# Appendix C

# Plum Creek Wind Pre-Construction Noise Assessment

Plum Creek Wind Farm, LLC
Site Permit Amendment Request
Docket No. IP6997 / WS-18-700
February 2025

# PLUM CREEK WIND PRE-CONSTRUCTION NOISE ASSESSMENT 2024

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**Report Title**:

Plum Creek Wind Pre-Construction Noise Assessment 2024

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**Report Prepared for**:

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# EXECUTIVE SUMMARY

Plum Creek Wind Farm, LLC is submitting a Site Permit Application (SPA) to the Minnesota Public Utilities Commission (PUC) to build Plum Creek Wind (Project) in Cottonwood, Murray and Redwood Counties. The Project is a proposed 414 MW power generation facility with up to 78 wind turbines.

The noise standards for all three counties in the Project area refer to Minnesota Pollution Control Agency Chapter 7030 (MN Noise Limit), which prescribes median one-hour limits for the daytime of 60 dBA ($L_{50}$) and nighttime of 50 dBA ($L_{50}$).

Consistent with Chapter 7030, and as part of the original application filing for the Project, background sound level monitoring in the proposed Project area was completed in late summer 2019. Daytime soundscapes were composed of anthropogenic sources typical in a rural agricultural landscape, such as vehicles on public roads, tractors, and commercial aircraft overflights; wind-induced sounds, birds, and insects were also common sounds. Nighttime sources of sound were mostly limited to wind-induced sounds, sporadic aircraft overflights, occasional vehicle passbys on public roadways, and consistent insect sound. The results of monitoring showed that the average nighttime $L_{50}$ across all onsite monitors was 42 dBA. When biogenic sound was removed, which was predominantly from insects in this case, median nighttime sound levels ($L_{50}$) were generally below 30 dB-ANS.

Sound propagation modeling was completed for an updated array of four wind turbine models in accordance with applicable technical standards and guidelines. The four modeled layouts all have 78 proposed turbine locations, though some are “alternates” for the final design. That is, between 68 and 77 turbines would actually be installed, depending on the turbine model and the associated Project layout.

A total of 461 discrete residences were modeled. The modeling parameters were set to calculate the worst-case one-hour equivalent continuous sound level ($L_{eq}$), which serves as a conservative estimate of the one-hour $L_{50}$. With noise reduced operations at night on specified turbines, wind turbine-only sound levels (one-hour $L_{50}$) from the Project are expected to be 47 dBA or less at night at discrete residences for all modeling scenarios considered herein. Thus, Project sound is modeled to meet the MN Noise Limit.

# 1.0 PROJECT DESCRIPTION

## 1.1 INTRODUCTION

This document serves as the Pre-Construction Sound Assessment Report ("Report") for the Plum Creek Wind ("Project") for the Site Permit Application (SPA) submitted to the Minnesota Public Utilities Commission. The Project will involve the construction of up to 77 turbines and have a rated capacity of 414 MW. This Report considers four scenarios, each with a different wind turbine model that could be installed at the site. Sound propagation modeling procedures and results are included. Note that RSG submitted a preconstruction noise assessment in 2020 ("2020 Noise Report")[1] for a prior design of the Project. Background sound level results from the 2020 Noise Assessment report are summarized in this Report.

A noise primer, with information related to wind turbine acoustics, is provided in Appendix A.

## 1.2 PROJECT DESCRIPTION

A map of the general Project area is provided in Figure 1. The Project Area extends to US-14 to the North (Redwood County), 121st Street to the South (Murray County), 430th Avenue (County Highway 4) to the East (Cottonwood County) and 225th Avenue to the west (Murray County). Land uses in the Project area are typically agricultural, with farm residences and rural neighborhoods throughout the area. The Project also includes two substations, with one transformer each, centrally located within the Project area.

Terrain in the area is primarily flat and increases in elevation by approximately 110 meters (360 feet) from the northwest to southwest corner of the Project area. Rural, county roads run through much of the Project area and major routes are to the north (US-14) and south (MN-30). The nearest cities to the Project are Dovray to the southwest and Walnut Grove to the north.

Four proposed layout configurations, each with a distinct turbine model, are currently under consideration for the Project. The layouts summarized in Table 1 below.

**TABLE 1: TURBINE MODELS AND NUMBER OF TURBINES UNDER CONSIDERATION**

| MAKE/MODEL | OUTPUT (MW) | HUB HEIGHT (m) | # OF PRIMARY TURBINES | # OF ALTERNATE TURBINES |
|---|---|---|---|---|
| GE 3.8-154 | 3.8 | 98 | 77 | 1 |
| GE 6.1-158 | 6.1 | 117 | 68 | 10 |
| Vestas V150-4.5 | 4.5 | 120 | 75 | 3 |
| Vestas V163-4.5 | 4.5 | 113 | 76 | 2 |

[1] RSG. Plum Creek Wind Farm Noise Compliance Assessment. August 2020. IP6997 / WS-18-700

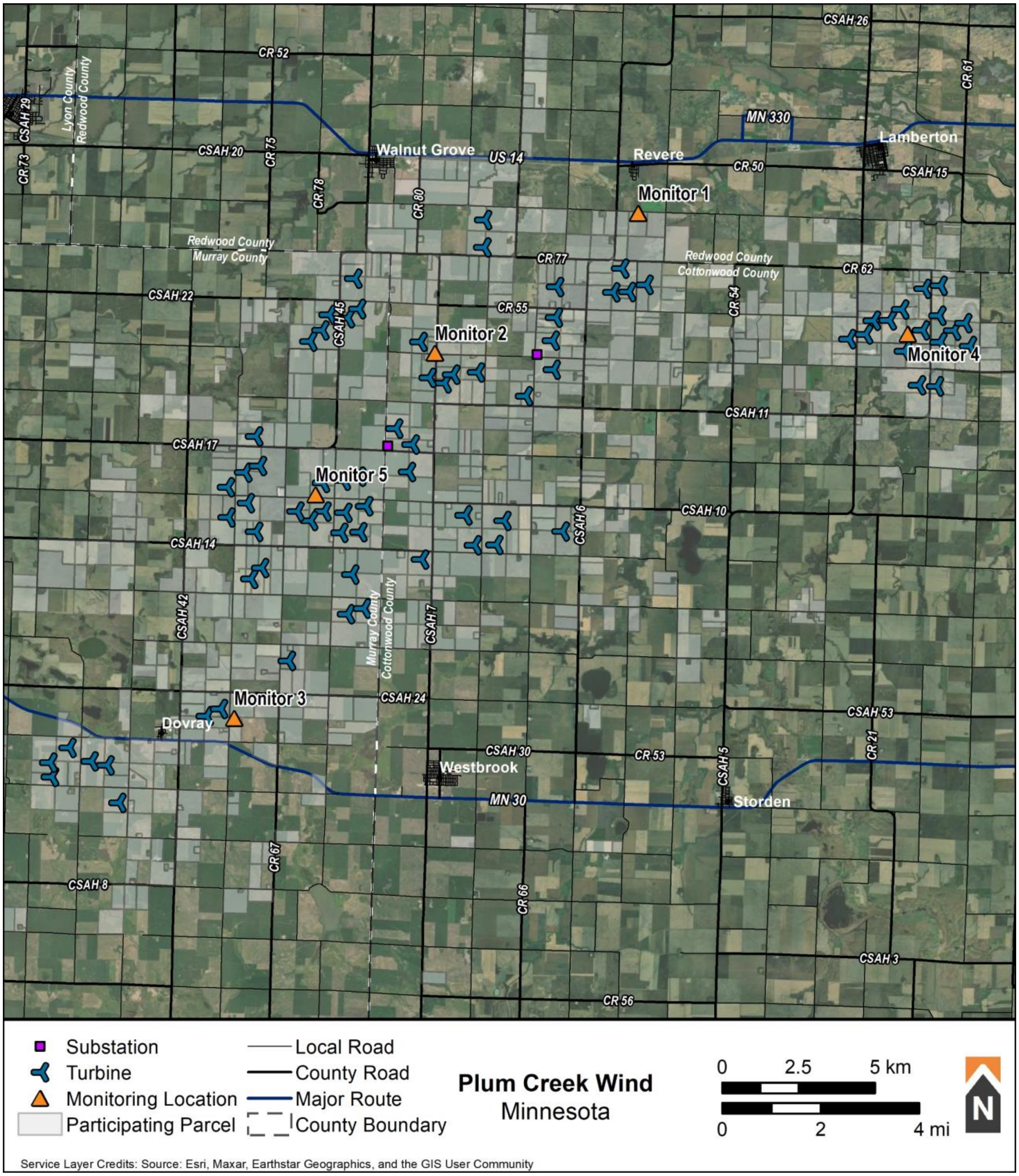


**FIGURE 1: PROJECT AREA MAP.**

*The map shows 78 turbine locations, which apply to all layouts modeled with all alternates included.*

# 2.0 SOUND LEVEL STANDARDS

## 2.1 LOCAL STANDARDS

All three counties in the Project area refer to the state noise standards for wind turbines. Specifically:

Cottonwood County addresses noise from wind turbines in Subdivision 7 of their Renewable Energy Ordinance which states:

> *Noise is regulated by the Minnesota Pollution Control Agency under Chapter 7030. These rules establish the maximum nighttime noise and day time noise levels that effectively limit wind turbine noise to 50 dB(A) at farm residences.*

Murray County addresses noise from wind turbines in Subdivision 4 of their Renewable Energy Ordinance which states:

> *All WECS shall comply with Minnesota Rules 7030, as amended, governing noise.*

Redwood County addresses noise from wind turbines in Section 153.357 of Title XV of the County Code which states:

> *Noise is regulated and the regulations are enforced by the state's Pollution Control Agency under Minn. Rules Ch. 7030. These rules establish the maximum nighttime and daytime noise levels.*

## 2.2 STATE STANDARD

The Project is required to comply with the noise limits set forth in Minnesota Rules Chapter 7030. Under this standard, a residence (Noise Area Classification ("NAC") 1) is limited to a median one-hour daytime and nighttime sound level of 60 dBA ($L_{50}$) and 50 dBA ($L_{50}$), respectively. The limits for the 90th percentile sound levels ($L_{10}$, which is the level exceeded 10% of the time over one hour) are 5 dB higher, as shown in Table 2.

**TABLE 2: MINNESOTA NOISE POLLUTION CONTROL 7030.0050 NOISE STANDARDS**

| | $L_{50}$ | $L_{10}$ |
|---|---|---|
| Daytime | 60 dBA | 65 dBA |
| Nighttime | 50 dBA | 55 dBA |

The noise standards in Minnesota Rules Chapter 7030 (MN noise limits) describes "the limiting levels of sound," which is total sound (source sound level plus background sound level). Wind turbine-only sound levels at 47 dBA (1-hour $L_{50}$) and below ensure that sound levels 50 dBA and above are not attributable to the Project.[2]

[2] Application Guidance for Site Permitting of Large Wind Energy Conversion Systems in Minnesota," July 2019, MN Department of Commerce

# 3.0 EXISTING SOUND LEVELS

Background sound level monitoring was conducted throughout the Project area to quantify the existing sound levels, including the nighttime $L_{50}$, and to identify existing sources of sound.[3] The results of the monitoring were conveyed in full in the 2020 Noise Report and are summarized here for completeness.

## 3.1 OVERVIEW

Long-term sound level monitoring occurred from August 27 to September 5, 2019 at five onsite and two offsite[4] monitor locations. The onsite monitors are listed in Table 3 and shown in Figure 1. Pictures and basic descriptions of the locations are provided in Appendix B. Monitors 4 and 5 represented the worst-case modeled receptors. Full monitoring results from the long-term background sound level monitoring completed in 2019 can be found in the 2020 Noise Report. The locations were selected as those with the highest modeled sound level in a prior design of the Project. In this case, Monitor 1 is no longer near any proposed Project turbines and thus it should be dropped or switched out for another site for post-construction monitoring.[5]

**TABLE 3: MONITOR LOCATION SUMMARY**

| MONITOR | MODEL RECEPTOR ID | MODELED SOUND LEVEL (dBA) | COORDINANTES (UTM NAD 83 ZONE 15N) | | PROJECT AREA | COUNTY |
|---|---|---|---|---|---|---|
| | | | X (m) | Y(m) | | |
| Monitor 1 | R-023 | 31 to 34 | 311,307 | 4,897,878 | North | Redwood |
| Monitor 2 | R-100 | 42 to 45 | 311,306 | 4,893,312 | Central | Cottonwood |
| Monitor 3 | R-286 | 42 to 44 | 304,664 | 4,881,389 | Southwest | Murray |
| Monitor 4 | R-319 | 46 to 47 | 298,105 | 4,893,932 | Northeast | Cottonwood |
| Monitor 5 | R-220 | 46 to 47 | 320,108 | 4,888,690 | West | Murray |

[3] Monitoring location selection was based upon the guidance provided in the Department of Commerce's "Guidance for Large Wind Energy Conversion System Noise Study Protocol and Report," July 2019. The guidance recommends a minimum of three locations within the Project area and that one monitor location be in proximity to the worst-case modeled receptor.
[4] Two offsite monitoring sites (located outside of the Project area) were also deployed to comply with EERA guidance at the time regarding using a parallel offsite location for determining background sound levels. Since then, the discrete shutdown method and related binning methodologies have become well accepted in Minnesota and the offsite monitors are unnecessary.
[5] Some candidates for a replacement site include R-292, R-322, or R-387

## 3.2 MONITORING RESULTS

The A-weighted sound level monitoring results are summarized in Table 4. The average nighttime $L_{50}$ across all onsite monitors was 42 dBA. The nighttime A-weighted sound levels shown in Table 4, were notably affected by biogenic sounds (primarily insects). Biogenic sound is subject to seasonality and would not be present at all times during the year. To account for this, high frequency tonal sounds such as insect sounds were filtered out of the dataset using ANS weighting[6]. ANS weighting is the same as A-weighting (see Appendix A), except that it discounts sound levels above the 1 kHz 1/1 octave band, the frequency range in which the biogenic sounds occur. Elevated background sound levels during nighttime hours were primarily attributable to biogenic sources such as insect sounds, particularly at the Monitor 2 location. Comparing the nighttime sound levels between A-weighted and ANS-weighted levels shows that the background sound levels were generally at least 10 dB less when biogenic sound was removed. The nighttime ANS-weighted $L_{50}$ was below 30 dBA at all monitors.

Wind near the ground was strongest and most influential at Monitor 1 and Monitor 5 because these locations were more exposed. Monitor 3 and Monitor 4 were located in more protected locations and did not experience consistently elevated winds near ground level. Vehicular traffic and aircraft overflights occurred daily through the monitoring. Agricultural equipment was observed at Monitor 2 and Monitor 3. Human-related activity such as music and social gatherings were observed at some of the monitors due to their location and the time of the year. Extraneous sources, such as recreational vehicle activity, nearby events, and wind gust exceedances were removed from the averages.

**TABLE 4: OVERALL BACKGROUND SOUND LEVEL MONITORING RESULTS (dBA OR dB-ANS)**

| MONITOR | DAYTIME | | | | | | | | NIGHTTIME | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A-WEIGHTED | | | | ANS-WEIGHTED | | | | A-WEIGHTED | | | | ANS-WEIGHTED | | | |
| | $L_{EQ}$ | $L_{10}$ | $L_{50}$ | $L_{90}$ | $L_{EQ}$ | $L_{10}$ | $L_{50}$ | $L_{90}$ | $L_{EQ}$ | $L_{10}$ | $L_{50}$ | $L_{90}$ | $L_{EQ}$ | $L_{10}$ | $L_{50}$ | $L_{90}$ |
| Monitor 1 | 44 | 46 | 42 | 38 | 41 | 44 | 36 | 22 | 40 | 43 | 39 | 34 | 33 | 35 | 23 | 15 |
| Monitor 2 | 51 | 52 | 45 | 41 | 49 | 49 | 35 | 22 | 48 | 50 | 46 | 42 | 41 | 39 | 26 | 16 |
| Monitor 3 | 42 | 46 | 37 | 31 | 41 | 45 | 32 | 22 | 42 | 47 | 39 | 35 | 31 | 34 | 26 | 17 |
| Monitor 4 | 52 | 55 | 42 | 34 | 52 | 55 | 38 | 24 | 51 | 51 | 43 | 34 | 50 | 44 | 27 | 19 |
| Monitor 5 | 43 | 45 | 41 | 38 | 37 | 39 | 28 | 21 | 44 | 47 | 43 | 37 | 28 | 32 | 23 | 16 |
| *Average* | *46* | *49* | *41* | *36* | *44* | *46* | *34* | *22* | *45* | *48* | *42* | *36* | *37* | *37* | *25* | *17* |

[6] ANSI S12.100, "Methods to Define and Measure the Residual Sound in Protected Natural and Quiet Residential Areas"

# 4.0 SOUND PROPAGATION MODELING

## 4.1 PROCEDURES

Sound propagation modeling for the Project was performed 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® Version 2023 from Datakustik GmbH which implements the ISO 9613-2 standard. CadnaA® is a widely accepted sound 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. The Project area was modeled with half hard and half porous ground (G=0.5). Otherwise, no reflections (such as due to buildings) were considered. Likewise, shielding by structures and foliage attenuation was not considered. Atmospheric absorption was based on 10˚C and 70% relative humidity and source contributions were considered up to 10,000 meters (6.2 miles) from each receiver. The model was laid over the USGS Digital Terrain Model to give accurate elevations throughout.

Sound levels were modeled at 461 discrete residences. All residential receivers were modeled at a 4-meter (13 foot) height above ground level. In addition, a 25-meter by 25-meter grid of receivers at 4-meters (13 feet) above ground level was set up in the model, covering about 1250 $km^2$ (480 $mi^2$) in and around the Project area.

Wind turbines were modeled with the maximum manufacturer-specified apparent sound power level. All turbine data used is the most recent available from the manufacturer. Further, a factor of +2 dB was added to all modeled wind turbine sound levels to account for sound power and propagation uncertainty. Results calculated with these parameters represent the highest one-hour equivalent continuous sound level ($L_{1h}$) with the Project operating at maximum sound emission capacity. Although all potential wind turbine locations were modeled as sources, not all of them are planned to be installed because there are some alternate locations.

The sound modeling methodology applied in this study follows the ANSI/ACP American National Standard for wind turbine sound modeling[7] and is in conformance with informative Annex D of ISO 9613-2.[8] Both standards are intended to represent the equivalent continuous sound pressure level ($L_{eq}$). Although the nighttime MN noise limits are specified as $L_{50}$, the ANSI/ACP technical standard states that “predictions made consistent with this standard may be deemed conservative assessments of these metrics.”

Noise Reduced Operations (NRO) were specified on turbines where necessary to limit the projected turbine-only sound level to 47 dBA at night. Summary tables with modeling parameters, NRO mode specification for each layout, and additional equipment noise source information are provided in Appendix C.

## 4.2 RESULTS

### Overall A-weighted Model Results

Modeled turbine-only sound levels were 47 dBA or below at all residences for all scenarios modeled. Maps with contour lines representing Project generated sound levels for each turbine model are shown Figure 2, Figure 3, Figure 4, and Figure 5. Sound level results are presented as contour lines representing 5-dB increments of calculated A-weighted sound pressure levels. The 47 dBA line represents the effective turbine-only MN noise limit for the Project.

Appendix D provides a list of the calculated sound pressure levels at each receiver in tabular format. Additionally, a series of maps are provided showing all receiver and turbine identification numbers for reference.

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[7] ANSI/ACP Standard 111-1, “Wind Turbine Sound Modeling,” American National Standards Institute, 2022.

[8] ISO 9613-2. Attenuation of sound during propagation outdoors — Part 2: Engineering method for the prediction of sound pressure levels outdoors. Annex D (informative): Calculation of sound pressure levels caused by wind turbines, 2024.

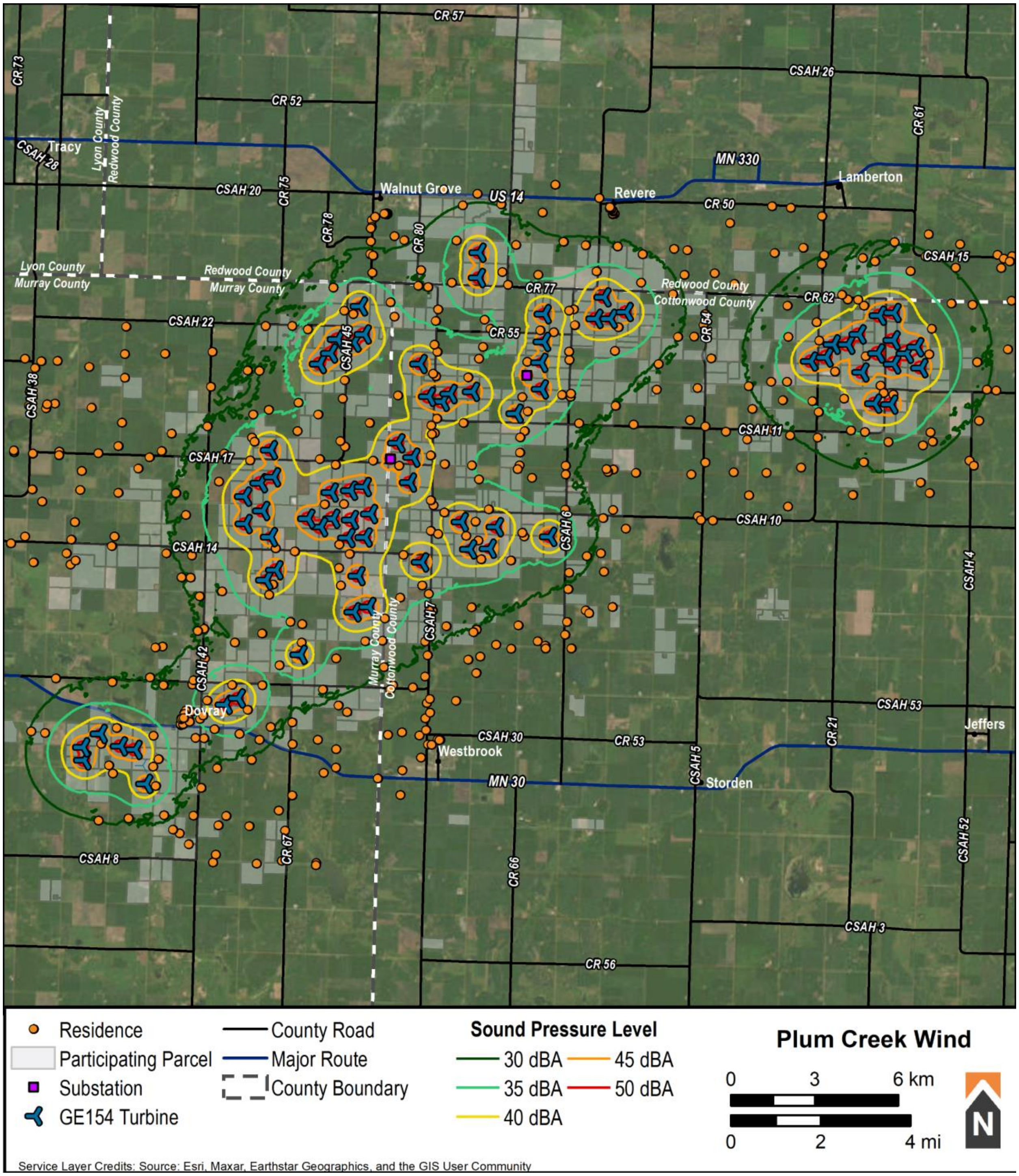


**FIGURE 2: PROJECT SOUND PROPAGATION MODELING RESULTS – GE154**

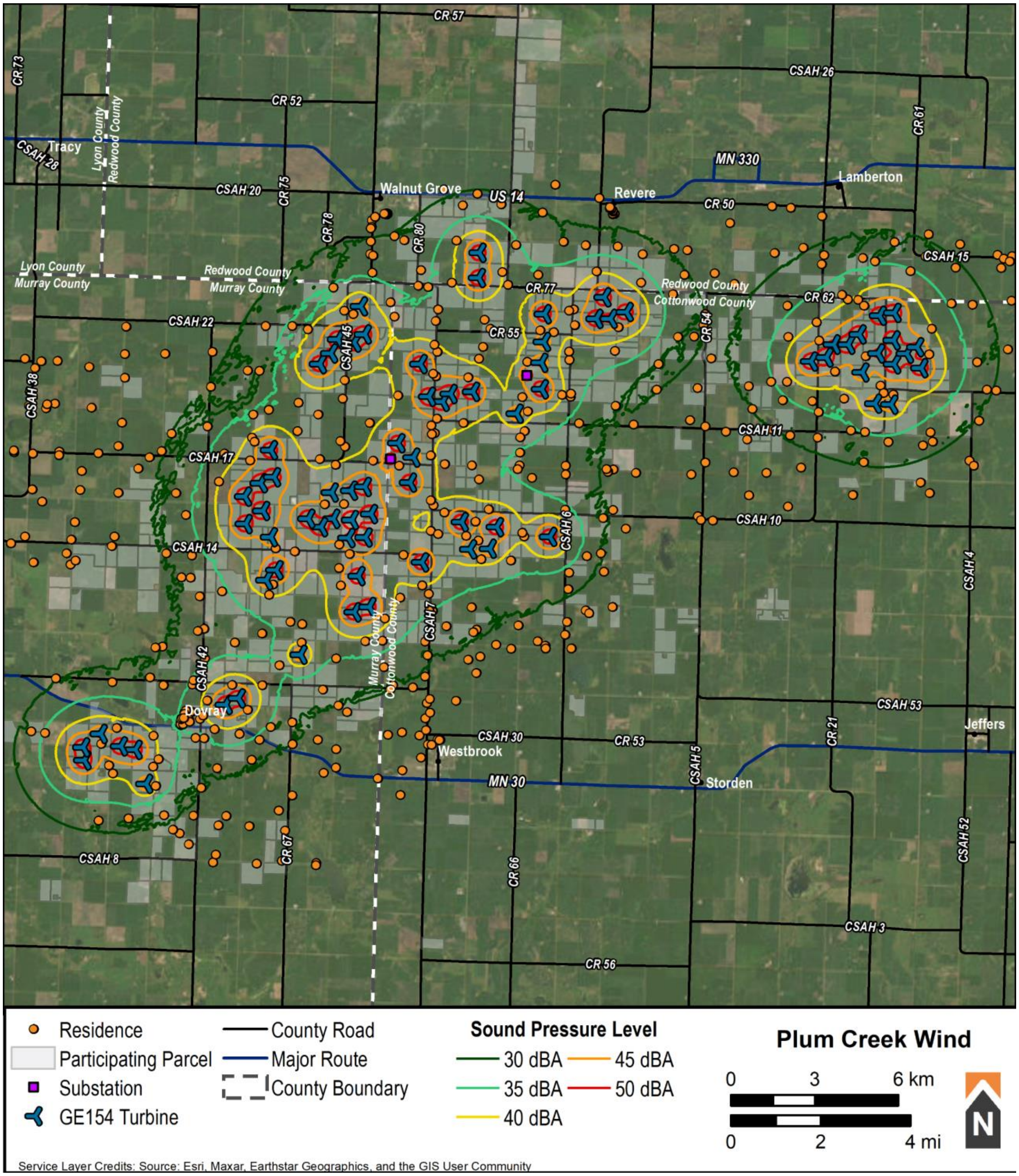


**FIGURE 3: PROJECT SOUND PROPAGATION MODELING RESULTS – GE158**

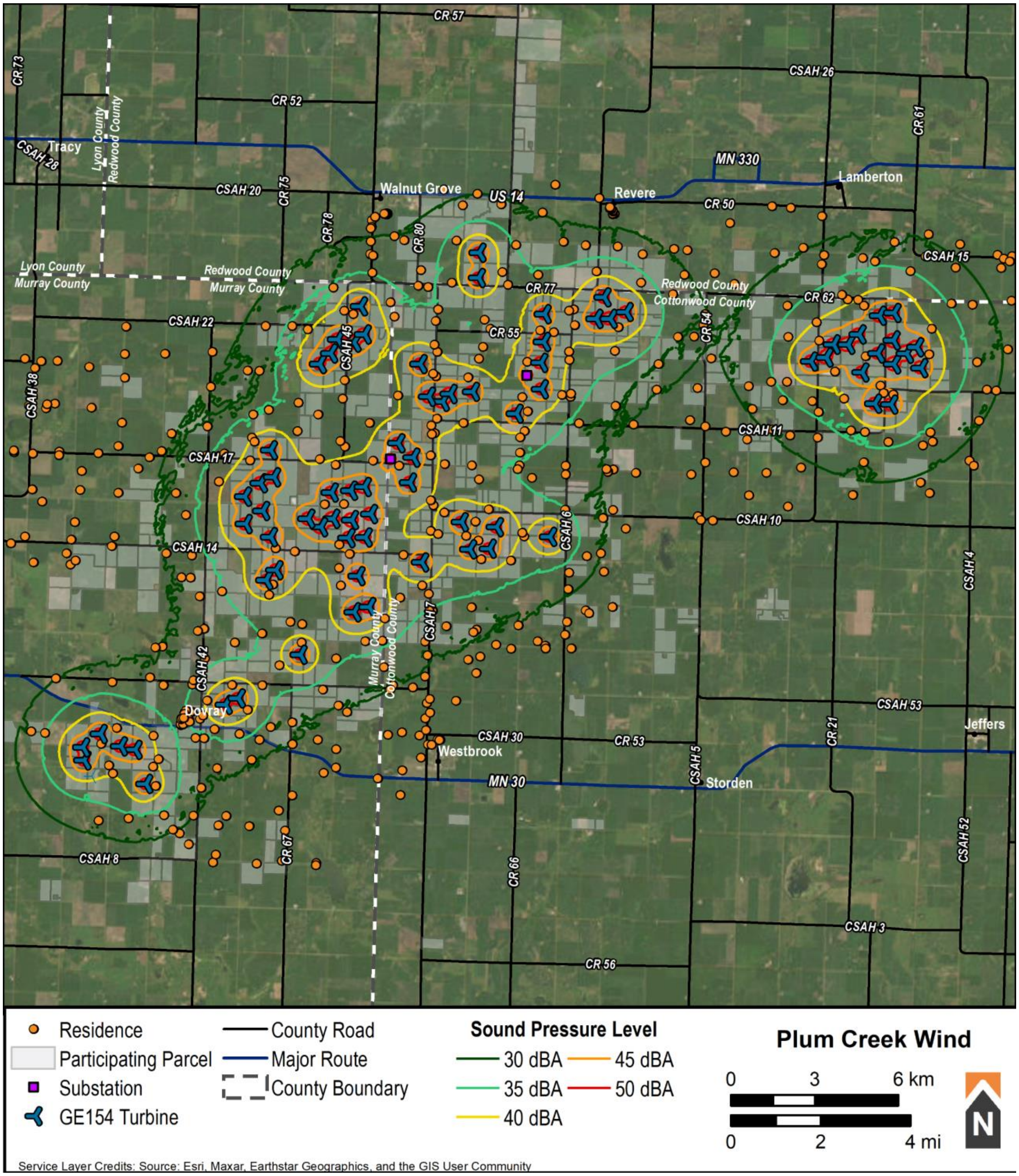


**FIGURE 4: PROJECT SOUND PROPAGATION MODELING RESULTS – V150**

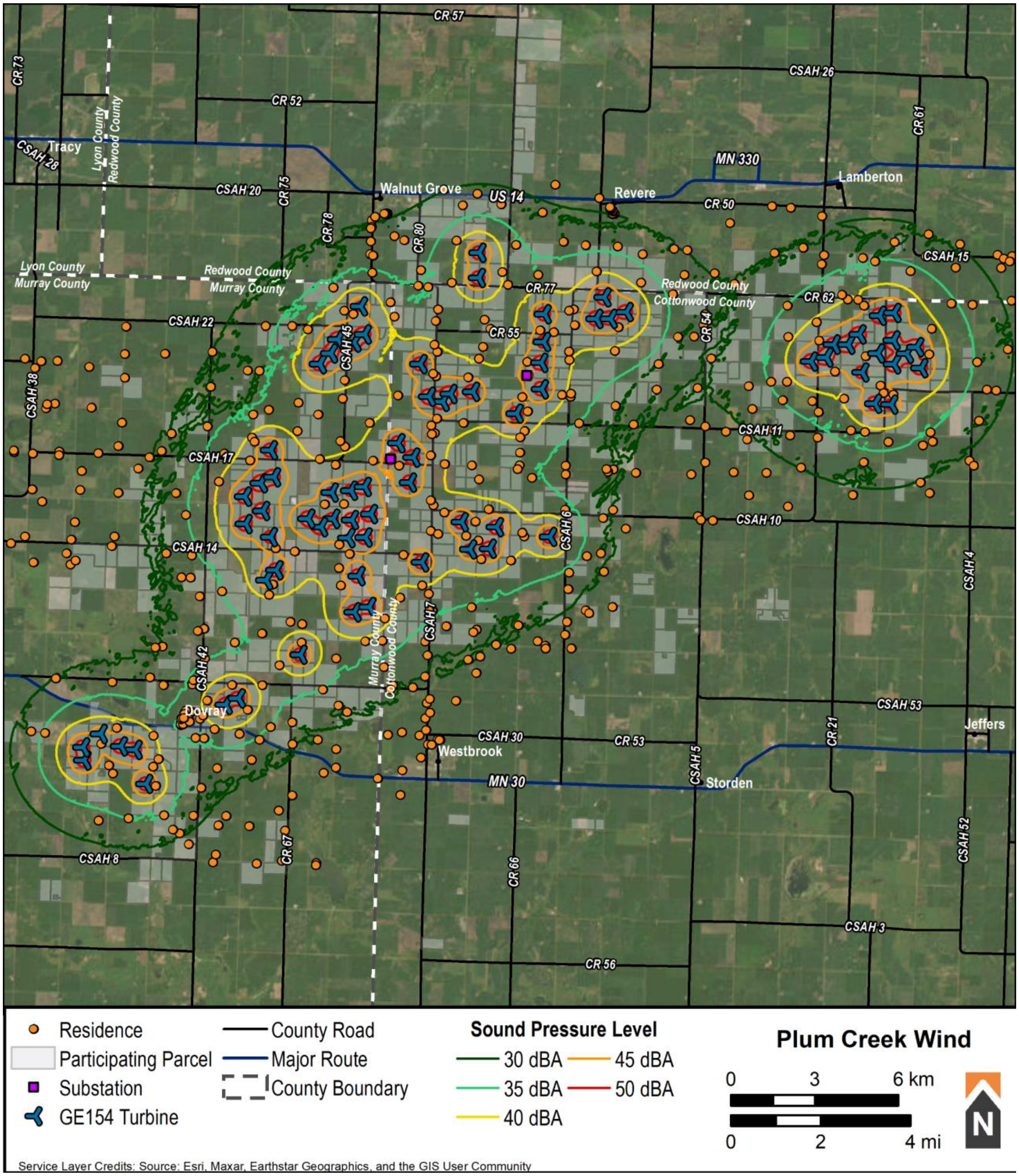


**FIGURE 5: PROJECT SOUND PROPAGATION MODELING RESULTS – V163**

# 5.0 CONCLUSION

The Plum Creek Wind Farm is a proposed wind power generation facility in Cottonwood, Murray, and Redwood counties of Minnesota. As the Project is still in the planning stages, four distinct wind turbine models were considered: GE 154, GE 158, V150, and V163. All potential 78 wind turbine locations were modeled for each turbine type. Though only 68 to 77 turbines are planned to be installed, depending on turbine type, for a total project capacity of 414 MW.

As part of the original application filing for this Project, RSG conducted background sound monitoring in the Project area between August 27 to September 5, 2019. The monitoring determined that the average nighttime $L_{50}$ across all onsite monitors was 42 dBA; when biogenic sound was removed (to represent other seasons like winter), median nighttime sound levels ($L_{50}$) were below 30 dBA.

Expected turbine-only sound levels at all residential receivers in the Project area were at or below 47 dBA for modeled scenarios. All alternates were included in the sound level model, so the actual sound levels will be less at locations near the wind turbines that are not constructed. The modeled equivalent continuous sound level ($L_{eq}$) is a conservative value (i.e., over-prediction) of the MN noise limit sound level metric ($L_{50}$). Thus, we conclude that with the noise reduced operations specified for each specific turbine layout, the Project will meet the MN noise limits.

# APPENDIX A. NOISE 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").[9] 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 6.

### *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.

[9] 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.

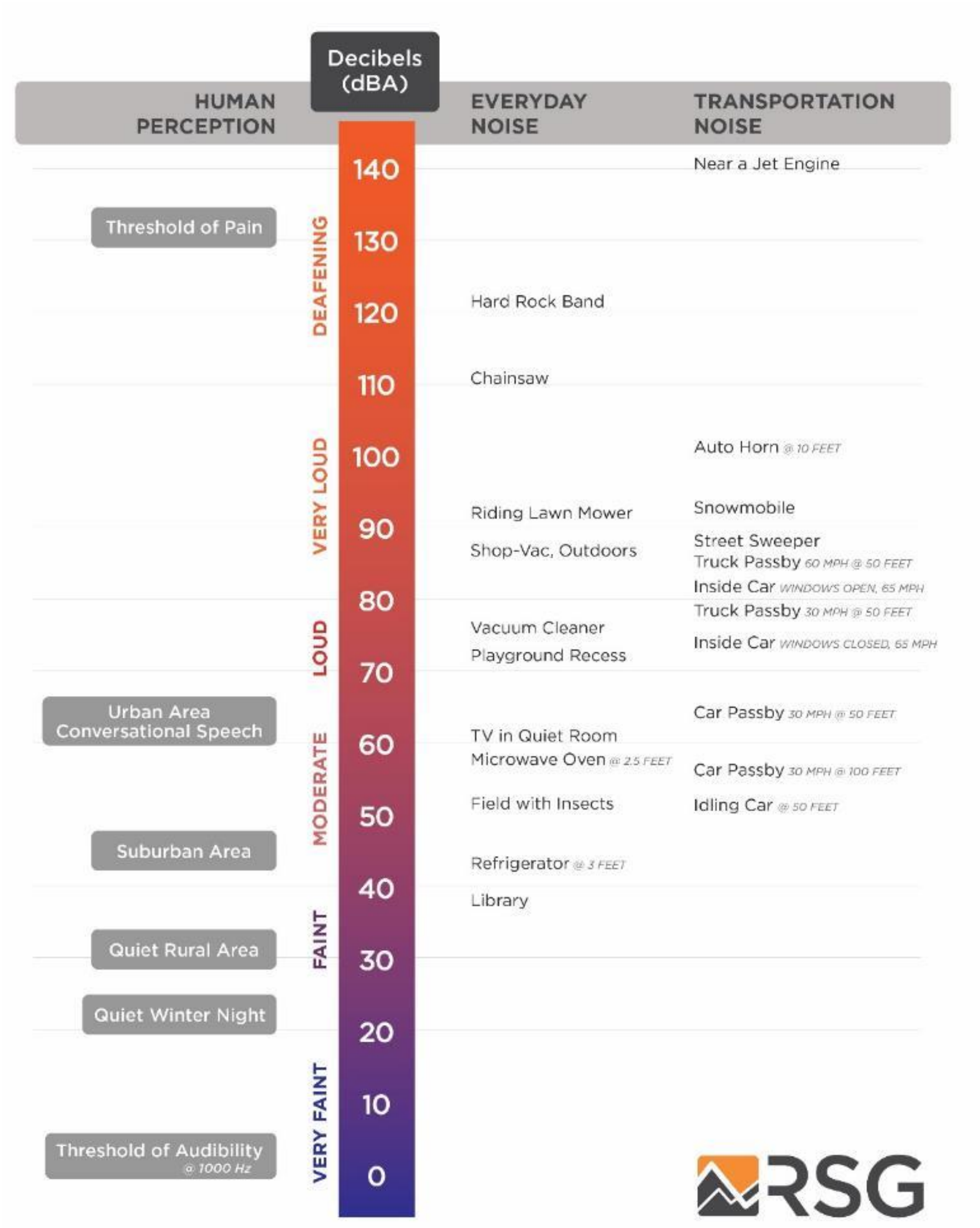


**FIGURE 6: A SCALE OF SOUND PRESSURE LEVELS FOR TYPICAL SOUND SOURCES**

### *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.[10] 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 $L_{eq,max}$.

### *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 7. 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 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.

[10] 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.

### *Equivalent Continuous Sound Level - $L_{eq}$*

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 7, 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.

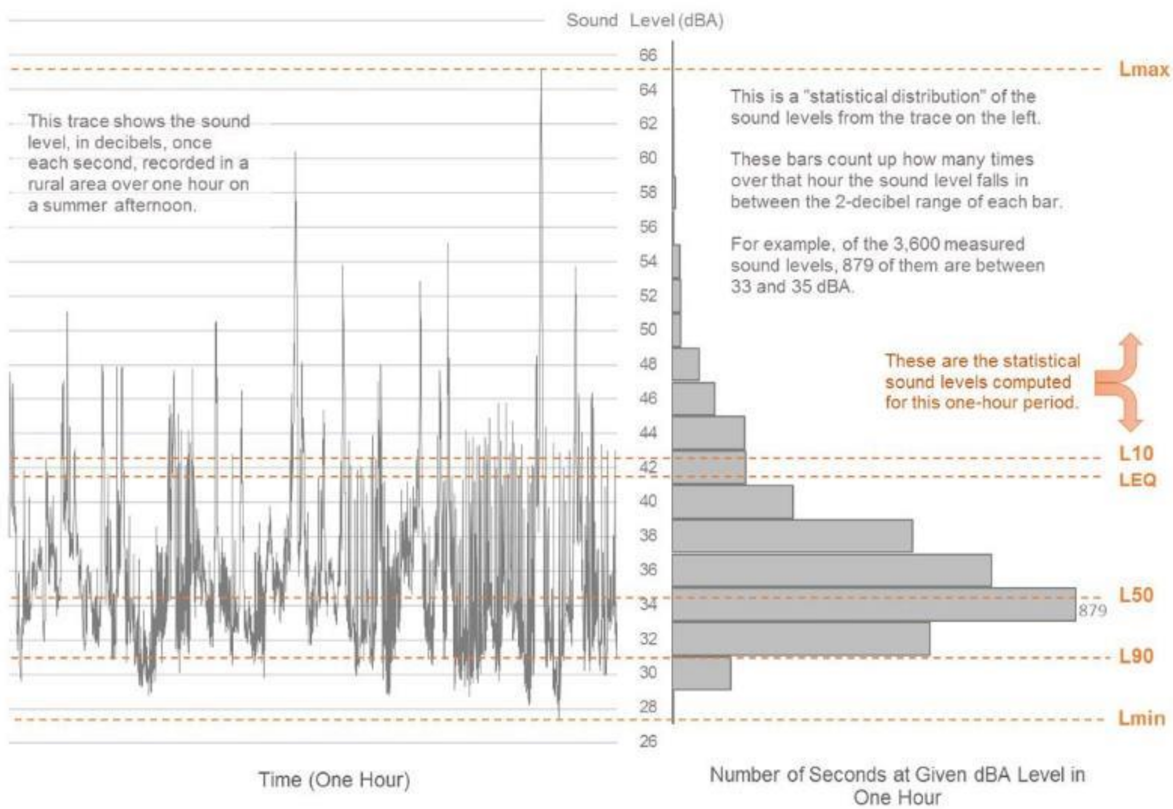


**FIGURE 7: EXAMPLE OF DESCRIPTIVE TERMS OF SOUND MEASUREMENT OVER TIME**

### *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 pressure) are not always the same, for reasons described in the previous section.

The $L_{90}$ 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.

## Wind Turbine Acoustics

## Sources of Sound Generation by Wind Turbines

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

Aerodynamic noise is the primary source of noise associated with wind turbines. These acoustic emissions can be either tonal or broad band. Tonal noise occurs at discrete frequencies, whereas broadband noise is distributed with little peaking across the frequency spectrum.

While unusual, tonal noise can also originate from unstable air flows over holes, slits, or blunt trailing edges on blades. Most modern wind turbines have upwind rotors designed to prevent blade impulsive noise. Therefore, the majority of audible aerodynamic noise from wind turbines is broadband at the middle frequencies, roughly between 200 Hz and 1,000 Hz.

Wind turbines emit aerodynamic broadband noise as the spinning blades interact with atmospheric turbulence and as air flows along their surfaces. This produces a characteristic "whooshing" sound through several mechanisms (Figure 8):

- Inflow turbulence noise 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 noise that varies across a wide range of frequencies but is most significant at frequencies below 500 Hz.
- Trailing edge noise is produced as boundary-layer turbulence as the air passes into the wake, or trailing edge, of the blade. This noise is distributed across a wide frequency range but is most notable at high frequencies between 700 Hz and 2 kHz.

- Tip vortex noise 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 noise further away.
- Stall or separation noise occurs due to the interaction of turbulence with the blade surface.

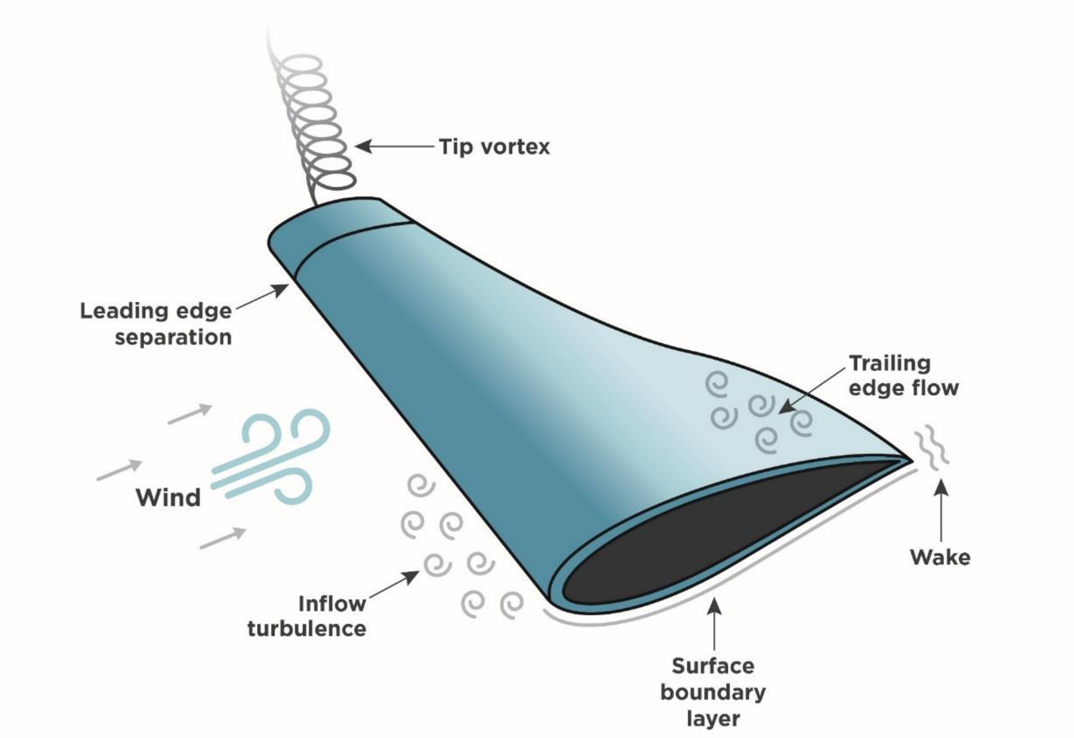


**FIGURE 8: AIRFLOW AROUND A ROTOR BLADE**

Mechanical sound from machinery inside the nacelle tends to be tonal in nature but can also have a broadband component. Potential sources of mechanical noise 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 noise. However modern wind turbines have nacelles that are designed to reduce internal noise, and rarely is the mechanical noise a significant portion of the total noise from a wind turbine.

## Amplitude Modulation

Amplitude modulation (AM) is a fluctuation in sound level that occurs at the blade passage frequency. No consistent definition exists for how much of a sound level fluctuation is necessary for blade swish to be considered AM, however sound level fluctuations in A-weighted sound level can range up to 10 dB. Fluctuations in individual 1/3 octave bands are typically more and can exceed 15 dB. 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 AM depth.[11] Most amplitude modulation is in the mid frequencies and most overall A-weighted AM is less than 4.5 dB in depth.[12]

Many confirmed and hypothesized causes of AM exist, including: blade passage in front of the tower, blade tip sound emission directivity, wind shear, inflow turbulence, and turbine blade yaw error. It has recently been noted that although wind shear can contribute to the extent of AM, wind shear does not contribute to the existence of AM in and of itself. Instead, there needs to be detachment of airflow from the blades for wind shear to contribute to AM.[13] 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. AM extent varies with the relative location of a receiver to the turbine. AM is usually experienced most when the receiver is between 45 and 60 degrees from the downwind or upwind position and is experienced least directly with the receiver 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 9).

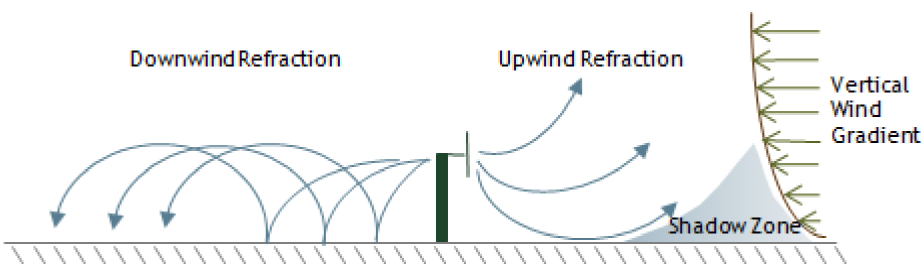


**FIGURE 9: SCHEMATIC OF THE REFRACTION OF SOUND DUE TO VERTICAL WIND GRADIENT (WIND SHEAR)**

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).

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[11] 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.
[12] RSG, et al., “Massachusetts Study on Wind Turbine Acoustics,” Massachusetts Clean Energy Center and Massachusetts Department of Environmental Protection, 2016
[13] “Wind Turbine Amplitude Modulation: Research to Improve Understanding as to its Cause and Effect.” *RenewableUK.* December 2013.

High winds and 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 noise at downwind receivers because the frequency spectrum from wind is similar to the frequency spectrum from a wind turbine. Figure 10 compares the shape of the sound spectrum measured during a 5 m/s wind event to that of the Vestas 163 4.5 MW wind turbine. As shown, the shapes of the spectra are similar at lower frequencies. In the mid frequencies, the wind turbine sounds are above the masking wind noise. At higher frequencies, the sounds from the masking wind noise are higher than the wind turbine. As a result, the masking of high frequency turbine noise occurs at higher wind speeds for some meteorological conditions. Masking will occur most when ground wind speeds are relatively high, creating wind-caused noise such as wind blowing through the trees and interaction of wind with structures.

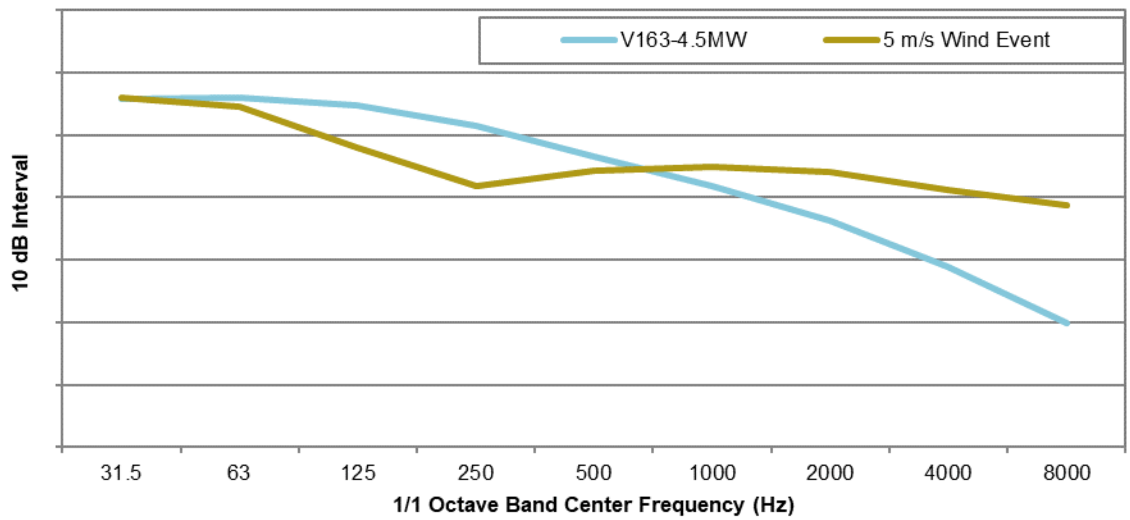


**FIGURE 10: COMPARISON OF NORMALIZED FREQUENCY SPECTRA MEASURED FROM A 5 M/S WIND EVENT AND THE SOUND POWER SPECTRA FROM THE VESTAS 163 4.5 MW TURBINE[14]**

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.

[14] 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.

# APPENDIX B. MONITOR LOCATION DESCRIPTIONS

## Monitor 1

Monitor 1 was located near the northern extent of the Project area in Redwood County, MN. It was approximately 60 meters (200 feet) south of 110th Street, and 710 meters (1,850 feet) west of Frontier Avenue in Revere, Minnesota. A photograph of the monitor setup is shown in Figure 11.

**FIGURE 11: PHOTOGRAPH OF MONITOR 1, FACING EAST (2019-09-03)**

## Monitor 2

Monitor 2 was located centrally within the Project area in Walnut Grove, which is in Cottonwood County, MN. It was situated 25 meters (80 feet) south of 220th Street, and 43 meters (140 feet) west of County Road 7. While the broader area was predominantly agricultural, three residences with associated agricultural buildings and infrastructure were in the immediate vicinity of the monitor. A photograph of the monitor setup is shown in Figure 12.

**FIGURE 12: PHOTOGRAPH OF MONITOR 2, FACING NORTH (2019-09-03)**

## Monitor 3

Monitor 3 was placed in the southwest portion of the Project area in Murray County, MN. It was located 170 meters (550 feet) from 270th Avenue, and 775 meters (2,550 feet) north of 141st Street in Dorvay. This location is 6.9 kilometers (4.3 miles) northeast of the City of Westbrook. A photograph of the monitor setup is shown in Figure 13.

**FIGURE 13: PHOTOGRAPH OF MONITOR 3, FACING NORTHEAST (2019-09-03)**

## Monitor 4

Monitor 4 was located in the northeastern section of the Project area in Cottonwood County, MN. The monitor was set up in a mowed field at a homestead situated next to a stream and goo area. The monitor was placed 300 meters (1000 feet) north of 215th Street and 750 meters (2500 feet) west of 420th Avenue (Country Road 54). A photograph of the monitor setup is shown in Figure 14.

**FIGURE 14: PHOTOGRAPH OF MONITOR 4, FACING NORTHEAST (2019-09-03)**

## Monitor 5

Monitor 5 was located on a parcel bordered by agricultural fields under active corn production in Murray County, MN. During the monitoring period, the home on the parcel was not inhabited, but a horse was fenced into the homestead area. The monitor was located at the rear of the homestead, about 100 meters (330 feet) from 191st Street and 600 meters west of 290th Avenue (County Road 45). A photograph of the monitor setup is shown in Figure 15.

**FIGURE 15: PHOTOGRAPH OF MONITOR 5, FACING EAST (2019-09-03)**

# APPENDIX C. SOUND MODELING DETAILS

**TABLE 5: SOUND PROPAGATION MODELING PARAMETERS**

| Parameter | Setting |
|---|---|
| Ground Absorption | Spectral for all sources, mixed ground (G=0.5) |
| Atmospheric Attenuation | Based on 10˚ Celsius, 70% relative humidity |
| Structure Reflections | None |
| Receiver Height | 4 meters above ground level for receivers and grid |
| Search Distance | 10,000 meters |

**TABLE 6: SUBSTATION LOCATIONS AND TRANSFORMER SOUND POWERS**

| Substation | Sound Power Level (dBA) | Source Height (m) | Coordinates (UTM NAD83 Zone 15N) | | |
|---|---|---|---|---|---|
| | | | X | Y | Z |
| Southwest | 105 | 3 | 303120 | 4890281 | 427 |
| Northeast | 105 | 3 | 307999 | 4893274 | 391 |

Table 7 (on the pages that follows) provides the locations and sound power levels of all sources in the model. Some abbreviations in the table are as follows:

- SWL = Overall sound power level (dBA) in model (includes +2 dB)
- HH = Hub height (in meters)
- Z = Ground elevation at turbine location (in meters)

Alternate turbines in Table 7 are indicated in grey for layouts where applicable and coordinates are listed in UTM NAD83 Zone 15 North.

**TABLE 7: PROJECT SCENARIO INFORMATION TABLE**

| | GE154 | | | GE158 | | | V150 | | | V163 | | | COORDINATES | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NAME | TURBINE MODE | SWL (dBA) | HH (m) | TURBINE MODE | SWL (dBA) | HH (m) | TURBINE MODE | SWL (dBA) | HH (m) | TURBINE MODE | SWL (dBA) | HH (m) | X (m) | Y (m) | Z (m) |
| T-01 | NRO_G | 105 | 98 | NRO_101 | 103 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 294316 | 4788637 | 471 |
| T-02 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 292108 | 4879480 | 464 |
| T-03 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 293937 | 4879860 | 468 |
| T-04 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 292057 | 4879950 | 471 |
| T-05 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 293413 | 4879991 | 471 |
| T-06 | NRO_G | 105 | 98 | *NRO_101* | *103* | *117* | *V150* | *107* | *120* | SO3 | 102 | 113 | 292686 | 4880429 | 476 |
| T-07 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 297170 | 4881469 | 452 |
| T-08 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 297637 | 4881702 | 447 |
| T-09 | NRO_G | 105 | 98 | NRO_101 | 103 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 299855 | 4883271 | 441 |
| T-10 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 301789 | 4884796 | 438 |
| T-11 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 302317 | 4884977 | 436 |
| T-12 | NRO_G | 105 | 98 | *NRO_100* | *102* | *117* | *LO2* | *105.7* | *120* | SO3 | 102 | 113 | 298628 | 4885947 | 445 |
| T-13 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 301926 | 4886085 | 433 |
| T-14 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 298987 | 4886307 | 441 |
| T-15 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 304214 | 4886583 | 426 |
| T-16 | NRO_G | 105 | 98 | NRO_101 | 103 | 117 | LO2 | 105.7 | 120 | *SO2* | *105.5* | *113* | 305931 | 4887046 | 426 |
| T-17 | NRO_G | 105 | 98 | NRO_101 | 103 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 306633 | 4887062 | 428 |
| T-18 | NRO_G | 105 | 98 | NRO_100 | 102 | 117 | LO2 | 105.7 | 120 | SO3 | 102 | 113 | 301574 | 4887452 | 429 |
| T-19 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 302193 | 4887475 | 428 |
| T-20 | NRO_G | 105 | 98 | NRO_101 | 103 | 117 | V150 | 107 | 120 | SO1 | 107 | 113 | 298790 | 4887485 | 445 |
| T-21 | NRO_D | 107 | 98 | NRO_101 | 103 | 117 | V150 | 107 | 120 | SO2 | 105.5 | 113 | 301025 | 4888147 | 432 |
| T-22 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 300586 | 4887838 | 436 |
| T-23 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 306897 | 4887842 | 424 |
| T-24 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 297882 | 4887951 | 445 |
| T-25 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 305628 | 4888022 | 429 |
| T-26 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 308801 | 4887499 | 417 |

| | GE154 | | | GE158 | | | V150 | | | V163 | | | COORDINATES | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NAME | TURBINE MODE | SWL (dBA) | HH (m) | TURBINE MODE | SWL (dBA) | HH (m) | TURBINE MODE | SWL (dBA) | HH (m) | TURBINE MODE | SWL (dBA) | HH (m) | X (m) | Y (m) | Z (m) |
| T-27 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | LO1 | 106.9 | 120 | SO1 | 107 | 113 | 301701 | 4888104 | 429 |
| T-28 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 300136 | 4888149 | 435 |
| T-29 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 302374 | 4888316 | 430 |
| T-30 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 298514 | 4888425 | 441 |
| T-31 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 297865 | 4888943 | 438 |
| T-32 | NRO_D | 107 | 98 | *NRO_101* | *103* | *117* | V150 | 107 | 120 | SO2 | 105.5 | 113 | 300968 | 4889088 | 431 |
| T-33 | NRO_D | 107 | 98 | NRO_101 | 103 | 117 | LO2 | 105.7 | 120 | SO2 | 105.5 | 113 | 301657 | 4889156 | 431 |
| T-34 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 302154 | 4889284 | 432 |
| T-35 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 303780 | 4889442 | 426 |
| T-36 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 298430 | 4889416 | 438 |
| T-37 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 298902 | 4889632 | 435 |
| T-38 | NRO_D | 107 | 98 | NRO_101 | 103 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 303903 | 4890334 | 419 |
| T-39 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 298791 | 4890603 | 431 |
| T-40 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 303367 | 4890855 | 421 |
| T-41 | NRO_G | 105 | 98 | NRO_101 | 103 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 307598 | 4891913 | 397 |
| T-42 | NRO_D | 107 | 98 | *NRO_101* | *103* | *117* | V150 | 107 | 120 | V163 | 108.3 | 113 | 320448 | 4892275 | 365 |
| T-43 | NRO_D | 107 | 98 | *NRO_101* | *103* | *117* | V150 | 107 | 120 | SO2 | 105.5 | 113 | 321030 | 4892236 | 358 |
| T-44 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 304947 | 4892337 | 404 |
| T-45 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 304452 | 4892516 | 406 |
| T-46 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 305232 | 4892622 | 399 |
| T-47 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 306028 | 4892693 | 397 |
| T-48 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 308508 | 4892786 | 388 |
| T-49 | NRO_D | 107 | 98 | *NRO_101* | *103* | *117* | V150 | 107 | 120 | SO1 | 107 | 113 | 319991 | 4893383 | 351 |
| T-50 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 322109 | 4893550 | 351 |
| T-51 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 304159 | 4893694 | 402 |
| T-52 | NRO_D | 107 | 98 | *GE158* | *109.5* | *117* | V150 | 107 | 120 | V163 | 108.3 | 113 | 321132 | 4893674 | 352 |
| T-53 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 300550 | 4893694 | 415 |

| | GE154 | | | GE158 | | | V150 | | | V163 | | | COORDINATES | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NAME | TURBINE MODE | SWL (dBA) | HH (m) | TURBINE MODE | SWL (dBA) | HH (m) | TURBINE MODE | SWL (dBA) | HH (m) | TURBINE MODE | SWL (dBA) | HH (m) | X (m) | Y (m) | Z (m) |
| T-54 | NRO_G | 105 | 98 | NRO_101 | 103 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 308477 | 4893730 | 382 |
| T-55 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 318161 | 4893779 | 353 |
| T-56 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 318710 | 4893928 | 355 |
| T-57 | NRO_D | 107 | 98 | *GE158* | *109.5* | *117* | V150 | 107 | 120 | V163 | 108.3 | 113 | 321587 | 4894058 | 352 |
| T-58 | NRO_D | 107 | 98 | NRO_101 | 103 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 300953 | 4894065 | 413 |
| T-59 | *NRO_D* | *107* | *98* | *NRO_101* | *103* | *117* | *LO2* | *105.7* | *120* | *SO3* | *102* | *113* | *320562* | *4894067* | 352 |
| T-60 | NRO_D | 107 | 98 | NRO_101 | 103 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 321956 | 4894297 | 350 |
| T-61 | NRO_G | 105 | 98 | NRO_101 | 103 | 117 | V150 | 107 | 120 | SO1 | 107 | 113 | 318963 | 4894380 | 360 |
| T-62 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 319485 | 4894387 | 359 |
| T-63 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 301789 | 4894460 | 411 |
| T-64 | NRO_G | 105 | 98 | NRO_101 | 103 | 117 | V150 | 107 | 120 | SO1 | 107 | 113 | 308583 | 4894483 | 376 |
| T-65 | NRO_D | 107 | 98 | *GE158* | *109.5* | *117* | V150 | 107 | 120 | V163 | 108.3 | 113 | 321109 | 4894540 | 351 |
| T-66 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 301197 | 4894576 | 409 |
| T-67 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 319890 | 4894747 | 353 |
| T-68 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 302152 | 4894754 | 403 |
| T-69 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 310456 | 4895312 | 369 |
| T-70 | NRO_G | 105 | 98 | NRO_101 | 103 | 117 | V150 | 107 | 120 | SO1 | 107 | 113 | 310974 | 4895314 | 368 |
| T-71 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 320618 | 4895421 | 352 |
| T-72 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 308607 | 4895479 | 370 |
| T-73 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 321151 | 4895525 | 351 |
| T-74 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 311541 | 4895547 | 365 |
| T-75 | NRO_G | 105 | 98 | NRO_101 | 103 | 117 | LO2 | 105.7 | 120 | SO2 | 105.5 | 113 | 302017 | 4895758 | 396 |
| T-76 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 310746 | 4896086 | 364 |
| T-77 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 306249 | 4896771 | 371 |
| T-78 | NRO_D | 107 | 98 | GE158 | 109.5 | 117 | V150 | 107 | 120 | V163 | 108.3 | 113 | 306268 | 4897675 | 366 |

# APPENDIX D. RECEPTOR RESULTS

Table 8 provides discrete receptor results for each residential receptor for each turbine scenario. In the Parcel Status Column, "NP" stands for Non-Participating and "P" stands for Participating.

Figure 16 through Figure 20 are maps that identify receivers by "Receiver ID" and Project turbines by turbine number throughout the Project area.

**TABLE 8: DISCRETE RECEIVER RESULTS (dBA)**

| RECEIVER ID | PARCEL STATUS | GE154 | GE158 | V150 | V163 |
|---|---|---|---|---|---|
| R_001 | NP | 28 | 29 | 29 | 30 |
| R_002 | NP | 28 | 29 | 29 | 30 |
| R_003 | NP | 28 | 29 | 29 | 31 |
| R_004 | NP | 29 | 30 | 30 | 32 |
| R_005 | NP | 29 | 30 | 30 | 32 |
| R_006 | NP | 27 | 28 | 28 | 30 |
| R_007 | NP | 27 | 28 | 28 | 29 |
| R_008 | NP | 27 | 29 | 28 | 30 |
| R_009 | NP | 27 | 29 | 28 | 30 |
| R_010 | NP | 27 | 28 | 28 | 30 |
| R_011 | NP | 27 | 28 | 28 | 30 |
| R_012 | NP | 30 | 31 | 31 | 32 |
| R_013 | NP | 37 | 39 | 38 | 39 |
| R_014 | P | 30 | 32 | 31 | 33 |
| R_015 | NP | 27 | 29 | 28 | 30 |
| R_016 | NP | 28 | 30 | 30 | 31 |
| R_017 | P | 30 | 32 | 31 | 32 |
| R_018 | NP | 28 | 30 | 29 | 30 |
| R_019 | NP | 28 | 30 | 30 | 31 |
| R_020 | NP | 31 | 32 | 32 | 33 |
| R_021 | NP | 31 | 33 | 33 | 34 |
| R_022 | NP | 37 | 39 | 38 | 39 |
| R_023 | P | 31 | 33 | 33 | 34 |
| R_024 | P | 31 | 33 | 32 | 34 |
| R_025 | P | 36 | 38 | 37 | 38 |
| R_026 | NP | 31 | 33 | 33 | 34 |
| R_027 | NP | 29 | 30 | 30 | 31 |
| R_028 | NP | 27 | 29 | 29 | 30 |
| R_029 | NP | 28 | 29 | 29 | 30 |
| R_030 | NP | 25 | 26 | 26 | 28 |

| RECEIVER ID | PARCEL STATUS | GE154 | GE158 | V150 | V163 |
|---|---|---|---|---|---|
| R_031 | NP | 26 | 28 | 28 | 29 |
| R_032 | NP | 25 | 26 | 26 | 27 |
| R_033 | NP | 26 | 27 | 27 | 28 |
| R_034 | NP | 27 | 28 | 28 | 29 |
| R_035 | NP | 28 | 29 | 30 | 31 |
| R_036 | P | 32 | 34 | 33 | 35 |
| R_037 | P | 33 | 35 | 34 | 35 |
| R_038 | P | 25 | 27 | 27 | 29 |
| R_039 | P | 34 | 35 | 35 | 36 |
| R_040 | NP | 31 | 32 | 32 | 33 |
| R_041 | NP | 30 | 31 | 31 | 32 |
| R_042 | NP | 22 | 24 | 25 | 26 |
| R_043 | NP | 26 | 28 | 28 | 29 |
| R_044 | NP | 26 | 27 | 27 | 28 |
| R_045 | NP | 25 | 26 | 26 | 27 |
| R_046 | NP | 26 | 27 | 27 | 28 |
| R_047 | NP | 26 | 26 | 27 | 28 |
| R_048 | NP | 27 | 28 | 28 | 29 |
| R_049 | NP | 31 | 32 | 32 | 33 |
| R_050 | NP | 33 | 34 | 35 | 36 |
| R_051 | NP | 38 | 40 | 39 | 40 |
| R_052 | NP | 39 | 41 | 41 | 42 |
| R_053 | NP | 29 | 31 | 31 | 32 |
| R_054 | NP | 31 | 32 | 32 | 33 |
| R_055 | P | 39 | 40 | 40 | 41 |
| R_056 | NP | 33 | 34 | 34 | 35 |
| R_057 | NP | 28 | 29 | 29 | 30 |
| R_058 | NP | 27 | 28 | 29 | 30 |
| R_059 | NP | 29 | 30 | 30 | 31 |
| R_060 | P | 44 | 45 | 46 | 46 |
| R_061 | P | 40 | 42 | 42 | 43 |
| R_062 | P | 40 | 42 | 41 | 42 |
| R_063 | P | 40 | 42 | 41 | 42 |
| R_064 | P | 42 | 43 | 44 | 45 |
| R_065 | P | 44 | 44 | 46 | 46 |
| R_066 | NP | 34 | 36 | 36 | 37 |
| R_067 | NP | 36 | 39 | 38 | 39 |
| R_068 | NP | 33 | 36 | 35 | 36 |
| R_069 | NP | 38 | 40 | 39 | 40 |
| R_070 | NP | 37 | 39 | 38 | 39 |
| R_071 | NP | 32 | 34 | 34 | 35 |

| RECEIVER ID | PARCEL STATUS | GE154 | GE158 | V150 | V163 |
|---|---|---|---|---|---|
| R_072 | P | 33 | 35 | 34 | 36 |
| R_073 | P | 32 | 34 | 34 | 35 |
| R_074 | NP | 31 | 32 | 32 | 33 |
| R_075 | P | 31 | 32 | 32 | 33 |
| R_076 | P | 33 | 34 | 35 | 36 |
| R_077 | P | 44 | 44 | 45 | 46 |
| R_078 | P | 41 | 42 | 42 | 43 |
| R_079 | P | 44 | 45 | 45 | 46 |
| R_080 | P | 39 | 40 | 40 | 41 |
| R_081 | NP | 36 | 38 | 38 | 39 |
| R_082 | P | 35 | 37 | 37 | 38 |
| R_083 | NP | 35 | 37 | 36 | 38 |
| R_084 | NP | 36 | 38 | 38 | 39 |
| R_085 | NP | 37 | 38 | 38 | 39 |
| R_086 | NP | 38 | 39 | 40 | 40 |
| R_087 | P | 38 | 38 | 39 | 39 |
| R_088 | NP | 37 | 38 | 38 | 39 |
| R_089 | P | 41 | 42 | 42 | 43 |
| R_090 | P | 40 | 40 | 41 | 41 |
| R_091 | P | 46 | 46 | 46 | 47 |
| R_092 | P | 41 | 41 | 42 | 43 |
| R_093 | NP | 40 | 42 | 42 | 43 |
| R_094 | NP | 39 | 41 | 41 | 42 |
| R_095 | P | 40 | 41 | 41 | 42 |
| R_096 | P | 42 | 45 | 43 | 45 |
| R_097 | NP | 37 | 39 | 38 | 40 |
| R_098 | NP | 38 | 41 | 40 | 41 |
| R_099 | P | 43 | 45 | 44 | 45 |
| R_100 | P | 43 | 45 | 44 | 45 |
| R_101 | NP | 40 | 42 | 41 | 42 |
| R_102 | P | 38 | 41 | 39 | 41 |
| R_103 | NP | 34 | 36 | 35 | 37 |
| R_104 | NP | 34 | 36 | 36 | 37 |
| R_105 | NP | 36 | 37 | 37 | 38 |
| R_106 | NP | 36 | 38 | 38 | 39 |
| R_107 | NP | 39 | 41 | 40 | 42 |
| R_108 | P | 43 | 45 | 44 | 45 |
| R_109 | NP | 36 | 37 | 37 | 38 |
| R_110 | NP | 37 | 39 | 38 | 40 |
| R_111 | NP | 35 | 36 | 37 | 38 |
| R_112 | P | 35 | 37 | 36 | 38 |

| RECEIVER ID | PARCEL STATUS | GE154 | GE158 | V150 | V163 |
|---|---|---|---|---|---|
| R_113 | P | 45 | 44 | 46 | 47 |
| R_114 | P | 42 | 42 | 43 | 44 |
| R_115 | P | 42 | 42 | 44 | 46 |
| R_116 | P | 38 | 38 | 40 | 41 |
| R_117 | P | 36 | 37 | 39 | 40 |
| R_118 | P | 33 | 34 | 35 | 37 |
| R_119 | P | 33 | 35 | 35 | 36 |
| R_120 | NP | 33 | 35 | 35 | 36 |
| R_121 | NP | 33 | 34 | 34 | 36 |
| R_122 | NP | 38 | 40 | 40 | 41 |
| R_123 | P | 36 | 37 | 37 | 39 |
| R_124 | P | 36 | 37 | 38 | 39 |
| R_125 | NP | 38 | 39 | 40 | 41 |
| R_126 | P | 38 | 39 | 40 | 41 |
| R_127 | NP | 32 | 33 | 34 | 35 |
| R_128 | NP | 30 | 31 | 32 | 33 |
| R_129 | NP | 29 | 29 | 30 | 31 |
| R_130 | P | 29 | 30 | 30 | 31 |
| R_131 | P | 36 | 38 | 38 | 39 |
| R_132 | P | 30 | 31 | 32 | 33 |
| R_133 | NP | 30 | 32 | 32 | 33 |
| R_134 | NP | 29 | 30 | 31 | 32 |
| R_135 | NP | 28 | 30 | 30 | 31 |
| R_136 | P | 36 | 38 | 38 | 39 |
| R_137 | P | 44 | 45 | 46 | 46 |
| R_138 | NP | 36 | 38 | 38 | 39 |
| R_139 | P | 43 | 45 | 44 | 45 |
| R_140 | P | 42 | 44 | 43 | 44 |
| R_141 | NP | 40 | 40 | 41 | 42 |
| R_142 | P | 45 | 45 | 45 | 46 |
| R_143 | NP | 26 | 27 | 27 | 29 |
| R_144 | P | 28 | 29 | 30 | 31 |
| R_145 | P | 28 | 29 | 29 | 30 |
| R_146 | NP | 30 | 31 | 31 | 32 |
| R_147 | NP | 29 | 30 | 31 | 32 |
| R_148 | NP | 33 | 35 | 34 | 35 |
| R_149 | P | 36 | 38 | 37 | 38 |
| R_150 | NP | 33 | 34 | 34 | 35 |
| R_151 | NP | 36 | 37 | 37 | 38 |
| R_152 | NP | 35 | 35 | 36 | 37 |
| R_153 | P | 31 | 32 | 33 | 34 |

| RECEIVER ID | PARCEL STATUS | GE154 | GE158 | V150 | V163 |
|---|---|---|---|---|---|
| R_154 | NP | 30 | 31 | 31 | 32 |
| R_155 | NP | 28 | 28 | 29 | 30 |
| R_156 | NP | 27 | 27 | 28 | 29 |
| R_157 | NP | 27 | 28 | 29 | 30 |
| R_158 | NP | 29 | 30 | 31 | 32 |
| R_159 | NP | 27 | 27 | 28 | 29 |
| R_160 | NP | 27 | 28 | 28 | 29 |
| R_161 | NP | 27 | 28 | 28 | 29 |
| R_162 | NP | 24 | 25 | 26 | 27 |
| R_163 | NP | 25 | 25 | 26 | 27 |
| R_164 | NP | 25 | 26 | 26 | 28 |
| R_165 | NP | 23 | 24 | 24 | 25 |
| R_166 | NP | 23 | 23 | 24 | 25 |
| R_167 | NP | 24 | 24 | 25 | 26 |
| R_168 | NP | 24 | 24 | 25 | 26 |
| R_169 | NP | 27 | 28 | 28 | 29 |
| R_170 | P | 27 | 28 | 29 | 30 |
| R_171 | NP | 28 | 29 | 30 | 31 |
| R_172 | NP | 27 | 29 | 29 | 31 |
| R_173 | P | 26 | 28 | 28 | 29 |
| R_174 | P | 29 | 31 | 30 | 32 |
| R_175 | NP | 24 | 26 | 27 | 28 |
| R_176 | NP | 28 | 29 | 29 | 30 |
| R_177 | NP | 28 | 30 | 30 | 31 |
| R_178 | NP | 31 | 33 | 32 | 34 |
| R_179 | P | 18 | 20 | 20 | 21 |
| R_180 | NP | 25 | 27 | 27 | 29 |
| R_181 | P | 24 | 25 | 26 | 27 |
| R_182 | NP | 25 | 27 | 27 | 29 |
| R_183 | NP | 29 | 31 | 31 | 32 |
| R_184 | P | 32 | 34 | 33 | 34 |
| R_185 | NP | 24 | 25 | 25 | 27 |
| R_186 | NP | 19 | 20 | 21 | 22 |
| R_187 | NP | 20 | 22 | 23 | 24 |
| R_188 | NP | 24 | 25 | 26 | 27 |
| R_189 | NP | 26 | 27 | 27 | 28 |
| R_190 | NP | 28 | 29 | 30 | 31 |
| R_191 | NP | 25 | 27 | 27 | 29 |
| R_192 | NP | 28 | 29 | 29 | 30 |
| R_193 | NP | 27 | 28 | 29 | 30 |
| R_194 | NP | 28 | 29 | 29 | 30 |

| RECEIVER ID | PARCEL STATUS | GE154 | GE158 | V150 | V163 |
|---|---|---|---|---|---|
| R_195 | NP | 27 | 28 | 28 | 29 |
| R_196 | NP | 26 | 27 | 27 | 28 |
| R_197 | NP | 34 | 36 | 35 | 37 |
| R_198 | NP | 31 | 32 | 32 | 34 |
| R_199 | P | 30 | 32 | 32 | 34 |
| R_200 | NP | 39 | 41 | 40 | 41 |
| R_201 | P | 39 | 41 | 40 | 41 |
| R_202 | NP | 37 | 38 | 39 | 40 |
| R_203 | P | 43 | 42 | 45 | 46 |
| R_204 | P | 45 | 45 | 46 | 47 |
| R_205 | P | 44 | 45 | 45 | 46 |
| R_206 | P | 43 | 45 | 44 | 45 |
| R_207 | P | 40 | 42 | 41 | 43 |
| R_208 | P | 38 | 40 | 40 | 41 |
| R_209 | P | 39 | 40 | 40 | 41 |
| R_210 | P | 38 | 40 | 40 | 41 |
| R_211 | NP | 39 | 41 | 40 | 42 |
| R_212 | P | 40 | 43 | 41 | 43 |
| R_213 | P | 43 | 44 | 44 | 44 |
| R_214 | P | 45 | 45 | 46 | 45 |
| R_215 | P | 41 | 43 | 42 | 43 |
| R_216 | P | 41 | 43 | 42 | 43 |
| R_217 | P | 35 | 36 | 37 | 38 |
| R_218 | NP | 36 | 36 | 38 | 39 |
| R_219 | P | 41 | 42 | 42 | 43 |
| R_220 | P | 46 | 46 | 47 | 47 |
| R_221 | P | 47 | 47 | 47 | 47 |
| R_222 | NP | 36 | 38 | 37 | 38 |
| R_223 | NP | 38 | 40 | 39 | 40 |
| R_224 | NP | 33 | 35 | 35 | 36 |
| R_225 | P | 34 | 35 | 35 | 36 |
| R_226 | NP | 31 | 32 | 33 | 34 |
| R_227 | NP | 31 | 33 | 32 | 34 |
| R_228 | NP | 29 | 31 | 30 | 31 |
| R_229 | NP | 26 | 28 | 29 | 30 |
| R_230 | NP | 35 | 37 | 36 | 38 |
| R_231 | NP | 31 | 33 | 32 | 34 |
| R_232 | NP | 28 | 30 | 30 | 31 |
| R_233 | NP | 29 | 30 | 30 | 31 |
| R_234 | NP | 26 | 29 | 29 | 30 |
| R_235 | NP | 27 | 28 | 28 | 29 |

| RECEIVER ID | PARCEL STATUS | GE154 | GE158 | V150 | V163 |
|---|---|---|---|---|---|
| R_236 | NP | 27 | 28 | 28 | 29 |
| R_237 | NP | 27 | 28 | 29 | 30 |
| R_238 | P | 29 | 30 | 31 | 32 |
| R_239 | NP | 28 | 30 | 30 | 31 |
| R_240 | P | 29 | 31 | 31 | 32 |
| R_241 | P | 32 | 32 | 34 | 35 |
| R_242 | NP | 34 | 35 | 36 | 37 |
| R_243 | NP | 37 | 39 | 38 | 39 |
| R_244 | P | 40 | 42 | 40 | 42 |
| R_245 | P | 37 | 39 | 38 | 40 |
| R_246 | NP | 32 | 33 | 34 | 35 |
| R_247 | P | 30 | 31 | 31 | 32 |
| R_248 | P | 30 | 31 | 31 | 32 |
| R_249 | P | 40 | 42 | 41 | 43 |
| R_250 | NP | 35 | 37 | 37 | 38 |
| R_251 | NP | 35 | 37 | 37 | 38 |
| R_252 | P | 38 | 39 | 39 | 40 |
| R_253 | P | 26 | 27 | 28 | 29 |
| R_254 | P | 33 | 34 | 35 | 36 |
| R_255 | P | 41 | 40 | 43 | 45 |
| R_256 | P | 36 | 36 | 38 | 40 |
| R_257 | NP | 32 | 34 | 34 | 35 |
| R_258 | NP | 31 | 32 | 32 | 33 |
| R_259 | NP | 30 | 31 | 31 | 32 |
| R_260 | P | 32 | 34 | 34 | 35 |
| R_261 | P | 31 | 32 | 32 | 33 |
| R_262 | NP | 31 | 32 | 32 | 33 |
| R_263 | NP | 32 | 33 | 33 | 34 |
| R_264 | NP | 33 | 35 | 34 | 35 |
| R_265 | NP | 38 | 40 | 39 | 40 |
| R_266 | NP | 32 | 35 | 34 | 35 |
| R_267 | P | 36 | 38 | 37 | 38 |
| R_268 | P | 31 | 33 | 33 | 34 |
| R_269 | NP | 29 | 31 | 30 | 32 |
| R_270 | P | 31 | 32 | 32 | 33 |
| R_271 | NP | 34 | 36 | 36 | 37 |
| R_272 | P | 39 | 41 | 40 | 41 |
| R_273 | P | 41 | 43 | 41 | 43 |
| R_274 | NP | 35 | 36 | 36 | 37 |
| R_275 | P | 41 | 44 | 42 | 43 |
| R_276 | NP | 32 | 34 | 33 | 35 |

| RECEIVER ID | PARCEL STATUS | GE154 | GE158 | V150 | V163 |
|---|---|---|---|---|---|
| R_277 | NP | 40 | 42 | 41 | 42 |
| R_278 | NP | 36 | 38 | 37 | 38 |
| R_279 | NP | 37 | 40 | 38 | 40 |
| R_280 | NP | 34 | 36 | 35 | 37 |
| R_281 | NP | 35 | 37 | 36 | 37 |
| R_282 | NP | 36 | 39 | 38 | 39 |
| R_283 | P | 33 | 35 | 35 | 36 |
| R_284 | P | 33 | 35 | 34 | 36 |
| R_285 | P | 35 | 38 | 36 | 38 |
| R_286 | P | 42 | 44 | 42 | 44 |
| R_287 | P | 42 | 45 | 43 | 44 |
| R_288 | NP | 36 | 38 | 38 | 39 |
| R_289 | NP | 32 | 34 | 34 | 35 |
| R_290 | NP | 32 | 34 | 33 | 34 |
| R_291 | P | 40 | 40 | 42 | 41 |
| R_292 | P | 45 | 45 | 46 | 45 |
| R_293 | P | 43 | 44 | 45 | 46 |
| R_294 | NP | 35 | 36 | 36 | 37 |
| R_295 | NP | 31 | 32 | 32 | 33 |
| R_296 | NP | 31 | 32 | 32 | 33 |
| R_297 | NP | 32 | 34 | 34 | 35 |
| R_298 | NP | 29 | 31 | 31 | 32 |
| R_299 | P | 34 | 36 | 35 | 36 |
| R_300 | NP | 33 | 36 | 35 | 36 |
| R_301 | NP | 26 | 27 | 28 | 29 |
| R_302 | NP | 27 | 28 | 28 | 29 |
| R_303 | NP | 23 | 25 | 25 | 26 |
| R_304 | NP | 23 | 24 | 24 | 25 |
| R_305 | NP | 21 | 23 | 23 | 24 |
| R_306 | NP | 26 | 27 | 27 | 28 |
| R_307 | NP | 25 | 27 | 27 | 28 |
| R_308 | NP | 25 | 26 | 26 | 27 |
| R_309 | NP | 25 | 26 | 26 | 27 |
| R_310 | NP | 26 | 27 | 27 | 28 |
| R_311 | NP | 24 | 26 | 26 | 27 |
| R_312 | NP | 24 | 25 | 25 | 26 |
| R_313 | NP | 24 | 25 | 25 | 26 |
| R_314 | NP | 24 | 25 | 25 | 26 |
| R_315 | NP | 24 | 25 | 25 | 26 |
| R_316 | NP | 24 | 25 | 25 | 26 |
| R_317 | NP | 24 | 24 | 24 | 26 |

| RECEIVER ID | PARCEL STATUS | GE154 | GE158 | V150 | V163 |
|---|---|---|---|---|---|
| R_318 | NP | 19 | 21 | 21 | 22 |
| R_319 | P | 47 | 46 | 47 | 47 |
| R_320 | P | 44 | 43 | 45 | 45 |
| R_321 | P | 46 | 43 | 46 | 46 |
| R_322 | P | 46 | 44 | 46 | 46 |
| R_323 | NP | 39 | 39 | 40 | 41 |
| R_324 | NP | 35 | 33 | 36 | 37 |
| R_325 | P | 37 | 35 | 38 | 39 |
| R_326 | NP | 35 | 34 | 36 | 37 |
| R_327 | NP | 31 | 30 | 32 | 33 |
| R_328 | NP | 27 | 27 | 28 | 29 |
| R_329 | NP | 25 | 25 | 26 | 27 |
| R_330 | P | 35 | 36 | 36 | 37 |
| R_331 | NP | 28 | 29 | 29 | 30 |
| R_332 | NP | 25 | 26 | 26 | 27 |
| R_333 | NP | 22 | 23 | 22 | 23 |
| R_334 | NP | 23 | 24 | 23 | 25 |
| R_335 | NP | 21 | 22 | 21 | 23 |
| R_336 | NP | 18 | 19 | 18 | 20 |
| R_337 | NP | 16 | 18 | 16 | 17 |
| R_338 | NP | 16 | 18 | 16 | 18 |
| R_339 | NP | 11 | 16 | 15 | 16 |
| R_340 | NP | 15 | 16 | 15 | 16 |
| R_341 | NP | 16 | 18 | 16 | 18 |
| R_342 | NP | 17 | 18 | 17 | 18 |
| R_343 | NP | 18 | 19 | 18 | 20 |
| R_344 | NP | 19 | 20 | 19 | 21 |
| R_345 | NP | 16 | 18 | 17 | 18 |
| R_346 | NP | 19 | 21 | 21 | 22 |
| R_347 | NP | 24 | 25 | 24 | 25 |
| R_348 | NP | 28 | 29 | 29 | 30 |
| R_349 | NP | 25 | 26 | 25 | 27 |
| R_350 | NP | 29 | 30 | 30 | 31 |
| R_351 | NP | 28 | 29 | 29 | 30 |
| R_352 | NP | 25 | 26 | 26 | 27 |
| R_353 | NP | 24 | 25 | 24 | 25 |
| R_354 | NP | 20 | 22 | 21 | 22 |
| R_355 | NP | 14 | 16 | 16 | 17 |
| R_356 | NP | 13 | 15 | 15 | 16 |
| R_357 | NP | 17 | 18 | 17 | 18 |
| R_358 | NP | 14 | 16 | 15 | 17 |

| RECEIVER ID | PARCEL STATUS | GE154 | GE158 | V150 | V163 |
|---|---|---|---|---|---|
| R_359 | NP | 17 | 19 | 19 | 20 |
| R_360 | NP | 16 | 18 | 18 | 19 |
| R_361 | NP | 19 | 20 | 20 | 21 |
| R_362 | NP | 15 | 19 | 19 | 20 |
| R_363 | NP | 22 | 24 | 24 | 25 |
| R_364 | P | 23 | 25 | 25 | 26 |
| R_365 | NP | 21 | 23 | 22 | 23 |
| R_366 | NP | 20 | 22 | 23 | 23 |
| R_367 | NP | 23 | 24 | 24 | 25 |
| R_368 | NP | 19 | 21 | 21 | 22 |
| R_369 | NP | 20 | 22 | 21 | 23 |
| R_370 | NP | 21 | 22 | 22 | 23 |
| R_371 | NP | 22 | 24 | 24 | 25 |
| R_372 | NP | 27 | 28 | 28 | 29 |
| R_373 | NP | 26 | 27 | 27 | 28 |
| R_374 | P | 26 | 27 | 27 | 28 |
| R_375 | NP | 29 | 30 | 30 | 31 |
| R_376 | NP | 28 | 30 | 30 | 31 |
| R_377 | NP | 28 | 30 | 30 | 31 |
| R_378 | NP | 30 | 32 | 32 | 33 |
| R_379 | NP | 29 | 31 | 31 | 32 |
| R_380 | NP | 33 | 35 | 35 | 36 |
| R_381 | NP | 31 | 32 | 33 | 33 |
| R_382 | NP | 28 | 30 | 30 | 30 |
| R_383 | NP | 31 | 33 | 32 | 33 |
| R_384 | NP | 33 | 36 | 35 | 36 |
| R_385 | NP | 39 | 41 | 41 | 42 |
| R_386 | NP | 41 | 43 | 42 | 43 |
| R_387 | P | 45 | 46 | 47 | 46 |
| R_388 | P | 42 | 44 | 43 | 43 |
| R_389 | NP | 38 | 40 | 39 | 40 |
| R_390 | P | 38 | 40 | 40 | 41 |
| R_391 | P | 40 | 41 | 41 | 43 |
| R_392 | P | 42 | 41 | 44 | 46 |
| R_393 | P | 31 | 31 | 34 | 35 |
| R_394 | NP | 28 | 29 | 30 | 31 |
| R_395 | P | 29 | 30 | 31 | 32 |
| R_396 | P | 30 | 32 | 32 | 33 |
| R_397 | NP | 32 | 32 | 34 | 35 |
| R_398 | NP | 29 | 31 | 31 | 32 |
| R_399 | P | 27 | 28 | 29 | 30 |

| RECEIVER ID | PARCEL STATUS | GE154 | GE158 | V150 | V163 |
|---|---|---|---|---|---|
| R_400 | NP | 28 | 29 | 30 | 32 |
| R_401 | NP | 25 | 26 | 27 | 29 |
| R_402 | NP | 17 | 18 | 19 | 20 |
| R_403 | NP | 24 | 24 | 25 | 26 |
| R_404 | NP | 19 | 22 | 22 | 24 |
| R_405 | P | 21 | 22 | 22 | 23 |
| R_406 | NP | 16 | 18 | 19 | 20 |
| R_407 | NP | 14 | 15 | 16 | 17 |
| R_408 | NP | 30 | 32 | 31 | 32 |
| R_409 | P | 20 | 22 | 23 | 24 |
| R_410 | NP | 24 | 26 | 26 | 27 |
| R_411 | NP | 22 | 23 | 24 | 25 |
| R_412 | P | 22 | 24 | 24 | 25 |
| R_413 | NP | 24 | 25 | 26 | 27 |
| R_414 | NP | 26 | 27 | 27 | 29 |
| R_415 | P | 26 | 27 | 27 | 29 |
| R_416 | NP | 34 | 36 | 35 | 36 |
| R_417 | NP | 34 | 36 | 35 | 36 |
| R_418 | NP | 34 | 36 | 35 | 37 |
| R_419 | NP | 34 | 36 | 35 | 36 |
| R_420 | NP | 34 | 36 | 35 | 36 |
| R_421 | NP | 34 | 37 | 36 | 37 |
| R_422 | NP | 34 | 36 | 35 | 36 |
| R_423 | NP | 34 | 36 | 35 | 36 |
| R_424 | NP | 33 | 35 | 35 | 36 |
| R_425 | NP | 33 | 35 | 35 | 36 |
| R_426 | NP | 33 | 35 | 35 | 36 |
| R_427 | NP | 33 | 35 | 35 | 36 |
| R_428 | NP | 33 | 35 | 35 | 36 |
| R_429 | NP | 33 | 35 | 35 | 36 |
| R_430 | NP | 33 | 35 | 35 | 36 |
| R_431 | NP | 33 | 35 | 35 | 36 |
| R_432 | NP | 33 | 35 | 35 | 36 |
| R_433 | NP | 33 | 36 | 35 | 36 |
| R_434 | NP | 33 | 36 | 35 | 36 |
| R_435 | NP | 33 | 35 | 35 | 36 |
| R_436 | NP | 33 | 35 | 35 | 36 |
| R_437 | NP | 33 | 35 | 35 | 36 |
| R_438 | NP | 33 | 35 | 35 | 36 |
| R_439 | NP | 27 | 29 | 29 | 30 |
| R_440 | NP | 27 | 29 | 29 | 30 |

| RECEIVER ID | PARCEL STATUS | GE154 | GE158 | V150 | V163 |
|---|---|---|---|---|---|
| R_441 | NP | 27 | 29 | 29 | 30 |
| R_442 | NP | 27 | 29 | 29 | 30 |
| R_443 | NP | 27 | 29 | 28 | 30 |
| R_444 | NP | 27 | 28 | 28 | 30 |
| R_445 | NP | 27 | 28 | 28 | 30 |
| R_446 | NP | 27 | 28 | 28 | 29 |
| R_447 | NP | 26 | 28 | 28 | 29 |
| R_448 | NP | 26 | 27 | 27 | 28 |
| R_449 | NP | 32 | 32 | 33 | 34 |
| R_450 | NP | 33 | 33 | 34 | 35 |
| R_451 | NP | 32 | 31 | 33 | 34 |
| R_452 | NP | 32 | 33 | 33 | 34 |
| R_453 | NP | 28 | 29 | 29 | 31 |
| R_454 | NP | 30 | 31 | 31 | 32 |
| R_455 | NP | 29 | 30 | 30 | 31 |
| R_456 | NP | 27 | 27 | 28 | 29 |
| R_457 | NP | 29 | 30 | 30 | 31 |
| R_458 | NP | 26 | 26 | 28 | 29 |
| R_459 | NP | 26 | 26 | 28 | 28 |
| R_460 | NP | 23 | 22 | 25 | 25 |
| R_461 | NP | 27 | 27 | 28 | 29 |

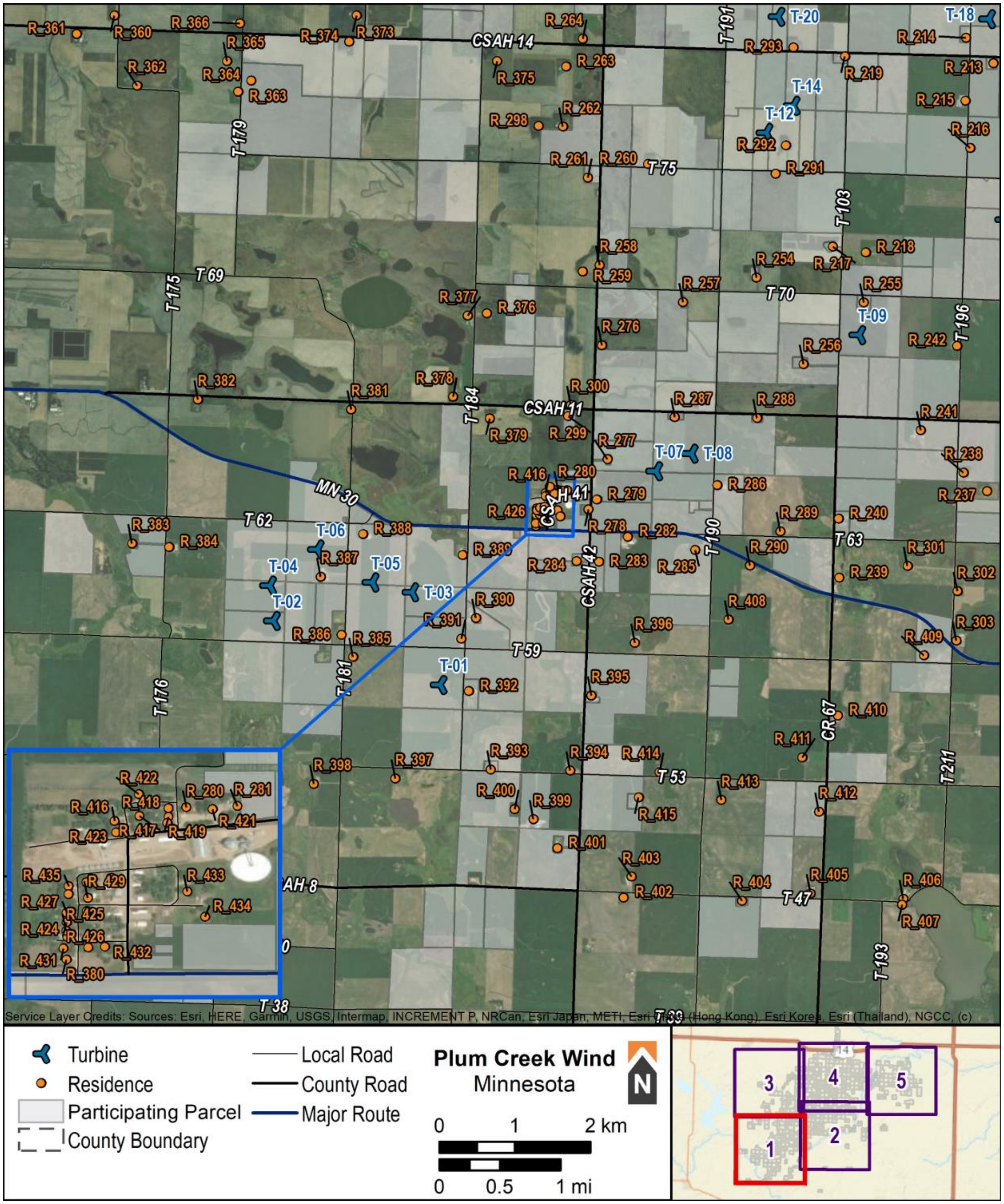


FIGURE 16: RECEIVER AND TURBINE ID MAP 1

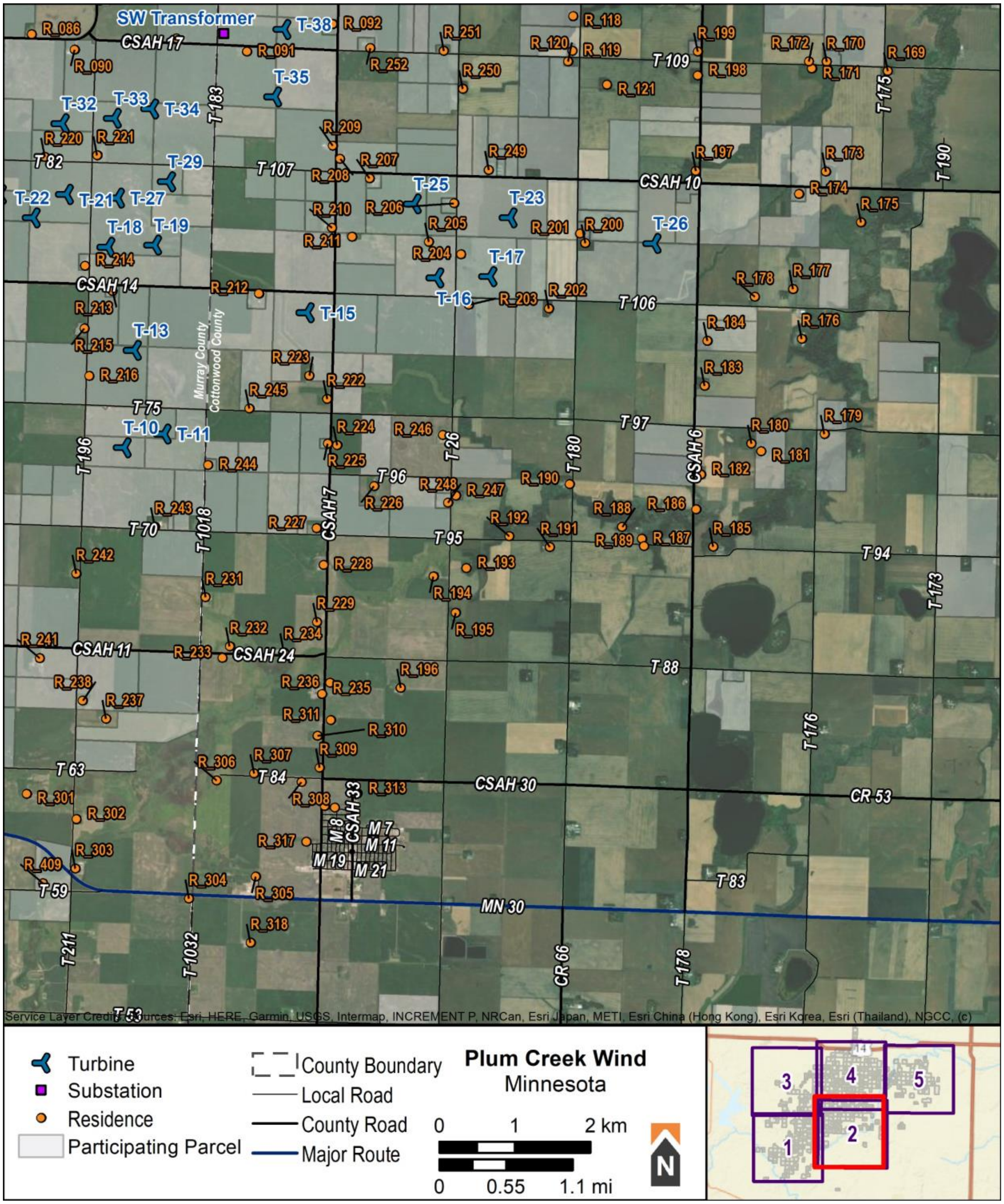


**FIGURE 17: RECEIVER AND TURBINE ID MAP 2**

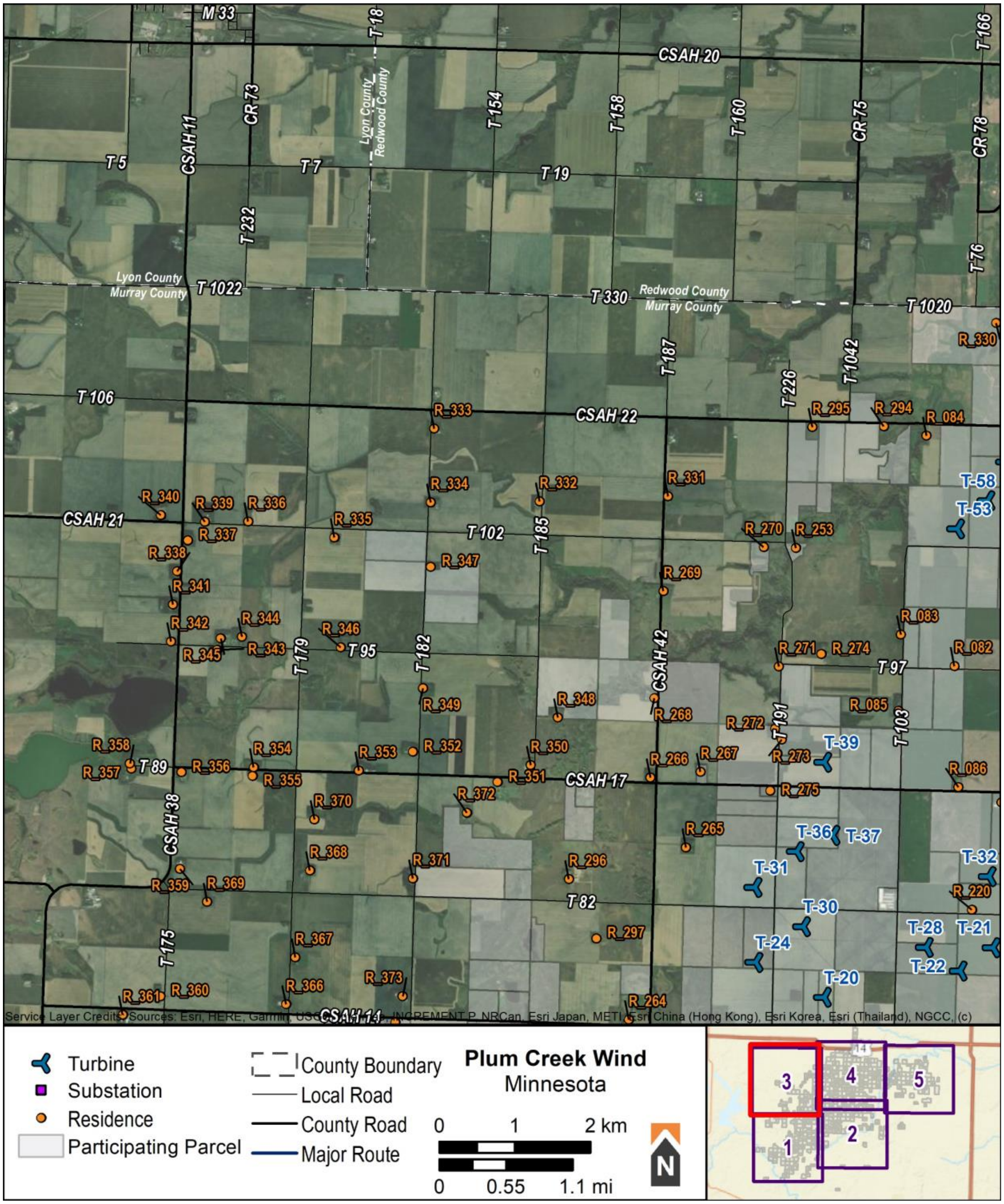


**FIGURE 18: RECEIVER AND TURBINE ID MAP 3**

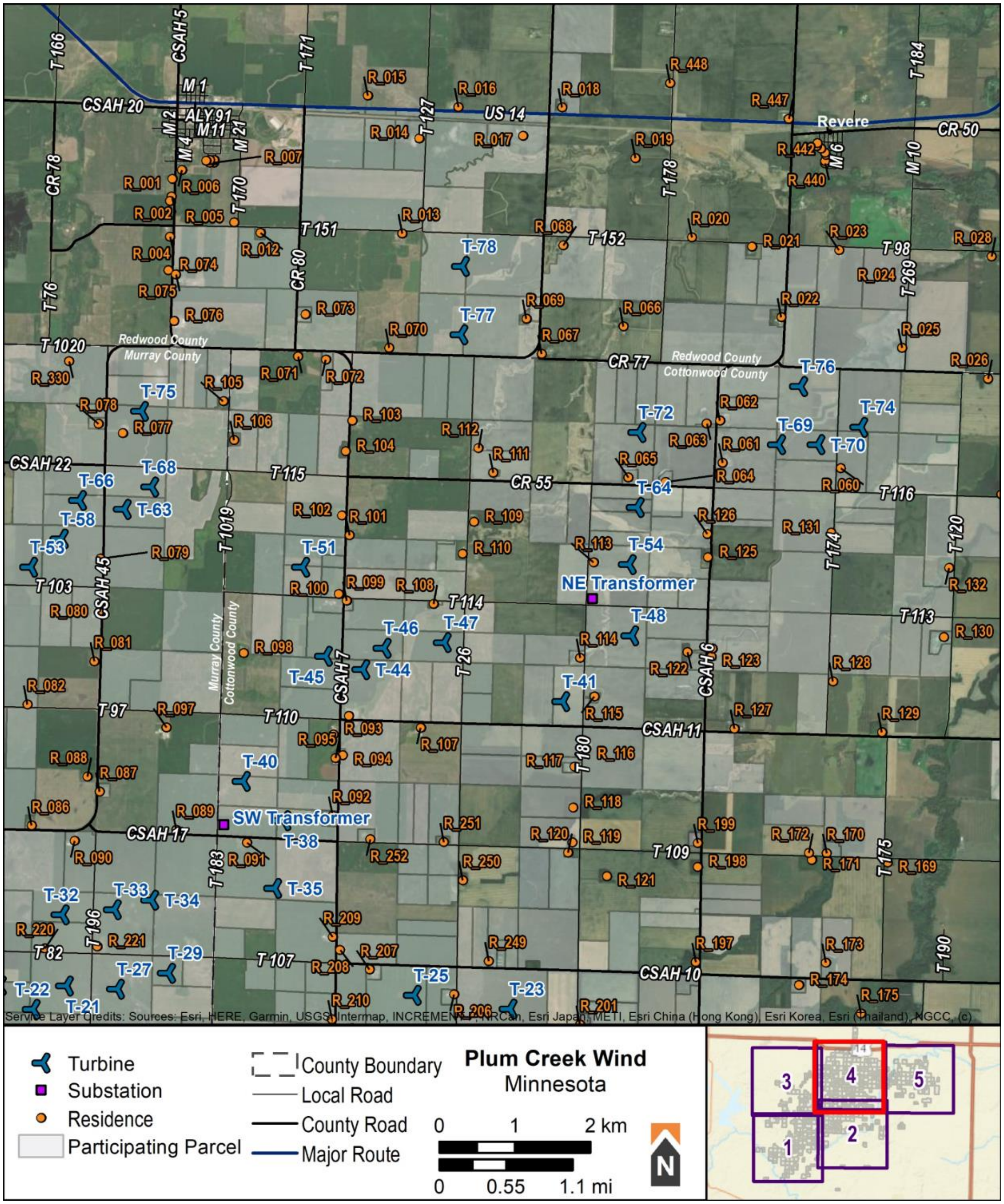


FIGURE 19: RECEIVER AND TURBINE ID MAP 4

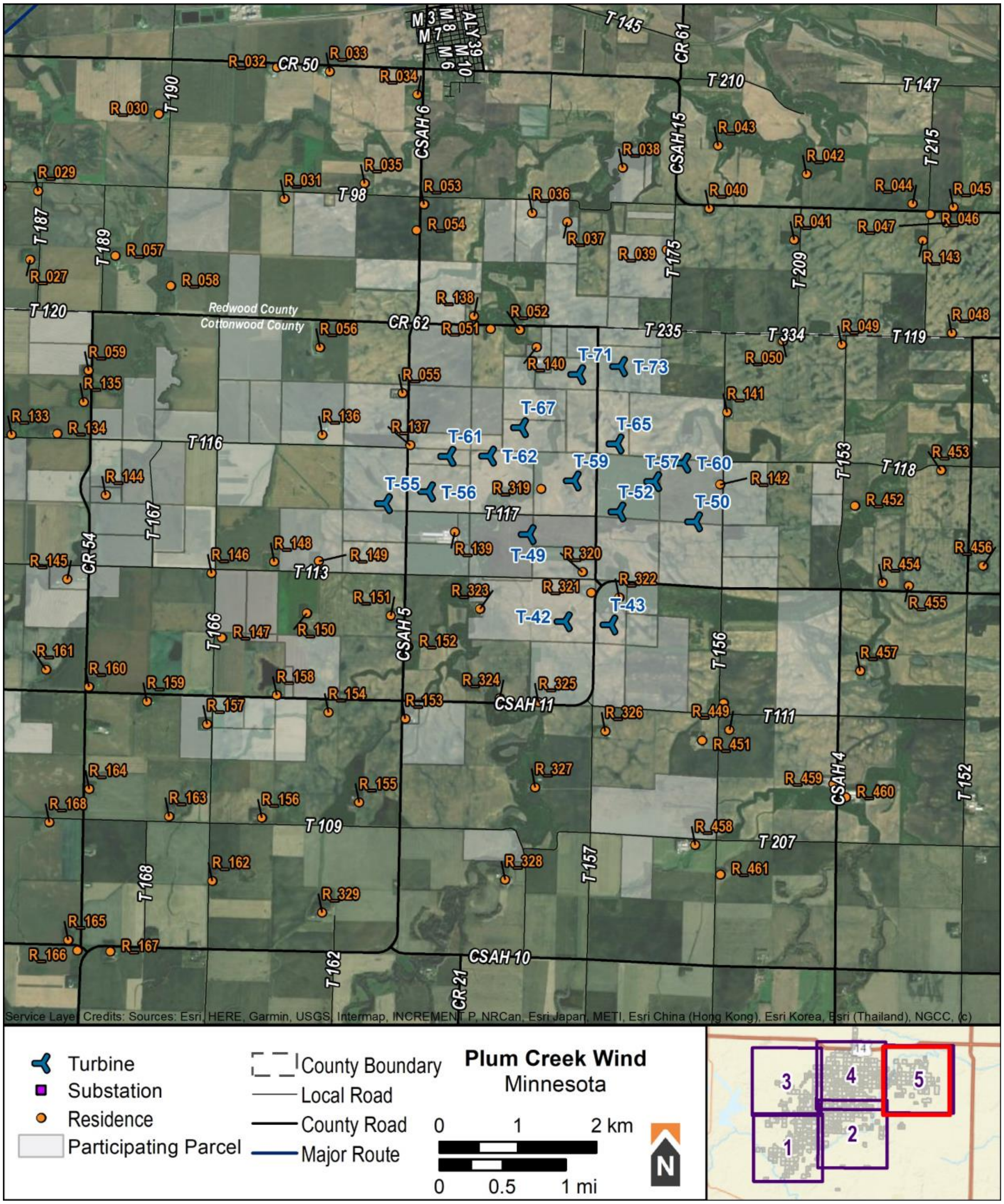


**FIGURE 20: RECEIVER AND TURBINE ID MAP 5**

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