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Orleans Watershed
Preliminary assessment of wind resource and Appropriateness of anemometry

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To:

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Figure 1: Site A, near water tower

Site visit

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Overview

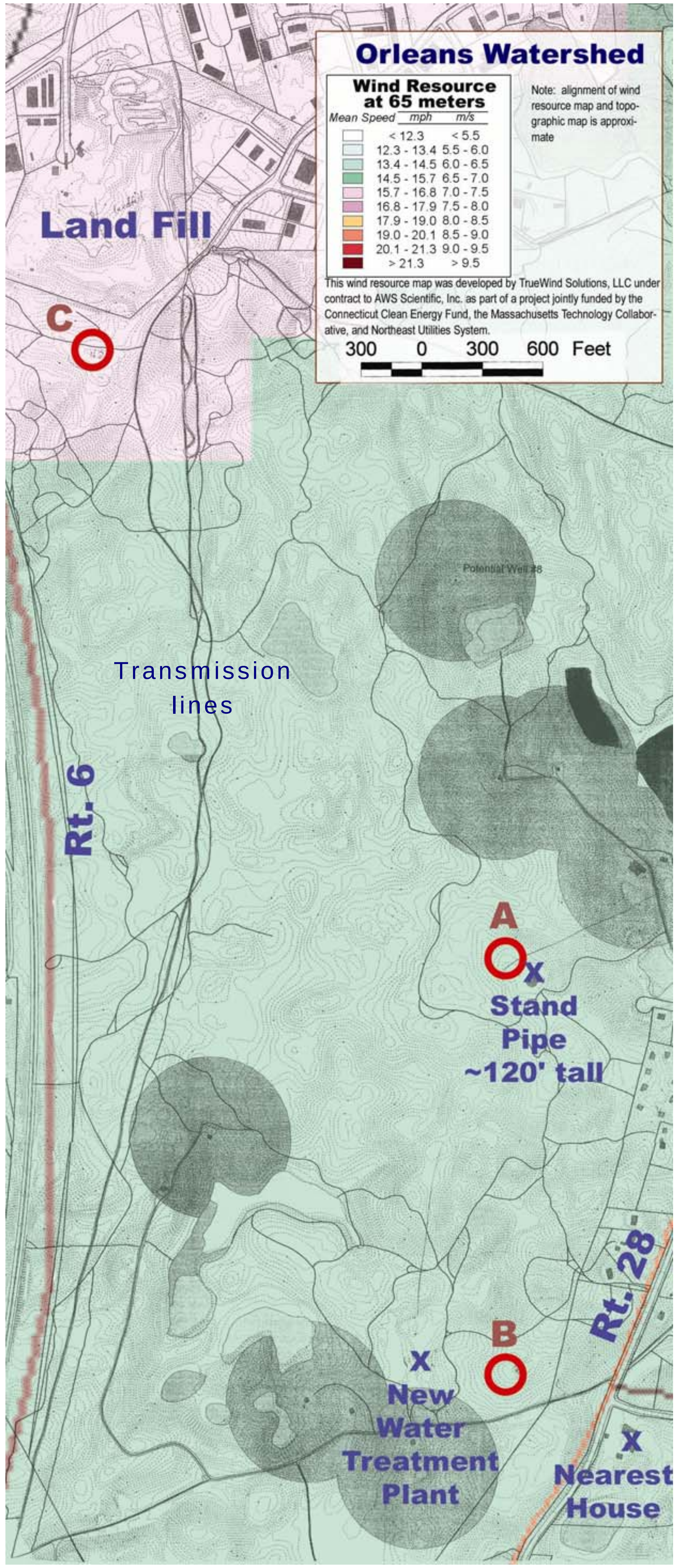
George & I visited three potential sites in the Orleans town watershed, looking for a good site to monitor the wind. The criteria considered are summarized in a table and discussion below. The landfill site (C) and the water treatment plant site (A) are both good anemometry sites. Recommendations are listed at the end of this report. The process leading to these recommendations is detailed below.

Figure 2: Site C, near landfill

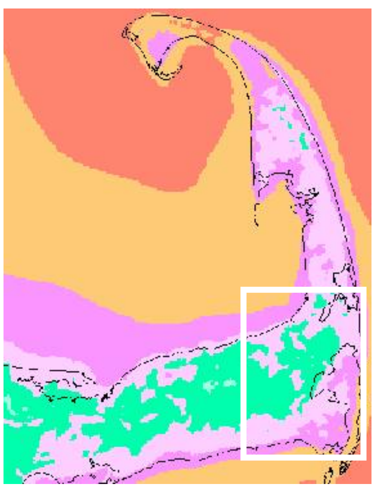
Figure 3: Map of Orleans watershed, with TrueWind 65m wind speed predictions approximately overlaid:

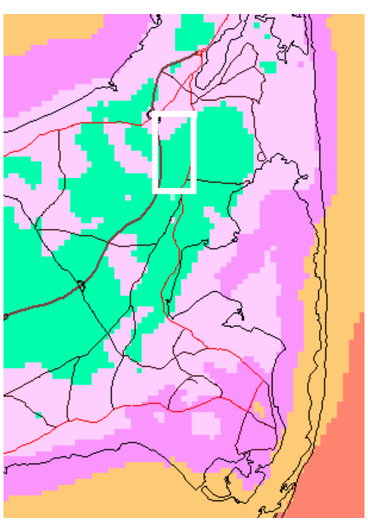
Green:	**6.5 - 7 m/s**
Pink:	**7 – 7.5 m/s**

This wind resource map was developed by TrueWind Solutions, LLC under contract to AWS Scientific, Inc. as part of a project jointly funded by the Connecticut Clean Energy Fund, the Massachusetts Technology Collaborative, and Northeast Utilities System.



Area maps





Siting issues

The three sites visited were:

Site	**A**	**B**	**C**
Near	**Water tower**	**Water treatment plant (WTP) (Currently under construction)**	**Landfill**
Approx. Dist. to Transmission Lines (23 kV)	2,000’	2,400’ (Also 700’ from WTP’s 480V)	500’
Pro		• Proximity to future electric load	• Good road access. • Fairly level site. • Possibly the highest winds (estimated by TrueWind, 65 m) • Closest to transmission lines
Con	• It will be difficult to get out of the influence of the water tower. • Possibly the tallest trees. • Possibly the worst road access	• House may be too close (it is across Route 28, which might mask some of the sound.)	• Possibly more danger of vandalism?

Distance to Transmission lines:

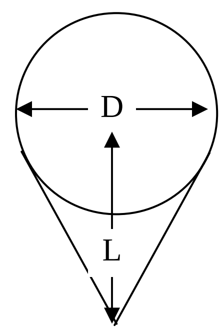
No site is prohibitively far from transmission lines, though sites C and B are more favorable in this respect.

Met tower height:

All sites have trees of more or less similar height, estimated to be about 35-50 feet (10-15 m). Due to the height of the trees, a 50-meter met tower is preferred over a 40m tower. A higher tower will produce more reliable data by getting farther from the disruption caused by the trees.

Clearing:

The town water commission is allowed to clear land as they see fit. This will be necessary in all cases. The *minimum* cleared areas for guyed towers are:



Tower Ht	Min. D *(guy diam.)*	Min. L *(Space to lay the tower down)*
40 meter	160 feet	135 feet
50 meter	240 feet	165 feet

In general, a larger cleared area reduces the disturbances seen by the instruments, and the better the data will be. That is, 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.

Elevation:

Several hilltops were considered, ranging from about 70 – 110’ in elevation. Site C is a local high point of 110’. It is not clear to what extent elevation influences the wind speeds. The TrueWind maps appear to use elevation as a key predictor of annual average wind speed, since they predict some higher wind speeds at local high point, and lower speeds at local low points.

Wind Roses:

Wind direction data for the Chatham Municipal Airport was obtained from the Northeast Regional Climate Center at Cornell University. Data are based on 4331 hourly observations during the years 1997 – 2003. The airport is 5 miles due south of the target site in Orleans, and will probably have similar wind roses. The data are summarized in the wind roses below. Note that this dataset is based on hourly averages, which is not sufficiently frequent to represent the variation in wind speeds; most notably the speeds of storm winds may not be accurately resolved in Figure 5.

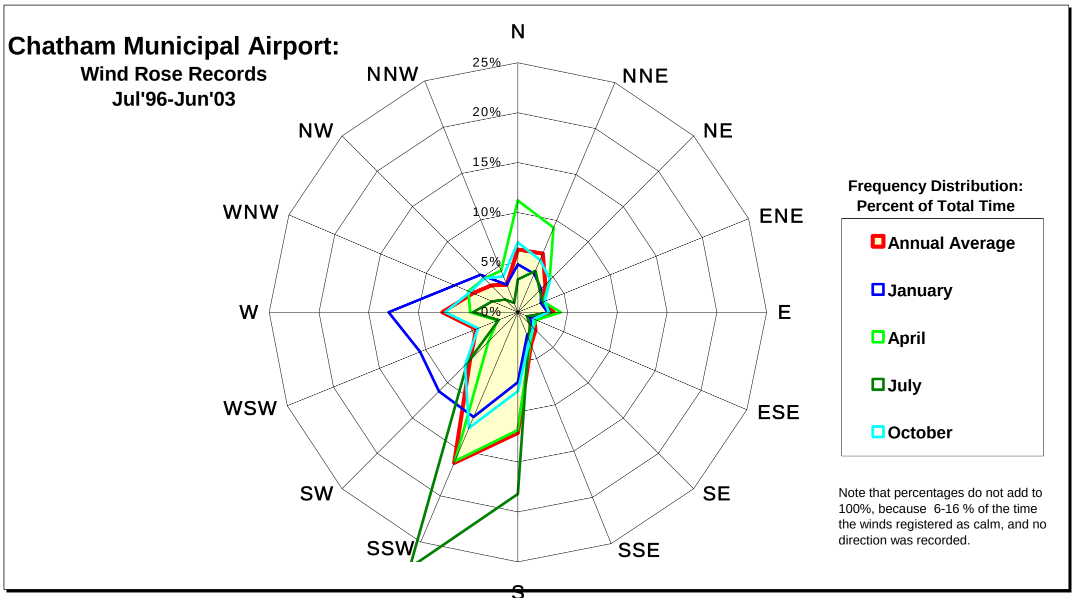


Figure 4: Chatham Municipal Airport Wind Rose (measured at 10m)

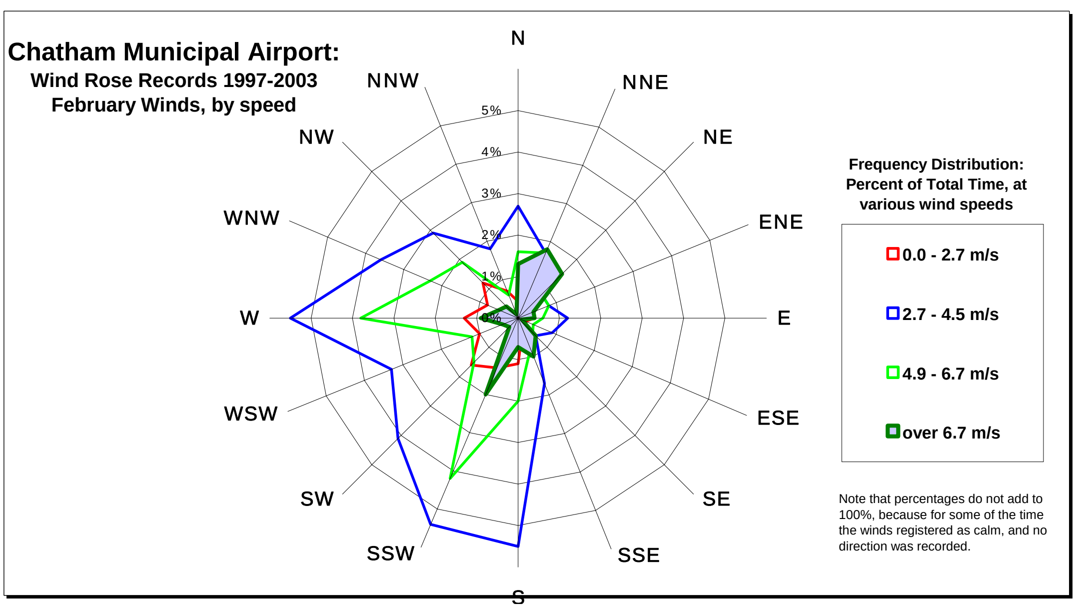


Figure 5: Chatham Municipal Airport Wind Rose, February directional distribution by speed (measured at 10m)

Prevailing winds in all seasons are from the southwest or thereabouts, but some of the higher winter winds come from the north to northeast, as shown in the February wind rose. When looking at potential wind power sites, we should be most concerned with obstacles to the southwest. Obstacles to the northeast may also be somewhat significant, though these may be storm winds during which a turbine would shut down anyway.

Potential advantages of generating near the WTP:

The WTP is projected to use 784,000 kWh/year, or *on average* over the year about 90 kW. Presumably the bulk of this is used in the summer, whereas the majority of a wind turbine's energy will be generated in the winter. For comparison, a Vestas V47 (660 kW) in a similar wind regime at Hull is making twice that amount of energy per year. A more detailed projection of the coincidence of the consumption and generation could be made for a given wind turbine. The level of coincidence will influence the value of on-site generation.

A wind turbine close enough to the WTP could presumably be connected behind the WTP's meter (Figure 6), rather than directly into the transmission line (via a transformer dedicated to the turbine).

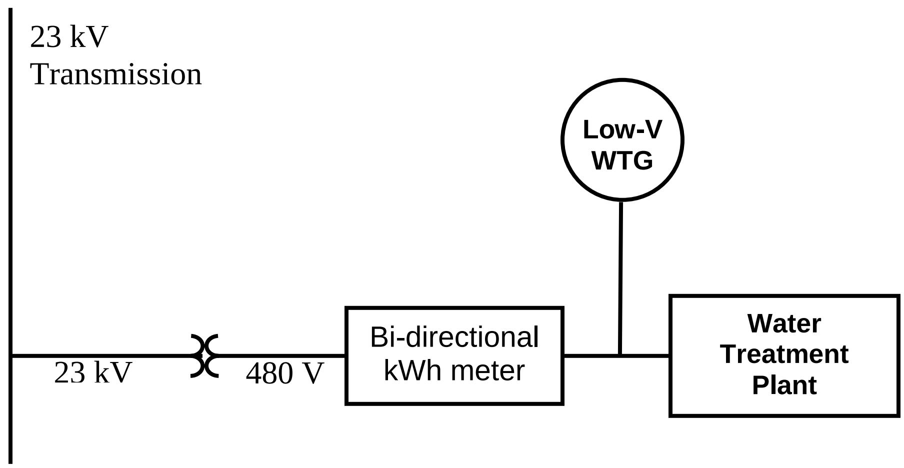


Figure 6: simple one-line electrical diagram, showing on-site power generation, with a small or medium wind turbine generator (low voltage, e.g. 120V or 480V)

Net metering vs. bi-directional meters: A "small" wind turbine (up to 60 kW) can be net metered under Massachusetts law. On the other hand, a medium (e.g. 100 or 250 kW) or large (e.g. 1 or 1.5 MW) turbine needs a bi-directional revenue-grade meter that separately records imported and exported energy. The exported energy will be sold at a lower price than the imported energy is bought for. Because they have different prices, they must be metered separately, i.e. with a bi-directional meter. All energy that is generated and used on site is more valuable than exported energy, because it defers purchase of the higher-priced energy.

Whether small or large, whether net-metered or not, the more energy made and used on-site, the better the economics of the wind system; this is why the level of coincidence is important.

Voltage: Figure 6 showed a simplified diagram of the relationship between the transmission lines, the generator, the electrical load, and the meter. If the wind turbine

(WTG) operates at the same voltage as the WTP, then both can operate behind the same transformer as in Figure 6. A larger wind turbine, however, can not operate at such a low voltage, and will need to be on the high side of the WTP's transformer, as shown in Figure 7. Note that the transformer has moved to the other side of the meter.

These figures are for discussion purposes only; the actual interconnection arrangement will have to be discussed with and approved by NStar.

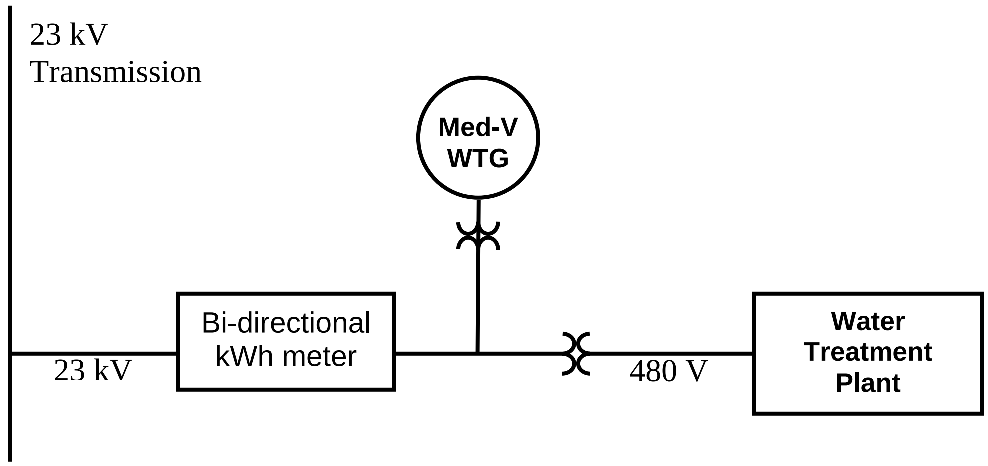


Figure 7: simple one-line electrical diagram, showing on-site power generation, with a full-size (e.g. 660 kW – 1.5 MW) wind turbine generator (WTG) at medium-voltage

Summary: On-site generation almost certainly has some financial advantages. However, the magnitude of the benefit depends on the size and type of turbine, the coincidence of generation and consumption, and the eventual power purchase contract. Interconnection agreements with the T&D company may also play a part. At this early stage, the extent of these advantages is hard to predict, quantify and weigh against the relative merits of the various sites. Despite this uncertainty, we will proceed on the assumption that the benefits of on-site generation out-weigh the costs.

Noise:

Massachusetts state law does not allow a rise of 10 dB or greater above background levels at a property boundary. This sound level is not likely to be a reached in any case at any of the sites we examined. However, we still need to consider the noise caused by an eventual turbine. We prefer to look for a site that will be inaudible or minimally audible at the nearest residences.

Preliminary noise estimations suggest that a wind turbine at site B would be audible at the large house on the corner of Rt. 28 and Namequoit Road. During summer days, traffic on Route 28 is likely to mask the turbine at most times. However, at times of low traffic, the turbine could be barely audible, or it could be plainly audible, depending on a number of factors including the ambient noise and the type of turbine.

For instance, a "quiet" turbine (100 dBA at the nacelle, slightly higher than GE's statement of the 1.5S's measured levels) in a fairly noisy ambient (45 dBA) gives an estimated 2 dB rise at the sound level at the house, which is barely noticeable. A noisier turbine (102.5 dB, GE's warranted sound level for the 1.5S) in a quieter ambient (40 dB) would probably be quite noticeable (estimated 7 dB rise at the house.)

Except for the proximity of that house, site B would probably be the favored site, since it is closer to the electric load of the water treatment plant. Before further considering site B, I would want to do more study of ambient noise levels in the area, to be able to estimate the impact on the house more closely. RERL would have to buy or rent sound monitoring instruments to do a full noise study compliant with IEC standards.

Alternate site near the WTP:

In an effort to retain the benefits of being near the WTP but stay away from residences, we considered several other sites around site B, as noted in Figure 8. The required distance from the house depends on the turbine's noise level (noise data is available for some but not all turbine models) and the height of the tower, and could range from less than 1000 feet, to about 1800 feet. Since it is too early to decide on a turbine, worst-case scenario estimations were used to choose sites B2-B5. A wind turbine at any one of sites B2-B5 will probably be rarely audible if at all, at the nearest residence.

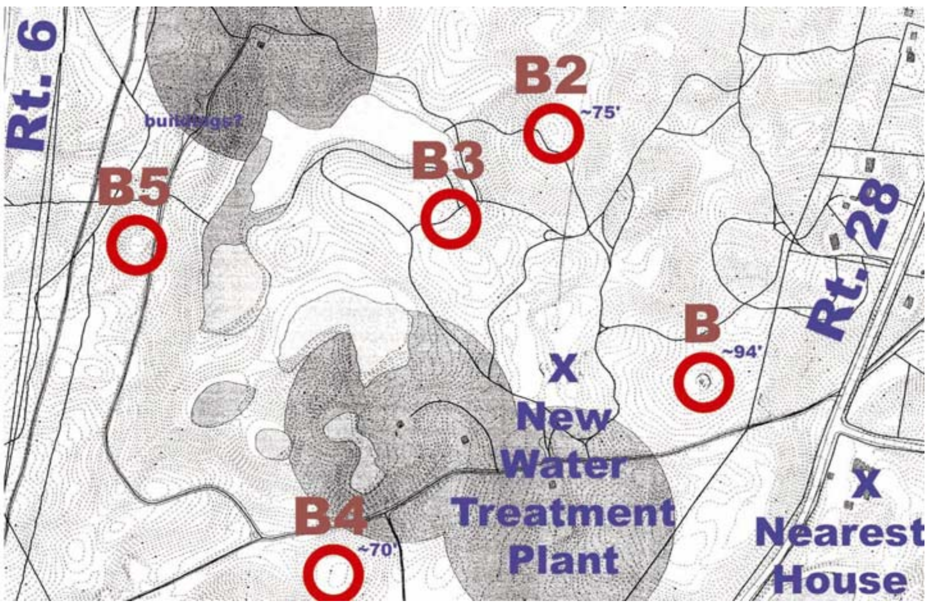


Figure 8: Alternate sites near the Water Treatment Plant

Site B2:

After discussions with George Meservey, we settled on site B2. Although it is a lower elevation than sites B and C, it is not clear that this deficit will be significant enough to warrant moving farther away from the WTP. There is a road to the site accessible by four-wheel-drive.

Comparing sites B2 and C:

Without more information, it is not possible to decide how great the benefits are of siting at the WTP, nor how great is the price for siting at a (apparently) lower wind site. If after enough data has been gathered at site B2, it seems that the site may have considerably lower winds than site C at the landfill, then we may be able to put our SODAR (sonic detection and ranging device) at the landfill for a period to correlate the two sites. With a long enough set of concurrent data, the two sites can be correlated, and the relative merits can better be determined. This is a point for later discussion.

Other siting issues

Nearby Airports and approximate distances:

Chatham Municipal Airport, 5 miles
Barnstable Municipal Airport, Hyannis, 16 miles

Road Access:

There are adequate roads to all sites. Site B2 is served by a four-wheel drive track. Site B is slightly off the road, so an eventual turbine there would require a short road. The bends in the roads to sites C and B2 might take a little straightening for eventual blades and tower sections, but are ample for a met tower.

Soil quality:

The area is overgrown with scrub oak and taller trees, and the soil appears somewhat rocky. Standard anchors may be sufficient. The soil should be tested before installing a met tower.

Security:

George reports that there is some vandalism in the landfill area. Regardless of the site, the security of the loaned equipment should be considered, and is the responsibility of the town. The town should do whatever it deems appropriate to protect the site to their satisfaction – e.g. a dog kennel fence around the base, or placing the logger high enough up the pole that a ladder is required to reach it.

Recommendations

- Anemometry:
    - We can expect that Orleans has a fairly good wind resource, and a year's worth of anemometry is worthwhile. Conclude the work with a study on the feasibility of wind power in both medium and large scales, including a time-series study that will predict the level of coincidence between the WTP's consumption and the turbine's production.
    - A 50-meter met tower is preferred.
- Site: We expect that there will be benefits in on-site generation at the WTP. Site B2 appears to be the best option in that area.
- Begin the public process of talking to town officials, local groups, etc. early. Take into consideration, as much as possible at this early stage, town preferences for the eventual wind turbine site. If there is strong leaning toward another turbine site, that site will be preferable for wind monitoring.
- When we have more detailed wind data, and when interconnection options are known in more detail, a time-series study of the coincidence of electricity generation and consumption will be helpful in understanding the costs and benefits of wind generation on the water treatment plant site.