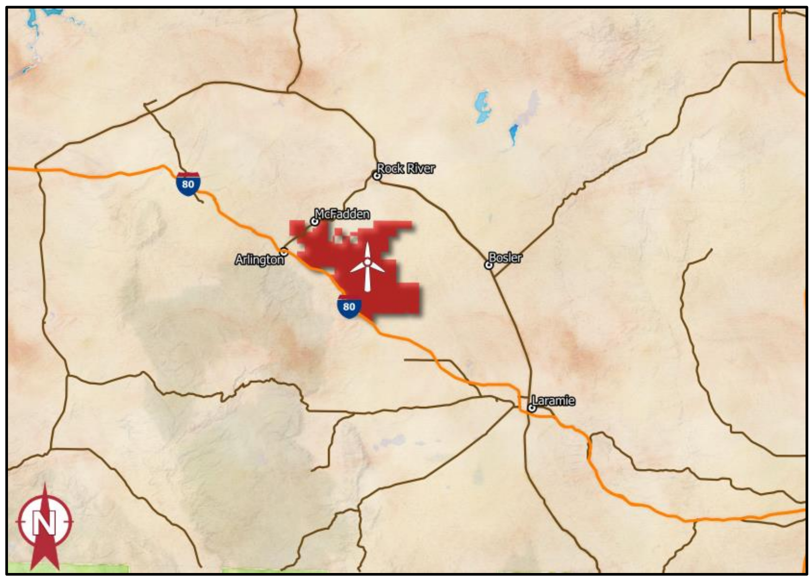
Pre-Construction Wind Turbine Noise Analysis

for the proposed

Rock Creek Wind Farm

September 15, 2021



Prepared for:

Rock Creek Wind, LLC
Albany County, Wyoming

Prepared by:

Hankard Environmental, Inc.
Verona, Wisconsin

Reviewed by:

Smith Environmental & Engineering
Dacono, Colorado

This noise analysis has been performed under my supervision and review. I believe that it conforms to good engineering practice, industry standard guidelines and shows compliance with the Albany County, Wyoming noise requirements for a Wind Energy Conversion System (WECS).

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1. Introduction

This report describes a pre-construction noise analysis conducted by Hankard Environmental for the proposed Rock Creek Wind Farm (Project, Facility). The analysis was performed under the supervision of a professional engineer licensed by the State of Wyoming. The analysis was conducted at the request of the Project proponent, Rock Creek Wind, LLC, for the purpose of demonstrating that the Project has been designed to meet Albany County's noise limits. The Project is expected to produce up to 590 megawatts (MW) of electrical power using up to 129 wind turbines, which will be located in Albany and Carbon Counties, Wyoming. Figure 1-1 shows the general location of the Project, which is approximately 25 miles northwest of Laramie, Wyoming.

Described herein are the applicable noise standard, the Project and its environs, the methods and data used to predict noise levels, and the results of the noise level predictions.

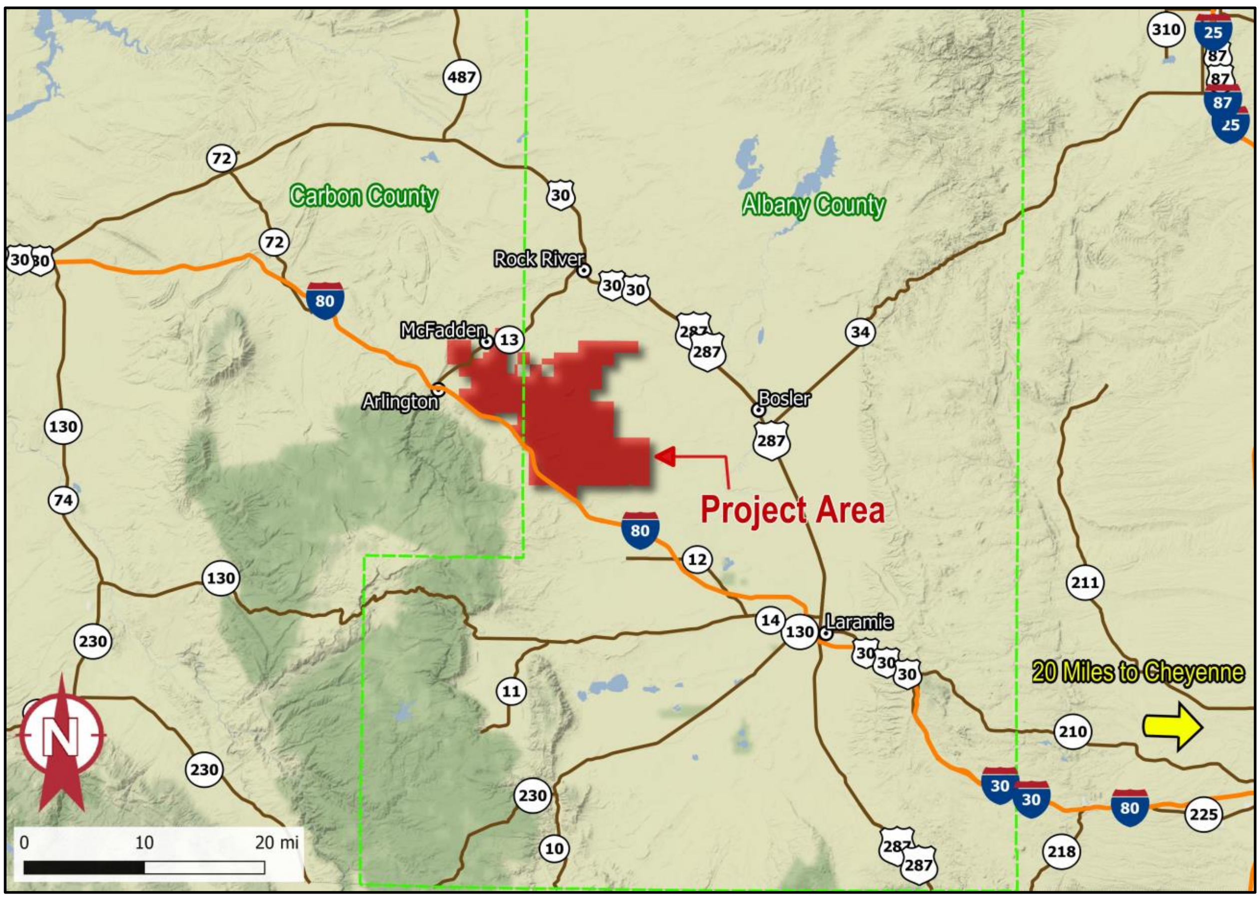

Figure 1-1. General Location of the Proposed Rock Creek Wind Farm

2. Applicable Noise Standards

There are no federal laws, rules, or regulations applicable to the Project. Carbon County Zoning Resolution of 2015 (Amended July 7, 2020) outlines the requirements for Commercial Scale Energy Facilities (Chapter 6), but there are no specific noise limits defined. The State of Wyoming outlines regulations for Wind and Solar Energy Facilities in *Title 18 Counties, Chapter 5, Article 5*, but does not directly address noise. *Title 35, Chapter 12 Industrial Development and Siting* states that a facility will not produce an unacceptable environmental impact.

The Albany County Zoning Resolution (October 1, 2015) defines noise limitations for Commercial Wind projects. Per *Chapter 5, Section 12 (G)(3)*,

> *Noise associated with Wind Energy Conversion Systems (WECS) operation shall not exceed 55 dBA as measured at any point along the common property lines between a non-participating property and a participating property.*

The Resolution provides no indication of the metric (e.g., maximum, average) or time interval (e.g., one hour). The most common time interval is one hour (required by most state level analyses, although 10-minutes is also common for wind turbine noise measurements). A one-hour metric is required by state law in Colorado, Minnesota, and Illinois, and is used in public service applications in most states. This analysis predicts the one-hour equivalent noise level (L_{eq}, dBA), as further described in Section 4.

A noise model was created and used to predict the one-hour L_{eq} from the Project assuming full acoustic output from all turbines and substations under normal operating conditions. Noise levels were predicted in the form of noise level contours (lines), which were overlaid onto maps showing the location of property lines. Compliance is demonstrated graphically by showing that the predicted 55 dBA noise level contours do not extend into any non-participating properties. Noise levels were also predicted at all habitable structures located within 1.5 miles of any wind turbine or substation.

3. Project Description

The Project consists of up to 129 wind turbines generating up to 590 MW of electric power. Associated facilities include gravel access roads and underground cabling to collect and transmit the power to two Project substations, each containing two step-up transformers.

The locations of the 129 proposed wind turbines are shown in Figures 3-1 and 3-2. 119 turbines are located in Albany County, and 10 turbines are located in Carbon County. The proposed turbine model analyzed in this study is the Vestas V150-5.6 (Mode 0-0S) with a hub-height of 95 meters. At the time of this report the Project is also considering the Vestas V150-4.5 and V150-6.0 wind turbine models, which may have a slightly different noise emission profile. If the V150-4.5 or V150-6.0 are selected for the Project, or if the Project makes any other significant changes to Project such as a revised layout, this noise analysis should be updated and compliance with the noise limit again be demonstrated. The substations are each assumed to include two 150 megavolt amperes (MVA) main power transformers. Also shown in Figures 3-1 and 3-2 are the locations of the substations in Carbon and Albany Counties, and the participating land parcels near the Project. The locations of the prediction points are described in the next section.

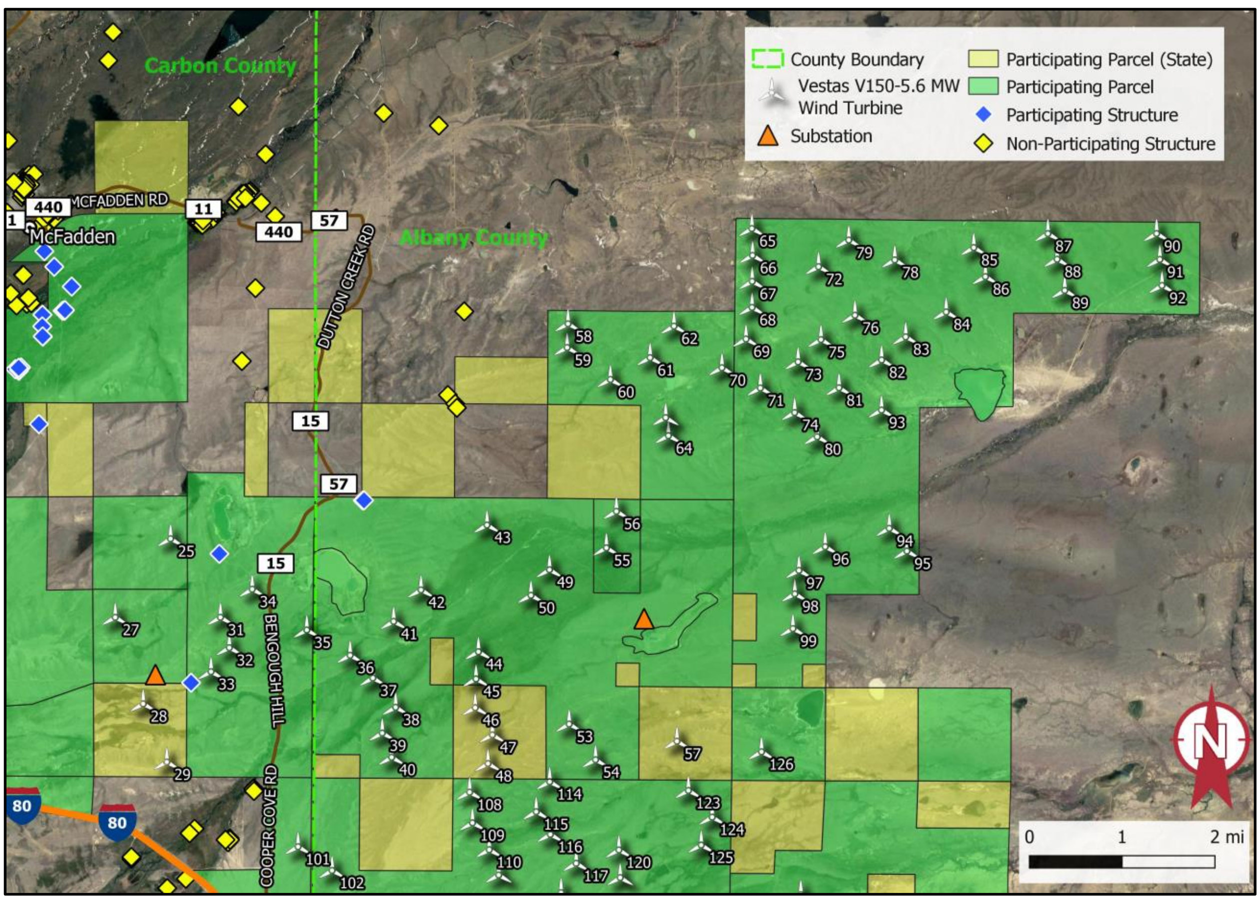

Figure 3-1. General Turbine Layout – Northern Area

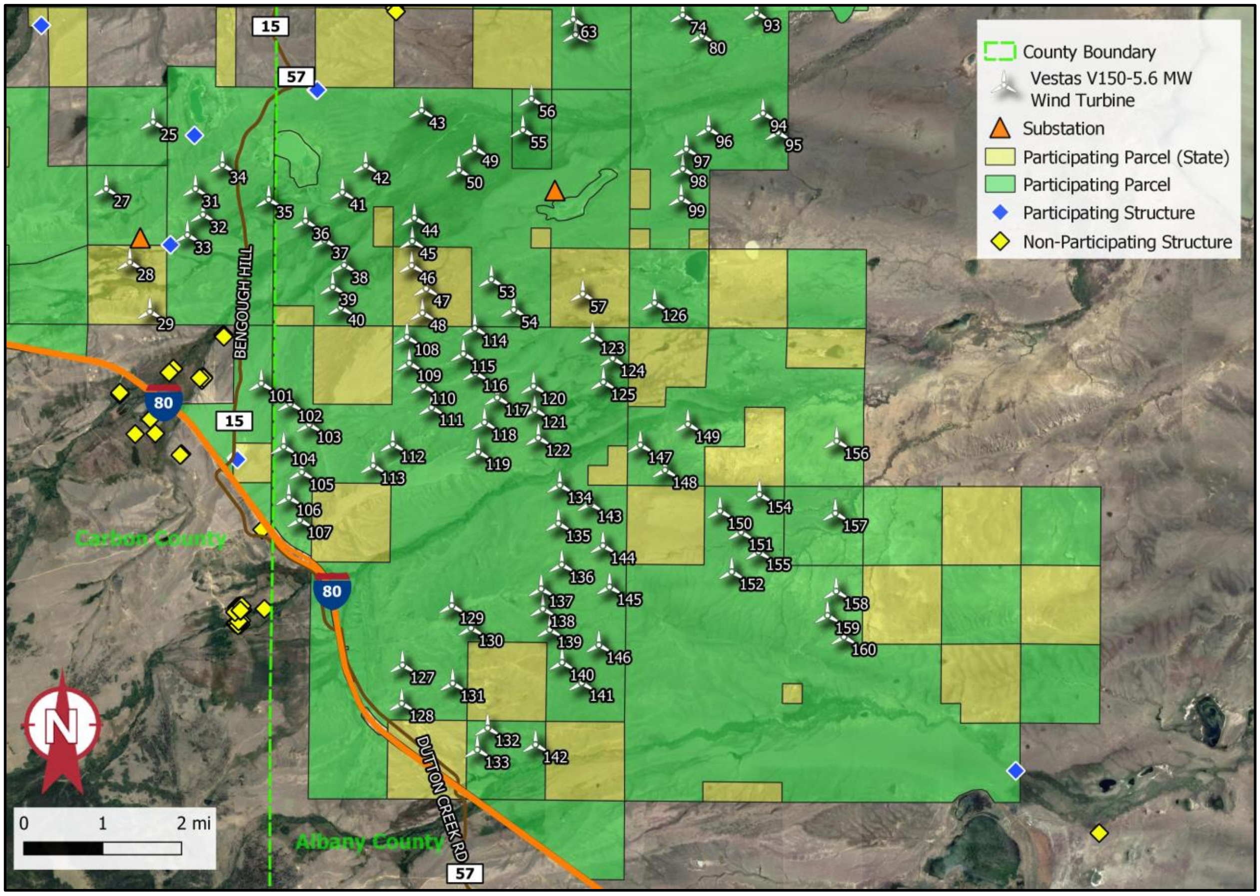

Figure 3-2. General Turbine Layout – Southern Area

4. Noise Modeling Method

Noise levels from the proposed Project were predicted using the modeling method set forth in International Organization for Standardization (ISO) Standard 9613-2:1996 - *Attenuation of Sound During Propagation Outdoors*. The method was implemented using the SoundPLAN v8.2 acoustical modeling program. Figure 4-1 shows a representative three-dimensional view of the SoundPLAN model of the Project.

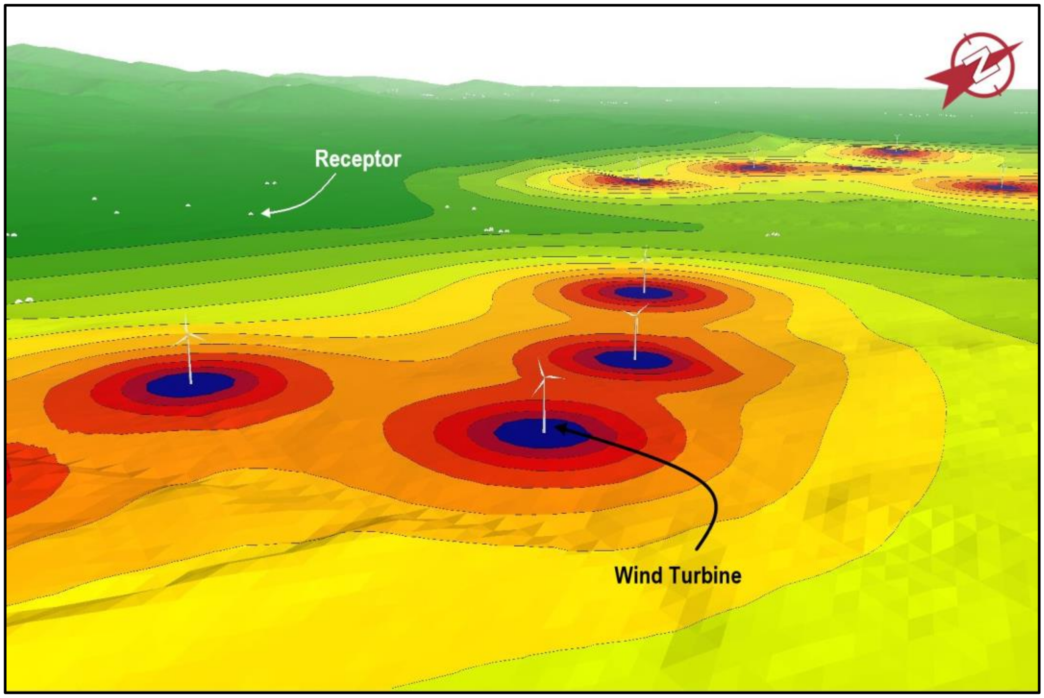

Figure 4-1. Three-Dimensional View of the SoundPLAN Noise Model

The ISO 9613-2:1996 method requires input data and the setting of certain parameters, including the locations of the noise sources and receivers, noise emission factors including frequency characteristics, terrain and ground type, and atmospheric propagation conditions. In general, the ISO method assumes optimal acoustic propagation in all directions, specifically that a "well-developed, moderate ground-based temperature inversion" is present or, equivalently, that all receptors are downwind of all noise sources at all times. The specific ISO 9613-2:1996 settings and input data used in this analysis are described below.

Noise Sources

Noise levels at all receptors were predicted assuming full operation of all 129 turbines located per the Project file *L017_129_Locations_20210716.kml*. All turbines were modeled as Vestas V150-5.6 without serrated trailing edges. The turbines were modeled running in Mode 0-0S, and assuming a hub-height wind speed of 11 meters per second which corresponds to maximum sound emissions (overall sound power level of 107.7 dBA per *Vestas 0079-5099_V02_Third Octave Mode 0-0S, May 20, 2019*).

Table 4-1 lists the octave band sound power levels used in the model for each source. The levels are expressed in terms of A-weighted decibels (dBA) for each of nine standard frequency octave-bands, as defined by the American National Standards Institute (ANSI) Standard S1.11: Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters. The noise emission levels of each turbine were provided by the manufacturer and were determined according to International Electrotechnical Commission Standard 61400-11. Wind turbine noise emissions increase with increasing wind speeds, up to approximately 10 to 11 m/s at hub-height. Noise levels do not increase when hub-height wind speeds continue increasing because the turbines reach a maximum rotational speed and the sound emission of a turbine is directly proportional to its rotational speed. This analysis used the octave band noise levels reported by the manufacturer for a wind speed of 11 m/s at hub height.

The Project includes two separate substations. At the time of this report, the quantity and sizes for the substation transformers is still being confirmed. For the purpose of this analysis, it was conservatively assumed that each substation will contain two 150 MVA step-up transformers, which along with their cooling fans are the only significant noise-producing equipment at a substation. The noise analysis also assumed the simultaneous operation of all four step-up transformers at their maximum rating (150 MVA). The sound power levels from the step-up transformers are listed in Table 4-1. The step-up transformers were modeled as point sources located three meters (10 feet) above the ground, with no barriers or directivity reductions. The sound spectrum of the transformers was estimated using the methodology published in the Edison Electric Institute, "Electric Power Plant Environmental Noise Guide," 2nd Edition, BBN, 1984.

The locations of each turbine and substation are shown in the site plan in Figures 3-1 and 3-2. The geographic coordinates, ground elevation, and hub-height elevation of each turbine and step-up transformer are listed in Appendix A.

Table 4-1. Source Sound Power Levels

Source	Octave Band Sound Power Level (dBA)									Overall Level
	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1,000 Hz	2,000 Hz	4,000 Hz	8,000 Hz	(dBA)
Vestas V150-5.6 (Mode 0-0S)	74.3	86.1	94.8	100.4	102.9	102.2	98.4	91.6	81.5	107.7
Transformer (150 MVA)	57.7	76.9	89	91.5	96.9	94.1	90.3	85.1	76.0	100.5

Receptors

The locations of receptors (prediction points) were provided by the Project in the file *Rock Creek Buildings.kmz* (December 23, 2020). There are 347 receptors which include a mixture of houses, trailers, sheds, towers, etc. Thus, not all points are residences, and among the residences not all are non-participating. In accordance with ISO 9613-2:1996, each receptor's height was set to 1.5 meters above the ground. The location of each receptor is provided in Appendix B.

Terrain and Ground Effect

The ground elevations in the Project area were modeled by importing DEM data from the USGS National Elevation Dataset into SoundPLAN. The acoustical effect of the ground was modeled using the ISO 9613-2:1996 General Method. All reductions due to terrain acting as a barrier were removed from the analysis resulting in a more conservative model and higher predicted noise levels. The ground absorption factors for the ground near the source, near the receiver, and in between range from 0.0 to 1.0 and represent the proportion of sound that is absorbed or reflected when sound waves interact with the ground. A value of 0.0 represents completely reflective ground material such as pavement and results in a higher level of sound reaching a receptor. A value of 1.0 represents absorptive material such as thick grass or fresh snow and results in a lower level of sound reaching a receptor. For this Project a ground factor of 0.5 (partially reflective) was chosen to represent the ground cover in the Project area which is mostly shortgrass prairie land with very low percentages of pavement or other reflective surfaces.

Atmospheric Conditions

The air temperature, relative humidity, and atmospheric pressure were set to conditions of 10°C, 70%, and 1 atmosphere, respectively. These values represent the lowest amount of atmospheric absorption of sound available in the ISO 9613-2:1996 method, and result in the highest levels of sound reaching the receptors.

Noise Level Metric

The L_{eq} is the most commonly used metric for predicting, regulating, and measuring wind turbine noise. It is the quantity referenced or required by relevant acoustic standards, such as IEC 61400-11 (the measurement of wind turbine noise by manufacturers), ISO 9613-2:1996 (the prediction of wind turbine noise), and ANSI S12.9 Part 3 (the measurement of wind turbine noise at receptor locations). It requires a stated time interval, with one-hour being most commonly used by states. The L_{eq} has the same acoustic energy as the time-varying sound level over the interval. The L_{eq} accounts for noise fluctuations from moment to moment by averaging the louder and quieter moments and giving more weight to the louder moments.

When using a metric such as the L_{eq} to quantify noise levels, the time interval must be stated. The most common time interval is one hour (required by most state level analyses, although 10-minutes is also common for wind turbine noise measurements). Noise limits are specified on a one-hour time interval in the states of Colorado, Illinois, Minnesota, and New York.

The noise level predictions in this analysis represent the energy equivalent average noise level (L_{eq}) over one hour of full acoustic emissions. In actuality, the predicted L_{eq} noise levels in this report are representative of the maximum energy equivalent average noise levels during full acoustic emissions for all time intervals greater than or equal to 10 seconds. In other words, the expected noise level when turbines are operating at full acoustic emissions for a 10-second, 5-minute, 10-minute, or one-hour L_{eq} measurement would all be equal. Noise levels from a wind turbine producing maximum acoustic emissions are steady over such time intervals and the wind-turbine noise source data provided by the manufacturer are derived from measurements integrated over a period of 10 seconds in accordance with IEC 61400-11.1[1].

Figure 4-2 shows the results of 24 hours of continuous noise measurements conducted by Hankard Environmental in 2021 at a site in the U.S. Midwest where a noise monitor was positioned outside a residence with the nearest turbines located about 2,300 feet away. This measurement period was selected because it clearly shows the noise levels produced by turbines-only (circled in green), as well as periods where wind, traffic, and other noise sources dominate. The x-axis for both the lower and upper portions of the plot is time (24 hours total). The lower portion of the plot shows the operational status of the four closest turbines (% of full). The upper portion of the plot shows measured noise levels, and both hub-height and ground-level wind speeds. In the upper plot the y-axis is A-weighted noise level on the left and wind speed (m/s) on the right. L_{eq} noise levels are shown on a 10-second and 10-minute time interval.

From approximately 20:00 to 23:00 (8 to 11pm) all nearby turbines are producing full acoustic emissions, ground level winds are almost completely calm, there is a complete lack of noise from human activity, and as a result noise levels become steady. This is an extremely good example of turbine-only noise, and how emissions from turbines are very steady on 10-second, 10-minute, or one-hour time intervals.

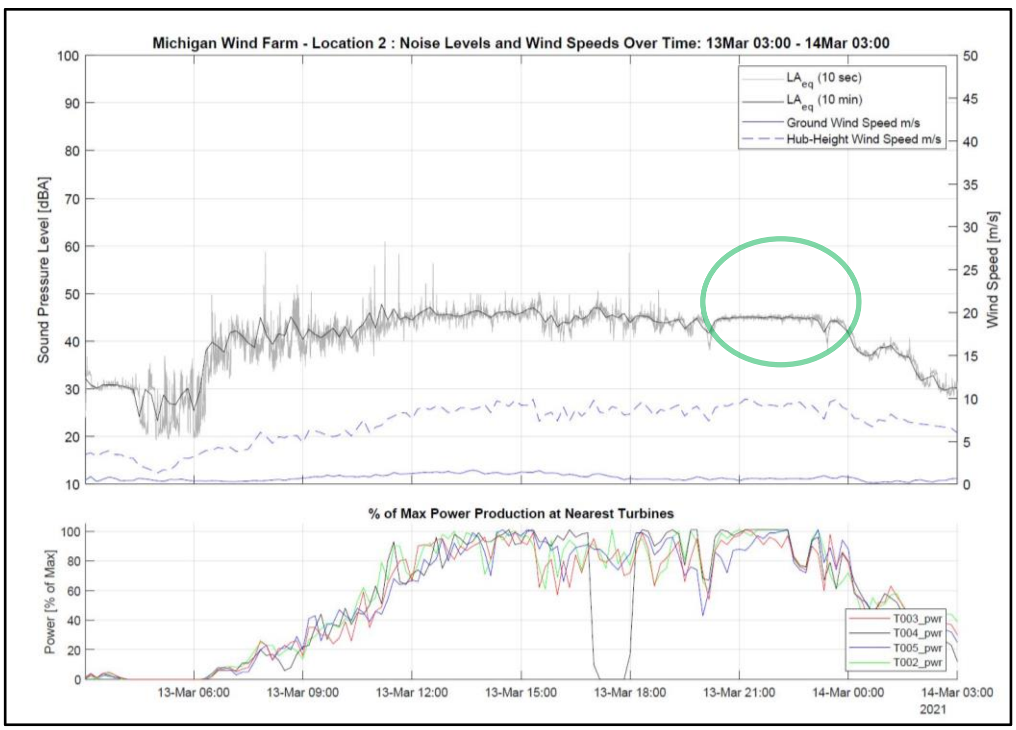

Figure 4-2. Example of Wind Turbine Noise Levels Showing 10-minute and 10-second Measurements

[1] International Electrotechnical Commission (IEC) 61400-11 Wind turbines – Part 11: Acoustic noise measurement techniques, June 2016

Model Validation

This noise level prediction method has been validated by Hankard Environmental by comparing predicted noise levels to those measured at operating wind farms.[2,3] An analysis of noise data collected at ten operating wind energy centers consisting of 50 individual measurement locations was conducted. The loudest turbine-only noise levels measured at each location over the course of many weeks of data collection were compared to the levels predicted at each location using the same methodology employed on this Project (ISO 9613-2:1996 with a 0.5 ground factor). The results show that, on average, the model accurately predicts the measured levels. At some locations the measured levels were as much as 2 dBA louder than the predicted levels. This result is consistent with findings from other acousticians that have researched and compared measured and modeled wind turbine noise levels[4]. To account for this, 2 dBA was added to the noise levels predicted by the ISO 9613-2:1996 method used as described above. All predicted noise levels and noise level contours presented in this report include this 2 dBA addition.

[2]*Comparison of wind turbine-only noise levels measured at operating wind farms...using ISO 9613-2:1996*, Acoustical Society of America, Fall 2020 Annual Meeting, Session 1aNSb, General Topics in Noise II

[3] *Comparison between modeled and measured sound levels*, Hot Topics in Wind Turbine Acoustics. Session at INTERNOISE 2021. August 2021.

[4]RSG, et al. (2016). “Massachusetts study on wind turbine acoustics, Section 6.5” Massachusetts Clean Energy Center and Department of Environmental Protection.

5. Predicted Noise Levels

Noise levels were predicted for the full and continuous operation of the proposed Project. Figures 5-1 through 5-5 show the results of the predictions in terms of the location of the 50 and 55 dBA noise level contours. For this analysis, state land was considered participating because leases are being negotiated with the State of Wyoming to place turbines on state land. As can be seen, none of the 55 dBA contours cross any non-participating property boundaries. Thus, based on this analysis, noise from the Project is expected to be within the Albany County noise limit.

In addition, though not required by any regulations, noise level predictions were also made at the 347 structures identified by the Project. As previously mentioned, these structures are a mixture of non-participating and participating sheds, garages, residences, animal pens, barns, etc. Table 5-1 lists the predicted noise level at the loudest 50 structures. The predicted noise levels at all locations range from 48 to 19 dBA, with the loudest predicted noise level at a Participant's animal pen. The loudest predicted level at a non-participating residence is 39 dBA. Figure 5-5 shows the location of the non-participating residences, none of which are in Albany County, with the loudest predicted noise levels, which range from 33 to 39 dBA.

The predicted noise levels at all locations are listed in Appendix B.

Table 5-1. Receptors with Loudest Predicted Noise Levels

Receptor	P or NP	Description	Noise Level (dBA)	Receptor	P or NP	Description	Noise Level (dBA)
R167	P	Animal Pen	47.8	R058	NP	Misc Structure	35.1
R271	P	Tower	42.7	R268	NP	Shed	35.0
R335	NP	Tower	42.2	R220	NP	Misc Ag Equip	34.9
R333	P	Storage Bldg	41.3	R210	NP	Misc Ag Equip	34.8
R274	P	Shed	41.2	R223	NP	Storage Bldg	34.8
R105	NP	Storage Bldg	39.5	R146	NP	House	34.7
R226	NP	Misc Bldgs	39.5	R329	NP	Field	34.2
R227	NP	Animal Pen	39.5	R269	NP	Shed	34.1
R104	NP	Barn	38.9	R270	NP	Shed	34.1
R225	NP	Misc Bldgs	38.9	R327	NP	House	34.1
R224	NP	Shed	38.8	R326	NP	Garage	34.0
R103	NP	House	38.7	R330	NP	Tanks	33.9
R286	NP	Shed	38.6	R331	NP	Tanks	33.9
R056	NP	Old Cabin	38.1	R209	NP	Misc Ag Equip	33.8
R057	NP	Old Cabin	37.8	R328	NP	Misc Ag Equip	33.6
R060	P	Misc Bldgs	36.9	R263	NP	Shed	33.5
R217	P	Misc Bldgs	36.9	R324	NP	Shed	33.5
R059	P	Misc Bldgs	36.8	R265	NP	Barn	33.4
R273	NP	Misc Bldgs	36.0	R266	NP	Barn	33.4
R165	NP	Misc Bldgs	35.9	R325	NP	Shed	33.4
R272	NP	Misc Bldgs	35.9	R262	NP	Shed	33.3
R334	NP	Misc Bldgs	35.9	R264	NP	Barn	33.3
R109	NP	Misc Structure	35.8	R261	NP	Shed	33.2
R332	NP	Misc Structure	35.8	R267	NP	House	33.2
R108	NP	Misc Structure	35.4	R323	NP	Misc Ag Equip	33.2

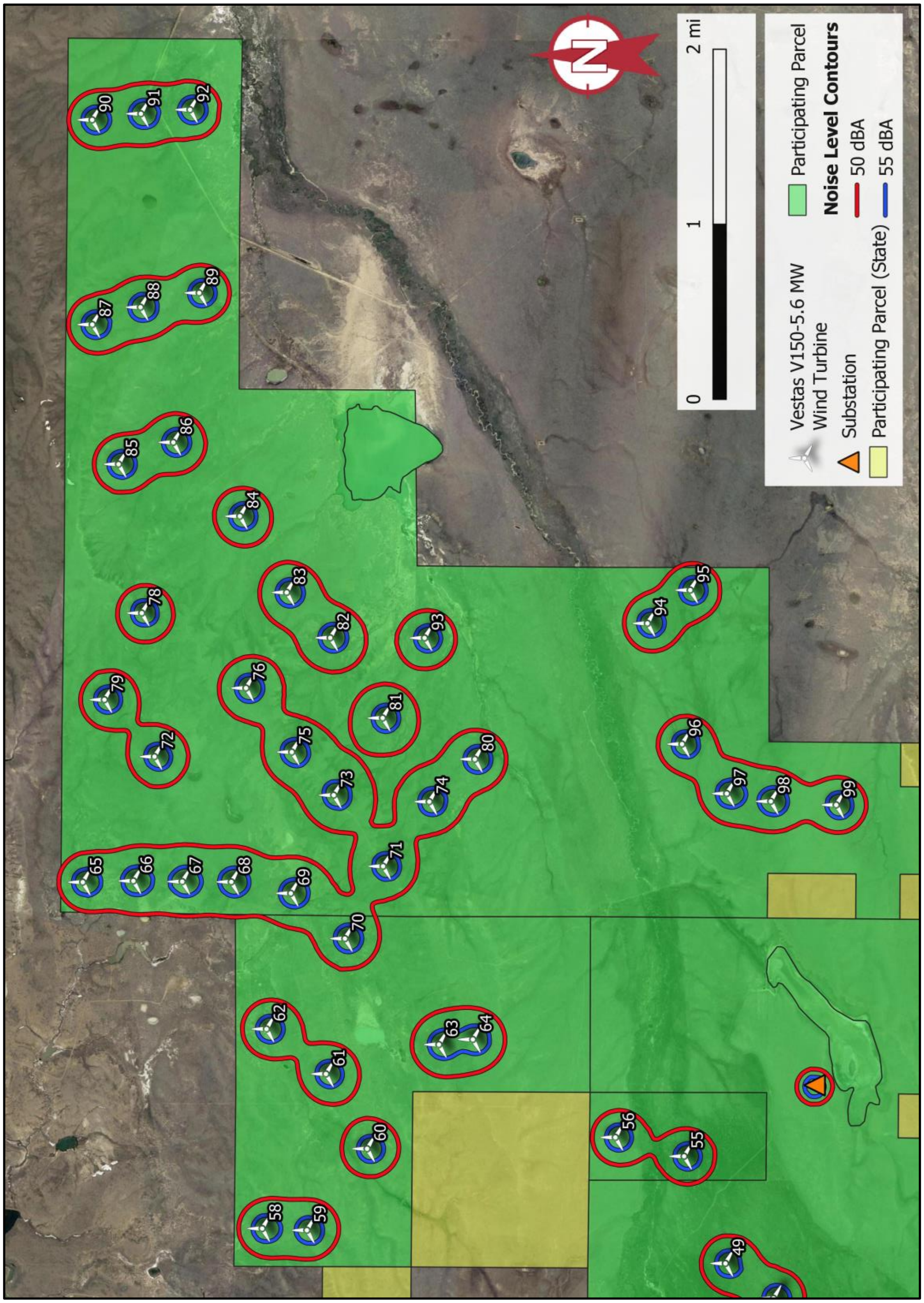

Figure 5-1. Predicted Noise Level Contours – Rock Creek Wind Northeastern Area

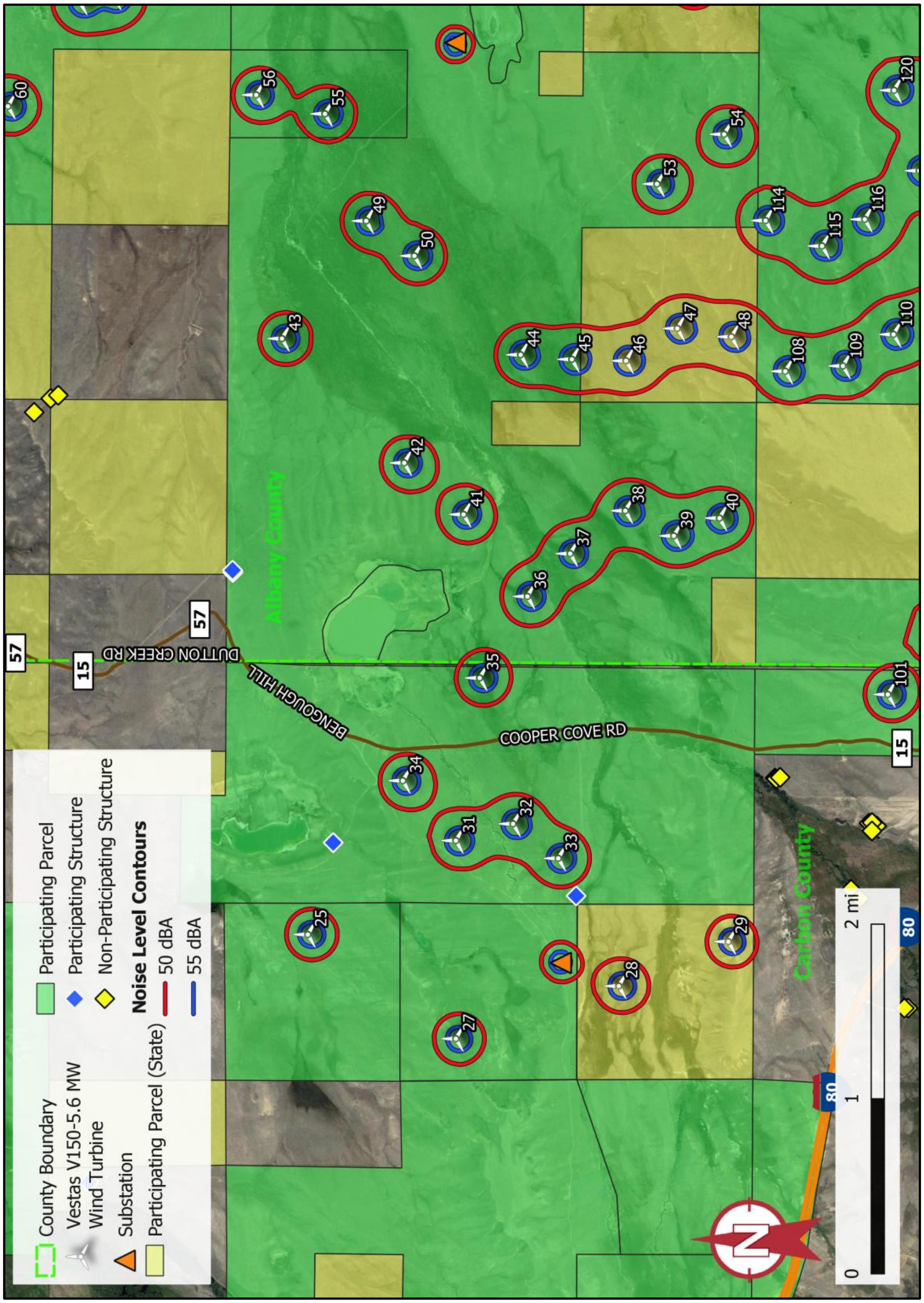

Figure 5-2. Predicted Noise Level Contours – Rock Creek Wind Northwestern Area

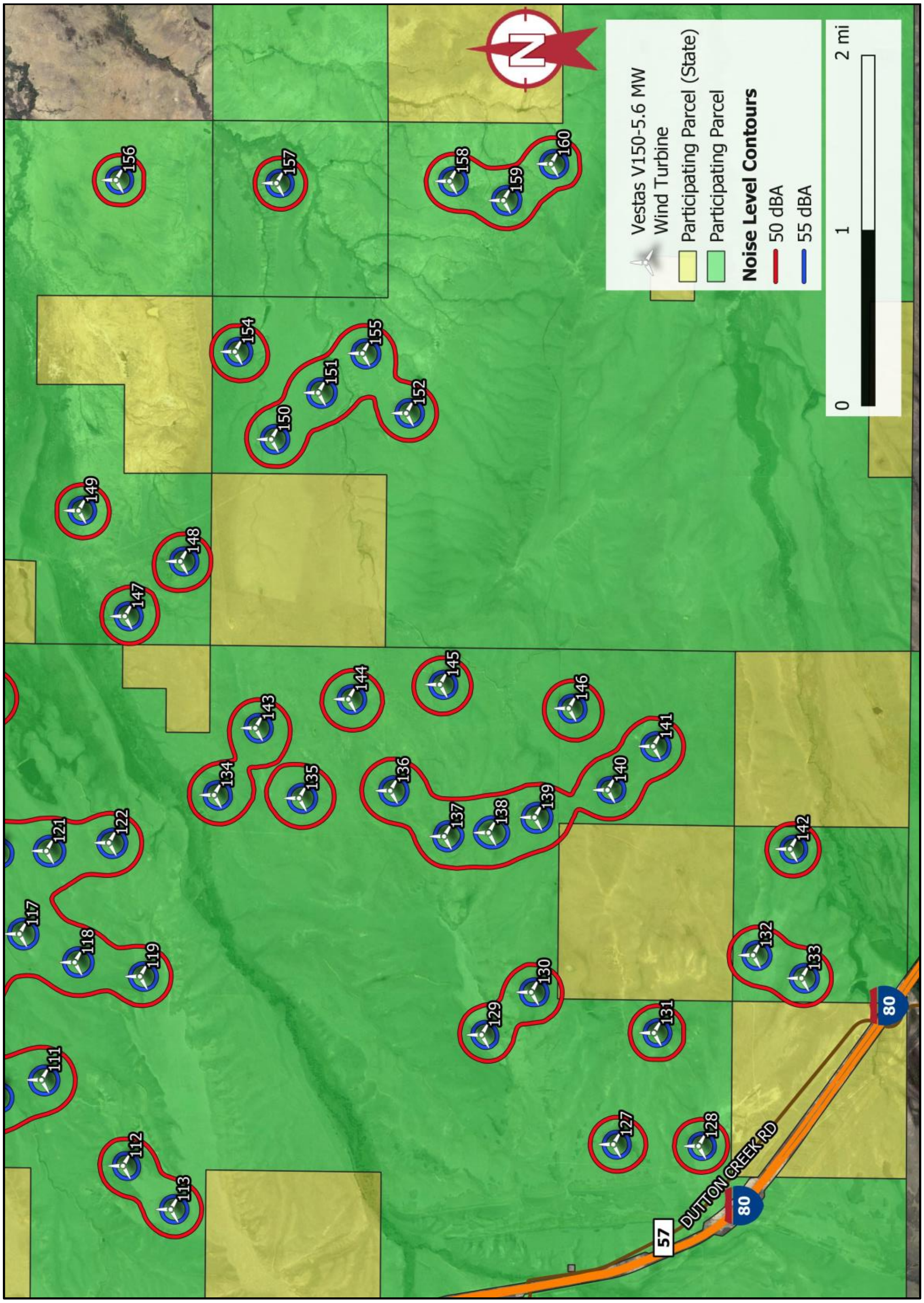

Figure 5-3. Predicted Noise Level Contours – Rock Creek Wind Southeastern Area

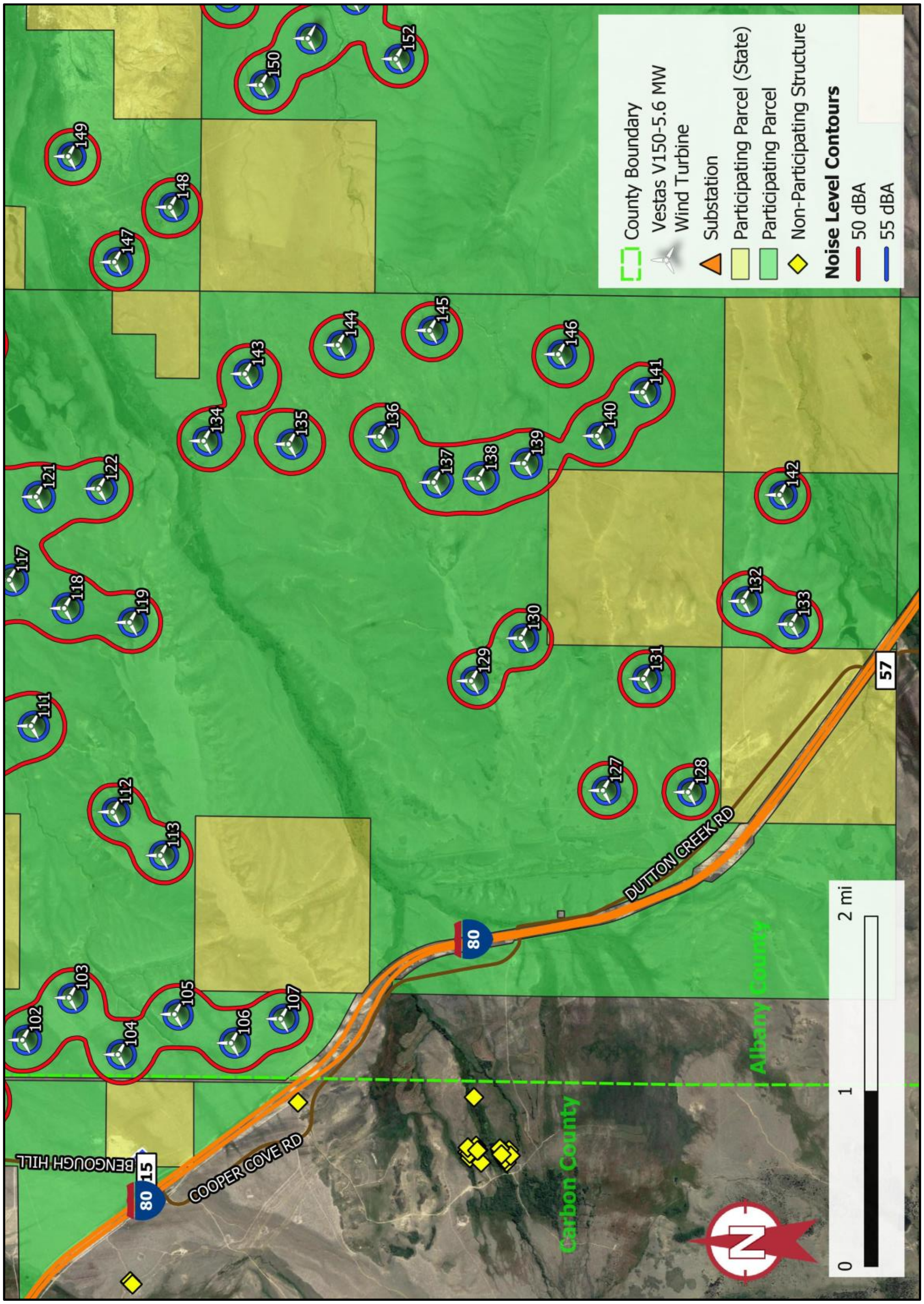

Figure 5-4. Predicted Noise Level Contours – Rock Creek Wind Southwestern Area

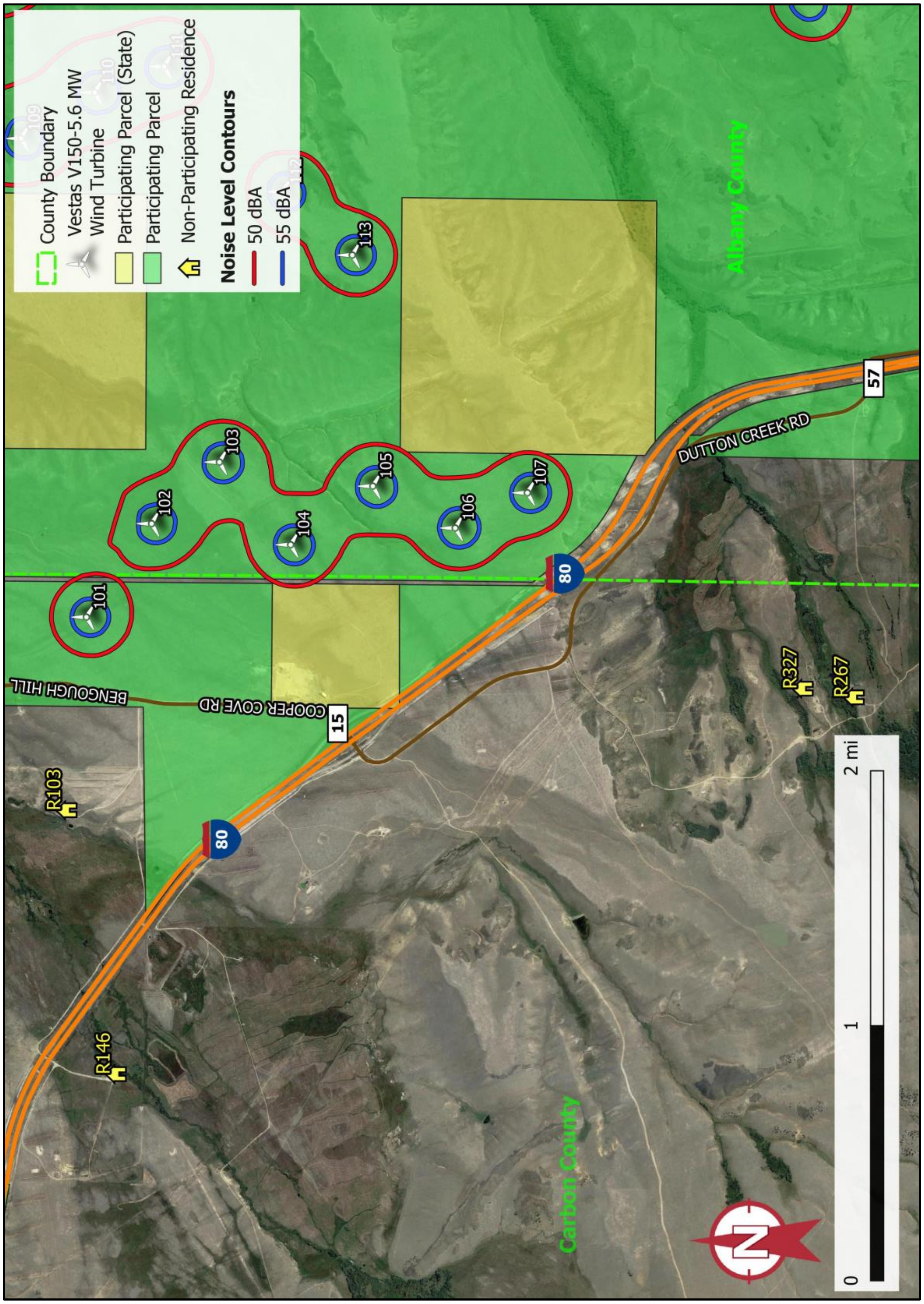

Figure 5-5. Rock Creek Wind - Loudest Predicted Levels at Non-Participating Residences

6. Conclusions

Noise levels from the full and continuous operation the proposed Project were predicted at the 347 structures provided by the Project. The predicted levels at receptors range from imperceptible to 48 dBA. As shown in Section 5, none of the 55 dBA noise level contours extend into non-participating properties, thus demonstrating compliance with the Albany County noise limits. The noise modeling (prediction) method used in this analysis has been demonstrated by Hankard Environmental and other acoustical consultants to result in predicted levels that are greater than actual measured noise levels.

The analysis focused on the very highest turbine noise levels expected. A majority of the time turbine noise levels will be less than those described herein. This occurs when the turbines are not producing full acoustic output due to low winds, and/or atmospheric conditions not as conducive to sound propagation as assumed herein (e.g., unstable atmosphere, receptors crosswind to the nearest turbines). Additionally, during very windy periods, the noise of the wind blowing through vegetation will be louder than that from the turbines.

Note that the results described herein are valid for the receptor locations provided, the Vestas V150-5.6 turbine model, the turbine and substation layout analyzed, the wind turbine sound power levels as provided by the manufacturer, and the mode of turbine operation. If the Project makes any significant changes, including turbine layout, turbine type, or operational mode, this noise analysis should be updated and compliance with the noise limit again demonstrated.

APPENDIX A
Noise Source Locations

Source Name	UTM 13N		Ground Elevation (m asl)	Source / Hub Height (m agl)	Wind Turbine Model or Transformer Size	Sound Power Level (dBA)
	Easting (m)	Northing (m)				
25	408210	4606566	2254	95	Vestas V150-5.6 Mode 0-0S	107.7
27	407252	4605205	2288	95	Vestas V150-5.6 Mode 0-0S	107.7
28	407736	4603708	2293	95	Vestas V150-5.6 Mode 0-0S	107.7
29	408145	4602701	2316	95	Vestas V150-5.6 Mode 0-0S	107.7
31	409074	4605206	2277	95	Vestas V150-5.6 Mode 0-0S	107.7
32	409228	4604680	2268	95	Vestas V150-5.6 Mode 0-0S	107.7
33	408911	4604264	2276	95	Vestas V150-5.6 Mode 0-0S	107.7
34	409625	4605693	2275	95	Vestas V150-5.6 Mode 0-0S	107.7
35	410570	4604986	2252	95	Vestas V150-5.6 Mode 0-0S	107.7
36	411320	4604548	2254	95	Vestas V150-5.6 Mode 0-0S	107.7
37	411713	4604155	2258	95	Vestas V150-5.6 Mode 0-0S	107.7
38	412108	4603648	2260	95	Vestas V150-5.6 Mode 0-0S	107.7
39	411877	4603202	2280	95	Vestas V150-5.6 Mode 0-0S	107.7
40	412040	4602782	2278	95	Vestas V150-5.6 Mode 0-0S	107.7
41	412074	4605135	2259	95	Vestas V150-5.6 Mode 0-0S	107.7
42	412548	4605680	2239	95	Vestas V150-5.6 Mode 0-0S	107.7
43	413691	4606804	2219	95	Vestas V150-5.6 Mode 0-0S	107.7
44	413542	4604610	2234	95	Vestas V150-5.6 Mode 0-0S	107.7
45	413501	4604139	2240	95	Vestas V150-5.6 Mode 0-0S	107.7
46	413487	4603641	2247	95	Vestas V150-5.6 Mode 0-0S	107.7
47	413785	4603170	2261	95	Vestas V150-5.6 Mode 0-0S	107.7
48	413708	4602673	2276	95	Vestas V150-5.6 Mode 0-0S	107.7
49	414774	4606029	2216	95	Vestas V150-5.6 Mode 0-0S	107.7
50	414452	4605587	2221	95	Vestas V150-5.6 Mode 0-0S	107.7
53	415114	4603357	2252	95	Vestas V150-5.6 Mode 0-0S	107.7
54	415571	4602740	2234	95	Vestas V150-5.6 Mode 0-0S	107.7
55	415759	4606409	2207	95	Vestas V150-5.6 Mode 0-0S	107.7
56	415932	4607041	2210	95	Vestas V150-5.6 Mode 0-0S	107.7
57	416981	4603060	2215	95	Vestas V150-5.6 Mode 0-0S	107.7
58	415094	4610288	2189	95	Vestas V150-5.6 Mode 0-0S	107.7
59	415079	4609877	2211	95	Vestas V150-5.6 Mode 0-0S	107.7
60	415828	4609323	2203	95	Vestas V150-5.6 Mode 0-0S	107.7
61	416516	4609701	2200	95	Vestas V150-5.6 Mode 0-0S	107.7
62	416929	4610248	2183	95	Vestas V150-5.6 Mode 0-0S	107.7
63	416786	4608663	2197	95	Vestas V150-5.6 Mode 0-0S	107.7
64	416833	4608351	2224	95	Vestas V150-5.6 Mode 0-0S	107.7
65	418279	4611937	2173	95	Vestas V150-5.6 Mode 0-0S	107.7
66	418291	4611472	2178	95	Vestas V150-5.6 Mode 0-0S	107.7
67	418284	4611022	2182	95	Vestas V150-5.6 Mode 0-0S	107.7
68	418282	4610571	2192	95	Vestas V150-5.6 Mode 0-0S	107.7
69	418177	4610025	2185	95	Vestas V150-5.6 Mode 0-0S	107.7
70	417760	4609527	2188	95	Vestas V150-5.6 Mode 0-0S	107.7
71	418425	4609176	2216	95	Vestas V150-5.6 Mode 0-0S	107.7
72	419434	4611277	2196	95	Vestas V150-5.6 Mode 0-0S	107.7
73	419079	4609630	2217	95	Vestas V150-5.6 Mode 0-0S	107.7
74	419019	4608751	2195	95	Vestas V150-5.6 Mode 0-0S	107.7
75	419476	4610015	2215	95	Vestas V150-5.6 Mode 0-0S	107.7
76	420064	4610436	2212	95	Vestas V150-5.6 Mode 0-0S	107.7
78	420754	4611395	2206	95	Vestas V150-5.6 Mode 0-0S	107.7
79	419957	4611738	2189	95	Vestas V150-5.6 Mode 0-0S	107.7

Source Name	UTM 13N		Ground Elevation (m asl)	Source / Hub Height (m agl)	Wind Turbine Model or Transformer Size	Sound Power Level (dBA)
	Easting (m)	Northing (m)				
80	419410	4608333	2184	95	Vestas V150-5.6 Mode 0-0S	107.7
81	419789	4609180	2190	95	Vestas V150-5.6 Mode 0-0S	107.7
82	420526	4609662	2174	95	Vestas V150-5.6 Mode 0-0S	107.7
83	420943	4610062	2180	95	Vestas V150-5.6 Mode 0-0S	107.7
84	421644	4610493	2174	95	Vestas V150-5.6 Mode 0-0S	107.7
85	422122	4611608	2182	95	Vestas V150-5.6 Mode 0-0S	107.7
86	422324	4611104	2171	95	Vestas V150-5.6 Mode 0-0S	107.7
87	423407	4611849	2181	95	Vestas V150-5.6 Mode 0-0S	107.7
88	423566	4611406	2173	95	Vestas V150-5.6 Mode 0-0S	107.7
89	423697	4610866	2161	95	Vestas V150-5.6 Mode 0-0S	107.7
90	425289	4611850	2164	95	Vestas V150-5.6 Mode 0-0S	107.7
91	425345	4611403	2160	95	Vestas V150-5.6 Mode 0-0S	107.7
92	425382	4610951	2152	95	Vestas V150-5.6 Mode 0-0S	107.7
93	420525	4608795	2175	95	Vestas V150-5.6 Mode 0-0S	107.7
94	420659	4606746	2196	95	Vestas V150-5.6 Mode 0-0S	107.7
95	420965	4606353	2192	95	Vestas V150-5.6 Mode 0-0S	107.7
96	419549	4606428	2200	95	Vestas V150-5.6 Mode 0-0S	107.7
97	419094	4606017	2205	95	Vestas V150-5.6 Mode 0-0S	107.7
98	419022	4605612	2204	95	Vestas V150-5.6 Mode 0-0S	107.7
99	418990	4605011	2194	95	Vestas V150-5.6 Mode 0-0S	107.7
101	410418	4601235	2307	95	Vestas V150-5.6 Mode 0-0S	107.7
102	411008	4600823	2309	95	Vestas V150-5.6 Mode 0-0S	107.7
103	411396	4600394	2325	95	Vestas V150-5.6 Mode 0-0S	107.7
104	410875	4599945	2337	95	Vestas V150-5.6 Mode 0-0S	107.7
105	411245	4599425	2347	95	Vestas V150-5.6 Mode 0-0S	107.7
106	410980	4598905	2354	95	Vestas V150-5.6 Mode 0-0S	107.7
107	411202	4598449	2368	95	Vestas V150-5.6 Mode 0-0S	107.7
108	413391	4602178	2284	95	Vestas V150-5.6 Mode 0-0S	107.7
109	413440	4601647	2291	95	Vestas V150-5.6 Mode 0-0S	107.7
110	413730	4601182	2257	95	Vestas V150-5.6 Mode 0-0S	107.7
111	413894	4600743	2261	95	Vestas V150-5.6 Mode 0-0S	107.7
112	413103	4599995	2333	95	Vestas V150-5.6 Mode 0-0S	107.7
113	412703	4599556	2340	95	Vestas V150-5.6 Mode 0-0S	107.7
114	414777	4602359	2241	95	Vestas V150-5.6 Mode 0-0S	107.7
115	414543	4601839	2240	95	Vestas V150-5.6 Mode 0-0S	107.7
116	414788	4601447	2240	95	Vestas V150-5.6 Mode 0-0S	107.7
117	415235	4600946	2246	95	Vestas V150-5.6 Mode 0-0S	107.7
118	414974	4600439	2263	95	Vestas V150-5.6 Mode 0-0S	107.7
119	414844	4599838	2308	95	Vestas V150-5.6 Mode 0-0S	107.7
120	415975	4601178	2234	95	Vestas V150-5.6 Mode 0-0S	107.7
121	415998	4600699	2239	95	Vestas V150-5.6 Mode 0-0S	107.7
122	416073	4600124	2246	95	Vestas V150-5.6 Mode 0-0S	107.7
123	417180	4602207	2210	95	Vestas V150-5.6 Mode 0-0S	107.7
124	417591	4601746	2210	95	Vestas V150-5.6 Mode 0-0S	107.7
125	417401	4601262	2216	95	Vestas V150-5.6 Mode 0-0S	107.7
126	418446	4602877	2196	95	Vestas V150-5.6 Mode 0-0S	107.7
127	413300	4595488	2337	95	Vestas V150-5.6 Mode 0-0S	107.7
128	413285	4594705	2361	95	Vestas V150-5.6 Mode 0-0S	107.7
129	414307	4596699	2395	95	Vestas V150-5.6 Mode 0-0S	107.7
130	414700	4596242	2290	95	Vestas V150-5.6 Mode 0-0S	107.7

Source Name	UTM 13N		Ground Elevation (m asl)	Source / Hub Height (m agl)	Wind Turbine Model or Transformer Size	Sound Power Level (dBA)
	Easting (m)	Northing (m)				
131	414326	4595115	2311	95	Vestas V150-5.6 Mode 0-0S	107.7
132	415040	4594203	2331	95	Vestas V150-5.6 Mode 0-0S	107.7
133	414828	4593759	2329	95	Vestas V150-5.6 Mode 0-0S	107.7
134	416512	4599158	2241	95	Vestas V150-5.6 Mode 0-0S	107.7
135	416483	4598377	2252	95	Vestas V150-5.6 Mode 0-0S	107.7
136	416552	4597538	2259	95	Vestas V150-5.6 Mode 0-0S	107.7
137	416132	4597043	2298	95	Vestas V150-5.6 Mode 0-0S	107.7
138	416166	4596634	2267	95	Vestas V150-5.6 Mode 0-0S	107.7
139	416306	4596212	2265	95	Vestas V150-5.6 Mode 0-0S	107.7
140	416558	4595541	2294	95	Vestas V150-5.6 Mode 0-0S	107.7
141	416959	4595122	2279	95	Vestas V150-5.6 Mode 0-0S	107.7
142	416016	4593864	2299	95	Vestas V150-5.6 Mode 0-0S	107.7
143	417128	4598778	2252	95	Vestas V150-5.6 Mode 0-0S	107.7
144	417393	4597924	2252	95	Vestas V150-5.6 Mode 0-0S	107.7
145	417527	4597082	2251	95	Vestas V150-5.6 Mode 0-0S	107.7
146	417308	4595898	2258	95	Vestas V150-5.6 Mode 0-0S	107.7
147	418155	4599978	2224	95	Vestas V150-5.6 Mode 0-0S	107.7
148	418659	4599468	2235	95	Vestas V150-5.6 Mode 0-0S	107.7
149	419126	4600403	2190	95	Vestas V150-5.6 Mode 0-0S	107.7
150	419781	4598632	2226	95	Vestas V150-5.6 Mode 0-0S	107.7
151	420210	4598200	2218	95	Vestas V150-5.6 Mode 0-0S	107.7
152	420021	4597392	2234	95	Vestas V150-5.6 Mode 0-0S	107.7
154	420587	4598967	2218	95	Vestas V150-5.6 Mode 0-0S	107.7
155	420571	4597793	2222	95	Vestas V150-5.6 Mode 0-0S	107.7
156	422164	4600059	2163	95	Vestas V150-5.6 Mode 0-0S	107.7
157	422136	4598585	2200	95	Vestas V150-5.6 Mode 0-0S	107.7
158	422154	4596993	2220	95	Vestas V150-5.6 Mode 0-0S	107.7
159	421977	4596499	2235	95	Vestas V150-5.6 Mode 0-0S	107.7
160	422313	4596061	2226	95	Vestas V150-5.6 Mode 0-0S	107.7
Substation 1 Transformer 1	407948	4604275	2288	3	150 MVA	100.5
Substation 1 Transformer 2	407967	4604278	2288	3	150 MVA	100.5
Substation 2 Transformer 1	416387	4605243	2218	3	150 MVA	100.5
Substation 2 Transformer 2	416412	4605243	2217	3	150 MVA	100.5

APPENDIX B
Receptor Locations and Predicted Noise Levels

Receiver	UTM 16N		Ground Elevation (m asl)	Predicted Noise Level (dBA)
	Easting (m)	Northing (m)		
R001	399297	4606221	2341	20.8
R002	399297	4606221	2341	20.8
R003	398867	4605019	2358	20.4
R004	398867	4605019	2358	20.4
R005	399269	4605509	2347	20.9
R006	399129	4606088	2348	20.6
R007	399322	4606553	2338	20.8
R008	400572	4606563	2317	22.4
R009	400504	4606588	2318	22.3
R010	401009	4606204	2315	23.1
R011	401010	4606240	2315	23.1
R012	401129	4606921	2306	23.0
R013	401104	4606932	2306	23.0
R014	401166	4606924	2305	23.1
R015	401174	4606952	2305	23.1
R016	400680	4607962	2297	22.0
R017	400782	4607939	2296	22.2
R018	400779	4607951	2296	22.1
R019	401105	4613679	2348	19.0
R020	403733	4610326	2234	24.1
R021	403802	4610320	2234	24.2
R022	403818	4610319	2234	24.2
R023	403806	4610272	2236	24.2
R024	403859	4610481	2231	24.1
R025	403743	4610480	2231	23.9
R026	403743	4610480	2231	23.9
R027	403806	4610482	2231	24.0
R028	403802	4610528	2230	24.0
R029	403421	4611173	2226	23.0
R030	403436	4611197	2225	23.0
R031	403469	4611195	2225	23.0
R032	403549	4611173	2225	23.1
R033	403537	4611133	2225	23.1
R034	403492	4611221	2225	23.0
R035	403444	4611256	2225	22.9

Receiver	UTM 16N		Ground Elevation (m asl)	Predicted Noise Level (dBA)
	Easting (m)	Northing (m)		
R036	403152	4611589	2229	22.4
R037	403534	4611251	2224	23.0
R038	404708	4611705	2211	23.7
R039	405630	4612540	2196	23.8
R040	405659	4612568	2196	23.8
R041	405678	4612576	2196	23.8
R042	405696	4612591	2195	23.8
R043	405642	4612599	2195	23.7
R044	405684	4612832	2192	23.5
R045	405655	4612857	2193	23.5
R046	398348	4605494	2383	19.7
R047	398356	4605431	2384	19.7
R048	398366	4605367	2386	19.7
R049	398500	4605427	2371	19.8
R050	405659	4612875	2193	23.5
R051	405757	4612931	2192	23.5
R052	408662	4612102	2188	26.6
R053	408686	4612096	2187	26.6
R054	408703	4612107	2187	26.6
R055	401684	4600362	2472	23.6
R056	408625	4601605	2298	38.1
R057	408539	4601526	2300	37.8
R058	413297	4610562	2196	35.1
R059	411540	4607288	2258	36.8
R060	411548	4607288	2258	36.9
R061	406498	4610993	2212	26.2
R062	406024	4611605	2213	25.1
R063	398840	4604993	2359	20.4
R064	398720	4605089	2359	20.2
R065	398578	4605152	2362	20.0
R066	398592	4605140	2361	20.0
R067	399114	4605548	2350	20.7
R068	399099	4605588	2349	20.7
R069	399134	4605527	2349	20.7
R070	399153	4605510	2349	20.8

Receiver	UTM 16N		Ground Elevation (m asl)	Predicted Noise Level (dBA)
	Easting (m)	Northing (m)		
R071	399242	4606071	2344	20.8
R072	399327	4606089	2342	20.9
R073	399302	4606640	2341	20.7
R074	399237	4606561	2346	20.6
R075	399620	4606728	2327	21.1
R076	399438	4606837	2338	20.8
R077	401061	4606269	2314	23.2
R078	401046	4606847	2308	23.0
R079	401082	4606911	2307	23.0
R080	401182	4607069	2302	23.1
R081	403787	4610346	2233	24.1
R082	403786	4610371	2233	24.1
R083	403919	4610665	2228	24.0
R084	403893	4610698	2228	23.9
R085	404934	4611927	2206	23.7
R086	404933	4611926	2206	23.7
R087	405317	4612188	2202	23.8
R088	405327	4612158	2202	23.9
R089	405162	4612308	2201	23.6
R090	405711	4612722	2193	23.7
R091	406025	4612177	2214	24.5
R092	406052	4612214	2214	24.4
R093	406109	4612196	2213	24.5
R094	406237	4612207	2212	24.6
R095	406191	4612162	2213	24.6
R096	405318	4613839	2185	22.3
R097	408719	4612095	2187	26.7
R098	408719	4612095	2187	26.7
R099	409423	4612535	2179	26.7
R100	409428	4612546	2179	26.7
R101	409459	4612512	2179	26.8
R102	409857	4613282	2171	26.3
R103	409198	4601393	2300	38.7
R104	409235	4601439	2298	38.9
R105	409650	4602304	2282	39.5

Receiver	UTM 16N		Ground Elevation (m asl)	Predicted Noise Level (dBA)
	Easting (m)	Northing (m)		
R106	405720	4610693	2220	25.8
R107	405798	4610705	2219	25.9
R108	413013	4609115	2260	35.4
R109	413141	4608963	2251	35.8
R110	411083	4612173	2215	28.7
R111	411062	4612168	2215	28.7
R112	410023	4612208	2220	27.6
R113	399169	4605510	2349	20.8
R114	399165	4605465	2350	20.8
R115	399200	4605521	2348	20.8
R116	399215	4605577	2347	20.8
R117	399337	4606537	2337	20.8
R118	399301	4606520	2339	20.7
R119	399323	4606501	2338	20.8
R120	398642	4609240	2298	18.8
R121	398672	4609207	2300	18.8
R122	399584	4606096	2337	21.2
R123	399614	4606073	2337	21.3
R124	400499	4606461	2320	22.4
R125	400629	4606528	2318	22.5
R126	401196	4607084	2303	23.1
R127	400733	4607937	2297	22.1
R128	401222	4608285	2286	22.6
R129	401275	4608282	2286	22.6
R130	403506	4608717	2255	25.2
R131	403738	4608705	2253	25.6
R132	403894	4608747	2251	25.8
R133	403709	4608859	2252	25.4
R134	403738	4608839	2252	25.5
R135	405210	4611434	2209	24.5
R136	404956	4611744	2209	23.9
R137	405363	4612273	2200	23.8
R138	405379	4612271	2200	23.8
R139	405317	4612274	2200	23.7
R140	405138	4612355	2201	23.5

Receiver	UTM 16N		Ground Elevation (m asl)	Predicted Noise Level (dBA)
	Easting (m)	Northing (m)		
R141	405664	4612823	2193	23.5
R142	405729	4612764	2193	23.6
R143	405910	4611938	2215	24.6
R144	406000	4612016	2214	24.6
R145	405975	4612112	2215	24.5
R146	407533	4601082	2320	34.7
R147	399847	4605372	2338	21.8
R148	400179	4605399	2337	22.2
R149	408813	4612160	2186	26.7
R150	408816	4612102	2186	26.7
R151	408879	4612170	2185	26.7
R152	408909	4612153	2185	26.8
R153	408948	4612173	2185	26.8
R154	409339	4612467	2180	26.8
R155	409356	4612490	2179	26.7
R156	409349	4612456	2180	26.8
R157	409461	4612539	2178	26.8
R158	409432	4612580	2178	26.7
R159	409440	4612595	2178	26.7
R160	409482	4612574	2178	26.8
R161	401772	4600495	2457	23.8
R162	401903	4600463	2460	24.0
R163	405748	4610797	2218	25.7
R164	412856	4613780	2203	28.7
R165	413170	4608893	2255	35.9
R166	409781	4612441	2195	27.2
R167	408566	4604133	2280	47.8
R168	405998	4610125	2221	26.9
R169	399159	4605492	2349	20.8
R170	399152	4605469	2350	20.8
R171	399244	4605552	2347	20.9
R172	399277	4605565	2346	20.9
R173	399478	4606490	2335	21.0
R174	400534	4606473	2319	22.4
R175	400531	4606544	2318	22.3

Receiver	UTM 16N		Ground Elevation (m asl)	Predicted Noise Level (dBA)
	Easting (m)	Northing (m)		
R176	400533	4606522	2318	22.4
R177	401400	4606666	2303	23.5
R178	403985	4609131	2247	25.5
R179	403926	4609184	2247	25.4
R180	403859	4609097	2248	25.4
R181	403851	4609131	2248	25.4
R182	404054	4609334	2244	25.4
R183	403783	4610272	2234	24.2
R184	403819	4610363	2233	24.1
R185	403533	4611191	2225	23.1
R186	405156	4612328	2201	23.5
R187	405650	4612622	2195	23.7
R188	405642	4612599	2195	23.7
R189	405677	4612674	2194	23.7
R190	405684	4612702	2194	23.7
R191	405656	4612797	2193	23.5
R192	405681	4612791	2193	23.6
R193	405845	4612940	2191	23.6
R194	406261	4612306	2211	24.5
R195	406172	4612365	2210	24.4
R196	406129	4612259	2213	24.5
R197	406100	4612278	2213	24.4
R198	406151	4612288	2212	24.4
R199	406140	4612322	2212	24.4
R200	399915	4605696	2339	21.8
R201	399892	4605688	2339	21.7
R202	405028	4613851	2183	22.1
R203	405297	4613781	2185	22.4
R204	408804	4612339	2187	26.5
R205	409020	4612257	2184	26.7
R206	408995	4612275	2184	26.7
R207	409591	4612646	2177	26.8
R208	409592	4612646	2177	26.8
R209	407845	4600271	2328	33.8
R210	408255	4600284	2319	34.8

Receiver	UTM 16N		Ground Elevation (m asl)	Predicted Noise Level (dBA)
	Easting (m)	Northing (m)		
R211	411902	4613997	2185	27.4
R212	409681	4610966	2228	28.8
R213	398564	4605289	2366	20.0
R214	405878	4611980	2215	24.5
R215	406077	4612244	2214	24.4
R216	401621	4600338	2477	23.5
R217	411561	4607291	2258	36.9
R218	405725	4612730	2193	23.7
R219	405314	4613013	2194	23.0
R220	408152	4600577	2318	34.9
R221	406373	4610581	2216	26.6
R222	409445	4609702	2236	30.5
R223	407533	4601116	2320	34.8
R224	409208	4601371	2302	38.8
R225	409240	4601413	2299	38.9
R226	409642	4602293	2282	39.5
R227	409655	4602258	2283	39.5
R228	408751	4612131	2186	26.7
R229	409567	4612626	2177	26.8
R230	409511	4612607	2178	26.7
R231	409407	4612536	2179	26.7
R232	407212	4615393	2163	22.3
R233	407129	4614902	2167	22.7
R234	405289	4613766	2185	22.4
R235	405300	4613765	2185	22.4
R236	405304	4613764	2186	22.4
R237	405314	4613767	2185	22.4
R238	405289	4613775	2185	22.4
R239	405398	4613518	2188	22.7
R240	405758	4612774	2193	23.6
R241	405709	4612778	2193	23.6
R242	405782	4612757	2193	23.7
R243	405716	4612747	2193	23.6
R244	405694	4612798	2193	23.6
R245	405662	4612670	2194	23.7

Receiver	UTM 16N		Ground Elevation (m asl)	Predicted Noise Level (dBA)
	Easting (m)	Northing (m)		
R246	405280	4612155	2202	23.8
R247	405280	4612160	2202	23.8
R248	405313	4612183	2202	23.8
R249	405340	4612161	2202	23.9
R250	405316	4612162	2202	23.8
R251	403361	4604794	2321	27.4
R252	403339	4604843	2319	27.3
R253	403388	4604853	2322	27.4
R254	405931	4608611	2242	29.1
R255	405589	4609565	2228	27.1
R256	405581	4609533	2228	27.2
R257	405521	4609562	2228	27.1
R258	404054	4609109	2246	25.6
R259	403467	4608751	2255	25.2
R260	427522	4592130	2208	22.5
R261	409882	4596405	2349	33.2
R262	409925	4596433	2348	33.3
R263	409993	4596461	2346	33.5
R264	409995	4596383	2347	33.3
R265	409987	4596435	2347	33.4
R266	409976	4596454	2347	33.4
R267	409911	4596421	2349	33.2
R268	410482	4596704	2327	35.0
R269	409978	4596765	2347	34.1
R270	410036	4596685	2344	34.1
R271	410435	4598322	2361	42.7
R272	408786	4599865	2334	35.9
R273	408790	4599864	2334	36.0
R274	409914	4599779	2332	41.2
R275	401593	4603069	2566	24.3
R276	401588	4603061	2566	24.2
R277	401604	4603073	2566	24.3
R278	406371	4610573	2216	26.6
R279	406340	4610574	2216	26.6
R280	405542	4610665	2221	25.7

Receiver	UTM 16N		Ground Elevation (m asl)	Predicted Noise Level (dBA)
	Easting (m)	Northing (m)		
R281	405441	4610873	2222	25.3
R282	405651	4611200	2218	25.2
R283	405991	4610504	2219	26.3
R284	404689	4611703	2211	23.7
R285	404995	4613133	2216	22.7
R286	409162	4601414	2299	38.6
R287	408762	4612059	2187	26.7
R288	408772	4612137	2186	26.7
R289	409528	4612574	2178	26.8
R290	409480	4612600	2178	26.7
R291	409387	4612515	2179	26.7
R292	409507	4612524	2179	26.8
R293	409387	4614111	2180	25.1
R294	407215	4615398	2163	22.3
R295	407131	4614907	2167	22.7
R296	405281	4613768	2185	22.4
R297	405285	4613767	2185	22.4
R298	405296	4613765	2185	22.4
R299	405282	4613775	2185	22.4
R300	405287	4613776	2185	22.4
R301	405337	4613796	2185	22.4
R302	405274	4613770	2185	22.4
R303	405702	4612770	2193	23.6
R304	405691	4612727	2194	23.6
R305	405673	4612683	2194	23.7
R306	405497	4612800	2194	23.4
R307	405279	4612150	2202	23.8
R308	405316	4612159	2202	23.8
R309	400778	4607965	2296	22.1
R310	403393	4604832	2322	27.5
R311	403369	4604895	2322	27.4
R312	405620	4609594	2227	27.1
R313	405593	4609572	2228	27.1
R314	405585	4609549	2228	27.2
R315	405580	4609586	2228	27.1

Receiver	UTM 16N		Ground Elevation (m asl)	Predicted Noise Level (dBA)
	Easting (m)	Northing (m)		
R316	405147	4610319	2227	25.7
R317	404000	4609110	2247	25.6
R318	404008	4609142	2246	25.5
R319	403898	4609149	2247	25.4
R320	403760	4609032	2250	25.3
R321	403925	4608761	2250	25.8
R322	403723	4608700	2253	25.6
R323	409946	4596368	2348	33.2
R324	410010	4596467	2345	33.5
R325	409956	4596452	2348	33.4
R326	409925	4596743	2348	34.0
R327	409966	4596744	2348	34.1
R328	409882	4596639	2349	33.6
R329	410020	4596761	2346	34.2
R330	409996	4596664	2345	33.9
R331	409993	4596673	2345	33.9
R332	408764	4599844	2334	35.8
R333	409929	4599753	2332	41.3
R334	408474	4600738	2312	35.9
R335	409055	4606366	2245	42.2
R336	406371	4610584	2216	26.6
R337	406381	4610585	2216	26.6
R338	405988	4610304	2220	26.6
R339	405995	4610131	2221	26.8
R340	405661	4611192	2218	25.2
R341	406195	4611336	2212	25.5
R342	405210	4611437	2209	24.5
R343	405047	4611648	2208	24.1
R344	404698	4611708	2211	23.7
R345	405122	4612820	2197	23.1
R346	404988	4613137	2216	22.7
R347	425820	4593400	2209	25.9