Appendix E

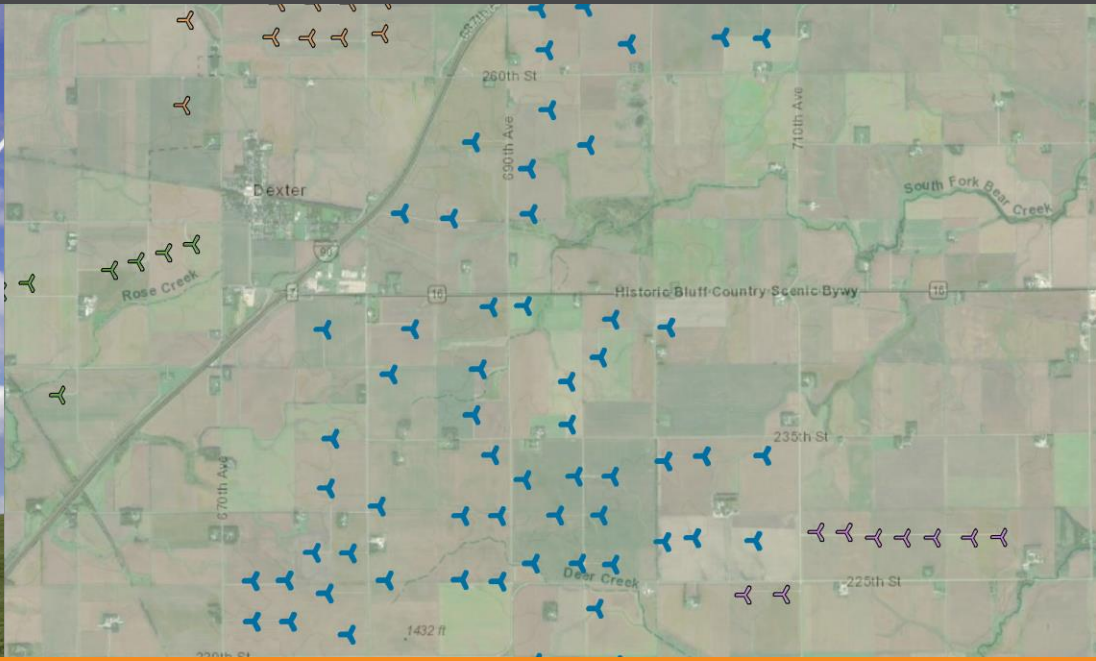
Noise Modeling for the Grand Meadow Repower Project

Northern States Power Company
Grand Meadow Wind Farm Repower Project
Docket No. IP-6646/WS-07-839
May 2021

GRAND MEADOW WIND FARM - REPOWER

NOISE ASSESSMENT

May 25, 2021



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CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

Xcel Energy ("Xcel") operates the Grand Meadow Wind Farm in Mower County, Minnesota. They are submitting a Site Permit Application ("SPA") to the Minnesota Public Utilities Commission ("PUC") to repower the wind farm. Repowering the Grand Meadow Wind Farm ("Project") will involve removing the hub and blades from 67 of the existing GE 1.5 MW turbines and installing a new hub and blades onto the existing towers which will upgrade the towers to 1.6 MW GE turbines. Additional details related to turbine modifications for the Project are provided in Section 2.0.

For the SPA, RSG conducted this noise assessment of the Project. Included in this report are:

- A description of the Project;
- A discussion of applicable sound level standards;
- A discussion of background sound levels;
- Sound propagation modeling procedures and results; and
- Conclusions.

Appendix A includes a primer on the science of sound, including descriptions of some of the acoustical terms used in this report, and Appendix B includes a discussion of sound issues that are particular to wind farms.

2.0 PROJECT DESCRIPTION

The Grand Meadow Wind Farm is located in Mower County, east of Dexter, Minnesota. The Project is bounded by Interstate 90 (I-90) to the northwest, 270th Street to the north, 710th Avenue to the east, 210th Street to the south, and 670th Avenue (Country Highway 7) to the west. Minnesota Route 16 (MN-16) runs west to east in the northern third of the Project area. The closest Grand Meadow turbine to Dexter is T-112 which lies approximately 1,000 meters (0.6 miles) to the east. To the southwest, T-156 is the closest turbine to the City of Elkton which lies approximately 1,350 meters (0.8 miles) south-southwest of the turbine. The area around the Project is composed primarily of agricultural land uses with rural and farm residences spread throughout the area. The terrain is mostly flat.

The Project is currently composed of 67 GE 1.5 MW turbines. Repowering them will involve removing the hub and blades and replacing them to upgrade to GE 1.6-91 LNTE[1] (1.6 MW and 91-meter rotor diameter) and GE 1.6-97 LNTE (1.6 MW and 97-meter rotor diameter) turbines.

The Project turbines are not the only wind turbines in the area. Wapsipinicon Wind, which is composed of 67 GE 1.5 MW wind turbines, is located northwest Project area on the other side of I-90. The southern end of Pleasant Valley Wind, which is composed of 100 Vestas V100 2.0 MW wind turbines, is west of the Project area on the other side of I-90. Lastly, Prairie Star Wind, which is composed of 61 Vestas V82 1.65 MW wind turbines, is located south and east of the Project area. Beyond Prairie Star Wind to the south is Mower County Wind which is made up of 38 Siemens 2.3 MW wind turbines.

The analysis presented in this report considers sound emissions from these other area wind projects[2] in addition to the Grand Meadow Wind Farm.

A map of the Project area, Project turbines, and some of the surrounding wind power developments is provided in Figure 1.

[1] Low Noise Trailing Edge ("LNTE") are blades that result in lower overall sound levels than standard blades. Some other manufacturers refer to them as STE or Serrated Trailing Edge.
[2] Wind turbines from other area wind project within 3.2 kilometers (2 miles) of the Grand Meadow Wind Farm are included in this assessment.

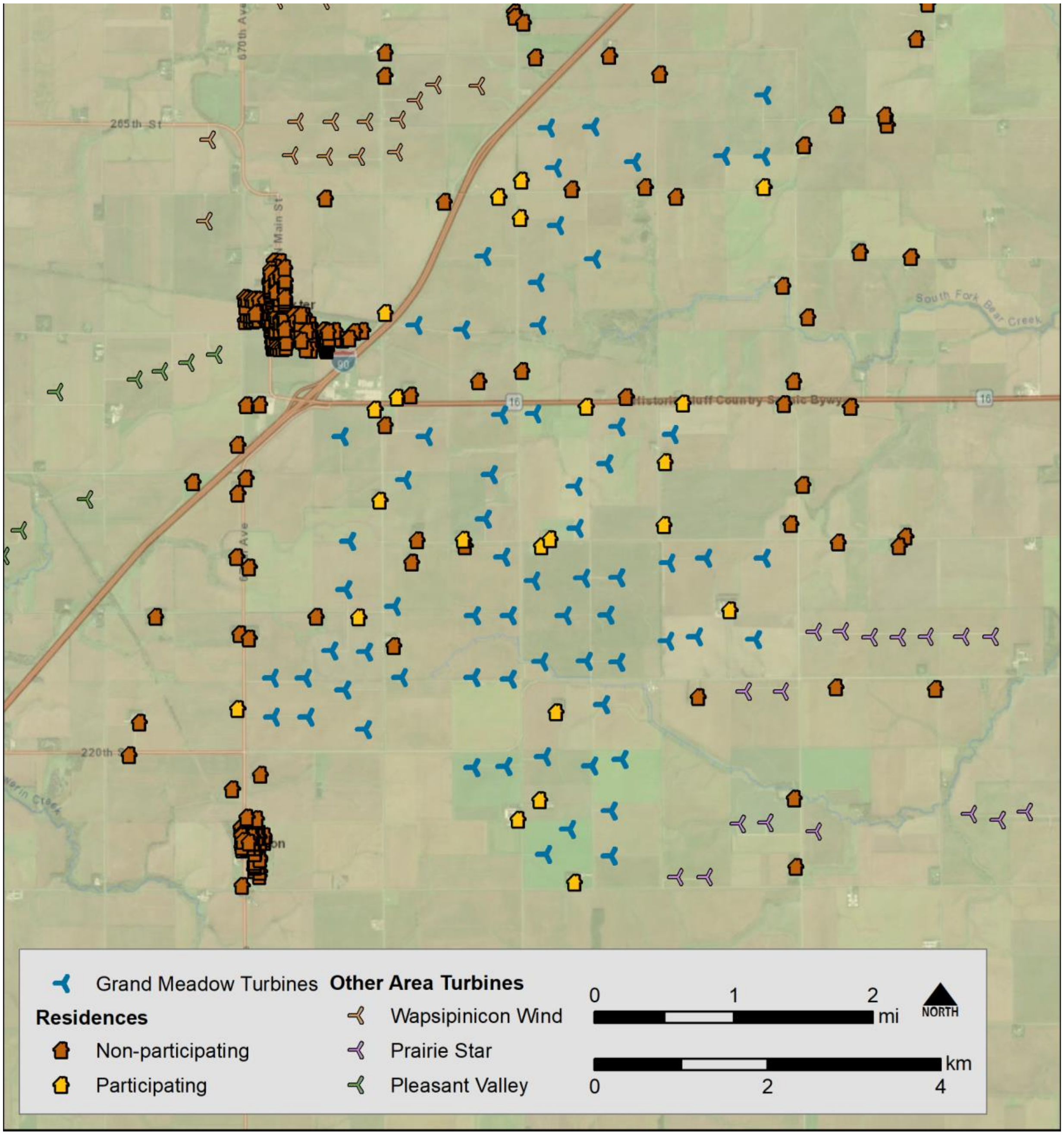

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FIGURE 1: PROJECT AREA MAP

3.0 SOUND LEVEL STANDARD & GUIDELINES

3.1 LOCAL STANDARDS

There are no noise limits or requirements in Section 14-18.61, *State Regulated Wind Turbines & Wind Farms,* of the Mower County Zoning Ordinance.

3.2 STATE STANDARDS

Minnesota Statute §116.07 charges the Pollution Control Agency with adopting noise standards. These standards are set in Minnesota Rules Chapter 7030, for which a wind power project must demonstrate it will comply with to receive a site permit from the PUC. The rule provides daytime and nighttime[3] sound level limits (Table 1) for a variety of land uses, which are grouped into three categories identified by a Noise Area Classification ("NAC"). The sensitive land uses around the Project are primarily within NAC 1 which includes residences (including farmhouses) and contains the most restrictive sound limits.

TABLE 1: SOUND LEVEL LIMITS (dBA) FROM MN RULES 7030.0040

NOISE AREA CLASSIFICATION	DAYTIME		NIGHTTIME	
	L_{50}	L_{10}	L_{50}	L_{10}
1	60	65	50	55
2	65	70	65	70
3	75	80	75	80

The Rule says that the limits are for the "…preservation of public health and welfare" and that they are "…consistent with speech, sleep, annoyance, and hearing conservation requirements…", but that they "…do not, by themselves, identify the limiting levels of impulsive noise[4] needed for the preservation of public health and welfare."

[3] MN Rules 7030.0020 define daytime as 7:00 a.m. to 10:00 p.m. and nighttime as 10:00 p.m. to 7:00 a.m.

[4] Impulsive noise is defined in Minnesota Rules Chapter 7030.0020. Typical, wind turbine sound at the distance of a residential receiver is not considered impulsive.

4.0 BACKGROUND SOUND LEVELS

Given the extent of existing operational wind farms in the area, background sound levels can be challenging to measure, particularly on a long-term basis. As such, background sound levels from other PUC dockets were reviewed to provide context to what the background sound levels in the Project area may be. Factors that were considered included types of roadways that run through the project areas, land use, proximity to Grand Meadow Wind Farm, population density, and how recent the background sound level data was collected.

Of the dockets reviewed the background sound level data reported in a post-construction noise assessment[5] for Pleasant Valley Wind Farm seem to be most appropriately applicable to the Project. Similarities between the project areas include:

- Location – The offsite background sound monitor was located northwest of Pleasant Valley Wind, approximately 28 kilometers (17 miles) northwest of the Project area.
- Land use – Primarily agricultural with a mixture of rural and farm residences
- Population density – 0 to 50 people per square mile in both areas[6]
- Types of Roadways - While the background monitor for Pleasant Valley was located further from I-90, Both the Grand Meadow and Pleasant Valley project areas are bordered by Interstate 90, a principal arterial road. Both projects also have a state highway that transects the project areas.

The background sound level data in the Pleasant Valley post-construction assessment was measured in 2016 and in accordance with the guidance[7] by the Minnesota Department of Commerce that was applicable at the time of the monitoring.

4.1 BACKGROUND SOUND LEVEL SUMMARY

As shown in the post-construction noise assessment[5], the hourly L50 at night was as low as 20 dBA and up to around 45 dBA. The hourly L50 was generally higher during the daytime with one hour up to 51 dBA. These background sound levels from the Pleasant Valley offsite background monitor are expected to be similar to those near secondary roads within the Project area but given the remoteness of the Pleasant Valley background monitor, background sound levels near I-90 and MN-16 in the Project area are expected to be higher.

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[5] Docket #IP-6828/WS-09-1197, Pleasant Valley Wind Farm, Post-Construction Noise Assessment, DNV-GL, August 24, 2016.
[6] Map of Minnesota Population Density, LeGISlative Coordinating Commission, July 2001, https://www.gis.leg.mn/pdf/pop/popdens00.pdf
[7] “Guidance for Large Wind Energy Conversion System Noise Study Protocol and Report,” October 2012.

5.0 SOUND PROPAGATION MODELING

5.1 MODELING PROCEDURE

Modeling for the Project was in accordance with the standard ISO 9613-2, “Acoustics – Attenuation of sound during propagation outdoors, Part 2: General Method of Calculation.” The ISO standard states,

> This part of ISO 9613 specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level … under meteorological conditions favorable to propagation from sources of known sound emissions. These conditions are for downwind propagation … or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night.

The model takes into account source sound power levels, surface reflection and absorption, atmospheric absorption, geometric divergence, meteorological conditions, walls, barriers, berms, and terrain. The acoustical modeling software used here was CadnaA, from Datakustik GmbH. CadnaA is a widely accepted acoustical propagation modeling tool, used by many noise control professionals in the United States and internationally.

ISO 9613-2 assumes downwind sound propagation between every source and every receiver, consequently, all wind directions, including the prevailing wind directions, are taken into account.

Model input parameters are listed in Appendix C including the modeled sound power spectra for each turbine model. For this analysis, we utilized a ground absorption factor of G=0.7, which is appropriate for comparing modeled results to the L_{50} metric used in the state standard, particularly when summing model results with the background L_{50} levels.[8] A 2-dB uncertainty factor was added to the turbine sound power level to account for uncertainty.[9] A search distance up to 10,000 meters (6.2 miles) allows for the contributions of distant turbines to be considered

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[8] Generally accepted wind turbine modeling procedure calls for a ground absorption factor of G = 0.5, with a 2 dB uncertainty factor added to the manufacturer’s guaranteed levels, to predict a maximum $L_{EQ(1-hr)}$. In this case, the Minnesota state limit utilizes an L_{50} metric instead of maximum $L_{EQ(1-hr)}$, which means a ground factor of G=0.7 can be used. Based on data from the Massachusetts Study on Wind Turbine Acoustics (2016) by Mass CEC, the L_{50} from wind turbines is typically 0.7 to 1.0 dB lower than the L_{EQ}. Using a ground factor of G=0.7 instead of 0.5 lowers the sound level projection of the model by 0.7 dB, on average, and as such serves as an adjustment factor to shift from an L_{EQ}-based model to and L_{50} -based model to adhere to the Minnesota L_{50} noise standard.

[9] Kaliski, et. al., Regulating and predicting wind turbine sound in the U.S., Inter-Noise 2018.

at receivers. The contribution of distant turbines will depend on the geometry and geography of the Project.

Residences were modeled as discrete receivers at a height of 4 meters (13 feet) above ground level.[10] A total of 272 residences were modeled throughout the Project area. The grid, represented in the results maps by sound pressure level contours, is also calculated at a height of 4 meters (13 feet). Use of a 4-meter receiver height in the model results in a conservative calculation of the expected sound levels at 1.5 meters (5 feet), which may be used for post-construction compliance monitoring. Modeling at a height of 4 meters is supported by post-construction monitoring at a number of projects,[9] and by the Institute of Acoustics' Good Practice Guide on Wind Turbine Noise (2013), "as it has the effect of reducing the potential oversensitivity of the calculation to the receiver region ground factor compared to lower receiver heights." The sound pressure level contours represent turbine-only sound levels.

5.2 MODELED SCENARIOS

Two scenarios were modeled:

- Scenario 1: Existing turbines at Grand Meadow, and existing turbines at other area wind projects within 3.2 kilometers (2 miles) of Grand Meadow.
- Scenario 2: Repower Grand Meadow turbines, existing turbines at other area wind projects within 3.2 kilometers (2 miles) of Grand Meadow.

For Scenario 2, the repowered Grand Meadow turbines are a mixture of the GE 1.6-91 LNTE and GE 1.6-97 LNTE turbines. Some of the Grand Meadow turbines were modeled with varying levels of Noise Reduced Operations ("NRO") to ensure that all residences are at 47 dBA or less.[11] The sound power levels used in the model and the NRO for each turbine are listed in Appendix C.

5.3 MODEL RESULTS

A summary of the sound propagation model results for each scenario is presented in Table 2. For each scenario results are presented as turbine-only sound levels from the sound

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[10] Some other site permit applications (PUC Docket Nos. 17-307, 18-179, and 19-394, for example) have used receiver heights of 1.5 meters as opposed to 4 meters. However, using a receiver height of 4 meters is more conservative and results in a projected sound level that is 1.6 dB higher, on average than the results modeled at a height of 1.5 meters.

[11] MN Department of Commerce guidance[7] states that, "If background sound levels are equal to or greater than the applicable state standard at nearby receptors, the wind farm should not contribute more than 47 dB(A) to total sound levels at nearby receptors. Therefore, for example, when nighttime background sound levels are at 50 dB(A), a maximum turbine-only contribution of 47 dB(A) would result in a non-significant increase in total sound of 3 dB(A)."

propagation model and total sound levels. The latter is calculated by summing (logarithmically)[12] the modeled turbine-only sound levels with a relatively high nighttime background sound level ($L_{50,\ 1\text{-hr}}$) of 45 dBA.

TABLE 2: MODEL RESULTS SUMMARY

SCENARIO	SOUND SOURCE	STATISTICAL L50 METRIC[13]	RESIDENCE CLASSIFICATION		
			ALL RESIDENCES	PARTICIPATING	NON-PARTICIPATING
Scenario 1 (All Existing Area Turbines)	Turbine-Only	Avg	41	47	40
		Max	49	49	49
		Min	31	45	31
	Total Sound (Background + Turbine)	Avg	46	49	46
		Max	51	51	51
		Min	45	48	45
Scenario 2 (Repower Grand Meadow)	Turbine-Only	Avg	41	46	40
		Max	48[14]	47	48[14]
		Min	31	45	31
	Total Sound (Background + Turbine)	Avg	46	49	46
		Max	50[14]	49	50[14]
		Min	45	48	45

Under the existing scenario (Scenario 1), the highest modeled turbine-only sound level (L_{50}) at a non-participating residence is 49 dBA, and the average across all non-participating residences is 40 dBA. At participating residences, the highest modeled turbine only sound level under Scenario 1 is also 49 dBA.

Under Scenario 2, the highest modeled turbine-only sound level (L_{50}) at a non-participating residence is 48 dBA, and the average across all non-participating residences is 40 dBA. The highest modeled non-participating residence at 48 dBA is at Receptor 11, and the sound level is due entirely to sound emissions from Wapsipinicon Wind. The closest Grand Meadow wind turbine to Receptor 11 is T-102 which is only projected to produce a sound level of 26 dBA at the receptor. All other non-participating residences are 47 dBA or less. At participating residences, the highest modeled turbine only sound level under Scenario 2 is 47 dBA.

[12] $L_{p1,2} = 10 \times \log_{10}\left(10^{L_{p1}/10} + 10^{L_{p2}/10}\right)$

[13] The average L_{50} across all residences is provided as a simple means of comparing the overall potential impact across the project area between the different scenarios. The maximum L_{50} represents the worst-case receptors. The minimum L_{50} represents the receptor with the least projected wind turbine sound.

[14] The sound level at Receptor 11 is due entirely to sound emissions from Wapsipinicon Wind. The closest Grand Meadow wind turbine to Receptor 11 is T-102 which is only projected to produce a sound level of 26 dBA at the receptor.

Results for each residence are provided in Appendix D. As can be seen in Appendix D, most receptors are projected to see no change in the maximum turbine-only sound level (L50) with some residences resulting in a change in sound level due to the repower of ±2 dB. On average, receptors across the project area will see a reduction of 0.2 dB in turbine-only sound level. These changes in broadband sound level are not considered a noticeable difference.

As discussed in Section 4.1, background sound levels can vary from hour to hour, and they can vary by location. Hourly nighttime background sound levels (L_{50}) in the Project area are expected to typically be 45 dBA or less but may be higher near I-90 and MN-16. Appendix D provides the model results summed with a range of potential background L_{50} values from 30 to 45 dBA in 5 dB increments. Table 2 shows the results of the modeled turbine-only sound levels with a nighttime background sound level ($L_{50,\ 1\text{-}hr}$) of 45 dBA. Using this ambient nighttime background noise level, which could be considered worst-case through much of the Project area, the sound level limits would not be exceeded at any participating or non-participating residence. It is possible for the background L_{50} to be greater than 45, but the Project has been modeled such that no receptors exceed a turbine-only sound level of 47 per Department of Commerce Guidance.[11]

5.4 MAPPED MODEL RESULTS

Maps of model results for each scenario are provided in Figures 2 and 3. Results are presented as contour lines representing 5-dB increments of calculated A-weighted turbine-only sound pressure levels. The pink contour line, however, does not represent a 5-dB increment, but rather 47 dBA.

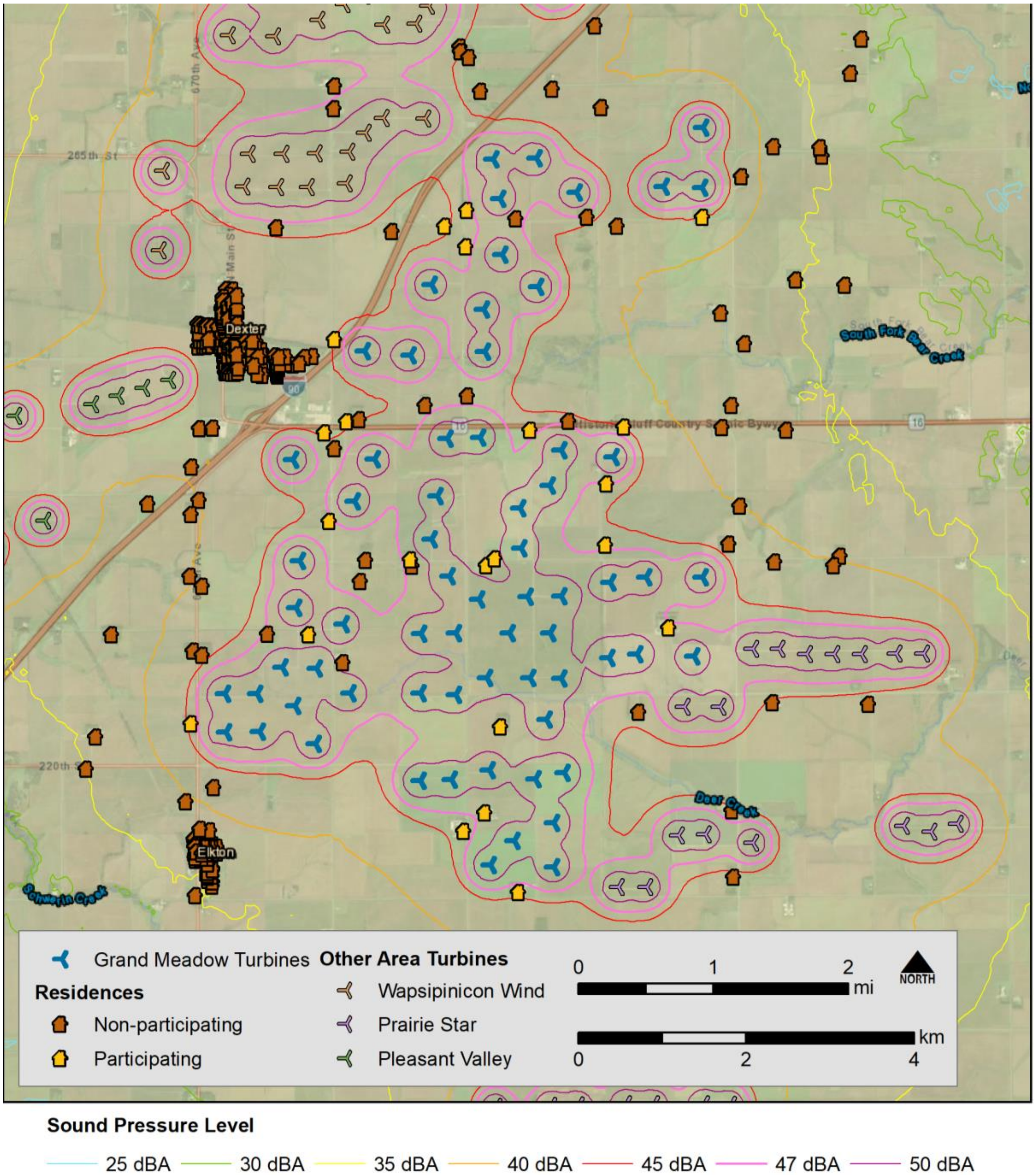

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FIGURE 2: MAP OF SOUND PROPAGATION MODEL RESULTS FOR SCENARIO 1 (EXISTING TURBINES)

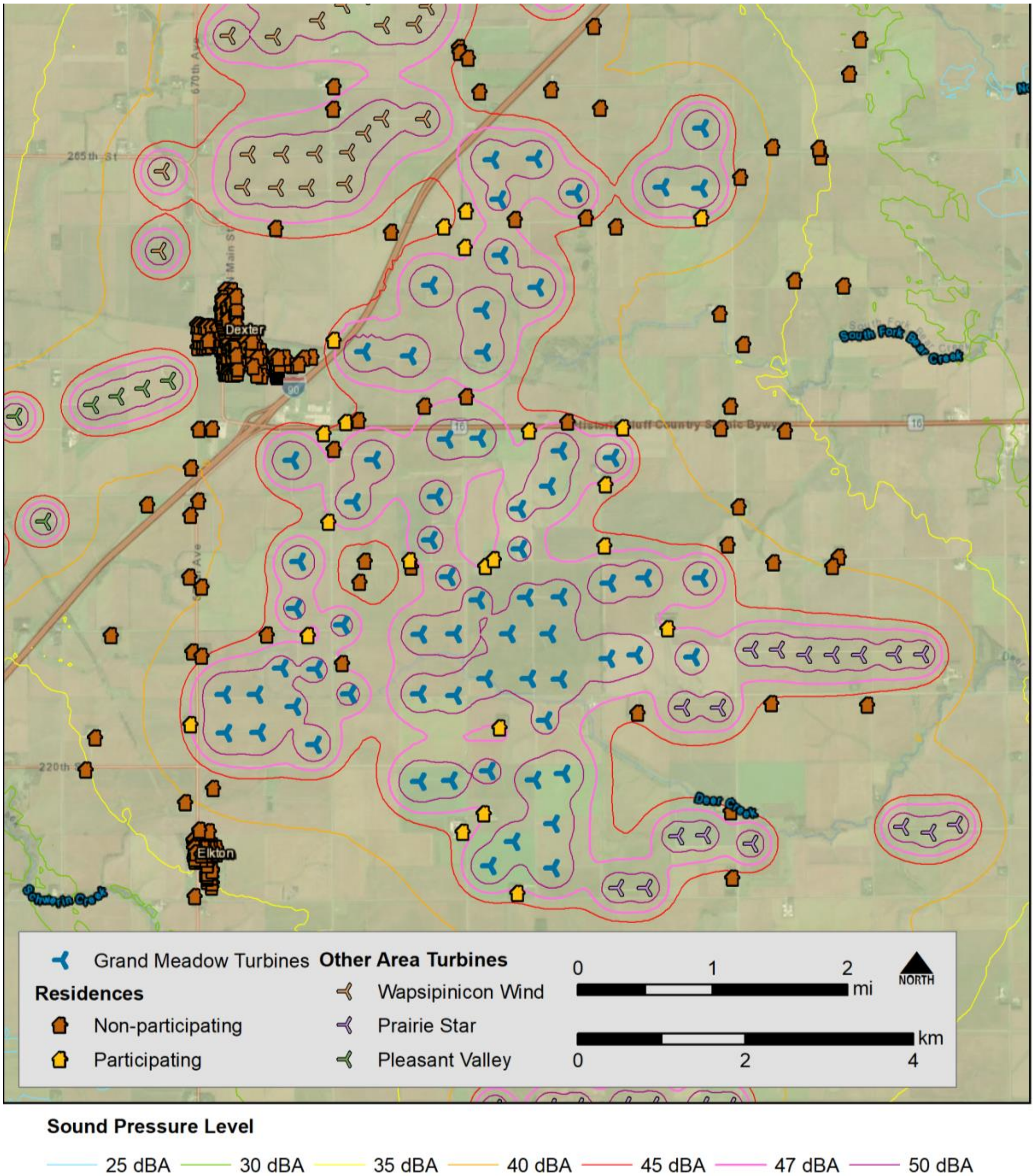

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FIGURE 3: MAP OF SOUND PROPAGATION MODEL RESULTS FOR SCENARIO 2 (REPOWER GRAND MEADOW)

6.0 CONCLUSIONS

Xcel is proposing to repower the Grand Meadow Wind Farm by upgrading 67 GE 1.5 MW turbines to GE 1.6-91 and GE 1.6-97 turbines by replacing the hub and blades and leaving the current towers in place. For the SPA, RSG performed a noise assessment of the Project including sound emissions from neighboring wind power projects so that cumulative noise impacts could be assessed. The noise assessment included two scenarios:

- Scenario 1: Existing turbines at Grand Meadow, and existing turbines at other area wind projects within 3.2 kilometers (2 miles) of Grand Meadow.
- Scenario 2: Repower Grand Meadow turbines, existing turbines at other area wind projects within 3.2 kilometers (2 miles) of Grand Meadow.

Background sound levels were not measured in the existing area due to difficulties measuring long-term background sound levels with several operational projects in the area. Instead, background sound levels measured in 2016 for the neighboring Pleasant Valley Wind Farm are discussed in Section 4.1 to provide context to the expected background sound levels in the Project vicinity.

Conclusions of the assessment are as follows:

1. Background sound levels for much of the project area are expected to be similar to the background sound levels from the Pleasant Valley Wind Farm's post-construction noise assessment which had hourly L50s at night between 20 and 45 dBA and daytime hourly L50s as high as 51 dBA. Background sound levels near I-90 and MN-16 in the Project area may be higher.
2. State noise regulations require that wind power generation facilities show compliance with a nighttime limit of 50 dBA (L_{50}) and a daytime limit of 60 dBA (L_{50}) at residences, but guidance from the Department of Commerce recommends that turbine-only sound levels not exceed 47 dBA.[11]
3. Sound propagation modeling was performed in accordance with ISO 9613-2 at 272 discrete receivers modeled at a height of 4 meters above grade, with spectral ground attenuation and a ground factor of G=0.7. As discussed in Section 5.1, these modeling parameters represent the highest hourly L_{50} of the proposed facility.
4. Projected turbine-only sound levels from the Project are about the same as the existing project, but existing residences that are above 47 dBA have been reduced down to 47 dBA or less. The average change in sound level across all modeled residences is a 0.2 dB reduction.

5. The Projected turbine-only sound levels from the repowered Project are 47 dBA or less at all residences. One residence is projected to have a turbine-only sound level of 48 dBA, but it is due entirely to Wapsipinicon Wind as discussed in Section 5.3. Otherwise, the highest projected turbine-only sound level (L_{50}) at a participating and a non-participating residence is 47 dBA. The average sound level across all modeled residences is 41 dBA.
6. Given that the projected turbine-only sound levels from the Project are 47 dBA or less, the Project is not expected to exceed the noise regulations on a turbine-only basis, nor significantly contribute[11] to sound levels in excess of the sound level limit of 50 dBA L_{50}.

APPENDIX A. ACOUSTICS PRIMER

Expressing Sound in Decibel Levels

The varying air pressure that constitutes sound can be characterized in many different ways. The human ear is the basis for the metrics that are used in acoustics. Normal human hearing is sensitive to sound fluctuations over an enormous range of pressures, from about 20 micropascals (the "threshold of audibility") to about 20 pascals (the "threshold of pain").[15] This factor of one million in sound pressure difference is challenging to convey in engineering units. Instead, sound pressure is converted to sound "levels" in units of "decibels" (dB, named after Alexander Graham Bell). Once a measured sound is converted to dB, it is denoted as a level with the letter "L".

The conversion from sound pressure in pascals to sound level in dB is a four-step process. First, the sound wave's measured amplitude is squared and the mean is taken. Second, a ratio is taken between the mean square sound pressure and the square of the threshold of audibility (20 micropascals). Third, using the logarithm function, the ratio is converted to factors of 10. The final result is multiplied by 10 to give the decibel level. By this decibel scale, sound levels range from 0 dB at the threshold of audibility to 120 dB at the threshold of pain.

Typical sound sources, and their sound pressure levels, are listed on the scale in Figure 4.

Human Response to Sound Levels: Apparent Loudness

For every 20 dB increase in sound level, the sound pressure increases by a *factor* of 10; the sound *level* range from 0 dB to 120 dB covers 6 factors of 10, or one million, in sound *pressure*. However, for an increase of 10 dB in sound *level* as measured by a meter, humans perceive an approximate doubling of apparent loudness: to the human ear, a sound level of 70 dB sounds about "twice as loud" as a sound level of 60 dB. Smaller changes in sound level, less than 3 dB up or down, are generally not perceptible.

[15] The pascal is a measure of pressure in the metric system. In Imperial units, they are themselves very small: one pascal is only 145 millionths of a pound per square inch (psi). The sound pressure at the threshold of audibility is only 3 one-billionths of one psi: at the threshold of pain, it is about 3 one-thousandths of one psi.

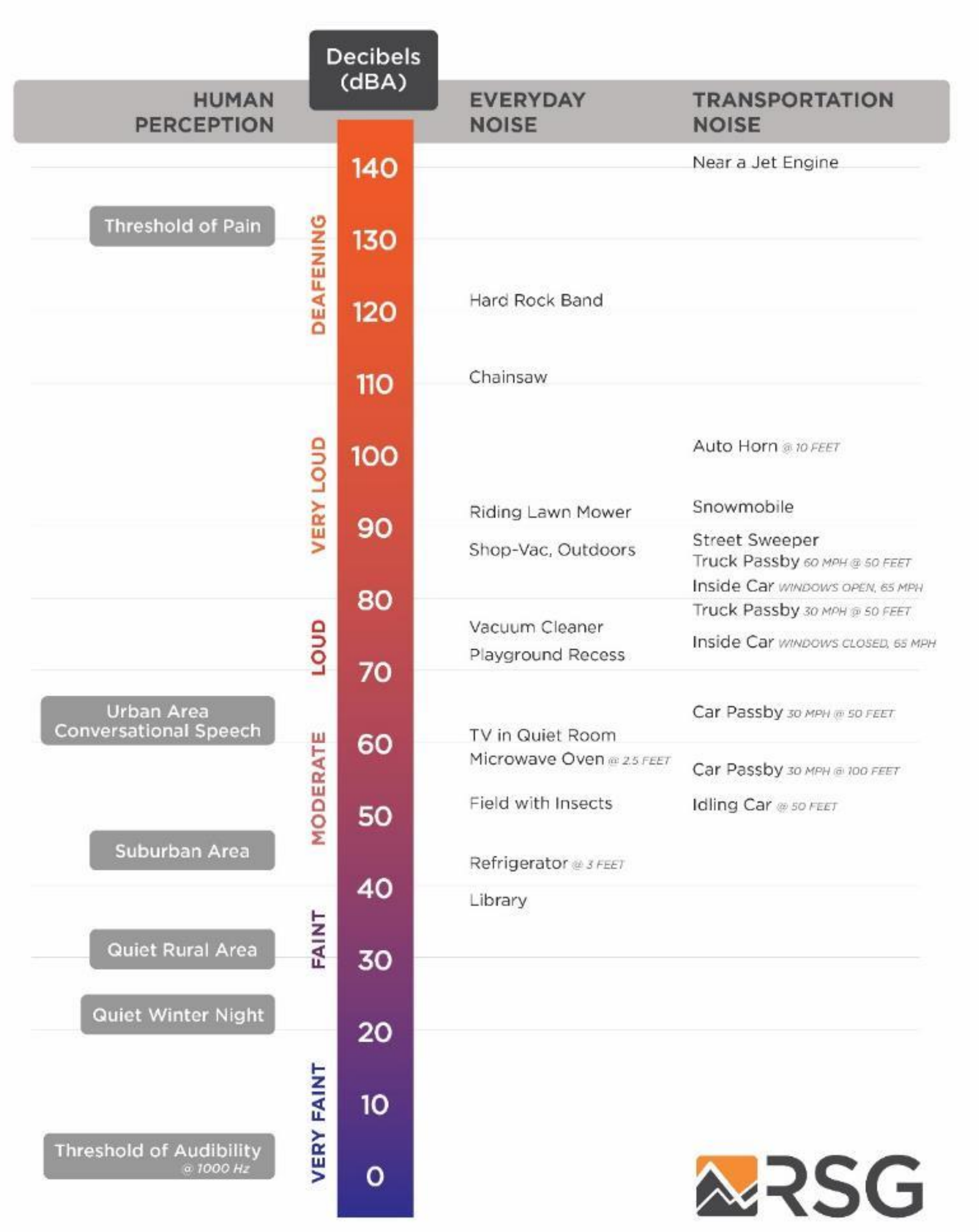

FIGURE 4: A SCALE OF SOUND PRESSURE LEVELS FOR TYPICAL SOUND SOURCES

Frequency Spectrum of Sound

The “frequency” of a sound is the rate at which it fluctuates in time, expressed in Hertz (Hz), or cycles per second. Very few sounds occur at only one frequency: most sound contains energy at many different frequencies, and it can be broken down into different frequency divisions, or bands. These bands are similar to musical pitches, from low tones to high tones. The most common division is the standard octave band. An octave is the range of frequencies whose upper frequency limit is twice its lower frequency limit, exactly like an octave in music. An octave band is identified by its center frequency: each successive band’s center frequency is twice as high (one octave) as the previous band. For example, the 500 Hz octave band includes all sound whose frequencies range between 354 Hz (Hertz, or cycles per second) and 707 Hz. The next band is centered at 1,000 Hz with a range between 707 Hz and 1,414 Hz. The range of human hearing is divided into 10 standard octave bands: 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1,000 Hz, 2,000 Hz, 4,000 Hz, 8,000 Hz, and 16,000 Hz. For analyses that require finer frequency detail, each octave-band can be subdivided. A commonly-used subdivision creates three smaller bands within each octave band, or so-called 1/3-octave bands.

Human Response to Frequency: Weighting of Sound Levels

The human ear is not equally sensitive to sounds of all frequencies. Sounds at some frequencies seem louder than others, despite having the same decibel level as measured by a sound level meter. In particular, human hearing is much more sensitive to medium pitches (from about 500 Hz to about 4,000 Hz) than to very low or very high pitches. For example, a tone measuring 80 dB at 500 Hz (a medium pitch) sounds quite a bit louder than a tone measuring 80 dB at 60 Hz (a very low pitch). The frequency response of normal human hearing ranges from 20 Hz to 20,000 Hz. Below 20 Hz, sound pressure fluctuations are not “heard”, but sometimes can be “felt”. This is known as “infrasound”. Likewise, above 20,000 Hz, sound can no longer be heard by humans; this is known as “ultrasound”. As humans age, they tend to lose the ability to hear higher frequencies first; many adults do not hear very well above about 16,000 Hz. Most natural and man-made sound occurs in the range from about 40 Hz to about 4,000 Hz. Some insects and birdsongs reach to about 8,000 Hz.

To adjust measured sound pressure levels so that they mimic human hearing response, sound level meters apply filters, known as “frequency weightings”, to the signals. There are several defined weighting scales, including “A”, “B”, “C”, “D”, “G”, and “Z”. The most common weighting scale used in environmental noise analysis and regulation is A-weighting. This weighting represents the sensitivity of the human ear to sounds of low to moderate level. It attenuates sounds with frequencies below 1000 Hz and above 4000 Hz; it amplifies very slightly sounds between 1000 Hz and 4000 Hz, where the human ear is particularly sensitive. The C-weighting scale is sometimes used to describe louder sounds. The B- and D- scales are seldom used. All of these frequency weighting scales are normalized to the average human hearing response at

1000 Hz: at this frequency, the filters neither attenuate nor amplify. G-weighting is a standardized weighting used to evaluate infrasound.

When a reported sound level has been filtered using a frequency weighting, the letter is appended to “dB”. For example, sound with A-weighting is usually denoted “dBA”. When no filtering is applied, the level is denoted “dB” or “dBZ”. The letter is also appended as a subscript to the level indicator “L”, for example “L_A” for A-weighted levels.

Time Response of Sound Level Meters

Because sound levels can vary greatly from one moment to the next, the time over which sound is measured can influence the value of the levels reported. Often, sound is measured in real time, as it fluctuates. In this case, acousticians apply a so-called “time response” to the sound level meter, and this time response is often part of regulations for measuring sound. If the sound level is varying slowly, over a few seconds, “Slow” time response is applied, with a time constant of one second. If the sound level is varying quickly (for example, if brief events are mixed into the overall sound), “Fast” time response can be applied, with a time constant of one-eighth of a second.[16] The time response setting for a sound level measurement is indicated with the subscript “S” for Slow and “F” for Fast: L_S or L_F. A sound level meter set to Fast time response will indicate higher sound levels than one set to Slow time response when brief events are mixed into the overall sound, because it can respond more quickly.

In some cases, the maximum sound level that can be generated by a source is of concern. Likewise, the minimum sound level occurring during a monitoring period may be required. To measure these, the sound level meter can be set to capture and hold the highest and lowest levels measured during a given monitoring period. This is represented by the subscript “max”, denoted as “L_{max}”. One can define a “max” level with Fast response L_{Fmax} (1/8-second time constant), Slow time response L_{Smax} (1-second time constant), or Continuous Equivalent level over a specified time period L_{EQmax}.

Accounting for Changes in Sound Over Time

A sound level meter’s time response settings are useful for continuous monitoring. However, they are less useful in summarizing sound levels over longer periods. To do so, acousticians apply simple statistics to the measured sound levels, resulting in a set of defined types of sound level related to averages over time. An example is shown in Figure 5. The sound level at each instant of time is the grey trace going from left to right. Over the total time it was measured (1 hour in the figure), the sound energy spends certain fractions of time near various levels, ranging from the minimum (about 27 dB in the figure) to the maximum (about 65 dB in the

[16] There is a third time response defined by standards, the “Impulse” response. This response was defined to enable use of older, analog meters when measuring very brief sounds; it is no longer in common use.

figure). The simplest descriptor is the average sound level, known as the Equivalent Continuous Sound Level. Statistical levels are used to determine for what percentage of time the sound is louder than any given level. These levels are described in the following sections.

Equivalent Continuous Sound Level - Leq

One straightforward, common way of describing sound levels is in terms of the Continuous Equivalent Sound Level, or L_{EQ}. The L_{EQ} is the average sound pressure level over a defined period of time, such as one hour or one day. L_{EQ} is the most commonly used descriptor in noise standards and regulations. L_{EQ} is representative of the overall sound to which a person is exposed. Because of the logarithmic calculation of decibels, L_{EQ} tends to favor higher sound levels: loud and infrequent sources have a larger impact on the resulting average sound level than quieter but more frequent sounds. For example, in Figure 5, even though the sound levels spends most of the time near about 34 dBA, the L_{EQ} is 41 dBA, having been “inflated” by the maximum level of 65 dBA and other occasional spikes over the course of the hour.

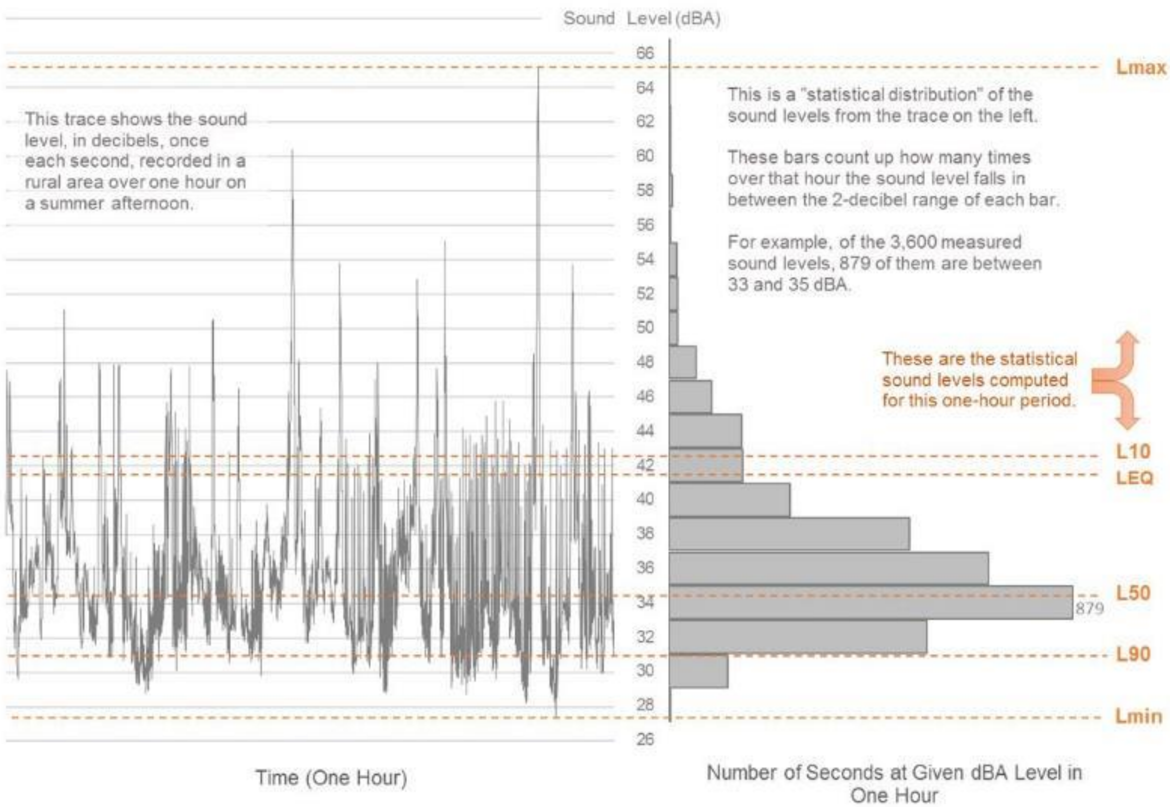

FIGURE 5: EXAMPLE OF DESCRIPTIVE TERMS OF SOUND MEASUREMENT OVER TIME

Percentile Sound Levels – Ln

Percentile sound levels describe the statistical distribution of sound levels over time. “L_N” is the level above which the sound spends “N” percent of the time. For example, L_{90} (sometimes called the “residual base level”) is the sound level exceeded 90% of the time: the sound is louder than L_{90} most of the time. L_{10} is the sound level that is exceeded only 10% of the time. (the “median level”) is exceeded 50% of the time: half of the time the sound is louder than , and half the time it is quieter than . Note that (median) and L_{EQ} (mean) are not always the same, for reasons described in the previous section.

L_{90} is often a good representation of the “ambient sound” in an area. This is the sound that persists for longer periods, and below which the overall sound level seldom falls. It tends to filter out other short-term environmental sounds that aren’t part of the source being investigated. L_{10} represents the higher, but less frequent, sound levels. These could include such events as barking dogs, vehicles driving by and aircraft flying overhead, gusts of wind, and work operations. L_{90} represents the background sound that is present when these event sounds are excluded.

Note that if one sound source is very constant and dominates the soundscape in an area, all of the descriptive sound levels mentioned here tend toward the same value. It is when the sound is varying widely from one moment to the next that the statistical descriptors are useful.

APPENDIX B. WIND TURBINE ACOUSTICS – SPECIAL CONSIDERATIONS

Sources of Sound Generation by Wind Turbines

Wind turbines generate two principal types of sound: aerodynamic, produced from the flow of air around the blades, and mechanical, produced from mechanical and electrical components within the nacelle.

Aerodynamic sound is the primary source of sound associated with wind turbines. These acoustic emissions can be either tonal or broadband. Tonal sound occurs at discrete frequencies, whereas broadband sound is distributed with little peaking across the frequency spectrum. While unusual, tonal sound can also originate from unstable air flows over holes, slits, or blunt trailing edges on blades. The majority of audible aerodynamic sound from wind turbines is broadband at the middle frequencies, roughly between 200 Hz and 1,000 Hz.

Wind turbines emit aerodynamic broadband sound as the rotating blades interact with atmospheric turbulence and as air flows along their surfaces. This produces a characteristic “whooshing” sound through several mechanisms (Figure 6):

- Inflow turbulence sound occurs when the rotor blades encounter atmospheric turbulence as they pass through the air. Uneven pressure on a rotor blade causes variations in the local angle of attack, which affects the lift and drag forces, causing aerodynamic loading fluctuations. This generates sound that varies across a wide range of frequencies but is most significant at frequencies below 500 Hz.
- Trailing edge sound is produced as boundary-layer turbulence as the air passes into the wake, or trailing edge, of the blade. This sound is distributed across a wide frequency range but is most notable at high frequencies between 700 Hz and 2 kHz.
- Tip vortex sound occurs when tip turbulence interacts with the surface of the blade tip. While this is audible near the turbine, it tends to be a small component of the overall sound further away.
- Stall or separation sound occurs due to the interaction of turbulence with the blade surface.

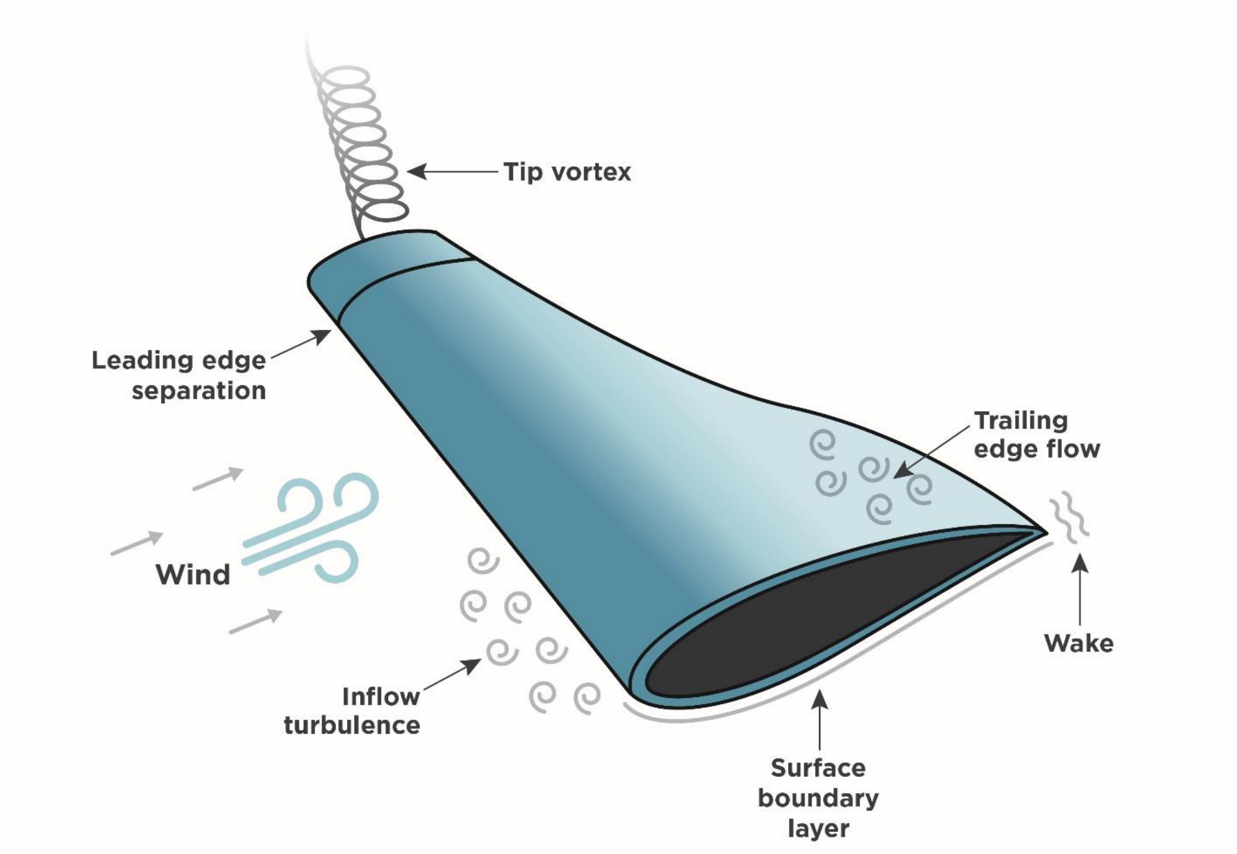

FIGURE 6: AIRFLOW AROUND A ROTOR BLADE

Mechanical sound from machinery inside the nacelle tends to be tonal in nature but can also have a broadband component. Potential sources of mechanical sound include the gearbox, generator, yaw drives, cooling fans, and auxiliary equipment. These components are housed within the nacelle, whose surfaces, if untreated, radiate the resulting sound. However modern wind turbines have nacelles that are designed to reduce the transmission of internal sound, and rarely is this a significant portion of the total wind turbine sound.

Amplitude Modulation

Amplitude modulation (AM) is a fluctuation in sound level that occurs at the blade passage frequency. There is no consistent definition how much of a sound level fluctuation is necessary for blade swish to be considered AM. Fluctuations in individual 1/3 octave bands are typically greater. Fluctuations in individual 1/3 octave bands can sometimes synchronize and desynchronize over periods, leading to increases and decreases in magnitude of the A-weighted fluctuations. Similarly, in wind farms with multiple turbines, fluctuations can synchronize and desynchronize, leading to variations in amplitude modulation depth.[17] Most amplitude modulation is in the mid-frequencies and most overall A-weighted AM is less than 4.5 dB in depth.[18]

There are many confirmed and hypothesized causes of amplitude modulation including: blade passage in front of the tower, blade tip sound emission directivity, wind shear, inflow turbulence, transient blade stall, and turbine blade yaw error. It has recently been noted that although wind shear can contribute to the extent of amplitude modulation, wind shear does not contribute to the existence of amplitude modulation in and of itself. Instead, there needs to be detachment of airflow from the blades for wind shear to contribute to amplitude modulation.[19] While factors like the blade passing in front of the tower are intrinsic to wind turbine design, other factors vary with turbine design, local meteorology, topography, and turbine layout. Mountainous areas, for example, are more likely to have turbulent airflow, less likely to have high wind shear, and less likely to have turbine layouts that allow for blade passage synchronization for multiple turbines. Amplitude modulation extent varies with the relative location of a receptor to the turbine. Amplitude Modulation is usually experienced most when the receptor is between 45 and 60 degrees from the downwind or upwind position and is experienced least directly with the receptor directly upwind or downwind of the turbines.

Meteorology

Meteorological conditions can significantly affect sound propagation. The two most important conditions to consider are wind shear and temperature lapse. Wind shear is the difference in wind speeds by elevation and temperature lapse rate is the temperature gradient by elevation. In conditions with high wind shear (large wind speed gradient), sound levels upwind from the source tend to decrease and sound levels downwind tend to increase due to the refraction, or bending, of the sound (Figure 7).

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[17] McCunney, Robert, et al. "Wind Turbines and Health: A Critical Review of the Scientific Literature." *Journal of Occupational and Environmental Medicine.* 56(11) November 2014: pp. e108-e130.
[18] RSG, et al., "Massachusetts Study on Wind Turbine Acoustics," Massachusetts Clean Energy Center and Massachusetts Department of Environmental Protection, 2016
[19] "Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect." *RenewableUK.* December 2013.

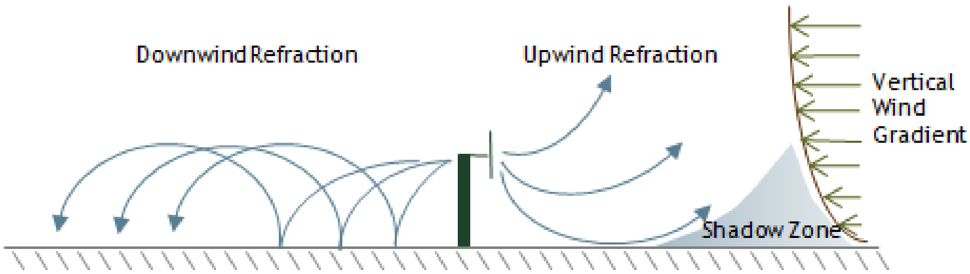

FIGURE 7: SCHEMATIC OF THE REFRACTION OF SOUND DUE TO VERTICAL WIND GRADIENT (WIND SHEAR)

With temperature lapse, when ground surface temperatures are higher than those aloft, sound will tend to refract upwards, leading to lower sound levels near the ground. The opposite is true when ground temperatures are lower than those aloft (an inversion condition).

High winds and/or high solar radiation can create turbulence which tends to break up and dissipate sound energy. Highly stable atmospheres, which tend to occur on clear nights with low ground-level wind speeds, tend to minimize atmospheric turbulence and are generally more favorable to downwind propagation.

In general terms, sound propagates along the ground best under stable conditions with a strong temperature inversion. This tends to occur during the night and is characterized by low ground level winds. As a result, worst-case conditions for wind turbines tend to occur downwind under moderate nighttime temperature inversions. Therefore, this is the default condition for modeling wind turbine sound.

Masking

As mentioned above, sound levels from wind turbines are a function of wind speed. Background sound is also a function of wind speed, i.e., the stronger the winds, the louder the resulting background sound. This effect is amplified in areas covered by trees and other vegetation.

The sound from a wind turbine can often be masked by wind sound at downwind receptors because the frequency spectrum from wind is very similar to the frequency spectrum from a wind turbine. Figure 8 compares the shape of the sound spectrum measured during a 5 m/s wind event to that of the GE 1.6-97 wind turbine. As shown, the shapes of the spectra are very similar. As a result, the masking of turbine sound occurs at higher wind speeds for some meteorological conditions. Masking will occur most, when ground wind speeds are relatively high, creating wind-caused sound such as wind blowing through the trees and interaction of wind with structures.

It is important to note that while winds may be blowing at turbine height, there may be little to no wind at ground level. This is especially true during strong wind gradients (high wind shear), which mostly occur at night. This can also occur on the leeward side of ridges where the ridge blocks the wind.

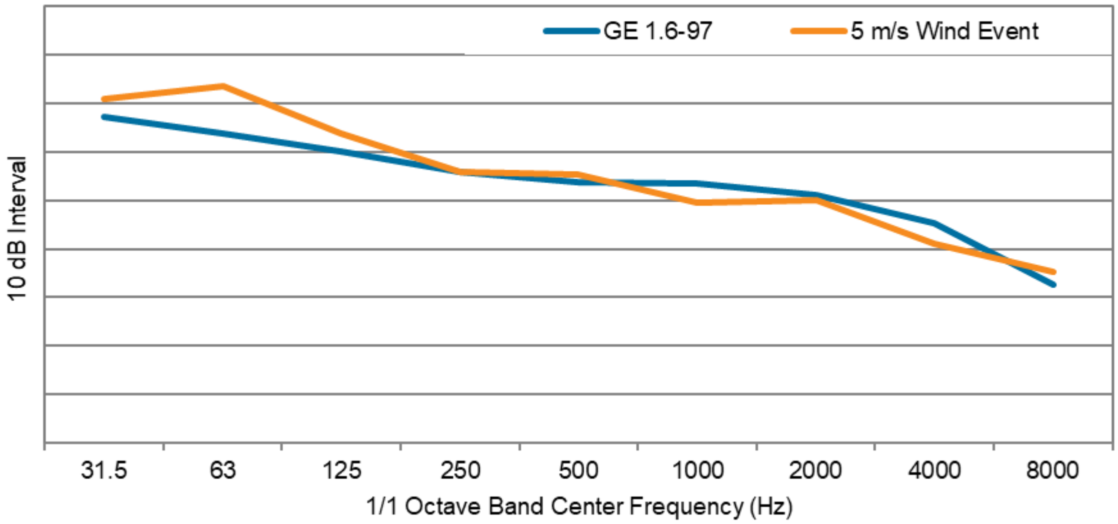

FIGURE 8: COMPARISON OF NORMALIZED FREQUENCY SPECTRA FROM WIND AND THE GE 1.6-97 TURBINE[20]

Infrasound and Low Frequency Sound

Infrasound is sound pressure fluctuations at frequencies below about 20 Hz. Sound below this frequency is only audible at very high magnitudes (90 dBG[21] and higher). Low frequency sound is in the audible range of human hearing, that is, above 20 Hz, but below 100 to 200 Hz depending on the definition.

Low frequency aerodynamic tonal sound is typically associated with downwind rotors on horizontal axis wind turbines. In this configuration, the rotor plane is behind the tower relative to the oncoming wind. As the turbine blades rotate, each blade crosses behind the tower's aerodynamic wake and experiences brief load fluctuations. This causes short, low-frequency pulses or thumping sounds. Large modern wind turbines are "upwind", where the rotor plane is upwind of the tower. As a result, this type of low frequency sound is at a much lower magnitude with upwind turbines than downwind turbines, well below established infrasonic hearing thresholds.

Figure 9 shows the sound levels 350 meters (1,148 feet) from a wind turbine when the wind turbine was operating (T-on) and shut down (T-off) for wind speeds at hub height greater than 9

[20] The purpose of this Figure is to show the shapes to two spectra relative to one another and not the actual sound level of the two sources of sound. The level of each source was normalized independently.
[21] See Appendix A for additional information on frequency-weighted sound levels.

m/s. Measurements were made over approximately two weeks.[22] The red 90 dBG line is shown here as the ISO 7196:1995 perceptibility threshold. As shown, the wind turbines generated measurable infrasound, but at least 20 dB below audibility thresholds.

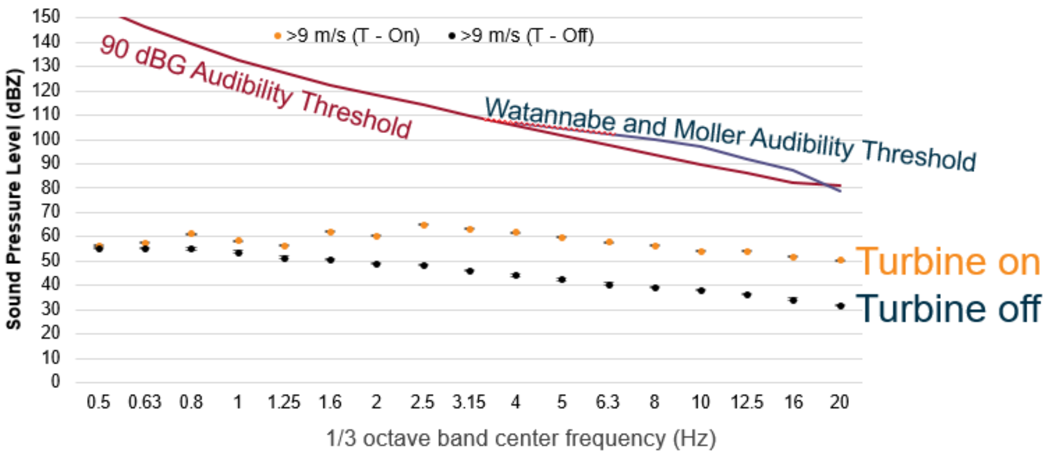

FIGURE 9: INFRASOUND FROM A WIND TURBINE AT 350 METERS (1,148 FEET) COMPARED WITH PERCEPTION THESHOLDS

Low frequency sound is primarily generated by the generator and mechanical components. Much of the mechanical sound has been reduced in modern wind turbines through improved sound insulation at the hub. Low frequency sound can also be generated by the blades at higher wind speeds when the inflow air is very turbulent. However, at these wind speeds, low frequency sound from the wind turbine blades is often masked by wind sound at the downwind receptors.

Finally, low frequency sound is absorbed less by the atmosphere and ground than higher frequency sound. This is taken into account in our modeling by using frequency-specific ground attenuation and atmospheric absorption factors.

Use of Sound Level Weighting Networks for Wind Turbine Sound

The human ear is not equally sensitive to sound pressure levels at all frequencies and magnitudes. Some frequencies, despite being the same decibel level (that is, magnitude), seem louder than others. For example, a 500 Hz tone at 80 dB will sound louder than a 63 Hz tone at the same level. In addition, the relative loudness of these tones will change with magnitude. For example, the perceived difference in loudness between those two tones is less when both are at 110 dB than when they are at 40 dB.

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[22] RSG, et al., “Massachusetts Study on Wind Turbine Acoustics,” Massachusetts Clean Energy Center and Massachusetts Department of Environmental Protection, 2016 – Graphic from RSG presentation to MassDEP WNTAG, March, 2016

To account for the difference in the perceived loudness of a sound by frequency and magnitude, acousticians apply frequency weightings to sound levels. The most common weighting scale used in environmental noise analysis is the “A-weighting”, which represents the sensitivity of the human ear at lower sound pressure levels. The A-weighting is the most appropriate weighting when overall sound pressure levels are relatively low (up to about 70 dBA). The A-weighting de-emphasizes sounds at lower and very high frequencies, since the human ear is insensitive to sound at these frequencies at low magnitude. The A-weighting is indicated by “dBA” or “dB(A)”.

At higher sound pressure levels (greater than approximately 70 dBA), a different weighting must be used since human hearing sensitivity does not change as much with frequency. The “C-weighting” mimics the sensitivity of the human ear for these moderate to higher sound levels (greater than approximately 70 dBA, which is higher ground-based sound levels produced by wind power projects). C-weighted sound levels are indicated by “dBC” or “dB(C)”.

The “Z-weighting” does not emphasize or de-emphasize sound at any frequency. “Z” weighted sound levels are sometimes labeled as “Flat” or “Linear”. The difference is that the “Z-weighting” is defined as being unweighted in a specific range, whereas “Flat” or “Linear” indicate that no weighting has been used. Z-weighting or unweighted levels are typically used when reporting sound levels at individual octave bands.

The most appropriate weighting for wind turbine sound is A-weighting, for two reasons. The first is that sound pressure levels due to wind turbine sound are typically in the appropriate range for the A-weighting at typical receiver distances (50 dBA or less). The second is that various studies of wind turbine acoustics have shown that the potential effects of wind turbine noise on people are correlated with A-weighted sound level (i.e. Pedersen et al, 2008[23]) as well as to the perceived loudness of wind turbine sound.[24,25] Other researchers found that 51% of the energy making up a C-weighted measurement of wind turbine sound is not audible. Thus, it is more difficult to relate the level of C-weighted sound to human perception. That is, two sounds may be perceived exactly alike, but there could be significant variations in the C-weighted sound level depending on the content of inaudible sound in each.[18]

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[23] Pedersen, Eja and Waye, Kerstin. “Perception and annoyance due to wind turbine noise - a dose-response relation.” Journal of the Acoustical Society of America. 116(6). pp. 3460-3470.
[24] Yokoyama S., et al. “Perception of low frequency components in wind turbine noise.” Noise Control Engr. J. 62(5) 2014
[25] Yokoyama et al. “Loudness evaluation of general environmental noise containing low frequency components.” Proceedings of InterNoise2013, 2013

APPENDIX C. MODEL INPUT DATA

TABLE 3: SOUND PROPAGATION MODELING PARAMETERS

PARAMETER	SETTING
Ground Absorption	Spectral for all sources, mixed ground (G=0.7)
Atmospheric Attenuation	Based on 10˚ Celsius, 70% relative humidity
Structure Reflections	None
Receiver Height	4 meters for residences and isoline contours
Search Distance	10,000 meters

TABLE 4: TURBINE 1/1 OCTAVE BAND MODELED SPECTRA (dBZ UNLESS OTHERWISE INDICATED)

TURBINE	1/1 OCTAVE BAND CENTER FREQUENCY (Hz)									SUM (dBA)	SUM (dBZ)
	31.5	63	125	250	500	1000	2000	4000	8000		
GE 1.5 MW sl/sle		111	110	106	102	98	93	86	79	104	115
Siemens SWT 2.3 MW		110	109	109	104	97	93	88	86	105	115
Vestas V100	114	113	107	102	99	99	97	98	93	105	117
Vestas V82		111	108	105	102	96	94	87	73	103	114
GE 1.6-97 LNTE	116	112	109	104	102	102	100	94	81	108	120
GE 1.6-91 LNTE	117	114	110	105	102	100	97	90	76	105	119

TABLE 5: MODELED TURBINE SOUND POWER LEVELS, NRO, & LOCATIONS

TURBINE	MODELED SOUND POWER LEVEL (dBA)		REPOWER TURBINE MODEL	NRO (dB)	HUB HEIGHT (m)	COORDINATES (UTM NAD83 Z15N)		GROUND ELEVATION + HUB HEIGHT (m)
	EXISTING	REPOWER				X (m)	Y (m)	
T-101	106.0	110.0	GE1.6-97-LNTE	0	80	529430	4843283	499
T-102	106.0	110.0	GE1.6-97-LNTE	0	80	526928	4842906	500
T-103	106.0	109.0	GE1.6-97-LNTE	-1	80	527443	4842919	496
T-104	106.0	103.0	GE1.6-91-LNTE	-4	80	527010	4842440	507
T-105	106.0	107.5	GE1.6-97-LNTE	-2.5	80	527920	4842510	503
T-106	106.0	110.0	GE1.6-97-LNTE	0	80	528958	4842581	501
T-107	106.0	110.0	GE1.6-97-LNTE	0	80	529417	4842572	503
T-108	106.0	107.5	GE1.6-97-LNTE	-2.5	80	527037	4841773	504
T-109	106.0	110.0	GE1.6-97-LNTE	0	80	526193	4841415	503
T-110	106.0	110.0	GE1.6-97-LNTE	0	80	527465	4841386	503
T-111	106.0	110.0	GE1.6-97-LNTE	0	80	526814	4841117	502
T-112	106.0	110.0	GE1.6-97-LNTE	0	80	525398	4840623	510
T-113	106.0	110.0	GE1.6-97-LNTE	0	80	525946	4840570	504

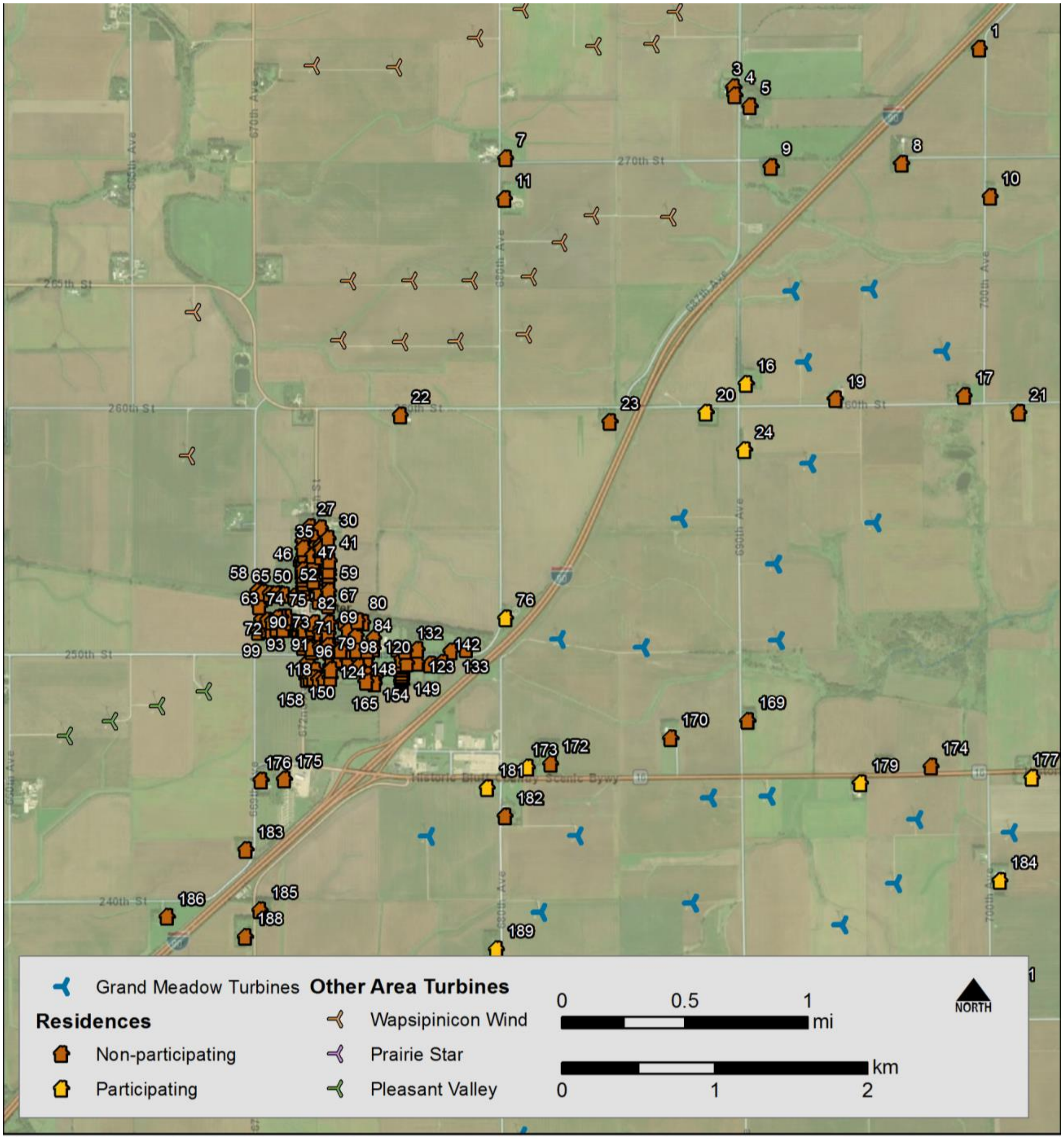
TURBINE	MODELED SOUND POWER LEVEL (dBA)		REPOWER TURBINE MODEL	NRO (dB)	HUB HEIGHT (m)	COORDINATES (UTM NAD83 Z15N)		GROUND ELEVATION + HUB HEIGHT (m)
	EXISTING	REPOWER				X (m)	Y (m)	
T-114	106.0	110.0	GE1.6-97-LNTE	0	80	526832	4840618	494
T-115	106.0	109.0	GE1.6-97-LNTE	-1	80	526385	4839583	502
T-116	106.0	108.5	GE1.6-97-LNTE	-1.5	80	526772	4839595	497
T-117	106.0	110.0	GE1.6-97-LNTE	0	80	524541	4839331	512
T-118	106.0	110.0	GE1.6-97-LNTE	0	80	525516	4839335	514
T-119	106.0	109.0	GE1.6-97-LNTE	-1	80	527739	4839444	504
T-120	106.0	107.5	GE1.6-97-LNTE	-2.5	80	528360	4839358	503
T-121	106.0	110.0	GE1.6-97-LNTE	0	80	527604	4839021	507
T-122	106.0	108.5	GE1.6-97-LNTE	-1.5	80	525276	4838834	514
T-123	106.0	107.5	GE1.6-97-LNTE	-2.5	80	526267	4838894	504
T-124	106.0	103.0	GE1.6-91-LNTE	-4	80	527251	4838753	502
T-125	106.0	104.0	GE1.6-91-LNTE	-3	80	526196	4838383	507
T-126	106.0	103.0	GE1.6-91-LNTE	-4	80	527261	4838276	510
T-127	106.0	108.5	GE1.6-97-LNTE	-1.5	80	524626	4838121	507
T-128	106.0	103.0	GE1.6-91-LNTE	-4	80	526408	4837939	513
T-129	106.0	108.5	GE1.6-97-LNTE	-1.5	80	528326	4837869	507
T-130	106.0	108.5	GE1.6-97-LNTE	-1.5	80	528753	4837927	501
T-131	106.0	108.5	GE1.6-97-LNTE	-1.5	80	529422	4837930	497
T-132	106.0	103.0	GE1.6-91-LNTE	-4	80	524580	4837566	509
T-133	106.0	103.0	GE1.6-91-LNTE	-4	80	526763	4837663	512
T-134	106.0	103.0	GE1.6-91-LNTE	-4	80	527335	4837699	509
T-135	106.0	107.5	GE1.6-97-LNTE	-2.5	80	527738	4837700	506
T-136	106.0	103.0	GE1.6-91-LNTE	-4	80	525145	4837368	513
T-137	106.0	108.5	GE1.6-97-LNTE	-1.5	80	526072	4837260	508
T-138	106.0	108.5	GE1.6-97-LNTE	-1.5	80	526483	4837262	507
T-139	106.0	107.5	GE1.6-97-LNTE	-2.5	80	527128	4837265	510
T-140	106.0	110.0	GE1.6-97-LNTE	0	80	527611	4837267	507
T-141	106.0	103.0	GE1.6-91-LNTE	-4	80	524421	4836854	509
T-142	106.0	103.0	GE1.6-91-LNTE	-4	80	524824	4836845	511
T-143	106.0	110.0	GE1.6-97-LNTE	0	80	528314	4836970	504
T-144	106.0	107.5	GE1.6-97-LNTE	-2.5	80	528644	4837015	507
T-145	106.0	107.5	GE1.6-97-LNTE	-2.5	80	529321	4836985	504
T-146	106.0	107.5	GE1.6-97-LNTE	-2.5	80	526856	4836730	503
T-147	106.0	107.5	GE1.6-97-LNTE	-2.5	80	527372	4836732	503
T-148	106.0	110.0	GE1.6-97-LNTE	0	80	527742	4836723	502

TURBINE	MODELED SOUND POWER LEVEL (dBA)		REPOWER TURBINE MODEL	NRO (dB)	HUB HEIGHT (m)	COORDINATES (UTM NAD83 Z15N)		GROUND ELEVATION + HUB HEIGHT (m)
	EXISTING	REPOWER				X (m)	Y (m)	
T-149	106.0	110.0	GE1.6-97-LNTE	0	80	523737	4836541	506
T-150	106.0	110.0	GE1.6-97-LNTE	0	80	524116	4836542	509
T-151	106.0	103.0	GE1.6-91-LNTE	-4	80	525228	4836546	515
T-152	106.0	108.5	GE1.6-97-LNTE	-1.5	80	526067	4836550	511
T-153	106.0	107.5	GE1.6-97-LNTE	-2.5	80	526486	4836529	506
T-154	106.0	103.0	GE1.6-91-LNTE	-4	80	524568	4836399	511
T-155	106.0	103.0	GE1.6-91-LNTE	-4	80	527567	4836233	501
T-156	106.0	110.0	GE1.6-97-LNTE	0	80	523747	4836086	510
T-157	106.0	110.0	GE1.6-97-LNTE	0	80	524150	4836087	511
T-158	106.0	108.5	GE1.6-97-LNTE	-1.5	80	524811	4835945	512
T-159	106.0	110.0	GE1.6-97-LNTE	0	80	526063	4835506	510
T-160	106.0	107.5	GE1.6-97-LNTE	-2.5	80	526433	4835518	508
T-161	106.0	103.0	GE1.6-91-LNTE	-4	80	526884	4835631	505
T-162	106.0	107.5	GE1.6-97-LNTE	-2.5	80	527433	4835522	507
T-163	106.0	110.0	GE1.6-97-LNTE	0	80	527779	4835601	506
T-164	106.0	110.0	GE1.6-97-LNTE	0	80	527653	4835001	515
T-165	106.0	107.5	GE1.6-97-LNTE	-2.5	80	527178	4834788	513
T-166	106.0	109.0	GE1.6-97-LNTE	-1	80	526897	4834498	511
T-167	106.0	110.0	GE1.6-97-LNTE	0	80	527655	4834479	510
Pleasant Valley	107.0		V100		95	520827	4838250	509
Pleasant Valley	107.0		V100		95	522772	4840186	522
Pleasant Valley	107.0		V100		95	522464	4840086	520
Pleasant Valley	107.0		V100		95	522168	4839991	519
Pleasant Valley	107.0		V100		95	521591	4838604	510
Pleasant Valley	107.0		V100		95	521251	4839849	514
Pleasant Valley	107.0		V100		95	520626	4837954	504
Pleasant Valley	107.0		V100		95	523080	4840280	525
Prairie Star	105.3		V82		80	530025	4834766	495
Prairie Star	105.3		V82		80	526965	4831621	504
Prairie Star	105.3		V82		80	532459	4834988	504
Prairie Star	105.3		V82		80	527949	4831636	502
Prairie Star	105.3		V82		80	529460	4834863	500
Prairie Star	105.3		V82		80	530022	4837076	500
Prairie Star	105.3		V82		80	529442	4831654	513
Prairie Star	105.3		V82		80	531362	4833240	504

TURBINE	MODELED SOUND POWER LEVEL (dBA)		REPOWER TURBINE MODEL	NRO (dB)	HUB HEIGHT (m)	COORDINATES (UTM NAD83 Z15N)		GROUND ELEVATION + HUB HEIGHT (m)
	EXISTING	REPOWER				X (m)	Y (m)	
Prairie Star	105.3		V82		80	528423	4834237	507
Prairie Star	105.3		V82		80	532062	4837019	496
Prairie Star	105.3		V82		80	529137	4834851	500
Prairie Star	105.3		V82		80	531822	4834963	498
Prairie Star	105.3		V82		80	530709	4833170	503
Prairie Star	105.3		V82		80	530668	4837013	505
Prairie Star	105.3		V82		80	529211	4836384	501
Prairie Star	105.3		V82		80	530990	4837014	505
Prairie Star	105.3		V82		80	530337	4837078	504
Prairie Star	105.3		V82		80	528845	4831651	507
Prairie Star	105.3		V82		80	531040	4833171	506
Prairie Star	105.3		V82		80	531320	4837016	503
Prairie Star	105.3		V82		80	528514	4831650	503
Prairie Star	105.3		V82		80	530354	4833168	501
Prairie Star	105.3		V82		80	531731	4837018	502
Prairie Star	105.3		V82		80	528761	4834238	508
Prairie Star	105.3		V82		80	529764	4831644	511
Prairie Star	105.3		V82		80	529639	4836386	502
Prairie Star	105.3		V82		80	527619	4831635	503
Prairie Star	105.3		V82		80	532144	4834898	500
Wapsipinicon	106.0		GE-1.5-sl		80	527684	4845251	496
Wapsipinicon	106.0		GE-1.5-sl		80	525633	4844510	513
Wapsipinicon	106.0		GE-1.5-sl		80	526012	4844523	509
Wapsipinicon	106.0		GE-1.5-sl		80	524368	4842573	498
Wapsipinicon	106.0		GE-1.5-sl		80	525997	4846367	504
Wapsipinicon	106.0		GE-1.5-sl		80	524841	4845518	499
Wapsipinicon	106.0		GE-1.5-sl		80	525158	4844753	508
Wapsipinicon	106.0		GE-1.5-sl		80	525213	4842998	506
Wapsipinicon	106.0		GE-1.5-sl		80	524330	4844372	500
Wapsipinicon	106.0		GE-1.5-sl		80	527777	4846029	491
Wapsipinicon	106.0		GE-1.5-sl		80	524861	4844563	506
Wapsipinicon	106.0		GE-1.5-sl		80	525399	4844853	507
Wapsipinicon	106.0		GE-1.5-sl		80	524826	4842974	501
Wapsipinicon	106.0		GE-1.5-sl		80	525339	4845587	507
Wapsipinicon	106.0		GE-1.5-sl		80	524167	4844938	504

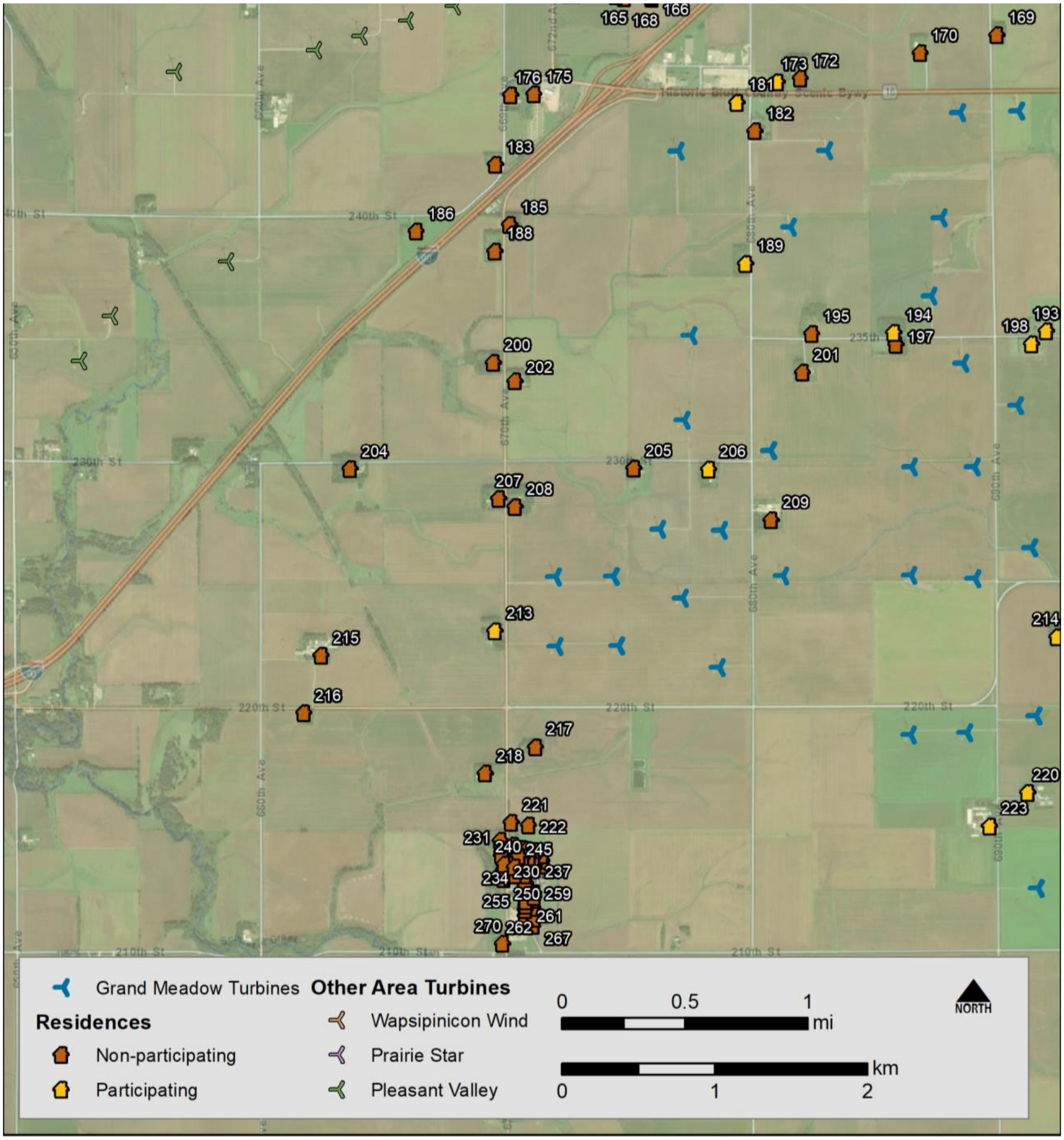
TURBINE	MODELED SOUND POWER LEVEL (dBA)		REPOWER TURBINE MODEL	NRO (dB)	HUB HEIGHT (m)	COORDINATES (UTM NAD83 Z15N)		GROUND ELEVATION + HUB HEIGHT (m)
	EXISTING	REPOWER				X (m)	Y (m)	
Wapsipinicon	106.0		GE-1.5-sl		80	522970	4841824	505
Wapsipinicon	106.0		GE-1.5-sl		80	525622	4843399	511
Wapsipinicon	106.0		GE-1.5-sl		80	524029	4842972	499
Wapsipinicon	106.0		GE-1.5-sl		80	526121	4843390	511
Wapsipinicon	106.0		GE-1.5-sl		80	523791	4844381	502
Wapsipinicon	106.0		GE-1.5-sl		80	526164	4844734	506
Wapsipinicon	106.0		GE-1.5-sl		80	523007	4842768	494
Wapsipinicon	106.0		GE-1.5-sl		80	527762	4845707	496
Wapsipinicon	106.0		GE-1.5-sl		80	525990	4845989	507
Wapsipinicon	106.0		GE-1.5-sl		80	527685	4844963	495
Wapsipinicon	106.0		GE-1.5-sl		80	525413	4843221	507
Wapsipinicon	106.0		GE-1.5-sl		80	525182	4842620	504
Wapsipinicon	106.0		GE-1.5-sl		80	524432	4842973	499
Wapsipinicon	106.0		GE-1.5-sl		80	524823	4846051	501
Wapsipinicon	106.0		GE-1.5-sl		80	523966	4842583	494
Wapsipinicon	106.0		GE-1.5-sl		80	527831	4846629	494
Wapsipinicon	106.0		GE-1.5-sl		80	525478	4845143	508
Wapsipinicon	106.0		GE-1.5-sl		80	524731	4842574	500
Wapsipinicon	106.0		GE-1.5-sl		80	526146	4845112	509
Wapsipinicon	106.0		GE-1.5-sl		80	527147	4846560	501
Wapsipinicon	106.0		GE-1.5-sl		80	525370	4846042	503
Wapsipinicon	106.0		GE-1.5-sl		80	524440	4844950	503

APPENDIX D. RECEIVER INFORMATION



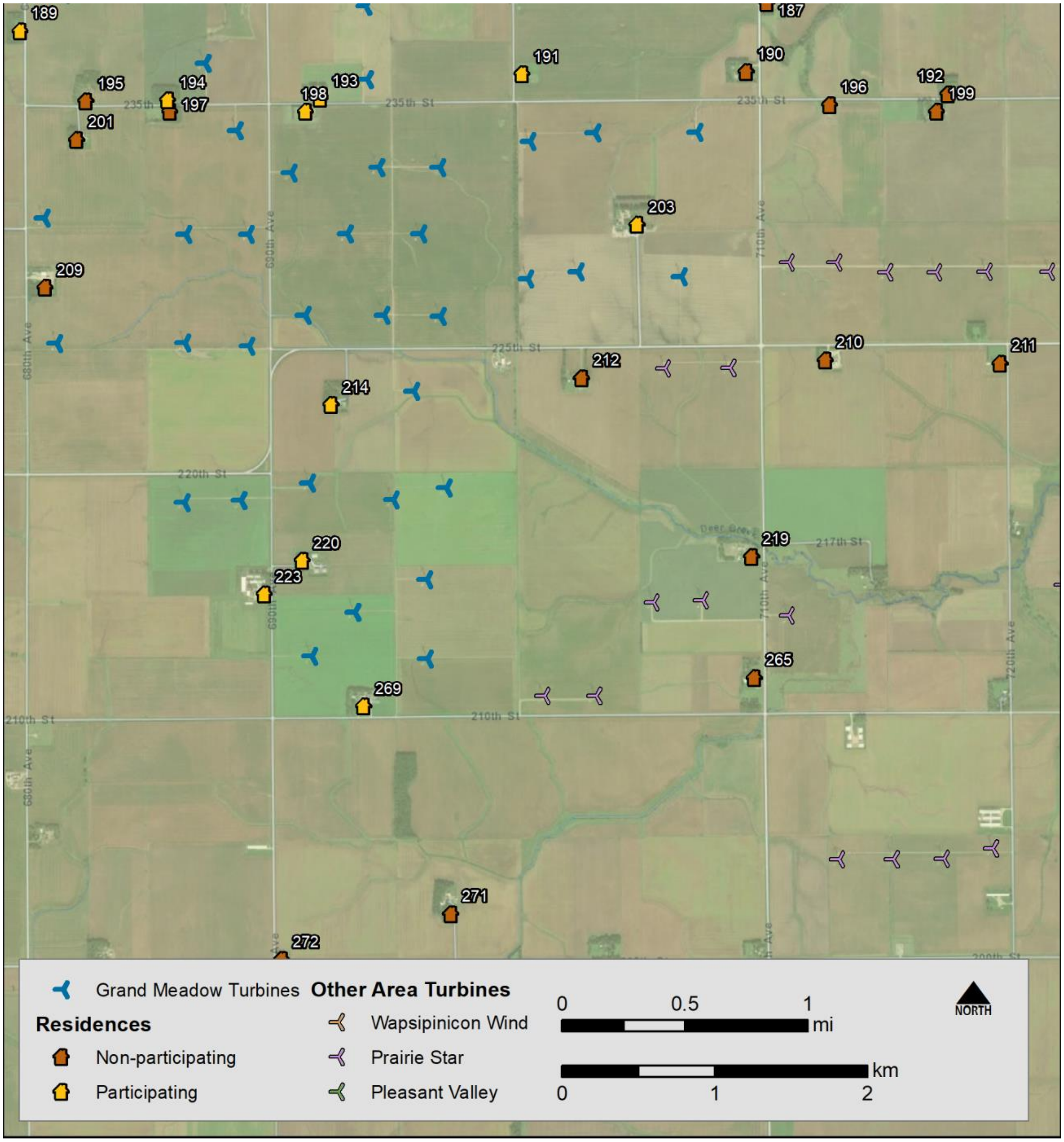
Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

FIGURE 10: RECEIVER ID MAP, NORTHWESTERN AREA



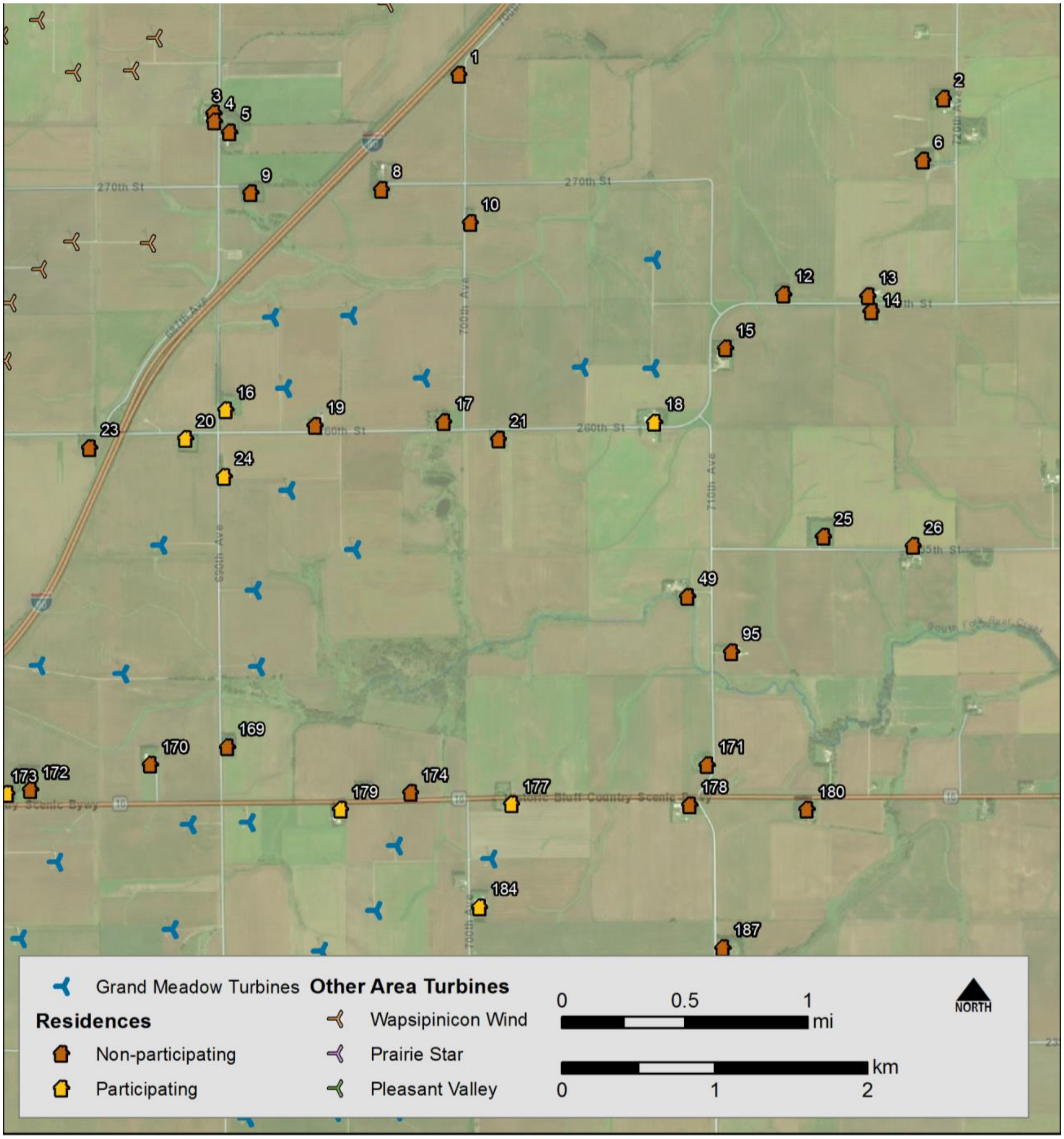
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FIGURE 11: RECEIVER ID MAP, SOUTHWESTERN AREA



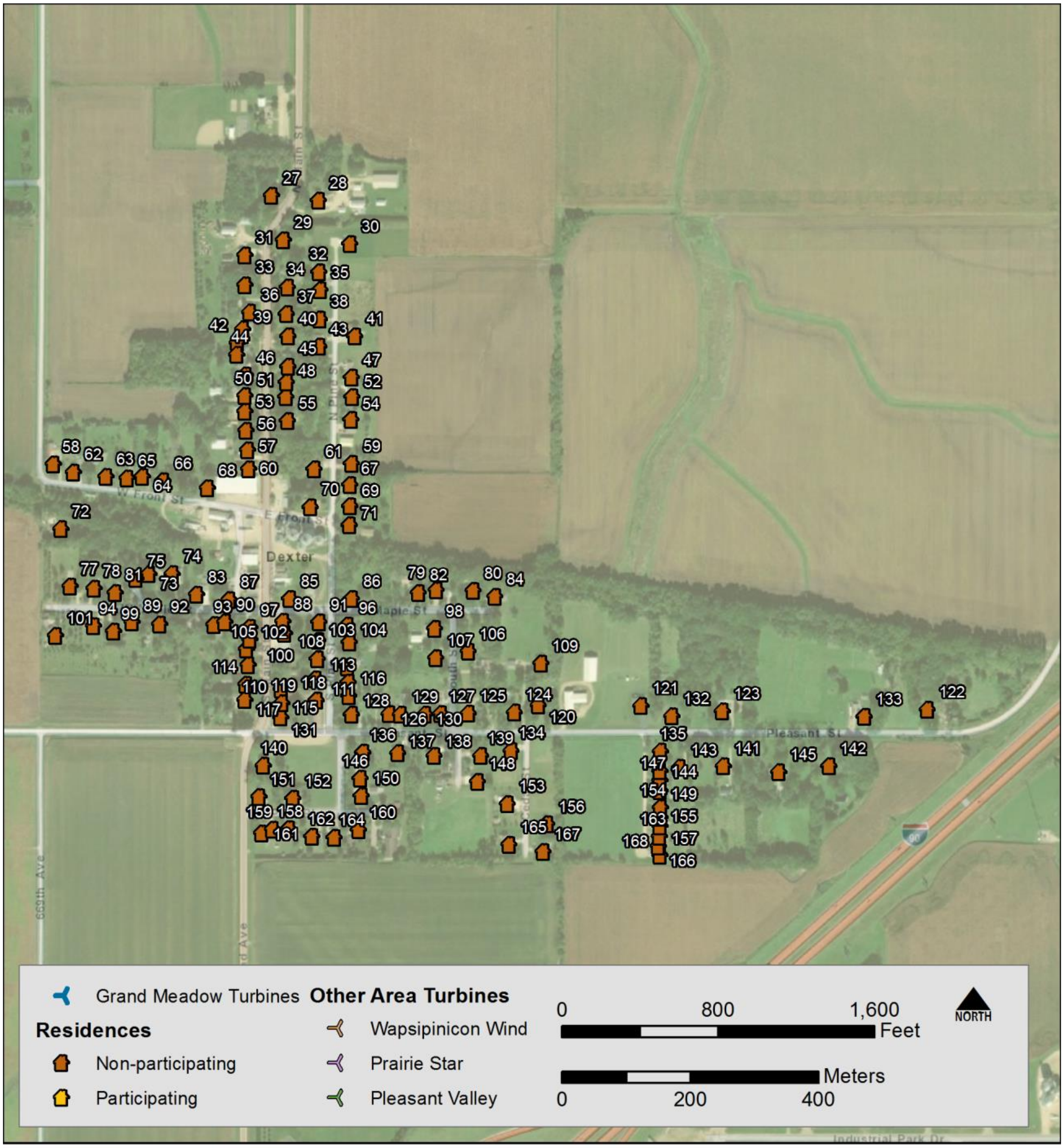
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

FIGURE 12: RECEIVER ID MAP, SOUTHEASTERN AREA



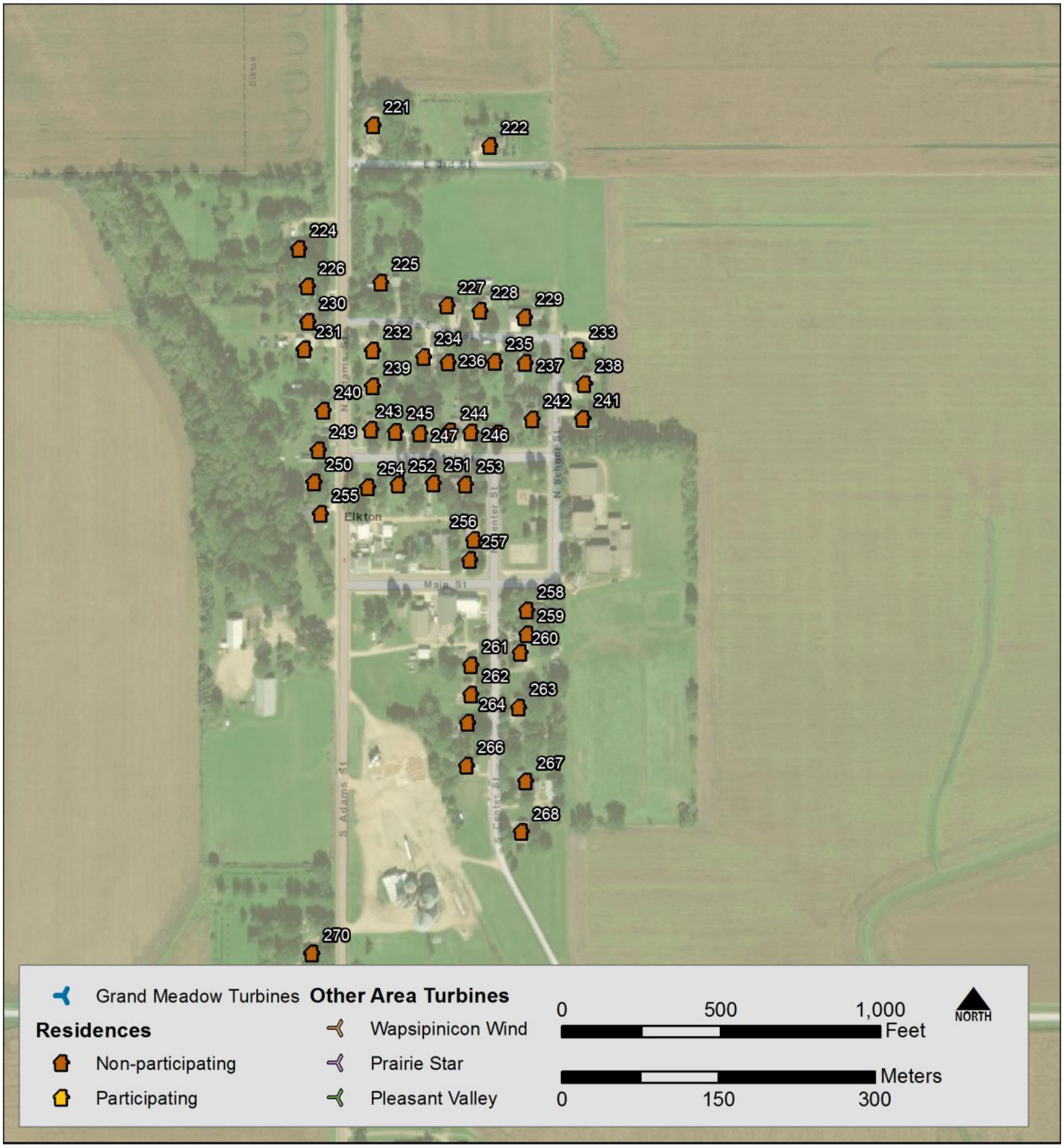
Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

FIGURE 13: RECEIVER ID MAP, NORTHEASTERN AREA



Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

FIGURE 14: RECEIVER ID MAP, DEXTER AREA



Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

FIGURE 15: RECEIVER ID MAP, ELKTON AREA

TABLE 6: MODEL RESULTS AND COORDINATES FOR EACH MODELED RECEIVER

REC. ID	STATUS [26]	MODELED TURBINE ONLY SOUND LEVEL (L_{50}, dBA)		DIFFERENCE (REPOWER-EXISTING)[27]	TOTAL SOUND LEVEL, EXISTING COMBINED WITH BACKGROUND				COORDINATES (UTM NAD 83 Z15N)		
		EXISTING	REPOWER		30 dBA BACKGROUND	35 dBA BACKGROUND	40 dBA BACKGROUND	45 dBA BACKGROUND	X(m)	Y(m)	Z (m)
R-1	NP	42	42	0	42	43	44	47	528157	4844495	424
R-2	NP	31	31	0	33	36	40	45	531331	4844341	409
R-3	NP	45	45	0	45	46	46	48	526548	4844243	434
R-4	NP	45	45	0	45	45	46	48	526552	4844189	435
R-5	NP	44	44	0	44	45	46	48	526653	4844120	435
R-6	NP	31	31	0	34	36	41	45	531197	4843934	414
R-7	NP	47	47	0	47	47	47	49	525051	4843779	429
R-8	NP	42	42	0	42	43	44	47	527647	4843743	427
R-9	NP	44	44	0	44	45	45	48	526790	4843720	429
R-10	NP	41	41	0	42	42	44	47	528230	4843525	421
R-11	NP	48	48	0	48	48	48	50	525045	4843510	432
R-12	NP	39	40	1	40	41	43	46	530285	4843058	424
R-13	NP	36	36	0	37	38	41	45	530836	4843047	432
R-14	NP	36	36	0	37	38	41	45	530861	4842945	430
R-15	NP	43	44	1	44	45	46	48	529901	4842703	429
R-16	P	46	46	-1	46	46	47	48	526627	4842298	435
R-17	NP	46	46	0	46	46	47	49	528058	4842220	425

[26] NP: Non-Participating, P: Participating

[27] The sound levels and the difference between the Repower and Existing scenarios are rounded to the nearest whole decibel. In some cases, the sound levels reported sound level for the Repower and Existing scenarios are the same, but a difference of 1 or -1 is reported. This is due to rounding. For example, the modeled Existing sound level may be 34.3 dBA, and the modeled Repower sound level may be 33.6 dBA. Both sound levels would be reported as 34 dBA, but a difference of -1 dB would be reported because the difference of 0.7 dB is rounded to the nearest whole number.

REC. ID	STATUS [26]	MODELED TURBINE ONLY SOUND LEVEL (L_{50}, dBA)		DIFFERENCE (REPOWER-EXISTING)[27]	TOTAL SOUND LEVEL, EXISTING COMBINED WITH BACKGROUND				COORDINATES (UTM NAD 83 Z15N)		
		EXISTING	REPOWER		30 dBA BACKGROUND	35 dBA BACKGROUND	40 dBA BACKGROUND	45 dBA BACKGROUND	X(m)	Y(m)	Z (m)
R-18	P	45	47	2	47	47	48	49	529435	4842218	425
R-19	NP	48	47	-1	47	47	48	49	527215	4842197	429
R-20	P	45	45	0	45	45	46	48	526363	4842109	438
R-21	NP	43	43	0	44	44	45	47	528416	4842108	427
R-22	NP	46	46	0	46	46	47	49	524364	4842091	423
R-23	NP	44	44	0	44	45	46	48	525735	4842051	436
R-24	P	46	46	0	46	47	47	49	526616	4841863	434
R-25	NP	36	35	0	36	38	41	45	530545	4841469	419
R-26	NP	34	34	-1	35	37	41	45	531133	4841410	420
R-27	NP	41	41	0	41	42	44	46	523768	4841359	432
R-28	NP	41	41	0	41	42	44	46	523841	4841352	433
R-29	NP	41	41	0	41	42	44	46	523786	4841290	433
R-30	NP	41	41	0	41	42	44	46	523891	4841284	432
R-31	NP	41	41	0	41	42	44	46	523726	4841266	434
R-32	NP	41	41	0	41	42	44	46	523843	4841240	432
R-33	NP	41	41	0	41	42	43	46	523726	4841220	434
R-34	NP	41	41	0	41	42	43	46	523794	4841217	433
R-35	NP	41	41	0	41	42	43	46	523844	4841212	432
R-36	NP	41	41	0	41	42	43	46	523734	4841177	434
R-37	NP	41	41	0	41	42	43	46	523792	4841175	433
R-38	NP	41	41	0	41	42	43	46	523843	4841167	432
R-39	NP	41	41	0	41	42	43	46	523723	4841151	434
R-40	NP	41	41	0	41	42	43	46	523794	4841140	433
R-41	NP	41	41	0	41	42	43	46	523898	4841140	431
R-42	NP	41	41	0	41	42	43	46	523715	4841130	434
R-43	NP	41	41	0	41	42	43	46	523842	4841124	432

REC. ID	STATUS [26]	MODELED TURBINE ONLY SOUND LEVEL (L_{50}, dBA)		DIFFERENCE (REPOWER-EXISTING)[27]	TOTAL SOUND LEVEL, EXISTING COMBINED WITH BACKGROUND				COORDINATES (UTM NAD 83 Z15N)		
		EXISTING	REPOWER		30 dBA BACKGROUND	35 dBA BACKGROUND	40 dBA BACKGROUND	45 dBA BACKGROUND	X(m)	Y(m)	Z (m)
R-44	NP	41	41	0	41	42	43	46	523714	4841112	434
R-45	NP	41	41	0	41	42	43	46	523794	4841093	433
R-46	NP	41	41	0	41	42	43	46	523728	4841079	434
R-47	NP	41	41	0	41	42	43	46	523893	4841076	432
R-48	NP	41	41	0	41	42	43	46	523792	4841068	434
R-49	NP	38	37	0	38	39	42	46	529654	4841076	411
R-50	NP	41	41	0	41	42	43	46	523726	4841047	434
R-51	NP	41	41	0	41	42	43	46	523791	4841045	434
R-52	NP	41	41	0	41	42	43	46	523894	4841045	433
R-53	NP	41	41	0	41	42	43	46	523726	4841023	434
R-54	NP	41	41	0	41	42	43	46	523892	4841010	433
R-55	NP	41	41	0	41	42	43	46	523793	4841008	434
R-56	NP	41	41	0	41	42	43	46	523728	4840993	434
R-57	NP	41	41	0	41	42	43	46	523730	4840963	435
R-58	NP	41	41	0	42	42	44	47	523428	4840940	434
R-59	NP	41	41	0	41	42	43	46	523893	4840941	434
R-60	NP	41	41	0	41	42	43	46	523732	4840933	435
R-61	NP	41	41	0	41	42	43	46	523835	4840933	435
R-62	NP	41	41	0	42	42	44	47	523459	4840928	434
R-63	NP	41	41	0	41	42	44	46	523510	4840921	434
R-64	NP	41	41	0	41	42	44	46	523567	4840921	434
R-65	NP	41	41	0	41	42	44	46	523543	4840918	434
R-66	NP	41	41	0	41	42	43	46	523599	4840914	434
R-67	NP	41	41	0	41	42	43	46	523890	4840908	434
R-68	NP	41	41	0	41	42	43	46	523668	4840903	435
R-69	NP	41	41	0	41	42	43	46	523891	4840875	434

REC. ID	STATUS [26]	MODELED TURBINE ONLY SOUND LEVEL (L_{50}, dBA) EXISTING	REPOWER	DIFFERENCE (REPOWER-EXISTING)[27]	TOTAL SOUND LEVEL, EXISTING COMBINED WITH BACKGROUND 30 dBA BACKGROUND	35 dBA BACKGROUND	40 dBA BACKGROUND	45 dBA BACKGROUND	COORDINATES (UTM NAD 83 Z15N) X(m)	Y(m)	Z (m)
R-70	NP	41	41	0	41	42	43	46	523829	4840874	435
R-71	NP	41	41	0	41	42	43	46	523890	4840846	434
R-72	NP	42	42	0	42	42	44	47	523439	4840840	435
R-73	NP	42	41	0	42	42	44	47	523577	4840769	436
R-74	NP	41	41	0	42	42	44	47	523613	4840769	436
R-75	NP	42	42	0	42	42	44	47	523556	4840761	436
R-76	P	45	46	1	46	47	47	49	525051	4840762	436
R-77	NP	42	42	0	42	43	44	47	523454	4840750	434
R-78	NP	42	42	0	42	43	44	47	523491	4840746	435
R-79	NP	41	41	0	41	42	43	46	524026	4840744	434
R-80	NP	41	41	0	41	42	43	46	524083	4840743	434
R-81	NP	42	42	0	42	42	44	47	523524	4840740	435
R-82	NP	41	41	0	41	42	43	46	523998	4840740	435
R-83	NP	41	41	0	41	42	44	46	523651	4840737	436
R-84	NP	41	41	0	41	42	43	46	524117	4840734	433
R-85	NP	41	41	0	41	42	43	46	523797	4840730	437
R-86	NP	41	41	0	41	42	43	46	523894	4840730	435
R-87	NP	41	41	0	41	42	43	46	523702	4840729	436
R-88	NP	41	41	0	41	42	43	46	523786	4840695	436
R-89	NP	42	42	0	42	43	44	47	523551	4840694	434
R-90	NP	41	41	0	41	42	44	46	523695	4840694	435
R-91	NP	41	41	0	41	42	43	46	523843	4840694	436
R-92	NP	42	42	0	42	42	44	47	523593	4840690	435
R-93	NP	41	41	0	41	42	44	46	523678	4840690	435
R-94	NP	42	42	0	42	43	44	47	523490	4840688	435
R-95	NP	37	36	-1	37	39	41	46	529940	4840713	409

REC. ID	STATUS [26]	MODELED TURBINE ONLY SOUND LEVEL (L_{50}, dBA)		DIFFERENCE (REPOWER-EXISTING)[27]	TOTAL SOUND LEVEL, EXISTING COMBINED WITH BACKGROUND				COORDINATES (UTM NAD 83 Z15N)		
		EXISTING	REPOWER		30 dBA BACKGROUND	35 dBA BACKGROUND	40 dBA BACKGROUND	45 dBA BACKGROUND	X(m)	Y(m)	Z (m)
R-96	NP	41	41	0	41	42	43	46	523887	4840689	436
R-97	NP	41	41	0	41	42	44	46	523734	4840686	436
R-98	NP	41	41	0	41	42	43	46	524023	4840684	436
R-99	NP	42	42	0	42	43	44	47	523521	4840679	434
R-100	NP	41	41	0	41	42	43	46	523789	4840676	437
R-101	NP	43	43	0	43	43	45	47	523431	4840673	434
R-102	NP	41	41	0	41	42	44	46	523734	4840667	436
R-103	NP	41	41	0	41	42	43	46	523841	4840665	436
R-104	NP	41	41	0	41	42	43	46	523890	4840663	436
R-105	NP	41	41	0	41	42	44	46	523729	4840652	436
R-106	NP	41	41	0	41	42	43	46	524075	4840648	435
R-107	NP	41	41	0	41	42	43	46	524025	4840638	436
R-108	NP	41	41	0	41	42	43	46	523840	4840636	436
R-109	NP	41	41	0	41	42	43	46	524189	4840630	434
R-110	NP	41	41	0	41	42	44	46	523731	4840627	436
R-111	NP	41	41	0	41	42	43	46	523886	4840624	436
R-112	NP	41	41	0	41	42	43	46	523837	4840605	436
R-113	NP	41	41	0	41	42	43	46	523889	4840600	437
R-114	NP	41	41	0	42	42	44	47	523728	4840597	436
R-115	NP	41	41	0	41	42	44	46	523783	4840589	436
R-116	NP	41	41	0	41	42	43	46	523889	4840579	437
R-117	NP	41	41	0	42	42	44	47	523726	4840573	435
R-118	NP	41	41	0	41	42	43	46	523839	4840572	436
R-119	NP	41	41	0	41	42	44	46	523784	4840568	436
R-120	NP	41	41	0	41	42	43	46	524184	4840564	434
R-121	NP	41	41	0	41	42	44	46	524345	4840564	433

REC. ID	STATUS [26]	MODELED TURBINE ONLY SOUND LEVEL (L_{50}, dBA)		DIFFERENCE (REPOWER-EXISTING)[27]	TOTAL SOUND LEVEL, EXISTING COMBINED WITH BACKGROUND				COORDINATES (UTM NAD 83 Z15N)		
		EXISTING	REPOWER		30 dBA BACKGROUND	35 dBA BACKGROUND	40 dBA BACKGROUND	45 dBA BACKGROUND	X(m)	Y(m)	Z (m)
R-122	NP	43	43	1	43	44	45	47	524792	4840557	435
R-123	NP	41	42	0	42	42	44	47	524472	4840555	435
R-124	NP	41	41	0	41	42	43	46	524147	4840553	434
R-125	NP	41	41	0	41	42	43	46	524076	4840551	436
R-126	NP	41	41	0	41	42	43	46	523952	4840551	437
R-127	NP	41	41	0	41	42	43	46	524032	4840551	436
R-128	NP	41	41	0	41	42	43	46	523894	4840550	437
R-129	NP	41	41	0	41	42	43	46	523970	4840550	437
R-130	NP	41	41	0	41	42	43	46	524007	4840550	436
R-131	NP	41	41	0	41	42	44	46	523782	4840546	436
R-132	NP	41	41	0	41	42	44	46	524393	4840548	434
R-133	NP	42	43	1	43	43	45	47	524693	4840546	435
R-134	NP	41	41	0	41	42	43	46	524142	4840494	434
R-135	NP	41	41	0	41	42	44	46	524375	4840493	434
R-136	NP	41	41	0	41	42	43	46	523911	4840491	437
R-137	NP	41	41	0	41	42	43	46	523965	4840490	437
R-138	NP	41	41	0	41	42	43	46	524022	4840485	437
R-139	NP	41	41	0	41	42	43	46	524094	4840486	436
R-140	NP	41	41	0	42	42	44	47	523755	4840470	435
R-141	NP	41	42	0	42	42	44	47	524473	4840469	436
R-142	NP	42	42	0	43	43	44	47	524638	4840470	436
R-143	NP	41	41	0	42	42	44	47	524405	4840467	435
R-144	NP	41	41	0	41	42	44	46	524374	4840462	434
R-145	NP	42	42	0	42	43	44	47	524559	4840460	436
R-146	NP	41	41	0	41	42	43	46	523907	4840450	436
R-147	NP	41	41	0	41	42	44	46	524374	4840447	434

REC. ID	STATUS [26]	MODELED TURBINE ONLY SOUND LEVEL (L_{50}, dBA)		DIFFERENCE (REPOWER-EXISTING)[27]	TOTAL SOUND LEVEL, EXISTING COMBINED WITH BACKGROUND				COORDINATES (UTM NAD 83 Z15N)		
		EXISTING	REPOWER		30 dBA BACKGROUND	35 dBA BACKGROUND	40 dBA BACKGROUND	45 dBA BACKGROUND	X(m)	Y(m)	Z (m)
R-148	NP	41	41	0	41	42	43	46	524090	4840445	435
R-149	NP	41	41	0	41	42	44	46	524374	4840431	434
R-150	NP	41	41	0	41	42	43	46	523909	4840423	436
R-151	NP	42	41	0	42	42	44	47	523748	4840421	435
R-152	NP	41	41	0	41	42	44	46	523802	4840418	435
R-153	NP	41	41	0	41	42	43	46	524136	4840411	435
R-154	NP	41	41	0	41	42	44	46	524375	4840404	435
R-155	NP	41	41	0	42	42	44	47	524374	4840389	435
R-156	NP	41	41	0	41	42	43	46	524198	4840379	435
R-157	NP	41	41	0	42	42	44	47	524374	4840375	435
R-158	NP	41	41	0	42	42	44	47	523795	4840371	435
R-159	NP	42	41	0	42	42	44	47	523770	4840370	435
R-160	NP	41	41	0	41	42	43	46	523904	4840369	437
R-161	NP	42	42	0	42	42	44	47	523753	4840364	435
R-162	NP	41	41	0	41	42	44	46	523831	4840359	436
R-163	NP	41	41	0	42	42	44	47	524373	4840360	435
R-164	NP	41	41	0	41	42	44	46	523866	4840357	436
R-165	NP	41	41	0	41	42	43	46	524139	4840347	435
R-166	NP	41	41	0	42	42	44	47	524371	4840345	436
R-167	NP	41	41	0	41	42	44	46	524192	4840336	436
R-168	NP	41	41	0	42	42	44	47	524374	4840329	436
R-169	NP	46	47	1	47	47	48	49	526637	4840091	425
R-170	NP	46	47	1	47	47	48	49	526133	4839975	428
R-171	NP	38	37	-1	38	39	42	46	529782	4839973	415
R-172	NP	45	46	1	46	46	47	48	525348	4839808	439
R-173	P	45	45	1	45	46	46	48	525194	4839783	438

REC. ID	STATUS [26]	MODELED TURBINE ONLY SOUND LEVEL (L_{50}, dBA)		DIFFERENCE (REPOWER-EXISTING)[27]	TOTAL SOUND LEVEL, EXISTING COMBINED WITH BACKGROUND				COORDINATES (UTM NAD 83 Z15N)		
		EXISTING	REPOWER		30 dBA BACKGROUND	35 dBA BACKGROUND	40 dBA BACKGROUND	45 dBA BACKGROUND	X(m)	Y(m)	Z (m)
R-174	NP	46	47	0	47	47	47	49	527839	4839791	423
R-175	NP	41	41	0	42	42	44	47	523603	4839705	435
R-176	NP	42	42	0	42	43	44	47	523448	4839697	435
R-177	P	45	45	0	45	45	46	48	528502	4839716	425
R-178	NP	38	37	-1	38	39	42	46	529669	4839710	417
R-179	P	46	47	0	47	47	47	49	527380	4839680	422
R-180	NP	37	36	-1	37	38	41	45	530437	4839681	411
R-181	P	45	46	1	46	46	47	48	524933	4839648	438
R-182	NP	46	47	1	47	47	47	49	525051	4839463	440
R-183	NP	40	40	0	41	41	43	46	523349	4839243	432
R-184	P	47	47	0	47	47	48	49	528291	4839041	428
R-185	NP	40	40	-1	40	41	43	46	523442	4838848	428
R-186	NP	39	39	-1	39	40	42	46	522832	4838804	427
R-187	NP	40	40	-1	40	41	43	46	529884	4838776	416
R-188	NP	40	39	-1	40	41	43	46	523347	4838675	427
R-189	P	47	47	0	47	47	47	49	524991	4838593	436
R-190	NP	43	43	0	43	44	45	47	529748	4838325	419
R-191	P	47	46	0	46	47	47	49	528283	4838310	434
R-192	NP	40	39	0	40	41	43	46	531074	4838179	420
R-193	P	49	47	-2	47	47	48	49	526960	4838150	436
R-194	P	48	46	-2	46	47	47	49	525959	4838139	437
R-195	NP	45	44	-1	44	45	46	48	525424	4838132	441
R-196	NP	42	41	0	42	42	44	47	530297	4838108	418
R-197	NP	48	46	-2	46	46	47	49	525974	4838063	438
R-198	P	49	47	-2	47	47	48	49	526863	4838065	437
R-199	NP	40	40	0	41	41	43	46	530999	4838066	423

REC. ID	STATUS [26]	MODELED TURBINE ONLY SOUND LEVEL (L_{50}, dBA)		DIFFERENCE (REPOWER-EXISTING)[27]	TOTAL SOUND LEVEL, EXISTING COMBINED WITH BACKGROUND				COORDINATES (UTM NAD 83 Z15N)		
		EXISTING	REPOWER		30 dBA BACKGROUND	35 dBA BACKGROUND	40 dBA BACKGROUND	45 dBA BACKGROUND	X(m)	Y(m)	Z (m)
R-200	NP	40	39	-1	40	41	43	46	523334	4837943	423
R-201	NP	46	44	-2	44	45	46	48	525362	4837880	441
R-202	NP	41	40	-1	40	41	43	46	523478	4837823	426
R-203	P	47	47	0	47	47	48	49	529036	4837325	430
R-204	NP	38	37	-1	38	39	42	46	522399	4837247	422
R-205	NP	47	46	-2	46	46	47	48	524256	4837251	429
R-206	P	49	47	-2	47	47	48	49	524746	4837244	434
R-207	NP	43	43	0	43	44	45	47	523371	4837051	430
R-208	NP	44	45	1	45	45	46	48	523477	4836999	431
R-209	NP	49	47	-2	47	47	48	49	525156	4836911	442
R-210	NP	45	45	0	45	45	46	48	530268	4836436	427
R-211	NP	44	43	0	44	44	45	47	531415	4836416	426
R-212	NP	46	46	0	46	46	47	48	528674	4836320	431
R-213	P	46	47	1	47	47	48	49	523348	4836184	431
R-214	P	48	47	-1	47	47	48	49	527031	4836146	430
R-215	NP	37	36	-1	37	39	42	46	522209	4836024	427
R-216	NP	35	34	-1	36	38	41	45	522093	4835647	423
R-217	NP	42	43	1	43	43	45	47	523612	4835424	424
R-218	NP	39	39	0	40	41	43	46	523284	4835253	421
R-219	NP	45	45	0	45	46	46	48	529785	4835149	419
R-220	P	48	47	-1	47	47	48	49	526840	4835125	436
R-221	NP	38	38	0	39	40	42	46	523454	4834929	423
R-222	NP	39	38	0	39	40	42	46	523567	4834910	424
R-223	P	46	46	0	46	46	47	49	526591	4834905	437
R-224	NP	38	37	0	38	39	42	46	523383	4834811	425
R-225	NP	38	37	-1	38	39	42	46	523462	4834779	426

REC. ID	STATUS [26]	MODELED TURBINE ONLY SOUND LEVEL (L_{50}, dBA)		DIFFERENCE (REPOWER-EXISTING)[27]	TOTAL SOUND LEVEL, EXISTING COMBINED WITH BACKGROUND				COORDINATES (UTM NAD 83 Z15N)		
		EXISTING	REPOWER		30 dBA BACKGROUND	35 dBA BACKGROUND	40 dBA BACKGROUND	45 dBA BACKGROUND	X(m)	Y(m)	Z (m)
R-226	NP	38	37	0	38	39	42	46	523391	4834775	426
R-227	NP	38	37	0	38	39	42	46	523525	4834757	427
R-228	NP	38	37	0	38	39	42	46	523557	4834752	426
R-229	NP	38	37	0	38	39	42	46	523600	4834745	426
R-230	NP	37	37	-1	38	39	42	46	523392	4834741	426
R-231	NP	37	37	-1	37	39	42	46	523388	4834715	426
R-232	NP	37	37	-1	38	39	42	46	523454	4834714	427
R-233	NP	38	37	-1	38	39	42	46	523651	4834714	427
R-234	NP	38	37	-1	38	39	42	46	523503	4834707	427
R-235	NP	38	37	-1	38	39	42	46	523571	4834703	428
R-236	NP	38	37	-1	38	39	42	46	523526	4834702	428
R-237	NP	38	37	-1	38	39	42	46	523600	4834702	428
R-238	NP	38	37	-1	38	39	42	46	523657	4834681	428
R-239	NP	37	37	-1	37	39	42	46	523454	4834679	427
R-240	NP	37	36	-1	37	39	42	46	523407	4834656	426
R-241	NP	38	37	-1	38	39	42	46	523655	4834648	428
R-242	NP	38	37	-1	38	39	42	46	523607	4834648	428
R-243	NP	37	36	-1	37	39	42	46	523453	4834638	428
R-244	NP	37	37	-1	38	39	42	46	523528	4834636	429
R-245	NP	37	37	-1	37	39	42	46	523476	4834636	428
R-246	NP	37	37	-1	38	39	42	46	523548	4834635	429
R-247	NP	37	37	-1	37	39	42	46	523499	4834634	429
R-248	NP	37	37	-1	38	39	42	46	523573	4834634	429
R-249	NP	37	36	-1	37	39	41	46	523402	4834618	427
R-250	NP	37	36	-1	37	39	41	46	523398	4834587	427
R-251	NP	37	36	-1	37	39	42	46	523512	4834586	430

REC. ID	STATUS [26]	MODELED TURBINE ONLY SOUND LEVEL (L_{50}, dBA) EXISTING	REPOWER	DIFFERENCE (REPOWER-EXISTING)[27]	TOTAL SOUND LEVEL, EXISTING COMBINED WITH BACKGROUND 30 dBA BACKGROUND	35 dBA BACKGROUND	40 dBA BACKGROUND	45 dBA BACKGROUND	COORDINATES (UTM NAD 83 Z15N) X(m)	Y(m)	Z (m)
R-252	NP	37	36	-1	37	39	42	46	523478	4834585	429
R-253	NP	37	37	-1	37	39	42	46	523543	4834585	430
R-254	NP	37	36	-1	37	39	41	46	523449	4834583	428
R-255	NP	37	36	-1	37	38	41	46	523404	4834557	428
R-256	NP	37	36	-1	37	39	42	46	523551	4834532	430
R-257	NP	37	36	-1	37	39	41	46	523547	4834513	430
R-258	NP	37	36	-1	37	39	41	46	523602	4834465	429
R-259	NP	37	36	-1	37	38	41	45	523602	4834442	429
R-260	NP	37	36	-1	37	38	41	45	523595	4834424	429
R-261	NP	36	35	-1	36	38	41	45	523548	4834412	428
R-262	NP	36	35	-1	36	38	41	45	523548	4834384	427
R-263	NP	36	35	-1	37	38	41	45	523594	4834372	428
R-264	NP	36	35	-1	36	38	41	45	523545	4834357	427
R-265	NP	44	44	0	44	45	46	48	529804	4834356	422
R-266	NP	36	35	-1	36	38	41	45	523544	4834316	427
R-267	NP	36	35	-1	37	38	41	45	523601	4834301	428
R-268	NP	36	35	-1	36	38	41	45	523596	4834252	427
R-269	P	46	46	1	46	47	47	49	527244	4834172	433
R-270	NP	35	34	-1	35	37	41	45	523396	4834136	423
R-271	NP	40	39	0	40	41	43	46	527815	4832810	426
R-272	NP	39	38	0	39	40	42	46	526705	4832512	434

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