
***REVISED ACOUSTIC STUDY OF THE
KINGSTON WIND TURBINE PROJECT
KINGSTON, MASSACHUSETTS***

November 2010

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1.0 EXECUTIVE SUMMARY

The Town of Kingston proposes to locate a wind turbine near its wastewater treatment plant off Cranberry Road near Route 3. This study examines the sound effects from three potential wind turbine models (Vestas V90 1.8-MW, Hyundai Heavy Industries HHI 1.65-MW, and HHI 2.0-MW) at an 80-meter hub height. Acoustic modeling was done for the cut-in and design wind speed operating conditions. The cut-in wind speed represents the lowest sound power output of the turbine. The design wind speed is the lowest wind speed at hub height at which maximum sound power is produced. Existing sound levels on the site and in nearby residential areas were measured on July 8 and 9, 2008. The study's conclusions are as follows:

- The wind turbine Project complies with the Massachusetts DEP Noise Policy concerning the increases in total sound level at all nearby residential properties for all turbine models evaluated.
- The wind turbine Project complies with the Massachusetts DEP Noise Policy concerning pure tones for all turbine models evaluated. The Project will not produce pure tones.
- The Project will increase the ambient L_{90} sound level¹ by 0.1 dBA to 7.5 dBA within the adjacent residential neighborhoods, depending on turbine type, exact receptor location, and weather conditions. The Vestas V90 would increase L_{90} levels 0.1 to 4.6 dBA, the HHI 1.65-MW turbine would increase L_{90} levels 0.3 to 5.5 dBA, and the HHI 2.0-MW turbine would increase L_{90} levels 0.2 to 7.5 dBA.
- The Vestas V90 turbine is the quietest of the three models examined, and the HHI 2.0-MW is the loudest one.
- The study results are conservative for four reasons: 1) Turbine vendor-guaranteed maximum sound power levels were assumed; 2) The minimum L_{90} sound levels were used as the ambient condition; 3) The acoustic model assumed favorable sound propagation with a ground-based temperature inversion, such as might occur on a clear night; and 4) winter frozen ground conditions were assumed with no attenuation from trees or vegetation.
- The Project will be audible at certain times in the residential areas next to the project area. The “swishing” sound characteristic of a wind turbine will be audible outdoors when these three conditions all occur: 1) the residential area is downwind of the wind turbine, 2) ambient sound levels are low (usually late at night with calm surface winds), and 3) wind speeds at the hub height of the turbine are high enough for wind turbine operation. Project sounds are unlikely to be audible inside any residence.

¹ The L_{90} sound level represents the quietest 10 percent of any time period.

2.0 COMMON MEASURES OF COMMUNITY SOUND

All sounds originate with a source – a human voice, vehicles on a roadway, or an airplane overhead. The sound energy moves from the source to a person’s ears as sound waves, which are minute variations in air pressure. The loudness of a sound depends on the sound pressure level, defined as the ratio of two pressures: the measured sound pressure from the source divided by a reference pressure (the quietest sound we can hear). The unit of sound pressure is the decibel (dB). The decibel scale is logarithmic to accommodate the wide range of sound intensities to which the human ear is subjected. On this scale, the quietest sound we can hear is 0 dB, while the loudest is 120 dB. Most sounds we hear in our daily lives have sound pressure levels in the range of 30 dB to 100 dB.

A property of the decibel scale is that the sound pressure levels of two separate sounds are not directly additive. For example, if a sound of 70 dB is added to another sound of 70 dB, the total is only a 3-decibel increase (or 73 dB), not a doubling to 140 dB. In terms of the human perception of sound, a halving or doubling of loudness requires changes in the sound pressure level of about 10 dB; 3 dB is the minimum perceptible change for broadband sounds, i.e. sounds that include all frequencies. Typical sound levels associated with various activities and environments are presented in Table 1. The distance to a major road often determines the acoustic environment in a semi-rural area such as the Kingston site, as roadway traffic establishes the background sound levels. In particular, noise from Route 3 determines much of the background level at locations near this site.

Sound exposure in a community is commonly expressed in terms of the A-weighted sound level (dBA); A-weighting approximates the frequency response of the human ear. Levels of many sounds change from moment to moment. Some are sharp impulses lasting one second or less, while others rise and fall over much longer periods of time. There are various measures of sound pressure designed for different purposes. To establish the background ambient sound level in an area, the L_{90} metric, which is the sound level exceeded 90 percent of the time, is typically used. The L_{90} can also be thought of as the level representing the quietest 10 percent of any time period and is a broadband sound pressure measure. The L_{eq} , or equivalent sound level, is the steady-state sound level over a period of time that has the same acoustic energy as the fluctuating sounds that actually occurred during that same period. It is commonly referred to as the average sound level. Sound level measurements typically include an

analysis of the sound spectrum into its various frequency components to determine tonal characteristics. The unit of frequency is Hertz (Hz), measuring the cycles per second of the sound pressure waves, and typically the frequency analysis examines eleven octave bands from 16 to 16,000 Hz.

TABLE 1
VARIOUS INDOOR AND OUTDOOR SOUND LEVELS

<u>Outdoor Sound Levels</u>	<u>Sound Pressure</u> <u>(μPa)</u>	-	<u>Sound Level</u> <u>(dBA)</u>	<u>Indoor Sound Levels</u>
Jet Over-Flight at 300 m	6,324,555	-	110	Rock Band at 5 m
Gas Lawn Mower at 1 m	2,000,000	-	105	Inside New York Subway Train
Diesel Truck at 15 m	632,456	-	100	Food Blender at 1 m
Noisy Urban Area--Daytime	200,000	-	95	Garbage Disposal at 1 m
Gas Lawn Mower at 30 m	63,246	-	90	Shouting at 1 m
Suburban Commercial Area	20,000	-	85	Vacuum Cleaner at 3 m
Quiet Urban Area -- Daytime	6,325	-	80	Normal Speech at 1 m
Quiet Urban Area--Nighttime	2,000	-	75	Quiet Conversation at 1m
Suburban Area--Nighttime	632	-	70	Dishwasher Next Room
Rural Area--Nighttime	200	-	65	Empty Theater or Library
Rustling Leaves	63	-	60	Quiet Bedroom at Night
Reference Pressure Level	20	-	55	Empty Concert Hall
		-	50	Average Whisper
		-	45	Broadcast and Recording Studios
		-	40	Human Breathing
		-	35	Threshold of Hearing
		-	30	
		-	25	
		-	20	
		-	15	
		-	10	
		-	5	
		-	0	

Notes:

μ Pa - Micropascals describe sound pressure levels (force/area).

dBA - A-weighted decibels describe sound pressure on a logarithmic scale with respect to 20 μ Pa.

3.0 NOISE REGULATIONS AND CRITERIA

3.1 Massachusetts DEP Noise Policy

The Department of Environmental Protection (DEP) regulates noise through 310 CMR 7.00, "Air Pollution Control". In these regulations "air contaminant" is defined to include noise, and a condition of "air pollution" includes the presence of an air contaminant in such concentration and duration as to "cause a nuisance" or "unreasonably interfere with the comfortable enjoyment of life and property". Regulation 310 CMR 7.10 prohibits "unnecessary emissions" of noise.

The DEP Noise Policy (Policy Statement 90-001, July 1, 1990) interprets a violation of this regulation to have occurred if the sound source causes either:

- 1) An increase in the broadband sound pressure level of more than 10 dBA above the ambient, or
- 2) A "pure tone" condition.²

The ambient background level is defined by DEP as the lowest L₉₀ level measured during equipment operating hours, which for a wind turbine is any hour night or day. The DEP Noise Policy is included in Appendix A.

3.2 Town of Kingston Noise By Law

The town of Kingston Zoning By-Law No. 4.16.6.3 states that noise from wind turbines shall conform to the MassDEP noise regulations, stated above.

²A "pure tone" condition occurs when any octave band sound pressure level exceeds both of the two adjacent octave band sound pressure levels by 3 dB or more.

4.0 AMBIENT SOUND LEVEL AND WIND MEASUREMENTS

The Kingston wind turbine will be located on town land near the existing wastewater treatment plant (WWTP). Figure 1 presents the potential turbine location, the short term sound monitoring locations (S1-S3), the long term monitoring location (L), and the 10-m meteorological tower where wind speed was recorded (WS). The closest residences are east of the wind turbine across Route 3 on Prospect Street. Other nearby residences are to the north and across Route 3 at Mayflower Street and to the west along Copper Beech Drive.

Wind measurements were made on-site during the entire measurement period. A 10-meter tower with a wind vane anemometer (R.M. Young Co. Model 3002) was used to record wind speed and direction, and one-hour averages were recorded by a data logger (R.M. Young Model 26700). The meteorological station was set up on an open location at the Kingston WWTP, as shown in Figure 1. The measured on-site wind data are included in Appendix B.

To estimate when the wind would be blowing and at what speed, the measured on-site wind speed at the 10-m tower was extrapolated to hub height of 80 meters using a reference roughness length of 0.3, corresponding to a wooded area.³ The result of this calculation states that wind speeds at hub height are on-average 1.59 times greater than 10-meter wind speeds.

The long-term sound monitoring station was placed behind the nearest residence to the west, near the southwest end of Copper Beech Drive. Long-term sound level monitoring was performed from 12 p.m. July 8, 2008 to 3:00 a.m., July 9, 2008, when the meter malfunctioned, to document L_{90} and L_{eq} hourly sound levels, day and night, over a range of wind conditions. Although this was a relatively short monitoring period, average wind speeds were above the cut-in speed of 4 m/sec for the entire monitoring period, giving better than expected data. When the long-term sound monitoring station was set up, skies were partly cloudy, the temperature was about 93⁰ F and the winds were gusty (5-15) mph

³ International Electrotechnical Commission, International Standard IEC 61400-11, "Wind turbine generator systems- Part 11: Acoustic sound measurements techniques," 2006, page 20.

from the southwest. The audible sounds in the residential areas were wind in the trees, traffic on Route 3, and small aircraft.

Supplemental short-term (30 minute) sound monitoring, day and night, was done in the areas surrounding the plant on July 8-9, 2008. This was done during winds of about 3-15 mph, during the day, and under slightly lower wind levels, about 1-5 mph at night. The short-term monitoring locations are labeled #S1 through #S3 on Figure 1, and are listed below in Table 2.

**TABLE 2
SHORT TERM MEASUREMENT LOCATIONS**

Receptor #	Residential Location
S1	47 Mayflower Street
S2	49 Prospect Street
S3	6 Copper Beech Drive

All sound level measurements were taken with Larson Davis Model 824 and CEL Model 593 real-time sound level analyzers, which are equipped with precision condenser microphones having an operating range of 5 dB to 140 dB, and an overall frequency range of 3.5 to 20,000 Hz. These meters meet or exceed all requirements set forth in the American National Standards Institute (ANSI) Standards for Type 1 for quality and accuracy. Prior to and immediately following both measurement sessions, the sound analyzers were calibrated (no level adjustment was required) with an ANSI Type 1 calibrator which has an accuracy traceable to the National Institute of Standards and Technology (NIST). All instrumentation was laboratory calibrated per ANSI recommendations. For all measurement sessions, the microphone was fitted with an environmental windscreen to negate wind noise and mounted at a height of 1.3 meters above grade. Measurements were made away from any vertical reflecting surfaces in compliance with ANSI Standard S12.9.⁴ The sound data are summarized in Appendix B.

⁴ Acoustical Society of America, ANSI Standard S12.9-1997/Part 2, "Quantities and Procedures for Description and Measurement of Environmental Sound. Part 2: Measurement of Long-Term Wind-Area Sound."

Appendix B-1 summarizes the hourly measurements of L_{90} sound levels at the long-term monitoring station and the estimated hourly average wind speed at hub height. The values that are in bold text correspond to hours when the wind turbines would likely be operating, which was the entire monitoring period (hub height wind speeds of 4 m/s or greater). The values that are in bold and italic text correspond to hours when the wind turbines would be near the design wind speed (hub height wind speeds of about 8 to 10 m/s or greater). The data in Appendix B-1 reveal 1-hour L_{90} sound levels at the Copper Beech Drive long-term monitoring station as low as 34 dBA and as high as 44 dBA; these measured levels are typical for a suburban area.

During the measurement period, there were 13 hours when hub height winds were above the typical cut-in wind speed of 4 m/sec and the wind turbines could have been operating. Hub height winds were in the range of 4-9 m/sec and averaged 6.6 m/sec for these hours; the corresponding L_{90} levels averaged 42 dBA, with the lowest L_{90} being 34 dBA. Winds were measured at or above the typical design wind condition of 8 m/s at hub height for about 3 hours; note however that these hours corresponded to rush hour traffic times on Route 3, so they cannot be used as typical noise levels at this location. Nighttime L_{90} levels (between midnight and 3:00 A.M.) averaged about 34 dBA when the wind was blowing above the cut-in speed. These correspond to the quietest nighttime hours. Since the wind blowing at 5 m/s was 3-5 m/sec below the 8-10 m/sec level during this time, a conservative 2-dBA correction⁵ was added to the levels to adjust for the difference between measured and design wind speeds, giving a level of 36 dBA as the background during operational periods for the design speed condition. This is the level which will be used for the DEP compliance verification at the nearest residences. For the purpose of the DEP Noise Policy compliance demonstration at other locations, the same, conservative 2 dBA correction was applied to the lowest L_{90} levels measured when hub height wind speed was 5 m/s. The ambient sound level for Berry Drive was assumed to be similar to that for Prospect Street.

⁵ Typically L_{90} sound level rises 1 dBA for every 1 m/s rise in hub-height wind speed, which would suggest a 3 to 5 dBA correction should be applied. Thus, the 2-dBA correction is conservative.

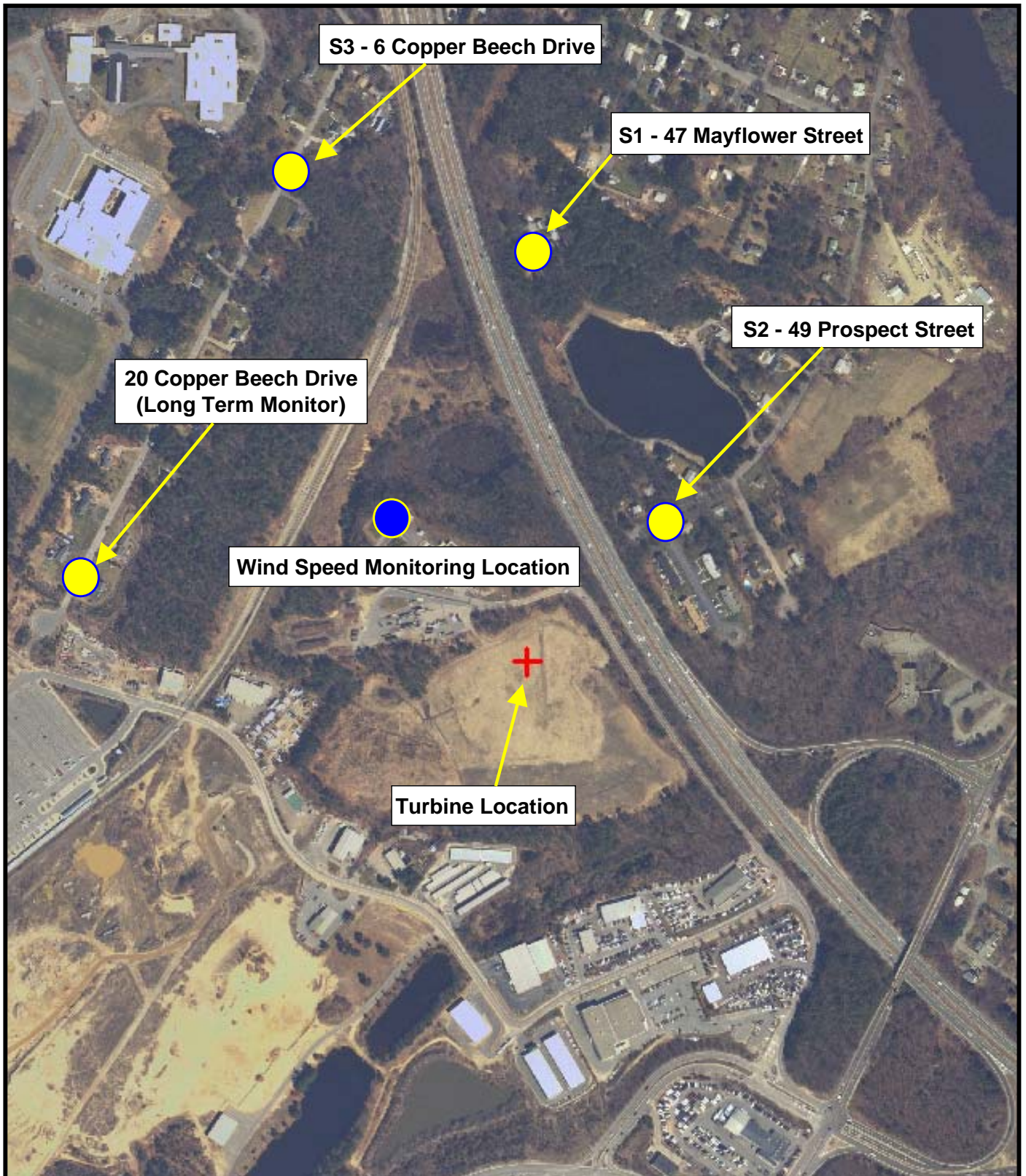


Figure 1.
Sound and Wind Speed
Monitoring Locations
Kingston Wind Turbine Project

5.0 CALCULATED FUTURE SOUND LEVELS

5.1 Methodology

Future sound level effects from the three potential Kingston wind turbines on nearby residences were calculated with the Cadna/A acoustic model. Cadna/A is a sophisticated 3-D model for sound propagation and attenuation based on International Standard ISO 9613⁶. Atmospheric absorption, the process by which sound energy is absorbed by the air, was calculated using ANSI S1.26-1995.⁷ Absorption of sound assumed standard day conditions and is significant at large distances. Ground surfaces were assumed to be mixed ground consisting of both hard and porous (vegetated) surfaces.⁸ This is a reasonable worst-case assumption and approximates winter frozen ground conditions in the area between the turbine and the nearest homes, with no attenuation from trees or vegetation. Digital terrain heights were extracted from MassGIS. The model assumes favorable sound propagation, as occurs under downwind conditions or a ground-based temperature inversion, such as might occur on a clear night. At other times, atmospheric turbulence and wind shadow effects will reduce sound levels by 5 to 20 dBA from those presented below.

For the Vestas V90 wind turbine, the cut-in wind speed at which the turbine begins operation is a hub height wind speed of 4 m/s; at cut-in the turbine has a sound power level of 94.4 dBA +/- 1.0 dBA. The maximum sound power level of 103.7 dBA +/- 1.0 dBA is reached at the design wind speed, which is a hub height wind speed of 8 m/s. For the purpose of acoustic modeling, the manufacturer-reported sound power levels plus uncertainty level of 1.0 dBA were used, namely 95.4 dBA and 104.7 dBA.

⁶ International Standard, ISO 9613-2, Acoustics – Attenuation of Sound During Propagation Outdoors, -- Part 2 General Method of Calculation.

⁷ American National Standards Institute, ANSI S1.26-1995, American National Standard Method for the Calculation of the Absorption of Sound by the Atmosphere, 1995.

⁸ Ground absorption factor G set equal to 0.5 in Cadna-A.

For the HHI 1.65-MW wind turbine, the cut-in wind speed at which the turbine begins operation is a hub height wind speed of 4 m/s; at cut-in the turbine has an estimated⁹ sound power level of 101.1 dBA +/- 2.0 dBA. The maximum sound power level of 104.0 dBA +/- 2.0 dBA is reached at the design wind speed, which is a hub height wind speed of 10 m/s. For the purpose of acoustic modeling, the manufacturer-reported sound power levels plus uncertainty level of 2.0 dBA were used, namely 103.1 dBA and 106.0 dBA.

For the HHI 2.0-MW wind turbine, the cut-in wind speed at which the turbine begins operation is a hub height wind speed of 4 m/s; at cut-in the turbine has an estimated⁹ sound power level of 99.0 dBA +/- 2.0 dBA. The maximum sound power level of 106.5 dBA +/- 2.0 dBA is reached at the design wind speed, which is a hub height wind speed of 10 m/s. For the purpose of acoustic modeling, the manufacturer-reported sound power levels plus uncertainty level of 2.0 dBA were used, namely 101.0 dBA and 108.5 dBA.

5.2 Results and Conclusions

Figures 2 through 4 show color-coded decibel contours (5 feet above ground level) for the Vestas V90, HHI 1.65-MW, and HHI 2.0-MW wind turbines, respectively, at the cut-in wind speed. Figures 5 through 7 provide similar decibel contour maps for the design wind speed operating condition. Note that these figures assume the sound receiving location is always downwind of the wind turbine, and the figures present a composite worst-case in which all locations are simultaneously downwind of the wind turbine. Model output is provided in Appendix C.

The acoustic modeling at the closest residences are summarized in Tables 3 through 5 for the cut-in wind speed operating condition, and in Tables 6 through 8 for the design wind speed operating condition. These tables provide the highest predicted sound level at the nearest residences, along with the maximum increase in the ambient sound level under the DEP Noise Policy. All predicted increases comply with the DEP Noise Policy limit of 10 dBA. An examination of octave band data from the turbines reveals they will comply with the DEP octave band requirement; there are no locations with

⁹ The lowest wind speed for which HHI publishes sound power level is 6 m/s. The cut-in wind speed value at 4 m/s has been estimated from the data available.

octave bands 3 decibels or more above the surrounding octave bands. Thus, the Project will not create pure tones.

Results for Vestas V90 For the cut-in operating condition, the Vestas V90 wind turbine will produce outdoor sound levels at the nearest residences in the range of 21.1 to 36.5 dBA and will increase the ambient level by <0.1 to 1.3 dBA. For the design wind operating condition, maximum wind turbine sound levels will be 30.4 to 45.8 dBA at the nearest residences, and the wind turbine will increase the ambient level by 0.2 to 4.6 dBA. All predicted sound level increases for the Vestas V90 comply with the DEP Noise Policy.

Results for HHI 1.65-MW For the cut-in operating condition, the HHI 1.65-MW wind turbine will produce outdoor sound levels at the nearest residences in the range of 28.8 to 44.2 dBA and will increase the ambient level by 0.3 to 4.9 dBA. For the design wind operating condition, maximum wind turbine sound levels will be 31.7 to 47.1 dBA at the nearest residences, and the wind turbine will increase the ambient level by 0.3 to 5.5 dBA. All predicted sound level increases for the HHI 1.65-MW comply with the DEP Noise Policy.

Results for HHI 2.0-MW For the cut-in operating condition, the HHI 2.0-MW wind turbine will produce outdoor sound levels at the nearest residences in the range of 26.7 to 42.1 dBA and will increase the ambient level by 0.2 to 3.6 dBA. For the design wind operating condition, maximum wind turbine sound levels will be 34.2 to 49.6 dBA at the nearest residences, and the wind turbine will increase the ambient level by 0.5 to 7.5 dBA. All predicted sound level increases for the HHI 2.0-MW comply with the DEP Noise Policy.

Although all three of the turbines would be in compliance with the DEP noise policy regarding the total sound level increase, it should be noted that the perceived loudness would vary depending on turbine type. The Vestas V90 turbine is the quietest of the three models examined, and the HHI 2.0-MW is the loudest one.

TABLE 3

**DEP NOISE POLICY COMPLIANCE FOR THE
KINGSTON WIND TURBINE PROJECT – VESTAS V90
CUT-IN WIND SPEED CONDITION (dBA)**

Location	Ambient L₉₀ Level	Maximum Project Sound	Combined Sound Level	Net Increase
47 Mayflower Street	39	29.0	39.4	0.4
49 Prospect Street	41	36.5	42.3	1.3
6 Copper Beech Drive	33	27.5	34.1	1.1
Berry Drive	41	21.1	41	0
Closest Residence Copper Beech Drive	34	29.3	35.3	1.3

Note: DEP Noise policy limits the increase in the ambient level to 10 dBA; changes below 3 dBA are considered imperceptible.

TABLE 4

**DEP NOISE POLICY COMPLIANCE FOR THE
KINGSTON WIND TURBINE PROJECT – HHI 1.65-MW
CUT-IN WIND SPEED CONDITION (dBA)**

Location	Ambient L₉₀ Level	Maximum Project Sound	Combined Sound Level	Net Increase
47 Mayflower Street	39	36.7	41	2.0
49 Prospect Street	41	44.2	45.9	4.9
6 Copper Beech Drive	33	35.2	37.2	4.2
Berry Drive	41	28.8	41.3	0.3
Closest Residence Copper Beech Drive	34	37.0	38.8	4.8

Note: DEP Noise policy limits the increase in the ambient level to 10 dBA; changes below 3 dBA are considered imperceptible.

TABLE 5

**DEP NOISE POLICY COMPLIANCE FOR THE
KINGSTON WIND TURBINE PROJECT – HHI 2.0-MW
CUT-IN WIND SPEED CONDITION (dBA)**

Location	Ambient L₉₀ Level	Maximum Project Sound	Combined Sound Level	Net Increase
47 Mayflower Street	39	34.6	40.3	2.3
49 Prospect Street	41	42.1	44.6	3.6
6 Copper Beech Drive	33	33.1	36.1	3.1
Berry Drive	41	26.7	41.2	0.2
Closest Residence Copper Beech Drive	34	34.9	37.5	3.5

Note: DEP Noise policy limits the increase in the ambient level to 10 dBA; changes below 3 dBA are considered imperceptible.

TABLE 6

**DEP NOISE POLICY COMPLIANCE FOR THE
KINGSTON WIND TURBINE PROJECT – VESTAS V90
DESIGN WIND SPEED CONDITION (dBA)**

Location	Ambient L₉₀ Level	Maximum Project Sound	Combined Sound Level	Net Increase
47 Mayflower Street	41	38.3	42.9	1.9
49 Prospect Street	43	45.8	47.6	4.6
6 Copper Beech Drive	35	36.8	39	4.0
Berry Drive	43	30.4	43.2	0.2
Closest Residence Copper Beech Drive	36	38.6	40.5	4.5

Note: DEP Noise policy limits the increase in the ambient level to 10 dBA; changes below 3 dBA are considered imperceptible.

TABLE 7

**DEP NOISE POLICY COMPLIANCE FOR THE
KINGSTON WIND TURBINE PROJECT – HHI 1.65-MW
DESIGN WIND SPEED CONDITION (dBA)**

Location	Ambient L₉₀ Level	Maximum Project Sound	Combined Sound Level	Net Increase
47 Mayflower Street	41	39.6	43.4	2.4
49 Prospect Street	43	47.1	48.5	5.5
6 Copper Beech Drive	35	38.1	39.8	4.8
Berry Drive	43	31.7	43.3	0.3
Closest Residence Copper Beech Drive	36	39.9	41.4	5.4

Note: DEP Noise policy limits the increase in the ambient level to 10 dBA; changes below 3 dBA are considered imperceptible.

TABLE 8

**DEP NOISE POLICY COMPLIANCE FOR THE
KINGSTON WIND TURBINE PROJECT – HHI 2.0-MW
DESIGN WIND SPEED CONDITION (dBA)**

Location	Ambient L₉₀ Level	Maximum Project Sound	Combined Sound Level	Net Increase
47 Mayflower Street	41	42.1	44.6	3.6
49 Prospect Street	43	49.6	50.5	7.5
6 Copper Beech Drive	35	40.6	41.7	6.7
Berry Drive	43	34.2	43.5	0.5
Closest Residence Copper Beech Drive	36	42.4	43.3	7.3

Note: DEP Noise policy limits the increase in the ambient level to 10 dBA; changes below 3 dBA are considered imperceptible.

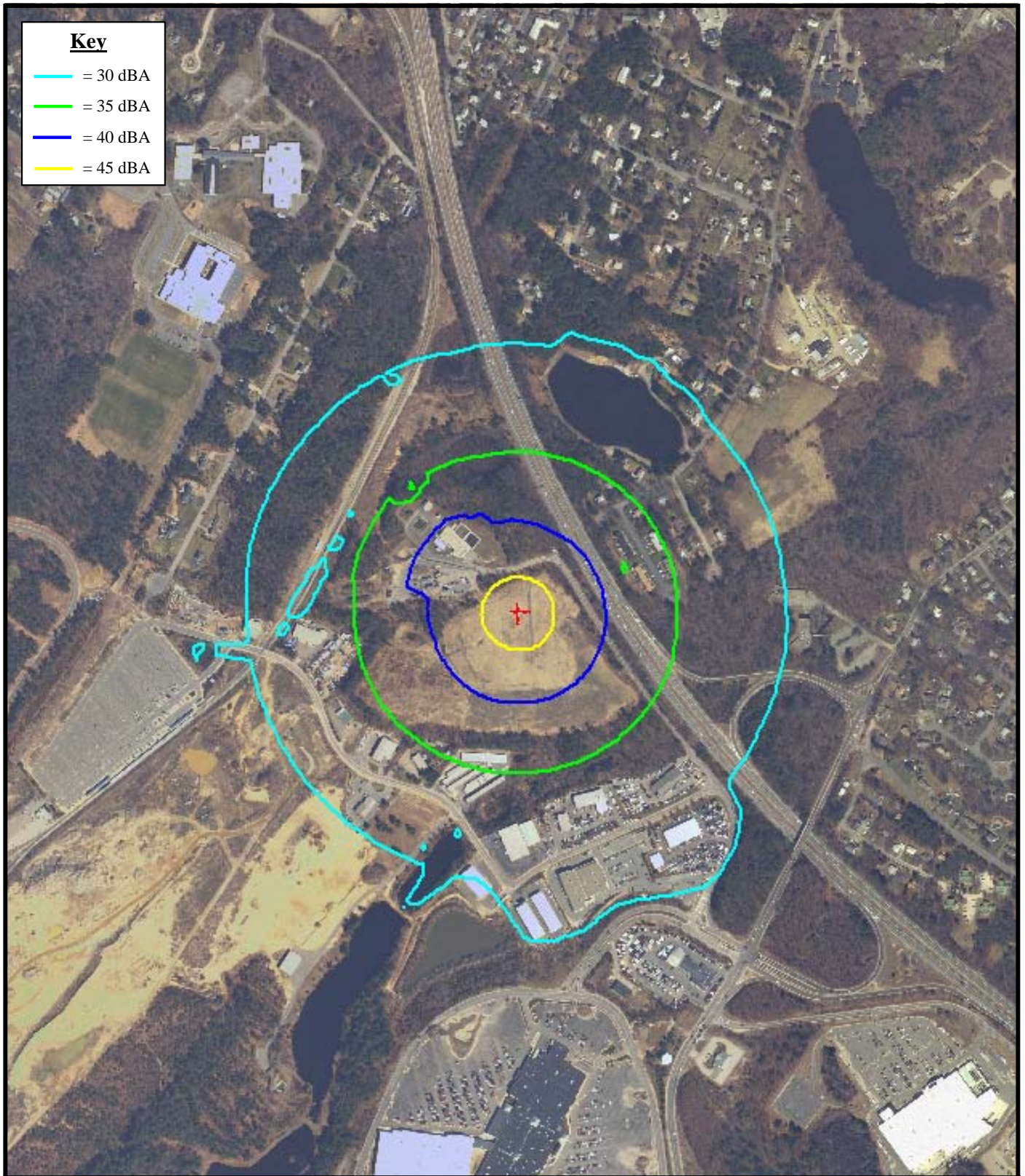


Figure 2.
Vestas V90 1.8 MW Sound Level Contours
Cut In Wind Speed

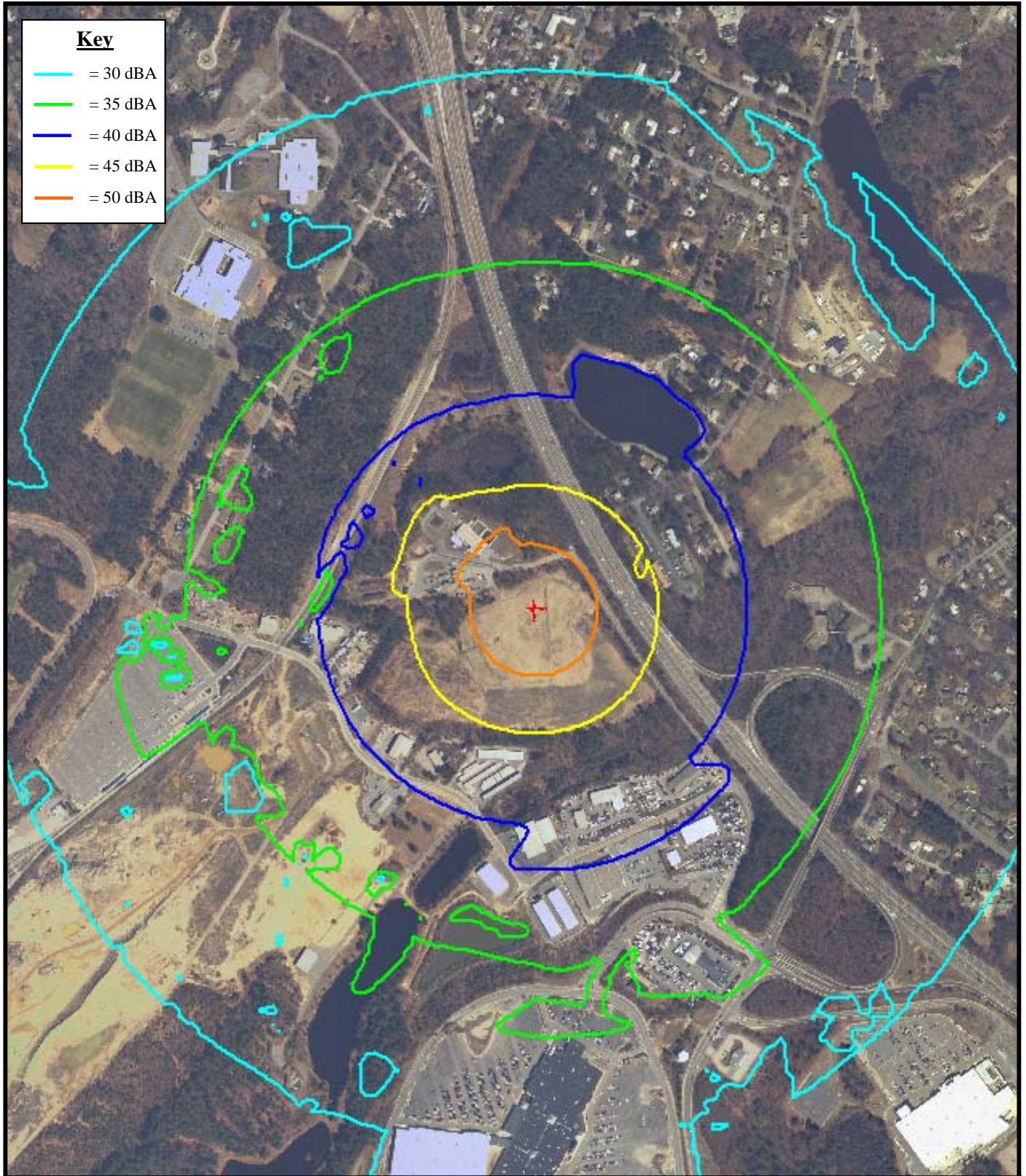


Figure 3.
HHI 1.65 MW Sound Level Contours
Cut-In Wind Speed

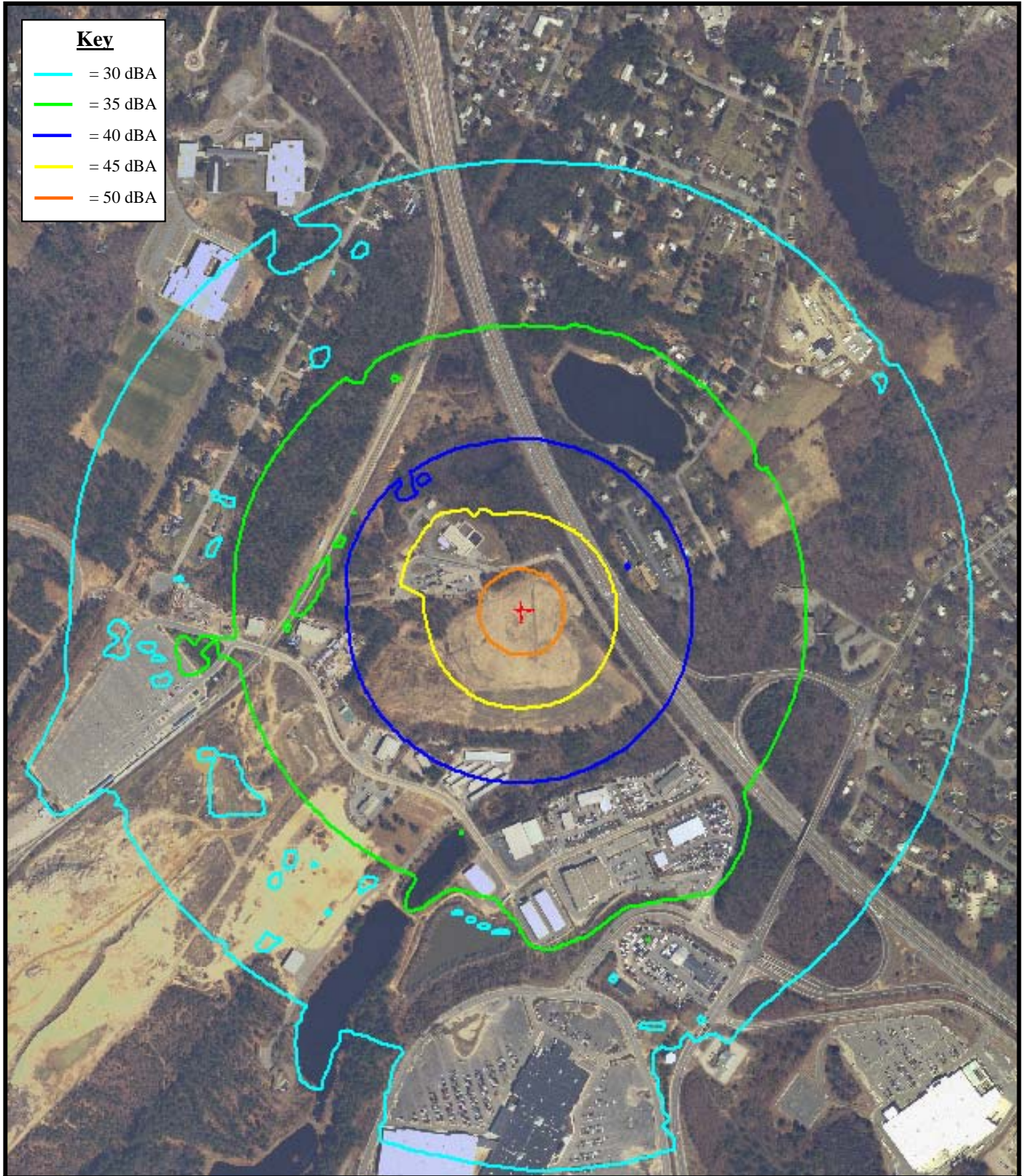


Figure 4.
HHI HQ2000 2.0 MW Sound Level Contours
Cut-In Wind Speed

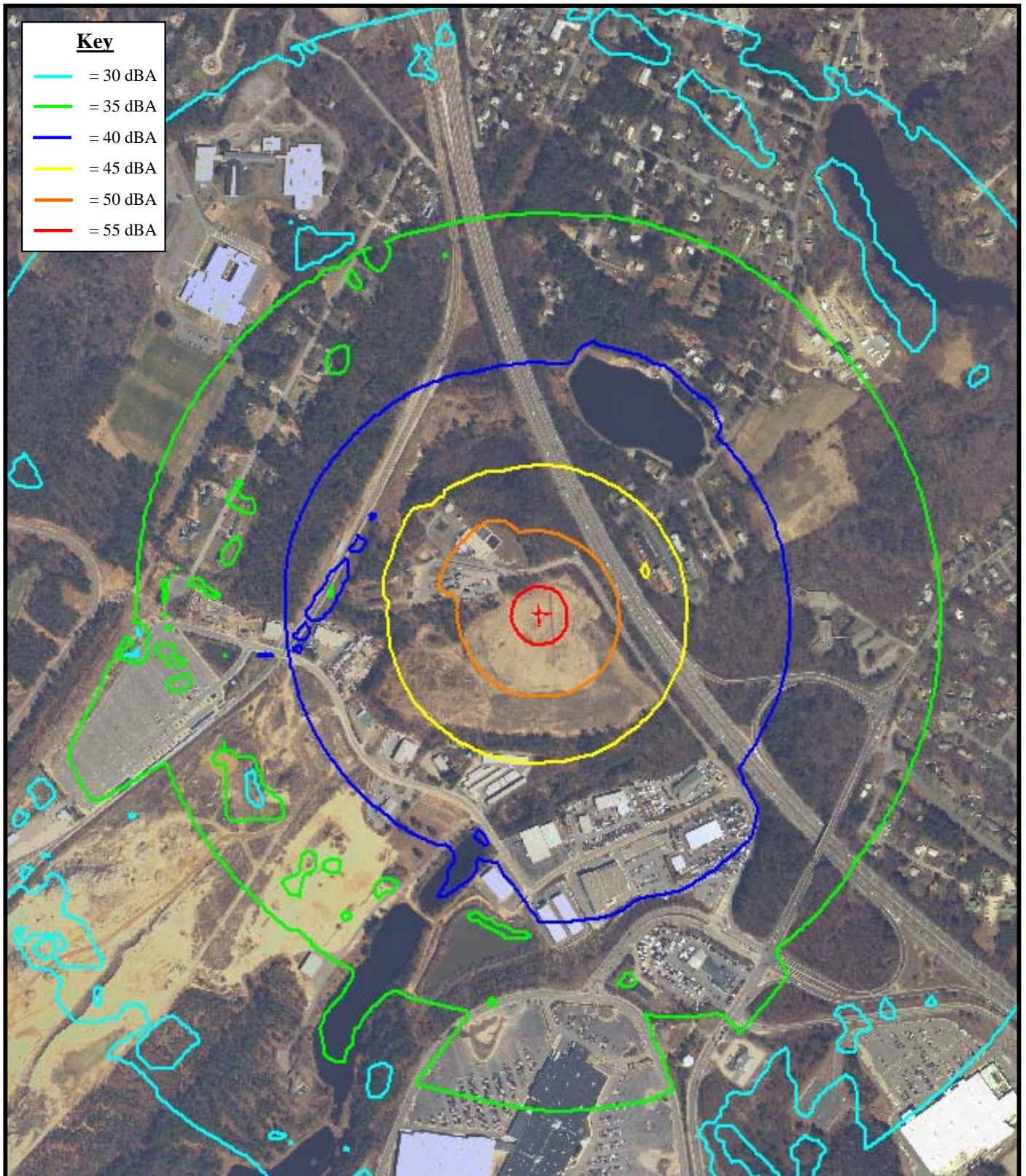


Figure 5.
Vestas V90 1.8 MW Sound Level Contours
Design Wind Speed

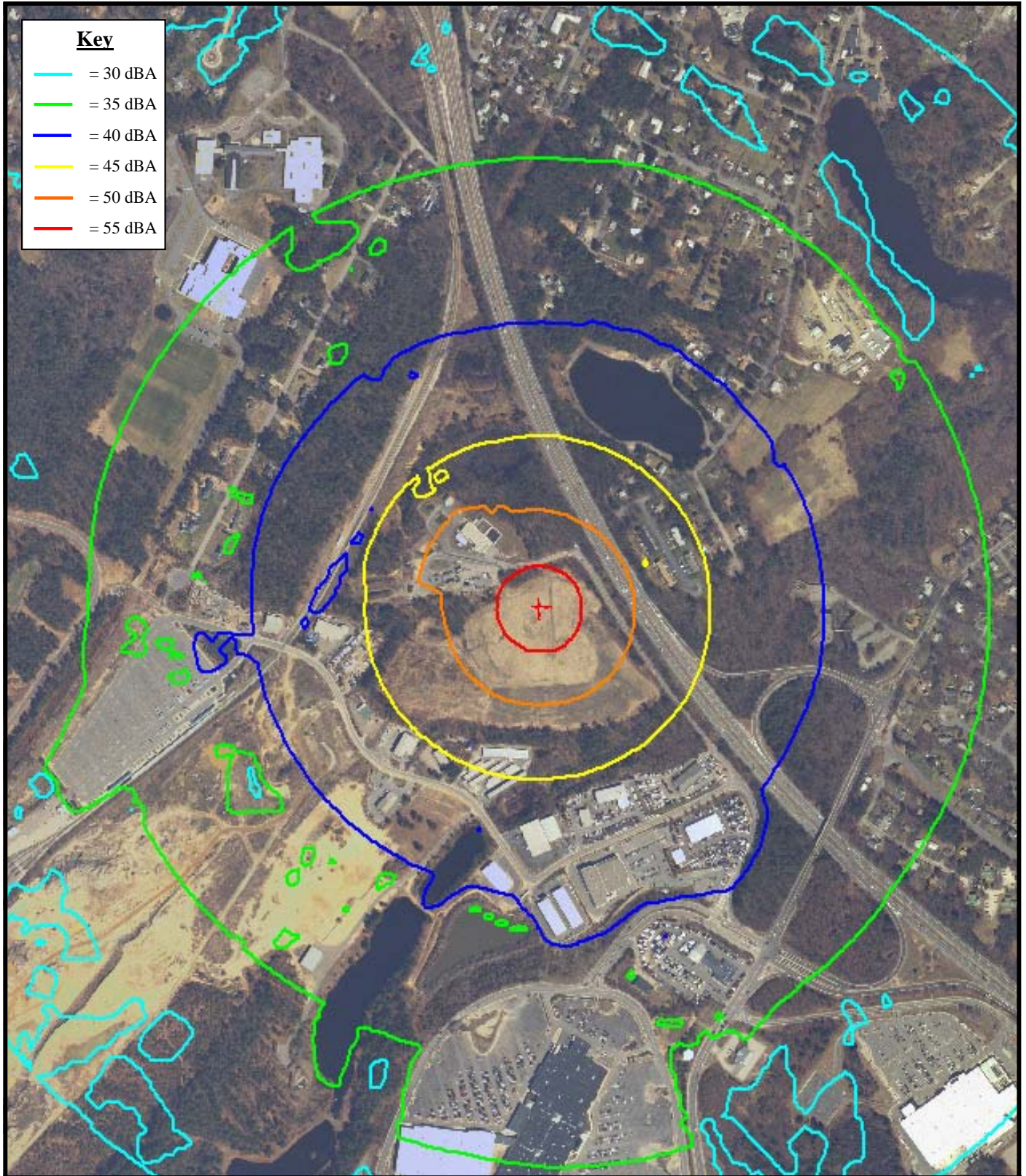


Figure 6.
HHI 1.65 MW Sound Level Contours
Design Wind Speed

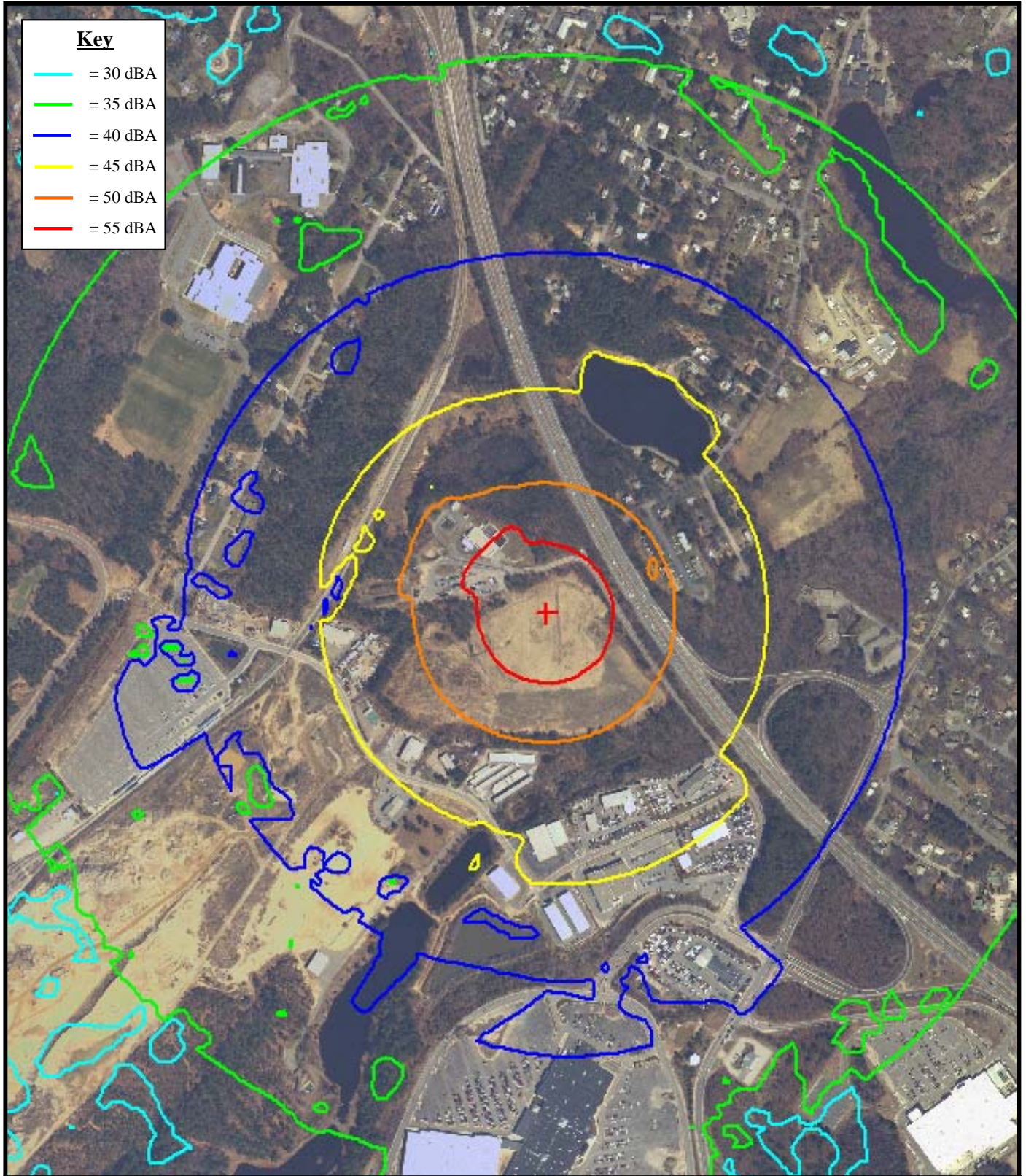


Figure 7.
HHI HQ2000 2.0 MW Sound Level Contours
Design Wind Speed

APPENDIX A

MASSACHUSETTS DEP NOISE POLICY

MADEP NOISE POLICY

Sound

Background

Sound is a type of air pollution that results from sounds that cause a nuisance, are or could injure public health, or unreasonably interfere with the comfortable enjoyment of life, property, or the conduct of business. Types of sounds that may cause sound include:

- “Loud” continuous sounds from industrial or commercial activity, demolition, or highly amplified music;
- Sounds in narrow frequency ranges such as “squealing” fans or other rotary equipment; and
- Intermittent or “impact” sounds such as those from pile drivers, jackhammers, slamming truck tailgates, public address systems, etc.

Policy

A sound source will be considered to be violating the Department’s sound regulation (310 CMR 7.10) if the source:

1. Increases the broadband sound level by more than 10 dB(A) above ambient,
or
2. Produce a “pure tone” condition – when any octave band center frequency sound pressure level exceeds the two adjacent center frequency sound pressure levels by 3 decibels or more.

These criteria are measured both at the property line and at the nearest inhabited residence. “Ambient” is defined as the background A-weighted sound level that is exceeded 90% of the time, measured during equipment operating hours. “Ambient” may also be established by other means with consent of the Department.

For more information:

For complaints about specific sound sources, call the Board of Health for the municipality in which the sound source is located. To learn more about responding to sound, odor and dust complaints or to request state assistance or support, please contact the service center in the nearest DEP regional office.

- Central Region, Worcester: (508) 792-7683
- Northeast Region, Wilmington: (978) 661-7677
- Southeast Region, Lakeville: (508) 946-2714
- Western Region, Springfield: (413) 755-2214

This Policy was originally adopted by the MA Department of Public Health in the early 1970's. It was reaffirmed by DEP's Division of Air Quality Control on July 1, 1990, and has remained in effect.

APPENDIX B

MEASURED SOUND LEVEL AND WIND DATA

APPENDIX B-1

**MEASURED AMBIENT SOUND LEVELS AND
MEASURED WIND SPEEDS NEAR
KINGSTON WIND TURBINE SITE**

Date	Starting-Time for Hour (EDT)	1-Hour L₉₀ Sound Level (dBA)	Hourly Average Wind Speed at 72 m Hub Height (m/s)
7/8/2008	12:00	41.1	N.A.
7/8/2008	13:00	41.3	N.A.
7/8/2008	14:00	41.2	6.5
7/8/2008	15:00	42.3	8.0
7/8/2008	16:00	44.5	8.6
7/8/2008	17:00	43.4	8.0
7/8/2008	18:00	43.0	7.6
7/8/2008	19:00	42.9	7.3
7/8/2008	20:00	42.5	6.8
7/8/2008	21:00	40.8	5.9
7/8/2008	22:00	38.0	4.9
7/8/2008	23:00	35.2	4.9
7/9/2008	0:00	33.9	4.9
7/9/2008	1:00	33.7	5.1
7/9/2008	2:00	33.8	5.2

APPENDIX B-2

**MEASURED SHORT TERM AMBIENT SOUND LEVELS AT
LOCATIONS NEAR KINGSTON WIND TURBINE SITE**

Kingston Wind Noise Monitoring – Kingston, MA – July 8, 2008

Daytime Measurements

Location #1: 49 Prospect Street

Weather: 93° F, 45% Humidity, 1-7 mph wind, Clear

CEL SoundTrack - dB2 3.0 © CEL Instruments Ltd 1998

- Run summary -

Instrument CEL-593.C1T Version 7.21 Type 1
Instrument ID (DPB) 112240
Run mode Octave band Environmental
Run start 07/08/2008 14:17:14
Run end 07/08/2008 14:37:17
Run duration 000 00:20:03.36
Last calibration 07/08/2008 14:14:15
Measurement range 15 - 90 dB
Microphone response Free Field
Polarizing voltage Off
Time weighting F
Frequency weighting L, A
Exchange rate (Q) 3
Period time 20 min
Periods too short for LNs No
Profiles recorded No
Profile sample interval 1 s
Number of records 1

Events enabled No

Overload occurred Yes
Low battery occurred No
Pause was used No

- Cumulative period results -

Number of records 1
Run start 07/08/2008 14:17:14
Run duration 000 00:20:03.36
Overload occurred Yes
Overload %time 0.05
Low battery occurred No
Pause was used No

Band (Hz)	Fw	Leq (dB)	SPLMAX F (dB)	LN1.0% F (dB)	LN10.0% F (dB)	LN50.0% F (dB)	LN90.0% F (dB)	LN99.0% F (dB)
Broadband	L	71.3	87.2	80.0	74.0	69.0	65.0	62.0
Broadband	A	66.1	83.0	74.0	68.0	65.0	61.0	58.0
16	L	51.2	68.7	60.0	54.0	49.0	46.0	43.0
32	L	57.9	73.7	65.0	60.0	56.0	53.0	49.0
63	L	66.3	85.9	76.0	69.0	63.0	59.0	55.0
125	L	65.8	81.9	77.0	68.0	62.0	57.0	52.0
250	L	59.2	84.2	69.0	60.0	54.0	50.0	45.0
500	L	61.1	81.4	71.0	63.0	58.0	53.0	50.0
1k	L	63.5	82.1	70.0	65.0	62.0	58.0	56.0
2k	L	58.7	74.7	66.0	60.0	58.0	54.0	51.0
4k	L	49.8	70.0	58.0	52.0	48.0	45.0	41.0
8k	L	41.1	63.6	50.0	43.0	39.0	35.0	31.0
16k	L	29.7	58.3	40.0	30.0	26.0	22.0	18.0

Kingston Wind Noise Monitoring – Kingston, MA – July 8, 2008

Daytime Measurements

Location #2: 47 Mayflower Street

Weather: 93° F, 40% Humidity, 1-5 mph wind, Partly Cloudy

CEL SoundTrack - dB2 3.0 © CEL Instruments Ltd 1998

- Run summary -

Instrument CEL-593.C1T Version 7.21 Type 1
Instrument ID (DPB) 112240
Run mode Octave band Environmental
Run start 07/08/2008 14:43:02
Run end 07/08/2008 15:03:04
Run duration 000 00:20:02.88
Last calibration 07/08/2008 14:14:15
Measurement range 5 - 80 dB
Microphone response Free Field
Polarizing voltage Off
Time weighting F
Frequency weighting L, A
Exchange rate (Q) 3
Period time 20 min
Periods too short for LNs No
Profiles recorded No
Profile sample interval 1 s
Number of records 1

Events enabled No

Overload occurred Yes
Low battery occurred No
Pause was used No

- Cumulative period results -

Number of records 1
Run start 07/08/2008 14:43:02
Run duration 000 00:20:02.88
Overload occurred Yes
Overload %time 0.00
Low battery occurred No
Pause was used No

Band (Hz)	Fw	Leq (dB)	SPLMAX F (dB)	LN1.0% F (dB)	LN10.0% F (dB)	LN50.0% F (dB)	LN90.0% F (dB)	LN99.0% F (dB)
Broadband	L	63.4	76.3	70.0	66.0	62.0	60.0	58.0
Broadband	A	57.3	67.6	62.0	59.0	57.0	55.0	53.0
16	L	49.3	64.5	57.0	52.0	48.0	44.0	42.0
32	L	53.6	69.0	61.0	56.0	52.0	50.0	47.0
63	L	57.5	74.0	65.0	60.0	56.0	53.0	50.0
125	L	57.4	76.0	67.0	60.0	54.0	51.0	49.0
250	L	53.7	68.6	61.0	56.0	52.0	49.0	47.0
500	L	52.1	64.9	58.0	54.0	51.0	49.0	47.0
1k	L	54.6	66.2	59.0	56.0	54.0	53.0	51.0
2k	L	49.4	62.4	54.0	51.0	49.0	47.0	45.0
4k	L	41.9	60.1	52.0	44.0	39.0	36.0	34.0
8k	L	36.3	58.4	48.0	38.0	31.0	27.0	24.0
16k	L	22.0	42.5	30.0	25.0	19.0	17.0	16.0

Kingston Wind Noise Monitoring – Kingston, MA – July 8, 2008

Daytime Measurements

Location #3: 6 Copper Beech Drive

Weather: 91° F, 45% Humidity, 5-10 mph wind (15 mph gusts), Partly Cloudy

CEL SoundTrack - dB2 3.0 © CEL Instruments Ltd 1998

- Run summary -

Instrument CEL-593.C1T Version 7.21 Type 1
Instrument ID (DPB) 112240
Run mode Octave band Environmental
Run start 07/08/2008 15:11:00
Run end 07/08/2008 15:31:02
Run duration 000 00:20:02.74
Last calibration 07/08/2008 14:14:15
Measurement range 5 - 80 dB
Microphone response Free Field
Polarizing voltage Off
Time weighting F
Frequency weighting L, A
Exchange rate (Q) 3
Period time 20 min
Periods too short for LNs No
Profiles recorded No
Profile sample interval 1 s
Number of records 1

Events enabled No

Overload occurred Yes
Low battery occurred No
Pause was used No

- Cumulative period results -

Number of records 1
Run start 07/08/2008 15:11:00
Run duration 000 00:20:02.74
Overload occurred Yes
Overload %time 0.00
Low battery occurred No
Pause was used No

Band (Hz)	Fw	Leq (dB)	SPLMAX F (dB)	LN1.0% F (dB)	LN10.0% F (dB)	LN50.0% F (dB)	LN90.0% F (dB)	LN99.0% F (dB)
Broadband	L	62.4	77.0	71.0	65.0	60.0	58.0	56.0
Broadband	A	52.8	67.3	58.0	54.0	52.0	51.0	50.0
16	L	54.3	72.1	65.0	58.0	48.0	43.0	40.0
32	L	54.1	70.0	63.0	57.0	52.0	48.0	46.0
63	L	54.8	71.1	64.0	57.0	52.0	49.0	48.0
125	L	52.7	69.2	61.0	55.0	51.0	49.0	47.0
250	L	50.6	66.9	59.0	52.0	49.0	48.0	46.0
500	L	49.6	63.7	56.0	51.0	49.0	47.0	46.0
1k	L	49.7	65.0	53.0	51.0	49.0	48.0	47.0
2k	L	43.3	58.3	49.0	45.0	42.0	41.0	40.0
4k	L	39.5	58.8	50.0	42.0	36.0	32.0	29.0
8k	L	34.6	50.9	44.0	38.0	31.0	25.0	21.0
16k	L	27.1	47.7	36.0	31.0	23.0	17.0	16.0

Kingston Wind Noise Monitoring – Kingston, MA – July 9, 2008

Nighttime Measurements

Location #1: 49 Prospect Street

Weather: 75° F, 70% Humidity, 1-5 mph wind, Clear

CEL SoundTrack - dB2 3.0 © CEL Instruments Ltd 1998

- Run summary -

Instrument CEL-593.C1T Version 7.21 Type 1
Instrument ID (DPB) 112240
Run mode Octave band Environmental
Run start 07/09/2008 00:43:31
Run end 07/09/2008 01:03:34
Run duration 000 00:20:03.10
Last calibration 07/09/2008 00:42:39
Measurement range 5 - 80 dB
Microphone response Free Field
Polarizing voltage Off
Time weighting F
Frequency weighting L, A
Exchange rate (Q) 3
Period time 20 min
Periods too short for LNs No
Profiles recorded No
Profile sample interval 1 s
Number of records 1

Events enabled No

Overload occurred Yes
Low battery occurred No
Pause was used No

- Cumulative period results -

Number of records 1
Run start 07/09/2008 00:43:31
Run duration 000 00:20:03.10
Overload occurred Yes
Overload %time 0.00
Low battery occurred No
Pause was used No

Band (Hz)	Fw	Leq (dB)	SPLMAX F (dB)	LN1.0% F (dB)	LN10.0% F (dB)	LN50.0% F (dB)	LN90.0% F (dB)	LN99.0% F (dB)
Broadband	L	58.0	76.5	68.0	61.0	52.0	47.0	46.0
Broadband	A	53.9	69.9	64.0	58.0	48.0	41.0	39.0
16	L	40.9	70.8	49.0	42.0	35.0	30.0	26.0
32	L	48.1	72.3	57.0	50.0	42.0	38.0	35.0
63	L	52.0	68.6	63.0	55.0	47.0	42.0	40.0
125	L	51.0	74.4	61.0	53.0	43.0	37.0	36.0
250	L	45.0	68.3	56.0	47.0	38.0	34.0	32.0
500	L	47.3	65.8	58.0	51.0	40.0	35.0	33.0
1k	L	51.5	67.9	62.0	55.0	45.0	37.0	34.0
2k	L	47.3	63.3	57.0	51.0	42.0	34.0	33.0
4k	L	38.5	54.9	49.0	42.0	33.0	28.0	27.0
8k	L	29.8	48.6	40.0	32.0	26.0	23.0	21.0
16k	L	19.9	42.4	28.0	22.0	18.0	17.0	16.0

Kingston Wind Noise Monitoring – Kingston, MA – July 9, 2008

Nighttime Measurements

Location #2: 47 Mayflower Street

Weather: 74° F, 74% Humidity, 1-5 mph wind, Clear

CEL SoundTrack - dB2 3.0 © CEL Instruments Ltd 1998

- Run summary -

Instrument CEL-593.C1T Version 7.21 Type 1
Instrument ID (DPB) 112240
Run mode Octave band Environmental
Run start 07/09/2008 01:07:56
Run end 07/09/2008 01:28:59
Run duration 000 00:21:03.56
Last calibration 07/09/2008 00:42:39
Measurement range 5 - 80 dB
Microphone response Free Field
Polarizing voltage Off
Time weighting F
Frequency weighting L, A
Exchange rate (Q) 3
Period time 20 min
Periods too short for LNs No
Profiles recorded No
Profile sample interval 1 s
Number of records 1

Events enabled No

Overload occurred No
Low battery occurred No
Pause was used No

- Cumulative period results -

Number of records 1
Run start 07/09/2008 01:07:56
Run duration 000 00:21:03.56
Overload occurred No
Overload %time 0.00
Low battery occurred No
Pause was used No

Band (Hz)	Fw	Leq (dB)	SPLMAX F (dB)	LN1.0% F (dB)	LN10.0% F (dB)	LN50.0% F (dB)	LN90.0% F (dB)	LN99.0% F (dB)
Broadband	L	53.5	67.4	62.0	56.0	51.0	48.0	45.0
Broadband	A	46.8	62.6	56.0	50.0	44.0	39.0	37.0
16	L	37.1	54.7	45.0	40.0	35.0	30.0	26.0
32	L	44.6	65.7	55.0	47.0	40.0	34.0	31.0
63	L	47.1	64.2	57.0	49.0	44.0	40.0	38.0
125	L	47.9	62.7	56.0	51.0	47.0	41.0	38.0
250	L	44.2	61.7	54.0	46.0	42.0	38.0	36.0
500	L	42.9	58.7	53.0	47.0	39.0	35.0	34.0
1k	L	44.1	62.2	54.0	47.0	41.0	34.0	31.0
2k	L	38.3	54.6	46.0	42.0	36.0	29.0	27.0
4k	L	29.3	43.6	37.0	32.0	28.0	25.0	23.0
8k	L	22.3	38.6	27.0	25.0	21.0	20.0	19.0
16k	L	16.1	26.9	19.0	17.0	16.0	15.0	15.0

Kingston Wind Noise Monitoring – Kingston, MA – July 9, 2008

Nighttime Measurements

Location #3: 6 Copper Beech Drive

Weather: 74° F, 80% Humidity, 1-5 mph wind, Clear

CEL SoundTrack - dB2 3.0 © CEL Instruments Ltd 1998

- Run summary -

Instrument CEL-593.C1T Version 7.21 Type 1
Instrument ID (DPB) 112240
Run mode Octave band Environmental
Run start 07/09/2008 01:37:18
Run end 07/09/2008 01:58:08
Run duration 000 00:20:50.76
Last calibration 07/09/2008 00:42:39
Measurement range 5 - 80 dB
Microphone response Free Field
Polarizing voltage Off
Time weighting F
Frequency weighting L, A
Exchange rate (Q) 3
Period time 20 min
Periods too short for LNs No
Profiles recorded No
Profile sample interval 1 s
Number of records 1

Events enabled No

Overload occurred Yes
Low battery occurred No
Pause was used No

- Cumulative period results -

Number of records 1
Run start 07/09/2008 01:37:18
Run duration 000 00:20:50.76
Overload occurred Yes
Overload %time 0.00
Low battery occurred No
Pause was used No

Band (Hz)	Fw	Leq (dB)	SPLMAX F (dB)	LN1.0% F (dB)	LN10.0% F (dB)	LN50.0% F (dB)	LN90.0% F (dB)	LN99.0% F (dB)
Broadband	L	50.2	75.1	59.0	53.0	47.0	44.0	43.0
Broadband	A	41.6	61.8	51.0	45.0	38.0	33.0	32.0
16	L	39.5	64.1	50.0	42.0	35.0	31.0	28.0
32	L	43.2	72.7	50.0	45.0	41.0	38.0	36.0
63	L	43.7	68.9	53.0	46.0	41.0	38.0	37.0
125	L	40.2	61.1	51.0	43.0	36.0	34.0	33.0
250	L	41.3	63.1	54.0	42.0	35.0	32.0	31.0
500	L	39.6	58.3	51.0	42.0	34.0	30.0	29.0
1k	L	38.2	57.8	47.0	42.0	34.0	28.0	26.0
2k	L	31.1	55.9	39.0	34.0	28.0	24.0	22.0
4k	L	24.3	46.5	31.0	26.0	23.0	21.0	19.0
8k	L	21.2	40.6	30.0	24.0	19.0	17.0	16.0
16k	L	17.6	42.8	26.0	19.0	16.0	15.0	15.0

APPENDIX C

CADNA/A ACOUSTIC MODEL OUTPUT

Vestas V90 Cut-In

Name	ID	Sound Level (dBA)	Height (m)	Coordinates		
				X (m)	Y (m)	Z (m)
47 Mayflower Street	S1	29	1.5	r 265012.5	859485.2	19.36
49 Prospect Street	S2	36.5	1.5	r 265112.7	859211	24.17
6 Copper Beech Drive	S3	27.5	1.5	r 264723.6	859482	29.97
Closest Copper Beech Residence	L	29.3	1.5	r 264608.7	859246.3	34.41
Closest Berry Drive Residence	R4	21.1	1.5	r 265774.4	858597.7	27.66

Vestas V90 Design

Name	ID	Sound Level (dBA)	Height (m)	Coordinates		
				X (m)	Y (m)	Z (m)
47 Mayflower Street	S1	38.3	1.5	r 265012.5	859485.2	19.36
49 Prospect Street	S2	45.8	1.5	r 265112.7	859211	24.17
6 Copper Beech Drive	S3	36.8	1.5	r 264723.6	859482	29.97
Closest Copper Beech Residence	L	38.6	1.5	r 264608.7	859246.3	34.41
Closest Berry Drive Residence	R4	30.4	1.5	r 265774.4	858597.7	27.66

HHI 1.65 MW Cut-In

Name	ID	Sound Level (dBA)	Height (m)	Coordinates		
				X (m)	Y (m)	Z (m)
47 Mayflower Street	S1	36.7	1.5	r 265012.5	859485.2	19.36
49 Prospect Street	S2	44.2	1.5	r 265112.7	859211	24.17
6 Copper Beech Drive	S3	35.2	1.5	r 264723.6	859482	29.97
Closest Copper Beech Residence	L	37	1.5	r 264608.7	859246.3	34.41
Closest Berry Drive Residence	R4	28.8	1.5	r 265774.4	858597.7	27.66

HHI 1.65 MW Design

Name	ID	Sound Level (dBA)	Height (m)	Coordinates		
				X (m)	Y (m)	Z (m)
47 Mayflower Street	S1	39.6	1.5	r 265012.5	859485.2	19.36
49 Prospect Street	S2	47.1	1.5	r 265112.7	859211	24.17
6 Copper Beech Drive	S3	38.1	1.5	r 264723.6	859482	29.97
Closest Copper Beech Residence	L	39.9	1.5	r 264608.7	859246.3	34.41
Closest Berry Drive Residence	R4	31.7	1.5	r 265774.4	858597.7	27.66

HHI 2.0 MW Cut-In

Name	ID	Sound Level (dBA)	Height (m)	Coordinates		
				X (m)	Y (m)	Z (m)
47 Mayflower Street	S1	34.6	1.5	r 265012.5	859485.2	19.36
49 Prospect Street	S2	42.1	1.5	r 265112.7	859211	24.17
6 Copper Beech Drive	S3	33.1	1.5	r 264723.6	859482	29.97
Closest Copper Beech Residence	L	34.9	1.5	r 264608.7	859246.3	34.41
Closest Berry Drive Residence	R4	26.7	1.5	r 265774.4	858597.7	27.66

HHI 2.0 MW Design

Name	ID	Sound Level (dBA)	Height (m)	Coordinates		
				X (m)	Y (m)	Z (m)
47 Mayflower Street	S1	42.1	1.5	r 265012.5	859485.2	19.36
49 Prospect Street	S2	49.6	1.5	r 265112.7	859211	24.17
6 Copper Beech Drive	S3	40.6	1.5	r 264723.6	859482	29.97
Closest Copper Beech Residence	L	42.4	1.5	r 264608.7	859246.3	34.41
Closest Berry Drive Residence	R4	34.2	1.5	r 265774.4	858597.7	27.66