Appendix F

Sound Level Modeling Report

Sound Level Modeling Report

2/13/2026

Homestead Wind

Apex Clean Energy

Paxwood Acoustics

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1.0 Introduction

Homestead Wind, LLC (Homestead or Applicant), an indirect subsidiary of Apex Clean Energy Holdings, LLC is developing a wind power project in Williams County, North Dakota. The Homestead Wind Project ("Project") includes 81 turbine locations, although no more than 67 will be constructed, for a total capacity of up to 256.5 MW. Paxwood Acoustics was retained by the Applicant to conduct an assessment of projected sound levels from the Project.

Based on the information provided in this report, the Project is expected to produce sound levels that meet the applicable North Dakota sound level limits, which are discussed in Section 3.2.

This report includes:

- A description of the Project,
- A discussion of sound level limits,
- Sound propagation modeling procedure and results, and
- Conclusions

In addition, an introduction to acoustics is provided in Appendix A, supporting information is provided in Appendices B through D, including information about Paxwood Acoustics in Appendix D.

2.0 Project Description

The Project includes 81 turbine locations, although no more than 67 will be constructed, for a total capacity of up to 256.5 MW in Williams County. There are two turbine models under consideration: the GE 154-3.8 MW with a hub height of 116 meters ("GE 154") and the Vestas V163-4.5 MW with a hub height of 113 meters ("V163"). The blades of the GE 154 have Low-Noise Trailing Edges, and the V163 have serrated trailing edges, both of which reduce the overall sound emissions from the turbines.

The Project area is located approximately 8 miles west of US Route 85 (CanAm Highway), 5.5 miles south of ND Route 50, and 4.5 miles east of the Montana border. At the widest areas the Project is approximately 7.5 miles from east to west and 11.5 miles north to south. The primary land use around the Project area is agricultural with some rural residences, and the terrain is relatively flat.

The Project substation will be located adjacent to an existing substation on the west side of the Project area on 151st Avenue NW.

A map showing the proposed layout, substation, and the surrounding area is provided in Figure 1.

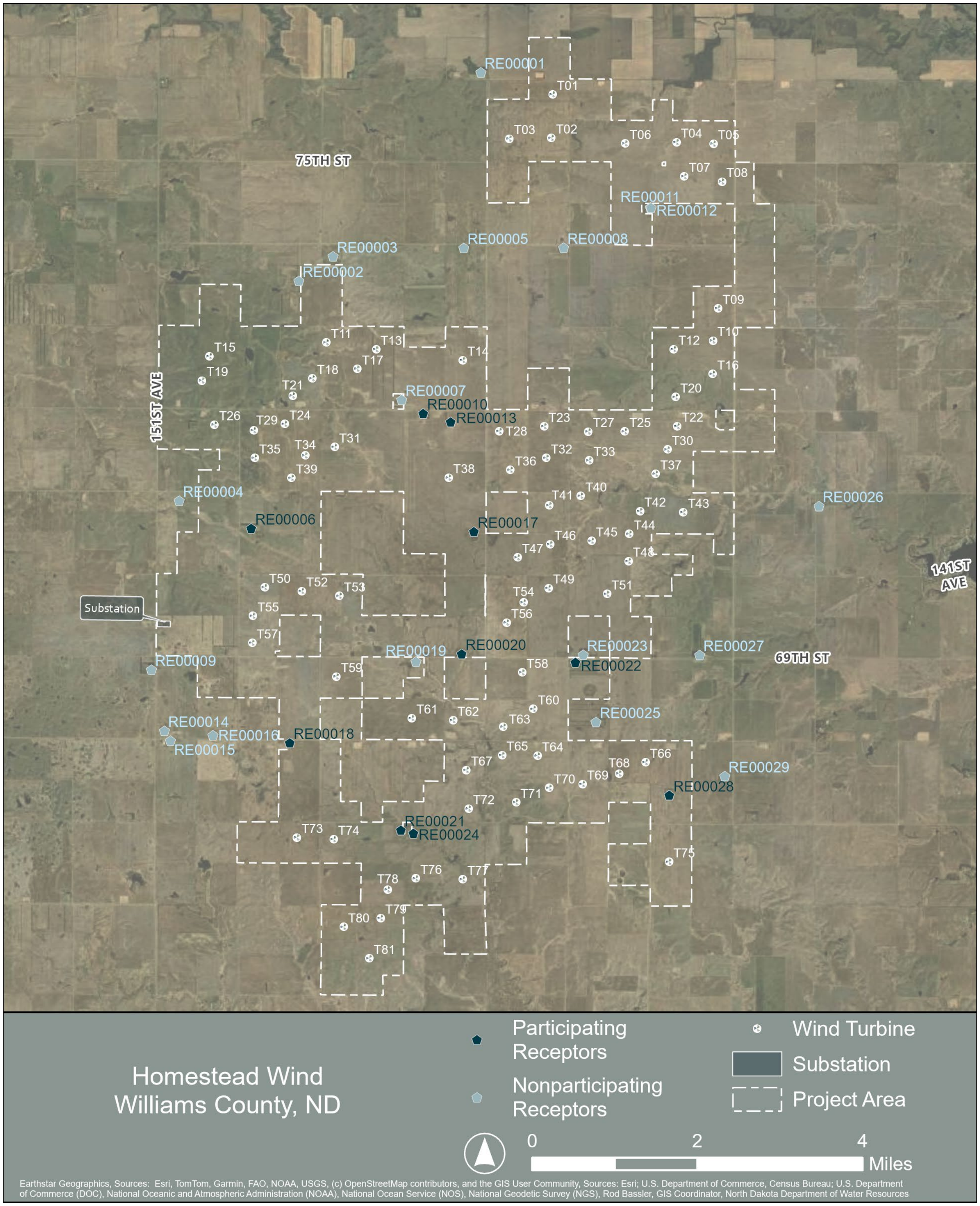

Figure 1: Map of the Project and Surrounding Area

3.0 Sound Level Limits

3.1 Local Standards

There are no quantified sound level limits in Williams County that are applicable to the Project.

3.2 State Standards

Applicable state limits are identified in ND Administrative Code 69-06-08 under Criterion 4 which states that,

> *A wind energy conversion facility site must not include a geographic area where, due to operation of the facility, the sound levels within one hundred feet of an inhabited residence or a community building will exceed forty-five dBA. The sound level avoidance criteria may be waived in writing by the owner of the occupied residence or the community building.*

This sets a limit of 45 dBA within 100 feet of an inhabited residence or community building unless there is a waiver. This is the limit that is evaluated in this assessment.

4.0 Sound Propagation Modeling

4.1 Modeling Procedure & Settings

Sound propagation modeling was completed using the modeling software CadnaA made by DataKustik GmbH. CadnaA implements the international sound propagation standard, ISO 9613-2 "Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation." Both CadnaA and the ISO 9613-2 standard are used by noise control professionals across the United States and are regularly relied upon by local and state jurisdictions. The model takes into account source sound emissions, topography, receptor locations, and several other factors. It calculates sound levels for meteorological conditions that are favorable for sound propagation, assuming that all receptors are downwind of the sound sources.

The modeling conducted for this report followed the ANSI/ACP wind turbine sound modeling standard[1] including a +2 dB factor added to the turbine sound power level and using a ground factor of G=0.5.[2] As stated in the ANSI/ACP standard, "The results yield a sound pressure level that is unlikely to be exceeded under normal operating conditions."

For this assessment, USGS terrain data was used for the Project to create the three-dimensional topography throughout the surrounding area. Other site features, including the proposed locations of equipment and receptor locations of inhabited residences within one mile of the Project, were provided by the Applicant.

Model input data and parameters are provided in Appendix B.

The model was used to calculate sound pressure levels throughout the area while each turbine was operating at its highest rated sound power level. Discrete receptors were modeled at 29 inhabited residences near the Project. There are no occupied community buildings within or near the Project. Each receptor was modeled at 13 feet (4 meters) above ground level.A 45 dBA sound level iso-line was also generated.

Modeling was completed for the two turbine models under consideration, the GE 154 and the V163, both using the same 81 turbine layout. In addition to the turbines, two high voltage transformers were modeled at the Project substation. One transformer has a rating of 120 MVA/450 kV BIL with a manufacturer specified ONAF[3] sound level of 82 dBA

[1] ANSI/ACP Standard 111-1, *Wind Turbine Sound Modeling*, American National Standards Institute, 2022.
[2] A ground factor of 0.5 is described in the ISO 9613-2 standard as mixed ground which includes both hard and porous ground. Use of a ground factor of 0.5 is supported by ANSI/ACP Standard 111-1.
[3] ONAF: Oil Natural Air Forced, in layman's terms, this is the transformer cooling mode with the fans operating.

at 6 feet. The other transformer is rated at 175 MVA/450 kV BIL with a manufacturer specified ONAF[3] sound level of 84 dBA at 6 feet. These rated sound pressure levels were converted to sound power levels for input into the sound propagation model. Modeled sound power levels of Project equipment are provided in Appendix B.

4.2 Model Results

Model results for each turbine model are provided in map format in Appendix C. The model results for each residential receptor are provided in Table 1.

For both turbine models, sound levels are projected to be 45 dBA or less at all receptors including within 100 feet of each residence[4]. Maps showing each labeled receptor relative to the Project are provided in Figures 2 and 3 after Table 1.

[4] Figures 7 through 16, in Appendix C, provide close-up maps of receptors where the relation of the receptor to the 45 dBA iso-line is difficult to see on the overview figure.

Table 1: Model Results (dBA)

Receptor	Model Scenario		Participation Status
	GE 154	V163	
RE00001	38	35	nonparticipant
RE00002	40	37	nonparticipant
RE00003	38	35	nonparticipant
RE00004	40	37	nonparticipant
RE00005	38	34	nonparticipant
RE00006	44	41	participant
RE00007	44	41	nonparticipant
RE00008	38	35	nonparticipant
RE00009	41	40	nonparticipant
RE00010	43	40	participant
RE00011	43	40	nonparticipant
RE00012	43	40	nonparticipant
RE00013	45	41	participant
RE00014	36	34	nonparticipant
RE00015	36	33	nonparticipant
RE00016	38	35	nonparticipant
RE00017	45	42	participant
RE00018	40	37	participant
RE00019	43	40	nonparticipant
RE00020	44	41	participant
RE00021	44	41	participant
RE00022	45	41	participant
RE00023	44	41	nonparticipant
RE00024	45	42	participant
RE00025	45	42	nonparticipant
RE00026	36	32	nonparticipant
RE00027	39	35	nonparticipant
RE00028	44	41	participant
RE00029	38	35	nonparticipant

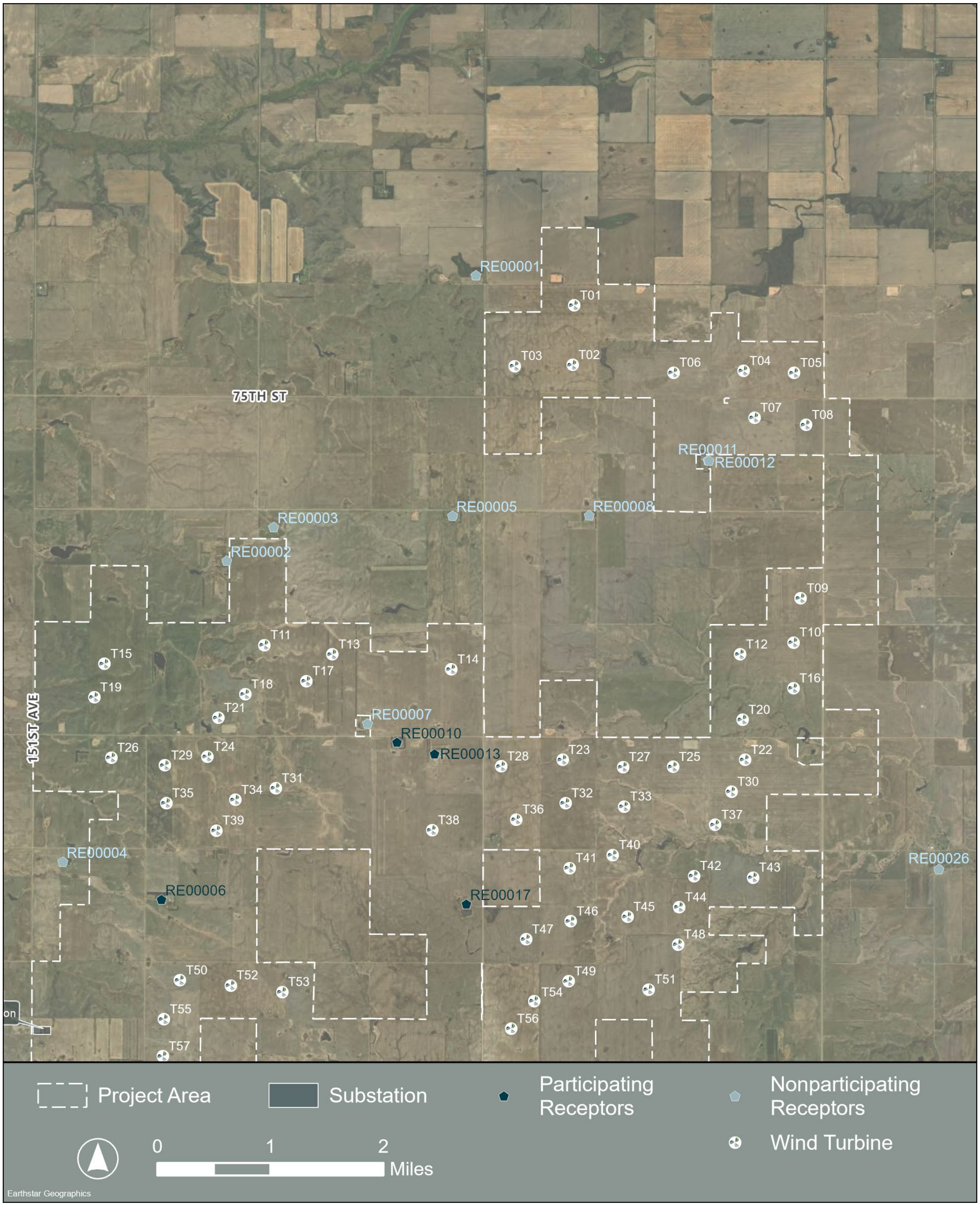

Figure 2: Map of Modeled Receptors (Northern Project Area)

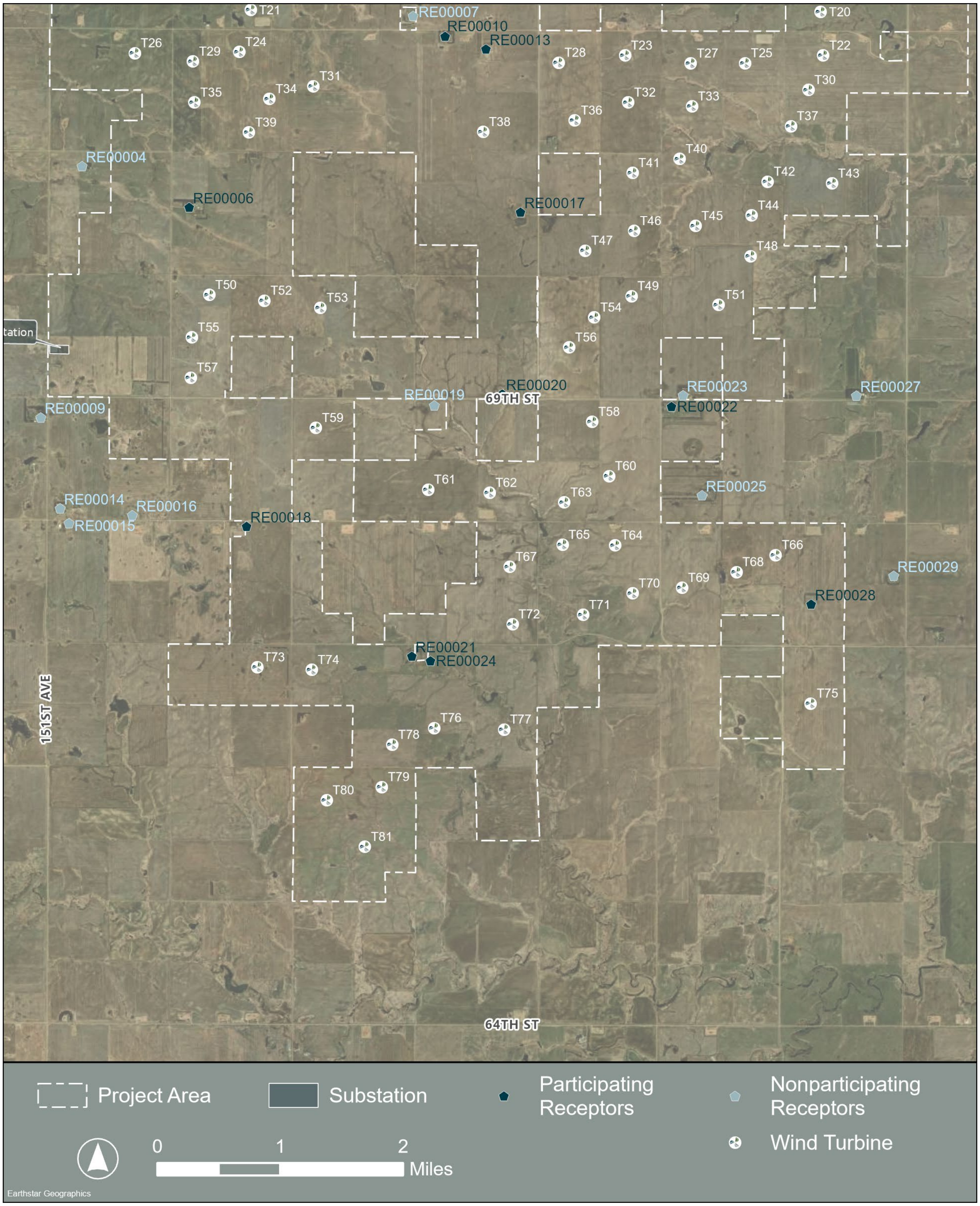

Figure 3: Map of Modeled Receptors (Southern Project Area)

5.0 Conclusions

Paxwood Acoustics conducted an assessment of projected sound levels from the proposed Homestead Wind Project located in Williams County, North Dakota. The Project includes 81 turbine locations, with up to 67 being constructed, for a total capacity of up to 256.5 MW. This assessment included a description of the Project area and equipment, a discussion of the applicable state sound level limits, and sound propagation modeling to project sound levels throughout the surrounding area.

The turbine models under consideration and evaluated in this report are the GE 154 and the V163, which use low-noise trailing edge and serrated trailing edge technology respectively, to reduce overall sound emissions from the turbines.

As discussed in Section 3.2, the sound level limit that applies to the Project is 45 dBA within 100 feet of an inhabited residence or community building unless there is a waiver.

Sound propagation modeling was completed using the ANSI/ACP wind turbine sound modeling standard[1] including a +2 dB factor added to the turbine sound power level and using a ground factor of G=0.5. As discussed in Section 4.2 and detailed in Appendix C and D, the projected sound levels are 45 dBA or less at all receptors.

Given this, Homestead Wind is expected to produce sound levels that meet the sound level requirements of ND Administrative Code 69-06-08.

Appendix A: Introduction to Acoustics

Sound, Sources, and Perception

Sound in air is caused by fluctuations in air pressure which can be due to a variety of sources. The sources of sound can generally be grouped into three major categories: anthropogenic, biogenic, and geophonic. Anthropogenic sounds are human caused sounds such as voices, instruments, vehicles, and mechanical and electrical equipment. Biogenic sounds are those that are caused by organisms such as animal calls or animal interaction with the environment. And lastly geophonic sounds are those caused by the environment itself such as waves hitting a shoreline or wind interacting with plants or other objects.

There are three primary characteristics of sound that affect human perception: frequency which may also be referred to as pitch or tone, amplitude which relates to perceived loudness or volume, and temporal fluctuations, which is to say that sound can change with time.

Frequency

Humans can hear sound over a range of frequencies typically from 20 Hz to 20,000 Hz. While not strictly defined, this range can be divided into three subranges which are described as low frequency (20 Hz to around 250 Hz), mid frequency (around 250 Hz to around 4,000 Hz), and high frequency (around 4,000 Hz to 20,000 Hz). The mid frequency range is where most human speech occurs. More defined ranges of frequency are divided into octave bands (31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, 8 kHz, and 16 kHz), or even further into 1/3 octave bands which are three smaller bands within each octave band.

Most sounds are broadband in nature and contain energy at a range of frequencies. If however, a sound contains notably more energy at a specific frequency compared to the adjacent frequencies, then the sound can be perceived as a tone, such as a note in music.

Amplitude

Humans can hear sound over a wide range of pressures, from approximately 20 micropascals to over 20 million micropascals. Sound can occur outside of this range, but below 20 micropascals is typically inaudible to humans and above 20 million micropascal can cause pain. In acoustics, this wide range of audible sound pressures is compressed using a logarithmic scale to create a range of sound pressure levels from 0 dB (20 micropascals) to 120 dB (20 million micropascals). It is in this logarithmic scale, denoted as decibel or dB, that acousticians and environmental regulations quantify the amplitude of sound.

Temporal Changes

Both frequency and amplitude can change with time. A sound may be constant in both frequency and level, but this is fairly uncommon. If one considers the fluctuation in sounds from people having conversations, birds chirping, or vehicles passing by, it becomes apparent how much sound can change from one instance to the next. It is for this reason that acousticians use a variety of metrics to define and describe sound. These metrics are discussed further below.

Weighting Networks, Sound Pressure Level, and Metrics

Weighting Networks

Humans are most sensitive to sound between 500 Hz and 5 kHz. Our sensitivity with sound decreases below 500 Hz and above 5 kHz. In order to account for this varying sensitivity, the A-weighting network or filter was developed to mimic the sensitivity of the human ear and how we perceive loudness. A-weighting discounts sound in varying degrees by frequency below 500 Hz and above 5,000 Hz. Between 1,000 Hz and 4,000 Hz, the A-weighting network amplifies sound slightly to account for the increased sensitivity of the human ear in that range. Since the A-weighting network accounts for human sensitivity at different frequencies, it is widely used in environmental acoustics and most environmental regulations. When a sound level is A-weighted, an "A" is typically added to the end of the abbreviation for decibel: dBA.

If a sound is not weighted or sometimes referred to as unweighted, it is considered Z-weighted or dBZ.

Sound Pressure Level

As was discussed previously, in acoustics, the amplitude of sound is often referred to in terms of sound pressure level. Representative sound pressure levels of some common sound sources and environments are shown in Figure 4. The sound levels presented in Figure 4 are meant to be illustrative, so any specific source or environment may be similar to or fall outside of the ranges shown in the graphic.

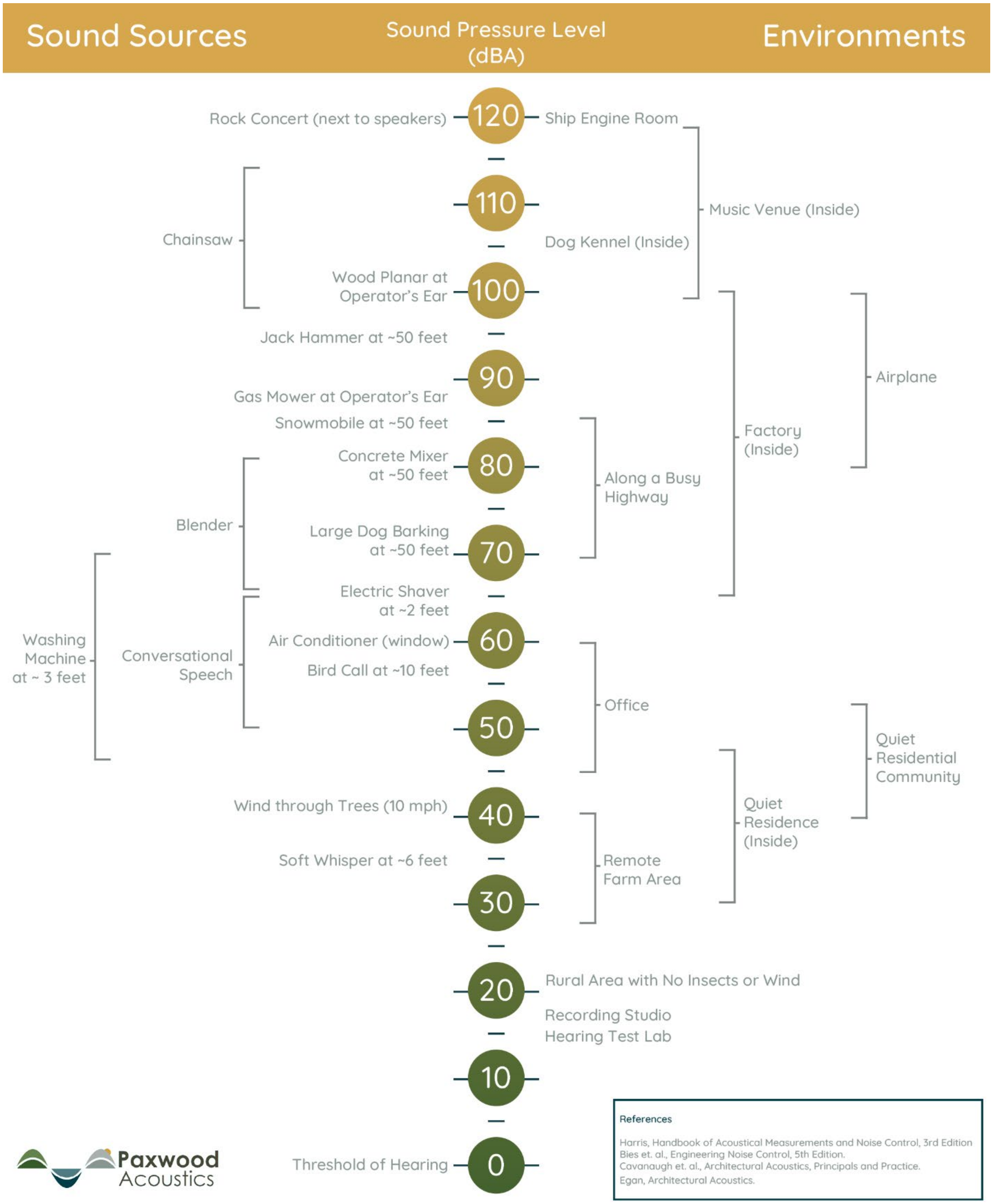

Figure 4: Representative Sound Pressure Levels (dBA) of Common Sound Sources & Environments

Since sound is a logarithmic function, one cannot use regular arithmetic operations to add and subtract sound levels. So, for example, conversational speech typically occurs at a level between 55 dBA and 65 dBA. If one person is speaking at a level of 60 dBA and another person is also speaking at a level of 60 dBA, the total sound level is not 120 dBA. (And a good thing too, otherwise, two people talking at the same time would quickly approach the threshold of pain, 120 dBA.) Instead, two voices at the same level only causes an increase of 3 dB, so 60 dBA plus 60 dBA equals 63 dBA. To illustrate this further, Table 2 provides a general guide on how two sound levels sum together.

Table 2: Guide to Sound Level Summation

If the difference between two sound levels is:	Add the following value to the greater of the two sound levels:
0 or 1 dB	3 dB
2 or 3 dB	2 dB
4 or 9 dB	1 dB
10 dB or more	0 dB
Note: For the precise calculation - $Lp_{total} = 10 \times \log_{10}\left(10^{Lp1/10} + 10^{Lp2/10}\right)$	

In terms of perception of sound level there are two helpful rules of thumb to be aware of: 1) A change in broadband sound level of 10 dB is perceived as a halving or doubling of loudness, depending on if the amplitude of the sound decreased or increased, and 2) Changes in sound level of less than 3 dB are generally considered not perceptible.

Sound Level Metrics

With sound levels in an environment continuously changing, different sound level metrics are used to describe the sound level versus time. The most common metric used in environmental acoustics and modeling of sound levels from wind turbines is the equivalent continuous sound level denoted as L_{eq}. The L_{eq} is the level of the average sound pressure over a specified period of time. It takes into account quieter, long-term sound levels along with louder, short-duration sound levels to provide an overall sound level for a given time period. The louder sound levels, even with a short-duration, can have a strong influence on the L_{eq}. The L_{eq} is often used in environmental acoustics to convey an average representation of the acoustical environment, even though it is influenced more strongly by higher sound levels that occur over the specified interval. An L_{eq} may be as short as 1-second or up to an hour or more depending on the purpose of the quantification.

Appendix B: Model Settings & Input

Table 3: Sound Propagation Model Settings

Model Parameter	Setting
Ground Attenuation	ISO 9613-2 spectral ground attenuation with a ground factor of 0.5 in accordance with ANSI/ACP Standard 111-1.[1]
Topography	USGS terrain.
Foliage Attenuation	No attenuation due to forest was taken into account in the model.
Atmospheric Attenuation	Based on 70% relative humidity and 10° C.
Search Radius	5 miles (8,000 meters).
Iso-line Grid	~100 feet by 100 feet (30 meters by 30 meters) throughout the Project and surrounding area at a height of 13 feet (4 meters).

Table 4: Source Model Input Data

Turbine/Source ID	Modeled Sound Power Level (dBA)[5]		Coordinates (UTM NAD83 Z13N)		Elevation (ground + source height, m)
	GE 154 LNTE (116m HH)	V163 STE (113m HH)	X (m)	Y (m)	
T01	111.0	108.3	585209	5374201	818
T02	111.0	108.3	585200	5373353	825
T03	111.0	108.3	584380	5373324	821
T04	111.0	108.3	587636	5373313	805
T05	111.0	108.3	588358	5373294	812
T06	111.0	108.3	586640	5373269	819
T07	111.0	108.3	587802	5372649	815
T08	111.0	108.3	588537	5372559	818
T09	111.0	108.3	588506	5370092	823
T10	111.0	108.3	588415	5369461	819
T11	111.0	108.3	580888	5369293	838
T12	111.0	108.3	587657	5369280	809
T13	111.0	108.3	581857	5369177	843
T14	111.0	108.3	583553	5368994	851
T15	111.0	108.3	578616	5368985	824
T16	111.0	108.3	588423	5368811	806
T17	111.0	108.3	581494	5368791	839
T18	111.0	108.3	580627	5368588	825

[5] The sound power level data for the turbines in Table 4 includes the +2 dB factor per ANSI/ACP Standard 111-1. The sound power level spectral data in Table 5 does not include the +2 dB factor as it is meant to show the sound power data from the turbine manufacturer.

Turbine/Source ID	Modeled Sound Power Level (dBA)[5]		Coordinates (UTM NAD83 Z13N)		Elevation (ground + source height, m)
	GE 154 LNTE (116m HH)	V163 STE (113m HH)	X (m)	Y (m)	
T19	111.0	108.3	578479	5368508	840
T20	111.0	108.3	587710	5368350	802
T21	111.0	108.3	580247	5368247	822
T22	111.0	108.3	587752	5367781	810
T23	111.0	108.3	585158	5367734	830
T24	111.0	108.3	580105	5367691	834
T25	111.0	108.3	586731	5367661	824
T26	111.0	108.3	578736	5367653	832
T27	111.0	108.3	586021	5367646	828
T28	111.0	108.3	584287	5367625	840
T29	111.0	108.3	579502	5367557	838
T30	111.0	108.3	587567	5367323	810
T31	111.0	108.3	581084	5367261	849
T32	111.0	108.3	585210	5367119	833
T33	111.0	108.3	586046	5367085	825
T34	111.0	108.3	580511	5367084	843
T35	111.0	108.3	579529	5367020	842
T36	111.0	108.3	584515	5366874	840
T37	111.0	108.3	587347	5366847	796
T38	111.0	108.3	583317	5366701	857
T39	111.0	108.3	580252	5366642	847
T40	111.0	108.3	585897	5366392	822
T41	111.0	108.3	585283	5366198	827
T42	111.0	108.3	587055	5366115	814
T43	111.0	108.3	587898	5366108	797
T44	111.0	108.3	586853	5365668	826
T45	111.0	108.3	586120	5365519	827
T46	111.0	108.3	585314	5365440	831
T47	111.0	108.3	584683	5365171	844
T48	111.0	108.3	586847	5365137	827
T49	111.0	108.3	585297	5364585	843
T50	111.0	108.3	579768	5364504	870
T51	111.0	108.3	586439	5364489	834
T52	111.0	108.3	580492	5364443	859
T53	111.0	108.3	581227	5364362	853
T54	111.0	108.3	584816	5364297	845
T55	111.0	108.3	579549	5363943	858

Turbine/Source ID	Modeled Sound Power Level (dBA)[5]		Coordinates (UTM NAD83 Z13N)		Elevation (ground + source height, m)
	GE 154 LNTE (116m HH)	V163 STE (113m HH)	X (m)	Y (m)	
T56	111.0	108.3	584494	5363899	845
T57	111.0	108.3	579542	5363417	870
T58	111.0	108.3	584813	5362932	849
T59	111.0	108.3	581195	5362789	851
T60	111.0	108.3	585044	5362225	843
T61	111.0	108.3	582679	5362006	835
T62	111.0	108.3	583483	5361979	826
T63	111.0	108.3	584466	5361869	821
T64	111.0	108.3	585142	5361317	833
T65	111.0	108.3	584451	5361316	816
T66	111.0	108.3	587245	5361228	843
T67	111.0	108.3	583761	5361013	822
T68	111.0	108.3	586734	5360996	839
T69	111.0	108.3	586027	5360780	834
T70	111.0	108.3	585380	5360693	833
T71	111.0	108.3	584736	5360401	807
T72	111.0	108.3	583815	5360263	822
T73	111.0	108.3	580483	5359642	857
T74	111.0	108.3	581196	5359620	847
T75	111.0	108.3	587738	5359293	827
T76	111.0	108.3	582812	5358885	824
T77	111.0	108.3	583727	5358882	802
T78	111.0	108.3	582266	5358659	838
T79	111.0	108.3	582141	5358102	842
T80	111.0	108.3	581421	5357917	846
T81	111.0	108.3	581932	5357315	833
Transformer 1	105.0	105.0	577925	5363762	758
Transformer 2	107.0	107.0	577925	5363748	758

Table 5: Source Sound Power Level (dB) by Octave Band Center Frequency

Turbine & Mode	Full Octave Band Center Frequency (Hz)									Overall Sound Power Level (dBA)
	31.5	63	125	250	500	1000	2000	4000	8000	
GE 154-3.8 MW with LNTE	123	119	113	108	104	104	102	95	81	109
V163-4.5 MW with STE	115	111	110	104	102	102	99	90	85	106
Transformer 1	94	88	105	105	107	95	86	80	75	105
Transformer 2	96	90	107	107	109	97	88	82	77	107

Appendix C: Model Result Maps

Model results maps for the entire Project area are provided in Figure 5 and Figure 6, for the GE 154 and the V163, respectively. Figures 7 through 16 provide close-up maps of receptors where the relation of the 45 dBA iso-line is difficult to see on the overview figures, showing that sound level remains below the limit within 100 feet of the residence.

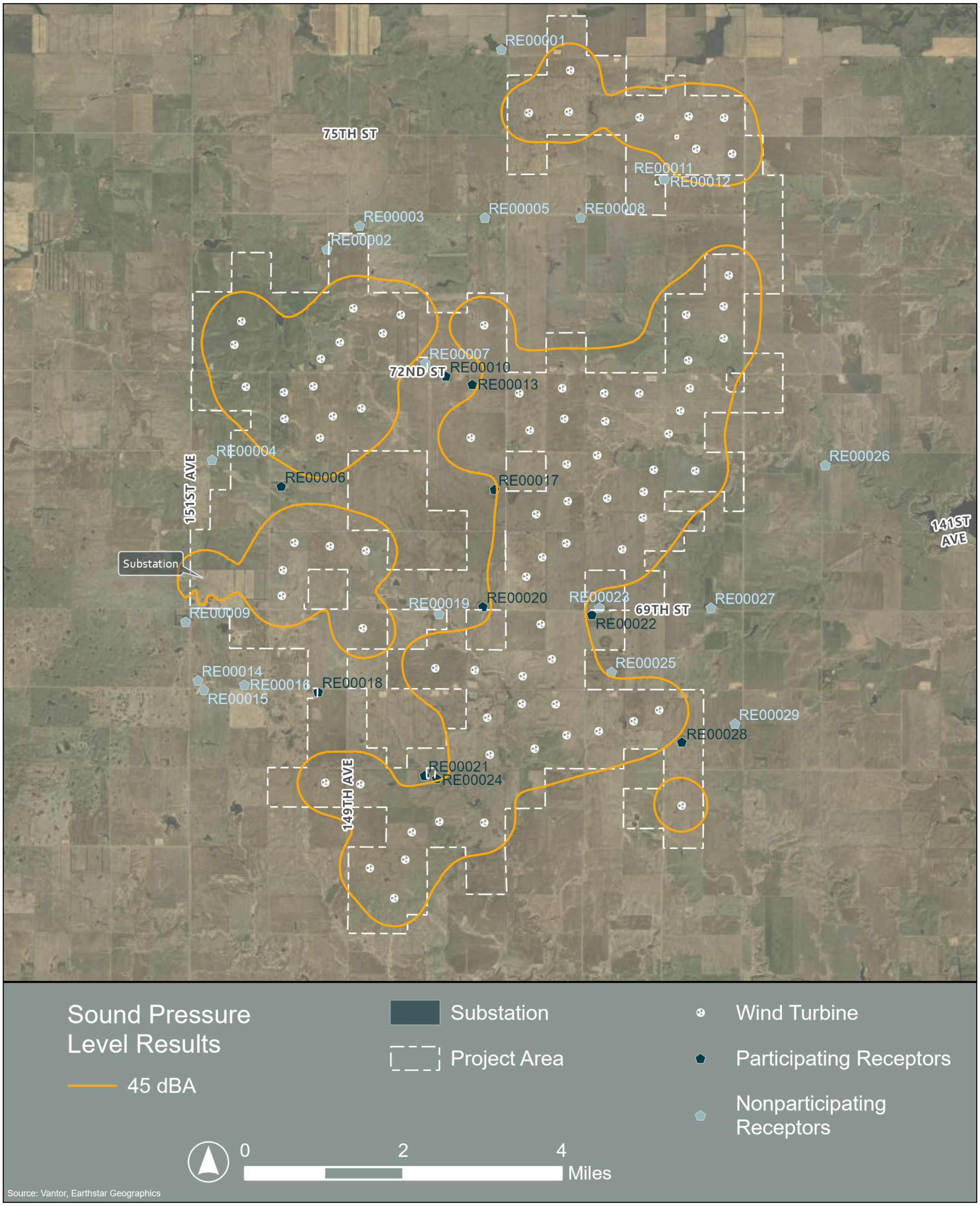

Figure 5: Model Results Map for the GE 154

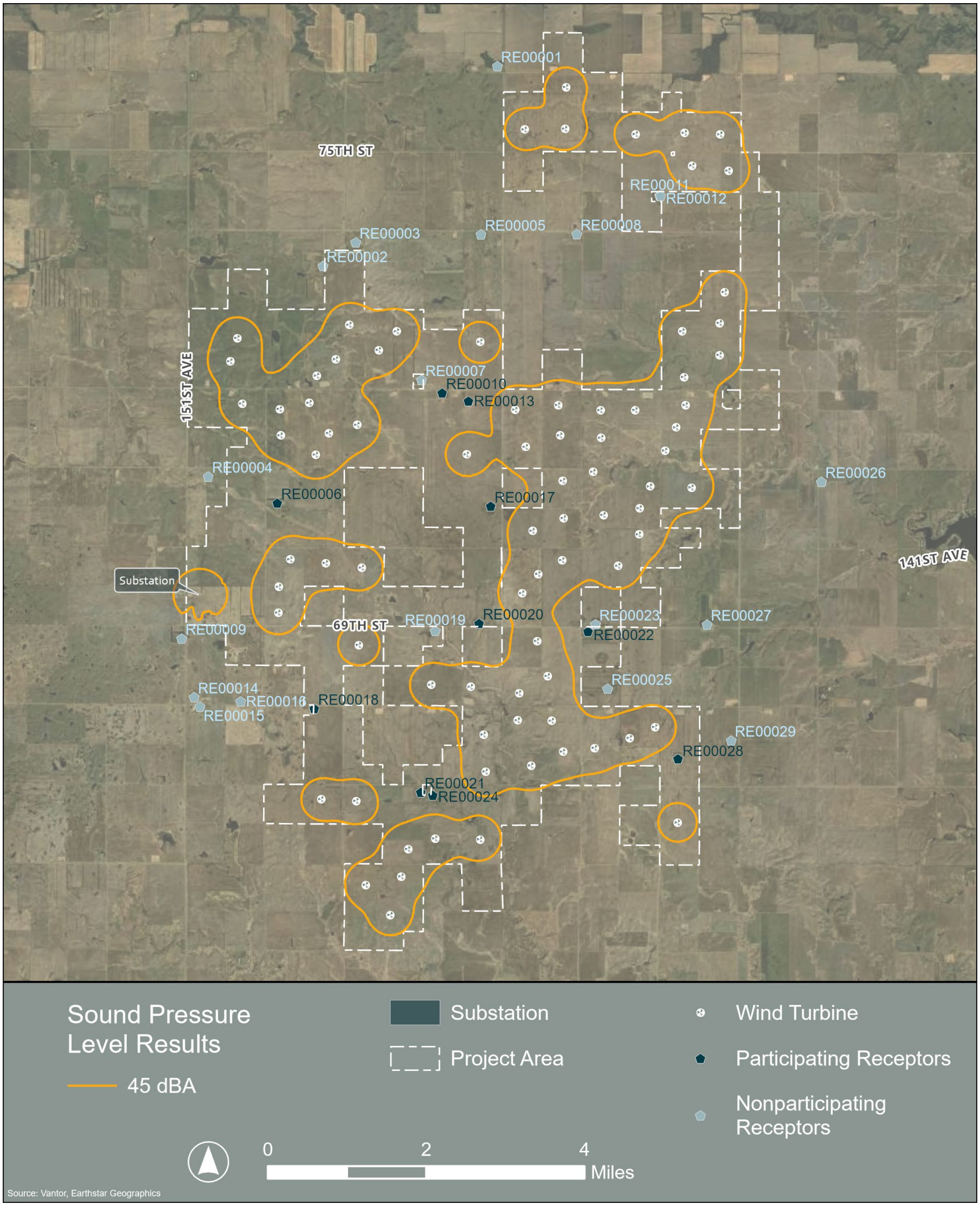

Figure 6: Model Results Map for the V163

Figure 7: Model Results Map for GE 154 at RE00006

Figure 8: Model Results Map for GE 154 at RE00007, RE00010, and RE00013

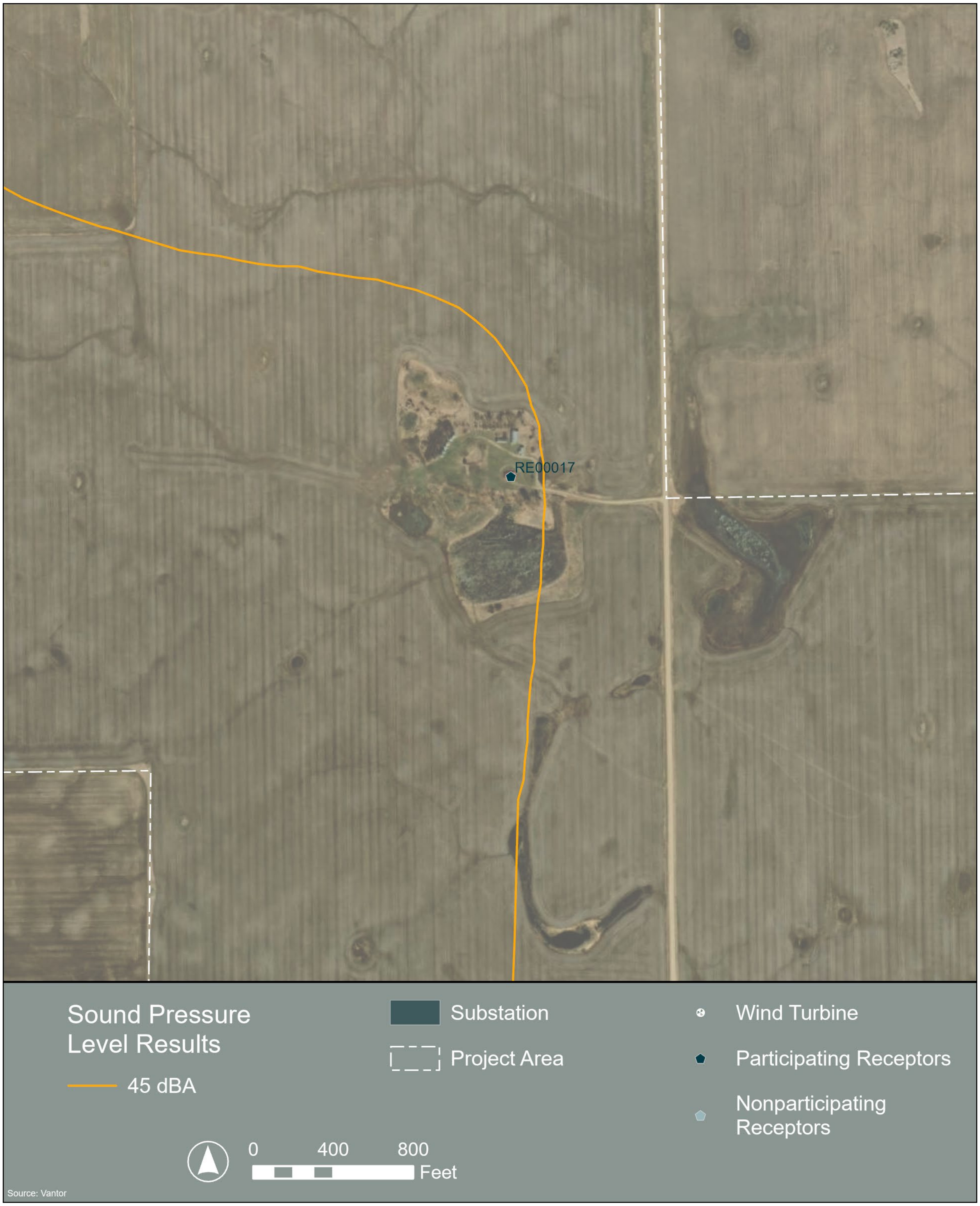

Figure 9: Model Results Map for GE 154 at RE00011 and RE00012

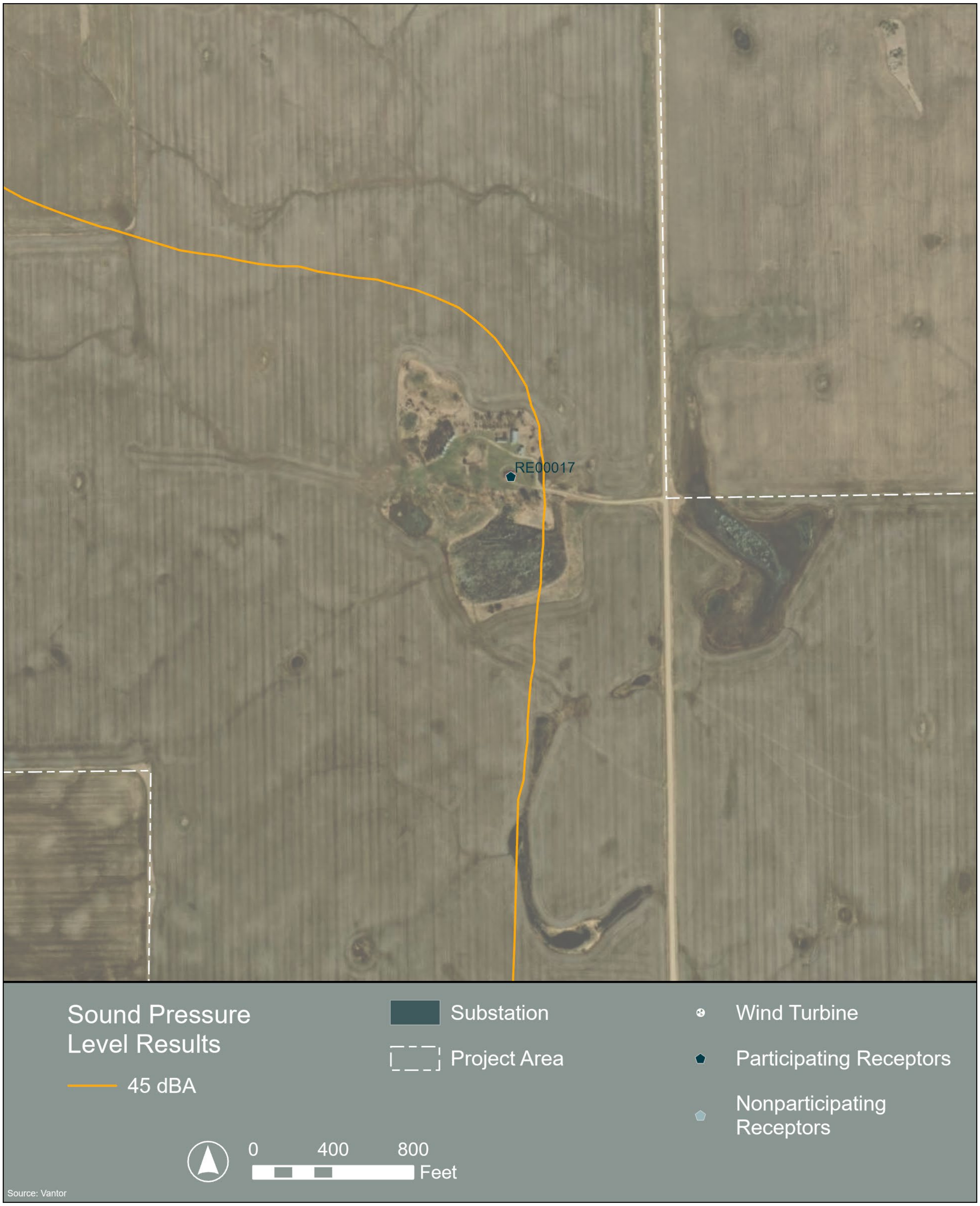

Figure 10: Model Results Map for GE 154 at RE00017

Figure 11: Model Results Map for GE 154 at RE00019

Figure 12: Model Results Map for GE 154 at RE00020

Figure 13: Model Results Map for GE 154 at RE00021 and RE00024

Figure 14: Model Results Map for GE 154 at RE00022 and RE00023

Figure 15: Model Results Map for GE 154 at RE00025

Figure 16: Model Results Map for GE 154 at RE00028

Appendix D: Qualifications

Paxwood Acoustics provides professional consulting services in acoustics and noise control engineering with a focus on environmental permitting and compliance. Eddie Duncan, Principal Consultant, is a Board-Certified Noise Control Engineer (#09002) through the Institute of Noise Control Engineering and is a member of the Acoustical Society of America. Mr. Duncan has been practicing acoustic consulting for over 20 years. In that time, he has managed over 400 acoustics projects and has worked on 120+ wind power projects, 85+ solar projects, and 70+ transmission projects. He has also managed noise assessments for a growing portfolio of BESS projects which have often been a component of other renewable energy projects.