WIND TURBINE FEASIBILITY STUDY

City of Worcester

B&V PROJECT NO. 135720.1100

PREPARED FOR

Massachusetts Clean Energy Center

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Report Revisions and Record of Issue

Rev.	Date	Issue Status	Revisions
A	2008/04/16	Draft	Issued for Client Review
B	2008/05/22	Draft	Revised draft incorporating comments from MassCEC and the City of Worcester.
C	2012/01/19	Final Draft	Incorporated onsite wind data into Wind Resource, Production Estimate, Economics sections. Reviewed revised City ordinance. Revised project options to evaluate Technical School.
D	2012/03/28	Final Report	Incorporated final MassCEC and City of Worcester comments. Expanded City Wind Ordinance review.

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Abstract

Black & Veatch reviewed the feasibility of developing a community wind energy project in Worcester, Massachusetts. The wind resource was estimated using wind data collected from nearby sources and the state wind resource map. Land use and operational issues were reviewed, with a focus on the urban nature of the project. The known electric infrastructure was reviewed to understand the feasibility the feasibility of on-site use and net metering. Likely permitting requirements were also listed. The cost for development of a single turbine project was estimated, and the cash flows of the projects were reviewed.

Keywords

Massachusetts Clean Energy Center
City of Worcester
Wind Energy
Urban Wind Projects
Black & Veatch
Feasibility Study

1.0 Executive Summary

The Massachusetts Clean Energy Center (MassCEC), formerly the Massachusetts Technology Collaborative (MTC), has entered into a Work Order (WO08-2) with Black & Veatch to perform a wind project feasibility study for the City of Worcester. The initial study was completed in 2008. This updated report incorporates onsite wind data collected by a SODAR unit and includes an evaluation of a potential project site at the Worcester Technical High School.

1.1 STUDY RESULTS

The results of this study show that there are challenges associated with constructing a single turbine wind project in Worcester. Available land is very limited within city limits, and the land available at the Technical High School is extremely constrained by the lot size and road, property line, and building setbacks. Without waivers of these setbacks, it is not possible to construct a large (1.5-2.0 MW) turbine on the Technical High School site. It may be possible to construct a smaller (600 kW) turbine; however, the constructible area is extremely limited and significant tree clearing would be required.

City ordinance restricts the maximum height of a wind turbine to 265 feet and maximum rotor diameter to 165 feet without a waiver. Because of this, construction of a large turbine in the City of Worcester is not possible without obtaining a turbine size waiver.

Based on information provided by MassCEC and the City, construction of a wind turbine on land in Green Hill Park, as investigated in the previous 2008 revisions of this report, will not be possible. This updated study therefore considers a single turbine project at the Technical High School. The GE 1.6-100, a 1.6 MW wind turbine with a 100 meter diameter rotor, best suited for low wind sites such as this, was considered. The 600 kW RRB PS-600 wind turbine, which meets maximum turbine and rotor sizes without a waiver, was also considered. Results for turbines similar to these models, including the Vestas V100, a 1.8 MW wind turbine with a 100 meter rotor, and the Turbowinds T600, a 600 kW turbine similar in size to the PS-600, will be similar.

The results of the wind and production analysis are summarized below:

- Based on wind data collected approximately 1,000 feet from the turbine site the estimated long-term wind resource at the Technical High School 5.0 m/s at 50 meters above ground level, about 5.8 m/s at 80 meters above ground level, and about 6.3 m/s at 100 meters above ground level. This is lower than what was previously estimated based on the Paxton tower several miles from the site. Lower wind speeds, especially at lower heights, is at least partially attributable to the significant tree cover in this area.
- Production from a single 600 kW wind turbine is estimated to be about a 13.1 percent capacity factor, which would generally be considered too low to develop a wind project.

- Production from a single 1.6 MW wind turbine with an 80 meter hub height is estimated to be about 31.5 percent, which in a net metering arrangement may be economical. Production with a 100 meter hub height is expected to be about 36.8 percent.
- Available land on the Technical High School property is very limited, and construction of a single large turbine is not possible without several setback waivers, turbine size waivers, and significant tree clearing. Construction of a smaller 600 kW turbine may be possible without waivers, but would still require significant tree clearing.
- Interconnection along existing distribution lines in the area or behind the meter at the Technical High School may be feasible options, but could require equipment upgrades.
- Black & Veatch estimates that installation of a single GE 1.6-100 at an 80 meter hub height would cost around $2,668 per kW, or about $4.3 million. Installation of this turbine at a 100 meter hub height is estimated to be about $2,853 per kW or about $4.6 million.
- On a per-capacity base, capital costs for a single small turbine are much higher than for larger projects or larger machines. Black & Veatch estimates that installation of a single PS-600 turbine would cost around $4,168 per kW, or about $2.5 million.
- Preliminary financial analysis indicates that a project using a 600 kW turbine may not be financially viable. A larger 1.6 MW turbine is expected to be financially viable assuming a virtual net metering arrangement is used and renewable energy credits are sold at a reasonable rate.

1.2 LIST OF RECOMMENDATIONS

- Construction of a large wind turbine within the City limits will almost certainly require a number of setback and size waivers. The likelihood of obtaining these waivers must be considered.
- Given the urban nature of the project, more detailed noise and visual studies, as well as a more detailed environmental review, will be needed if project development continues. These, along with open communication with the community, may be critical to a project's success.
- Because of the large number of communications towers and antennas in the area, a formal communications study should be performed if project development progresses.

1.3 CONCLUSIONS

The urban nature of a large or medium wind turbine project within the Worcester city limits presents many challenges. A significant amount of open space is needed to meet all required setbacks, and very few locations are available. The evaluated land at the Worcester Technical High

School is very limited in available space. Because of this limited space, the setback restrictions, the urban nature of the area, a relatively low wind resource, and potential safety concerns, construction of a medium or large wind turbine at the Technical High School is not recommended.

2.0 Introduction

2.1 BACKGROUND

The Worcester City Council issued a Climate Action Plan in January of 2007. The plan is largely focused on reduction of greenhouse gas emissions and the City's greenhouse gas footprint. One of the proposed measures in this plan was the installation of a single wind turbine in the city.

Through coordination by the Massachusetts Clean Energy Center (MassCEC), Black & Veatch was brought on board to perform a feasibility study for a single turbine wind project. Black & Veatch met with the City and visited the proposed turbine locations in January 2008. Based on the information obtained from MassCEC, The Renewable Energy Research Laboratory at the University of Massachusetts Amherst (RERL), the City of Worcester, the site visit, and other public data sources, Black & Veatch produced a feasibility study that reviewed several sites within the footprint of Green Hill Park, with wind resource and energy production estimates based on data from an instrumented radio tower several miles west of the City.

To better understand the wind resource near the park, a single SecondWind Triton sonic detection and ranging (SODAR) based device was installed to measure wind speeds in the area of interest. The device was in place for a full year, and measured wind speed, direction, and other characteristics at several heights above ground level. This revised study incorporates the wind data collected onsite. It also investigates the feasibility of installing a single turbine at the Worcester Technical High School, as development within the Park boundary was indicated by the City to unlikely to succeed.

2.2 OBJECTIVE

The objective of this report is to assess the feasibility of constructing a single wind turbine on the property of the Worcester Technical High School. Feasibility of a wind project in an urban area requires careful assessment of not only the wind resource, but also the impacts of a turbine on the environment and nearby homes and businesses.

2.3 REPORT ORGANIZATION

This report is organized into the following sections:

- Wind Resource: This section looks at the available wind resource data for the area as well as long-term reference data from the Worcester Municipal Airport, and makes an estimate of the wind resource at the Technical High School.
- Site Physical Characteristics: This section contains a general description of the potential project site, its current use, existing infrastructure, site access, and the overall suitability of the potential site for wind project development.
- Site Electrical Infrastructure: This section explores the known electrical infrastructure near the site, including potential interconnection points and overall interconnection feasibility.

- Potential Environmental Concerns: This section outlines the various environmental concerns associated with the site, including known habitats of threatened or endangered flora and fauna, areas of critical environmental concern, wetlands, and overall environmental impact.
- Permitting: This section is an outline of the various permitting issues, including zoning and the possible impact of Worcester's wind turbine ordinances. It includes a list of likely permits and a general timeline for obtaining them.
- Conceptual Design: This section discusses project options and lays out a conceptual design using a single small turbine. Potential shadow flicker and noise impacts are discussed.
- Project Development Considerations: This section is an overview of ownership options, financing sources, operations and management of the project, and other development considerations.
- Estimated Energy Production: This section estimates net energy production from the chosen wind project based on the wind resource assessment.
- Cost Estimate: This section contains a general cost estimate.
- Financial Analysis: This section attempts to quantify the costs and revenue of energy production from a small project and performs a simple cash flow analysis.

3.0 Wind Resource

The wind energy resource of a project site is one of the most critical aspects to understand, and is one of the few that cannot be overcome with technical solutions. Onsite wind resource monitoring using a SecondWind Triton SODAR was conducted from October 2009 through October 2010.

3.1 WIND DATA REVIEWED

To prepare an estimate of the wind resource at potential turbine sites in Worcester, Black & Veatch reviewed available wind resource information from a variety of sources. The primary source was SODAR data collected by the University of Massachusetts Wind Energy Center (WEC). The data sources reviewed include:

- Wind data collected by a SecondWind Triton SODAR installed at the end of the parking area on the western side of Skyline Drive. Data was collected at multiple heights. Heights of interest for this study were 50, 80, and 100 meter levels (October 15, 2009 to October 15, 2010).
- The final wind data report for the Worcester SODAR unit (October 15, 2009 to October 15, 2010).
- Wind data collected at the Worcester Municipal Airport ASOS station (July 1996 through September 2011).
- The New England Wind Map generated by TrueWind Solutions (now AWS Truepower) and obtained from MassCEC.

The information available from each above resource is discussed in this section, and the resources are combined into a complete wind resource estimate for Worcester in Section 3.3.

3.1.1 Worcester Triton SODAR

The WEC installed and commissioned a SecondWind Triton SODAR unit at the Green Hill Park complex in Worcester on October 15, 2009. The Triton unit was installed at the end of a parking lot near the baseball fields west of Skyline Drive, at approximately 42.27927 N, 71.78072 W (WGS84). The unit operated for a full year, and was decommissioned in October 2010. Black & Veatch obtained the raw Triton output in CSV format from the WEC. Black & Veatch was not able to physically verify the Triton unit's location; however, review of available aerial photographs of the area clearly shows the installed location of the unit which matches the coordinates supplied by the WEC.

The Triton SODAR unit was installed in a relatively sheltered, low lying area. The elevation and terrain surrounding the potential sites at the Technical High School have similar characteristics. These similarities and the close proximity (1,000 feet) indicate that the SODAR unit should be well suited to characterize energy production from a wind turbine at the Technical High School.

The SODAR unit is based on emitting audible high frequency chirps in three directions, each 120 degrees apart, and measuring the Doppler shifts of the returning echoes. Because of the scattering effects of the atmosphere, return rates are lower at greater heights above the unit. The SODAR unit recorded horizontal and vertical wind speed, direction, quality (based on strength of the return signal), and turbulence at multiple heights from 40 meters (131 feet) to 200 meters (656 feet) above ground level. The heights of interest for this study were at 50, 80, and 100 meters (164, 262, and 328 feet) above ground. Black & Veatch reviewed the raw SODAR data and the *Wind Data Report: Worcester, MA* report from the WEC. Black & Veatch filtered the data based on reported quality using in-house tools based on the SODAR manufacturer's recommendations. Monthly average wind speeds based on this filtered data are shown in Table 3-1 and Figure 3-1. Data recovery rates are shown in Table 3-2. Data quality was lower during winter months, especially December and January, and at higher levels above ground. This is expected to have an impact on the accuracy of resource estimates during these months.

Table 3-1 Worcester Triton SODAR Monthly Average Wind Speeds

YEAR	MONTH	50 M	80 M	100 M
2009	October	5.28	6.32	6.95
2009	November	5.45	6.45	6.96
2009	December	5.99	7.13	7.57
2010	January	6.02	6.86	7.35
2010	February	6.26	7.10	7.56
2010	March	6.32	7.28	7.70
2010	April	5.48	6.20	6.59
2010	May	5.21	5.98	6.34
2010	June	4.78	5.54	5.94
2010	July	4.84	5.59	6.02
2010	August	4.95	5.79	6.28
2010	September	5.42	6.36	6.89
2010	October	6.23	7.26	7.79
Average		**5.51**	**6.38**	**6.83**

Note: All wind speeds in m/s

Table 3-2 Worcester Triton SODAR Monthly Data Recovery Rate

YEAR	MONTH	50 M	80 M	100 M
2009	October	92.9%	92.4%	88.8%
2009	November	94.5%	92.0%	87.5%
2009	December	70.7%	61.4%	52.3%
2010	January	61.2%	61.0%	56.5%
2010	February	84.7%	85.1%	80.1%
2010	March	88.1%	86.4%	82.0%
2010	April	95.0%	93.2%	89.1%
2010	May	96.7%	95.6%	92.7%
2010	June	96.3%	96.1%	95.4%
2010	July	95.0%	94.5%	92.5%
2010	August	96.1%	95.2%	92.7%
2010	September	97.3%	97.0%	95.4%
2010	October	94.3%	92.7%	89.2%
Average		**89.2%**	**87.5%**	**83.8%**

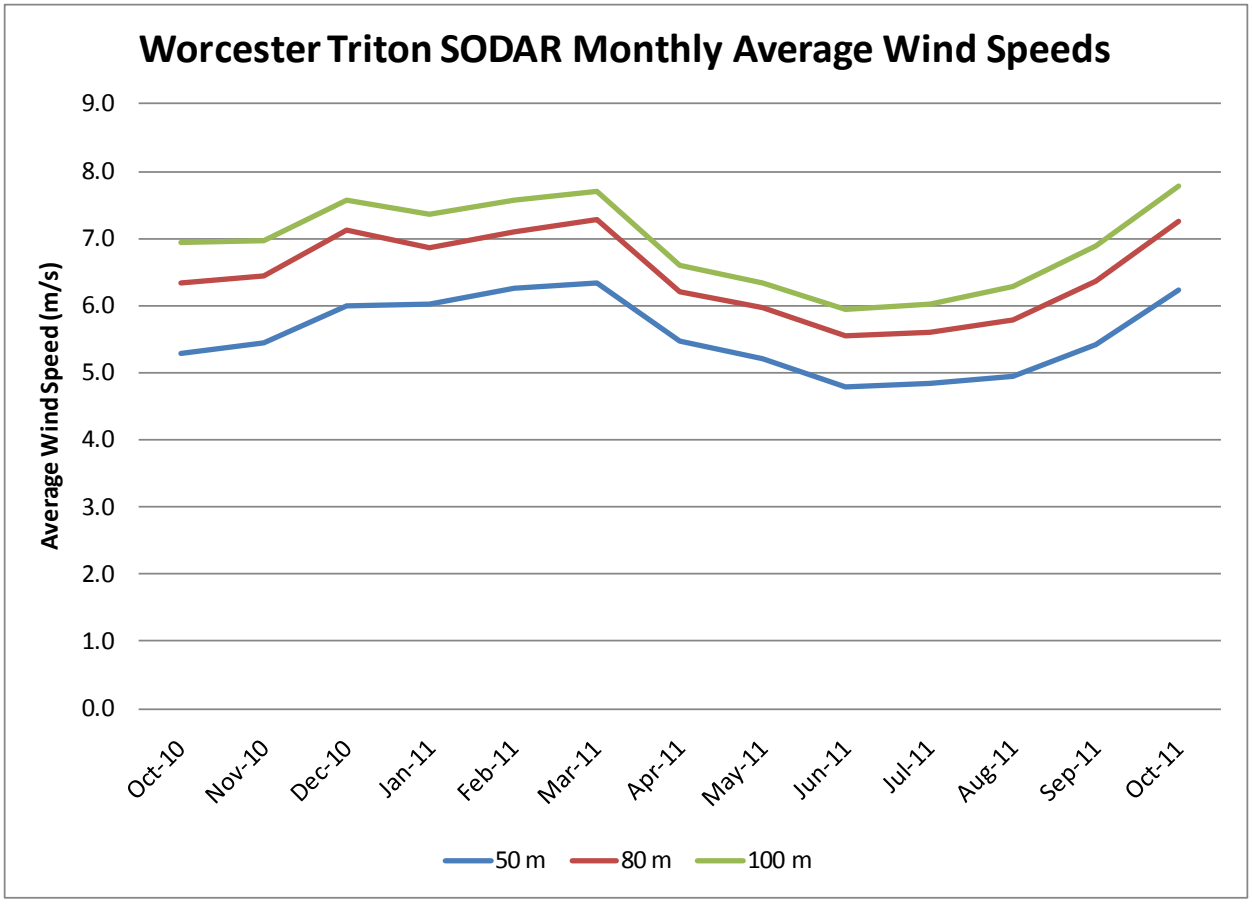


Figure 3-1 Worcester Triton SODAR Monthly Average Wind Speeds

3.1.2 Worcester Municipal ASOS Station

Black & Veatch used 15 years of wind data collected at the Worcester Municipal Airport to put the data collected at the Worcester SODAR into historical perspective. The met tower at the Worcester Municipal Airport is located at 42°16'14" N, 71°52'23" W (NAD83). This is about 5 miles west of the potential site.

The Worcester Municipal Airport met tower is a National Oceanic and Atmospheric Administration (NOAA) Automated Surface Observation Systems (ASOS) station, identified by call sign "KORH" and WBAN identification number 94746. A photograph of the Worcester station was not available from the NOAA, but Figure 3-2 shows a typical example of this type of ASOS station.

Figure 3-2 Typical ASOS Met Station (from NOAA web site)

The NOAA publishes hourly data collected at this station, and Black & Veatch reviewed the data collected from January 1996 through September 2011. Monthly averages from these years are presented in Table 3-3, and shown in Figure 3-3.

Wind data collected at airports is not intended for wind energy resource measurement since it is commonly collected with instruments fairly low to the ground. At Worcester Municipal Airport, the data was collected at 10 meters (33 feet) above ground level, far lower than the typical 80 meter hub height used in wind projects. Since scaling this low-level data upward to the proposed turbine hub heights is not preferable when a better data source is available, Black & Veatch did not attempt to use this data directly for wind resource estimation. Instead, Black & Veatch used the Worcester Municipal Airport data to review how the Paxton met tower data compares with the long-term average of the same data source.

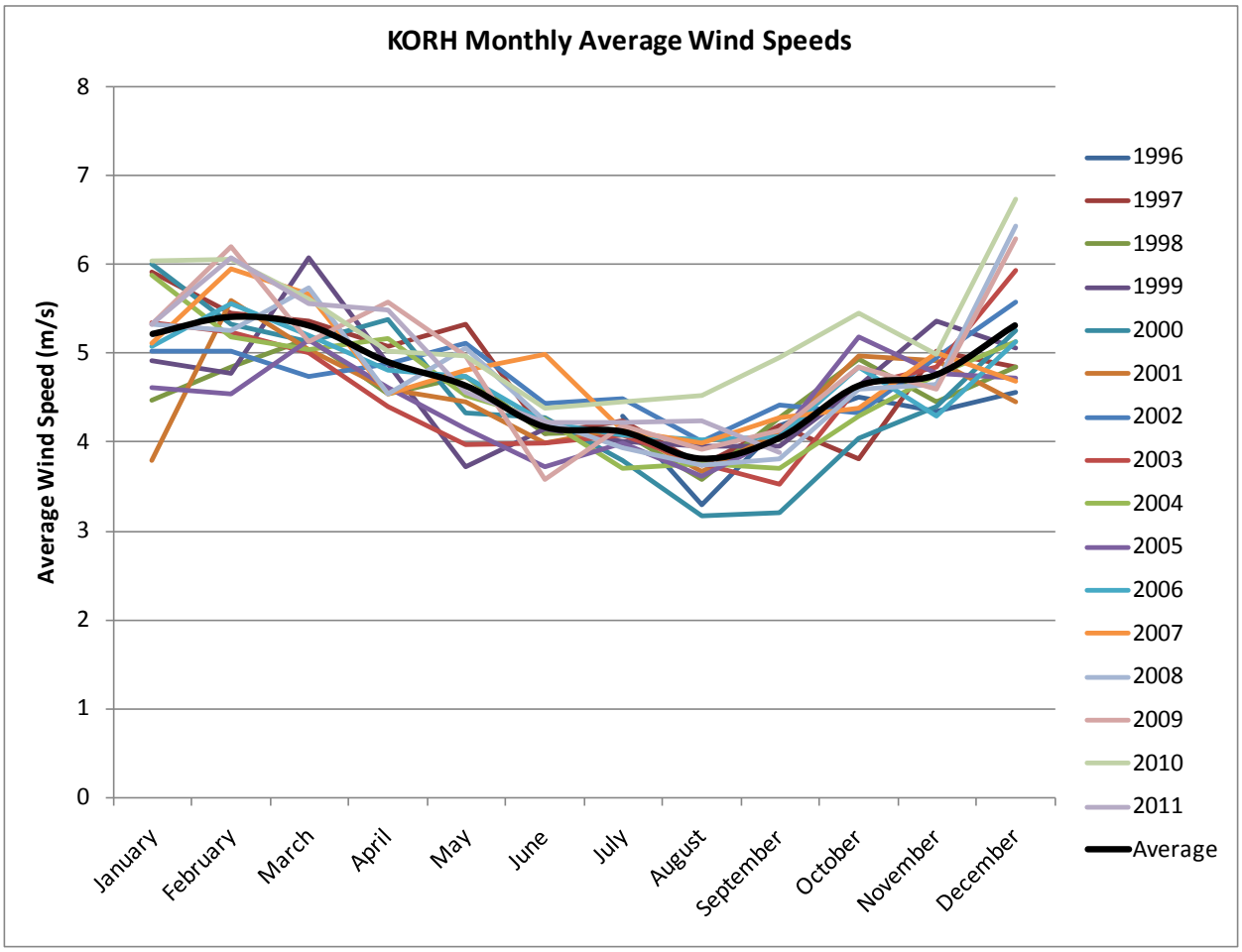


Figure 3-3 KORH Monthly Average Wind Speeds

Table 3-3 KORH Monthly Average Wind Speeds

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	AVG
Jan		5.91	4.47	4.92	6.01	3.79	5.02	5.35	5.89	4.62	5.08	5.12	5.33	5.33	6.05	5.33	5.22
Feb		5.46	4.86	4.78	5.32	5.60	5.03	5.24	5.18	4.55	5.56	5.95	5.26	6.20	6.05	6.08	5.41
Mar		5.36	5.17	6.09	5.13	5.04	4.73	5.01	5.04	5.15	5.21	5.67	5.73	5.13	5.61	5.55	5.31
Apr		5.07	4.55	4.88	5.39	4.59	4.88	4.40	5.16	4.61	4.82	4.54	4.54	5.58	5.02	5.49	4.90
May		5.33	4.75	3.72	4.33	4.46	5.12	3.98	4.52	4.14	4.74	4.81	5.06	4.98	4.98	4.55	4.63
Jun		4.10	4.10	4.15	4.27	3.99	4.43	3.99	4.25	3.73	4.22	4.99	4.24	3.58	4.39	4.22	4.17
Jul	4.29	4.24	4.11	4.01	3.79	4.15	4.48	4.08	3.70	4.00	4.08	4.13	3.93	4.19	4.45	4.21	4.12
Aug	3.30	3.74	3.58	3.96	3.17	3.67	4.01	3.76	3.76	3.61	4.03	3.98	3.74	3.92	4.53	4.24	3.81
Sep	4.19	4.18	4.28	3.95	3.21	4.11	4.41	3.52	3.70	4.06	4.07	4.28	3.80	4.13	4.96	3.88	4.05
Oct	4.50	3.82	4.93	4.64	4.04	4.97	4.33	4.63	4.29	5.19	4.85	4.37	4.60	4.84	5.45		4.63
Nov	4.36	5.02	4.45	5.36	4.40	4.92	4.95	4.84	4.76	4.78	4.29	5.01	4.65	4.60	4.98		4.76
Dec	4.57	4.85	4.84	5.07	5.25	4.46	5.58	5.93	5.13	4.73	5.13	4.68	6.44	6.29	6.73		5.31
Avg	**4.20**	**4.75**	**4.51**	**4.63**	**4.52**	**4.47**	**4.75**	**4.56**	**4.62**	**4.43**	**4.67**	**4.78**	**4.78**	**4.89**	**5.27**	**4.84**	**4.68**

Note: All wind speeds in m/s

3.1.3 Massachusetts Wind Resource Map Information

Black & Veatch also referenced the New England Wind Resource Map, a GIS-based wind map developed by AWS Truewind and obtained from the Massachusetts Clean Energy Center, for general information on the wind resource for the area around the project site. This map is a model of the wind resources for all of New England, and was created from atmospheric data and then calibrated using various data measurement locations. An image of the map is provided in Appendix A. Creation of this map by TrueWind Solutions was funded by the Massachusetts Clean Energy Center, the Connecticut Clean Energy Fund, and the Northeast Utilities System.

Using the query tools in the published GIS map, the model estimated annual average wind speed at a given location can be determined at heights of 30, 50, 70, and 100 meters above ground level. The annual average wind speeds for the Green Hill Park location was obtained using this tool. These wind speeds are summarized in Table 3-4.

Table 3-4 New England Wind Map Estimates

HEIGHT ABOVE GROUND	WIND SPEED, M/S
50 m	6.1
70 m	6.5
100 m	6.9

Source: TrueWind Solutions New England Wind Map GIS Tool

A wind rose for the site was also obtained from this map and is shown in Figure 3-4. These results should be considered to be a general estimate for the area. The model has a specified resolution of 200 meters and a standard error estimated at 0.6 m/s. The wind resource estimates obtained from this resource map are intended to be general estimates with a fairly wide error band, and are not a substitute for on-site data measurement. In this study, the wind data recorded by the SODAR unit near the site was used as the primary data source for all energy production estimates.

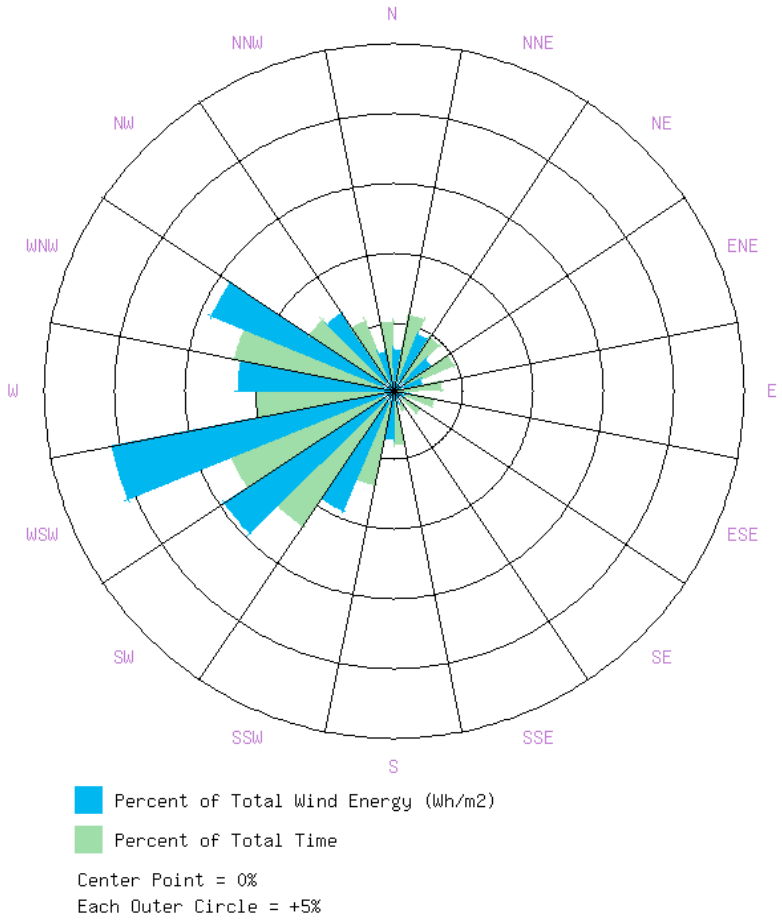


Figure 3-4 Worcester Wind Rose from New England Wind Map

3.2 RESOURCE ESTIMATE ACCURACY

A full year of on-site wind data collection is typically considered the minimum requirement for development of a wind energy project. This requirement is generally met based on one year of continuous data recorded near the site using a Triton SODAR unit. Data recovery at the heights of interest during most times is good; however accuracy may be low during the winter months because of reduced data quality. Taken in historical context based on the nearby airport ASOS data, the onsite SODAR data is the best data source available to make wind resource and energy production predictions.

3.3 LONG-TERM WIND RESOURCE

Table 3-5 shows the estimated long-term wind resource based on the wind data collected by the SODAR unit and at the Worcester airport. The New England Wind Map data was used as a reference. Wind speeds at 50, 80, and 100 meters above ground are directly based on 50, 80, and 100 meter measurements by the SODAR unit.

Table 3-5 Estimated Long-term Wind Resource

MONTH	50 M	80 M	100 M
January	5.19	5.92	6.34
February	5.59	6.34	6.76
March	5.98	6.88	7.28
April	5.35	6.05	6.44
May	4.85	5.56	5.90
June	4.54	5.26	5.64
July	4.48	5.17	5.57
August	4.17	4.88	5.29
September	4.43	5.19	5.63
October	5.24	6.17	6.69
November	5.63	6.67	7.20
December	5.06	6.02	6.40
Average	**5.04**	**5.84**	**6.26**

Note: All wind speeds in m/s

3.4 SITE VIABILITY

Predicted long-term average wind speeds are relatively low. Short term measured speeds are higher, but review of long-term data shows that the past few years, including the measurement period, had stronger winds than historical averages. At just over 5 m/s, the predicted wind speed at 50 meters above ground is likely too low to support development of a wind turbine at that hub height. Long-term predicted wind speeds of 5.8 m/s at 80 meters above ground and 6.3 m/s at 100 meters may be considered viable if an aggressive low-wind turbine model is employed.

4.0 Site Physical Characteristics

This section evaluates the site physical characteristics, including topography, land cover, land use, access roads, and buildings.

4.1 GENERAL DESCRIPTION AND POTENTIAL TURBINE SITE

The potential project location described in this report is within the City of Worcester, in central Massachusetts. Worcester is about 45 miles west of central Boston, and is the largest city in Massachusetts outside the Boston metropolitan area. Worcester's general location is shown in Figure 4-1.

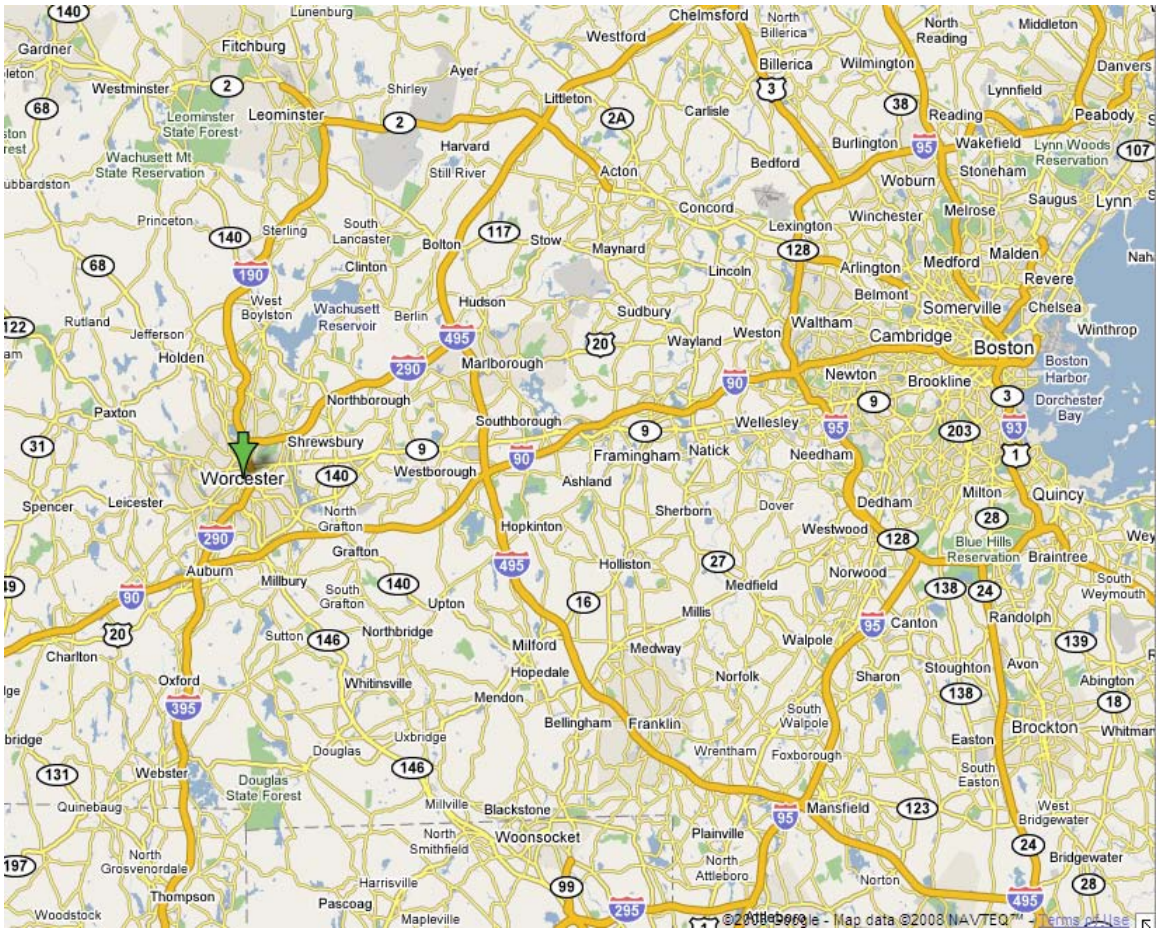


Figure 4-1 General Location of Worcester

In a previous revision of this report issued in 2008, several sites within Green Hill Park were evaluated. The park was considered a potentially viable area as it was at a relatively high elevation compared to the surrounding area and had large amounts of open space relative to most of the City. Later discussions with MassCEC and the City indicated that obtaining approval for the development of a large wind turbine on park land was not considered to be feasible because of

development restrictions on the Park. Based on this, an alternate site at the Worcester Technical High School in the same area of town was evaluated.

The Technical High School is located on about 20 acres of land to the east of Skyline Drive, in the same area of the City as Green Hill Park. The sites considered for a turbine at high school are about 1,000 feet east of the Triton SODAR monitoring location, and about ¼ to ½ a mile from the previously investigated park sites. Road access to the Technical High School would be similar to that investigated for the park. About 5 acres of the parcel is wooded or otherwise relatively undeveloped. The rest is occupied by several buildings, grounds, and parking lots. The high school is on the east side of the hill, at a lower elevation than the road.

The turbine location proposed during discussions with MassCEC and the City was at the center of the circular area in the drive at the north side of the school. This area is immediately adjacent to park property to the north and the school buildings to the south. Black & Veatch considered this location during the site evaluation, but also investigated the school parcel as a whole.

4.2 SITE USAGE AND INFRASTRUCTURE

The area reviewed is the undeveloped land and existing access roads on the north and east sides of the school. Most of the site that is not used for school buildings, roads, or parking lots is forested. There also appear to be several small ponds east of the school buildings. Infrastructure at the school itself, including underground utilities, would need to be evaluated before any development plans could be made. Black & Veatch was not provided with drawings of school infrastructure.

4.3 POTENTIAL TURBINE LOCATION SUITABILITY

Potential sites identified by Black & Veatch on the Technical High School parcel are very challenged by available space, the close proximity of the school itself, proximity of proximity of businesses and homes, the urban nature of the area, and the proximity of Green Hill Park. There are visual, shadow flicker, noise, and safety issues that must be considered if a turbine were to be built in such close proximity to these buildings. Construction of any turbine within the boundary of the Technical High School parcel would require road alignment changes and significant tree clearing for construction. While a large wind turbine will physically fit within the parcel, the requirements for transport, construction, and operation may result in significant impacts to the site.

4.4 TURBINE SPACING AND SETBACK

Although the development of a wind turbine for city purposes could be considered exempt from the City's Zoning Ordinance, this study includes a zoning analysis to examine its compliance - in particular its setback from residential uses in the area. The City of Worcester has a fairly complete zoning ordinance governing the requirements for installing a wind energy project. The primary setback rules are 650 feet from any occupied structure not owned by the project owner or participating landowner, 1.25 times the total turbine height from a participating landowner's

occupied building, and 1.1 times the total turbine height from the nearest right of way, property line, or existing transmission line. Occupied structures include schools, churches, hospitals, libraries, and residences. The ordinance is discussed in more detail in Section 7.2.

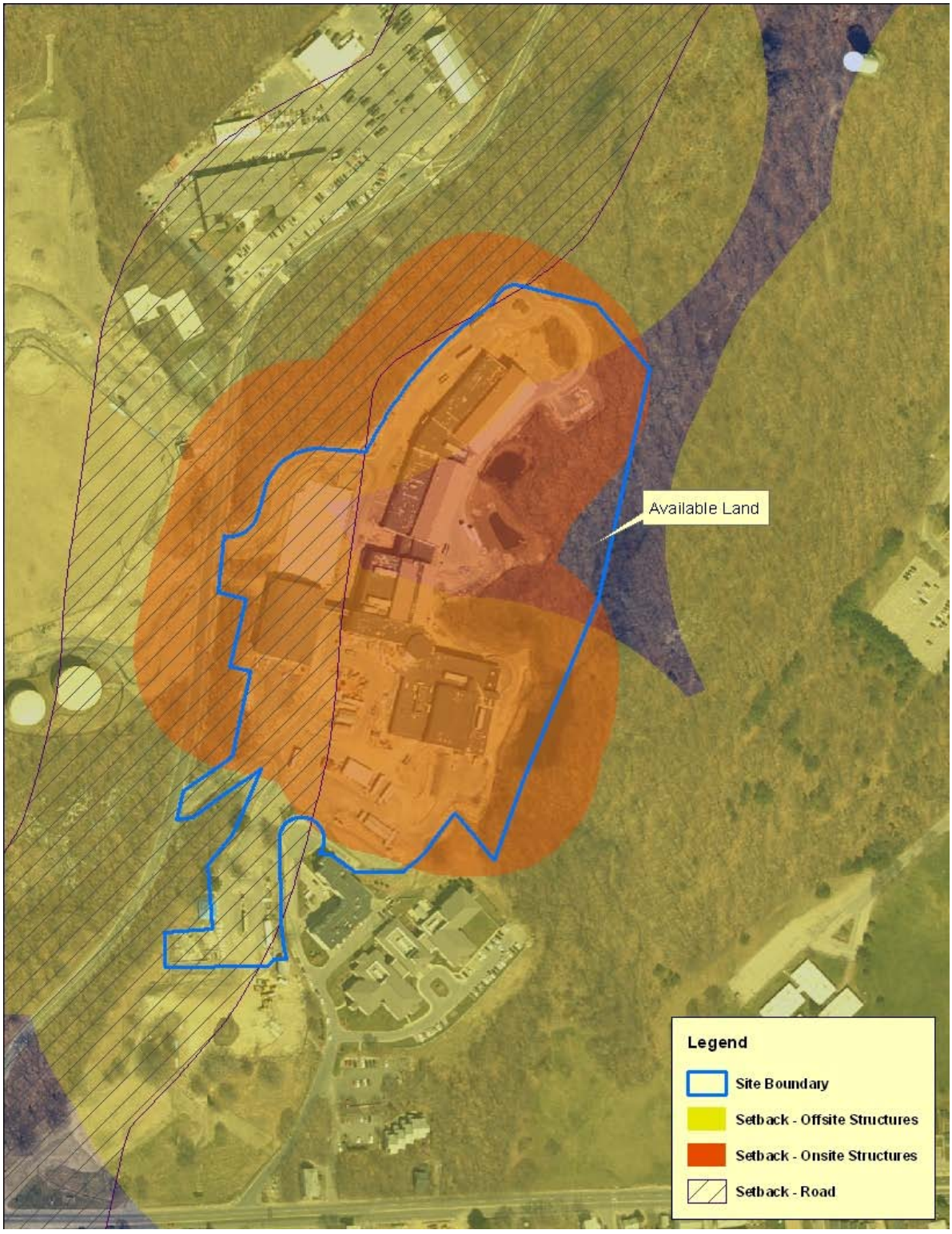


Figure 4-2 Structure Setbacks, Medium Turbine (50m rotor, 50m hub height)

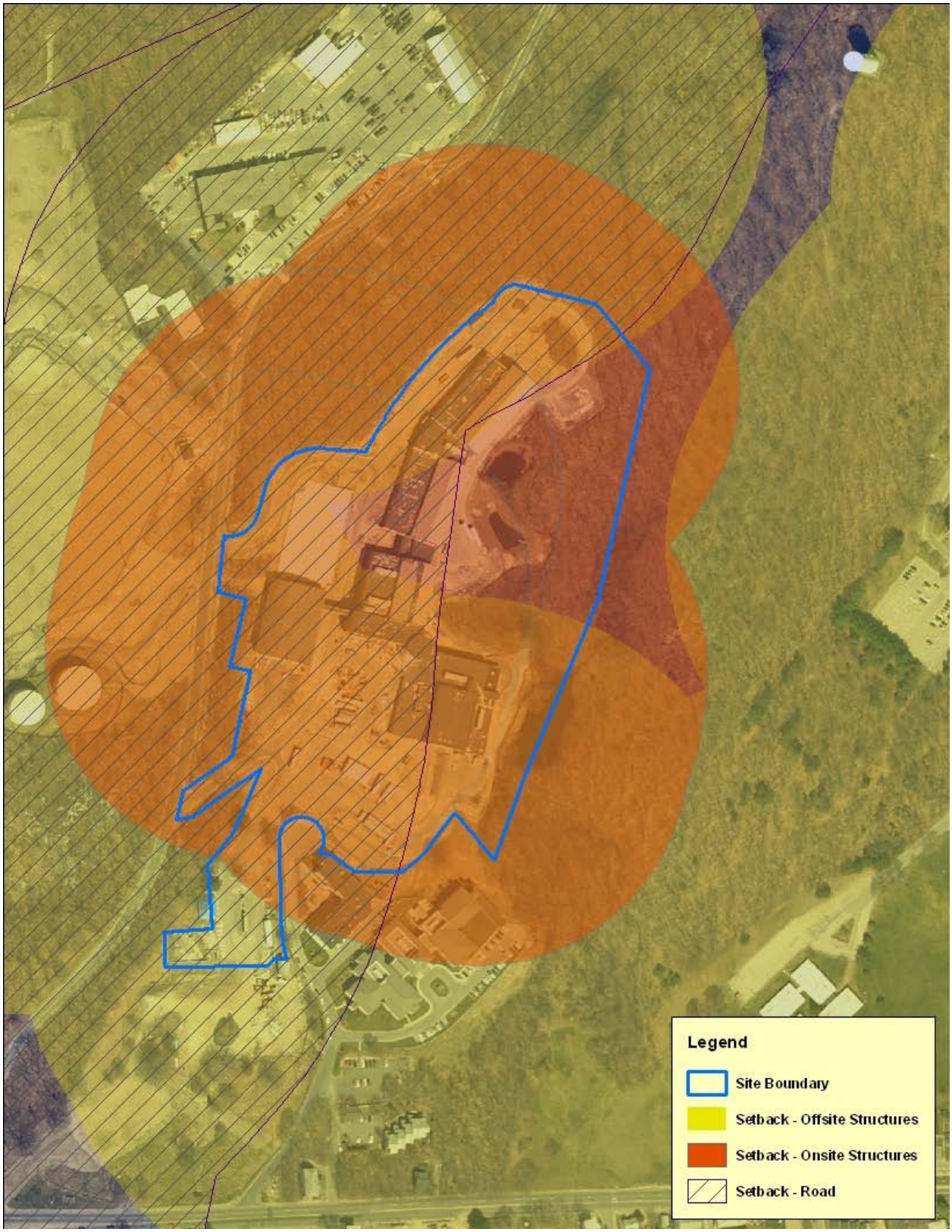


Figure 4-3 Structure Setbacks, Large Turbine (100m rotor, 80m hub height)

Figure 4-2 shows the results of applying the building and road setbacks in the City ordinance for the RRB PS-600 turbine. Without a setback waiver for the school only a small portion of the wooded area on the eastern side of the parcel is available. This available area also assumes that a waiver can also be obtained for the setback from the property line of the school.

Figure 4-3 shows the building and road setbacks for a large turbine with an 80 meter hub height. Because the participating parcel setbacks are based on a multiple of turbine height, the setback distance from the Technical High School increases. Without setback waivers for the high school buildings no portion of the parcel meets setback requirements for a large wind turbine. In both cases, the required 650 foot setback from the nearest nonparticipating occupied structure encroaches on the potential turbine site at the northern edge of the property. The required setback for the public right of way, Skyline Drive, also encroaches on this area.

4.5 SITE ACCESS

Access to potential project sites on the school property may be somewhat of a challenge, but should be possible without major interruption to traffic or utility services. A possible route is shown in Figure 4-4. This route exits Interstate 290 at Belmont Street and then turns left on Skyline Drive. A quick road survey using Google Street View shows that Belmont Street should be wide enough to move the required equipment, though it may require a temporary road closing. There is what appears to be a pedestrian overpass just past Merrifield Street which may present clearance issues, but the height marked on the overpass is illegible in the photographs available. Visual verification of the clearance for this bridge will be needed. There do not appear to be any low hanging power or communication lines over the road.

Skyline Drive also appears to be wide enough to move the required equipment, but will almost certainly require a temporary road closing. Moving trucks to the end of the north-south section should be possible. Truck access to a turbine site on the east side of the school grounds will require changes to existing onsite roads and construction of new access roads.

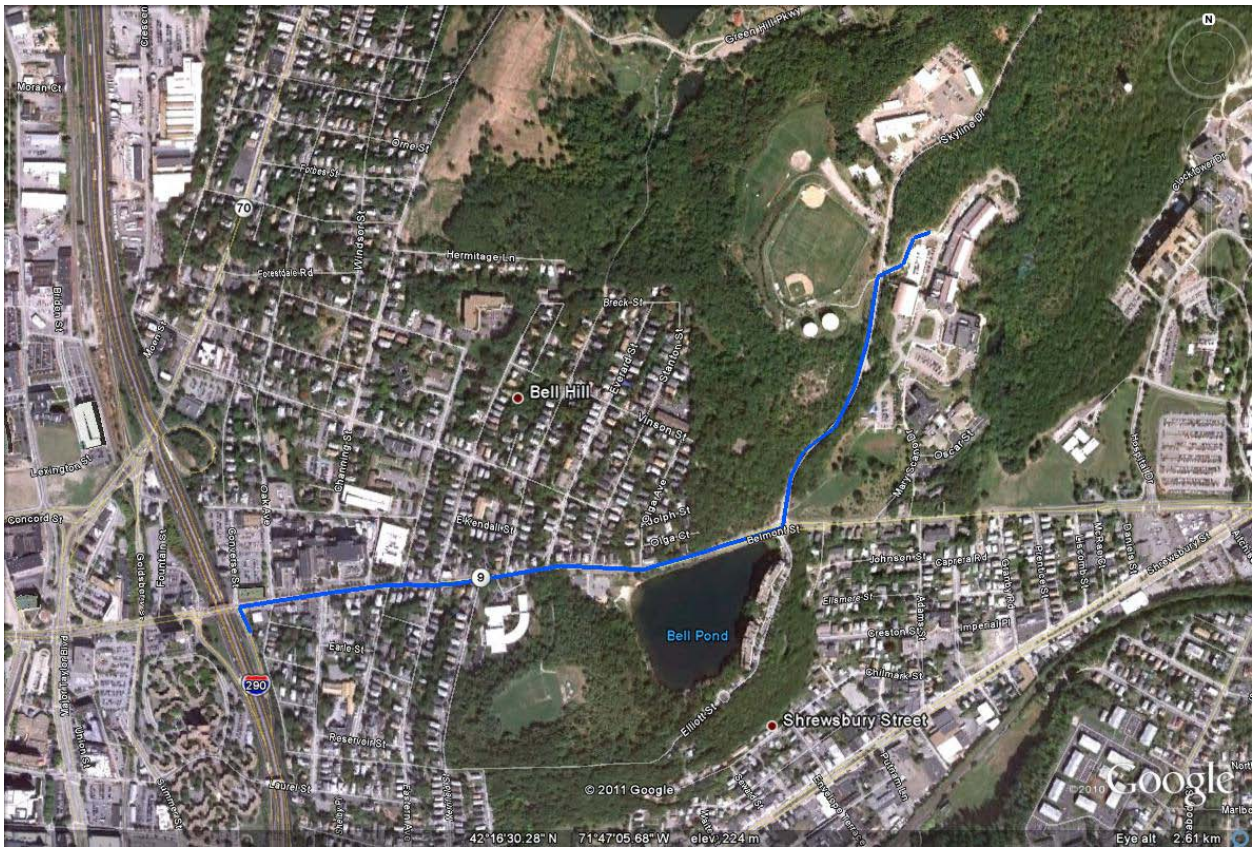


Figure 4-4 Potential Site Access Route

5.0 Site Electrical Infrastructure

This section is an evaluation of the site electrical infrastructure, including existing transmission and/or distribution system line locations and voltages.

5.1 POSSIBLE INTERCONNECTION POINTS

There are two basic ways a single turbine project in Worcester could be interconnected with the grid. The first would be to interconnect at an existing service location in a standard direct offset arrangement. In this case, the possible interconnection point would be a behind the meter connection at the Technical High School, possibly at the existing connection with the distribution grid. The second would be to connect a turbine directly to the Worcester electrical grid, either on a distribution line or an existing transmission line.

The project site is centrally located between two legs of 115 kV transmission lines owned by the New England Power Company. Approximately one mile west of the possible wind turbine sites is a New England Power Company 115 kV line that terminates at Nashua Street Substation. Approximately 1.5 miles southeast of the possible turbine sites is another 115 kV transmission line that taps into Bloomingdale Substation from the southwest and continues to the south. A general overview of the area showing the potential wind turbine location as well as nearby transmission lines and substations is shown below in Figure 5-1. Because of the distance between these transmission lines and the Technical High School, along with the expected cost of interconnecting a single turbine at high voltage, interconnection along existing distribution lines along Skyline Drive may be preferred. A distribution connection would eliminate the need for an interconnection substation and the individual wind turbine transformer would likely be directly connected to the distribution grid at a lower medium voltage (15 kV class). Coordination with the local utility would be important in determining this as an interconnection possibility. Consideration of the current loading of the distribution feeders and other equipment would also be important in determining the feasibility of this type of interconnection.

Figure 5-1 Transmission Lines and Substations near the Project

5.2 INTERCONNECTION FEASIBILITY

The project site is surrounded by residential and commercial developments, and therefore has a significant amount of infrastructure such as roads and piping obstructing a direct path for interconnection of any of the three turbine sites to either of the neighboring substations.

Connection to existing distribution lines would be simpler. The connection of a small wind energy project to a distribution line can often be done without requiring a substation or any other electrical equipment. The underground or overhead collection system would be brought close to the nearest distribution line, which would be the low-voltage distribution line for these three proposed sites. At this point, the underground cable comes above ground to a transition pole. From here, the system is connected to meters, switching, and any other equipment required by the interconnecting utility, and finally to the distribution line. An example of this type of interconnection appears in Figure 5-2.

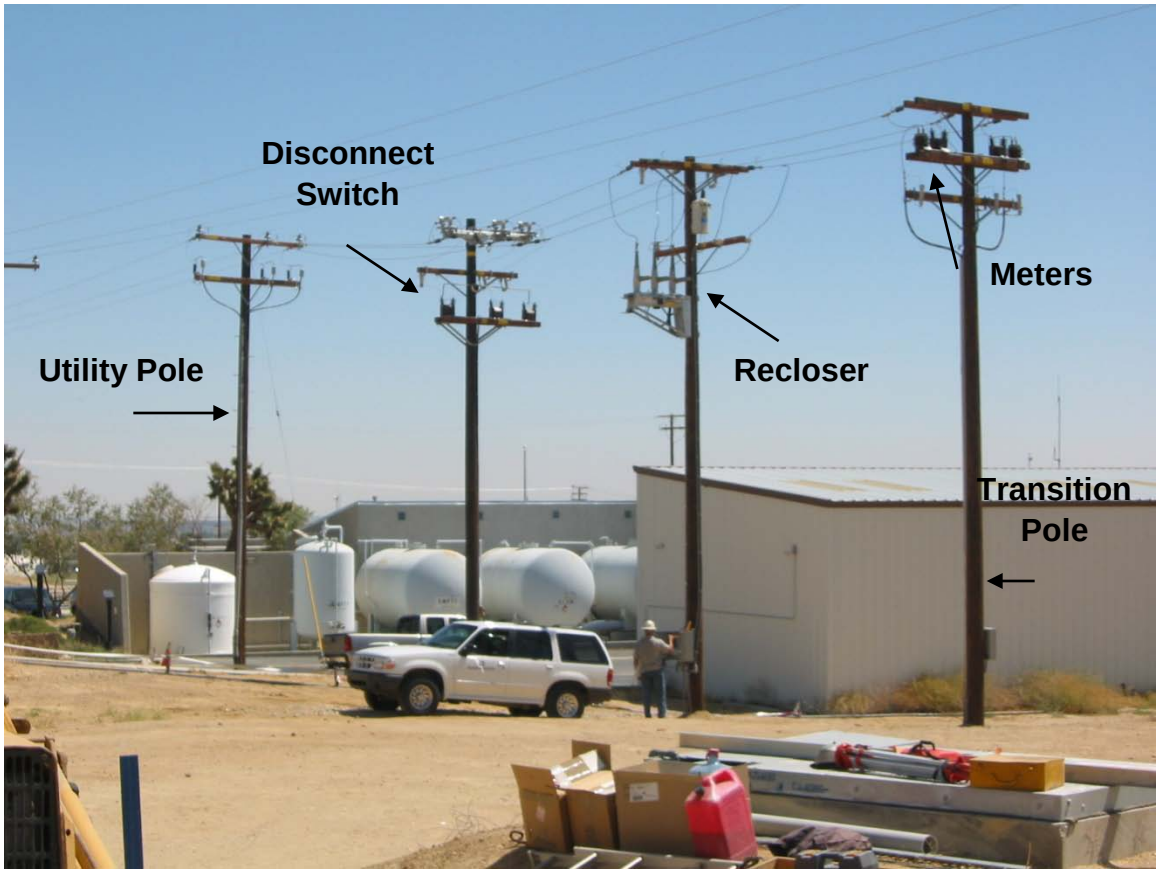


Figure 5-2 Distribution Line Interconnection

There are several significant electrical loads that exist nearest to the possible wind turbine locations such as the nearby high school, and other commercial loads. Black & Veatch feels that interconnecting the wind turbine to offset on-site electrical loading at a place such as the high school may offer the lowest-cost option for interconnection. Electricity generated by the wind turbine would lower the peak power consumption of the load and ultimately lower the amount needed to be purchased from the grid. The length of underground power cables would be minimized in this type of interconnection and have the least impact on the surrounding areas during the construction of the collection system.

5.3 ON-SITE ENERGY USE

Because of the relatively low wind resource in Worcester and the small size of a single turbine project, obtaining the retail value of generated energy will be very important for the economics of a project. The full retail value of energy can be obtained through direct energy offset or through a net metering arrangement with the local utility. With direct offset, the turbine would be connected on the customer side of an existing utility connection. Energy generated by a turbine would directly lower the amount of energy purchased from the utility. If the turbine generates more energy than is consumed at any given time, that energy would be sold back to the utility. With net

metering, the total energy purchased and sold would be added up over a billing period and net energy use calculated. This would allow more value of generated energy to be captured. Current net metering rules for renewable energy projects would allow all excess energy generated during a billing period to be assigned to other utility accounts. These rules would make it possible to obtain full retail value for all energy generated by a small project in Worcester.

6.0 Potential Environmental Concerns

Environmental concerns regarding a community wind energy project are expected to be an important component of the project's feasibility. Black & Veatch has prepared an initial list of likely environmental issues. Black & Veatch recommends a more complete environmental review be performed prior to committing to a wind energy project.

6.1 NATURAL HERITAGE AND ENDANGERED SPECIES PROGRAM

The Massachusetts Division of Fisheries and Wildlife's Natural Heritage and Endangered Species Program (NHESP) maintains a web site (www.nhesp.org) that identifies volatile plant and animal species as well as sensitive core habitats broken down by town. While this information is a good resource for an initial feasibility study, Black & Veatch would not consider the information identified below to be exhaustive, and would recommend a specific environmental review be done at the project site in future phases of project development.

The following information was obtained from the NHESP website:

- Areas of Critical Environmental Concern (ACEC): These are areas in Massachusetts that are considered special and highly significant due to their natural and cultural resources. Nominations for areas to receive ACEC designation are made by communities to the state Secretary of Environmental Affairs. Administration of the ACEC program is done by the Department of Conservation and Recreation.
- Priority Habitat for Rare Species: These areas are NHESP estimates of habitats for rare species. The boundaries of these habitats are considered approximate.
- Protected and Recreational Open Space: These are areas that have been designated at the state or community level as areas for limited or no development. The Massachusetts Geographic Information System (MassGIS), the service from where the data was obtained, indicated the accuracy of the identified open space locations was limited. Data used was obtained from MassGIS and last updated in July 2011.
- BioMap Core Habitats: The BioMap program was completed in 2001 by NHESP, and identified areas considered to represent "habitats for the state's most viable rare plant and animal populations". BioMap Core Habitats and Living Water Core Habitats encompass almost 1.4 million acres, or about 28 percent of the land area of Massachusetts.
- Certified Vernal Pools: NHESP define vernal pools as "small, shallow ponds characterized by lack of fish and by periods of dryness." These pools are deemed critical to some wildlife, and are protected under a variety of state programs including the Massachusetts Wetlands Protection Act.
- Living Waters Critical Supporting Watersheds: These watersheds are identified as being critical for supporting Living Waters Core Habitats. They were identified in the Living Waters project completed in 2003 by NHESP.

- Living Waters Core Habitats: Similar to the BioMap Core Habitats, the Living Waters Core Habitats are those rivers, streams, lakes, and ponds critical to the biological diversity of Massachusetts.
- BioMap2: The BioMap2 plan was completed in late 2010 by NHESP, and GIS data layers were made available in late February 2011. BioMap2 replaces the previous BioMap and Living Waters plans. BioMap2 data was reviewed alongside previous BioMap data, with the former taking precedence in evaluation.

6.1.1 Protected and Recreational Open Space

Figure 6-1 shows the protected spaces in the area around the Technical High School. The only known open space immediately adjacent to the project is Green Hill Park.

Figure 6-1 Protected and Recreational Open Space

6.1.2 BioMap2

Core Habitats in the vicinity of the Technical High School are shown in Figure 6-2. Most of the forested area surrounding the high school is identified as a core habitat of a species of conservation concern. Although development on portions of the school parcel may be possible without impact to this core habitat, it appears that any tree clearing in the area to facilitate construction would have a direct impact.

Figure 6-2 BioMap2 Core Habitats

6.2 WETLANDS

A review of the National Wetlands Inventory shows several identified wetlands within the forested area east of the school. These lands, shown in Figure 6-3, would need to be avoided during design and construction.

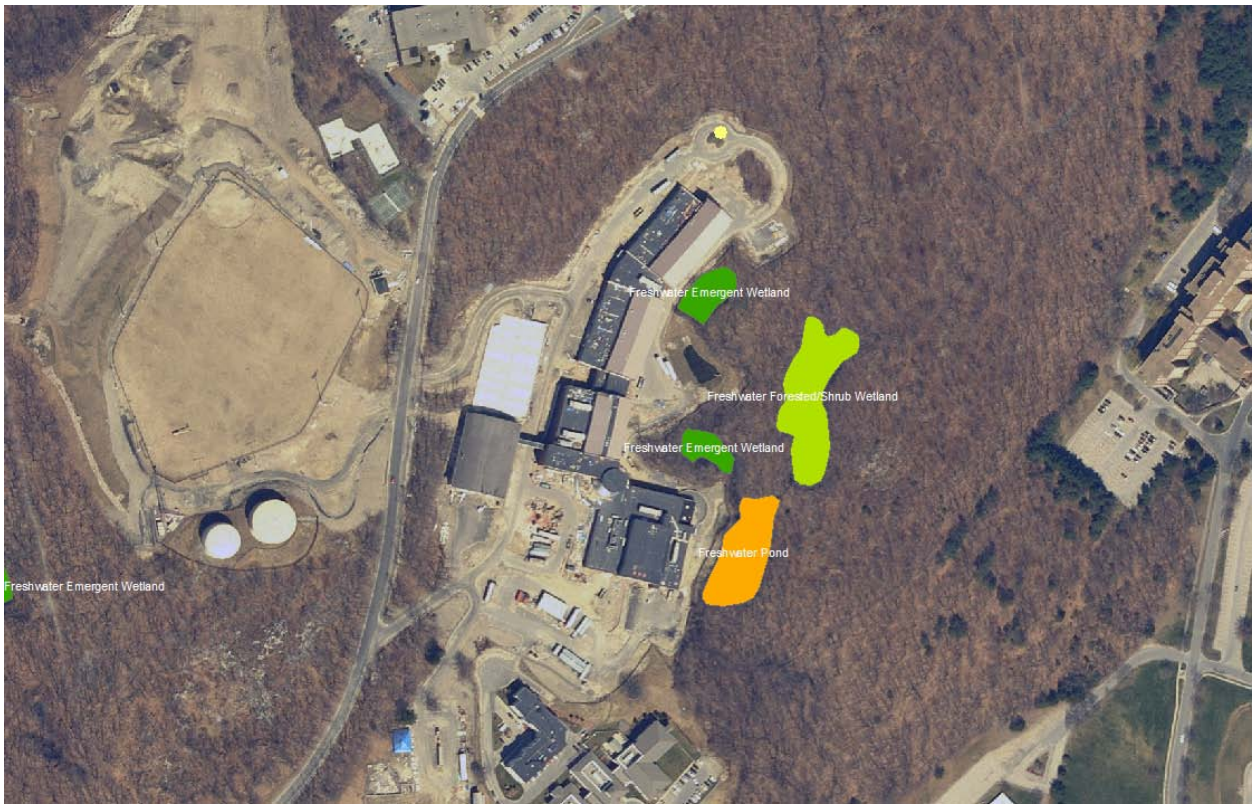


Figure 6-3 National Wetlands Inventory

6.3 ENVIRONMENTAL IMPACT

Based on the review of the impact of required setbacks on available land, it appears that any turbine location on the Technical High School site may require clearing of trees and construction in forested areas north and east of the school. Review of the BioMap2 data shows that the majority of this area is considered a core habitat. In addition, there are several identified wetlands in this area. The environmental impact of a wind energy project is not expected to be large, but may still prove an effective barrier to development.

7.0 Permitting

Black & Veatch has examined the general permitting requirements for energy projects in Massachusetts, and has prepared an initial list with our expectations regarding which permits would apply to a wind energy project in Worcester.

7.1 SITE ZONING

Based on the most recent zoning map obtained from the City of Worcester, the land the Technical High School is located on is zoned ML-0.5, Manufacturing, Limited. Based on this along with the requirement for obtaining a special permit, it is not expected that zoning will affect the development of a municipal project on this land.

7.2 WIND DEVELOPMENT ORDINANCE

Article IV, Section 13 of the most recent zoning ordinances from the City of Worcester, as amended through June 14, 2011, include detailed requirements for the construction and operation of wind projects (designated as Wind Energy Conversion Facilities, or WECFs). The requirements are summarized here, and the full text including definitions is included in Appendix E.

The criteria for approval of a WECF are:

- The proposed WECF does not derogate from the purposes and intent of the City Zoning Ordinance.
- The application information submitted is adequate for the Planning Board to consider approving the special permit request.
- The proposed design, installation and operation of the WECF will meet the requirements of the Ordinance.
- The acoustical assessment provided adequately predicts resulting sound levels as may be measured in accordance with the provisions of the Ordinance.
- Reasonable efforts have been made to minimize shadow flicker on neighboring or adjacent uses.
- The maintenance plan proposed adequately provides for the ongoing safe operation of the WECF.
- There will be no substantial adverse affect on the environment or wildlife.
- The documentation and information for setback, sound and shadow flicker waiver requests, if any, provide sufficient assurance that the affected participating and non-participating property owners are fully informed and consent to the waiver requests.
- That documentation and information for height and rotor diameter (as applicable) waiver requests, if any, are sufficient to meet the requirements of such requests.

WECF project requirements, restrictions, and setbacks are:

- Heights and sizes
  - Turbine height shall not exceed 265 feet (base to rotor tip). A waiver may be obtained. This requires a comparison of energy produced and greenhouse gas emissions prevented between the size options.
  - Maximum rotor size shall not exceed 165 feet. A waiver may be obtained. This requires a comparison of energy and greenhouse gas emissions like that for total turbine height.
  - The minimum distance between the rotor and the ground shall be 30 feet.
- Setbacks (distances measured from center of tower base)
  - Turbines shall be setback a minimum of 650 feet from the nearest non-participating landowner's occupied building.
  - Turbines shall be setback the greater of 165 feet or 1.25 times the total turbine height from the nearest participating landowner's occupied building
  - Turbines shall be setback a minimum of 1.1 times the total turbine height from the nearest wind turbine, right of way, property line, or existing above-ground utility transmission lines.
  - Guy wires (such as for a met tower) shall be setback at least 10 feet from the property line.
  - Met towers taller than 85 feet shall be subject to the same setback provisions as for wind turbines.
- Audible sound generated by a wind project shall not exceed 55 dB(A) at any non-participating landowner's occupied building.
- A reasonable effort shall be made to minimize shadow flicker to any occupied building on a non-participating landowner's property.
- Turbines must be certified with conformance to FCC rules regarding interference with radio and television reception, and the project owner must make efforts to avoid interference.

The Planning Board has the authority to waive setback, sound, and shadow flicker provisions if certain requirements are met. These waivers are part of the special permit approval for a WECF. The requirements of the ordinance are summarized below.

- Participating properties
  - Waivers may be granted for participating properties provided that the request is submitted in writing.
  - The participating property owner's written consent to the waivers must be submitted as well.
- Non-participating properties

  - Waivers may be granted for non-participating properties provided that the request is submitted in writing along with a signed affidavit showing the non-participating property owner's written support for the request.
  - The affidavit shall contain the non-participating property owner's acknowledgement of the setback, sound or shadow flicker requirements of the wind ordinance and what is proposed in lieu thereof. It must describe the impact on the nonparticipating property owner(s), and state the non-participating property owner's support for the applicant's waiver request.
- Public ways
  - Waivers may be granted for provisions that affect a public way, provided that the request is submitted in writing.
  - No waiver may be granted to the extent it would affect an existing above-ground utility transmission line unless the utility company owning the line consents to the waiver in writing.
- Turbine height
  - The Planning Board has the authority to waive the turbine height provisions in the ordinance.
  - The applicant must provide a comparison of a proposed WECF with the alternative in terms of energy produced and greenhouse gas emissions prevented, measured in tons of eCO2, that demonstrates that the increased height will significantly increase the energy produced by the WECF.
  - For small WECFs, the applicant must demonstrate that obstacles within 500 feet of the proposed location of a WECF will significantly reduce the available wind resource, or is likely to cause wind turbulence that would result in unsafe conditions for the operation of the proposed wind turbine. In these cases the Planning Board is limited to a waiver of 30 feet above the highest obstruction identified or 125 feet, whichever is less.
- Rotor diameter
  - The Planning Board has the authority to waive the turbine height provisions in the ordinance.
  - The applicant must provide a comparison of the proposal comparing the energy produced and tons of greenhouse gas emissions prevented, measured in tons of eCO2, that demonstrates that the increased rotor diameter will significantly increase the energy produced by the WECF.

The City ordinances also set forth design requirements for code and regulation compliance, access restriction, warning signs, and visual appearance. The ordinances require maintenance of a

turbine by certified personnel. A permit is required to use public streets for equipment transport, and the requirements include road condition surveys before and after construction and prompt repair of damage at the project owner's expense. The ordinances also set forth requirements for decommissioning and repair, public inquiries, and complaints.

The maximum term of any special permit for a wind project is 20 years or the length of the land lease, whichever is less. Extensions for up to 5 years at a time may be obtained within 6 months of the permit expiration.

The application requirements for a special permit include the following items:

- A project overview narrative
- A detailed site vicinity plan prepared by a registered engineer
- A detailed project site plan prepared by a registered engineer
- A wind map showing the wind characteristics of the general area and primary wind direction
- A sightline analysis from key vantage points including photographs of the project site with and without wind turbines (visual simulations), a map of photo locations, and technical descriptions
- A proposed date, time, and location for a balloon or crane test
- Compliance certificates and statements, including turbine certificates, structural analysis, FAA determinations, certification by an acoustical engineer, and evidence of conformance with FCC requirements
- A maintenance plan
- A detailed sound assessment report
- A shadow flicker assessment
- An environmental and wildlife impact assessment
- Requests for waivers of requirements in these ordinances with supporting documents
- Documents related to decommissioning
- Required fees
- Other relevant studies, reports, and certifications

The requirements for wind projects set forth by the City of Worcester are fairly detailed and appear well thought out. The overall height limit of 265 feet (81 meters) and rotor size limit of 165 feet (50 meters) without a waiver means that a large wind turbine will require a waiver. A smaller turbine such as an RRB PS-600 would not, but would not produce as much energy.

7.3 LIST OF REQUIRED PERMITS

At present, the permit requirements that seem very likely to apply to a community wind energy project in Worcester are found in Table 7-1. A list of abbreviation can be found at the end of the table.

Table 7-1 List of Permits

AGENCY	PERMIT	REGULATED ACTIVITY	REQUIRED PROJECT PHASE	APPLICABLE TO PROJECT	MINIMUM REVIEW TIME	COMMENTS/ISSUES
FEDERAL						
COE	Section 10 Nationwide Permit	Construction activities in navigable waters of the US	Construction	MAYBE	3 - 4 months for nationwide; 2 - 3 months for individual	Required for construction in navigable waters of the US. Site reconnaissance needed to determine applicability.
COE	Section 404 Nationwide Permit	Discharge of dredge or fill material into US waters, including jurisdictional wetlands	Construction	MAYBE	3 - 4 months for nationwide; 2 - 3 months for individual	Required only if wetlands will be filled on site or along off-site utility right-of-way. Site reconnaissance needed to determine applicability.
EPA	SPCC Plan	On site storage of oil > 1,320 gallons	Construction	MAYBE	3 months	Threshold may be exceeded due to construction equipment at site. Exceeding threshold not expected for operational activities.
FAA	Notice of Proposed Construction or Alteration	Construction of an object which has the potential to affect navigable airspace (height in excess of 200 feet or within 20,000 feet of an airport)	Construction	YES	3 - 4 months	Worcester Regional Airport is approximately 5 miles from the nearest candidate site. FAA will require lighting or marking of turbines or temporary construction crane. The tallest estimated turbine blade height is about 400 feet above ground level. May be concerns about height if close to existing flight paths. Refer also to MAC/MPA review.

AGENCY	PERMIT	REGULATED ACTIVITY	REQUIRED PROJECT PHASE	APPLICABLE TO PROJECT	MINIMUM REVIEW TIME	COMMENTS/ISSUES
FERC	EWG Status	Selling electric energy at wholesale to a utility or other generator	Construction	MAYBE	3 - 4 months	Electricity will likely be sold to the grid.
FERC	Qualifying Facility Certification	Qualification for PURPA benefits for small power production facility using renewable resources	Construction	MAYBE	Formal certification, 3 - 5 months. Self-certification, upon filing.	Electricity will likely be sold to the grid. This certification is for facilities producing less than 80 megawatts of power.
EPA	NPDES Stormwater Construction General Permit	Discharge of stormwater from construction sites disturbing 1 acre or more	Construction	MAYBE	9 - 12 months	Requires joint approval with MDEP. Dependent on candidate site selected. Project may disturb less than 1 acre if only one small turbine is built
USFWS	Migratory Bird Treaty Act Compliance	Activity with potential to harm migratory bird species	Construction	YES	1 - 2 months	Design turbines to avoid avian impacts. ESA compliance review may also incorporate this Migratory Bird Treaty Act review.
USFWS	Endangered Species Act Compliance	Confirmation of no impacts to threatened and endangered species	Construction	YES	1 - 2 months	Consultation recommended if species and/or habitat onsite or along utility interconnection right-of-way may be impacted.

AGENCY	PERMIT	REGULATED ACTIVITY	REQUIRED PROJECT PHASE	APPLICABLE TO PROJECT	MINIMUM REVIEW TIME	COMMENTS/ISSUES
FEDERAL	NEPA	Major federal action affecting the environment	Construction	NO		May be required if COE individual permit needed.
STATE						
MDPU/EFSB	Site Certification	Construction of an energy generating facility	Construction	NO	10 - 12 months	Project size below threshold.
DOER	Application for Statement of Qualification pursuant to Massachusetts Renewable Portfolio Standard	Construction and operation of a new renewable energy facility proposing to sell energy to the grid	Construction	YES	2 - 3 months	Project would be considered a Small Power Production Qualifying Facility with respect to selling power to utilities that are required under Massachusetts law to purchase electricity from certain classes of renewable energy and distributed generation facilities.
EOEA	MEPA Determination: Environmental Notification Form (or expanded form)	Alteration of more than 25 acres of land	Construction	MAYBE	2 - 3 months	Must be filed if more than 25 acres of land will be directly altered or certain other EOEA criteria met.

AGENCY	PERMIT	REGULATED ACTIVITY	REQUIRED PROJECT PHASE	APPLICABLE TO PROJECT	MINIMUM REVIEW TIME	COMMENTS/ISSUES
EOEA	MEPA Review: Environmental Impact Report	Alteration of more than 50 acres of land	Construction	NO	6 - 9 months	Evaluation of effects of state agency permitting action on the environment based on review of the Environmental Notification Form by the Secretary of Environmental Affairs. Environmental Impact Report required if more than 50 acres of land will be altered or other criteria met. Project will likely not meet 50 acre threshold.
EOEA	Protected Land Regulation Compliance	Activities on protected land	Construction	MAYBE	1 - 2 months	EOEA Article 97 Policy and Massachusetts General Law Chapter 61 govern the use of protected land. Compliance with these laws is necessary for a successful EIR or ENF process. These laws may apply if the project requires access or easements on protected parkland or agricultural land.
MDEP	Notice of Intent	Wetland alteration	Construction	MAYBE	3 - 4 months	Site reconnaissance necessary to determine any wetland impacts from the project. GIS resources show no direct impact.

AGENCY	PERMIT	REGULATED ACTIVITY	REQUIRED PROJECT PHASE	APPLICABLE TO PROJECT	MINIMUM REVIEW TIME	COMMENTS/ISSUES
MDEP	Noise Control Policy Compliance	Noise from wind turbine	Operation	MAYBE	1 - 2 months	Policy discourages a broadband noise level greater than 10 dB(A) above ambient, or pure tone noise. Noise is not expected to be an issue as long as the project is properly evaluated and any necessary mitigation requirements are implemented. City of Worcester Noise Requirements must be considered as well. All candidate sites are close to residences.
MDEP	NPDES Individual Wastewater/Storm Water Discharge Permit	Wastewater discharge and storm water runoff during facility operation. NOTE: This program is jointly administered by EPA and MDEP.	Operation	NO	9 - 12 months	Operation of a wind farm is not considered an industrial activity under the stormwater program.

AGENCY	PERMIT	REGULATED ACTIVITY	REQUIRED PROJECT PHASE	APPLICABLE TO PROJECT	MINIMUM REVIEW TIME	COMMENTS/ISSUES
MDEP	Massachusetts Clean Waters Act, Section 401 Water Quality Certification	Required for federal activities affecting state land	Construction	MAYBE	3 months	Necessary if Section 404 permit is required. Permit required if wetlands will be altered in any way. The permit application is a Notice of Intent and is also sent to the City of Worcester Conservation Commission. If an area less than 5,000 square feet of wetland is altered, the Order of Conditions also serves as the project's Section 401 Water Quality Certificate. The project will most likely not affect wetlands.
MDF&G Natural Heritage and Endangered Species Program	Notice of Intent	Wetland alteration	Construction	MAYBE	3 - 4 months	Same as form submitted to MDEP. Required if project is in "estimated habitat" of rare wildlife (many rare species are present in the area).
MDF&G Natural Heritage and Endangered Species	Endangered Species Act Consultation/ Compliance	Activities that could potentially affect threatened or endangered species	Construction	YES	3 - 4 months	Conservation and Management Permit required for any take of a state endangered species.
MDOH	General Access Permit	Alteration of state roads	Construction	MAYBE	2 - 3 months	May be needed if project involves alterations to state roads to access site.

AGENCY	PERMIT	REGULATED ACTIVITY	REQUIRED PROJECT PHASE	APPLICABLE TO PROJECT	MINIMUM REVIEW TIME	COMMENTS/ISSUES
MDOH	Wide Load Permit	Movement of oversize project equipment	Construction	MAYBE	2 - 3 months	May be necessary for transport of oversized equipment like turbine components or certain construction equipment.
ISO New England (and transmission line owner at interconnection point)	NEPOOL Interconnection System Impact Study and Facility Study	Transmission interconnection	Construction	MAYBE	9 - 12 months	Electricity will likely be sold to the grid. Project owner determine participation in NEPOOL.
EFSB	Transmission line approval	Transmission interconnection	Construction	MAYBE	2 - 3 months	Electricity will likely be sold to the grid. Candidate sites are adjacent to a 115 kV transmission line; however, contact with City of Worcester and Worcester County is also recommended to determine right-of-way requirements.
Massachusetts DPU	Section 72 Transmission Line Approval	Transmission interconnection	Construction	MAYBE	2 – 3 month	Electricity will likely be sold to the grid. Candidate sites are adjacent to a 115 kV transmission line;
MAC	Request for Airspace Review courtesy notice	Structures over 200 feet tall	Construction	YES	3 - 4 months	Provide courtesy notification of any projects over 200 feet tall (similar to FAA review, but not a permit per se).

AGENCY	PERMIT	REGULATED ACTIVITY	REQUIRED PROJECT PHASE	APPLICABLE TO PROJECT	MINIMUM REVIEW TIME	COMMENTS/ISSUES
MPA	Request for Airspace Review	Structures over 200 feet tall near airports	Construction	YES	3 - 4 months	Worcester Regional Airport is in fairly close proximity, approximately 5 miles from the nearest candidate site. May be concerns about the ~400 foot turbine blade height if close to existing flight paths. This review may be done concurrent with the FAA review.
CZM	Massachusetts General Law Chapter 91 (Public Waterfront Act) authorization	Structures in tidelands, ponds, certain rivers and streams	Construction	MAYBE	1 - 2 months	Chapter 91 authorization is required for structures in tidelands, Great Ponds (over 10 acres in natural state) and certain rivers and streams. Types of structures include piers, wharves, floats, retaining walls, revetments, pilings, bridges, dams, and some waterfront buildings (if on filled lands or over water). Can file Determination of Applicability if applicability of Chapter 91 in question. Site reconnaissance necessary to determine applicability.
MHC	Archaeological and Historical Review	Activities that could potentially affect archaeological or historical resources	Construction	YES	3 - 4 months	Archaeological and historical review generally required for construction of wind projects.

AGENCY	PERMIT	REGULATED ACTIVITY	REQUIRED PROJECT PHASE	APPLICABLE TO PROJECT	MINIMUM REVIEW TIME	COMMENTS/ISSUES
LOCAL						
City of Worcester Conservation Commission	Order of Conditions/ Wetlands Bylaw compliance review	Alteration of wetlands	Construction	MAYBE	3 - 4 months	Permit required if wetlands will be altered in any way. The permit application is a Notice of Intent and is also sent to the Massachusetts Department of Environmental Protection. If an area less than 5,000 square feet of wetland is altered, the Order of Conditions also serves as the project's Section 401 Water Quality Certificate. Site reconnaissance necessary to determine wetland impacts.
City of Worcester - Building Department	Building permit	New construction activity in Worcester	Construction	YES	1 - 2 months	
City of Worcester - Planning and Zoning Department	Zoning/Site Plan Approval - Special Permit	Construction of a wind farm outside the scope of current zoning designations	Construction	MAYBE	2 - 3 months	Reviews project for compliance with zoning code. Contact with Department needed to determine specific requirements.
Fire Marshal	Fire Code Approval	New development	Construction	MAYBE	NA	Possible substation inclusion in project may trigger need for this approval. Contact with Fire Marshal needed to determine specific requirements.

List of Abbreviations

- COE - Army Corps of Engineers
- CZM - Massachusetts Office of Coastal Zone Management
- dB(A) - A-weighted decibel
- DOE - Department of Energy
- DOER - Massachusetts Office of Consumer Affairs and Business Regulation - Division of Energy Resources
- EFSB - Massachusetts Department of Telecommunications and Energy - Energy Facility Siting Board
- EOEA - Executive Office of Environmental Affairs
- EPA - US Environmental Protection Agency
- EWG - Exempt Wholesale Generator
- FAA - Federal Aviation Administration
- FERC - Federal Energy Regulatory Authority
- ISO/NEPOOL - Independent System Operator/New England Power Pool
- MAC - Massachusetts Aeronautics Commission
- MDEP - Massachusetts Department of Environmental Protection
- MDF&G - Massachusetts Department of Fish and Game
- MDOH - Massachusetts Department of Highways
- MDPU - Massachusetts Department of Public Utilities
- MEPA - Massachusetts Environmental Policy Act
- MHC - Massachusetts Historical Commission
- MNHP - Massachusetts Natural Heritage Program
- MPA - Massachusetts Port Authority
- NEPA - National Environmental Policy Act
- NPDES - National Pollutant Discharge Elimination System
- NPS - National Park Service
- OOC - Order of Conditions
- PURPA - Public Utilities Regulatory Policy Act
- SPCC - Spill Prevention, Control and Countermeasure
- USFWS - US Fish and Wildlife Service
- WWTP - Wastewater Treatment Plant

7.4 ADDITIONAL RESEARCH

In this phase of the study, Black & Veatch did not contact any local, state, or federal agencies to explore the permit requirements for this project. The above list represents a collection of permits that may be required and it is identified which permits are likely to be needed for the project. Black & Veatch recommends contacting the appropriate local, state, or federal agencies in order to determine final permitting requirements.

7.5 PERMITTING TIMELINE

To prepare for these permits, it may be advisable to have informal meetings with each agency to discuss the project and that agency's study expectations. The majority of the permits listed in this section are expected to require approximately 2 to 4 months to obtain, following completion of appropriate study work. However, due the potential project's proximity to Park land, the community involvement and permitting time may be extended to 6 to 12 months.

8.0 Conceptual Design

This section reviews the conceptual wind plant configuration as well as the proposed wind turbine types for the project.

8.1 WIND TURBINE MODELS

Based on initial wind resource screening and analysis and project specifics, Black & Veatch chose to use two different turbine types representing two major machine categories: modern utility-scale wind turbines designed for lower wind sites and smaller community-scale turbines. Two representative turbines of these two classes are:

- General Electric 1.6-100. 1.6 MW, 100 meter rotor, 80 or 100 meter tower. This will be referred to as the "large turbine" below.
- RRB PS-600. 600 kW, 47 meter rotor, 50 meter tower. This will be referred to as the "medium turbine" below.

Other turbines that, like the above designs, appear suitable for the wind resource in Worcester were considered but not directly evaluated. These include the Vestas V100 1.8 MW and the Turbowinds T600. These turbines are very similar to the GE 1.6-100 and PS-600, respectively. Overall performance and cost for these models is expected to be similar.

8.1.1 GE 1.6-100

The 1.5 MW series wind turbines from GE Energy are the most widely installed line of wind turbine generators in the U.S. The GE 1.5sle, with a 77 meter diameter rotor and 80 meter hub height, is considered something of a workhorse of the U.S. wind turbine fleet. More recently, GE has been developing variants of this platform that are meant for lower wind resource sites. The most recent and most aggressive of these is the 1.6-100, which has a 1.6 MW generator, 100 meter rotor diameters, and is available on 80 and 100 meter towers. Because of its large rotor size on what is a relatively small generator platform, the 1.6-100 is estimated to produce significantly higher capacity factors at low wind sites than previous versions of this platform.

8.1.2 RRB PS-600

The PS-600 is based on the design of the widely installed Vestas V47 wind turbine. It is a relatively modern 600 kW fixed speed pitch-regulated machine manufactured in India based on the original Vestas designs and component suppliers. This turbine is available with a 47 meter rotor on a 50 meter tall tower. Other tower heights can be custom manufactured. Two of these turbines are installed at the Deer Island Treatment Plant in Boston Harbor.

8.2 POTENTIAL CONFIGURATIONS

Because available land is so limited, Black & Veatch considered a single project configuration in this study. This configuration is a single wind turbine located north and east of the

Technical High School. Changes to the turbine location within the high school parcel are expected to result in only minimal changes to production and cost. This location is shown in Figure 8-1.

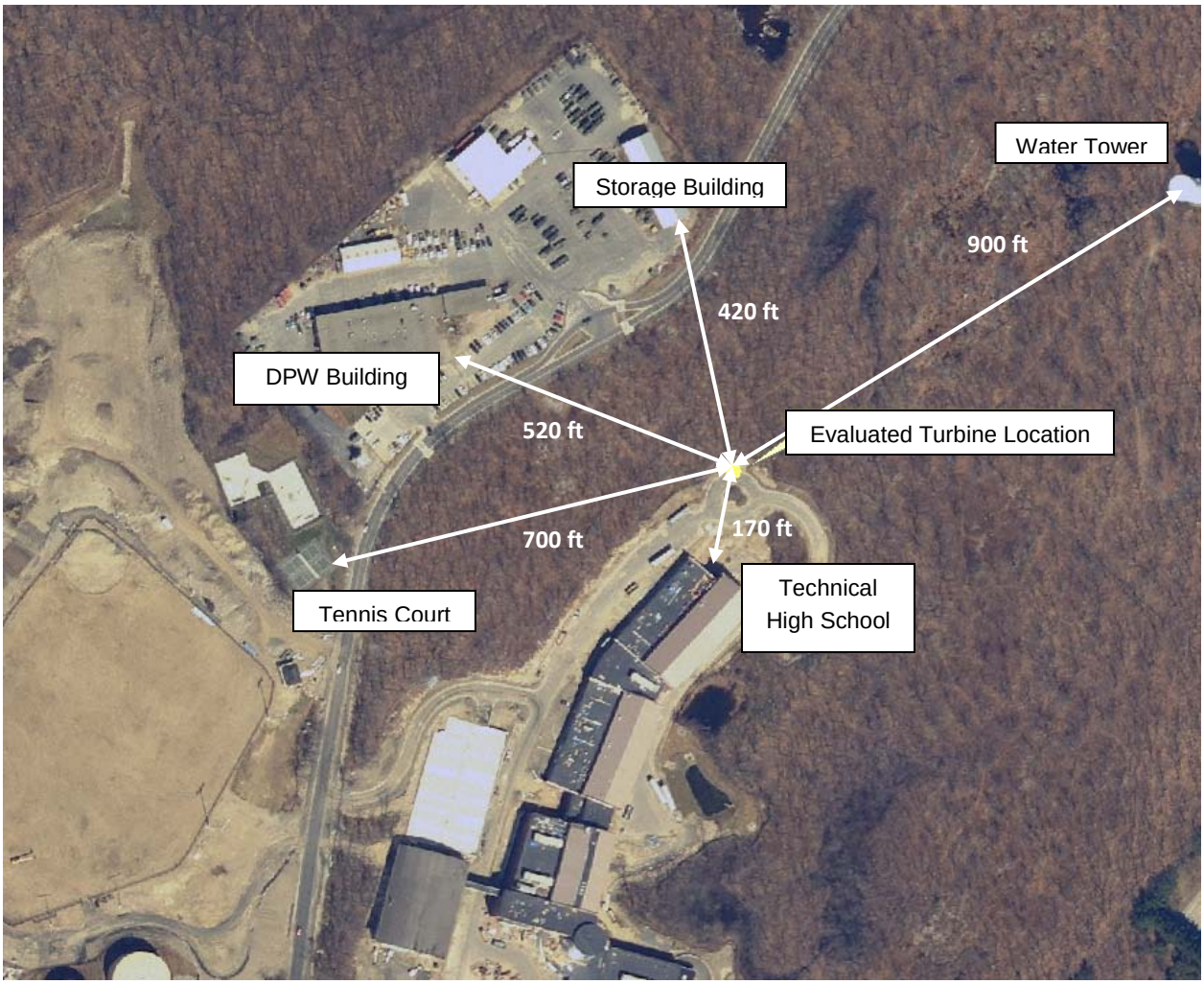


Figure 8-1 Conceptual Turbine Location

8.3 DISTANCE FROM KEY LOCATIONS

The urban nature the area means that a project at the Technical High School will be in close proximity to a school, homes, businesses, and recreation facilities. The nearest building is the school itself, which is only about 170 feet to the south of the proposed location. At this distance, the 100 meter diameter rotor of the large turbine will be nearly overhanging the building. City buildings to the west are 400 – 500 feet from the turbine. Key distances are shown in Figure 8-1 above.

8.4 NOISE AND SHADOW FLICKER

Any wind turbine installed in an urban area is at risk of having some adverse impacts on residential or commercial areas, though careful siting can often minimize these impacts. Two of the most common concerns are the potential noise impacts and the potential shadow flicker impacts of a turbine on nearby homes and businesses.

Potential noise impacts include the aerodynamic noise of the turbine blades as well as noise produced by the generation equipment mounted in the turbine nacelle. Manufacturers typically provide noise data for wind turbines, which can be used along with measurements of ambient noise levels to model the likely noise impacts of a wind turbine. Shadow flicker is a term describing the moving shadows that can be produced by rotating turbine blades. These moving shadows can produce a distracting strobe-like flickering effect. This generally occurs in the early morning and late evening, when shadows are longest. It is much more likely to be a concern for residents in the surrounding area than for those using the area recreationally. Preliminary noise and shadow impacts were modeled for all three scenarios using the WindFarmer computer software.

The results of shadow flicker modeling are shown in Figure 8-2 for the medium turbine scenario and Figure 8-3 and Figure 8-4 for the large turbine. The model results show the number of hours per year that moving shadows from the turbine rotor are expected to affect each location, based on terrain and sun position. Mitigating effects such as clouds, fog, and vegetation are not included. The distinctness of shadows and relative strength of light in shaded and unshaded areas is also not considered. The greatest effects are seen at buildings to the east and west of the turbines.

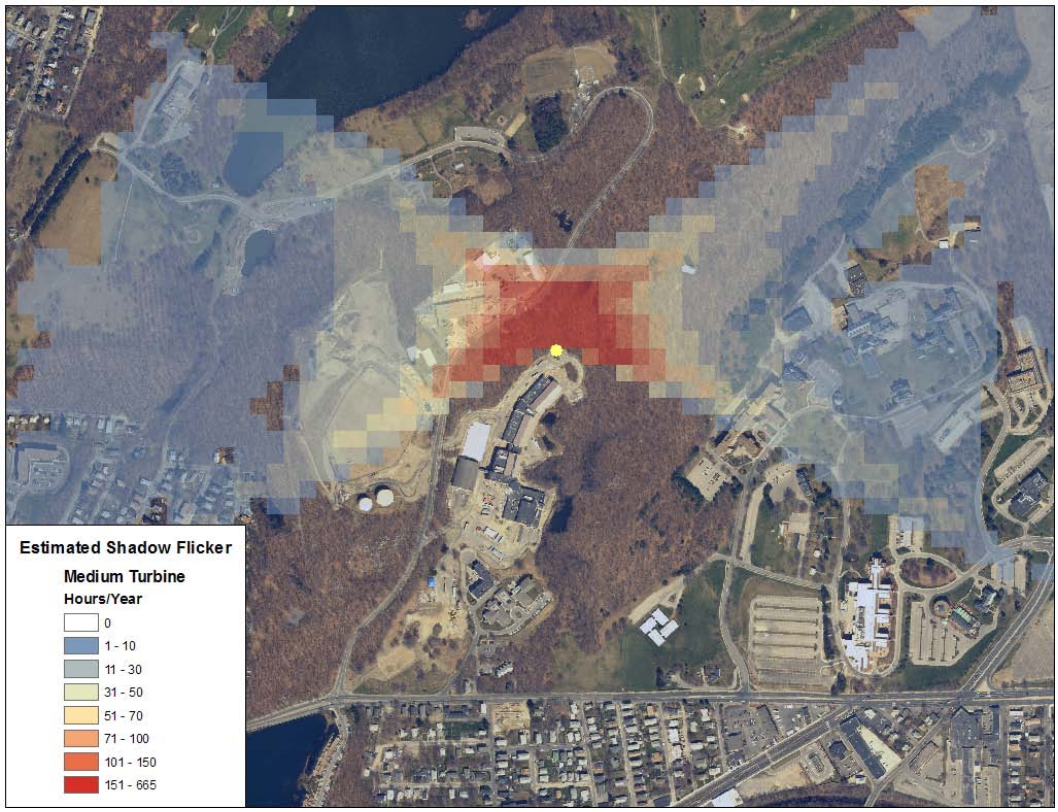


Figure 8-2 Estimated Shadow Flicker for Medium Turbine

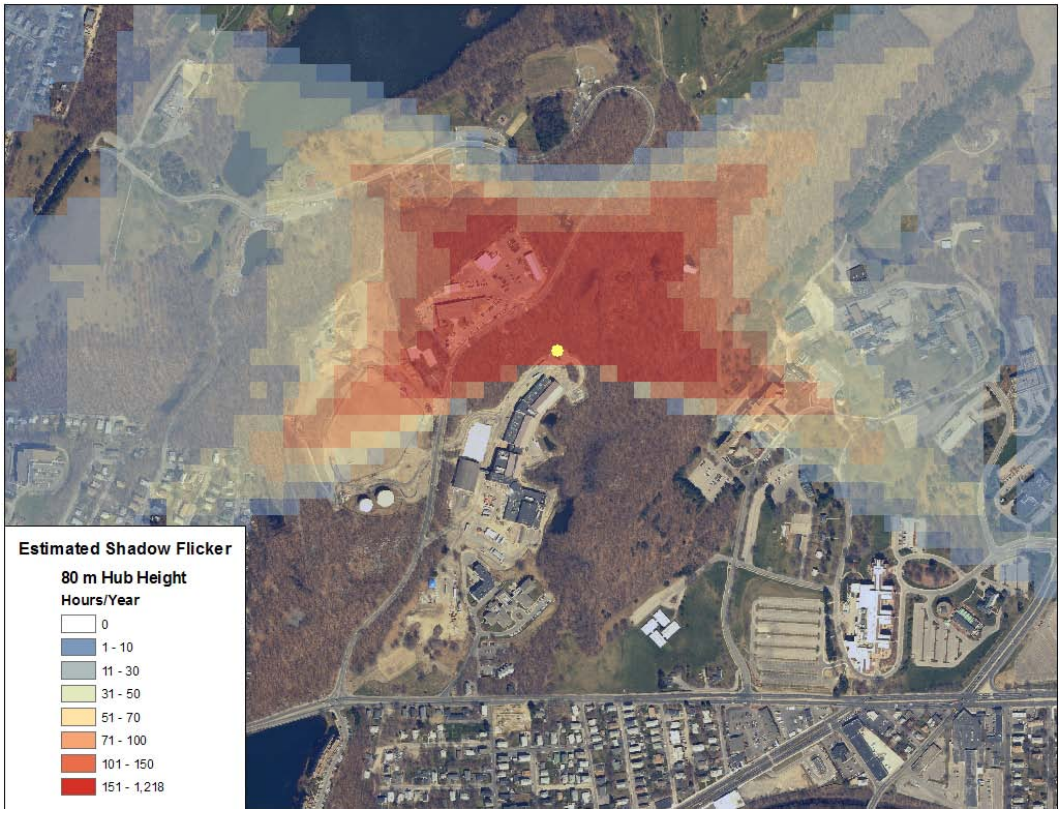


Figure 8-3 Estimated Shadow Flicker for Large Turbine, 80m Hub Height

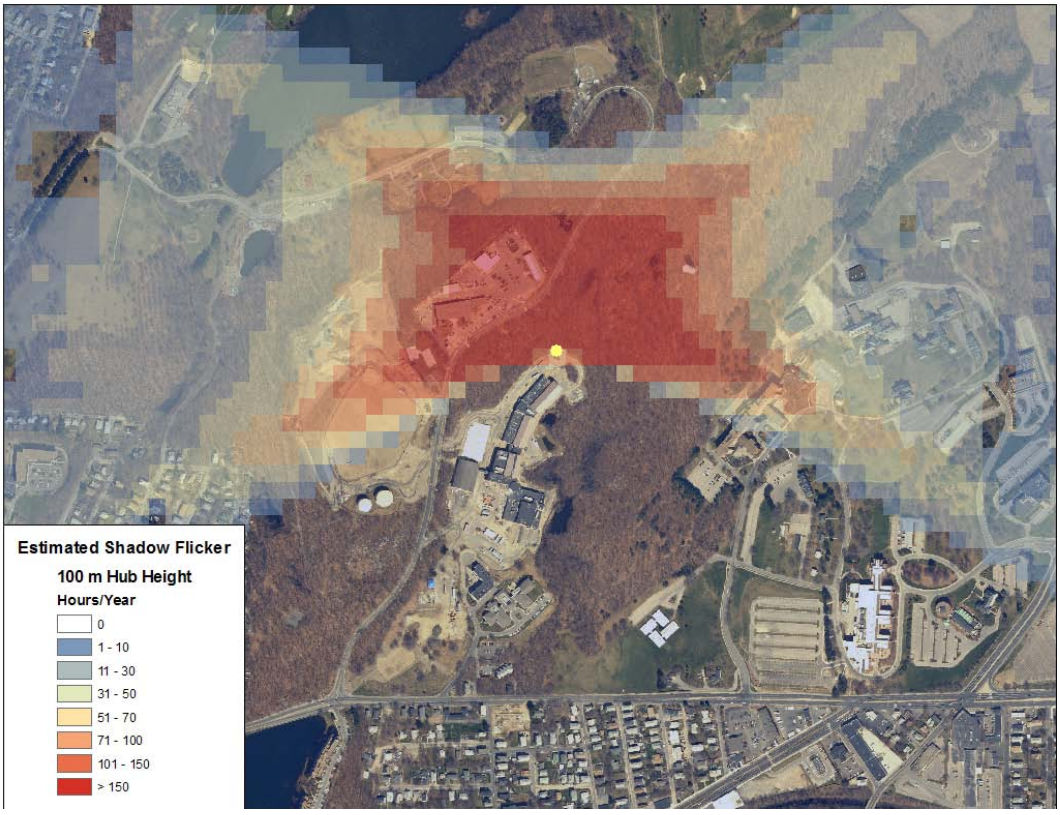


Figure 8-4 Estimated Shadow Flicker for Large Turbine, 100m Hub Height

The estimated noise impacts from these turbine scenarios are shown in Figure 8-5, Figure 8-6, and Figure 8-7. These estimates are based on basic noise emissions data on the evaluated turbine models and general atmospheric data. They do not include ambient noise, which was not measured during the site visit, or the effects of vegetation and buildings. A separate, more detailed noise study would be required to estimate the actual noise effects on surrounding buildings and land.

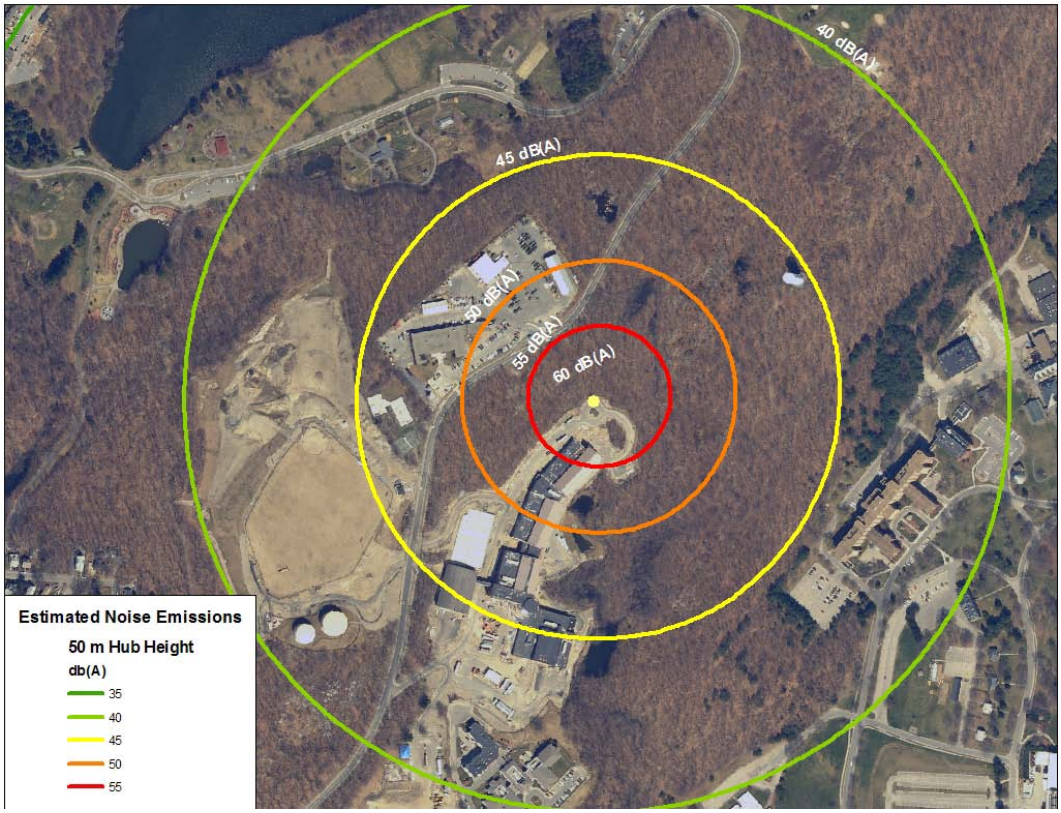


Figure 8-5 Estimated Noise Emissions, Medium Turbine

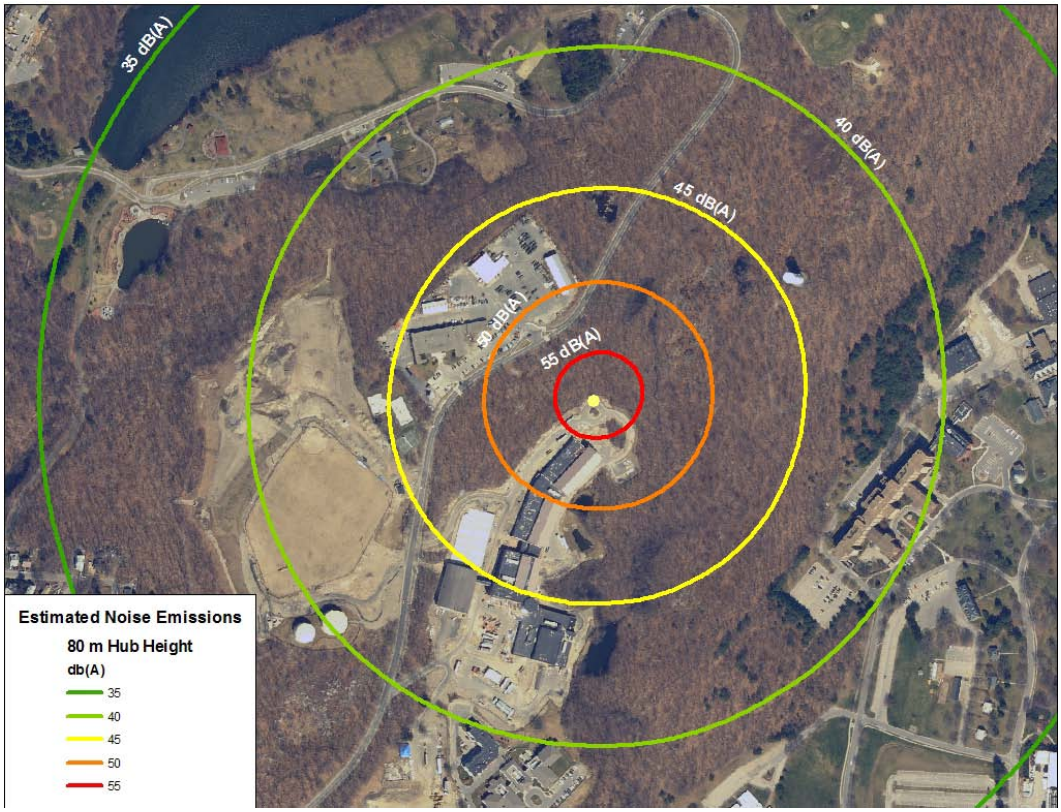


Figure 8-6 Estimated Noise Emissions, Large Turbine, 80m Hub Height

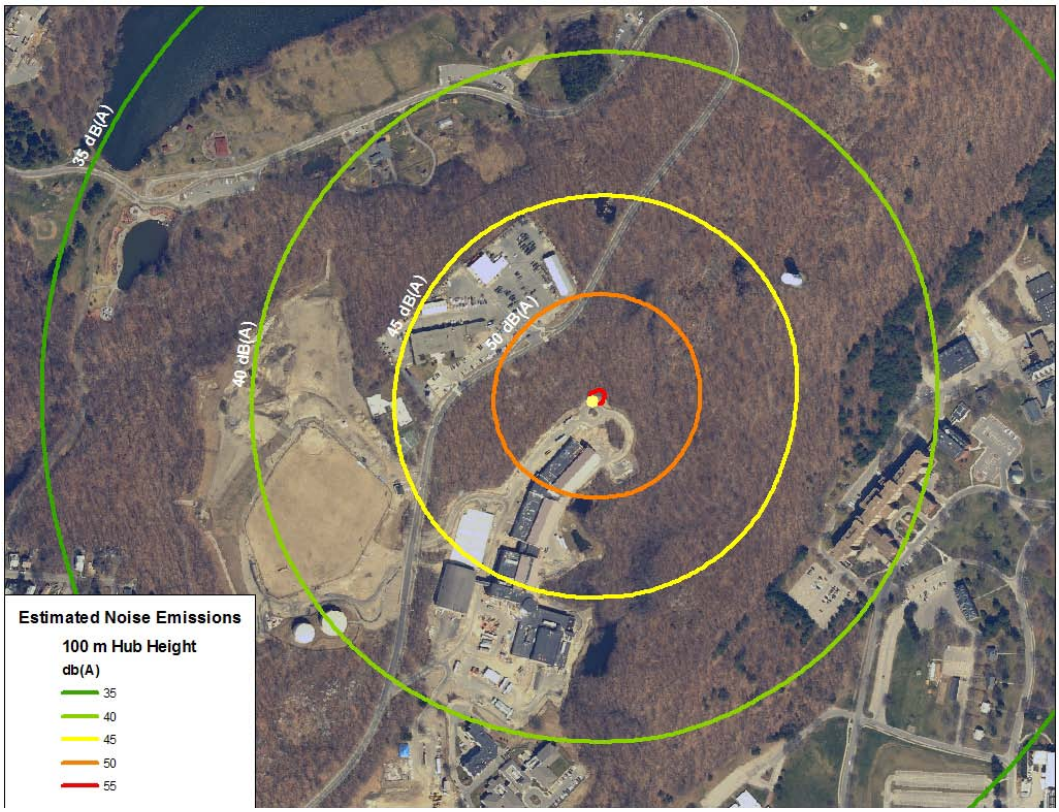


Figure 8-7 Estimated Noise Emissions, Large Turbine, 100m Hub Height

8.5 AIRSPACE IMPACT

The nearest airport is the Worcester Municipal Airport, about 5 miles west of the project. There are several private airstrips or airfields a little farther away. The nearest of these are shown in Figure 8-8.

Figure 8-8 Nearby Airports

According to Federal Aviation Administration (FAA) Advisory Circular 70/7460-2J, a Notice of Proposed Construction must be filed with the FAA for the construction of any structure over 200 feet (61 meters) tall or within a certain distance-height zone from commercial or military airports. All commercial-scale wind turbines are more than 200 feet tall, so a notice will be required to be filed with the FAA and will require markings and lighting.

The distance from these smaller airports is expected to be great enough that the FAA would issue a Determination of No Hazard to Air Navigation (DNH) for a turbine at any of the potential sites. Aviation Systems, Inc. (ASI), an airspace consultant, performed preliminary assessments for turbines on the golf course and at the technical high school, and concluded that there should be no issues with obtaining approval for turbines up to 397 feet in total height. These assessments are included in Appendix G.

8.6 COMMUNICATIONS IMPACT

Figure 8-9 shows known communication towers within 4 miles of the potential turbine sites, obtained using tools on the AntennaSearch web site (http://www.antennasearch.com). There are many towers near the site, especially in central Worcester. The nearest tower to any of the sites appears to be the communications tower located to the south of the baseball fields. Figure 8-10 shows known antennas in the same area. Given the density of towers and antennas in the area, a formal communications study is recommended to determine the impact of a wind turbine.

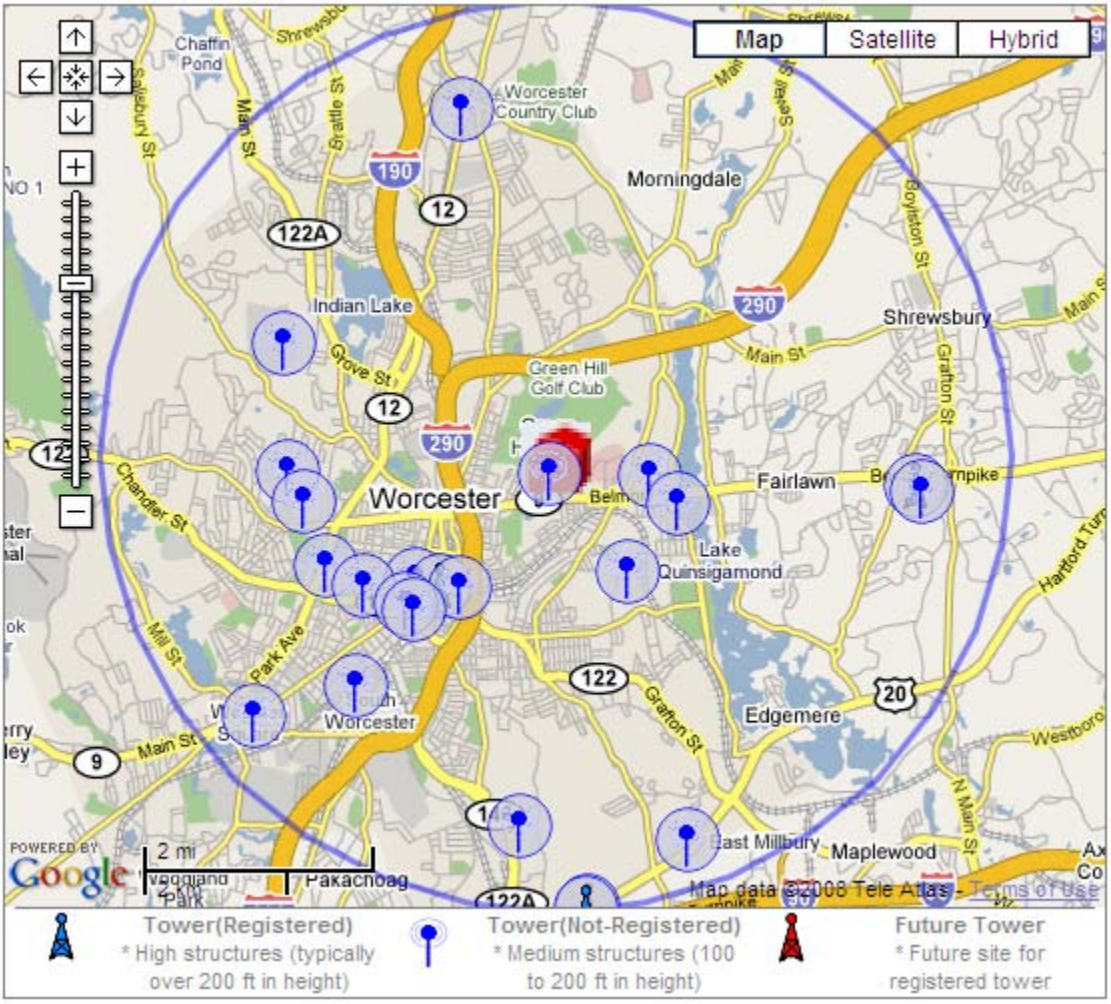


Figure 8-9 Nearby Tower Structures

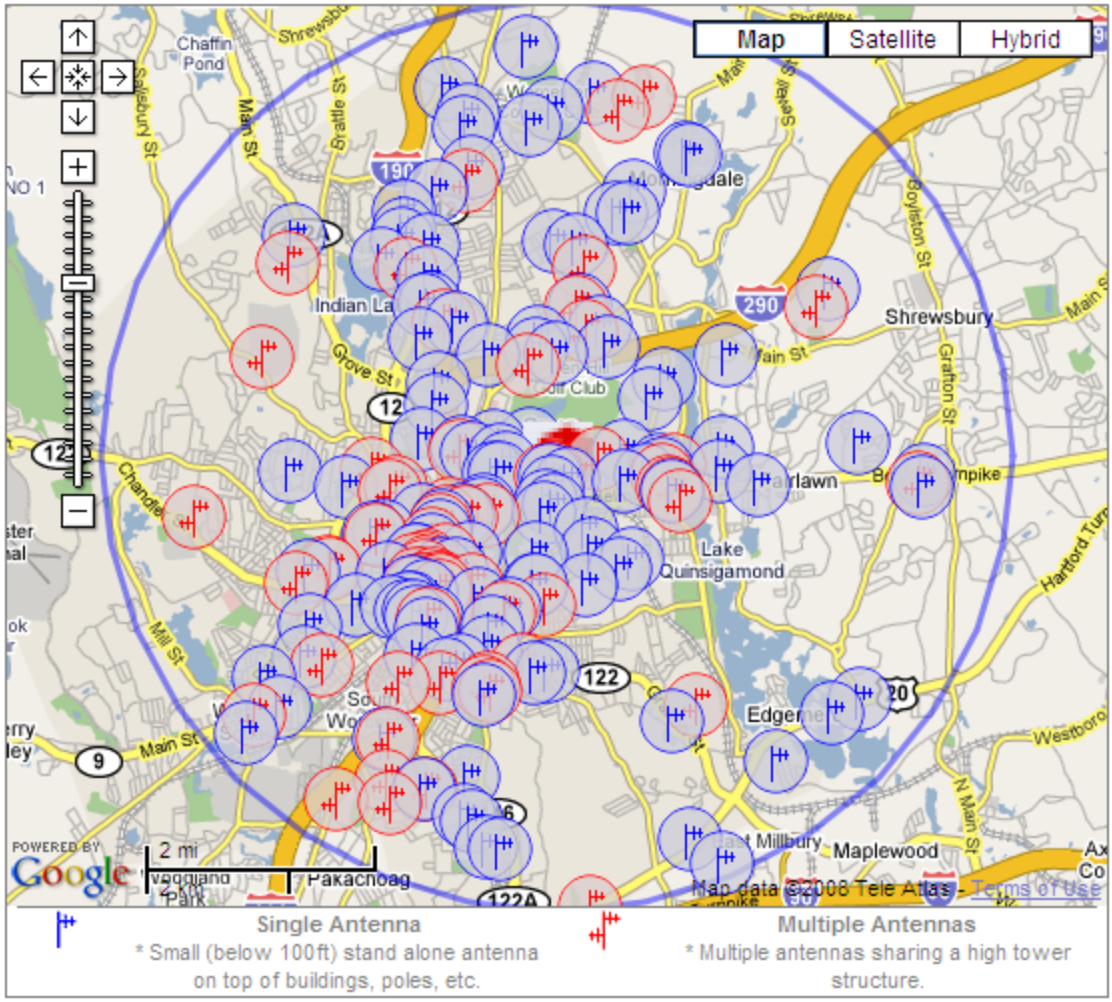


Figure 8-10 Known Antennas

8.7 APPROPRIATENESS AND COMMUNITY IMPACT

On the whole, a single turbine project at the Technical High School should not have major adverse effects on the surrounding area. However, because of the project's urban nature and limited available land, it does not appear possible to avoid all negative impact on businesses, homes, wildlife, and the community.

No medium or large wind project at the Technical High School will be able to meet all setback requirements from homes, streets, utility lines, other structures, and property lines. Some waivers of setbacks will be required, and there may be perceptible shadow flicker and noise impacts. There may also be safety impacts related to ice throw in the winter because of the close proximity of a turbine and the school.

9.0 Project Development Considerations

The following section discusses the project development considerations for a wind project in the City of Worcester.

9.1 DEVELOPMENT AND OWNERSHIP OPTIONS

The potential wind project is located on the property of the Worcester Technical High School. There are typically two ownership options for Massachusetts communities that seek to host utility scale wind projects: municipal ownership and third party ownership. For this project, municipal ownership appears to be the preferred option, based on the City's Climate Action Plan, the relatively low wind resource in the area, and the high cost of a single turbine project. Financial terms and hurdles for municipal projects tend to be more favorable than those for commercial projects.

The City has several options for project development, engineering, procurement, and construction, but Black & Veatch believes the best option may be for the city to perform some up-front development and environmental study work, and then issue an RFP for complete engineering, procurement, and construction for a project from a third party. This could be a turbine vendor who directly performs such work, or a firm that will procure all necessary equipment and perform the work. Several such firms perform this type of small wind work in New England.

9.2 PROJECT FINANCING

Black & Veatch has assumed that the City of Worcester would finance the installation of a single wind turbine with 100 percent debt in the form of 10-year municipal bonds.

9.3 DEVELOPMENT CONSIDERATIONS

A wind energy project in Worcester will generate Renewable Energy Credits (RECs) equivalent to the number of megawatt-hours (MWh) of energy it produces. Massachusetts has an operating REC market where credits can be bought and sold. The City could elect to keep these credits and be able to claim the use of green energy. Alternatively, the City could choose to sell the RECs to another party or parties who needs or wants the green aspect of the project. In this study Black & Veatch assumed that the City would sell all RECs generated by the project.

Project management and procurement would likely be handled by a third party contractor who will actually do the project engineering and install the turbine. Alternatively, the City could buy a turbine themselves and hire a contractor to perform the remaining engineering, construction, and installation. Often with large projects the project owner procures the turbines directly because the long lead time to obtain turbines means they are often bought before a construction contractor is selected, though there are several aggregators in Massachusetts that are able to provide a full service installation including turbine procurement for small projects.

9.4 OPERATIONS AND MANAGEMENT

Many of the operating wind projects in Massachusetts are small installations of 1-2 turbines, similar to that investigated in this report. The nearest dedicated service personnel may be at projects in New York State. Since the manufacturer would likely perform routine maintenance and repair on the turbines for the first five years of operations, it is likely that personnel from other wind projects in New England would be dispatched to Worcester as necessary, and a project would most likely be operated and monitored from an existing project facility elsewhere as well. This may introduce delays in servicing faults that require on-site repair, though many faults could be reset remotely.

After the turbine warranty period ends, the City would have the option of hiring a third party operations and maintenance company that would operate and maintain the turbines similarly to the manufacturer, or could have city employees trained in the operation and maintenance of the turbine.

10.0 Estimated Energy Production

Black & Veatch used the wind energy estimate from Section 3 to estimate energy production from a single turbine wind project in Worcester.

10.1 WIND TURBINE POWER CURVES

Based on the site elevation and climatic information, Black & Veatch chose to use the sea level air density (1.225 kg/m3) power curves to estimate production from a GE 1.6-100 or Vestas RRB V47 turbine. The power curves, shown in Table 10-1, represent the power output from the turbines at various wind speeds. Although these models have nominal ratings of 1.6 MW and 600 kW, they will generate less energy at wind speeds lower than about 11 m/s. This means that the turbine will generate less power than its nominal rated power the majority of the time.

Table 10-1 Turbine Power Curves

HUB HEIGHT WIND SPEED, M/S	PS-600 OUTPUT, KW	GE 1.6-100 OUTPUT, KW
0	0	0
1	0	0
2	0	0
3	0	0
4	21	80
5	42	260
6	80	500
7	142	800
8	218	1,160
9	303	1,420
10	401	1,570
11	473	1,610
12	532	1,620
13	564	1,620
14	582	1,620
15	597	1,620
16	600	1,620
17	602	1,620
18	600	1,620
19	600	1,620
20	600	1,620
21	600	1,620
22	600	1,620
23	600	1,620
24	600	1,620
25	600	1,620

Note: Power output data based on sales material.

10.2 PRODUCTION LOSSES

The energy production estimated based on solely the turbine power curve and wind resource data is a gross production estimate, and does not include energy losses. There are many factors that can contribute to the loss of energy in a wind project. Several sources of energy loss were considered for a single turbine project in Worcester. Each factor was examined and an assumed energy loss percentage was chosen. These loss factors are summarized in Table 10-2, and discussed further below.

Table 10-2 Energy Production Losses

LOSS TYPE	LOSS PERCENT	ADJUSTMENT FACTOR
Topographic Effect	0.00%	1.000
Wake Effect	0.00%	1.000
Turbine Availability	5.00%	0.950
Turbine Power Curve	0.00%	1.000
Grid Availability	2.00%	0.980
Electrical Losses	1.00%	0.990
Columnar Losses	0.00%	1.000
Blade Contamination	1.50%	0.985
Icing	1.00%	0.990
Model Estimate	1.00%	0.990
High Wind Hysteresis	0.00%	1.000
Total Losses	**11.0%**	**0.890**

- **Topographic Effect:** This is the loss due to wind speed reductions between the met tower and turbine caused by the site's topography. This effect was not considered in this analysis.
- **Wake Effect:** This is the energy loss due to the effect one turbine will have on another, or the wake caused by any structure on the wind turbines. With only a single turbine, wake interactions were not considered.
- **Turbine Availability:** Wind turbines generally experience downtime during the year related to both general maintenance and turbine faults. Typical modern turbines can operate with availability above 95 percent.
- **Turbine Power Curve:** The wind turbine manufacturer will warranty a performance level from the turbine at a percentage of the power curve values (this may also be difficult to obtain for a single turbine installation.) Typical warranty levels are 95 to 97 percent of published power curve. However, industry practice is

usually not to consider this as a potential loss, given most wind turbines operate at or slightly above their published power curves. For this study, Black & Veatch left the value as a 0 percent loss.

- **Grid Availability:** An estimate is made as to the amount of time the utility (or in this case, the electrical system of the plant) will be available to receive power from the project. All grid systems are off-line periodically for maintenance, and projects in more remote locations will be connected to weaker grid systems that are more prone to failure. Losses for grid availability vary between 0.1 percent for very strong grid system to as high as 5 percent for weak systems (and even larger for systems outside the US). As Black & Veatch has no specific information on grid reliability in the project area, an estimated loss of 2 percent was assumed.
- **Electrical Losses:** Losses in the lines and electrical equipment prior to the plant's revenue meters are covered by this factor. Points of significant electrical losses in a wind energy project usually include the underground and overhead distribution lines connecting the turbines to a substation, and the substation's primary transformer. Typical electrical loss values range from as low as 1 percent to 10 percent or more, depending on the layout and equipment used.
- **Columnar Losses:** If a project of many wind turbines is arranged in rows, turbine manufacturers may require the shutdown of some turbines when the winds are coming from directions parallel to the rows. These losses will not apply to the options defined in this report.
- **Blade Contamination:** Wind turbine performance is sensitive to the cleanliness of the turbine's blades. In areas of high dust or insects, contamination can build on the wind turbine blades that will limit the turbine's performance (causing losses up to 5 percent or more). Often the blades are cleaned by occasional rainfall, but in some areas periodic blade washing is required. As the plant is not an area of high dust, the potential for blade contamination is fairly low and due mostly to insects. As such, an annual loss of 1.5 percent was assumed for blade contamination.
- **Icing:** During winter storms, snow and ice will build on the wind turbine blades causing the same degradation as caused by dust and insects. While this contamination will build much faster than summer contamination, it is often cleared after a few hours of direct sunlight (even at continued subzero temperatures). Given the anticipated likelihood of several significant storms per winter, a loss of 1 percent was assumed for the lost energy due to icing.
- **Model Estimate:** Black & Veatch estimated the performance of potential wind turbines using a spreadsheet based approach. The model was assigned a 1 percent loss due to any variations in aggregating the multiple years into a single representative annual average.
- **High Wind Hysteresis:** When wind speeds exceed the operational range of a wind turbine, the turbine shuts down to protect itself. Such shut-downs normally require

the turbine to remain offline for several minutes, regardless if the wind speed returns to the operational range. Sites with a significant number of these high wind events suffer lost energy due to this hysteresis effect, which is additional to the amount of time the average wind speeds remain above the cut-out wind speed. As the Project site does not have a significant number of high wind events on record, no losses due to this hysteresis effect were applied.

10.3 PRODUCTION ESTIMATES AND COMPARISONS

Adjusted long-term wind data was "binned" by wind speed to determine the number of hours per year that the wind speed would be within a 0.1 m/s bin (for instance, the 6.0 m/s bin represents all wind speed data points between 5.95 m/s and 6.05 m/s). With the hours per bin known, the energy produced in each wind speed bin was estimated by multiplying the wind turbine power curve rating for that wind speed bin by the number of hours in the bin. The power curve data from Table 10-1 was interpolated to estimate production at these 0.1 m/s intervals. The sum of the energy production for each wind speed bin is the estimate of the gross annual energy production from the turbine. The loss factors discussed in Section 10.2 were then applied to estimate net energy production.

In addition to energy production, net capacity factor was calculated. This represents the net annual generation compared to maximum possible generation from the wind turbine (a value of 100% would mean the turbine would operate at rated power every hour of the year; a typical capacity factor for a project in the Northeast U.S. is in the range of 30 – 35 percent). Table 10-3 summarizes the calculated net energy production for a single RRB PS-600 at a 50 meter hub height, and a single GE 1.6-100 at both 80 and 100 meter hub heights. Net capacity factors are summarized in Table 10-4.

Table 10-3 Estimated Monthly Net Energy Production (MWh)

MONTH	RRB PS-600	GE 1.6-100, 80M	GE 1.6-100, 100M
January	58	363	428
February	69	417	474
March	97	513	573
April	69	412	469
May	55	346	401
June	39	287	346
July	38	284	345
August	31	240	300
September	34	267	332
October	65	425	502
November	80	491	567
December	59	394	446
Annual (P50)	**695**	**4440**	**5182**

Table 10-4 Estimated Monthly Net Capacity Factor (%)

MONTH	RRB PS-600	GE 1.6-100, 80M	GE 1.6-100, 100M
January	13.0%	30.5%	36.0%
February	17.2%	38.8%	44.1%
March	21.7%	43.1%	48.1%
April	16.0%	35.8%	40.7%
May	12.3%	29.1%	33.7%
June	9.0%	24.9%	30.0%
July	8.6%	23.9%	29.0%
August	6.8%	20.2%	25.2%
September	7.9%	23.2%	28.8%
October	14.6%	35.7%	42.2%
November	18.5%	42.6%	49.2%
December	13.2%	33.1%	37.5%
Annual (P50)	**13.1%**	**31.5%**	**36.8%**

11.0 Cost Estimate

Black & Veatch prepared high level factored cost estimates for the installation of a wind energy project at the Technical High School in Worcester. The estimates considered the installation of a single medium or large turbine at the site, interconnected with the existing distribution system along Skyline Drive. The cost estimates provided in this section rely on the assumption that a project can be connected to the local distribution line.

The cost estimates shown in Table 11-1 and Table 11-2 are based on general pricing data from wind turbine vendors and the cost breakdown of a recent single wind turbine project. A detailed estimate has not been generated for this study, nor has Black & Veatch requested cost proposals from local construction contractors. This estimate is also not a bid from Black & Veatch to install this project for this price, but rather intended for study purposes only. These estimates also do not attempt to capture any internal City of Worcester costs for any necessary engineering or project oversight.

On a cost per kW basis, the single large turbine projects appear much more attractive than the small wind turbine projects. A single Vestas V90 may cost about $5.3 million, or about $2,945 per kW of capacity, while an RRB PS-600 turbine may cost about $2.9 million, over $4,000 per kW of capacity. As a comparison, a large wind energy project may expect total installed costs between $1,900 and $2,300 per kW, the difference largely made up by economies of scale.

Table 11-1 Preliminary Project Cost Estimate

COST ITEM	PS-600	GE 1.6-100, 80M	GE 1.6-100, 100M
Turbine Rating, MW	0.6	1.6	1.6
Development and Project Management			
Total Development and Project Management	$400,000	$400,000	$400,000
Wind Turbines and Balance of Plant			
Engineering (BOP Only)	$104,000	$109,000	$114,000
Procurement: Wind Turbines	$1,275,000	$2,765,000	$2,880,000
Procurement: Balance of Plant Equipment	$52,500	$77,500	$77,500
Civil Works	$305,000	$390,000	$485,000
Electrical Works	$30,000	$35,000	$35,000
Turbine Erection	$150,000	$225,000	$300,000
Construction Management / Indirects	$35,000	$35,000	$35,000
Total Wind Turbines and Balance of Plant	**$1,951,500**	**$3,636,500**	**$3,926,500**
Interconnection			
Facility Interconnection	$100,000	$135,000	$135,000
System Upgrades	$10,000	$25,000	$25,000
Total Substation and Transmission	**$110,000**	**$160,000**	**$160,000**
Contingency			
Total Construction Contingency	$39,030	$72,730	$78,530
Total Cost	**$2,500,530**	**$4,269,230**	**$4,565,030**

Table 11-2 Preliminary Project Cost per kW of Capacity

COST ITEM	PS-600	GE 1.6-100, 80M	GE 1.6-100, 100M
Development and Project Management	$667	$250	$250
Wind Turbine Procurement	$2,125	$1,728	$1,800
Balance of Plant	$1,128	$545	$654
Substation and Transmission	$183	$100	$100
Other Costs	$65	$45	$49
Total Cost	**$4,168**	**$2,668**	**$2,853**

12.0 Preliminary Economic Analysis

Black & Veatch reviewed potential economic performance for a wind project in Worcester using economic criteria established by Black & Veatch and MassCEC. This section provides an overview of the economic model, the economic assumptions, and the analysis results.

12.1 ECONOMIC MODEL OVERVIEW

The financial model consists of a spreadsheet-based, 20-year annual cash flow (pro forma) model. The model takes into account the project's capital and operating costs, performance characteristics (e.g., capacity factor), REC sales, net metering credits, and energy sales.

The project options discussed in Section 8 were evaluated using the financial model for a 100 percent debt to finance the project. For the 100 percent debt assumption, since there is no equity investment, only net present value (NPV) is calculated. The payback is the amount of time in years it takes for the revenues to pay for the initial investment. Discounted payback takes into account the time value of money, and discounts the future savings to obtain the net present value. Simple payback does not include the time value of money, and is a simple comparison of annual revenue to the initial project cost. Both incorporate interest on debt. In general, projects that result in a lower payback time periods are preferred to those with a higher payback times. For all project options, a profitability index (cost/benefit ratio) is also calculated. This index is based on the ratio of the net present value of the project benefits (energy savings, energy sales, and REC sales) to the net present value of the project costs (maintenance, land lease, insurance, loan payments, and other costs). A ratio greater than 1 indicates a project with a net benefit.

The results are driven by many assumptions made regarding project capital costs, operating costs, retail cost of energy, net-metering credits, REC values, and escalation of costs and revenues. Although this is a relatively simple economic model, in general, the results of the analysis should be sufficient to indicate general project viability, to differentiate between the various possible scenarios. As a wind project continues the development process, refinement of the inputs to the cash flow model can be made to improve the accuracy of the results.

12.2 REVENUE ASSUMPTIONS

12.2.1 Assumed Value of Energy

Black & Veatch assumed that the majority of energy produced by a wind turbine at the Technical High School would be used to either directly offset purchases at the school or to offset City electric use the net metering arrangements made possible by the Green Communities Act. A single wind turbine would be classified as a "Class III net metering facility" according to the language of the act. The corresponding "Class III net metering credit" is equal to the value, on a per kWh basis, of the sum of the default service charge, the transmission charge, the transition charge, and the distribution charge. The distribution charge is only included if the project is municipal or government owned.

Black & Veatch reviewed two main sources of data to determine the value of energy use offset by a wind turbine in Worcester. The first was City electrical bills, which list distribution, transition, and transmission charges on a per kWh basis. The second was published NSTAR rate schedules. A number of town bills are based on demand metering. Establishing the value of energy for demand-based metering is more difficult than for energy based metering, especially as a wind project will not be able to reduce the average demand for off-site loads. Based on data provided by the City, Black & Veatch therefore assumed the average energy value for onsite use and net metering to be $115 per MWh, escalating with inflation.

12.2.2 Renewable Energy Credits (RECs)

Massachusetts has an active REC sales market. REC prices are somewhat volatile, and Black & Veatch has made REC price assumptions based on information from the MassCEC that are believed to be reasonable. During the first 10 years of project life, Black & Veatch assumed a price for REC sales to be $15 per MWh credit, reduced to $10 per MWh in years 11 through 20. Black & Veatch believes these to be realistic target values, but cautions that the market may change and that forward predictions of REC value are uncertain.

12.3 COST AND PERFORMANCE ASSUMPTIONS

Capital cost assumptions come from the cost estimates developed in Section 11. Performance assumptions come from the estimates performed in Section 10. Financial assumptions are based on Black & Veatch estimates and financial assumptions provided by the MassCEC and the City of Worcester. The various cost and financial assumptions are provided in Table 12-1. This analysis includes a provision for Renewable Energy Certificate (REC) sales. These renewable energy certificates represent the environmental value of the clean energy the turbines will produce.

Table 12-1 Economic Analysis Assumptions

ASSUMPTION	VALUE	BASIS
Project Assumptions		
Annual Power Generation	Varies	Dependant on project option. See Section 10.
Capital Costs, per kW	Varies	Dependant on project option. See Section 11.
Turbine Operations & Maintenance Costs, per Wind Turbine, years 1 and 2	$0	Included in Capital Cost
Large Turbine Operations & Maintenance Costs, per Wind Turbine, years 3 and on	$60,000/year	B&V estimate
Medium Turbine Operations & Maintenance Costs, per Wind Turbine, years 3 and on	$40,000/year	B&V estimate
Balance of Plant Maintenance Costs	$10,000/year	B&V estimate
O&M Escalation	2.5%	B&V estimate, based on project experience
Class III Virtual Net-Metering Credit	$115.00/MWh	City Data from 2008 / Green Communities Act of 2008
Worcester Financial/Economic Assumptions		
Debt Percentage	100%	Assume 100% debt financing with bonds
Debt Interest Rate	4.5%	B&V estimate of bond rate
Debt Term	10 years	B&V assumption
Energy Price Escalation	2.5%	B&V estimate
Nominal Discount Rate	4.0%	B&V estimate
Annual Inflation Rate	2.5%	B&V estimate
Insurance Costs	$8.75/kW-year	B&V estimate based on discussions with Massachusetts CEC
REC Price Assumptions		
REC Rate (years 1-10)	$15/MWh	B&V estimate based on current trends and discussion with MassCEC
REC Rate (years 11-20)	$10/MWh	B&V assumption

12.4 RESULTS

The results of the preliminary financial analysis are shown in Table 12-2. The results show a relatively strong net benefit to building a large turbine project with an aggressive low-wind machine. The results for a medium turbine project are less favorable, with poor energy production at a lower hub height and less aggressive design contributing. Based on this small sample of utility-scale wind turbines, it appears that a modern large turbine optimized for low wind sites may be economical.

The full 20-year cash flow sheets are included in Appendix D.

Table 12-2 Preliminary Financial Results

	PS-600	GE 1.6-100, 80M	GE 1.6-100, 100M
Project Capacity	0.6 MW	1.6 MW	1.6 MW
Capital Cost	$2,500,530	$4,269,230	$4,565,030
Grant	$600,000	$600,000	$600,000
Town Outlay	$1,900,530	$3,669,230	$3,965,030
20 Year Cash Flows	-$1,697,646	$7,637,345	$9,628,742
Cash Flow Net Present Value	-$1,438,228	$4,227,309	$5,440,924
Simple Payback	N/A	11.2 years	9.5 years
Discounted Payback	N/A	20.2 years	16.8 years
Benefit to Cost Ratio	0.5	1.9	2.1

Appendix A. Wind Resource Map of Massachusetts

A wind resource map of Massachusetts from the New England Wind Map is shown below.

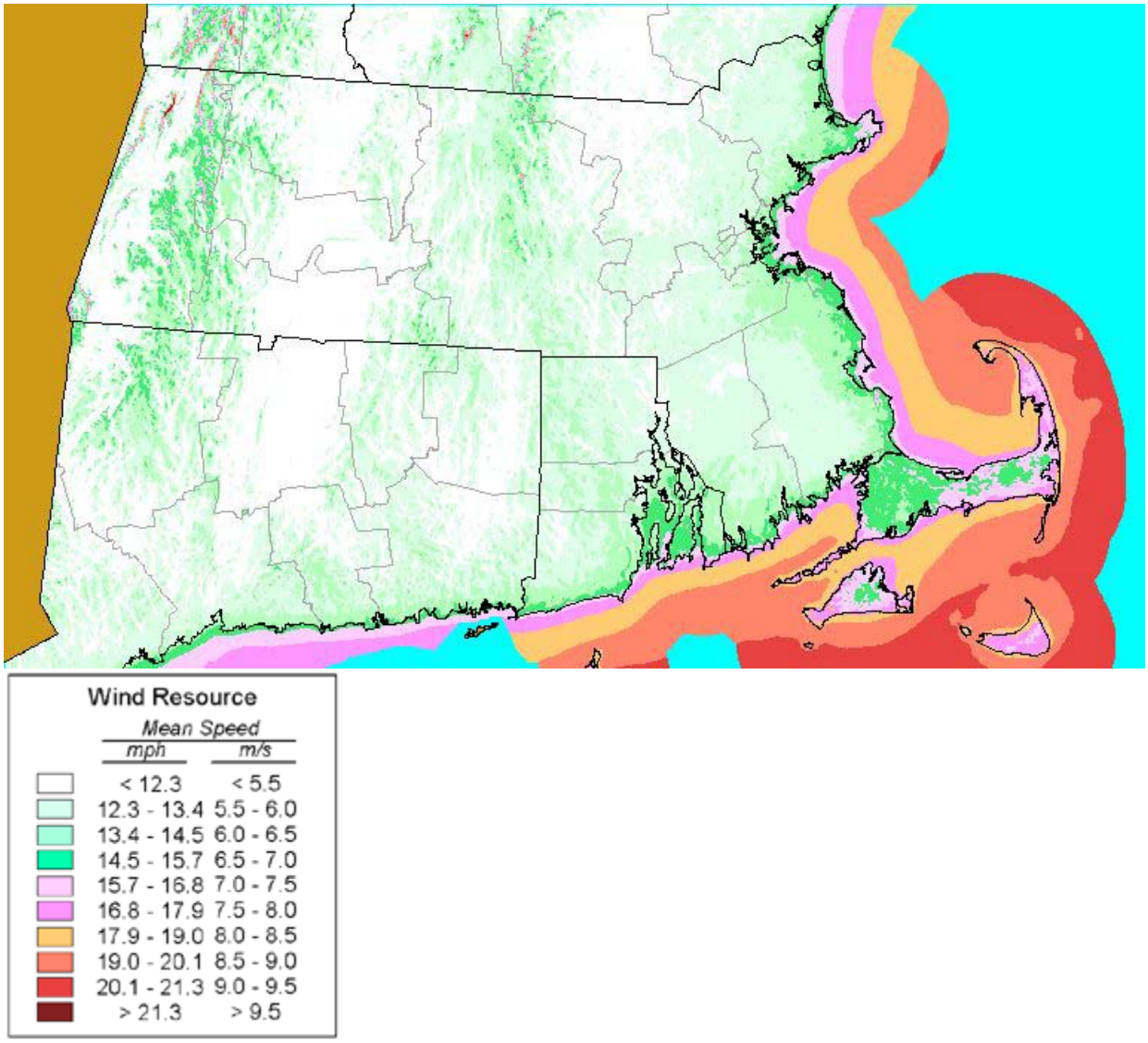


Figure A-1 Massachusetts Wind Resource Map

Appendix B. Cash Flow Results

Massachusetts Clean Energy Center

Life Cycle Economic Evaluation

City of Worcester

Project Scenario	
Site Name	**High School**
Turbine Type	**RRB PS-600**
No. of Turbines	1
Rated Capacity (MW)	0.6
Project Capacity (MW)	0.6
Capital Cost ($/kW)	$4,504
Capital Cost	$2,702,530
Grant	$600,000
Total Outlay	$2,102,530
Net Capacity Factor	13.22%
Annual Generation (MWh)	695
Percent Energy Used Onsite	100%

Project Life and Financing	
Debt Term (years)	10
Debt Percentage	100%
Debt Rate	4.50%
Project Life (years)	20
Discount Rate	4.0%

Energy and REC Sales	Escalation	
Onsite Energy Value	2.50%	$115.00
Energy Sales Price	2.50%	$115.00
REC Price Years 1-10	0.00%	$15.00
REC Price years 11+	0.00%	$10.00

Operating Costs	Escalation	
Land Lease ($/year)	2.50%	$0
Utility Insurance ($/kW-year)	0.00%	$8.75
WTG Service ($/WTG/yr)	2.50%	$40,000
WTG Service Length (years)		2
BOP Service ($/yr)	2.50%	$10,000

Summary	
Net Present Value	-$1,438,228
20 Year Cash Flows (Not Discounted)	-$1,697,646
Simple Payback (Years)	-31.8
Discounted Payback (Years)	-37.6
Benefit to Cost Ratio	0.5

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production (MWh)	**695**	**695**	**695**	**695**	**695**	**695**	**695**	**695**	**695**	**695**	**695**	**695**	**695**	**695**	**695**	**695**	**695**	**695**	**695**	**695**
Pricing																				
Energy Savings	$115.00	$117.88	$120.82	$123.84	$126.94	$130.11	$133.36	$136.70	$140.12	$143.62	$147.21	$150.89	$154.66	$158.53	$162.49	$166.55	$170.72	$174.99	$179.36	$183.84
Energy Sales	$115.00	$117.88	$120.82	$123.84	$126.94	$130.11	$133.36	$136.70	$140.12	$143.62	$147.21	$150.89	$154.66	$158.53	$162.49	$166.55	$170.72	$174.99	$179.36	$183.84
RECs Years 1-10	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
RECS Years 11+	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
Revenues																				
Energy Savings	$79,925	$81,923	$83,971	$86,070	$88,222	$90,428	$92,688	$95,006	$97,381	$99,815	$102,311	$104,869	$107,490	$110,177	$112,932	$115,755	$118,649	$121,615	$124,656	$127,772
Energy Sales	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
RECs	$10,425	$10,425	$10,425	$10,425	$10,425	$10,425	$10,425	$10,425	$10,425	$10,425	$6,950	$6,950	$6,950	$6,950	$6,950	$6,950	$6,950	$6,950	$6,950	$6,950
Total	**$90,350**	**$92,348**	**$94,396**	**$96,495**	**$98,647**	**$100,853**	**$103,113**	**$105,431**	**$107,806**	**$110,240**	**$109,261**	**$111,819**	**$114,440**	**$117,127**	**$119,882**	**$122,705**	**$125,599**	**$128,565**	**$131,606**	**$134,722**
O&M Expenses																				
Land Lease	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
WTG Service	$0	$0	$40,000	$41,000	$42,025	$43,076	$44,153	$45,256	$46,388	$47,547	$48,736	$49,955	$51,203	$52,483	$53,796	$55,140	$56,519	$57,932	$59,380	$60,865
BOP Service	$10,000	$10,250	$10,506	$10,769	$11,038	$11,314	$11,597	$11,887	$12,184	$12,489	$12,801	$13,121	$13,449	$13,785	$14,130	$14,483	$14,845	$15,216	$15,597	$15,987
Utility Insurance	$5,250	$5,250	$5,250	$5,250	$5,250	$5,250	$5,250	$5,250	$5,250	$5,250	$5,250	$5,250	$5,250	$5,250	$5,250	$5,250	$5,250	$5,250	$5,250	$5,250
Total	**$15,250**	**$15,500**	**$55,756**	**$57,019**	**$58,313**	**$59,640**	**$60,999**	**$62,393**	**$63,822**	**$65,286**	**$66,787**	**$68,325**	**$69,902**	**$71,519**	**$73,175**	**$74,873**	**$76,614**	**$78,398**	**$80,227**	**$82,101**
Operating Cashflow	**$75,100**	**$76,848**	**$38,640**	**$39,477**	**$40,334**	**$41,213**	**$42,114**	**$43,038**	**$43,984**	**$44,954**	**$42,474**	**$43,493**	**$44,538**	**$45,609**	**$46,707**	**$47,832**	**$48,985**	**$50,167**	**$51,379**	**$52,621**
Debt Service																				
Opening Balance	$2,102,530	$1,931,429	$1,752,628	$1,565,781	$1,370,525	$1,166,484	$953,260	$730,442	$497,596	$254,273	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Interest Payment	$94,614	$86,914	$78,868	$70,460	$61,674	$52,492	$42,897	$32,870	$22,392	$11,442	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Equity Payment	$171,101	$178,801	$186,847	$195,255	$204,042	$213,223	$222,819	$232,845	$243,323	$254,273	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Payment	**$265,715**	**$265,715**	**$265,715**	**$265,715**	**$265,715**	**$265,715**	**$265,715**	**$265,715**	**$265,715**	**$265,715**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Closing Balance	**$1,931,429**	**$1,752,628**	**$1,565,781**	**$1,370,525**	**$1,166,484**	**$953,260**	**$730,442**	**$497,596**	**$254,273**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Net Income																				
$0	**($190,615)**	**($188,867)**	**($227,075)**	**($226,239)**	**($225,381)**	**($224,502)**	**($223,601)**	**($222,678)**	**($221,731)**	**($220,761)**	**$42,474**	**$43,493**	**$44,538**	**$45,609**	**$46,707**	**$47,832**	**$48,985**	**$50,167**	**$51,379**	**$52,621**

Massachusetts Clean Energy Center

Life Cycle Economic Evaluation

City of Worcester

Project Scenario	
Site Name	**High School**
Turbine Type	**GE 1.6-100, 80**
No. of Turbines	1
Rated Capacity (MW)	1.6
Project Capacity (MW)	1.6
Capital Cost ($/kW)	$2,668
Capital Cost	$4,269,230
Grant	$600,000
Total Outlay	$3,669,230
Net Capacity Factor	31.68%
Annual Generation (MWh)	4,440
Percent Energy Used Onsite	100%

Project Life and Financing	
Debt Term (years)	10
Debt Percentage	100%
Debt Rate	4.50%
Project Life (years)	20
Discount Rate	4.0%

Energy and REC Sales	Escalation	
Onsite Energy Value	2.50%	$115.00
Energy Sales Price	2.50%	$115.00
REC Price Years 1-10	0.00%	$15.00
REC Price years 11+	0.00%	$10.00

Operating Costs	Escalation	
Land Lease ($/year)	2.50%	$0
Utility Insurance ($/kW-year)	0.00%	$8.75
WTG Service ($/WTG/yr)	2.50%	$60,000
WTG Service Length (years)		2
BOP Service ($/yr)	2.50%	$10,000

Summary	
Net Present Value	$4,227,309
20 Year Cash Flows (Not Discounted)	$7,637,345
Simple Payback (Years)	11.2
Discounted Payback (Years)	20.2
Benefit to Cost Ratio	1.9

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production (MWh)	**4,440**	**4,440**	**4,440**	**4,440**	**4,440**	**4,440**	**4,440**	**4,440**	**4,440**	**4,440**	**4,440**	**4,440**	**4,440**	**4,440**	**4,440**	**4,440**	**4,440**	**4,440**	**4,440**	**4,440**
Pricing																				
Energy Savings	$115.00	$117.88	$120.82	$123.84	$126.94	$130.11	$133.36	$136.70	$140.12	$143.62	$147.21	$150.89	$154.66	$158.53	$162.49	$166.55	$170.72	$174.99	$179.36	$183.84
Energy Sales	$115.00	$117.88	$120.82	$123.84	$126.94	$130.11	$133.36	$136.70	$140.12	$143.62	$147.21	$150.89	$154.66	$158.53	$162.49	$166.55	$170.72	$174.99	$179.36	$183.84
RECs Years 1-10	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
RECS Years 11+	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
Revenues																				
Energy Savings	$510,600	$523,365	$536,449	$549,860	$563,607	$577,697	$592,139	$606,943	$622,117	$637,669	$653,611	$669,951	$686,700	$703,868	$721,464	$739,501	$757,989	$776,938	$796,362	$816,271
Energy Sales	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
RECs	$66,600	$66,600	$66,600	$66,600	$66,600	$66,600	$66,600	$66,600	$66,600	$66,600	$44,400	$44,400	$44,400	$44,400	$44,400	$44,400	$44,400	$44,400	$44,400	$44,400
Total	**$577,200**	**$589,965**	**$603,049**	**$616,460**	**$630,207**	**$644,297**	**$658,739**	**$673,543**	**$688,717**	**$704,269**	**$698,011**	**$714,351**	**$731,100**	**$748,268**	**$765,864**	**$783,901**	**$802,389**	**$821,338**	**$840,762**	**$860,671**
O&M Expenses																				
Land Lease	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
WTG Service	$0	$0	$60,000	$61,500	$63,038	$64,613	$66,229	$67,884	$69,582	$71,321	$73,104	$74,932	$76,805	$78,725	$80,693	$82,711	$84,778	$86,898	$89,070	$91,297
BOP Service	$10,000	$10,250	$10,506	$10,769	$11,038	$11,314	$11,597	$11,887	$12,184	$12,489	$12,801	$13,121	$13,449	$13,785	$14,130	$14,483	$14,845	$15,216	$15,597	$15,987
Utility Insurance	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000
Total	**$24,000**	**$24,250**	**$84,506**	**$86,269**	**$88,076**	**$89,928**	**$91,826**	**$93,771**	**$95,766**	**$97,810**	**$99,905**	**$102,053**	**$104,254**	**$106,510**	**$108,823**	**$111,194**	**$113,623**	**$116,114**	**$118,667**	**$121,284**
Operating Cashflow	**$553,200**	**$565,715**	**$518,543**	**$530,191**	**$542,131**	**$554,370**	**$566,914**	**$579,772**	**$592,951**	**$606,460**	**$598,106**	**$612,299**	**$626,846**	**$641,757**	**$657,041**	**$672,707**	**$688,765**	**$705,224**	**$722,095**	**$739,387**
Debt Service																				
Opening Balance	$3,669,230	$3,370,632	$3,058,598	$2,732,522	$2,391,772	$2,035,689	$1,663,582	$1,274,730	$868,380	$443,744	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Interest Payment	$165,115	$151,678	$137,637	$122,963	$107,630	$91,606	$74,861	$57,363	$39,077	$19,969	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Equity Payment	$298,598	$312,035	$326,076	$340,749	$356,083	$372,107	$388,852	$406,350	$424,636	$443,744	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Payment	**$463,713**	**$463,713**	**$463,713**	**$463,713**	**$463,713**	**$463,713**	**$463,713**	**$463,713**	**$463,713**	**$463,713**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Closing Balance	**$3,370,632**	**$3,058,598**	**$2,732,522**	**$2,391,772**	**$2,035,689**	**$1,663,582**	**$1,274,730**	**$868,380**	**$443,744**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Net Income																				
$0	**$89,487**	**$102,002**	**$54,830**	**$66,478**	**$78,418**	**$90,657**	**$103,201**	**$116,059**	**$129,238**	**$142,747**	**$598,106**	**$612,299**	**$626,846**	**$641,757**	**$657,041**	**$672,707**	**$688,765**	**$705,224**	**$722,095**	**$739,387**

Massachusetts Clean Energy Center

Life Cycle Economic Evaluation

City of Worcester

Project Scenario	
Site Name	**High School**
Turbine Type	**GE 1.6-100, 100**
No. of Turbines	1
Rated Capacity (MW)	1.6
Project Capacity (MW)	1.6
Capital Cost ($/kW)	$2,853
Capital Cost	$4,565,030
Grant	$600,000
Total Outlay	$3,965,030
Net Capacity Factor	36.97%
Annual Generation (MWh)	5,182
Percent Energy Used Onsite	100%

Project Life and Financing	
Debt Term (years)	10
Debt Percentage	100%
Debt Rate	4.50%
Project Life (years)	20
Discount Rate	4.0%

Energy and REC Sales	Escalation	
Onsite Energy Value	2.50%	$115.00
Energy Sales Price	2.50%	$115.00
REC Price Years 1-10	0.00%	$15.00
REC Price years 11+	0.00%	$10.00

Operating Costs	Escalation	
Land Lease ($/year)	2.50%	$0
Utility Insurance ($/kW-year)	0.00%	$8.75
WTG Service ($/WTG/yr)	2.50%	$60,000
WTG Service Length (years)		2
BOP Service ($/yr)	2.50%	$10,000

Summary	
Net Present Value	$5,440,924
20 Year Cash Flows (Not Discounted)	$9,628,742
Simple Payback (Years)	9.5
Discounted Payback (Years)	16.8
Benefit to Cost Ratio	2.1

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Production (MWh)	**5,182**	**5,182**	**5,182**	**5,182**	**5,182**	**5,182**	**5,182**	**5,182**	**5,182**	**5,182**	**5,182**	**5,182**	**5,182**	**5,182**	**5,182**	**5,182**	**5,182**	**5,182**	**5,182**	**5,182**
Pricing																				
Energy Savings	$115.00	$117.88	$120.82	$123.84	$126.94	$130.11	$133.36	$136.70	$140.12	$143.62	$147.21	$150.89	$154.66	$158.53	$162.49	$166.55	$170.72	$174.99	$179.36	$183.84
Energy Sales	$115.00	$117.88	$120.82	$123.84	$126.94	$130.11	$133.36	$136.70	$140.12	$143.62	$147.21	$150.89	$154.66	$158.53	$162.49	$166.55	$170.72	$174.99	$179.36	$183.84
RECs Years 1-10	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
RECS Years 11+	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00	$10.00
Revenues																				
Energy Savings	$595,930	$610,828	$626,099	$641,751	$657,795	$674,240	$691,096	$708,374	$726,083	$744,235	$762,841	$781,912	$801,460	$821,496	$842,033	$863,084	$884,661	$906,778	$929,447	$952,684
Energy Sales	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
RECs	$77,730	$77,730	$77,730	$77,730	$77,730	$77,730	$77,730	$77,730	$77,730	$77,730	$51,820	$51,820	$51,820	$51,820	$51,820	$51,820	$51,820	$51,820	$51,820	$51,820
Total	**$673,660**	**$688,558**	**$703,829**	**$719,481**	**$735,525**	**$751,970**	**$768,826**	**$786,104**	**$803,813**	**$821,965**	**$814,661**	**$833,732**	**$853,280**	**$873,316**	**$893,853**	**$914,904**	**$936,481**	**$958,598**	**$981,267**	**$1,004,504**
O&M Expenses																				
Land Lease	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
WTG Service	$0	$0	$60,000	$61,500	$63,038	$64,613	$66,229	$67,884	$69,582	$71,321	$73,104	$74,932	$76,805	$78,725	$80,693	$82,711	$84,778	$86,898	$89,070	$91,297
BOP Service	$10,000	$10,250	$10,506	$10,769	$11,038	$11,314	$11,597	$11,887	$12,184	$12,489	$12,801	$13,121	$13,449	$13,785	$14,130	$14,483	$14,845	$15,216	$15,597	$15,987
Utility Insurance	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000	$14,000
Total	**$24,000**	**$24,250**	**$84,506**	**$86,269**	**$88,076**	**$89,928**	**$91,826**	**$93,771**	**$95,766**	**$97,810**	**$99,905**	**$102,053**	**$104,254**	**$106,510**	**$108,823**	**$111,194**	**$113,623**	**$116,114**	**$118,667**	**$121,284**
Operating Cashflow	**$649,660**	**$664,308**	**$619,323**	**$633,213**	**$647,450**	**$662,043**	**$677,000**	**$692,332**	**$708,047**	**$724,155**	**$714,756**	**$731,679**	**$749,026**	**$766,806**	**$785,030**	**$803,711**	**$822,858**	**$842,484**	**$862,600**	**$883,220**
Debt Service																				
Opening Balance	$3,965,030	$3,642,361	$3,305,171	$2,952,808	$2,584,588	$2,199,799	$1,797,694	$1,377,495	$938,386	$479,518	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Interest Payment	$178,426	$163,906	$148,733	$132,876	$116,306	$98,991	$80,896	$61,987	$42,227	$21,578	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Equity Payment	$322,669	$337,190	$352,363	$368,219	$384,789	$402,105	$420,200	$439,109	$458,868	$479,518	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Payment	**$501,096**	**$501,096**	**$501,096**	**$501,096**	**$501,096**	**$501,096**	**$501,096**	**$501,096**	**$501,096**	**$501,096**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Closing Balance	**$3,642,361**	**$3,305,171**	**$2,952,808**	**$2,584,588**	**$2,199,799**	**$1,797,694**	**$1,377,495**	**$938,386**	**$479,518**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**
Net Income																				
$0	**$148,564**	**$163,212**	**$118,227**	**$132,117**	**$146,354**	**$160,947**	**$175,905**	**$191,236**	**$206,951**	**$223,059**	**$714,756**	**$731,679**	**$749,026**	**$766,806**	**$785,030**	**$803,711**	**$822,858**	**$842,484**	**$862,600**	**$883,220**

Appendix C. Worcester Wind Turbine Zoning Ordinance

Section 13 – Wind Energy Conversion Facilities

A. Purpose and Intent

The purpose of this Section is to provide for the construction and operation of Wind Energy Conversion Facilities (WECF) in the city of Worcester, and to provide standards for the placement, design, installation, modification, monitoring and decommissioning of these facilities subject to reasonable conditions that will protect the public health, safety and welfare while providing for the production of clean, renewable energy.

B. Administration

Special Permit Granting Authority (SPGA) shall be the Planning Board.

C. Definitions

APPLICANT: the person or entity filing an application under this Section.

AMBIENT SOUND LEVEL: the background A-weighted sound level that is exceeded 90% of the time.

A-WEIGHTED SOUND LEVEL - dB(A): a measurement of sound pressure level, which has been filtered or weighted to progressively de-emphasize the importance of frequency components below 1,000 Hz and above 5,000 Hz. This range corresponds to the human speech band and reflects that human hearing is more sensitive to the mid-range frequencies within this range than the frequencies below and above this range.

DECIBEL (dB): the measurement of a sound pressure relative to the logarithmic conversion of the sound pressure reference level – often set as 0 dB(A). In general, this means the quietest sound humans can hear is near 0 dB(A) and the loudest humans can hear without pain is near 120 dB(A). Most sounds range from 30 to 100 dB(A). Normal speech at 3 feet averages about 65 dB(A).

eCO2: Carbon Dioxide Equivalent: Emissions of greenhouse gases are typically expressed in a common metric, so that their impacts can be directly compared, as some gases are more potent (have a higher global warming potential or GWP) than others. The international standard practice is to express greenhouse gases in carbon dioxide (CO_2) equivalents. Emissions of gases other than CO_2 are translated into CO_2 equivalents using global warming potentials according to the following schedule, as amended by the United States Department of Environmental Protection:

	GWP
Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O)	310
Hydrofluorocarbon (HFC)-134a	1,300
(used in mobile source air conditioning)	

FACILITY OWNER: the entity or entities having an equity interest in the wind energy conversion facility, including their respective successors and assigns.

HUB HEIGHT: the distance measured from the base of the tower foundation at grade to the height of the wind turbine hub, to which the blade is attached.

METEOROLOGICAL TOWER (MET): a facility consisting of a tower and related wind-measuring devices that is solely used to measure the characteristics of winds.

NACELLE: the enclosure located at the top of a wind turbine tower that houses the gearbox, generator and other equipment.

PARTICIPATING LANDOWNER: a landowner on whose property all or a portion of a WECF is located.

OCCUPIED BUILDING: a church, hospital, library, residence, school, or other building used for public gathering that is occupied or in use when the permit application is submitted. Accessory structures and businesses are not considered occupied buildings.

OPERATOR: the entity responsible for the day-to-day operation and maintenance of the wind energy conversion facility.

OVERSPEED CONTROL: the action of a control system, or part of such system, that prevents excessive rotor speed.

ROTOR: the rotating part of a wind turbine, including turbine blades.

ROTOR DIAMETER: for propeller-blade design WECF, the diameter of the circle swept by

the furthest outreaching part of the rotor blades; for vertical-axis WECF, the diameter of the cross sectional circle encompassing the furthest outreaching part of the rotating parts of the WECF.

SHADOW FLICKER: the moving shadows cast by rotating wind turbine blades that cause a flickering effect.

STALL CONTROL: a braking mechanism on wind turbines where the rotor blades are bolted onto the hub at a fixed angle. The rotor blade profile is aerodynamically designed to ensure that the moment wind speed becomes too high it creates turbulence on the side of the rotor blade which is not facing the wind. This "stall" prevents the lifting force of the rotor blade from acting on the rotor.

TOWER: with regard to WECF, the structure on which a wind turbine is mounted.

TURBINE: an electric generator that converts wind energy into electrical power - see wind turbine.

TURBINE HEIGHT: the distance measured from the surface of the tower foundation to the highest point of the turbine rotor plane (tip of blade at highest point).

WECF: see Wind Energy Conversion Facility.

WIND ENERGY CONVERSION FACILITY (WECF), LARGE OR SMALL: an electricity generating facility whose main purpose is to supply electricity, consisting of one or more wind turbines and other accessory structures and buildings, including substations, meteorological towers, electrical infrastructure, transmission lines and other appurtenant structures and facilities.

WIND ENERGY CONVERSION FACILITY (WECF), LARGE: A WECF with a Rotor Diameter greater than twenty (20) feet.

WIND ENERGY CONVERSION FACILITY (WECF), SMALL: A WECF with a Rotor Diameter equal to or less than twenty (20) feet.

WIND ENERGY CONVERSION SYSTEM: see the definition for wind turbine.

WIND TURBINE: a wind energy conversion system, including but not limited to propeller-shaped blade and vertical-axis design facilities, that converts wind energy into electricity through the use of a turbine, and includes the nacelle, rotor, tower, and pad transformer, if any.

D. Use Regulations

Wind Energy Conversion Facilities (WECF) and Meteorological Towers (METs) shall be permitted in accordance with **Article IV-Section 2, Table 4.1** subject to the provisions of this Section 13.

1) No WECF requiring guy wires for support shall be permitted.

2) No WECF with a rotor diameter in excess of one hundred sixty-five (165') feet shall be permitted.

3) Multiple wind turbines are allowed on a single parcel only if the WECF as a whole, and each wind turbine within it, complies with the provisions of subsections E, F, G and H governing sound and shadow flicker respectfully.

4) No WECF shall be erected until evidence has been provided that the electric utility company has been informed of the applicant's intent to install an interconnected customer-owned generator. Off-grid systems shall be exempt from this requirement.

5) An applicant who is not a participating landowner shall submit an executed lease or purchase and sale agreement, or power purchase agreement, documenting the applicant's contingent property interest and legal right to install, operate and maintain the WECF and MET on the affected property(ies).

6) To the extent that the foundation of a WECF affects the dimensions or the number, or both, of required off-street parking spaces, said parking requirement shall be reduced by the number of spaces directly affected for the purposes of calculating minimum parking requirements.

7) Meteorological towers (MET): Provided that it does not exceed the height recommended by the manufacturer of the meteorological tower and equipment:

    a) Guy wires are permitted for temporary METs only.

    b) All special permits related to METs shall be issued pursuant to the criteria set forth in **Article II**.

    c) Term:

        i) METs may be erected for a period not to exceed twenty-seven months. A longer period may be considered by the Director of Code Enforcement or the SPGA, for by-right and specially permitted METs respectively.

        ii) Permanent METs are permitted regardless of height only in association with and accessory to a permitted WECF provided that said MET does not have guy wires.

    d) Setbacks:

        i) METs eighty-five (85) feet or less shall be subject to regulations regarding setbacks for Small WECFs with the exception that guy wires, if any, shall be setback at least (10) ten feet from a property line.

ii) METs more than eighty-five (85) feet in height shall be subject to regulations regarding setbacks for Large WECFs with the exception that guy wires, if any, shall be setback at least twenty (20) feet from a property line.

E. Dimensional Requirements

1. **Large WECFs**. Notwithstanding anything to the contrary in **Article IV-Section 4, Table 4.2**, Large WECFs shall comply with the following requirements:

a) Height

i) Turbine height shall not exceed the height recommended by the manufacturer of the wind turbine and tower, or both, or two hundred and sixty-five (265) feet, whichever is less.

ii) The minimum distance between the ground and any part of a rotor, or turbine blade, shall be thirty (30) feet.

b) Setbacks

i) Wind turbines shall be set back:

(aa) a distance not less than six hundred and fifty (650) feet from the nearest non-participating landowner's occupied building. This setback distance shall be measured from the center of the wind turbine tower at its base to the nearest point on the foundation of a non-participating landowner's occupied building.

(bb) a distance not less than one-hundred and sixty-five (165) feet or 1.25 times the turbine height, whichever is greater, from the nearest participating landowner's occupied building. This setback distance shall be measured from the center of the wind turbine tower foundation to the nearest point on the foundation of a participating landowner's occupied building.

(cc) a distance not less than 1.1 times the turbine height from the nearest wind turbine, right-of-way line of the nearest public way, property line, or existing above ground utility transmission line(s).

2. **Small WECF**. Notwithstanding anything to the contrary in **Article IV-Section 4, Table 4.2**, Small WECFs shall comply with the following requirements:

a) Height

i) Turbine height shall not exceed the height recommended by the

manufacturer of the wind turbine and tower, or both, or ninety-five (95) feet, whichever is less.

ii) The minimum distance between the ground and any part of a rotor, or turbine blade at its lowest position, shall be twenty (20) feet.

b) Setbacks

i) Wind turbines shall be setback a distance not less than one-hundred and sixty-five (165) feet from the nearest non-participating landowner's occupied building. This setback distance shall be measured from the center of the wind turbine tower at its base to the nearest point on the foundation of a non-participating landowner's occupied building.

ii) Wind turbines shall be setback a distance not less than 1.1 times the turbine height from the nearest wind turbine, abutting property owner's property line, or existing above ground utility transmission line(s).

F. Sound

1. All WECFs shall comply with the provisions of the Department of Environmental Protection's Division of Air Quality Noise Regulations (310 CMR 7.10) and associated policies.

2. For all WECFs allowed by Special Permit in Table 4.1: Audible sound generated by a WECF shall not exceed fifty-five (55) dB(A), as measured at the exterior of any non-participating landowner's occupied building except during short-term events such as utility outages and/or uncharacteristically windy periods.

3. Notwithstanding anything to the contrary within this Section, for Small WECFs listed as of right in Table 4.1 and within 650 feet of the nearest non-participating landowner's occupied building located within a residential district: Audible sound generated by a WECF shall not exceed fifty-five (55) dB(A), as measured at the exterior of any non-participating landowner's occupied building, located in a residential district, except during short-term events such as utility outages and/or uncharacteristically windy periods.

G. Shadow Flicker

The facility owner and operator shall make reasonable efforts to minimize shadow flicker to any occupied building on a non-participating landowner's property.

H. Signal Interference

1. The WECF shall be certified by the manufacturer to be in conformance with the regulations of the Federal Communications Commission (47 CFR Part 15 as revised)

relating to harmful interference with radio or television reception.

2. The WECF owner or operator shall make reasonable efforts to avoid any disruption or loss of radio, telephone, television or similar signals, and shall mitigate any harm caused by the WECF.

I. Waiver of Setbacks, Sound, Shadow Flicker, Height, and Rotor Diameter, Provisions

1. Notwithstanding anything to the contrary in **Article IV**, one or more waivers may be granted by the SPGA in accordance with this subsection provided that all such waivers are part of a special permit approval for a WECF and in accordance with this subsection. To the extent that any waiver effects compliance with setback and shadow flicker requirements, those items shall also require a waiver.

2. To the extent these provisions affect a participating property, the SPGA, in its discretion, shall be authorized to waive the setback, sound and shadow flicker provisions of this Section provided that:

    a. The applicant submits the request in writing, and if the applicant is not the property owner, the property owner's written consent to the waiver(s) shall also be submitted.

3. To the extent these provisions affect a non-participating property, the SPGA, in its discretion, shall be authorized to waive the setback, sound and shadow flicker provisions of this Section provided that:

    a. The applicant submits the request in writing, accompanied by an affidavit signed by the affected non-participating property owner(s) in support of the applicant's request for waiver.

    b. The affidavit shall contain the non-participating property owner's acknowledgement of the setback, sound or shadow flicker requirements of this Section and what is proposed in lieu thereof, describe the impact on the non-participating property owner(s), and state the non-participating property owner's support for the applicant's waiver request. A non-participating property owner's affidavit shall be made a part of the special permit decision and shall be separately recorded with the Worcester District Registry of Deeds at the same time that the special permit decision is recorded to provide notice to all subsequent purchasers of the non-participating property of the waiver(s) granted.

4. To the extent these provisions affect a public way, the SPGA, in its discretion, shall be authorized to waive the setback, sound and shadow flicker provisions of this Section provided that:

    a. The applicant submits the request in writing, provided further however, that

no waiver may be granted to the extent it would affect an existing above ground utility transmission line unless the utility company owning such line consents to the waiver in writing.

5. To the extent these provisions affect the turbine height of a WECF, the SPGA, in its discretion, shall be authorized to waive the turbine height provisions of this Section provided that:

    a. For any WECF, the applicant provide a comparison of the proposal with the alternative in terms of energy produced and greenhouse gases prevented, measured in tons of eCO2, that demonstrates that the increased height will significantly increase the energy produced by the WECF; and

    b. For Small WECFs, the applicant demonstrates that obstacles within five-hundred (500) feet of the proposed location of a WECF will significantly reduce the available wind resource, or is likely to cause wind turbulence that would result in unsafe conditions for the operation of the proposed wind turbine. The SPGA shall be limited to a waiver of thirty (30) feet above the highest obstruction identified or one-hundred and twenty-five (125) feet, whichever is less.

6. To the extent these provisions affect the rotor diameter of a Large WECF, the SPGA, in its discretion, shall be authorized to waive the rotor diameter provisions of this Section provided that:

    a. The applicant provide a comparison of the proposal with, and without, the waiver in terms of energy produced and greenhouse gases prevented, measured in tons of eCO2, that demonstrates that the increased rotor diameter will significantly increase the energy produced by the WECF.

J. <u>Design and Installation</u>

1. Compliance and Certifications: Prior to the operation of any WECF, the facility owner and operator must submit a signed affidavit to the director of Code Enforcement's satisfaction verifying that the WECF, and all of its equipment, was designed and installed in accordance with the following standards:

    a) The design and installation of the WECF complies with the most current applicable industry safety standards, including those of the American National Standards Institute, related to all wind turbine subsystems such as control and protection mechanisms, internal electrical systems, mechanical systems and support structures.

    b) To the extent applicable, the WECF complies with Massachusetts State Building Code and International Conference of Building Officials Building Code.

c) All electrical components of the WECF comply with relevant and applicable local, state and national codes, and relevant and applicable international standards.

d) All wind turbines are equipped with the following systems and controls: redundant braking systems, aerodynamic overspeed controls (including variable pitch, tip, and other similar systems), and mechanical brakes. Mechanical brakes shall be operated in a fail-safe mode and stall control regulation shall not be considered a sufficient braking system for overspeed protection. Except for Small WECFs, which shall provide adequate redundant (primary and fail safe) automatic overspeed protection.

e) The design and installation of the WECF complies with applicable Federal Aviation Administration and Federal Communications Commission regulations as applicable.

f) To the extent applicable, WECFs shall be adequately protected from impact by vehicles through use of a physical barrier whether included as part of the foundation design or as separate elements including, but not limited to, bollards or guardrails.

2. Security and Warnings:

a) WECFs and METs shall not be climbable up to fifteen (15) feet above ground surface.

b) All access doors to wind turbines and electrical equipment shall be locked or fenced, as appropriate, to prevent entry by non-authorized persons.

c) Visible, reflective, colored objects, such as flags, reflectors, or tape shall be placed on the anchor points of guy wires and along the guy wires up to a height of ten (10) feet from the ground (pertains to METs only, see subsection D – Use Regulations).

d) A clearly visible warning sign concerning voltage must be placed at the base of all pad-mounted transformers and substations.

3. Visual Appearance:

a) Wind turbines and associated structures shall be a non-obtrusive color such as white, off-white, gray or light-blue.

b) No WECF shall be artificially lit, except to the extent required by the Federal Aviation Administration, or other applicable governmental authority that regulates air safety.

c) Wind turbines shall not be used for the location of accessory or non-accessory signs except for reasonable identification of the turbine manufacturer, host site, or both.

d) On-site transmission and power lines between wind turbines shall, to the maximum extent practicable, be placed underground (not applicable to Small WECFs).

e) Inverters and pendant power cables shall be located inside the wind turbine tower, nacelle or structure.

f) No telecommunication dishes, antennas, cellular telephone repeaters or other similar devices shall be attached to wind turbine towers, except for accessory antenna associated with the operation of the WECF.

g) All appurtenant structures to such WECF shall be subject to reasonable regulations concerning the bulk and height of structures and for determining lot area, setbacks, open space, parking and building coverage requirements. All such appurtenant structures, including but not limited to equipment shelters, storage facilities, transformers, and substations shall be screened from view by vegetation and clustered to minimize visibility.

K. Maintenance

WECF owners and operators shall provide for the ongoing maintenance by appropriately certified professionals in accordance with manufacturer's specifications and all governmental regulations for all structural, electrical and mechanical components of the WECF to ensure the safe operation of the WECF.

L. Emergency Services Plan

Upon request, the applicant shall cooperate with emergency services providers to develop and coordinate implementation of an emergency response plan for the WECF(s).

M. Use Of Public Streets Plan (not applicable to Small WECFs)

1. At least sixty (60), but no greater than ninety (90), days prior to construction, the applicant shall obtain the requisite permit from the Department of Public Works and Parks approving the route and method of transporting the equipment and parts for the construction, operation or maintenance of the WECF. In addition to the permit requirements promulgated by the commissioner of DPWP, the applicant shall submit, with its request for a permit, a report identifying all state and city streets within the city of Worcester to be used as its transport route. A copy of the report shall also be submitted to the Division of Planning and Regulatory Services.

2. An engineer or a qualified third party engineer hired by the City of Worcester and paid for by the applicant, shall document road conditions along the route chosen prior to construction. Said engineer shall document road conditions again thirty (30) days after construction is complete or as weather permits. This documentation shall be provided to the commissioner of Public Works and Parks for review.

3. The applicant shall demonstrate to the satisfaction of the commissioner of Public Works and Parks that the applicant has adequate financial resources to ensure the prompt repair of damaged roads.

4. Any road damage caused by the applicant or its contractors shall be promptly repaired at the applicant's expense.

N. Abandonment, Discontinuation of Use Or Repair

1. Notification:

   a) The WECF owner or operator shall notify the Director of Code Enforcement by certified U.S. Mail thirty (30) days prior to the proposed date of abandonment or discontinuation of use of any WECF or individual wind turbine.

   b) On a yearly basis, from the date of the issuance of a building permit, the WECF owner or operator shall provide the Director of Code Enforcement a report indicating the total electricity generated by each wind turbine by month of service.

   c) The use of a WECF or individual wind turbine will be considered discontinued if no electricity is generated for a continuous period of twelve (12) months.

2. Decommissioning:

   a) Upon abandonment or discontinuation of use of a WECF, the facility owner, operator or landowner shall, at its expense, remove wind turbines, and all above ground structures, buildings, cabling, electrical components, roads, and any other associated facilities within twelve (12) months.

   b) All waste materials from a decommissioning shall be disposed of in accordance with local and state solid waste disposal regulations.

   c) Disturbed earth shall be graded and re-seeded, unless the landowner requests in writing that the access roads or other land surface areas not be restored.

   d) If neither the WECF owner or operator nor the landowner, if different, completes decommissioning within the period prescribed in this subsection, the City of Worcester may take such measures as necessary to complete the decommissioning. The costs incurred by the city shall constitute a debt due the

city upon completion of the decommissioning activities and the rendering of an account to the facility owner, operator and the landowner, if applicable, and shall be recoverable from such party(ies) in an action of contract. For Large WECFs only, the Special Permit Granting Authority may require the applicant to post a bond at the time of construction equal to the estimated costs associated with the removal of the WECF in the event the City of Worcester must remove the WECF.

3. Repair:

   a) Any WECF determined to be unsafe by the Director of Code Enforcement shall be turned off immediately upon notice and repaired as soon as practicable by the WECF owner or operator to meet federal, state and local safety standards. Evidence of such repair shall be reviewed and approved, if deemed satisfactory, by the Director of Code Enforcement prior to resuming use of the WECF. If the Director of Code Enforcement deems the timetable for corrective action as unreasonable or inadequate to ensure proper safety, the WECF owner or operator shall decommission the WECF in accordance with subsection N(2) except that the period of time shall be prescribed by the Director of Code Enforcement.

O. Public Inquiries and Complaints

1. The WECF owner and operator shall maintain a phone number and identify a responsible person for the public to contact with inquiries and complaints throughout the life of the project. The applicant shall notify all abutters within three-hundred (300) feet of this phone number prior to the operation or testing of any WECF.

2. The WECF owner and operator shall post an emergency telephone number so that the appropriate people may be contacted should any wind turbine need immediate attention. This telephone number shall be clearly visible on a permanent structure(s) or post(s) located at a distance at least 1.25 times the turbine height. (Not applicable to Small WECFs, which shall provide a number on tower.)

3. The WECF owner and operator shall make reasonable efforts to respond to the public's inquiries and complaints.

4. Upon receipt of a complaint by the Code Enforcement Division regarding sound from an existing WECF, the division will investigate the complaint. If the director of Code Enforcement determines the complaint to be reasonable, the WECF owner or operator shall be required, at its expense, to have prepared, by an independent professional acoustical engineer approved by the city, an acoustical study that measures sound levels and demonstrates compliance with the sound standards in this Section.

5. Methods for measuring and reporting acoustic emissions from wind turbines and the WECF shall be equal to or exceed the minimum standards for precision described in American Wind Energy Association Standard 2.1 - 1989 titled *Procedures for the Measurement and Reporting of Acoustic Emissions from Wind Turbine Generation*

Systems Volume I: First Tier as revised.

P. Special Permit Approval Criteria

1. After notice and public hearing, and after due consideration of the evidence submitted, including the reports and recommendations of city departments, the SPGA, in addition to the special permit criteria under **Article II**, may grant such a special permit provided that it finds that:

   a) The proposed WECF does not derogate from the purposes and intent of this Section and the Zoning Ordinance.

   b) The application information submitted is adequate for the SPGA to consider approving the special permit request.

   c) The proposed design, installation and operation of the WECF will meet the requirements of this Section.

   d) The acoustical assessment provided adequately predicts resulting sound levels as may be measured in accordance with the provisions of this Section. (Not applicable to Small WECFs)

2. Reasonable efforts have been made to minimize shadow flicker on neighboring or adjacent uses.

3. The maintenance plan proposed adequately provides for the ongoing safe operation of the WECF.

4. There will be no substantial adverse affect on the environment or wildlife. (Not applicable to Small WECFs)

5. The documentation and information for setback, sound and shadow flicker waiver requests, if any, provide sufficient assurance that the affected participating and non-participating property owners are fully informed and consent to the waiver requests.

6. That documentation and information for height and rotor diameter (as applicable) waiver requests, if any, are sufficient to demonstrate the requirements of subsection I.

Q. Term of Special Permit

A special permit issued for any WECF shall be valid for no more than twenty (20) years, but in no event, if the applicant is a lessee of the property owner, shall a special permit be granted for a term greater than the term of the lease. No more than six months prior to the expiration of a special permit granted hereunder, the applicant, or its successor in interest, may apply for an extension of the term through a special permit amendment. The SPGA may grant one or more extensions of the term, of up to five (5) years per extension,

provided it finds that the WECF is operating in accordance with this Section, and that the WECF has been, and will continue to be, properly maintained. The applicant shall provide documentation regarding ongoing maintenance of the WECF in accordance with the maintenance plan proposed, and an inspection report verifying that the WECF can continue to operate safely.

R. Application Requirements

1. All applicants are encouraged to contact the SPGA staff to schedule a pre-application meeting.

2. In addition to all application requirements related to special permits under **Article II**, the applicant shall include the following at the time of application submittal:

   a) Project Overview: A narrative describing the proposed WECF including an overview of the project with the following information: the project location, the number, representative types, generating capacity, cut-in and cut-out wind speed, overspeed controls, materials, dimensions and respective manufacturers of each wind turbine to be constructed, and a detailed description of all ancillary facilities. This overview shall also include a comparison of estimated electric generation vs. on-site electric consumption, a cost-benefit analysis demonstrating that the proposed hub height and turbine height are necessary to achieve economic viability (including the variation of electricity generated at alternative heights), and an estimate of the number of tons of pollution prevented.

   b) Vicinity Plan: A vicinity plan shall be prepared by a registered engineer and must show the scale, a north arrow, legend or annotation (for each symbol used) and identify the sheet number in sequence. Use separate sheets for various layers as appropriate to improve clarity – include overview sheet will all layers. (Not Applicable to Small WECFs)

      i) Vicinity plans shall depict the following information for the subject property and all adjacent properties within 300 feet:

         (aa) Property lines, layout of existing buildings (including their use status - e.g., occupied buildings), accessory structures, location and name of all public, private roads, and railroads.

         (bb) Any significant natural, topographical or physical features of the area including existing contours at two (2) feet in one hundred (100) feet.

         (cc) Lines representing the sight line showing viewpoint and visible point from “sight lines” subsection below.

         (dd) Annotation(s) identifying all parcels and occupied buildings

affected by waivers, if any.

(ee) Area of estimated wind turbine shadow flicker.

ii) The vicinity plan shall depict the proposed location of each wind turbine(s), street address, property lines, wind turbine setback lines (depicted as a radius from the center of the wind turbine), access road and turnout locations, substation(s), electrical cabling from the WECF to substation(s), ancillary equipment, buildings, and structures, including permanent meteorological towers, associated transmission lines (including whether they are above or below ground), and layout of all structures within the geographical boundaries of any applicable setback.

c) Site Plan: A site plan to a scale of not less than forty (40) feet to the inch, on one or more sheets, prepared by a registered engineer, and indicate the scale used, a north arrow, legend or annotation (for each symbol used), and identify the sheet number in sequence. Use separate sheets for various layers as appropriate to improve clarity – include overview sheet with all layers. The site plan shall also include the following information:

i) Title block information that identifies location, applicant, property owner, WECF owner/operator, and party responsible for preparing the plan.

ii) A table that compares all required dimensional requirements of this Section with those proposed for the WECF when an applicant seeks one of more dimensional waivers.

iii) Annotation(s) identifying all parcels and occupied buildings affected by waivers, if any.

iv) The boundary lines and dimensions of the subject property, existing subdivision lots, available utilities, easements, roadways, railroads, rail lines and public rights-of-way, crossing and adjacent to the subject property.

v) Any proposed re-grading of the subject property and any significant natural, topographical or physical features of the property including, at least, watercourses, marshes, floodplain and wetlands, trees in excess of nine (9) inches in diameter, soil types, and existing contours at two (2) feet in one hundred (100) feet. (Not Applicable to Small WECFs)

vi) Location of each wind turbine, WECF setback lines (measured at grade and depicted as a radius from the center of the wind turbine), access road and turnout locations, substation(s), electrical cabling from the WECF to substation(s), ancillary equipment, buildings, and structures, including permanent meteorological towers, associated transmission lines (including

whether they are above or below ground).

vii) Layout of all existing buildings (including their use status - e.g., occupied buildings), and structures within the geographical boundaries of any applicable setback.

viii) All existing and proposed surface and subsurface drainage facilities, including detention or retention ponds. Drainage circulation with data on predevelopment and post-development condition should be provided. (Not Applicable for Small WECFs)

ix) Location and size of all signs (including emergency phone number signs) and lighting as it pertains to the WECF.

x) Proposed landscaping (noting how the existing vegetation is to be retained and used) including type, location and quantity of all plant materials, location and height of fences or screen plantings and the type or kind of building materials or plantings to be used for fencing and screening of the WECF.

xi) Methods and locations of erosion and sedimentation control devices used during and after construction of the WECF.

d) Wind Map: A map showing the wind characteristics of the general area and the dominant wind direction – the direction from which fifty (50) percent or more of the energy contained in the wind flows. (Not Applicable to Small WECFs)

e) Sightline Analysis: Photographs shall be provided depicting views from a reasonable number of key vantage points as determined by the applicant in consultation with the Division of Planning and Regulatory Services. Sites for the view representations shall be selected from areas within a two (2) mile radius of the site. (Not Applicable to Small WECFs)

i) Existing (before condition) photographs. Each sightline shall be illustrated by one (1) four-inch by six-inch color photograph of what can currently be seen from any public way within 300 feet of the subject property.

ii) Proposed (after condition) photographs. Each of the existing condition photographs shall have the proposed WECF superimposed on it to show what will be seen from public roads if the proposed facility is built.

iii) A sightline map depicting the points from which sightline photographs were taken.

iv) A description of the technical procedures followed in producing the visualization (distances, angles, lens, etc.).

f) Balloon or Crane Test: The applicant will provide a statement proposing a date, time and location of such test. (Not Applicable to Small WECFs)

i) Within ten (10) days of filing an application, the applicant shall arrange with the Division of Planning and Regulatory Services for a balloon or crane test at the proposed site to illustrate the height of the proposed WECF. The date, time and location of such test shall be advertised by the applicant in a newspaper of general circulation in the City of Worcester at least seven (7) days, but not more than fourteen (14) days prior to the test. Evidence of this advertisement must be provided to the SPGA at the time of public hearing.

g) Compliance Certificates and Statements:

i) Certificate(s) of design compliance obtained from the equipment manufacturers that the system's wind turbine and other components meet or exceed the standards of one of the following national and international certification programs: American National Standards Institute (ANSI), Det Norske Veritas Germanishcer Llloyd Wind Energies, International Electrotechnical Commission (IEC), National Electrical Code (NEC), Underwriters Laboratories (UL), or other certification program recognized by the American Wind Energy Association.

ii) Standard drawings and a structural engineering analysis of tower(s) showing compliance with applicable Massachusetts State Building Codes and certification by a Commonwealth of Massachusetts licensed professional engineer.

iii) A determination from the Federal Aviation Administration of no hazard to air navigation, and that the WECF as proposed complies with all applicable Federal Aviation Administration regulations. (Not Applicable to Small WECFs unless height waiver is requested or, is located within an A-1 District, Airport Environs Overlay District, or both.)

iv) The applicant shall provide a statement certified and signed by an acoustical engineer stating that the sound estimates and measurements provided meet industry professional standards for accuracy, and that the WECF as proposed will be in conformance with the performance standards of this Section related to sound. (Not Applicable to Small WECF)

v) Evidence that the proposed hub height and turbine height do not exceed the height recommended by the manufacturer or distributor of the wind energy conversion system.

vi) Evidence, certified by the manufacturer, that the WECF and its accessory equipment is in conformance, as applicable, with the Regulations of the Federal Communication Commission (47 CFR Part 15 as revised) relating to harmful interference with radio or television reception.

h) Maintenance Plan: The applicant shall provide a detailed maintenance plan in accordance with manufacturer's specifications and all governmental regulations to ensure the safe operation of the WECF. Plan shall include but not be limited to: preventative and periodic maintenance, routine checks and testing, and cleaning, associated with all structural, electrical and mechanical components of the WECF.

i) Notifications: The applicant shall provide notification letters and evidence that a notice to construct a WECF has been received by the appropriate electric utility company and the Federal Aviation Administration.

i) Sound Assessment:

i) The applicant shall provide a report estimating current ambient sound at appropriate locations and maximum projected sound from the proposed WECF, measured in dB(A) (decibels A-weighted), including but not limited to the following: (Not Applicable to Small WECF)

(aa) An estimation or measurement of the existing ambient background sound levels.

(bb) Identification of a model for sound propagation (sound modeling software will include a propagation model).

(cc) A prediction or measurement of sound levels from the WECF(s) at the nearest non-participating landowner's occupied building(s), at all participating landowner's occupied building(s), and the nearest property line.

(dd) A comparison of calculated sound pressure levels from the WECF with background sound pressure levels at the locations of concern.

(ee) An estimate of the maximum total sound in the environment after the WECF is operational.

(ff) All sound data and information provided by the wind turbine manufacturer.

ii) For Small WECFs the applicant shall provide a letter or report from the WECF manufacturer indicating compliance with sound standards of this ordinance as they relate to Small WECFs.

j) Shadow Flicker Assessment: The applicant shall provide a report estimating the area of shadow flicker from wind turbine(s). (Not Applicable to Small WECF)

k) Environmental and Wildlife Impact Assessment: The applicant shall provide a report assessing the impact of the proposed project on avian and non-avian wildlife, public safety, quality of life, culturally/historically significant areas, scenic areas, sedimentation, runoff and watershed. As part of these assessments the applicant shall consult the local chapter of the Audubon Society prior to application. (Not Applicable to Small WECF)

l) Waiver Requests and Supporting Documentation: The applicant shall provide all waiver requests along with supporting agreement documentation as required under this Section.

m) Documents related to decommissioning: The applicant, if other than the property owner, shall provide an affidavit signed by the property owner that he/she understands and acknowledges the provisions of subsection N(2)(d), above.

n) Fees: The permit application or amended permit application shall be accompanied with a fee in accordance with the SPGA's fee schedule, as revised.

o) Other Information: Other relevant studies, reports, certifications and approvals as may be reasonably requested by the SPGA to ensure compliance with this Section and the Zoning Ordinance.

p) Application Requirement Waivers: Upon written request, the SPGA may waive one or more of the application requirements listed above if the SPGA determines, in its discretion, that the information is not needed to consider a specific WECF.

S. Building Permit Application Requirements

1. All by-right WECFs shall provide the following information at the time of application for a building permit:

a) Project Overview: A narrative describing the proposed WECF including an overview of the project with the following information: the project location, the number, representative types, generating capacity, cut-in and cut-out wind speed, overspeed controls, materials, dimensions and respective manufacturers of each wind turbine to be constructed, and a detailed description of all ancillary facilities.

b) Site Plan: A site plan to a scale of not less than forty (40) feet to the inch, on one or more sheets, prepared by a registered engineer, and indicate the scale used, a north arrow, legend or annotation (for each symbol used), and identify the sheet number in sequence. Use separate sheets for various layers as appropriate to improve clarity – include overview sheet with all layers. The site plan shall also include the following information:

i) Title block information that identifies location, applicant, property owner, WECF owner/operator, and party responsible for preparing the plan.

ii) The boundary lines and dimensions of the subject property, existing subdivision lots, available utilities, easements, roadways, railroads, rail lines and public rights-of-way, crossing and adjacent to the subject property.

iii) Location of each wind turbine, WECF setback lines (measured at grade and depicted as a radius from the center of the wind turbine), access road and turnout locations, substation(s), electrical cabling from the WECF to substation(s), ancillary equipment, buildings, and structures, including permanent meteorological towers, associated transmission lines (including whether they are above or below ground).

iv) Layout of all existing buildings (including their use status - e.g., occupied buildings), and structures within the geographical boundaries of any applicable setback.

v) Location and size of all signs (including emergency phone number signs) and lighting as it pertains to the WECF.

vi) Proposed landscaping (noting how the existing vegetation is to be retained and used) including type, location and quantity of all plant materials, location and height of fences or screen plantings and the type or kind of building materials or plantings to be used for fencing and screening of the WECF.

vii) Methods and locations of erosion and sedimentation control devices used during and after construction of the WECF.

c) Compliance Certificates and Statements:

i) Certificate(s) of design compliance obtained from the equipment manufacturers that the system's wind turbine and other components meet or exceed the standards of one of the following national and international certification programs: American National Standards Institute (ANSI), Det Norske Veritas Germanishcer Llloyd Wind Energies, International Electrotechnical Commission (IEC), National Electrical Code (NEC), Underwriters Laboratories (UL), or other certification program recognized by the American Wind Energy Association.

ii) Standard drawings and a structural engineering analysis of tower(s) showing compliance with applicable Massachusetts State Building Codes and certification by a Commonwealth of Massachusetts licensed

professional engineer.

iii) A determination from the Federal Aviation Administration of no hazard to air navigation, and that the WECF as proposed complies with all applicable Federal Aviation Administration regulations. (Not Applicable to Small WECFs unless located within an A-1 District or the Airport Environs Overlay Zone.)

iv) Evidence that the proposed hub height and turbine height do not exceed the height recommended by the manufacturer or distributor of the wind energy conversion system.

v) Evidence, certified by the manufacturer, that the WECF and its accessory equipment is in conformance, as applicable, with the Regulations of the Federal Communication Commission (47 CFR Part 15 as revised) relating to harmful interference with radio or television reception.

d) Maintenance Plan: The applicant shall provide a detailed maintenance plan in accordance with manufacturer's specifications and all governmental regulations to ensure the safe operation of the WECF. Plan shall include but not be limited to: preventative and periodic maintenance, routine checks and testing, and cleaning, associated with all structural, electrical and mechanical components of the WECF.

e) Notifications: The applicant shall provide notification letters and evidence that a notice to construct a WECF has been received by the appropriate electric utility company and the Federal Aviation Administration.

f) Sound Assessment: Adequate evidence that the proposed installation is compliant with the applicable sound standards of this Section.

g) Documents related to decommissioning: The applicant, if other than the property owner, shall provide an affidavit signed by the property owner that he/she understands and acknowledges the provisions of subsection N(2)(d), above.

h) Other Information: Other relevant studies, reports, certifications and approvals as may be reasonably requested by the Director of Code Enforcement to ensure compliance with this Section and the Zoning Ordinance.

Appendix D. Overview of Wind Energy Technology

The design of the typical wind turbine has changed greatly over the past twenty years. Although many types of wind turbine designs were initially developed, the "Danish" design of a three-bladed, up-wind horizontal axis turbine has emerged as the standard of the industry.

Although the size and complexity of wind turbines has increased, their basic operating principles have remained virtually unchanged. Figure D-1 from the U.S. Department of Energy shows the typical layout of equipment in a turbine's nacelle, which is the "pod" of equipment at the top of the tower to which the turbine's blades are connected. Wind energy is captured by the wind turbine blades, causing the rotor to rotate the turbine's low-speed shaft. This shaft will rotate at a speed of about 15 to 20 revolutions per minute (RPM). The low speed shaft is then connected to a gearbox, which transfers the energy to the high-speed shaft connected to the generator. The speed of the high-speed shaft depends on the generator type and electrical frequency of the site, but for the U.S. typical speeds are 1,800 and 3,600 RPM. The electrical output of the generator is then transferred to the base of the wind turbine via electrical droop cables. At the base, these cables connect to a transformer, which increases the voltage of the power from the low voltage of the generator (480 or 600 VAC) to the distribution voltage of the plant (anywhere from 12 kV to 46 kV). The orientation of the wind turbine is kept into the wind by a yaw drive, with the wind direction determined by a wind vane located on top of the nacelle. The turbine's controller has independent control of the wind turbine's operation, without requiring commands from a user or central control center. If the controller senses a problem, the wind speed increases beyond the turbine's operational range, or a shut-down command is given manually, the turbine will come to a stop by means of electrical, mechanical, and aerodynamic brakes (the design of which depend on the turbine).

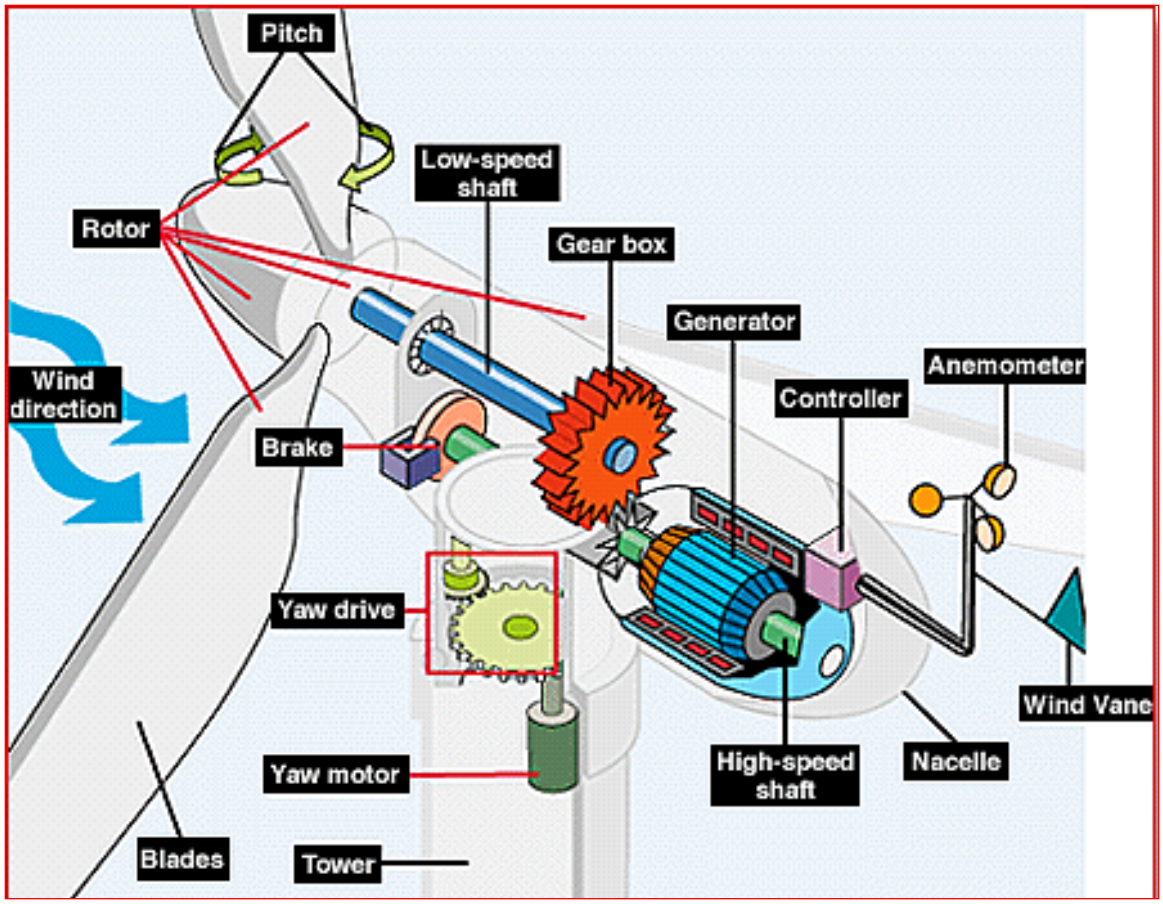


Figure D-1 Wind Turbine Components (from US Dept. of Energy).

Obviously, the output of the wind turbine is dependent upon wind speed. The relationship of a wind turbine's electrical output as a function of wind speed is given in its power curve. A typical curve will show power production beginning when the wind speed increases beyond the turbine's minimum (cut-in) wind speed. As wind speed increases, the output power also increases in a roughly linear manner until the turbine's rated power is reached. The minimum wind speed at which a wind turbine delivers this nameplate output power is called its rated wind speed. For most modern wind turbines, winds higher than the rated wind speed will not produce any additional power, and turbine will continue to output its rated power. If the wind speed increases beyond the safe operating limits of the turbine (cut-out), the turbine will automatically shutdown and wait for the wind speeds to decrease. The wind speeds and power amounts for the above values depend mostly on the size of the wind turbine and the design of the blade airfoils. On average, larger wind turbines have lower cut-in wind speeds, have higher rated power, and reach that power at lower winds.

Appendix E. Aviation Systems, Inc. Reports

AVIATION SYSTEMS INC.

Date: MAY 30 2007

To: Aaron Bouchane
Massachusetts Tech Collaborative
75 North Drive
Westborough, MA 01581

ASI #: 07-N-0448.008
Client Site ID: Technical High School
FAA #:

We are sending you herewith the following via:

☑ **US Mail** ☐ **Overnight** ☐ **Fax** ☑ **Email** ☐ **2nd Day**

☑ ASI FAR Part 77 Airspace Obstruction Report
☐ Search Area Study Report
☐ Copies of our filing(s) with FAA and/or State
☐ Responses from FAA and/or State
☐ ASI Opinion Letter
☑ Quad Chart
☑ See attachments for Airport Runway data and/or AM Stations(s)
☐ Certified Survey

Comments:

Sincerely,

Aviation Systems, Inc.
By:

2510 W. 237th Street • Suite 210 • Torrance, CA 90505
Tel: 310.530.3188 • Fax: 310.530.3850 • email: crisj@aviationsystems.com • www.aviationsystems.com

AVIATION SYSTEMS, INC.
Phone: 310-530-3188 Fax: 310-530-3850
crisj@aviationsystems.com
www.aviationsystems.com

FAR PART 77 AIRSPACE OBSTRUCTION REPORT

To:
Aaron Bouchane
Massachusetts Tech Collaborative
75 North Drive
Westborough, MA 01581

Date: May 29, 2007

Location: Worcester, MA
Client Case No: Technical High School
ASI Case No: 07-N-0448.008

SUMMARY OF FINDINGS:

At this location any structure over 200 feet AGL will have to be filed with the FAA. A structure up to 397 feet AGL should receive a routine approval.

SITE DATA:

Structure: Wind Turbine

Coordinates: 42°-16'-46.61" / 071°-46'-47.25" **[NAD 27]**
42°-16'-46.95" / 071°-46'-45.51" **[NAD 83]**

Site Ground Elevation:	764 ' **[AMSL]**
Studied Structure Height (with Appurtenances):	397 ' **[AGL]**
Total Overall Height:	1,161 ' **[AMSL]**

SEARCH RESULTS:

- The nearest public use or military air facility subject to FAR Part 77 is Worcester Regional Airport.
- The studied structure is located 3.88 NM / 23,593 feet East (078 ° True) of the Worcester Regional Airport Runway 29.
- Other public or private airports or heliports within 3 NM: ☐ None ☑ Printout attached
- AM radio station(s) within 3NM: ☐ None ☑ Printout attached

Highlighted AM stations on printout require notice under FCC Rules and Policy (Ref.: 47 CFR 73.1692).

ASI Case No: 07-N-0448.008

FINDINGS

- **FAA Notice (Ref.: FAR 77.13 (a)(1); FAR 77.13 (a)(2) i, ii,iii):**

  ☐ Not required at studied height.

  ☑ Required at studied height.

  ☑ The No Notice Maximum height is 200 feet AGL.

  IMPORTANT: Our report is intended as a planning tool. If notice is required, actual site construction activities are not advisable until an FAA Final Determination of No Hazard is issued.

- **Obstruction Standards of FAR Part 77 (Ref.: FAR 77.23 (a)(1),(2),(3),(4),(5)):**

  ☑ Not exceeded at studied height.

  ☐ Exceeded at studied height and Extended Study may be required.

  ☐ Maximum nonexceedance height is _____ feet AGL.

- **Marking and Lighting (Ref.: AC 70/7460-1K, Change 1):**

  ☐ Will not be required.

  ☑ Will be required at studied height, if structure exceeds:

  ☑ 200 feet AGL

  ☐ Obstruction Standard

- **Operational Procedures (Ref.: FAR 77.23 (a)(3), (4); FAA Order 7400.2; FAA Order 8260.3B):**

  ☑ Not affected at studied height (FAA should issue a Determination of No Hazard.)

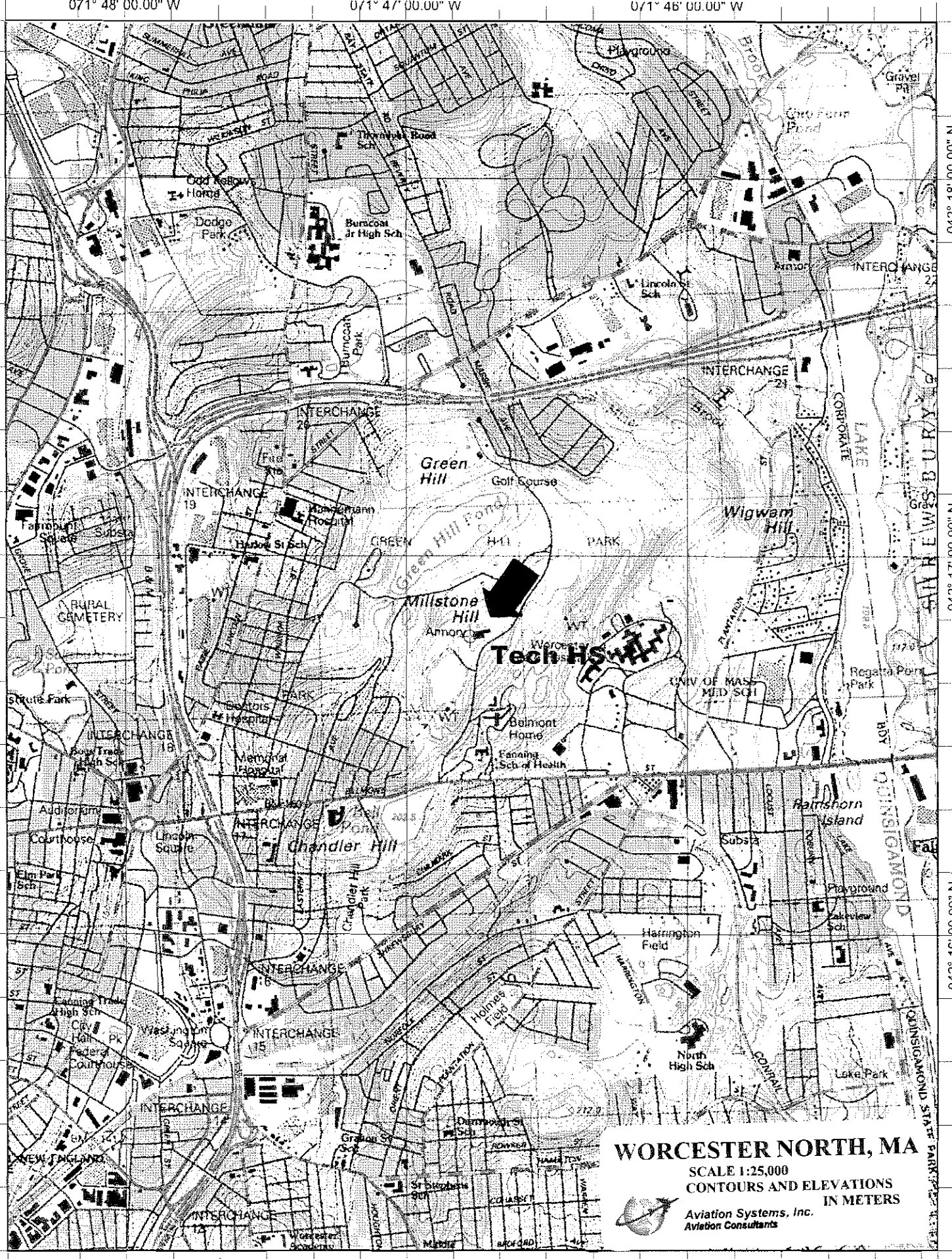
  ☐ Affected at studied height and the FAA will consider the studied structure to be a hazard to air navigation.

  ☐ Maximum height that would not affect operational procedures is _____ feet AMSL.

Conclusions/Comments

Actions:

ASI will file with FAA Region and State ☐ Yes ☑ No



AM Stations

Search Latitude: 42-16-47 **Search Radius:** 3

Search Longitude: 071-46-47 **Height (MSL):**

Freq	Call Sign	State	City	Latitude	Longitude	Power KW	Domestic Status	Hours Of Oper	Antenna Mode	Complete Schedule	Last Update	Distance NM	Distance Feet	Bear
1230	WNEB	MA	WORCESTER	42-16-23N	071-49-23W	100	L	U	ND1	U		1.97	11,957	258.28

FCC Rules (47 CFR Section 22.371) require that notice be given to AM station(s) by licensees/permittees proposing antennas within 1.0 km (0.54 NM) of an AM nondirectional tower or within 3.0 km (1.62 NM) of an AM directional tower

Airports with Runways

Search Latitude: 42-16-47 ***Search Radius:*** 3

Search Longitude: 071-46-46 ***Height (MSL):***

ID	*Name*	*City*	*State*	*ARP Lat*	*ARP Long*	*Type*	*Rways*	*Primary*	*RwyLat*	*RwyLong*	*Elev.*	*Dist/NM*	*Dist/feet*	*Bear*
MA32	ATLANTIC TRADE	WORCESTER	MA	42-15-40.3060N	071-46-10.2700W	PR						1.20	7,303	158 28
1MA2	UMASS MEML MEDICAL CENTER - UNIV CAMPUS	WORCESTER	MA	42-16-30.0000N	071-45-36.0000W	PR						0.91	5,528	108.14
42MA	WORCESTER MEDICAL CENTER	WORCESTER	MA	42-15-15.5500N	071-47-51.5900W	PR						1.73	10,516	207.65
MA94	PARKER	WORCESTER	MA	42-16-31.3350N	071-47-55.2560W	PR						0.89	5,426	252 63

AVIATION SYSTEMS INC.

Date: MAY 31 2007

To: Chris Clark
Massachusetts Tech Collaborative
75 North Drive
Westborough, MA 01581

ASI #: 07-N-0448.009
Client Site ID: Green Hill Park: Golf Course
FAA #:

We are sending you herewith the following via:

☑ **US Mail** ☐ **Overnight** ☐ **Fax** ☑ **Email** ☐ **2nd Day**

☑ ASI FAR Part 77 Airspace Obstruction Report
☐ Search Area Study Report
☐ Copies of our filing(s) with FAA and/or State
☐ Responses from FAA and/or State
☐ ASI Opinion Letter
☑ Quad Chart
☑ See attachments for Airport Runway data and/or AM Stations(s)
☐ Certified Survey

Comments:

Sincerely,

Aviation Systems, Inc.
By:

2510 W. 237th Street • Suite 210 • Torrance, CA 90505
Tel: 310.530.3188 • Fax: 310.530.3850 • email: crisj@aviationsystems.com • www.aviationsystems.com

AVIATION SYSTEMS, INC.
Phone: 310-530-3188 Fax: 310-530-3850
crisj@aviationsystems.com
www.aviationsystems.com

FAR PART 77 AIRSPACE OBSTRUCTION REPORT

To:
Chris Clark
Massachusetts Tech Collaborative
75 North Drive
Westborough, MA 01581

Date: May 31, 2007

Location: Worcester, MA
Client Case No: Green Hill Park: Golf Course
ASI Case No: 07-N-0448.009

SUMMARY OF FINDINGS:

At this location any structure over 200 feet AGL will have to be filed with the FAA. A structure up to 397 feet AGL should receive a routine approval.

SITE DATA:

Structure: Wind Turbine

Coordinates: 42°-17'-01.40" / 071°-47'-07.14" **[NAD 27]**
42°-17'-01.74" / 071°-47'-05.40" **[NAD 83]**

Site Ground Elevation:	694 ' **[AMSL]**
Studied Structure Height (with Appurtenances):	397 ' **[AGL]**
Total Overall Height:	1,091 ' **[AMSL]**

SEARCH RESULTS:

- The nearest public use or military air facility subject to FAR Part 77 is Worcester Regional Airport.
- The studied structure is located 3.73 NM / 22,597 feet East (073 ° True) of the Worcester Regional Airport Runway 29.
- Other public or private airports or heliports within 3 NM: ☐ None ☑ Printout attached
- AM radio station(s) within 3NM: ☐ None ☑ Printout attached

Highlighted AM stations on printout require notice under FCC Rules and Policy (Ref.: 47 CFR 73.1692).

ASI Case No: 07-N-0448.009

FINDINGS

- **FAA Notice (Ref.: FAR 77.13 (a)(1); FAR 77.13 (a)(2) i, ii,iii):**

  ☐ Not required at studied height.

  ☑ Required at studied height.

  ☑ The No Notice Maximum height is 200 feet AGL.

  IMPORTANT: Our report is intended as a planning tool. If notice is required, actual site construction activities are not advisable until an FAA Final Determination of No Hazard is issued.

- **Obstruction Standards of FAR Part 77 (Ref.: FAR 77.23 (a)(1),(2),(3),(4),(5)):**

  ☑ Not exceeded at studied height.

  ☐ Exceeded at studied height and Extended Study may be required.

  ☐ Maximum nonexceedance height is _____ feet AGL.

- **Marking and Lighting (Ref.: AC 70/7460-1K, Change 1):**

  ☐ Will not be required.

  ☑ Will be required at studied height, if structure exceeds:

  ☑ 200 feet AGL

  ☐ Obstruction Standard

- **Operational Procedures (Ref.: FAR 77.23 (a)(3), (4); FAA Order 7400.2; FAA Order 8260.3B):**

  ☑ Not affected at studied height (FAA should issue a Determination of No Hazard.)

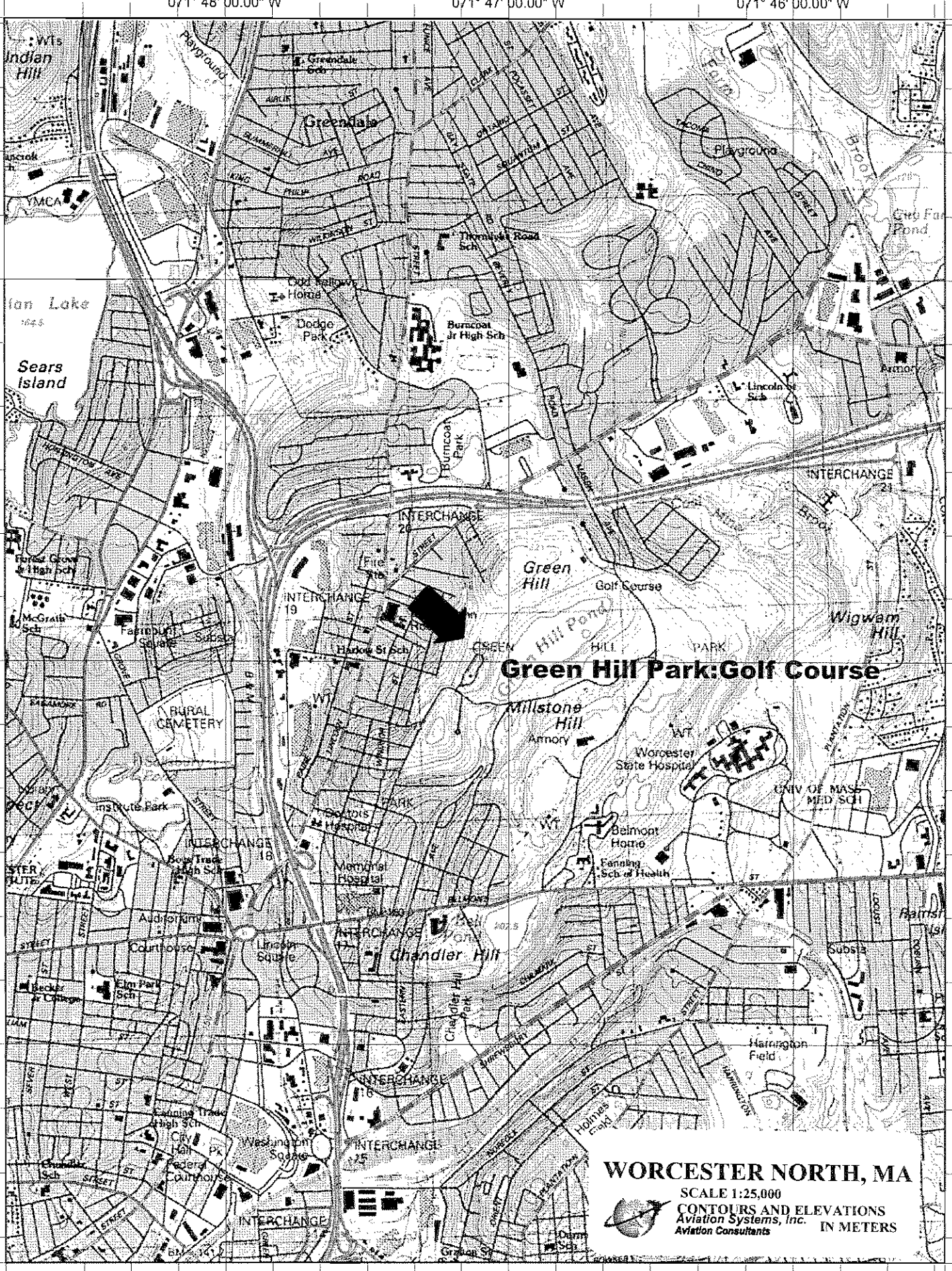
  ☐ Affected at studied height and the FAA will consider the studied structure to be a hazard to air navigation.

  ☐ Maximum height that would not affect operational procedures is _____ feet AMSL.

Conclusions/Comments

Actions:

ASI will file with FAA Region and State ☐ Yes ☑ No



Airports with Runways

Search Latitude: 42-17-02 **Search Radius:** 3

Search Longitude: 071-47-05 **Height (MSL):**

ID	Name	City	State	ARP Lat	ARP Long	Type	Rways	Primary	RwyLat	RwyLong	Elev.	Dist/NM	Dist/feet	Bear
MA32	ATLANTIC TRADE	WORCESTER	MA	42-15-40.3060N	071-46-10.2700W	PR						1.53	9,273	153.56
1MA2	UMASS MEML MEDICAL CENTER - UNIV CAMPUS	WORCESTER	MA	42-16-30.0000N	071-45-36.0000W	PR						1.22	7,424	115.88
42MA	WORCESTER MEDICAL CENTER	WORCESTER	MA	42-15-15.5500N	071-47-51.5900W	PR						1.87	11,372	197.68
MA94	PARKER	WORCESTER	MA	42-16-31.3350N	071-47-55.2560W	PR						0.81	4,892	230.09

AM Stations

Search Latitude: 42-17-01 **Search Radius:** 3

Search Longitude: 071-47-07 **Height (MSL):**

Freq	Call Sign	State	City	Latitude	Longitude	Power KW	Domestic Status	Hours Of Oper	Antenna Mode	Complete Schedule	Last Update	Distance NM	Distance Feet	Bear
1230	WNEB	MA	WORCESTER	42-16-23N	071-49-23W	100	L	U	ND1	U		1.80	10,907	249.35
1440	WVEI	MA	WORCESTER	42-17-25N	071-50-47W	500	L	D	DAN	U		2.75	16,684	278.37
1440	WVEI	MA	WORCESTER	42-17-25N	071-50-47W	500	L	N	DAN	U		2.75	16,684	278.37

FCC Rules (47 CFR Section 22.371) require that notice be given to AM station(s) by licensees/permittees proposing antennas within 1.0 km (0.54 NM) of an AM nondirectional tower or within 3.0 km (1.62 NM) of an AM directional tower