



Renewable Energy Research Laboratory

Department of Mechanical and Industrial Engineering
University of Massachusetts
160 Governor's Drive
Amherst, MA 01003-9265

Phone: 413-545-4359
Fax: 413-577-1301
www.ceere.org/rerl
rerl@ecs.umass.edu



Wind Power In Yarmouth: Siting Considerations for a Wind Turbine

Melissa Elkinton and Sally Wright, M.S., P.E.

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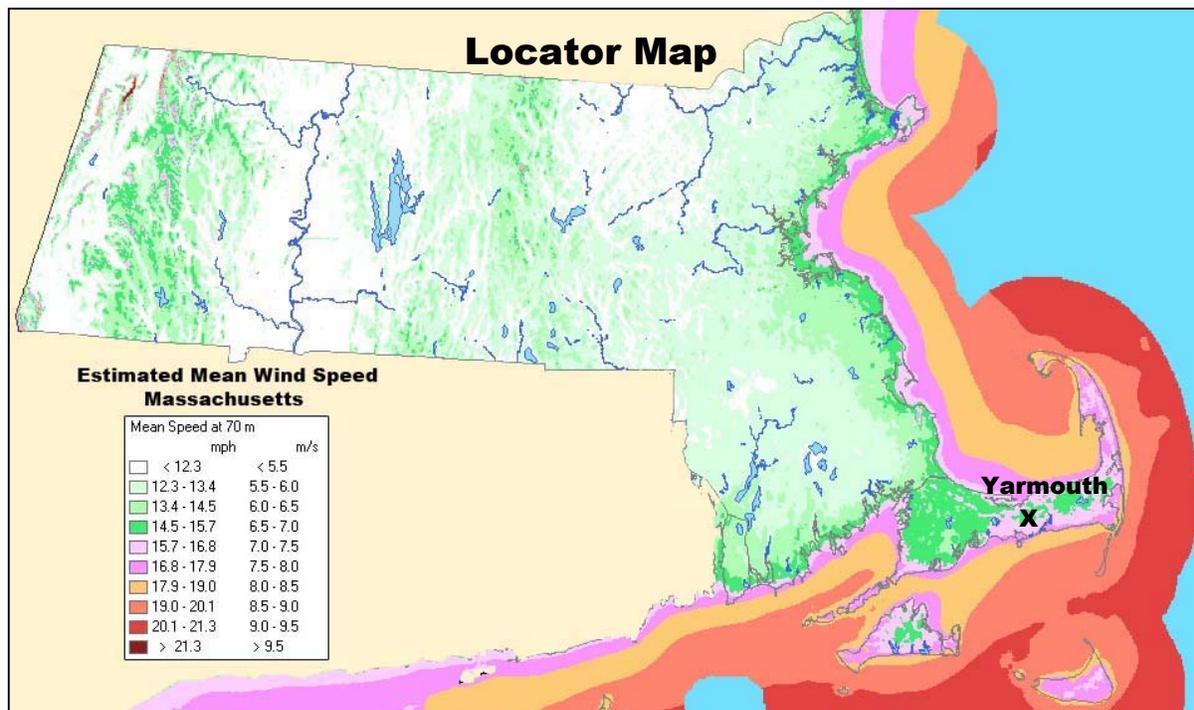
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I. Introduction

At the request of the Massachusetts Technology Collaborative's Renewable Energy Trust, Melissa Elkinton of the UMass Renewable Energy Research Laboratory (RERL) visited potential wind turbine and/or wind-monitoring sites in the town of Yarmouth, along with the Director of Public Works, Mr. George Allaire.

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 town should move forward in considering this type of wind power project.

The "Locator Map" on the previous page is an AWS-TrueWind map of the estimated mean wind speeds in Massachusetts at 70 meters height. Areas of primary interest for utility-scale wind power have estimated mean wind speeds of 6.5 m/s or greater (dark green or more). On this map, the town of Yarmouth 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 Yarmouth. 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 town explores its options for wind development at municipally owned sites.

II. Sites Considered

The town of Yarmouth requested that six locations be evaluated for suitability for a wind power project (Appendix A, lines 1-7).

1. Septage Treatment Facility
The Septage Treatment Facility is located at the ends of Forest and Workshop Roads. A treatment facility, a large sewage storage tank, and a railroad transfer station occupy the 34.5-acre parcel. The elevation of the site is about 76 feet.
2. Well Pump Sites #10 & #11
These wells are on a 61.4-acre town parcel that is at an elevation of about 26 feet. The parcel, which can be accessed from Forest Road, is forested and bisected by a creek with a well on each side.
3. Dennis-Yarmouth Regional High School
Located at 210 Station Avenue, the high school parcel is 105.2 acres and consists of several school buildings, athletic fields, and a newly constructed water treatment plant. The high school is surrounded by trees and is at an elevation of about 43 feet. Station Avenue Elementary School and the Dennis-Yarmouth Regional School District administration buildings are directly northwest of the high school.
4. Well Pump Sites #15 & #16
These well sites are accessed from N. Dennis Road, north of Route 6. The 247-acre parcel is forested and at an elevation of about 34 feet.
5. Department of Public Works Water Division Headquarters
Located at 99 Buck Island Road, the DPW headquarters is a 155.2-acre parcel consisting of an office building, police dog training facility, and an effluent leaching field. The elevation is approximately 16 feet.
6. Well Pump Site #13
This site is on a large, forested town parcel that abuts the Mattacheese Middle School and the Yarmouth Police Department. It is also near Marguerite E. Small Elementary School. The property is forested, relatively flat, and at an elevation of about 52 feet. There is an area on the parcel that was previously cleared as a site for a met tower.

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 (generally, these “fatal flaws” vary with the heights of the specific turbines and their applications). 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)

The AWS-TrueWind model estimates annual average wind speeds at the Yarmouth sites in the range of 6.5 and 7.0 m/s at a height of 50 meters. While not ideal, these wind speed estimates are suitable for utility- or medium-scale wind power. The septage treatment facility and high school in particular, warrant further consideration because they have the ability to use some of the energy on-site.

Other available wind data (Line 13)

The RERL installed wind-monitoring equipment in Yarmouth, Harwich, and Barnstable. The data from Yarmouth is for most of 1996 and 1997, but is only at heights of 30 and 20 meters. The Yarmouth site is between 1 and 3 miles from the proposed wind turbine sites.

Wind monitoring started in Harwich in July 2006 and eight months of wind data are available from this site, which is between 6 and 9 miles from the Yarmouth sites. The measurement heights in Harwich are 50, 38, and 20 meters.

The Barnstable wind-monitoring site is between 4 and 6 miles from the Yarmouth locations, and one year of wind data is available from this site at measurement heights of 39, 30, and 10 meters.

These wind data sets are either too far away or at too low a height; if a utility-scale wind turbine is under consideration, on-site wind monitoring is advisable.

Depending on the chosen site, the Yarmouth and Barnstable wind data may be close enough to be useful in determining the feasibility of a medium-scale wind project.

These RERL wind data sets are available on the web:

http://www.ceere.org/rerl/publications/resource_data/

Obstacles to wind flow (Lines 18-19)

The primary obstacle to wind flow at the septage treatment plant is the small hill to the east of the facility. The 100-120 foot ridge west of the well pump sites #15 and #16 is also a significant obstacle. The main obstacles to wind flow at the rest of the sites are trees and/or buildings.

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

B. Noise

About Noise in general

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

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

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

For example, this first-pass rule of thumb tells us that a turbine with a 77-meter rotor diameter on a 60-meter tower should be about 300 meters (~1000 feet) from residences. Other 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 town's citizens. The town's decision to site a wind turbine must take into consideration the community's needs and priorities.

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

Noise at the Yarmouth sites (Lines 20-21)

Noise could be a siting constraint for a wind turbine at several of the sites since there are residences in the general area of each. Consideration of the neighbors will be an important factor in siting and sizing a wind turbine on these municipal parcels.

The nearest houses to the septage treatment plant and well pump site #13 are all more than 400 meters (1,300 ft) away. Depending on the micrositing on the DPW headquarters parcel, the closest houses are between 300 – 350 meters (1,000 – 1,150 ft) away. From a noise perspective, the “three-times-blade-tip” distance guideline suggests a large utility-scale wind turbine (1.5 MW or larger) is possible at these sites.

Depending on micrositing, potential turbine sites on the high school, and well pump sites #15 and #16, and well pump sites #10 and #11 parcels are approximately 250 meters (820 ft) to the nearest houses. For these sites, a small utility-scale wind turbine (e.g. 660 kW) may be more appropriate to minimize noise.

If a wind turbine is considered for the police station, which is near well pump site #13, the nearest houses are less than 200 meters (670 feet) away. For this site, a medium-scale turbine would be more appropriate to minimize noise.

Maps 4-8 show locations at a selection of the sites where various turbines are most appropriate with respect to noise.

C. Nearby Airports

About airspace in general

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

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

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

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

Airspace at the Yarmouth Sites (Line 27)

Barnstable Municipal Airport is between 1.6 and 4.1 miles away from the Yarmouth proposed wind turbine sites. In 2006, after Yarmouth filed a FAA 7460-1 in 2005 for a proposed turbine site near well pump site #13, the FAA issued a “Determination of Presumed Hazard,” stating that the highest structure at that location that would not impact instrument approach to Barnstable Municipal Airport is 218 feet above ground level (or 280 feet mean sea level). A Fuhrländer FL 250 turbine on 50-meter tower, which has a blade-tip-height of 212 feet, would just satisfy this criterion. The FAA determination report can be found on the FAA website:

<https://www.oecaaa.faa.gov/oecaaa/external/searchAction.jsp?action=displayOECCase&oeCaseID=428878>

Consultants for MTC, Aviation Systems Inc., conducted FAA studies for the remaining sites. They reported that at the septage treatment facility a wind turbine with a blade-tip-height up to 180 feet above ground level (AGL) should receive a routine approval from the FAA. A Fuhrländer FL 100 turbine with a blade-tip-height of 149 feet would fit this criterion. A wind turbine with a blade-tip-height up to 225 feet, such as the FL 250 on a 50-meter tower, should be approved at well pump sites #10 and #11. At the regional high school and well pump sites #15 and #16, a structure up to 316 and 317 feet, respectively, should receive a routine approval. For these locations a Vestas V47 with a blade-tip-height of 241 feet would be a wind turbine that would satisfy these criteria. A wind turbine with a blade-tip-height up to 235 feet, such as the FL 250 on a 50-meter tower, should be approved at the DPW headquarters.

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 Yarmouth sites. The U.S. Air Force has published a memo establishing the following policy:

The Department of Defense/Department of Homeland Security Long Range Radar Joint Use Program Office Interim Policy is to contest any establishment of windmill farms within radar line of sight of the national Air Defense and Homeland Security Radars.

The Nantucket Memorial Airport Surveillance Radar is about 30 statute miles south of the sites and the FAA will have to assess the potential impact (if any) of a wind turbine proposed in Yarmouth.

Due to the close proximity of the Yarmouth sites to the Barnstable Municipal Airport, we recommend filing the FAA form 7460-1 early in the wind turbine project process.

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 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 Yarmouth sites (Lines 22-26)

Four of the six sites have some form of land-use designation. Well pump site #13 is designated as NHESP Core Habitat. There are Department of Environmental Protection wetlands on all of the well pump site parcels, and any turbine location should be outside an appropriate buffer from these. The well pump site parcels are also designated as open space with “in perpetuity” protection. The high school parcel has “limited” open space protection. It is not known if the sites carry Article 97 restrictions.

There are no Massachusetts Audubon Society Important Bird Areas (IBAs) at any of the Yarmouth sites. The nearest IBAs are West Dennis Beach, Yarmouth Beaches, Kalmus Beach Park, and South Cape Beaches at Sandy Neck. These IBAs are approximately 2 – 5 miles from the Yarmouth sites.

None of the Yarmouth sites are current or former landfills.

At this stage, environmental permitting does not appear to be a fatal flaw to wind power development in Yarmouth.

E. Wind Turbine Component Transportation & Access

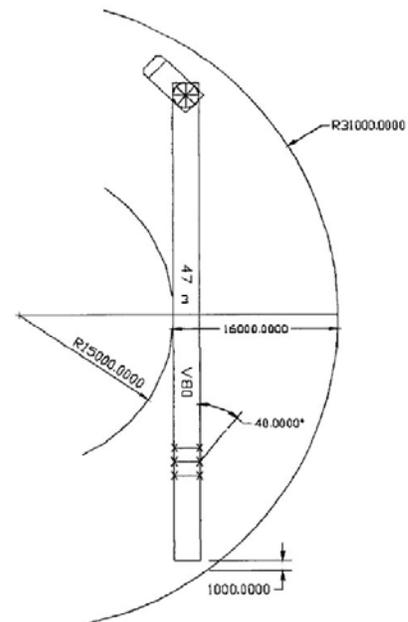
About transportation and access in general

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 Yarmouth sites (Line 17)

There may be some logistical difficulties in moving wind turbine components to the sites, but site access does not appear to be a fatal flaw at this stage.

Route planning will be necessary for all of the sites. On-site road improvements and/or construction may also be necessary, especially at the well pump sites. If the town proceeds with a wind power project at this site, an access plan would need to be discussed as 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 Yarmouth sites (Line 16)

All of the Yarmouth sites have three-phase distribution or transmission lines on-site. The ratings of these lines are unknown, but interconnection does not appear to be a fatal flaw at this stage. The point of interconnection would be determined later in the project.

G. Potential Electrical Loads Offset

About offsetting loads in general

Energy used on-site is more valuable than energy sold onto the wholesale market. At this preliminary stage, we 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 Yarmouth sites (Lines 14-15)

A significant amount of electricity is consumed on-site at the septage treatment facility and the high school. The town properties, namely Mattacheese Middle School and the police station, that are near well pump site #13 also consume a significant amount of electricity. The table below summarizes the approximate annual electricity consumption at each of the Yarmouth sites, and also the on-site use of the town parcels adjacent to well pump site #13. The septage treatment facility, the well pump sites, the DPW headquarters, and the police station have fairly constant consumption throughout the year. The electricity usage at the schools is expected to be higher during the school year and concentrated in a limited number of hours over the week.

Annual Energy Consumption at the Yarmouth Sites

Site	KWh/year
Septage treatment facility	1,800,000
Well pump stations #10 & #11	114,000
Regional high school	1,609,000
Well pump sites #15 & #16	186,000
DPW water division headquarters	108,000
Well pump site #13	2,300
Mattacheese Middle School	440,000
Marguerite E. Small Elementary School	130,000
Yarmouth Police Station	625,000

To maximize the economic benefits of a wind turbine installation in Yarmouth, it is helpful for most or all of the electricity produced to be used on-site. Rough estimates of the annual energy productions of four sizes of wind turbines hypothetically installed at the proposed sites are given in the table below. These estimates are based on the following assumptions:

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

Estimated Annual Energy Production of Selected Turbines

Wind Turbine (rated power) hub height	Annual Energy Production (kWh/year)					
	Septage Facility	Wells #10 & #11	High School	Wells #15 & #16	DPW HQ	Well #13
Fuhrländer FL 100 (100 kW) 50 m	265,000	290,000	282,000	257,000	307,000	298,000
Fuhrländer FL 250 (250 kW) 50 m	545,000	596,000	580,000	528,000	630,000	613,000
Vestas V47 (660 kW) 70 m	1,701,000	1,609,000	1,747,000	1,792,000	1,701,000	1,701,000
General Electric GE 1.5sl (1,500 kW) 70m	4,269,000	4,052,000	4,377,000	4,483,000	4,269,000	4,269,000

A more detailed analysis at a later date could compare the annual and diurnal profiles of electricity production and consumption at these sites.

At this point, we can estimate that nearly all of the output of the 100 kW and 250 kW turbines could be used on-site at the septage treatment facility and high school.

We can safely predict that at all the sites, especially those with smaller on-site loads, most of the output of a utility-scale turbine would be exported to the grid.

IV. Conclusions

The town of Yarmouth is interested in a wind power project on municipally owned land. It appears that for most of the sites, only a medium- or small utility-scale wind turbine is possible due to FAA height restrictions. The estimated mean wind speeds at the sites are moderately good for wind power development, and large on-site loads at the septage treatment facility and regional high school make the economic outlook more favorable.

For any wind power project, the town will need to balance the costs and benefits of its investment. At this stage, three of the proposed sites are most promising: a medium-scale turbine installation at the septage treatment plant or on the town parcels near well pump site #13 and a medium- to small utility-scale turbine at the regional high school.

Site Recommendations

1. Septage Treatment Facility
Due to FAA height restrictions, only a turbine with a blade-tip-height similar to a FL 100 is possible at this site. Space is somewhat limited, but the large on-site load creates more favorable economics. This location could accommodate a single medium-scale turbine.
2. Well Pump Sites #10 & #11
Due to FAA height restrictions, only a turbine with a blade-tip-height similar to a FL 250 on a 50-meter tower is possible at this site. With a relatively small on-site load, it seems unlikely that a wind project at this site would be economically viable.
3. Dennis-Yarmouth Regional High School
In order to satisfy FAA height restrictions, only a small utility-scale wind turbine, such as a V47 is possible at this site. With good estimated wind speeds, a large on-site load, and several possible turbine locations where noise is unlikely to be an issue for nearby residences, the high school appears to be a promising location for a wind turbine project.
4. Well Pump Sites #15 & #16
FAA height restrictions for this location are not known, but it is likely that nothing larger than a V47 would be possible at this site. With a relatively small on-site load, it seems unlikely that a wind project at this site would be economically viable.
5. Department of Public Works Headquarters
FAA height restrictions for this location are not known, but it is likely that they will be similar to the restrictions at the well pump sites #10 and #11. With a relatively small on-site load, the economics of a wind project at this site may be marginal.
6. Well Pump Site #13
The largest turbine possible at this site, in order to satisfy FAA height restrictions, is an FL 250 turbine on a 50-meter tower. The on-site load at the pump station is very small, however, so the siting of a turbine at the middle school or police station would create a better economic outlook. Depending on micrositing, a turbine at the police station may be less than 200 meters (660 ft) from the nearest residences, suggesting noise issues should be considered in more detail.

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 siting considerations are discussed in Appendix B.

In addition to wind monitoring and public outreach, these site-specific items related to pursuing wind power in Yarmouth should be explored:

- File FAA form 7460-1
- Investigate the potential load offsets
- Determine any land-use restrictions, wetlands delineations, etc.
- Check status of Core Habitat near well pump site #13

A preliminary economic analysis is also important to help the town decide whether a wind power project 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 Yarmouth: Siting Considerations for a Wind Turbine” for a discussion of these data.

		1. Septage Treatment Facility	2. Well Sites #10 & #11	3. Regional High School	4. Well Sites #15 & #16	5. DPW Water Division HQ	6. Well Site #13
Site overview							
1.	Description, current land use	Treatment plant, sewage storage tank, transfer station	Pump houses	Buildings, parking lots, athletic fields	Pump houses	Building, DPW yard, police dog training facility, grass leach field	Pump houses, near Police station and elementary and middle schools
2.	Address	Forest Road & Workshop Road	Forest Road	210 Station Avenue	North Dennis Road	99 Buck Island Road	Chickadee Lane
3.	Owner	Town	Town	Town	Town	Town	Town
Location							
4.	NAD 83, lat & long	41.688557 N	41.676241 N	41.677137 N	41.695358 N	41.662976 N	41.673248 N
		70.217861 W	70.220449 W	70.194368 W	70.193079 W	70.225118 W	70.238747 W
5.	Degree, minute, second	41°41'18.76"N 70°13'04.30"W	41°40'34.39"N 70°13'13.46"W	41°40'37.68"N 70°11'39.82"W	41°41'43.18"N 70°11'35.16"W	41°39'46.68"N 70°13'30.49"W	41°40'23.51"N 70°14'19.44"W
6.	Elevation (feet)	76	36	43	34	16	52
7.	Notes	34.5 acres	61.4+ acres	105.2 acres	247 acres	155.2 acres	

		1. Septage Treatment Facility	2. Well Sites #10 & #11	3. Regional High School	4. Well Sites #15 & #16	5. DPW Water Division HQ	6. Well Site #13
Wind Speeds							
<i>Estimated Mean Speeds* in m/s</i>							
<i>To convert m/s to mph, multiply by 2.24</i>							
8.	• At height of 100 m	7.6	7.6	7.8	7.8	7.7	7.7
9.	• At height of 70 m	7.0	6.8	7.1	7.2	7.0	7.0
10.	• At height of 50 m	6.5	6.8	6.7	6.4	7.0	6.9
11.	• At height of 30 m	5.8	6.0	6.1	5.6	6.4	6.3
12.	Wind Speed Summary:	Good	Fair	Good	Good	Good	Good
13.	Existing wind data	4.7 miles to Barnstable, 1 mile to Yarmouth, 8 miles to Harwich	4.5 miles to Barnstable, 2 miles to Yarmouth, 8 miles to Harwich	5.9 miles to Barnstable, 2.3 miles to Yarmouth, 6.7 miles to Harwich	6.2 miles to Barnstable, 1.2 miles to Yarmouth, 6.3 miles to Harwich	4.1 miles to Barnstable, 3 miles to Yarmouth, 8.5 miles to Harwich	3.4 miles to Barnstable, 2.6 mile to Yarmouth, 9.2 miles to Harwich
Wind Turbine Considerations:							
<i>Economic</i>							
14.	On-site Electric Loads	Yes	Yes	Yes	Yes	Yes	Yes
15.	Electric Loads, kWh/year	1,800,000	114,200	1,609,385	185,800	108,400	Pump station: 2,300 Mattacheese Middle School: 440,000 M.E. Small Elementary School: 130,000 Yarmouth Police Station: 625,000
16.	Distance to Distribution/ Transmission lines**	On-site	On-site	On-site	On-site	On-site	On-site

		1. Septage Treatment Facility	2. Well Sites #10 & #11	3. Regional High School	4. Well Sites #15 & #16	5. DPW Water Division HQ	6. Well Site #13
17.	Access for blade transportation**	Route planning required. On-site road modifications may be necessary.	Route planning and some on-site road construction required.	Route planning required, good access.	Route planning and some on-site road construction required.	Route planning required. On-site road modifications may be necessary.	Route planning and some on-site road construction required.
<i>Obstructions to wind</i>							
18.	Terrain	Some hills, trees, industrial buildings	Fairly level, trees	Fairly level, trees, buildings	Hills, trees	Fairly level, trees, building	Fairly level, trees
19.	Obstacles to wind	Trees (20'-30') Buildings Small hill east of facility.	Trees (20'-30')	Trees (20'-30') Buildings	Trees (20'-30') Ridge to west of site (100'-120')	Trees (20'-30') Building	Trees (20'-30')
<i>Noise</i>							
20.	Nearby residential areas:	No	Yes	Yes	Yes	Yes	No
21.	Radius to residences: (m): (ideally >~300m for utility scale‡)	> 400 meters	< 150 meters, depending on micrositing	~ 250 meters, depending on micrositing	250-350 meters, depending on micrositing	> 300 meters, depending on micrositing	> 400 meters
<i>Environmental permitting †</i>							
22.	Designated by the Natural Heritage & Endangered Species Program as a Core Habitat or a Supporting Natural Landscape?	No	No	No	No	No	Core Habitat
23.	Designated by the DEP as Wetlands?	No	Yes	No	Yes	No	Yes
24.	Designated by the Massachusetts Audubon Society as an Important Bird Area (IBA)?	No	No	No	No	No	No
Sites are approximately 2-5 miles from IBAs: West Dennis Beach, Yarmouth Beaches, Kalmus Beach Park, and South Cape Beaches – Sandy Neck							

		1. Septage Treatment Facility	2. Well Sites #10 & #11	3. Regional High School	4. Well Sites #15 & #16	5. DPW Water Division HQ	6. Well Site #13
25.	Is the site a current or former land-fill? (<i>RERL does not install met towers on landfills</i>)	No	No	No	No	No	No
26.	Other land-use restrictions, e.g. Article 97 †	None known	Open space: In Perpetuity protection	Open space: limited protection	Open space: In perpetuity protection	None known	Open Space: In Perpetuity protection
Other permitting							
27.	Distance to airport(s) Maximum structure height for routine FAA approval:	Barnstable Municipal Airport is 4.4 km (2.7 miles) away. 180' AGL	Barnstable Municipal Airport is 3.9 km (2.4 miles) away. 225' AGL	Barnstable Municipal Airport is 6.0 km (3.7 miles) away. 316' AGL	Barnstable Municipal Airport is 6.6 km (4.1 miles) away. 317' AGL	Barnstable Municipal Airport is 3.7 km (2.3 miles) away. 235' AGL	Barnstable Municipal Airport is 2.5 km (1.6 miles) away. Extended study required: 218' AGL
Wind Turbine: Conclusions							
28.	Primary constraint(s): <i>If this site is of interest for a utility-scale wind turbine, what factors will most affect feasibility and/or micrositing?</i>	- Proximity to airport - Somewhat limited space	- Proximity to airport - Relatively small on-site loads	- Proximity to airport	- Proximity to airport - Relatively small on-site loads	- Proximity to airport - Relatively small on-site loads	- Proximity to airport - Relatively small on-site loads depending on micrositing

		1. Septage Treatment Facility	2. Well Sites #10 & #11	3. Regional High School	4. Well Sites #15 & #16	5. DPW Water Division HQ	6. Well Site #13
29.	<p><i>Next step / To be determined</i></p> <p><i>To pursue wind power at this site, these items should be explored first (along with wind monitoring and public outreach):</i></p>	<ul style="list-style-type: none"> - File FAA form 7460-1 - Investigate potential load offsets - Determine land-use designations, wetlands delineations, etc. 	<ul style="list-style-type: none"> - File FAA form 7460-1 	<ul style="list-style-type: none"> - File FAA form 7460-1 - Investigate potential load offsets - Determine land-use designations, wetlands delineations, etc. 	<ul style="list-style-type: none"> - File FAA form 7460-1 	<ul style="list-style-type: none"> - File FAA form 7460-1 	<ul style="list-style-type: none"> - File FAA form 7460-1 - Investigate potential load offsets - Check status as Core Habitat - Determine land-use designations, wetlands delineations, etc.
30.	<p><i>Recommendation</i></p> <p><i>Should the town consider this site for a <u>utility-scale</u> wind turbine?</i></p> <p><i>For a smaller wind turbine?</i></p> <p><i>See also the discussion section.</i></p>	<p>No</p> <p>Yes</p>	<p>No</p> <p>Possibly</p>	<p>Yes</p> <p>Yes</p>	<p>Possibly</p> <p>Possibly</p>	<p>Possibly</p> <p>Possibly</p>	<p>No</p> <p>Yes</p>
31.	<p><i>Multiple Turbines</i></p> <p><i>If the town is interested in installing more than one turbine, how many could fit at this site?</i></p>	<p>1</p>	<p>1</p>	<p>1</p>	<p>1</p>	<p>2</p>	<p>2</p>

		1. Septage Treatment Facility	2. Well Sites #10 & #11	3. Regional High School	4. Well Sites #15 & #16	5. DPW Water Division HQ	6. Well Site #13
Met Tower Siting Factors							
32.	Space availability & level terrain	Yes	Yes	Yes	Yes	Yes	Yes
33.	Power lines or other obstructions to met tower. <i>(Met tower must be set at least 1.5 x the tower height away from power lines.)</i>	None	None	None	None	None	None
34.	Obstacles to wind	Trees and hill to the northwest of possible met tower site	Trees	Trees	Trees and 100'-120' ridge west of site	Trees	Trees
35.	Clearing requirements	Yes, the entire met tower area would need to be cleared.	Yes, the entire met tower area would need to be cleared.	If the athletic fields are not used, then an area of trees would need to be cleared.	Yes, the entire met tower area would need to be cleared	The DPW yard could be used, but the area would need to be cleared of equipment and dirt/gravel piles.	An area had been cleared previously. It would require some additional brushing since the vegetation has grown since the clearing.
36.	Soil quality – for met tower anchors	Sandy soil	Sandy soil	Sandy soil	Sand/clay soil	Sandy/clay soil	Sandy soil
37.	Road Access – for met tower installation	Good	Good	Good	Good	Good	Good
38.	Security	Municipal facility	Locked gate	School	Locked gate	Municipal facility	Locked gate
39.	Existing towers on or near site	None known	None known	None known	None known	None known	50' radio tower at police station, not suitable for anemometry
40.	Distance to AC power if lighting is required	100 meters	100 meters	On-site	200 meters	On-site	200 meters

		1. Septage Treatment Facility	2. Well Sites #10 & #11	3. Regional High School	4. Well Sites #15 & #16	5. DPW Water Division HQ	6. Well Site #13
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?)	2 – Well pump sites #10 & #11 6 – Well pump site #13	1 – Septage treatment facility 5 – DPW water division headquarters 6 – Well pump site #13	None	None	2 – Well pump sites #10 & #11 6 – Well pump site #13	2 – Well pump sites #10 & #11 5 – DPW water division headquarters
Met Tower: Primary Constraint							
42.	What factors will most affect feasibility and/or siting of a met tower here?	The area for a met tower will have to be cleared.	The area for a met tower will have to be cleared.	Clearing trees or using the athletic fields.	The area for a met tower will have to be cleared. The ridge to the west of the site may obstruct the wind flow.	The DPW yard, or an area near it, would have to be cleared.	Extra brush clearing would be required.
Met Tower Recommendation:							
43.	Recommended site:	Yes – This is an appropriate site for a met tower.	Yes – This is an appropriate site for a met tower.	Yes – This is an appropriate site for a met tower.	Yes – This is an appropriate site for a met tower.	Yes – This is an appropriate site for a met tower.	Yes – This is an appropriate site for a met tower.
44.	Recommended met tower height (meters)	50 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 town’s responsibility to ensure the environmental appropriateness of the chosen site.

Appendix B: Wind-Monitoring Logistics

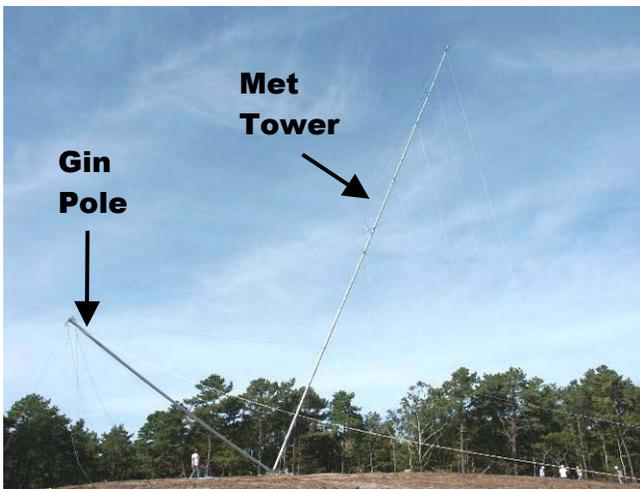
Traditionally, wind is monitored for about a year with a met tower. Some sites may be suitable for other types of monitoring in addition to a met tower. This section will concentrate on the siting of a met tower. Figure 1 in Appendix C is a schematic of a met tower.

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

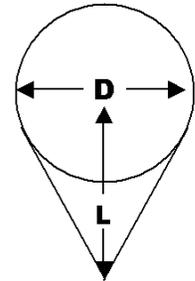


An anchor, installed, with 2 guy wires attached

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 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
<i>Dimensions of a football field, for comparison:</i>			<i>300 x 160 feet</i>



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 Yarmouth sites.

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

All the Yarmouth sites have enough level terrain somewhere on the site parcel to install a met tower.

Clearing requirements (Line 35)

If a met tower is installed at the septage treatment facility or well pump sites #10 & #11 or #15 & #16, then an area large enough for a met tower would need to be cleared of trees. Little or no clearing would be required at the high school if the athletic fields are chosen for a met tower site. If the town does not want to restrict use of a field for one year, then a section large enough for a met tower would need to be cleared in the wooded area.

In order to install a met tower at the DPW headquarters, the yard would have to be cleared of equipment and gravel piles. Some of the yard could remain open for use if part of the police dog training area or grass effluent leaching field were used.

In preparation for a 50-meter met tower, the town of Yarmouth cleared an area near well pump site #13. This site is mostly clear, but would require some additional brush clearing.

Soil quality & anchor requirements (Line 36)

The soil at the site was not tested, but the soil in Yarmouth is mostly sand. Installing anchors will require some planning; longer or larger anchors will probably 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, and can only be estimated on a site-specific basis.

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

If the town of Yarmouth chooses to pursue a wind turbine the septage treatment facility or the DPW headquarters, a met tower could be installed at the well pump sites #10 & #11 or #13. If well pump sites #10 & #11 are chosen, a met tower could be installed at the septage treatment facility, DPW headquarters or well pump site #13. If well pump site #13 is chosen for a wind turbine, a met tower could be installed at the well pump sites #10 & #11 or the DPW headquarters.

The high school and well pump sites #15 & #16 are too far from the other sites to be compatible. If one of these sites is preferred as a wind turbine location, the met tower should also be put there.

Met tower size recommendation (Line 43-44)

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

If wind monitoring is pursued, a 50-meter met tower is recommended for all of the 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 town is interested in installing a utility-scale wind turbine at one of the sites, 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 town decides to monitor the wind resource, then it is recommended that a 50-meter met tower be installed at the site of interest

Appendix C: Maps, Photos, and Figures

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

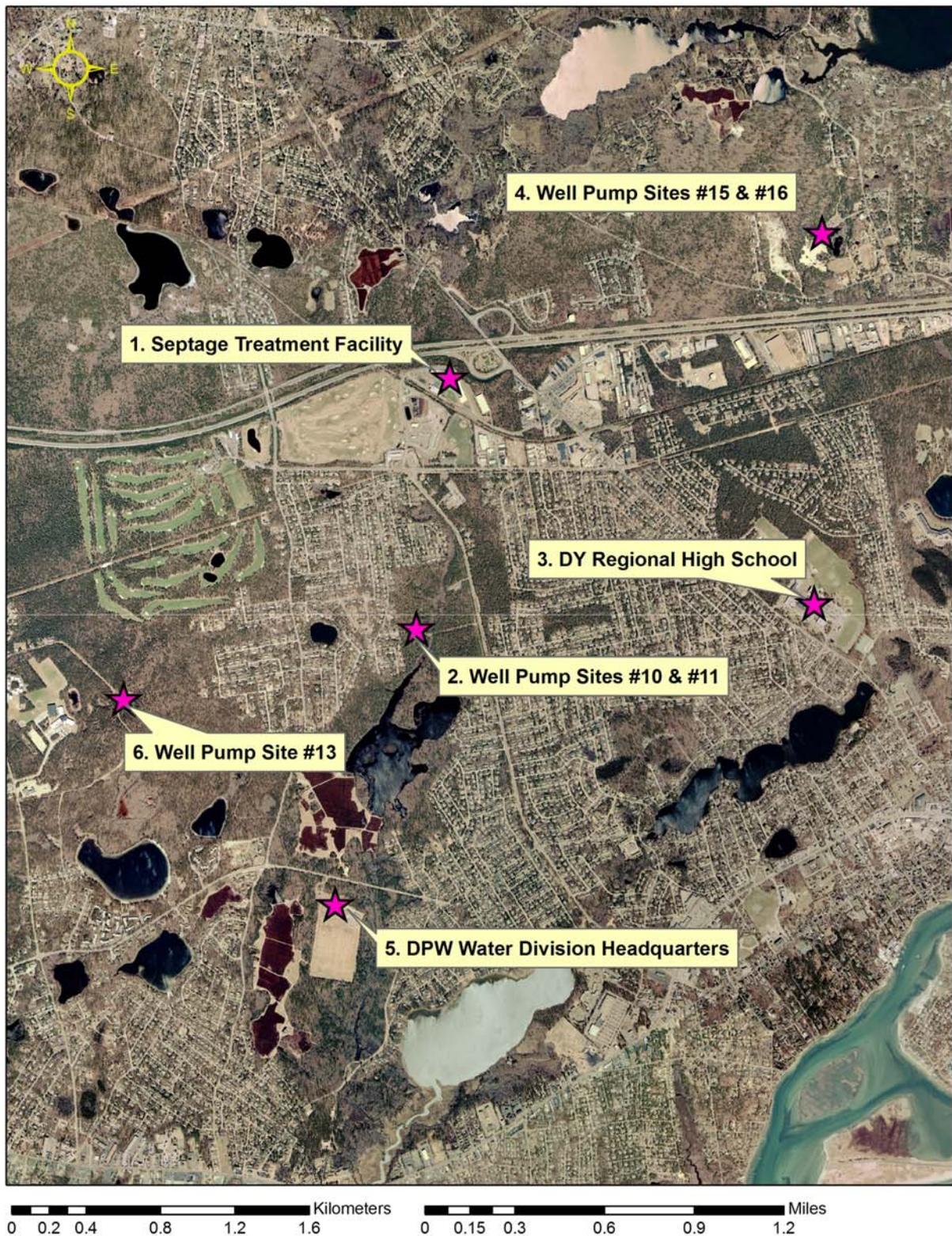
Source for base maps:

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

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

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

Yarmouth proposed wind turbine sites



Map 1: Orthophotograph of the town of Yarmouth. The sites under consideration for a wind power project that are discussed in this report are marked in pink stars and labeled accordingly.

Estimated mean wind speeds at 50 meters



Map 2: Estimated mean wind speeds at 50-meters height at the Yarmouth sites, based on AWS-TrueWind models.

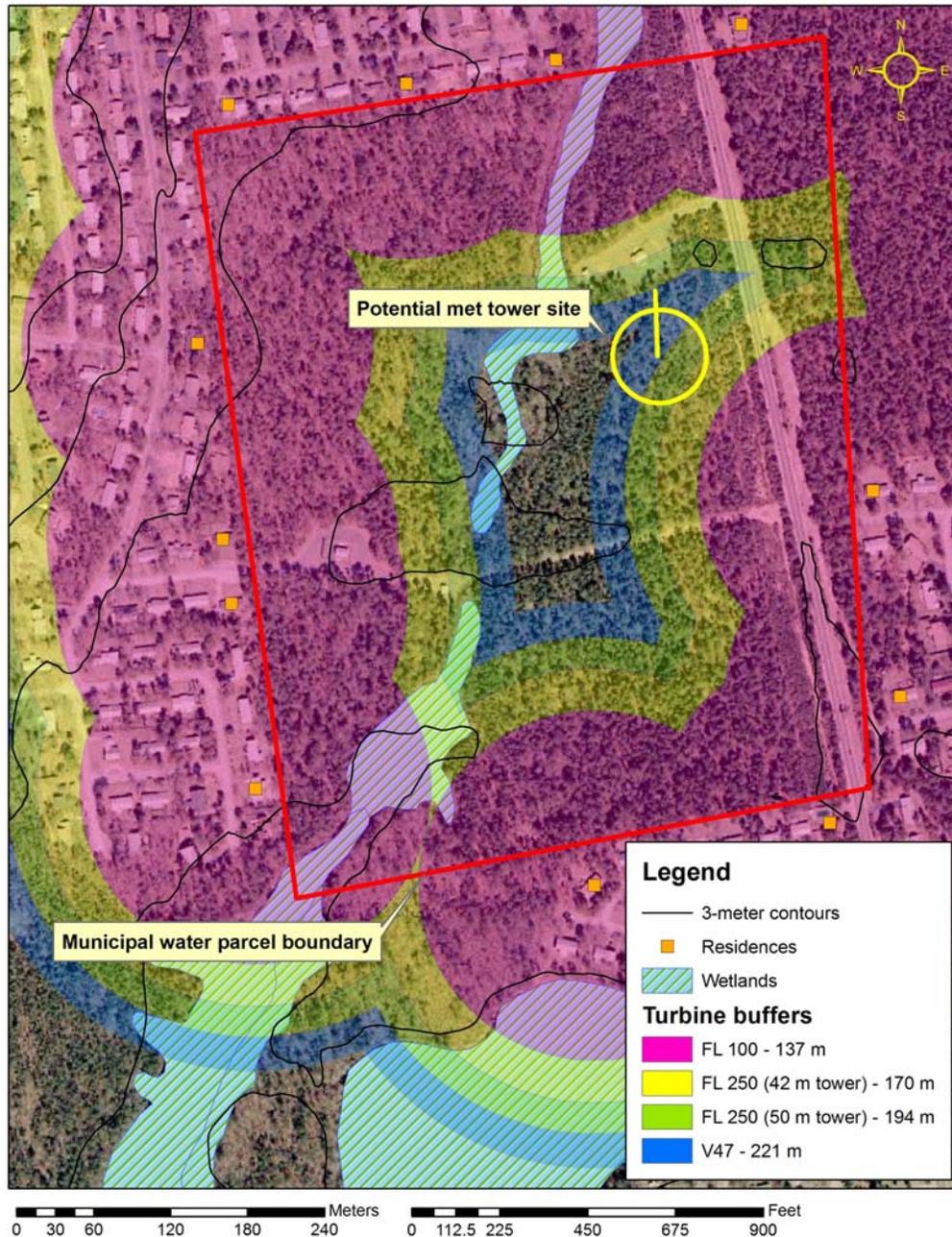
For more information, see TrueWind Solutions, truwind.teamcamelot.com/ne/

Septage Treatment Facility



Map 3: An orthophotograph of the septage treatment facility, where the parcel boundary is outlined in red and overlaid with 3-meter elevation contours. A potential met tower layout is also shown (clearing would be required).

Well Pump Sites #10 & #11

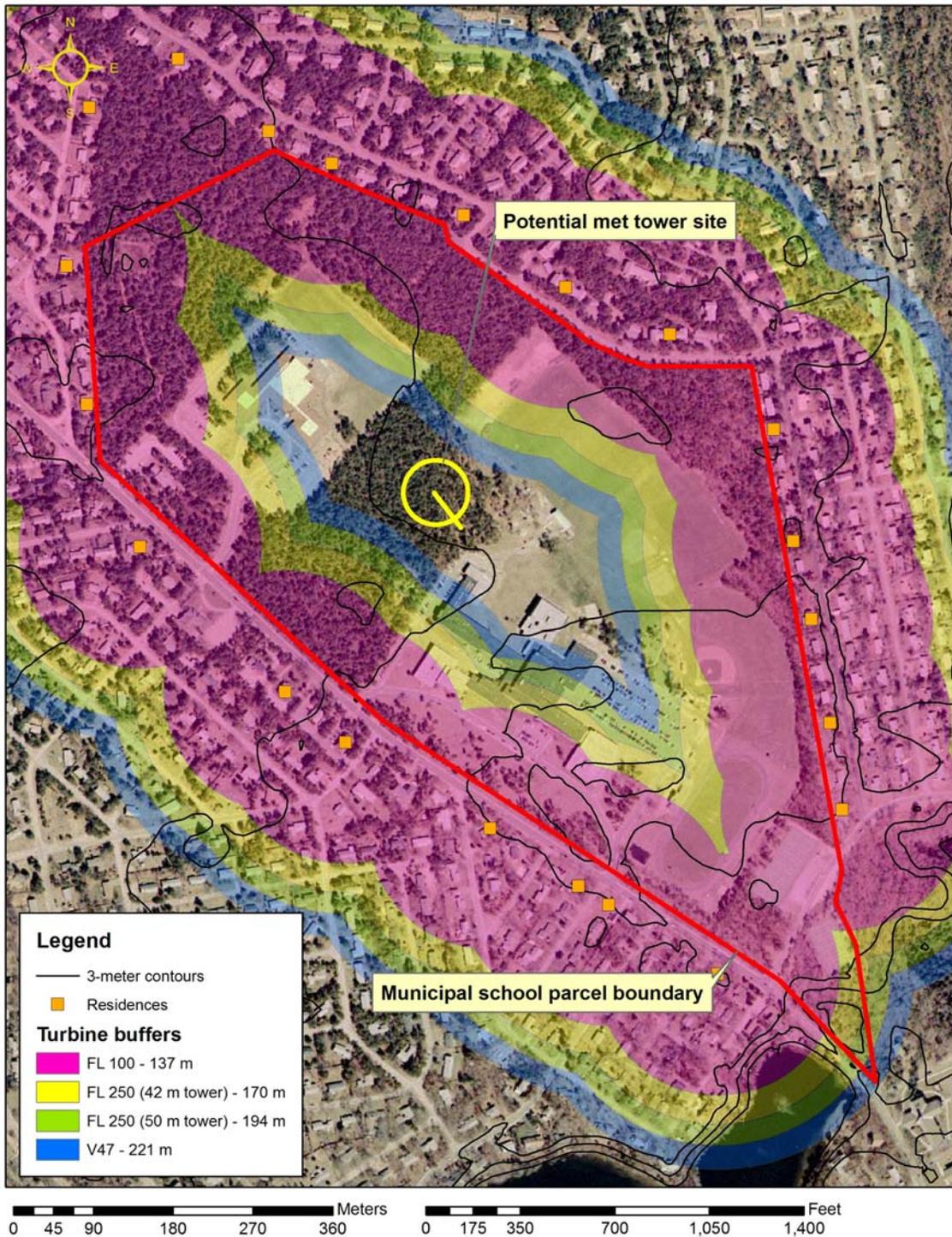


Map 4: Orthophotograph of the well pump sites #10 & #11, with the water parcel boundary outlined in red and overlaid with 3-meter elevation contours and DEP wetlands. A potential met tower layout is also shown.

In this map, selections of nearby houses are denoted with orange squares. The colored areas on this map indicate the recommended “three-times-blade-tip” distances from houses for various sizes of turbines. For example, the FL 100 has a three-times-blade-tip-height of 170 meters and is most appropriate, from a noise perspective, beyond the pink shaded area. Similarly, a FL 250 on a 42-meter tower would be most suitable beyond the yellow buffer, and so on.

If turbines that are larger than the buffer suggestions are considered, a more detailed, site-specific noise study is recommended.

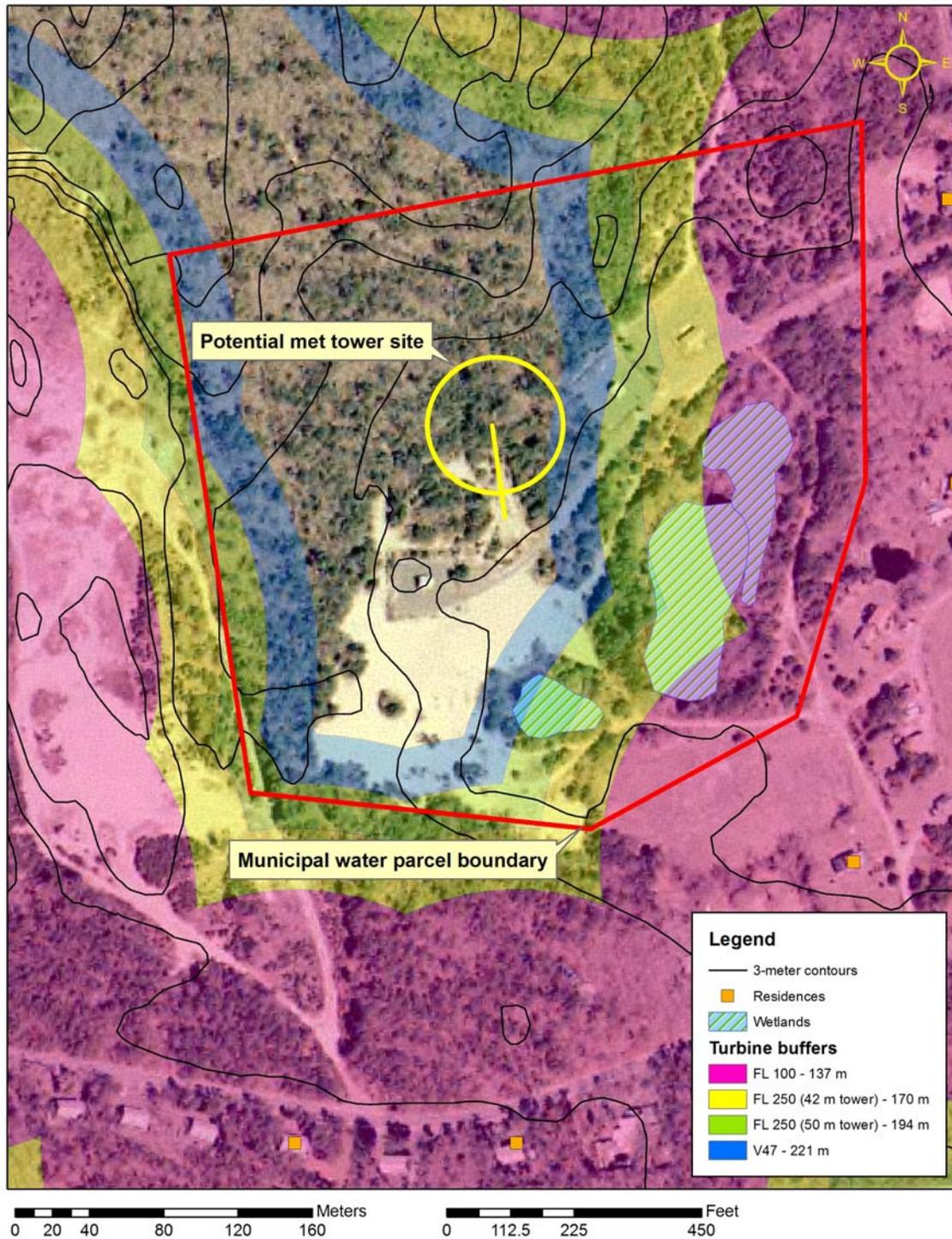
Dennis-Yarmouth Regional High School



Map 5: Orthophotograph of the regional high school, with the municipal parcel boundary outlined in red and overlaid with 3-meter elevation contours. A potential met tower layout is also shown.

Selections of nearby residences are denoted by orange squares and the colored areas on this map indicate the recommended “three-times-blade-tip” distances from houses for various sizes of turbines. See the previous figure description for a more detailed explanation.

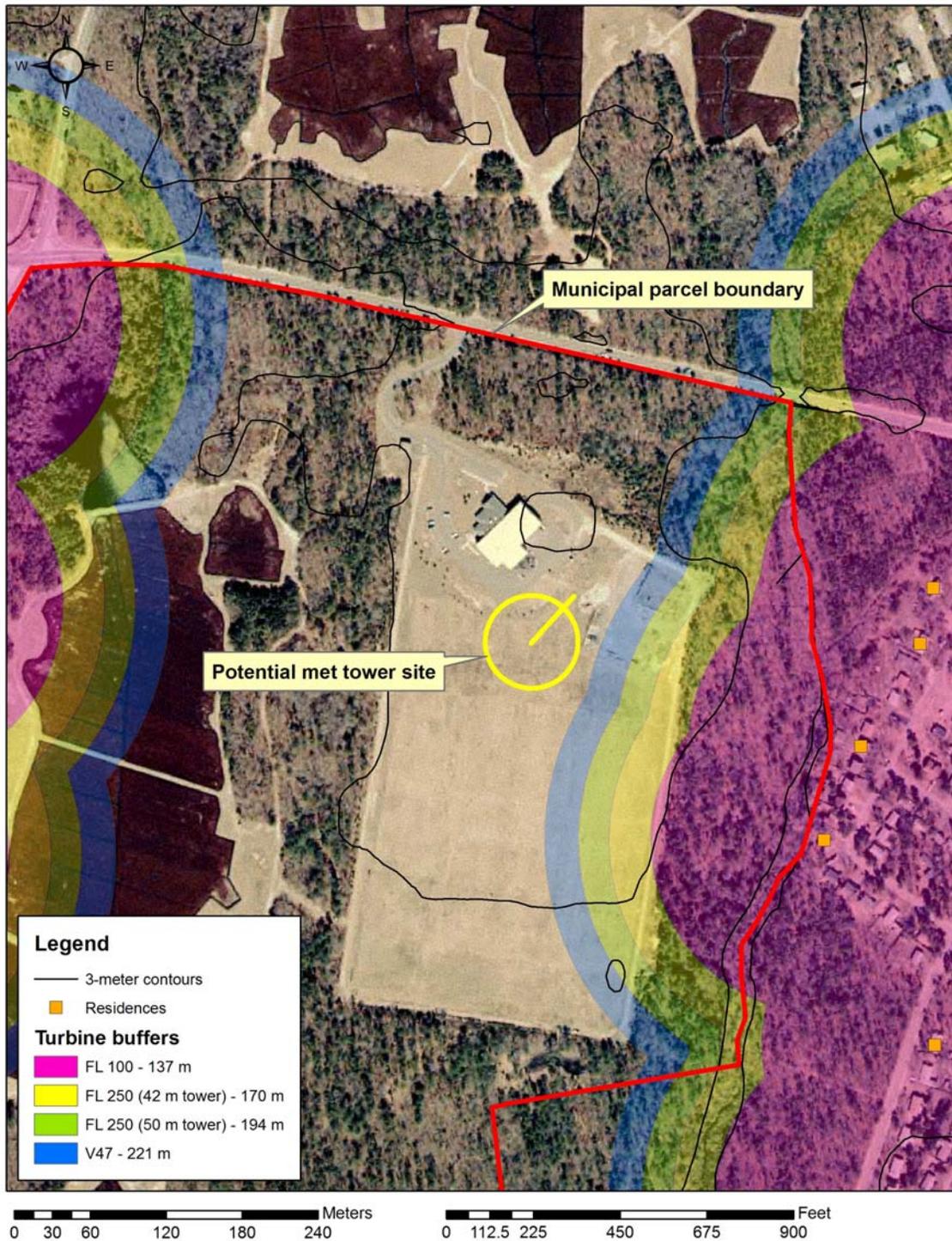
Well Pump Sites #15 & #16



Map 6: Orthophotograph of the well pump sites #15 & #16, with the water parcel boundary outlined in red and overlaid with 3-meter elevation contours and DEP wetlands. A potential met tower layout is also shown.

In this map, some nearby houses are denoted with orange squares. The colored areas on this map indicate the recommended “three-times-blade-tip” distances from houses for various sizes of turbines. See the Map 4 description for a more detailed explanation.

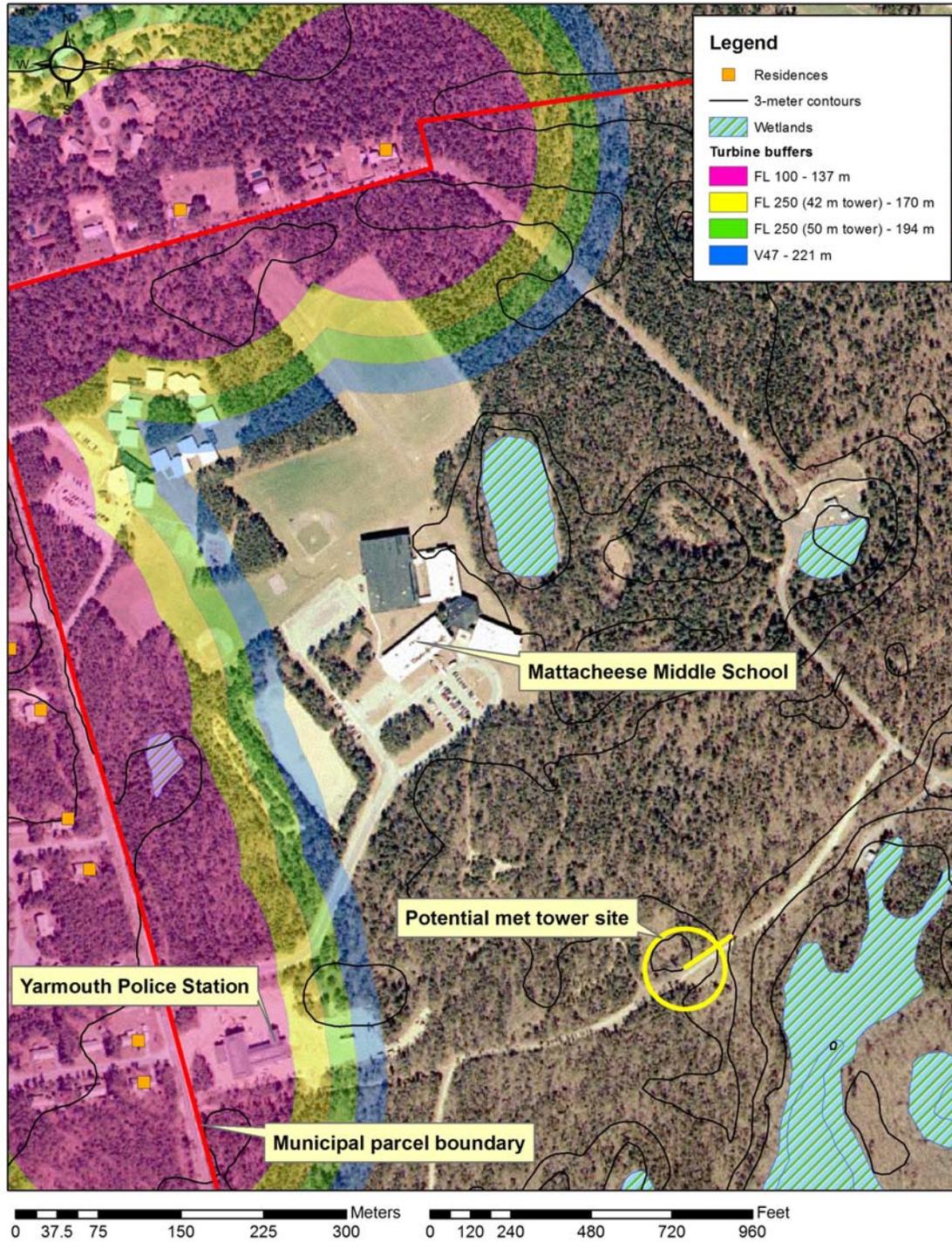
DPW Water Division Headquarters



Map 7: Orthophotograph of the DPW water division headquarters site, with the municipal parcel boundary outlined in red and overlaid with 3-meter elevation contours. A potential met tower layout is also shown.

Selections of nearby residences are denoted by orange squares and the colored areas on this map indicate the recommended “three-times-blade-tip” distances from houses for various sizes of turbines. See the Map 4 description for a more detailed explanation.

Area surrounding Well Pump Site #13



Map 8: Orthophotograph of the area surrounding the well pump site #13, with the municipal parcel boundary outlined in red and overlaid with 3-meter elevation contours and DEP wetlands. The location that had previously been cleared for a met tower is labeled at the site for a potential met tower.

In this map, some nearby houses are denoted with orange squares. The colored areas on this map indicate the recommended “three-times-blade-tip” distances from houses for various sizes of turbines. See the Map 4 description for a more detailed explanation.

Photos:

- 1) Entrance to the septage treatment facility, looking east
- 2) Septage treatment facility exit, looking west. The concrete structure on top of the hill is treatment storage tank.
- 3) DY Regional High School, looking northwest towards the soccer fields.



Photos:

- 4) DY Regional High School, looking southeast toward athletic fields and school building.
- 5) Area near well pump site #13 that was cleared for a met tower, looking northeast along road.
- 6) Cleared area near well #13, looking north-northeast.



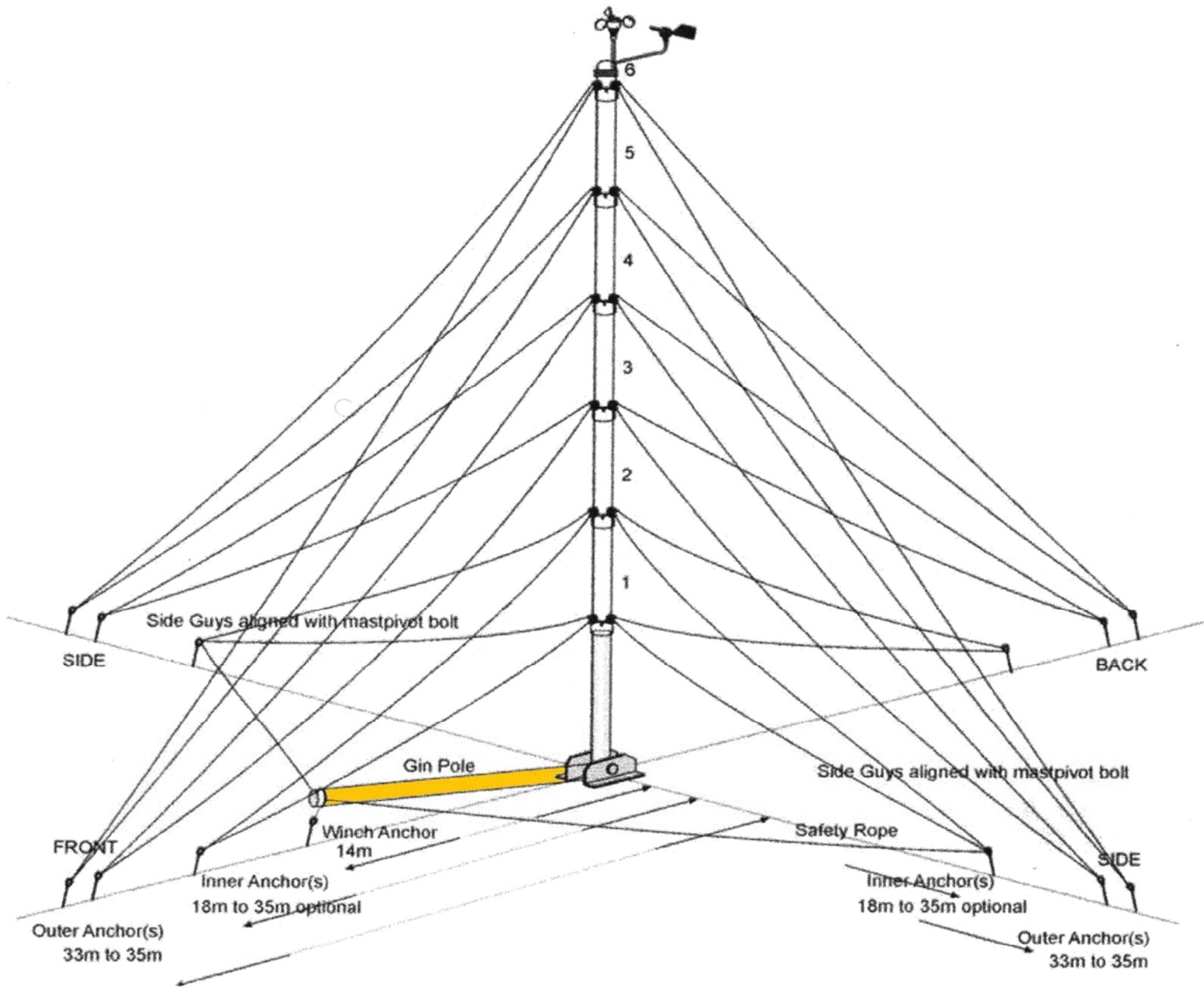


Figure 1. Guy line layout for a 50-meter met tower from Second Wind, Inc.