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Wind Power in Swampscott:
Siting Considerations for a Wind Turbine

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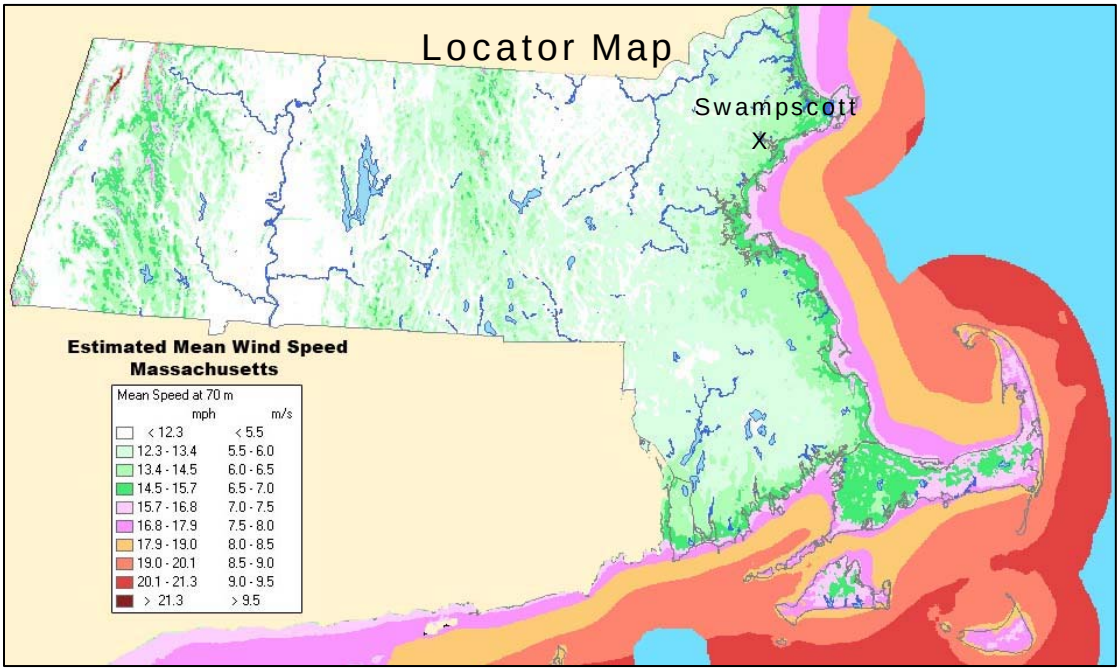


I. Introduction

At the request of the Massachusetts Technology Collaborative, Charles McClelland, Mary Knipe, and Fred Letson of the Renewable Energy Research Laboratory (RERL) visited four proposed sites in the town of Swampscott, Massachusetts in order to evaluate their suitability for 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 power 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 each site 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 Swampscott is marked with an "X".

Appendix A provides details related to each site in tabular form.

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

Appendix C provides wind resource maps, topographic maps, ortho (aerial) photos, and figures 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

II. Site Considered

Representatives of the town requested that four parcels of town property be evaluated for their suitability for wind power projects. The four sites, along with brief descriptions, are listed below:

1. **Forest Avenue** – Comprised of several baseball diamonds north of the Swampscott Middle School. The site lays adjacent to The Tedesco Country Club in a residential community.
2. **Phillips Park** – Comprised of several playing fields and a parking lot. This site is located approximately 300 meters from the coast in a residential area.
3. **Jackson Park** – Comprised of a densely wooded park adjacent the Swampscott high school, in a residential community.
4. **Swampscott Quarry** – Comprised of a small, elevated gravel platform surrounded by brush, located to the south of the quarry near a residential community.

None of the sites feature fatal flaws to wind development. Noise considerations are likely to prevent the development of large, utility-scale projects at all sites; however, medium scale projects may be possible at several of the sites. A more detailed discussion related to noise issues is presented in **Section C**.

Details related to each site are located in **Appendix A**. The primary constraints are listed on line 28. 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. A site characteristic that is described as a fatal flaw is almost sure to prevent medium or utility-scale wind development. 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.** Wind Turbine Component Transportation & Access
- **C.** Noise
- **D.** Environmental Issues and Permitting
- **E.** Proximity to Airports
- **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 locations of data within the table are noted in parentheses next to section sub-headings. For example, data presented in the subsection titled "TrueWind estimates of annual average wind speed" can also be found in lines 8-12 of the table.

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 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 its power production and longevity, 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 following table displays the AWS TrueWind estimates of annual average wind speeds at 70 meters (for large-scale turbines), 50 meters (for medium-scale turbines), and 30 meters (small-scale turbines).

TrueWind Estimates of Annual Average Wind Speed at Proposed Sites (m/s)			
	70 meters	**50 meters**	**30 meters**
Phillips Park	7.0	6.6	6.0
Forest Avenue	6.9	6.5	5.9
Jackson Park	6.6	6.1	5.6
Swampscott Quarry	6.6	6.1	5.5

Other available wind data (Line 13)

RERL has monitored the wind resource in the towns of Lynn and Marblehead, which are approximately two to three miles from the proposed sites. RERL is also currently monitoring the wind resource in Salem during the spring and summer of 2008. Data from these sites could be used as reasonable approximation of the wind resource at the Swampscott sites; however, the reliability of wind data diminishes with distance. Wind characteristics are dependent upon any land formations, trees, and structures in the local vicinity; therefore, for the most accurate assessment of project feasibility, on site wind monitoring is advisable.

Obstacles to wind flow (Lines 18-19)

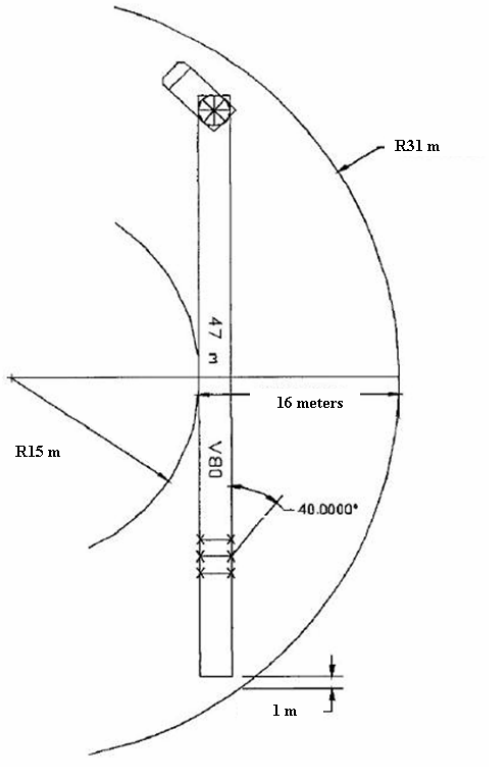
AWS indicates that obstacle interference occurs downwind at a distance of about 10-20 times the obstacle height, up to a height of about twice that of the obstacle itself. Obstacle interference would become a siting constraint particularly if small- or medium-scale turbines are considered, which typically have hub heights in the range of 150 to 250 feet. The Jackson Park site features a large, elevated grove of mature trees ranging from 20 to 70 feet in height, located directly south of the track. Additionally, the presence of the high school, which sits to the east of the track, increases the likelihood of obstruction or turbulence at this site.

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. The presence of wind shear may present significant challenges to a wind power project at the Swampscott Quarry, Forest Avenue, and Jackson Park sites. If the town is interested in pursuing a wind project at one of these sites, on-site wind monitoring is strongly advised.

B. 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 meters) required for transporting one of the 47-meter turbine blades of a Vestas V80, a 1.8 MW machine. Transportation accessibility for turbine installation is an important consideration for a potential wind turbine site.



Transportation and access to the Swampscott sites (Line 17)

Each of the sites would pose some logistical challenges to transporting wind turbine components to the sites, especially for large, utility-scale wind turbines.

The Forest Avenue, Jackson Park and Quarry sites would require on-site road improvements, and possibly improvement of the roads leading to the site.

While access does not appear to be a fatal flaw for any of the sites, road construction and/or improvements could add significant costs to a wind power project in Swampscott. If the town decides to pursue a project at one of the sites, it is advisable that an access plan, which includes detailed cost estimates, be completed as a next step.

C. 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 siting, but also sizing 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. 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 could be performed that takes into account the actual ambient levels and terrain; this site-specific information would then supersede the rough rule of thumb. This could be performed in conjunction with full-feasibility study.

Noise at the Swampscott sites (Lines 20-21)

Swampscott is a built-up community and noise will be a siting consideration for a wind turbine at all of the proposed sites. Consideration of the neighbors will be an important factor in siting and sizing wind turbines for the Swampscott sites. From a noise perspective, the "three times blade-tip height" guideline suggests that a large, utility-scale wind turbine (1 MW or greater) would most likely present a nuisance at all four proposed sites. See **Figure 3** in **Appendix C** related to Residential Buffer Zones for a map depicting residences, buffer zones, and town boundaries in Swampscott.

Recommendations are made with respect to the largest turbine sizes that would be appropriate for each site. The maximum blade-tip-heights that a site can support correspond to approximately one-third of the site's distance to the nearest residence (essentially, a restatement of the "three times blade-tip height" rule).

A medium-scale turbine (~660kW) may be possible at the Forest Avenue and Swampscott Quarry sites, subject to careful micro-siting. However, space considerations at Phillips Park and Jackson Park would likely limit turbine size to 250 kW. In the event that a turbine project is pursued at any of the proposed sites, a detailed noise study would be completed as part of the full feasibility analysis.

Alternatively, the town might consider an agreement with the town of Salem to jointly develop the area north of the quarry, where adequate space exists for at least one utility-scale wind turbine.

Note: these recommendations are not "hard" rules, but rather first pass estimates based upon the "three time blade-tip height" guideline. If the town pursues a wind project at one of the proposed sites, it is advisable to complete a detailed noise study which takes into account actual ambient sound levels at the sites. This study would supersede the rule of thumb.

See **Appendix C** for photos depicting these locations.

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 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 RERL is not aware. It is the town's responsibility to ensure the environmental appropriateness of the chosen site.

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

Phillips Park is categorized as Protected Open Space (limited). The Forest Avenue and Jackson Park sites are categorized under Chapter 61 regulations. Jackson Park is also categorized under Article 97 laws with portions of the surrounding area designated as wetlands. The quarry is categorized as a mining area, with portions designated as wetlands. Areas north of the quarry are designated as Priority Habitats of Rare and Endangered Species. The town should investigate the applicable environmental designations in the event that one of the sites is chosen for a wind turbine project. Environmental permitting is not expected to be a fatal flaw for any of the sites.

E. 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.

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.* 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 Swampscott site (Line 27)

There are no airports within 8 kilometers of the proposed sites; however, Logan International Airport is located approximately 8.5 miles to the southwest of the proposed sites. A detailed airspace review could be completed if the Town moves forward with a particular site.

While there are no military airports in the vicinity, nearly all of Massachusetts is within 60 miles of a Long Range Radar Site. Any potential impacts on the Long Range Radar system will 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.

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 Swampscott sites (Line 16)

All four proposed sites are within 200 meters of distribution lines. Whether or not these lines would be in need of upgrading depends upon the size of the intended wind project. Still, interconnection would, in most cases, add significant costs to a wind project in Swampscott, with the amounts varying in proportion to a given site's distance to existent power lines. In the cases where on-site loads are present, a further feasibility study would weigh the cost and benefits of using the power to offset onsite loads. Doing so could dramatically reduce the payback period of a wind power project. Load offsetting is discussed in further detail in the following section.

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

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

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 are intended to provide rough estimates of energy production at the proposed sites for wind turbines in the range of 100 to 660 kW. This range of turbine sizes has been chosen with respect to the noise issues discussed in **Section C** of this report. The turbine models presented below are representative of common turbine sizes on the market; the exact model may not necessarily be commercially available. Precise turbine selection would follow a full feasibility study.

The following assumptions were employed:

- TrueWind estimated mean wind speeds at given hub heights,
- Uniform wind speed over swept area,
- Rayleigh wind speed distribution,
- Standard air density, and
- 10% reduction of energy production due to availability, electrical losses, etc.

Table 1 presents estimated energy production at the Forest Avenue and Phillips Park sites, which have similar estimated wind speeds. Keep in mind that AWS estimates are slightly higher at the Phillips Park site, a difference which could potentially translate into higher annual production figures. At first pass, Phillips Park appears too close to residences to accommodate turbines with ratings exceeding 250 kW.

Table 1: Estimated Annual Energy Production of Selected Turbines at Phillips Park and Forest Ave.

Wind Turbine (rated power)	Hub Height (meters)	Estimated Annual Mean Wind Speed at Hub Height (m/s)	Estimated Annual Energy Production (kWh/year)	Site Potential
Fuhrländer 100 kW	35	5.9*	211,202	Forest Avenue Phillips Park
Fuhrländer 250 kW	50	6.5	482,963	Forest Avenue Phillips Park
Vestas V47 (660 kW)	50	6.5	1,550,000	Forest Avenue

*Estimated Annual Mean Wind Speed at 35 meters height was unavailable at the time of this report; 30 meter estimate used.

Table 2 presents estimated annual energy production associated with the Jackson Park and Swampscott Quarry sites, which also have roughly identical estimated wind speeds. At first pass, Jackson Park appears too close to residences to accommodate turbines with ratings exceeding 250 kW.

Table 2: Estimated Annual Energy Production of Selected Turbines at Jackson Park and Quarry

Wind Turbine (rated power)	Hub Height (meters)	Estimated Annual Mean Wind Speed at Hub Height (m/s)	Estimated Annual Energy Production (kWh/year)	Siting Potential Based on Noise
Fuhrländer 100 kW	35	5.5*	177,761	Jackson Park, Quarry
Fuhrländer 250 kW	50	6.1	422,000	Jackson Park, Quarry
Vestas V47 (660 kW)	50	6.1	1,360,000	Quarry

*Estimated Annual Mean Wind Speed at 35 meters height was unavailable at the time of this report; 30 meter estimate used.

A more detailed analysis at a later date would provide estimates for the payback period corresponding to each of these scenarios.

IV. Conclusions

The town of Swampscott is interested in a wind power project at four locations on town property. From a noise perspective, the Swampscott Quarry and Forest Avenue sites are feasible for medium-scale wind projects (660 kW to 850 kW). The estimated mean wind speeds at these sites are fair and good, respectively, for utility-scale wind power. Project proponents should keep in mind that smaller projects tend to have longer payback periods, and so an economic analysis would be warranted if the Town pursues a medium-scale project.

With careful micrositing, the Phillips Park and Jackson Park sites may support a smaller scale wind turbine (~250 kW). The Jackson Park site, in addition, presents challenges with regards to tree clearing, road access, and obstacles to wind flow.

If the town is interested in installing a large, utility-scale turbine (1 MW or greater) in Swampscott, it is advisable that a more suitable site be identified than those considered in this report. One option would be to consider the possibility of accessing near or offshore wind resources, as the town of Hull is currently doing. Another option would be to consider a joint development with the town of Salem on property to the north of the Swampscott Quarry.

For any wind power project, the Town of Swampscott will need to balance the costs and benefits of its investment.

Next steps (Line 29)

After deciding whether to pursue a wind project at the Swampscott sites, establishing full feasibility (which may include wind resource monitoring) is an important 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 sites should be explored:

- File FAA form 7460-1
- Check on local ordinances related to structure heights
- Investigate logistics and costs of transporting turbine components and installing equipment
- Conduct noise and electrical interconnection studies

A preliminary economic analysis is also important to help the town of Swampscott decide whether a wind power project at any of the proposed sites is practical. For an introduction to economic issues, 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 Swampscott: Siting Considerations for a Wind Turbine" for a discussion of these data.

Swampscott, MA					
		Forest Avenue	**Phillips Park**	**Jackson Park**	**Swampscott Quarry**
Site Overview					
1	Description, current land use	Adjacent to ball fields and golf course, partly wooded with nearby residential areas.	Recreational park, several playing fields, near coast, residential area.	High School track, residential area, heavily wooded.	Unused lot south of quarry, atop small hill, neighboring woods and nearby residences.
2	Address	207 Forest Avenue Swampscott, MA 01907	565 Humphrey Street Swampscott, MA 01907	200 Essex Street Swampscott, MA 01907	Swampscott Road Swampscott, MA 01907
3	Owner	Town of Swampscott	Town of Swampscott	Town of Swampscott	Aggregate Industries
Location					
4	NAD 83, lat & long	42° 28.573'N	42° 27.989'N	42° 28.816'N	42° 28.976'N
		70° 54.077'W	70° 54.063'W	70° 55.328'W	70° 55.146'W
5	Degree, Minute, Second	42°28'34.24"N	42°27'59.36"N	42°28'48.96"N	42°28'58.53"N
		70°54'4.63"W	70°54'3.75"W	70°55'19.69"W	70°55'8.73"W
6	Elevation (feet)	84	7	128	134
7	Notes	Zoned Residential A-2 Property Easements on nearby privately owned properties needed.	Zoned Residential A-2	Zoned Residential A-2	Zoned B-2 District Property Easements on nearby privately owned properties needed.
Wind Speeds					

Swampscott, MA					
		Forest Avenue	**Phillips Park**	**Jackson Park**	**Swampscott Quarry**
Estimated Mean Speeds* in m/s **(to convert m/s to mph, multiply by 2.24)**					
8	At height of 100 m	7.4	7.5	7.1	7.1
9	At height of 70 m	6.9	7.0	6.6	6.6
10	At height of 50 m	6.5	6.6	6.1	6.1
11	At height of 30 m	5.9	6.0	5.6	5.5
12	Wind Speed Summary (poor, fair, good, very good):	good	good	fair	fair
13	Existing wind data	RERL has monitored wind in Marblehead and Lynn and is currently monitoring wind in Salem.			
Wind Turbine Considerations:					
Economic					
14	On-site Electric Loads	Swampscott Middle School	Pump house	Swampscott High School	Quarry
15	Electric Loads, kWh/year	800,00 kWh/yr	438,600 kWh/yr	1,970,000 kWh/yr	2,100,000 kWh/yr
16	Distance to Distribution/ Transmission lines**	~200 meters	~200 meters	~200 meters	~200 meters
17	Access for blade transportation**	Fair, on-site improvements needed	Good	Fair, on-site improvements needed	Fair, on-site improvements needed
Obstructions to wind					
18	Terrain	Hill top	Flat, low-lying area	Heavily wooded hill	Hill top
19	Obstacles to wind	Trees	Low lying buildings, few trees	High school to east, trees	Trees, quarry walls

Swampscott, MA					
		Forest Avenue	**Phillips Park**	**Jackson Park**	**Swampscott Quarry**
Noise					
20	Nearby residential areas:	Yes	Yes	Yes	Yes
21	Radius to residences: (m): (ideally >~300m for utility scale‡)	~ 220 meters	~ 150 meters	~ 150 meters	~ 220 meters
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?	No	No	Portions	Portions
24	Designated by the Massachusetts Audubon Society as an Important Bird Area (IBA)?	No	No	No	No
25	Is the site a current or former land-fill? *(RERL does not install met towers on landfills)*	No	No	No	No
26	Other land-use restrictions? (e.g. Article 97†, etc.)	Chapter 61 (F)	Open Space Level of Protection: Limited	Open Space Level of Protection: Limited Article 97	Mining Area
Other permitting					
27	Distance to airport(s)	No airports within 8 kilometers.	No airports within 8 kilometers.	No airports within 8 kilometers.	No airports within 8 kilometers.

Swampscott, MA					
		Forest Avenue	**Phillips Park**	**Jackson Park**	**Swampscott Quarry**
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?*	- Nearby residences - Road Access - Space Availability - Possible Wind Shear	- Nearby residences - Space Availability	- Nearby residences - Space Availability - Marginal Wind Speeds - Article 97	- Nearby residences - Marginal wind speeds - Wind Shear
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):*	- Investigate town noise and structure height ordinances - Economic analysis - File FAA form 7460-1for the desired turbine height - Investigate logistics of transporting turbine components and installation equipment to site - Electrical Interconnection study - Noise study (See Discussion)	- Investigate town noise and structure height ordinances\- - Economic analysis - File FAA form 7460-1for the desired turbine height - Investigate logistics of transporting turbine components and installation equipment to site - Electrical Interconnection study - Noise study (See Discussion)	- Investigate town noise and structure height ordinances - Economic analysis - File FAA form 7460-1for the desired turbine height - Investigate logistics of transporting turbine components and installation equipment to site - Electrical Interconnection study - Noise study (See Discussion)	- Investigate town noise and structure height ordinances. - Economic analysis - File FAA form 7460-1for the desired turbine height - Investigate logistics of transporting turbine components and installation equipment to site - Investigate local wind shear - Electrical Interconnection study (See Discussion)
30	***Recommendation*** *Should the town consider this site for a <u>utility-scale</u> wind turbine?*	Possibly	No	No	Possibly

Swampscott, MA					
		Forest Avenue	**Phillips Park**	**Jackson Park**	**Swampscott Quarry**
	For a smaller wind turbine? ***See also the discussion section.***	Possibly	Possibly	Possibly	Possibly
31	***Multiple Turbines*** *If the town is interested in installing more than one utility-scale turbine, how many could fit at this site?*	-	-	-	-
Met Tower: Siting Factors					
32	Space availability & level terrain	Perhaps, see discussion	Perhaps, see discussion	Perhaps, see discussion	No
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.)*	Border fence between fields and golf course	Utility pole (lighting), fence	Space is confined by trees, fence, and playing field	Yes, power lines
34	Obstacles to wind	Trees to the north and east.	Low lying buildings, few trees	Densely wooded, hill	-
35	Clearing requirements	Yes	No	Yes	-
36	Soil quality – for met tower anchors	Soils not tested	Soils not tested	Soils not tested	-
37	Road Access – for met tower installation	No	Yes	Yes	-
38	Security	Poor, nearby residential community, middle school	Poor, nearby residential community	Poor, nearby residential community, high school	-

Swampscott, MA					
		Forest Avenue	**Phillips Park**	**Jackson Park**	**Swampscott Quarry**
39	Existing towers on or near site	No	No	No	-
40	Distance to AC power if lighting is required	~200 meters	~200 meters	~200 meters	-
41	Compatibility: If this site were chosen for a wind turbine but not a met tower, where else could wind be monitored?	Phillips Park, Jackson Park	Forest Avenue, Jackson Park	Forest Avenue, Phillips Park	Forest Avenue, Phillips Park, Jackson Park
Met Tower: Primary Constraint					
42	What factors will most affect feasibility and/or siting of a met tower here?	Road Access, Structure Permitting	Road Access, Structure Permitting, Ball Field Usage Considerations (see discussion)	Obstruction, Clearing, Structure Permitting	Power lines, space
Met Tower: Recommendation					
43	Recommended site:	Perhaps, see discussion	Perhaps, see discussion	Perhaps, see discussion	No
44	Recommended met tower height (meters)	50	50	50	-

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 flaws. 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 town's responsibility to ensure the environmental appropriateness of the chosen site.

Appendix B: Wind-Monitoring Logistics

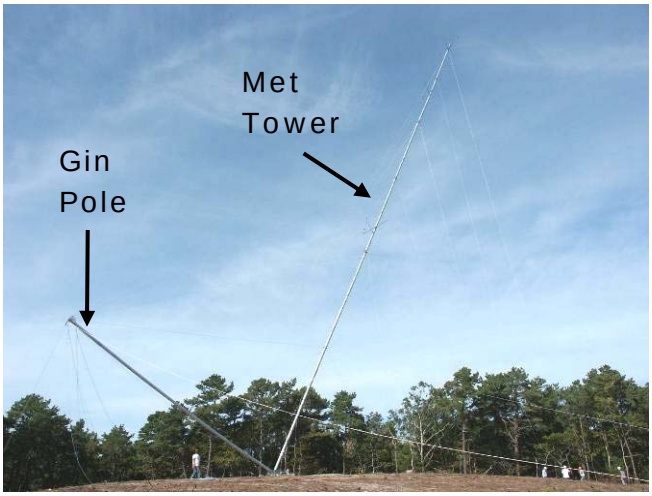
Traditionally, wind is monitored for about a year with a met tower. Some sites may be suitable for other types of monitoring in addition to a met tower. This section will concentrate on the siting of a met tower. Figure 1 in **Appendix C** is a schematic of a met tower.

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.

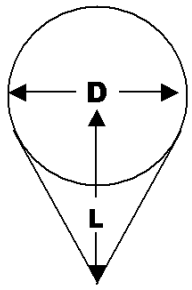
Typical 6-foot-long utility screw-in anchor

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 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 Swampscott.

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

Phillips Park: There is adequate space for a met tower at this site. However, the guy wires supporting the met tower would prevent the use of one or more ball fields at the site for the duration of wind monitoring, or about one year. For safety reasons, the RERL will not install a met tower with guy wires straddling the road leading to the parking lot.

Forest Avenue: There is insufficient space at this site for a met tower, unless a portion of the golf course property were cleared and utilized for one or more anchors. In addition, the unlevel terrain would present significant challenges to raising a met tower at this site.

Jackson Park: If the track is used for the met tower, then adequate space exists at this site. However, the track would remain unusable for the duration of wind monitoring, or about one year. In addition, the tree grove would impact the quality and reliability of collected wind data. If the town does not wish to

occupy the track with a met tower, then an area approximately the size of the track would need to be cleared of trees.

Swampscott Quarry: The proposed site south of the quarry is not large enough to accommodate a met tower. Power lines at the site also prohibit the RERL from installing a met tower at this location. Wind monitoring at this site will not be discussed further.

Clearing requirements (Line 35)

A met tower requires a cleared area approximately the size of a football field.

Phillips Park: Minimal clearing may be necessary at the Phillips Park site, depending upon micro siting decisions.

Forest Avenue: Significant clearing would be necessary for a met tower installation; further, part of the golf course property adjacent the site would also need to be cleared to accommodate one or more anchor placements.

Jackson Park: If the track is used for the met tower, then minimal clearing would be necessary. If the tree grove is chosen, extensive clearing of mature trees would be necessary.

Soil quality & anchor requirements (Line 36)

The soils at the sites were not tested; however soil quality for anchor placement is not expected to be a fatal flaw for any of the sites at this time. The anchors would be tested at the time of installation.

Accessibility for met tower installation (Line 37)

Phillips Park: This site offers sufficient access for the RERL's pick up truck.

Forest Avenue: The site is not immediately accessible by road. At the very least, fences and trees would need to be removed in order to allow for the RERL's pick up truck to access the site.

Jackson Park: If the track is chosen for a met tower installation, the site could be accessed from the road leading from the high school to the track. If the tree grove adjacent the track was chosen, the site could be accessed from Foster Road; however, extensive clearing would be needed as the area is heavily wooded.

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.

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 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 this can only be estimated on a site-specific basis. Thus, an understanding of preferred turbine spots is necessary to choosing a met tower site.

All sites proposed in this report are within two miles of one another; thus, data collected at one site could be used to evaluate wind speeds at any of the other proposed sites. However, as previously noted, accuracy diminishes as the distance between the turbine and monitoring locations increases. For instance, the difference in wind characteristics between the Phillips Park and Quarry sites is likely to be significantly greater, given both their surrounding environments and respective distances from the coast, than between the Phillips Park and Forest Avenue sites.

If the Town elects to monitor winds speeds at one site for the purposes of predicting wind characteristics at another site, than the aforementioned caveats should be given careful consideration. The most-accurate and site-specific data would be provided through monitoring at the exact location of interest.

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 were pursued at any of the proposed sites, a 50-meter met tower would be recommended.

Conclusion: met tower siting recommendations

Wind-monitoring options should be discussed further depending on the site and the turbine size considered. If the town is interested in installing a medium or utility-scale wind turbine in Swampscott, then on-site wind monitoring is recommended.

If the town decides to monitor wind speeds at Phillips Park, then a 50-meter tower would be recommended. The town should keep in mind that a met tower installation at this site would render one or more of the playing fields unusable for the duration of wind monitoring, or about one year.

If the town decides to monitor wind speeds at Forest Avenue, then a 50-meter tower would be recommended. However, due to the clearing, access, and topographical challenges that this site presents, the town might consider alternative means of wind speed measurement, including SODAR and LIDAR, which require neither extensive clearing nor a large, relatively flat area. The Town of Swampscott could explore these options in consultation with the MTC if a full feasibility study is pursued at one of the proposed sites.

If the town decides to monitor wind speeds at Jackson Park, then a 50-meter tower would be recommended. The town should keep in mind that a met tower installation at the this site would either render the playing field unusable for one year or would require that a large number of the mature trees in Jackson Park be removed.

The town should also keep in mind that RERL plans to monitor the wind resource in the town of Salem during the spring and summer of this year.

If smaller scale turbine sizes (less than 600 kW) are considered, wind monitoring is beneficial but may not be essential.

Appendix C: Maps, Photos, and Figures

Refer to the report "Wind Power in Swampscott: 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.

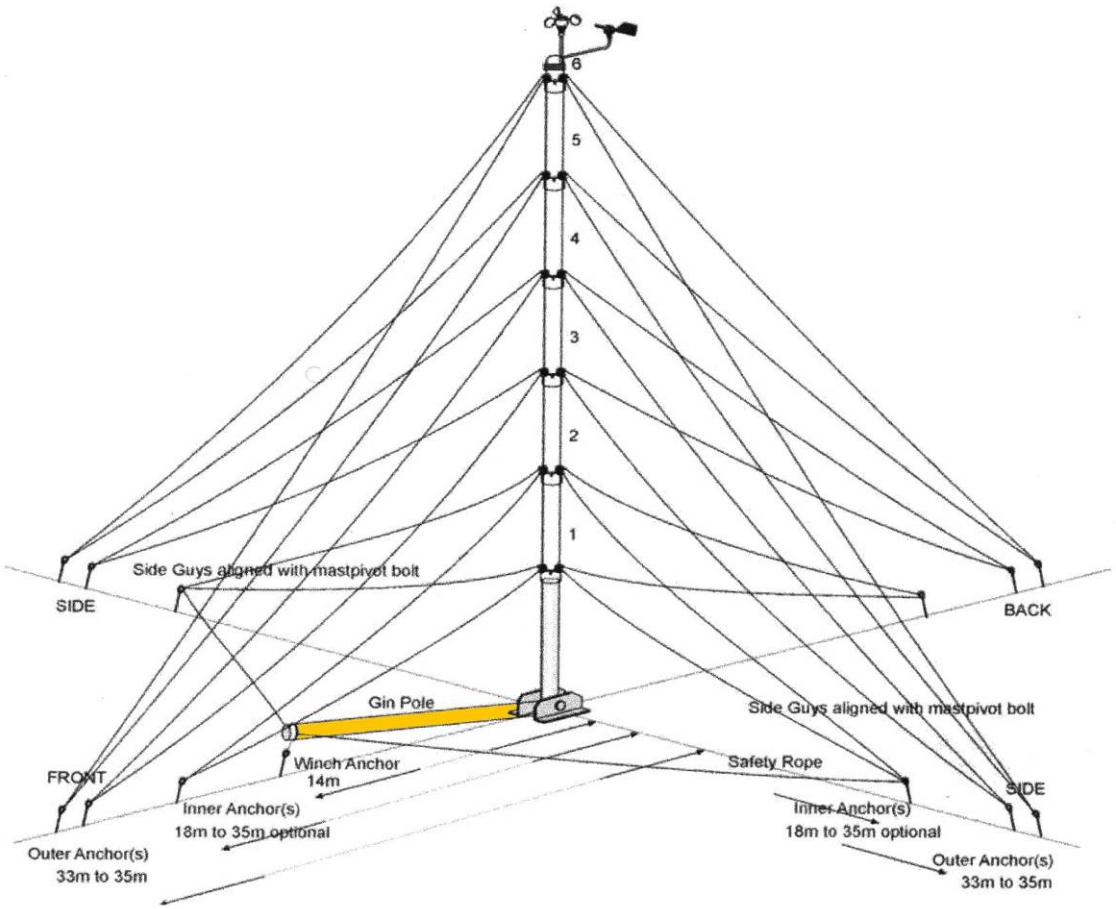
Topographic maps, roads, and town boundaries are also from MassGIS.

Mean wind speeds are AWS-Truewind's estimates for New England, 2003.

Notes regarding residential buffer zones (Figures 5 - 8)

Orthophotographs at each site were overlaid with residential buffer rings corresponding to the suggested "three times blade tip height guideline." According to this guideline, a 100 kW turbine could be sited outside the navy blue zone, whereas a 250 kW turbine would be sited outside both the navy blue and lime green zones.

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



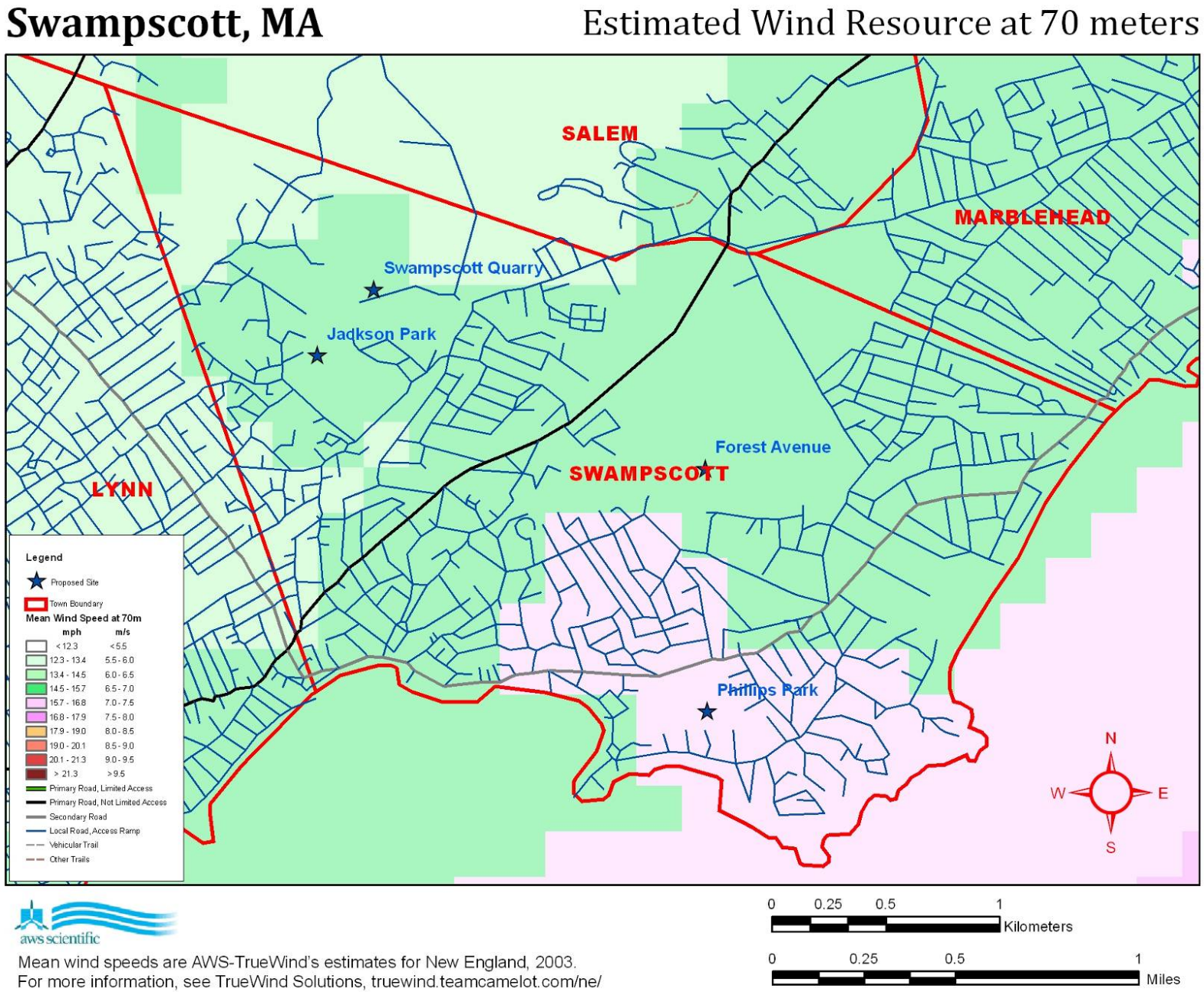


Figure 2: This map depicts wind speeds at 70 meters, approximately the hub-height of utility-scale wind turbines (~1.0 MW or greater). The sites described in this report are too close to residences to accommodate utility scale wind projects.

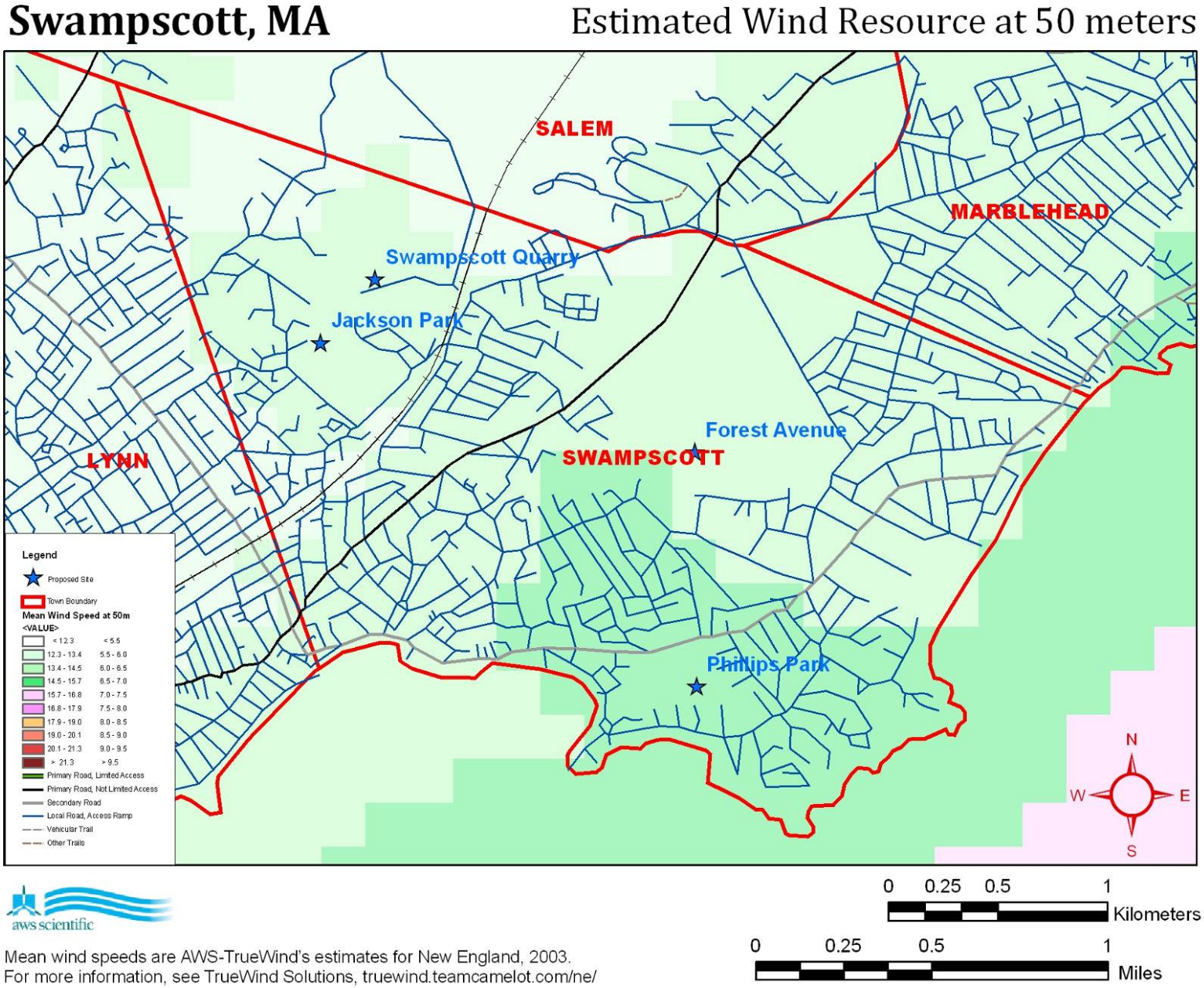


Figure 3: This map depicts wind speeds at 50 meters, approximately the hub-height of medium-scale wind turbines (~660 kW). From a first pass estimate, the Forest Avenue and Swampscott Quarry sites appear to feature sufficient space for this scale of wind turbine.

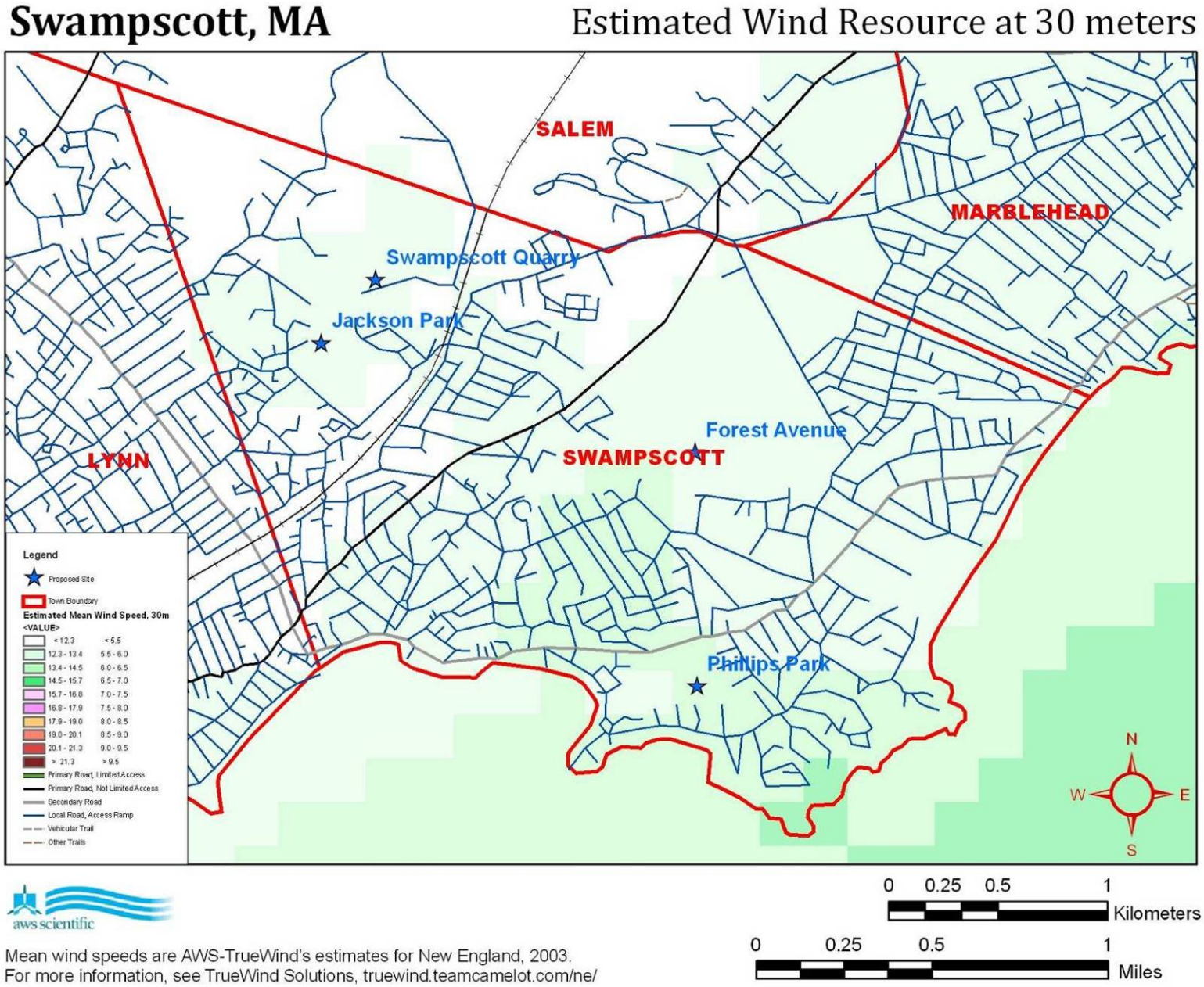


Figure 4: This map depicts wind speeds at 30 meters, approximately the hub-height of small to medium-scale wind turbines (~250 kW or less). The Phillips Park and Jackson Park sites could potentially accommodate turbines in this range.

Swampscott, MA: Forest Avenue

Residential Buffer Zones for Medium-Scale Turbines

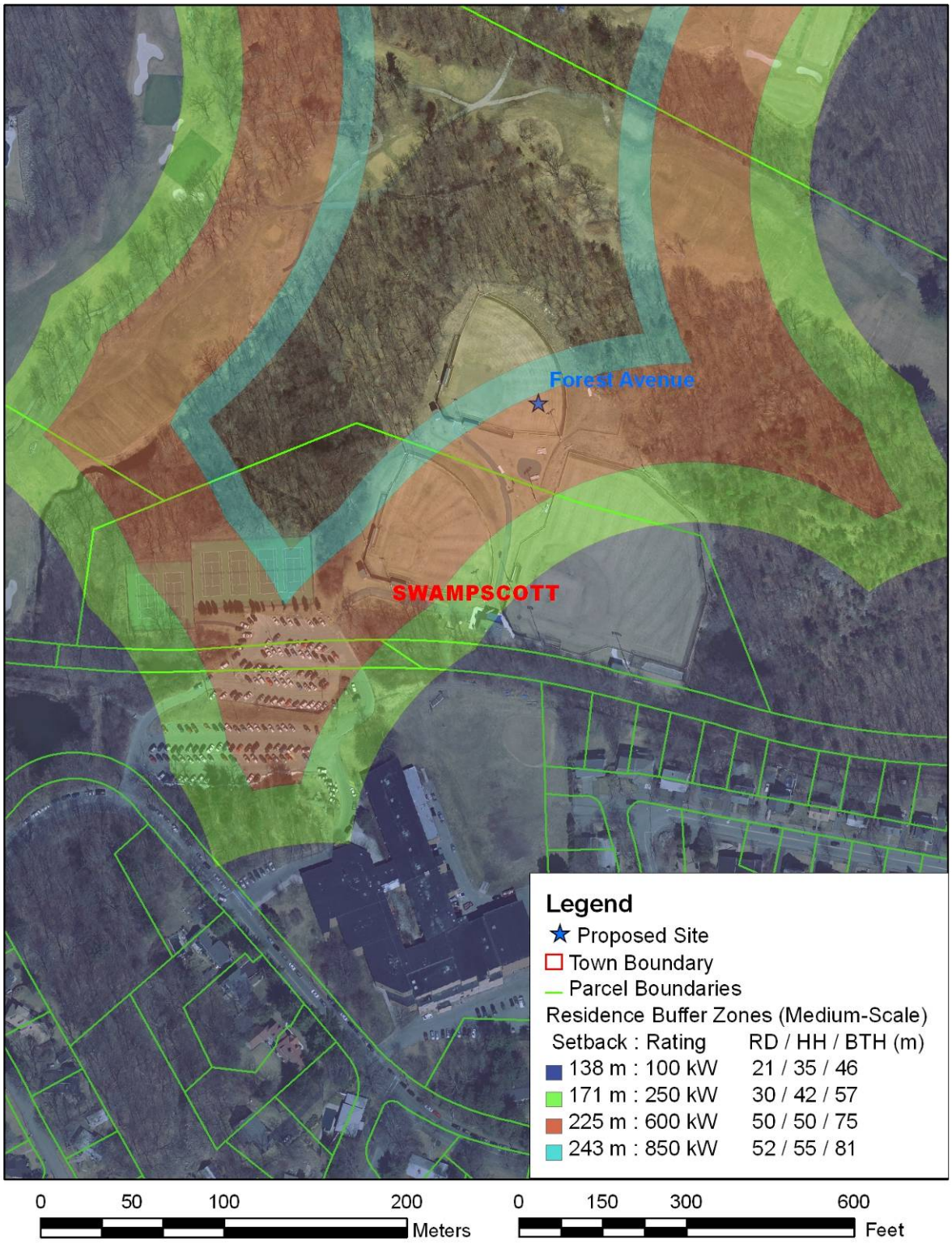


Figure 5: This aerial photo displays residential buffer zones at the Forest Avenue Site. A 600 kW turbine would be sited outside the orange region, towards the center of the photo. A slightly larger turbine (~850 kW) might also be possible beyond the teal ring buffer ring.

Figure 6: This aerial photo displays residential buffer zones in at the Phillips Park site. A 250 kW turbine could potentially be sited in the orange region in the center of the photo, according to the "three times blade tip height" rule of thumb.

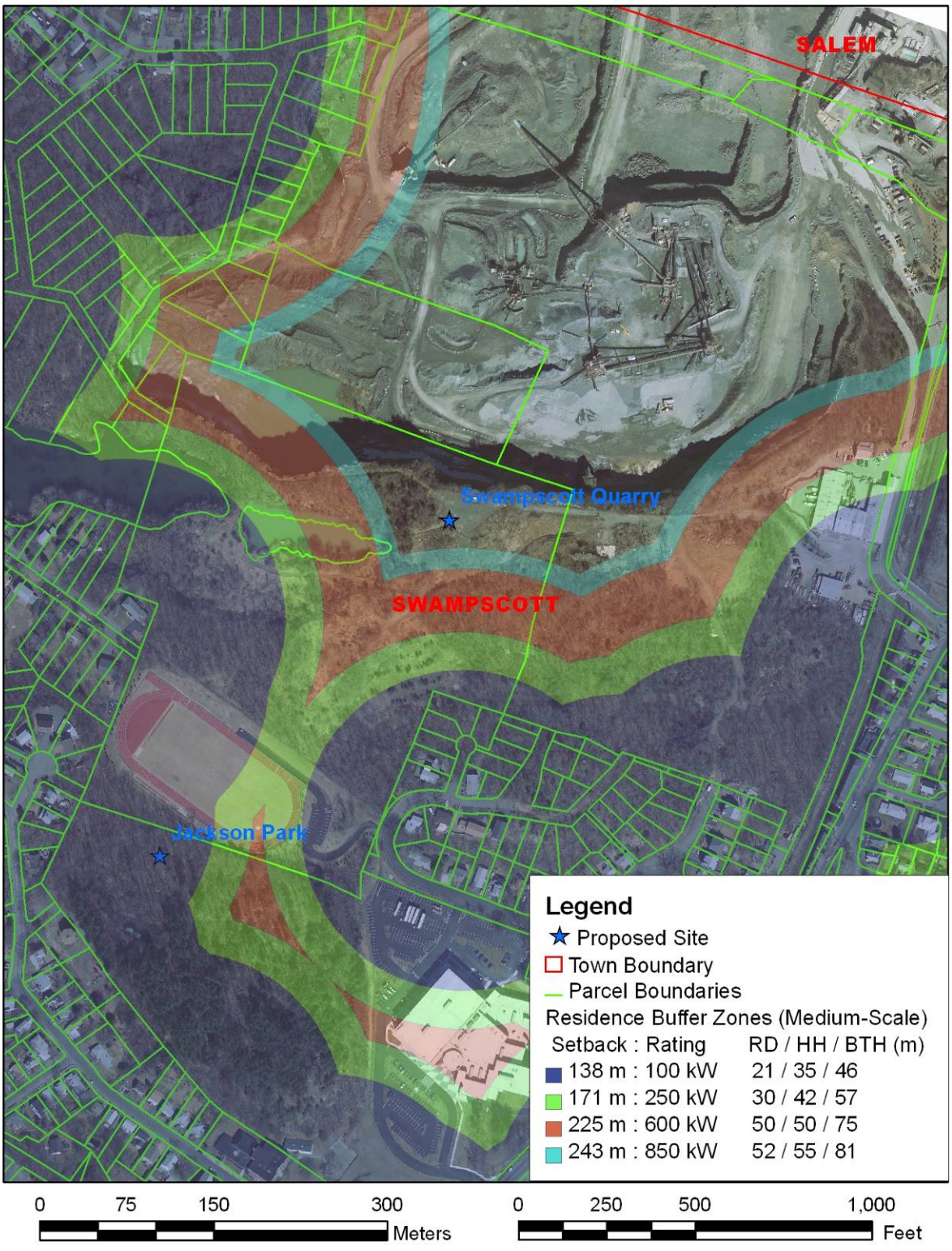


Figure 7: This aerial photo depicts residential buffer zones at the Swampscott Quarry. Jackson Park can also be seen in the lower portion of the photo.

Swampscott, MA: Jackson Park

Residential Buffer Zones for Medium-Scale Turbines

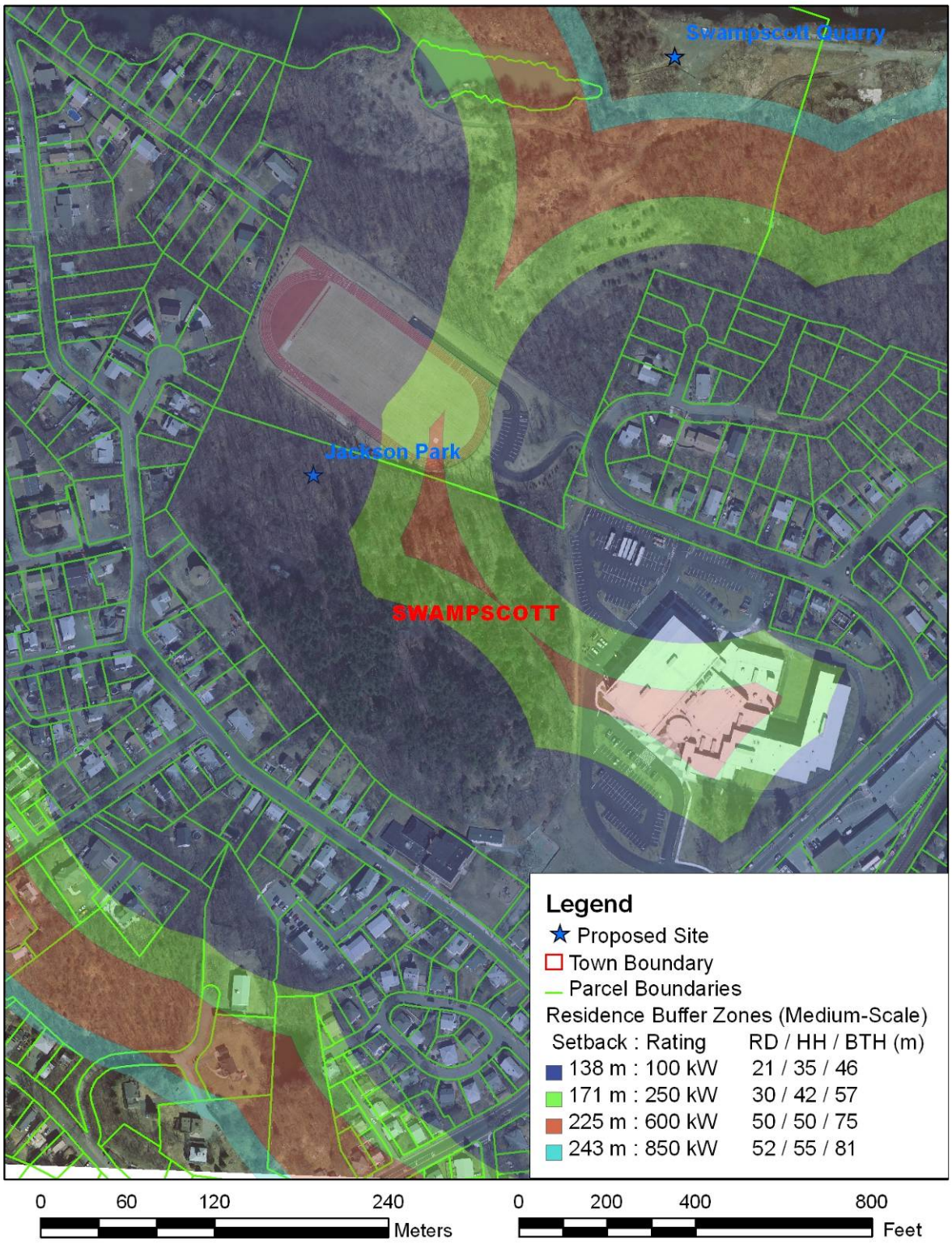


Figure 8: This aerial photo depicts residential buffer zones at Jackson Park. With careful micrositing, the site could potentially support a 250 kW turbine in the orange region near the track or school facility.

Swampscott, MA

Environmental Designations, Jackson Park & Quarry

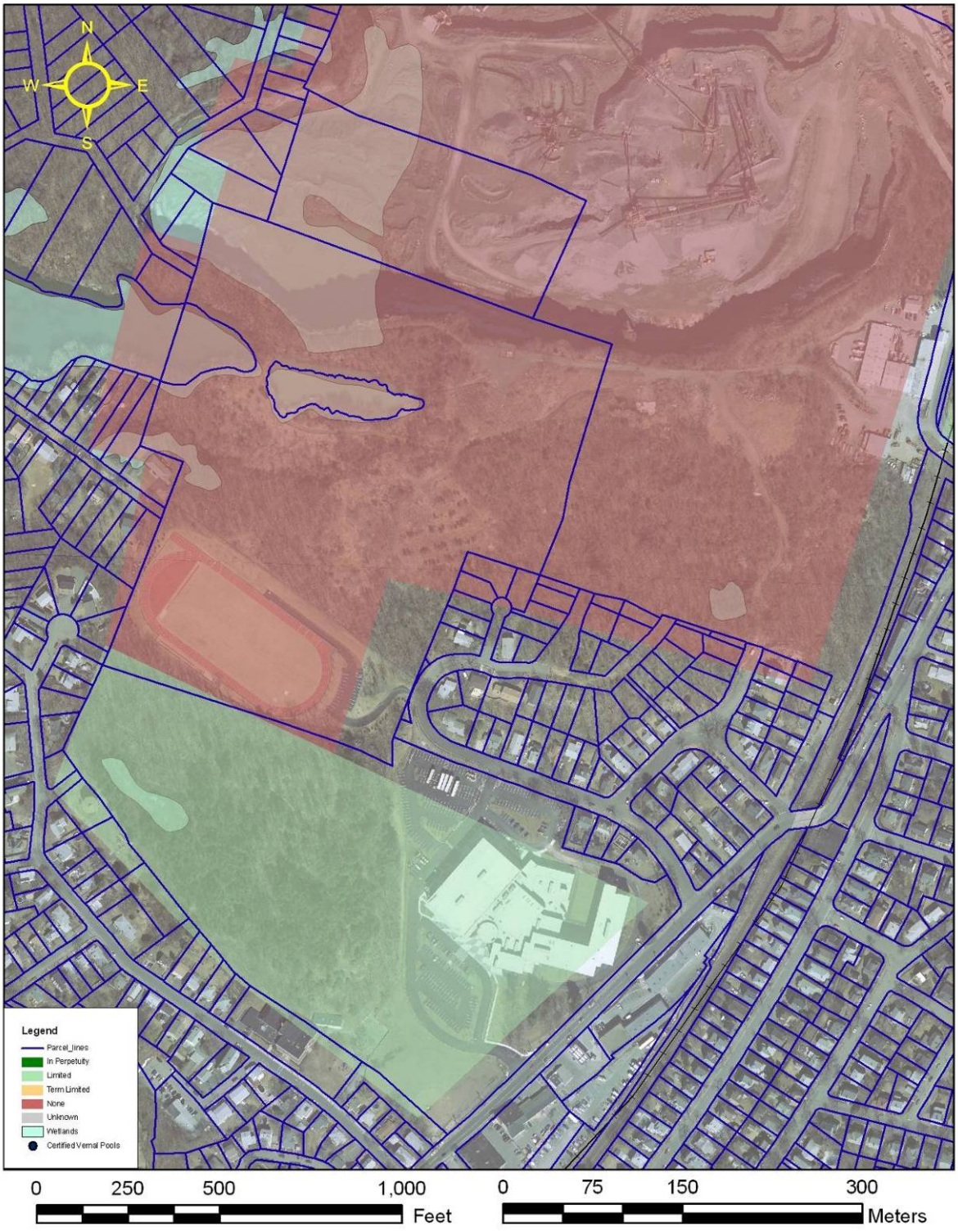


Figure 9: This aerial photo depicts environmental designations around the Swampscott Quarry and Jackson Park. The red overlay on the quarry indicates a mining area. Jackson Park is designated as protected open space. The amorphous teal overlays indicate areas of wetlands.

Figure 10: This is an aerial photograph of Phillips Park. There is adequate space for a met tower, however a met tower installation would leave one or more playing fields unusable for the duration of wind monitoring, or about one year.

Figure 11: This is a recent aerial photograph of the Forest Avenue site. Adequate space for a met tower exists to the northeast of the playing fields, provided that several trees are cleared on both school and golf course property. The uneven terrain at this site would present challenges to raising a met tower.

Figure 12 (above): This is an aerial photograph of the proposed Jackson Park site. One possibility is to place the met tower on the track, rendering it unusable for about one year. Alternatively, the town might consider clearing a space roughly equal to the size of the track in the tree grove located in the center of the photo.

Figure 13 (below): This is an aerial photograph of the Swampscott Quarry. The proposed site, labeled by the red marker, is not large enough for a met tower. There are also power lines located at this site, making it infeasible for a met tower installation.