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Wind Power in Worcester:

Siting Considerations for a Wind Turbine

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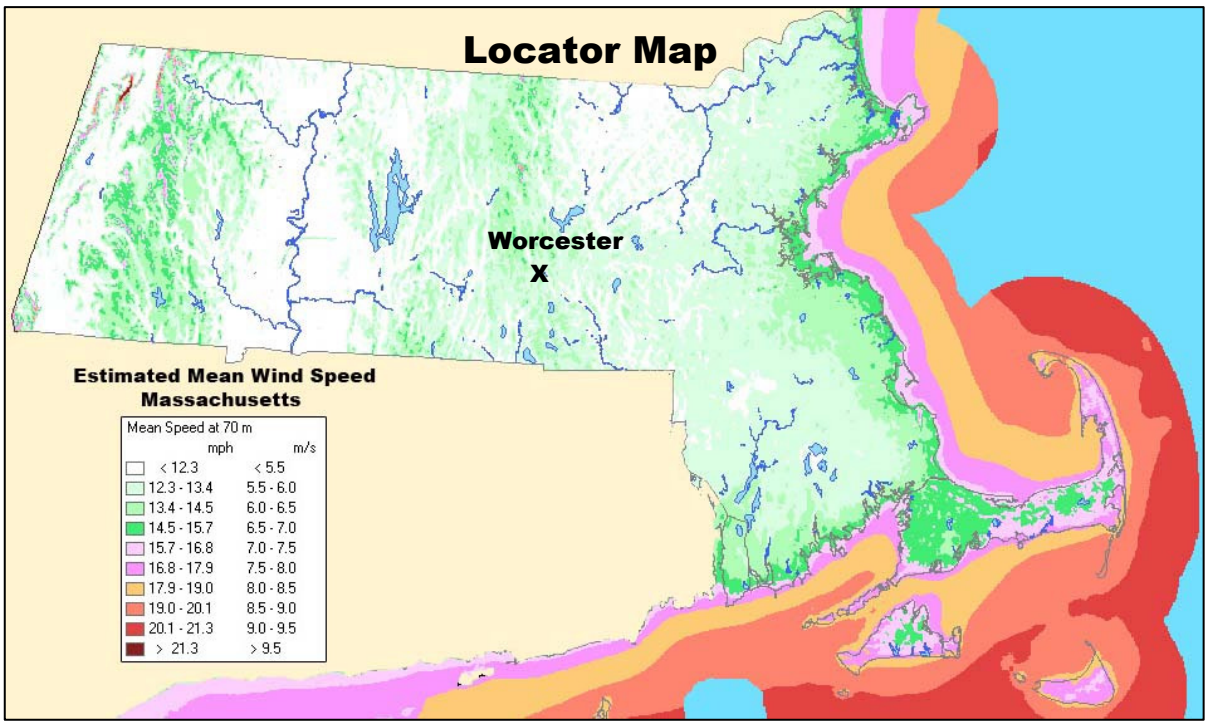
Table of contents



I. Introduction

The City of Worcester is a participant in the international group Cities for Climate Protection (CCP) and a city Climate Action Plan was developed this year by the Energy Officer and Energy Task Force. Because clean energy generation is an important part of a climate action plan, installing wind power generation is one of the Plan's "Key Proposed Reduction Measures." Several specific sites for wind turbines were suggested in the Plan. The City is now taking the next step, and formally reviewing potential sites through the Massachusetts Renewable Energy Trust's Community Wind Collaborative (MRET CWC).

At the request of the City of Worcester and the MRET, Sally Wright of the UMass Renewable Energy Research Laboratory (RERL) visited potential wind turbine and/or wind-monitoring sites in the City of Worcester. She was accompanied by representatives of the Worcester DPW's Architectural Services Department.

This report provides an initial assessment of the suitability of the proposed site for utility- or medium-scale wind turbines. The report is in the form of a broad "fatal flaw" analysis, which is designed to determine whether the City should move forward in considering this type of wind power project.

The "Locator Map" on the previous page is an AWS-TrueWind map of the estimated mean wind speeds in Massachusetts at 70 meters height. Areas of primary interest for utility-scale wind power have estimated mean wind speeds of 6.5 m/s or greater (dark green or more). On this map, the City of Worcester is marked with an "X".

Appendix A provides details of the site discussed in this report in tabular form.

Appendix B focuses on siting considerations for wind-monitoring towers (met towers) in Worcester. Wind monitoring is an important aspect in determining feasibility.

Appendix C provides photographs, ortho (aerial) photographs and maps for the site.

For more background information

This report assumes some familiarity with wind resource assessment, wind power siting, and other issues that arise with wind power technology. For an introduction to these areas, please refer to RERL's Community Wind Fact Sheets, which are available on the web at: http://www.ceere.org/rerl/about_wind/.

These sheets include information on the following subjects:

- Wind Technology Today
- Performance, Integration, & Economics
- Capacity Factor, Intermittency, and what happens when the wind doesn't blow?
- An Introduction to Major Factors that Influence Community Wind Economics
- Impacts & Issues
- Siting in Communities
- Resource Assessment
- Interpreting Your Wind Resource Data
- Permitting in Your Community

More information on wind turbine technology, policy, and general information can be found at these websites:

- American Wind Energy Association, www.awea.org
- Danish Wind Industry Association, www.windpower.org

Use of this report

This engineering report is intended to be used in consultation with MTC as the City explores its options for wind development at municipally owned sites.

II. Site Considered

The City of Worcester requested that three sites be evaluated for suitability for a wind power project. Additionally, during the site visit, RERL was asked to include Crow Hill for comparison, although it is not under consideration. These four sites are summarized below (see also Appendix A, lines 1-7).

1. Technical High School: this new school is near the top of one the City's many hills. The property includes school buildings, parking lots, playing fields and a recreational area.
2. Green Hill Park: a municipal golf course north of the Technical High School. The specific area considered is a DPW garage on the southern end of the course, with a vacant lot and bins for sand and wood chips.
3. North High School: this school property in a residential area includes school buildings, athletic fields, and parking lots. It neighbors an environmental museum and education center called the Ecotarium.
4. Crow Hill: a wooded hill surrounded by residential streets. The area is divided into several parcels. This site's characteristics will be listed in Appendix A for comparison, but will not be discussed in detail in the text.

This report will evaluate these sites for preliminary feasibility of a wind power project.

III. Wind Turbine Siting Considerations

Purpose

The purpose of this section is to consider whether there are any "fatal flaws" to siting a wind turbine in the site under discussion (generally, these "fatal flaws" vary with the heights of the specific turbines and their applications). For this discussion, we primarily examine the potential for a "utility-" or "commercial-scale" (600 – 2,500 kW) turbine. The blade-tip heights of these turbines range between 250 and 450 feet.

The following characteristics are important in considering a wind turbine site, and are examined in this report:

A. Predicted Wind Resource
B. Noise
C. Proximity to Airports
D. Environmental Issues and Permitting
E. Wind Turbine Component Transportation & Access
F. Distance to Transmission/Distribution Lines for Power Distribution
G. Potential Electrical Loads Offset

Each section below briefly describes why the characteristic is important in general, and then discusses it in particular for this site. Information about these characteristics for the site is also presented in tabular form in Appendix A. The corresponding lines are noted in parentheses after each subject line.

A. Predicted Wind Resource

About wind resource in general

The economics of wind power at a given site depend on many factors; one of the most important is wind speed. Understanding wind speed and turbulence is critical to estimating the energy that can be produced at a given site. The power in wind is related to its speed, and small changes or inaccuracies in estimated wind speed can mean big changes in annual energy production. For these reasons, wind speed is the first criterion to examine when considering a wind power project.

The primary motivation for understanding the winds at a proposed wind power site is an improved understanding of the project feasibility and returns, and thus a lowering of investment risk. Better, longer, and more site-specific data leads to lower risks. Additional information regarding the monitoring of wind resources can be found in Appendix B.

When considering wind resource at this screening stage, we look at several factors:

TrueWind estimates: An initial site screening can use estimated wind speeds based on computer models by AWS TrueWind (http://truewind.teamcamelot.com/ne/); for more detail, the wind is monitored on site.

Existing wind data: High-quality wind data from nearby locations can be useful, primarily for correlation with on-site data. Concurrent, long-term, nearby data is most useful. Wind resource data collected by RERL are available on the web: http://www.ceere.org/rerl/publications/resource_data/.

Obstacles to wind: Obstacles cause both turbulence and slowing of the wind. If the surrounding landscape is built up, forested, or otherwise rough, turbulence will increase. These are important factors in site selection for a wind turbine because they affect the power production and the longevity of a wind turbine, and may affect the type of turbine that can function reliably at the site.

TrueWind estimates of annual average wind speed (Lines 8-12)

The AWS-TrueWind model estimates annual average wind speeds at these sites between 5.7 m/s and 6.3 m/s at a height of 50 meters, and 6.0-6.6 m/s at 70 meters, respectively.

These wind speed estimates are not ideal for utility- or medium-scale wind power, but these sites could warrant further consideration, particularly where some of the energy can be used on site.

Other available wind data (Line 13)

The RERL has maintained wind-monitoring equipment in Paxton, about 7 miles to the north, since September 2003. This site is far enough away and has different terrain than the sites considered here, so if a utility-scale wind turbine is under consideration, on-site wind monitoring is advisable.

These RERL wind data sets are available on the web: www.ceere.org/rerl/publications/resource_data.

Obstacles to wind flow (Lines 18-19)

All sites are wooded to some extent and have buildings on site (with the exception of Crow Hill, which does not have buildings at the top).

While the sites are not ideally clear, obstacles and turbulence should not be fatal flaws.

B. Noise

About Noise in general

Noise considerations generally take two forms, state regulatory compliance and nuisance levels at nearby residences:

A. *Regulatory compliance:* Massachusetts state regulations do not allow a rise of 10 dB or greater above background levels at a property boundary (Massachusetts Air Pollution Control Regulations, Regulation 310 CMR 7.10). Regulatory compliance will rarely impose a siting constraint on a large modern wind turbine, since in most cases modern turbines are quiet enough to meet these criteria easily.

B. *Human annoyance:* Aside from Massachusetts regulations, residences must also be taken into consideration. Any eventual wind turbine would be sited such that it would be inaudible or minimally audible at the nearest residences. At this stage, to check for fatal flaws, this rule of thumb can be used to minimize possible noise: site wind turbines at least three times the blade-tip height from residences. Distances from mixed-use areas may be shorter.

For example, this first-pass rule of thumb tells us that a turbine with a 77-meter rotor diameter on a 60-meter tower should be about 300 meters (~1000 feet) from residences. Other turbines sizes would suggest other distances. Note that many factors affect the transmission of sound and that this is a rule of thumb only.

The three-times-blade-tip height suggestion is not a hard rule; wind turbines can be and often are positioned closer to residences. This initial recommendation is meant to be the beginning of a conversation among the town's citizens. The town's decision to site a wind turbine must take into consideration the community's needs and priorities.

If the town would like to consider a site closer than this distance, then a more detailed sound study can be performed that takes into consideration actual ambient levels and terrain; this site-specific information would then supersede this rough rule-of-thumb.

Noise at Worcester sites (Lines 20-21)

Noise will be a siting or sizing consideration for a wind turbine proposed at some of these sites. Using the rule of thumb mentioned above, the height of the turbine would be limited at all sites but the Technical High School. When a specific site and wind turbine size have been chosen, the City may consider performing a sound level study to refine this rough estimation.

Ambient noise levels perceived during the afternoon site visits varied among these sites. At Green Hill Park, the traffic noise from Route 290 to the west was significant. These levels play an important role in the impact of a wind turbine's noise. A sound study will measure ambient noise levels and take them into consideration.

C. Nearby Airports

About airspace in general

The form "7460-1 - Notice Of Proposed Construction or Alteration" must be filed with the Federal Aviation Administration (FAA) before construction of any structure over 200 feet (i.e. all utility-scale wind turbines). The corresponding form for the Massachusetts Aeronautics Commission (MAC form E10, Request for Airspace Review) must also be filed.

These filings are reviewed by the FAA and the Department of Defense (DOD) for any potential obstruction or interference with air traffic, aircraft navigation/communication systems, military RADAR, etc. This process typically takes about three months for a first response. We recommend that these filings, or a detailed analysis of airspace issues, be undertaken as soon as possible if a site is seriously being considered for a wind turbine.

While we cannot predict the FAA or DOD response, most sites that are not within about 3-5 miles of a public or military airport are not considered a hazard to air traffic. At this preliminary stage, we look for fatal flaws by considering the distance to public and military runways.

Note that the FAA requires that any structure over 200' be lit. All utility-scale wind power installations are lit.

Airspace at Worcester sites (Line 27)

Worcester Municipal Airport is about 4-5 miles away from these sites. While we do not expect aviation safety to impose a height limit on turbines at these sites, if one of the sites is considered for a wind turbine, then filing the FAA 7460-1 early is recommended.

D. Environmental Issues and Permitting

Environmental permitting in general

At this early stage, the following items are reviewed:

- State designations of Natural Heritage & Endangered Species Program (NHESP), Open Space, Wetlands, and other land-use restrictions
- Massachusetts Audubon Society Important Bird Area (IBA)
- Current or former landfill

The permitting implications of these designations are not clear-cut in all cases. For instance, a "Core Habitat" designation may require a filing with the NHESP, but does not eliminate the possibility of a wind turbine installation. Compatibility of some land-use restrictions with wind power has not yet been determined.

Please note that this report is based on publicly available information and conversations with City representatives. There may, however, be other land-use restrictions, unregistered wetlands, etc. of which RERL is not aware. It is the City's responsibility to ensure the environmental appropriateness of the chosen site.

Environmental permitting at Worcester sites (Lines 22-26)

All sites have wetlands on or near the parcel but suitable setbacks will be possible.

The two northern sites are designated as Open Space with "In Perpetuity Protection".

Part of the Technical High School site is a former landfill, but RERL expects that a met tower can be installed that avoids the cap. If the City chooses to install a turbine on the closed landfill, the foundation design will take this into consideration and the cost of the foundation will likely be higher.

It is not known if any sites are covered by Article 97,

Worcester City Wind Turbine Ordinance

The City of Worcester has a wind turbine by-law that restricts wind turbine installations in several ways, including a setback of 650 feet from the nearest "non-participating landowner's occupied building." Some of these restrictions may be waivable with a property-owner's consent.

When a specific site and turbine size is chosen, it will require careful review in light of the full city by-law and the possible participation of neighboring land-owners. At this stage, only the distance to neighboring buildings will be considered:

1. Technical High School: depending on the specific siting, the National Guard structures will probably be within the 650' limit.

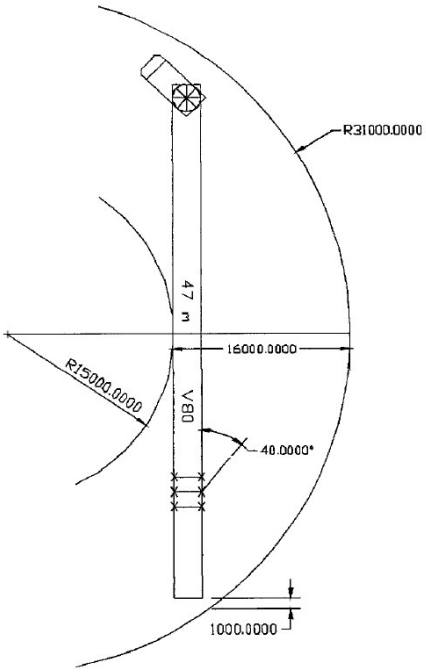
2. Green Hill Park: the garage buildings are within 650' but might not be considered occupied.

3. North High School: the Ecotarium is within the 650' limit. The museum may have interest in being a participant in some form.

E. Wind Turbine Component Transportation & Access

About transportation and access in general

With blades up to 130 feet long, modern wind turbines require transportation on roads with fairly large turning radii and only small changes in slope. The example at right shows the set of turning radii (in millimeters) required for transporting one of the 39-meter turbine blades of a Vestas V80, a 1.8 MW machine, on a 47-meter (154') trailer. Transportation accessibility for turbine installation is an important consideration for a potential wind turbine site.



Transportation and access to Worcester sites (Line 16)

Careful route planning, on-site road improvements, and/or construction will be necessary to bring turbine components to these urban locations.. There may be some logistical difficulties in moving wind turbine components within the City, but site access does not immediately appear to be a fatal flaw for the primary three sites. However, it is recommended that an access plan be considered more carefully for any site that the City pursues further.

F. Distance to Transmission/Distribution Lines for Power Distribution

About power distribution in general

The power generated by any installed wind turbine must be transported to adequately sized lines, either on the "load side" of a meter, or out to transmission or distribution lines. Proximity to utility distribution or transmission lines is an important cost consideration for a wind turbine project.

Power distribution at Worcester sites (Line 17)

The Technical High School has three-phase 13.7 kV distribution lines on-site and it is expected that any installed turbine will connect on the school side of the meter. The ratings and locations of the distribution lines at the other sites were not discussed, but interconnection does not appear to be a fatal flaw at this stage.

The point of interconnection would be determined later in the project.

G. Potential Electrical Loads Offset

About offsetting loads in general

Energy used on-site is more valuable than energy sold onto the wholesale market. At this preliminary stage, we note that the schools electric loads could largely be met by a utility-scale wind turbine, and possibly partly met by a smaller medium-scale machine, such as a 100-kW turbine.

In fact, a more detailed analysis is needed to better understand the value of the generated energy. For on-site generators over 60 kW (Massachusetts' current net-metering limit), energy must be generated at the same time that it is consumed or else sold to the grid. Therefore, the extent to which on-site loads can be offset depends on how well the daily profiles of consumption and generation align with each other. This more detailed analysis could be carried out in a later feasibility study.

About offsetting loads at the Worcester sites (Lines 14-15)

The two schools have an economic advantage over the golf course due to their larger electric loads that an on-site wind turbine could partially or possibly entirely offset. A more detailed analysis at a later date could compare the annual and diurnal profiles of electricity production and consumption.

IV. Conclusions

The City of Worcester is interested in a community wind power project and has suggested three sites for consideration. The estimated mean wind speeds at the three suggested sites are not ideal for wind turbines, but the on-site electric loads at the schools would improve a project's economics.

The Technical High School is the preferred choice of the three, because of its higher wind speeds and larger available area.

Next steps (Line 29)

After deciding to pursue a wind project, wind monitoring and a full feasibility analysis is the next step. The wind monitoring process and siting considerations are discussed in Appendix B.

In addition to wind monitoring and public outreach, these site-specific items related to pursuing wind power at the Tech School should be explored:

- File FAA form 7460-1
- Determine whether a conservation restriction or other land-use restrictions put limits on the project.
- Work with school and neighbors, including the state and the Army National Guard, to determine the most favorable site based on the existing land-use patterns. A joint project could be considered.
- Investigate the potential load offset at the school

The feasibility analysis will include a detailed economic analysis. For a brief introduction to wind turbine economics and how it affects site choice, please visit the RERL's Community Wind Fact Sheet related to community wind economics:
An Introduction to Major Factors that Influence Community Wind Economics

Appendix A: Site Survey Data

Key:

Green shading: Particularly positive aspect that distinguishes this site from the others.
Yellow shading: Significant constraints: these items may force micrositing choices, or may make the site difficult
Red shading: Fatal flaws: these make placement impossible at this site.

Refer to the report "Wind Power in City of Worcester: Siting Considerations for a Wind Turbine" for a discussion of these data.

		1. Technical High School	2. Green Hill Park: Golf Course	3. North High School	4. Crow Hill
Site overview					
1.	Description, current land use	School buildings, parking lots, recreational area	Municipal Golf Course	School buildings, athletic fields	Wooded hill; conservation land
2.	Address	Skyline Drive	Green Hill Parkway	Bigelow Lane	Between Plantation, Hamilton & Harrington Roads
3.	Owner	Town	Town	Town	Various parcels owned by the City, the Greater Worcester Land Trust, the Ecotarium and private owner(s)
Location					
4.	NAD 83, lat & long	42.279709 N 71.779307 W	42.283817 N 71.784832 W	42.262021 N 71.766997 W	42.259028° N 71.774278° W
5.	Degree, minute, second	42º16'47.02"N 71º46'45.51"W	42º17'01.92"N 71º47'05.26"W	42º15'43.26"N 71º46'01.17"W	42°15'32.50"N 71°46'27.40"W
6.	Elevation (feet)	764	694	538	676
7.	Notes	Unknown area. The school property neighbors the Worcester Army National Guard facility,	455.9 acres	18.9 acres Neighboring the Ecotarium: www.ecotarium.org/	*City-owned parcel: 19.2 acres* *Not under consideration for the Community Wind Collaborative. This site is shown here for comparison at the request of the City.*

		1. Technical High School	2. Green Hill Park: Golf Course	3. North High School	4. Crow Hill
Wind Speeds					
Estimated Mean Speeds* in m/s *To convert m/s to mph, multiply m/s by 2.24*					
8.	• At height of 100 m	6.2	6.1	6.1	6.7
9.	• At height of 70 m	6.6	6.4	6.0	6.3
10.	• At height of 50 m	6.3	6.1	5.7	5.9
11.	• At height of 30 m	5.8	5.7	5.1	5.5
12.	Wind Speed Summary:	Fair	Fair	Fair	Fair
13.	Existing wind data	RERL data is available from Paxton (6 miles away) Note that Worcester Regional Airport may have wind speed data available for use, but it is measured at too low a height and is too far away (4-5 miles) to be of real use.	RERL data is available from Paxton (6 miles away)	RERL data is available from Paxton (7 miles away)	RERL data is available from Paxton (7 miles away)
Wind Turbine Considerations:					
Economic					
14.	On-site Electric Loads	Yes	Yes	Yes	No
15.	Electric Loads, kWh/year	1,000,000	230,000	1,000,000	–
16.	Access for blade transportation**	Some tight turns. Route should be considered in more detail	Some tight turns. Route should be considered in more detail	Some tight turns. Route should be considered in more detail	Steep access
17.	Distance to Distribution/ Transmission lines**	New 13.8 kV lines on site	Not known	Not known	Not known

		1. Technical High School	2. Green Hill Park: Golf Course	3. North High School	4. Crow Hill
Obstructions to wind					
18.	Terrain	Near top of hill.	A local peak. Drops significantly to the west	Rolling terrain. Low bedrock ridge between the school and the Ecotarium to the north.	Wooded hill. Clay mining on the NNW of this drumlin* appears to have created some steep grades.
19.	Obstacles to wind	Trees, National Guard facilities, various structures	Trees. One-story garage building.	Mature trees, buildings	Trees
Noise					
20.	Nearby residential areas:	Yes	Yes	Yes	Yes
21.	Radius to residences: (m): (ideally >~300m for utility scale‡)	~1500 feet (> 350 meters) depending on micrositing	~750 feet (~230 meters) depending on micrositing	~650' (~ 200 meters) depending on micrositing	~ 550' from top of hill. There are spots on Crow Hill that are 650' from any residence. Whether those spots are suitable and available for a wind turbine is not known and is not considered here.
Environmental permitting †					
22.	Designated by the Natural Heritage & Endangered Species Program as a Core Habitat or a Supporting Natural Landscape?	No	No	No	No
23.	Designated by the DEP as Wetlands?	Wetlands on the parcel but not nearby	Wetlands on the parcel but not nearby	Wetlands on the parcel but not nearby	Possibly wetlands on the parcel but not nearby
24.	Designated by the Massachusetts Audubon Society as an Important Bird Area (IBA)?	No	No	No	No

* Reference: the City of Worcester Open Space & Recreation Plan, March 2000. Accessed May 2007, http://www.ci.worcester.ma.us/reports/OSRPlan.pdf

		1. Technical High School	2. Green Hill Park: Golf Course	3. North High School	4. Crow Hill
25.	Is the site a current or former land-fill? *(RERL does not install met towers on landfills)*	Parts are	No	No	No
26.	Other land-use restrictions, e.g. Article 97 †	Open space: In Perpetuity protection Possible Conservation Restriction	Open space: In Perpetuity protection	None known	Conservation Restriction. Greater Worcester Land Trust
Other permitting					
27.	Distance to airport(s)	7 km (4 miles) to Worcester Regional Airport	7 km (4 miles) to Worcester Regional Airport	No airports within 8 km (5 miles)	7 km (4 miles) to Worcester Regional Airport
Wind Turbine: Conclusions					
28.	***Primary constraint(s):*** *If this site is of interest for a utility-scale wind turbine, what factors will most affect feasibility and/or micrositing?*	Moderate wind speed Varied & crowded site use	Moderate wind speed Sound (i.e. Distance to Residences) By-law setback	Moderate wind speed Sound By-law setback	Moderate wind speed Sound By-law setback Access
29.	***Next step / To be determined*** *To pursue wind power at this site, these items should be explored first (along with wind monitoring and public outreach):*	Conservation Restriction FAA form 7460-1 Work with neighbors Investigate load offset	FAA form 7460-1	FAA form 7460-1 Investigate load offset	(no recommendations are offered for this site.)

		1. Technical High School	2. Green Hill Park: Golf Course	3. North High School	4. Crow Hill
30.	***Recommendation*** *Should the town consider this site for a utility-scale wind turbine?* *For a medium-scale turbine?* *See also the discussion section.*	Yes Possibly	Possibly Possibly	Probably not Possibly	(no recommendations are offered for this site.)
31.	***Multiple Turbines*** *If the town is interested in installing more than one utility-scale turbine, how many could fit at this site?*	Possibly only 1. Consider cooperating with neighbors for more.	Possibly only 1	1	(no recommendations are offered for this site.)

Notes for Appendix A:

* Estimated Mean Annual Wind speeds, in m/s: based on the AWS-TrueWind computer models. For more information, see TrueWind Solutions, truewind.teamcamelot.com/ne/

‡ Note that this will vary based on location, turbine size, terrain, ambient noise, etc.

** These items can have significant impacts on installation cost. The intention of this report is not to estimate the costs of these items, but only looks for indications of fatal flaw. However, if one appears to be an issue for the chosen site, it may be advisable to study it further relatively early in the project.

† Please note that this report is based on publicly available information and conversations with site owner representatives. There may, however, be other land-use restrictions, unregistered wetlands, etc. of which RERL is not aware. It is the City's responsibility to ensure the environmental appropriateness of the chosen site

		1. Technical High School	2. Green Hill Park: Golf Course	3. North High School	4. Crow Hill
Met Tower Siting Factors					
32.	Space availability & level terrain	Possible at the playing field parking lot.	Not without modification. (This site was not paced out for a met tower.)	Not without clearing woods, or using a parking lot or ball field	No site visit was conducted
33.	Power lines or other obstructions to met tower. *(Met tower must be set at least 1.5 x the tower height away from power lines.)*	Some lamp posts will need to be temporarily removed	Ok	Power lines run between the school & Ecotarium	Ok
34.	Obstacles to wind	Terrain, some structures	Some trees, structures	Trees, terrain, structures	Trees
35.	Clearing requirements	The layout of the tower guy lines will take some careful thought but appears possible.	At a minimum, the fences, several trees, and chip/sand bins would need to be removed.	Depends on site chosen.	Tree would need to be cleared, minimum 310 x 270 feet
36.	Soil quality – for met tower anchors	Macadam over unknown soil	Ledge, presumably rocky soil	Ledge, presumably rocky soil	Unknown
37.	Road Access – for met tower installation	Good	Good	Good	Unknown
38.	Security	School	Unknown	School	Four-wheeler tracks
39.	Existing towers on or near site	None	Radio tower of unknown ht.	None	None
40.	Distance to AC power if lighting is required	Close	Close	Close	Unknown
41.	Compatibility: If this site were chosen for a wind turbine but not a met tower, where else could wind be monitored? (i.e, which of the other sites are within about 1 mile and have similar terrain?)	Sites #1& 2 are close but terrain is different enough that separate monitoring is recommended	See note under #1	Sites #3& 4 are close but terrain is different enough that separate monitoring is recommended	See note under #3
Met Tower: Primary Constraint					
42.	What factors will most affect feasibility and/or siting of a met tower here?	Fitting guys around existing land use and obstacles.	Fitting guys around existing land use and obstacles.	Lack of space and existing land use	Clearing, et al.
Met Tower Recommendation:					
43.	Recommended site:	Yes	Not ideal	Not ideal	Not ideal
44.	Recommended met tower height (meters)	50 meters	50 meters	50 meters	50 meters

Appendix B: Wind-Monitoring Logistics

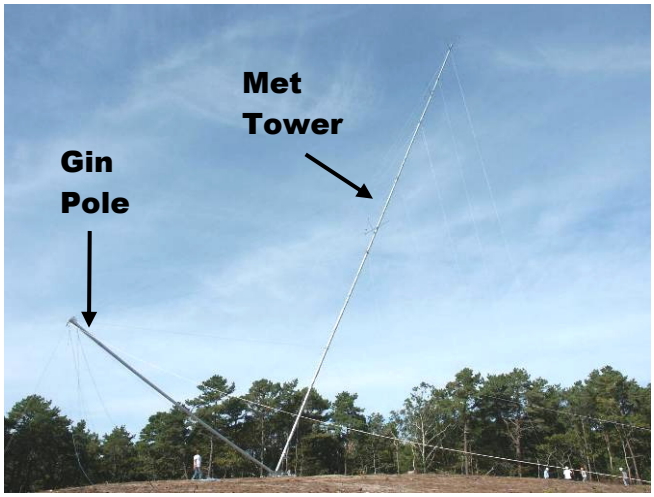
Traditionally, wind is monitored for about a year with a met tower. Some sites may be suitable for other types of monitoring in addition to a met tower. This section will concentrate on the siting of a met tower. Figure 1 in Appendix C is a schematic of a met tower.

About met towers

Most met towers are temporary structures that do not require a foundation and are supported by guy wires in 4 directions. Towers are usually 40 meters (131') or 50 meters (164') tall. In most cases, standard utility anchors are used to anchor the guy wires. The number and type of anchors required depends on the particular site. They will be proof-tested at installation to make sure they can hold enough load.

The tower is raised using a winch; no crane is required. The tower consists of a set of 6" diameter pipes that stack together; the whole set-up can be brought in on a pick-up truck.

The pictures on this page give an idea of what this equipment looks like.



In the process of raising a met tower, the "gin pole" gives the winch leverage to lift the tower.

RERL's truck loaded with the sections of a 50-meter met tower

A met tower base-plate sits directly on the ground.

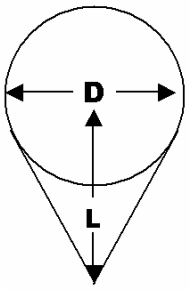
Typical 6-foot-long utility screw-in anchor

An anchor, installed, with 2 guy wires attached

Space required for a met tower

Clearing is necessary both for met tower installation and to reduce ground effect disturbance during data collection. The cleared area is shaped like a circle for the guy wires, with an additional "wedge" in which the tower is assembled before raising. An additional buffer is then cleared around that area to leave some area to work. The **minimum** cleared areas for guyed towers are:

Tower Height	D (Guy Diam.)	L (Space to lay the tower down)	Approximate total envelope to be cleared
40 meter (131')	160 feet	135 feet	240 x 190 feet
50 meter (164')	240 feet	165 feet	310 x 270 feet
Dimensions of a football field, for comparison:			*300 x 160 feet*



In general, a larger cleared area reduces the disturbances seen by the instruments, and improves data quality. Therefore, **a cleared area larger than the minimum size is preferred**.

While it is not necessary to pull stumps, removing as much obstruction and underbrush as possible will facilitate the raising of the tower. Guy-wires will be pulled across this field, and any obstacles that entangle the wires make the job more difficult.

It is also essential that there not be any electric or telephone wires within 1.5 times the height of the tower, i.e. 200 feet of a 40 m tower, or 250 feet of a 50 m tower.

Trees must be cleared at least the height of the trees away from the anchors to eliminate the danger of a falling tree hitting the guys. For example, a 50-foot-tall tree within less than 50 feet of an anchor must be cut down.

Note that it is possible to use some of this cleared area after the met tower has been installed; in other words, after installation, the space is left largely open.

Proximity of anemometry & turbine

While wind resource assessment directly on the proposed wind turbine site is preferred, it is not required. If wind data are collected in one spot, but a site for a wind turbine is later chosen in another nearby location, then a computer model that considers the wind data and terrain can be used to extrapolate the data from one location to the other. As the two sites become farther apart, however, the level of certainty in the data goes down, and thus the amount of risk in the investment goes up. It is difficult to predict the rate at which the certainty changes with distance, and can only be estimated on a site-specific basis.

If the proposed turbine and met tower sites are close enough, measurements at one site could be used to evaluate the feasibility of a turbine at the other. Thus, an understanding of preferred turbine spots is necessary in choosing a met tower site.

Met Tower Siting Considerations

This section provides an overview of the feasibility of placing a met tower at the Worcester sites. Fortunately, of the three sites considered, the Technical High School is the favored site for both a wind turbine and a met tower. This section will consider primarily met tower siting factors for this site.

Space Availability at Worcester Sites (Line 32-34 & 41)

The exact site for a wind turbine on the parcel was not discussed, but a met tower on the parcel will be close enough to an eventual turbine at the school.

There appears to be just barely enough space for a 50-meter met tower in the playing field parking lot; however, an exact met tower anchor layout was not done during the site visit. The anchor placement will have to avoid the landfill cap to the south. The Architectural Services Department offered assistance in laying out the anchor, guy, and tower lay-down area; the layout will take into consideration the landfill cap, the lamp-posts, the fences around the skate park, and the low slopes to the sides of the parking lot.

Clearing requirements (Line 35)

At least one lamp post will need to be temporarily removed; its low concrete base may stay in place. Some fencing may need to be removed, depending on layout.

The parking lot will be closed during raising and lowering. During the time that the met tower is in place, the parking lot will be somewhat restricted. The City will place jersey barriers around and under all guy wires, to keep vehicles from driving into the wires.

A few small areas of macadam will need to be broken up in order to allow placing of anchors.

Soil quality & anchor requirements (Line 36)

The soil at the site was not tested. Installing anchors will require some planning; longer or larger anchors may be required, depending on soil quality beneath the parking lot.

The anchors would be tested at the time of installation.

Accessibility for met tower installation (Line 37)

The parking lot has full road access for RERL's pick-up truck.

Permitting: Local approval process

Some local permits may be required for the temporary met tower, such as building permits, zoning variances, DigSafe, etc**.**

Nearby airports & FAA restrictions for met towers

Most met towers are shorter than 200 feet and do not require registration with the FAA.

Lighting

The FAA does not require met tower lighting at these sites.

Met tower size recommendation (Line 43-44)

There are usually two size options for met towers: 40-meter and 50-meter. The choice of a met tower depends on the site.

If wind monitoring is pursued, a 50-meter met tower is recommended at all sites.

Conclusion: met tower siting recommendations

If the City is interested in installing a utility-scale wind turbine, wind monitoring is recommended. The met tower should be near the desired wind turbine site; if the Technical High School parcel is considered for a turbine, then a 50-meter met tower should be installed somewhere nearby for at least a year.

The playing field parking lot appears to be possible for a 50-meter but will require some careful layout with the assistance of the City to avoid the landfill cap. Use of the parking lot will be partially restricted during the monitoring period.

Appendix C: Maps, Photos, and Figures

Refer to the report "Wind Power in Worcester: Siting Considerations for a Wind Turbine" for a discussion of these maps, photos, and figures.

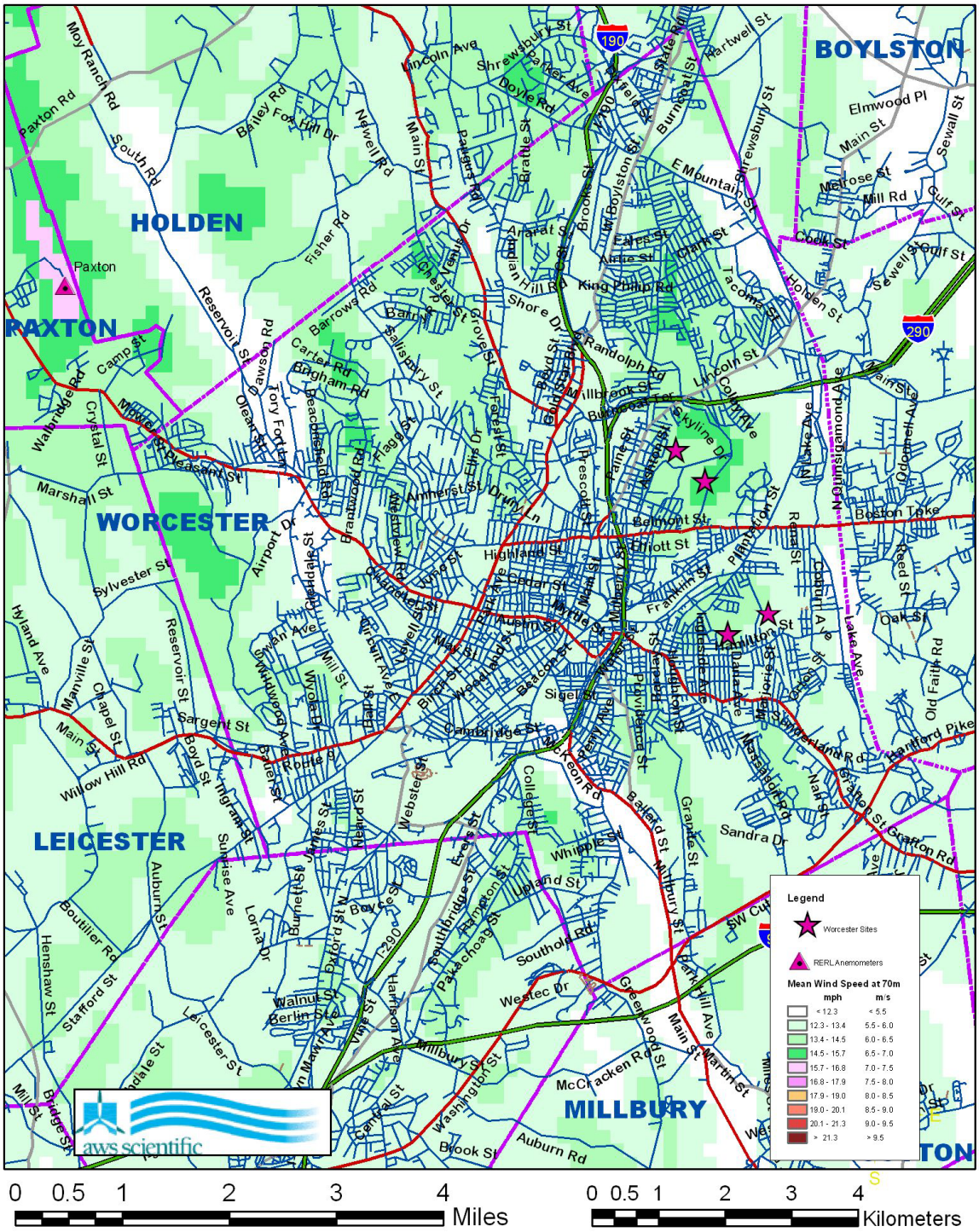
Source for base maps:

Ortho (aerial) photographs are from the MassGIS website, www.mass.gov/mgis/dwn-imgs.htm. The entire commonwealth was photographed in April 2005, when deciduous trees were mostly bare and the ground was generally free of snow.

Topographic maps, roads, and town boundaries are also from MassGIS.

Mean wind speeds are AWS-Truewind's estimates for New England, 2003. For more information, see TrueWind Solutions, truewind.teamcamelot.com/ne/.

Estimated Mean Wind Speed at 70 Meters



Mean wind speeds are AWS-TrueWind's estimates for New England, 2003. For more information, see TrueWind Solutions, truewind.teamcamelot.com/ne/

Map 1: Estimated mean wind speeds at 70 meters height in the City of Worcester, based on AWS-TrueWind models. The many hills in the City are clearly visible as darker green areas. The sites proposed by the City are marked with a red star. The Paxton anemometry site can be seen to the northwest.

For more information, see TrueWind Solutions, truewind.teamcamelot.com/ne/

Map 2: Orthophotograph of the area, with the four suggested sites marked.

Photographs

Photo 1: the Technical High School's playing field parking lot, looking approximately east-southeast.

At least one lamppost will need to be temporarily removed for a met tower.

Photo 2: the playing field parking lot, from the same spot but looking approximately west.

The land drops off in this direction.

The fenced in playing field visible here to the left is on top of a capped landfill.

Photo 3: the Municipal Golf Course, looking roughly southeast.

One of the garages and the sand bins are visible here.

Photo 4: the North High School, from the parking lot, looking west-northwest toward the low ridge between the school and the Ecotarium.

The utility lines between the two are visible here.

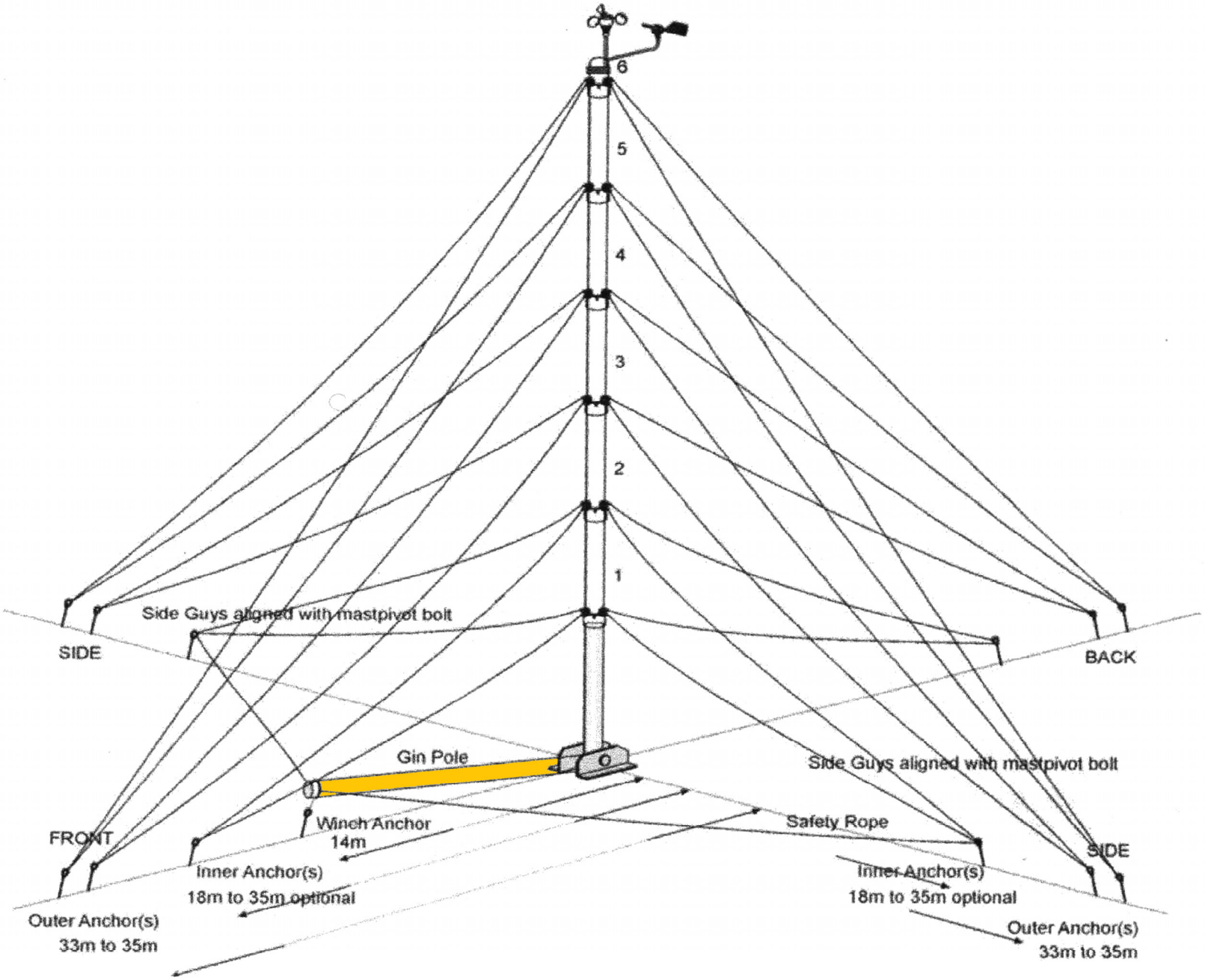


Figure 1: Guy line layout for a 50-meter met tower from Second Wind, Inc.