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Wind Power in Northborough:
Siting Considerations for a Wind Turbine

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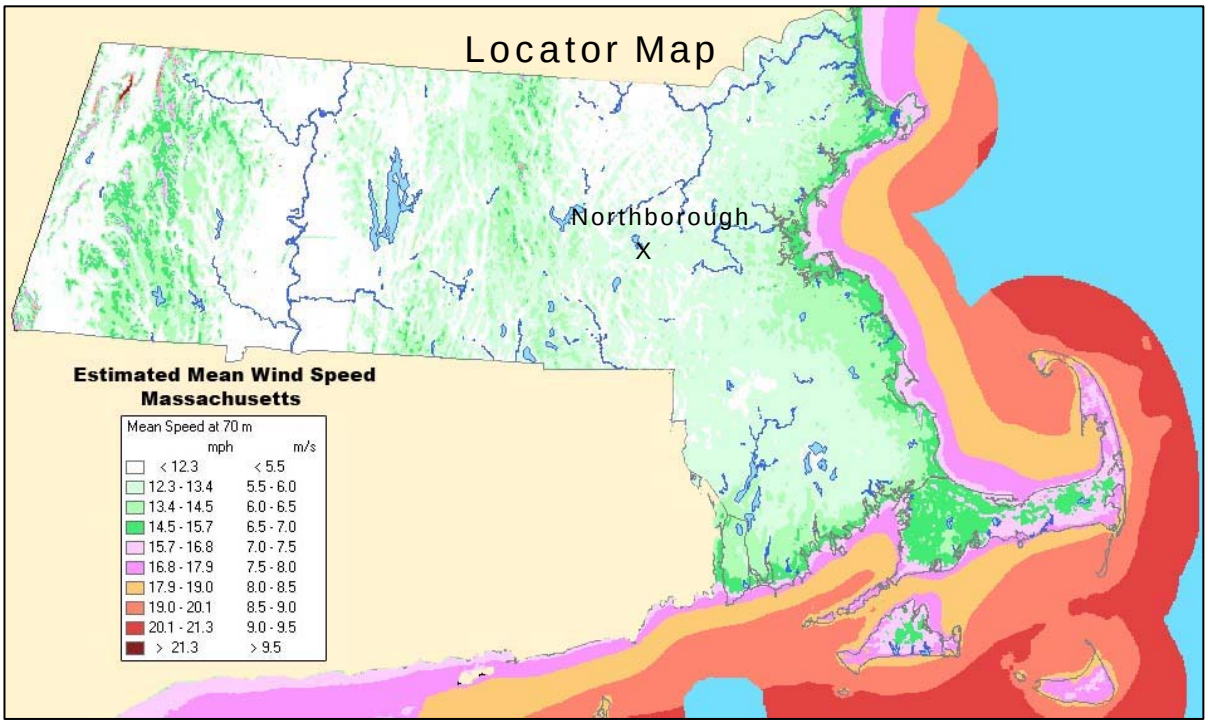

I. Introduction

At the request of the Massachusetts Technology Collaborative, Charles McClelland and Mary Knipe of the UMass Wind Energy Center (WEC) have conducted a wind site analysis for three potential wind sites in Northborough, Massachusetts in order to evaluate their suitability for medium and utility-scale wind turbines.

The report is in the form of a broad "fatal flaw" analysis, which is designed to determine whether the town should move forward in considering a utility-scale wind project. Many factors are discussed in this report, not all of which present major influence at these sites; at the end of the report, the factors most significant for the proposed sites are summarized.

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 town of Northborough is marked with an "X".

Appendix A: Provides site specific details in tabular form.

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

Appendix C: Provides wind resource maps, topographic maps, ortho (aerial) photos, and figures for the sites.

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 WEC's Community Wind Fact Sheets, which are available on the web at: http://www.ceere.org/rerl/publications/published/communityWindFactSheets.

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
- 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 the WEC as the town explores its options for wind development sites.

II. Sites Considered

Representatives of the town requested that three sites be evaluated for their suitability for utility scale wind power projects. General details related to each of the three sites are listed below.

1. **Mt. Pisgah:** Broad, densely forested hill located east of Ball Hill Road and south of Linden Street.
2. **Davidian Brothers Farm:** Farmland, gently sloping hill with surrounding houses. Located adjacent to Tougas Farm.
3. **Tougas Farm:** Farmland, gently sloping hill with surrounding houses. Located adjacent to Davidian Brothers Farm.

Detailed information about each site is located in **Appendix A**. For aerial photos, see **Appendix C**.

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 at the proposed locations. For this discussion, we 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. A medium-sized (250 kW or similar) turbine is also considered; these have blade-tip heights ranging from 150 to 250 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. Environmental Issues and Permitting

D. Proximity to Airports

E. Wind Turbine Component Transportation & Access

F. Distance to Transmission/Distribution Lines for Power Distribution

G. Net-metering

H. Production Estimates for Selected Turbines

Each section below briefly describes why the characteristic is important in general and then discusses it in particular for these sites. Site information 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 investigating the winds at a proposed wind power site is to gain an improved understanding of project feasibility and returns, and thus a lowering of investment risk. Better, longer, and more site-specific data can help to minimize this risk. Additional information regarding the monitoring of wind resources can be found in **Appendix B**.

Wind speeds increase with elevation, so wind speeds are always given at a specific height. For first-pass production estimates, the mean wind speed at the proposed hub-height is used:

- For utility-scale turbines, refer to mean wind speeds at a height of 70 meters, which falls between common hub-heights of 65 and 80 meters.
- For medium-scale wind turbines, consider 50 meters.

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; for more detail, the wind is monitored on site. Wind monitoring logistics are discussed in **Appendix B.**

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 WEC are available on the web: http://www.ceere.org/rerl/rerl_resourcedata.html.

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 its power production and longevity, and may affect the type of turbine that can function reliably a particular site.

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

The AWS TrueWind estimates of annual average wind speed at heights of 70 and 50 meters for each site are listed in the table below. AWS estimates at other heights are presented in **Appendix A.**

AWS TrueWind Estimates of annual average wind speeds at selected heights.			
Hub height	**Mt. Pisgah**	**Davidian Bros. Farm**	**Tougas Farm**
70 m	6.4	6.2	6.2
50 m	6.1	5.9	5.9

Other available wind data (Line 13)

In general, data can be used to reliably predict wind speeds within a one- to two-mile radius of where it was collected. This is not a hard rule; in fact, several things influence wind speeds at a particular site,

including local weather patterns, surface roughness, elevation, etc. For the most accurate understanding of wind characteristics at a particular site, on site wind monitoring is advisable.

The WEC is currently monitoring wind speeds at a site in West Boylston located approximately 5 miles from the Northborough sites. If the Town of Northborough pursues a utility scale wind project at one of the proposed sites, then on-site wind monitoring is advisable.

Obstacles to wind flow (Lines 18-19)

AWS indicates that obstacle interference occurs downwind at a distance of about 10-20 times the obstacle height, up to a height of about twice that of the obstacle itself. Obstacle interference may be a siting constraint particularly if small- or medium-scale turbines are considered, which typically have hub heights in the range of 150 to 250 feet.

Wind shear, which is defined as the difference in wind speed and direction over a relatively short distance in the atmosphere, often occurs over areas featuring severe changes in elevation. Excessive wind shear can upset the normal operation of a wind turbine, and may decrease the turbine's lifetime.

Mt. Pisgah site: The primary obstacles to wind flow at this site are mature trees.

Davidian Brothers and Tougas Farms: These sites consists mainly of open farmland and a few, low-lying buildings. Mature trees (25' – 65') surround the farm land.

Obstacles to wind flow at these sites are not necessarily fatal flaws for a utility scale wind project. In some cases, a taller turbine tower may be necessary to avoid the effects obstacle interference. In the event that a particular site is chosen for a utility scale wind project, wind data collected on-site would inform the turbine selection and siting decisions.

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 should also be taken into consideration. Any eventual wind turbine would be sited such that it would be minimally audible at the nearest residences. At this stage, to check for fatal flaws, the following 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. Note that noise considerations can influence not only <u>siting</u>, but also <u>sizing</u> decisions.

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 (60 + 77/2 = 98.5, times 3 comes to ~300 m or ~1000 feet) from residences. Other turbine 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 an inflexible 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 project stakeholders. If the town would like to consider a site closer than this distance, then a more detailed sound study could be performed on site. This study would take into

account the actual ambient levels and terrain at the site and would then supersede the rough rule of thumb.

Noise at the Northborough sites (Lines 20-21)

The Mt. Pisgah site features adequate space for one or more utility scale wind turbines. The presence of houses along Lyman and Ball Hill Roads suggests that development would likely take place in the area west of the ridge.

The farm sites are located in a rural-residential area. The Davidian Brothers Farm would allow for a maximum setback distance of approximately 200 meters from residences, depending on micrositing decisions. This suggests a maximum turbine size in the range of 250 kW, or slightly larger.

Tougas Farm features more space than Davidian Brothers Farm, and one particular location on farm property may allow for a setback of approximately 300 meters, suggesting its suitability for a turbine in the range of 1 MW, or slightly larger. Several locations on the Tougas Farm property would likely be suitable for 850 kW installations.

These recommendations are made with respect to the "three times blade-tip height" described in the previous sub-section and are not hard rules, but rather first pass estimates. If a wind project is pursued at one of the proposed sites, it is advisable to complete a detailed noise study which takes into account actual ambient sound levels and terrain at the sites. This study would supersede the rule of thumb. See **Appendix C** for maps depicting residences, residential buffer zones, and parcel boundaries in Northborough.

C. 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 designations or restrictions
- Massachusetts Audubon Society Important Bird Areas (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 town representatives. There may, however, be other land-use restrictions, unregistered wetlands, etc. of which WEC is not aware. It is the town's responsibility to ensure the environmental appropriateness of the chosen site.

Environmental permitting at the Northborough site (Lines 22-26)

Portions of the Mt. Pisgah site are designated as wetlands. These designations could potentially restrict certain access routes, though they are not likely to present a fatal flaw for this site. See maps in **Appendix C** for an illustration of wetlands at the site. The WEC is not aware of any other environmental restrictions at this site.

The Davidian Brothers and Tougas Farms are classified as agricultural conservation land, though it is unclear how this designation would affect wind development at these sites. There is also a small portion of wetlands at the north end of Tougas Farm.

D. Proximity to 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.

The U.S. Air Force recently published a policy to "contest … windmill farms within radar line of sight of the national Air Defense and Homeland Security Radars." In Massachusetts, these include the Long Range Radar Sites in North Truro, Boston, and in the foothills of the Berkshires.[1] Nevertheless, wind projects have been approved within 60 nautical miles of these long-range radar sites.

While we cannot predict the FAA or DOD response, most sites that are not within about 3-5 miles (5-8 kilometers) 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 the Northborough site (Line 27)

No major airports are located within 8 kilometers (~5 miles) of the proposed sites.

The Radar Pre-Screening Tool, found on the FAA website, evaluates the potential impacts of obstructions on Air Defense and Homeland Security radars or Weather Surveillance Radar-1988 Doppler radars. A preliminary screening has indicated that a wind project at one of the proposed sites would be likely to impact Air Defense and Homeland Security Radars. An aeronautical study likely would be required in the event that a wind project is planned for the proposed sites. This ruling applies to many sites in Massachusetts, and should not be interpreted as a fatal flaw for any of the Northborough sites.

Any potential impacts on the Long Range Radar system would be reviewed as part of the 7460-1 process. If any of the sites are considered for a wind turbine project, then early filing of the FAA 7460-1 form is recommended.

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[1] The FAA offers a "Long Range Radar Tool" that displays these 60 nautical mile radius areas. See their Obstruction Evaluation/Airport Airspace Analysis (OE/AAA) website: https://oeaaa.faa.gov/oeaaa/external/gisTools/gisAction.jsp?action=showLongRangeRadarToolForm

E. Wind Turbine Component Transportation & Access

About transportation and access in general

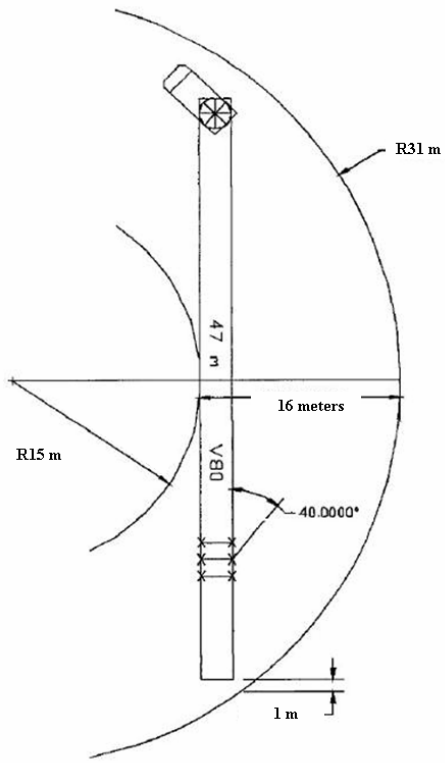
With blades up to 130 feet long, modern wind turbines require transportation on roads with fairly large turning radii and only small changes in slope. The illustration below shows the set of turning radii (in meters) required for transporting one of the 47-meter turbine blades of a Vestas V80, a 1.8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

Transportation and access to the Northborough sites (Line 17)

Mt. Pisgah: Locations nearby this site can be accessed from I-495 via Route 62 (Linden and Central Streets), though the final turn on to Ball Hill Road may present challenges to component transport, depending upon the size of turbine. Accessing the site itself from Ball Hill Road would require major improvements to the road that currently leads up the mountain.

Farm sites: The farm sites can be reached from I-290 via Ball Street. This route is likely to be feasible for transporting turbines in the range of 250 – 660 kW.

Transportation costs would likely represent a substantial portion of the total cost of a wind power project at the Mt. Pisgah site. If the town decides to pursue a project at any of the proposed sites, an access plan, which includes detailed transportation routes and cost estimates, would be completed as a next step.



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 the Northborough sites (Line 16)

Northborough's power needs are served by National Grid. Major transmission lines are located approximately 7 km from the proposed sites, and distribution lines are located along the nearest routes for both sites.

Mt. Pisgah: Interconnection would add significant costs to a wind project at the Mt. Pisgah site. According to the Town's contact at National Grid, the nearest three-phase power is located at the intersection of Linden and Derby Streets.

Farm Sites: Three phase power is located at the cold storage building on the Davidian Brothers Farm.

Whether or not the lines leading up to these sites would be in need of upgrading depends upon both the current rating of the lines and the size of the intended wind project. A further feasibility study would quantify these costs for the chosen site.

G. Net Metering

Massachusetts regulations allow customer-sited wind projects of up to 2 MW in size to qualify for net-metering. In this manner, towns are able to offset the retail cost of electricity consumed at municipal sites with power produced by a wind project. Any net excess generation would then be credited towards the town's energy bill during the following month. Further, "virtual" net-metering provisions allow towns to aggregate and offset multiple municipal loads with power produced by a single wind project, so long as their meters are under the same distribution company and located in the same ISO-NE load zone. Recoverable electricity costs include associated default service, transmission, transition, and distribution kWh charges. Other specifics will be spelled out in the forthcoming rulemaking process by appropriate regulatory authorities.

H. Production Estimates for Selected Turbines

The following tables provide rough estimates of energy production at the two locations. At Mt. Pisgah, larger turbines were considered for the Mt. Pisgah site, which features more space than the farm sites.

These estimates are based upon the following general capacity factor correlation, which provides a reasonable approximation for wind speeds between 4 and 10 m/s.*

$$\boxed{capacity\ \ factor = 0.087 \times V_{ave}(m/s) - \frac{P_{rated}(kW)}{D^2(m)}}$$

Where:

V_{ave} = average wind speed at the site
P_{rated} = rated power of the turbine
D = rotor diameter of the turbine

*Equation taken from Renewable and Efficient Electric Power Systems by G.M. Masters, 2004.

The capacity factor estimates were then used to approximate the production of various turbines at the proposed sites. The results of these calculations are presented in the table below.

Power Production Estimates: Mt. Pisgah					
Wind Turbine (rated power)	**Hub Height (meters)**	**Blade Tip Height (meters)**	**Estimated Annual Mean Wind Speed at Hub Height (m/s)**	**Estimated Capacity Factor**	**Estimated Annual Energy Production (kWh/year)**
Nordic N1000 (1 MW)	70	99.5	6.4	0.27	2,129,000
GE 1.5sl (1.5 MW)	64.7	103.5	6.33	0.295	3,270,000
Vestas 2.0 (2.0 MW)	78	118	6.52	0.253	3,989,000

Power Production Estimates: Farm Sites					
Wind Turbine (rated power)	**Hub Height (meters)**	**Blade Tip Height (meters)**	**Estimated Annual Mean Wind Speed at Hub Height (m/s)**	**Estimated Capacity Factor**	**Estimated Annual Energy Production (kWh/year)**
Fuhrländer (250 kW)	42	57	5.75	0.22	434,000
Enertech E48 (600 kW)	50	74	5.9	0.25	1,192,000
Vestas V-47 (850kW)	55	75	6.0	0.21	1,407,000
Nordic N1000 (1 MW)	70	99.5	6.2	0.25	1,987,000

Readers of this report should keep in mind that these production figures are *extremely* rough at best, and are meant to provide the Town of Northborough with conservative estimates of production for various turbines at the proposed sites. Note also that the equation used in calculation is only a general correlation based upon few parameters, and these numbers are not an adequate comparison of performance between turbine models.

IV. Conclusions

The town of Northborough is interested in a wind power project at three locations on town and private property. It is estimated that all three sites feature marginal wind speeds for utility-scale wind project, with Mt. Pisgah being the most favorable in this regard. In addition, the Mt. Pisgah site features the greatest setback from nearby residences, and so from a noise perspective, it is also more favorable than the farm sites for larger wind projects.

The Mt. Pisgah site is large enough to accommodate more than one turbine; however, the site is densely wooded and far removed from roads and power lines. These are all factors which increase development costs. The extent of these costs for developing one or more turbines at this site would be determined in a later feasibility study if a project is pursued in Northborough. This site also features wetlands in surrounding areas, which could potentially complicate permitting and access plans.

The farm sites are located in close proximity to nearby residences. Wind projects at the Davidian Brothers farm would likely be limited to 250 kW, while slightly larger turbines in the range of 600 - 1000 kW may be possible in select locations at Tougas Farm. These sites feature less challenges in terms of access and interconnection; however, in general, smaller projects typically have longer payback periods.

If the Town of Northborough determines that a utility-scale project would be possible at multiple sites, a further feasibility study would evaluate the tradeoffs between electrical production and development costs for the chosen sites.

The presence of on-site loads is given minimal consideration due to the recently adopted ‘virtual’ net-metering provisions which are likely to allow municipalities to aggregate and off-set multiple municipal loads; further, these loads need not be located in the same location as the generation facility. As mentioned previously, the precise implications of the legislation will be determined in the forthcoming rulemaking process by appropriate regulatory authorities.

Next steps (Line 29)

After deciding whether or not to pursue a wind project at one or more of the proposed sites, establishing full feasibility (which would likely include wind resource monitoring) is an important next step.

In the event that a project is pursued on privately held land, a Memorandum of Understanding outlining the benefits to any project stakeholders (primarily the Town of Northborough and landowners) may be needed before public funds can be allocated to the predevelopment process.

The wind monitoring process and siting considerations are discussed in **Appendix B**. In addition to wind monitoring and public outreach, some, though not necessarily all, of the following site-specific items related to pursuing wind power at the sites would be explored in a full-feasibility study.

- Preliminary economic analysis
- File FAA form 7460-1
- Local ordinances related to structure heights
- Logistics and costs of transporting turbine components and installing equipment
- Noise study
- Preliminary electrical interconnection study
- Environmental permitting (wetlands) at the Mt. Pisgah site

A preliminary economic analysis may be critical in helping the Town of Northborough decide upon a particular site. For an introduction to economic issues, please consult the WEC's Community Wind Fact Sheet series related to community wind economics, which is available on-line:

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 Northborough: Siting Considerations for a Wind Turbine" for a discussion of these data.

Table 1: Summary Data Table

Northborough				
		Mt. Pisgah	**Davidian Brothers Farm**	**Tougas Farm**
Site Overview				
1	Description, current land use	Forested mountain top, conservation land	Farmland on 107.5 acre lot consisting of relatively flat open space farm land. Surrounded by woodlands and suburban residential house lots separated by trees.	Farmland on 83.7 acre lot consisting of relatively flat open space farmland. Surrounded by woodlands and suburban residential house lots separated by trees.
2	Address	Smith Road	150 Ball Street	234 Ball Street
3	Owner	Town of Northborough	Davidian	Tougas

Northborough				
		Mt. Pisgah	**Davidian Brothers Farm**	**Tougas Farm**
4	NAD 83, lat & long	42.3602° -71.6629°	42.3422° -71.6789°	42.3422° -71.6774°
5	Degrees, Min., Sec.	42°21'36.72"N 71°39'46.44"W	42°20'31.92"N 71°40'44.04"W	42°20'31.96"N 71°40'38.68"W
6	Elevation (feet)	700	600	580
7	Notes			
Wind Speeds				
Estimated Mean Speeds* in m/s **(to convert m/s to mph, multiply by 2.24)**				
8	At height of 100 m	6.9	6.6	6.6
9	At height of 70 m	6.4	6.2	6.2
10	At height of 50 m	6.1	5.9	5.9
11	At height of 30 m	5.6 m/s	5.4	5.4
12	Wind Speed Summary (poor, fair, good, very good):	fair to good	fair	fair
13	Existing wind data	No	No	No

Northborough				
		Mt. Pisgah	**Davidian Brothers Farm**	**Tougas Farm**
Wind Turbine Considerations:				
Economic				
14	On-site Electric Loads	No	-	Small
15	Electric Loads, kWh/year	-	-	1 kWh/yr
16	Distance to Distribution/ Transmission lines**	Site not visited.	3-phase power on site	3-phase power at nearby site
17	Access for blade transportation**	Fair to poor	Fair	Fair
18	Terrain	Forested Hill	Flat farmland	Flat farmland
19	Obstacles to wind	Trees	Few trees to west	None
Noise				
20	Nearby residential areas:	No	Yes	Yes
21	Radius to residences: (m): (ideally >~300m for utility scale‡)	~ 600 meters	~ 225 meters	~ 300 meters

Northborough				
		Mt. Pisgah	**Davidian Brothers Farm**	**Tougas Farm**
Environmental Permitting †				
22	Designated by the Natural Heritage & Endangered Species Program as a Core Habitat or a Supporting Natural Landscape?	No	No	No
23	Designated by the DEP as Wetlands?	Portions (see discussion)	No	No
24	Designated by the Massachusetts Audubon Society as an Important Bird Area?	No	No	No
25	Is the site a current or former land-fill? *(WEC does not install met towers on landfills)*	No	No	No
26	Other land-use restrictions?	Protected Open Space (In Perpetuity) Mt. Pisgah Conservation Area	Agricultural Preservation Restrictions Protected Open Space (In Perpetuity)	Agricultural Preservation Restrictions Protected Open Space (In Perpetuity)
Other permitting				
27	Distance to airport(s)	Located ~8 miles (~13 kilometers) from Marlboro and Sterling Airports		
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?*	-Conservation Restriction - Less than ideal wind speeds - Restricted Access to site (wetlands) - Road Construction Costs - Interconnection Costs	- Achieving suitable residential setbacks - Less than ideal wind speeds	- Achieving suitable residential setbacks - Less than ideal wind speeds

Northborough				
		Mt. Pisgah	**Davidian Brothers Farm**	**Tougas Farm**
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):*	- Preliminary economic analysis - File FAA form 7460-1 for the desired turbine height - Investigate logistics of transporting turbine components and installation equipment to site - Preliminary electrical Interconnection study	- Preliminary economic analysis - File FAA form 7460-1 for the desired turbine height - Investigate logistics of transporting turbine components and installation equipment to site - Preliminary electrical Interconnection study	- Preliminary economic analysis - File FAA form 7460-1 for the desired turbine height - Investigate logistics of transporting turbine components and installation equipment to site - Preliminary electrical Interconnection study
30	***Recommendation*** *Should the town consider this site for a utility-scale wind turbine?*	Possibly	No	Possibly
	For a medium-scale wind turbine? ***See also the discussion section.***	No	Yes	Yes
31	***Multiple Turbines*** *If the town is interested in installing more than one utility-scale turbine, how many could fit at this site?*	2 – 4 (question of space, access, and economics)	1 – 2 (question of turbine size, land-use restrictions)	1 – 2 (question of turbine size, land-use restrictions)

Northborough				
		Mt. Pisgah	**Davidian Brothers Farm**	**Tougas Farm**
Met Tower: Siting Factors				
32	Space availability & level terrain	Significant clearing required	Yes	Yes
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.)*	No	Not a fatal flaw	Not a fatal flaw
34	Obstacles to wind	Trees (25' – 65')	Trees and buildings (15' – 35')	Trees and buildings (15' – 35')
35	Clearing requirements	Yes	Minimal	Minimal
36	Soil quality – for met tower anchors	bedrock with a layer of glacial till, shallower soil over bedrock near summit	fertile soil	fertile soil
37	Road Access – for met tower installation	Poor	Good	Good
38	Security	Good	OK	OK
39	Existing towers on or near site	No	No	No
40	Distance to AC power if lighting is required	~ 600 – 800 meters	250 – 300 meters	250 – 300 meters
41	Compatibility: If this site were chosen for a wind turbine but not a met tower, where else could wind be monitored?	Due to the complexity of surrounding terrain, on-site wind monitoring is highly advisable for this site.	Tougas Farm	Davidian Brothers Farm

Northborough				
		Mt. Pisgah	**Davidian Brothers Farm**	**Tougas Farm**
Met Tower: Primary Constraint				
42	What factors will most affect feasibility and/or siting of a met tower here?	Wetlands, access, clearing	Land use preferences	Land use preferences
Met Tower: Recommendation				
43	Recommended site:	Yes, see discussion	Yes	Yes
44	Recommended met tower height (meters)	50 meters	50 meters	50 meters

Notes:

* Estimated Mean Annual Wind speeds, in m/s: based on the AWS-TrueWind computer models.

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

** These items can have significant impacts on installation costs. 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 the WEC is not aware. It is the town's responsibility to ensure the environmental appropriateness of the chosen site.

Appendix B: Wind-Monitoring Logistics

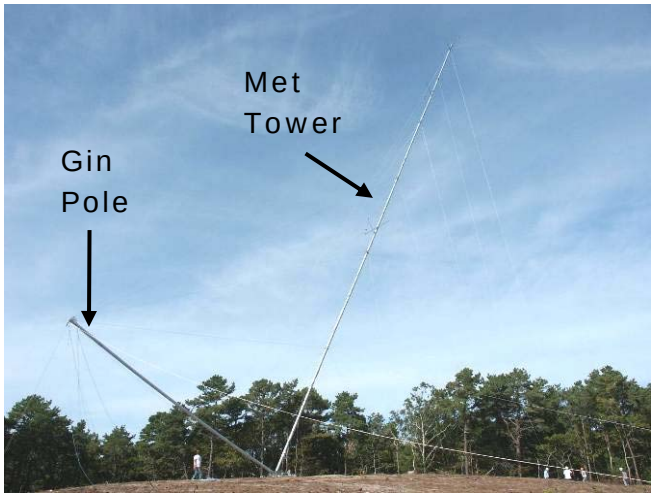
Traditionally, wind is monitored for about a year with a met tower. Some sites may be suitable for other types of monitoring, though this section concentrates on the siting of a met tower. Figure 1 in **Appendix C** is a schematic of a met tower.

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 the required 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.

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

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

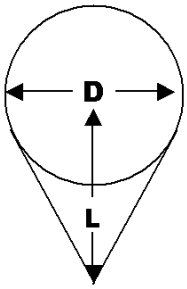
Typical 6-foot-long utility screw-in anchor

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 being raised. 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.

Met Tower Siting Considerations

Generally speaking, wind speed and turbulence should be monitored at, or as close as possible to, the preferred wind turbine site. However, met tower siting involves certain additional considerations, and it may not always be possible to monitor wind at the proposed turbine site. This section provides an overview of the feasibility of placing a met tower in Northborough.

Space Availability at the Northborough sites (Line 32-34)

All sites feature adequate space for a met tower.

Mt Pisgah: While this site features adequate space, the area is heavily wooded and presently lacks access suitable roads to the summit.

Tougas and Davidian Brothers Farms: Both sites feature adequate space for a met tower, and several suitable locations were identified at Tougas Farm. However, property owners must consider the impact that guy wires will have on land-use capabilities, since guy wires are anchored in four directions at a distance of 80 feet from the base of the tower.

Clearing requirements (Line 35)

The Mt. Pisgah site is heavily wooded and so extensive clearing would be needed at the met tower location. Some clearing of the road leading to the site will also be needed to allow for met tower components to be transported to the site.

Adequate cleared space is available at the farm sites.

Soil quality & anchor requirements (Line 36)

The sites have not been visited; however, it is not anticipated that soil quality will be a fatal flaw for these sites.

Accessibility for met tower installation (Line 37)

The Mt. Pisgah site would require additional clearing of the path leading to the site in order to allow for met tower components to be transported to the site. This is normally accomplished with the Wind Energy Center's pick-up truck; however, sites featuring especially challenging access routes industrial often require the use of heavy machinery.

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; however, in some cases nearby airports will warrant hazard determinations from the FAA.

The TOWAIR determination tool, found on the FCC website, is a preliminary screening tool used by the communications industry to evaluate the potential impacts of antennae on surrounding airspace. The findings are neither definitive nor binding, and results should only be used to assist the air space review participant in exercising due diligence. For conclusive findings, further investigation may be necessary.

TOWAIR results for the Northborough sites indicate that a met-tower would not require registration with the FAA.

Lighting

The FAA <u>does not require</u> met tower lighting at these sites.

Proximity of anemometry & turbine (Line 41)

While wind resource assessment directly on the proposed 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, consequently, the amount of risk in the investment increases. It is difficult to predict the rate at which the certainty changes with distance; this 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 for choosing a met tower site.

The most-accurate and site-specific data would be provided through monitoring at the exact location of the intended wind project. Due to the complexity of terrain at the Mt. Pisgah site, on-site wind monitoring is strongly advisable. As the farm sites are adjacent one another, monitoring at either site would be suitable for evaluating the wind potential at both 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. Ideally, wind monitoring at any of the sites would be accomplished with a 50-meter towers, as data collected at greater heights is more reliable. A 50-meter tower would also be recommended for the Mt. Pisgah site; however, space restrictions may necessitate a 40-meter tower.

Conclusion: met tower siting recommendations

On-site wind monitoring is strongly advised where larger turbines are being considered, especially at sites featuring steep changes in elevation. Given the clearing requirements for a met-tower installation at the Mt. Pisgah site, the Town of Northborough may wish to consider remote sensing options, such as LiDAR or SoDAR devices; these options could be explored in consultation with the MTC. The farm sites feature adequate space for a met-tower, though land-use considerations should be taken into account.

Wind-monitoring options should be discussed further depending on the site and the turbine size considered. If the town is interested in installing a utility-scale wind turbine in Northborough, then on-site wind monitoring is recommended. If a small- to medium-scale turbine is considered, wind monitoring is beneficial but may not be essential.

Appendix C: Maps, Photos, and Figures

Refer to the report "Wind Power in Northborough: Siting Considerations for a Wind Turbine" for a discussion of the following 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.

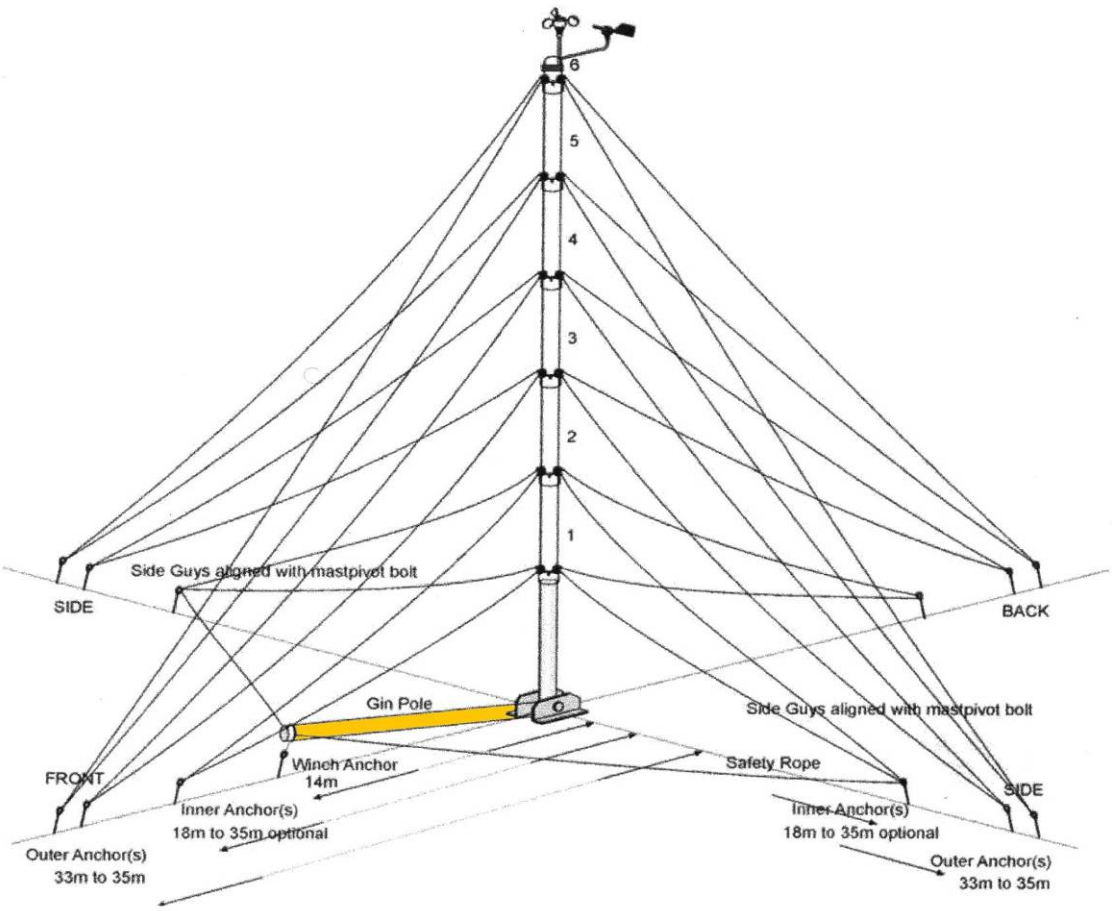


Figure 1: Guy line layout for a 50-meter met tower from Second Wind, Inc.

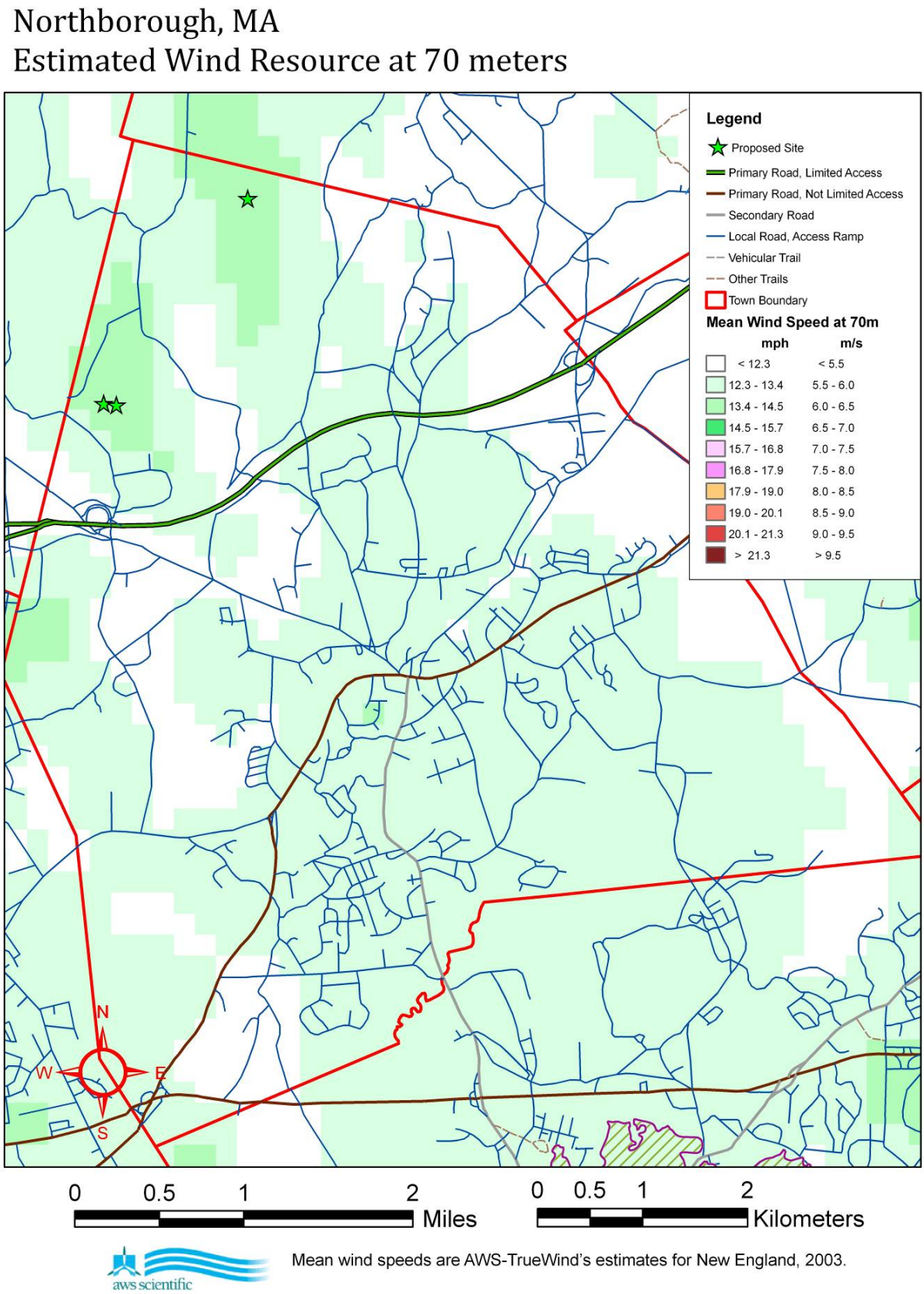


Figure 2: This figure displays AWS annual mean wind speeds at 70 meters in the Town of Northborough. Utility-scale turbines typically have hub-heights in the range of 70 meters.

Northborough, MA
Mt. Pisgah: Estimated Wind Resource at 70 meters

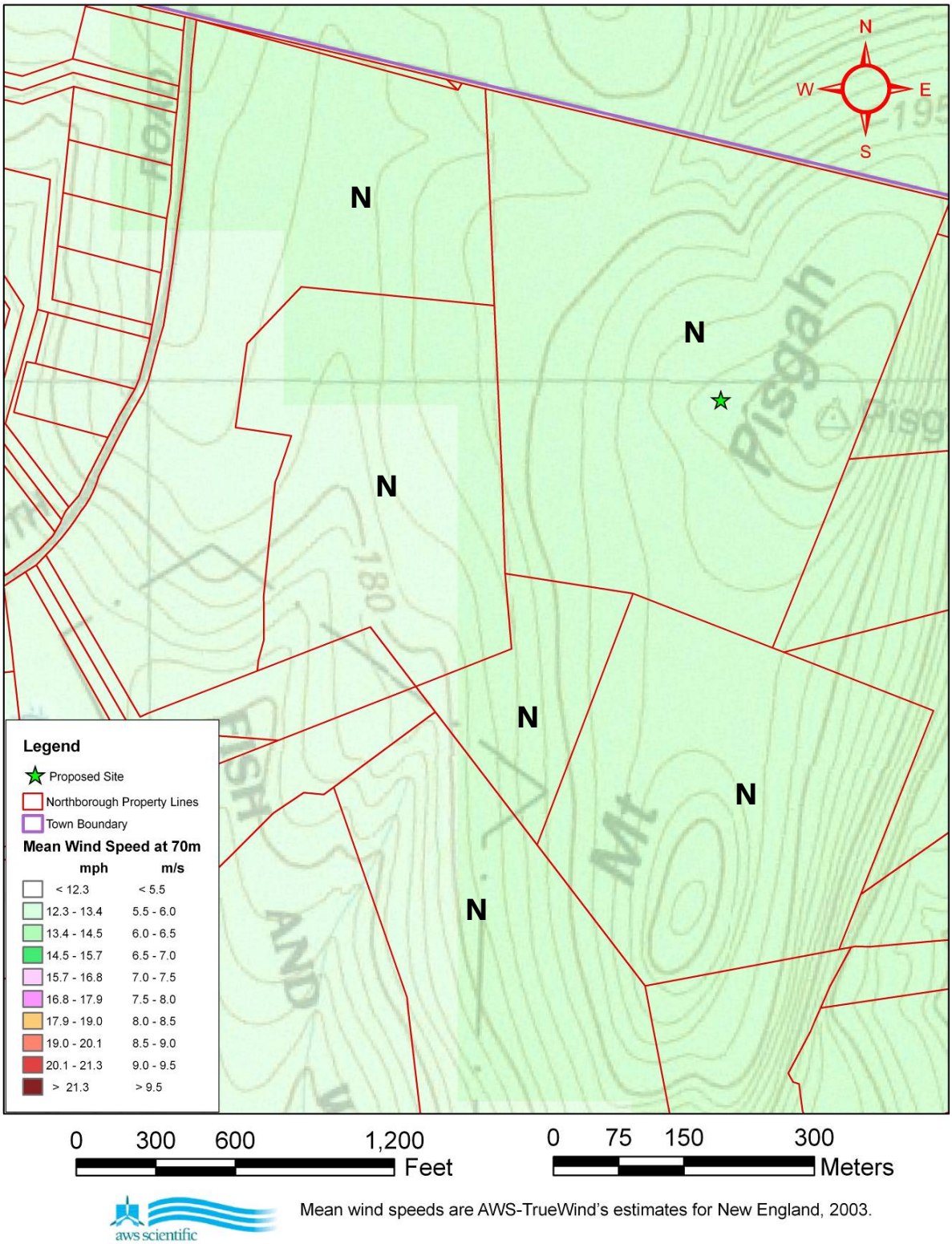


Figure 3: This figure displays AWS annual mean wind speeds at 70 meters at the Mt. Pisgah site. Parcel boundaries are also displayed; the town of Northborough controls parcels labeled with an "N."

Northborough, MA
Mt. Pisgah: Environmental Designations

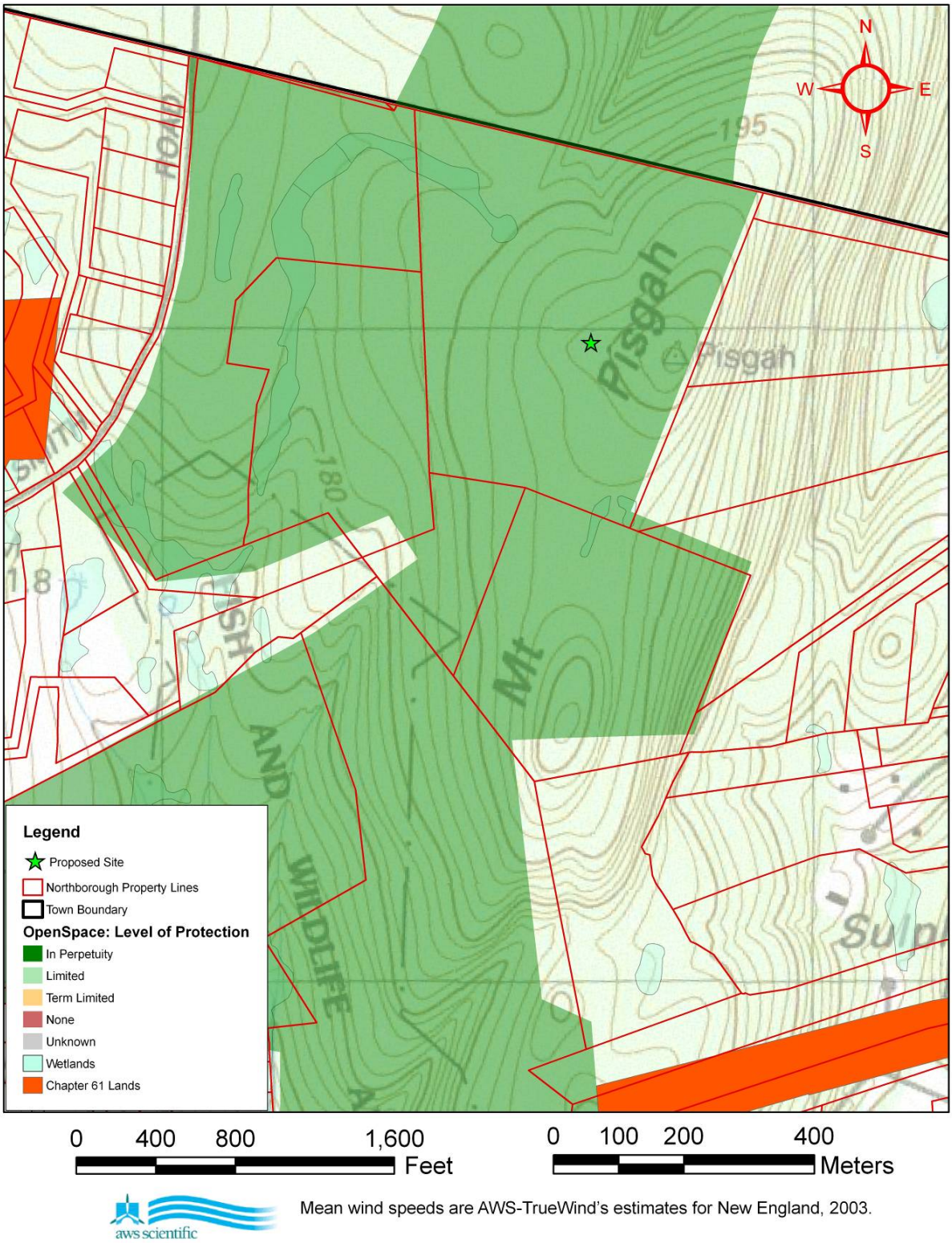


Figure 4: This figure depicts Open Space designations at the Mt. Pisgah Site, along with parcel boundaries. The site is classified as Open Space, protected in perpetuity.

Northborough, MA
Mt. Pisgah: Residence Buffer Zones for Utility-Scale Projects

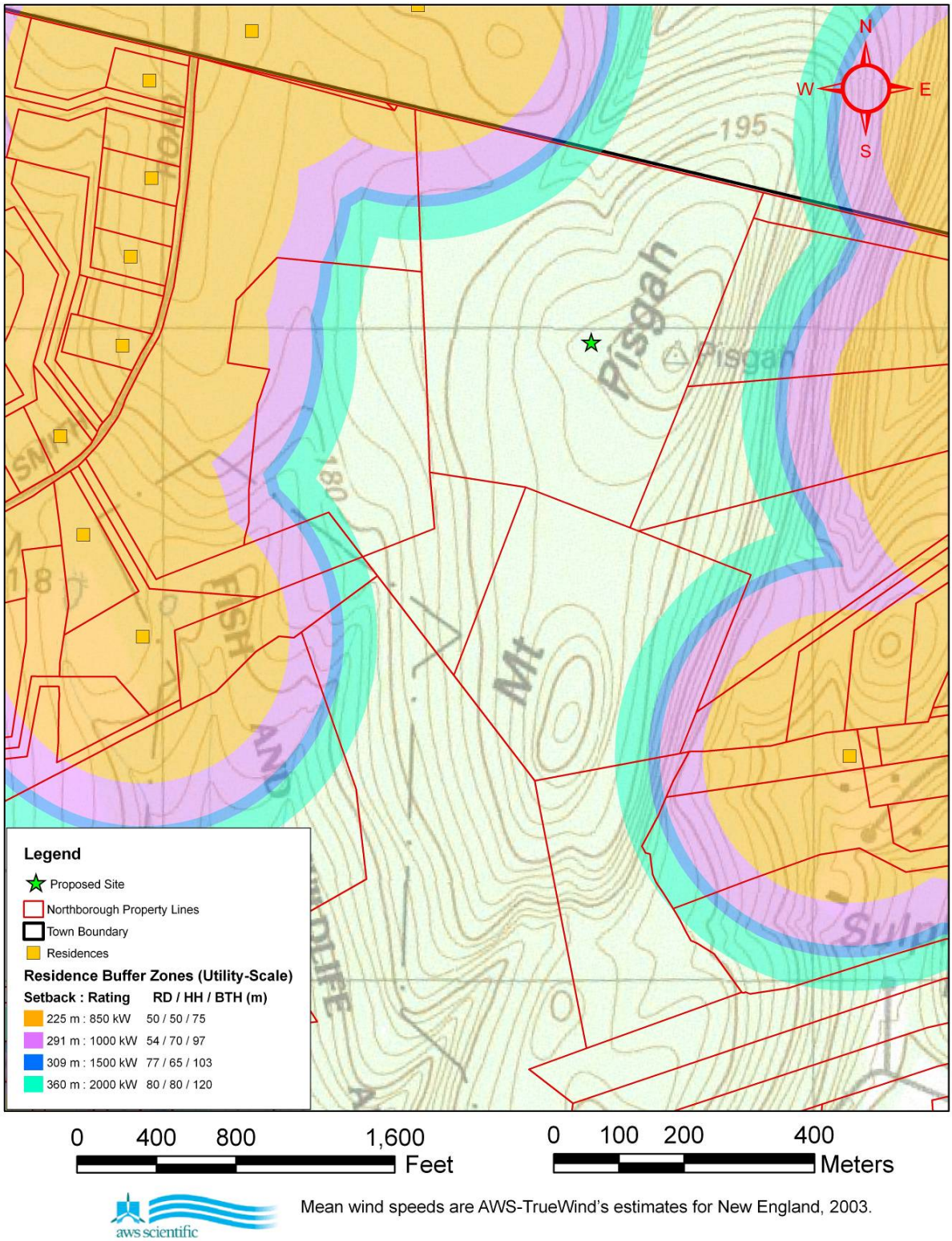


Figure 5: This figure displays residential buffer zones for utility-scale wind projects. An 850 kW turbine, for instance, would be sited outside the orange buffer zone, according to the "three-times-blade-tip-height rule of thumb."

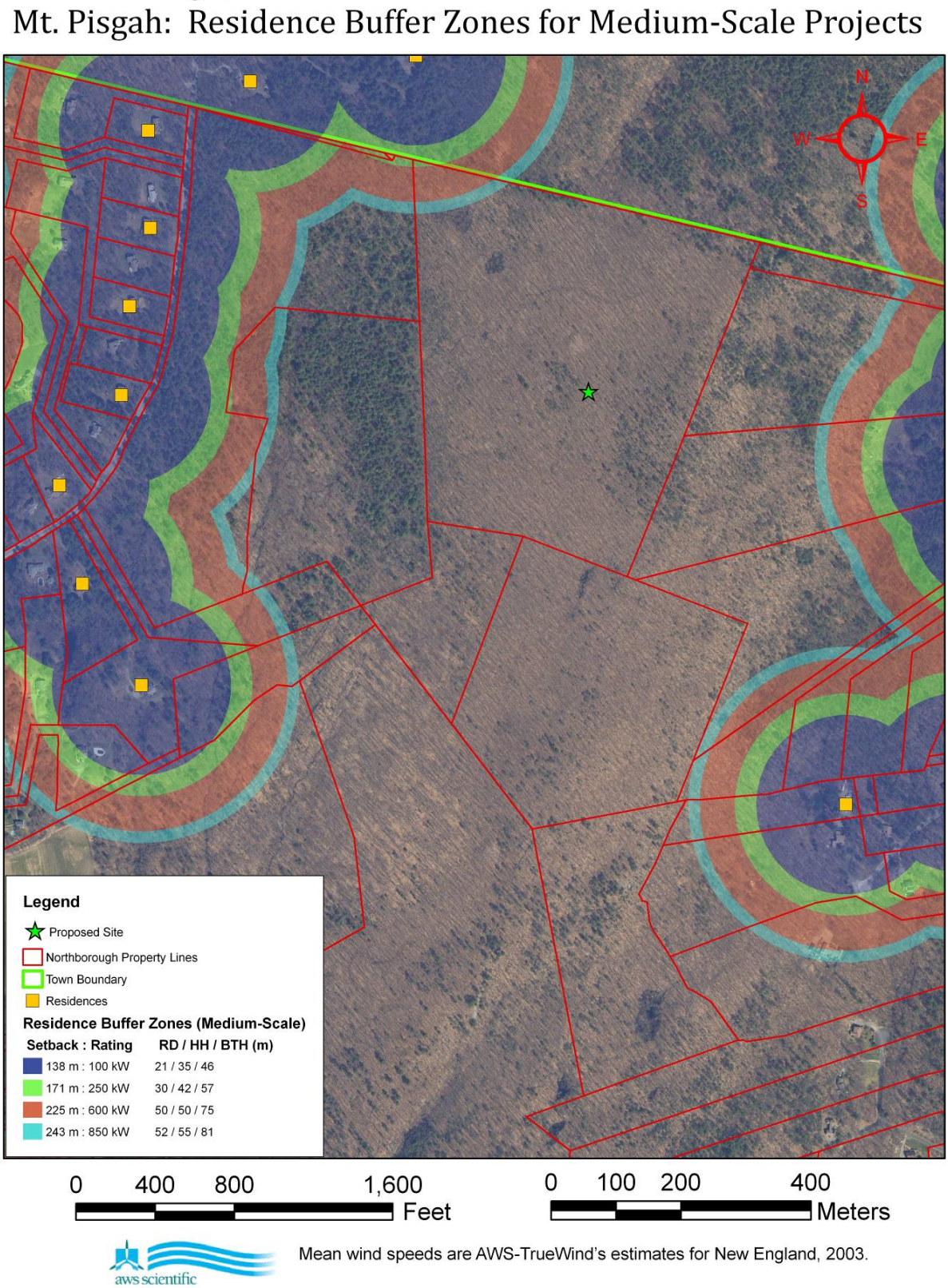


Figure 6: This figure displays residential buffer zones for medium-scale wind projects. A 250 kW turbine, for instance, would be sited outside the green buffer zone, according to the "three-times-blade-tip-height rule of thumb."

Northborough, MA
Farm Sites: Estimated Wind Resource at 70 meters

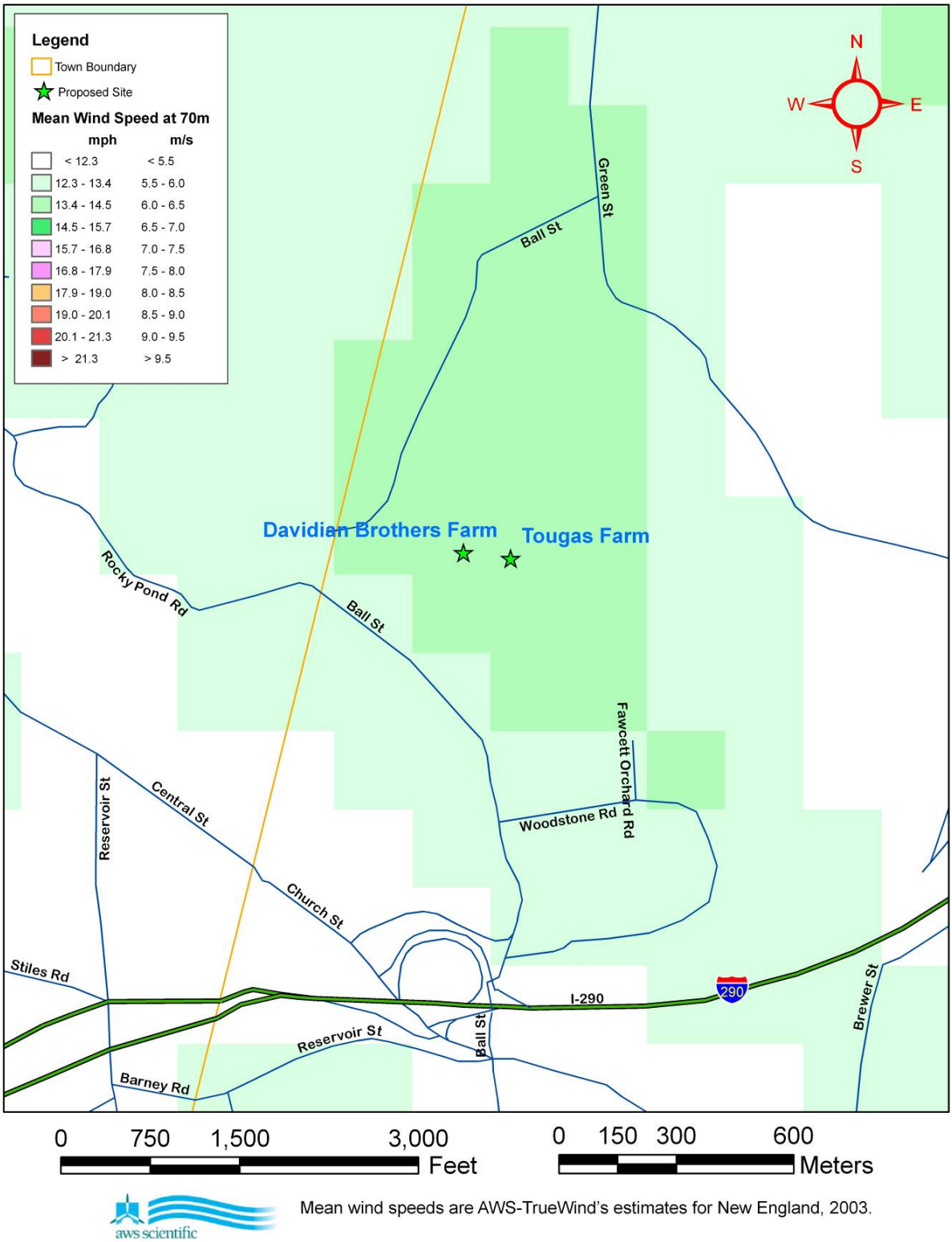


Figure 7: This figure displays AWS annual mean wind speeds at 70 meters at the Tougas and Davidian Brothers Farm sites. The darker green portion encompassing the proposed sites feature estimated wind speeds in the range of 6.0 to 6.5 m/s at 70 meters height.

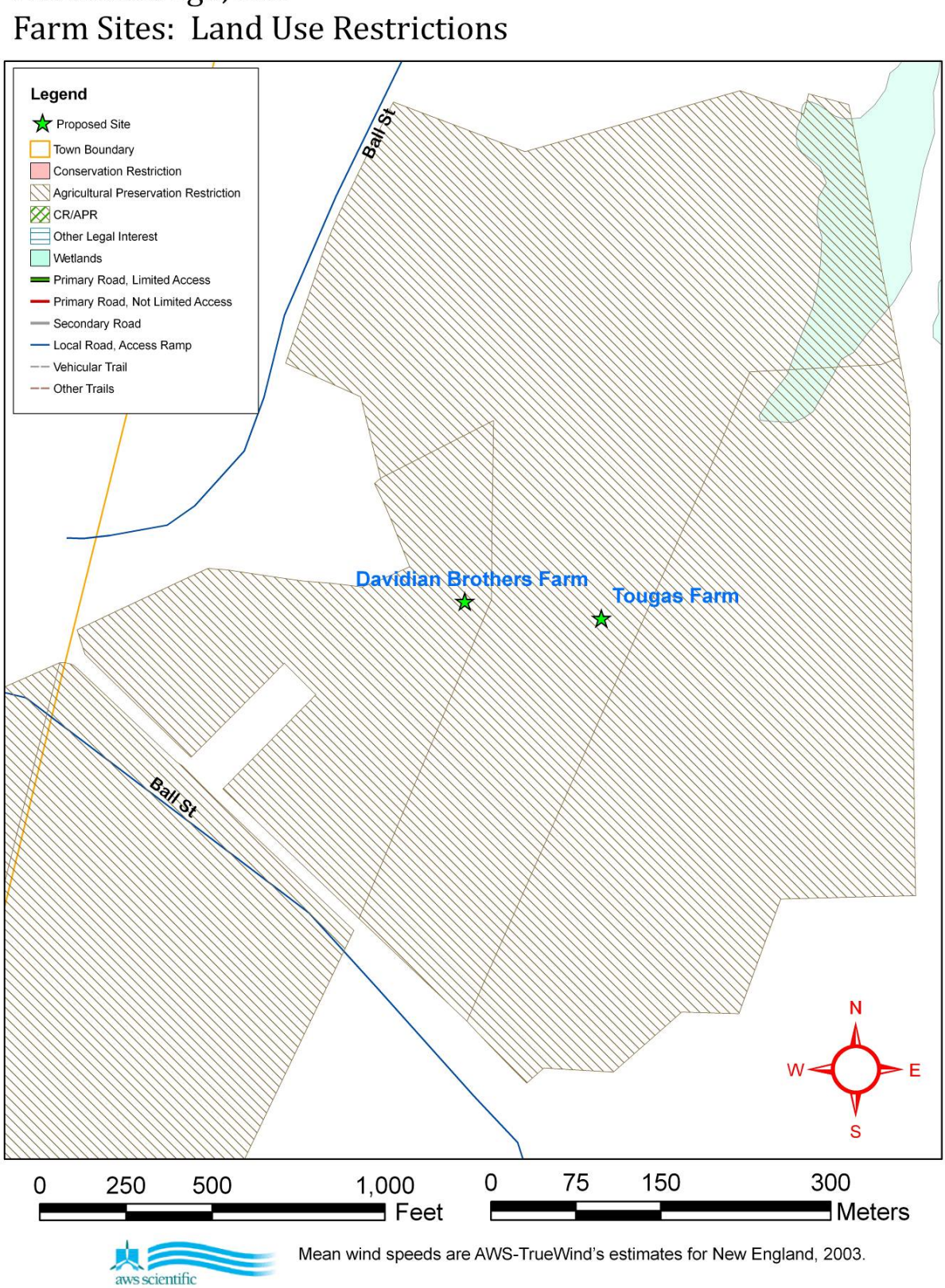


Figure 8: This figure displays land use and environmental restriction as the farm sites. The striped section is designated features Agricultural Preservation Restrictions. There is also a small area of wetlands located to the northeast of the proposed sites. Neither of these designations is anticipated to be a fatal flaw for these sites.

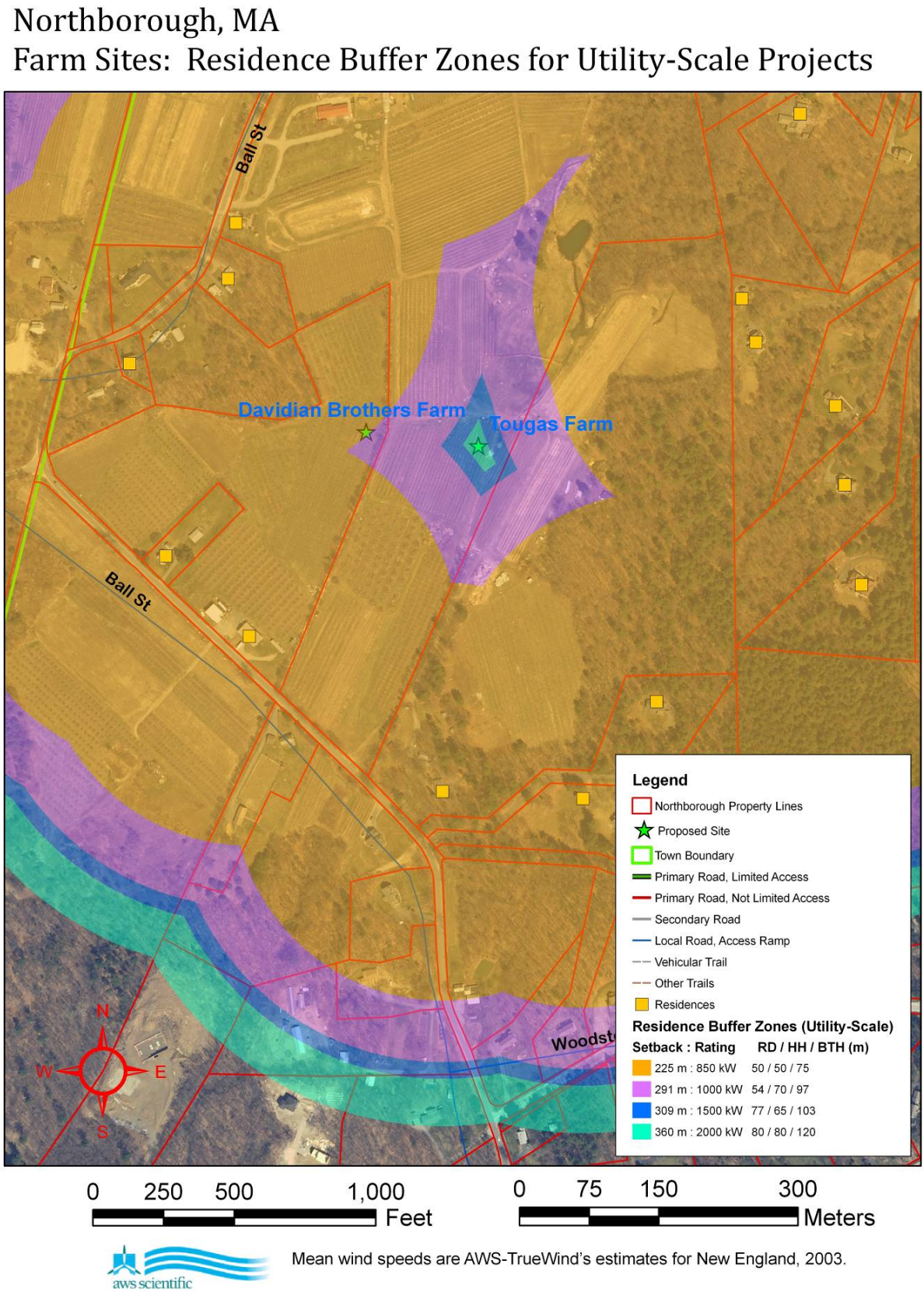


Figure 9: This figure displays residential buffer zones for utility-scale wind projects. An 850 kW turbine, for instance, would be sited outside the orange buffer zone, according to the "three-times-blade-tip-height rule of thumb."

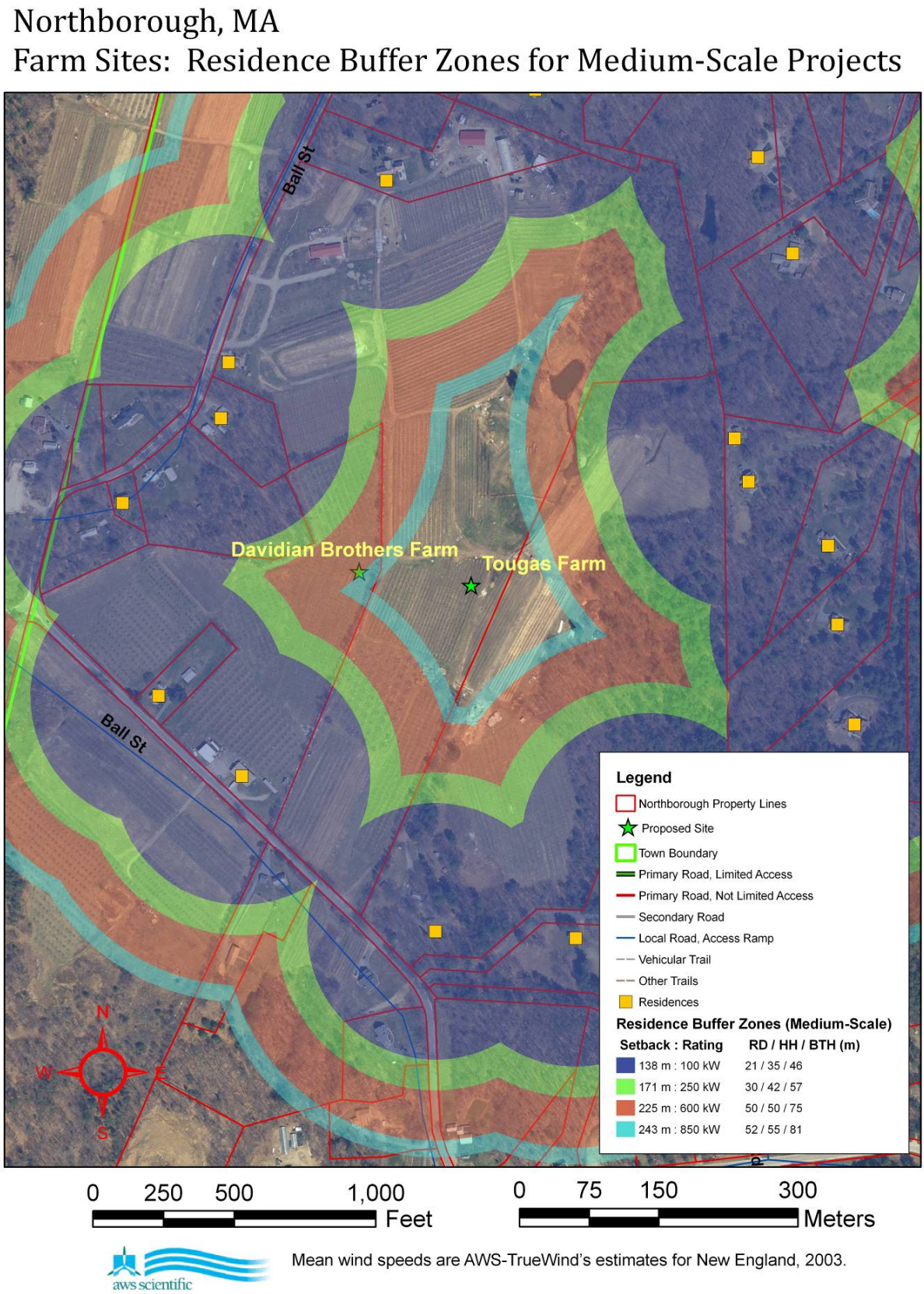


Figure 10: This figure displays residential buffer zones for medium-scale wind projects. A 250 kW turbine, for instance, would be sited outside the green buffer zone, according to the "three-times-blade-tip-height rule of thumb."

TOWAIR Determination Results

*** NOTICE ***

TOWAIR's findings are not definitive or binding, and we cannot guarantee that the data in TOWAIR are fully current and accurate. In some instances, TOWAIR may yield results that differ from application of the criteria set out in 47 C.F.R. Section 17.7 and 14 C.F.R. Section 77.13. A positive finding by TOWAIR recommending notification should be given considerable weight. On the other hand, a finding by TOWAIR recommending either for or against notification is not conclusive. It is the responsibility of each ASR participant to exercise due diligence to determine if it must coordinate its structure with the FAA. TOWAIR is only one tool designed to assist ASR participants in exercising this due diligence, and further investigation may be necessary to determine if FAA coordination is appropriate.

DETERMINATION Results

Structure does not require registration. There are no airports within 8 kilometers (5 miles) of the coordinates you provided.

Your Specifications

NAD83 Coordinates

Latitude	42-21-41.3 north
Longitude	071-39-51.0 west

Measurements (Meters)

Overall Structure Height (AGL)	60.7
Support Structure Height (AGL)	NaN
Site Elevation (AMSL)	210.3

Structure Type

TOWER - Free standing or Guyed Structure used for Communications Purposes

Tower Construction Notifications
Notify Tribes and Historic Preservation Officers of your plans to build a tower.

CLOSE WINDOW

TOWAIR Determination Results

*** NOTICE ***

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DETERMINATION Results

Structure does not require registration. There are no airports within 8 kilometers (5 miles) of the coordinates you provided.

Your Specifications

NAD83 Coordinates	
Latitude	42-20-42.8 north
Longitude	071-40-36.9 west
Measurements (Meters)	
Overall Structure Height (AGL)	60.7
Support Structure Height (AGL)	NaN
Site Elevation (AMSL)	182.9

Structure Type

TOWER - Free standing or Guyed Structure used for Communications Purposes

Tower Construction Notifications
Notify Tribes and Historic Preservation Officers of your plans to build a tower.

CLOSE WINDOW