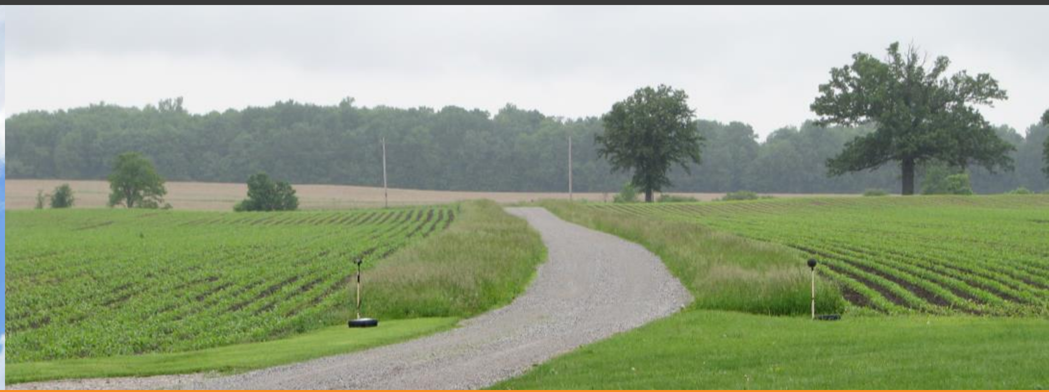
REPORT

BLACK FORK WIND: REVISED SOUND MODELING

9.27.2018

PREPARED FOR:
CAPITAL POWER

SUBMITTED BY:
RSG

55 Railroad Row
White River Junction, VT 05001
802.295.4999
www.rsginc.com

BLACK FORK WIND: REVISED SOUND MODELING

PREPARED FOR:
CAPITAL POWER

CONTENTS

1.0 INTRODUCTION 1
2.0 PROJECT DESCRIPTION 2
2.1 | Project OPSB Certificate 2
2.2 | Project Area 2
2.3 | Sound Source Details 3
3.0 SOUND MODELING 5
3.1 | Methodology 5
3.2 | Modeling Results 5
4.0 SUMMARY AND CONCLUSIONS 10

List of Figures

FIGURE 1: SIEMENS DINOTAILS SHOWN NEXT TO A CONVENTIONAL SERRATED TRAILING EDGE (PICTURE PRODUCED BY SIEMENS - WWW.SIEMENS.COM/PRESS) 4
FIGURE 2: A-WEIGHTED SOUND PRESSURE LEVELS (NORTH) – SIEMENS G132 3.55 MW WITH DINO TAILS 7
FIGURE 3: A-WEIGHTED SOUND PRESSURE LEVELS (SOUTH) – SIEMENS G132 3.55 MW WITH DINO TAILS 8
FIGURE 4: TONALITY ANALYSIS ACCORDING TO ANSI S12.9 PART 4 9

List of Tables

TABLE 1: MODELED TRANSFORMER OCTAVE BAND SOUND POWER LEVELS (DBZ) 3
TABLE 2: MAXIMUM C-WEIGHTED AND LOW-FREQUENCY OCTAVE BAND LEVELS 6

1.0 INTRODUCTION

Black Fork Wind is a proposed wind energy project in Crawford and Richland County, Ohio. The project has an Ohio Power Siting Board (OPSB) Certificate of Environmental Compatibility and Public Need (Certificate) (Case No. 10-2865-EL-BGN), but has not yet been built. For the original Certificate application, RSG performed sound propagation modeling, as summarized in RSG's report, *Sound Modeling for Black Fork Wind Farm: Richland & Crawford County, Ohio,* dated March 2011 (the "2011 Report"). Updates to sound modeling for the V100 2.2 MW turbine were provided in a memorandum to Capital Power on April 2, 2015.

Between the original report and modeling revisions, the project was permitted for the option of four turbine models: Vestas V100 1.8 MW, GE 1.6 XLE (1.6 MW), the Siemens 2.3-101 (2.3 MW), and the Vestas V100 2.2 MW.

Capital Power has retained RSG to conduct sound modeling of the new Siemens G132 3.55 MW turbine with DinoTail technology[1] and a reduced 56 turbine layout. This report provides results of the modeling, including

- Background information on the project and proposed turbine;
- Modeling of sound levels; and
- Conclusions.

[1] Dino-Tails are a wind turbine blade trailing edge treatment, developed by Siemens that lowers sound emissions.

2.0 PROJECT DESCRIPTION

2.1 | PROJECT OPSB CERTIFICATE

Black Fork Wind received a Certificate to Site a Wind-Powered Electric Generating Facility on January 23, 2012 (Case No. 10-2865-EL-BGN). The Certificate refers to the following stipulations that the Project will conform with:

(50) At least 30 days prior to the pre-construction conference and upon selection of the turbine model to be developed, the applicant shall provide the following to Staff for review and approval to the extent such information exists and is released to the applicant by the turbine manufacturer:

- (a) The low frequency sound values [sound pressure level (SPL), dB, Hz] expected to be produced.
- (b) The A-weighted and C-weighted sound power levels, as well as one-third octave band measurements for the 20 and 25 Hz bands, and a separate evaluation of the data for low frequency and impulsivity in accordance with the methodologies set forth within lEC 61400-11, Annex A, A.3, Low Frequency Noise, and A.4, Impulsivity.
- (c) The tonal audibility.

(51) If preconstruction acoustic modeling indicates a facility contribution that exceeds the project ambient nighttime L_{eq} (43 dBA) plus 5 dBA at the exterior of any nonparticipating residences within one mile of the facility boundary, the facility shall be subject to further study of the potential impact and possible mitigation prior to construction.

(52) After commencement of commercial operation, the applicant shall conduct further review of the impact and possible mitigation of all project noise complaints. Mitigation shall be required if the project contribution at the exterior of any nonparticipating residence within one mile of the project boundary exceeds the greater of: (a) the project ambient nighttime L_{eq} (43 dBA) plus 5 dBA; (b) the validly measured ambient L_{eq} plus five dBA at the location of the complaint and during the same time of day or night as that identified in the complaint; or (c) other means of mitigation approved by Staff in coordination with the affected receptors.

2.2 | PROJECT AREA

The proposed turbines are located to the west of Shelby, Ohio within Auburn, Plymouth, Vernon, Sharon, and Jackson Townships. The area is primarily flat and used for agriculture. There are approximately 1,500 homes in and around the project area.

Within one mile of any turbine, there are 84 participating residences, 819 non-participating residences, 12 schools, and one church.

2.3 | SOUND SOURCE DETAILS

The proposed project will have a power output of up to 200 MW in total. Depending on the individual turbine capacity, this would consist of up to 91 individual turbines. For the Siemens G132 3.55 MW, a maximum of 56 wind turbines could be installed, which is what is assumed for this configuration.

The G132 3.55 MW will be fitted with "DinoTails". These are serrations placed on portions of the trailing edge of each blade, developed by Siemens, which reduce the overall sound power by 1.5 dB. A photograph of the trailing edge is shown in Figure 1, next to a more conventional serrated trailing edge.

If further noise mitigation is required, then turbines can be put into a noise-reduced operating mode (NRO). NRO modes can reduce noise levels under specific conditions or times of day by reducing the rotational speed of the blade. However, in general, the more the blade speed is reduced, the lower the power output of the turbine. Therefore, NRO modes are used selectively. In this modeling study, none of the turbines are under NRO.

Sound power levels for the Siemens G132 3.55 MW wind turbine is under restricted release by the manufacturer. These can be made available under a proper protective agreement. The sound power used for modeling matches the specified sound power for the DinoTail-equipped turbine.

In addition to the wind turbines, there will be a transformer at the project substation. It steps voltage up from 36.5 to 138 kV and has a top rating of 100 MVA and 750 kV BIL for which the NEMA TR-1 standard is 79 dBA ONAN (fans off) and 82 dBA (fans on). The modeled sound power levels are shown in Table 1.

TABLE 1: MODELED TRANSFORMER OCTAVE BAND SOUND POWER LEVELS (dBZ)

31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	dBA
92	97.5	109.6	101.8	97.9	95.3	90.4	84.5	74.9	101

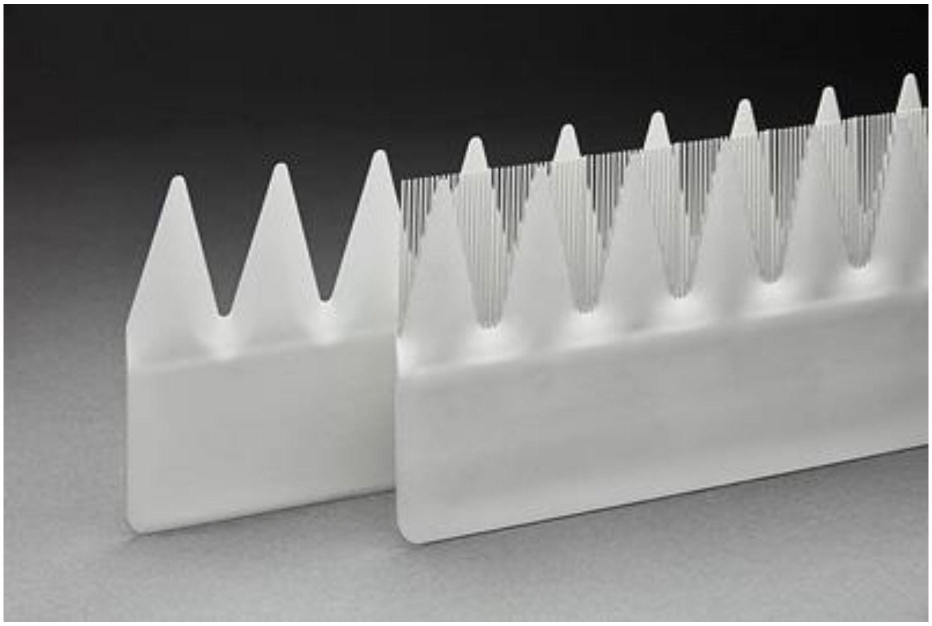


FIGURE 1: SIEMENS DINOTAILS SHOWN NEXT TO A CONVENTIONAL SERRATED TRAILING EDGE (PICTURE PRODUCED BY SIEMENS - WWW.SIEMENS.COM/PRESS)

3.0 SOUND MODELING

3.1 | METHODOLOGY

The same modeling methodology used to model the Siemens G132 3.55 MW turbine, was used in the 2011 Report and 2015 Memo. All modeling was based on the International Standards Organization ISO 9613-2 standard, "Acoustics – Attenuation of sound during propagation outdoors, Part 2: General Method of Calculation." The ISO standard states,

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

The model takes into account source sound power levels, surface reflection and absorption, atmospheric absorption, geometric divergence, meteorological conditions, walls, barriers, berms, and terrain. The ISO standard was implemented in the Cadna/A acoustical modeling software. Made by Datakustik GmbH, Cadna A is an internationally accepted acoustical model, used by many other noise control professionals in the United States and abroad. Cadna/A has also been used in the past for other OPSB permitting cases.

We modeled the sound propagation in accordance with ISO 9613-2 with spectral ground attenuation and hard ground (G=0). Each turbine was modeled at the manufacturer's maximum sound power level. These are conservative assumptions, consistent with prior modeling performed for the project.

The sound propagation model was run for 56 Siemens G132 3.55 MW wind turbines, all with DinoTails, and the Project substation transformer. Sound levels were calculated at over 1,400 participating and non-participating homes, schools, and churches around the project. A grid of receivers was also set up in the model, covering over 275 square kilometers (106 square miles), in which sound pressure levels were calculated every 20 meters (65 feet). This grid of receivers was used to develop sound level contour maps. Turbines were modeled with an 84-meter hub height.

3.2 | MODELING RESULTS

With all turbines producing maximum sound power, no participating or non-participating receptors exceed the 48 dBA OPSB Certificate limit. The highest modeled sound level is 47.3 dBA at a residence.

The sound contour maps are shown in Figures 2 and 3.

Table 2 shows low frequency sound levels at the worst-case residence with the mitigated turbines. C-weighted, 31.5 Hz, and 63 Hz octave band levels are directly modeled. The 16

Hz octave band is calculated as the modeled level at 31.5 Hz plus 3 dB, the overall slope of a wind turbine noise spectrum as determined by the Health Canada Study.[2]

The standard for interior noise to prevent moderately perceptible vibration and rattles, under American National Standards Institute standard, ANSI S12.2, "Criteria for Evaluating Room Noise," is 65 dB at 16 Hz and 31.5 Hz and 70 dB at 63 Hz, inside. At the worst-case non-participating residences, the modeled exterior sound level at 16 Hz, 31.5 Hz, and 63 Hz are 3.1 dB, 6.1 dB, and 20.5 dB below these criteria, respectively. The building shell will provide some additional attenuation, even with windows open. According to O'Neal et al 2011, the 16 Hz and 31.5 Hz open-windows attenuation is approximately 3 dB and 6 dB, respectively, which adjusts the ANSI S12.2 criterion to 68 dB at 16 Hz and 71 dBA at 31.5 Hz, outside the home.[3] Under this revised criterion, all non-participating and participating residences be well below the ANSI S12.2 criteria for moderately perceptible building vibration from wind turbine noise.

Tonal audibility levels under IEC 61400-14 are unavailable for the G132 wind turbine. However, our analysis of manufacturer 1/3 octave band sound power levels shows that there are no tones under the ANSI S12.9 Part 4 tonality criteria (Figure 4).

TABLE 2: MAXIMUM C-WEIGHTED AND LOW-FREQUENCY OCTAVE BAND LEVELS

	dBC	16 Hz (dB)	31.5 Hz (dB)	63 Hz (dB)
Participating	55.8	61.8	58.8	49.4
Non-Participating	55.9	61.9	58.9	49.5

[2] Keith, Stephen, et al. "Wind Turbine Sound Power Measurements." J. Acoust. Soc. Am. 139(3). March 2016.
[3] O'Neal, R., Hellweg, R., Lampeter, R., "Low frequency noise and infrasound from wind turbines," Noise Control Eng. J. 59(2), March-April 2011

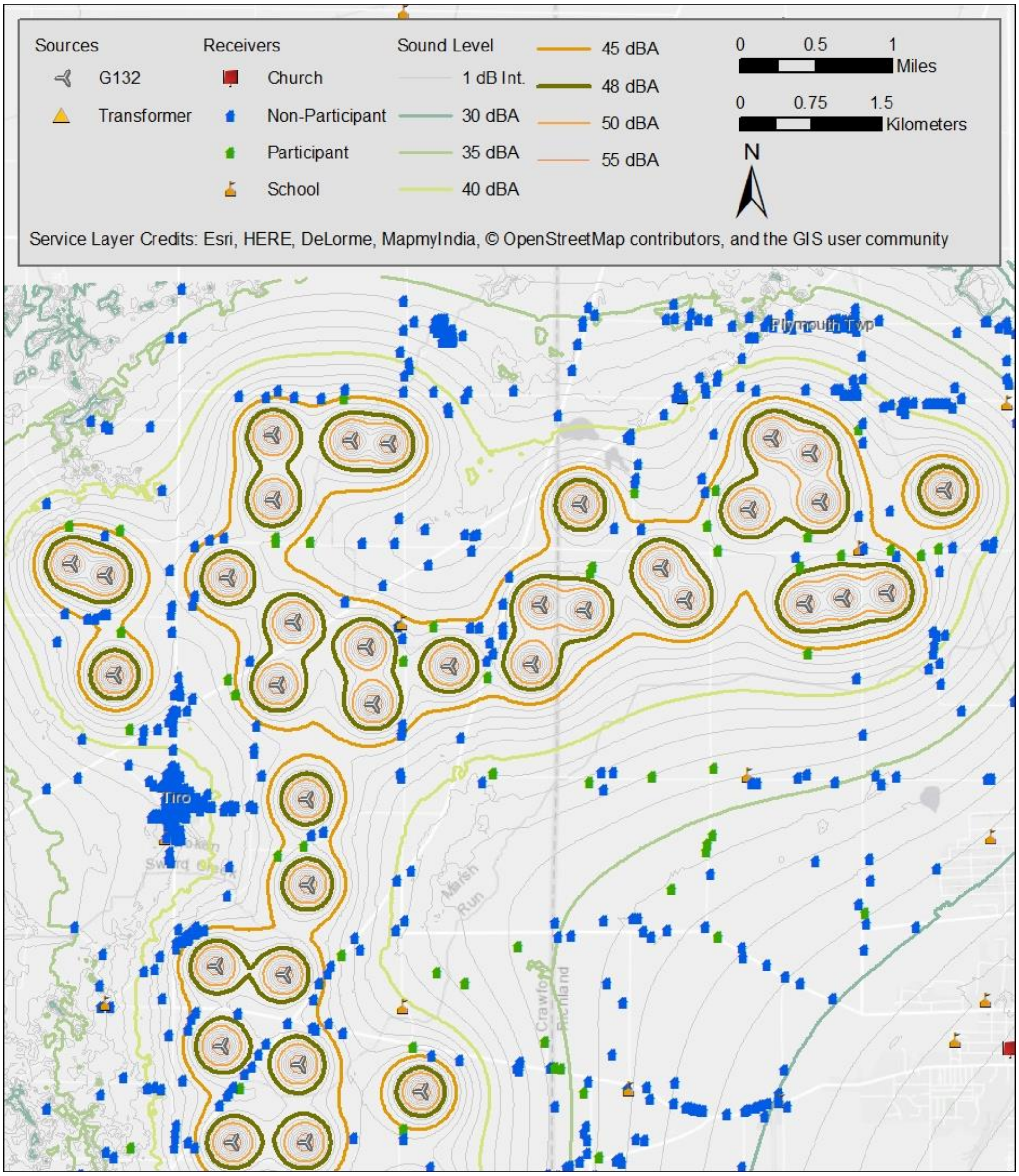


FIGURE 2: A-WEIGHTED SOUND PRESSURE LEVELS (NORTH) – SIEMENS G132 3.55 MW WITH DINOTAILS

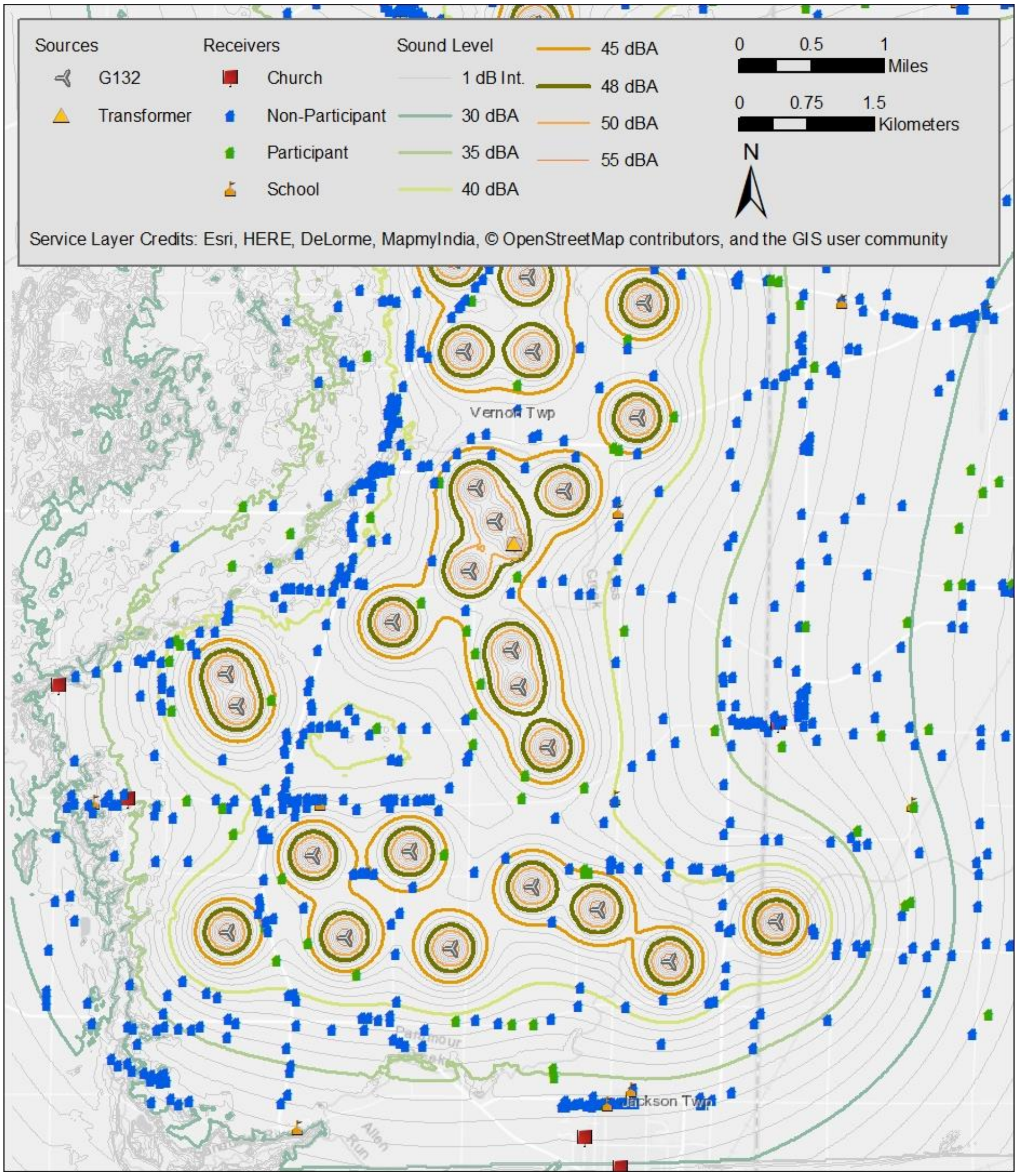


FIGURE 3: A-WEIGHTED SOUND PRESSURE LEVELS (SOUTH) – SIEMENS G132 3.55 MW WITH DINOTAILS

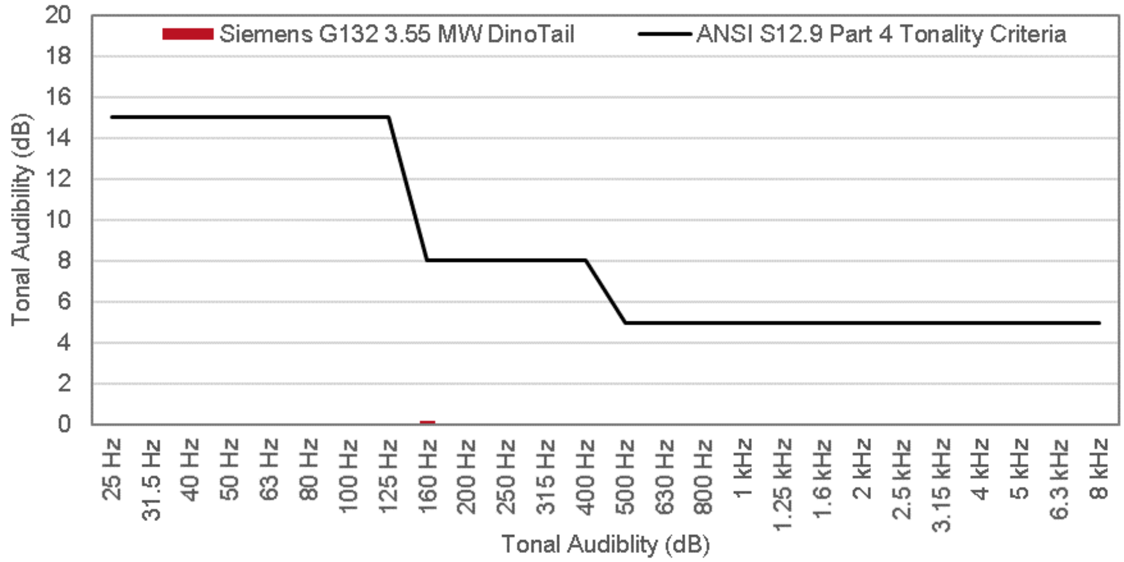


FIGURE 4: TONALITY ANALYSIS ACCORDING TO ANSI S12.9 PART 4

4.0 SUMMARY AND CONCLUSIONS

Black Fork Wind has a Siting Certificate from the Ohio Public Siting Board (OPSB). Since the Certificate was issued, the proposed turbine model was initially changed to a Vestas V110-2.2 MW wind turbine with STEs and reduced to 82 turbines. Now, the Siemens G132 3.55 MW with Dino Tails at an 84-meter hub height turbine is proposed to be used, as part of a 56-turbine array. This report updates the sound propagation model to include the new wind turbine model and layout.

The modeling methodology used in this report is the same as the original report and subsequent updates. The only items changed are the sound power of the selected wind turbine, the hub height of the selected turbine, and the quantity of modeled turbines. Some residences were also added to those modeled, due to the results of a recent survey. The results of the modeling are summarized as follows:

- The highest modeled sound level at a non-participating residence is 47.3 dBA, which is below the OPSB Certificate limit of 48 dBA.
- All non-participating and participating receivers are modeled to have interior sound levels below ANSI S12.2 - 2008 criteria for moderately perceptible noise-induced building vibration.
- The highest C-weighted sound level modeled at any non-participating receiver is 56 dBC.
- The turbine sound power levels show no indications of tonality using ANSI S12.9 Part 4 Annex C criteria.

Overall, the sound levels of the Siemens G132 3.55 MW DinoTail-equipped turbine as part of a 56-turbine array are modeled to meet the OPSB Certificate limits for the project.