Appendix B

Sound Modeling Assessment

BITTER ROOT WIND PROJECT

Sound Modeling Assessment for the Bitter Root Wind Project

Flying Cow Wind, LLC

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EXECUTIVE SUMMARY

Flying Cow Wind, LLC is developing the Bitter Root Wind Project in Minnesota. Flying Cow Wind, LLC has instructed DNV KEMA Renewables, Inc. (DNV GL) to carry out a sound modeling assessment of the proposed wind project. The results of the work are reported here. DNV GL previously performed a sound modeling assessment for this project in October 2016.

The site is located in Yellow Medicine County, Minnesota, approximately 10 miles west of Canby, Minnesota. The Project layout currently consists of 40 Vestas V136 serrated trailing edge (STE) wind turbine generators operating in Noise Mode 0, and one transformer. Only 37 of the 40 modeled turbines will be constructed; therefore the results contained herein can be considered conservative. While the project is in Minnesota, the transformer is located in South Dakota. The final layout will consist of a combination of V136 3.45 MW and V136 4.2 MW wind turbines. The current report assumes the loudest of the two turbine models (the V136 3.45 MW) at all 40 locations. The results can therefore be considered conservative.

The sound pressure level (SPL) at each noise receptor for the aggregate of all wind turbine generators and transformers associated with the Project was calculated based on the ISO 9613-2 method. In the current analysis, a total of 61 receptors in Minnesota and 198 receptors in South Dakota (including 184 receptors located on the shoreline of Lake Cochrane) were included in the analysis, for a grand total of 259 receptors. The results indicate that the calculated sound levels at all receptors included in the analysis are within the allowable limits under applicable Minnesota and South Dakota state and county level noise regulations.

1 INTRODUCTION

This report is issued to Flying Cow Wind, LLC ("Customer") pursuant to a written agreement arising from the *2017-08-02 Bitter Root DNV KEMA Contract for Services* dated 2 August 2017. The Customer has requested that DNV KEMA Renewables, Inc. (DNV GL) perform Project Development services, including a sound modeling assessment for the Bitter Root Wind Project (the "Project") located in Yellow Medicine County, Minnesota.

The Project layout considered for the sound assessment currently consists of 40 wind turbine generators. Two different turbine models are being considered for the final project: the Vestas V136 4.2 MW and V136 3.45 MW. DNV GL has modeled the Vestas V136 3.45 MW at all turbine locations because it has the highest sound power level of the two turbines considered[1]. Therefore, the V136-3.45 is referenced throughout this report. All turbines are operating in Noise Mode 0 with serrated trailing edges at a hub height of 344 feet (105 m).The objective of this assessment is to predict the sound levels generated by the Project's wind turbine generators at all receptors within or near the project area, using the ISO 9613-2 method [1] and in accordance with the Minnesota Administrative Rules section 7030 [3][4], as further detailed under Section 3.

[1] The V136 3.45 MW has a sound power level of 105.5 dBA, which is louder than the 4.2 MW version with a sound power level of 103.9 dBA.

2 ENVIRONMENTAL SOUND BACKGROUND

Sound levels are expressed in the decibel unit and are quantified on a logarithmic scale to account for the large range of acoustic pressures to which the human ear is exposed. A decibel (dB) is used to quantify sound levels relative to a 0 dB reference. The reference level of 0 dB is defined as a sound pressure level of 20 micropascals (μpa), which is the typical lower threshold of hearing for humans.

Sound levels can be presented both in broadband (sound energy summed across the entire audible frequency spectrum) and in octave band spectra (audible frequency spectrum divided into bands). Frequency is expressed in the Hertz unit (Hz), measuring the cycles per second of the sound pressure waves. The audible range of humans spans from 20 to 20,000 Hz. Since the human ear does not perceive every frequency with equal loudness, spectrally varying sounds are often adjusted with a weighting filter. The A-weighting filter is applied to closely approximate the human ear's response to sound. This scale is commonly used in environmental and industrial sound. Sound expressed in the A-weighted scale is denoted dBA.

A sound source has a certain sound power level rating which describes the amount of sound energy per unit of time. This is a basic measure of how much acoustical energy it can produce and is independent of its surroundings. Sound pressure is created as sound energy flows away from the source. The measured sound pressure level (SPL) at a given point depends not only on the power rating of the source and the distance between the source and the measurement point (geometric divergence), but also on the amount of sound energy absorbed by environmental elements between the source and the measurement point (attenuation). Sound attenuation factors include meteorological conditions such as wind direction, temperature, and humidity; sound interaction with the ground; atmospheric absorption; terrain effects; diffraction of sound around objects and topographical features; and foliage.

3 APPLICABLE REGULATIONS

The Bitter Root Wind Project is in Yellow Medicine County in the state of Minnesota. However, the project immediately borders the state of South Dakota. DNV GL has performed the sound modeling using the applicable regulations of Minnesota, as they are more conservative and therefore all receptors in compliance with Yellow Medicine County, MN regulations will also be in compliance with the Deuel County, SD regulations. Both regulations are explained below.

The intent of this report is to verify the Project is in compliance with the applicable regulations in Minnesota.

3.1 Minnesota

Minnesota Administrative Rule 7030.0040 Noise Standards [3] state the following:

> ***7030.0040 Noise Standards.***
>
> ***Subpart 1. Scope.*** *These standards describe the limiting levels of sound established on the basis of present knowledge for the preservation of public health and welfare. These standards are consistent with speech, sleep, annoyance, and hearing conservation requirements for receivers within areas grouped according to land activities by the noise area classification (NAC) system established in part 7030.0050. However, these standards do not, by themselves, identify the limiting levels of impulsive noise needed for the preservation of public health and welfare. Noise standards in subpart 2 apply to all sources.*
>
> ***Subpart. 2. Noise Standards.***

Table 3-1 Minnesota Noise Standards

	Daytime		*Nighttime*	
Noise Area Classification	L_{50}	L_{10}	L_{50}	L_{10}
1	*60*	*65*	*50*	*55*
2	*65*	*70*	*65*	*70*
3	*75*	*80*	*75*	*80*

Wind farms are considered under noise area classification 1, which includes homes, other residential uses, religious activities, and educational services [4]. The applicable nighttime limit is therefore 50 dBA for Project receptors in Minnesota.

SPL limits in dBA can be reported in a variety of ways. L50 and L10 represent noise levels that are exceeded 50% and 10% of the time, respectively. Wind farms produce a generally constant sound. Acoustic specifications for wind turbines, as per IEC 61400-11 [6], are reported in terms of Leq, which is a logarithmic sound pressure average over a certain period of time. The anticipated sound levels generated by wind farms are typically reported in terms of Leq over a 1-hour period. Due to the generally constant nature of the wind turbine sound, the L50 and Leq are considered equivalent for the purpose of this analysis. In fact, the Leq will typically overestimate compared to the L50 for areas affected by wind turbine noise, which adds a degree of conservatism to the analysis.

The state of Minnesota prepared the 2010 Application Guidance for Site Permitting of Large Wind Energy Conversion Systems in Minnesota ("LWECS 2010") [7]. Subsequently, the state issued an update in October 2012 ("LWECS 2012") in order to provide additional details regarding the noise study requirements [8]. To meet these requirements, DNV GL compared total noise (turbine operation noise in addition to typical ambient or background noise), as requested in LWECS Guidance 2012 [8] and as recommended by the Minnesota Pollution Control Agency [9], against the applicable limits described above [3]. DNV GL has added a typical rural ambient background sound level (35 dBA) to modeled results and compared to the Noise Standards. 35 dBA is described in [9] as being representative of rural nighttime conditions.

On the topic of wind turbine noise, the Yellow Medicine County zoning standards [11] refer to the Minnesota Administrative Rule 7030 described above.

3.2 South Dakota

For reference, the South Dakota Public Utilities Commission has drafted a Wind Energy Ordinance that states:

> *Noise level produced by the LWES shall not exceed 55 dBA, average A-weighted sound pressure at the perimeter of occupied residences existing at the time the permit application is filed, unless a signed waiver or easement is obtained from the owner of the residence.*

However it also outlines that:

> *South Dakota Codified Law 11-2-2 delegates the responsibility to the Board of County Commissioners of each county to adopt and enforce regulations designed for the purpose of promoting health, safety, and general welfare of the county.*

Considering this delegation of authority to individual counties, Section 1215.03, Paragraph 13 of the Deuel County Zoning Ordinance [2] states,:

> *13. Noise. Noise level shall not exceed 50 dBA, average A-Weighted Sound pressure at the perimeter of existing residences.*

For the purposes of this assessment, the more conservative[2] Minnesota limit of 50 dBA was applied to all receptors in Deuel County, South Dakota.

[2] Since Minnesota requires the addition of 35 dBA ambient noise to the modeled sound levels, it can be considered more conservative than the Duel county limit of 50 dBA, which excludes ambient noise contribution.

4 DESCRIPTION OF THE WIND PROJECT SITE

4.1 Site description

The site is primarily located in Yellow Medicine County, Minnesota, approximately 10 miles east of Clear Lake, South Dakota and 10 miles west of Canby, Minnesota.

The proposed wind project is situated in relatively simple terrain, consisting of flat farm land, with wind turbine base elevations ranging from 1,476 feet (450 m) to 1,706 feet (520 m). The ground cover on and near the site is primarily composed of farm land and open fields. Dwellings are interspersed throughout the Project site.

4.2 Wind project layout

The proposed turbine layout, which consists of 40 Vestas V136 3.45 MW STE wind turbine generators at a hub height of 344 feet (105 m) operating in Noise Mode 0 and one transformer, has been provided by the Customer [12]. While the project is located in Minnesota, the main step-up transformer is located in South Dakota. The coordinates of each turbine and one transformer are presented in Appendix A.

4.3 Receptor locations

A list of 349 receptors to be considered as sound receptors was provided by the Customer [13] and subsequently reviewed and edited by DNV GL in August 2017, increasing the total number of receptors to 357, using available aerial imagery. DNV GL has excluded any receptors that have been confirmed to be uninhabited barns by the Customer.

Of the total number of identified receptors, results for 61 receptors in Minnesota within one mile of a turbine or transformer, 14 receptors in South Dakota within one mile of a turbine or transformer, and 184 additional receptors along the shores of Lake Cochrane regardless of distance to a turbine, are reported herein. Coordinates of each receptor center point are presented in Appendix B.

5 SOUND ASSESSMENT

5.1 Description of the sound source

The sources of sound considered in this analysis are the Project wind turbine generators and substation transformer. Sound associated with other sources in the vicinity of the Project, such as construction activities, have not been considered.

Broadband and one third octave band sound power levels for the Vestas V136 3.45 MW[3] STE wind turbine generators operating in Mode 0, at a hub height of 344 feet (105 m), were provided by the Customer [14], and shown in Appendix C. This acoustic emissions data were determined in accordance with the International Electrotechnical Commission (IEC) 61400-11 standard [15]. At the request of the Customer, an uncertainty level of 2 dBA was added to the maximum wind turbine acoustic emissions. The maximum wind turbine acoustic emission plus the 2 dB uncertainty level, total of 107.5 dBA is considered in this assessment and is presented in Table 5-1.

Table 5-1 Vestas V136 3.45 MW STE Mode 0 acoustic emission summary

Frequency [Hz]	31.5	63	125	250	500	1000	2000	4000	8000	Broadband
Sound Power Level [dBA]	80.6	90.3	95.8	100.4	100.6	101.6	100.7	93.6	76.0	107.5

Note: includes 2dB uncertainty and data for the worst case wind speed of 20 m/s was used in this report

For the transformer, a broadband sound power level of 112.0 dBA was estimated based on standard NEMA TR.1 Table 0-1 [16] and IEEE standard C57.12.90-2006 [17] for one 150 MVA, 345 kV utility scale transformer, as specified by the Customer. A typical transformer octave band distribution was estimated, as shown in Table 5-2. The sound power level of the transformer includes a 5 dB penalty for tonality.

Table 5-2 Transformer acoustic emission summary

Frequency [Hz]	31.5	63	125	250	500	1000	2000	4000	8000	Broadband
Sound Power Level [dBA]	69.2	88.4	100.5	103.0	108.4	105.6	101.8	96.6	87.5	112.0

Note: includes 5dB penalty for tonality

[3] The V136 3.45 MW has a sound power level of 105.5 dBA, which is louder than the 4.2 MW version with a sound power level of 103.9 dBA. While both turbine models are being considered, this report conservatively models the louder of the two models at all turbine locations.

5.2 Assessment methodology

The SPL at each receptor for the aggregate of all wind turbine generators and transformers associated with the Bitter Root Wind Project were calculated using CadnaA 4.2 acoustic modeling software based on the ISO 9613-2 method [1]. The simulation was run for the wind speed corresponding with the maximum sound power level of the turbines (20 m/s) and the maximum sound power level of the transformer. The hub height of the turbines is 344 feet (105 m). The Bitter Root transformer was modeled as a point source at a height of 15 feet (4.5 m) above ground level. All receptors were modeled at a best practice height of 4.9 feet (1.5 m).

The ISO 9613 standard provides a prediction of the equivalent continuous SPL at a distance from one or more point sources. The method consists of octave-band algorithms (i.e., with nominal mid band frequencies from 31.5 Hz to 8 kHz) for calculating the attenuation of the emitted sound. The algorithm takes into account the following physical effects:

- Geometrical divergence – attenuation due to spherical spreading from the sound source
- Atmospheric absorption – attenuation due to absorption by the atmosphere
- Ground absorption – attenuation due to the acoustical properties of the ground

The ISO 9613-1 standard calculates attenuation under meteorological conditions favorable to propagation from sources of sound emission. These conditions are for downwind propagation or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, such as it commonly occurs at night. In other words, though a physical impracticality, the ISO 9613-2 standard treats every receptor as being downwind from every source of sound emission (in this case, turbines and transformers).

The ISO 9613-2 standard accounts for ground effect by assigning a numerical coefficient (G) with a value ranging from 0 to 1. A value of G = 0 equates to hard ground (paving, water, ice, concrete, tamped ground, and other ground surfaces with a low porosity), while a G = 1 value equates to porous ground (ground covered by grass, trees, or other vegetation, and other ground surfaces suitable for the growth of vegetation such as farming land). Though the ground use on and around the site is farming, a mixed (semi-reflective) global ground factor of G = 0.5 was used in this assessment, with the exception of G = 0 for water bodies.

Additionally, temperature, barometric pressure, and humidity parameters were selected to represent conditions favorable to sound propagation, and topographical information to accurately represent terrain in three-dimensions was included in this assessment.

Specifically, the ISO 9613-2 parameters were set as follows:

- Ambient air temperature: 50º F (10º C)
- Ambient barometric pressure: 101.32 kPa
- Humidity: 70%
- Overall ground factor: 0.5
- Water body ground factor: 0
- Topography included

Additional attenuation from foliage was not considered in this assessment, implying that the lower sound levels are expected in areas where there is foliage present in the line of sight between any turbine and a sound receptor. Similarly, because the model assumes every receptor is downwind of every sound source at all times, lower sound levels are expected at times when a receptor is upwind of any sound source [1].

The wind turbine and transformer sound emission ratings used for each octave band were those specified in Table 5-1 and Table 5-2. The sound impact was calculated for each receptor and the calculated sound level was then compared with the applicable sound limit.

No distinction was made between daytime or night time sound emissions in the simulation because the project is assumed to be operating at maximum capacity at all times.

6 RESULTS

Detailed maps illustrating predicted sound pressure levels at receptors located in the vicinity of the Project is presented in Figure 6-1. An additional map near Lake Cochrane is shown in Figure 6-2 for receptor clarity purposes.

The results of the sound study are presented for all sound receptors in tabular format in Appendix B. For each receptor, the following information is provided:

- ID;
- Coordinates in UTM projection and NAD83 Datum;
- Sound levels in dBA at the receptor location at 4.9 feet (1.5 m) above ground level.
- Closest wind turbine; and
- Distance to the closest wind turbine.

The SPLs at each of the 198 South Dakota receptors and 61 Minnesota receptors located within or near the project area are within the allowable limits under the applicable regulations.

The highest modelled result in South Dakota and Minnesota respectively is 46.7 dBA at receptor 242 and 45.5 dBA at receptor 355.

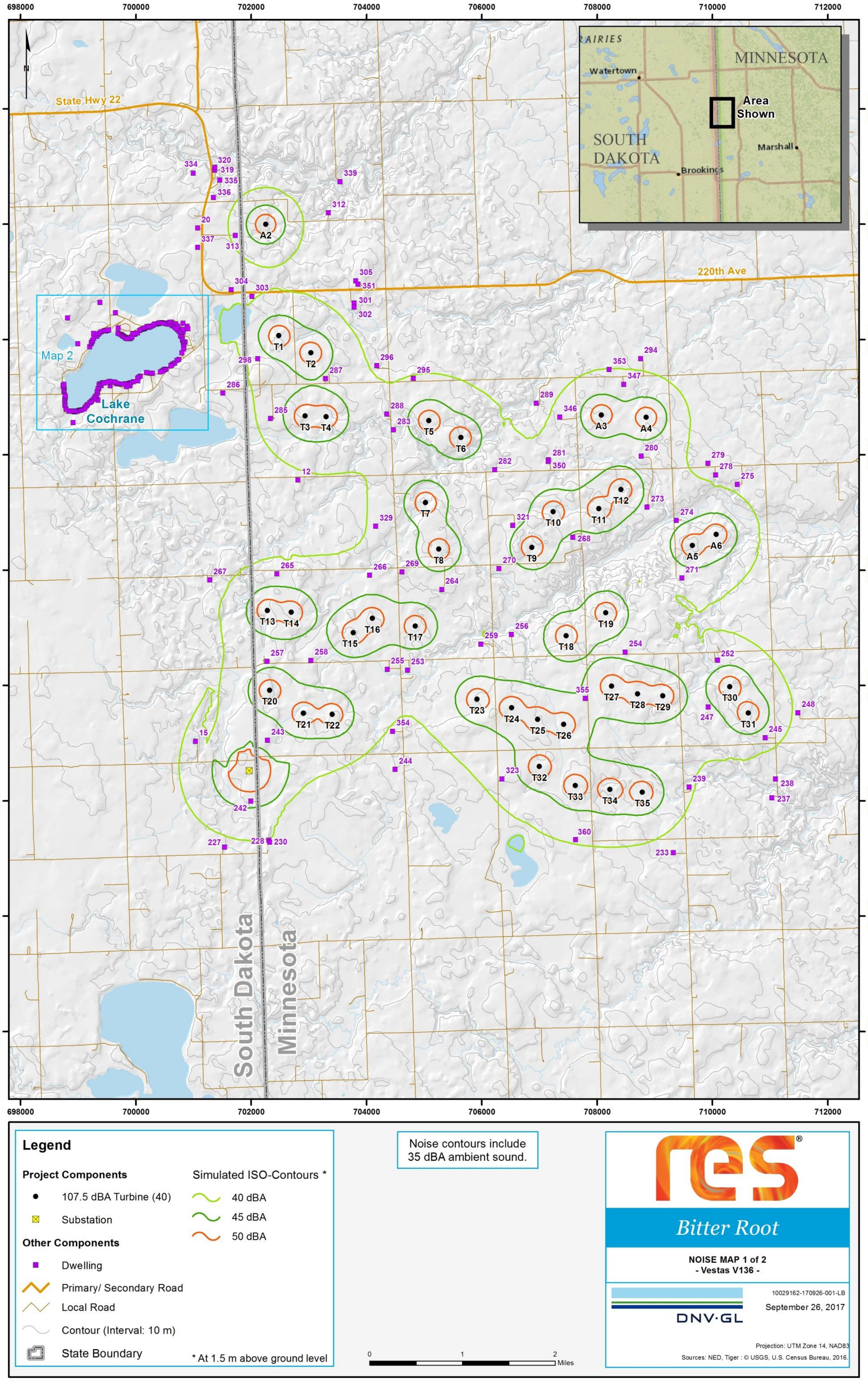

Figure 6-1 Modeled sound levels at Bitter Root Wind Project

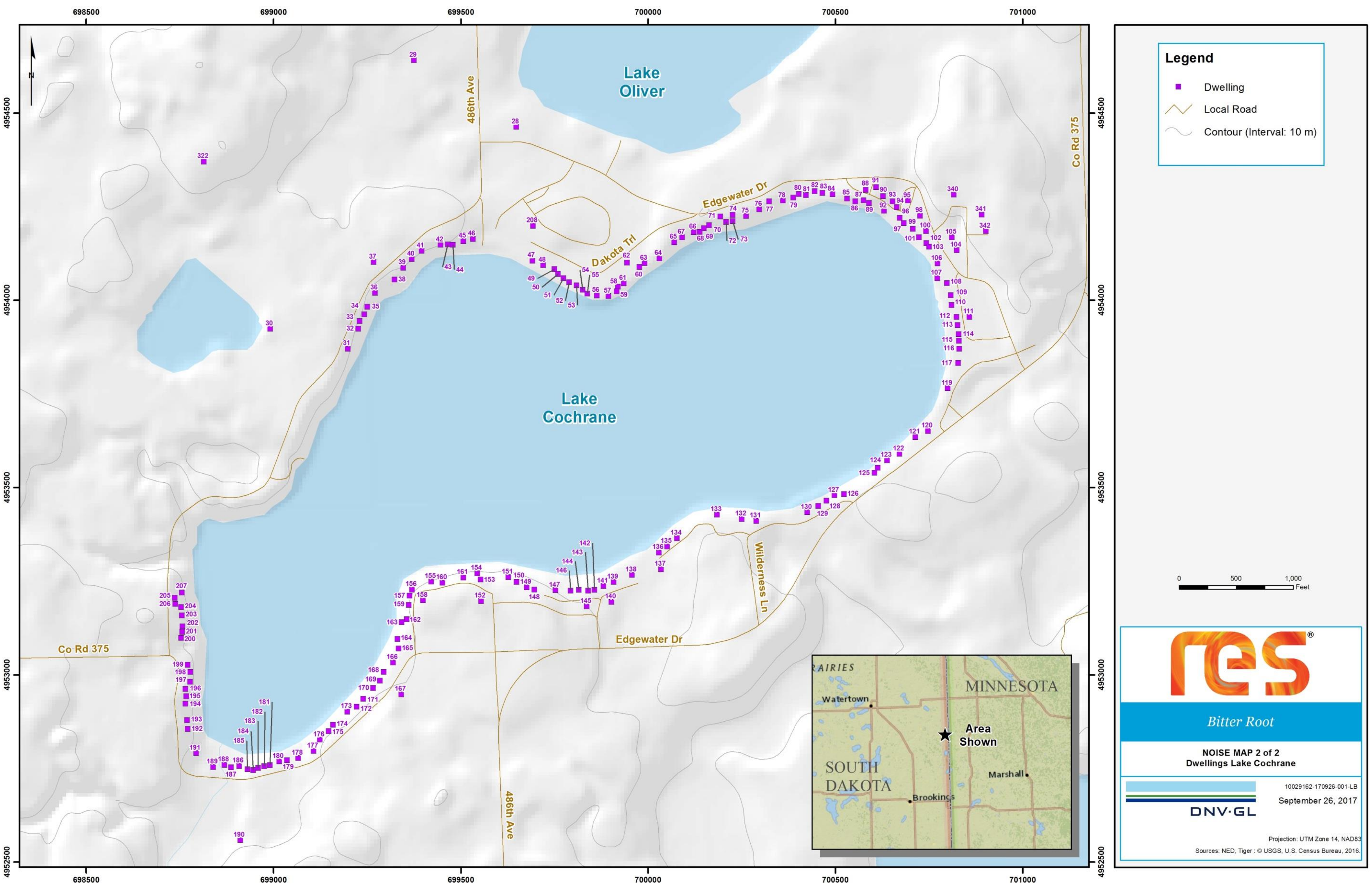

Figure 6-2 Detailed Map near Lake Cochrane

7 CONCLUSION

DNV GL has conducted an analysis to determine the maximum sound levels predicted to be experienced at sound receptors in the vicinity of the Bitter Root Wind Project in Yellow Medicine County, Minnesota[4]. This analysis was undertaken specifically for the Vestas V136 3.45 MW STE, in Mode 0 wind turbine generator at a hub height of 344 feet (105 m). Forty turbines and one transformer were included in the model.

The results indicate that the calculated sound levels are within the allowable limit of 50 dBA, inclusive of ambient noise, under the Minnesota Rule 7030[5] at each of the 259 total receptors included in this report.

These results can be considered conservative because a portion of the layout will eventually implement the quieter V136 4.2 MW turbine, and only 37 of the 40 modeled turbines will be constructed.

[4] The project substation is the only component not located in Minnesota. It is located in Deuel County, South Dakota.

[5] The more conservative sound pressure level limit of 50 dBA inclusive of ambient noise prescribed in Minnesota Rule 7030 was applied to receptors located in South Dakota.

8 REFERENCES

[1] International Organization for Standardization. ISO 9613-2: Acoustics – Attenuation of Sound During Propagation Outdoors – Part 2: General Method of Calculation. 15 December 1996.

[2] Deuel County Zoning Ordinance. B2004-01, Section 1215.03 Wind Energy System (Wes) Requirements - General provisions.

[3] Minnesota Administrative Rules 7030.0040 Noise Standards. Posted 12 December 2003, https://www.revisor.leg.state.mn.us/rules/?id=7030.0040.

[4] Minnesota Administrative Rules 7030.0050 Noise Area Classification. Posted 12 December 2003, https://www.revisor.leg.state.mn.us/rules/?id=7030.0050.

[5] South Dakota Public Utilities Commission - Draft model ordinance for siting of wind energy systems (WES). *https://puc.sd.gov/commission/twg/WindEnergyOrdinance.pdf*

[6] International Electrotechnical Commission. IEC 61400-12 Power Performance of electricity-producing wind turbines based on nacelle anemometry.

[7] Minnesota Department of Commerce, Office of Energy Security-Energy Facilities Permitting, "Application Guidance for Site Permitting of Large Wind Energy Conversion Systems in Minnesota," http://mn.gov/commerce/energyfacilities/documents/LWECS_APP_Guide_AUG2010.pdf, August 2010.

[8] Minnesota Department of Commerce, Energy Facility Permitting. "Guidance for Large Wind Energy Conversion System Noise Study Protocol and Report." October 8 2012.

[9] A Guide to Noise Control in Minnesota – Acoustic Properties, Measurement, Analysis and Regulation, Minnesota Pollution Control Agency, 2008.

[10] Minnesota Department of Commerce, Office of Energy Security-Energy Facilities Permitting, "Application Guidance for Site Permitting of Large Wind Energy Conversion Systems in Minnesota," http://mn.gov/commerce/energyfacilities/documents/LWECS_APP_Guide_AUG2010.pdf, August 2010.

[11] Yellow Medicine County Section XVI-Renewable Energy – Subdivision 1.0 Wind Energy Conversion Systems (WECS)

[12] Turbine layout locations sent by email, by RES, to A. Nercessian, DNV GL, 15 August 2017, "PUSAbrt047_46_PPM_UTMz14_NAD83_feet".

[13] Receptor locations sent by email, by RES, to S. Dokouzian, DNV GL, 20 September 2016, "all_houses.shp" and confirmed by RES 15 August 2017.

[14] Turbine acoustic specifications confirmed by email, by RES, to A. Nercessian, DNV GL, 17 August 2017, "0055-9919_V03 - Vestas V126-3.45MW Third Octaves.pdf".

[15] International Electrotechnical Commission. IEC 61400-11 Wind Turbine Generator Systems – Part 11: Acoustic Measurement Techniques. 07 November 2012.

[16] National Electrical Manufacturers Association. NEMA Standards Publication No TR 1-1993 (R2000): Transformers, Regulators, and Reactors. 2000.

[17] C57.12.90-2006 IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers.

APPENDIX A – WIND TURBINE AND TRANSFORMER COORDINATES

Customer ID	Easting [m]	Northing [m]
T1	702481	4954063
T2	703038	4953767
T3	702934	4952670
T4	703302	4952660
T5	705081	4952591
T6	705636	4952296
T7	705023	4951170
T8	705254	4950361
T9	706869	4950393
T10	707238	4951012
T11	708028	4951063
T12	708415	4951396
T13	702284	4949299
T14	702696	4949266
T15	703771	4948913
T16	704101	4949160
T17	704846	4949028
T18	707462	4948861
T19	708151	4949258
T20	702319	4947915
T21	702904	4947515
T22	703403	4947497
T23	705918	4947760
T24	706516	4947609
T25	706969	4947409
T26	707421	4947322
T27	708248	4947988
T28	708701	4947853
T29	709136	4947817
T30	710299	4947977
T31	710624	4947520
T32	706999	4946593
T33	707619	4946260
T34	708221	4946195
T35	708781	4946148
A2	702251	4955997
A3	708072	4952689
A4	708851	4952646
A5	709652	4950426
A6	710065	4950615
Transformer	701966	4946521

Coordinates are in UTM NAD 83 Zone 14

APPENDIX B – RECEPTOR LOCATIONS AND ASSOCIATED SOUND LEVELS

Receptor ID	UTM Coordinates		SPL at Receptor [dBA]	SPL at Receptor including 35 dBA ambient noise [dBA]	Nearest sound source [ID]	Distance to Nearest Turbine [feet]
	Easting [m]	Northing [m]				
MN12	702811	4951562	37.2	39.3	T3	3658
SD15	701032	4947031	40.1	41.2	Transformer	3491
SD20	701072	4955930	33.1	37.1	A2	3875
SD28	699648	4954463	28.3	35.8	T1	9387
SD29	699375	4954641	27.6	35.7	T1	10365
SD30	698991	4953924	27.1	35.7	T1	11459
SD31	699198	4953871	28.1	35.8	T1	10789
SD32	699226	4953924	28.4	35.9	T1	10688
SD33	699230	4953945	28.2	35.8	T1	10673
SD34	699242	4953962	28.5	35.9	T1	10632
SD35	699250	4953983	28.5	35.9	T1	10604
SD36	699271	4954020	28.0	35.8	T1	10533
SD37	699267	4954102	27.6	35.7	T1	10545
SD38	699323	4954055	27.9	35.8	T1	10361
SD39	699346	4954087	27.9	35.8	T1	10286
SD40	699369	4954110	27.9	35.8	T1	10211
SD41	699395	4954132	27.9	35.8	T1	10127
SD42	699446	4954148	28.0	35.8	T1	9961
SD43	699465	4954149	28.1	35.8	T1	9899
SD44	699479	4954148	28.1	35.8	T1	9853
SD45	699507	4954158	28.1	35.8	T1	9762
SD46	699532	4954164	28.2	35.8	T1	9681
SD47	699691	4954106	28.6	35.9	T1	9155
SD48	699720	4954094	28.7	35.9	T1	9059
SD49	699750	4954083	28.7	35.9	T1	8960
SD50	699759	4954070	28.8	35.9	T1	8931
SD51	699774	4954059	28.9	36.0	T1	8881
SD52	699789	4954048	29.0	36.0	T1	8832
SD53	699809	4954040	29.1	36.0	T1	8767
SD54	699825	4954028	29.2	36.0	T1	8715
SD55	699838	4954018	29.5	36.1	T1	8673
SD56	699863	4954013	29.9	36.2	T1	8591
SD57	699894	4954011	30.7	36.4	T1	8490
SD58	699920	4954036	30.1	36.2	T1	8403
SD59	699916	4954024	30.6	36.3	T1	8416
SD60	699977	4954089	29.9	36.2	T1	8216
SD61	699935	4954045	30.4	36.3	T1	8353
SD62	699944	4954101	29.2	36.0	T1	8324
SD63	699991	4954099	29.9	36.2	T1	8170

Receptor ID	UTM Coordinates		SPL at Receptor [dBA]	SPL at Receptor including 35 dBA ambient noise [dBA]	Nearest sound source [ID]	Distance to Nearest Turbine [feet]
	Easting [m]	Northing [m]				
SD64	700030	4954112	30.7	36.4	T1	8043
SD65	700070	4954155	30.1	36.2	T1	7916
SD66	700122	4954182	30.3	36.3	T1	7749
SD67	700091	4954168	30.2	36.2	T1	7849
SD68	700138	4954183	30.9	36.4	T1	7697
SD69	700149	4954192	30.4	36.3	T1	7663
SD70	700163	4954200	30.2	36.2	T1	7618
SD71	700193	4954224	29.9	36.2	T1	7525
SD72	700208	4954209	30.2	36.2	T1	7473
SD73	700226	4954211	30.2	36.3	T1	7414
SD74	700226	4954228	30.0	36.2	T1	7418
SD75	700262	4954225	30.3	36.3	T1	7300
SD76	700297	4954243	30.2	36.3	T1	7190
SD77	700323	4954264	30.2	36.3	T1	7111
SD78	700360	4954266	30.4	36.3	T1	6991
SD79	700388	4954274	30.6	36.3	T1	6902
SD80	700402	4954284	30.6	36.3	T1	6859
SD81	700421	4954281	30.8	36.4	T1	6796
SD82	700445	4954291	30.8	36.4	T1	6722
SD83	700465	4954287	30.9	36.4	T1	6655
SD84	700492	4954283	31.0	36.5	T1	6565
SD85	700531	4954271	31.2	36.5	T1	6434
SD86	700553	4954264	31.4	36.6	T1	6360
SD87	700575	4954267	31.3	36.5	T1	6289
SD88	700581	4954295	31.2	36.5	T1	6280
SD89	700590	4954260	31.4	36.6	T1	6238
SD90	700627	4954278	31.4	36.6	T1	6124
SD91	700609	4954302	31.3	36.5	T1	6192
SD92	700630	4954239	31.4	36.6	T1	6100
SD93	700653	4954264	31.5	36.6	T1	6034
SD94	700664	4954249	31.5	36.6	T1	5993
SD95	700694	4954266	31.6	36.6	T1	5901
SD96	700672	4954220	31.6	36.6	T1	5957
SD97	700683	4954206	31.6	36.6	T1	5918
SD98	700726	4954226	31.8	36.7	T1	5783
SD99	700707	4954191	31.7	36.7	T1	5835
SD100	700742	4954185	31.9	36.7	T1	5719
SD101	700723	4954168	31.8	36.7	T1	5778
SD102	700743	4954153	31.9	36.7	T1	5710
SD103	700750	4954143	31.9	36.7	T1	5685
SD104	700824	4954134	32.2	36.8	T1	5441

Receptor ID	UTM Coordinates		SPL at Receptor [dBA]	SPL at Receptor including 35 dBA ambient noise [dBA]	Nearest sound source [ID]	Distance to Nearest Turbine [feet]
	Easting [m]	Northing [m]				
SD105	700811	4954168	32.2	36.8	T1	5490
SD106	700773	4954098	32.0	36.8	T1	5605
SD107	700773	4954059	32.0	36.8	T1	5606
SD108	700798	4954046	32.1	36.8	T1	5522
SD109	700808	4954014	32.2	36.8	T1	5490
SD110	700810	4953987	32.2	36.8	T1	5488
SD111	700858	4953956	32.4	36.9	T1	5336
SD112	700823	4953956	32.3	36.9	T1	5451
SD113	700826	4953934	32.3	36.9	T1	5446
SD114	700829	4953910	32.3	36.9	T1	5443
SD115	700830	4953892	32.3	36.9	T1	5447
SD116	700831	4953871	32.3	36.9	T1	5450
SD117	700828	4953833	32.3	36.9	T1	5475
SD119	700800	4953765	32.2	36.8	T1	5601
SD120	700747	4953651	31.9	36.7	T1	5846
SD121	700714	4953635	31.8	36.7	T1	5966
SD122	700671	4953590	31.6	36.6	T1	6138
SD123	700638	4953573	31.5	36.6	T1	6257
SD124	700614	4953553	31.4	36.6	T1	6351
SD125	700605	4953540	31.4	36.6	T1	6391
SD126	700523	4953483	31.0	36.5	T1	6700
SD127	700498	4953479	31.0	36.5	T1	6783
SD128	700476	4953465	30.9	36.4	T1	6864
SD129	700454	4953451	30.8	36.4	T1	6947
SD130	700425	4953434	30.7	36.4	T1	7054
SD131	700289	4953411	30.3	36.3	T1	7503
SD132	700250	4953416	30.2	36.2	T1	7621
SD133	700184	4953428	30.1	36.2	T1	7819
SD134	700077	4953365	29.7	36.1	T1	8213
SD135	700051	4953343	29.6	36.1	T1	8315
SD136	700029	4953327	29.6	36.1	T1	8399
SD137	700035	4953282	29.6	36.1	T1	8424
SD138	699957	4953267	29.4	36.1	T1	8683
SD139	699908	4953248	29.3	36.0	T1	8855
SD140	699902	4953195	29.3	36.0	T1	8928
SD141	699881	4953237	29.2	36.0	T1	8950
SD142	699857	4953227	29.1	36.0	T1	9035
SD143	699840	4953225	29.0	36.0	T1	9090
SD144	699815	4953227	28.9	36.0	T1	9167
SD145	699836	4953183	29.0	36.0	T1	9146
SD146	699793	4953225	28.9	36.0	T1	9238

Receptor ID	UTM Coordinates		SPL at Receptor [dBA]	SPL at Receptor including 35 dBA ambient noise [dBA]	Nearest sound source [ID]	Distance to Nearest Turbine [feet]
	Easting [m]	Northing [m]				
SD147	699753	4953226	28.8	35.9	T1	9362
SD148	699696	4953228	28.7	35.9	T1	9539
SD149	699676	4953234	28.6	35.9	T1	9596
SD150	699649	4953248	28.6	35.9	T1	9668
SD151	699627	4953261	28.5	35.9	T1	9726
SD152	699554	4953197	28.3	35.8	T1	10015
SD153	699553	4953255	28.4	35.9	T1	9965
SD154	699544	4953271	28.4	35.9	T1	9980
SD155	699421	4953249	28.1	35.8	T1	10389
SD156	699370	4953228	28.0	35.8	T1	10568
SD157	699363	4953211	27.9	35.8	T1	10603
SD158	699399	4953199	28.0	35.8	T1	10501
SD159	699361	4953187	27.9	35.8	T1	10632
SD160	699451	4953246	28.1	35.8	T1	10296
SD161	699507	4953260	28.3	35.8	T1	10107
SD162	699356	4953149	27.9	35.8	T1	10682
SD163	699342	4953141	27.9	35.8	T1	10734
SD164	699331	4953096	27.9	35.8	T1	10811
SD165	699334	4953070	27.8	35.8	T1	10827
SD166	699319	4953033	27.6	35.7	T1	10911
SD167	699341	4952948	27.1	35.6	T1	10932
SD168	699294	4953008	27.4	35.7	T1	11014
SD169	699284	4952985	26.9	35.6	T1	11069
SD170	699266	4952965	26.7	35.6	T1	11146
SD171	699239	4952936	26.2	35.5	T1	11261
SD172	699222	4952915	26.1	35.5	T1	11337
SD173	699197	4952902	26.0	35.5	T1	11428
SD174	699159	4952867	25.8	35.5	T1	11584
SD175	699147	4952850	25.8	35.5	T1	11640
SD176	699124	4952827	25.7	35.5	T1	11737
SD177	699107	4952797	25.7	35.5	T1	11823
SD178	699066	4952778	25.6	35.5	T1	11971
SD179	699036	4952772	25.5	35.5	T1	12070
SD180	699015	4952769	25.5	35.5	T1	12138
SD181	698990	4952759	25.4	35.5	T1	12226
SD182	698975	4952756	25.4	35.5	T1	12276
SD183	698959	4952752	25.4	35.4	T1	12330
SD184	698946	4952746	25.3	35.4	T1	12377
SD185	698930	4952748	25.3	35.4	T1	12423
SD186	698908	4952757	25.3	35.4	T1	12481
SD187	698886	4952753	25.2	35.4	T1	12553

Receptor ID	UTM Coordinates		SPL at Receptor [dBA]	SPL at Receptor including 35 dBA ambient noise [dBA]	Nearest sound source [ID]	Distance to Nearest Turbine [feet]
	Easting [m]	Northing [m]				
SD188	698869	4952760	25.2	35.4	T1	12598
SD189	698839	4952754	25.2	35.4	T1	12697
SD190	698911	4952559	24.1	35.3	T1	12710
SD191	698793	4952791	25.2	35.4	T1	12799
SD192	698771	4952856	25.7	35.5	T1	12800
SD193	698769	4952879	25.9	35.5	T1	12783
SD194	698765	4952923	26.1	35.5	T1	12752
SD195	698767	4952943	26.3	35.5	T1	12727
SD196	698765	4952963	26.4	35.6	T1	12715
SD197	698777	4952982	26.6	35.6	T1	12659
SD198	698778	4953008	26.6	35.6	T1	12632
SD199	698771	4953027	26.5	35.6	T1	12638
SD200	698753	4953099	26.7	35.6	T1	12633
SD201	698756	4953115	26.8	35.6	T1	12611
SD202	698757	4953130	26.8	35.6	T1	12596
SD203	698755	4953159	26.8	35.6	T1	12579
SD204	698753	4953181	26.8	35.6	T1	12569
SD205	698736	4953206	26.8	35.6	T1	12604
SD206	698738	4953190	26.8	35.6	T1	12610
SD207	698755	4953220	27.1	35.7	T1	12533
SD208	699693	4954199	28.5	35.9	T1	9158
SD227	701539	4945198	36.9	39.1	Transformer	4561
MN228	702307	4945318	38.1	39.9	Transformer	4103
MN230	702318	4945283	37.8	39.7	Transformer	4223
MN233	709321	4945099	35.6	38.3	T35	3870
MN237	711029	4946052	33.4	37.3	T31	4996
MN238	711091	4946378	34.5	37.8	T31	4048
MN239	709593	4946236	39.0	40.4	T35	2680
SD242	701993	4945992	46.4	46.7	Transformer	1738
MN243	702282	4947047	43.0	43.6	Transformer	2013
MN244	704496	4946545	36.0	38.6	T22	4756
MN245	710913	4947095	41.4	42.3	T31	1686
MN247	709927	4947628	43.7	44.2	T30	1673
MN248	711483	4947527	37.3	39.3	T31	2818
MN252	710088	4948438	42.4	43.1	T30	1663
MN253	704711	4948265	40.8	41.8	T17	2542
MN254	708487	4948578	43.6	44.1	T27	2086
MN255	704360	4948279	41.2	42.2	T15	2839
MN256	706512	4948882	40.1	41.3	T18	3118
MN257	702272	4948417	43.2	43.8	T20	1654
MN258	703037	4948433	42.3	43.1	T15	2877

Receptor ID	UTM Coordinates		SPL at Receptor [dBA]	SPL at Receptor including 35 dBA ambient noise [dBA]	Nearest sound source [ID]	Distance to Nearest Turbine [feet]
	Easting [m]	Northing [m]				
MN259	705986	4948717	40.1	41.3	T23	3149
MN264	705305	4949662	41.6	42.5	T8	2299
MN265	702445	4949933	41.4	42.3	T13	2146
MN266	704055	4949911	40.8	41.8	T16	2469
SD267	701283	4949829	35.7	38.4	T13	3717
MN268	707580	4950569	43.8	44.4	T10	1836
MN269	704614	4949967	41.3	42.2	T8	2465
MN270	706297	4950025	41.0	42.0	T9	2231
MN271	709469	4949862	41.3	42.2	A5	1945
MN273	708865	4951091	42.7	43.4	T12	1784
MN274	709375	4950861	42.9	43.5	A5	1692
MN275	710428	4951486	37.2	39.3	A6	3096
MN278	710057	4951651	37.5	39.4	A6	3398
MN279	709919	4951851	37.1	39.2	A6	4083
MN280	708762	4951975	42.3	43.0	T12	2215
MN281	707153	4951915	39.8	41.1	T10	2976
MN282	706224	4951742	39.8	41.0	T6	2651
MN283	704468	4952431	41.0	42.0	T5	2077
MN285	702337	4952627	41.0	42.0	T3	1964
SD286	701509	4953069	35.2	38.1	T1	4561
MN287	703291	4953319	43.8	44.3	T2	1688
MN288	704353	4952705	40.2	41.3	T5	2418
MN289	706945	4952894	37.1	39.2	A3	3760
MN294	708752	4953668	36.5	38.8	A4	3369
MN295	704811	4953323	38.8	40.3	T5	2560
MN296	704178	4953544	37.7	39.6	T2	3811
MN298	702112	4953664	41.5	42.3	T1	1783
MN301	703787	4954629	36.0	38.5	T2	3747
MN302	703784	4954558	36.3	38.7	T2	3567
MN303	702011	4954748	37.8	39.7	T1	2726
SD304	701652	4954864	35.6	38.3	T1	3782
MN305	703812	4955013	34.4	37.7	T2	4814
MN312	703338	4956195	33.6	37.4	A2	3625
SD313	701724	4955801	39.8	41.1	A2	1846
SD319	701367	4956937	30.9	36.4	A2	4234
SD320	701368	4956986	30.6	36.3	A2	4352
MN321	706536	4950774	43.2	43.8	T9	1660
SD322	698814	4954370	26.2	35.5	T1	12073
MN323	706349	4946378	41.0	42.0	T32	2246
MN329	704160	4950759	39.0	40.5	T7	3136
SD334	700994	4956881	29.8	36.2	A2	5042

Receptor ID	UTM Coordinates		SPL at Receptor [dBA]	SPL at Receptor including 35 dBA ambient noise [dBA]	Nearest sound source [ID]	Distance to Nearest Turbine [feet]
	Easting [m]	Northing [m]				
SD335	701456	4956763	32.8	37.0	A2	3623
SD336	701344	4956459	34.0	37.5	A2	3339
SD337	701072	4955596	33.0	37.1	A2	4088
MN339	703541	4956735	29.9	36.2	A2	4874
SD340	700816	4954282	32.1	36.8	T1	5510
SD341	700891	4954229	32.5	36.9	T1	5245
SD342	700902	4954185	32.6	37.0	T1	5197
MN346	707352	4952653	39.6	40.9	A3	2365
MN347	708463	4953219	41.1	42.1	A3	2162
MN350	707151	4951886	40.0	41.2	T10	2881
MN351	703850	4954957	34.5	37.7	T2	4727
MN353	708207	4953477	38.5	40.1	A3	2625
MN354	704454	4947204	38.0	39.8	T22	3579
MN355*	707793	4947775	45.1	45.5	T27	1649
MN360	707624	4945325	38.9	40.4	T33	3068

Coordinates given in UTM Zone 14, NAD83 Datum

*Receptor MN355 is a town hall. It does not fall under the *Noise Area Classification 1* category, as defined in [4]. It can be categorized as "governmental services" or "public assembly", which is listed under *Noise Area Classification 2*, with a night time L_{50} sound limit of 65 dBA, defined in [3].

Frequency	Hub height wind speeds [m/s]																	
	3 m/s	4 m/s	5 m/s	6 m/s	7 m/s	8 m/s	9 m/s	10 m/s	11 m/s	12 m/s	13 m/s	14 m/s	15 m/s	16 m/s	17 m/s	18 m/s	19 m/s	20 m/s
6.3 Hz	21.0	19.6	20.5	22.9	25.2	27.9	29.8	30.0	30.7	31.2	31.4	31.7	31.8	31.9	32.1	32.3	32.2	32.3
8 Hz	22.1	21.6	24.0	27.8	31.3	34.9	37.3	37.6	38.0	38.3	38.5	38.6	38.7	38.8	38.8	38.9	38.9	39.0
10 Hz	28.4	27.9	30.3	34.0	37.5	41.0	43.5	43.8	44.2	44.5	44.7	44.8	44.9	45.0	45.0	45.1	45.1	45.2
12.5 Hz	36.7	36.2	38.2	41.7	45.1	48.5	50.9	51.2	51.7	52.0	52.2	52.3	52.4	52.5	52.6	52.7	52.6	52.7
16 Hz	43.4	42.9	45.0	48.3	51.4	54.6	56.8	57.0	57.4	57.7	57.9	58.0	58.0	58.1	58.2	58.3	58.3	58.3
20 Hz	47.9	47.6	49.9	53.4	56.8	60.2	62.5	62.8	63.2	63.4	63.6	63.7	63.7	63.8	63.9	64.0	63.9	64.0
25 Hz	55.0	54.5	56.7	59.9	63.0	66.1	68.3	68.5	68.9	69.2	69.3	69.4	69.5	69.6	69.6	69.7	69.7	69.8
31.5 Hz	58.4	57.4	59.2	62.5	65.6	69.0	71.3	71.6	72.2	72.6	72.8	73.0	73.1	73.2	73.3	73.5	73.4	73.6
40 Hz	60.6	61.0	63.6	67.0	70.4	73.5	75.7	75.8	75.9	76.0	76.0	76.1	76.1	76.1	76.1	76.1	76.1	76.1
50 Hz	66.0	66.2	68.4	71.6	74.7	77.8	79.9	80.0	80.2	80.4	80.4	80.5	80.5	80.6	80.6	80.6	80.6	80.7
63 Hz	74.4	74.0	75.0	76.8	78.8	80.8	82.3	82.4	82.7	83.0	83.1	83.2	83.3	83.4	83.4	83.5	83.5	83.6
80 Hz	76.2	77.1	78.7	80.5	82.5	84.3	85.5	85.5	85.4	85.4	85.3	85.3	85.3	85.3	85.2	85.2	85.2	85.2
100 Hz	75.3	75.2	77.1	79.8	82.6	85.2	87.1	87.2	87.5	87.7	87.8	87.9	87.9	88.0	88.0	88.1	88.1	88.1
125 Hz	81.2	80.1	80.6	82.3	84.1	86.1	87.6	87.7	88.3	88.7	89.0	89.1	89.2	89.4	89.5	89.6	89.6	89.7
160 Hz	77.3	78.8	81.4	83.9	86.6	88.9	90.3	90.3	90.0	89.8	89.7	89.5	89.5	89.4	89.4	89.3	89.3	89.2
200 Hz	77.4	78.3	80.8	83.8	86.9	89.7	91.6	91.7	91.6	91.6	91.6	91.5	91.5	91.5	91.5	91.4	91.5	91.4
250 Hz	81.5	80.8	82.6	85.5	88.3	91.2	93.2	93.4	93.9	94.2	94.3	94.5	94.6	94.7	94.7	94.9	94.8	94.9
315 Hz	84.0	83.5	84.6	86.7	88.7	91.0	92.5	92.7	93.1	93.4	93.5	93.6	93.7	93.8	93.9	94.0	93.9	94.0
400 Hz	75.8	77.1	80.4	84.2	87.9	91.1	93.3	93.4	93.2	93.0	92.9	92.8	92.8	92.8	92.7	92.6	92.7	92.6
500 Hz	76.1	77.3	80.6	84.6	88.7	92.2	94.6	94.7	94.5	94.4	94.3	94.2	94.2	94.1	94.1	94.0	94.0	94.0
630 Hz	79.0	79.4	81.9	85.3	88.8	92.0	94.3	94.4	94.5	94.6	94.6	94.6	94.7	94.7	94.7	94.7	94.7	94.7
800 Hz	78.7	79.9	82.3	85.5	89.0	92.0	94.1	94.2	94.0	93.8	93.7	93.6	93.6	93.5	93.5	93.4	93.5	93.4
1 kHz	84.8	84.9	86.3	88.5	90.9	93.3	94.9	95.0	95.2	95.4	95.5	95.6	95.6	95.6	95.7	95.7	95.7	95.7
1.25 kHz	80.6	81.8	84.3	87.5	91.0	94.0	96.0	96.1	95.8	95.6	95.5	95.4	95.4	95.3	95.2	95.2	95.2	95.1
1.6 kHz	79.6	80.7	83.3	86.6	90.2	93.2	95.3	95.4	95.3	95.2	95.1	95.0	95.0	95.0	94.9	94.9	94.9	94.9
2 kHz	78.5	79.3	81.9	85.3	88.8	91.9	94.1	94.2	94.1	94.1	94.1	94.0	94.0	94.0	94.0	94.0	94.0	94.0
2.5 kHz	76.5	77.4	80.2	83.7	87.3	90.5	92.7	92.8	92.8	92.7	92.7	92.6	92.6	92.6	92.6	92.6	92.6	92.6
3.15 kHz	74.5	75.1	77.5	80.8	84.3	87.4	89.6	89.7	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8
4 kHz	72.9	72.8	74.6	77.3	80.2	83.0	84.9	85.1	85.4	85.6	85.7	85.8	85.8	85.9	85.9	86.0	86.0	86.0
5 kHz	64.3	64.4	66.8	70.2	73.6	76.8	79.1	79.3	79.5	79.6	79.7	79.8	79.8	79.9	79.9	80.0	79.9	80.0
6.3 kHz	62.5	61.3	61.9	64.1	66.3	68.9	70.8	71.1	71.8	72.3	72.6	72.9	73.0	73.1	73.3	73.5	73.4	73.5
8 kHz	61.7	61.0	60.1	60.2	60.5	61.2	61.7	61.7	62.2	62.5	62.7	62.9	62.9	63.0	63.1	63.2	63.2	63.3
10 kHz	58.5	59.4	58.5	57.8	57.5	57.3	57.1	57.0	56.9	56.8	56.8	56.8	56.8	56.7	56.7	56.7	56.7	56.7
A-wgt	92.2	92.5	94.5	97.4	100.5	103.4	105.4	105.5	105.5	105.5	105.5	105.5	105.5	105.5	105.5	105.5	105.5	105.5

Table 2: V136-3.45 MW, expected 1/3 octave band performance, Mode 0 & Mode 0 (HWO) – (Blades with serrated trailing edge)

About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas and energy industries. We also provide certification services to customers across a wide range of industries. Combining leading technical and operational expertise, risk methodology and in-depth industry knowledge, we empower our customers' decisions and actions with trust and confidence. We continuously invest in research and collaborative innovation to provide customers and society with operational and technological foresight. Operating in more than 100 countries, our professionals are dedicated to helping customers make the world safer, smarter and greener.