A description of each of the three factors included in this analysis (location in the migration corridor, attractiveness of the landscape, and presence of foraging and roosting sites) and how scores are assigned for each is provided in Table I.

**Table I. Summary of parameters used in the likelihood index calculation.**

Parameter	Score	Justification
<b>Location in the Migration Corridor (L)</b>		
Within the 75-percent buffer	7.5	75 percent of all whooping crane observations occur within the 75-percent buffer
Between the 75-percent and 95-percent buffers	2.0	20 percent of all observations occur between 75-percent and 95-percent buffers
Outside the 95-percent buffer	0.5	5 percent of observations occur outside the 95-percent buffer
<b>Attractiveness on the Landscape (A)</b>		
Ratio of wetlands per total acreage for Project Area / wetland per total acreage for the Surrounding Area	Actual ratio	Indicates if the Project Area is similar (=), less (<), or more (>) attractive than the surrounding landscape to migrating cranes searching for roosting habitat
<b>Presence of Foraging and Roosting Habitat (W)</b>		
Proportion of Project Area that is a wetland-agricultural matrix	Actual proportion	Indicates the proportion of the Project Area that is favored by cranes for foraging and roosting habitat

## **6.1 Location of a Project Area in the Migration Corridor (L)**

### *Biological Justification*

The location of a potential wind facility influences the likelihood of whooping crane occurrence due to the well-defined migratory pattern of the cranes. The median location of all crane observations was statistically derived and was used to describe the migration route from the breeding grounds to the wintering grounds (CWS and USFWS 2007). Buffers were then calculated based on the percentage of observations (Figure 3). For example, 75 percent of all observations occurred within the 75-percent buffer. If two sites are compared, whooping cranes are more likely to stop over at a site within the 75-percent buffer than at a site outside the 95-percent buffer.

### *Scoring*

Tetra Tech developed scores for the location of a Project Area based on the percent of observations within each buffer. If a Project Area fell within the 75-percent buffer, it was given a score of 7.5. If a Project Area fell between the 75-percent and 95-percent buffers, it was given a score of 2.0 because 20 percent of all observations occur between these buffers. If a Project Area fell outside of the 95-percent buffer, it was given a score of 0.5 because 5 percent of all observations occur outside the 95-percent buffer.

### *Assumptions*

- The likelihood of whooping crane occurrence in the future will not deviate from the patterns observed through 2010 which is the most current available data (USFWS 2010).
- If a portion of the Project Area fell on the boundary of a buffer or in two buffers, the Project Area was assumed to be within the buffer closer to the middle of the migratory corridor.

## **6.2 Attractiveness of the Landscape (A)**

### *Biological Justification and Data Source*

Wetlands are used by whooping cranes for feeding and roosting and the amount of wetlands within a given area compared to the surrounding landscape may influence whooping crane use of a site during migration. After whooping cranes have descended from migration flight altitudes, they may travel up to 35 miles in search of suitable roosting habitat. Therefore, Tetra Tech determined that if a Project Area contained a higher proportion of wetlands than was found within the 35 miles surrounding the Project Area, the Project Area would be more attractive than the surrounding area. A site visit on December 16 – 19, 2014 to the Project

Area was made by Tetra Tech staff to perform a wetland reconnaissance survey of existing wetlands and waterways within the Project Area.

#### *Scoring*

Tetra Tech used National Wetlands Inventory (NWI) data (USFWS 2014c) and National Land Cover Database (NLCD) data (USGS 2014) to determine the total acreage of wetlands within the Project Area and within 35 miles of the Project Area. The use of multiple data sources helped to avoid the limitations of any one data source (e.g., Stahlecker 1992). Tetra Tech then calculated the proportion of the total acreage of the Project Area that was comprised of wetlands and the proportion of the total acreage of the area within the Surrounding Area. Tetra Tech divided the proportion of the Project Area that was wetlands by the proportion of Surrounding Area that was wetlands to determine if the Project Area contained a higher proportion of wetlands than the surrounding area. Tetra Tech used the ratio as the score in the likelihood index equation. If the ratio was greater than 1, the Project Area contained more wetlands and was considered to be more attractive than the Surrounding Area. If the ratio was equal to 1, the Project Area contained a similar proportion of wetlands and was considered to be as attractive as the Surrounding Area. If the ratio was less than 1, the Project Area contained a lower proportion of wetlands and was considered to be less attractive than the Surrounding Area.

#### *Assumptions*

- The wetlands in the 35-mile buffer shown in the NWI and NLCD Database were accurate and are considered useable by Whooping Cranes.
- 35 miles is an appropriate scale to examine whooping crane habitat use.

### **6.3 Presence of Foraging and Roosting Sites (W)**

#### *Biological Justification*

Whooping cranes often make low altitude flights between roosting and foraging habitat and are thus at risk of collision with power lines and other structures (CWS and USFWS 2007; Stehn and Wassenich 2008; USFWS 2009).

Austin and Richert (2001) found the majority of foraging sites were upland crops (73.8 percent) adjacent to wetland roosting sites. Wetland roosting sites were defined in three broad categories as palustrine (58.2 percent), riverine (33.3 percent), or lacustrine (7.8 percent) roost sites (Austin and Richert 2001). For the upland crop foraging sites; 83 percent of grain stubble was wheat stubble, 75 percent of row-crop stubble was corn, and 80 percent of green crops was winter wheat (Austin and Richert 2001). The distances traveled between roost to foraging sites varied by wetland systems with 75 percent feeding sites being 0.8 km (0.5 miles) or less

from the palustrine roost sites to over 50 percent of riverine roost sites being 1.2 km or greater from foraging sites (Austin and Richert 2001). Therefore Tetra Tech used an average of 1 km (0.62 miles) to assess the presence of foraging and roosting sites within the Project Area and a 56.3 km (35 mile) buffer area around the Project Area. Tetra Tech considered wetlands located within 0.62 mile of agricultural crops to form a wetland-agricultural matrix that may be used by whooping cranes during migration (Austin and Richert 2001). Tetra Tech used GIS to calculate the proportion of the Project Area that was comprised of this wetland-agricultural crop matrix, using a minimum 1-acre patch size for both wetlands and crops. The 1-acre minimum for wetlands was used to avoid including wetlands unusable by whooping cranes (e.g., borrow pits). The 1-acre minimum size for agriculture was used because the majority of whooping crane observations occurred in agriculture patches larger than 1.0 acre (Austin and Richert 2001).

### *Scoring*

To quantify the amount of roosting and foraging habitat in the Project Area, geographic information system (GIS) land cover data (NLCD data) was obtained for North Dakota (USGS 2014). Water features and the spatial extent of waters were verified with NWI data (USFWS 2014c). The GIS analysis was designed to calculate the total area of wetland-agricultural matrix, which may have included other habitat types between patches of wetlands and agriculture. Thus, based on the size restrictions and spatial configuration, the total acres of wetland-agricultural matrix could be greater or less than the sum of the acres of wetland and agriculture. Tetra Tech calculated the proportion of the Project Area that was wetland-agricultural matrix by dividing the total acres of wetland-agricultural matrix by the total acres of the Project Area. Tetra Tech used the proportion as the score in the likelihood index; therefore, scores could range from 0 to 1.

### *Assumptions*

- The average distance of foraging habitat from roosting habitat is 0.62 mile.
- Habitats not classified as wetlands or agriculture are of neutral value and do not influence the availability of wetlands or agriculture on the landscape.

## **6.4 Likelihood Index Formula (LI)**

The likelihood index of whooping cranes occurring at the Project Area was calculated by evaluating the landscape features in and around the Project Area. Tetra Tech used the following formula to calculate the likelihood index:

$$LI = (L \times A) + W$$

Where L = location of Project Area in relation to the migration corridor score, A = attractiveness score, or the ratio of wetlands in a Project Area to wetlands in a 35-mile area

around a Project Area, and  $W$  = wetland-agricultural matrix score. The equation places the most weight on the location in the migration corridor because of the wide range of scores for each feature in the likelihood index. Thus, a Project Area within the 75-percent corridor will tend to score higher than a Project Area within the 95-percent corridor unless the attractiveness score for the Project Area within the 75-percent corridor is low (e.g.,  $<0.50$ ) or the attractiveness score for the Project Area within the 95-percent corridor is high ( $>4.0$ ), when other values are equal. Project Areas located outside of the 95-percent corridor will tend to score low unless the attractiveness score is high because the location score is less than 1.0.

## 7.0 PROJECT AREA ASSESSMENT AND SUMMARY

The Project is located within the 95-percent buffer which is on the outskirts of the whooping crane migration corridor; therefore, the Location ( $L$ ) parameter was 2.0. The proportion of wetlands within the Project is higher than the surrounding 35-mile buffer area, with a calculated Attractiveness on the Landscape ( $A$ ) value of 1.51. Fifty-five percent of the Project consists of suitable wetland-agriculture matrix habitat, making the Presence of Foraging and Roosting Sites ( $W$ ) value 0.55 (Figure 4). The likelihood index score was 3.57 for the Project Area (Table 2) implying low likelihood of occurrence. Thus, the overall likelihood index score was driven by the Attractiveness on the Landscape ( $A$ ) value, which indicates that whooping cranes migrating in the vicinity of the Project Area would be more likely to stop-over inside of the Project because of the higher proportion of wetland habitat compared to outside of the Study Area.

**Table 2. Likelihood index scores for the Dickinson Wind Energy Center.**

Location in the Migration Corridor ( $L$ ) <sup>1</sup>	Attractiveness on the Landscape ( $A$ ) <sup>2</sup>	Presence of Foraging and Roosting Habitat ( $W$ ) <sup>3</sup>	Likelihood Index Score ( $LI$ ) <sup>4</sup>	Likelihood Index Category <sup>5</sup>
2.0	1.56	0.55	3.57	Low
1. Location in the Migration Corridor ( $L$ ) values: 7.5 = within the 75% buffer, 2.0 = between the 75% and 95% buffers, or 0.5 = outside of the 95% buffer 2. Attractiveness on the Landscape ( $A$ ) value: Ratio of wetlands per total acreage for Project Area / wetland per total acreage for 35-mile area not including Project Area 3. Presence of Foraging and Roosting Habitat ( $W$ ) value range: Proportion of Project Area that is a wetland-agricultural matrix 4. Likelihood Index Score ( $LI$ ): $LI = (L \times A) + W$ 5. Likelihood Index Category values: Low = less than 5, Medium = 5-10 , High = greater than 10				

Overall, based on the location of the Project Area within the migration corridor, whooping cranes could occur in the vicinity of the Project Area. The higher proportion of wetlands in the Project Area compared to the Surrounding Area may be an attractant to migrating cranes; however, the location of the Project on the western edge of the migration corridor in the 95 percent buffer indicates that there is a low likelihood of whooping cranes stopping over within

the Project Area because the majority of whooping crane sightings (90 percent) occur closer to the center of the migration corridor and further away from the Project Area.

## 8.0 LITERATURE CITED

- Allen, R.P. 1952. The whooping crane. National Audubon Society Resource Report 3. 246pp.
- Austin, J.E. and A.L. Richert. 2001. A comprehensive review of the observational and site evaluation data of migrant whooping cranes in the United States, 1943-99. U.S. Geological Survey, Northern Prairie Wildlife Research Center, Jamestown, North Dakota, and State Museum, University of Nebraska, Lincoln, Nebraska. 157 pp.
- Banks, R. 1978. The size of the early whooping crane populations. Unpublished Report USFWS files. 10pp.
- Binkley, C.S., and R.S. Miller. 1983. Population characteristics of the whooping crane, *Grus americana*. Canadian Journal of Zoology 61:2768–2776.
- Bryce, S.A., J.M. Omernik, D.A. Pater, M. Ulmer, J. Schaar, J. Freeouf, R. Johnson, P. Kuck, and S.H. Azevedo. 1996. Ecoregions of North Dakota and South Dakota, (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,500,000).
- CWS and USFWS (Canadian Wildlife Service and U.S. Fish and Wildlife Service). 2007. International recovery plan for the whooping crane. Ottawa: Recover of the Nationally Endangered Wildlife (RENEW), and U.S. Fish and Wildlife Service, Albuquerque, NM.
- Hahn, P. 1963. Where is that vanished bird? Royal Ontario Museum, Univ. Toronto, Canada.
- Johns, B.W. 1992. Preliminary identification of whooping crane staging areas in prairie Canada. Proceedings of the 1988 North American Crane Workshop. Pgs. 61–66.
- Johns, B.W., E.J. Woodsworth, and E.A. Driver. 1997. Proceedings of the North American Crane Workshop 7:123–131
- Kyut, E. 1992. Aerial radio-tracking of whooping cranes migrating between Wood Buffalo National Park and Aransas National Wildlife Refuge, 1981-84. Occasional Paper 74, Canadian Wildlife Service, 53 pp.
- Morkill, A.E. and S.H. Anderson. 1991. Effectiveness of marking powerlines to reduce sandhill crane collisions. Wildlife Society Bulletin 19: 442-449.
- Nagy, L., B. Gibson, K.L. Kosciuch, J. Jones, and J. Taylor. 2012. Whooping and Sandhill Crane Behavior at an Operating Wind Farm. Poster presented at National Wind Coordinating Committee Annual Research Meeting, Denver, CO.

- North Dakota Game and Fish Department (NDGF). 2012. Threatened and Endangered Species. Available online at: <http://gf.nd.gov/wildlife/fish-wildlife/threatened-and-endangered-species>.
- Stahl, J.T. and M.K. Oli. 2006. Relative importance of avian life-history variables to population growth rate. *Ecological Modeling* 198:23-39.
- Stahlecker, D.A. 1992. Using National Wetlands Inventory maps to quantify whooping crane stopover habitat in Oklahoma. *Proceedings of the North American Crane Workshop* 6:62–68.
- Stehn, T.V. 1997. Pair formation by color-marked whooping cranes on the wintering grounds. *Proceedings of the North American Crane Workshop* 7:24–28.
- Stehn, T.V. and T. Wassenich. 2008. Whooping crane collisions with power lines: an issue paper. *Proceedings of the North American Crane Workshop* 10:25–36.
- USFWS (U.S. Fish and Wildlife Service). 2014a. Winter 2013-2014 Whooping Crane Survey Results. Available online at: <http://www.fws.gov/nwrs/threecolumn.aspx?id=2147544385>.
- USFWS. 2014b. Wintering Whooping Crane Update, December 17, 2014. Available online at: <http://www.fws.gov/nwrs/threecolumn.aspx?id=2147563747>.
- USFWS. 2014c. National Wetlands Inventory: Classification of Wetlands and Deepwater Habitats of the United States, May 2014. Available online at: <http://www.fws.gov/wetlands/>.
- USFWS. 2010. Whooping crane migration corridor in the United States.
- USFWS. 2009. Whooping cranes and wind development – An issues paper. USFWS Regions 2 and 6. Available at: <http://www.fws.gov/southwest/es/library/>
- USGS (U.S. Geological Survey). 2014. National Land Cover Database 2011. Available online at [http://www.mrlc.gov/nlcd11\\_data.php](http://www.mrlc.gov/nlcd11_data.php).

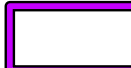


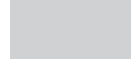



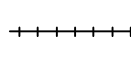

## FIGURES

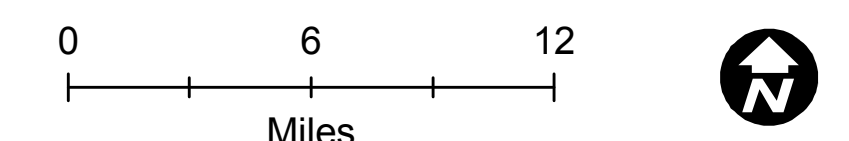
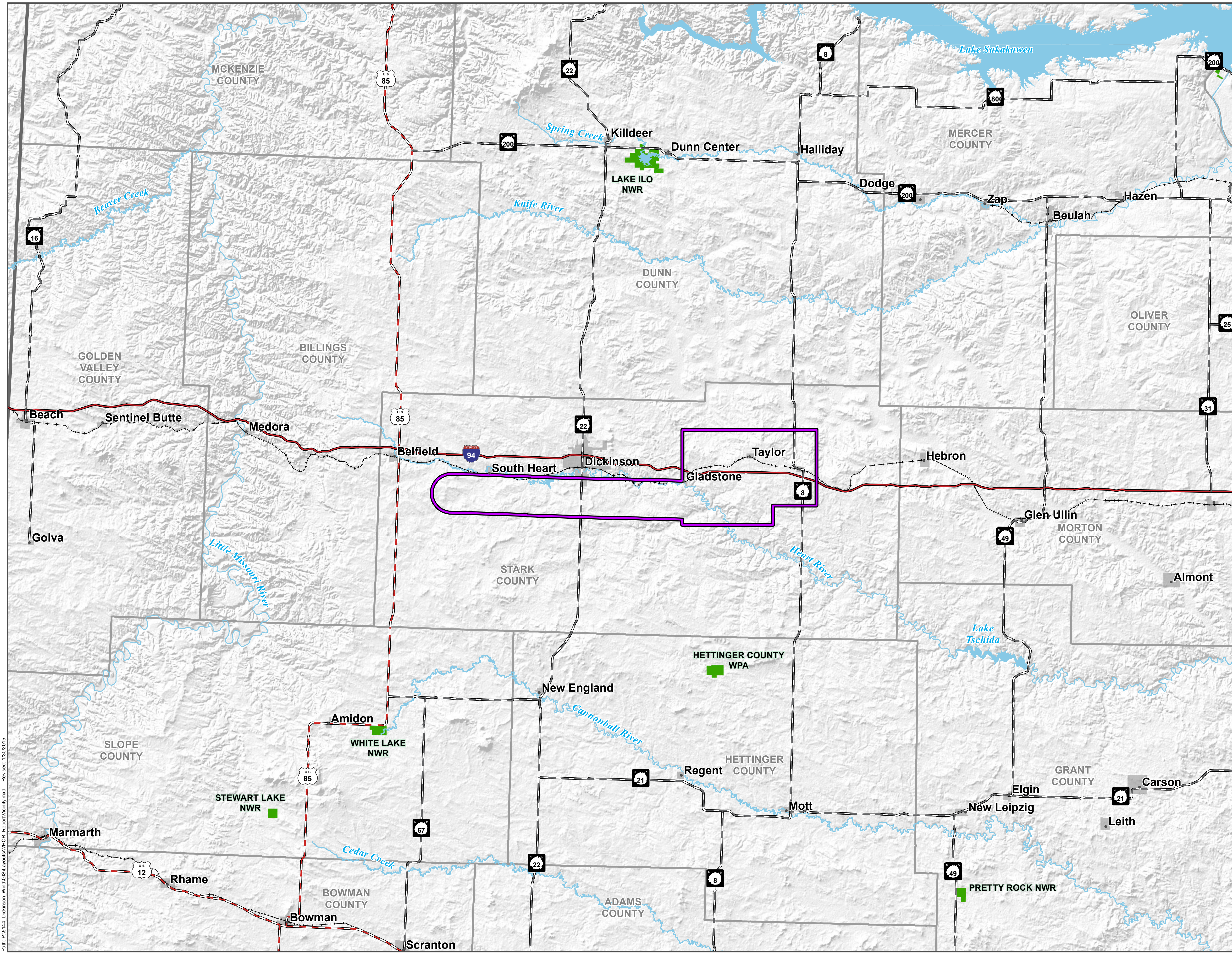
# Dickinson Wind Energy Center

Stark County, ND

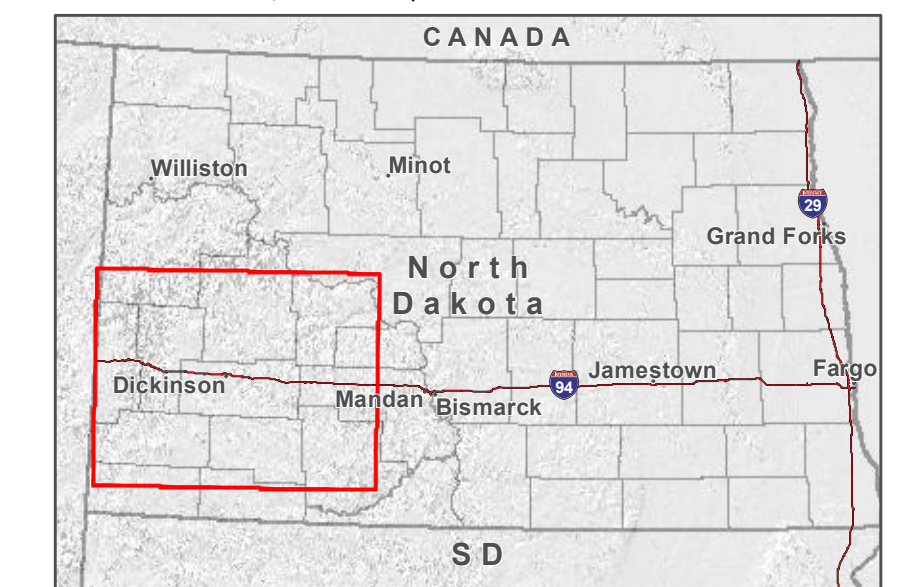
## Figure 1 Vicinity Map

### Legend

-  Project Area
-  County Boundary
-  Major River
-  Municipal Boundary
- Transportation**
  -  Interstate Highway
  -  U.S. Highway
  -  State Highway
  -  Rail
- Jurisdiction**
  -  U.S. Fish and Wildlife Service



Scale is 1:300,000 when printed at 22 x 34





**Legend**

- Whooping Crane Critical Habitat
- State Border
- County Border

**Percentage of Sightings Within the Whooping Crane Migration Corridor**

- 75%
- 80%
- 85%
- 90%
- 95%

**Dickinson Wind Energy Center**

Stark County, ND

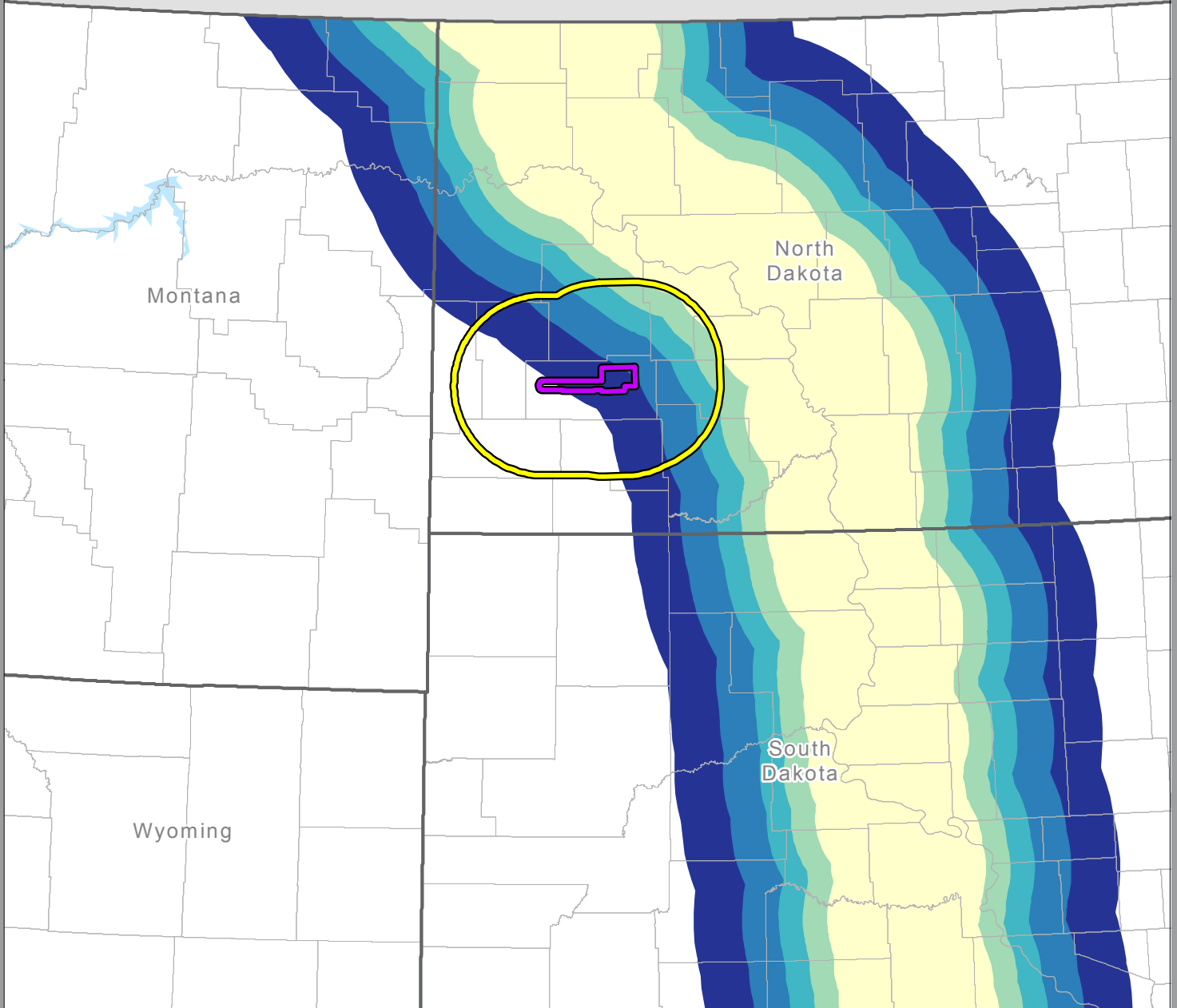
**Figure 2**  
Whooping Crane Migration Corridor







0 100 200 Miles  
Scale is 1:13,000,000 when printed at 8.5x11"








CANADA



**Legend**

-  Project Area
-  Project Area, 35-mile Buffer
-  State Border
-  County Border

**Percentage of Sightings  
Within the Whooping Crane Migration Corridor**

-  75%
-  80%
-  85%
-  90%
-  95%

**Dickinson Wind  
Energy Center**

Stark County, ND

**Figure 3  
Whooping Crane  
Migration: North Dakota**



0 30 60 Miles  
Scale is 1:4,000,000 when printed at 8.5x11"















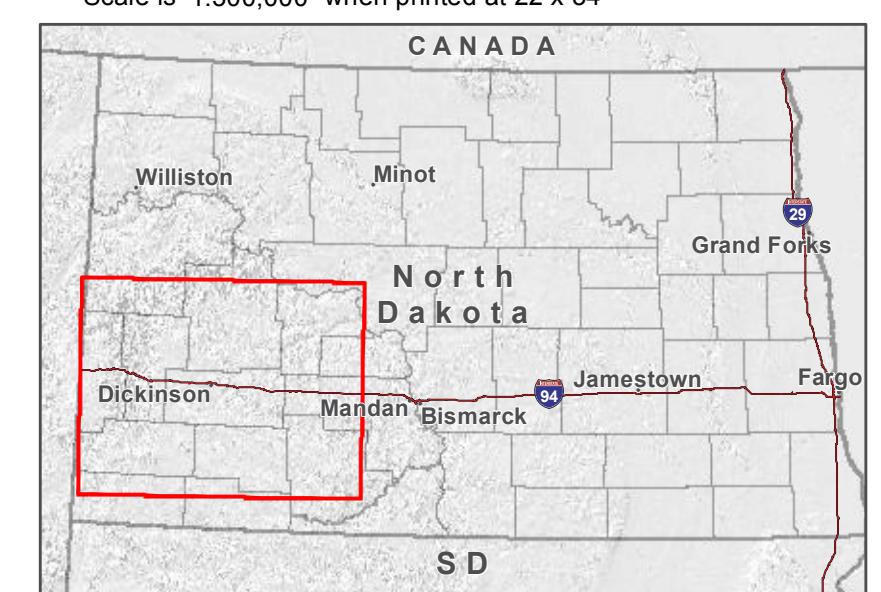
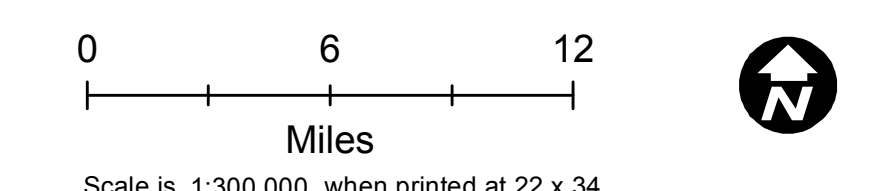
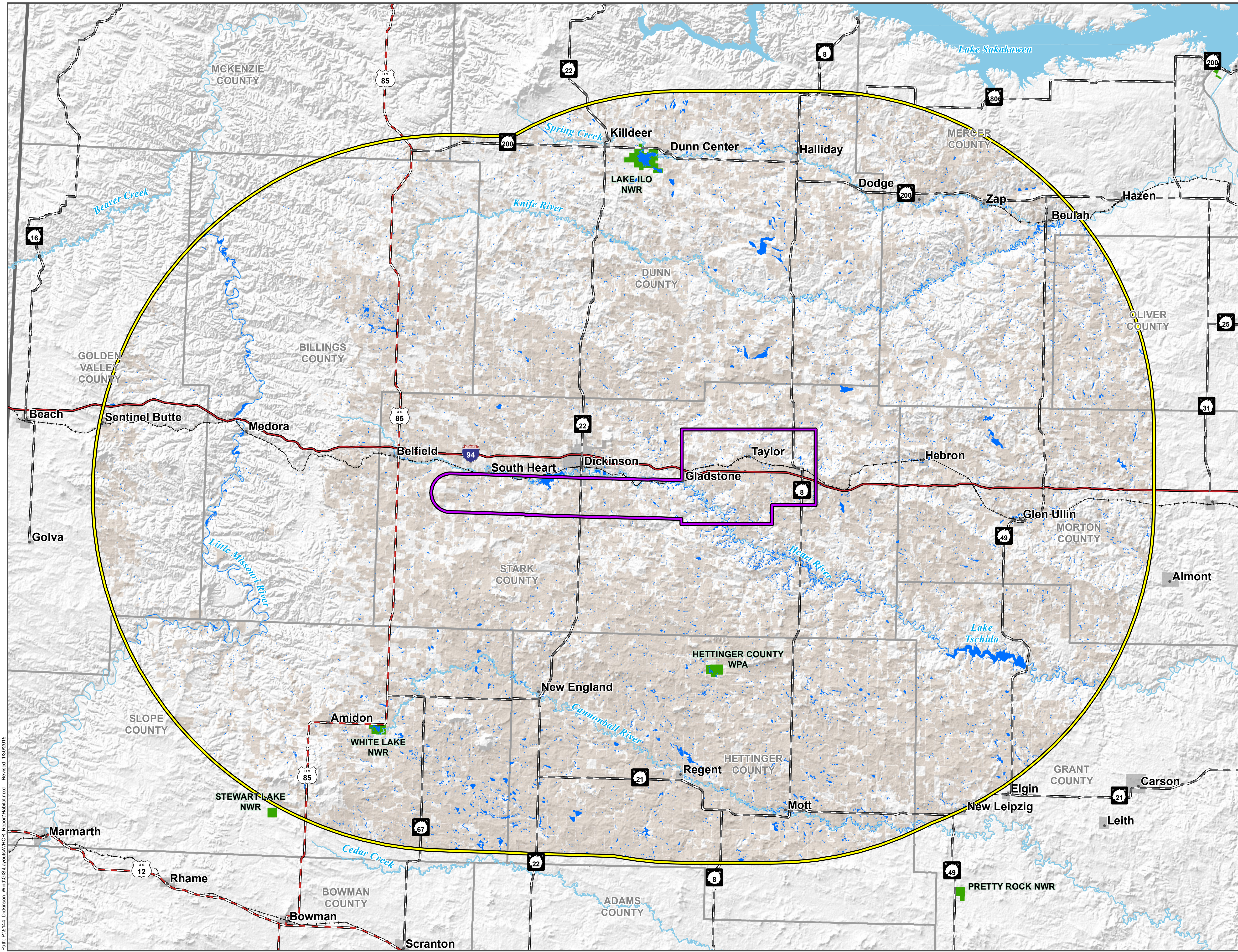
# Dickinson Wind Energy Center

Stark County, ND

## Figure 4 Whooping Crane Habitat Map

### Legend

-  Project Area
-  Project Area 35-mile Buffer
-  County Boundary
-  Major River
-  Municipal Boundary
-  Wetland
-  Wetland/Agricultural Matrix
- Jurisdiction**
  -  U.S. Fish and Wildlife Service
- Transportation**
  -  Interstate Highway
  -  U.S. Highway
  -  State Highway
  -  Rail



Path: P:\5144\_Dickinson\_Wind\GIS\Layouts\WHICE\_Report\Habitat.mxd Revised: 1/30/2015

# Bat Habitat Assessment

## Dickinson Wind Energy Center Stark County, North Dakota



### ***Confidential Business Information***

Prepared for:

**NextEra Energy Resources, LLC**

**700 Universe Blvd.**

**Juno Beach, Florida 33408**

**February 2015**

## TABLE OF CONTENTS

1.0 INTRODUCTION.....	1
2.0 BACKGROUND .....	2
2.1 Project Area Description .....	2
2.2 Wind Energy and Bats .....	2
2.3 Regulatory Framework .....	6
Federal Protection .....	6
State Protection.....	7
Voluntary Guidelines for Wind Power Projects.....	7
3.0 SPECIES EXPECTED TO OCCUR IN THE PROJECT VICINITY .....	8
All Bat Species .....	8
Northern Long-eared Bats .....	9
4.0 HABITAT ASSESSMENT.....	11
4.1 Land Use and Land Cover.....	11
4.2 Roosting Habitat.....	12
All Bat Species .....	12
Northern Long-eared Bats .....	13
4.3 Winter Habitat.....	14
Northern Long-eared Bats .....	14
4.4 Foraging Habitat.....	15
All Bat Species .....	15
Northern Long-eared Bats .....	15
4.5 Bat Migration and Movement Characteristics.....	15
5.0 SUMMARY.....	17
5.1 NLEB Habitat Suitability Conclusion .....	17
5.2 Critical Habitat for Listed Species .....	18
6.0 LITERATURE CITED .....	19

## LIST OF FIGURES

- Figure 1. Vicinity Map
- Figure 2. Land Cover
- Figure 3. Land Cover Buffer
- Figure 4. Geology
- Figure 5. Northern Long-eared Bat Range and USFWS White-nose Syndrome Buffer

## LIST OF TABLES

- Table 1. Regional Estimates of Mean Bat Fatalities per Megawatt at Wind Facilities in the northern Great Plains and Midwest Regions with Publicly Available Data. .... 5
- Table 2. Bat Species List and Likelihood of Occurrence at the Dickinson Wind Energy Center, Stark County, North Dakota. ....10
- Table 3. Land Use and Land Cover Present in the Project Area and Project Buffer, Stark County, North Dakota. ....12

## 1.0 INTRODUCTION

NextEra Energy Resources, LLC (NextEra) is proposing to develop the Dickinson Wind Energy Center (Project) in Stark County, North Dakota, located in southwestern North Dakota near the town of Dickinson (Figure 1). The Project has a proposed nameplate capacity of approximately 150 megawatts (MW), anticipated to consist of 80 GE 1.7-MW Xle wind turbine generators and 7 GE 1.79-MW Xle wind turbine generators. The Project also includes a planned approximately 31-mile, 230-kilovolt (kV) overhead transmission interconnect line. Additional Project facilities include access roads, electrical collection systems and cabling, a collection substation, an operation and maintenance (O&M) building, and a construction laydown area. Three guyed temporary meteorological towers have been installed for the Project and up to three additional temporary towers are planned. Up to two of the towers may be converted to permanent meteorological towers.

NextEra contracted Tetra Tech, Inc. (Tetra Tech) to evaluate the suitability of habitat within the Project area for bats, with a focus on the northern long-eared bat (*Myotis septentrionalis*; NLEB). We evaluated the area where wind turbines are proposed and the associated transmission line corridor (Project Area; Figure 2) as well as a 1.5-mile buffer of the Project Area (Project Buffer; Figure 3)

The objectives of the habitat assessments were to:

- Evaluate habitat features within the Project Area and Project Buffer for bats, focusing specifically on NLEB;
- Assess the likelihood of NLEB and other bat species occurring within the Project Area and Project Buffer based on known distributions and habitat requirements of bat species in the region

In October 2013, the NLEB was proposed for listing as endangered under the federal Endangered Species Act (ESA) and a final listing determination is expected in April 2015 (USFWS 2013, USFWS 2014a). As part of NextEra's environmental due diligence for the Project and compliance with U.S. Fish and Wildlife Service (USFWS) recommendations for NLEB impact assessments, Tetra Tech has prepared this bat habitat assessment. Tetra Tech examined publically available information and habitat requirements of NLEB and other bat species that may occur in the vicinity of the Project Area, the results of which are summarized in Section 3.0. Sections are subdivided into habitat suitability for NLEB and all bat species.

NextEra also contracted Tetra Tech to conduct a NLEB presence-absence study. This report provides the results of the habitat assessment only. Acoustic surveys are scheduled to occur in the Project Area from April 15 through June 15, 2015 to document use.

Letters were sent to both USFWS and NDGF on December 23, 2014 introducing the Project requesting information on sensitive biological resources. No responses have been received from the agencies to date.

## 2.0 BACKGROUND

This section describes the Project Area and includes background information on bats in the region, a summary of current information regarding bat interactions with wind energy projects, and a discussion of the legal and regulatory framework applicable to bats and wind energy.

### 2.1 Project Area Description

The 146,380-acre Project Area is located on privately-owned lands in southwestern North Dakota and is approximately 12 miles east of Dickinson in eastern Stark County (Figure 1). The Project Area is located in the Missouri Plateau subregion of the Northwestern Great Plains Ecoregion (Bryce et al. 1996). Bedrock geology in the ecoregion is primarily sandstone and shale and geology within the vicinity of the Project Area is sandstone and siltstone (Bryce et al. 1996, NDGS and NDDH 2001; Figure 4). Due to the local geology and topography, caves do not form regularly in the sandstone and siltstone of the Project Area and there no known caves within 20 miles of the Project Area (Murphy 2007).

Land use within the ecoregion is primarily dryland farming and cattle grazing. Coal mining in western North Dakota for lignite coal deposits is common and primarily done through surface mining although underground mines are also used (Figure 4; Murphy no date; NDPSC 2013). The topography of the region is a semiarid rolling plain (Bryce et al. 1996). Vegetation in the region was historically mixed-grass prairie with blue grama (*Bouteloua gracilis*), little bluestem (*Schizachyrium scoparium*), prairie sandreed (*Calamovilfa longifolia*) and a wheatgrass-needlegrass association (Bryce et al. 1996). Native grasslands occur in areas of steep topography. The existing land use in the Project Area is primarily cattle production and agriculture. The area contains numerous small wetlands that vary from shallow vegetated depressions, man-made cattle ponds, and intermittent creeks. There are few wetlands evident that are not associated with a stream system. Residences and a few abandoned farmsteads are scattered throughout the Project Area. The Project Area is a mix of cattle pastures, agriculture, and remnant native prairie. Trees and forested areas are restricted to riparian areas and windbreaks for houses and fields.

Based upon the National Land Cover Database (NLCD) information for the Project Area, the land cover is dominated by grassland which includes pastures, hayfields, and regional native grasslands (48.5 percent) and agricultural crops (39.8 percent; Figure 2; Jin et al. 2013). The topography within the Project Area is primarily rolling plains and lacks prominent landscape features (e.g. hills, valleys), with the exception of an area south of the transmission line route approximately 7 miles southwest of Dickinson, which has some more prominent elevation.

### 2.2 Wind Energy and Bats

Bat mortality associated with wind turbine operations has been reported at locations around the world, including wind energy facilities in the United States (Kunz et al. 2007, Arnett et al. 2008, Rydell et al. 2010, Hayes 2013). Rates of overall bat mortality from wind turbines vary by region (Arnett et al. 2008, Baerwald and Barclay 2009, Cryan 2011, Hein et al. 2013). The highest numbers of fatalities reported in the United States are from wind energy facilities in the eastern

U.S., particularly those located along forested ridges in the Appalachian region where annual mortality estimates have ranged from 20.8 to 69.6 bats per turbine per year, or 14.9 to 53.3 bats per MW per year (Arnett et al. 2008, Strickland et al. 2011). However, relatively high fatality estimates for bats also have been reported at wind energy facilities in agricultural settings in the central and Midwestern U.S. (Jain 2005, Gruver et al. 2009, Poulton 2010).

Bat mortality at wind energy facilities is caused primarily by direct collision with moving turbine blades (Horn et al. 2008). There is little information about the indirect causal factors that influence bat mortality at wind energy facilities, although several hypotheses have been proposed (Kunz et al. 2007, Arnett et al. 2008, Cryan and Barclay 2009, Rydell et al. 2010). The current leading hypotheses are that bats are attracted to turbines for several reasons including as potential roosting locations (Kunz et al. 2007), potential pairing or mating sites (Cryan and Barclay 2009), or the potential accumulation of migratory insects around turbine rotors (Rydell et al. 2010). Thus, variables that may contribute to bat fatalities from wind turbines include, but are not limited to: the biology of the bat species, season, region, and turbine design (Kunz et al. 2007). Regardless of the specific causes of bat fatalities, two general patterns of fatalities are consistent across nearly all wind energy facilities:

1. Migratory tree-roosting bats represent the majority of fatalities; and
2. The majority of bat fatalities occur during late summer and early fall, coinciding with the fall migratory movements of bats (Arnett et al. 2008, Cryan 2011).

Some migratory bats travel long distances at altitudes that may overlap with the height of wind turbine blades, making them more susceptible to collisions. The probability of mortality events may also increase during periods of poor weather, such as just before or after the passing of a storm front (Arnett et al. 2008).

Tree bats, such as eastern red bats (*Lasiurus borealis*), silver-haired bats (*Lasionycteris noctivagans*), and hoary bats (*Lasiurus cinereus*), make long latitudinal migrations to warmer climates, and peaks in fatality rates appear to coincide with increasing bat activity levels associated with the southward migration of these species (Cryan 2003, Arnett et al. 2008). *Myotis* species are not considered particularly susceptible to direct mortality from wind turbines, but individuals, mostly little brown bat (*Myotis lucifugus*), have been found during mortality searches (Arnett et al. 2008, BHE Environmental 2011, Grodsky and Drake 2011).

NLEB may be most susceptible to impacts during the summer residency period if roosting habitat is cleared during wind project construction, as well as during the spring and fall periods when migrating bats, more likely to be flying within the rotor swept area (RSA), could collide with operational turbines. Although there are less than 30 confirmed records of NLEB fatalities at wind energy facilities (USFWS 2013), the USFWS considers wind projects to be a threat to the species. The USFWS believes that the large decline in NLEB populations as a result of white-nose syndrome (WNS) may be compounded by the loss of even small numbers of the NLEB as a result of collision with wind turbines. USFWS has indicated that there “is no evidence suggesting effects from wind energy development in itself have led to population declines...” (USFWS 2013).

All known NLEB fatalities are from wind energy facilities located east of the Mississippi River. The greatest numbers of NLEB have been found at wind energy facilities on forested ridge tops in West Virginia, where a total of seven fatalities have been documented (Kerns and Kerlinger 2004, Young et al. 2009). NLEB mortality has also been documented in New York, Pennsylvania, and Ontario Canada (Arnett et al. 2005, Jacques Whitford 2009, Stantec 2011). In all cases, NLEB documented mortality rates at wind energy facilities are substantially lower than mortality rates of long-distance migratory species (i.e. migratory tree bats), and other *Myotis* species. Recently, WNS has caused large declines in populations of cave-hibernating species throughout eastern North America. WNS has been especially devastating to populations of species in the *Myotis* genus, including NLEB (*Myotis septentrionalis*), prompting proposed federal protection for this species by USFWS (USFWS 2013).

Table 1 summarizes publicly available regional bat mortality data reported from wind projects with habitat similar to the Project Area.

**Table 1. Regional Estimates of Mean Bat Fatalities per Megawatt at Wind Facilities in the northern Great Plains and Midwest Regions with Publicly Available Data.**

Wind Facility <sup>1</sup>	State	Habitat	Turbine Model (turbine rotor-swept area) <sup>2</sup>	Estimated mean fatality/MW/year	Bat Species Recorded as Fatalities (in order of decreasing frequency)	Source
Cedar Ridge	Wisconsin	Agricultural cropland	Unknown, 1.6MW (5,281 m <sup>2</sup> )	30.40 (per 169 days)	hoary, silver-haired, big brown, eastern red, little brown	Poulton 2010
Blue Sky Green Field	Wisconsin	Agricultural cropland	Vestas V-82, 1.65MW (5,281 m <sup>2</sup> )	24.57	little brown, silver-haired, big brown, hoary, eastern red, unidentified	Gruver et al. 2009
Forward Energy	Wisconsin	Agricultural cropland	Not stated	15.63	hoary, silver-haired, eastern red, unidentified, little brown, big brown	Grodsky and Drake 2011
Judith Gap (2006/2007)	Montana	Agricultural cropland	GE 1.5SLE, 1.5MW (4,657 m <sup>2</sup> )	8.9	Hoary, silver-haired, unidentified	TRC Environmental 2008
Top of Iowa (2004)	Iowa	Agricultural cropland	NEG Micon 52 (2,107.69 m <sup>2</sup> )	7.94	hoary, little brown, eastern red, big brown, silver-haired	Jain 2005, Jain et al. 2011
Kewaunee County	Wisconsin	Agricultural cropland	Vestas 0.66MW (1,734 m <sup>2</sup> )	6.45	eastern red bat, hoary bat	Howe et al. 2002
Top of Iowa (2003)	Iowa	Agricultural cropland	NEG Micon 52 (2,107.69 m <sup>2</sup> )	4.94	hoary bat, little brown bat, eastern red bat, big brown bat, silver-haired bat	Jain 2005, Jain et al. 2011
Judith Gap (2009)	Montana	Agriculture and grassland	Unknown, 1.5MW (4,657 m <sup>2</sup> )	4.8	hoary, silver-haired, <i>Myotis</i> sp, unidentified	Poulton and Erickson 2010
Ainsworth	Nebraska	Mixed grass prairie	Vestas V82 (5,281 m <sup>2</sup> )	1.16	hoary bat, unidentified bat species, big brown bat, eastern red bat	Derby et al. 2007

<sup>1</sup> Facilities arranged by estimated mean fatality/MW/year

<sup>2</sup> If varying models were used in the Project, the largest rotor-swept area is given.

## 2.3 Regulatory Framework

Although the majority of bird species in the U.S. are protected under the federal Migratory Bird Treaty Act, and selected bird species or groups of species are protected under other statutes, there are relatively few laws or regulations that protect bats. At the federal level, there are no laws or regulations specific to bats; existing environmental laws primarily address the protection of habitat favored by bats, such as caves, and prohibit wanton destruction of wildlife. Bat species determined to be at risk are listed under the federal ESA, or at the state level. Beyond that, federal land management agencies such as the U.S. Forest Service, USFWS, and the Bureau of Land Management have developed habitat management guidelines and other provisions to enhance or minimize disturbance to natural habitats, including bat habitats. In some cases these provisions have been established by regulations, such as the National Forest Management Act, while in other cases the protective provisions are implemented as agency policies lacking regulatory force. Habitat protections implemented by these federal agencies are applicable to federal lands administered by the respective agencies.

### ***Federal Protection***

Of the 45 species of bats known to occur in the continental U.S., seven species are currently federally listed as endangered and protected under the ESA (USFWS 2015a): gray bat (*Myotis grisescens*), Indiana bat (*M. sodalis*), Florida bonneted bat (*Eumops floridanus*), Ozark big-eared bat (*Corynorhinus townsendii ingens*), Virginia big-eared bat (*C. t. virginianus*), lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*), and Mexican long-nosed bat (*L. nivalis*). One additional species, NLEB, is proposed for listing as endangered (USFWS 2013, USFWS 2014a). None of the currently listed bat species are known to occur in North Dakota. North Dakota is within the western edge of the range of NLEB, although many areas of the state do not support suitable habitat for the species.

### ***Northern Long-eared Bat***

In July 2011, the USFWS was petitioned to list the NLEB as endangered or threatened and to designate critical habitat under the ESA (USFWS 2011). On October 2, 2013 USFWS released the results of their 12-Month Finding on the 2011 petition (USFWS 2013). The USFWS concluded that listing for the NLEB was warranted, and the species is now “proposed for listing as endangered.” The USFWS also concluded that critical habitat was not determinable for NLEB at this time. The public comment period on the proposed federal listing was originally scheduled to be closed on January 2, 2014, but on June 30, 2014 USFWS published a six-month extension (USFWS 2014a). On January 16, 2015, the USFWS proposed a rule under Section 4(d) of the Endangered Species Act for the NLEB (USFWS 2015b). The USFWS is still evaluating the listing of NLEB, and has not yet determined if the species will listed as endangered, threatened, or threatened with a Section 4(d) rule. If listed under a Section 4(d) rule, there would only be NLEB take prohibitions within counties affected by WNS and an additional 150-mile buffer around these counties (USFWS 2015c). All other take incidental to other lawful activities would not be prohibited in those areas of the NLEB range not in proximity to documented occurrence of WNS as identified by the USFWS (Figure 5). The Section 4(d) rule propose is currently in a 60-day public comment

period. If, when the USFWS makes a listing decision in April 2015, the Section 4(d) rule is implemented, North Dakota, and the Project Area specifically, would fall outside of the area where take is prohibited (Figure 5).

### **State Protection**

The protection and regulation of bat species not listed under the federal ESA is typically at the discretion of state wildlife agencies. North Dakota does not have a state endangered or threatened species list, but the North Dakota Game and Fish has identified 100 species of conservation priority, or those in greatest need of conservation in the State (Dyke 2014).

Species are categorized into three levels according to conservation need:

- Level I – species in greatest need of conservation;
- Level II – species in need of conservation, but have had support from other wildlife programs; and
- Level III – species in moderate need of conservation, but are believed to be on the edge of their range in North Dakota.

There are three bat species on the conservation priority list categorized as Level I: big brown bat (*Eptesicus fuscus*), little brown bat (*Myotis lucifugus*), and NLEB. Big brown bat and little brown bat are common throughout the state while the northern long-eared bat is considered to be on the western edge of its range and rare in the state.

There are no bat species on the conservation priority list categorized as Level II.

There are three bat species on the conservation priority list categorized as Level III: western small-footed bat (*Myotis ciliolabrum*), long-eared bat (*Myotis evotis*), and long-legged bat (*Myotis volans*). These species are known to occur in western North Dakota.

### **Voluntary Guidelines for Wind Power Projects**

The USFWS has developed Land-Based Wind Energy Guidelines (USFWS 2012), a non-regulatory tiered framework for assessing risk and collecting data on wildlife for wind energy projects. These guidelines are voluntary. This bat habitat assessment is consistent with the USFWS recommendations for Tier 2 – Site Characterization in the Land-Based Wind Energy Guidelines. North Dakota has not developed state-specific siting guidelines for wind power developers and other stakeholders for the consideration of potential wind power projects located in North Dakota but defers to the USFWS guidelines (ASFWA 2010).

### 3.0 SPECIES EXPECTED TO OCCUR IN THE PROJECT VICINITY

Tetra Tech evaluated the potential for all bats known to occur in North Dakota to use the Project Area, but with a focus on NLEB. Tetra Tech considered the suitability of the Project Area's habitat and habitats within a 1.5-mile buffer around the Project Area to develop the list of species expected to occur in the Project Area and vicinity. The 1.5-mile buffer is based upon the Northern Long-eared bat Interim Conference and Planning Guidance from the USFWS as the foraging range from roosts used to estimate home ranges for NLEB (USFWS 2014b).

Identifying if a species' constituent habitat elements for roosting and foraging occur in an area is key to determining habitat suitability (Duchamp et al. 2004). Habitat variables evaluated in this assessment included the amount of suitable foraging and roosting habitat, as well as potential migration and movement corridors in and near the Project Area. Habitat variables reviewed in the assessment included identification of the bat species known to occur in the region surrounding the Project Area and their behavioral characteristics relative to roosting, foraging and migratory activity. This information was used to derive a high, moderate, or low likelihood of occurrence in the Project Area for each species with ranges overlapping the Project Area, and specifically the NLEB.

#### **All Bat Species**

A total of 10 bat species are known to occur in North Dakota (Table 2; Gullickson *no date*). Of these 10 species, available information about species-specific suitable habitat, known distribution ranges, and documented occurrences indicate that five species are expected to have a moderate or high potential to occur within, and in the vicinity of the Project Area, and the remaining five species are expected to have a low potential of occurrence.

Roosting colonies of big brown bat and little brown bat have a high probability of occurring within the Project Area because of their known association with edge habitats and human-made structures (Table 2). Little brown bats are thought to be the most common bat in North Dakota (Gullickson *no date*). In addition, big brown bats are known to forage in agricultural lands (Rogers et al. 2006). Both species have been documented as fatalities at wind energy projects (Arnett et al. 2008).

Eastern red bat, hoary bat, and silver-haired bat have a moderate likelihood of occurring in the Project Area, primarily during migration. These species have been the predominant species found during post-construction mortality studies at operational wind energy facilities in North America (Arnett et al. 2008). The eastern red bat, hoary bat, and silver-haired bat are all associated with forested habitats and would most likely occur in small woodlots while moving through the Project Area during migration (Table 2). Each of these species are found in North Dakota from May through September (Cryan 2003, Cryan and Veilleux 2007).

The remaining species found in North Dakota (fringed bat, long-eared bat, long-legged bat, western small-footed bat, and northern long-eared bat) are expected to have a low likelihood of occurrence in the Project Area based upon species range, known habitat associations, and occurrence of similar habitats within the Project Area.

***Northern Long-eared Bats***

NLEB are expected to have a low likelihood of occurrence within the Project Area and Project Buffer during the summer residency period and during migration. The species' range includes Stark County (USFWS 2013, USFWS2015b, BCI 2014).

Few data are available on NLEB in North Dakota; however, the species is believed to occur statewide in suitable habitats (Harvey et al. 2011; Gullickson *no date*). Surveys conducted in the summers of 2009, 2010, and 2011, confirmed the presence of NLEB in the Turtle Mountains, Missouri River Valley, and in the Badlands regions (USFWS 2013). All recorded instances of NLEB in the Dakotas have been in ecoregions (Turtle Mountains, Little Missouri Badlands, River Breaks) with more topographic relief and trees than the Missouri Plateau ecoregion of the Project Area and Project Buffer.

**Table 2. Bat Species List and Likelihood of Occurrence at the Dickinson Wind Energy Center, Stark County, North Dakota.**

Likelihood of Occurrence <sup>1</sup>	Common Name	Scientific Name	Habitat Association <sup>2</sup>	Wind-energy Fatalities
Low	Northern long-eared bat	<i>Myotis septentrionalis</i>	Forages along forested hillsides and ridges. Roosts in cavities, caves and mines, underneath bark, or in crevices of trees and snags; rarely roosting in barns. Hibernates in caves and mines.	Relatively few fatalities documented in North America (Arnett et al. 2008)
High	Eastern red bat	<i>Lasiurus borealis</i>	Migratory Species. Found in hardwood deciduous forests. Generally found in close association with riparian areas. Roosts in foliage of trees.	One of most common fatalities documented in North America; fatalities assumed to be migratory individuals (Johnson et al. 2002, Kunz et al. 2007)
High	Hoary bat	<i>Lasiurus cinereus</i>	Migratory Species. Forested upland habitats, including bottomland hardwoods. Roosts in foliage of trees along the edge of clearings.	Most common fatality documented in North America; fatalities assumed to be migratory individuals (Kunz et al. 2007, Arnett et al. 2008)
High	Little brown bat	<i>Myotis lucifugus</i>	Found in close proximity to a water source for foraging and in close proximity to human-made structures. Roosts in tree cavities, caves and human-occupied structures.	Relatively few fatalities documented in North America (Arnett et al. 2008)
Moderate	Big brown bat	<i>Eptesicus fuscus</i>	Habitat generalist found in deciduous forests, urban development, and agricultural croplands. Roosts in tree cavities, under loose bark, buildings, mines, bridges, caves, and crevices in cliff faces.	Relatively few fatalities documented in North America (Arnett et al. 2008).
Moderate	Silver-haired bat	<i>Lasionycteris noctivagans</i>	Migratory Species. Closely associated with conifer and mixed hardwood forests; Generally found in association with riparian areas. Roosts in foliage of trees.	One of most common fatalities in North America; fatalities assumed to be migratory individuals (Johnson et al. 2002, Kunz et al. 2007)
Low	Fringed bat	<i>Myotis thysanodes</i>	Found in a variety of habitats. Oak and pinyon woodlands are the most commonly used. Roosts in caves, mines, and buildings.	None documented
Low	Long-eared bat	<i>Myotis evotis</i>	Found associated with caves and mines, and closely associated with human-made structures	None documented
Low	Long-legged bat	<i>Myotis volans</i>	Found in rugged, rocky terrain in variety of habitats. Roosts in trees, rock crevices, and buildings.	None documented
Low	Western small-footed bat	<i>Myotis ciliolabrum</i>	Found in rugged, rocky terrain in variety of habitats. Roosts in rock crevices, caves, tunnels, buildings, and underneath bark.	None documented

<sup>1</sup> Likelihood of Occurrence: **High** = Suitable habitat, species range overlaps with the Project Area and known occurrences within and/or near the Project Area. **Moderate** = Species known to occur in habitat similar to the Project Area, species' range overlaps with Project Area, and known occurrences near the Project Area. **Low** = Marginally suitable habitat in the Project Area, species' range does not overlap with the Project Area, no known occurrences within and/or near the Project Area, and/or known as migratory species during spring and fall migration.

<sup>2</sup> Sources: Gullickson *no date*, Western Bat Working Group 2005, Harvey et al. 2011, Bat Conservation International (BCI) 2014, American Society of Mammologists 2015.

## 4.0 HABITAT ASSESSMENT

The habitat assessment was conducted via a desktop evaluation of land cover and land uses within the Project Area and a 1.5-mile buffer (Figures 2 and 3). Identification of suitable habitats in the Project Area, and the bat species that may use these habitats, may prove helpful when designing the Project to minimize interactions between wind turbines and bats (Duchamp et al. 2004).

Habitat variables evaluated in this assessment included the amount of suitable foraging and roosting habitat, as well as potential migration and movement corridors in and near the Project Area.

Although there are still substantive information gaps on bat migration patterns across North America, there is speculation that bats migrate in a similar manner to some birds (i.e., possibly as broad front migration; Cryan 2003). Migratory bats moving through the area during migration may still be at risk of colliding with wind turbines regardless of habitat conditions. The likelihood of mortality or other impacts during migration to NLEB, and other bats, is difficult to determine based on available data.

### 4.1 Land Use and Land Cover

Land use and land cover types in the Project Area and Project Buffer were characterized using the National Land Cover Database in GIS (Jin et al. 2013). Habitats were compared between the Project Area and Project Buffer to understand if bats were potentially favoring or disfavoring the Project Area in the context of the surrounding landscape. For example, if the Project Area supported a relatively higher concentration of suitable habitat areas than the Project Buffer, it is possible the site would concentrate bats in densities slightly higher than the surrounding areas.

A comparison of the Project Area and Buffer Area demonstrates that percentages of different land uses and cover types in the Project Area are similar to those within the Buffer Area. The vast majority of cover within the Project Area is grassland including native grasslands and pasture/hayfields (51.3 percent), as is the majority of cover within the Buffer Area (57.7 percent). The percentage of suitable bat habitat cover types (shown in bold in Table 3) are similar between the Project Area and the Project Buffer (Table 3). Suitable bat habitat (open water, emergent herbaceous wetlands, deciduous forest, evergreen forest, mixed forest, shrub/scrub, and woody wetlands) comprises 3.7 percent of the total Project Area and 3.2 percent of the Project Buffer. Based on the percentage of cover types available in the Project Area versus the Project Buffer, it is unlikely that bats would favor the Project Area disproportionately for roosting or foraging, over other areas in the vicinity.

**Table 3. Land Use and Land Cover Present in the Project Area and Project Buffer, Stark County, North Dakota.**

Land Use/Land Cover Description	Acres in Project Area	Percent of Project Area	Acres in Project Buffer	Percent of Project Buffer
Grassland/Herbaceous	62,412	42.6	48,876	50.3
Cultivated Crops	58,267	39.8	31,649	32.6
Pasture/Hay	12,692	8.7	7,210	7.4
Developed, Open Space	5,870	4.0	3,982	4.1
<b>Woody Wetlands</b>	<b>1,940</b>	<b>1.3</b>	<b>835</b>	<b>0.9</b>
Developed, Low Intensity	1,343	0.9	1,390	1.4
<b>Deciduous Forest</b>	<b>1,163</b>	<b>0.8</b>	<b>541</b>	<b>0.6</b>
<b>Shrub/Scrub</b>	<b>990</b>	<b>0.7</b>	<b>660</b>	<b>0.7</b>
<b>Open Water</b>	<b>955</b>	<b>0.7</b>	<b>925</b>	<b>1.0</b>
<b>Emergent Herbaceous Wetlands</b>	<b>264</b>	<b>0.2</b>	<b>118</b>	<b>0.1</b>
Barren Land (Rock/Sand/Clay)	231	0.2	85	0.1
Developed, Medium Intensity	170	0.1	706	0.7
<b>Mixed Forest</b>	<b>43</b>	<b>Less than 0.1</b>	<b>20</b>	<b>Less than 0.1</b>
<b>Evergreen Forest</b>	<b>34</b>	<b>Less than 0.1</b>	<b>13</b>	<b>Less than 0.1</b>
Developed, High Intensity	7	Less than 0.1	118	0.1
<b>Total</b>	<b>146,380</b>		<b>97,129</b>	

Note: **Bold** text indicates habitat types that are most suitable for foraging and roosting habitat.

## 4.2 Roosting Habitat

Non-migratory bats use caves or similar habitat for winter hibernacula, and then disperse onto the landscape for the warmer seasons (typically April 15 – November 15) and shelter in “summer roosts”. Similarly, migratory bats migrate north from wintering areas and use some of the same habitat features (e.g. tree cavities and bark) as non-migratory species during the summer. This section describes summer roosting habitat in the Project area, winter hibernacula are discussed in Section 4.3. Summer roosts are important to bats because they provide shelter from the environment and adverse weather, resting places during migration or regional movements, protection from predators, and are used for social interaction and rearing of young. Due to bats’ dependence on roost structures during all stages of their life cycle; the preservation of summer roosting habitat, as well as winter hibernacula, has been identified as critical for the conservation of bats in North America (Kunz 1982, Kunz and Fenton 2003).

### **All Bat Species**

Bats may roost in rock formations, caves, human-made structures, live trees (often in the foliage), dead trees (snags), and partially dead trees (partial snags) with cavities and loose bark. North Dakota’s species can be broadly classified as tree-roosting bats (those that roost in live trees, snags and partial snags) and species adapted to roosting in multiple habitats (generalists that roost in natural habitat, but also frequently roost in human-made structures such as barns) (Harvey et al. 2011).

Tree-roosting species (NLEB, hoary bat, silver-haired bat, and eastern red bat) prefer larger trees in early stages of decay, which are often found in older forest stands (Crampton and Barclay 1998, Barclay and Brigham 1996). In the absence of mature forest stands, tree-roosting species may roost in living trees (although eastern red bats often prefer roosting in the foliage of live trees; Kunz 1982, Harvey et al. 2011). Suitable natural roosting habitats in the Project Area are limited to individual trees, windrows, woodlots and riparian zones. These wooded locations are generally near homes, along riparian corridors, or are planted windbreaks. The availability of tree-roosting habitat in the Project Area is limited due to the small size and fragmented nature of the wooded habitat and accounts for less than 2 percent of the Project Area. Therefore, roost tree availability is almost certainly a limiting factor to the occurrence of bats in the Project Area (Carter and Menzel 2007).

In addition to trees, potential roosting locations are also available in farmstead buildings (houses, barns, etc.) and in the abandoned mines within the Project Area and Project Buffer (Figure 4; NDPSC 2013). The suitability of these man-made structures have not been evaluated. However, they are present in the Project Area and Project Buffer and could be used by roosting bats.

### ***Northern Long-eared Bats***

During the spring, summer, and early fall, NLEB roost in suitable forest habitat typically within 50 miles of wintering sites (USFWS 2013). Like other North American forest bats, reproductive NLEB females will roost colonially during the late-spring and summer maternity period (approximately May to July). Maternity colonies (averaging 30–60 individuals) are most frequently found in mature forests, with a higher abundance of standing dead trees (snags), but the species also may roost in partially live or live mature trees. Both male and female NLEB generally prefer relatively large trees in early stages of decay, which are often found in older forest stands (Crampton and Barclay 1998, Barclay and Brigham 1996). Less commonly, NLEB summer day roost sites may also include human-made structures, including variety of shelters such as buildings, behind shutters, under live tree bark, and in small tree cavities (Harvey et al. 2011). Roosts are often used for a period of 2–11 nights, but maternity colonies may be occupied for longer. Because of NLEB's preference for switching roosts, multiple suitable roosting locations in a given forested patch may be indicative of higher quality summer habitat. Summer home ranges for females are estimated to be between 47 and 425 acres (USFWS 2013).

There is no significant interior forest habitat (at least 300 feet from non-forest land cover) in the assessment area with a total of eight acres of interior forest among three forested areas in the Project Area and none within the Project Buffer. The majority of forests within the Project Area are associated with riparian areas rather than ridges which are preferred by NLEB (USFWS 2014b). The only potentially suitable NLEB roosting habitat in the Project Area consists of trees associated with riparian features and small woodlots or windbreaks near homesteads. Although these sites do contain suitable roost trees, they are isolated and not connected with or contiguous to other forest patches and account for less than 4 percent of the Project Area. Average forest patch size in the Project Area is approximately 3.7 acres and the average forest patch size in the Buffer Area is approximately 2.9 acres. There is evidence suggesting that NLEB select forest

patches with greater connectivity to other patches and larger forest patches with a closed canopy (mature forests) than those available in the Project Area (USFWS 2013).

### **4.3 Winter Habitat**

Of the bat species with a moderate or high likelihood of occurring in the Project Area, silver-haired bat, hoary bat, and eastern red bat migrate to southern latitudes during winters. The remaining species, big brown bat, little brown bat, and NLEB, hibernate locally or regionally (typically within 168 miles of where they spend the summer). This section focuses on winter habitat for NLEB in the Project Area vicinity, and briefly touches on the suitability of winter habitat for other species as well.

#### ***Northern Long-eared Bats***

NLEB do not undertake long-distance seasonal migrations between summer and winter ranges but do undertake shorter distance movements between summer roosts and winter hibernacula. These seasonal movements are generally between 35 miles and 55 miles, but may be substantially longer in some areas, perhaps as great as 168 miles (USFWS 2013). Information on habitat use during migration is limited, but individuals in transit are likely to use foraging habitats at least part of the time.

NLEB arrive at hibernacula in August or September, begin hibernation in October and November, and exit hibernacula in March or April (USFWS 2013). NLEB prefers hibernacula with large entrances such as caves and mines, as well as less traditional hibernacula including dams, dry wells, and other human-made structures. Individuals may hibernate in cracks and crevices in hibernacula walls, and as such, may be overlooked during winter surveys. Although NLEB are often found with other congeneric species (i.e. *Myotis* spp.), they generally prefer cooler temperatures and higher humidity (USFWS 2013). Hibernacula where NLEB occur may also be used by big brown bat and little brown bat, and possibly western small-footed bat (*Myotis ciliolabrum*; Brack et al. 2010).

There were no caves or other natural rock or crevice formations in the Project Area based on sources for the region that would be suitable hibernacula (Murphy 2007, NDGS and NDDH 2001). All known caves are greater than 20 miles from the Project Area. The closest caves are Bear Cave, approximately 23 miles to the southwest, and Lion's Cave, approximately 25 miles to the west (Figure 4). Bear Cave extends only 12 feet and Lion's cave is likely similar as both are located along caprock (Murphy 2007). In addition to natural formations, there are six abandoned underground mines within the Project Area and six abandoned underground mines within the Project Buffer that could provide potential roosting habitat for bats (NDPSC 2013); however, the suitability of these mines for roosting bats is unknown. No known hibernacula for NLEB have been documented in North Dakota, although a thorough assessment of potential hibernacula in western North Dakota has not been completed (USFWS 2013). The closest known hibernacula occur in the Black Hills of Wyoming and South Dakota over 150 miles to the southwest (USFWS 2013).

#### **4.4 Foraging Habitat**

Foraging habitats are not necessarily exclusive of roosting or migrating habitat. However, there are notable preferences among species for different foraging habitats, which are often different from preferred roosting locations (Harvey et al. 2011).

##### ***All Bat Species***

All bats known to occur in North Dakota are insectivorous, and feed on a variety of prey, including moths, beetles, flies, and mosquitoes (Kunz and Fenton 2003). Bats typically forage in areas with high prey concentrations (i.e. high nocturnal insect densities) in riparian areas (Waldien and Hayes 2001), over waterbodies (Henry et al. 2002, Lacki et al. 2007), and along forest edges (Hayes and Gruver 2000, Rogers et al. 2006). Non-developed and non-agricultural types of habitats (open water, forested, wetlands, and scrub shrub) provide the best foraging opportunities for bats and account for less than 4 percent of the Project Area. Although there is some evidence to indicate that some species, such as the big brown bat, prefer foraging over agricultural lands (Rogers et al. 2006, BCI 2014), agricultural lands within the Project Area are typically the least suitable locations for foraging and account for approximately 40 percent of the Project Area.

##### ***Northern Long-eared Bats***

Unlike other *Myotis* in the region that typically forage along streams and within floodplains, NLEB are adapted to gleaning and hawking for insects in the sub-canopy of deciduous and mixed forests and therefore typically forage along ridge tops and forested hillsides (Harvey et al. 2011). However, foraging may also occur in forest clearings, above roadways, and along trails or near water (USFWS 2013). Agricultural lands within the Project Area (approximately 40 percent of the land cover) are the least suitable locations for NLEB foraging. Suitable foraging habitat for NLEB includes forested areas, wind breaks, riparian corridors, and open water areas in the Project Area. This suitable foraging habitat accounts for less than 3 percent of the Project Area which is a small percentage of overall land cover.

#### **4.5 Bat Migration and Movement Characteristics**

Bat migration includes seasonal movement from summer residency areas to wintering areas. Wintering areas for long-distance migrants are typically in southern latitudes (Fleming and Eby 2003). Long-distance migratory bats such as the eastern red bat, silver-haired bat, and hoary bat undertake seasonal movements greater than 62 miles and less than 1,200 miles (Cryan 2003, Cryan 2011). Wintering areas for other species include natural or man-made hibernacula (Fleming and Eby 2003). NLEB, little brown bat, and others migrate short distances from summer colonies to winter hibernacula (i.e., partial or short-distance migration) (Fleming and Eby 2003). Most species, including NLEB, are thought to move along linear landscape features that connect habitats, such as horizontal forest features, (e.g., forest edges), vertical forest features (e.g., between forest canopy structures), or riparian corridors (Hayes and Gruver 2000, Downs and Racey 2006, Furmankiewicz and Kucharska 2009). Beyond these generalities, the current understanding of bat migration is limited (Baerwald and Barclay 2009, Cryan 2011).

NLEB and other species may fly thorough the Project Area during spring and fall migration en route to hibernacula. The Project Area contains small forested riparian corridors that bats could follow or utilize as day roosting sites, although these are not significant features from a regional perspective. The limited roosting habitat within the Project Area is a major limiting factor for use of the Project Area by migrating bats. Therefore, bat migration through the Project Area is likely low in magnitude.

## 5.0 SUMMARY

There is little suitable roosting or foraging habitat in the Project Area or within the Project Buffer for the NLEB. There is slightly more suitable roosting and foraging habitat for other bat species, primarily big brown bat and little brown bat, in the Project Area and the Project Buffer. The small size and small number of wooded parcels in the Project Area and the Project Buffer likely limits the density and diversity of bats in the Project Area. Because of this lack of forested habitat within the Project Area and Project Buffer and the location of the Project Area at the edge of the species range, NLEB have a low likelihood of occurring in the Project Area. There are no known NLEB hibernacula in North Dakota and the NLEB is considered to be rare in the state (USFWS 2013, Dyke 2014).

### 5.1 NLEB Habitat Suitability Conclusion

The NLEB Guidance (USFWS 2014a) includes a stepwise assessment approach with specific questions intended to facilitate review of potential impacts to the species. The following questions (in bold) and responses are based on our current knowledge of the Project Area and the results of the 2015 desktop habitat assessment. Sections 4.1 – 4.5 provide information requested by USFWS for habitat assessments, as part of the NLEB interim guidance (USFWS 2014b, USFWS 2014c).

#### **Is the project within the range of NLEB?**

Yes. The Project is within the range of NLEB (Gullickson *no date*, Harvey et al. 2011, USFWS 2014a, USFWS 2015c).

#### **Is suitable summer or winter habitat present?**

The proposed Project is located in the Northern Great Plains ecoregion, which has been intensively cultivated but historically consisted of prairie habitat. In this ecoregion forested habitat is almost exclusively associated with human development (e.g. wind breaks), lakesides, and riparian areas.

Less than 2 percent of the 146,380-acre Project Area is forested. Forested habitat in the Project Area (woody wetlands, evergreen forest, mixed forest, deciduous forest) is relegated to small woodlots that are disconnectedly distributed along riparian areas, as woody wetlands, and as windbreaks along fields or at homesteads. The majority of the forest habitat within the Project Area occurs in the northeastern portion of the Project Area where terrain is more variable. Trees in this location occur within drainages and slopes of the rolling terrain. The Heart River and associated tributaries in the southwestern portion of the Project Area have intermittent tree stands along the riparian corridor. Large, contiguous tracks of upland forested habitat, preferred by NLEB, are not present in the Project Area.

Based on the desktop habitat assessment, the NLEB has a low likelihood to occur in the Project Area during the summer residency period (approximately May 15–August 15) because of the lack of large contiguous woodlots and due to the species being uncommon

in the far western extent of its range which includes the Project Area. The species could occur in the Project Area during seasonal movements to hibernacula. Although we have not assessed the Project Area for potential winter hibernacula, Tetra Tech is not aware of any available data that indicate the occurrence of NLEB hibernacula in western North Dakota and no hibernacula are known in the state (USFWS 2013).

### **Is lethal take during migration possible?**

NLEB have been found during mortality searches at wind energy facilities (e.g., Arnett et al. 2005, Jacques Whitford 2009), so lethal take is possible if NLEB migrate through the Project. However, the occurrence of the species in North Dakota, including potential winter hibernacula, is poorly understood and NLEB are expected to be uncommon or rare in western North Dakota (USFWS 2013). Therefore, the likelihood of NLEB occurring in the Project Area during the summer residency period is low. No clear migratory pathways, or known hibernacula are in the Project Area or vicinity; however, migration patterns are poorly understood. The likelihood of the species occurring during the migration period (spring and fall) is expected to be very low because of distance to known hibernacula and low availability of suitable foraging or roosting habitat in the Project Area and Project Buffer. All records of NLEB mortality at wind energy facilities are from eastern North American projects.

### **Is there an existing summer or winter occurrence record near the Project Area (e.g., within 1.5 miles of a known roost tree, 3 miles of capture location, or 5 miles of a hibernaculum)?**

Tetra Tech is not aware of any existing summer or winter occurrence records within 5 miles of the Project Area. Bat acoustic surveys for NLEB will be initiated in spring 2015. Winter habitat surveys are not planned.

### **Was the presence of NLEB documented during surveys?**

Bat acoustic surveys for NLEB will be initiated in spring of 2015 and will continue through the summer. The objective of the bat acoustic surveys will be to estimate the seasonal distribution and spatial patterns of bat activity within the Project. The 2015 bat acoustic surveys will be conducted in accordance with NLEB Guidance from USFWS (USFWS 2014b, USFWS 2014c).

### **Is this an existing or ongoing project within the range of the Indiana bat with a prior determination for Indiana bat?**

No. The Project Area is outside the range of the Indiana bat.

## **5.2 Critical Habitat for Listed Species**

At the time this report was prepared, the USFWS has not designated or proposed any critical habitat for NLEB and no bats with designated critical habitat occur within the Project Area (USFWS 2013, USFWS 2015a). If USFWS were to designate critical habitat for NLEB, designated areas would likely consist of large well-known hibernacula, similar to critical habitat designated for the Indiana bat.

## 6.0 LITERATURE CITED

- Arnett, E.B., W.P. Erickson, J. Kerns, and J. Horn. 2005. Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Fatality Search Protocols, Patterns of Fatality and Behavioral Interactions with Turbines. Prepared for Bats and Wind Cooperative. 187 pgs.
- Arnett, E.B., W.K. Brown, W.P. Erickson, K.K. Fiedler, B.L. Hamilton, T.H. Henry, A. Jain, G.D. Johnson, J. Kerns, R.R. Koford, C.P. Nicholson, T.J. O'Connell, M.D. Piorkowski, and R.D. Tankersley, Jr. 2008. Patterns of bat fatalities at wind energy facilities in North America. *Journal of Wildlife Management* 72:61–78.
- American Society of Mammologists (ASM). 2015. Mammals of North Dakota. Available online at: <http://www.mammalsociety.org/mammals-north-dakota>. Accessed January 2015.
- Association of Fish and Wildlife Agencies (ASFWA). 2010. Federal and State Wind Energy Siting Guidelines: North Dakota. Available online at: [http://www.fishwildlife.org/files/North\\_Dakota.pdf](http://www.fishwildlife.org/files/North_Dakota.pdf). Accessed January 2015
- Baerwald, E.F. and R.M.R. Barclay. 2009. Geographic variation in activity and fatality of migratory bats at wind energy facilities. *Journal of Mammalogy* 90:1341–1349.
- Barclay, R.M.R. and M.R. Brigham (eds). 1996. Bats and Forests Symposium, October 19–21, 1995, Victoria, British Columbia, Canada. Ministry of Forests Research Program, Victoria, B.C. Work Paper 23.1996.
- Bat Conservation International (BCI). 2014. Species profiles. Available online at <http://www.batcon.org/index.php/resources/media-education/species-profiles>. Accessed January 2015.
- BHE Environmental, Inc. 2011. Post-Construction Bird and Bat Mortality Study: Cedar Ridge Wind Farm, Fond Du Lac County, Wisconsin Final Report prepared for Wisconsin Power and Light, Madison, Wisconsin. Prepared by BHE Environmental, Inc. Cincinnati, Ohio. February 2011.
- Brack Jr., V., D. W. Sparks, J. O. Whitaker Jr., B. L. Walters, and A. Boyer. 2010. Bats of Ohio. Indiana State University Center for North American Bat Research and Conservation. 92 pp.
- Bryce, S.A., J.M. Omernik, D.A. Pater, M. Ulmer, J. Schaar, J. Freeouf, R. Johnson, P. Kuck, and S.H. Azevedo. 1996. Ecoregions of North Dakota and South Dakota, (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,500,000).
- Carter, T.C. and J.M. Menzel. 2007. Behavior and day-roosting ecology of North American foliage-roosting bats. Pages 61-82 in J. P. H. M.J. Lacki, and A. Kurta, editor. *Bats in Forests: Conservation and Management*. The Johns Hopkins University Press, Baltimore, MD.

- Crampton, L.H. and R.M.R. Barclay. 1998. Selection of roosting and foraging habitat by bats in different-aged aspen mixedwood stands. *Conservation Biology* 12:1347–1358.
- Cryan, P.M. 2003. Seasonal distribution of migratory tree bats (*Lasiurus* and *Lasionycteris*) in North America. *Journal of Mammalogy* 84:579–593.
- Cryan, P.M. 2011. Wind Turbines as Landscape Impediments to the Migratory Connectivity of Bats. *Environmental Law* 41: 355-370.
- Cryan, P. M. and J. P. Veilleux. 2007. Migration and use of autumn, winter and spring roosts by tree bats. Pages 153–176 *in* *Bats in Forests: Conservation and Management*, eds. J. P. H. M.J. Lacki, and A. Kurta. Baltimore, MD, The Johns Hopkins University Press.
- Cryan, P.M. and R.M.R. Barclay. 2009. Causes of bat fatalities at wind turbines: hypotheses and predictions. *Journal of Mammalogy* 90:1330–1340.
- Derby, C., A. Dahl, W. Erickson, K. Bay, and J. Hoban. 2007. Post-Construction Monitoring Report for Avian and Bat Mortality at the NPPD Ainsworth Wind Farm. Unpublished report prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming, for the Nebraska Public Power District.
- Downs, N.C. and P.A. Racey. 2006. The use by bats of habitat features in mixed farmland in Scotland. *Acta Chiropterologica* 8:169–185.
- Duchamp, J.E., D.W. Sparks, and J.O. Whitaker Jr. 2004. Foraging-habitat selection by bats at an urban-rural interface: comparisons between a successful and a less successful species. *Canadian Journal of Zoology* 82:1157–1164.
- Dyke, S. 2014. North Dakota Species of Conservation Priority: 2014 List Update. Available online at: <http://gf.nd.gov/magazines/june-2014/north-dakota-species-conservation-priority>.
- Fleming, T.H. and P. Eby. 2003. Ecology of bat migration. *In* T.H. Kunz and M.B. Fenton (eds.). *Bat Ecology*. University of Chicago Press, Chicago, Illinois.
- Furmankiewicz, J. and M. Kucharska. 2009. Migration of bats along a large river valley in southwestern Poland. *Journal of Mammalogy* 90:1310–1317.
- Grodsky, S.M. and D. Drake. 2011. Assessing Bird and Bat Mortality at the Forward Energy Center. Final Report. Public Service Commission (PSC) of Wisconsin. PSC REF#:152052. Prepared for Forward Energy LLC. Prepared by Department of Forest and Wildlife Ecology, University of Wisconsin-Madison, Madison, Wisconsin. August 2011.
- Gruver, J., M. Sonnenburg, K. Bay, and W. Erickson. 2009. Post-Construction Bat and Bird Fatality Study at the Blue Sky Green Field Wind Energy Center, Fond Du Lac County, Wisconsin July 21 – October 31, 2008 and March 15 – June 4, 2009. Unpublished report prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming. December 17, 2009.
- Gullickson, G. *no date*. Bats of North Dakota. North Dakota Game and Fish and Bat Conservation International.

- Harvey, M. J., J. S. Altenbach, and T. L. Best. 2011. Bats of the United States and Canada. The Johns Hopkins University Press, Baltimore, MD. USA. .
- Hayes, J.P., and J.C. Gruver. 2000. Vertical stratification of activity of bats in an old-growth forest in western Washington. *Northwest Science* 74:102–108.
- Hayes, M. A. 2013. Bats Killed in Large Numbers at United States Wind Energy Facilities. *BioScience*: 63(12).
- Hein, C. D., J. Gruver, and E.B. Arnett. 2013. Relating Pre-Construction Bat Activity and Post-Construction Bat Fatality to Predict Risk at Wind Energy Facilities: A Synthesis. Prepared for the National Renewable Energy Laboratory, Golden, CO. March 2013.
- Henry, M., D. W. Thomas, R. Vaudry, and M. Carrier. 2002. Foraging distances and home range of pregnant and lactating little brown bats (*Myotis lucifugus*). *Journal of Mammalogy* 83:767–774.
- Horn, J.W., E.B. Arnett, and T.H. Kunz. 2008. Behavioral responses of bats to operating wind turbines. *Journal of Wildlife Management* 72:123-132.
- Howe, R.W., W. Evans, and A.T. Wolf. 2002. Effects of wind turbines on birds and bats in northeastern Wisconsin. Prepared by University of Wisconsin-Green Bay, for Wisconsin Public Service Corporation and Madison Gas and Electric Company, Madison, Wisconsin. November 21, 2002.
- Jacques Whitford Stantec Limited (Jacques Whitford). 2009. Ripley Wind Power Project Post-construction Monitoring Report. Project No. 1037529.01. Report to Suncor Energy Products Inc., Calgary, Alberta, and Acciona Energy Products Inc., Calgary, Alberta. Prepared for the Ripley Wind Power Project Post-Construction Monitoring Program. Prepared by Jacques Whitford, Markham, Ontario. April 30, 2009.
- Jain, A.A. 2005. Bird and Bat Behavior and Mortality at a Northern Iowa Windfarm. M.S. Thesis. Iowa State University, Ames, Iowa.
- Jain, A.A., R.R. Koford, A.W. Hancock, and G.G. Zenner. 2011. Bat Mortality and Activity at a Northern Iowa Wind Resource Area. *American Midland Naturalist* 165:185-200.
- Jin, S., Yang, L., Danielson, P., Homer, C., Fry, J., and Xian, G. 2013. A comprehensive change detection method for updating the National Land Cover Database to circa 2011. *Remote Sensing of Environment* 132:159–175. Available online at <http://www.mrlc.gov/nlcd2011.php>
- Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd, D.A. Shepherd, and S.A. Sarappo. 2002. Collision mortality of local and migrant birds at a large-scale wind power development on Buffalo Ridge, Minnesota. *Wildlife Society Bulletin* 30:879–887.
- Kerns, J. and P. Kerlinger. 2004. A Study of Bird and Bat Collisions at the Mountaineer Wind Energy Facility, Tucker County, West Virginia: Annual Report for 2003. Prepared for FPL Energy and the Mountaineer Wind Energy Center Technical Review Committee. February

- 14, 2004. Technical report prepared by Curry and Kerlinger, LLC., for FPL Energy and Mountaineer Wind Energy Center Technical Review Committee. Curry and Kerlinger, LLC. 39 pp. <http://www.wvhighlands.org/Birds/MountaineerFinalAvianRpt-%203-15-04PKJK.pdf>
- Kunz, T.H. 1982. Roosting Ecology of Bats. *In Ecology of Bats*. T.H. Kunz (ed.) Plenum Publishing Corporation, New York, New York.
- Kunz, T.H. and M.B. Fenton (eds.). 2003. *Bat Ecology*. The University of Chicago Press. Chicago, Illinois.
- Kunz, T.H., E.B. Arnett, W.P. Erickson, A.R. Hoar, G.D. Johnson, R. P. Larkin, M.D. Strickland, R.W. Thresher, and M.D. Tuttle. 2007. Ecological impacts of wind energy development on bats: questions, research needs, and hypotheses. *Frontiers in Ecological Environments* 5:315-324.
- Lacki, M.J., Hayes, J.P., and A. Kurta. 2007. *Bats in Forests: Conservation and Management*. The Johns Hopkins University Press. Baltimore, Maryland.
- Murphy, E. 2007. Caves in North Dakota. Available online at: [https://www.dmr.nd.gov/ndgs/ndnotes/caves/caves\\_h.asp](https://www.dmr.nd.gov/ndgs/ndnotes/caves/caves_h.asp). Accessed February 2015.
- Murphy, E. no date. Mineral Resources of North Dakota: Coal. North Dakota Geological Survey. Available online at: [https://www.dmr.nd.gov/ndgs/mineral/nd\\_coalnew.asp](https://www.dmr.nd.gov/ndgs/mineral/nd_coalnew.asp). Accessed February 2015.
- National Research Council. 2007. Environmental impacts of wind energy projects. The National Academies Press, Washington, D.C.
- NDPSC (North Dakota Public Service Commission). 2013. Abandoned Mines. Available online at: <https://apps.nd.gov/hubdataportal/srv/en/main.home>
- NDGS and NDDH (North Dakota Geological Survey and North Dakota Department of Health). 2001. Bedrock Geology. Available online at: <https://apps.nd.gov/hubdataportal/srv/en/main.home>
- Poulton, V. 2010. Summary of Post-Construction Monitoring at Wind Projects Relevant to Minnesota, Identification of Data Gaps, and Recommendations for Further Research Regarding Wind-Energy Development in Minnesota. Prepared for State of Minnesota Department of Commerce. 52 Pgs.
- Poulton, V., and Erickson, W. 2010. Post-Construction Bat and Bird Fatality Study Judith Gap Wind Farm Wheatland County, Montana: Final Report Results from June-October 2009 Study and Comparison with 2006-2007 Study. Prepared for Judith Gap Energy LCC. Prepared by Western EcoSystems Technology, Inc. (WEST) Cheyenne, Wyoming. March 2010.

- Rogers, D.S., M.C. Belk, M.W. Gonzalez, and B.L. Coleman. 2006. Patterns of habitat use by bats along a riparian corridor in northeastern Utah. *The Southwestern Naturalist* 51:52–58.
- Rydell, J., L. Bach, M. Dubourg-Savage, M. Green, L. Rodrigues, and A. Hedenstrom. 2010. Mortality of bats at wind turbines links to nocturnal insect migration? *European Journal of Wildlife Research* 56:823–827.
- Stantec Consulting, Inc. (Stantec). 2011. Cohocton and Dutch Hill Wind Farms Year 2 Post-Construction Monitoring Report, 2010, for the Cohocton and Dutch Hill Wind Farms in Cohocton, New York. Prepared for Canandaigua Power Partners, LLC, Portland Maine. Prepared by Stantec, Topsham, Maine. January 2011.
- Strickland, M.D., E.B. Arnett, W.P. Erickson, D.H. Johnson, G.D. Johnson, M.L. Morrison, J.A. Shaffer, and W. Warren-Hicks. 2011. Comprehensive guide to studying wind energy/wildlife interactions. Prepared for the National Wind Coordinating Collaborative. Washington, D.C.
- TRC Environmental Corporation. 2008. Post-Construction Avian and Bat Fatality Monitoring and Grassland Bird Displacement Surveys at the Judith Gap Wind Energy Project, Wheatland County, Montana. Prepared for Judith Gap Energy, LLC, Chicago, Illinois. TRC Environmental Corporation, Laramie, Wyoming. TRC Project 51883-01 (112416). January 2008.
- USFWS (United States Fish and Wildlife Service). 2011. Federal Register Notice of a 90-day finding for the Eastern Small-footed Bat and the NLEB. Available online at [http://www.fws.gov/midwest/es/soc/mammals/FR90DayFndngNLEB\\_ESFB29June2011.html](http://www.fws.gov/midwest/es/soc/mammals/FR90DayFndngNLEB_ESFB29June2011.html). Accessed August 2014.
- USFWS. 2012. Land-Based Wind Energy Guidelines. Available online at <http://www.fws.gov/windenergy>.
- USFWS. 2013. 12-month Finding on a Petition to List the Eastern Small-footed Bat and the NLEB as Endangered or Threatened; Listing the NLEB as an Endangered Species – Proposed Rule. Federal Register 78(191):61046–61080. Available online at <http://www.gpo.gov/fdsys/pkg/FR-2013-10-02/pdf/2013-23753.pdf>. Accessed January 2015.
- USFWS. 2014a. Endangered and Threatened Wildlife and Plants; 6-month Extension of the Final Determination on the Proposed Endangered Status of the Northern Long-Eared Bat. Available online at: <http://www.gpo.gov/fdsys/pkg/FR-2014-06-30/pdf/2014-15213.pdf>
- USFWS. 2014b. Northern long-eared bat interim conference and planning guidance. USFWS Regions 2, 3, 4, 5, and 6. January 6, 2014. Available online at: <http://www.fws.gov/midwest/endangered/mammals/nlba/pdf/NLEBinterimGuidance6Jan2014.pdf>

- USFWS 2014c. 2014 Range-wide Indiana bat summer survey guidelines. January 2014. Available online at: <http://www.fws.gov/athens/pdf/2014IBatSummerSurveyGuidelines13Jan2014.pdf>.
- USFWS. 2015a. Endangered species of the United States. Available online at: <http://www.fws.gov/endangered/species/us-species.html>.
- USFWS. 2015b. Endangered and Threatened Wildlife and Plants; Listing the Northern Long-Eared Bat With a Rule Under Section 4(d) of the Act. Federal Register 80(11): 2371–2378. Available online at: <http://www.fws.gov/midwest/endangered/mammals/nlba/pdf/FRnlebProposed4dRule16Jan2015.pdf>
- USFWS. 2015c. Northern Long-eared Bat Proposed 4(d) Rule: White-Nose Syndrome Buffer zone Around WNS/Pd Positive Counties/Districts. Available online at: <http://www.fws.gov/Midwest/endangered/mammals/nlba/pdf/nlebRangeMapWithWNS150MileBuffer15Jan2015.pdf>
- Waldien, D.L., and J.P. Hayes. 2001. Activity areas of female long-eared myotis in coniferous forests in western Oregon. *Northwest Science* 75:307–314.
- Western Bat Working Group. 2005. Species Accounts. Available online at: [http://www.wbwg.org/speciesinfo/species\\_accounts/species\\_accounts.html](http://www.wbwg.org/speciesinfo/species_accounts/species_accounts.html). Accessed January 2015.
- Young, D.P. Jr., W.P. Erickson, Bay, K., Nomani, S., and Tidhar, W. 2009. Mount Storm Wind Energy Facility, Phase 1 Post-Construction Avian and Bat Monitoring: July - October 2008. Prepared for NedPower Mount Storm, LLC, Houston, Texas. Prepared by Western EcoSystems Technology, Inc. (WEST), Cheyenne, Wyoming.

## FIGURES

# Dickinson Wind Energy Center

Stark County, ND

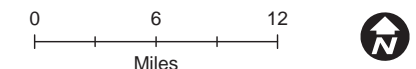
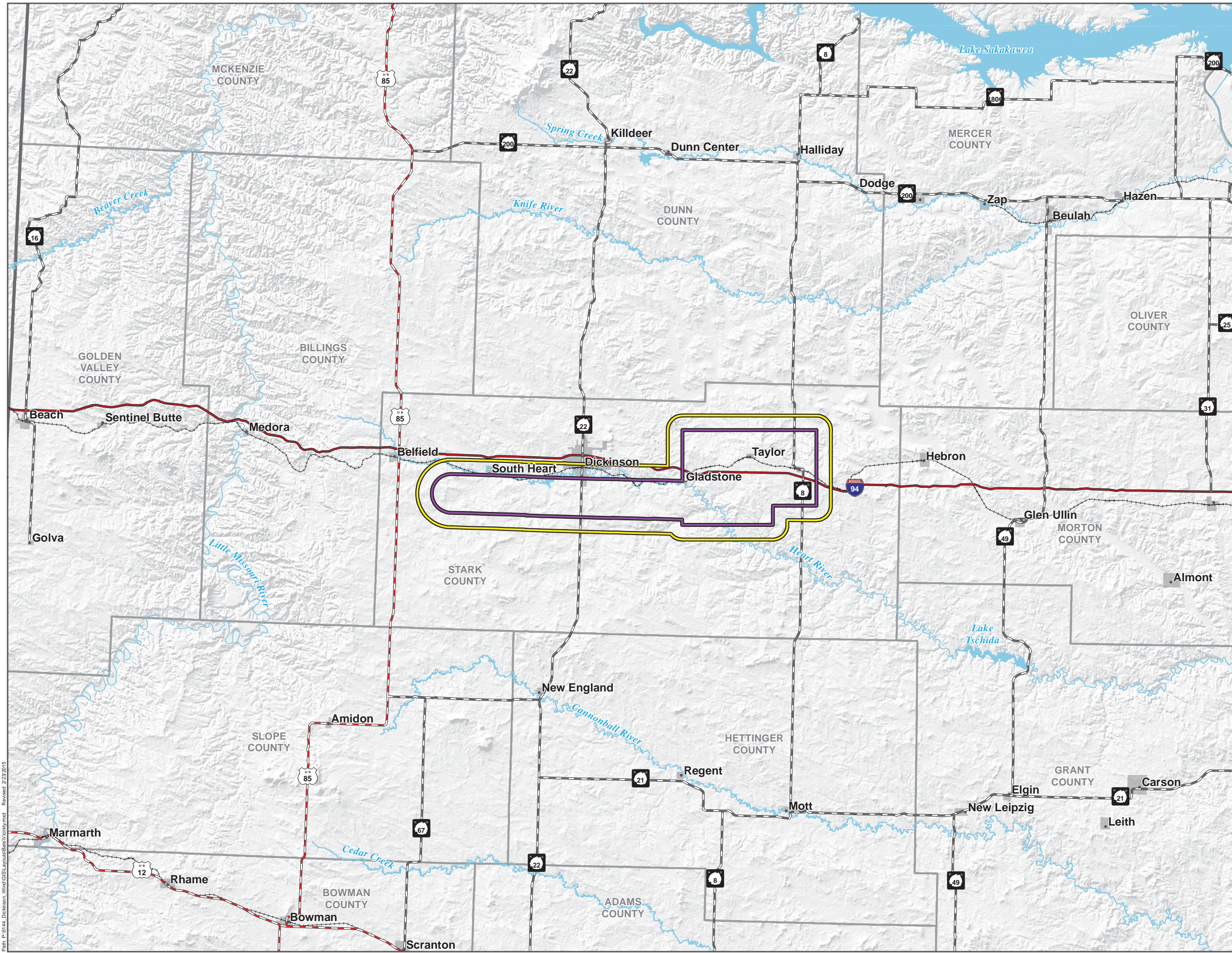
## Figure 1 Vicinity Map

### Legend

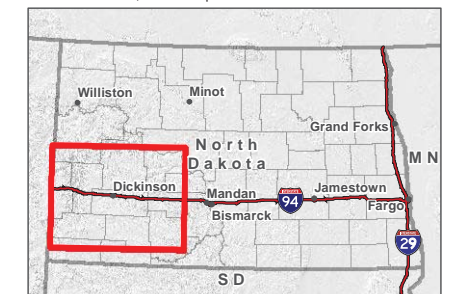
- Project Area
- Buffer Area
- County Boundary
- Major River
- Municipal Boundary

### Transportation

- Interstate Highway
- U.S. Highway
- State Highway
- Rail



Scale is 1:300,000 when printed at 22 x 34







# Dickinson Wind Energy Center
















Stark County, ND

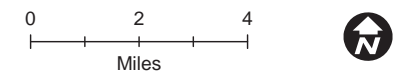
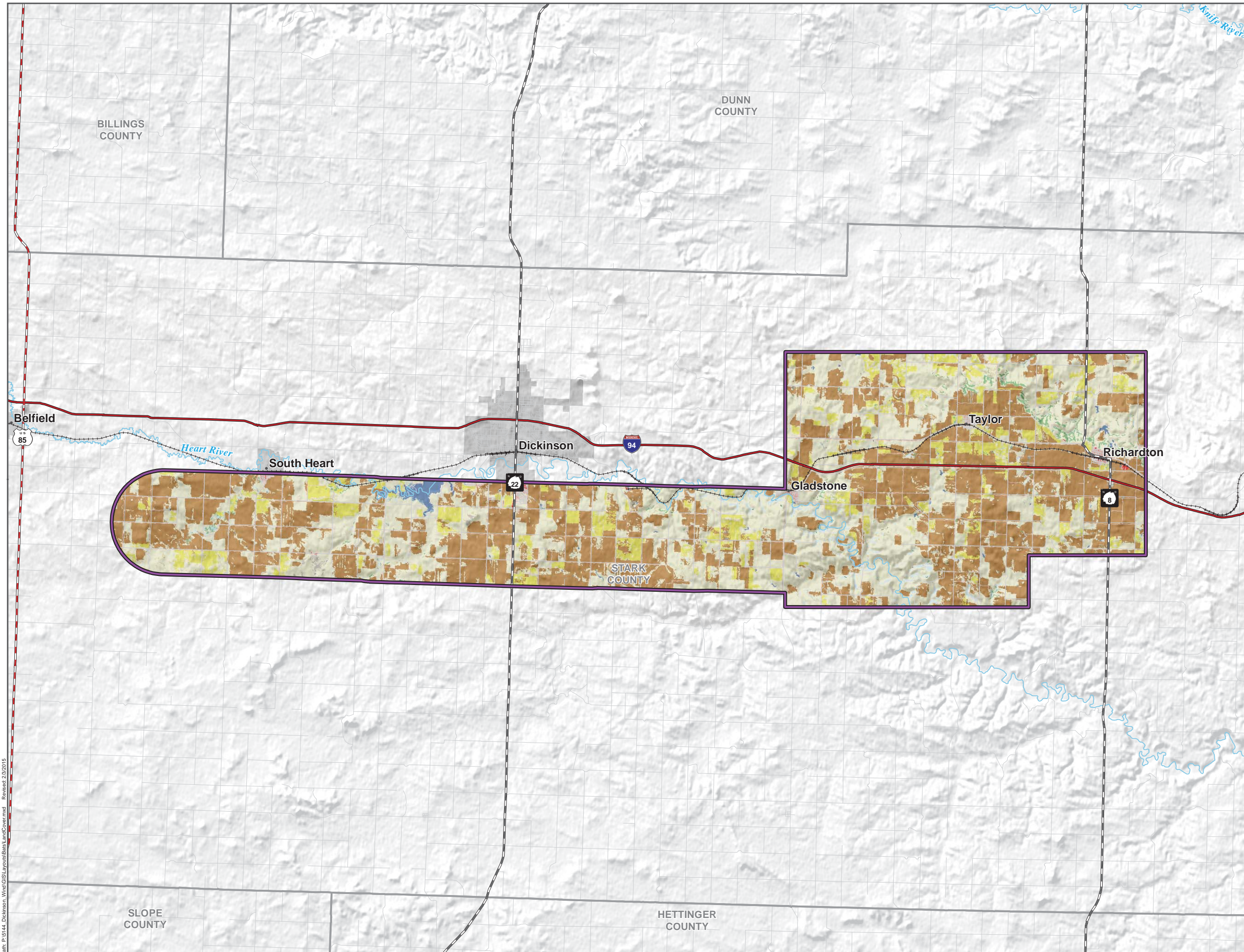
## Figure 2 Land Cover

### Legend

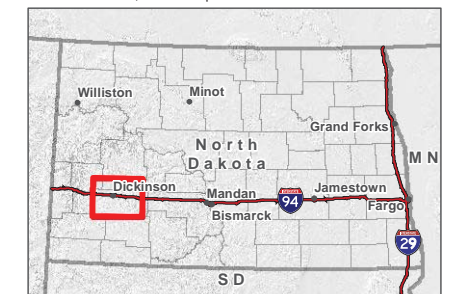
-  Project Area
-  County Boundary
-  Major River
-  Municipal Boundary

### Land Cover

-  Open Water
-  Developed, Open Space
-  Developed, Low Intensity
-  Developed, Medium Intensity
-  Developed, High Intensity
-  Barren Land (Rock/Sand/Clay)
-  Deciduous Forest
-  Evergreen Forest
-  Mixed Forest
-  Shrub/Scrub
-  Grassland/Herbaceous
-  Pasture/Hay
-  Cultivated Crops
-  Woody Wetlands
-  Emergent Herbaceous Wetlands



Scale is 1:112,000 when printed at 22 x 34



# Dickinson Wind Energy Center

Stark County, ND

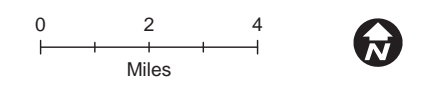
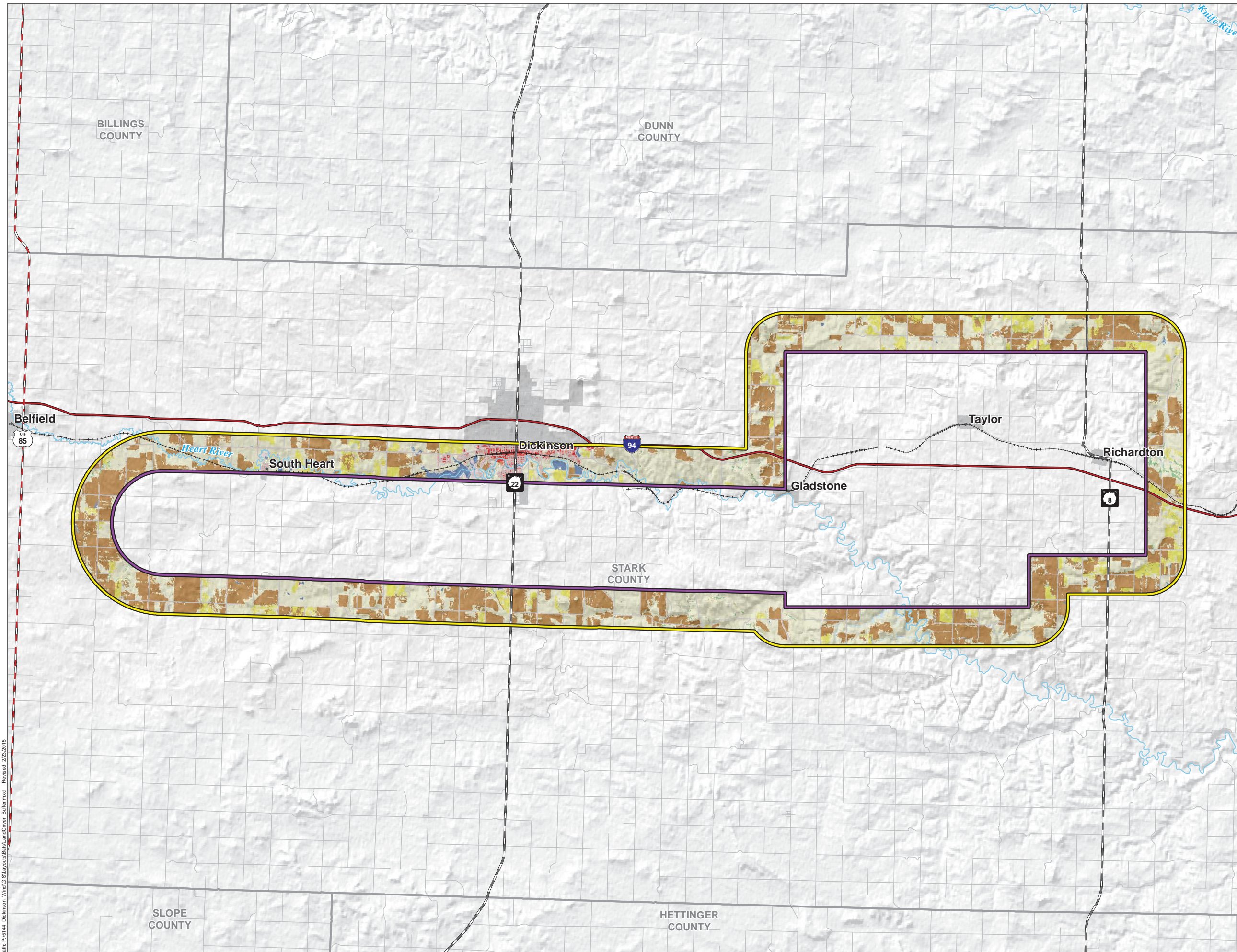
## Figure 3 Land Cover Buffer

### Legend

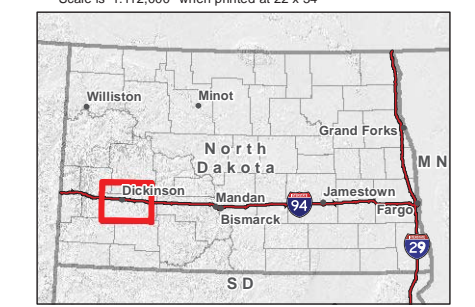
- Project Area
- Buffer Area
- County Boundary
- Major River
- Municipal Boundary

### Land Cover

- Open Water
- Developed, Open Space
- Developed, Low Intensity
- Developed, Medium Intensity
- Developed, High Intensity
- Barren Land (Rock/Sand/Clay)
- Deciduous Forest
- Evergreen Forest
- Mixed Forest
- Shrub/Scrub
- Grassland/Herbaceous
- Pasture/Hay
- Cultivated Crops
- Woody Wetlands
- Emergent Herbaceous Wetlands



Scale is 1:112,000 when printed at 22 x 34



Path: P:\5144\_Dickinson\_Wind\GIS\Layouts\Basemap\_LandCover\_Buffer.mxd Revised: 2/22/2015









# Dickinson Wind Energy Center



Stark County, ND

## Figure 4 Geology





### Legend

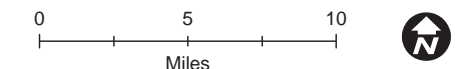
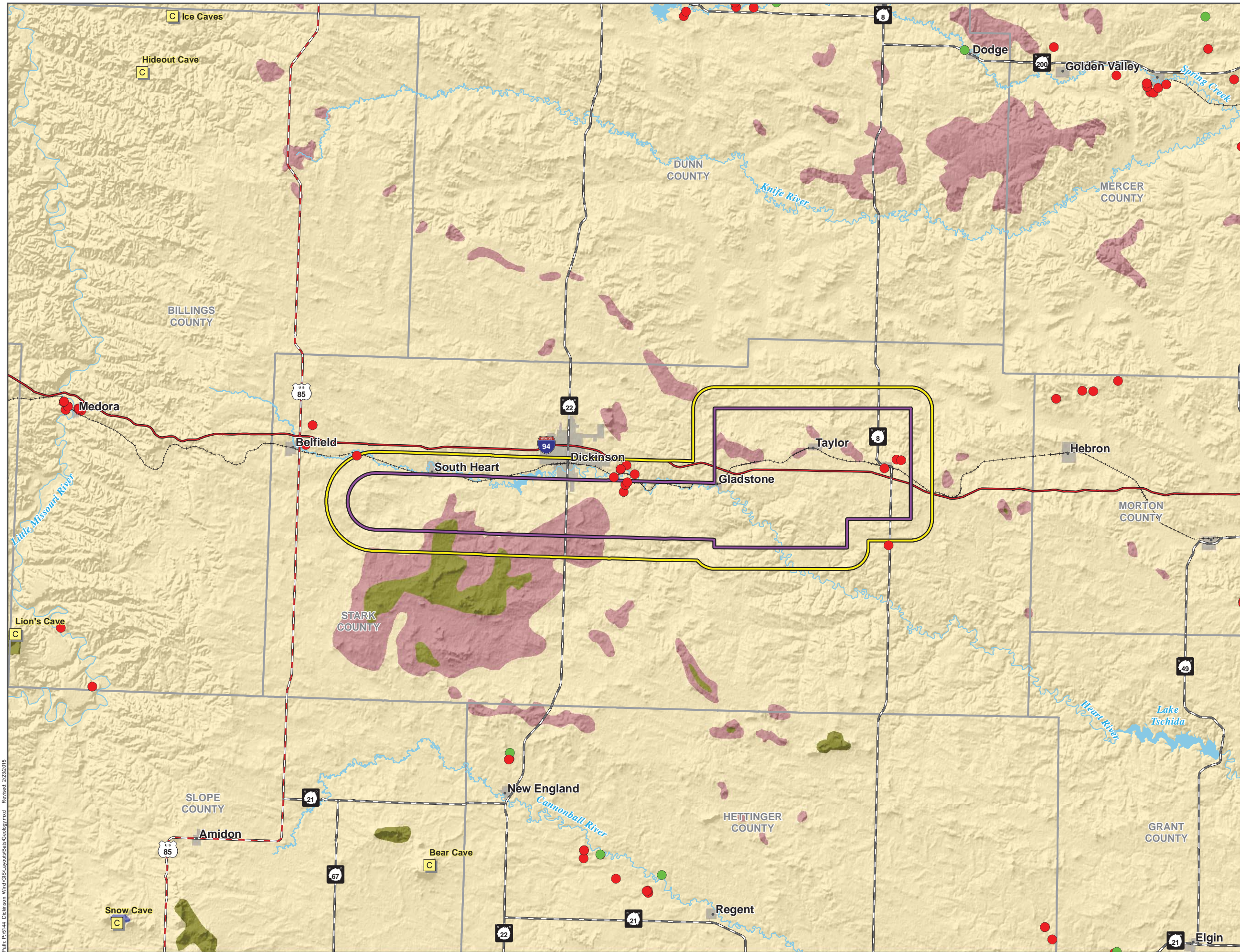
-  Project Area
-  Buffer Area
-  County Boundary
-  Major River
-  Municipal Boundary
-  Approximate Cave Location

### Abandoned Mines

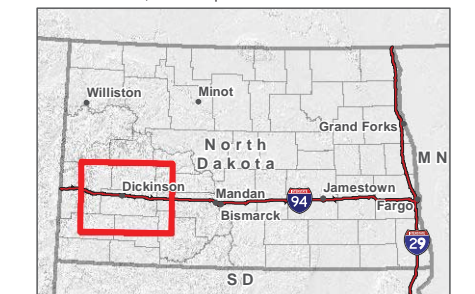
-  Underground
-  Underground/Surface

### Bedrock Geology

-  Micaceous Sandstone, Sand, Silt, Clay
-  Sandstone or Limestone, Butte Caprock
-  Silt, Sand, Clay, Sandstone, and Lignite
-  Siltstone, Clay, Sand







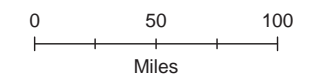
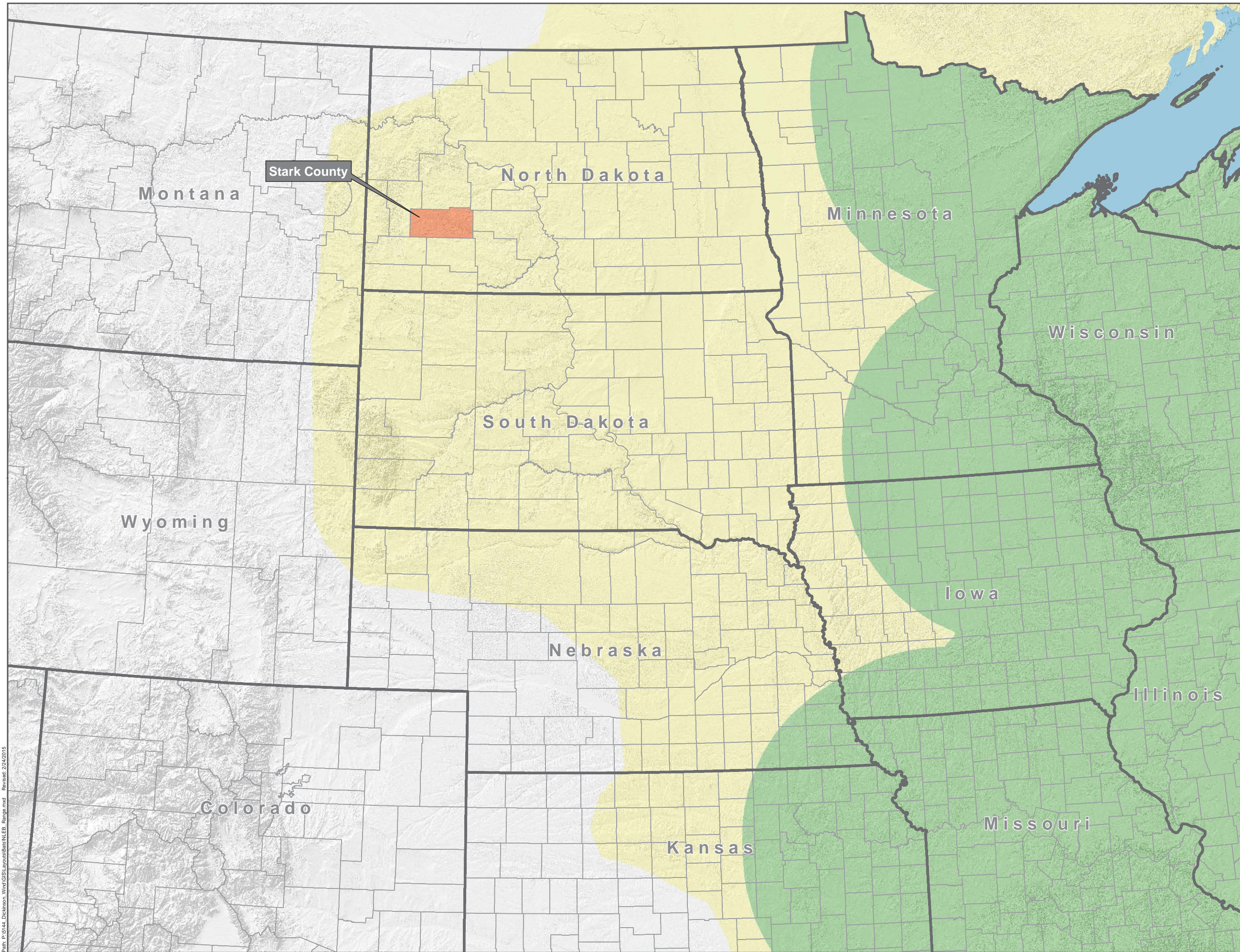
Scale is 1:205,000 when printed at 22 x 34



**Figure 5**  
Northern Long-eared Bat Range and USFWS White-nose Syndrome Buffer

**Legend**

-  USFWS White-nose Syndrome Buffer
-  Northern Long-eared Bat Range
-  State Boundary
-  County Boundary



Scale is 1:2,500,000 when printed at 22 x 34

