SOUND LEVEL MODELING REPORT

Stark Wind Project
Herkimer County, New York

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1.0 EXECUTIVE SUMMARY

The Stark Wind Project (the Project) is a proposed wind power generation facility expected to consist of two (2) wind turbines in Herkimer County, New York. The Project is being developed by New Leaf Energy, Inc. (New Leaf). Epsilon Associates Inc. (Epsilon) has been retained by New Leaf to conduct a sound level modeling study for this Project. This report presents results of the sound level modeling from the proposed wind turbines in Herkimer County.

This sound level assessment includes computer modeling to predict worst-case future L_{eq} sound levels from the Project, and a comparison of operational sound levels to regulatory limits. The analysis was conducted for three different scenarios: two (2) Vestas V150-4.3 wind turbines; two (2) Vestas V163-4.5 wind turbines; and two (2) GE 3.4-140 wind turbines. This Project is required to comply with the Local Law of the Town of Stark, Herkimer County, New York (Local Laws) which are presented in Section 4 of this report. The Local Laws limit sound produced by wind turbines to 50 dBA at adjacent dwellings.

The worst-case L_{eq} sound levels produced by the Project were predicted through modeling. The highest predicted worst-case Project Only L_{eq} sound level at a modeling receptor is 39 dBA with the Vestas V150-4.3 wind turbines, 41 dBA with the Vestas V163-4.5 wind turbines, and 40 dBA with the GE 3.4-140 wind turbines. Therefore, under any wind turbine option, the Project meets the Town of Stark sound limit of 50 dBA.

2.0 INTRODUCTION

The proposed Project will consist of two (2) wind turbines. New Leaf is considering three different wind turbines: a Vestas V150-4.3 unit with a hub height of 120 meters, a Vestas V163-4.5 unit with a hub height of 113 meters, or a GE 3.4-140 unit with a hub height of 120 meters. Figure 2-1 shows the location of the wind turbines in Herkimer County over aerial imagery.

A detailed discussion of sound from wind turbines is presented in a white paper prepared by the Renewable Energy Research Laboratory.[1] A few points are repeated herein. Wind turbine sound can originate from two different sources: mechanical sound from the interaction of turbine components, and aerodynamic sound produced by the flow of air over the rotor blades. Prior to the 1990's, both were significant contributors to wind turbine sound. However, recent advances in wind turbine design have greatly reduced the contribution of mechanical sound. Aerodynamic sound has also been reduced from modern wind turbines due to slower rotational speeds and changes in materials of construction. Aerodynamic sound, in general, is broadband (has contributions from a wide range of frequencies). It originates from encounters of the wind turbine blades with localized airflow inhomogeneities and wakes from other turbine blades and from airflow across the surface of the blades, particularly the front and trailing edges. Aerodynamic sound generally increases with increasing wind speed up to a certain point, then typically remains constant, even with higher wind speeds. However, sound levels in general also increase with increasing wind speed with or without the presence of wind turbines.

This report presents the findings of a sound level modeling analysis for the Project. The Project wind turbine was modeled in CadnaA using sound data from Vestas and GE technical reports. The results of this analysis are found within this report.

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[1] Renewable Energy Research Laboratory, Department of Mechanical and Industrial Engineering, University of Massachusetts at Amherst, Wind Turbine Acoustic Noise, June 2002, amended January 2006.

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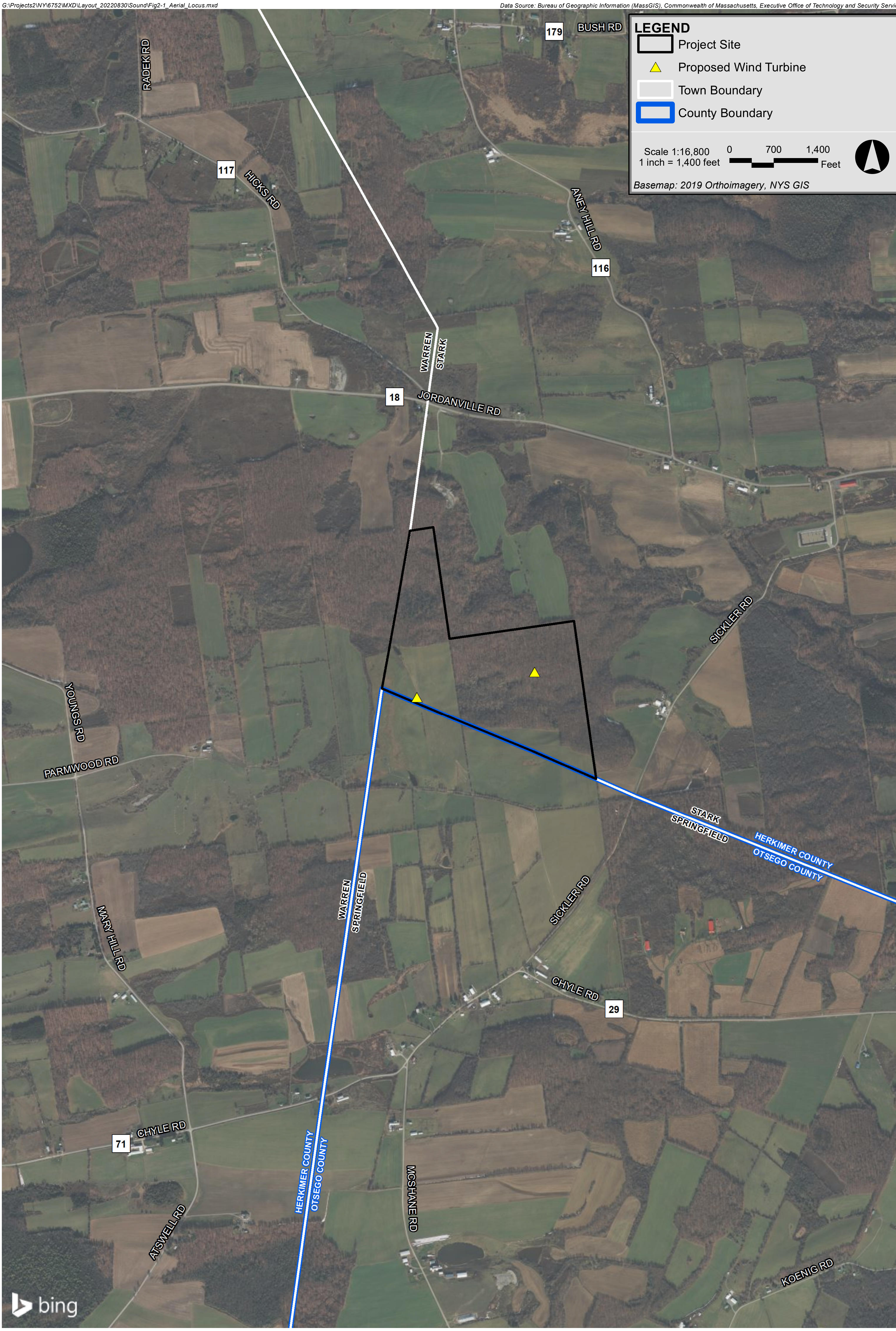
Data Source: Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services



Stark Wind **Stark, New York**

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Figure 2-1

Aerial Locus

3.0 SOUND TERMINOLOGY

There are several ways in which sound levels are measured and quantified. All of them use the logarithmic decibel (dB) scale. The following information defines the sound level terminology used in this analysis.

The decibel scale is logarithmic to accommodate the wide range of sound intensities found in the environment. A property of the decibel scale is that the sound pressure levels of two or more separate sounds are not directly additive. For example, if a sound of 50 dB is added to another sound of 50 dB, the total is only a 3-decibel increase (53 dB), which is equal to doubling in sound energy, but not equal to a doubling in decibel quantity (100 dB). Thus, every 3-dB change in sound level represents a doubling or halving of sound energy. The human ear does not perceive changes in the sound pressure level as equal changes in loudness. Scientific research demonstrates that the following general relationships hold between sound level and human perception for two sound levels with the same or very similar frequency characteristics[2]:

- 3 dBA increase or decrease results in a change in sound that is just perceptible to the average person,
- 5 dBA increase or decrease is described as a clearly noticeable change in sound level, and
- 10 dBA increase or decrease is described as twice or half as loud.

Another mathematical property of decibels is that if one source of sound is at least 10 dB louder than another source, then the total sound level is simply the sound level of the higher-level source. For example, a sound source at 60 dB plus another sound source at 47 dB is equal to 60 dB.

A sound level meter (SLM) that is used to measure sound is a standardized instrument.[3] It contains "weighting networks" (e.g., A-, C-, Z-weightings) to adjust the frequency response of the instrument. Frequencies, reported in Hertz (Hz), are detailed characterizations of sounds, often addressed in musical terms as "pitch" or "tone". The most commonly used weighting network is the A-weighting because it most closely approximates how the human ear responds to sound at various frequencies. The A-weighting network is the accepted scale used for community sound level measurements; therefore, sounds are frequently reported as detected with a sound level meter using this weighting. A-weighted sound levels emphasize middle frequency sounds (i.e., middle pitched – around 1,000 Hz), and de-emphasize low and high frequency sounds. These sound levels are reported in decibels designated as "dBA". The C-weighting network has a nearly flat response for frequencies between 63 Hz and 4,000 Hz and is noted as dBC. Z-weighted sound

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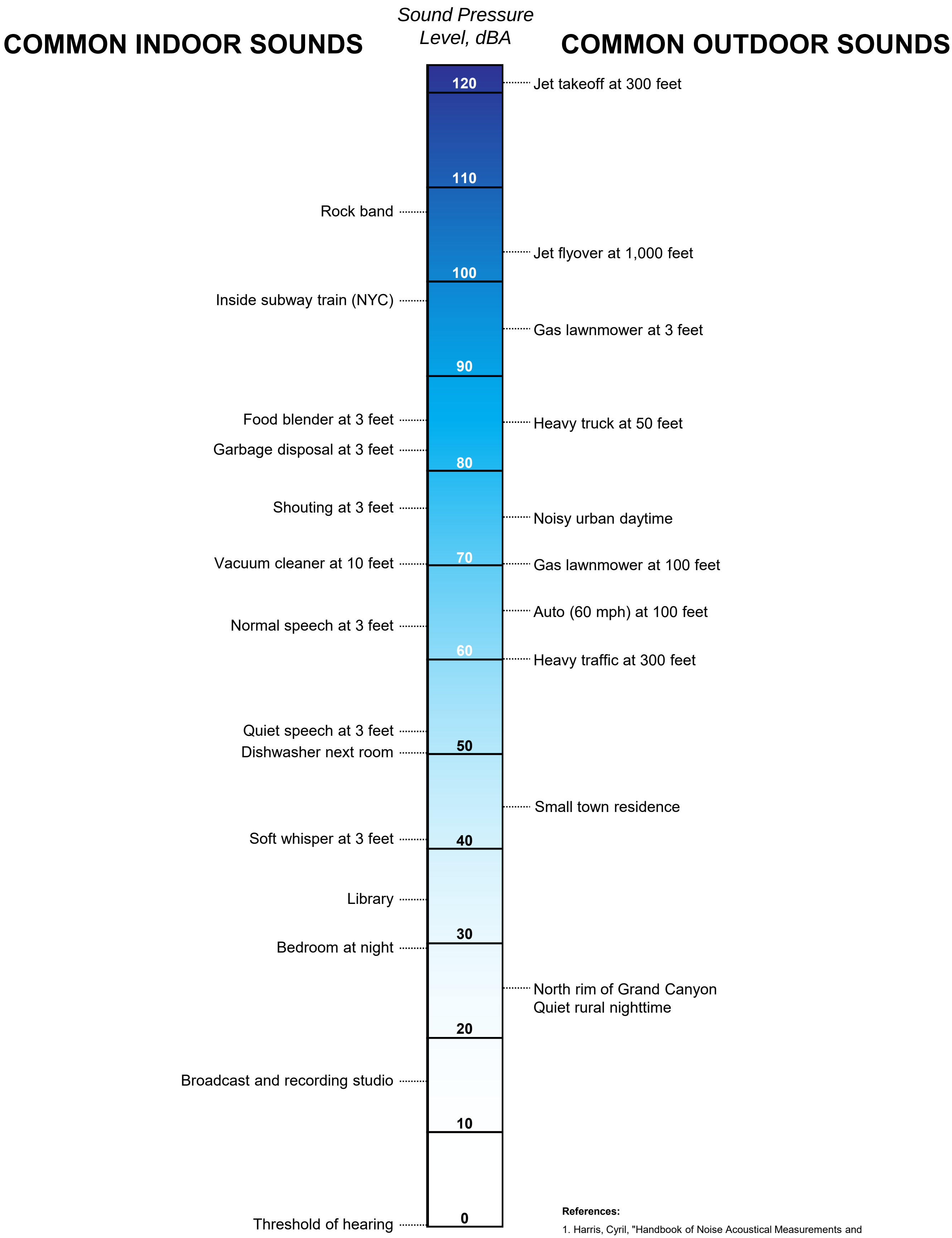
2 Bies, David, and Colin Hansen. 2009. *Engineering Noise Control: Theory and Practice*, 4th Edition. New York: Taylor and Francis.

3 *American National Standard Specification for* Sound *Level Meters*, ANSI S1.4-1983 (R2006), published by the Standards Secretariat of the Acoustical Society of America, Melville, NY.

levels are measured sound levels without any weighting curve and are otherwise referred to as "unweighted". Sound pressure levels for some common indoor and outdoor environments are shown in Figure 3-1.

Sounds in our environment vary with time. There are several sound level metrics that are reported in community sound monitoring. The Leq is referred to as the equivalent sound level and is the level of hypothetical steady sound that would have the same energy (i.e., the same time-averaged mean square sound pressure) as the actual fluctuating sound observed. The equivalent level is designated Leq and is typically A-weighted. The equivalent level represents the time average of the fluctuating sound pressure, but because sound is represented on a logarithmic scale and the averaging is done with linear mean square sound pressure values, the Leq is mostly determined by loud sounds is there are fluctuating sound levels.



References:

1. Harris, Cyril, "Handbook of Noise Acoustical Measurements and Noise Control", p 1-10., 1998
2. "Controlling Noise", USAF, AFMC, AFDTC, Elgin AFB, Fact Sheet, August 1996
3. California Dept. of Trans., "Technical Noise Supplement", Oct, 1998

Figure 3-1

Common Indoor and Outdoor Sound Levels

4.0 NOISE REGULATIONS

4.1 Town of Stark, NY Local Law

The Project, located within the Town of Stark, NY is required to comply with the Local Law of the Town of Stark, Herkimer County, New York which states:

> *Audible sound due to wind turbine operation shall not exceed fifty (50) dBA on a one hour average, when measured from adjacent dwelling units. In the event that the projected sound levels from a wind energy facility exceed the criteria listed above, a waiver to said levels may be granted by the Town Board provided that the following has been accomplished:*
>
> *(I) The Applicant implements sound mitigation measures that reduce sound levels below 50 dBA when measured from adjacent dwelling units, or;*
>
> *(II) The applicant obtains a permanent Sound Impact Easement to be recorded in the Herkimer County Clerk's office which describes the benefitted and burdened properties and which advises all subsequent owners of the burdened property that sound levels in excess of those permitted by this local law may exist on or at the burdened property as a result of the wind energy facility.*

Therefore, receptors have been evaluated against the L_{eq} sound level limit of 50 dBA in this analysis.

5.0 MODELED SOUND LEVELS

5.1 Sound Sources

5.1.1 Project Wind Turbines

The sound level analysis for the Project includes two (2) wind turbines. The Project will consist of either two Vestas V150-4.3 units with Serrated Trailing Edge (STE) blades, two Vestas V163-4.5 units with Serrated Trailing Edge (STE) blades, or two GE 3.4-140 unit with Low Noise Trailing Edge (LNTE) blades.

The V150-4.3 wind turbine has a rotor diameter of 150 meters. The wind turbine has a hub height of 120 meters. A technical report from Vestas[4] was provided to Epsilon which documented the expected sound power levels associated with the V150-4.3 under normal operation.

The V163-4.5 wind turbine has a rotor diameter of 163 meters. The wind turbine has a hub height of 113 meters. A technical report from Vestas[5] was provided to Epsilon which documented the expected sound power levels associated with the V163-4.5 under normal operation.

The GE 3.4-140 wind turbine has a rotor diameter of 140 meters. The wind turbine has a hub height of 120 meters. A technical report from GE[6] was provided to Epsilon which documented the expected sound power levels associated with the GE 3.4-140 under normal operation.

5.2 Modeling Methodology

The sound impacts associated with the proposed wind turbines were predicted using the CadnaA sound level calculation software developed by DataKustik GmbH. This software uses the ISO 9613-2 international standard for sound propagation.[7] The benefits of this software are a more refined set of computations due to the inclusion of topography, ground attenuation, multiple building reflections (if applicable), drop-off with distance, and atmospheric absorption. The CadnaA software allows for octave band calculation of sound from multiple sources as well as computation of diffraction.

Inputs and significant parameters employed in the model are described below.

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4 Restricted V150-4.3 MW Third Octave Noise Emission, 11-11-2020.

5 Restricted V163-4.5 MW Third Octave Noise Emission, 9-15-2022.

6 General Electric Company, Technical Documentation Wind Turbine Generator Systems Sierra 140 – 60 Hz Product Acoustic Specifications, 2021.

7 *Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation,* International Standard ISO 9613-2:1996 (International Organization for Standardization, Geneva, Switzerland, 1996).

- *Project Layout:* This analysis is for the wind turbine array dated August 30, 2022. The proposed Project layout is identified in Figure 5-1 and location coordinates are provided in Appendix A.
- *Modeling Receptor Locations:* Epsilon generated a modeling receptor dataset consisting of 25 receptors via desktop analysis. The dataset is representative of residential buildings within the vicinity of the project. All modeling receptors were input as discrete points at a height of 1.5 meters above ground level to mimic the ears of a typical standing person.
- *Modeling Grid:* A modeling grid with 20-meter spacing was calculated for the entire Project Area and the surrounding region. The grid was modeled at a height of 1.5 meters above ground level for consistency with the discrete modeling points. This modeling grid allowed for the creation of sound level isolines.
- *Terrain Elevation:* Elevation contours for the modeling domain were directly imported into CadnaA which allowed for consideration of terrain shielding where appropriate. The terrain height contour elevations for the modeling domain were generated from elevation information derived from the National Elevation Dataset (NED) developed by the U.S. Geological Survey.
- *Source Sound Levels:* Sound power levels used in the modeling were described in Section 5.1. Documentation from Vestas and GE provided levels that represent "worst-case" operational sound level emissions for the Project's proposed wind turbines.
- *Meteorological Conditions:* A temperature of 10°C (50°F) and a relative humidity of 70% was assumed in the model.
- *Ground Attenuation:* Spectral ground absorption was calculated using a G-factor of 0 which corresponds to "hard ground" consisting of a hard ground surface. The model, consistent with the standard, allows inputs between 0 (hard ground) and 1 (porous ground). This is a conservative approach as the vast majority of the area is actually agricultural.

Octave band sound power levels corresponding to the highest available wind turbine broadband sound power level for the wind turbine were input into CadnaA to model wind turbine generated broadband sound pressure levels during conditions when worst-case sound power levels are expected. Sound pressure levels were modeled at 25 receptors within the vicinity of the Project. In addition to modeling at discrete points, sound levels were also modeled throughout a large grid of points, each spaced 20 meters apart to allow for the generation of sound level isolines.

Several modeling assumptions inherent in the ISO 9613-2 calculation methodology, or selected as conditional inputs by Epsilon, were implemented in the CadnaA model to ensure conservative results (i.e., higher sound levels), and are described below:

- All modeled sources were assumed to be operating simultaneously and at the design wind speed corresponding to the greatest sound level impacts.

- As per ISO 9613-2, the model assumed favorable conditions for sound propagation, corresponding to a moderate, well-developed ground-based temperature inversion, as might occur on a calm, clear night or equivalently downwind propagation.
- Meteorological conditions assumed in the model (T=10℃/RH=70%) were selected to minimize atmospheric attenuation in the 500 Hz and 1 kHz octave bands where the human ear is most sensitive.
- No additional attenuation due to tree shielding, air turbulence, or wind shadow effects was considered in the model.

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Data Source: Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services

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Figure 5-1

Sound Level Modeling Locations

5.3 Sound Level Modeling Results

All modeled sound levels, as output from CadnaA are A-weighted equivalent sound levels (L_{eq}, dBA). Calculations were conducted at the 25 receptors modeled within the project area. In addition to the discrete modeling points, sound level isolines were generated from the modeling grid.

5.3.1 Project Only Results – V150-4.3

Table B-1 in Appendix B shows the predicted "Project Only" broadband (L_{eq}, dBA) sound levels from the Vestas V150-4.3 wind turbines at the 25 receptors modeled in the vicinity of the Project. These broadband sound levels range from 23 to 39 dBA and represent the worst-case sound levels produced solely by the Project wind turbines. The highest predicted sound level of 39 dBA occurs at receptor #10. In addition to the discrete modeling points, sound level isolines generated from the modeling grid are presented in Figure 5-2.

5.3.2 Project Only Results – V163-4.5

Table B-2 in Appendix B shows the predicted "Project Only" broadband (L_{eq}, dBA) sound levels from the Vestas V150-4.3 wind turbines at the 25 receptors modeled in the vicinity of the Project. These broadband sound levels range from 26 to 41 dBA and represent the worst-case sound levels produced solely by the Project wind turbines. The highest predicted sound level of 41 dBA occurs at receptor #10. In addition to the discrete modeling points, sound level isolines generated from the modeling grid are presented in Figure 5-3.

5.3.3 Project Only Results – GE 3.4-140

Table B-3 in Appendix B shows the predicted "Project Only" broadband (L_{eq}, dBA) sound levels from the GE 3.4-140 wind turbines at the 25 receptors modeled in the vicinity of the Project. These broadband sound levels range from 24 to 40 dBA and represent the worst-case sound levels produced solely by the Project wind turbines. The highest predicted sound level of 40 dBA occurs at receptor #10. In addition to the discrete modeling points, sound level isolines generated from the modeling grid are presented in Figure 5-4.

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Data Source: Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services

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Figure 5-2

Project Only Sound Level Modeling Results – Vestas V150-4.3

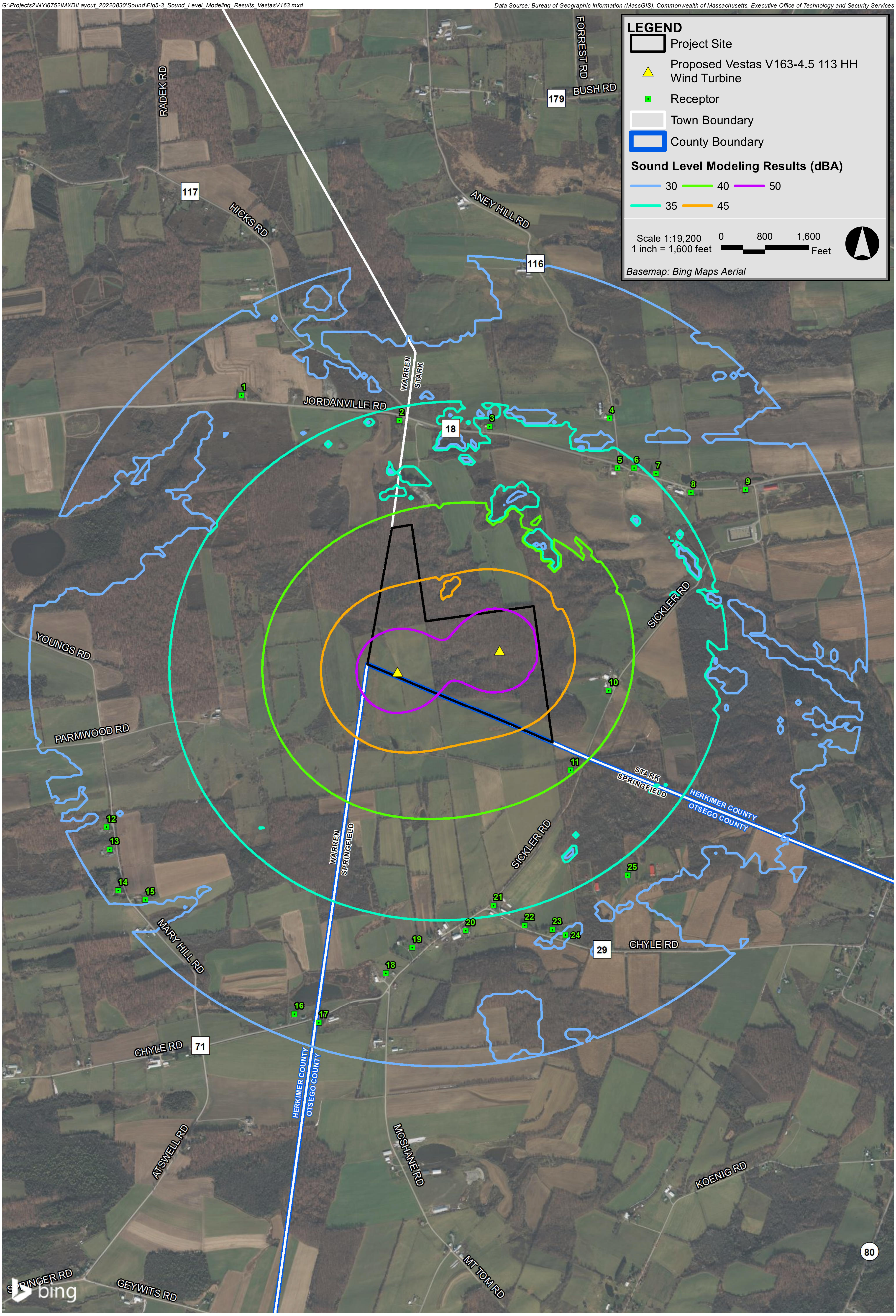

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Figure 5-3

Project Only Sound Level Modeling Results – Vestas V163-4.5

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Data Source: Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services

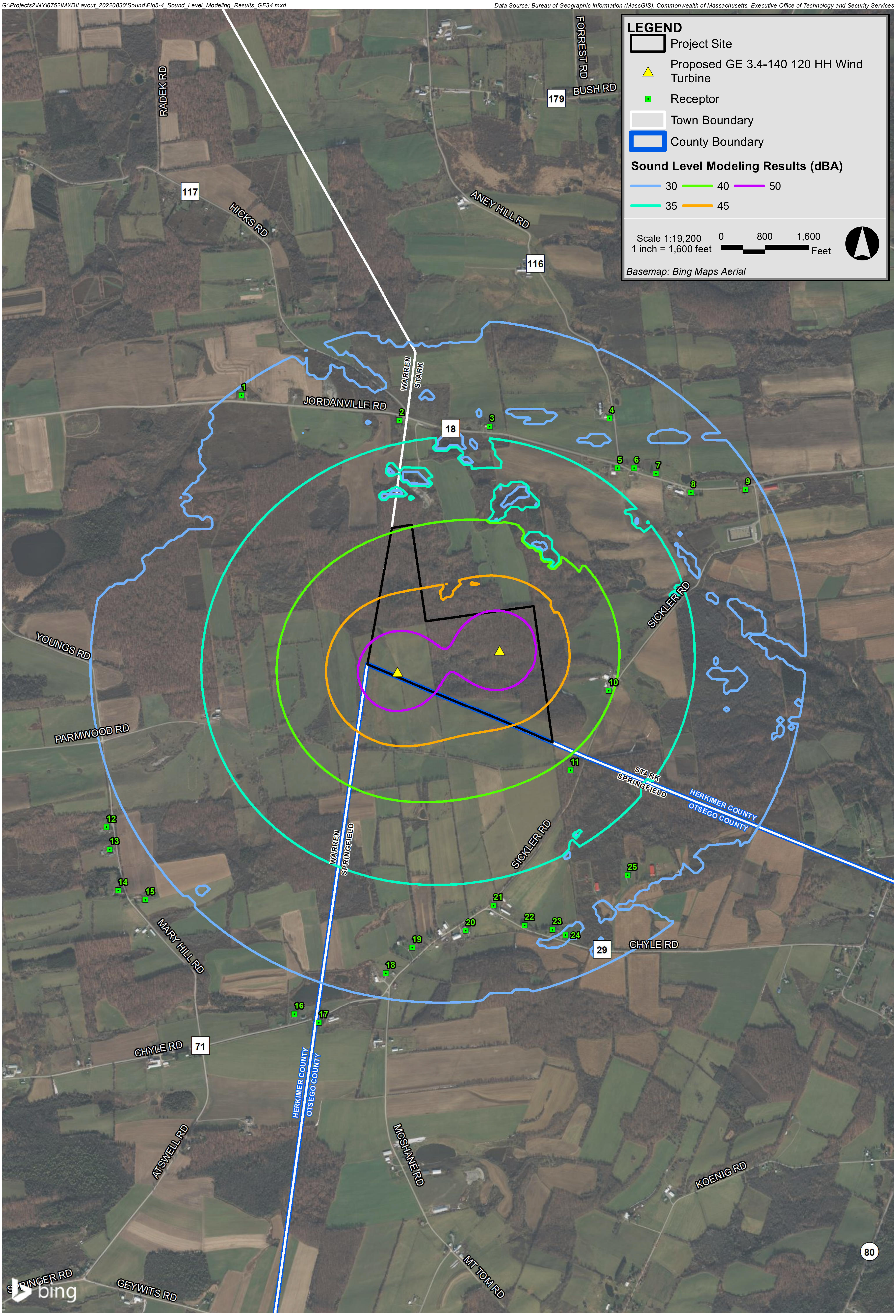

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Figure 5-3

Project Only Sound Level Modeling Results – GE 3.4-140

6.0 EVALUATION OF SOUND LEVELS

The proposed Stark Wind Project within Herkimer County, New York is required to comply with the sound level requirements in the Local Law of the Town of Stark, New York. The Local Law limits sound levels from wind turbines to 50 dBA at adjacent dwellings. Therefore, receptors within the Town of Stark have been evaluated against the sound level limit of 50 dBA in this analysis.

All modeled sound levels, as output from CadnaA, are A-weighted equivalent sound levels (L_{eq}, dBA). These levels may be used in evaluating measured sound pressure levels over typical averaging durations, (i.e., 10 minutes or 1 hour). The highest predicted worst-case Project Only L_{eq} sound level at a modeling receptor is 39 dBA with the Vestas V150-4.3 wind turbines, 41 dBA with the Vestas V163-4.5 wind turbines, and 40 dBA with the GE 3.4-140 wind turbines. This occurs at receptor ID #10 for all modeling scenarios. All predicted worst-case Project Only L_{eq} sound levels are below 50 dBA; therefore, the Project meets the requirements with respect to sound in the Local Law.

7.0 CONCLUSIONS

A comprehensive sound level modeling assessment was conducted for the proposed Stark Wind Project. A total of two (2) wind turbines are included for this Project with three different scenarios. Sound levels resulting from the operation of these two scenarios were calculated at 25 discrete modeling points, and isolines were generated from a grid encompassing the area surrounding the wind turbines using the provided layout. The predicted sound levels at receptors in the Town of Stark ranged from 23 to 39 dBA assuming a Vestas V150-4.3 wind turbines, 26 to 41 dBA assuming a Vestas V163-4.5 wind turbines, and 24 to 40 dBA assuming a GE 3.4-140 wind turbines. Therefore, the Project meets the requirements with respect to sound in the Town of Stark Local Law.

Appendix A

Wind Turbine Coordinates

Table A-1.1: Wind Turbine Coordinates - V150

Wind Turbine ID	Wind Turbine Type	Hub Height (m)	Coordinates NAD83 UTM Zone 18N (meters)	
			X (Easting)	Y (Northing)
1	Vestas V150-4.3	120	510066.90	4749510.03
2	Vestas V150-4.3	120	510635.55	4749631.03

Table A-1.2: Wind Turbine Coordinates - V163

Wind Turbine ID	Wind Turbine Type	Hub Height (m)	Coordinates NAD83 UTM Zone 18N (meters)	
			X (Easting)	Y (Northing)
1	Vestas V163-4.5	113	510066.90	4749510.03
2	Vestas V163-4.5	113	510635.55	4749631.03

Table A-1.3: Wind Turbine Coordinates - GE 3.4-140

Wind Turbine ID	Wind Turbine Type	Hub Height (m)	Coordinates NAD83 UTM Zone 18N (meters)	
			X (Easting)	Y (Northing)
1	GE 3.4-140	120	510066.90	4749510.03
2	GE 3.4-140	120	510635.55	4749631.03

Appendix B

Project Only Sound Level Modeling Results at Discrete Points

Table B-1: Sound Level Modeling Results Sorted by Receptor ID (V150-4.3)

Receptor ID	Coordinates UTM NAD83 Zone 18N		Source Only L_{eq} Broadband Sound Level (dBA)
	X (m)	Y (m)	
1	509197.47	4751051.79	29
2	510076.60	4750909.69	33
3	510580.35	4750877.12	33
4	511248.38	4750922.84	31
5	511293.16	4750644.94	33
6	511384.60	4750644.73	32
7	511506.61	4750614.60	32
8	511702.33	4750509.17	31
9	512006.72	4750524.79	30
10	511244.08	4749405.28	39
11	511031.70	4748960.72	38
12	508444.60	4748644.52	28
13	508462.85	4748519.47	28
14	508509.56	4748291.42	27
15	508660.65	4748239.10	28
16	509491.44	4747601.00	28
17	509628.50	4747553.11	28
18	510001.15	4747829.23	30
19	510148.07	4747972.39	31
20	510448.11	4748066.93	32
21	510601.15	4748207.84	33
22	510776.39	4748097.01	32
23	510929.80	4748072.64	31
24	511002.82	4748043.00	23
25	511349.45	4748375.62	32

Table B-2: Sound Level Modeling Results Sorted by Receptor ID (V163-4.5)

Receptor ID	Coordinates UTM NAD83 Zone 18N X (m)	Coordinates UTM NAD83 Zone 18N Y (m)	Source Only L_{eq} Broadband Sound Level (dBA)
1	509197.47	4751051.79	32
2	510076.60	4750909.69	36
3	510580.35	4750877.12	36
4	511248.38	4750922.84	34
5	511293.16	4750644.94	36
6	511384.60	4750644.73	35
7	511506.61	4750614.60	35
8	511702.33	4750509.17	34
9	512006.72	4750524.79	32
10	511244.08	4749405.28	41
11	511031.70	4748960.72	40
12	508444.60	4748644.52	31
13	508462.85	4748519.47	31
14	508509.56	4748291.42	31
15	508660.65	4748239.10	31
16	509491.44	4747601.00	31
17	509628.50	4747553.11	31
18	510001.15	4747829.23	33
19	510148.07	4747972.39	34
20	510448.11	4748066.93	35
21	510601.15	4748207.84	35
22	510776.39	4748097.01	34
23	510929.80	4748072.64	34
24	511002.82	4748043.00	26
25	511349.45	4748375.62	34

Table B-3: Sound Level Modeling Results Sorted by Receptor ID (GE 3.4-140)

Receptor ID	Coordinates UTM NAD83 Zone 18N		Source Only L_{eq} Broadband Sound Level (dBA)
	X (m)	Y (m)	
1	509197.47	4751051.79	30
2	510076.60	4750909.69	34
3	510580.35	4750877.12	34
4	511248.38	4750922.84	32
5	511293.16	4750644.94	34
6	511384.60	4750644.73	34
7	511506.61	4750614.60	33
8	511702.33	4750509.17	33
9	512006.72	4750524.79	31
10	511244.08	4749405.28	40
11	511031.70	4748960.72	39
12	508444.60	4748644.52	29
13	508462.85	4748519.47	29
14	508509.56	4748291.42	28
15	508660.65	4748239.10	29
16	509491.44	4747601.00	29
17	509628.50	4747553.11	29
18	510001.15	4747829.23	31
19	510148.07	4747972.39	32
20	510448.11	4748066.93	33
21	510601.15	4748207.84	34
22	510776.39	4748097.01	33
23	510929.80	4748072.64	32
24	511002.82	4748043.00	24
25	511349.45	4748375.62	33