TOWN OF ORLEANS
WIND ENERGY FEASIBILITY STUDY

March 15, 2005

Revision 1

Prepared by:

Global Energy Concepts LLC

R. W. Beck, Incorporated

Funded by the Community Wind Collaborative
of the Renewable Energy Trust

Via E-mail

March 15, 2005

Mr. Nils Bolgen
Massachusetts Technology Collaborative
Community Wind Collaborative
75 North Drive
Westborough, MA 01581-3340

Dear Mr. Bolgen:

Subject: **Community Wind Collaborative**
Town of Orleans Final Feasibility Study, Rev. 1

Enclosed is Revision 1 to our final feasibility report for wind energy generation at Orleans.

On behalf of Global Energy Concepts and R. W. Beck, we welcome this opportunity to support MTC in its Community Wind Initiative. If you have any questions, you are welcome to call me at (508) 935-1846 or email me at pcleri@rwbeck.com.

Very truly yours,

R. W. BECK, INC.

Paul D. Cleri, PE

PDC\
c: G. Meservey, Orleans
K. Conover, GEC
D. Patton, RWB

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NOTICE AND ACKNOWLEDGMENTS

The following is by the Massachusetts Technology Collaborative.

This report was prepared by the wind consulting team of R. W. Beck, Inc. and Global Energy Concepts, LLC in the course of performing work sponsored by the Renewable Energy Trust (“RET”), as administered by the Massachusetts Technology Collaborative (“MTC”), pursuant to Work Order Number 05-02 The opinions expressed in this report do not necessarily reflect those of MTC or the Commonwealth of Massachusetts, and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it.

ABSTRACT

The following abstract is for RET's web posting purposes.

This report investigates the feasibility, planning, and development issues of wind energy generation at the Orleans, Massachusetts watershed. The wind consulting team of R. W. Beck, Inc. and Global Energy Concepts, LLC performed this study, under contract to the MTC. This study considers multiple wind energy plant concepts, analyzes wind data from the University of Massachusetts Renewable Energy Research Laboratory ("RERL"), performs a feasibility assessment, identifies predevelopment tasks, identifies specific site preparation work, evaluate project economics, identifies technical data to prepare anticipated permits and approvals applications, considers community electric loads, considers electric interconnect to the water treatment I&M Plant, provides photo simulations, considers environmental receptors, and reports certain conclusions and observations regarding the feasibility of the proposed project.

The following list of keywords is for RET's project database and website search feature.

Keywords:

- Orleans
- Feasibility
- Planning
- Development
- Wind
- Energy
- Watershed
- R. W. Beck
- Global Energy Concepts
- Wind Turbine Generator
- University of Massachusetts Renewable Energy Research Laboratory, RERL
- Project Economics
- Permits and Approvals
- Electric Loads
- Electric Interconnect
- Water Treatment I&M Plant
- Photo Simulations
- Environmental Receptors
- Renewable

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EXECUTIVE SUMMARY

The Town of Orleans, Massachusetts ("Orleans") desires to investigate the feasibility of wind energy generation at its watershed area.

Under contract to MTC, the wind consulting team of R. W. Beck, Inc. and Global Energy Concepts, LLC performed this planning and development study for Orleans. This study has been performed in close cooperation with Orleans and with the support of MTC. The consulting team made site visits to the town's watershed during June, July, and August 2004, and received supportive and informative assistance from the Orleans Planning Department.

The objective of this study is to: (a) provide Orleans and MTC with a wind turbine generator plant concept; (b) perform feasibility and predevelopment tasks; (c) identify specific site preparation work that could be completed as soon as possible; (d) complete analyses required to finalize the wind turbine site; (e) evaluate project economics; (f) identify technical data to prepare anticipated permits and approvals applications or notices; and (g) report certain conclusions and observations regarding the feasibility of the proposed project. .

On the basis of our level of review and the documentation reviewed, this study supports the following conclusions.

- The Orleans watershed area appears to be a viable location for installation of a wind turbine. Overall, we did not uncover any major technical hurdles, including transportation of equipment to the site, to the installation of a 1.5 MW class or a 660 kW class wind turbine on the proposed site.
- A wind turbine can be electrically interconnected to the watershed's iron and manganese treatment plant's electric distribution system to export power to the utility grid as well as supply the intermittent needs of the treatment plant.
- The regulatory hurdles as well as the capital costs to run power from the wind turbine site to any Orleans municipal buildings at the watershed site appear to be too prohibitive to be considered at this time.
- No significant neighborhood impact issues, such as negative impacts to wildlife or wetlands, have been identified at this time; however, it is likely that the visual impact will be noticeable from some distance at various points of view in Orleans. No problematic environmental permitting issues have has been identified at this time.
- While there is well-documented regional public concern for development of a wind power project off the coast of Cape Cod, we could not find material documentation at this time to support the concept that there would be significant public resistance to this type of on-land wind project in this area of the Cape.
- Should this project be considered further, during the next phase of review – likely a business planning stage – the wind resource data should be updated and expanded with new data to provide a more comprehensive data set.

1 INTRODUCTION

R. W. Beck, Inc. and Global Energy Concepts, LLC (collectively referred to herein as "we" or "us") have been retained by MTC to conduct a feasibility study of implementing wind energy generation at the Orleans watershed area. This feasibility study has been performed in close cooperation with the Orleans Planning Department.

This study is in response to the scope of work negotiated with MTC which is described more fully in a professional services agreement with MTC. This report (the "Report") identifies issues raised during preparation of the feasibility study and is submitted to MTC for its review and use. All statements in the Report concerning the various technical issues are on the basis of information provided to us by Orleans, MTC, the RERL, equipment vendors, and those assumptions identified herein.

The Orleans Wind Energy Committee has selected the town's watershed as the focus for a potential development location. This study and Report focuses solely on this area of Orleans. Additionally, the Orleans Wind Energy Committee asked that this study initially consider a wind energy plant comprised of multiple wind turbines as well as a single wind turbine.

In support of the Orleans Wind Energy Committee, the objective herein is to prepare a wind energy planning and development study intended to provide sufficient information to support local decision-making regarding whether to proceed with the project. The study addresses technical, environmental, and regulatory aspects of the project to:

- Identify wind plant configuration options (e.g., number, size and location of wind turbines);
- Evaluate technical feasibility of wind plant options;
- Understand environmental and community impacts as well as community acceptance of a potential project;
- Develop capital and operating cost assumptions for two wind plant options;
- Document and evaluate permitting and approvals aspects of the project;
- Estimate wind energy production levels for two wind plant options; and
- Estimate project economics.

The study is not intended to identify and evaluate project ownership and financing options (e.g. local bonding, public-private partnerships). MTC is separately preparing a generic evaluation of community wind ownership and financing options.

We performed a screening analysis to identify and evaluate factors that would make it infeasible, inappropriate, or overly difficult to develop a wind energy project at the Orleans watershed. We examined the aspects of wind energy development identified herein and assessed how these factors would impact a proposed wind turbine installation. Our analysis included an inspection of the site and vicinity, discussions with Orleans planning staff, and consultation of readily available public databases (e.g., wind resource maps, endangered species locators) and information sources. Our screening analysis determined that there were no technical impediments to going forward with such a project and that project economics would likely be the governing factor in determining if such a project should go forward. The balance of this feasibility study is intended to combine feasibility, planning, and predevelopment tasks, the objectives of which are to: (a) identify specific site preparation work that could be completed as soon as possible; (b) complete analyses required to finalize the location of proposed wind turbines; (c) estimate the project economics; and (d) identify technical data that can be used in preparing applications or notices for anticipated permits and approvals. Accordingly, the scope of this study and this report includes the following:

1. Perform a high-level site screening analysis to identify and evaluate factors that would make it infeasible, inappropriate, or overly difficult to develop the project and potential wind turbine configuration options, analyze the aspects of wind energy development, and assess how they impact a potential wind turbine installation at the watershed site.
2. Prepare photo-simulations depicting one wind turbine from up to four vantage points.
3. Identify and evaluate required permits and approvals, including federal, state, local, and utility interconnection requirements, including: identify and list required permits and approvals; identify additional research that must be completed prior to filing for permits and approvals; and estimate the required timeframe for securing permits and approvals.
4. Evaluate technical issues related to development of the project, including: site characteristics; electrical infrastructure; neighborhood impacts; environmental impacts; recommendations for the wind turbine location; identify technical issues associated with the project; and develop detailed, project-specific information required for permitting and approvals processes.
5. Prepare a project site plan with preliminary layout of wind turbine, components and interconnection point.
6. Review and evaluate wind data collected on site by other parties, including correlation with appropriate long-term wind data sources, to the extent feasible, including: refine estimates of the wind resource at the project site; and develop a wind resource profile for use in estimating annual electricity production and the allocation of generated electricity between on-site loads and exports to the grid.
7. Characterize on-site electric loads, including diurnal and seasonal variability, and understand the potential for use of wind-generated electricity on site.
8. Estimate turbine annual energy production and the allocation of generated electricity between on-site loads and exports to the grid, including: estimate predicted life-cycle productivity of the wind turbine; and estimate the potential value of wind-generated electricity.
9. Prepare a preliminary economic analysis, including: identify assumed capital, reserve, operating, and maintenance costs; and estimate life-cycle energy production costs.

Throughout this report, data and results are provided in Système International ("SI") units (metric units) to be consistent with the raw data available and to be consistent with wind industry standard practice; accordingly, with a few exceptions data are not represented in traditional British/American-based English units.

2
WIND RESOURCE ASSESSMENT AND ENERGY ESTIMATE

Wind data from a meteorological ("met") tower located at the Orleans watershed were furnished us for the purposes of estimating the long-term wind resource and expected annual energy output for several proposed wind power project configurations. The RERL installed the meteorological tower in October 2003 and has managed the data collection since. The RERL provided us raw ten-minute meteorological data from November 2003 through August 2004. The first four months of this dataset were used by RERL in preparation of the two Orleans Wind Data Reports.

While the wind resource assessment and energy estimates presented herein are on the basis of the RERL data obtained during the period noted above, the assessments herein can and should be updated during the anticipated business planning stage in the near future. Updating these data will allow consideration of a year of data and allow improved focus on the specific project configuration (e.g., quantity of turbines, size, and location).

Detailed tower and sensor documentation was also furnished by RERL. We visited the tower in August 2004. The tower appeared to be in good condition and the installation was consistent with RERL documentation. The tower is instrumented with five anemometers, two each at approximately 50 meters and 40 meters and one at 20 meters above ground level ("AGL"). The anemometers at each level are mounted on 1.4-meter, side-mount booms, typically one northwest and one southeast of the tower (northwest only in the case of the 20-meter level). The tower is also instrumented with three wind vanes, one each at approximately 50 meters, 40 meters, and 20 meters AGL. The wind vanes are mounted on the same type of boom as the anemometers. The 50-meter and 20-meter wind vanes are located north of the tower; the 40-meter wind vane is located south of the tower. The raw dataset provided by RERL includes data from October 27, 2003, through August 27, 2004.

Figure 1 shows the approximate met tower location, which is on a hill approximately 260 meters (850 feet) north-northwest of a recently constructed drinking water purification plant. The tower is sited within an approximately 75 meters (245 feet) diameter clearing made from a dense forest of coniferous and deciduous trees. The surrounding coniferous trees are estimated to be 13 meters (43 feet) tall and the deciduous trees are approximately 10 meters (33 feet) tall.

Figure 1 - Met Tower Location

Data Review and Validation

We reviewed, reduced, and quality checked the raw dataset using industry standard techniques and best practices. In addition to some periods of missing data, we removed a few hours of wind speed data to account for sensor icing and other irregularities. Table 1 summarizes the valid data recovery percentage as a percent of calendar time, after our validation review.

Table 1
Sensor Valid Data Recovery

	Anemometers					Wind Vanes		
	50 m NW	50 m SE	40 m NW	40 m SE	20 m NW	50 m N	40 m S	20 m N
October 2003	15%	15%	15%	15%	15%	15%	15%	15%
November	100%	100%	100%	100%	100%	41%	100%	100%
December	100%	100%	100%	100%	100%	0%	100%	100%
January 2004	99%	100%	99%	100%	100%	0%	100%	100%
February	100%	100%	100%	98%	100%	0%	100%	100%
March	100%	100%	100%	100%	100%	0%	100%	100%
April	100%	100%	100%	99%	100%	0%	100%	100%
May	83%	83%	83%	82%	83%	0%	83%	83%
June	100%	100%	100%	100%	100%	0%	100%	100%
July	100%	100%	100%	100%	100%	0%	100%	100%
August	85%	85%	85%	85%	85%	0%	85%	85%
Overall	89%	89%	89%	89%	89%	5%	89%	89%

We used the validated data to complete a wind resource assessment and preliminary energy estimates for the Orleans watershed site using several different project configuration options. Following is a summary of the analysis including comparison to the RERL Orleans Wind Data Report, where applicable.

Wind Data Summary

A monthly summary of the 50-meter, 40-meter, and 20-meter measured wind speeds is presented in Table 2. The table indicates an average 50-meter wind speed of 5.9 meters per second ("m/s") measured during the period of record. The measured monthly average wind speeds are consistent with those months included in the RERL Wind Data Reports. The monthly data recovery of 50-meter wind speeds is 99% or better, with the exception of October 2003 and August 2004, which are partial months, and May 2004, when there were five days of missing data because of a replacement of the data logger.

Table 2
Measured Monthly Average Wind Speeds (m/s)

Height AGL	20 m	40 m	50 m
October 2003	3.8	5.3	5.8
November	3.9	5.3	5.9
December	5.1	6.8	7.5
January 2004	4.8	6.2	6.9
February	4.1	5.4	6.0
March	4.4	5.9	6.5
April	4.2	5.6	6.1
May	3.5	4.6	5.1
June	3.5	4.7	5.2
July	3.0	4.1	4.5
August	3.2	4.5	4.9
Overall	**4.0**	**5.3**	**5.9**

The diurnal pattern of the 50-meter winds during the period of record is illustrated in Figure 2. As shown in the figure, the wind speeds have a pronounced difference in magnitude between fall and winter compared to spring and summer. Aside from the overall magnitude difference, the diurnal patterns do not vary significantly between fall and winter compared to spring and summer. These observations are based on only the measured dataset and may not necessarily represent the long-term pattern. The diurnal graphs presented in the Wind Data Reports did not delineate the seasonal variation in the diurnal winds.

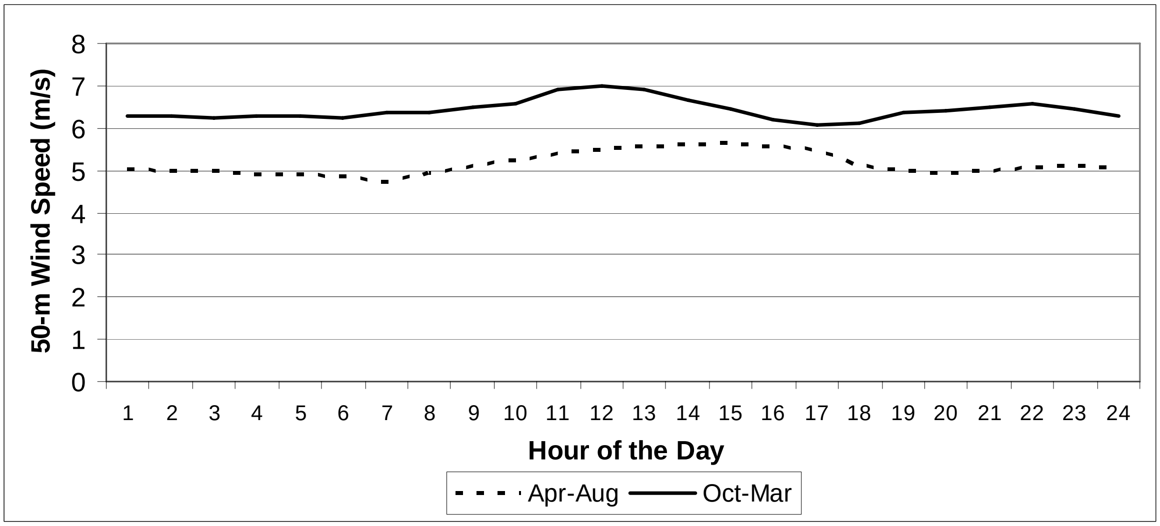


Figure 2 - Diurnal Wind Speed Pattern by Season

Wind Direction

The 50-meter wind vane malfunctioned in November 2003 and has not been repaired or replaced. Therefore, the 40-meter wind vane data were used to represent the wind direction at the met tower site. A wind rose graph presenting directional summaries of the measured dataset is provided as Figure 3.

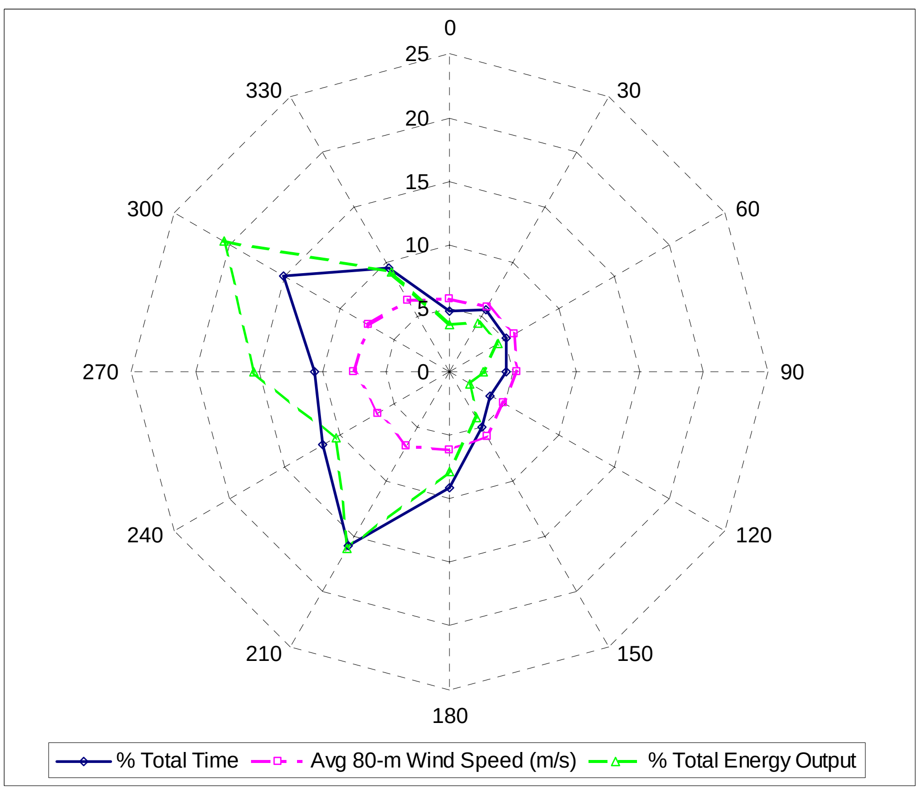


Figure 3 - Measured Wind Rose from October 2003 to August 2004

Figure 3 shows the average wind speed, percent of total time, and calculated energy output from a GE 1.5sl wind turbine for each direction sector. As shown in the graph, based on the available data, the predominant energy directions during the period of record were from the west to northwest which is similar to the predominate direction based on duration. The wind rose graph is created from concurrent wind speed and direction data and is therefore limited to hours where both wind speed and direction are available. The wind rose is based on the entire period of on-site measurement but normalized to represent one year. These results are consistent with those reported in the RERL Wind Data Reports. These results may not be representative of the long-term pattern since they are based on only approximately eleven months of measured data. Data measured at other locations on Cape Cod indicate a strong northerly component of energy in addition to the southwest, west, and northwest directions that the measured data indicate; however, because of the complicated topography and coastline of Cape Cod, there may be significant spatial differences in wind directions even for sites that are relatively close. As more data become available this topic can be investigated further.

Long-Term Representativeness

Data collected from the Orleans watershed met tower may represent a period of relatively high or low wind speeds compared to the long-term average. To determine the representativeness of the data collection period and make adjustments to long-term conditions, we needed to establish a correlation to a long-term reference site. We obtained data from the Barnstable Municipal Airport in Hyannis, Massachusetts, located approximately 34 kilometers ("km") west-southwest of the Orleans watershed met tower. We performed a linear regression analysis using concurrent daily average wind speeds from the met tower and from the airport for the overlapping period of record. The two sites are relatively well correlated with a correlation coefficient of 0.86 (R-squared of 0.74). The results of this analysis are shown in Figure 4.

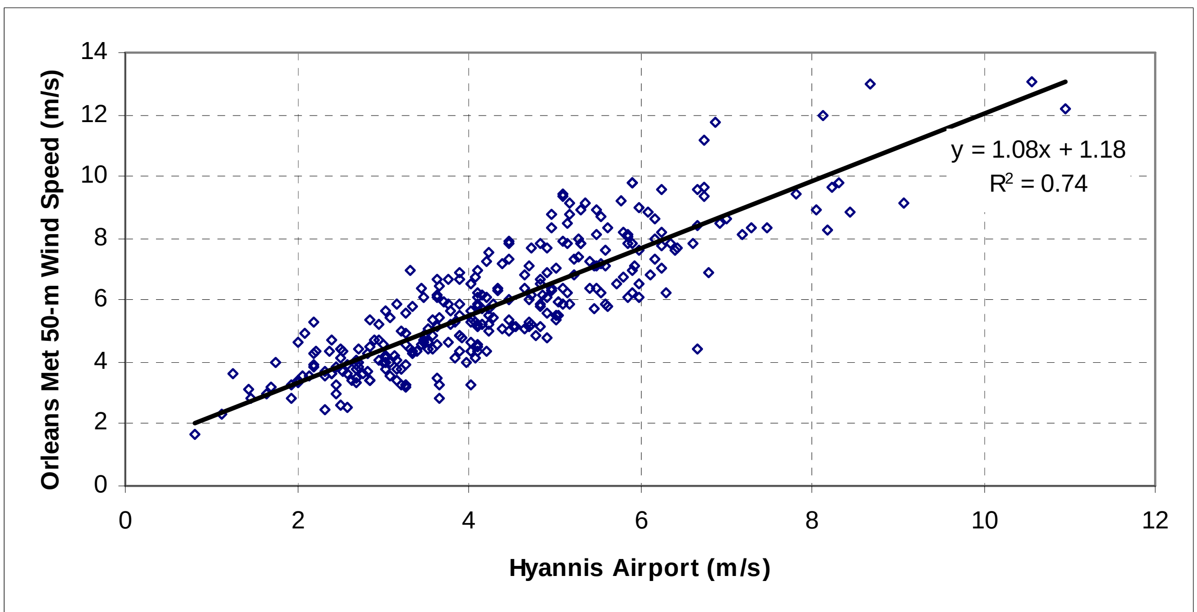


Figure 4 - Linear Regression: Daily Average Wind Speed from October 2003 through August 2004

When compared to the longer term period of record at the Barnstable Airport, the average wind speed for the entire measured period of record is slightly higher than normal. As shown in Table 3, the long-term average wind speed measured at the airport was 4.2 m/s compared to the average wind speed of 4.4 m/s at the airport observed during the measured period of record, excluding October 2003 which includes only a few days of measured data. There were, however, some fairly significant monthly variations. For example, the average wind speed for December 2003 was 19% greater than the long-term average wind speed for December.

Table 3
Long-Term Wind Speed Analysis – Barnstable Municipal Airport

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1998	10.4	10.3	10.9	9.2	9.5	9.2	8.6	7.5	8.1	9.9	8.4	9.0	9.2
1999	10.1	10.3	12.3	10.4	7.9	8.9	9.2	8.5	7.8	9.3	9.9	9.1	9.5
2000	11.6	9.8	11.0	11.6	8.9	9.1	8.0	7.3	8.5	8.5	9.5	9.8	9.5
2001	7.4	9.8	10.8	9.4	9.0	8.7	8.9	8.1	8.5	9.4	9.1	8.8	9.0
2002	9.0	9.8	10.5	10.1	10.3	9.9	9.3	9.1	8.9	8.6	11.0	10.0	9.7
2003	10.2	10.2	9.8	10.4	8.3	7.6	8.6	9.3	6.5	8.0	9.4	11.5	9.1
2004	10.3	9.8	10.7	10.5	9.0	8.9	8.4	9.5					
Avg mph	9.9	10.0	10.9	10.2	9.0	8.9	8.7	8.5	8.1	9.0	9.6	9.7	9.4
Avg m/s	4.4	4.5	4.9	4.6	4.0	4.0	3.9	3.8	3.6	4.0	4.3	4.3	4.2
Comparisons to Long-Term (m/s)													
11/03-8/04 Avg	4.6	4.4	4.8	4.7	4.0	4.0	3.8	4.2	-	-	4.2	5.1	-
11/03-8/04 Avg / Long Term Avg	104%	98%	99%	103%	100%	100%	96%	112%	-	-	98%	119%	-

To account for monthly, seasonal, and other wind speed differences during the met tower period of record compared to the long-term trend, the results of the regression analysis were applied to the Barnstable Airport measured dataset. This resulted in the creation of a synthesized long-term wind speed dataset at the met tower site. This dataset was then used to estimate the average annual long-term wind speed at the met tower site. This adjustment resulted in a slight reduction of the 50-meter annual measured wind speed from 5.9 m/s to 5.7 m/s, representing the long-term annual average wind speed. The RERL reports do not list a long-term corrected annual average wind speed.

Wind Shear and Estimated Hub-Height Wind Speeds

To estimate the wind speeds at the proposed wind turbine hub height of 80 meters, the vertical wind speed profile was estimated using the measured data and the characteristics of the site. Wind shear was estimated using the 50-meter, 40-meter, and 20-meter AGL wind speed measurements in a variety of ways. To reduce tower-shadow error, wind shear was only calculated when each anemometer was clear of significant tower wake. Data when wind speeds at any level were less than 4 m/s were also excluded from the wind shear analysis. Using the power law method of wind shear calculation, as shown in Equation 1 below,

$$V(z) = V_R \left(\frac{z}{z_R} \right)^{\alpha}$$

where V_R is the reference wind speed, z is the proposed wind turbine hub height, z_R is the reference height and α is the shear exponent, it is apparent that the lower anemometers are either heavily influenced by the surrounding foliage, or the sensor heights listed in the tower installation documentation may not be precise. Table 4 shows the wind shear exponents calculated from the measured data. These values are much higher than expected considering the moderate complexity of the surrounding terrain and the moderate surface roughness. Shear exponents of approximately 0.25 to 0.30 are expected for low forests in moderately complex terrain, such as the Orleans met tower site. The measured shear exponent values are more consistent with extremely steep and complex terrain with trees of widely varying heights and within urban areas or both.

Table 4
Vertical Wind Shear Exponent Calculation from the Measured Data

Center of Direction Sector (deg)	20-50m Shear	Data Points	40-50m Shear	Data Points
0	0.41	605	0.42	1134
30	0.42	833	0.42	1415
60	0.42	604	0.46	1323
90	N/A [1]	0	0.41	1018
120	N/A [1]	0	0.42	568
150	0.40	281	0.41	1203
180	0.37	1566	0.39	2521
210	0.35	3540	0.37	5176
240	0.35	2088	0.40	3627
270	0.34	2826	0.36	3681
300	0.36	3638	0.53	4673
330	0.39	1713	0.43	2706
Overall	**0.36**	**17694**	**0.42**	**29045**

[1] 20-m wind speed data were excluded from the shear analysis due to tower wake influence on the 20-m anemometer for wind directions between 65 and 155 deg.

Furthermore, it is peculiar that the calculated shear exponent values are similar in magnitude between 20 meters and 50 meters compared to between 40 meters and 50 meters. The 20-meter wind speed measurements are expected to be influenced by the approximately 13-meter tall trees in the surrounding area. This would result in an artificially high shear exponent calculation using these data, which is consistent with what the data indicate. However, the 40-meter and 50-meter anemometers are relatively free from foliage influence and should indicate a lower shear exponent than that calculated using the 20-meter and 50-meter data, which is not the case. Conversely, the data indicate a larger shear exponent from 40 meters to 50 meters compared to between 20 meters and 50 meters. A possible explanation for this inconsistency is that the 40 meters anemometers may actually be located below 40 meters, which will introduce error in the shear exponent calculation. Other sources of random or biased error may also be influencing the data, such as sensors that are not level or functioning properly. These errors become particularly pronounced when shear is analyzed for a relatively small layer of wind flow such as between 40 meters and 50 meters. At least a 15-meter vertical separation between sensors is recommended to allow accurate wind shear calculation.

This issue has been discussed with RERL staff who has indicated that they also have concerns about the measured vertical shear exponent being unreasonable. The RERL plans to measure the wind speeds at much higher levels than the met tower with a portable sonic detection and ranging ("SODAR") unit sometime during the spring or summer of 2005. An analysis on these data –

when they are available – may help to reduce the uncertainty in the vertical wind speed profile estimate.

Due to the lack of confidence in the vertical wind speed profile estimation using the measured shear exponents, an alternative method was used to estimate the wind speeds at 80 meters AGL. The wind speed profile as a function of height AGL was estimated using the logarithmic law, as shown in Equation 2 below,

$$V(z) = V_R \frac{\ln(\frac{z}{z_0})}{\ln(\frac{z_R}{z_0})}$$

where V_R is the reference wind speed, z is the proposed wind turbine hub height, z_R is the reference height, and z_0 is the roughness length. Estimates on the surface roughness in the vicinity of the met tower were based on the RERL documentation and a site visit. A baseline value of 0.3 meters is assumed, which is appropriate for wooded areas with generally uniform canopy heights. The reference height is estimated at 41 meters, which represents the difference between the 50-meter sensor height and the "effective ground level" at which the wind speeds are expected to be close to zero, independent of wind speeds aloft. This height is assumed to be two-thirds of the tree height, or 8.7 meters. The turbine height, used in Equation 2, is the "effective turbine height" which is the difference between the turbine hub height AGL and the reference ground level or 71.3 m in this case. With these assumptions, the long-term, 80-meter AGL height (71.3 m "effective height") annual average wind speed was calculated to be 6.3 m/s. This is generally consistent, but slightly less than the value shown on the New England Wind Map. The RERL did not estimate wind speeds at the 80-meter height or analyze wind shear. Table 5 lists the long-term estimated monthly average wind speeds at 50 meters AGL and 80 meters AGL for the met tower site.

Table 5
Long-Term Monthly Average Wind Speeds

Month	50 m	80 m
January	6.0	6.6
February	6.0	6.7
March	6.4	7.1
April	6.1	6.8
May	5.5	6.1
June	5.5	6.1
July	5.4	6.0
August	5.3	5.9
September	5.1	5.6
October	5.5	6.1
November	5.8	6.4
December	5.9	6.5
Annual	**5.7**	**6.3**

The estimated wind speed at 80 meters is highly sensitive to the surface roughness and effective ground level assumptions used in Equation 2. The baseline values are a best estimate of site conditions; however, there is a high level of uncertainty associated with these estimates. Additional on-site wind speed measurements nearer to wind turbine hub height[1] may reduce these uncertainties.

Table 6 shows the influence on the estimated long-term average wind speed from varying estimates of surface roughness.

Table 6
Long-Term Average Wind Speeds for Several Different Roughness Lengths

Roughness Length (m)	Corresponding Wind Shear Exponent 50 to 80 m AGL	80 m AGL Long-term Wind Speed[1]
0.1	0.18	6.2
0.3	**0.22**	**6.3**
0.5	0.25	6.4
2.0	0.35	6.7
3.5	*0.42*	*7.0*

Notes:
1 Calculated using an effective ground level of 8.7 m.
2. Italicized values result from the application of the measured vertical wind shear coefficient, which is believed to be in error.
3. Bold values represents best estimate given the information available

Energy Estimates and Expected Losses

The proposed wind turbine location is the existing met tower location; therefore, the wind resource measured at the met tower was used to estimate the annual energy for a single-wind turbine project. The estimated hourly average 80-meter AGL wind speeds were summarized in a frequency distribution calculated using the met tower period of record data scaled for agreement with the long-term average annual wind speed, and normalized to represent one typical year. The gross annual energy production was estimated using the power curve from three different wind turbines and the annual average frequency distribution. The three wind turbines studied are: the 77-meter diameter GE 1.5sl, which is a 1.5 MW wind turbine; the 70.5-meter diameter GE 1.5s, which is also a 1.5 MW wind turbine; and the 47-meter diameter Vestas V47, which is a 660-kilowatt ("kW") wind turbine. Compared to the GE 1.5s, the GE 1.5sl wind turbine is designed to be more efficient in lower wind resource sites such as that expected at the Orleans watershed. This GE 1.5sl version wind turbine has a 77-meter diameter rotor that allows it to capture more wind energy than the standard 70.5-meter GE 1.5s version.

Note that data for the GE 1.5sl unit are representative of the "1.5 MW class" wind turbines since the large turbines in wide-spread use in the U.S. are 1.8 MW units. The V-47 properties are not

[1] 60-meter met towers are commonly used in the wind power industry. Measurement above 60 meters will involve significant additional cost.

as representative of an entire class such as for the GE 1.5sle since there are only a few different turbine models available between 500 kW and 1,000 kW rated power.

Table 7 presents the sea-level wind turbine power curves for the GE 1.5s, GE 1.5sl, and Vestas V47 wind turbines and the 80-meter AGL annual wind speed distribution estimated for the proposed watershed site.

Table 7
80-m AGL Annualized Measured Wind Speed Frequency Distribution for the Proposed Site and Reference Power Curves for a GE 1.5sl, GE 1.5s, and Vestas V-47 Turbine

Wind Speed Bin Center, m/s	Annualized Hours	GE 1.5sl Power Output, kW	GE 1.5s Power Output, kW	Vestas V-47 Power Output, kW
0	0	0	0	0
0.5	91	0	0	0
1	82	0	0	0
1.5	119	0	0	0
2	152	0	0	0
2.5	274	0	0	0
3	405	0	0	0
3.5	393	20	0	1
4	565	43	36	3
4.5	640	83	66	23
5	586	131	104	44
5.5	764	185	150	70
6	571	250	205	97
6.5	639	326	269	131
7	569	416	344	166
7.5	406	521	428	209
8	440	640	528	252
8.5	388	785	644	301
9	282	924	774	350
9.5	308	1062	927	400
10	264	1181	1079	450
10.5	159	1283	1211	494
11	165	1359	1342	538
11.5	138	1402	1401	569
12	90	1436	1460	600
12.5	75	1463	1477	618
13	49	1481	1494	635
13.5	43	1488	1500	643
14	29	1494	1500	651

Table 7
80-m AGL Annualized Measured Wind Speed Frequency Distribution for the Proposed Site and Reference Power Curves for a GE 1.5sl, GE 1.5s, and Vestas V-47 Turbine

Wind Speed Bin Center, m/s	Annualized Hours	GE 1.5sl Power Output, kW	GE 1.5s Power Output, kW	Vestas V-47 Power Output, kW
14.5	17	1500	1500	654
15	16	1500	1500	657
15.5	14	1500	1500	658
16	10	1500	1500	659
16.5	7	1500	1500	660
17	5	1500	1500	660
17.5	1	1500	1500	660
18	1	1500	1500	660
>18	0	1500	1500	660

Table 8 presents the estimated gross annual energy for these three turbine types on a per turbine basis.

Table 8
Sea-Level Air Density Estimated Gross Annual Energy Output on a per Turbine Basis

Turbine	GE 1.5sl	GE 1.5s	V-47
Rotor Diameter (m)	77	70.5	47
Hub Height (m)	80	80	65
Rated Power (MW)	1.5	1.5	0.66
Gross Annual Output (MWh)	3740	3308	1304
Gross Annual Capacity Factor	28.5%	25.2%	23.0%

The GE 1.5sl, GE 1.5s, and the V47 wind turbines were specified by MTC to be used as the basis for this study. There are several other similar wind turbines currently available that may also be suitable for this site. We expect the results of this analysis to be representative of results that would be obtained if other similar wind turbines were analyzed. However, a detailed analysis of candidate wind turbines should be conducted before detailed project design and equipment procurement activities commence.

The gross annual energy presented above represents the energy delivered at the base of the tower under ideal conditions. Net annual energy production takes into account typical losses and represents the energy delivered to the grid interconnection point for a typical (average) year. For the Orleans site, we estimated energy losses from a variety of sources. Exact losses can vary significantly from project to project and from time to time; for example, some projects with poor transmission access may experience significant line outages or curtailment. For the purpose of this assessment, we assumed typical values for parameters where site-specific information was not available at this time. The following items provide an overview of the sources of losses.

Mechanical Availability: This item includes downtime for scheduled maintenance and unscheduled maintenance/repairs. Other downtime such as weather-related downtime and grid outages are included in other items, described below. The typical assumption is that modern wind turbines will be unavailable for scheduled and unscheduled maintenance approximately 3% of the time; this wind turbine will likely have somewhat higher availability losses compared to larger utility-scale wind projects due to a lack of a dedicated support staff at the wind turbine. We assumed a mean availability loss of 4%.

Electric Line: Electric line losses are primarily a function of efficiency of the transformers (both pad-mount transformers and substation transformers) and of the electric cabling comprising the on-site collection and distribution system. We assumed a mean electric loss of 2%; this value is generally reasonable considering the proposed electric system.

Turbulence/Control System: Turbulence and control system losses include a variety of issues related to the normal control of the wind turbine that prevent performance in accordance with the ideal power curve. These issues include high-wind hysteresis (production lost during the time it takes to recover from automatic high-wind shutdowns), low-wind hysteresis (startup and cut-in), off-yaw operations, cable untwists, atmospheric conditions that result in reduced performance of a wind turbine relative to its power curve, particularly at the "knee" where the wind turbine reaches rated power, etc. We estimated 2% losses for these issues.

Blade Contamination: This item, which includes accumulation of dirt and insects on blades, can impact energy production, particularly in dry environments. These losses will be site-dependent; we estimated 0.5% since the site is not particularly dry or dusty and because the wind turbines under consideration are pitch-regulated and are affected less from these issues than stall-regulated wind turbines.

Icing/Weather: The types and magnitudes of weather-related losses will vary by project, but may include icing, high ambient temperature cutouts, low ambient temperature cutouts, and shutdowns to avoid hail, lightning, or other storm damage. At these sites, high and low ambient temperature cutouts should be rare, and storm-related shutdowns are not likely to be as significant as at some Midwest wind farms. There may be some icing downtime during winter months. Based on our observations on the meteorological data recovery from the Orleans met tower and other nearby sites, we assumed approximately 1% icing and weather losses.

Utility Outage: The utility outage losses will include both scheduled forced outages (either for maintenance activities, such as utility substation maintenance, or for curtailment) and unscheduled grid outages. Based on our experience with similar projects, we assumed a 0.2% loss, equivalent to approximately one day per year for line maintenance.

Uncertainties

This section presents our estimates of uncertainties on the annual energy production for the proposed project given the aforementioned assumptions and considerations, as a percentage of the values which have a 50% probability of being exceeded, commonly referred to as P50 values. Uncertainties are presented for both long-term (20-year) and one-year values. In this assessment, the difference in the long-term and one-year values is related only to the variability in the wind over the period of record. While some other parameters, such as machine availability and weather, will also exhibit slightly more variability over single years than over the long-term average, these effects are very difficult to predict and tend to be small compared to the wind effects, so they have been ignored for this level of analysis.

The net energy production estimates at a range of confidence levels are evaluated using a stochastic model to evaluate the uncertainty in the assumptions, methods, and losses used for the analysis. Distributions appropriate for each were determined and a probabilistic description of the annual net energy was built integrating each source. The model was then run in 10,000 iterations with each parameter changed randomly and independently to describe the distribution of net energy estimates. These results were then summarized to determine the probability of exceedance at various levels of confidence. The following bullet items briefly describe the various sources of uncertainty and how they are estimated.

- **Anemometer Accuracy**: This parameter represents the variability in measurement of wind by individual anemometers. An uncertainty of approximately 1.5% on wind speed was assumed based on the typical error on measurements found in testing of a large number of Maximum #40 anemometers commonly used in wind resource assessment. Consequently, the values used in this assessment are the baseline 1.5% on wind speed.
- **Tower Effects/Measurement Biases**: Sensor type and placement will have an effect on wind speed measurements due to a variety of reasons, including slowing of winds downwind of the tower, upwind obstacles (such as trees), and others. Based on our current knowledge of the Orleans tower, we estimated an uncertainty of 1.5% on wind speed associated with these effects.
- **Data Capture/Recovery, Quality Control/Validation Procedures**: This item covers issues related to missing, invalid, or questionable data. Some data have been lost from the Orleans and Barnstable Airport towers for a variety of reasons, including icing, failed sensors, and failed tower components. We estimated an uncertainty of 1% on wind speed for this issue.
- **Period of Record of Data (Data Quantity):** This item generally reflects the period of record of data used as the long-term reference for each of the sites, which is approximately 6.5 years of data at this location. This is a relatively short period of record compared with a typical 20-year project life. The uncertainty was estimated as 4% of wind speed divided by the square root of the 6.7 years of data available from the reference site; the 4% value represents an estimate of the inter-annual variability in wind speed, which is typical for many parts of North America and should be reasonable for this site.
- **Long-Term Correlations**: This topic represents uncertainties in the correlations to the long-term reference sites; this uncertainty is based on the apparent accuracy of the correlation (based on the R^2 [coefficient?] of the linear regressions), the period of record of site data available to perform the correlation, whether or not seasonal variabilities are represented in the correlations, etc. We estimated an uncertainty of 1.3% on wind speed for this parameter.
- **Uncertainty on Wind Shear Estimates**: The uncertainty on wind shear is primarily dependent on the measurement height of the meteorological tower (50 meters) relative to the expected hub height of the wind turbine, which is currently expected to be 80 meters for the GE 1.5sl wind turbine or 65 meters for the V47 wind turbine. Shear can also vary based on the relative exposure at a meteorological tower relative to wind turbine locations, vegetation or seasonal changes in vegetation, and other effects. We estimated the overall shear

uncertainty based on a combination of these issues. Shear uncertainty was assumed to be partially dependent on the measurement uncertainty; if the measurements at the tower were biased low due to vegetation effects, the effective shear would most likely be higher. The effective uncertainty associated with shear is approximately 3.4% on wind speed for the GE 1.5sl wind turbine with an 80-meter hub height and approximately 2.5% on wind speed for the Vestas V47 wind turbine with a 65-meter hub height.

- **Uncertainty on Whether the Long-Term Average Occurs Over the Life of the project/Single Year**: Even if the long-term average is known accurately, there is some statistical probability that the wind speeds over a 20-year (or similar) project lifespan will average higher or lower than the long-term average. An uncertainty of 1.3% of wind speed was used to account for this factor for the long-term assessment (equivalent to 4% divided by the square root of 20). For the single-year assessment, this value was set to 4%.
- **Changes in Long-Term Average over Time**: There is some chance that changing climate conditions, on a local or global scale, could change the wind speeds from those estimated from historical measured data. The extent to which this may occur remains unknown. An uncertainty value of 1.0% of the wind speed was used for this parameter.

Many uncertainties are estimated as percentages of wind speed; these values are converted to uncertainties on energy output by multiplying by the ratio of change in annual energy to change in annual average wind speed given the distribution of winds at the site. This ratio can vary depending on the wind turbine type (i.e., the steepness of a wind turbine's power curve), mean wind speed, and other parameters, and there is technically uncertainty on this value as well. Based on the gross energy estimate for the project and the baseline estimate of wind speed, we calculated an average ratio of 2.4 times the change in energy per unit change in wind speed as multiplier for the project (i.e., a 1% increase in average wind speed is estimated to contribute to a 2.4% increase in annual energy output). After converting all uncertainties to percentages of energy, the uncertainties were added as the square root of the sum of the square of each value.

Table 9 summarizes the uncertainty on wind speed and energy for each component, and the root-sum-square of each component.

Table 9
Uncertainty Element Summary (Nominal Values)

Uncertainty Type	GE 1.5sl wind turbine		Vestas V47 wind turbine	
	Uncertainty on Wind Speed	Uncertainty on Energy	Uncertainty on Wind Speed	Uncertainty on Energy
Anemometer Accuracy	1.5%	3.6%	1.5%	3.1%
Tower Effects on Measurements	1.5%	3.6%	1.5%	3.1%
Data Reduction Procedure Accuracy	1.0%	2.4%	1.0%	2.3%
Data Quantity Uncertainty	1.6%	3.7%	1.6%	3.2%
Long-Term Correlation	2.0%	4.7%	2.0%	4.2%
Wind Shear Uncertainty	3.4%	8.0%	2.5%	5.2%

Table 9
Uncertainty Element Summary (Nominal Values)

Uncertainty Type	GE 1.5sl wind turbine		Vestas V47 wind turbine	
	Uncertainty on Wind Speed	Uncertainty on Energy	Uncertainty on Wind Speed	Uncertainty on Energy
Uncertainty on Whether the Long-Term Average Occurs Over the Life of the project	0.9%	2.1%	0.9%	1.9%
Changes in Long-Term Average Over Time	1.0%	2.4%	1.0%	2.1%
Root-Sum-Square	**5.0%**	**11.9%**	**4.5%**	**9.3%**

The following tables, Tables 10-13, present various net energy estimates, which are discussed further below, that are based on measured data and various probabilities that wind-generated energy will exceed a certain amount in a given period. These estimates, however, do not represent how much energy would have been generated over the period of data collection.

Table 10 and Table 11 present the resulting net energy estimates and capacity factors for one 80-meter hub height GE 1.5sl wind turbine located on the proposed Orleans site at a range of probability-of-exceedance levels. For example, there is a 75% probability that the energy will exceed the P75 level and a 25% probability it will be less.

Table 10
Long-Term Net Annual Energy Estimates – GE 1.5sl

Probability	MWh/yr	Capacity Factor	% of P50
P99	2,482	18.9%	73.9%
P95	2,734	20.8%	81.5%
P90	2,868	21.8%	85.4%
P75	3,097	23.6%	92.3%
P50	3,357	25.5%	100.0%

Energy estimates were generated to represent long-term net annual energy as shown in Table 10; these long-term P75 values were used as the basis for the 1.5 MW economic model herein.

Energy estimates were also generated to represent one-year net annual energy as shown in Table 11; however, these data are not used in the feasibility analysis herein.

Table 11
One-Year Net Annual Energy Estimates – GE 1.5sl

Probability	MWh/yr	Capacity Factor	% of P50
P99	2,295	17.5%	68.5%
P95	2,583	19.7%	77.1%
P90	2,735	20.8%	81.6%
P75	3,018	23.0%	90.1%
P50	3,351	25.5%	100.0%

Table 12 and Table 13 present the resulting net energy estimates and capacity factors for one 65-meter hub height Vestas V47 wind turbine located on the proposed Orleans site at a range of probability-of-exceedance levels.

Table 12
Long-Term Net Annual Energy Estimates – Vestas V47

Probability	MWh/yr	Capacity Factor	% of P50
P99	937	16.2%	79.7%
P95	1,000	17.3%	85.0%
P90	1,035	17.9%	88.0%
P75	1,102	19.1%	93.7%
P50	1,176	20.3%	100.0%

Energy estimates were generated to represent long-term net annual energy as shown in Table 12; these long-term P75 values were used as the basis for the 660 kW economic model herein. Energy estimates were also generated to represent one-year net annual energy, as shown in Table 13; however, these data are not used in the feasibility analysis herein.

Table 13
One-Year Net Annual Energy Estimates – Vestas V47

Probability	MWh/yr	Capacity Factor	% of P50
P99	867	15.0%	73.9%
P95	946	16.4%	80.7%
P90	992	17.2%	84.6%
P75	1,076	18.6%	91.7%
P50	1,173	20.3%	100.0%

3
SITE PROFILE

Orleans

The Town of Orleans, incorporated in 1797, is a resort community located in Southeastern Massachusetts, at the elbow of Cape Cod, which is bordered by Eastham on the north, the Atlantic Ocean on the east, Chatham and Harwich on the south, and Brewster and Cape Cod Bay on the west. Orleans is approximately 34 km from Hyannis, Massachusetts; 142 km southeast of Boston, Massachusetts; 150 km east of Providence, Rhode Island; and 435 km northeast of New York City.

Site and Existing Conditions

Cape Cod's drinking water comes from six groundwater flow lenses, which are separate under natural hydrological conditions. Orleans, as well as the towns of Brewster, Chatham, Harwich and parts of Dennis and Yarmouth, pump water from the Monomoy Lens, which is bound by the Nantucket Sound, Pleasant Bay, Atlantic Ocean, Cape Cod Bay, Bass River and the Nauset lens. The Town of Orleans watershed area, which occupies approximately 500 acres of principally conservation land, is located in the triangular area between U.S. Route 6 and Massachusetts Route 28 and south of Route 6A as shown in Figure 5 below.

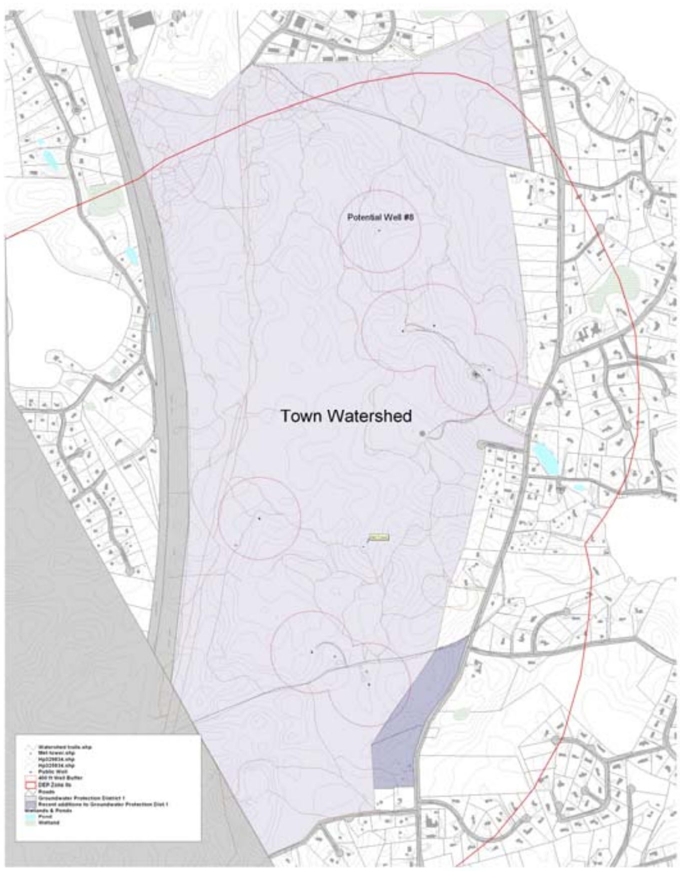


Figure 5 - Orleans Watershed Area

The watershed area has six groundwater wells that pump water from the Monomoy Lens. Town Wells No. 1 through No. 6 are located on the watershed area. (Orleans has a seventh well, Well No. 7, which is located on approximately 13.5 acres of town-owned land off Quanset Road.) Each well has an approximately 400-foot radius groundwater protection zone around the wellhead, which represents an area around the wellhead of approximately 11.54 acres. Figure 6 below provides satellite imagery of the Orleans watershed.

Figure 6 – Orleans Satellite Photograph

There are several buildings and structures scattered on the watershed site devoted to pumping, maintenance, water treatment, and other water supply-related activities. One of the buildings on the watershed site, the iron and manganese removal treatment plant (the "I&M Plant"), which is dedicated to reduce hardness from the well water, has the greatest electric load in the immediate vicinity.

The general are proposed for a wind turbine is the site of the met tower, which is on a hill approximately 260 meters north-northwest of the I&M Plant, which has been cleared approximately 75 meters diameter from a dense forest of coniferous and deciduous trees. The surrounding coniferous trees are estimated to be 13 meters tall and the deciduous trees are approximately 10 meters tall.

The nearest residential neighbors (receptor) are at least approximately a quarter mile away from this site.

Electric Load Profiles

The annual electric profile of the watershed area facilities is seasonally cyclic depending on water usage and potable water (demand) draw. The I&M Plant does not yet have an established electric load profile; however, we have been advised that the annual electric energy consumption from the I&M Plant is expected to be approximately 780,000 kilowatt-hours ("kWh"), also seasonally cyclic.

The disadvantage of the seasonally cyclic electric energy consumption from the loads at the watershed are: (1) the loads are not constant enough to provide a baseline load in which to consume power generated by a wind turbine (i.e., displace electric demand from NSTAR), and (2) the ability to compare energy consumption on-site to that generated by the wind turbine(s) is effectively impossible. There will be times however when the wind turbine generates power but there is no significant power consumption at the Orleans watershed and times when the watershed consumes power yet there will be generation from the wind turbine.

Other town buildings and loads, such as Town Hall, the elementary school on Eldredge Parkway, and the Snow Library on Main Street, have more established loads; however, upon initial screening we have determined that the length of electric power lines necessary to interconnect from the watershed area to these community loads – as well as the likely encroachment into public utility space in doing so – make these scenarios unattractive due to the likelihood of excessive capital costs to run long power lines and the regulatory issues in encroaching on utility territory.

Accordingly for these reasons the balance of this study considers interconnecting power generated by the wind turbine(s) directly to the nearby I&M Plant for the purpose of distributing power to the grid and alternatively – or from time to time – displace electric load from the I&M Plant.

With the understanding that Orleans is mandated to ensure that any development on the watershed be supportive of watershed activities, we would advocate that the interconnect be negotiated with the local utility, NSTAR, or future electric service provider to the Town to allow energy generated by the wind turbine(s) be sold to the grid on condition that the I&M Plant as well as any other grid connected watershed loads are first displaced by the wind energy with the balance for export sale.

Existing Electric Infrastructure

Orleans is within the regional NSTAR Electric distribution system. Orleans' electric power supply is provided through the Cape Light Compact and delivered by NSTAR.

The Orleans watershed has a number of site-dedicated distribution lines feeding off the NSTAR distribution system to provide power to the various water supply/treatment buildings throughout the watershed, including the I&M Plant, the well stations, and water pumps.

The capacity of NSTAR's local distribution system in the vicinity of the watershed as well as the distribution system feeding other municipal buildings is unclear. Equally unclear is the capacity of NSTAR's immediate regional transmission system. Preliminary discussions with NSTAR have yet to identify these system capacities. Without this information in hand it is unclear how much excess capacity exists in the local distribution system to carry excess power or exported power generated from a wind turbine or multiple wind turbines at the watershed.

While the scope of this study did not focus discussion on multiple wind turbines at the watershed (Refer to Section 4 herein), we note that the ability of the local distribution system to carry power from multiple wind turbines at the watershed is unclear at this time. For example, six 1.5 MW wind turbines would generate approximately 9 MW – a small fraction of which would be used at the watershed – resulting in an export of power of greater than 8 MW which the local distribution system might not be able to convey.

Additionally it's unclear if the immediate transmission system could absorb a fluctuating generating capacity of 8 MW to 9 MW exported to it; if not, such an installation would cause instability on the transmission system. We note that there is a 25-kV transmission line to the west of the watershed that is approximately one half mile from the proposed wind turbine site; however, it is unclear if there is a viable interconnect point along this line within reasonable proximity.

Accordingly until such time occurs that NSTAR is able to provide us this needed information regarding the capacity of its local distribution and transmissions systems, we believe the prudent course is to focus on a single wind turbine installation at the watershed.

For further detail regarding the NSTAR system/grid, refer to the discussion of electric interconnect in Section 4 herein.

4 CONCEPTUAL DESIGN

Site Physical Characteristics and Potential Wind Plant Configuration Options

Our objective was to assess the site physical characteristics, including topography, land cover, land use, access roads, and buildings; to evaluate the suitability of potential wind turbine locations from an operational viewpoint; to describe required and recommended spatial separation of the wind turbine from buildings and pedestrian or vehicular traffic; to evaluate the ability to deliver wind turbine components and installation equipment to the site (via land or air); and to identify necessary access road modifications required for each potential wind turbine location.

Based on detailed maps and other information provided by Orleans and site visits by our engineers, the Orleans watershed site was evaluated to determine its suitability for wind energy project development. Issues that were investigated include:

- The constructability of the site;
- The suitability of potential wind turbine locations with regard to operational considerations;
- The presence of any buildings or other obstacles that may hamper the productivity of a site.

Following is a summary of the investigation including recommendations of issues that Orleans should consider if it intends to move forward with development of a wind power project.

Obstructions to the Wind Resource

On-site measured wind speed and direction data from November 2003 through September 2004 indicate the prevailing wind direction, from both time duration and an energy-content basis, are generally from the southwest and west. (For more detail, refer to Section 2 herein.) However, data measured at other locations on the cape indicate a strong northerly component of energy in addition to the southwest and west directions. The potential for a significant northerly wind component was taken into account during this study.

The only possible obstruction to the wind resource in the watershed is the water tower. The water tower is estimated to be 36 meters (120 feet) tall and 24 meters (80 feet) wide. The tower is located on top of an approximately 30-meter (98-feet) elevation above sea level, wooded hill approximately 183 meters (600 feet) northwest of the meteorological tower. Wind turbines located to the east and possibly to the south of the water tower would experience some reduction in wind resource due to the downstream wake of the water tower. This reduction is not expected to be large since the water tower is significantly lower than the proposed hub height (80 meters) of the wind turbine(s). The impact of this issue on the potential wind turbine locations is relatively small since the water tower is located near the eastern boundary of the watershed parcel which precludes siting wind turbines to the east of the water tower regardless of the wind resource impact issue. Wind turbines should not be sited to the south within close proximity to the water tower, unless the existence of a significant northerly component of winds is disproved. These issues were considered in the development of potential wind power project layouts for the watershed site.

The I&M Plant located near Cliff Pond Rd is not expected to significantly influence the wind resource at any of the potential wind turbine sites. The building is estimated to be 6 meters (20 feet) tall, which is about half the height of the surrounding forest and the building is sited in one of the lower elevation areas of the watershed. Therefore, the flow disturbance caused by the building is expected to be masked by the topographic and foliage effects.

Required Setbacks

Aside from avoiding potential obstructions to the wind resource, adequate space is needed for siting the wind turbines at a reasonable distance from residences, other buildings, sensitive areas, and roadways. Orleans has created a Commercial and Non-Commercial Wind Facilities Bylaw, which includes height restrictions, noise limits, and setback criteria as summarized in Table 14.

Table 14
Summary of Certain Bylaw Requirements

Item	Criteria	Waivers
Height Limit	Measured from average grade, maximum height(1) must be less than 300 feet	Zoning Board of Appeals may grant a waiver.
Minimum Blade Clearance	Blade clearance from ground immediately below must be at least 30 feet	
Minimum setbacks from adjacent parcels	Greater of a) engineer design fall zone plus 100 feet, or b) 300 feet from all boundaries of the site.	
Noise	Except during short-term events, noise cannot exceed 60 dBA measured from the nearest property line. Can be met through a 600-ft setback or scientific analysis to the satisfaction of the Zoning Board of Appeals.	

Notes:
1. Maximum height for a wind turbine is typically referred to as maximum tip height, which is equal to the hub height plus the radius of the rotor.

The setbacks shown in Table 14 are consistent with ranges of setbacks used in similar wind turbine projects. For example, a common setback used in the industry for homes and other structures is 1.5 times the maximum tip height ("MTH"). A common setback from roads and non-participating property lines is the MTH. The Orleans Bylaw height limit may restrict the type of wind turbine that can be installed unless a waiver is issued.

Table 15 identifies the MTH and 1.5 times the MTH, and compares these values with the setbacks and height restrictions in the referenced Orleans Bylaw.

Table 15
Setbacks at MTH and 1.5 times MTH

Wind Turbine	GE 1.5sl	Vestas V47
Tower Height	80 meters (262 feet)	60 meters (197 feet)
Rotor Diameter	77 meters (253 feet)	47 meters (154 feet)
MTH	118.5 meters (389 feet)	83.5 meters (274 feet)
1.5 times MTH	178 meters (583 feet)	125 meters (411 feet)
Maximum Height	Under 300 feet, unless waiver obtained	
Setback Adjacent Parcel	489 feet (MTH +100 feet)	374 feet (MTH +100 feet)
Noise Setback	600 feet, or other as approved by Board	

The MTH of the GE 1.5sl is 389 feet, which exceeds the limit of 300 feet. If this wind turbine or other similar wind turbines are proposed, the Zoning Board of Appeals would need to issue a waiver on the maximum height limit. The MTH of a wind turbine in the size range of the V47 is within the 300-ft limit.

The setback required by the Orleans Bylaw for an adjacent parcel must be equal to or greater than either the MTH or the MTH plus 100 feet. For the GE 1.5sl, this setback is 489 feet, while for the V47 it is 374 feet However, the noise setback of 600 feet (or other distance if scientifically proven and approved by the Zoning Board of Appeals) will override the setback from adjacent parcels when residences are located on those adjacent parcels. The 600-foot setback is only 17 feet more than 1.5 times MTH for the GE 1.5sl. However, the 600-foot setback is significantly more the 1.5 times MTH of 411 feet for the V47. The criteria of 1.5 times MTH is often used in the industry because perceived wind turbine noise levels at this distance are often low enough to be masked by background noise. The siting of V47s or similar sized machines may require detailed noise studies to be conducted and the approval of the Zoning Board of Appeals.

Wind Turbine Locations

We estimate that the Orleans watershed is capable of supporting up to six 1.5 MW class wind turbines. While this study is based on the potential installation of one wind turbine, hypothetical project layouts were generated for multiple wind turbine layouts to establish the maximum capacity of the site. Figure 7, Figure 8, and Figure 9 show potential wind turbine locations for projects with one wind turbine, three wind turbines, and six wind turbines. These layouts are based on the GE 1.5sl with a tower height of 80 meters (262 feet) and a rotor diameter of 77 meters (253 feet). The locations represent what is expected to be the highest wind resource and lowest construction cost locations that are suitable for wind turbine installation. The proposed locations take into account the predominate wind direction, elevation, access to roads, potential interference from the water tower and other wind turbines, and the setbacks as described above. These locations are suggestions, and with further input from the Town, adjustments to the configurations can be investigated further. For example, if only one wind turbine is installed, any of the six locations identified would be suitable; however, wind turbine Site 1, which is the location of the met tower, represents the closest access to roads and infrastructure without being too close to property lines and residences. It may be determined that, for a single wind turbine project, one of the western sites that is farther away from the neighboring properties is more suitable to maximize the separation between these properties and the wind turbine. Figure 7 shows the potential location with one wind turbine, based on the GE 1.5sl unit.

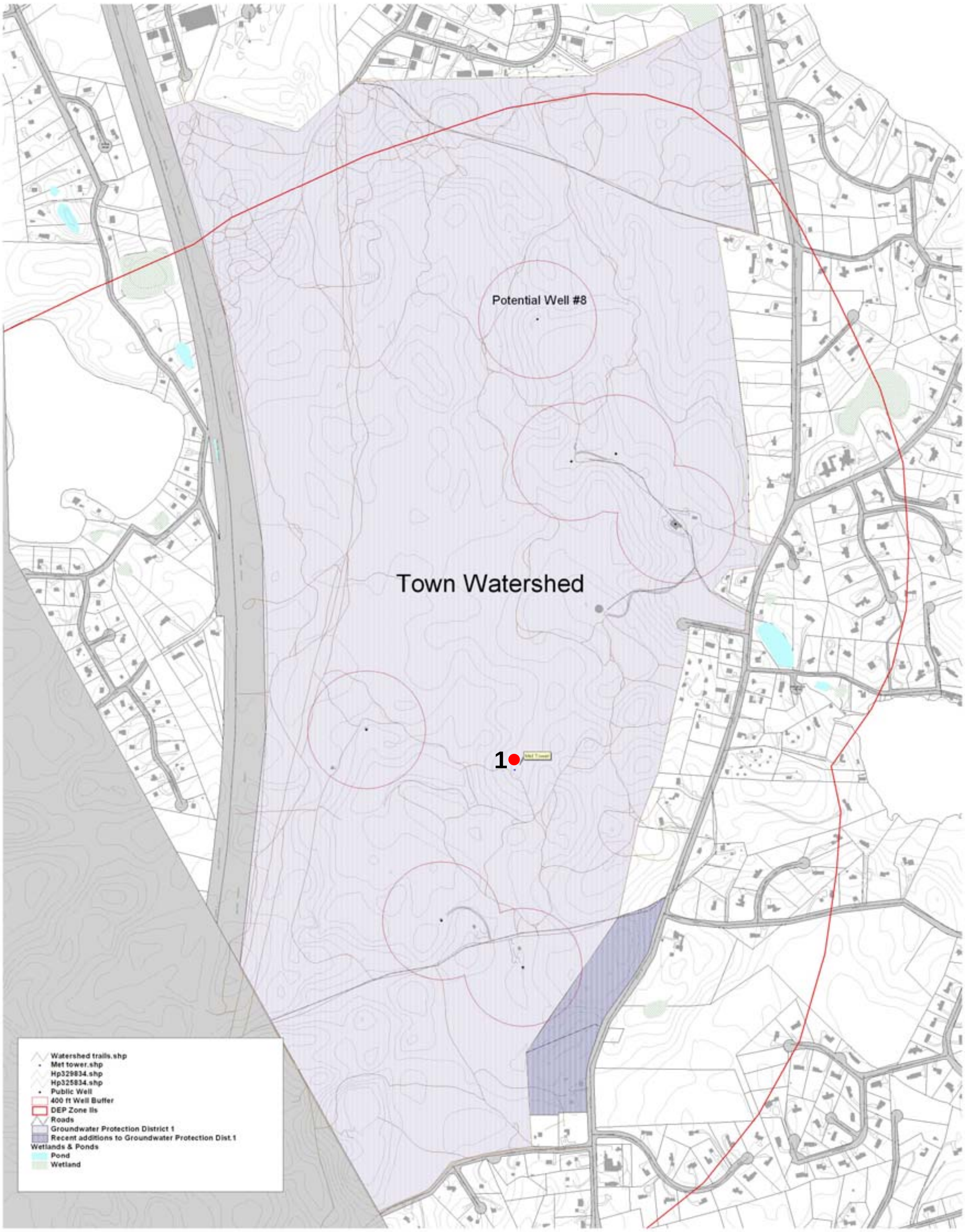


Figure 7 - Single-Turbine Layout

Figure 8 shows potential locations with three wind turbines, based on the GE 1.5sl unit.

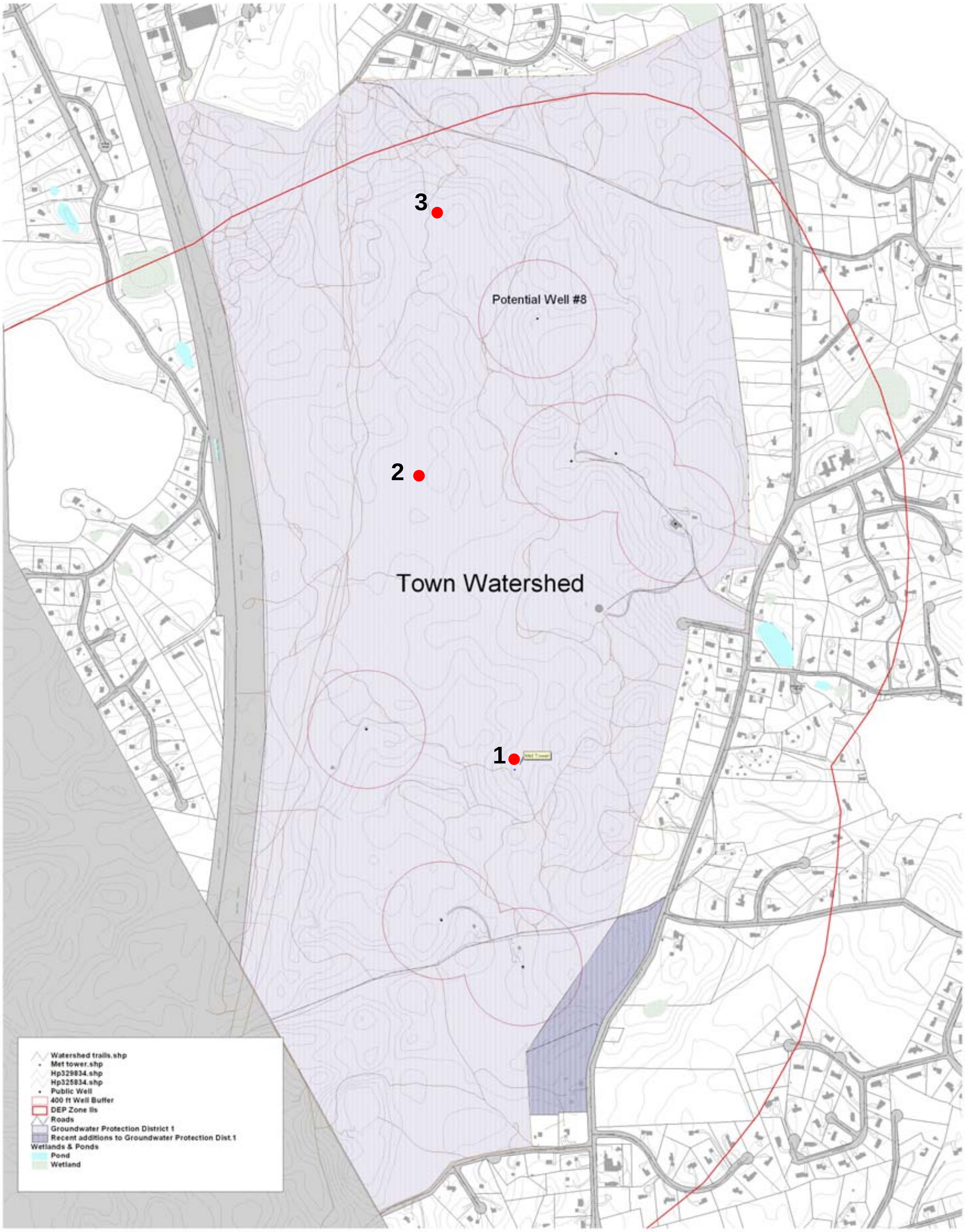


Figure 8 - Three-Turbine Layout

Figure 9 shows potential locations with six wind turbines, based on the GE 1.5sl unit.

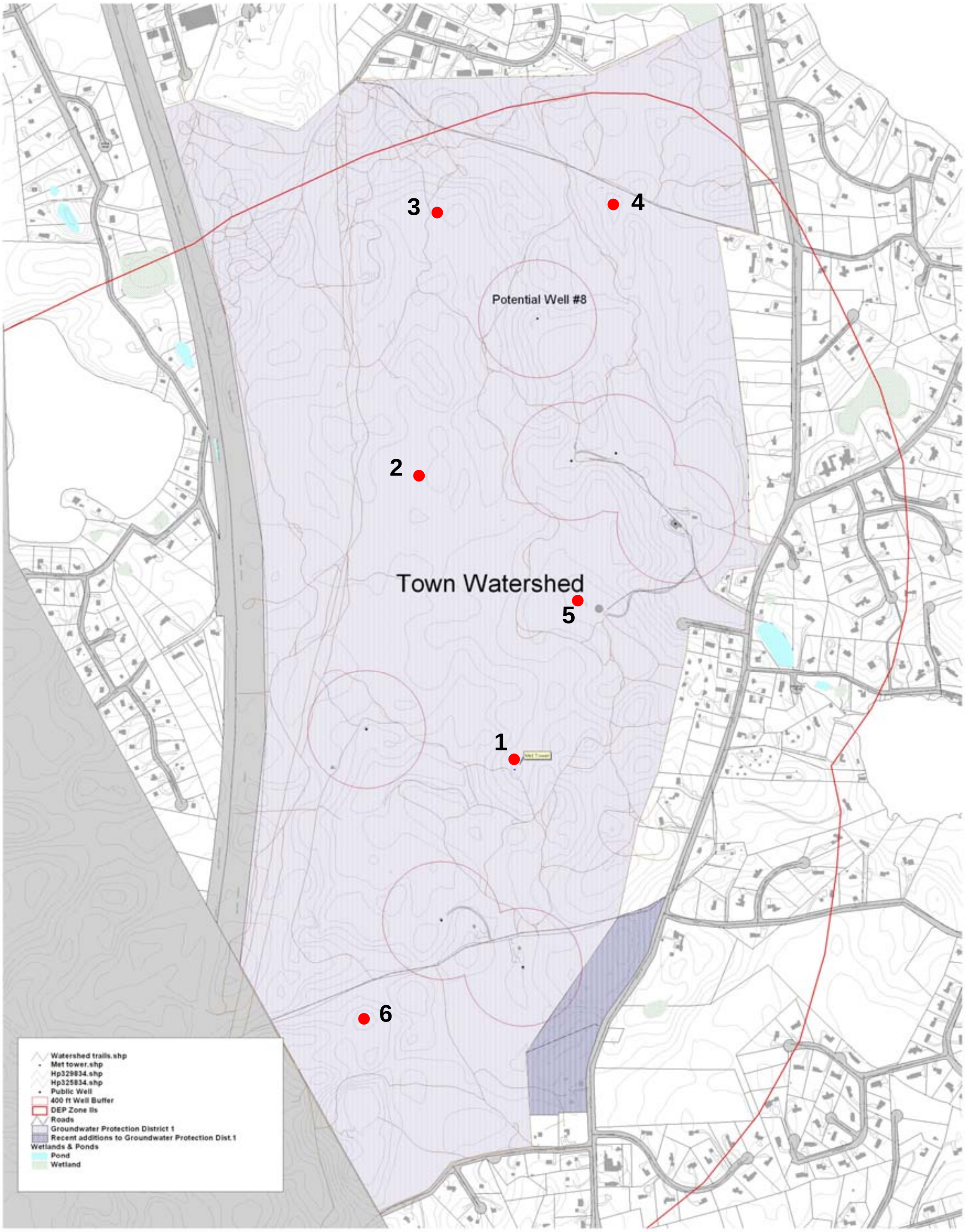


Figure 9 - Six-Turbine Layout

Spatial Separation from Key Structures, High-Use Areas, and Off-Site Visual and Noise Receptors

The wind turbines are spaced to meet the setbacks outlined in the Bylaws. The two structures of most concern are the water tower and the I&M Plant. The water tower would be within MTH of wind turbine Site 5. Wind turbines are design to meet stringent structural safety codes, which minimize the chance of a wind turbine tower collapse. The I&M Plant is 850 feet from the met tower and wind turbine Site 1 and approximately 850 feet from wind turbine Site 6. This spacing is more than sufficient, and exceeds the largest setback in the bylaws of 600 feet by approximately 250 feet.

Wind turbine Site 6 is also 230 feet from Cliff Pond Rd, which is inside the MTH setback limit. Depending on the average use of this road, and if this road is ever used by the public, this distance may be sufficient. Trails also crisscross the watershed property but were not considered in determining setbacks from the wind turbines.

Electric Interconnect

We observed potential electric interconnection points near the proposed site in the general area of the watershed. The context of the following electrical discussion is with regard to interconnecting a single wind turbine.

In developing a concept for the interconnection of the wind turbine we have considered the loads for the I&M Plant, loads for well pumping, and the load at the Orleans Middle School which is located some distance from the watershed, where the wind turbine or wind turbines would be. The most concentrated load will be at the I&M Plant. Although the I&M Plant has not gone permanently on-line, its electric load has been estimated by its design engineers to be approximately 500 kW on an intermittent (batch-load depending on potable water draw) basis. Data for the watershed pumping loads appear to indicate an electric load of less than 100 kW, while NSTAR billing data for the Orleans Middle School indicates a billing demand load of approximately 300 kilovolt-Amperes (“kVA”).

Further study should be performed to determine if it’s possible to synchronize the batch electric loads from the I&M Plant for maximum coincidence with the wind resource (i.e., turbine generation).

Also, further study may need to be performed with regard to certain energy storage devices that could store energy generated by the wind turbine when there is no load at the I&M Plant. While there are many types of energy storage technologies – the suitability of each type being dependant on the specific application – the reality is that most energy storage technologies are relatively expensive, and could easily double the cost of a wind turbine project, as well as require relatively considerable land use.

For the purposes of this study, we have focused on a potential interconnection at the I&M Plant. The cost of constructing new distribution lines to connect the wells to be served from parallel connections to the wind turbine and the utility system and the potential reduced reliability that could potentially be associated with the complexity of the wind turbine operating in parallel with multiple utility connections argues against that configuration at this level of study. Similarly, the long distance between the wind turbine site and the possible legal issues related to installing a power line by a non-electric utility entity in an area franchised to an existing utility have led us to discount that option for the purpose of this study. Both of these points can be revisited at some later time if warranted by the value of the output of the wind turbine.

The concept for the electric interconnection of the wind turbine would be to run shielded power cable in an underground conduit between the power circuit breaker included as part of the wind turbine scope of supply approximately 1,200 feet to the vicinity of the I&M Plant and interconnecting to electric system adjacent to the 500 kVA transformer through a padmount switch. There would need to be a new electric manhole at each end of the conduit run to facilitate cable pulling and replacement.

The interconnection voltage would be 23 kV nominal to match the local distribution system voltage. The cable used for the interconnection proposed to be Size #1 AWG shielded power cable with a rating of 172 Amperes at 100% load factor. This is somewhat oversized for the application given that the current output of a wind turbine in the 900 kW to 2,000 kW range will be on the order of 23 Amperes to 50 Amperes; however, this is the smallest cable size that is generally produced in the 25 kV insulation class.

The three cables (one per phase) would need to be routed in one duct of two 4-inch, Schedule-80 PVC conduits extending from a manhole installed adjacent to the wind turbine to a manhole located in the vicinity of the I&M Plant transformer. The route of the conduits is assumed to be relatively straight down the hill from the wind turbine toward the I&M Plant and off to the side of any road constructed to access the wind turbine site. The use of direct buried conduit is proposed because the route does not involve crossing roadways. Two ducts are included to provide separate ducts for the power cable and a communications duct for any wired remote indication/control provided with the wind turbine package or required for utility control.

The tie-in to the electric system would need to be made adjacent to the existing 500 kVA transformer at the I&M Plant. To make the interconnection, a three-way, pad-mounted switch would need to be installed at that location to permit the wind turbine to be interconnected to the existing electric distribution system between the high voltage terminals of the transformer and the existing NSTAR feeder from the road. The switch is used to permit any of the three circuits intersecting at the switch to be isolated for maintenance. The switch leg connecting the wind turbine to the existing system would need to be fused to protect the existing system in the event of a fault on the cable run to the wind turbine. It should be noted that Orleans may have to purchase the existing 500 kVA transformer from NSTAR if the I&M Plant electric supply is obtained at the low voltage terminals of the transformer.

A change may be required to the way that energy at the I&M Plant is metered. In its simplest form the meter supplied with the wind turbine could be used to measure output; however, this may result in the full output of the wind turbine being considered as sold to the grid. Installation of some form of bidirectional metering (power in/power out) at the point where the plant electric system connects to the NSTAR system will be required if consumption by the I&M Plant is to be offset by the output of the wind turbine. This would be dependent on the manner in which the wind turbine(s) is connected to the system and how the energy from the wind turbine is ultimately distributed in the I&M Plant and sold.

Also, additional protective relaying may have to be installed to meet the NSTAR interconnection technical requirements depending on the protection package provided as part of the wind turbine. Different wind turbine manufacturers have different scopes of supply including the supply of protective devices, circuit breakers, and step-up transformers. Until a specific wind turbine is selected and negotiation of an interconnection agreement with NSTAR commences additional changes cannot be identified in greater detail.

Civil and Site Modifications

The context of the following discussion is with regard to installation of a single wind turbine.

Site Development

A single wind turbine would be located at or near the site of the existing meteorological tower within Orleans watershed. It would be approximately 820 feet north of the I&M Plant located off Cliff Pond Road. At the present time, the location of the meteorological tower has been substantially cleared of vegetation; however, it has not been leveled to a slope that will support the construction of a wind turbine. Therefore, construction of the wind turbine site will require that a circular area approximately 260 feet in diameter (approximately 1.22 acres) be cleared and leveled. Where the existing tree line is within this limit, the felling of additional trees will be required. An access road approximately 2,050 feet long will be required from Route 28 to the proposed wind turbine site via the I&M Plant.

Preferred Construction Routing

We identified two potential construction haul routes during our site visits to the watershed. One of the possible haul routes would involve entry to the watershed area via the town maintenance area access road located north of Lisa Way. The second haul route would enter the watershed area at Cliff Pond Road (west of Namequoit Road on Route 28).

The total length of the maintenance area haul route is approximately 2,650 feet. The first 570 feet would consist of the existing paved access road. The balance of the haul route (approximately 2,080 feet) would follow the existing access trails to the wind turbine site. At the time of our site visit, these trails consisted of a compacted sand base. In some locations, the sand base was covered with wood chips. During our site visit, we noted that the existing grades along the maintenance area haul route were generally less steep than those along the Cliff Pond Road haul route; however, to meet the maximum grade requirements for the equipment hauls, cuts of up to 10 feet and fills of 6 feet would be necessary to properly grade the haul route. Additionally, the unimproved length of the maintenance area haul route is estimated to be approximately 2.5 times the longer than that which be required from the I&M Plant. Along the maintenance area haul route, the width of the existing roadway varied; however, the minimum width appeared to be approximately 16 feet. We also noted that the existing turning radii from Route 28 to the paved access road are extremely tight. Turns from Route 28 would also be complicated by the presence of a private driveway on the north side of the access road. Additionally, the turn from the paved access road to the unimproved trail is significantly less than that required for the typical haul vehicles. Therefore, the initial 570 feet of the haul (from Route 28) would require the haul vehicles to back up, which, while uncommon, we believe can be accomplished.

The total length of the Cliff Pond Road haul route is approximately 2,050 feet. This length is currently comprised of approximately 1,080 feet of compacted gravel roadway (Cliff Pond Road), approximately 150 feet of bituminous paving (through the I&M Plant) and approximately 820 feet sand base trails (as described above) located north of the I&M Plant. In addition to the improvements to the existing trails, this route would require the initial 620 feet to be widened from its present width of approximately 12 feet to a minimum of 16 feet. The grades along Cliff Pond Road would not require improvement, however, as noted above, significant fill work would be required for the section north of the I&M Plant to the wind turbine site. From the I&M Plant, the grade drops approximately 20 feet and then rises about 35 feet to the wind turbine site. This will require up to approximately 13 feet of fill to produce grades that will allow the transport of the wind turbine components. In comparison to the maintenance area access road, the existing turning radii from Route 28 to Cliff Pond Road are significantly better. Additionally, there are no apparent interferences with private property.

Based on these observations, we recommend the Cliff Pond Road haul route (by the I&M Plant). The costs to widen, grade, and fill this route are less than the costs associated with roadway improvement along the length of the maintenance area haul route.

As noted previously, the minimum width of the construction/access road between the water treatment facility and the wind turbine site is 16 feet. If the erector elects to use a crawler crane and assemble the crane in the existing parking lots, a minimum roadway width of 24 feet will be required. We recommend that the access roadway be constructed using compacted gravel. The minimum recommended roadway thickness is 12 inches. The gravel should be compacted to a minimum of 95% of its maximum dry density as determined by ASTM D1557. The above gravel and compaction requirements should also be used for the locations indicated above where the existing traffic and parking lot islands are removed.

Construction of the wind turbine site and the access road would be accomplished by conventional means and methods. Clearing of the site would likely be performed by bulldozers. As the observed surface soils appeared to consist predominantly of sandy materials, blasting is not expected to be required. Once the site and access roadway is cleared, bulldozers, graders, vibrating rollers, and other conventional earthmoving equipment would be used to grade and compact the access road.

Additional Watershed Considerations

Depending upon the wind turbine selected, the results of geotechnical study, and the design of the foundation, the depth of the turbine foundation could be as shallow as 8-10 feet with a spread foundation to approximately 30 feet with a pier foundation. We do not anticipate any negative impacts on the watershed as a result of the physical depth of a chosen foundation. The final location of any turbine installed at the watershed area is expected to be a location of sufficient relative elevation that it is very unlikely that any foundation would come into contact with an aquifer or subsurface stream.

Preliminary Work

Work that can be performed in advance of the actual construction of the wind turbine includes all of the site preparation work as listed below:

1. Geotechnical investigations and surveys. Subsurface investigations should be performed to confirm the soil parameters that will be used to determine the foundation requirements and access road design parameters. We recommend that a single soil boring be taken at the proposed wind turbine location. Additionally, one or two test pits should be dug along the proposed access road alignment.

2. Site clearing operations. Removal of the existing trees at the wind turbine site and the creation of an access roadway can be performed in advance of the actual wind turbine procurement activities.
3. Grading operations at the site and along the access road alignment can be performed.
4. Installation of the crane pad (an area approximately 120 feet long by 40 feet wide adjacent to the wind turbine foundation), consisting of gravel or crushed stone compacted to approximately 6,000 psf (minimum 95% dry density in accordance with ASTM D1557).
5. Installation of electrical conduits and manholes (including trenching operations).
6. Removal of approximately 24 linear feet of existing fencing along the north side of the water treatment area, and installation of an access gate to allow transportation of materials through the water treatment plant to the wind turbine site.

Transportation Considerations

Highway access to Orleans is relatively convenient. Orleans is reached directly from the Mid-Cape Highway (U.S. Route 6). From U.S. 6, transportation would be along local surface roads to the watershed area consisting of a combination of 2-lane and 4-lane roads. There are some significant bends in the roads; however, none appear to pose a problem in transporting wind turbine components to the site.

Direct rail access to Orleans is not available; however, there is rail access to Cape Cod via the Bay Colony rail line. Preliminary contact with rail officials suggest that rail access would be viable along the Bay Colony rails emanating from CSX rails on the mainland to as far as Barnstable. Accordingly, access between a possible rail laydown area at the end of the rail line to Orleans would require highway travel along U.S. 6.

Alternatively, transportation via the ocean may be available given the significant number of ports in Orleans. Unfortunately, many of the ports are serviced by smaller local roads.

Regardless, we do not expect transportation via the ocean to be an economical option since the Orleans landings cannot accept container ships. Also, road transport would have to be arranged from a landing (most likely Delaware) to the wind turbine site which would require the same trucks necessary to travel between the port and the site. These trucks would probably come from out of state, so surface travel costs would be the same as if the wind turbine components were picked up at a major port. These same arguments would apply to rail transport as well.

Project Development Considerations

Most turbine models are not available until early 2006 due to the high demand for equipment before the expiration of the federal production tax credits (“PTCs”) on December 31, 2005; accordingly, it is not expected that Orleans can procure a 1.5 MW-class turbine in 2005. First quarter 2006 delivery for 1.5 MW class turbines may not be realistic for orders placed after the first quarter 2005. An exception is for the V-47 unit. Several 65-m hub height V-47 units can be made available in the third quarter 2005 due to the availability of towers for these turbines. Normally the V-47 lead-time is 26 weeks but tower availability can be impacted by a 1.5-MW class turbine demand.

Attached herein Appendix C is a likely planning level project schedule for a single 1.5-MW class wind turbine project at the Town of Orleans.

5
ENVIRONMENTAL CONSIDERATIONS

General Environmental Considerations

We assessed environmental concerns, including the likely presence of rare or endangered species and wetlands, through a cursory site inspection and review of publicly-available databases. This was done to determine the likelihood that the proposed wind turbine will have unacceptable environmental impacts, or that environmental permitting will be overly contentious and time consuming (with MTC's understanding that this is difficult to predict).

Limited research through public and some private databases suggests that the potential installation site at the watershed will not impact any rare or endangered species. Observations while walking about the specific location of the proposed installation did not find any wetlands or vernal pools or evidence of the earlier existence of such; however, there are wetlands and signs of vernal pools in the general watershed area; so should multiple wind turbines be considered in the future, careful consideration of these wetlands and vernal pools should be undertaken.

We note also that the proposed location of the wind turbine is nearby an area already partially developed by Orleans for potable water treatment.

In summary, no significant environmental impact or permitting issues, such as negative impacts to wildlife or wetlands, and no overly contentious environmental permitting have been identified at this time for installation of a single wind turbine unit.

Neighborhood Impact

We assessed the characteristics of the neighborhood within the visual proximity of the watershed, including type and proximity of neighbors, typical activities (recreation, commerce, industry), and nearby historic or scenic sites, to identify key visual and noise receptors and characterize the potential level of impact, and to evaluate the anticipated level of community acceptance (with MTC's understanding that this is difficult to predict).

We drove and walked along significant surrounding areas and much of Orleans. With the watershed area situated on a relatively high hill in Orleans and the region, potential receptors likely include a significant portion of the community.

The Orleans topography is generally hilly and densely forested providing in essence good cover and visual impact mitigation for the proposed wind turbine for some areas of the community, at least during the seasons when one would expect leaf density to be greatest, although much of forestation appears to be coniferous suggesting good leaf density throughout the year. The forestation also will help mitigate noise impacts.

Distance is a very effective tool for sound attenuation. Setbacks are designed to meet noise levels at residences and other inhabited structures. The specific distances necessary to achieve acceptable background sound levels vary by wind turbine manufacturer. Based on our experience, we would expect the sound pressure level to be less than 55 dBA at a distance of 389 feet (118.5 m) from the GE 1.5sl or similar wind turbines. Since no proposed wind turbine location is within 600 feet of residential property lines, perceived noise levels should be within the acceptable range outlined in the bylaws.

Wind turbines are objects that stand out in the environment and there is relatively little that can be done to hide them from view. Visual aesthetics is a subjective topic; some people like the wind turbine structures while others feel they take away from the natural scenery. The proposed locations are sufficiently distant from residential buildings that the wind turbines are expected to only be visible from select vantage points.

Although there is well-documented regional public concern for development of a wind power project off the coast of Cape Cod, we could not find material documentation at this time to support the concept that there would be significant public resistance to this type of wind project in Orleans or this area of the Cape.

Photo Visualizations

To understand what a 1.5 MW class wind turbine may look like at the Orleans watershed site, we developed several photo visualizations, or simulations, of a 1.5 MW scale wind turbine located on the prospective site from various locations in the community, which appears in Appendix A herein. The wind turbine used in the images has a hub height of 80 meters (260 feet) and a rotor diameter of 80 meters. The top-of-blade height is therefore 120 meters (400 feet). There are several wind turbine models available in this general size range. While the exact proposed wind turbine configuration has not been determined yet, the height and rotor diameter are expected to be within a few meters of these figures.

Photo visualizations were developed from photographs of nearby representative positions from where the proposed wind turbine is expected or suspected to be visible, based on the topography and vegetation. The investigated locations were limited to public land and roads. We did not attempt simulations from private lands for this investigation. The current met tower location was used as the wind turbine location. Other suitable wind turbine sites exist in the watershed which may be more or less visible from any given vantage point.

The photographs were made in August 2004, corresponding with maximum leaf density on deciduous vegetation. The proposed wind turbine is expected to be seen from additional vantage points in the winter when deciduous trees lose their leaves. This is especially true for locations close to the proposed site such as along Rt. 28 and Rt. 6. The wind turbine's distance above the horizon as shown in the photo visualizations are based on our estimation of the relative elevation difference between the vantage point and the wind turbine site. Thus the actual views may differ from those shown here.

Figure A-1 shows the vantage points and proposed wind turbine location for which photo visualizations were developed. Figures A-2 through A-6 show the photo visualizations for each vantage point. All figures are in Appendix A herein.

General Permitting Considerations

A wind turbine project would need to be designed, constructed, and operated in accordance with applicable federal, state, and local regulations, codes, standards, guidelines, policies, and laws. The principal regulatory agencies charged with overseeing these provisions include the U.S. Environmental Protection Agency ("USEPA") and the Massachusetts Department of Environmental Protection ("MDEP").

A project would have to undergo certain permitting processes at the federal, state, and local levels as discussed herein. The key permits and approvals associated with a project are listed in Table 16 and are discussed below.

Table 16
Orleans Wind Energy Generation
Summary of Expected Key Permits and Approvals

Permit/Approval	Responsible Agency	Notes	Purpose
FEDERAL			
Exempt Wholesale Generator ("EWG") Status	Federal Energy Regulatory Commission ("FERC")	--	Pursuant to the Public Utility Holding Company Act of 1935.
Acknowledgment of Notice of Proposed Construction or Alteration	Federal Aviation Administration ("FAA")	--	Required to indicate that the wind turbine tower does not pose a threat to air navigation.
National Pollutant Discharge Elimination System ("NPDES") Stormwater Discharge General Permit for Construction	U.S. Environmental Protection Agency ("USEPA")	--	Required for stormwater management during construction activities.

Table 16
Orleans Wind Energy Generation
Summary of Expected Key Permits and Approvals

Permit/Approval	Responsible Agency	Notes	Purpose
NPDES Stormwater Discharge General Permit for Operations	USEPA	Modify existing watershed area general permit.	Required for the discharge of stormwater; establishes effluent limitations, monitoring and reporting requirements.
Endangered Species Review(s)	U.S. Fish and Wildlife Service ("USFWS")	None expected for this project as there are no endangered species identified in the project area	For project construction as it may impact endangered species.
Phase I Avian Risk Assessment	USFWS	MTC independently undertaking this task.	For project operation as it may impact birds and bats.
Natural Resource Characterization Report	USFWS	May be required	For project operation as it may impact natural resources
Breeding Bird Survey	USFWS	May be required	For Project operation as it may impact birds and bats.
Wildlife Habitat Evaluation	USFWS	May be required	For Project operation as it may impact nearby wildlife.
STATE			
Final Decision to Approve Project Siting	Massachusetts Energy Facilities Siting Board ("MEFSB")	Not required	Required for the siting of electric utility unit or energy generating plants greater than 50 MW and therefore not applicable for this project.
MEPA Review	Massachusetts Office of Environmental Affairs ("MOEA")	--	MEPA review will be required; however, it is unlikely that an EIR will be required.
Environmental Notification Form ("ENF")	MOEA	--	MEPA review will be required and preparation of an ENF will be required.
Vernal Pool Approvals	MDEP	None expected for this project as there are no vernal pools identified in the project area	Required for impacts to vernal pools.

Table 16
Orleans Wind Energy Generation
Summary of Expected Key Permits and Approvals

Permit/Approval	Responsible Agency	Notes	Purpose
Access Permit	Massachusetts Highway Department	May be required	Required for possible transportation-related issues, access, or modifications to roads and highways.
Project Review	Massachusetts Historical Commission	May be required	For Project operation as it may impact historic resources
Project Review	Massachusetts Aeronautics Commission	May be required	Required to identify if project poses a threat to air navigation.
Conservation Permit	Massachusetts Division of Fisheries and Wildlife (“MDFW”)	May be required	Required to identify if project poses a threat to air navigation.
Article 97 Review	MDFW	May be required	Required to identify if project impacts Article 97 lands.
LOCAL			
Site Plan Approval	Town of Orleans	--	Required for zoning approval
Architectural Review Approval	Town of Orleans	--	Required planning approval to preserve town character
Zoning Board of Appeals Special Permit	Town of Orleans	--	Required for planning and zoning approval
Building Permit	Town of Orleans	--	Required to indicate that project is in compliance with Orleans Bylaws and complies with Massachusetts State Building Code.
Permit to Open Road	Town of Orleans	--	May be required if any access road is constructed
UTILITY			
Uniform Approval for Distributed Generation Interconnect	NSTAR Electric/ Commonwealth Electric Company	--	Required for interconnect approval

Massachusetts Permitting

The proposed project involves development of a renewable energy facility, the impacts of which allow certain state permitting agencies to act on the project.

The principal regulatory process under which the project will likely be subject would be the Massachusetts Environmental Policy Act ("MEPA") approval. Though the project will not affect greater than 25 acres of land (a MEPA trigger), the project will likely need to undergo review pursuant to Section 11.03(1)(b)1 of the MEPA regulations, because the project requires state permitting and the project involves a form of financial assistance from an agency of the Commonwealth. The MEPA jurisdiction extends to all aspects of the project that may cause significant Damage to the Environment as defined in the MEPA statute.

Pursuant to the MEPA (M.G.L. c. 30, ss. 61-62H) and Section 11.06 of the MEPA regulations (301 CMR 11.00), it is unlikely that the proposed project will require preparation of an Environmental Impact Report ("EIR"). Preparation of an Environmental Notification Form ("ENF") will be required, particularly to demonstrate that the potential impacts of the project will not warrant preparation of an EIR.

The proposed project will have significant environmental benefits and advance a number of Commonwealth policies on energy and air quality. The proposed project may be committed to a follow-up monitoring program to provide data useful well beyond the boundaries of the site. The Project will result in emissions offsets of sulfur dioxide, nitrogen oxides, and carbon dioxide.

The project supports compliance with the Commonwealth's mandated renewable energy portfolio standards (M.G.L. Ch. 25A s. 11F and 225 CMR 14.00), supports Massachusetts in its commitments for reduction of greenhouses gases made in the Climate Change Action Plan and Resolution 27-7 of the Annual Conference of New England Governors and Eastern Canadian Premiers, and supports the goals of the Sustainable Development Principles adopted by the Commonwealth's Office of Commonwealth Development.

The project will likely require a Conservation Permit from the Massachusetts Division of Fisheries and Wildlife. The project will require review by the Massachusetts Historical Commission. The project may require an Access Permit from the Massachusetts Highway Department for transportation access to accommodate the relatively large components of the wind turbine. The project will require review by the Massachusetts Aeronautics Commission.

Land Alteration

The project results in the direct alteration of only a few acres of land some of which has already been partially developed by Orleans for watershed development and potable water treatment. The amount of disturbed land is below the mandatory EIR threshold (50 acres) for land alteration. Though the project could have the potential to cause significant damage to the environment, an EIR should not be required.

Protected Open Space/Article 97

The project will require physical modifications to state properties. Such activities do not necessarily constitute the conversion of Article 97 lands to a non-Article 97 use, nor do such activities constitute the release of an interest in land held for conservation purposes; however, other aspects of the project may result in conversion of Article 97 lands. These issues should be reviewed by appropriate Orleans staff.

Wetlands

The project will not result in alteration of any wetlands. It should be noted however that there wetlands within close proximity to the proposed site.

Rare Plant Species

Through research of available public databases there appears to be no rare species identified at the proposed site. In the event that a rare plant is identified at the site, the project may need to develop a transplantation program and conservation management plan for impacts to rare plants, as well as require a Conservation Permit from the Massachusetts Division of Fisheries and Wildlife.

Rare or Endangered Species

Research of available public databases could identify no rare or endangered species at the proposed site.

Mitigation

The project will produce air quality benefits for the Commonwealth. The project will be required to avoid or minimize negative impacts to the greatest feasible extent, and to mitigate any unavoidable impacts. As discussed above, the project permitting review process should ensure that appropriate mitigation is developed for any unavoidable impacts. It is expected that mitigation commitments, if any, would become permit conditions as the project moves through the permitting process.

Educational Opportunities/Tour Groups

The project represents a significant opportunity for public education. The project will likely become a tourist attraction particularly given the concentrated degree of tourism in the region. Decisions regarding the type and degree of public access that will be allowed at the project site rest ultimately with Orleans. It is expected that the MEPA review process will encourage the project to allow public access for educational purposes, consistent with the charter of MTC, and the needs for site safety and security.

Regional & Local Permitting

The project will require Orders of Conditions from the Orleans Conservation Commission. In addition, the project may need to undergo a Special Permit Review in Orleans.

Orleans has a Site Plan Review process in the zoning by-laws 164-33, under which a site plan review is required of, among other things, any project requiring a special permit, any new construction, and any activity that would affect drainage, utilities, lighting, or sewage disposal requirements. Criteria for the site plan review include adequate stormwater drainage, conservation of natural resources, protection of public scenic views, and maintaining old established trees among others. The special permit review process is outlined in Zoning Section 164-44C with the review criteria including consideration of impact on neighborhood character, views and vistas, adequate utilities, and impact on ground/surface water quality and recharge.

Orleans has developed a long-range planning document titled the Local Comprehensive Plan, which sets forth a 20-year vision for orderly growth and development in the community to protect the environment and preserve the character of the community for its residents. Wind energy development at the proposed site would have to adhere to this plan. Additionally, Orleans has a By-Law for Wind Turbine Generators which would be applicable for this project.

Orleans has an Architectural Review process as part of its zoning by-laws, under which a review is in place to preserve town character to prevent new construction or alterations that are incompatible with older, existing building styles or that are of inferior quality or appearance; to promote conservation of buildings and groups of buildings that have aesthetic or historic significance; and enhance the social and economic viability of the town by preserving property values and promoting visual attractiveness. A special permit or a building permit cannot be issued without approval of this Committee or the deadline for an action has expired.

It appears that the project would comply with the Cape Cod Commission's "Cape Cod Regional Policy Plan." Orleans does not have a "District of Critical Planning Concern" as identified by the Cape Cod Commission.

The project also appears to be consistent with the goals of the Cape Light Compact to promote renewable energy sources, energy independence, and energy conservation on the Cape.

Visual/Aesthetic

Visual and aesthetic impacts are often the most controversial aspects of wind power development projects among the general public, the perception of which is inherently subjective. We anticipate that the project will receive comments critical of the industrialization of Cape Cod as well as comments from those who find wind turbines a beautiful addition to the Orleans landscape. This debate, which has been seen on other wind energy projects, is not new and is likely to continue.

Noise

As part of the local review process, the project will likely need to conduct a study of project-related noise impacts and developed noise contours for the project with emphasis on residential structures that may fall within the noise contours associated with the project.

Operations Monitoring & Decommissioning

We anticipate that certain government wildlife and resource management agencies, including the Massachusetts Executive Office of Environmental Affairs ("MEOEA"), the Massachusetts Audubon Society, and the Conservation Law Foundation, will request that the project provide post-construction monitoring of impacts to birds and bats. Development of a monitoring program will provide evidence to evaluate the accuracy of the predictions for minimal impacts to wildlife, as well as scientifically useful information in a much broader context of the Commonwealth's energy and environmental policies. We anticipate that the project will need to perform this post-construction monitoring commensurate with the size and potential impacts of the project and consistent with the requirements of any applicable permits as a baseline-level of research.

We anticipate that the project will be expected to develop a decommissioning plan as part of the local review of the project.

Federal Permitting

At the federal level, the project will require review by the U.S. Army Corps of Engineers ("USACOE") and possibly the Federal Aviation Administration ("FAA").

An FAA determination may need to be obtained for the site to ensure that the wind turbine can be installed without interference with nearby flight paths although none have been identified in the area. Regardless, obstruction lighting may be required at a minimum since there are no other tall towers in the vicinity. State and local aviation regulations will need to be addressed.

The project is not expected to employ lighting during daytime hours and may likely use medium-intensity red obstruction lights with the longest allowable off-cycle during nighttime hours. Lighting requirements will need to balance visual concerns and potential impacts on birds and bats (some of which may be attracted to certain types of lighting) with the need to ensure the safety of the structures, particularly with respect to aviation. The project site is not close to an airport; however, the project may penetrate defined aviation spaces. The FAA will review wind turbine location and height, and issue essentially binding recommendations on lighting as part of its "Part 77" review process. The FAA process is intended to balance consideration of safety, aesthetics, and environmental impact. The project would be required to implement the least intrusive lighting plan allowable by the FAA to ensure an appropriate level of aviation safety.

The project site has already been partly developed by Orleans and may have undergone an archaeological survey; if not, such a study may be required. The USACOE may need to review the project for compliance with Section 106 of the National Historic Preservation Act of 1966. If so, the USACOE would define an Area of Potential Effect ("APE") for the portion of the project within its jurisdiction and evaluate how the project would affect any historic properties or districts within the APE. The USACOE would also consult with the State Historic Preservation Officer at the Massachusetts Historical Commission to determine whether any historical resources are located within the APE; whether the project may have an effect upon any historical resources within the APE; and whether there exist feasible measures to avoid, minimize, or mitigate impacts to historical resources within the APE.

Avian Impacts

The project may be required to prepare a Wildlife Habitat Evaluation, Natural Resource Characterization Report, Breeding Bird Survey, and Phase I Avian Risk Assessment, with the latter likely required by the U.S. Fish & Wildlife Service ("USFWS").

It is not anticipated that the project would result in a "take" of any rare birds or bats; however, MTC has advised that it plans to undertake a Phase I avian study. Studies from the nearby wind farm in Searsburg, VT also provide confirmation that avian impacts should prove minimal; while this study is informative, the conclusions reached are tentative. The USFWS is concerned about higher than anticipated impacts to bats from a wind farm in West Virginia. The Commonwealth has expressed a desire on other regional interior wind projects to obtain additional data on impacts to avian species from an operational wind farm in the interior of the Commonwealth and has concluded that studies performed to-date represent an appropriate amount of research on wildlife impacts. Further analysis in an EIR would be unlikely to alter the basic conclusions of any of the studies; therefore, the MEPA review is unlikely to require such.

6
PLANNING LEVEL OPINION OF PROBABLE CAPITAL COSTS AND O&M COSTS

Capital Costs

Equipment, material, and transportation pricing was based on published pricing and budget quotations where available and was supplemented by information from our proprietary cost databases (the "Cost Databases"), which contain information on similar equipment purchased for other projects with which we are familiar. Installation labor hours were developed mainly from the Cost Databases and then adjusted based on the project's location, site conditions and expected labor productivity.

Turbine Capital Costs

The GE 1.5sl as discussed herein is estimated to cost approximately $1,350,000 for the wind turbine and tower (FOB manufacturer) without transportation, and includes an FAA-required aviation beacon and cold weather package believed to be suitable for the site. The Vestas V47 as discussed herein is estimated to cost approximately $440,000 for the wind turbine and tower (FOB manufacturer) without transportation, and includes an FAA-required aviation beacon and cold weather package believed to be suitable for the site. It should be understood that final wind turbine cost will depend on a number of factors such as warranty, options purchased, market factors, and contract negotiations. Several wind turbines other than those identified herein may also be suitable for this site. Costs for comparable machines may differ from those mentioned herein; however, on a unit cost basis, these figures can be viewed as representative of wind turbines in these capacity ranges. To obtain more accurate cost estimates, a request-for-proposals ("RFP") is typically issued following feasibility and pre-development studies. More accurate costs based on the specific characteristics, conditions and requirements of the project can then be obtained from a review of proposal submissions.

Turbine Transportation Costs

Transportation costs are estimated to cost approximately $255,000 for the GE 1.5sl discussed herein and approximately $205,000 for the Vestas V47 discussed herein, excluding road modifications if required. The transportation estimate is based on recent costs for the transportation of similar equipment taking into account the typical origination of the various wind turbine components. A mix of ocean freight and truck transport was assumed depending on the origination point of the equipment, and the "best known methods" for transport in the region. These costs will vary depending on the exact origin of each piece of equipment and on the exact transportation methods and routes used by the wind turbine supplier or transportation contractor. Road medications are not included in the cost estimate because the need and extent if necessary of such modifications are unclear; such costs may likely be absorbed by project contingency.

Civil, Sitework, and Erection

Civil, sitework, and erection costs encompass the scope of civil and sitework discussed in Section 4 herein. An arbitrary allowance of $25,000 is provided for road repair work if this is necessary. This item includes concrete work, consisting mainly of foundations and concrete to support the wind turbine and electric transmission cabling.

Electrical costs include the costs to furnish and install the electrical and controls equipment and material. A material (procurement) and installation breakdown is provided for these costs. Electrical costs include procurement and erection for the aviation lighting, switchgear, electric breakers, wire, cable, cable tray and conduit, iso-phase bus, and other electrical specialties. Labor costs are based on regional (Massachusetts) labor rates.

Electrical Systems

Electrical systems costs encompass the scope of electrical work discussed in Section 4 herein. This item includes

Total Construction Costs

The estimated total construction cost is the sum of all of the costs described above.

Owner's Costs

Owner's project costs are in addition to the constructor probable costs. These costs include the owner's (or developer's) costs for project management, administration, permitting, interfacing with municipal agencies, land and right of way acquisition, local benefits, costs for construction of the electric interconnection, spare parts, insurance, taxes, legal costs, accounting, working capital allowances, and similar costs not included in the construction contractors scope. These costs vary significantly from project to project and can be from 15% to 45% of the construction cost. The owner should evaluate these costs based on its experience and include a realistic value in its financial analysis. For the purposes herein we used approximately 15% plus certain anticipated permitting fees.

Contingency

A project contingency allowance for unknown costs is normally included. On the basis of the Cost Databases, this allowance is commonly at least 5% to 10% of the total construction costs. To provide a breakdown of procurement and construction contingency, we have included an allowance for material and equipment costs and for construction costs. For this proposed project we have allowed a contingency of approximately 15% of anticipated project costs.

Total Estimated Project Costs (without Finance Costs)

This is the total estimated cost of the project and is the sum of the EPC construction costs and other project costs described above. This total does not include finance costs or cost of a construction loan. The range of project costs per unit of kilowatt generation represents the range of project costs without contingency and optional systems to project costs with contingency and optional systems.

Summary of Planning Level Capital Costs

Table 17 below summarizes our opinion of the proposed wind turbine plant's probable planning level capital costs.

Table 17
Summary of Opinion of Probable Planning Level Project Capital Costs (1)
for a Single Wind Turbine Plant

Item	Cost for Vestas V47	Cost for GE 1.5sl
Subtotal for wind turbine generator	$440,000	$1,350,000
Subtotal for civil/sitework and turbine erection	$460,000	$475,000
Subtotal for electrical systems and erection	$80,000	$80,000
Subtotal for wind turbine transportation (2)	$230,000	$280,000
Subtotal - Construction Costs	**$1,210,000**	**$2,185,000**
Owner's Costs, including engineering & permitting	$285,000	$285,000
Subtotal – Project Costs	**$1,495,000**	**$2,470,000**
Subtotal for optional electrical systems (3)	$80,000	$120,000
Project Contingency	$225,000	$370,000
Total Estimated Project Costs	**$1,800,000**	**$2,960,000**
Installed Cost per Kilowatt ($/kW)	***$2,265 - $2,727***	***$1,646 - $1,973***

***Notes**:*
(1) In 2005 dollars.
(2) Includes a nominal value for road modifications, if necessary.
(3) Optional electrical equipment to interface with the utility grid as required depending upon the particular final interconnect design.

Operations and Maintenance Costs

Turbine O&M Costs

Recurring operations and maintenance ("O&M") costs will vary depending on a number of factors. O&M costs vary significantly depending on the O&M strategy employed, the reliability of the equipment and the roles and responsibilities of the equipment manufacturer in providing service and warranty repairs. O&M costs generally are divided into the following categories:

- Operations (e.g., resetting wind turbines which have tripped off-line due to a fault).
- Scheduled, preventive maintenance on the wind turbines and other equipment (e.g., routine oil changes and inspections of transformers).
- Unscheduled maintenance including activities ranging from simple component replacements to major component repairs.
- Periodic component overhauls and scheduled replacements (as specified by wind turbine supplier).

The first three categories occur during the course of each year while the fourth category occurs at periodic intervals over the life of the project.

For purposes of this evaluation, recurring O&M costs have been estimated for an assumed warranty period (first two years) and escalating in subsequent years. These O&M estimates are not specifically for the wind turbines proposed herein but representative of typical 660 kW and 1,500 kW wind turbines, since the analysis of a specific wind turbine is not warranted by the scope of this study. Individual components of this total cost will vary. Most notably, the repair costs of the wind turbine are expected to increase above inflation. Table 18 indicates how O&M costs are expected to change over the project life. These estimates assume the purchase of a two year all-inclusive O&M warranty.

Table 18
Estimated O&M Costs of a Typical Wind Turbine

O&M Item	Year 1-2	Year 3-5	Year 6-10	Year 11-15	Year 16-20
Typical 1.5 MW wind turbine					
Operations, scheduled and unscheduled maintenance, warranty (first two years)	$32,700	$34,800	$36,900	$41,000	$44,000
Administration	$2,600	$2,700	$2,700	$2,800	$2,900
Total $/wind turbine	**$35,300**	**$37,500**	**$39,600**	**$43,800**	**$46,900**
Typical 660 kW wind turbine					
Operations, scheduled and unscheduled maintenance, warranty (first two years)	$14,400	$15,400	$16,300	$18,000	$19,500
Administration	$2,600	$2,700	$2,700	$2,800	$2,900
Total $/wind turbine	**$17,000**	**$18,100**	**$19,000**	**$20,800**	**$22,400**
Constant 2005 Dollars					

The greatest unknowns with near-term recurring costs are what service and warranty provisions and payments are negotiated as part of the wind turbine purchase. The biggest unknowns associated with long-term recurring costs are the reliability and lifetime of major wind turbine components such as gearboxes, generators, and blades. This is especially true for a single-wind turbine installation. For large projects, the reliability and replacement costs can be estimated with reasonable certainty on an average project-wide basis. (Some wind turbines have better than average reliability and others worse than average.) However, a single wind turbine with only slightly better or worse reliability than the fleet-wide average may result in much lower or higher costs than average and these costs are not offset by the averaging affects of a larger project. This long-term recurring cost uncertainty can be reduced by entering into longer than two-year warranty contracts; however, few wind turbine manufacturers offer all-inclusive warranty periods longer than five years. Machinery insurance can also be purchased to shelter the owner from some amount of risk.

Wind turbine plant maintenance would be categorized in three distinct areas: preventive, corrective, and predictive. It's conceivable that Orleans staff could perform some preventive maintenance and some minor corrective maintenance, while most corrective maintenance, major preventive maintenance, and all predictive maintenance would be provided by outside contractors or the wind turbine manufacturer. Maintenance management is expected to be performed using industry-standard computer based planning software, which would include programming the manufacturer's recommended maintenance requirements into the software. Routine preventive maintenance activities would be performed by technicians assigned to day-to-day work. The wind turbine would generally run unattended, and have a 6-month scheduled service interval.

The wind turbine plant would need a long term major maintenance plan to schedule preventive maintenance outages. Major equipment overhaul – either preventive or corrective – is expected to be contracted to the manufacturer or a qualified off-site contractor. We expect that that the wind turbine would be maintained under a long-term service contract.

Other O&M Costs

Other than already specifically identified, no other O&M costs are considered herein.

The wind turbine plant is expected to maintain an appropriate set of spare parts on hand. For space reasons, certain major items may be inventoried in other nearby facilities. Spare parts could be stored in a separate secured room nearby – possibly in one of the maintenance buildings in the watershed area – in racks and bins.

Miscellaneous

Lubricating oil requirements for the wind turbines, including types and quantities, vary by manufacturer and the particular unit selected. Moving parts that required lubrication are within the nacelle, which is essentially a closed room with a floor. While quantities of lubricating oil are relatively small, it is important to note that the turbines are essentially closed and sealed units with little if any opportunity of lubricating oil reaching the environment.

7
PROJECT ECONOMICS

It is expected that during the business development phase of the project, the Projected Operating Results herein will be significantly revised to reflect additional metrics to better support the needs of the Town of Orleans and its planning requirements.

Projected Operating Results

We have developed Projected Operating Results for both a GE 1.5sl wind turbine and a Vestas V47 wind turbine to assist the stakeholders from both Orleans and MTC in making decisions on the feasibility of installing a wind turbine. We have developed estimates for energy production and operating and maintenance costs including major maintenance costs. For the purposes of the Projected Operating Results, we have assumed the installation of a single wind turbine on the proposed site and assumed the value of that generation will be determined by the revenue received from selling the energy and the value of energy credits from both the state and federal government. Expenses for the wind turbine include annual operation and maintenance costs, major maintenance, and administration costs. The Projected Operated Results for the GE 1.5sl option is presented in Appendix B, Table 1 herein and the Vestas V47 option presented in Appendix B, Table 2 herein. The Projected Operating Results have been prepared using assumptions and considerations set forth in this report and the footnotes to Appendix B.

Annual Operating Revenues

Revenues from Energy Production

For the purposes of the Projected Operating Results, the project is assumed to become commercially operational on July 1, 2006. For the purposes of the Projected Operating Results for each option, we have used the long term net annual energy estimates identified as P75 in Table 10 and Table 12 herein. The P75 case represents a level of energy production that has a 75% probability of being exceeded and a 25% probability of not being achieved. We have assumed a level annual energy production through the term of the study. Based on the uncertainty of the hourly Orleans domestic load and the uncertainty of the hourly wind production, we have assumed that no energy production from the wind turbine will displace domestic Orleans load. All of the energy production was assumed to be sold into the market at assumed market rates. Market electricity rates were projected by MTC at $37.00 per MWh in 2004 dollars assumed to increase at the assumed annual rate of change in the general inflation rate of 2.4% through the term of the study.

Revenues from Energy Certificates and Credits

We have assumed the project is eligible to receive Massachusetts Renewable Energy Certificates ("RECs") for each MWh of energy produced from the wind turbine. We have assumed that the RECs will be sold into the market at $35.00 per MWh through 2007 and at $25.00 per MWh beyond 2007 in nominal dollars as projected by MTC.

For the purposes of the Projected Operating Results, we have assumed no additional revenue from PTCs or federal Renewable Energy Production Incentives ("REPIs").

Annual Operating Costs

For the purposes of the Projected Operating Results, the operating costs of a single GE 1.5sl wind turbine consist of $32,700 in 2005 dollars. The operating costs include major maintenance which would be encompassed in the warranty agreement for the first two years. After the first two years we have assumed the cost of operations in 2005 dollars would increase to $34,800 in years 3-5, $36,900 in years 6-10, $41,000 in years 11-15, and $44,000 in years 16-20. For the purposes of the Projected Operating Results, the operating costs of a single Vestas V47 wind turbine consist of $14,400 in 2005 dollars. The operating costs include major maintenance which would be encompassed in the warranty agreement for the first two years. After the first two years we have assumed the cost of operations in 2005 dollars would increase to $15,400 in years 3-5, $16,300 in years 6-10, $18,000 in years 11-15, and $19,500 in years 16-20.

We have estimated administration costs in the first two years to be $2,600 in 2005 dollars. After the first two years, we have assumed the cost of administration in 2005 dollars would increase to $2,700 in years 6-10, $2,800 in years 11-15, and $2,900 in years 16-20. All costs are in 2005 dollars which we assume would increase at the assumed rate of inflation of 2.4% as projected by Blue Chip Economic Indicators on October 10, 2004. We have not included any costs for insurance or property tax in the estimate of administration costs. MTC should estimate these costs and include them in its analyses.

8
CONCLUSIONS, ASSUMPTIONS & REFERENCES

Principal Conclusions

On the basis of our level of review and documentation reviewed, this study supports the following conclusions:

1. The Orleans watershed area appears to be a viable location for installation of a wind turbine. Overall, we did not uncover any major technical hurdles, including transportation, to the installation of a 1.5 MW class or a 660 kW class wind turbine on the proposed site.
2. A wind turbine can be electrically interconnected to the watershed iron and manganese treatment plant's electric distribution system to export power to the utility grid as well as supply the intermittent needs of the treatment plant.
3. The regulatory hurdles as well as the capital costs to run power from the wind turbine site to any Orleans municipal buildings at the watershed site appear to be too prohibitive to be considered at this time.
4. No significant neighborhood impact issues, such as negative impacts to wildlife or wetlands, have been identified at this time; however, it is likely that the visual impact will be noticeable from some distance at various points of view in Orleans. No overly contentious environmental permitting have been identified at this time.
5. While there is well-documented regional public concern for development of a wind power project off the coast of Cape Cod, we could not find material documentation at this time to support the concept that there would be significant public resistance to this type of on-land wind project in this area of the Cape.
6. Further study should be performed to determine if it's possible to synchronize the batch electric loads from the I&M Plant for maximum coincidence with the wind resource (i.e., turbine generation).

Principal Considerations and Assumptions

In the preparation of this report and the opinions presented herein, we have made certain assumptions with respect to conditions which may exist or events which may occur in the future. While we believe these assumptions to be reasonable for the purpose of this report, they are dependent upon future events, and actual conditions may differ from those assumed.

In addition, we have used and relied upon certain information provided to us by sources which we believe are reliable. While we believe the use of such information and assumptions to be reasonable for the purposes of this report, we offer no other assurances with respect thereto and some assumptions may vary significantly due to unanticipated events and circumstances. To the extent that actual future conditions differ from those assumed herein or provided to us by others, the actual results will vary from those projected herein. This report summarizes our work up to the date of the report; thus, changed conditions occurring or becoming known after such date could affect the material presented to the extent of such changes.

The principal considerations and assumptions made by us in developing the Projected Operating Results and the principal information provided to us by others include the following:

1. Orleans and the operator will operate and maintain the wind turbine in accordance with generally-accepted industry practices, will make all required renewals and replacements and major maintenance expenditures, will not operate the equipment to cause it to exceed the equipment manufacturers' recommended maximum ratings, and will employ qualified and competent personnel who will generally operate the wind turbine in a sound and businesslike manner.
2. All licenses, permits and approvals, and permit modifications necessary to operate the wind turbine have been, or will be, obtained on a timely basis and any changes in required licenses, or permits and approvals will not require reduced operation of, or increased costs to the wind turbine.
3. Where wind turbine characteristics are required to complete the analysis, we assume either a GE 1.5sl or a Vestas V47 rated as indicated herein.
4. Subsurface conditions were based on existing geotechnical data provided by Orleans from past and recent development, engineering, and construction activities at the watershed area. Geotechnical borings were not conducted; however, we recommend that subsurface investigations be performed prior to or in conjunction with further design activities.
5. The actual output and availability of the wind turbine in each year will be equal to the estimated long-term averages presented as the P75 case.
6. All energy generated will be sold into the market at average energy clearing prices of $37.00 per MWh in 2004 dollars assumed to increase at the assumed change in general inflation rate through the term of the study as projected by the MTC.
7. The RECs will be as projected by the MTC through the term of the study.
8. General inflation will increase at a rate of 2.4% per year based on an October 10, 2004 projection prepared by Blue Chip Economic Indicators, Inc.
9. The operating and maintenance expenses, including the cost of major maintenance and capital expenditures, will be consistent with the estimates prepared herein and will increase at the assumed rate of change in the general inflation rate.

References & Data Sources

The following references and data sources were utilized for this study:

1. Manwell, James et. al., University of Massachusetts Amherst Renewable Energy Research Lab, *Wind Data Report Orleans October 27, 2003 – November 31, 2003*, January 15, 2004; and *Wind Data Report Orleans December 2003 – February 29, 2004*, April 15, 2004.
2. Johansson, Thomas B et. al., *Renewable Energy: Sources for Fuels and Electricity*, Island Press, Washington, D.C., 1993.
3. *European Wind Atlas*, Risø National Laboratory, Roskilde, Denmark, 1989.
4. Kline, Jack, *Effects of Tubular Towers on Wind Speed Measurements*, AWEA Wind Power Conference, 1999, Burlington, Vermont.
5. *New England Wind Map*, TrueWind Solutions.
6. Wind resource data collected at the Orleans site by the University of Massachusetts Renewable Energy Research Laboratory.
7. Cape Cod Commission Publications: *Assessment of Distributed Generation Technology*, *Cape Cod Land Bank*, *Cape Cod Commission Act*, *Districts of Critical Planning Concern*, *Guide to the Review Process for Developments of Regional Impact*, *Model Bylaws and Regulations*, *Regional Policy Plan,* and *Siting Criteria for Personal Wireless Service Facilities*, various dates.
8. Cape Light Compact *Final Resource Assessment Report*, Ridley & Associates, March 12, 2004; and *Final Resource Assessment Report Technical Studies Appendix*, Ridley & Associates, April 5, 2004.
9. NSTAR Electric/Commonwealth Electric Company, *Standards for Interconnection of Distributed Generation*, DTE0238 Tariff, April 2004.
10. Town of Orleans, *Wind Turbine Bylaw, §164-13 Schedule of Use Regulations.*
11. *Massachusetts Environmental Policy Act Guidelines (various)*, Massachusetts Executive Office of Environmental Affairs.
12. *Massachusetts DEP Guidelines (various)*, Massachusetts Department of Environmental Protection.
13. *Code of Federal Regulations ("CFR") (various)*, U.S. Government Various Agencies.

APPENDIXES

APPENDIX A
PHOTO SIMULATIONS

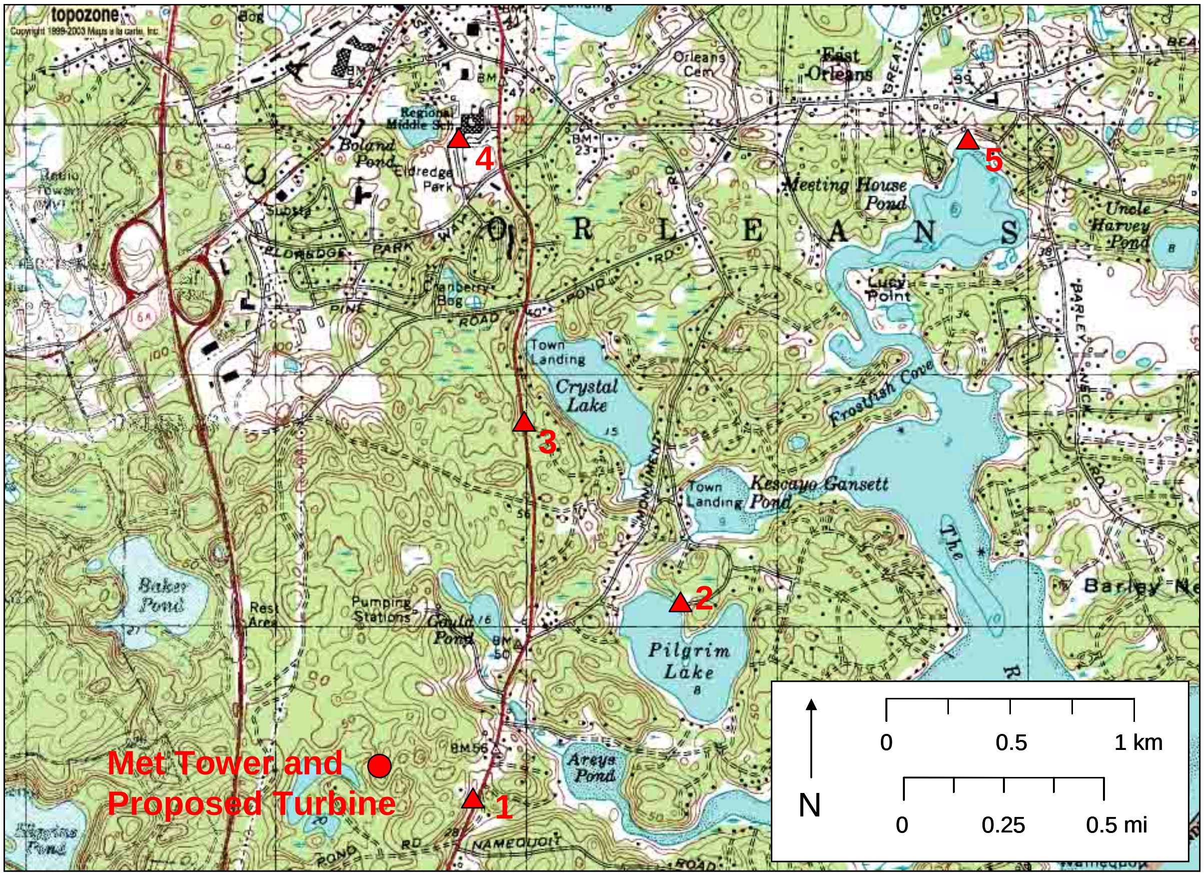


Figure A-1. Photo visualization vantage points and the proposed wind turbine site

Figure A-2. Location 1 – Rt. 28, 0.4 km Northeast of Site Looking Southwest

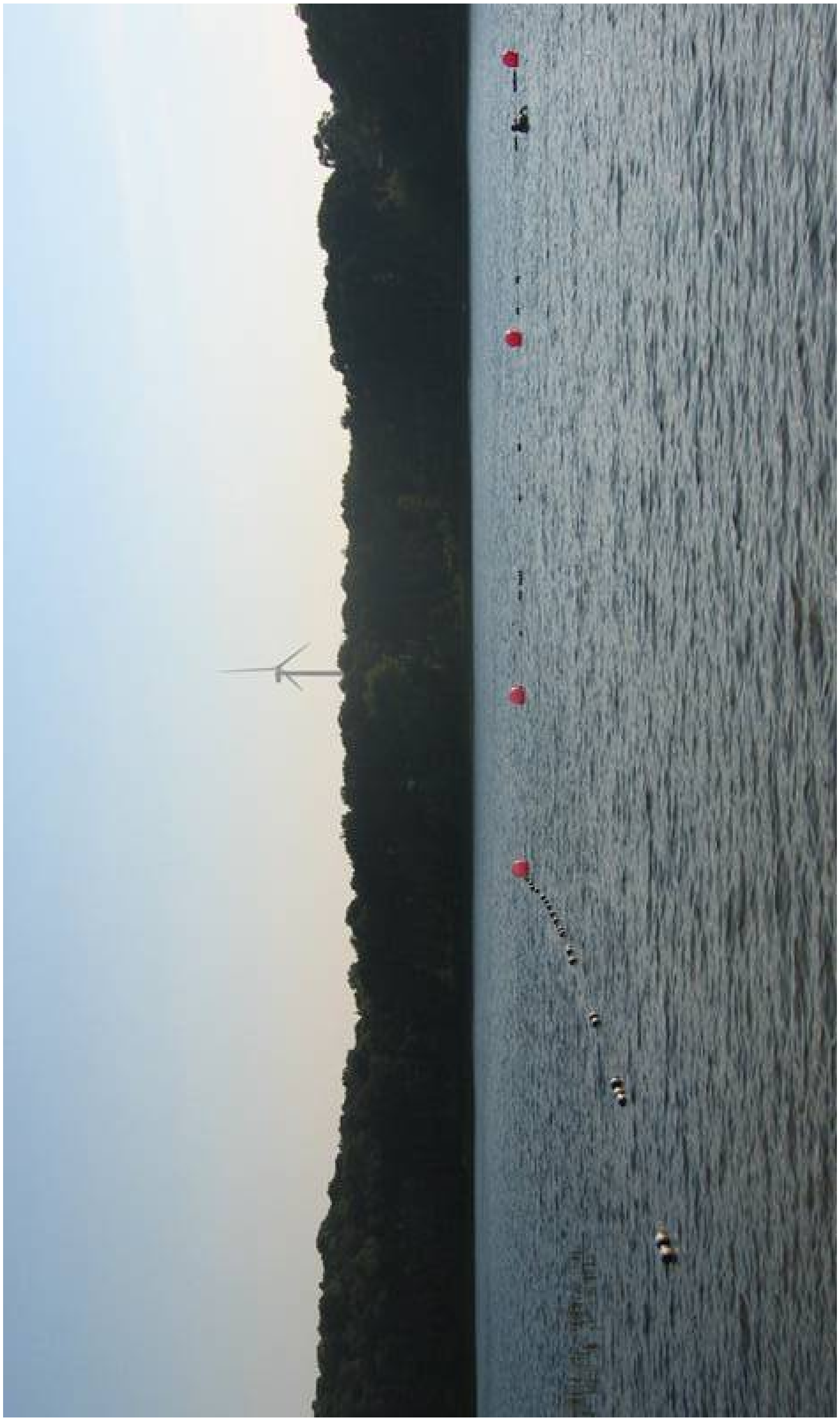


Figure A-3. Location 2 – Pilgrim Lake Looking West-Southwest

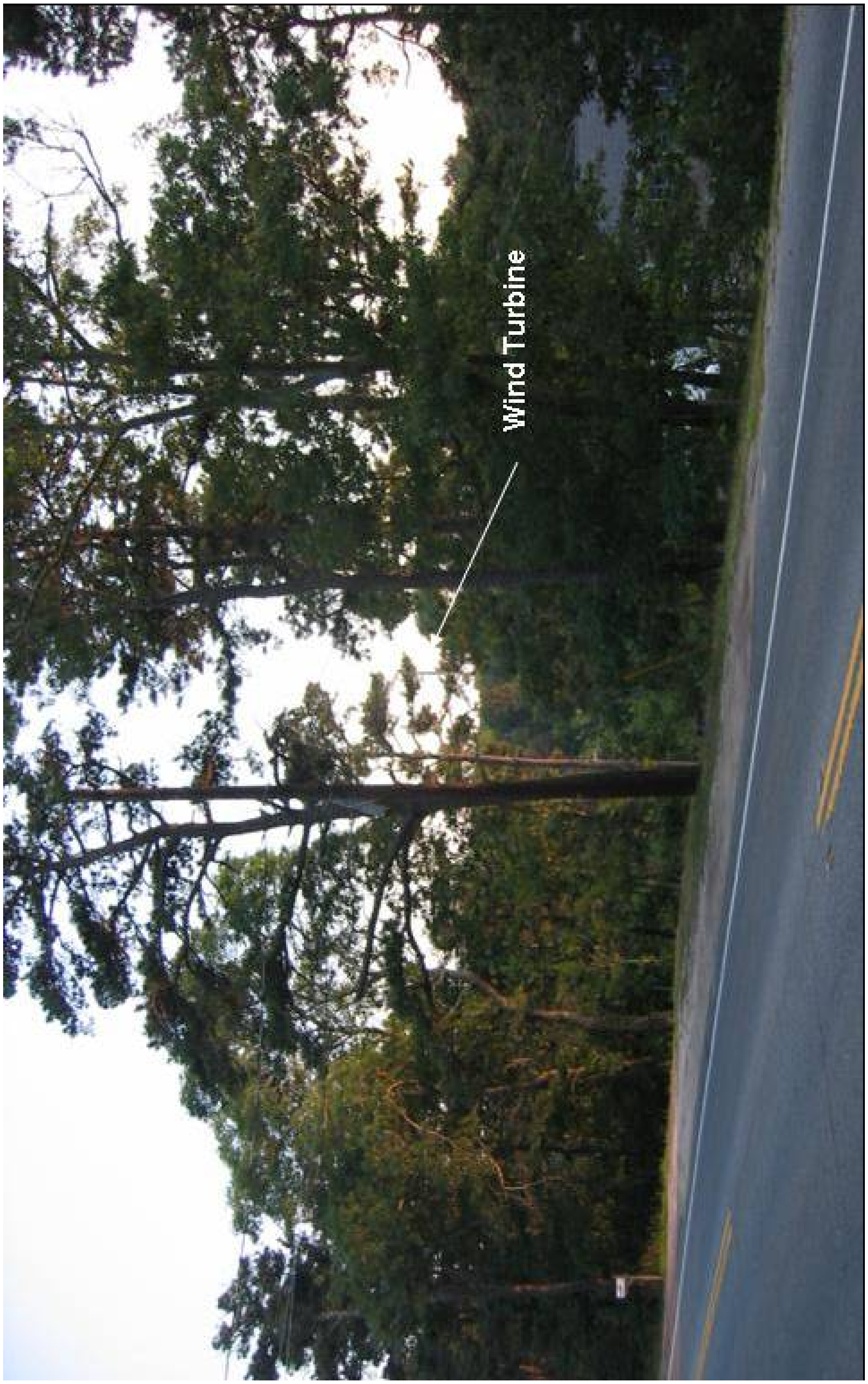


Figure A-4. Location 3 – Rt. 28, 1.5 km NE of Watershed Looking Southwest

Figure A-5. Location 4 – Soccer Field in Eldredge Park Looking South

Figure A-6. Location 5 – Nauset Marine Dock on Meeting House Pond Looking Southwest

APPENDIX B
PROJECTED OPERATING RESULTS

APPENDIX B-1: 1.5 MW WIND TURBINE SCENARIO

Town of Orleans
Wind Feasibilty Study
Orleans GE 1.5sl P75

Year Ending December 31,	2006(1)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
PERFORMANCE											
Average Annual Capacity (MW)(1)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Average Annual Displaced Capacity (MW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capacity Factor (%)	23.6%	23.6%	23.6%	23.6%	23.6%	23.6%	23.6%	23.6%	23.6%	23.6%	23.6%
Annual Energy Generation (MW)(2)	1,551	3,101	3,101	3,101	3,101	3,101	3,101	3,101	3,101	3,101	3,101
COMMODITY PRICES											
General Inflation (%)(5)	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
Market Energy Pricing ($/MWh)(8)											
Peak Load Market Energy Clearing Price ($/MWh)	$38.80	39.73	40.68	41.66	42.66	43.68	44.73	45.80	46.90	48.03	49.18
Low Load A Market Energy Clearing Price ($/MWh)	$38.80	39.73	40.68	41.66	42.66	43.68	44.73	45.80	46.90	48.03	49.18
Low Load A Market Energy Clearing Price ($/MWh)	$38.80	39.73	40.68	41.66	42.66	43.68	44.73	45.80	46.90	48.03	49.18
Government Renewable Credit Revenue ($/MWh)(9)											
PTC Credits ($/MWh)	$0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass REC's ($/MWh)	$35.00	35.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
REPI Credits ($/MWh)	$0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OPERATING REVENUES ($000)											
Electricity Revenues											
Market Electricity Revenue											
Market Peak Load Energy Costs	$12	25	25	26	26	27	28	28	29	30	31
Market Low Load A Energy Costs	$17	36	37	37	38	39	40	41	42	43	44
Market Low Load B Energy Costs	$31	63	64	66	67	69	71	72	74	76	78
Government Renewable Credit Revenue											
Production Tax credits	$0	0	0	0	0	0	0	0	0	0	0
Mass Renewable Energy Credits	$54	109	78	78	78	78	78	78	78	78	78
Renewable Energy production Incentives	$0	0	0	0	0	0	0	0	0	0	0
Total Revenue	$114	232	204	207	210	213	216	220	223	226	230
OPERATING EXPENSES ($000)(10)											
Operating and Maintenance											
Fixed O&M	$17	34	37	38	39	43	44	45	46	47	53
Administrative and General											
Administration	$1	3	3	3	3	3	3	3	3	3	4
Insurance	$0	0	0	0	0	0	0	0	0	0	0
Property Tax	$0	0	0	0	0	0	0	0	0	0	0
Administrative and General	$1	3	3	3	3	3	3	3	3	3	4
Total Operating Expenses	$19	40	43	44	45	49	50	51	52	53	61
NET OPERATING REVENUES ($000)	$95	192	160	162	165	164	166	169	171	173	169

Town of Orleans
Wind Feasibilty Study
Orleans GE 1.5sl P75

Year Ending December 31,	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
PERFORMANCE										
Average Annual Capacity (MW)(1)	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Average Annual Displaced Capacity (MW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capacity Factor (%)	23.6%	23.6%	23.6%	23.6%	23.6%	23.6%	23.6%	23.6%	23.6%	23.6%
Annual Energy Generation (MW)(2)	3,101	3,101	3,101	3,101	3,101	3,101	3,101	3,101	3,101	3,101
COMMODITY PRICES										
General Inflation (%)(5)	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
Market Energy Pricing ($/MWh)(8)										
Peak Load Market Energy Clearing Price ($/MWh)	$50.36	51.57	52.81	54.08	55.37	56.70	58.06	59.46	60.88	62.34
Low Load A Market Energy Clearing Price ($/MWh)	$50.36	51.57	52.81	54.08	55.37	56.70	58.06	59.46	60.88	62.34
Low Load A Market Energy Clearing Price ($/MWh)	$50.36	51.57	52.81	54.08	55.37	56.70	58.06	59.46	60.88	62.34
Government Renewable Credit Revenue ($/MWh)(9)										
PTC Credits ($/MWh)	$0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass REC's ($/MWh)	$25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
REPI Credits ($/MWh)	$0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OPERATING REVENUES ($000)										
Electricity Revenues										
Market Electricity Revenue										
Market Peak Load Energy Costs	$31	32	33	34	34	35	36	37	38	39
Market Low Load A Energy Costs	$45	46	47	49	50	51	52	53	55	56
Market Low Load B Energy Costs	$80	82	84	86	88	90	92	94	96	99
Government Renewable Credit Revenue										
Production Tax credits	$0	0	0	0	0	0	0	0	0	0
Mass Renewable Energy Credits	$78	78	78	78	78	78	78	78	78	78
Renewable Energy production Incentives	$0	0	0	0	0	0	0	0	0	0
Total Revenue	$234	237	241	245	249	253	258	262	266	271
OPERATING EXPENSES ($000)(10)										
Operating and Maintenance										
Fixed O&M	$54	56	57	59	64	66	67	69	71	72
Administrative and General										
Administration	$4	4	4	4	4	4	4	4	4	5
Insurance	$0	0	0	0	0	0	0	0	0	0
Property Tax	$0	0	0	0	0	0	0	0	0	0
Administrative and General	$4	4	4	4	4	4	4	4	4	5
Total Operating Expenses	$62	64	65	67	73	74	76	78	79	82
NET OPERATING REVENUES ($000)	$171	174	176	179	177	179	182	184	187	189

Footnotes to Appendix B-1

1. Represents operation beginning July 1, 2005.
2. Assumed annual energy generation based on wind data at the proposed site and estimated power curves for the GE 1.5sl wind turbine.
3. Assumes 1,768 Peak Load Period hours each year, 2,516 Low Load A Period hours each year, and 4,478 Low Load B Period hours each year. Additionally, we have assumed that the energy generation will occur proportionately across each period in each year.
4. Assumes that none of the generated energy will be used to displace domestic Orleans energy load.
5. Based on projections prepared by Blue Chip Economic Indicators.
6. Estimated energy charges incurred by Orleans servicing their domestic load, based on information supplied by Orleans.
7. Estimated weighted average energy charge per MWh of load displaced by wind generation at Orleans.
8. As estimated by MTC.
9. As estimated by MTC.
10. All related operating expenses are assumed to increase at the general rate of inflation, insurance and taxes were not included in the analysis.

APPENDIX B-2: 660 KW WIND TURBINE SCENARIO

Town of Orleans
Wind Feasibilty Study
Orleans Vestas V-47 P75

Year Ending December 31,	2006(1)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
PERFORMANCE											
Average Annual Capacity (MW)(1)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Average Annual Displaced Capacity (MW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capacity Factor (%)	20.4%	20.4%	20.4%	20.4%	20.4%	20.4%	20.4%	20.4%	20.4%	20.4%	20.4%
Annual Energy Generation (MW)(2)	670	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340
COMMODITY PRICES											
General Inflation (%)(5)	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
Market Energy Pricing ($/MWh)(8)											
Peak Load Market Energy Clearing Price ($/MWh)	$38.80	39.73	40.68	41.66	42.66	43.68	44.73	45.80	46.90	48.03	49.18
Low Load A Market Energy Clearing Price ($/MWh)	$38.80	39.73	40.68	41.66	42.66	43.68	44.73	45.80	46.90	48.03	49.18
Low Load A Market Energy Clearing Price ($/MWh)	$38.80	39.73	40.68	41.66	42.66	43.68	44.73	45.80	46.90	48.03	49.18
Government Renewable Credit Revenue ($/MWh)(9)											
PTC Credits ($/MWh)	$0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass REC's ($/MWh)	$35.00	35.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
REPI Credits ($/MWh)	$0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OPERATING REVENUES ($000)											
Electricity Revenues											
Market Electricity Revenue											
Market Peak Load Energy Costs	$5	11	11	11	11	12	12	12	13	13	13
Market Low Load A Energy Costs	$8	15	16	16	17	17	17	18	18	19	19
Market Low Load B Energy Costs	$13	27	28	28	29	30	31	31	32	33	34
Government Renewable Credit Revenue											
Production Tax credits	$0	0	0	0	0	0	0	0	0	0	0
Mass Renewable Energy Credits	$23	47	34	34	34	34	34	34	34	34	34
Renewable Energy production Incentives	$0	0	0	0	0	0	0	0	0	0	0
Total Revenue	$49	100	88	89	91	92	93	95	96	98	99
OPERATING EXPENSES ($000)(10)											
Operating and Maintenance											
Fixed O&M	$7	15	17	17	17	19	19	20	20	21	23
Administrative and General											
Administration	$1	3	3	3	3	3	3	3	3	3	4
Insurance	$0	0	0	0	0	0	0	0	0	0	0
Property Tax	$0	0	0	0	0	0	0	0	0	0	0
Administrative and General	$1	3	3	3	3	3	3	3	3	3	4
Total Operating Expenses	$10	21	22	23	23	25	25	26	27	27	31
NET OPERATING REVENUES ($000)	$40	79	66	66	67	67	68	69	70	71	68

Town of Orleans
Wind Feasibilty Study

Orleans Vestas V-47 P75

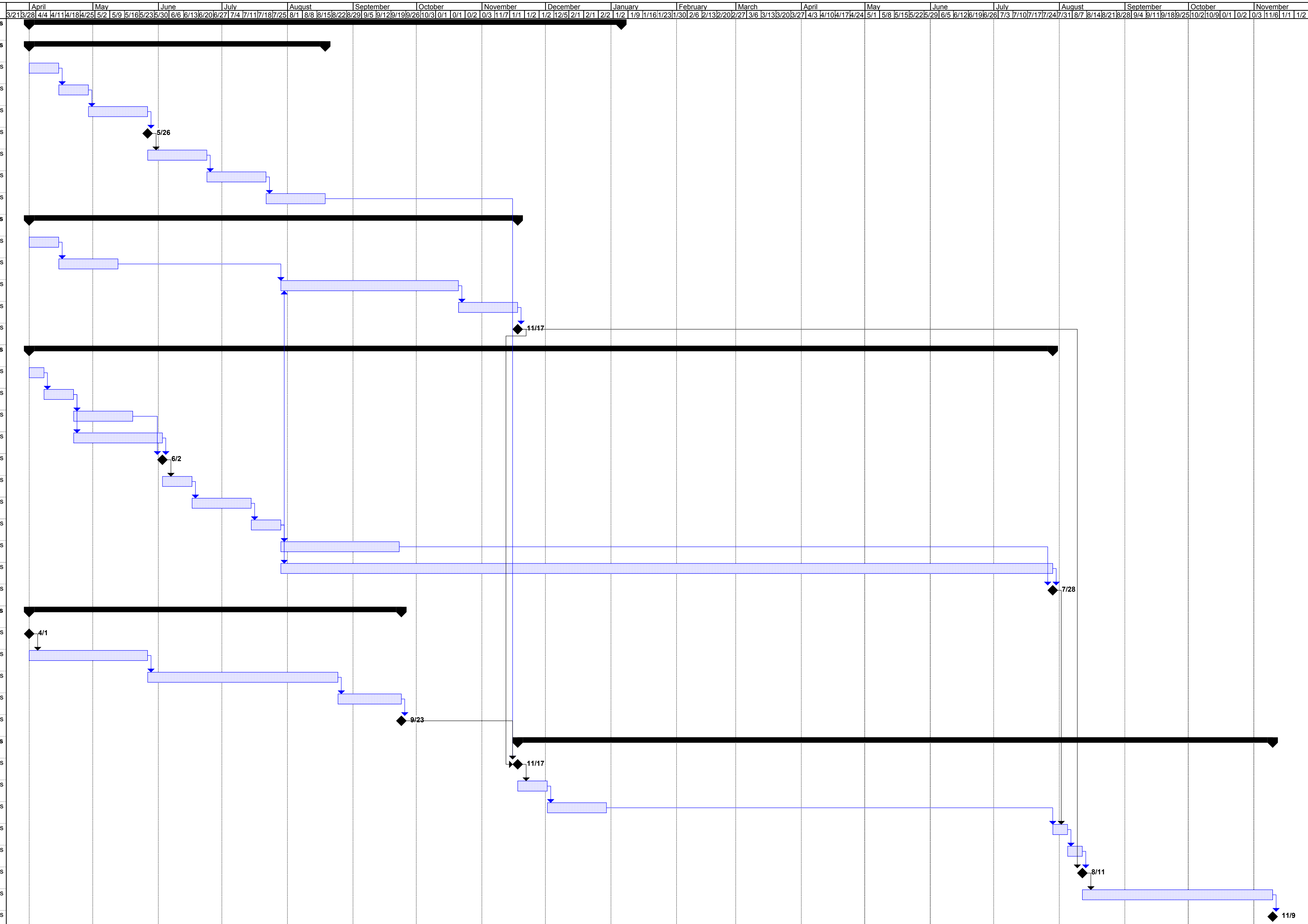
Year Ending December 31,	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
PERFORMANCE										
Average Annual Capacity (MW)(1)	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Average Annual Displaced Capacity (MW)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Capacity Factor (%)	20.4%	20.4%	20.4%	20.4%	20.4%	20.4%	20.4%	20.4%	20.4%	20.4%
Annual Energy Generation (MW)(2)	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340	1,340
COMMODITY PRICES										
General Inflation (%)(5)	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40	2.40
Market Energy Pricing ($/MWh)(8)										
Peak Load Market Energy Clearing Price ($/MWh)	$50.36	51.57	52.81	54.08	55.37	56.70	58.06	59.46	60.88	62.34
Low Load A Market Energy Clearing Price ($/MWh)	$50.36	51.57	52.81	54.08	55.37	56.70	58.06	59.46	60.88	62.34
Low Load A Market Energy Clearing Price ($/MWh)	$50.36	51.57	52.81	54.08	55.37	56.70	58.06	59.46	60.88	62.34
Government Renewable Credit Revenue ($/MWh)(9)										
PTC Credits ($/MWh)	$0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mass REC's ($/MWh)	$25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00	25.00
REPI Credits ($/MWh)	$0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OPERATING REVENUES ($000)										
Electricity Revenues										
Market Electricity Revenue										
Market Peak Load Energy Costs	$13	14	14	14	15	15	16	16	16	17
Market Low Load A Energy Costs	$20	20	21	21	22	22	23	23	24	24
Market Low Load B Energy Costs	$34	35	36	37	38	39	40	41	42	43
Government Renewable Credit Revenue										
Production Tax credits	$0	0	0	0	0	0	0	0	0	0
Mass Renewable Energy Credits	$34	34	34	34	34	34	34	34	34	34
Renewable Energy production Incentives	$0	0	0	0	0	0	0	0	0	0
Total Revenue	$101	103	104	106	108	110	111	113	115	117
OPERATING EXPENSES ($000)(10)										
Operating and Maintenance										
Fixed O&M	$24	25	25	26	28	29	30	31	31	32
Administrative and General										
Administration	$4	4	4	4	4	4	4	4	4	5
Insurance	$0	0	0	0	0	0	0	0	0	0
Property Tax	$0	0	0	0	0	0	0	0	0	0
Administrative and General	$4	4	4	4	4	4	4	4	4	5
Total Operating Expenses	$32	32	33	34	37	38	38	39	40	42
NET OPERATING REVENUES ($000)	$69	70	71	72	71	72	73	74	75	75

Footnotes to Appendix B-2

1. The Footnotes to Exhibit B-2 are the same for Exhibit B-1, except
2. Assumed annual energy generation based on wind data at the proposed site and estimated power curves for the Vestas V47 wind turbine.

APPENDIX C
PLANNING LEVEL PROJECT SCHEDULE

ID	Task Name	Duration
1	**Business Plan & Project Development**	**280 days**
19	**Procure EPC Contractor**	**140 days**
20	Identify qualified EPC contractors	14 days
21	Prepare draft EPC contract/term sheet	14 days
22	Prepare RFP for contractor	28 days
23	RFP to street	0 days
24	Await bids	28 days
25	Review bid responses	28 days
26	Finalize EPC contract and execute	28 days
27	**Electric Interconnect**	**231 days**
28	Initiate dialogue with NSTAR	14 days
29	Apply for electric interconnect	28 days
30	NSTAR system interconnect study	84 days
31	Post-Study review	28 days
32	Approval for interconnect	0 days
33	**Procure Wind Turbine Generator**	**484 days**
34	Identify turbine vendors	7 days
35	Identify turbine performance requireme	14 days
36	Draft O&M agreement/term sheet	28 days
37	Prepare procurement RFP (incl. interna	42 days
38	RFP to street	0 days
39	Await bids	14 days
40	Review bid responses	28 days
41	Finalize P.O. and execute	14 days
42	Execute O&M agreement	56 days
43	Turbine delivery	365 days
44	Turbine on-site	0 days
45	**Environmental/Regulatory Permitting**	**176 days**
46	Identify needed permits	0 days
47	Prepare and submit permit applications	56 days
48	Agency(ies) review	90 days
49	Comment period	30 days
50	Receive regulatory approvals	0 days
51	**Construction**	**357 days**
52	Break ground	0 days
53	Site preparation	14 days
54	BOP construction	28 days
55	Turbine erection	7 days
56	Start-up	7 days
57	Initial export	0 days
58	Performance testing	90 days
59	Commerical operation	0 days



Project: MTC Orleans Planning Level P
Date: 3/15/05

Task	Progress	Summary	Rolled Up Split	Rolled Up Progress	Project Summary	Deadline
Split	Milestone	Rolled Up Task	Rolled Up Milestone	External Tasks	External Milestone	