Dakota Range Wind Project

Acoustic Assessment

Northern States Power Company, a Minnesota corporation, d/b/a Xcel Energy

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Prepared for:

Northern States Power Company, a Minnesota corporation, d/b/a Xcel Energy
414 Nicollet Mall, 8th Floor
Minneapolis, MN, 55401

Prepared by:

AECOM
1000 East Calgary Avenue, Suite 1
Bismarck, ND 58503
aecom.com

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Executive Summary

This acoustic assessment has been completed by AECOM for the proposed Dakota Range Project (project) in Grant and Codington counties, South Dakota. The project will consist of 72 wind turbine generators (WTGs) and associated access roads, underground electrical systems, collection substations, a laydown yard, an operations and maintenance building, meteorological evaluation towers, and a concrete batch plant. For the acoustic assessment, two WTG layout arrangements were considered, one with alternate WTGs (83 WTGs) and the other without (72 WTGs). The WTGs in these layout designs include three Vestas WTG model types, a 4.2-megawatt (MW) generator, a 3.6-MW generator, and a 2.2-MW generator. The objective of this assessment was to determine whether nominal project operations would be compliant with the jurisdictionally applicable sound level limits.

WTG sound source data was obtained from Vestas for the proposed V136 4.2-MW, V136 3.6-MW, and V120 2.2-MW generators. Outdoor sound propagation modeling of aggregate WTG operation sound level was performed with Datakustik CadnaA software, a program that predicts sound levels near industrial sound-generating sources, based on the International Organization of Standardization 9613-2 standards for outdoor sound propagation calculation (ISO 1996). This software uses industry-accepted propagation algorithms and accepts input of sound reference levels as provided by equipment manufacturers and other sources of relevant information.

Predicted sound levels attributed to aggregate WTG operations were compared with the Grant and Codington county thresholds at each receptor in the project vicinity. The results of this assessment conclude that the project would not generate exceedances of any applicable thresholds at any receptor locations. Thus, the project would be compliant with regulatory sound level thresholds.

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Acronyms and Abbreviations

Dakota Range	Dakota Range I, LLC and Dakota Range II, LLC
dB	decibel(s)
dBA	A-weighted decibel(s)
Hz	hertz
ISO	International Organization for Standardization
kV	kilovolt(s)
L_{eq}	equivalent sound level
L_n	a sound level exceeded for a cumulative “n” percentage of a measurement or studied period
LORS	laws, ordinances, regulations, and standards
L_w	sound power
MW	megawatt(s)
OBCF	octave band center frequency
project	Dakota Range Wind Energy Project
SPL	sound pressure level
WTG	wind turbine generator

1. Introduction

Dakota Range I, LLC and Dakota Range II, LLC (Dakota Range), a wholly-owned, indirect subsidiary of Northern States Power Company, Minnesota (doing business as Xcel Energy), is proposing to construct an approximately 300-megawatt (MW) wind energy conversion facility in Grant and Codington counties, South Dakota, known as the Dakota Range Wind Energy Project (project). The project would have up to 72 turbines, 11 alternative turbine locations, access roads, underground electrical collection and communication systems, collection substation, meteorological evaluation towers, an operations and maintenance facility, and temporary works spaces for a construction laydown area and a batch plant.

1.1 Study Area and Existing Acoustic Environment

The noise study area was expanded beyond typical receptor screening distances to remain consistent with previous noise studies, conducted for the project's original South Dakota Public Utility Commission (Commission) application submission (Epsilon 2018). Therefore, the acoustic assessment study area encompasses approximately 103,500 acres, approximately bounded on the north by 146th Street, on the east by 465th Avenue, on the south by 162nd Street, and on the west by 451st Avenue.

The receptors in the area include rural farmstead residences and a church. In addition to using the receptor locations identified in the previous noise studies for the project's original Commission application, aerial imagery surrounding the immediate turbine vicinity (captured in spring 2020) was reviewed to add any new receptors constructed since the original study. This updated aerial imagery also was used to refine the existing receptor locations (e.g., where homes appear to have been reconstructed at different locations). The re-analysis of study area receptors resulted in shifting two receptor locations and adding 13 newly identified receptors.

Grant and Codington counties generally are considered rural agricultural areas, and thus are expected to have reasonably low ambient sound levels. Existing sound sources in the area are likely to be dominated by distant traffic noise, generated by arterial roadways (e.g., Interstate 29 and 157th Street), intermittent aircraft overflights, seasonal sounds from agricultural operations, and natural sounds, such as those generated by wildlife (e.g., bird call, insect sounds) and the meteorological environment (e.g., wind-generated noise).

1.2 Glossary of Acoustical Terminology

Fundamental concepts and terms discussed in this report are summarized as follows.

Sound and Noise: For this analysis, sound is a physical phenomenon generated by vibrations that result in waves that travel through a medium, such as air, and result in auditory perception by the human brain. Whether sound is perceived as noise is influenced by the type of sound, the perceived importance of the sound, and its appropriateness in the setting, the time of day, the type of activity during which the noise occurs, and the sensitivity of the listener. Local jurisdictions may have legal definitions of what constitutes "noise" and such environmental parameters to consider.

Frequency: Sound frequency or "pitch" is measured in hertz (Hz), which is a measure of how many times each second the crest of a sound pressure wave passes a fixed point. For example, when a cone of a loudspeaker pulses forwards and back 100 times per second, it generates a sound pressure wave that is oscillating at 100 Hz, and this pressure oscillation is perceived by the brain as a tonal pitch of 100 Hz. Sound frequencies between 20 and 20,000 Hz are within the range of sensitivity of the best human ear. As humans age, the ability to perceive frequencies at the top end of this spectrum gradually is lost.

Amplitude or Level: Sound levels are measured in decibels (dB) using a logarithmic scale. A sound level of zero dB is approximately the threshold of human hearing and is barely audible under extremely quiet listening conditions. Normal speech has a sound level of approximately 60 dB. Sound levels above approximately 110 dB begin to be felt inside the human ear as discomfort and eventually as pain at 120 dB and higher levels. The minimum change in the sound level of individual events that the average human ear can detect is about 1 to 2 dB in an ideal acoustic environment. A 3 to 5 dB change is more-readily perceptible. A change in sound level of about 10 dB usually is perceived by the average person as a doubling (or if decreasing by 10 dB, halving) of the sound's loudness.

Sound pressure: Sound level usually is expressed by reference to a known standard. This report refers to sound pressure level (SPL), which is expressed on a logarithmic scale with respect to a reference value of 20 micropascals. SPL depends not only on the power of the source, but also on the distance from the source and the acoustical characteristics of the space surrounding the source.

Sound power (L_w): Unlike sound pressure, which varies with distance from a source, sound power (and its counterpart sound power level) is the acoustic power of a source, typically expressed in watts.

A-weighting: Sound from a tuning fork contains a single frequency (a pure tone), but most sounds heard in the environment do not consist of a single frequency and instead are composed of a broad band of frequencies, differing in sound levels. The method commonly used to quantify environmental sounds consists of evaluating all frequencies of a sound according to a weighting system that reflects the typical frequency-dependent sensitivity of average healthy human hearing. This is called "A-weighting," and the measured decibel level is referred to as dBA.

Equivalent sound level (L_{eq}): Environmental noise levels vary continuously and include a mixture of noise from near and distant sources. A single descriptor, L_{eq} may be used to describe such sound that is changing in level from one moment to another. L_{eq} is the energy-average sound level during a measured time interval. It is the "equivalent" constant sound level that has to be produced by a single, steady source to equal the acoustic energy contained in the fluctuating sound level measured.

Statistical Distribution L_n (e.g., L_{90}): A sound level exceeded for a cumulative "n" percentage of a measurement or studied period, such as L_{10}, L_{50} or L_{90}. L_{90}, commonly is called the "background" level because it typically represents acoustical contribution from continuous or "steady-state" sound sources and the perceived indistinct din of background noise from the amalgamation of many contributing distant sound sources in the environment.

Receptor: For this study and consistency with the local regulations (summarized in Chapter 2), a receptor is defined as a residence, business, or a building owned and/or maintained by a governmental entity.

1.3 Acoustical Concepts

Sound Propagation

Atmospheric conditions (e.g., wind, temperature gradients, humidity) can change how sound propagates over distance and can affect the level of sound received at a given location. The degree to which the ground surface absorbs acoustical energy also affects sound propagation. Sound traveling over an acoustically absorptive surface (e.g., grass) attenuates at a greater rate than sound traveling over a hard surface (e.g., pavement, expanses of open water). When located near either the sound source or the listener position, physical barriers (e.g., naturally occurring ridgelines or buildings, and other topography that block the line-of-sight between a source and receiver) also increase the attenuation of sound over distance.

Multiple Sound Sources

Because SPLs in decibels are based on a logarithmic scale, they cannot be added or subtracted in an arithmetic fashion. Therefore, SPLs in dB are added logarithmically on an energy summation basis. In other words, adding a new noise source to an existing noise source, both producing noise at the same level, does not double the noise level. Instead, if the difference between two noise sources is 10 dBA or more, the louder noise source dominates, and the resultant noise level is equal to the noise level of the louder source. In general, if the difference between two noise sources is 0 to 1 dBA, the resultant noise level is 3 dBA higher than the louder noise source, or both sources if they are equal. If the difference between two noise sources is 2 to 3 dBA, the resultant noise level is 2 dBA above the louder noise source. If the difference between two noise sources is 4 to 10 dBA, the resultant noise level is 1 dBA higher than the louder noise source.

1.4 Review of Sound Generated by Wind Turbine Generator Facilities

Sound generated by operation of a modern downwind-mast (i.e., a supporting tower downstream from the spinning bladed rotor) wind turbine generator (WTG) is a combination of the following sound sources:

- blade sounds created by trailing edge pressure fluctuations and turbulence, leading edge inflow turbulence, and tip vortex structures; and
- the mechanical equipment housed within the nacelle just behind the WTG bladed rotor hub, which includes a gearbox, generator, and cooling fan(s).

For large, utility-scale WTGs currently engineered and offered by leading manufacturers, such as the models considered for this project, mechanical sounds from the nacelle tend to be much less than the sound produced from aerodynamic effects caused by rotor interaction with the incoming wind.

At rest, when little or no wind energy exists to convert, a WTG produces negligible sound. As wind speeds rise to a "cut-in" magnitude, the WTG bladed rotor begins rotation and power generation. WTG energy conversion and corresponding aerodynamic sound then increase with increasingly greater received wind speed, up to a maximum rotational speed when the WTG maximum power capacity is attained. Although the WTG may experience elevated wind speeds that exceed what is necessary for maximum power capacity, the rotor rotational speed will not increase further and will produce an essentially constant SPL.

2. Regulatory Setting and Acoustic Impact Criteria

A review was conducted of federal, State, and local laws, ordinances, regulations, and standards (LORS), applicable to sound levels expected to be generated by project construction and operations. This review did not identify any applicable LORS at the federal or State level. At the local level, both Grant County and Codington County maintain zoning ordinances with established sound level limits applicable to wind energy systems.

2.1 Grant County

The northern portion of the project area is in Grant County and includes 101 of the 186 studied receptors. The Grant County Compiled Zoning Regulations (Grant County 2019) include special provisions for sound levels generated by wind energy systems, in Article 12, Section 11.04, Part 14, as follows:

> *Noise level shall not exceed 45 dBA, average A-weighted sound pressure including constructive interference effects measured twenty-five (25) feet from the perimeter of the existing non-participating residences, businesses, and buildings owned and/or maintained by a governmental entity.*
>
> *Noise level shall not exceed 50 dBA, average A-weighted sound pressure including constructive interference effects measured twenty-five (25) feet from the perimeter of the participating residences, businesses, and buildings owned and/or maintained by a governmental entity.*
>
> *Noise level measurements shall be made with a sound level meter using the A-weighting scale, in accordance with standards promulgated by the American National Standards Institute. A L_{90} measurement shall be used and have a measurement period no less than ten (10) minutes unless otherwise specified by the Board of Adjustment.*

Therefore, the project cannot exceed 45 dBA at 25 feet from non-participating receptors, and 50 dBA at 25 feet from participating receptors.

2.2 Codington County

The southern portion of the project area is in Codington County and includes 85 of the 186 studied receptors. Codington County Ordinance 68 (Codington County 2016) includes special provisions for sound levels generated by wind energy systems, in Chapter 5.22 Section 3, Part 12, as follows:

a. *Noise level generated by wind energy system shall not exceed 50 dBA, average A-weighted sound pressure level effects at the property line of existing non-participating residences, businesses, and buildings owned and/or maintained by a government entity.*

b. *Noise level measurements shall be made with a sound level meter using the A-weighting scale, in accordance with standards promulgated by the American National Standards Institute. A L_{90} measurement shall be used and have a measurement period no less than ten minutes unless otherwise specified by the Board of Adjustment.*

Therefore, the project cannot exceed 50 dBA at the property line of non-participating receptors. To assess this impact threshold, the Codington–Grant county line has been included in the report figures, along with hatched participating parcel polygons, to allow visual assessment of sound levels generated by project operations in Codington County.

Noise impact thresholds are defined by receptor county and participation status, as shown in Table 1.

Table 1. Regulatory Threshold per County of Residence and Participation Status

County	Participation Status	Sound Level Limit	Assessment Location
Grant	Participating	50 dBA	25 feet from structure
	Non-Participating	45 dBA	25 feet from structure
Codington	Participating	No Limit	Not applicable
	Non-Participating	50 dBA	Property line

Note:

dBA = A-weighted decibel(s)

Source: Compiled by AECOM in 2020

3. Sound Prediction Methodology and Results

3.1 Modeling Software and Calculation Methods

The DataKustik CadnaA® Noise Prediction Model (Version 2020 MR2) was used to estimate the aggregate SPL from proposed project operations at the identified receptor locations. CadnaA is a Microsoft Windows-based software program that predicts sound levels near sound sources based on the International Organization for Standardization (ISO) 9613-2 standard for outdoor sound propagation calculation. The model uses these industry-accepted propagation algorithms and accepts full-octave band (1/1) and one-third octave band (1/3) L_w (in dB re: one picoWatt), provided by the equipment manufacturer and other sources.

The software's calculations account classical sound wave geometric divergence, reflection off surfaces, source directivity, meteorological effects, and attenuation factors resulting from air absorption, basic ground effects, and barrier/shielding from structures and/or topography. Topographical information was imported into the model using the official U.S. Geological Survey's National Elevation Dataset to accurately represent existing topography in the project area.

3.2 Modeling Inputs and Parameters

3.2.1 Receptor Representation

Representative receiver points were modeled at each identified receptor structure in the study area. Receivers were modeled at a height of 1.5 meters (relative to the ground), which is representative of a typical listener height. A total of 186 receptors were identified.

3.2.2 WTG Source Representation

The predictive acoustic assessment reviewed two project WTG layouts, one with additional WTG locations ("With Alternates") and one without the additional WTGs ("No Alternates").

The project would install Vestas V136 4.2 MW, V136 3.6 MW, and V120 2.2 MW WTG units throughout the project vicinity. Sources in the model were located at each discrete proposed WTG pole location as a single, omnidirectional point source with a relative hub height of 269 and 263 feet (specified hub heights of the V136 and V120 WTG models, respectively). The project would incorporate serrated, trailing edge blade technology at all WTG units, effectively reducing the potential non-serrated sound emission from each WTG unit by 2 to 3 dBA.

Performance specifications and proprietary sound data for the selected WTG units were provided by the manufacturer for this study. Table 2 shows the various A-weighted SPL ratings for each studied unit at various wind speeds.

Table 2. Maximum Turbine Sound Power Levels Correlated with Wind Speed

WTG Model	3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11–19 m/s	20 m/s
Vestas V136 4.2 MW	90.9	91.1	92.8	95.9	99.5	102.8	103.9		EQUAL	103.9
Vestas V136 3.6 MW	94.1	94.5	95	97.3	100.3	103.2	105.3	105.5	EQUAL	105.5
Vestas V120 2.2 MW	99.1	99	100.6	103.4	105.3	107.6	108.6		EQUAL	108.6

Notes:

m/s = meters per second

MW = megawatt(s)

WTG = wind turbine generator

Source: Compiled by AECOM in 2020

In addition to anticipated sound levels at various wind speeds and blade types, these specifications also reported the spectral content of the WTGs in one-third octave band center frequency (OBCF) resolution. These documents report that source measurements were conducted in accordance with the International Electrotechnical Commission standard 61400-11 for acoustic measurement techniques. Specified one-third OBCF SPLs provided by the manufacturer for both WTG models are shown in Table 3. Because no power level uncertainty values were provided in the manufacturer specifications, a typical +2 dB adjustment was applied across all frequency bands for each WTG source.

Table 3. WTG Sound Power Level by One-Third Octave Band Center Frequency

WTG Model	One-Third Octave Band Center Frequency, Hz (bold) and Respective A-Weighted Sound Power Level, dBA									Total L_wA
Vestas V136 4.2 MW (Serrated)	**25**	**31.5**	**40**	**50**	**63**	**80**	**100**	**125**	**160**	**103.9**
	66.1	70.2	74.0	77.3	80.4	83.3	85.6	87.7	89.7	
	200	**250**	**315**	**400**	**500**	**630**	**800**	**1k**	**1.25k**	
	91.2	92.3	93.3	93.9	94.1	94.1	93.8	93.2	92.2	
	1.6k	**2k**	**2.5k**	**3.15k**	**4k**	**5k**	**6.3k**	**8k**	**10k**	
	90.9	89.3	87.5	85.3	82.7	80.0	76.9	73.3	69.7	
Vestas V136 3.6 MW (Serrated)	**25**	**31.5**	**40**	**50**	**63**	**80**	**100**	**125**	**160**	**105.5**
	68.2	72.2	75.9	79.2	82.2	85.0	87.4	89.4	91.4	
	200	**250**	**315**	**400**	**500**	**630**	**800**	**1k**	**1.25k**	
	92.8	94.0	94.9	95.5	95.7	95.7	95.3	94.7	93.8	
	1.6k	**2k**	**2.5k**	**3.15k**	**4k**	**5k**	**6.3k**	**8k**	**10k**	
	92.5	90.9	89.1	87.0	84.4	81.7	78.6	75.1	71.5	
Vestas V120 2.2 MW (Serrated)	**25**	**31.5**	**40**	**50**	**63**	**80**	**100**	**125**	**160**	**108.6**
	67.3	71.4	75.3	78.7	82.0	85.0	87.6	89.9	92.2	
	200	**250**	**315**	**400**	**500**	**630**	**800**	**1k**	**1.25k**	
	93.9	95.4	96.6	97.6	98.2	98.6	98.7	98.5	98.0	
	1.6k	**2k**	**2.5k**	**3.15k**	**4k**	**5k**	**6.3k**	**8k**	**10k**	
	97.2	96.2	94.9	93.2	91.2	89.1	86.6	83.7	80.8	

Notes:
dBA = A-weighted decibel(s)
Hz = hertz
L_wA = A-weighted sound power
MW = megawatt(s)
WTG = wind turbine generator

3.2.3 Meteorological Input and Model Configuration

The sound propagation prediction model developed for this study assumed an outdoor air temperature of 50 degrees Fahrenheit and relative humidity of 70 percent, consistent with modeling recommendations from the Institute of Acoustics (IOA 2013).

The average ground absorption coefficient, which can range from zero (for acoustically reflective surfaces, such as water or pavement) to unity (1, for acoustically absorptive ground coverings, such as loose, porous soils or snow), was set to an average of 0.5 for consistency with modeling recommendations from the Institute of Acoustics (IOA 2013). This input parameter is notably conservative in comparison to actual site conditions, which are expected to exhibit higher ground absorption coefficients of 0.8 to 1 because of the prevalence of natural grasslands, agricultural soils, and seasonal snow cover.

As sounds waves propagate from the source, their energy continuously is degraded by atmospheric absorption. Atmospheric absorption rates improve as acoustical frequency increases and vary with temperature and moisture content. Although acoustical energy loss because of this environmental factor generally is modest at distances less than 1,000 feet, over greater distances the result is a substantial reduction of high-frequency sound and the apparent preservation of low-frequency sound that attenuates (because of ground and atmospheric absorption) at much lower rates.

With respect to wind speed and direction, the ISO 9613-2 standard conservatively assumes that all receptors are downwind from the sound-producing source. Acknowledged as a physical impossibility (i.e., because wind is experienced as having direction), this downwind assumption is intended to represent worst-case meteorological conditions, such as moderate temperature inversions. Such conditions are assumed to be valid for the study of WTG operational sound, which assumes operation under wind conditions at which the “maximum [rotor] rotational speed” is expected, coinciding with maximum power production per tower.

3.2.4 Substation Sound

One 345-kilovolt (kV) collection substation would be constructed in the project area, featuring one 188-megavolt-ampere transformer. Sound generated by the substation would be dominated by a “humming” sound from the main transformer, which is specified to be 79 dBA, SPL or less at a 1-meter distance. Transformer OBCF L_w data was based on the “Estimation Method 1” adjustment factors provided in the Electric Power Plant Environmental Noise Guide (EEI 1984). The maximum OBCF sound power levels for the transformer are shown in Table 4. The 345 kV collection substation is approximately 0.25 mile west of the corner of 459th Avenue and 150th Street, and is approximately 4,370 feet from the closest receptor, receptor 2158 to the east-northeast.

Table 4. Substation Transformer A-Weighted Sound Power Levels

Transformer Rating (MVA)	A-Weighted Sound Power Level, dBA, per One-Third OBCF, Hz									Total L_wA
	31.5	63	125	250	500	1k	2k	4k	8k	
167	98	104	106	101	101	95	90	85	78	102

Notes:
dBA = A-weighted decibel(s)
Hz = hertz
L_wA = A-weighted sound power
MVA = megavolt-ampere
OBCF = octave band center frequency

3.3 Predictive Modeling Results

Each predictive operations model assumed that all WTGs would be operating concurrently in a maximum rotational wind speed scenario. Predicted levels are provided in tabulated form in Appendix A (Tables A-1 and A-2) and are shown at the end of this chapter in Figures 1a, 1b, 2a, and 2b. The figures show the predicted project-generated sound levels as they propagate into the study area as color-coded isopleths or “sound contours.” Although aggregate WTG operational sound levels may be compliant with County requirements, under the right meteorological conditions, WTG sound still may be audible at a receptor.

Grant County Non-Participating Receptors

As shown in Table A-1, project-generated sound levels at non-participating receptors would range from 16 to 44 dBA. Thus, project-generated sound levels would not exceed the Grant County 45 dBA sound level limit at any non-participating receptors.

Grant County Participating Receptors

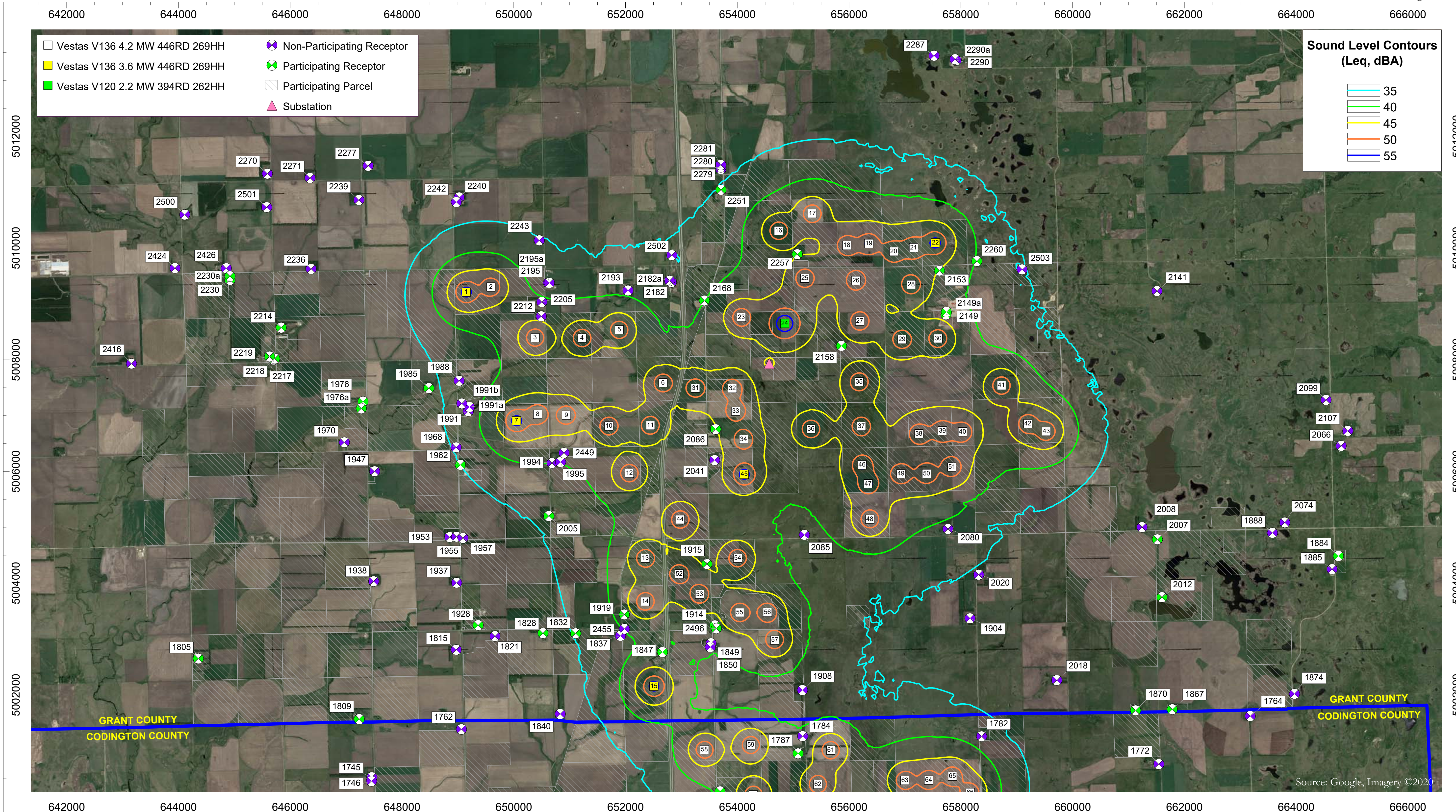
As shown in Tables A-1, project-generated sound levels at participating receptors would range from 16 to 45 dBA. Thus, project-generated sound levels would not exceed the Grant County 50 dBA sound level limit at any non-participating receptors.

Codington County Non-Participating Receptors

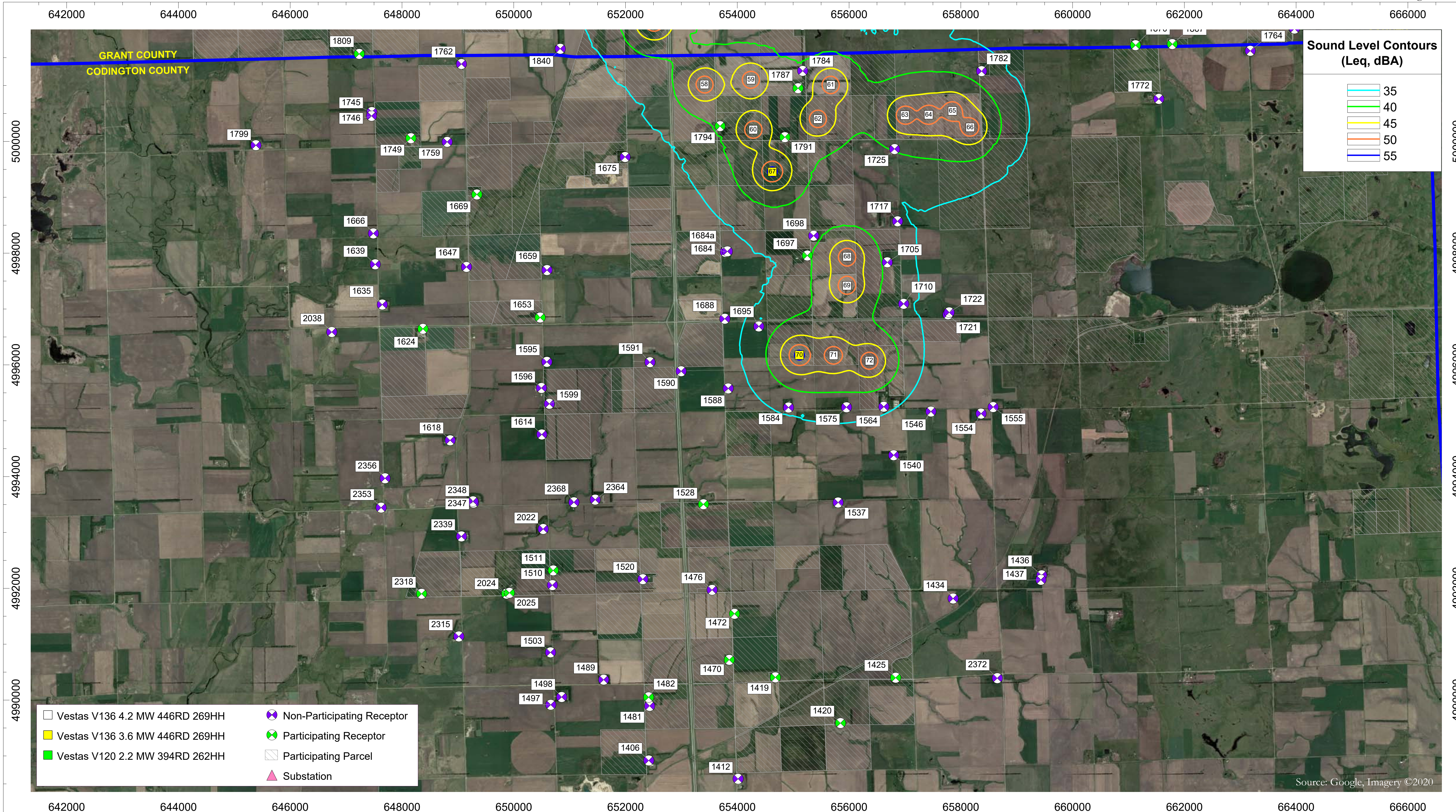
As shown in Table A-2, project-generated sound levels at non-participating receptors would range from 11 to 41 dBA. Although these predicted levels are well below the Codington County sound level limit of 50 dBA, sound level impacts are assessed at the receptor property line. Figures 1a, 1b, 2a, and 2b show that project-generated sound levels would not exceed 50 dBA at any non-participating receptor parcel boundaries.

Codington County Participating Receptors

As shown in Table A-2, project-generated sound levels at participating receptors would range from 13 to 43 dBA. Participating receptors in Codington County are not held to any sound level limit regulations. Thus, project-generated sound levels would be compliant.



N	Date Created: 8/13/2020	**Operational Sound Levels | No Alternates**	**Figure 1a**
	Created by: CK	**Wind Turbines at Maximum Rotational Wind Speed**	
AECOM Imagine it. Delivered. Acoustics & Noise Control Practice		**Predicted Project Operation Noise Contours** **Dakota Range Wind Energy Project** **Codington and Grant Counties, SD**	



Date Created: 8/13/2020	Operational Sound Levels | No Alternates Wind Turbines at Maximum Rotational Wind Speed	Figure 1b
Created by: CK	Predicted Project Operation Noise Contours Dakota Range Wind Energy Project Codington and Grant Counties, SD	

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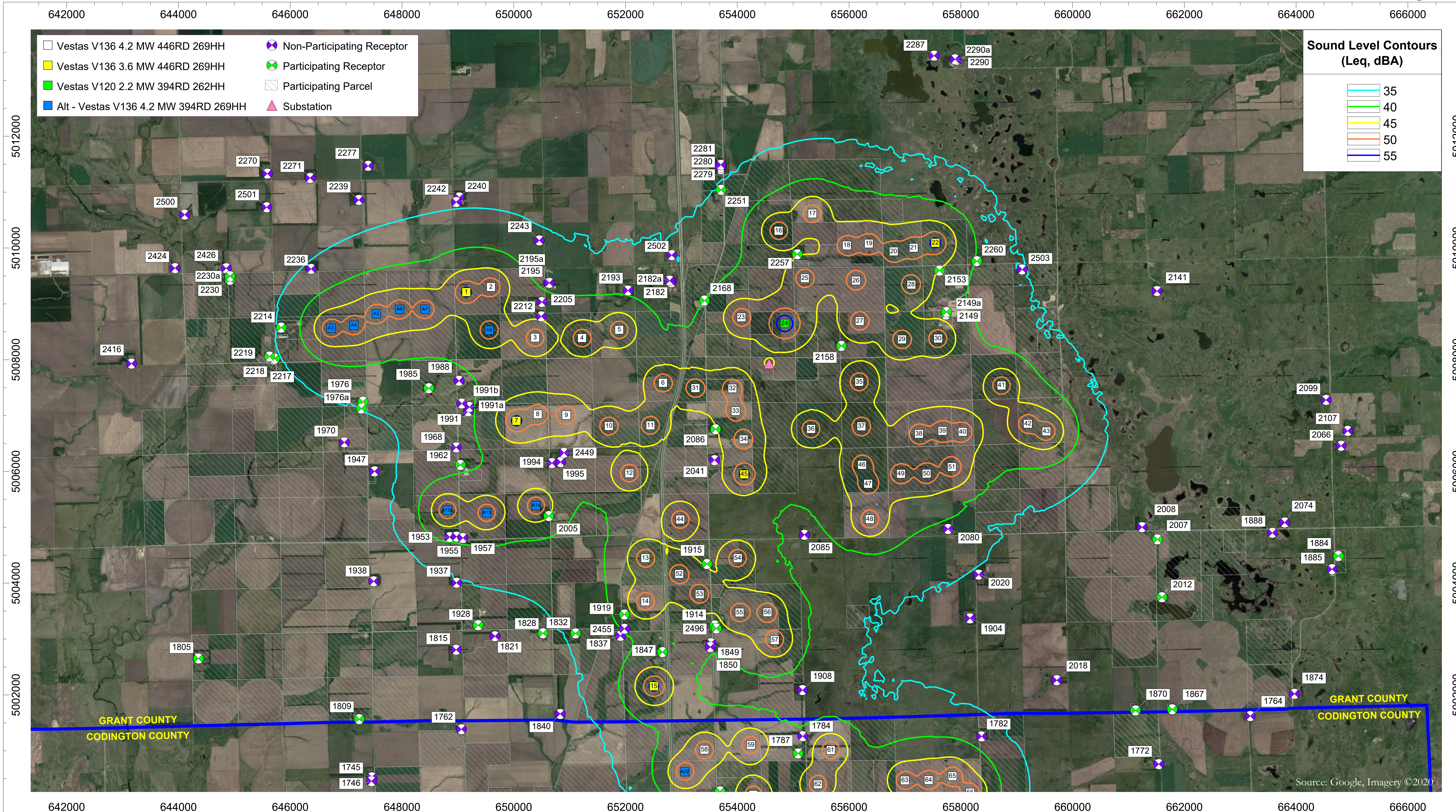

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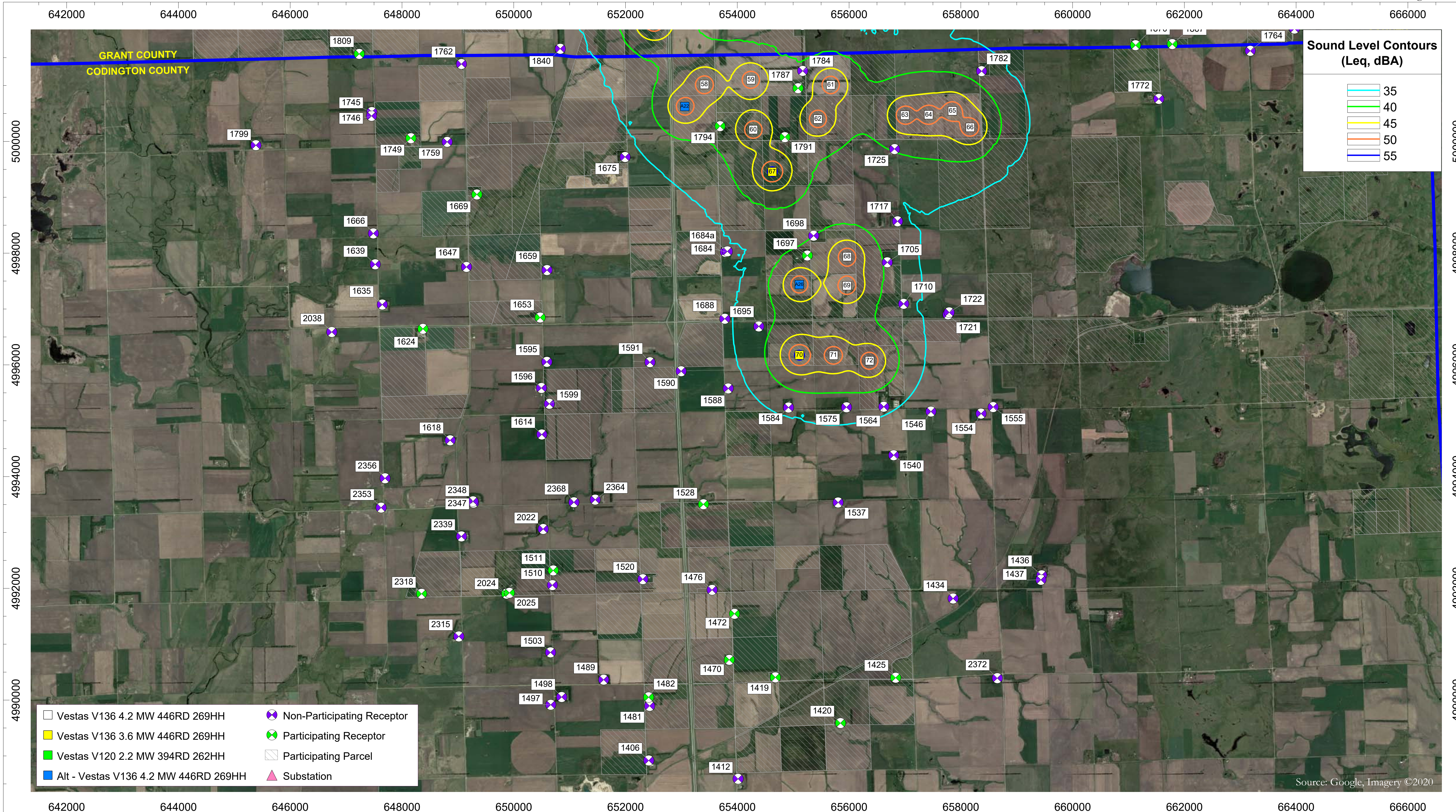
Operational Sound Levels | With Alternates
Wind Turbines at Maximum Rotational Wind Speed

Predicted Project Operation Noise Contours
Dakota Range Wind Energy Project
Codington and Grant Counties, SD

Figure 2a



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Date Created: 8/13/2020

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Operational Sound Levels | With Alternates
Wind Turbines at Maximum Rotational Wind Speed

Predicted Project Operation Noise Contours
Dakota Range Wind Energy Project
Codington and Grant Counties, SD

Figure 2b

4. Conclusions

The project's operational sound has been predicted and assessed against the applicable Grant County and Codington County sound limits. The predictive operational acoustical modeling, inclusive of conservative parameter assumptions and uncertainty corrections, demonstrates that the project would not generate exceedances of any applicable sound level thresholds at any studied receptors.

5. References

Codington County. 2016. *Ordinance #65, Zoning Ordinance of Codington County*. Available: https://www.codington.org/wp-content/uploads/2018/07/Ordinance-68-Section-5.22-WES.pdf. Accessed July 28, 2020.

Grant County. 2019 (March 1). *Grant County Compiled Zoning Ordinances*. Available: https://www.grantcounty.sd.gov/photos/downloads/Zone030119.pdf. Accessed July 28, 2020.

Edison Electric Institute (EEI). 1984. *Electrical Power Plant Environmental Noise Guide*. Report No. 3637, prepared by Bolt Beranek and Newman Inc.

Epsilon. 2018. *Dakota Range Wind Project Sound Level Modeling Report*.

Institute of Acoustics (IOA). 2013. *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise*.

International Organization for Standardization (ISO). 1996. "Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation." ISO 9613-2:1996(E).

Appendix A Prediction Results Tables

A.1 Predicted Project Operational Sound Levels at Grant County Receptors

Receptor ID	Receptor Coordinates (UTM Zone 14, NAD 83) Easting (m)	Northing (m)	Participation Status	Receptor Type	Grant County Sound Level Limit (L_{eq}, dBA)	Predicted Sound Level (L_{eq}, dBA) No Alternates	With Alternates
1805	644357	5002651	Participating	House	50	20	23
1809	647235	5001567	Participating	House	50	25	27
1815	648971	5002809	Non-Participating	House	45	29	31
1821	649665	5003051	Non-Participating	House	45	31	33
1828	650524	5003104	Participating	House	50	33	34
1832	651108	5003102	Participating	House	50	35	36
1837	651910	5003058	Non-Participating	House	45	39	40
1840	650833	5001658	Non-Participating	House	45	33	33
1847	652661	5002766	Participating	House	50	41	41
1849	653531	5002925	Non-Participating	House	45	41	41
1850	653518	5002857	Non-Participating	House	45	41	41
1867	661784	5001742	Participating	House	50	25	25
1870	661127	5001722	Participating	House	50	26	26
1874	663970	5002020	Non-Participating	House	45	22	22
1884	664756	5004487	Participating	House	50	16	16
1885	664644	5004251	Non-Participating	Business	45	20	20
1888	663576	5004902	Non-Participating	House	45	24	24
1904	658165	5003370	Non-Participating	House	45	33	33
1908	655166	5002087	Non-Participating	House	45	39	39
1914	653600	5003245	Participating	House	50	43	44
1915	653457	5004344	Participating	House	50	45	45
1919	651979	5003440	Participating	House	50	42	43
1928	649364	5003248	Participating	Barn	50	29	32
1937	648978	5004009	Non-Participating	Barn	45	30	35
1938	647494	5004033	Non-Participating	House	45	25	30
1947	647511	5006002	Non-Participating	Barn	45	29	34
1953	648855	5004825	Non-Participating	House	45	31	41
1955	648977	5004832	Non-Participating	House	45	31	42
1957	649090	5004809	Non-Participating	House	45	31	41
1962	649046	5006118	Participating	House	50	35	39
1968	648970	5006430	Non-Participating	House	45	35	38
1970	646969	5006521	Non-Participating	House	45	28	33
1976	647304	5007251	Participating	House	50	30	36
1976a	647274	5007128	Participating	House	50	29	35
1985	648481	5007490	Participating	House	50	34	38
1988	649022	5007624	Non-Participating	House	45	37	39
1991	649187	5007078	Non-Participating	House	45	38	39
1991a	649207	5007154	Non-Participating	House	45	38	40
1991b	649069	5007217	Non-Participating	House	45	37	39
1994	650685	5006150	Non-Participating	House	45	40	42
1995	650838	5006169	Non-Participating	House	45	40	41
2005	650627	5005202	Participating	House	50	36	45
2007	661518	5004784	Participating	House	50	29	29
2008	661243	5005003	Non-Participating	House	45	30	30
2012	661600	5003749	Participating	House	50	28	28

Receptor ID	Receptor Coordinates (UTM Zone 14, NAD 83)		Participation Status	Receptor Type	Grant County Sound Level Limit (L_{eq}, dBA)	Predicted Sound Level (L_{eq}, dBA)	
	Easting (m)	Northing (m)				No Alternates	With Alternates
2018	659717	5002264	Non-Participating	House	45	31	31
2020	658319	5004153	Non-Participating	House	45	35	35
2041	653594	5006202	Non-Participating	House	45	44	44
2066	664806	5006460	Non-Participating	House	45	17	17
2074	663797	5005086	Non-Participating	House	45	23	23
2080	657770	5004970	Non-Participating	House	45	39	39
2085	655202	5004866	Non-Participating	House	45	39	39
2086	653613	5006756	Participating	House	50	45	45
2099	664537	5007281	Non-Participating	House	45	17	17
2107	664924	5006726	Non-Participating	House	45	16	16
2141	661511	5009230	Non-Participating	House	45	25	25
2149	657735	5008810	Participating	House	50	43	43
2149a	657743	5008855	Participating	House	50	43	43
2153	657619	5009595	Participating	House	50	45	45
2158	655865	5008248	Participating	House	50	44	44
2168	653412	5009060	Participating	House	50	40	40
2182	652821	5009387	Non-Participating	House	45	37	38
2182a	652790	5009416	Non-Participating	House	45	37	38
2193	652045	5009239	Non-Participating	House	45	39	39
2195	650621	5009376	Non-Participating	House	45	39	39
2195a	650638	5009376	Non-Participating	House	45	39	39
2205	650503	5009034	Non-Participating	House	45	41	41
2212	650494	5008777	Non-Participating	House	45	43	44
2214	645841	5008575	Participating	House	50	26	36
2217	645709	5008004	Participating	House	50	25	34
2218	645721	5008021	Participating	House	50	26	34
2219	645631	5008057	Participating	House	50	26	34
2230	644923	5009430	Participating	House	50	23	30
2230a	644923	5009495	Participating	Church	50	23	30
2236	646375	5009625	Non-Participating	House	45	27	36
2239	647229	5010860	Non-Participating	House	45	28	32
2240	649025	5010906	Non-Participating	House	45	32	34
2242	648974	5010823	Non-Participating	House	45	33	34
2243	650458	5010136	Non-Participating	House	45	35	36
2251	653709	5011042	Participating	House	50	35	36
2257	655074	5009887	Participating	House	50	45	45
2260	658287	5009765	Participating	House	45	40	40
2270	645592	5011331	Non-Participating	House	45	23	28
2271	646356	5011254	Non-Participating	House	45	25	29
2277	647395	5011472	Non-Participating	House	45	27	30
2279	653707	5011413	Non-Participating	House	45	34	34
2280	653707	5011446	Non-Participating	House	45	34	34
2281	653705	5011489	Non-Participating	House	45	34	34
2287	657521	5013443	Non-Participating	House	45	29	29
2290	657918	5013363	Non-Participating	House	45	28	28
2290a	657897	5013379	Non-Participating	House	45	28	28
2416	643160	5007930	Non-Participating	House	45	19	24
2424	643939	5009640	Non-Participating	House	45	20	26

Recepto r ID	Receptor Coordinates (UTM Zone 14, NAD 83) Easting (m)	Northing (m)	Participation Status	Receptor Type	Grant County Sound Level Limit (L_{eq}, dBA)	Predicted Sound Level (L_{eq}, dBA) No Alternates	With Alternates
2426	644856	5009638	Non-Participating	House	45	23	29
2449	650900	5006334	Non-Participating	House	45	42	42
2455	651982	5003185	Non-Participating	House	45	40	41
2496	653626	5003190	Participating	House	50	43	43
2500	644112	5010598	Non-Participating	House	45	15	24
2501	645580	5010730	Non-Participating	House	45	24	29
2502	652828	5009872	Non-Participating	House	45	36	36
2503	659098	5009616	Non-Participating	House	45	35	35

Notes:

dBA = A-weighted decibel(s)

L_{eq} = equivalent sound level

m = meter(s)

Source: Compiled by AECOM in 2020

A.2 Predicted Project Operational Sound Levels at Codington County Receptors

Receptor ID	Receptor Coordinates (UTM Zone 14, NAD 83) Easting (m)	Northing (m)	Participation Status	Receptor Type	Codington County Sound Level Limit (L_{eq}, dBA)	Predicted Sound Level (L_{eq}, dBA) No Alternates	With Alternates
1406	652416	4988919	Non-Participating	House	50[1]	14	15
1412	654042	4988526	Non-Participating	House	50[1]	14	15
1419	654682	4990406	Participating	House	50[1]	13	13
1420	655847	4989588	Participating	House	50[1]	16	17
1425	656835	4990400	Participating	House	50[1]	18	18
1434	657862	4991817	Non-Participating	House	50[1]	16	17
1436	659447	4992233	Non-Participating	House	50[1]	20	20
1437	659433	4992153	Non-Participating	House	50[1]	20	20
1470	653858	4990720	Participating	House	50[1]	19	19
1472	653951	4991544	Participating	House	50[1]	21	22
1476	653550	4991972	Non-Participating	House	50[1]	22	22
1481	652432	4989894	Non-Participating	House	50[1]	10	11
1482	652414	4990051	Participating	House	50[1]	16	17
1489	651609	4990365	Non-Participating	House	50[1]	15	15
1497	650662	4989915	Non-Participating	House	50[1]	14	15
1498	650857	4990054	Non-Participating	House	50[1]	14	15
1503	650658	4990853	Non-Participating	House	50[1]	16	16
1510	650693	4992058	Non-Participating	House	50[1]	18	19
1511	650707	4992321	Participating	House	50[1]	19	20
1520	652311	4992164	Non-Participating	House	50[1]	19	20
1528	653395	4993505	Participating	House	50[1]	25	26
1537	655804	4993536	Non-Participating	House	50[1]	28	28
1540	656798	4994383	Non-Participating	House	50[1]	30	31
1546	657465	4995164	Non-Participating	House	50[1]	32	32
1554	658362	4995128	Non-Participating	House	50[1]	27	28
1555	658579	4995244	Non-Participating	House	50[1]	24	24
1564	656622	4995251	Non-Participating	House	50[1]	36	36
1575	655955	4995240	Non-Participating	House	50[1]	37	37
1584	654917	4995237	Non-Participating	House	50[1]	36	37
1588	653838	4995578	Non-Participating	House	50[1]	33	33
1590	652996	4995886	Non-Participating	House	50[1]	29	30
1591	652437	4996048	Non-Participating	House	50[1]	28	29
1595	650593	4996054	Non-Participating	House	50[1]	24	25
1596	650496	4995587	Non-Participating	House	50[1]	24	24
1599	650637	4995303	Non-Participating	House	50[1]	23	24
1614	650527	4994742	Non-Participating	House	50[1]	23	23
1618	648862	4994650	Non-Participating	House	50[1]	19	20
1624	648375	4996645	Participating	House	50[1]	20	22
1635	647648	4997080	Non-Participating	House	50[1]	21	22
1639	647523	4997800	Non-Participating	House	50[1]	21	22
1647	649155	4997753	Non-Participating	House	50[1]	24	24
1653	650473	4996848	Participating	House	50[1]	25	26
1659	650596	4997697	Non-Participating	House	50[1]	26	27
1666	647489	4998353	Non-Participating	House	50[1]	22	23
1669	649341	4999050	Participating	House	50[1]	24	25

Receptor ID	Receptor Coordinates (UTM Zone 14, NAD 83) Easting (m)	Northing (m)	Participation Status	Receptor Type	Codington County Sound Level Limit (L_{eq}, dBA)	Predicted Sound Level (L_{eq}, dBA) No Alternates	With Alternates
1675	651994	4999721	Non-Participating	House	50[1]	32	34
1684	653787	4998023	Non-Participating	House	50[1]	31	33
1684a	653823	4998032	Non-Participating	House	50[1]	33	34
1688	653778	4996826	Non-Participating	House	50[1]	33	34
1695	654385	4996688	Non-Participating	House	50[1]	37	38
1697	655254	4997957	Participating	House	50[1]	39	42
1698	655366	4998312	Non-Participating	House	50[1]	39	40
1705	656685	4997836	Non-Participating	House	50[1]	39	39
1710	656977	4997093	Non-Participating	House	50[1]	37	37
1717	656868	4998570	Non-Participating	House	50[1]	36	36
1721	657770	4996904	Non-Participating	House	50[1]	33	33
1722	657793	4996940	Non-Participating	House	50[1]	33	33
1725	656816	4999863	Non-Participating	House	50[1]	40	41
1745	647461	5000525	Non-Participating	House	50[1]	24	26
1746	647456	5000456	Non-Participating	House	50[1]	24	26
1749	648160	5000058	Participating	House	50[1]	25	26
1759	648809	4999992	Non-Participating	House	50[1]	26	27
1762	649064	5001386	Non-Participating	House	50[1]	27	28
1764	663179	5001621	Non-Participating	House	50[1]	24	24
1772	661543	5000761	Non-Participating	House	50[1]	25	25
1782	658372	5001257	Non-Participating	House	50[1]	38	38
1784	655170	5001262	Non-Participating	House	50[1]	41	41
1787	655087	5000952	Participating	House	50[1]	42	42
1791	654852	5000076	Participating	House	50[1]	43	43
1794	653693	5000273	Participating	House	50[1]	41	42
1799	645387	4999932	Non-Participating	House	50[1]	19	21
2022	650528	4993062	Non-Participating	House	50[1]	20	21
2024	649872	4991904	Participating	House	50[1]	17	18
2025	649922	4991918	Participating	House	50[1]	17	18
2038	646744	4996588	Non-Participating	House	50[1]	18	20
2315	649019	4991139	Non-Participating	House	50[1]	14	14
2318	648352	4991903	Participating	House	50[1]	14	15
2339	649064	4992930	Non-Participating	House	50[1]	15	16
2347	649280	4993534	Non-Participating	House	50[1]	19	19
2348	649271	4993557	Non-Participating	House	50[1]	19	19
2353	647627	4993445	Non-Participating	House	50[1]	16	17
2356	647698	4993970	Non-Participating	House	50[1]	17	17
2364	651457	4993587	Non-Participating	House	50[1]	22	23
2368	651076	4993540	Non-Participating	House	50[1]	21	21
2372	658654	4990393	Non-Participating	House	50[1]	17	18

Notes:

dBA = A-weighted decibel(s)

L_{eq} = equivalent sound level

m = meter(s)

1. The Codington County sound level limit of 50 dBA is assessed at non-participating receptor property lines only. Thus, this table should not be used for impact assessment. Figures 1a, 1b, 2a, and 2b, showing both predicted sound level contours and property boundaries, should be used for compliance assessment, in accordance with the Codington County zoning ordinance.

Source: Compiled by AECOM in 2020

Appendix B Wind Turbine Locations

B.1 Coordinates of Studied Wind Turbine Generators

Turbine ID	UTM Coordinates X	UTM Coordinates Y	Turbine ID	UTM Coordinates X	UTM Coordinates Y	Turbine ID	UTM Coordinates X	UTM Coordinates Y
T-001(1)	649151	5009211	T-029	656948	5008365	T-057	654672	5002981
T-002	649593	5009301	T-030	657593	5008380	T-058	653413	5001019
T-003	650382	5008394	T-031	653251	5007492	T-059	654244	5001104
T-004	651221	5008389	T-032	653912	5007486	T-060	654286	5000211
T-005	651888	5008536	T-033	653972	5007080	T-061	655673	5001011
T-006	652671	5007586	T-034	654113	5006574	T-062	655443	5000400
T-007(1)	650048	5006906	T-035	656181	5007604	T-063	656999	5000470
T-008	650429	5007024	T-036	655319	5006761	T-064	657424	5000476
T-009	650942	5007008	T-037	656220	5006808	T-065	657851	5000546
T-010	651702	5006813	T-038	657250	5006673	T-066	658167	5000252
T-011	652445	5006824	T-039	657671	5006727	T-067(1)	654626	4999457
T-012	652068	5005967	T-040	658032	5006709	T-068	655965	4997937
T-013	652355	5004449	T-041	658728	5007539	T-069	655963	4997416
T-014	652354	5003672	T-042	659200	5006854	T-070(1)	655111	4996175
T-015(1)	652508	5002155	T-043	659531	5006717	T-071	655723	4996172
T-016	654739	5010310	T-044	652980	5005140	T-072	656367	4996074
T-017	655343	5010618	T-045(1)	654125	5005949	A12a	648811	5005306
T-018	655960	5010046	T-046	656234	5006118	A13	649517	5005260
T-019	656354	5010078	T-047	656341	5005779	A14	650399	5005390
T-020	656800	5009939	T-048	656373	5005145	A22	653061	5000625
T-021	657156	5010005	T-049	656929	5005957	A26	655110	4997437
T-022(1)	657545	5010093	T-050	657388	5005960	A3	646727	5008564
T-023	654074	5008760	T-051	657840	5006079	A4	647138	5008617
T-024(2)	654850	5008650	T-052	652960	5004165	A5	647540	5008821
T-025	655210	5009459	T-053	653327	5003802	A6	647957	5008902
T-026	656124	5009415	T-054	654008	5004449	A7	648410	5008903
T-027	656191	5008691	T-055	654041	5003475	A8	649561	5008528
T-028	657114	5009343	T-056	654539	5003479			

(1) V136 3.6 MW Turbines
(2) V120 2.2 MW Turbines

Source: AECOM 2020

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