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Wind Power in Salem:

Siting Considerations for a Wind Turbine

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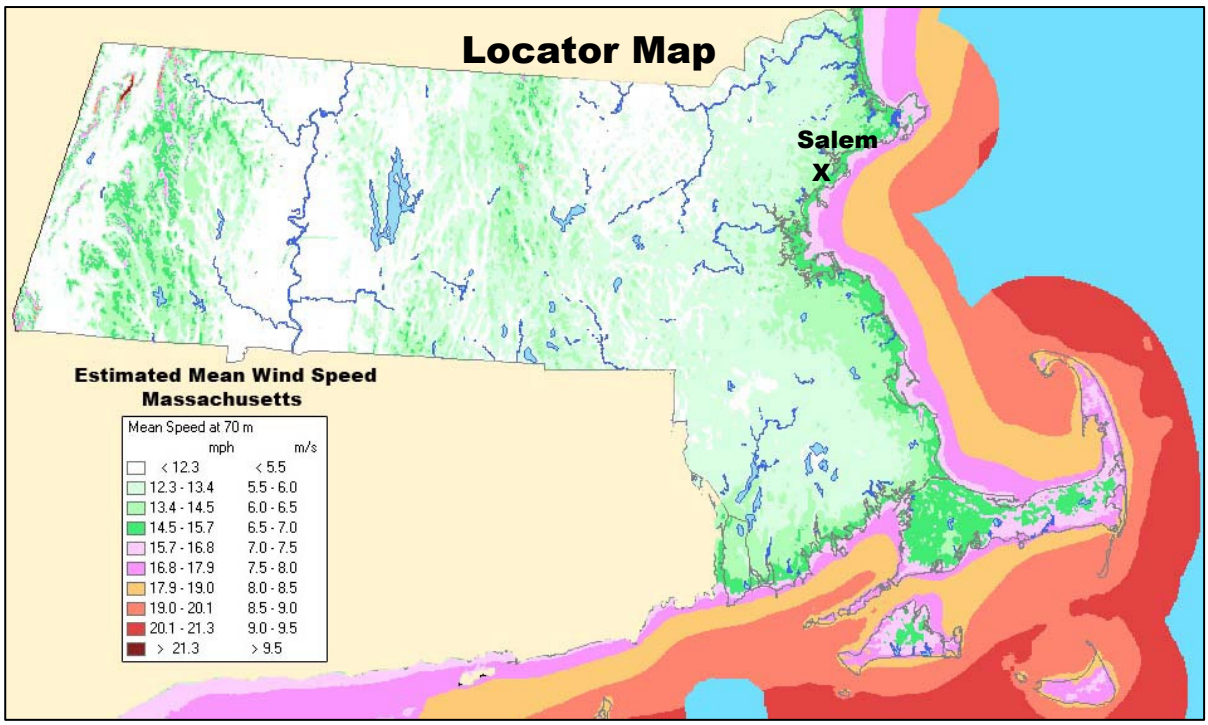

I. Introduction

The city of Salem has formed a Renewable Energy Task Force and is considering pursuing a Climate Action Plan through the Cities for Climate Protection program (www.iclei.org). Tapping renewable energy resources is typically an important part of a Climate Action Plan, and the city contacted the UMass Renewable Energy Research Laboratory (RERL) in order to better understand its options for wind power generation.

At the request of the Massachusetts Technology Collaborative's Renewable Energy Trust, Sally Wright and Lynn DiTullio of the RERL visited potential wind turbine and/or wind-monitoring sites in Salem, along with representatives of the city, the Salem Renewable Energy Task Force, the wastewater treatment facility, and the Massachusetts Technology Collaborative (MTC.)

This report provides an initial assessment of the suitability of the proposed sites for utility- or medium-scale wind turbines. The report is in the form of a broad "fatal flaw" analysis, which is designed to determine whether the city should move forward in considering this type of wind power project. Many factors are discussed in this report, not all of which present major influence for every site; at the end of the report, the most significant factor for each site is 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 city of Salem is marked with an "X".

Appendix A provides details of the site discussed in this report in tabular form. Appendix B focuses on siting considerations for wind-monitoring towers (met towers) in Salem. Wind monitoring is an important aspect in determining feasibility. Appendix C provides photographs, ortho (aerial) photographs, 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

Use of this report

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

II. Sites Considered

The city of Salem requested that eight locations be evaluated for their suitability for a wind power project (Appendix A, lines 1-7 in tables A1 and A2). Additionally, a review of Bertram Field was requested during the site visits. Bertram Field was not toured, but will be summarized here briefly.

1. SESD: The South Essex Sewerage District's wastewater treatment plant on Cat Cove, north of the Salem power plant, and south of Salem State College's Cat Cove Marine Laboratory. Because the property has extensive buried infrastructure, the plant manager suggested that only one spot on the parcel be considered: a cul-de-sac on the NE side of the parcel
2. Winter Island: town-owned mixed-use recreation area on a peninsula. We focus here on the southern end of the peninsula, where the wind can be expected to be strongest, though other parts of the parcel could be considered later.
3. Forest River Park: a coastal town park with swimming area and tennis courts.
4. Willows Recreation area: an amusement park area with town beaches
5. Saltonstall School: elementary school with coast-line playing field
6. Bentley School: elementary school, also with coastal access
7. Bertram Field: playing field at Francis Xavier Collins Middle School
8. Salem High School: high school with surrounding land, abutting the town golf course. City representatives suggested that we focus on a soccer field on the eastern most edge of the parcel, near the golf course.
9. Salem Greens Golf Course: a town-owned golf course

III. Wind Turbine Siting Considerations

Purpose

The purpose of this section is to consider whether there are any "fatal flaws" to siting a wind turbine in the sites under discussion. 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. In some of the cases, a medium-sized (250 kW or similar) turbine is also considered.

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

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

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

A. Predicted Wind Resource

About wind resource in general

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

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

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

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

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

Obstacles to wind: Obstacles cause both turbulence and slowing of the wind. If the surrounding landscape is built up, forested, or otherwise rough, turbulence will increase. These are important factors

in site selection for a wind turbine because they affect the power production and the longevity of a wind turbine, and may affect the type of turbine that can function reliably at the site.

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

Of the sites suggested by the city, only Winter Island and Forest River Park meet or exceed 6.5 m/s at 70 meters, according to the AWS-TrueWind model estimates. The other sites range from 6.1-6.4 m/s at 70 meters.

Other available wind data (Line 13)

RERL has maintained anemometry in Marblehead and Lynn. These wind data sets are either too far away and/or at too low a height to yield sufficient accuracy for determining the feasibility of a utility-scale wind turbine. Therefore on-site wind monitoring is still advisable. The Marblehead and Lynn RERL wind datasets are available on the web: http://www.ceere.org/rerl/publications/resource_data/. Additionally, an anemometer was mounted on a 15-foot pole on a building near the SESD; this, however, is too low and too close to the building to be useful for evaluating wind power feasibility.

Obstacles to wind flow (Lines 18-19)

Mature trees obstruct all the sites under consideration. An especially tall wind turbine tower will be advisable.

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, this rule of thumb can be used to minimize possible noise: site wind turbines at least three times the blade-tip height from residences. Distances from mixed-use areas may be shorter. Note that noise considerations 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 a hard rule; wind turbines can be and often are positioned closer to residences. This initial recommendation is meant to be the beginning of a conversation among the city's citizens. The city's decision to site a wind turbine must take into consideration the community's needs and priorities.

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

Noise at the Salem sites (Lines 20-21)

Salem is a built-up community and noise will be a siting consideration for a wind turbine at all of the sites under consideration. Consideration of the neighbors will be an important factor in siting and sizing a wind turbine in Salem.

From a noise perspective, the "three-times-blade-tip" distance guideline suggests a utility-scale wind turbine is possible at the first three sites: SESD, Winter Island, and Forest River Park. In each case, noise considerations will influence micro-siting and turbine choice. The High School and Golf Course may have sufficient space as well.

C. Nearby Airports

About airspace in general

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

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

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; additionally, parts of northeastern Massachusetts are within 60 nm of a long-range radar site in New Hampshire[*]. Nevertheless, wind projects have been approved within less than 60 nm 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 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 Salem Sites (Line 27)

Beverly Municipal Airport is within 8 kilometers (5 miles) of the four most northern sites (SESD, Winter Island, Bentley School, and the Willows), so it is important to file with the FAA early if one of these sites is chosen. The others are farther so we do not expect aviation safety concerns to impose a height limit on turbines at any of these sites. Nevertheless, we recommend filing the FAA 7460-1 early in the process in all cases.

While there are no military airports in the vicinity, the North Truro Joint Use Long Range Radar Site is within 60 nautical miles (69 statute miles) of the Salem sites.

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[*] 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

While we do not expect a Salem wind project to be limited by airspace restrictions, the FAA and the DOD will assess the potential impact (if any) of a wind turbine proposed on Salem city land.

D. Environmental Issues and Permitting

Environmental permitting in general

At this early stage, the following items are reviewed:

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

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

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

Environmental permitting at the Salem sites (Lines 22-26)

All sites other than SESD and the High School carry a land-use designation of open space protection. Some of the sites include Department of Environmental Protection wetlands on the parcel and any wind turbine installation should be sited with a suitable setback from these wetlands.

It is not known if any site carries Article 97 restrictions.

At this stage, environmental permitting does not appear to be a fatal flaw to wind power development on Salem city lands.

E. Wind Turbine Component Transportation & Access

About transportation and access in general

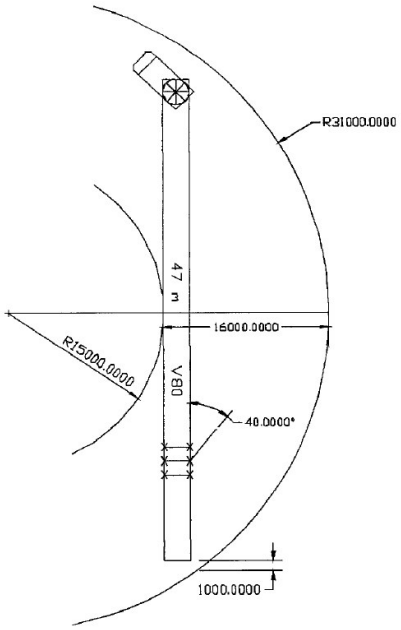
With blades up to 130 feet long, modern wind turbines require transportation on roads with fairly large turning radii and only small changes in slope. The example at right shows the set of turning radii (in millimeters) required for transporting one of the 39-meter turbine blades of a Vestas V80, a 1.8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

Transportation and access to the Salem sites (Line 17)

There may be some logistical difficulties in moving wind turbine components to the sites. Sea access may be the most practical at the coastal sites. An economic analysis of transportation and route options will be necessary for the chosen site, but site access does not appear to be a fatal flaw at this stage.

On-site road improvements and/or construction may be necessary for some sites, particularly at Forest River Park.

If the city proceeds with a wind power project, an access plan will be an important part of the feasibility analysis.



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 Salem sites (Line 16)

SESD has sufficiently sized, medium voltage lines on site. All other sites have three-phase distribution lines at the road or on-site, though voltage and line capacity was not determined.

Interconnection does not appear to be a fatal flaw at this stage. The point of interconnection would be determined later in the project.

G. Potential Electrical Loads Offset

About offsetting loads in general

Energy used on-site is more valuable than energy sold onto the wholesale market. At this preliminary stage, we can compare the energy (kWh) used in a year with the predicted energy that could be generated in a year of turbine operation.

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

About offsetting the load at the Salem sites (Lines 14-15)

SESD: SESD consumes a significant amount of electricity and is a good candidate for distributed generation (DG). While RERL was not provide with detailed energy usage records, at this point, we can estimate that nearly all of the output of a utility-scale wind turbine could be used on-site at SESD.

The facility's energy manager has plans for DG at the plant; their current preferred option is for the primary DG to be cogen with a natural gas turbine, supplemented by a large or medium-scale wind turbine on-site. If steam is available from the neighboring plant, steam turbine cogen may be possible instead of the gas turbine.

If cogen is to be the lead DG, then the design of the cogen plant will influence the size of the wind turbine. To avoid exporting power, the wind turbine may have to be sized smaller than otherwise optimum.

Given the price volatility of natural gas, preferential sizing the wind turbine may be more cost effective in the long run, rather than centering the DG design on a gas turbine and under-sizing the wind turbine. Evaluating the relative economic benefits of DG options are beyond the scope of this report.

Other sites: RERL was not supplied with energy usage of the other sites. To maximize the economic benefits of a wind turbine installation in Salem, it is helpful for most or all of the electricity produced to be used on-site, so a site's electric loads will influence the sizing of a wind turbine for that site. A more detailed analysis at a later date could compare the annual and diurnal profiles of electricity production and consumption at these sites, but given the expected small electric loads, these sites are more likely to be suitable for a small or medium scale turbine.

IV. Conclusions

The city of Salem is interested in a wind power project on municipally owned land. The purpose of this report is to guide the city to its most promising site(s) for further study of wind power feasibility.

The **SESD** wastewater treatment plant is the town's most favorable location for a utility-scale wind power project. Its large on-site electric loads serve to offset the drawback of its lower estimated mean wind speeds. Furthermore, the site is large enough that potential turbine locations on the parcel are suitable distances from neighboring houses.

Winter Island is also an option that the city could pursue further. Extending into the harbor, it is expected to have higher wind speeds than the inland sites, and the current land use is compatible with a wind turbine.

Similarly, **Forest River Park** has higher predicted wind speeds and could be pursued if the city prefers, though space is more constrained at this site and noise may be more of a concern here.

Some of the other sites (Willows, High School, Salem Greens, and Bertram Field) might be candidates for medium or small wind turbines, but the remaining sites (the two elementary schools) are too space-constrained for wind power.

Next steps (Line 29)

After choosing a site for consideration, establishing full feasibility (which may include wind resource monitoring) is an important next step. The wind monitoring process and met tower siting considerations are discussed in Appendix B.

In any case, next steps include:

- Wind resource assessment (to extent appropriate to project size)
- File FAA form 7460-1, and
- Public outreach.

In addition, these site-specific items should be explored:

1. SESD
    - Coordinate with the plant energy manager in considering options for integrating DG into plant's operation.
    - Consider transportation/access cost in feasibility analysis
    - Discuss potential cooperation with neighboring facilities to north and south.
2. Winter Island
    - Investigate potential load offsets
    - Consider transportation/access cost in feasibility analysis

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

Table A1: Data for sites 1-4

		1: SESD	2. Winter Island	3. Forest River Park	4. Willows Recreation Area
Site overview					
1.	Description, current land use	South Essex Sewerage District (SESD): A regional wastewater treatment plant, north of the Salem power plant.	Winter Island Marine Park: town-owned recreation area on a peninsula	A coastal town park with swimming area and tennis courts.	Willows Recreation area: an amusement park area with town beaches
2.	Address	50 Fort Avenue Salem, MA 01970	Winter Island Road Salem, MA	Forest River Park Salem, MA	Fort Ave. & Restaurant Row Salem, MA
3.	Owner	SESD (Consortium of 10 entities, including city of Salem)	City	City	City
Location					
4.	NAD 83, lat & long	42.528992	42.526861	42.504760	42.534828
		-70.873880	-70.868465	-70.884386	-70.872861
5.	Degree, minute, second	42°31'44.37"N 70°52'25.97"W	42°31'36.70"N 70°52'6.47"W	42°30'17.14"N 70°53'3.79"W	42°32'5.38"N 70°52'22.30"W
6.	Approximate Elevation (feet)	3	0 - 31	9	0-20
7.	Notes	–	–	–	–

		1: SESD	2. Winter Island	3. Forest River Park	4. Willows Recreation Area
Wind Speeds					
Estimated Mean Speeds* in m/s					
To convert m/s to mph, multiply by 2.24					
8.	• At height of 100 m	6.8	6.9 – 7.0	6.9	6.8
9.	• At height of 70 m	6.4	6.3 - 6.6	6.4	6.3
10.	• At height of 50 m	5.9	5.9 - 6.2	5.9	5.9
11.	• At height of 30 m	5.5	5.4 - 5.8	5.5	5.4
12.	Wind Speed Summary (for utility-scale):	Marginal, but may be sufficient given large electric load	Marginal	Marginal	Marginal
13.	Existing wind data	Marblehead: ~3 km away Lynn: ~11 km away	Marblehead: ~2 km away Lynn: ~11 km away	Marblehead: ~3 km away Lynn: ~9 km away	Marblehead: ~3 km away Lynn: ~12 km away
Wind Turbine Considerations:					
Economic					
14.	On-site Electric Loads	Waste water treatment plant	Minor	Minor	Minor
15.	Electric Loads, kWh/year	~10 million kWh/year	Minor	Minor	Minor
16.	Distance to Distribution/ Transmission lines**	13.8kV on site	Distribution at site	Distribution at site	Distribution at site
17.	Access for blade transportation**	Coastal access	Sea access may be the best option for Salem's coastal sites, due to the narrow town roads. This should be explored in more detail for a chosen site.	Coastal access	Coastal access
Obstructions to wind					
18.	Terrain	Low peninsula	Low peninsula	Coastal park in sheltered harbor	Low peninsula
19.	Obstacles to wind	Buildings, Large trees	Large trees	Very large trees	Large trees, buildings

		1: SESD	2. Winter Island	3. Forest River Park	4. Willows Recreation Area
Noise					
20.	Nearby residential areas:	Homes lie across plant and are unlikely to be impacted by a wind turbine's noise	Residences on northern end of peninsula, as well as residential youth home	Some residences to the west in Salem, and to the east across water in Marblehead.	Fort Ave. homes, across park
21.	Radius to residences: (m): (ideally >~300m for utility scale‡)	~280 m, depending on micrositing	~310 m to youth home, ~430 m to private residence, depending on micrositing. Also 830 m across water to Marblehead homes.	~320 m to closest Salem homes, and ~560 across water to Marblehead	~200 m, Depending on micrositing. Also ~800 m across water to homes in Beverly
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?	(Adjacent open water)	Some on parcel	Some on parcel	Some on parcel
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 †	No	Open space: Plummer School for Boys & Waikiki Beach	Open Space: Forest River Park	Open Space: Willows
Other permitting					
27.	Distance to airport(s) *(statute miles)*	~ 4 miles to Beverly Municipal Airport ~ 12 miles to Logan Airport	~4 miles to Beverly Municipal Airport ~13 miles to Logan Airport	~ 5 miles to Beverly Municipal Airport ~ 11 miles to Logan Airport	3.8 mi to Beverly M.A.: *may cross surface.* ~ 13 miles to Logan Airport

		1: SESD	2. Winter Island	3. Forest River Park	4. Willows Recreation Area
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?*	Marginal wind speeds but electric load may make this site acceptable.	Marginal wind speeds.	Marginal wind speeds and little electric load. Limited space & nearby residences .	Marginal wind speeds and little electric load. Limited space & nearby residences Possibly airspace obstruction
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):*	Wind resource assessment Coordinate with plant's DG strategy Discuss potential cooperation with neighboring facilities.	Wind resource assessment Discuss potential cooperation with neighboring facilities.	Wind resource assessment	Wind resource assessment FAA filing
30.	***Recommendation*** *Should the city consider this site for a utility-scale wind turbine?* *See also the discussion section.*	Yes	Yes	Possibly	Possibly
31.	***Multiple Turbines*** *If the city is interested in installing more than one turbine, how many could fit at this site?*	Probably only 1 full-scale turbine on SESD land, though cooperation with neighboring facilities may be possible.	1 - 2	1 or conceivably 2	1 or conceivably 2
Met Tower Siting Factors					
32.	Space availability & level terrain	No. This site will not be considered further	May be difficult but possibly, depending on land usage, clearing and terrain.	Yes, in & around tennis courts with removal of fences and some clearing.	Not without clearing or taking over ball field
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.)*	–	Probably not, depending on chosen spot	Light posts would need to be moved	–
34.	Obstacles to wind	–	Large trees, buildings. However, the cove to the SSW offers an open (though short) fetch to the predominant winds	Large trees	Large trees, buildings

		1: SESD	2. Winter Island	3. Forest River Park	4. Willows Recreation Area
35.	Clearing requirements	–	Depends on site chosen.	Removal of fences and some minor clearing.	Significant
36.	Soil quality – for met tower anchors	–	Not tested.	Not tested. Likely rocky.	Not tested.
37.	Road Access – for met tower installation	–	Good	Good	Good
38.	Security	–	Gated park	Gated park	Open public area
39.	Existing towers on or near site	Anemometer nearby	Anemometer nearby	No	No
40.	Distance to AC power if lighting is required	–	–	–	–
41.	Compatibility: If this site were chosen for a wind turbine but not a met tower, where else could wind be monitored? (i.e., which of the other sites are within about 1 mile and have similar terrain?)	Bentley, Willows, Winter Island	Bentley, Willows, SESD	Saltonstall	Bentley, SESD, Winter Island
Met Tower: Primary Constraint					
42.	What factors will most affect feasibility and/or siting of a met tower here?	Insufficient space	Difficulty finding space compatible with land usage	Nearby tall trees will disrupt the wind flow and make the data difficult to interpret	Insufficient space. Nearby trees
Met Tower Recommendation:					
43.	Recommended site:	Insufficient space on site. Possibly make arrangements with Winter Island, neighboring parcels or parcel across the street	Work with site managers to allot sufficient space.	Confirm that the tennis court area is sufficient	Not recommended
44.	Recommended met tower height (meters)	50 meters	50 meters	50 meters	50 meters

Table A2: Data for sites 5-9

		5. Saltonstall School	6. Bentley School	7. Bertram Field at Collins Middle School	8. Salem High School	9. Salem Greens Golf Course
Site overview						
1.	Description, current land use	Primary School	Primary School	Francis Xavier Collins Middle School, with adjacent playing field (Bertram Field) and undeveloped area to the NE	High School	Golf Course
2.	Address	211 Lafayette Street Salem, MA 01970	25 Memorial Dr. Salem, MA	29 Highland Ave. Salem, MA	77 Willson Street Salem, MA	75 Willson Street Salem, MA
3.	Owner	City	City	City	City	City
Location						
4.	NAD 83, lat & long	42.513757°	42.527385	42.512960°	42.504864°	42.503474°
		-70.888579°	-70.881414	-70.904406°	-70.909213°	-70.906141°
5.	Degree, minute, second	42°30'49.53"N 70°53'18.88"W	42°31'38.59"N 70°52'53.09"W	42°30'46.66"N 70°54'15.86"W	42°30'17.51"N 70°54'33.17"W	42°30'12.51"N 70°54'22.11"W
6.	Approximate Elevation (feet)	0-20	10	35-69	68	15-79
7.	Notes	–	–	This site was not toured. The generally available data shown here is sufficient to draw some conclusions, but if the town is interested in pursuing wind at this site, another visit will be needed.	–	–

		5. Saltonstall School	6. Bentley School	7. Bertram Field at Collins Middle School	8. Salem High School	9. Salem Greens Golf Course
Wind Speeds						
Estimated Mean Speeds* in m/s						
To convert m/s to mph, multiply by 2.24						
8.	• At height of 100 m	6.8	6.7	6.8	6.8	6.8
9.	• At height of 70 m	6.3	6.2	6.4	6.4	6.3
10.	• At height of 50 m	5.8	5.8	6.0	5.9	5.8
11.	• At height of 30 m	5.2	5.4	5.6	5.3	5.2
12.	Wind Speed Summary (for utility-scale):	Marginal	Marginal	Marginal	Marginal	Marginal
13.	Existing wind data	Marblehead: ~3 km away Lynn: ~9 km away	Marblehead: ~3 km away Lynn: ~11 km away	Marblehead: ~4 km away Lynn: ~8 km away	Marblehead: ~5 km away Lynn: ~7 km away	Marblehead: ~43 km away Lynn: ~7 km away
Wind Turbine Considerations:						
Economic						
14.	On-site Electric Loads	School, including ball field lights	School	School, including ball field lights	School, including ball field lights	Minor: golf course
15.	Electric Loads, kWh/year	TBD	TBD	TBD	TBD	TBD
16.	Distance to Distribution/ Transmission lines**	Distribution at site	Distribution at site	Distribution at site	Distribution at site	Distribution at site
17.	Access for blade transportation**	Coastal access	Coastal access	May be difficult in narrow streets	May be difficult in narrow streets	May be difficult in narrow streets
Obstructions to wind						
18.	Terrain	Coastal	Coastal	Irregular terrain on site	Low rise	Irregular
19.	Obstacles to wind	Buildings, trees	Buildings, trees	Buildings, terrain, trees	Buildings, terrain, trees	Terrain, trees

		5. Saltonstall School	6. Bentley School	7. Bertram Field at Collins Middle School	8. Salem High School	9. Salem Greens Golf Course
Noise						
20.	Nearby residential areas:	Yes	Yes	Yes. Also hospital to SW	Houses to north and east	Houses to north and east
21.	Radius to residences: (m): (ideally >~300m for utility scale‡)	~80 m	~75 m	~150 m to residences, depending on micrositing	~300 m, depending on micrositing	200-500 m, depending on micrositing
Environmental permitting †						
22.	Designated by the Natural Heritage & Endangered Species Program as a Core Habitat or a Supporting Natural Landscape?	No	No	No	No	No
23.	Designated by the DEP as Wetlands?	Some on parcel	No	No	Some on parcel	Some on parcel
24.	Designated by the Massachusetts Audubon Society as an Important Bird Area (IBA)?	No	No	No	No	No
25.	Is the site a current or former landfill? *(RERL does not install met towers on landfills)*	No	No	No	No	No
26.	Other land-use restrictions, e.g. Article 97 †	Open Space: Palmer Cover	Open Space: Bentley Park	Open Space: Bertram Field	None known	Open Space: Highland Park
Other permitting						
27.	Distance to airport(s)	~ 5 miles to Beverly Municipal Airport ~ 11 miles to Logan Airport	~ 4 miles to Beverly Municipal Airport ~ 12 miles to Logan Airport	~ 5 miles to Beverly Municipal Airport ~ 11 miles to Logan Airport	~ 5 miles to Beverly Municipal Airport ~ 10 miles to Logan Airport	~ 5 miles to Beverly Municipal Airport ~ 10 miles to Logan Airport

		5. Saltonstall School	6. Bentley School	7. Bertram Field at Collins Middle School	8. Salem High School	9. Salem Greens Golf Course
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?*	Low wind speed & little electrical load. Nearby residences. Possibly access.	Low wind speed & little electrical load. Nearby residences. Possibly access.	Low wind speed & little electrical load. Nearby residences. Possibly access.	Low wind speed & little electrical load. Possibly access.	Low wind speed & little electrical load. Possibly access.
29.	***Next step / To be determined*** *To pursue wind power at this site, these items should be explored first (along with wind monitoring and public outreach):*	–	–	–	Preliminary economic feasibility study prior to wind resource assessment.	Preliminary economic feasibility study prior to wind resource assessment.
30.	***Recommendation*** *Should the city consider this site for a utility-scale wind turbine?* *See also the discussion section.*	No	No	No	Possibly, but not the most favorable site Possibly consider a smaller wind turbine	Possibly, but not the most favorable site Possibly consider a smaller wind turbine
31.	***Multiple Turbines*** *If the city is interested in installing more than one turbine, how many could fit at this site?*	–	–	–	TBD	TBD
Met Tower Siting Factors						
32.	Space availability & level terrain	Not without taking ball field out of use	Not without taking ball field out of use	Not known, because the open area to the north of football field was not toured. If terrain is level and clear, this may be a possibility	Yes, if soccer field can be used, fences removed, and some minor clearing	Rolling terrain makes it difficult to find a large enough level area without clearing
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.)*	–	–	Unknown	No	No

		5. Saltonstall School	6. Bentley School	7. Bertram Field at Collins Middle School	8. Salem High School	9. Salem Greens Golf Course
34.	Obstacles to wind	–	–	Trees, terrain, buildings	Low trees, terrain	Trees, terrain
35.	Clearing requirements	–	–	Unknown	Some clearing is necessary to create lay-down space for a 50-meter met tower. Some of the fence would need to be removed	Probably would require significant clearing
36.	Soil quality – for met tower anchors	–	–	Unknown	Not checked. Special anchoring may be required	Not checked.
37.	Road Access – for met tower installation	–	–	Unknown	Good	Depends on specific site
38.	Security	–	–	Unknown	Fence would need to be removed, at least partially	Gated area
39.	Existing towers on or near site	–	–	Unknown	None known	None known
40.	Distance to AC power if lighting is required	–	–	–	–	–
41.	Compatibility: If this site were chosen for a wind turbine but not a met tower, where else could wind be monitored? (i.e., which of the other sites are within about 1 mile and have similar terrain?)	Forest Park	Willows, SESD, Winter Island	High School, Golf Course	Bertram Field, Golf Course	High School, Bertram Field
Met Tower: Primary Constraint						
42.	What factors will most affect feasibility and/or siting of a met tower here?	Insufficient space	Insufficient space	Unknown	Use of soccer field. Ability to clear some brush or possibly trees	Insufficient space. terrain
Met Tower Recommendation:						
43.	Recommended site:	Not recommended	Not recommended	Unknown	Soccer field if it can be used and minor clearing is possible	Not recommended
44.	Recommended met tower height (meters)	50 meters	50 meters	50 meters	50 meters	50 meters

Notes:

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

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

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

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

Appendix B: Wind-Monitoring Logistics

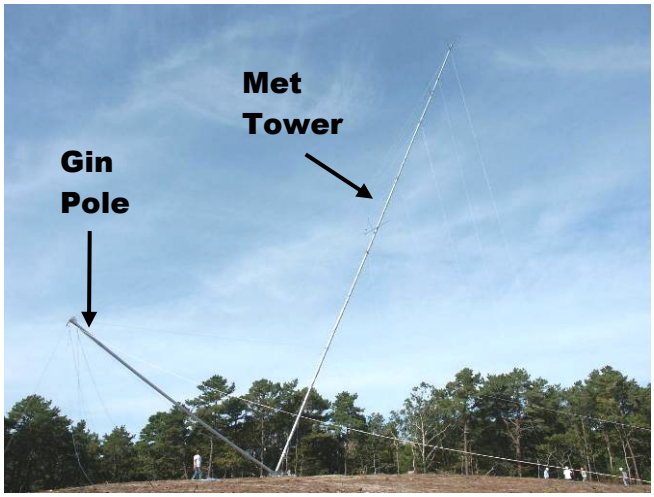
Traditionally, wind is monitored for about a year with a met tower. Some sites may be suitable for other types of monitoring in addition to a met tower. This section will concentrate on the siting of a met tower. Figure 1 in Appendix C is a schematic of a met tower.

About met towers

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

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

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



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

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

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

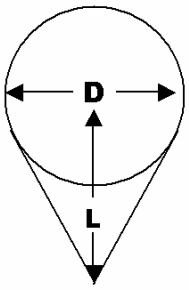
Typical 6-foot-long utility screw-in anchor

An anchor, installed, with 2 guy wires attached

Space required for a met tower

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

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



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

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

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

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

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

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. Met tower siting, however, 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 at the Salem sites.

Space Availability at the Salem Sites (Line 32-34)

Forest River and the High School have room for a 50-meter met tower, each with some clearing required. Bertram Field was not checked for met tower space. SESD, Saltonstall and Bentley have insufficient space. The Willows, the golf course and Winter Island could probably have sufficient space but would probably require excessive clearing.

Clearing requirements (Line 35)

See tables in Appendix A for notes on clearing required at individual sites.

Soil quality & anchor requirements (Line 36)

The soils at the sites were not tested. Installing anchors will require some planning; longer or larger anchors may be required. The anchors would be tested at the time of installation.

Accessibility for met tower installation (Line 37)

All of the sites have good accessibility for RERL's pick-up truck.

Permitting: Local approval process

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

Nearby airports & FAA restrictions for met towers

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

Lighting

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

Proximity of anemometry & turbine (Line 41)

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

See tables in Appendix A for notes on compatibility of sites.

Met tower size recommendation (Line 43-44)

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

If wind monitoring is pursued, a 50-meter met tower is recommended for these sites.

Conclusion: met tower siting recommendations

Wind-monitoring options should be discussed further depending on the turbine size considered and the allowable uncertainty associated with the project. If the city is interested in installing a utility-scale wind turbine at either site, then wind monitoring is recommended for that site. If a medium-scale wind turbine is considered, wind monitoring is not essential, but would improve the level of certainty in the success of the project.

If the city decides to monitor the wind resource, then it is recommended that a 50-meter met tower be installed at the site of interest.

The preferred resource assessment method depends on the chosen turbine site:

1. SESD & Winter Island: arrange to use existing nearby data
2. Forest River Park: if the tennis court area can be used, there is sufficient space. However, the tall trees nearby will distort the data.
3. Bertram: this site needs to be reviewed
4. Salem High School: with some clearing, the soccer field could be used for a met tower.
5. Golf Course: if a wind turbine were proposed here, significant land would have to be cleared. Monitoring at the high school could also be an option

Appendix C: Maps, Photos, and Figures

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

Source for base maps:

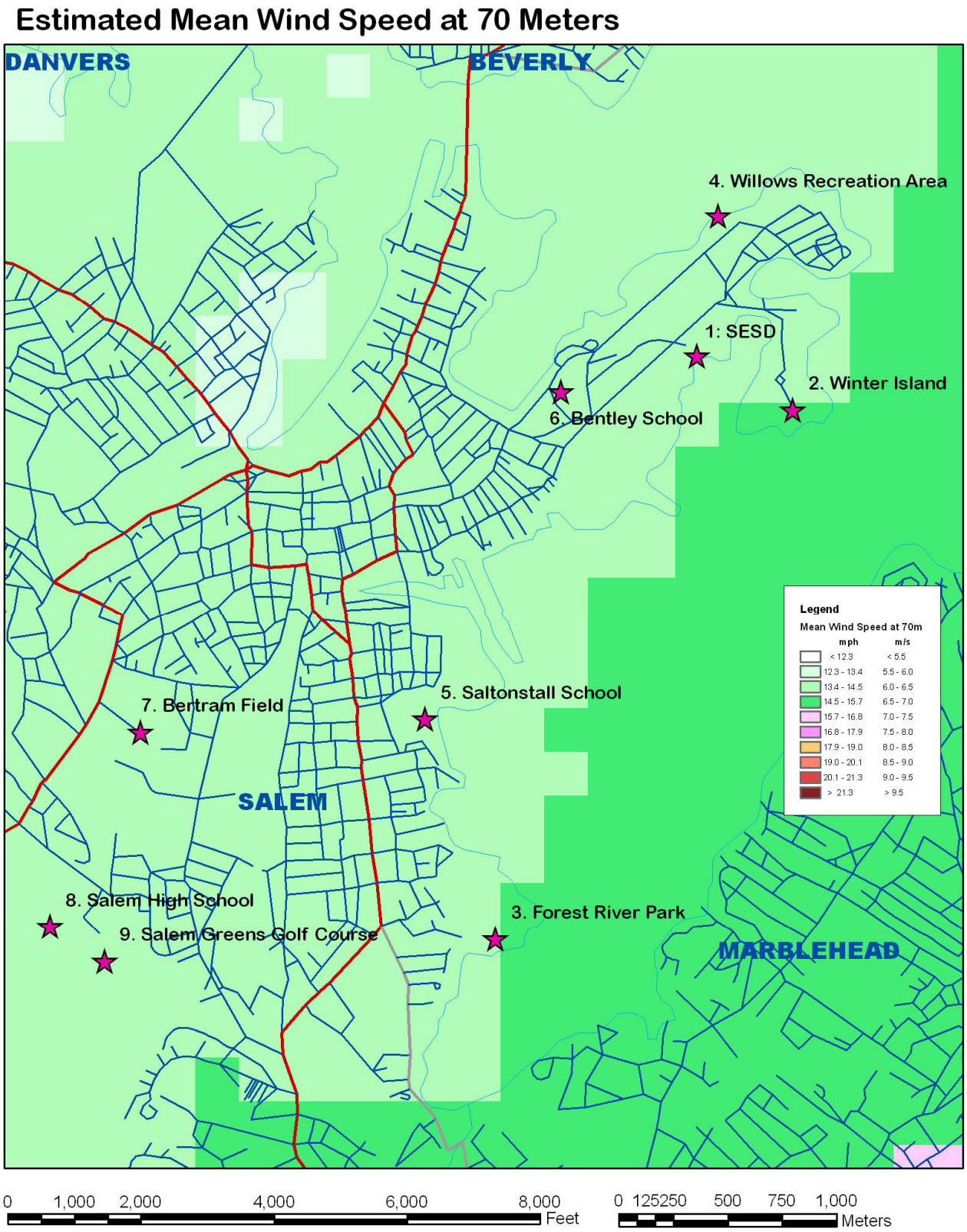
Ortho (aerial) photographs are from the MassGIS website, www.mass.gov/mgis/dwn-imgs.htm. The entire Commonwealth was photographed in April 2005, when deciduous trees were mostly bare and the ground was generally free of snow.

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

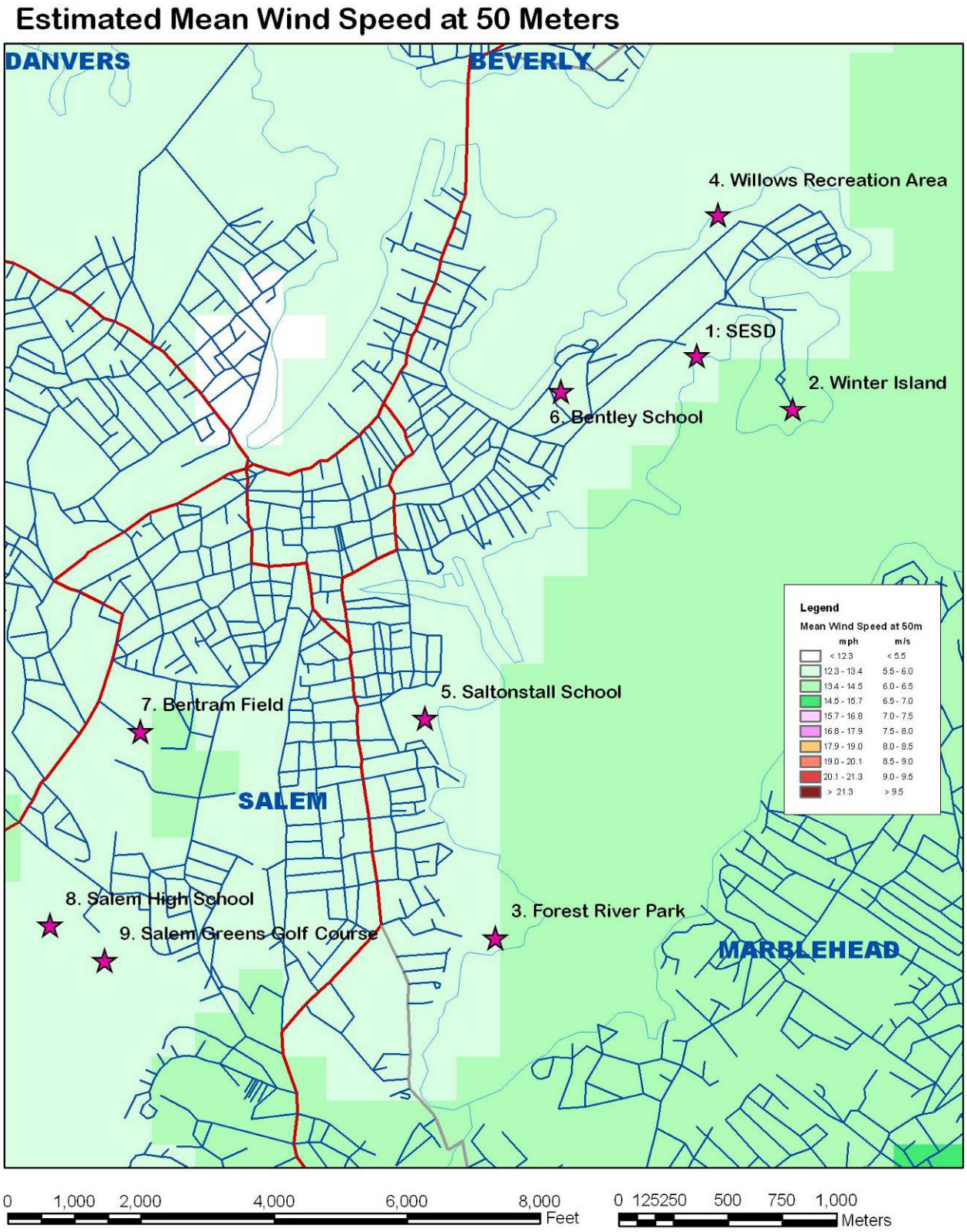
Mean wind speeds are AWS-Truewind's estimates for New England, 2003. For more information, see TrueWind Solutions, truewind.teamcamelot.com/ne/.

Map 1: Orthographic (aerial) photo of the city of Salem. The sites under consideration for a wind power project that are discussed in this report are marked in pink stars and labeled.

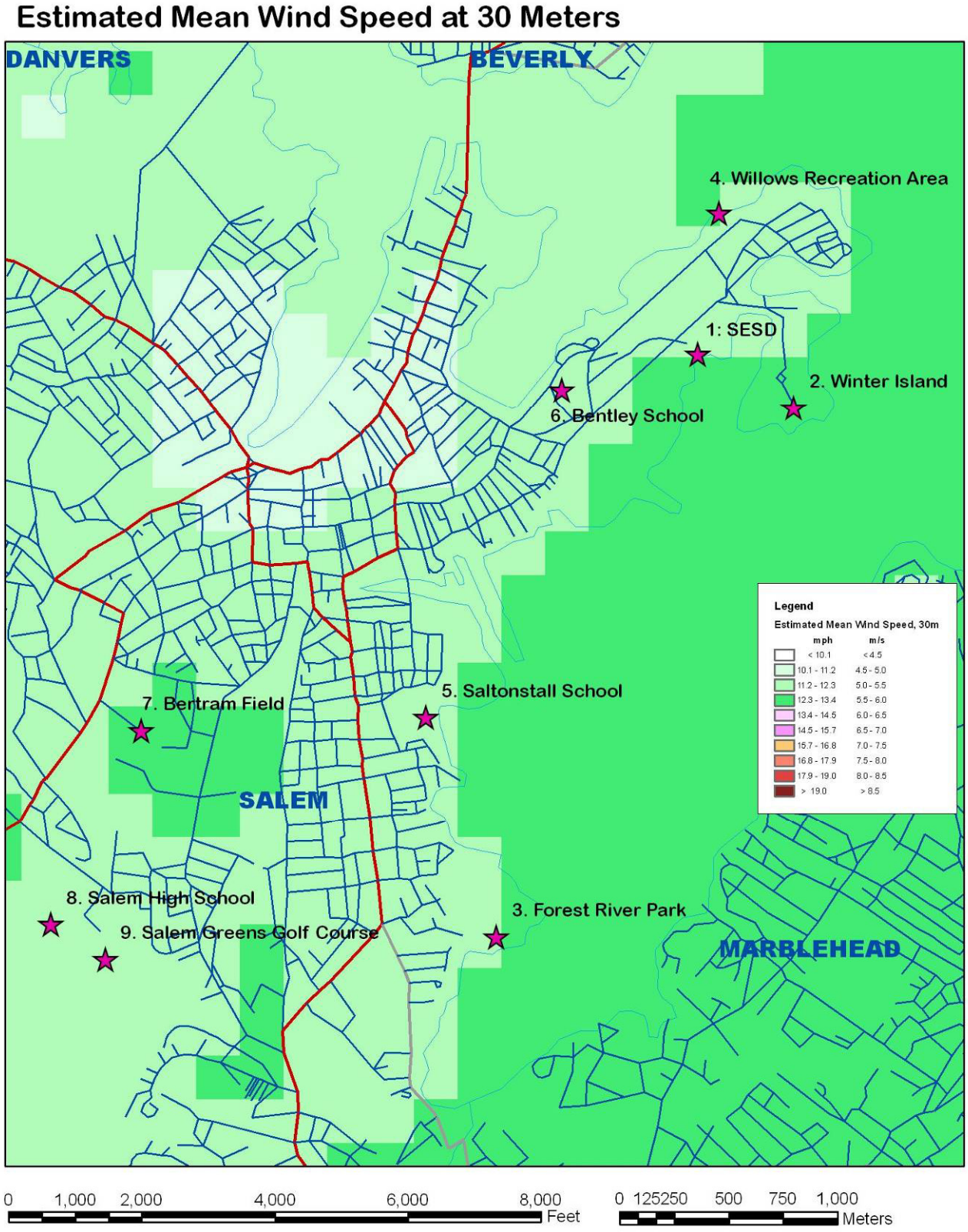
Map 2: Estimated mean wind speeds at 70-meters height at the Salem sites, based on AWS-TrueWind models. For more information, see TrueWind Solutions, truewind.teamcamelot.com/ne/



Map 3: Medium-Scale Wind Turbines: Estimated mean wind speeds at 50-meters height at the Salem sites, based on AWS-TrueWind models. For more information, see TrueWind Solutions, truewind.teamcamelot.com/ne/



Map 4: Small-scale wind turbines: Estimated mean wind speeds at 30-meters height at the Salem sites, based on AWS-TrueWind models. For more information, see TrueWind Solutions, truewind.teamcamelot.com/ne/



Map 5: Orthophotograph of the three northeastern sites

Photo 1: SESD: looking north at the cul-de-sac at NE side of parcel.

Photo 2: Winter Island: Harbormaster's office, with power plant in the background

Photo 3: Winter Island: boat launch parking lot

Photo 4: Forest River Park: possible turbine location on eastern shore of park

Photo 5: Forest River Park: looking east across tennis courts. Possible met tower location.

Photo 6: Forest River Park: looking west across tennis courts. Possible met tower location.

Photo 7: Willows Recreation area: gravel parking area surrounded by mature trees

Photo 8: High school soccer field

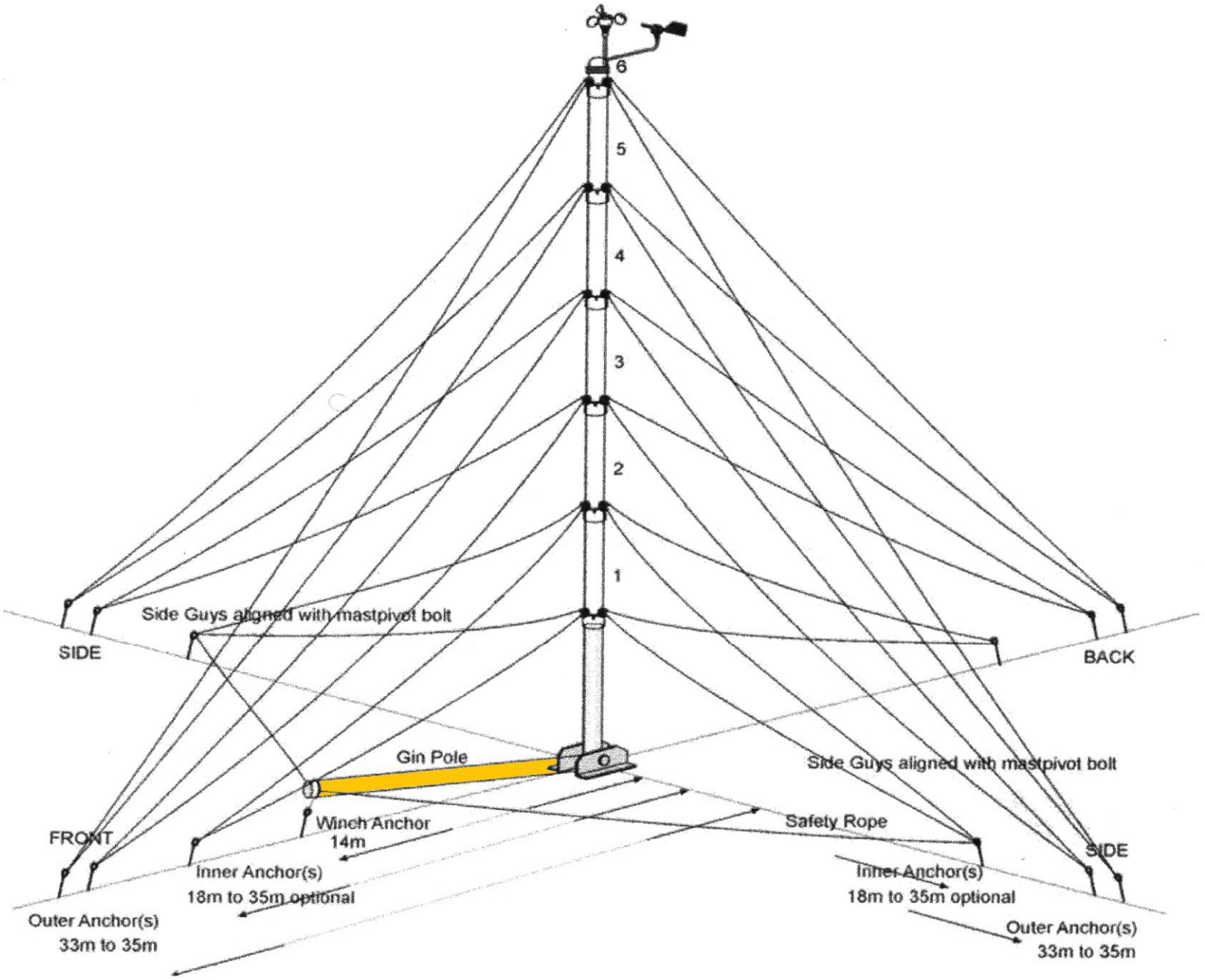


Figure 1. Guy line layout for a 50-meter met tower from Second Wind, Inc.