Appendix 1:

Town of Brewster Wind Turbine Feasibility Study (June 15, 2009)

Town of Brewster

Wind Turbine Feasibility Study

June 15, 2009

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Abstract

Black & Veatch reviewed six sites near Brewster, Massachusetts for the potential of installing a community wind energy project. The wind resource was estimated using wind data collected on site, as well as from local meteorological weather stations and the state wind resource map. Land use and operational issues were reviewed, specifically the proximity of the sites to protected open space, homes and to privately-owned land. The electrical infrastructure near the sites was reviewed to understand the feasibility of connecting a wind turbine to the existing electrical grid. Production from a candidate wind turbine was estimated, and the likely cost for project was reviewed. Black & Veatch found no obvious or irresolvable fatal flaws for the project sites, although concerns regarding setbacks, protected open space, and electrical interconnection will require further review.

Keywords

Renewable Energy Trust
Massachusetts Technology Collaborative
Community Wind Collaborative
Town of Brewster
Town of Brewster Alternative Energy Committee
Cape Cod
Wind Energy
Wind Power
Black & Veatch
Site Screening and Development Options
Feasibility Study

1.0 Conclusions and Recommendations

The Massachusetts Technology Collaborative (MTC) has entered into a Work Order (WO07-2) with Black & Veatch to perform a wind turbine feasibility study for a potential on-site wind energy project located near the Town of Brewster, MA for the Town of Brewster Alternative Energy Committee. This report provides the results from this study, and recommendations regarding further review of the project sites. A summary of the results and recommendations are:

- The annual long-term average wind resource at the project site is approximately 4.91 m/s (10.98 mph) at 49 meters above ground level, and 6.80 m/s (15.21 mph) at 80 meters. The wind shear component α was estimated at 0.330. (Section 4)
- The Golf Course turbine locations have Bylaw setback issues that may represent a fatal flaw, as golf course facilities & holes are located within the Fall Zone Setbacks. Special permitting may be required if this site is to be considered for development. (Sections 5 and 7)
- The Barrows, Police Station, and Waste Transfer Station sites may impact nearby residences with noise or shadow flicker. Further investigation into these matters for these sites is needed to determine if this situation could represent a fatal flaw in any of these locations. (Section 7)
- The electrical infrastructure at each location should be able to accept the generation from one or two large wind energy turbines. A formal interconnection request would be needed to establish specific system upgrades and associated costs. (Section 6)
- The production modeled under the Net-metering arrangement shows Brewster's electrical consumption can be completely offset by a two turbine wind energy project. (Section 6)
- Open Space designation of the Pumping Station site will require a deposition of Article 97 should the Town wish to proceed with development in this area.
- All portions of the Barrows, Pumping Station, and WTS sites are on land designated as part of a Biological Core Habitat and/or NHESP Estimated Habitats of Rare Wildlife. The Town should consider performing a wildlife study for these areas prior to further development. (Section 7)
- Airspace obstruction study indicates perspective turbine size and locations may impact a local long range radar facility and will require further review. (Section 7)
- The FAA has issues a determination of no hazard to air navigation for the two turbine case located at the Pumping Station location.
- Annual production (P95) for a single turbine is expected to be approximately 2,875 MWh to 3,342 MWh per turbine for large turbines with net capacity factors between 20 percent and 23 percent. Annual production (P95) for dual turbines, depending on the site, is expected to be approximately 5,991 MWh to 6,654 MWh for both of the large turbines combined with net capacity factors between 20 percent and 23 percent. Black & Veatch would classify the capacity factors as "good". (Section 9)

- The capital costs for a single 1.65 MW wind turbine at any of the sites is approximately \$4.8 million, or \$2,900 per kilowatt. (Section 10)
- Assuming net-metering, a single-turbine project is expected to have a Net Present Value of approximately \$3.6 million and 20-year cash flows of over \$6.6 million. (Section 11)
- Assuming net-metering, a two-turbine project is expected to have a Net Present Value of approximately \$8.9 million and 20-year cash flows of over \$15.8 million. (Section 11)
- Black & Veatch has determined that the Pumping Station Site may have a fatal flaw. The proximity of the water wells in this area has lead to the concern of drinking water contamination via a leak of fluids from the nacelle. To address this concern, any turbines in this area would have to use food grade lubricants in the turbine instead of specially designed synthetic blends. Manufactures are unlikely to approve the use of food grade lubricants for the wind turbines.
- Black & Veatch found no obvious fatal flaws concerning the remaining four locations, Barrows, Commerce Park, Police Station, or WTS sites. Black & Veatch recommends the Barrows site as the best candidate for development of a two-turbine site. Commerce Park is recommended as the best candidate for a single turbine site.

2.0 Review of On-Site and Community Wind Energy

Black & Veatch has included the following section to help readers better understand the technology being evaluated in this study, as well as the feasibility of installing wind turbines near or within facilities and cities.

2.1 Wind Energy Technology

The design of the typical wind turbine has changed greatly over the past twenty years. Although many types of wind turbine designs were initially developed, the "Danish" design of a three-bladed, up-wind horizontal axis turbine has emerged as the standard of the industry.

Although the size and complexity of wind turbines has increased, their basic operating principles have remained virtually unchanged. Figure 2-1 from the U.S. Department of Energy shows the typical layout of equipment in a turbine's hub, which is the "pod" of equipment at the top of the tower to which the turbine's blades are connected. Wind energy is captured by the wind turbine blades, and causes the rotor to rotate the turbine's low-speed shaft. This shaft will rotate at a speed of about 15 to 30 revolutions per minute (RPM). The low speed shaft is then connected to a gearbox, which transfers the energy to the high-speed shaft connected to the generator. The speed of the high-speed shaft depends on the generator type and electrical frequency of the site, but for the U.S. typical speeds are 1,800 and 3,600 RPM. The electrical output of the generator is then transferred to the base of the wind turbine via electrical droop cables. At the base, these cables connect to a transformer, which increases the voltage of the power from the low voltage of the generator (480 or 600 VAC) to the distribution voltage of the plant (anywhere from 12 kV to 46 kV). The orientation of the wind turbine is kept into the wind by a yaw drive, with the wind direction determined by a wind vane located on top of the hub. The turbine's controller has independent control of the wind turbine's operation, without requiring commands from a user or central control center. If the controller senses a problem, the wind speed increases beyond the turbine's operational range, or a shut-down command is given manually, the turbine will come to a stop by means of electrical, mechanical, and aerodynamic brakes (the design of which depend on the turbine).

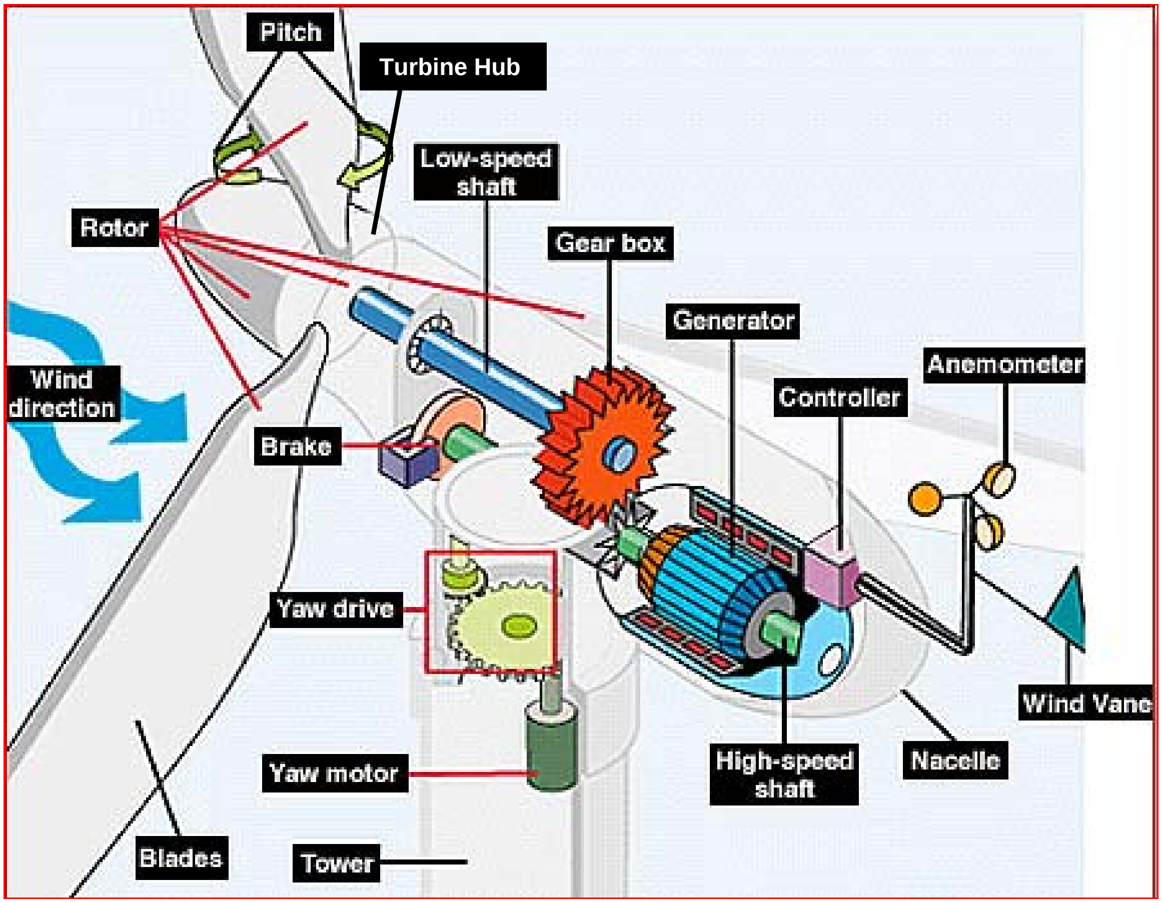


Figure 2-1. Wind Turbine Components (from US Dept. of Energy)

Obviously, the output of the wind turbine is dependent upon wind speed. The relationship of a wind turbine's electrical output as a function of wind speed is given in its power curve. A typical curve will show power production beginning when the wind speed increases beyond the turbine's minimum (cut-in) wind speed. As wind speed increases, the output power also increases in a roughly linear manner until the turbine's rated power is reached. The minimum wind speed at which a wind turbine delivers this nameplate output power is called its rated wind speed. For most modern wind turbines, winds higher than the rated wind speed will not produce any additional power, and turbine will continue to output its rated power. If the wind speed increases beyond the safe operating limits of the turbine (cut-out), the turbine will automatically shutdown and wait for the wind speeds to decrease. The wind speeds and power amounts for the above values depend mostly on the size of the wind turbine and the design of the blade airfoils. On average, larger wind turbines have lower cut-in wind speeds, have higher rated power, and reach that power at lower winds.

Three representative designs of large commercial wind turbines are discussed below. The Vestas V80 & V82 and the General Electric 1.5MW wind turbines are currently two of the most popular turbine designs for new wind farms in the U.S., and have been chosen by MTC as the standard designs for study purposes. Wind turbines from other manufacturers may be equally appropriate for these sites.

2.1.1 Vestas V80

Vestas is one of the world's largest manufacturers of wind turbines. Based in Denmark, Vestas has about one-third of the market for wind turbine sales. They recently merged with the wind turbine manufacturer NEG Micon, and together represent a major vendor and installer for wind turbines in the United States.

Figure 2-2. Vestas V80s in Buffalo Mountain, Tennessee

The V80 is currently one of the largest on-shore wind turbines available in the U.S. Rated at 1,800 kW (1.8 MW), the V80 has a 80 meter rotor diameter, is commonly installed on 80 meter towers (although Vestas offers tower options between 60 and 80 meters), and has a rotational speed of 15.5 RPM (about one revolution every four seconds). For wind projects at sites of medium to high average wind speeds, the V80 has become the primary turbine design from Vestas. The Town of Hull (Massachusetts) recently installed a V80 as their "Hull 2" turbine, located at a closed landfill in that community.

2.1.2 Vestas V82

The Vestas V82 turbine was originally developed by NEG Micon, a wind turbine manufacturer that merged with Vestas in 2004. This turbine design is optimized for lower wind conditions than the Vestas V80, by mating a slightly larger rotor on a smaller generator. This turbine is a 1,650 kilowatt machine with a rotor diameter of 82 meters commonly placed on 78 or 80 meter towers. This turbine model is used in the Jimmy Peak wind project in Massachusetts, through the MTC Community Wind Collaborative program.

Figure 2-3. Installation of a Vestas V82 in Northern Michigan

2.1.3 GE 1.5MW

General Electric (GE) purchased Enron Wind Energy in 2002, and has integrated the company into GE's Power Systems company. GE has applied their efforts since this acquisition to improving the design and production of their only commercial on-shore wind turbine, the GE 1.5MW. This turbine is a 1,500 kilowatt machine with a rotor diameter of 65, 70.5 or 77 meters. The turbine is commonly placed on either 65 or 80 meter towers. Because of its variable-speed ability, the GE 1.5MW has a rotational speed range between 10 and 20 RPM (or one revolution every three to six seconds). Projects with this design wind turbine include the Somerset, Mill Run, and Waymart projects in Pennsylvania and Fenner in New York.

Figure 2-4. GE 1.5MW turbines at Colorado Green Project

2.2 Examples of On-Site and Community Wind Energy Projects

Black & Veatch has included an example each of wind energy projects installed on a community power level or directly onsite of major power consumers.

2.2.1 Palmdale, California

Black & Veatch was the engineer for the Palmdale Water District in Palmdale, California, for the design and installation a single 950 kilowatt wind turbine at their water treatment facility. The wind turbine is a Micon (now Vestas) NM54, and is connected directly to the 12kV system of the treatment plant. This project was completed in July 2004.

This project was able to make use of two programs unique to California: the Self-Generation Incentive Program and a large Net Energy Metering allowance. The Self-Generation Incentive essentially requires the local utility (Southern California Edison) to pay for half of the costs of the project. The Net Energy Metering program in California allows for wind turbines up to 1MW to qualify for net metering, which is a requirement that the utility purchase of energy produced by the wind turbine at the same rate the customer who owns it buys power, up to the point where the wind turbine offsets the total annual consumption of their site. The Net Energy Metering allows the Palmdale project to have a turbine that will generate power at times greater than the site's consumption. Neither of these programs are presently available in Massachusetts.

Figure 2-5. Palmdale Water District On-Site Wind Turbine

2.2.2 Boston, Massachusetts

There are currently three projects in Boston that utilize wind energy on a community or smaller scale. The first is the single Vestas V47 installed by Hull Municipal Light Plant in Hull, Massachusetts. This project was installed in 2002, and is located near the local high school on the northern tip of the peninsula. The Town of Hull has a Municipal Light Board that provides electricity to the residents of Hull, and because of this they are able to use the wind generation to offset electricity purchases made by the Town. To date the Hull wind turbine has offset over 5,500 MWh of electricity purchases for the town's street and traffic lights. Due to the positive performance of this turbine, Hull Municipal Light Board has subsequently installed a larger Vestas V80 wind turbine.

Another example of small wind in Boston is the 100 kilowatt Furhlander installed at the International Brotherhood of Electrical Workers (IBEW) training center in Dorchester. This small turbine connects directly into the building's utility connection, and offsets the electricity purchased for the building in the same manner the Hull turbine offsets a portion of the electricity purchased for the town. The IBEW turbine was installed in 2005.

Figure 2-6. Hull 1 Wind Turbine

Figure 2-7. IBEW Wind Turbine

2.2.3 Toronto, Ontario

As part of a community wind power effort, the people of Toronto developed a single 750kW Lagerway wind turbine project for installation at the city's Exhibition Place. This turbine was installed in 1999, and is used to provide the power for the exhibition complex in downtown Toronto. While intended for a grassroots beginning for wind power in Ontario, this project has proven that urban wind power can work well in North America, as it does in much of Northern Europe.

Figure 2-8. Wind Turbine at Toronto's Exhibition Place

3.0 Project and Site Descriptions

Black & Veatch is supporting MTC in technical aspects of the Community Wind Collaborative. The goal of the Community Wind Collaborative is to support communities in determining the feasibility of developing utility scale (>500kW) wind energy projects, and aiding in the development of those projects found to be feasible. This report is the result of an initial site screening review and development feasibility analysis for a wind energy project for the Town of Brewster Alternative Energy Committee, Massachusetts. Issues of general development feasibility and obvious fatal flaws were reviewed, and Black & Veatch has prepared recommendations for future activities toward development of a project in Brewster. Figure 3-1 shows the location of Brewster on Cape Cod.

Figure 3-1. Brewster Location.

The Town of Brewster's Alternative Energy Committee has identified six potential locations where there is sufficient land owned by the Town to place one or more large wind turbines. These areas are referred to in this report at the Barrows, Commerce Park, Golf Course, Police Station, Pumping Station and Waste Transfer Site (WTS) locations. All six locations are shown in Figure 3-2.

1 – Barrows	2 – Commerce Park	3 – Golf Course	4 – Police Station	5 – Pumping Station	6 - WTS

Figure 3-2. Brewster Site Locations

The Barrows location is approximately 1,550 feet to the Northwest of the Freemans Way overpass of Mid-Cape Highway 6. This site is in a moderately wooded area, but is still easily accessible due to do its proximity to major roads. The land is moderately hilly with the terrain sloping gently upward to the East. The second site is Commerce Park, located within an industrial area adjacent to Mid-Cape Highway 6 approximately a quarter mile from the Captain's Golf Course driving range parking lot. The surrounding rolling hills in this location are heavily wooded, however; this site is easily accessible from the local roads. The Golf Course locations are set in roughly the center of the Golf Course in mostly cleared areas near the location where RERL MET tower was previously installed and in the middle of the course itself.. The fourth site, the Police Station location, is located approximately 750 feet northeast of the Brewster Police Department near Harwich Road. The area has little change in elevation and is heavily wooded, but several nearby roads make this site easily accessible. A railroad line runs to the east, and the area has several buildings to the northeast, west, and southwest, but is relatively empty to the south and southeast. The Pumping Station location is approximately 2,200 feet to the southwest of the Freemans Way overpass of Mid-Cape Highway 6. This site is located on relatively flat terrain within a densely wooded area. This location is zoned as Residential Rural and includes parcels of land used for the Brewster Water Department water wells. The last site, the WTS location, is approximately 1 mile west of the police station and 0.3 miles south of the intersection of Main Street and Stony Brook Road. The site will share space with the Brewster

Waste Transfer Station, and is predominantly clear of obstructions as a result. The area is surrounded by wooded areas and bordered by Smiths Pond to the north. The land in this area slopes gently upward south and east of the pond. Existing roads to the Waste Transfer Station makes this site easily accessible. Two locations on the site have been identified for potential wind turbine placement. The first is along the border of Smith Pond on the east shore. The second location is roughly 1000 feet northeast of the entrance to the Waste Transfer station from Hill Road.

4.0 Site Wind Resource

The wind energy resource of a project site is the most critical single aspect to understand, and is one of the few that cannot be overcome with technical solutions. This section discusses the various sources of wind resource information available for the region, and combines them into an estimate of the wind resource for Brewster.

4.1 Wind Data Reviewed

For Brewster, Black & Veatch reviewed seven different wind data sources, four of which were generated by the University of Massachusetts Renewable Energy Research Laboratory (RERL). These sources were:

- Wind data collected by RERL on a meteorological tower at the Golf Course Location (February 2006 – March 2007)
- Wind data collected by RERL on various sized meteorological towers on Cape Cod at the following locations:
  - Nantucket, MA
  - Highlands Center, Truro, MA
- Wind Data Collected by the Chatham Municipal Airport ASOS station (July 1996 – March 2007)
- *Wind Data Report: Brewster*, RERL, Spring 2006 Quarterly Report
- *Wind Data Report: Brewster*, RERL, Summer 2006 Quarterly Report
- *Wind Data Report: Brewster*, RERL, Fall 2006 Quarterly Report
- *Wind Data Report: Brewster*, RERL, Winter 2006 Quarterly Report
- *Wind Data Report: Brewster*, RERL, Winter 2007 Quarterly Report
- *Eastham, MA: Sodar-Based Wind Resource Assessment*, RERL, July 10, 2007
- *SODAR Shear Measurements at Brewster, Massachusetts,* DNV Global Energy Concepts Inc (DNV-GEC), June 6, 2008
- The New England Wind Map web site operated by TrueWind Solutions (http://truewind.teamcamelot.com/ne/)

The information available from each above resource is discussed in this section, and the resources are combined into a complete wind resource estimate for Brewster in Section 4.2. Figure 4-1 shows a map with the locations of the wind data sources in respect the Brewster met tower.

Figure 4-1. Wind Data Source Locations.

4.1.1 Brewster Wind Data

RERL installed a 50 meter (164 feet) tall meteorological (met) tower at the Golf Course location on February 1, 2006. The exact location of the tower was at coordinates 41° 44’ 08.84” North by 70° 01’ 12.73” West (WGS84) in the western portion of the Golf Course, which places it about 0.42 km (0.26 miles) east of the Pumping Station location and 0.52 km (0.35 miles) southwest of the Commerce Park location. The tower collected wind speed and direction data from sensors at 49, 38, and 20 meters (160.7 feet, 124.6 feet and 65.6 feet, respectively) above ground level, as well as a temperature sensor installed at 2 meters (6.5 feet). Site commissioning forms for Brewster’s MET tower were provided by RERL and found to be well organized and accurate as compared with information collected by Black & Veatch from site visits. These forms provided information on the specific configurations by which the tower was installed and were used by Black & Veatch in the independent review of the raw MET data.

The met tower was located in the center of a cleared wooded area with trees in every direction, but east. Trees surrounding the site appeared to be 10 meters (33 feet) in height or less, meaning the winds measured by the anemometers were likely slowed due to the height and surface roughness imposed by the trees, Figure 4-2 and Figure 4-3 shows the location of the met tower at the Golf Course.

As over a year of data available from this met tower, which was equipped and installed primarily for wind energy resource measurement, Black & Veatch concluded this to be the best source of data to base wind energy predictions upon. Also, the close proximity of these sites and similarity of the terrain features qualifies the wind data to be used in developing wind energy production estimates at each site.

Figure 4-2. Brewster Met Tower Location

Figure 4-3. Tree line from Met Tower Site

Black & Veatch reviewed each of the four *Wind Data Report: Brewster* RERL reports prepared quarterly on the met tower's data collection, as well as raw (or unfiltered) 10 minute data for February 1, 2006 through March 28, 2007. This information was obtained from the RERL web site and directly from RERL. The monthly average wind speeds are listed in Table 4-1 and shown in Figure 4-4. The values of wind shear were determined between the anemometers mounted at 49 meters and 38 meters above ground level; the results will be discussed further in Section 4.2.

Table 4-1. Measured Brewster Monthly Averages: February 2006 – March 2007

Month/Year	Wind Speed			Wind Shear
	49 Meters	38 Meters	20 Meters	(49 meters-38 meters)
*January – 06’				
February – 06’	6.36	5.71	4.18	0.369
March – 06’	5.68	5.10	3.69	0.355
April – 06’	5.96	5.36	3.94	0.367
May – 06’	5.59	5.08	3.79	0.322
June – 06’	5.16	4.66	3.41	0.349
July – 06’	5.23	4.76	3.50	0.321
August – 06’	4.45	4.01	2.66	0.339
September – 06’	4.76	4.23	2.86	0.382
October – 06’	5.93	5.26	3.75	0.407
November – 06’	5.15	4.56	3.08	0.424
December – 06’	5.94	5.19	3.81	0.458
January – 07’	6.30	5.57	4.13	0.422
February – 07’	6.15	5.50	4.09	0.376
**March – 07’	6.77	6.09	4.51	0.356
Annual	**5.58**	**4.91**	**3.67**	**0.376**

Notes: **All wind speed values in meters per second.**

Wind speed values are averages of all wind speed sensors at the same height above ground.

Wind shear values determined between anemometers at 49 and 38 meters.

* Incomplete month of data

**Only 28 days of data for this month.

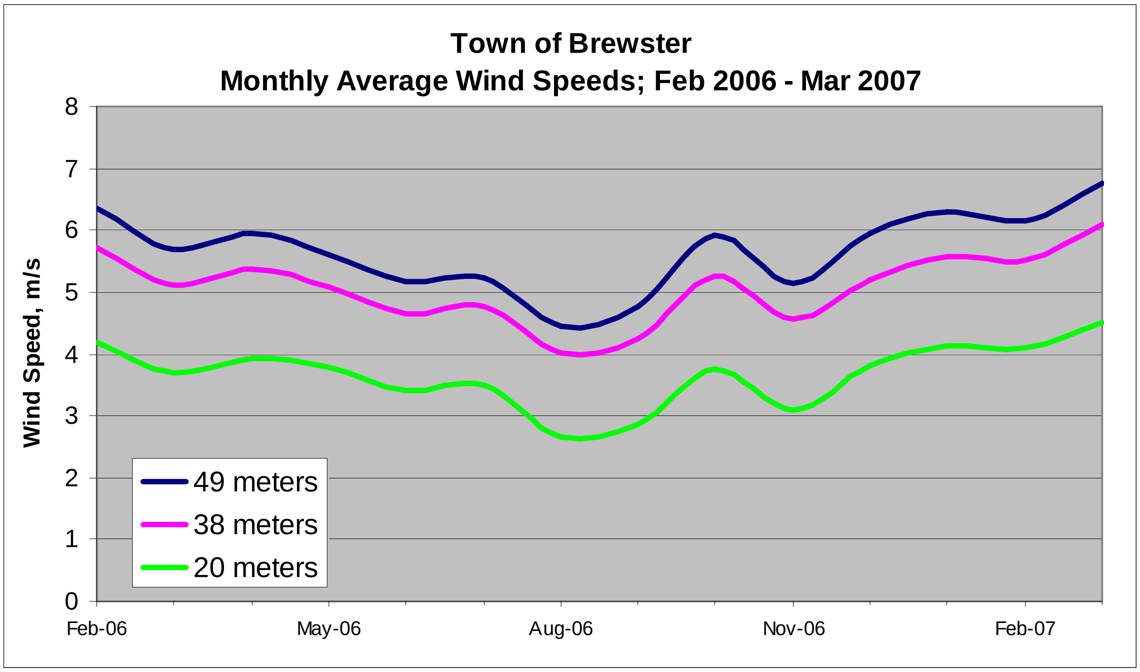


Figure 4-4. Brewster Monthly Wind Speed Averages

4.1.2 Nantucket Wind Data

RERL operated a met tower in Nantucket, MA located at coordinates 41º 16’ 49.836” North, 70º 10’ 9.084” West (WGS84), and is about 32 miles from the Town of Brewster met tower (29.5 miles from the Chatham Municipal Airport). This meteorological campaign utilized a radio tower to collect wind speed and direction data from sensors mounted at 99 meters, 68 meters and 58 meters above ground level (324.8 feet, 223.0 feet and 190.3 feet, respectively). RERL monitored wind conditions at this site from July 22, 2005 through October 3, 2006. This data set was used to validate the accuracy of the 80 meter (262.5 feet) wind speed predictions and wind shear values for the Town of Brewster met tower. This dataset was chosen for its high level wind speed readings and high correlation to the Town of Brewster met tower.

Black & Veatch reviewed the 2005/2006 RERL reports on the met tower’s data collection was well as 10 minute data from July 2005 through October 2006. This information was all obtained from the RERL website. The monthly average wind speeds are listed in Table 4-2 and shown in Figure 4-5. The percent energy wind rose for the 2005/2006 dataset is shown in Figure 4-6.

Table 4-2. Measured Nantucket Monthly Averages: July 2005 – September 2006.

Month/Year	Wind Speed			Wind Shear
	99 Meters	68 Meters	58 Meters	(68 meters-58 meters)
*July – 05'				
August – 05'	7.86	7.11	6.65	0.554
September – 05'	7.69	7.07	6.73	0.494
October – 05'	10.19	9.43	9.02	0.317
November – 05'	10.83	9.70	9.13	0.459
December – 05'	10.14	9.43	9.02	0.283
January – 06'	11.16	10.13	9.61	0.405
February – 06'	10.99	10.10	9.64	0.327
March – 06'	9.33	8.56	8.14	0.382
April – 06'	9.98	9.00	8.60	0.426
May – 06'	9.90	8.74	8.30	0.489
June – 06'	9.95	8.68	8.08	0.550
July – 06'	9.16	7.97	7.43	0.624
August – 06'	7.47	6.76	6.44	0.431
September – 06'	7.74	7.13	6.88	0.336
*October – 06'				
Annual	9.42	7.18	7.04	0.437

Notes: **All wind speed values in meters per second.**

Wind speed values are averages of all wind speed sensors at the same height above ground.

Wind shear values determined between anemometers at 68 and 58 meters.

*Incomplete month of data.

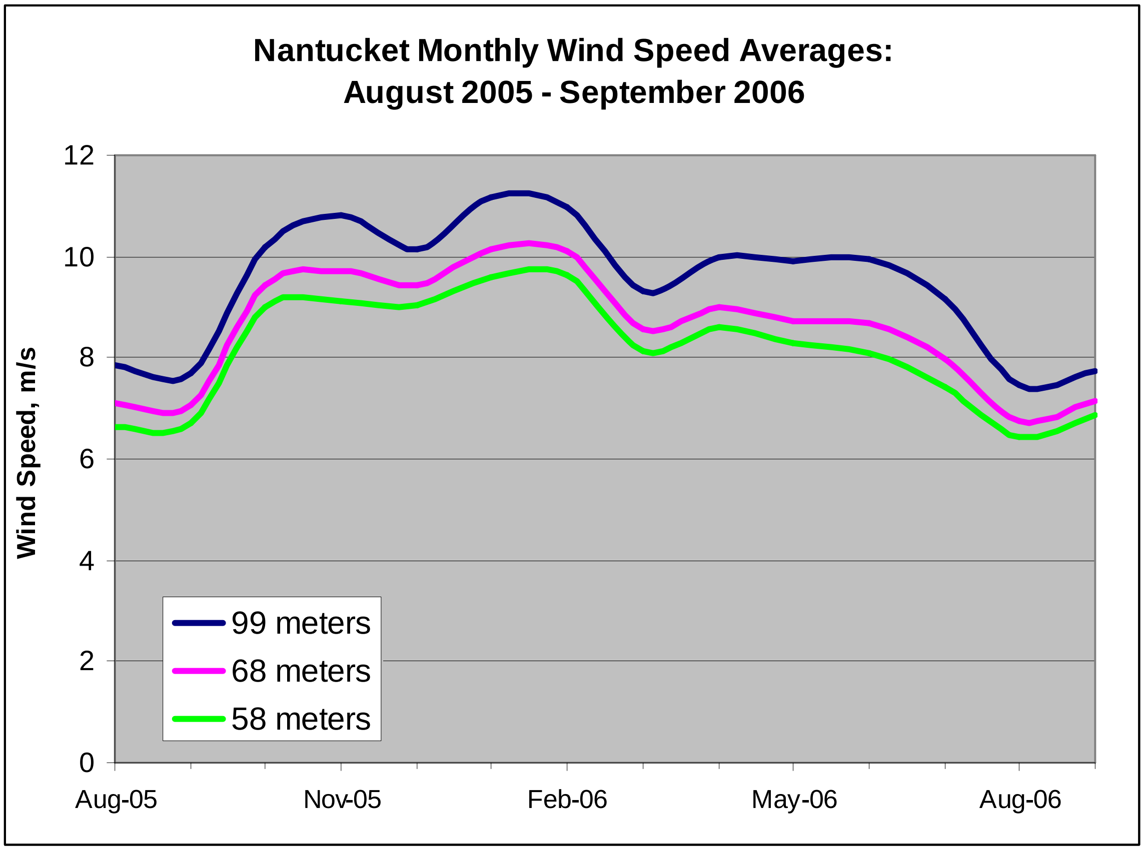


Figure 4-5. Nantucket Monthly Wind Speeds.

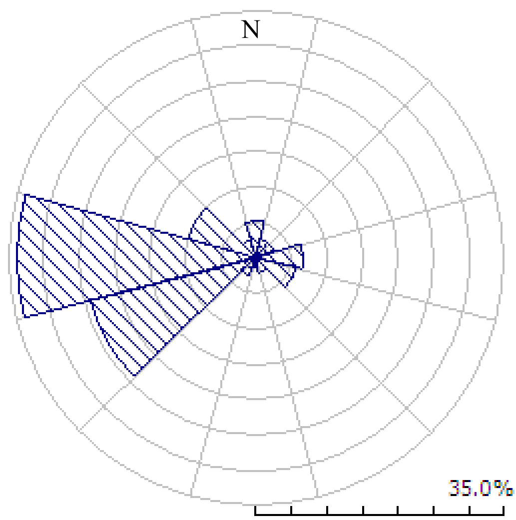


Figure 4-6. Nantucket 2005/2006 Percent Energy Wind Rose.

4.1.3 Highlands Center, Truro Wind Data

RERL operated a met tower in Truro, MA located at coordinates 42º 01' 47.316" North, 70º 03' 3.924" West (WGS84), and is about 20.4 miles from Brewster met tower (23.70 miles from the Chatham Municipal Airport). This meteorological campaign utilized a standard 50 meter met tower to collect wind speed and direction data from sensors mounted at 50 meters, 38 meters and 35 meters above ground level. RERL monitored wind conditions at this site from March 24, 2006 through April 25, 2007. This data set was also used to validate the shear profile for the Town of Brewster met tower.

Black & Veatch reviewed the 2005/2006 RERL reports on the met tower's data collection was well as 10 minute data from July 2005 through October 2006. This information was all obtained from the RERL website. The monthly average wind speeds are listed in Table 4-3 and shown in Figure 4-7. The percent energy wind rose for the 2006/2007 dataset is shown in Figure 4-8.

Table 4-3. Measured Truro Monthly Averages: July 2005 – September 2006

Month/Year	Wind Speed			Wind Shear
	50 Meters	38 Meters	35 Meters	(50 meters-38 meters)
*March – 06'				
April – 06'	7.90	7.28	7.05	0.305
May – 06'	7.68	7.10	6.87	0.314
June – 06'	6.84	6.32	6.10	0.305
July – 06'	6.94	6.37	6.16	0.325
August – 06'	5.88	5.40	5.23	0.322
September – 06'	6.47	5.96	5.74	0.328
October – 06'	8.12	7.48	7.22	0.318
November – 06'	7.42	6.86	6.58	0.329
December – 06'	8.18	7.49	7.24	0.322
January – 07'	8.72	8.04	7.76	0.304
February – 07'	8.63	8.00	7.74	0.279
March – 07'	9.15	8.44	8.17	0.309
**April – 07'				
Annual	**7.75**	**7.16**	**6.92**	**0.309**

Notes: **All wind speed values in meters per second.**

Wind speed values are averages of all wind speed sensors at the same height above ground.

*Incomplete month of data.

**Less than 25 days of data

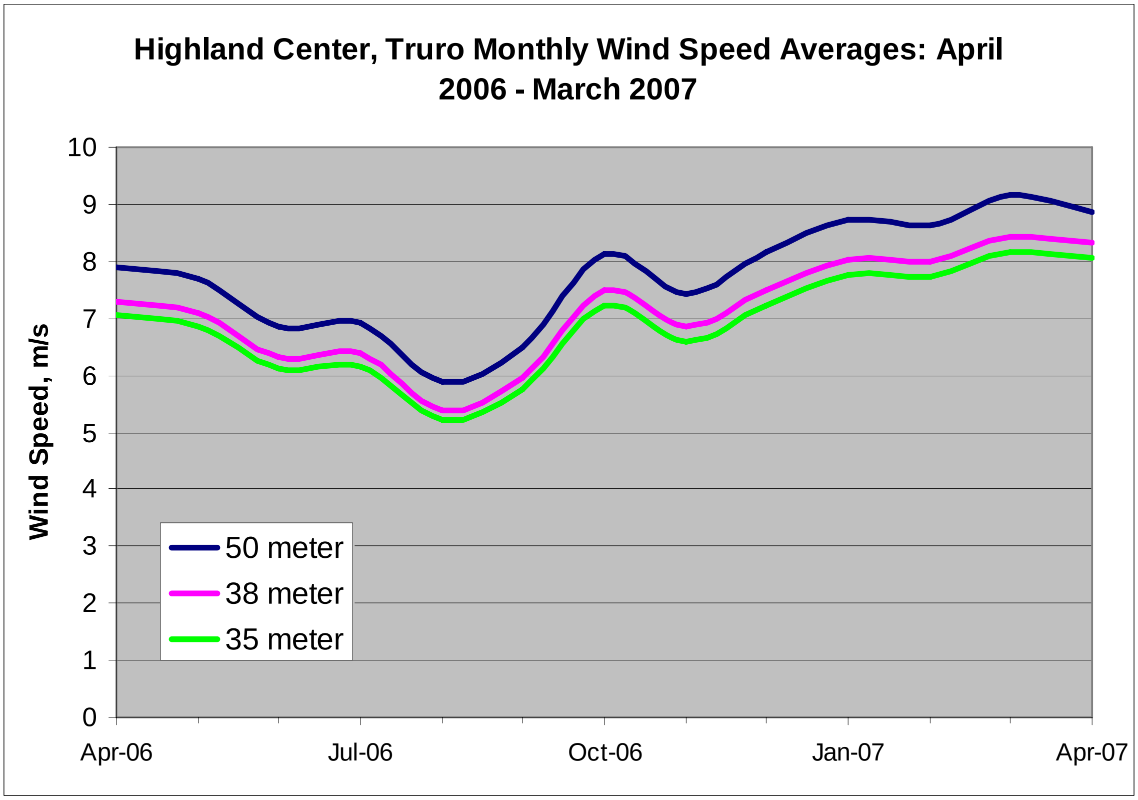


Figure 4-7. Highland Center, Truro Monthly Wind Speed Averages.

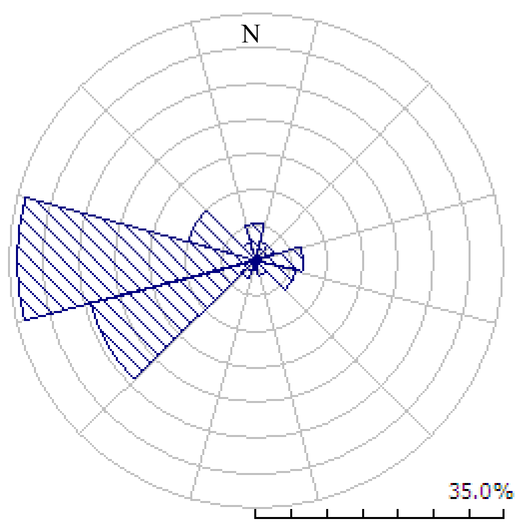


Figure 4-8. Highland Center, Truro Percent Energy Wind Rose

4.1.4 Eastham SODAR Data

RERL performed wind resource analysis at a site in Eastham utilizing a portable Sound Detection and Ranging (SODAR) system. SODAR systems use acoustic signals to observe wind speed and direction conditions between 30 meters and 160 meters above ground level (at 10 meter intervals). RERL used their SODAR system to collect data over a six month period in Eastham, and reported their findings in the report referenced above.

The RERL SODAR system was installed at the Eastham site on November 17, 2006, and removed on May 8, 2007. RERL reported problems keeping the SODAR unit operating (due to power issues) during the first few months of their campaign, and only recorded data for a few hours each day resulting in an overall data recovery of less than 40 percent. RERL indicated that by February 10, 2007 the SODAR unit was operating with limited interruptions in the data stream and the total recovery of valid data increased to 65 – 70 percent (at heights up to 120 meters, but also recovered valid data up to 160 meters).

Black & Veatch reviewed the RERL report for this analysis, but did not review the collected data. The data available in the report was used with other stated data sources to validate the use of a power law approximation to determine hub height wind speeds. This review is discussed in the subsequent sections below.

4.1.5 Brewster SODAR Data

DNV Global Energy Concepts Inc (DNV-GEC) performed a wind resource analysis at the previous met tower site in Brewster utilizing a portable Sound Detection and Ranging (SODAR) system. Like the Eastham SODAR campaign carried out by RERL, the Brewster study analyzed wind speeds from 30 meters to 160 meters above ground, but placed more focus on reviewing the wind shear profile at the site.

DNV-GEC began data collection at the Brewster met tower site on January 5, 2008 and removed the SODAR unit on March 11, 2008. Similar to the Eastham SODAR campaign, the DNV-GEC study also experienced overall low data recovery (between 65 percent at 40 meters to 25 percent at 145 meters). These recovery rates are mainly attributed to the filtration of invalid data points associated with rain and those data values exhibiting low signal-to-noise ratios (SNR) from the dataset.

While the duration of this study was shorter than typical SODAR campaigns (usually 3 to 6 months), the goal of confirming the shear profile at the Brewster met tower site did not require a long-term study. Despite the low recovery of valid data, a sufficient amount of valid data was collected to conclude that the power law approximation derived from the Brewster met tower provides a reasonable estimation of the hub height wind speeds.

Black & Veatch reviewed the DNV-GEC report for this analysis, but did not review the collected data. The data available in the report was used with other stated data sources to validate the use of a power law approximation to determine hub height wind speeds. This review is discussed in the subsequent sections below.

4.1.6 Chatham Municipal Airport Wind Data

While a year of data collection at or near a project site is usually deemed necessary for a wind energy project, a long-term data source is also needed to put the collected data into a historical perspective. Since the wind conditions at a site can change considerably between individual years, comparing the year over which data was collected to a long-term average becomes important to understand a site's average long term wind resource. Therefore Black & Veatch used the wind data collected at the Chatham Municipal Airport as the long-term data source for Brewster's wind resource estimates.

The Chatham Municipal Airport met tower location is 41º 41' 15" North, 69º 59' 36" West (WGS84). The Chatham met tower is approximately 3.7 miles southeast of Brewster's met tower location. The Chatham Municipal Airport met tower is a National Oceanic and Atmospheric Administration (NOAA) Automated Surface Observation Systems (ASOS) station, identified by call sign "CQX" and WBAN Identification number 94624. Figure 4-9 shows this ASOS station.

NOAA publishes hourly data collected at this station, and Black & Veatch reviewed the data collected from July 1996 through July 2007. Monthly averages from these years are presented in Table 4-4, and shown in Figure 4-10.

Figure 4-9. Chatham Municipal Airport Met Tower (from NOAA web site).

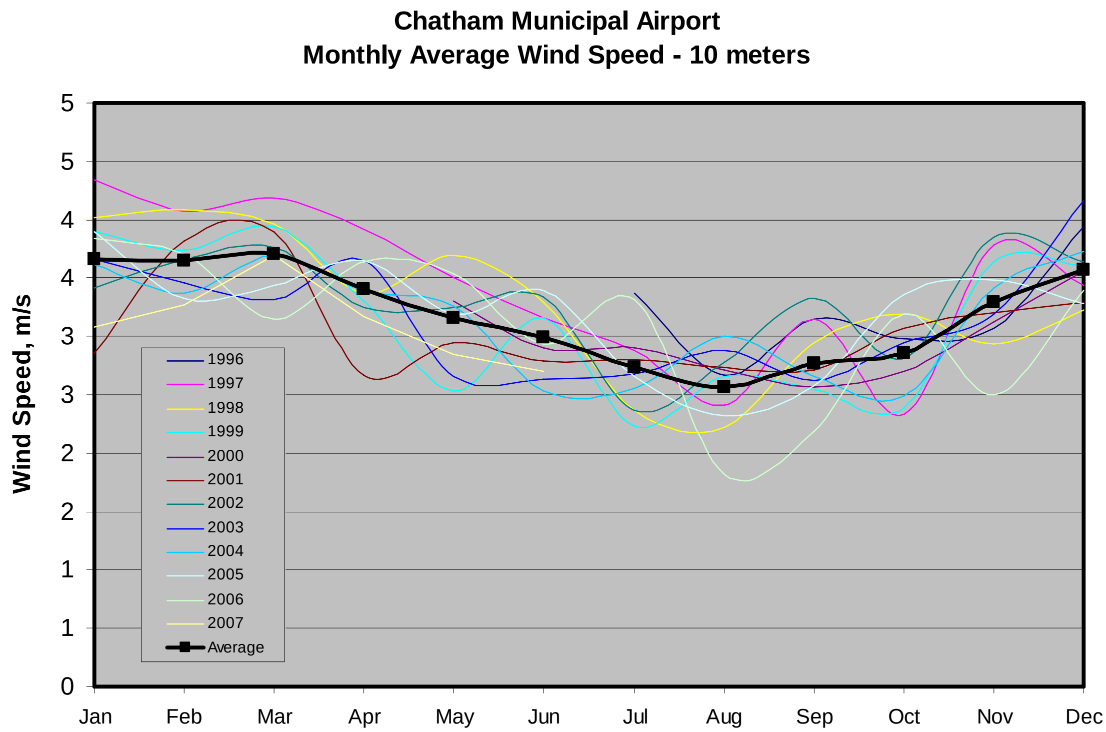


Figure 4-10. Chatham Municipal Airport Monthly Wind Speed Averages.

Table 4-4. Chatham Municipal Airport Monthly Average Wind Speeds

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1996							3.4	2.7	3.1	3.0	3.1	3.9
1997	4.3	4.1	4.2	3.9	3.5	3.2	2.9	2.4	3.1	2.3	3.8	3.4
1998	4.0	4.1	4.0	3.4	3.7	3.3	2.4	2.2	3.0	3.2	2.9	3.2
1999	3.9	3.7	3.9	3.3	2.5	3.2	2.2	2.7	2.5	2.4	3.6	3.6
2000					3.3	2.9	2.9	2.7	2.6	2.7	3.1	3.6
2001	2.9	3.8	3.9	2.7	2.9	2.8	2.8	2.7	2.7	3.1	3.2	3.3
2002	3.4	3.7	3.8	3.2	3.2	3.3	2.4	2.8	3.3	2.8	3.9	3.6
2003	3.7	3.5	3.3	3.7	2.7	2.6	2.7	2.9	2.6	2.9	3.2	4.2
2004	3.6	3.4	3.7	3.4	3.3	2.5	2.6	3.0	2.7	2.5	3.4	3.7
2005	3.9	3.3	3.4	3.7	3.2	3.4	2.7	2.3	2.6	3.4	3.5	3.3
2006	3.8	3.7	3.1	3.6	3.5	2.9	3.3	1.8	2.2	3.2	2.5	3.4
2007	3.1	3.3	3.7	3.2	2.8	2.7	2.2					
Average	**3.7**	**3.7**	**3.7**	**3.4**	**3.2**	**3.0**	**2.7**	**2.6**	**2.8**	**2.9**	**3.3**	**3.6**
Notes: **All values in meters per second.**												

Wind data collected at airports is not intended for wind energy resource measurement since it is commonly collected with instruments fairly low to the ground. At Chatham Municipal Airport, the data was collected at 10 meters (33 feet) above ground level, far lower than the 80 meter hub height of interest in this report. Since scaling this low-level data upward to the proposed turbine hub heights is not preferable when a better data source is available, Black & Veatch did not attempt to use this data directly for wind resource estimation. Instead, Black & Veatch used the Chatham Municipal Airport data to review how data collected at the Chatham tower over the time period when the Brewster met tower compares with the long-term average from the Chatham tower. This comparison, and the subsequent impact to the Brewster data is presented in Section 4.2

4.1.7 Massachusetts Wind Resource Map Information

Black & Veatch also referenced the New England Wind Resource Map web site (truewind.teamcamelot.com/ne/) for general information on the wind resource for the area around the project site. This map is a model of the wind resources for all of New England, and was created from atmospheric data and then calibrated using various data measurement locations. The map is provided at Appendix A. Creation of this map by TrueWind Solutions was funded by MTC, the Connecticut Clean Energy Fund, and the Northeast Utilities System.

By entering the coordinates of the Brewster Met Tower, the web service estimated the annual average wind speed to be 6.3 m/s at 50 meters above ground level, and 6.9 m/s at 70 meters above ground level. A wind rose for the site was also downloaded from the web site and shown below in Figure 4-11. These results should be considered to be a general estimate for the area, and not as accurate at the site collected data. The model has a specified resolution of 200 meters and a standard error estimated at 0.6 m/s.

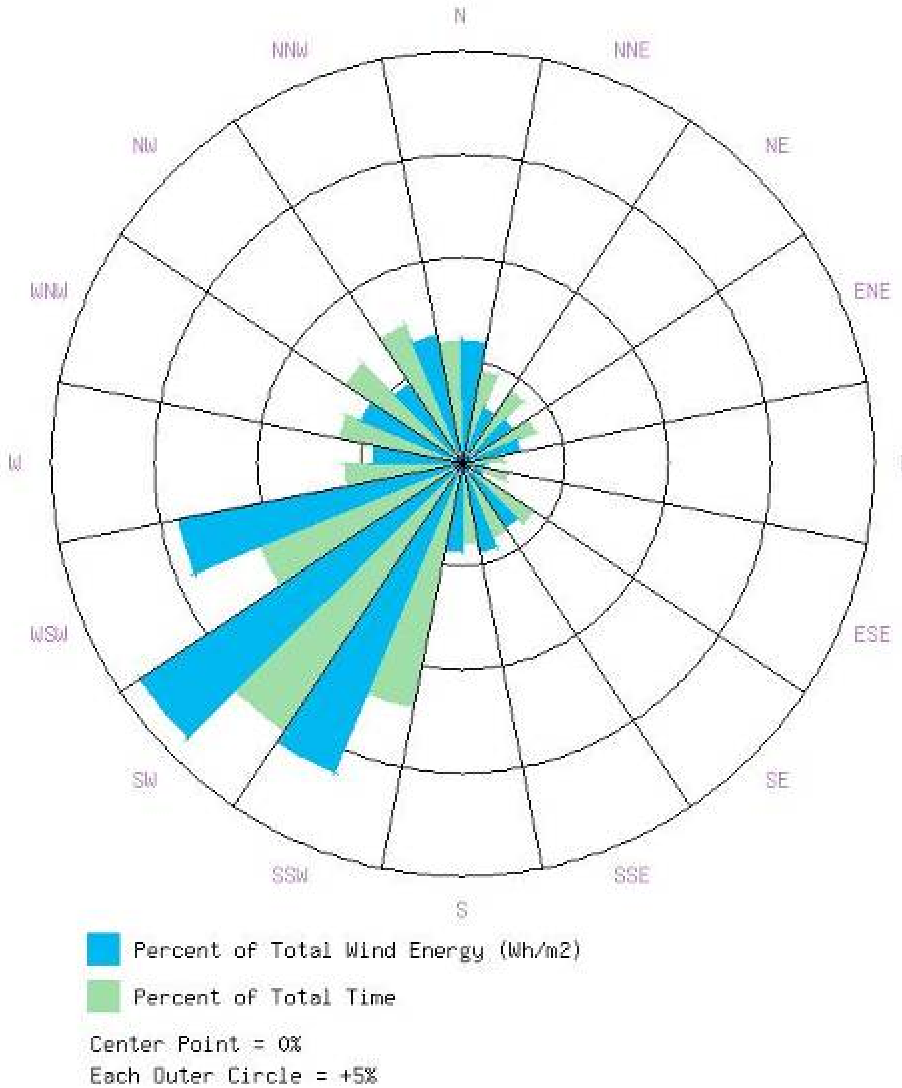


Figure 4-11. AWS TrueWind Wind Rose for Brewster.

As a check on data quality and relevance, Black & Veatch performed correlations between the Town of Brewster's met data and the other local data sources on a daily and monthly basis. **Error! Reference source not found.** and **Error! Reference source not found.** show the daily and monthly correlation estimates (respectively) of the Nantucket, Truro and Chatham Municipal Airport dataset to the Town of Brewster's.

Table 4-5.
Daily Met Data Correlations to Other Local datasets.

	Nantucket 58m Wind Speed	Truro 50m Wind Speed	Truro 38m Wind Speed	Truro 35m Wind Speed	Chatham Municipal Airport 10mWind Speed
Brewster **49m** Wind Speed	0.956	0.956			
Brewster **38m** Wind Speed			0.944		
Brewster **20m** Wind Speed				0.929	0.685

Table 4-6.
Monthly Met Data Correlations to Other Local Datasets.

	Nantucket 58m Wind Speed	Truro 50m Wind Speed	Truro 38m Wind Speed	Truro 35m Wind Speed	Chatham Municipal Airport 10mWind Speed
Brewster **49m** Wind Speed	0.971	0.982			
Brewster **38m** Wind Speed			0.966		
Brewster **20m** Wind Speed				0.942	0.903

The correlations of the Town of Brewster's met data and the Nantucket and Truro met data are strong enough to indicate that these towers were experiencing similar wind condition changes on a daily and monthly basis. Black & Veatch hypothesizes the reason for the poorer correlation of the Brewster met tower to the Chatham Municipal airport on a daily basis may be due nearby obstructions to the weather station impacting the effect of how wind speed changed on this time interval.

4.2 Site Wind Resource Estimate

As discussed in the previous section, Black & Veatch had seven sources of wind resource information available for the Town of Brewster. As the closest site to the perspective development areas with over a year of wind data at a height near typical wind turbine hub heights, the Town of Brewster's met tower dataset was used as the primary data source. Other data sources mentioned in the previous section were used to validate wind resource characteristics such as seasonal wind speed patterns and shear. Black & Veatch prepared an estimate of the wind resource within the project area using the Linear Regression Measure-Correlate-Predict (MCP) method. The procedure used to develop this estimate of is described in this section.

As mentioned in Section 4.1.1, the Brewster met tower was installed in an area mostly surrounded by a forested area. The size and thickness (or density) of a forest alters the way how the wind flows over them, as compared to how wind would flow over an open field. Wind speeds measured in forested areas are therefore slower in comparison to wind speeds measured in an open area with good exposure to prevailing winds. When preparing estimates of hug height wind speeds with data collected in forested areas an adjustment in anemometer height is necessary yield accurate estimates.. Based upon the approach provided within the white paper published in March 2005 by Wiley Interscience titled “WAsP in the Forest”, Black & Veatch calculated an anemometer displacement height of 7.26 meters. Meaning, the 38 and 49 meter anemometers were treated as being installed at 30.7 and 41.7 meters, respectively. In order to verify this correction, a ratio of the anemometer displacement to canopy height was determined and compared against other measurements. The ratio value was found to be in agreement with those calculated for projects in similar forested areas.

After making adjustments to the height of the anemometers, the ten-minute wind data collected at the Brewster met tower was averaged to match the hourly time step of the reference dataset from the Chatham Municipal Airport. The next step in the MCP process is to put the adjusted wind data measured at the Brewster met tower into historical perspective. Black & Veatch compared the average wind speeds for the data collected at the Chatham Municipal Airport over the period the data was collected from the Brewster met tower (February 2006 through March 2007). This comparison was done by separating both onsite and reference data into direction bins in thirty degree intervals and then performing a least squares regression analysis between the onsite met tower data and the reference station data. For each corresponding direction sector, the ratios from the least squares regression were then applied to the reference data sets to adjust the recorded wind speeds and create an estimate of the long-term expected wind speeds at the met tower site. These directional wind speeds are shown below in Table 4-7 & Table 4-8 for each sensor height along with the corresponding short term and calculated long term wind speeds.

Table 4-7. Estimated Long Term Monthly Average Wind Speeds, 38 meters

Direction Sector	Measured		Long-Term Predictions
	38 meters	Historical Correlation	38 meters
1 (0°-29°)	4.59	1.15	4.99
2 (30°-59°)	5.11	0.99	4.82
3 (60°-89°)	4.93	1.03	4.62
4 (90°-119°)	4.94	1.14	4.59
5 (120°-149°)	4.67	1.17	4.83
6 (150°-179°)	4.34	1.16	4.69
7 (180°-209°)	4.10	1.24	5.14
8 (210°-239°)	5.35	1.22	5.22
9 (240°-269°)	5.05	1.39	5.17
10 (270°-299°)	5.13	1.35	5.36
11 (300°-329°)	5.23	1.38	5.42
12 (330°-359°)	5.30	1.38	5.26

Notes: All wind speed values in meters per second

Table 4-8. Estimated Long Term Monthly Average Wind Speeds, 49 meters

Direction Sector	Measured		Long-Term Predictions
	49 meters	Historical Correlation	49 meters
1 (0°-29°)	5.17	1.25	5.47
2 (30°-59°)	5.66	1.09	5.30
3 (60°-89°)	5.46	1.14	5.10
4 (90°-119°)	5.45	1.27	5.10
5 (120°-149°)	5.20	1.31	5.37
6 (150°-179°)	4.90	1.27	5.14
7 (180°-209°)	4.58	1.36	5.62
8 (210°-239°)	5.93	1.35	5.76
9 (240°-269°)	5.69	1.54	5.72
10 (270°-299°)	5.79	1.51	5.98
11 (300°-329°)	5.87	1.56	6.08
12 (330°-359°)	5.94	1.55	5.89

Notes: All wind speed values in meters per second

The next step in the MCP process is to adjust the long-term Brewster met tower wind data to estimate the long-term wind speeds at the wind turbine hub height of interest, 80 meters. To make this height adjustment, Black & Veatch utilized the wind shear power law approximation, which defines the relationship between wind speed and height above ground as:

$$V(Z) = V(z_r) \cdot \left(\frac{z}{z_r} \right)^{\alpha}$$

where: V(z) = wind speed at height of interest
$V(z_r)$ = wind speed at reference height
z = height of interest
z_r = reference height
α = wind shear component

Black & Veatch utilized the Brewster data collected at 38 and 49 meters to estimate the wind shear component, alpha "α", to be about 0.330, a value considerable higher than most wind energy sites in the U.S. As a validation check, Black & Veatch reviewed the shear values from similar heights of other datasets collected on Cape Cod. Table 4-9 shows the resulting values for the wind shear component at other sites.

Table 4-9. Cape Cod Average Wind Shear

Data Source	Heights used	Alpha, α
Brewster Met Data (Short -Term)	49 and 38 meters	0.376
Brewster Met Data (Long - Term)	49 and 38 meters	0.330
Brewster SODAR Data	50 and 40 meters	0.310
	80 and 50 meters	0.380
Nantucket Met Data	58 and 68 meters	0.435
	99 and 58 meters	0.329
Truro Met Data	50 and 38 meters	0.323
Eastham Met Data	39 and 30 meters	0.400
Eastham SODAR Data	50 and 40 meters	0.450
	80 and 50 meters	0.420

While each of these sites experience similar average wind shear values, differences between values from each site are likely due to differences between site characteristics and the length of the datasets used in the averaging. While the surface roughness at each site is similar, the impact on wind flow can vary significantly between sites. Also, the wind measurements via a cup anemometer and by SODAR units are both performed in much different ways. In addition to this, met towers generally collect more valid data points than a SODAR unit over the same time period.

A useful wind resource parameter Black & Veatch does note from the SODAR data is that the vertical wind shear characteristics can be verified for a particular area. Confirming that the vertical wind shear profile can be described with a power law approximation is critical when wind data collected at lower levels (such as the case of the Town of Brewster's met tower) is used to predict the performance of a wind turbine whose rotor is centered at a greater height (such as 80 meters, as was done for this study). Figure 4-12 shows a comparison of the Eastham & Brewster SODAR data with the Brewster met data. Based upon this comparison, and that the datasets exhibited a string correlation, the power law approximation can be considered a valid method for estimating hub height wind speeds at the Brewster site.

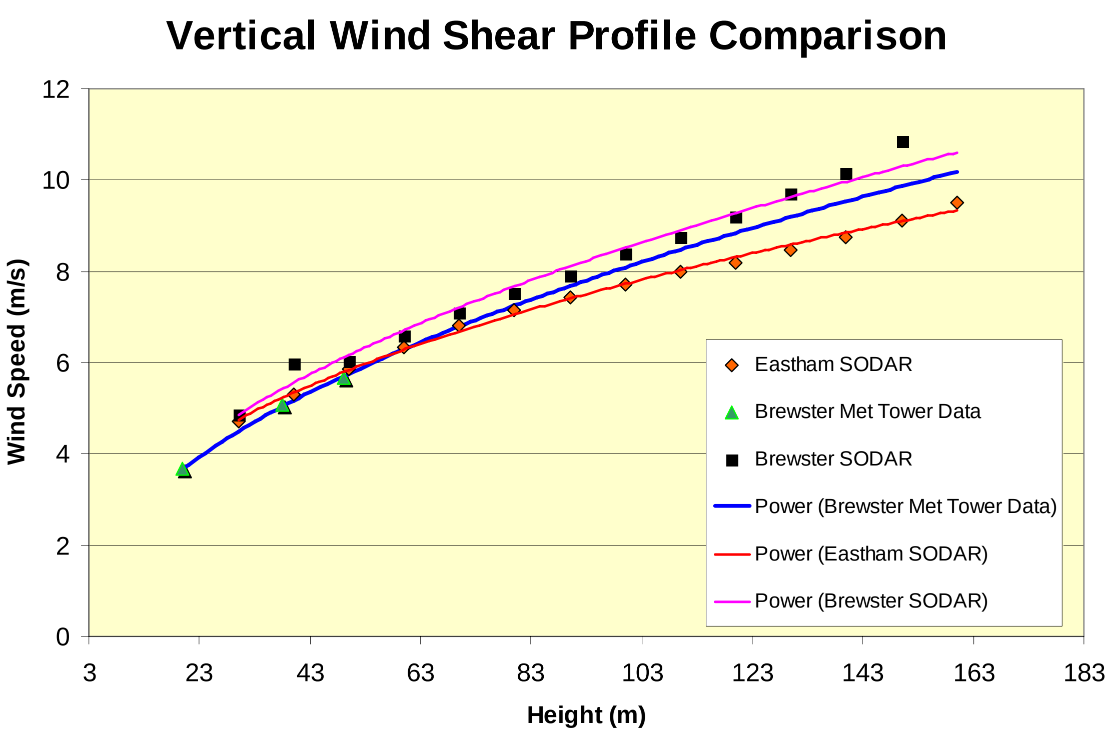


Figure 4-12. Vertical Wind Shear Profile Comparison.

The resulting long-term averages for Brewster at various heights above ground are given in Table 4-10, and shown in Figure 4-13. The resulting percent energy wind rose for the 80 meter data is shown in Figure 4-14.

Table 4-10.
Estimated Brewster Long-Term Monthly Averages

Month	38 meters	49 meters	Shear	80 meters
January	4.90	5.44	0.343	7.38
February	4.90	5.43	0.338	7.43
March	5.11	5.66	0.333	7.49
April	4.88	5.39	0.327	7.17
May	4.47	4.92	0.320	6.64
June	4.22	4.65	0.318	6.25
July	3.97	4.37	0.316	6.11
August	3.72	4.10	0.320	5.83
September	3.79	4.19	0.329	6.13
October	4.07	4.51	0.334	6.74
November	4.47	4.96	0.339	6.98
December	4.82	5.36	0.347	7.50
Annual	**4.44**	**4.91**	**0.330**	**6.80**

Notes: **All wind speed values in meters per second.**

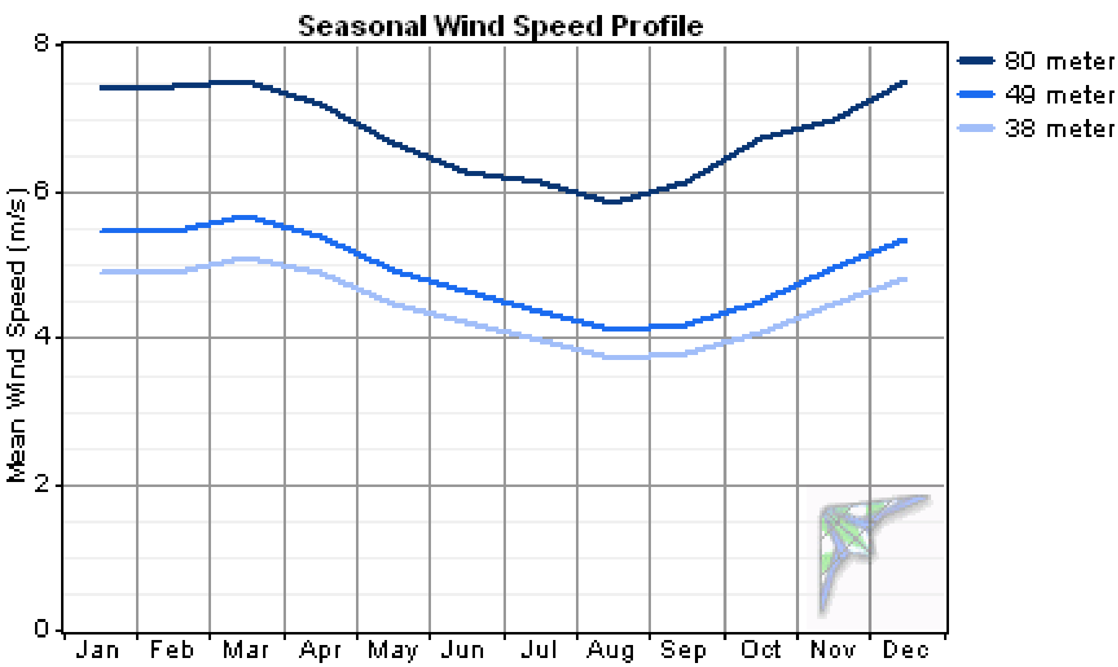


Figure 4-13. Brewster Long-Term Seasonal Wind Speed Profile

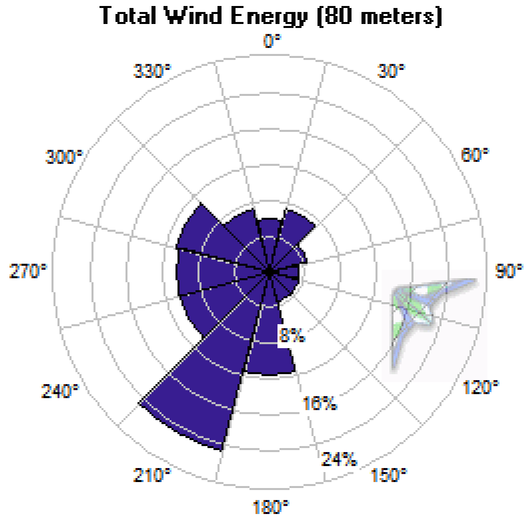


Figure 4-14. Brewster 80 Meter Percent Energy Wind Rose

As part of the International Electrotechnical Commission (IEC) 61400 series of standards governing the design of wind turbines, a series of designation are given to the wind resource of a site. These designations are used to match the appropriate turbine designs and models for a site's wind conditions. Based on the 3rd edition of the IEC standard 61400-1, the wind resource in the Brewster site area appears to have a low Class III designation; however, the high characteristic turbulence intensity of the site appears to be beyond Category A. Figure 4-15 shows the mean characteristic turbulence intensity graph of the 49 meter data. This graph also includes the IEC turbulence categories for comparison. Figure 4-16 shows the return period for extreme wind speeds based upon a best-fit Gumbel distribution. Ultimately, the designation of the site as it applies to the design of a specific wind turbine will be evaluated by the wind turbine manufacturer to ensure the proper wind turbine model is provided.

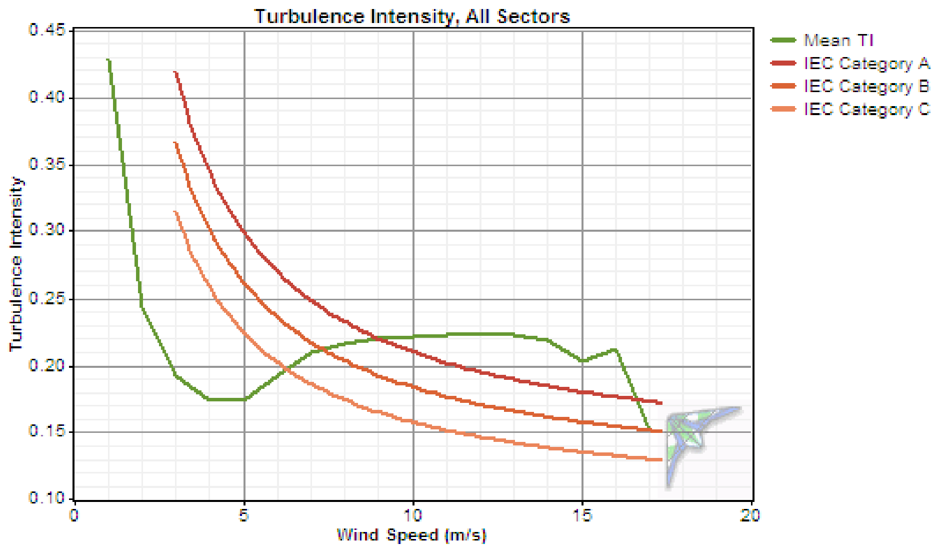


Figure 4-15. Town of Brewster Turbulence Intensity

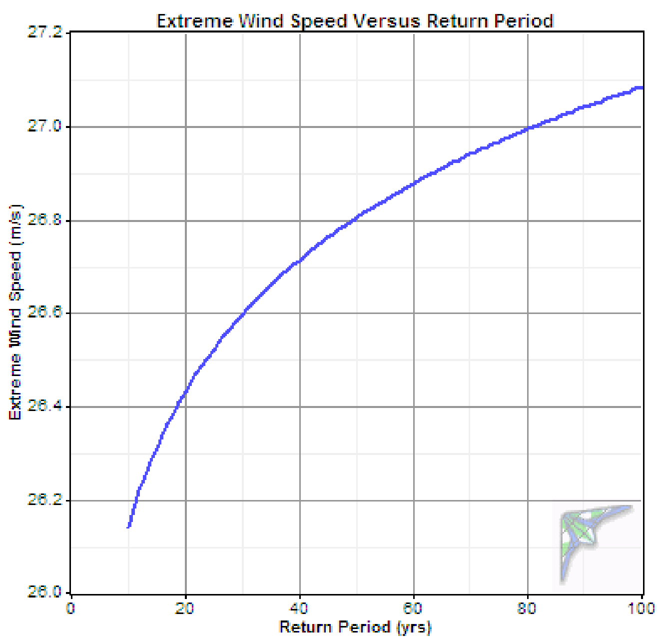


Figure 4-16. Town of Brewster Extreme Wind Speeds.

5.0 Site Physical Characteristics

The six project locations described in this report are all within the town of Brewster, Massachusetts. Brewster is located on Cape Cod near the southern end of the north-south peninsula. The topography around the project locations is relatively flat with elevations varying between sea-level and 100 feet. There is significant tree cover surrounding each of these areas, with tree heights estimated to be up to about 10 to 15 meters (50 feet) tall. Of the homes and buildings close to the six locations, none were observed to be higher than the tree cover. A cellular (Cingular) tower and an AM Radio (WFPB 1170 AM) tower were observed to be in closest proximity to the Commerce Park location; however, these structures should not impose any significant losses to turbine performance, nor should a turbine effect the operations of the cellular tower or radio tower. As mentioned earlier, there are many airports located on Cape Cod, the closet being Chatham Municipal Airport, approximately 3.7 miles to the southeast of the general area under review. Four of the locations can be readily accessed from Freemans Way or Mid-Cape Highway 6, while the other two towers are near either Harwich Road or Stony Brook Road, making transport of wind turbine components to the sites relatively easy.

This section of the feasibility study is focused on evaluating the option of placing a single large wind turbine at either Commerce Park or the Police Station, or two large turbines at the Barrows, Golf Course, Pumping Station, or WTS locations. The area within these four locations provide sufficient space to keep wake effects between wind turbines low (which greatly diminish the overall performance of each machine) and adhere to siting guidelines set by the Town.

After meeting with the Tower of Brewster Wind Energy Committee on March 1, 2007, Black & Veatch inspected each identified location. Review of the Golf Course and Commerce Park sites was performed with a representative of the Massachusetts Technology Collaborative, and review of the Pumping Station site was done with the Superintendent of the Brewster Water Department. On-site inspections of the Barrows, Police Station and WTS locations have not been conducted by Black & Veatch to verify the assumptions made fro these sites.

While reviewing these locations and finding potential wind turbine sites, Black & Veatch applied the Town of Brewster's setback requirements described by Bylaw 179-40.2, *Wind Energy Turbines Bylaw*. The Bylaw defines a setback requirement, or "Fall Zone" as being equal in distance to the total height of the wind turbine as measured from the base of turbine tower. This setback is the minimum distance from the base of the turbine tower to any property line, road (except for roads used exclusively for servicing the wind turbine), habitable dwelling, business or institutional use, or public recreational area. These setback areas must also be kept free of all habitable structures during the operational life of the wind project.

To apply this setback criteria Black & Veatch estimated parcel boundaries for each site location as illustrated in the subsequent figures below. Final turbine location options will need to be reviewed and revised based upon confirmation of exact boundary locations. Black & Veatch applied the size characteristics for a general large wind turbine with an 80 meter (262.5 feet) rotor diameter on an 80 meter tower to establish the setback distances. This yields a setback of 120 meters (394 feet).

5.1 Barrows Location

The Barrows location has room for two sites, both in a rural residential area that is moderately wooded with several recreational fields to the East. The coordinates of the first site are approximately 41°44'30.18" North, 70°1'30.47" West (WGS84), and the base elevation is about 27 meters (87 feet) above sea level. The second site is located at approximately 41°44'22.26" North, 70°1'33.09" West (WGS84) at roughly the same elevation. The land on this site is moderately wooded and is designated as part of the Living Watersheds as well as a NHESP Estimated Habitats of Rare Wildlife region. Black & Veatch would recommend performing an environmental review for this area before committing to development in this area. The site is bordered by Freemans Way to the south and Silas Road to the north with a small road linking the two major streets to the east of the site, providing several nearby points of access. Some clearing would be required for turbine installation in order to construct roads, foundations, crane pads and lay-down/assembly areas.

Black & Veatch applied the Bylaw setback criteria discussed above to determine the potential impacts of a two turbine project at this site. The nearest building is roughly 400 feet away to the West. This structure is beyond the setback described in the Bylaws. However, if this building is a home, the homeowner may be impacted by noise or shadow flicker. The height of the trees and the distance of the structure to the tower may mitigate both of these issues, but if the Town of Brewster Alternative Energy Committee has an interest in further developing this site, Black & Veatch recommends the site be further examined and the project discussed with any homeowners close to the site. The location of this building, as well as the setback limits for this site, is shown in Figure 5-1.

Figure 5-1. Barrows Location Aerial View.

5.2 Commerce Park Location

The Commerce Park site is located within an industrial zoned area. The site coordinates are approximately 41°44'28.1"North, 70°0'47.28West (WGGS84) and the base elevation is about 26 meters (85 feet) above sea level. The land within this area is undeveloped and densely wooded with 30 foot to 50 foot trees. Under the Bylaw requirements and considering adequate turbine-to turbine spacing, this site has room for only one large wind energy turbine. The nearest residence to this site is over 1300 feet away to the north; however, homeowners will likely not experience shadow flicker or experience high level of noise from the turbine operation. Turbine installation will require portions of this wooded area to be cleared for the construction of roads, foundations, crane pads and lay-down/assembly areas. A wind turbine at this site should not impact normal traffic except possibly due to construction vehicles on the road during the turbine's installation. Public access to the site can be minimized relatively easily so that no safety issues arise.

Figure 5-2. Commerce Park Location Aerial View

5.3 Golf Course Location

The Town of Brewster Alternative Energy Committee is considering Captain's Golf Course for the potential siting of one or two large wind turbines. The northeast corner of this parcel was also the location where an RERL met tower was installed. For reference, Site #1 is located very close to the previous location of the RERL met tower, and Site #2 is located in the rough center of the golf course, about 2600 feet southeast of the Mid-Cape Highway 6's underpass of Freemans Way in a rural residential area. The land surrounding this site is densely wooded with 30 foot to 50 foot trees, whereas the land within this site is relatively clear of any significant obstructions and turbine installation would require little alterations to the existing roads or parking lots. Black & Veatch did not take measurements of the entry way into the parking lot, but it is possible that this short stretch of road would need to be widened to allow delivery of wind turbine parts and the crane used in construction.

Black & Veatch applied the Bylaw setback criteria discussed above to determine the potential impacts of a one and two wind turbine case at this site (see Figure 5-3). The coordinates of Site #1 are approximately 41˚ 44' 7.15" North, 70˚ 01' 14.70" West (WGS84), and base elevation is about 22 meters (73 feet) above sea level. The closest residence to this site is over 720 feet away. The coordinates of Site #2 are approximately 41˚ 43’ 52.20” North, 70˚ 0’ 59.15” West (WGS84), and base elevation is about 32 meters (105 feet) above sea level. The closest residence a turbine location is about 1370 feet away from Site #2; however, the aerial photos show buildings in close proximity to this site (approx 220 feet). For both sites, portions of the golf course are within the ‘Fall Zone’ described in the Bylaws.

Black & Veatch has prepared visual simulations of a wind turbine of a size discussed above at this location; these figures are included at Appendix C. If the Town of Brewster Alternative Energy Committee has an interest in further developing this site, Black & Veatch recommends discussing the project with any homeowners close to the site.

While these turbine locations are not final, Black & Veatch expects that, due to the nearby Golf Course, any location will put the turbines close to public areas. This proximity creates safety concerns difficult to mitigate. One example of a possible safety concern associated with this location could be ice build-up on the turbine blades separating from the turbine during operation. While modern turbine models can detect blade imbalances caused by ice formation and shut down operation, it is also probable that any ice which falls from the turbine will do so directly towards the ground; however, but it is possible for ice to be “thrown” a short distance from the turbine. While ice may be a common occurrence at this location, the wind resource should still be high enough to keep a wind turbine operating and thereby limiting the amount of ice buildup possible.

If this site is to remain under review, Black & Veatch recommends discussions should be held with turbine manufactures regarding ice throw experience so that an appropriate safety zone can be established during those times ice build-up is possible. Additionally, the town should consider restricting public access to an area outside of the overhang radius of the turbine to maximize public safety.

Figure 5-3. Golf Course Location Aerial View.

5.4 Police Station Location

Under the Bylaw requirements and considering adequate turbine-to turbine spacing, the police station has room for only one large wind energy turbine. The coordinates of the site are approximately 41°44'43.40” North, 70°4'38.04” West (WGS84). The present position for this turbine is located approximately 750 feet northeast of the Brewster Police Department near Harwich Road. To the east of the site, approximately 700 feet away, runs both the Cape Cod Rail Train road and a bike path. The land in this area is moderately wooded with little to no elevation change in this area with a base elevation of approximately 28m (94 feet) above sea level. Turbine installation will require portions of this wooded area to be cleared for the construction of roads, foundations, crane pads and lay-down/assembly areas. The nearest residence is located approximately 530 feet to the northwest. This structure is beyond the setback described in the bylaws, but homeowners may be impacted by noise or shadow flicker. If the Town of Brewster Alternative Energy Committee has an interest in further developing this site, Black & Veatch recommends discussing the project with any homeowners close to the site.

Additionally, Black & Veatch expects that the turbine location's proximity to public areas, such as the bike path and police station, around the wind turbines would create safety concerns such as ice build-up described for the Golf Course location above. This concern may be mitigated by the fact that the location chosen is reasonably well removed from the Police Station itself and access by road to the site could be controlled. If this site is to remain under review, Black & Veatch recommends taking measures to account for these safety issues, particularly by holding discussions with turbine manufactures regarding ice throw experience. The site location is shown in Figure 5-4.

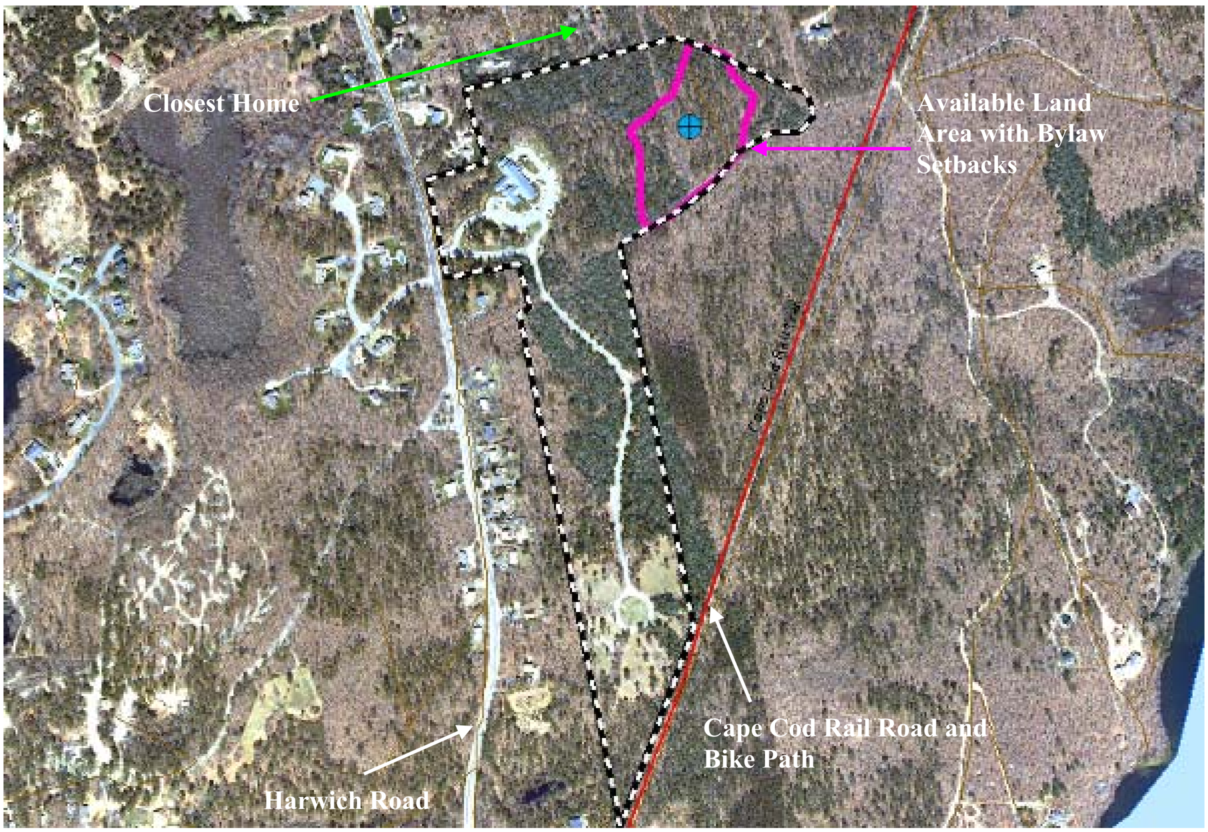


Figure 5-4. Police Station Location Aerial View

5.5 Pumping Station Location

Black & Veatch identified two possible wind turbine sites near the town's water watershed conservation pumping stations No. 1 & 2 along Freemans Way, near the Mid-Cape Highway 6 underpass in a rural residential area. As mentioned earlier, this location has the available land to support the placement of two large turbines while still adhering to the Town of Brewster's Bylaw requirements. In addition to the setbacks, Black & Veatch also applied additional criteria such that no turbine is placed within 500 feet (with a 100 foot inner buffer) of a water well. This additional setback from the water wells was incorporated to reduce the possible impact that an uncontained spill of leak from the turbine would have on the water supply. Other precautionary measures incorporated into the design of the turbine and it's components to prevent such rare occurrences are discussed in Section 7.

The site locations are shown in Figure 5-5. Black & Veatch has prepared visual simulations of a wind turbine of a size discussed above at this location; these figures are included at Appendix C.

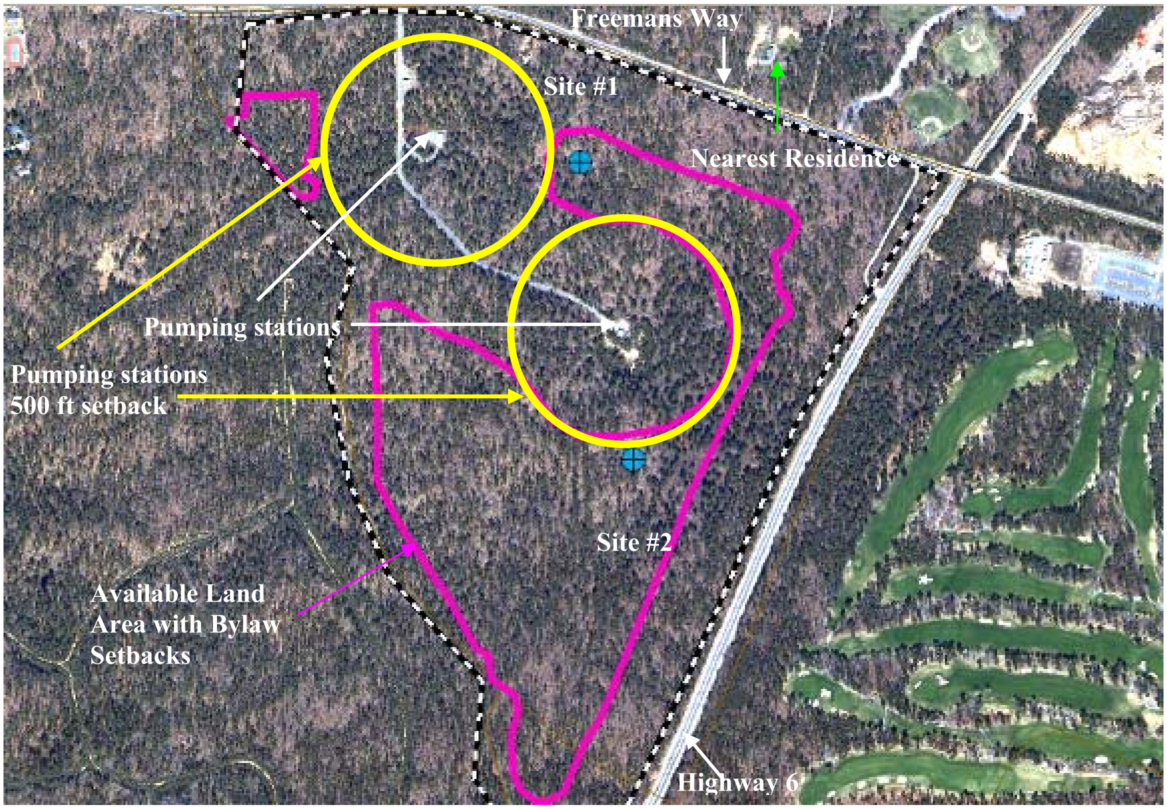


Figure 5-5. Pumping Station Location Aerial View

The coordinates of the single turbine location (Site #1) is approximately 41°44'13.65" North, 70°1'41.58" West (WGS84), and base elevation is about 22 meters (72 feet) above sea level. The second turbine location (Site #2) is approximately 41°44'0.82" North, 70°1'38.69" West (WGS84), and base elevation is about 21 meters (70 feet). The land around these two sites is densely wooded with trees between 30 feet and 50 feet tall; turbine installation will require portions of this wooded area to be cleared for the construction of roads, foundations, crane pads and lay-down/assembly areas. The extent of the alteration to the landscape for an installation at both sites will involve clearing an area of approximately 2-4 acres around the base of the turbine depending on construction requirements, as well as clearing for road construction to access the site. This area is designated as Open Space, part of a Biological Core Habitat, and a NHESP Estimated Habitats of Rare Wildlife region. Development of this location will require a deposition of Article 97. Black & Veatch would recommend performing an environmental review for this area as well.

While this location has sufficient room to support two large wind turbines; a local residence exists approximately 1,600 feet away from the base of the closest turbine location. Although this home is far beyond the setback described in the bylaws, it is possible this homeowner will hear the wind turbine operating in light winds, and may be impacted by shadow flicker during sunset. Although, the height of the trees in this area combined with the distance and position the turbines in relation to the residence would be form this residence could likely mitigate this concern. If the Town of Brewster Alternative Energy Committee has an interest in further developing this site, Black & Veatch recommends the homeowners closest to the sites be contacted and the project discussed. Otherwise, no other setback or overhang issues appear to exist at this site.

In addition to these specific siting criteria, Black & Veatch also contacted Paul Hicks, Town of Brewster Water Department Superintendent to identify the water main route connecting the two wells. Mr. Hicks indicated that the water main for the pumps generally follows the path of access road connecting the two pump sites. While a one or two turbine project should not impact the water main, a civil impact study to review how a project might affect the water department infrastructure at this site should be completed. An additional issue with the proximity of the towers to the wells is the risk of drinking water contamination via fluid leak from the nacelle. Any turbines in this area would be required food grade lubricants in the turbine instead of specially designed synthetic blends. Since manufactures are unlikely to approve the use of food grade lubricants for their wind turbines, this problem could represent a fatal flaw for the site.

5.6 Waste Transfer Station (WTS) Location

The land available on the Waste Transfer Station (WTS) site is in a municipal redistrict and has sufficient room for one or two wind turbines. The northwest corner, on the shoreline of Smith Pond, and the southeast corner near Hill road are both sites suitable for wind turbine placement, taking road and WTS facilities into account.

Black & Veatch applied the Bylaw setback criteria discussed above to determine the potential impacts of a one and two wind turbine case at this site (see Figure 5-6). The coordinates of Site #1 are approximately 41° 44' 51.73” North, 70° 06' 10.21” West (WGS84), and base elevation is about 9 meters (30 feet) above sea level. The closest residence to this site is over 530 feet away. The coordinates of Site #2 are approximately 41° 44' 39.53” North, 70° 06' 8.43” West (WGS84), and base elevation is about 18 meters (60 feet) above sea level. The closest structure to Site #2 is about 550 feet away.

Both sites are within a Biological Core Habitat and Site #1 is near a DEP Wetland. Black & Veatch recommends performing an environmental review if the Town wishes to pursue development of this site. Each site will require some level of clearing for turbine installation for the construction of roads, foundations, crane pads and lay-down/assembly areas. However, Site #2 will require considerably less clearing due to its proximity to the WTS facility, which has already been cleared of obstructions.

In both cases the nearest structure is beyond the setback described in the bylaws, but homeowners may be impacted by noise or shadow flicker. If the Town of Brewster Alternative

Energy Committee has an interest in further developing this site, Black & Veatch recommends discussing the project with any homeowners close to the site. Due to the setback requirements, there are few options for turbine placement that do not result in a turbine being in close proximity to the Waste Transfer Station. Wind turbines in this are could pose a safety concern to personnel nearby, creating hazards such as ice throw. If this site is to remain under review, Black & Veatch recommends discussions should be held with turbine manufactures regarding ice throw experience so that an appropriate safety zone can be established during those times ice build-up is possible.

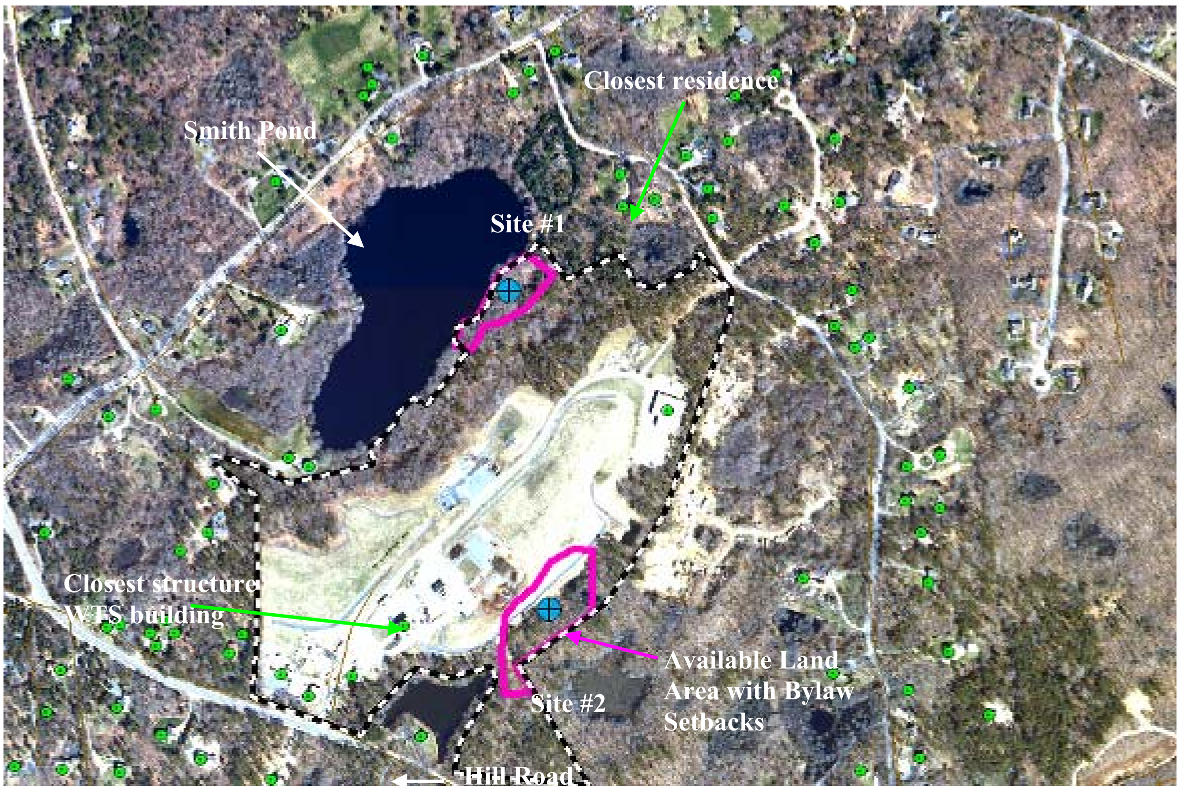


Figure 5-6. Waste Transfer Station Location Aerial View

5.7 Black & Veatch Recommendations

Black & Veatch anticipates that the Barrows site will be the best location for a two large turbine project. The number of nearby residences is reasonably low, the site has sufficient room for two wind turbines, and nearby roads provide easy access to the site for construction. As mentioned earlier, if the Town of Brewster Alternative Energy Committee has an interest in further developing a wind energy project at this site, Black & Veatch recommends the homeowners closest to the sites be contacted and the project discussed. Additionally, an environmental review should be performed to fully investigate the impact of two wind turbines in this area.

If a single turbine project is preferred, Black & Veatch determined that Commerce Park would be the best location. There are no nearby residences to be concerned with, nor are there any concerns with protected areas for wildlife. Much of the land surrounding this area is already cleared, making access to the site much easier for construction.

A community scale wind energy project at either location would provide on-site generation to the Town of Brewster electrical loads and bring with it the possibility to sell the excess generation to the utility.

6.0 Electrical Interconnection and Offset

This section briefly discusses the likely manner in which the wind turbines would be electrically connected to the power grid, and the potential for offset of local electrical loads.

6.1 Electrical Interconnection

Wind turbines typically have low voltage (around 600 V) induction generators in the turbine's nacelle. Each turbine will have a transformer to increase the voltage to a medium voltage (typically between 12 and 34.5 kV), so the power can be transmitted without high-current losses. This voltage can be selected to match with local distribution system voltages if that system has sufficient capacity to allow the wind turbine to interconnect. Figure 6-1 shows a typical arrangement of a wind turbine's transformer to the base of the turbine tower (note that some larger wind turbines located this transformer in the turbine's nacelle).

Figure 6-1. Typical Wind Turbine Transformer Arrangement

Community wind energy projects can be connected in two general ways. The first is for the project to connect directly to a utility's transmission (high-voltage) or distribution (medium voltage) line. Under this arrangement, the project owner would become an Independent Power Producer (IPP) which is not a public utility, but an entity that sells power from the turbines directly to the utility or general public. In this arrangement, revenue meters would be positioned at the point of connection and the project owner would receive revenues at a certain rate for the energy that is produced. This is the manner large commercial wind energy projects are connected, and the value for the energy would be similar to other commercial power plants. The other connection method is used when the goal is to first offset a large electrical load, and then sell any excess to the grid. For this method, the wind turbine must be located next to the large load, and electrically connected on the load side of the utility's meter. This connection method is sometimes referred to as co-metering, and allows the community to get the benefit of the wind energy at the same price the electricity is purchased.

Limitations for these types of interconnections will be determined by many factors including site location, proximity of resources, local utility requirements, and ultimately, cost.

6.2 Electrical Infrastructure near Project Site

Northwest of the three proposed sites is a single 115 kV NSTAR transmission line connecting the Orleans and Wellfleet substations, with the Waster Transfer Station and Police Station sites being the closest. This transmission line can be seen in Figure 6-2, which shows the Cape Cod area transmission. Southeast of the development area is a 23 kV distribution line for local residents (believed also to be owned by NSTAR), with the Golf Course Location being the closest site at under a mile.

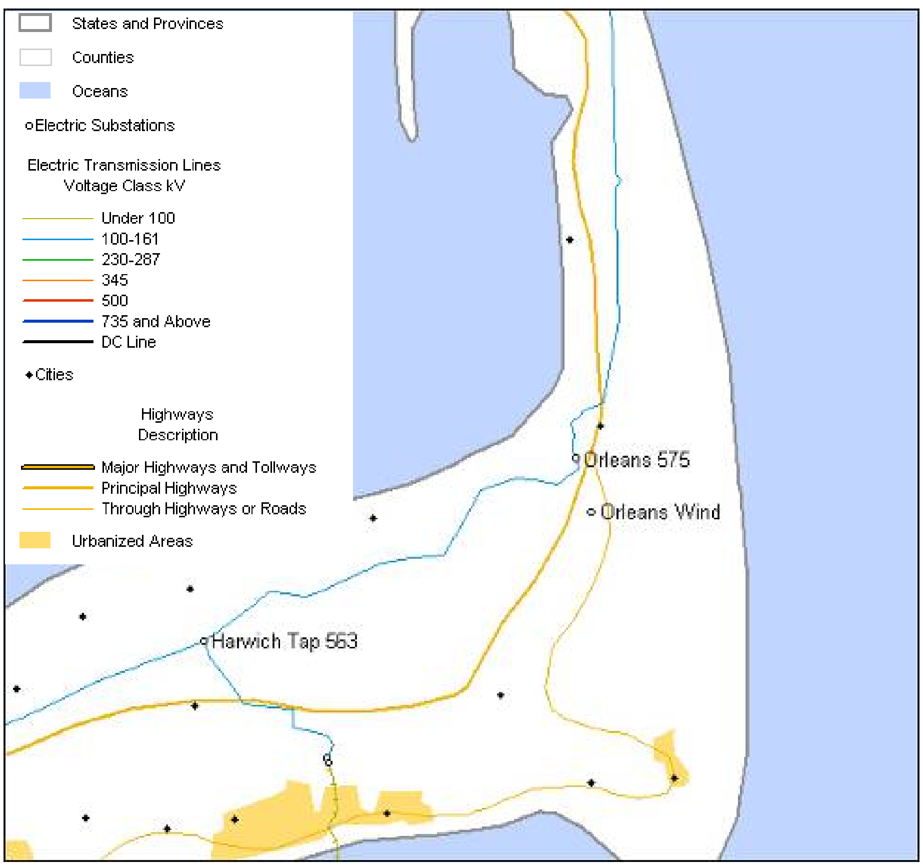


Figure 6-2. Cape Cod Regional Transmission Lines

The majority of access to the grid within close proximity of all six proposed sites is low-voltage, local distribution lines. The local distribution lines for the Brewster area are typically 23kV, though 4kV and 8kV lines exist as well. For all six proposed turbine locations, the nearest likely point of interconnection would be the low-voltage (either 4kV or 8kV) lines running adjacent to the roads near the sites. A map showing the locations of these lines is shown in Figure 6-3.

Figure 6-3. Location of Southeast Brewster Transmission Lines.

The manner in which a wind energy project would be interconnected will depend on the capacities of the nearby lines and how large of a wind energy project is built. Connecting to the lower voltage distribution lines would likely be less expensive, because it could be done without constructing a project substation. However, low voltage lines may only accommodate the generation from a smaller, single turbine project. For more turbines, the project may need to connect either to the 23 kV distribution line or 115 kV transmission line. Either of these lines will likely be able to accept the generation from a larger, multi-turbine project as what could be sited at the Barrows location, Golf Course location, Pumping Station location, or WTS location. However, to interconnect to this line a substation with a large transformer will be required, as would a transmission tie line from the project to the NSTAR 115 kV line. Both options are discussed in greater detail below.

6.2.1 Transmission Line Connection

As mentioned above, it is the expectation of Black & Veatch that connecting a project of any size to a high voltage transmission line (generally defined as 69 kV and higher) would require an interconnecting substation. Such a substation would include a collection feeder where power from multiple turbines is connected to a medium voltage bus. This bus may also use capacitor banks for voltage support and protection equipment such as breakers. The medium voltage bus then connects to a transformer that steps the voltage up to the proper transmission voltage on the high voltage bus. A project revenue meter is generally connected to the high voltage bus or point of interconnection to measure and record the amount of power generated by the project. For an overhead connection, a riser structure would then be used to connect the power from the high voltage bus to the transmission line. An example of this general design for an interconnecting substation is shown in Figure 6-4 .

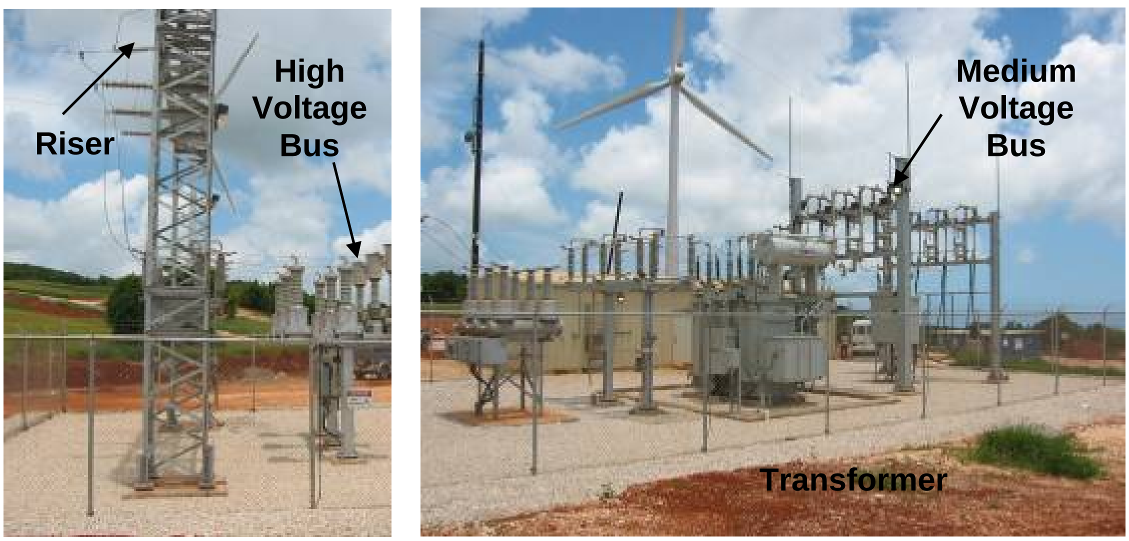


Figure 6-4. Interconnection Substation Example.

6.2.2 Distribution Line Interconnection

The connection of a small wind energy project to a distribution line can often be done without requiring a substation or any other electrical equipment. The underground collection system would be brought close to the nearest distribution line, which would be the low-voltage distribution line for these three proposed sites. At this point, the underground cable comes above ground to a transition pole. From here, the system is connected to meters, switching, and any other equipment required by the interconnecting utility, and finally to the distribution line. An example of this type of interconnection appears in Figure 6-5.

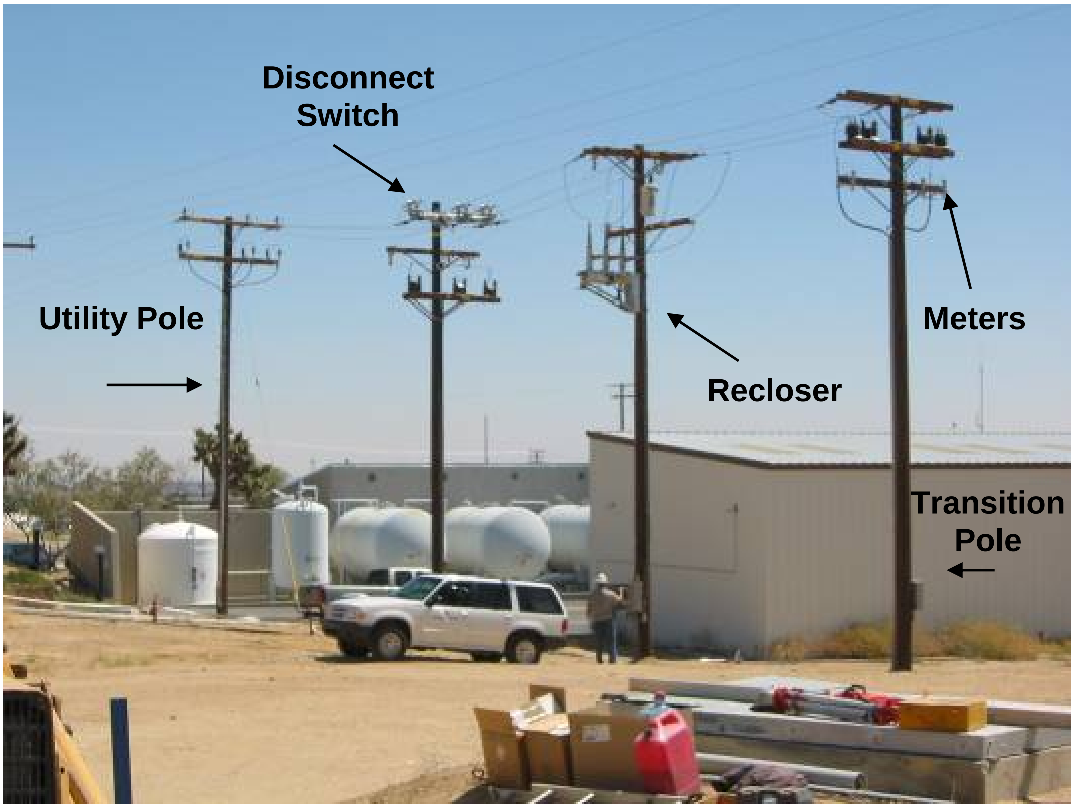


Figure 6-5. Distribution Interconnection Example.

6.2.3 Project Interconnection Assumptions

This review focuses on a project consisting of installing either a single turbine at one of the six proposed locations, or two turbines at the Barrows, Golf Course location, Pumping Station, or WTS location. Therefore, the project capacity will be between 1.5 MW and 3.6 MW.

In order to determine the capacities of both the NSTAR transmission line and local distribution lines, and feasibility of connecting to either, Black & Veatch contacted Mr. Charles Salamone of Cape Power Systems. Mr. Salamone indicated it was his understanding that both the transmission lines and the local distribution lines would easily be capable of supporting 1-2 MW of wind energy generation. If two turbines were to be installed at either the Barrows, Golf Course location, Pumping Station, or WTS location, a detailed study would need to be performed to determine whether the lines could support more than 2 MW of generation. Otherwise, the low-voltage distribution lines would likely have sufficient capacity to handle a single turbine project, based on Mr. Salamone's knowledge of the area. However, depending on the point of interconnection, certain distribution line upgrades such as increasing conductor sizes may need to take place in order to satisfy the current that would be supplied by the wind generators. Another issue that will need to be addressed by the local utility will be the reactive power component of the generators, which is normally done through the interconnection process.

Due to the location of the proposed sites for the project with respect to nearby transmission and distribution lines and equipment require for interconnection, Black & Veatch expects that interconnecting to the NSTAR's 115 kV transmission line will prove to be more costly solution for the project. However, interconnecting to the low-voltage distribution lines may require upgrades that would add to this lower-cost option. While the project initially appears feasible regarding interconnection, detailed studies performed throughout the interconnection process with NSTAR will determine the project's ultimate requirements and limitations.

Because Black & Veatch was not in a position to start a long and expensive interconnection study, an assumption that each project option could connect to the local distribution lines was used. It is also assumed that this interconnection approach could be achieved without requiring an approach more complex that the simple recloser and tap as described above. The intention of this approach is to provide a cost estimate for the most probable method for interconnection.

6.3 Interconnection Request Procedure

The relatively small size of the project and the options of interconnecting the project, seem to place the process for requesting and studying the interconnection of the project into a gray area. The approach described below represents the current understanding of an interconnection request approach that would likely be successful and least-cost to the project. Black & Veatch recommends that this approach be monitored, and modified as needed, as additional information is obtained during the development process.

Step One: Initial Contact and Study by NSTAR. Black & Veatch was provided the *Standards for Interconnection of Distributed Generation*, which applies to power projects installed in a co-metering arrangement. The project being studied here would be in an IPP arrangement, however given the size range of the project and that the least-cost approach would likely be to connect to the distribution line, Black & Veatch recommends the project begin the interconnection study process by completing the distributed generation application. This is because NSTAR does not have a procedure for connecting to a distribution line, so the distributed generation application would be the closest thing NSTAR could use to start the process.

Step Two: Complete NSTAR Study (if applicable). The next step in the interconnection process would depend upon the initial study results. If NSTAR determined that connection of the full project could be done on the local distribution (4 kV – 8 kV) line, Black & Veatch recommends that the distributed generation study and interconnection agreement process be continued. While NSTAR would not comment on the total cost of this study, they did indicate the total required time normally is less than 6 months. At the completion of this process, the project would have an agreement with NSTAR to connect the project to the local distribution line, an understanding of the interconnection requirements, and a cost estimate for the upgrades required to accommodate the project. No further interconnection study work would be needed. If NSTAR determined that the local distribution line could not accept the generation from the project, and that connection to the 23 kV or 115 kV line would be needed, the project would either continue the study considering the 23 kV line or end the study with NSTAR and proceed to Step Three.

Step Three: ISO New England Generation Interconnection Study (if applicable). Interconnection to the 115 kV line would require coordination with the regional Independent System Operations (ISO), which for Massachusetts is ISO New England. This is because ISO's coordinate the use of all transmission lines in their regions, regardless of who owns the lines. When Black & Veatch contacted ISO New England about connecting to the 115 kV line, the procedure provided was specific to ISO New England and not the new FERC-developed Small Generation Interconnection Procedure (SGIP). This is significant because the SGIP is supposed to define the manner in which all generation projects less than 20 MW go through the interconnection process. It could be that ISO New England has either decided not to follow the FERC procedure, has not yet made the change, or has not yet had a small generation interconnection request since the SGIP was issued (in December 2005). The SGIP process would likely require about $50,000 to perform all the studies, and is supposed to take no longer than 1.5 months. If this is indeed ISO New England's first project using the SGIP, it may take longer to complete. At the end of the process, the project would have an agreement to interconnect to the 115 kV line, a basic substation design, and a cost estimate for any system upgrades necessary to accommodate the project.

6.4 Usage Offset

One stated goal of a community wind energy project is to directly provide energy for Town of Brewster facilities. Monthly electrical load data was provided to Black & Veatch and analyzed for two general project scenarios:

- A single net-metered wind turbine
- Two wind turbines; net-metered

The details and results of this analysis are discussed in the sections below. Table 6-1 shows the monthly electrical consumption data for all the utility billing accounts well the output associated with each project location using Vestas V82 turbines. Table 6-1 clearly shows that any of the project options can easily offset the aggregated load for each site.

Table 6-1. Town of Brewster Monthly Electrical Consumption.

Month	2008 Total Monthly Load Consumption For all Accounts (kWh)	Barrows (kWh)	Commerce Park (kWh)	Golf Course (kWh)	Police Station (kWh)	Pumping Station (kWh)	WTS (kWh)
# V82s	N/A	2	1	2	1	2	2
Jan	196,110	785,716	377,055	804,471	438,301	795,028	872,668
Feb	198,020	552,547	265,160	565,736	308,231	559,096	613,695
Mar	178,695	636,486	305,441	651,679	355,055	644,029	706,924
Apr	198,282	405,134	194,418	414,804	225,999	409,935	449,968
May	191,983	326,905	156,877	334,708	182,360	330,779	363,083
Jun	205,354	349,250	167,600	357,586	194,825	353,389	387,900
Jul	281,425	207,610	99,629	212,565	115,812	210,070	230,585
Aug	313,557	557,340	267,460	570,643	310,905	563,945	619,018
Sep	278,918	529,841	254,264	542,488	295,565	536,121	588,477
Oct	229,407	410,015	196,761	419,802	228,722	414,875	455,390
Nov	198,631	626,262	300,535	641,211	349,352	633,684	695,568
Dec	175,098	603,892	289,800	618,306	336,873	611,049	670,722
Annual	**2,645,480**	**5,991,000**	**2,875,000**	**6,134,000**	**3,342,000**	**6,062,000**	**6,654,000**

7.0 Environmental Concerns and Permitting

Given Brewster's location on Cape Cod, environmental concerns regarding a community wind energy project are expected to be an important component of the project's feasibility. Black & Veatch has prepared an initial list of likely environmental issues. Black & Veatch recommends a more complete environmental review be performed prior to committing to a wind energy project.

7.1 Potential Environmental Impacts

Black & Veatch reviewed information on environmental sensitivities at or near Brewster, based on publicly available information. The items listed in this section indicate some issues that need to be explored during a project environmental review.

7.1.1 Natural Heritage and Endangered Species Program

To determine which environmental concerns are likely to exist for a wind energy project in Brewster, Black & Veatch reviewed information obtained from the Massachusetts Division of Fisheries and Wildlife's Natural Heritage and Endangered Species Program (NHESP) web site (www.nhesp.org). This web site identifies areas of the state that are of particular concern for endangered wildlife and plant life. While this information is a good resource for an initial feasibility study, Black & Veatch would not consider the information below to be an exhaustive list, and would recommend a specific environmental review be done at the project site in future phases of project development.

The NHESP area designations reviewed and mapped for this site include:

- **Areas of Critical Environmental Concern (ACEC):** These are areas in Massachusetts that are considered special and highly significant due to their natural and cultural resources. Nominations for areas to receive ACEC designation are made by communities to the state Secretary of Environmental Affairs. Administration of the ACEC program is done by the Department of Conservation and Recreation.
- **Priority Habitat for Rare Species:** These areas are NHESP estimates of habitats for rare species. The boundaries of these habitats are considered approximate.
- **Protected and Recreational Open Space**: These are areas that have been designated at the state or community level as areas for limited or no development. The Massachusetts Geographic Information System (MassGIS), the service from where the data was obtained, indicated the accuracy of the identified open space locations was limited.
- **BioMap Core Habitats**: The BioMap program was completed in 2001 by NHESP, and identified areas considered to represent "habitats for the state's most viable rare plant and animal populations". BioMap Core Habitats and

Living Water Core Habitats encompass almost 1.4 million acres, or about 28 percent of the land area of Massachusetts.

- **Certified Vernal Pools**: NHESP define vernal pools as "small, shallow ponds characterized by lack of fish and by periods of dryness." These pools are deemed critical to some wildlife, and are protected under a variety of state programs including the Massachusetts Wetlands Protection Act.
- **Living Waters Critical Supporting Watersheds:** These watersheds are identified as being critical for supporting Living Waters Core Habitats. They were identified in the Living Waters project completed in 2003 by NHESP.
- **Living Waters Core Habitats:** Similar to the BioMap Core Habitats, the Living Waters Core Habitats are those rivers, streams, lakes, and ponds critical to the biological diversity of Massachusetts

Figure 7-1 and Figure 7-2 are maps showing the BioMap Core habitats and Living Waters Critical Supporting Watersheds identified near Brewster. There is a BioMap Core Habitat (BM1245) and permanently protected open space defined for the entire Barrows and Pumping Station locations, and part of the Golf Course and WTS locations, due to rare plant and animal species. While a wildlife survey would be necessary to ascertain the specific species thought to exist in this area, areas designated as Permanently Protected Open Spaces generally restrict all development. However, since this land is thought to be owned by the Town of Brewster, the source of the funds used to purchase this land would likely dictate the applicable restrictions for its development. To determine the details of the Pumping Station Location Permanently Protected Open Space, Black & Veatch contacted Michael Trust, a Senior GIS Database Administrator for Massachusetts Geographic Information System (MassGIS) about the data layer used in the NHESP BioMap. Mr. Trust indicated that the land was municipally owned land and managed by the Town of Brewster Water Department. Black & Veatch also contacted David H. Tately, Deputy Assessor for the Town Brewster. Mr. Tately also confirmed that the town owned the land and that only town funds were used to purchase the property; however, could not provide any information of where the funds for acquiring the property originated. Mr. Tately indicated that at the time this property was acquired (approximately 40 years ago) there were very few state or federal grant programs available to purchase land, and if the town used one it would have been stated in the Town Meeting Warrant Article and probably the Order of Taking. Mr. Tately was unable to find any such reference. Black & Veatch hypothesizes that the designation of the property as Permanently Protected Open Space was established to prohibit the development any projects that could potentially adversely affect water resource provided by the wells. Should the Brewster Alternative Energy Committee wish to pursue this project area further, a disposition of Article 97, which prohibits the use of open space land, would be required in addition to any other environmental notification to the Massachusetts Environmental Policy Act office (MEPA).

In respect to the impact a wind turbine could have on the water utility, a large wind turbine nacelle contains components (such as the hydraulic system and gear box) which utilize different fluids for normal operation. While leaks and spills from these components are rare, they are possible. Manufacturers have addressed this issue by incorporating passive spill containment into the design of the turbine. Any spills or leaks that occur are contained within the tower on which the nacelle sits. In some wind turbine models, fluids exchange between the nacelle and hub and leaks or ruptures in this connection would be external to the tower. However, a wind turbine's control system would sense any drop in the fluid pressure and the turbine would be immediately shut down, limiting the amount of fluid lost by the system. Further precautions can be taken by designing a turbine foundation in such a manner that an additional (redundant) containment system capable of holding the total volume of fluids within the nacelle be implemented at this site. Black & Veatch has incorporated the additional cost for this design feature into the project cost estimate discussed in Section 10.

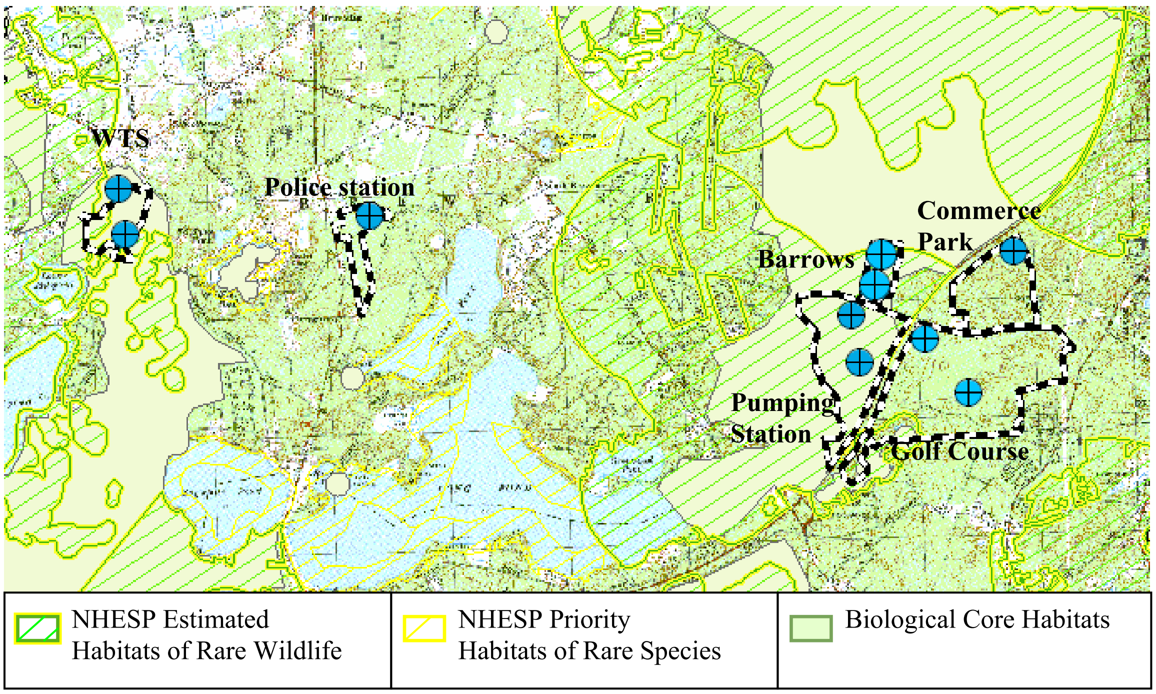
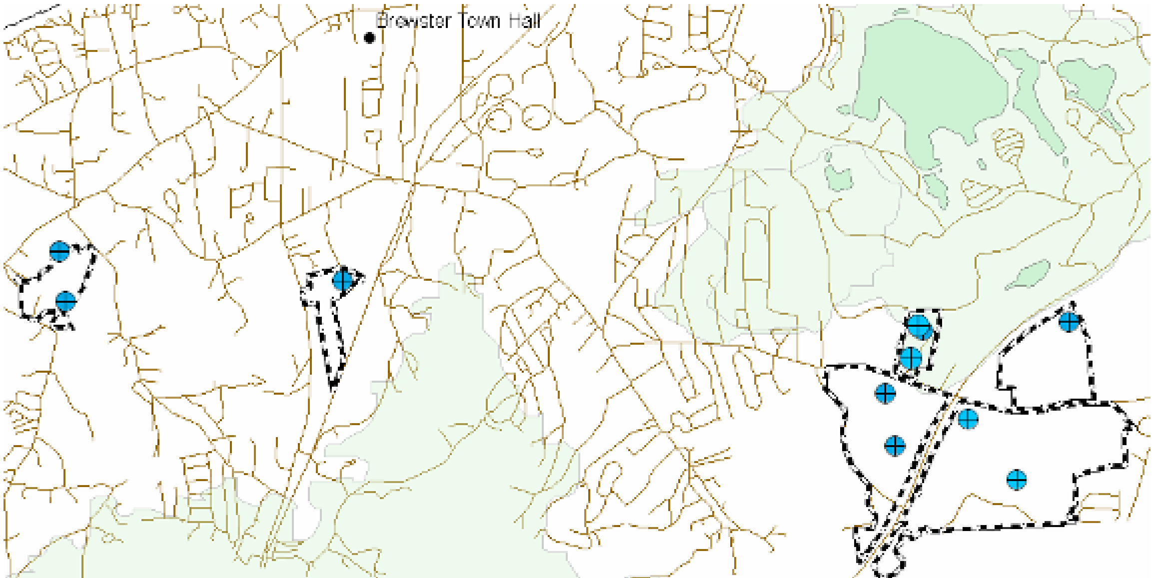


Figure 7-1. Environmental Protected Areas near Brewster



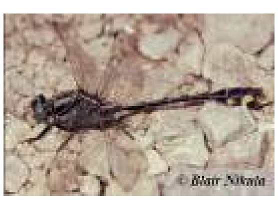
Living Waters Critical Supporting Watersheds	Living Waters Core Habitats

Figure 7-2. Protected Waters and Wetlands near Brewster

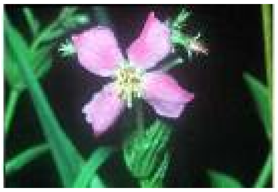
The NHESP BioMap report *Core Habitats of Eastham*, dated January 2005, includes a listing of those natural communities, plants, invertebrates, and vertebrates that have special designation under the Massachusetts Endangered Species Act (MESA) and an unofficial NHESP watch list. MESA has three levels of classification for rare species: Endangered, Threatened, and Special Concern. As defined in the BioMap report, the definitions of these classifications are:

- **Endangered**: Species in danger of extinction, or of no longer being found in Massachusetts.
- **Threatened**: Species deemed likely to become Endangered in Massachusetts in the foreseeable future.
- **Special Concern**: Species that have suffered a decline that could threaten their existence, or that are very rare in Massachusetts.

The BioMap report lists one Endangered invertebrate species and two Endangered plant species in the Brewster area:



Midland Clubtail Dragonfly: A medium to large-sized semi-aquatic insect that inhabits rivers and large lakes. Known only to the Connecticut River in Massachusetts, over 130 miles from any of the perspective sites. The included photo is from the NHESP web site.

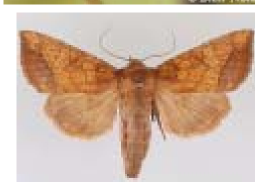


Maryland Meadow Beauty: This purple flower has only been recorded in the cape area in Massachusetts. The included photo is from the US Department of Agriculture's Natural Resources Conservation Service website.

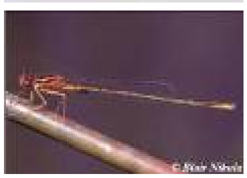
Purple Milkweed: Another purplish flower that inhabits moist meadows in woodlands or near rivers. The included photo is from the US Department of Agriculture's natural Resources Conservation Service website.

NHESP indicates that the last recorded observation of the Midland Clubtail was in 1977. Also, here are three invertebrate and two vertebrate species in Brewster classified as Threatened, which include:

Pine Barrens Bluet: This is a small insect about 1 inch in length that is found in coastal plain ponds on Cape Cod and various other locations in New England. The included photo is from the Massachusetts Division of Fisheries and Wildlife.



Water-Willow Stern Borer: This nocturnal moth has been observed in 59 sites throughout Cape Cod and southeast Massachusetts. The included photo is from the Moth Photographers Group web page, take by Jim Wiker.



Scarlet Bluet: A small semi-aquatic insect that inhabits acidic, sandy ponds, usually with floating vegetation. The included photo is from the NHESP web site.

Diamondback Terrapin: This medium-sized turtle is found along the Atlantic coast from Cape Cod to Cape Hatteras (North Carolina). The included photo is from the University of Delaware Graduate College of Maritime Studies web site.

Northern Parula: A small songbird that nests in the upper canopy in lichen. Breeds from northern New York to southern New Hampshire. The photo is taken by Bill Dyer and was found on the Cornell Lab of Ornithology web site.

Additionally, BM 1245 has several species listed as Special Concern, along with many invertebrate, plant, and natural community species of several designations. Appendix B includes the NHESP BioMap report for Brewster and summaries for three of the five above Threatened species.

Due to the existence of at-risk species, any project development in Brewster should include a wildlife survey that specifically reviews these species, as well as any others that may surface from a more in-depth study. Additional discussion specifying this project's impact on avian species is provided in Section 7.1.2

7.1.2 Avian & Bat Impacts

The largest biological concern for this project's development may be potential or perceived risk to avian and bat species. During the permitting phase of project development, a wildlife impact study should be performed to identify any potential avian and bat species that would be at risk. Modern wind turbines include slow rotating blades, and tower and hub designs that provide almost no perching or nesting points for birds. While most wind energy projects have little or no recorded bird or bat strikes, it can be a significant problem at a few sites (such as Altamont, California, or the Mountaineer Wind Energy project in West Virginia). It is therefore important to determine if species known to be susceptible to wind turbine strikes can be found at the site. The BioMap Core Habitat indicates no protected or endangered species habitats on or near any of the perspective sites.

7.1.3 Nearby Residences

Some public concern is likely going to be generated regarding the visual and noise impacts of the project, and concerns for public safety. Black & Veatch recommends that visual simulations of project options be presented to the public at the first hearing of the project, including animations showing the rotational speed of the turbine. Additionally, noise readings should be taken and reviewed by acoustical experts prior to committing to a project, to ascertain if Massachusetts state requirements and Brewster's Bylaws requirements will be met. Experience shows that sharing this information with the public early in the process can avoid unnecessary concerns regarding what the project might look and sound like. Black & Veatch has prepared some initial visual simulations of wind turbines as part of this study (see Appendix F). MTC and the Town of Brewster Alternative Energy Committee may wish to consider having additional simulations done in the future from other locations of likely public concern.

All of the locations, with the exception of Commerce Park, are close enough to homes that issues regarding noise, shadow flicker and visual impacts may arise. Trees, buildings, topography, temperature and wind speed can affect how the sounds levels carry though and area.

Wind turbine sound pressure graphs for the Brewster sites are shown below in Figure 7-3, marking out nearby structures with green circles. From these maps the sound emissions from the turbine 200-500 feet away will be at a 40-45 db level, or the equivalency of what a refrigerator sounds like several feet away. However, much of the sound coming from them will likely be masked by the sound of the wind.

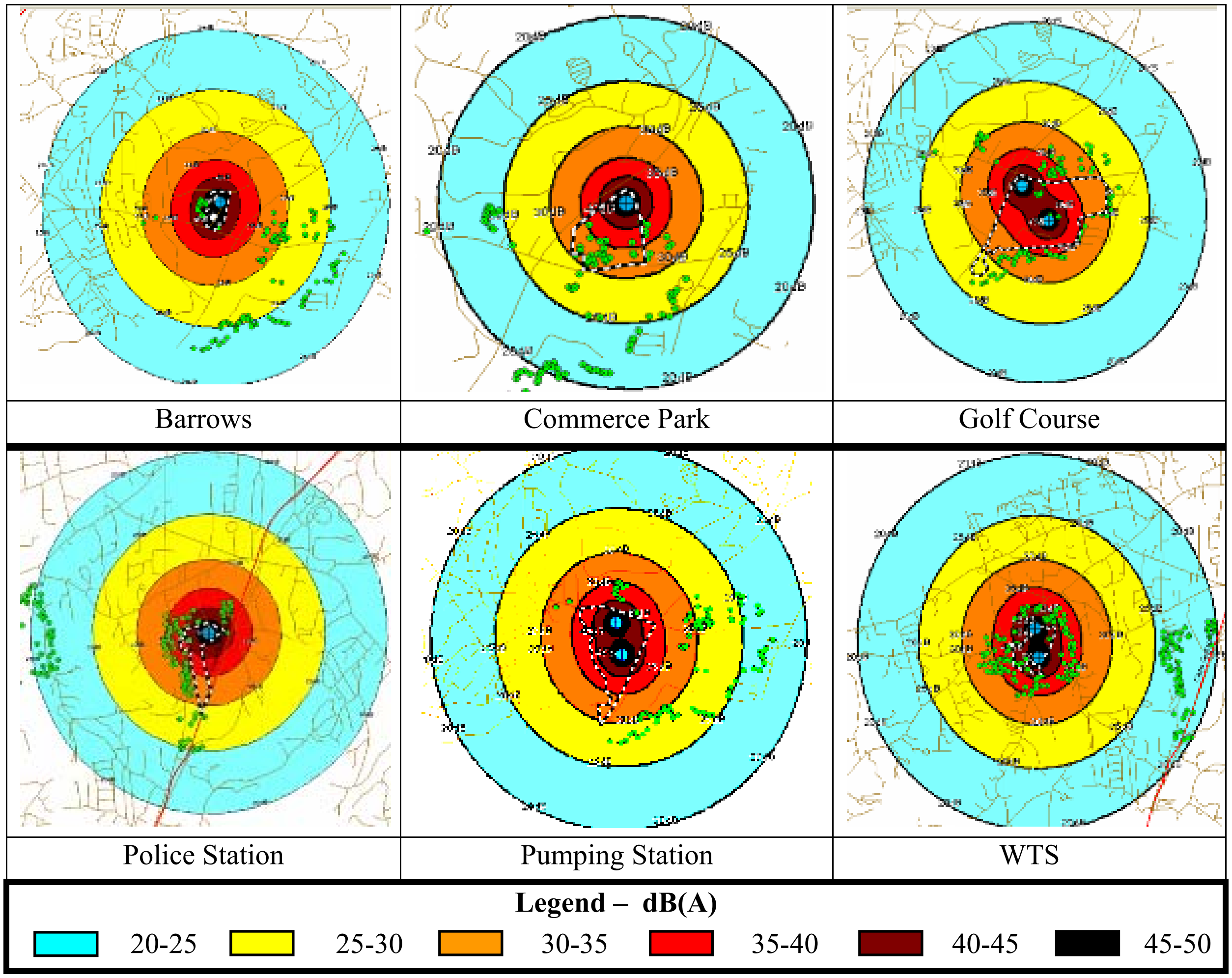
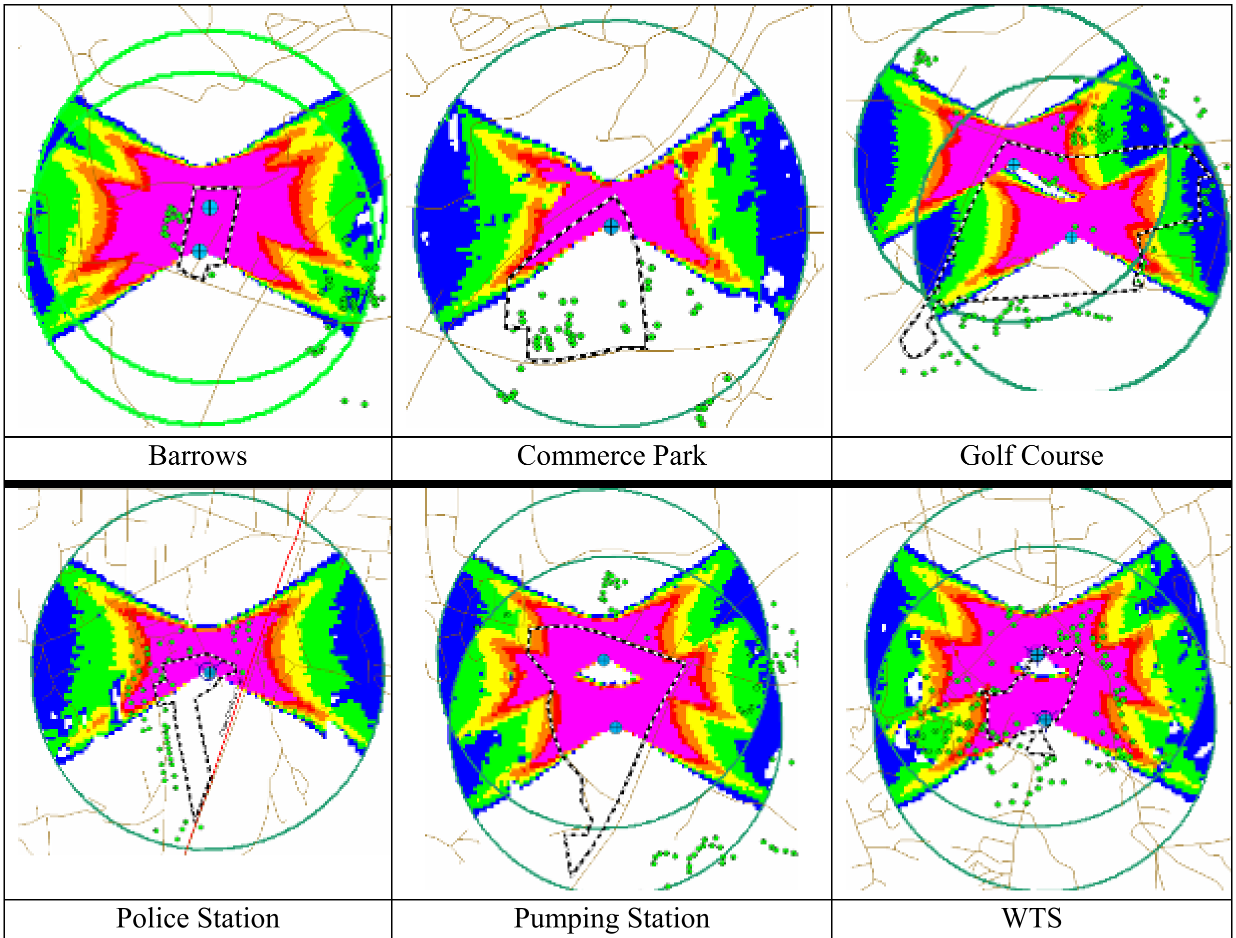


Figure 7-3. Wind Turbine Noise Levels, per Site

During a site visit on April 26, 2007, Black & Veatch collected ambient sound pressure samples at various locations around the site locations as shown in Figure 7-4. The sound pressure levels shown are averages consisting of readings during traffic moving along the roadways and while the roadways were clear of any near or approaching vehicles. Generally, the ambient sound pressure level when with no traffic averaged between 40 and 55 dB. At times when traffic was moving through an area, sound pressure levels reached as high as 82.5 dB. This indicates that a turbine located within this area may be heard by local residents under higher wind speeds, but would still emit sound pressure levels below the threshold defined by the local zoning and Bylaws (new facilities must not emit noise greater than 10 dB above ambient). While these sites should have no trouble conforming to Massachusetts law, a detailed acoustical analysis may need to be performed.

Figure 7-4. Average Sound Pressure Levels near Site Areas

Shadow flicker is a sunlight strobe effect caused by the rotating turbine blades. Trees and other obstructions between the residences and the tower can mitigate this concern by preventing the interrupted light from reaching the structure. However, it is possible for shadow flicker to become a source of irritation if the structure is close to the wind turbine or not sheltered from the flicker effect by trees or other obstructions. Wind turbine flicker shadow graphs for the Brewster sites are shown below, marking out nearby structures with green circles. Once the locations of the desired sites are finalized, Black & Veatch recommends creating full shadow flicker maps to establish which local structures will be impacted the most severely by the installation of a wind turbine in that area.



Legend – Units in hours per year

0 | 1-10 | 11-20 | 21-30 | 31-40 | 41-50 | 51-618

While each of the turbine sites have been located far enough from homes that even complete failure of the turbine's structure should not endanger them, public perception may be these that sites put the homeowners in undue risk. As mentioned earlier, Black & Veatch recommends these homeowners be contacted directly by the Town of Brewster, and their support on the project obtained, before committing to these sites.

7.1.4 Airports

The closest airports to the Brewster locations are the Chatham Municipal Airport to the north, and the Barnstable Municipal Airport to the southwest. The Chatham Municipal Airport is approximately 3.7 miles from the closest wind turbine site in the Commerce Park location and the Barnstable Airport is about 14 miles, from the turbine site at the Pumping Station. According to Federal Aviation Administration (FAA) Advisory Circular 70/7460-2J, a Notice of Proposed Construction must be filed with the FAA for the construction of any structure over 200 feet (61 meters) tall or within a certain distance-height zone from commercial or military airports. All commercial-scale wind turbines are more than 200 feet tall, so a notice will be required to be filed with the FAA and will require markings and lighting.

Per direction from MTC and the Town of Brewster Alternative Energy Committee, Black & Veatch submitted notices of intended construction (Form 7460-1) to the FAA for Vestas V80s (or similar) at each of the Pumping Station sites under consideration. The FAA has issued a determination that a structure (or turbine) of 443 feet above ground level does not exceed obstruction standards and would not be a hazard to air navigation. These letters of determination are provided at Appendix C.

An airspace obstruction study was performed by Aviation Systems Inc. (ASI) in November 2006, whose review focused on a location within the vicinity of the Pumping Station location (see Appendix C). In light of the FAA determination, the ASI study results indicate that the studied locations are within 60 nautical miles of a long range radar site Therefore, an individual assessment of the effects that a wind turbine could have upon the North TURO Joint use long range radar site will need to be reviewed.

7.2 Permitting Requirements

Black & Veatch has examined the general permitting requirements for energy projects in Massachusetts, as well as major projects on Cape Cod, and has prepared an initial list with our expectations regarding which permits would apply to a wind energy project in Brewster (see Appendix E). Due to confidentiality, Black & Veatch did not contact any local, state, or federal agencies to explore the permit requirements for this project. Such consultations will be required before the final permitting requirements can be completely understood. At present, the permit requirements that seem very likely to apply to a community wind energy project in Brewster are (abbreviations defined in Appendix E):

- Federal Aviation Administration (FAA) Notice of Proposed Construction and Alteration
- Federal Energy Reliability Commission (FERC) Exempt Wholesale Generator (EWG) and Qualifying Facility (QF) Status
- United States Environmental Protection Agency (EPA) Stormwater Discharge Permit
- Massachusetts Office of Consumer Affairs and Business Regulation – Division of Energy Resources (DOER) Statement of Qualification for Massachusetts Renewable Portfolio Standard (RPS)
- Massachusetts Aeronautics Commission (MAC) Request for Airspace Review
- Massachusetts Historical Commission (MHC) Archeological and Historical Review
- Barnstable County – Cape Cod Commission Development of Regional Impact Permit
- Town of Brewster Building Permit

- Town of Brewster Zoning Department Conditional Use Permit
- Town of Brewster Large-Scale Wind Energy Turbine Special Permit

To prepare for these permits, it may be advisable to have informal meetings with each agency to discuss the project and that agency's study expectations. The majority of the permits listed above are expected to require approximately 3 to 4 months to obtain, following completion of appropriate study work. Black & Veatch recommends that scheduling for the project allow for 6 months for permitting to allow for delays or some level of unexpected difficulty. Black & Veatch understands the political nature of permitting may add more time to the process, but by meeting with each agency in advance it is believed some of this delay can be avoided.

Should the project move forward, with MTC providing support to the Town of Brewster and Black & Veatch remaining the owner's engineer, it is expected that Black & Veatch can provide the necessary studies and reviews for the required permits, as well as guide the Town of Brewster through the permit process. The Town of Brewster, as the owner and operator of the treatment plant and wind project, will provide the previous study work performed, allow access to the site for any additional on-site studies, and submit the permit applications. Further definition of project roles will need further discussion between the parties and development of a development plan.

8.0 Potential Wind Project Options

Based upon recommendations in Section 5, the electrical infrastructure and load the information in Section 6, Black & Veatch determined the most feasible project options would be either a one or two turbine project in the Barrows Location or a single turbine project at the Commerce Park Site. However, due to the similarity between electrical connection methods, aggregate loads and constructability, the discussions and analysis that follow below are also relevant for the Golf Course, Pumping Station, Police Station and WTS Sites. The project options below discuss the recommended build-out methods for 1 or 2 turbines in a net-metered configuration. The performance, cost, ownership structures and economic estimates for these options are discussed in subsequent sections.

Net-metering projects are typically setup where an on-site load is satisfied before selling power to the utility. Among other equipment, a bi-directional meter is placed in-line between the wind turbine and electrical grid and tracks the usage and generation of the project.

While the net-metering design option may require some level of upgrades to the distribution lines near project sites, this study assumes that the electrical connections for each of the sites would be reconfigured so that each turbine has a single point of connection with an it's own utility meter. The wind turbine would be connected behind that meter, and would meet the needs of any loads on the site before sending excess power out to the grid. Such an approach also requires careful planning with the local utility providing power to the site.

8.1 Option 1: One Turbine; Net-Metered

Under this option a single large wind turbine having a capacity between 1.5 and 1.8MW would be placed at either the Commerce Park or Police Station location. As mentioned in Section 5, this option would require little alteration to the surrounding area thus minimizing the impact to the environment. As discussed in Section 6, Black & Veatch expects that a single turbine at either location would connect to the 4 kV (or 8 kV) distribution line adjacent to the property with little upgrades needed to the existing infrastructure.

8.2 Option 2: Two Turbines; Net-Metered

As mentioned above, Black & Veatch estimates the Barrows, Golf Course, Pumping Station, or WTS site can support two GE1.5MW or Vestas V80/V82 wind turbines; meaning that the sites would have a capacity between about 3.0 and 3.6 MW. A general guidance for the separation of wind turbines is to place them 2 to 3 rotor diameters apart in the direction perpendicular to the prevailing winds. As the prevailing wind direction is from the southwest, the preferred alignment of the towers is northwest to southeast. The both sites allow for two turbines to have at least 3 rotor diameters of separation regardless of which turbine model is considered. While the capacities of the local distribution lines are uncertain, it is thought that these lines will not support the additional generation from two turbines without significant upgrades and the need to interconnect to either the 115 kV transmission line or the 23 kV distribution line. Under the proposed Senate Act No. 2768, only facilities with a generating capacity less than or equal to 2 MW may qualify for net metering credits. As mentioned above, the particular wind turbines considered for this study would collectively have a total generating capacity of 3.0 to 3.6 MW. In order to qualify for the net meting credit, each wind turbine would have to be independently metered. Therefore, while the site may have two wind turbines, each turbine would essentially be a separate “Class III net-metering facility”. While the proposed net-metering language does not place a restriction on this sort of arrangement, it is assumed that the distribution company would accept the interconnection of the project and provide the net metering service for both turbines. Should the Town choose to pursue this option; Black & Veatch recommends that the Town seek further clarification on the net-metering terms and restrictions.

9.0 Preliminary Energy Production Estimate

Based on the wind resource data collected at the Golf Course location met tower, Black & Veatch estimated the potential energy production for the three project options discussed in Section 8. The method and assumptions for these estimates are discussed below.

9.1 Wind Turbine Power Curves

The Vestas V82 was the large wind turbine model used to evaluate the differences in energy production between the sites reviewed for this report. The tower height assumption chosen for V82 was 80 meters. Based on site elevations between 15 and 28 meters (50 and 90 feet) and the annual average temperature data collected by the RERL met tower (approximately 13ºC or 55ºF), Black & Veatch determined the site's average air density was about 1.23 kg/m^3. The sea level air density power curves from wind turbine manufacturers reference 1.225 kg/m^3, so Black & Veatch used sea level power curves for the Vestas V82 shown in Table 9-1.

Table 9-1. Wind Turbine Power Curves.

Hub Height Wind Speed, m/s	V82 1.65 MW Output Power, kW
0	0
1	0
2	0
3	0
4	29
5	146
6	313
7	517
8	767
9	1028
10	1299
11	1518
12	1639
13	1648
14	1650
15	1650
16	1650
17	1650
18	1650
19	1650
20	1650

9.2 Production Losses

Black & Veatch has examined the option of a large turbine project for each of sites previously discussed to estimate the potential production losses that might impact wind turbines. Each loss factor is discussed below, and summarized in Table 9-2.

Table 9-2. Energy Production Loss Factors.

Loss Type	Barrows [%]	Commerce Park [%]	Golf Course [%]	Police Station [%]	Pumping Station [%]	Waste Transfer Site
Array efficiency	94.84	100.00	99.47	100.00	98.34	98.13
Availability	95.00	95.00	95.00	95.00	95.00	95.00
Electrical efficiency	98.00	98.00	98.00	98.00	98.00	98.00
Hysteresis	100.00	100.00	100.00	100.00	100.00	100.00
Icing & blade degradation	98.00	98.00	98.00	98.00	98.00	98.00
Other factors	97.00	97.00	97.00	97.00	97.00	97.00
Power curve turbulence variation	100.00	100.00	100.00	100.00	100.00	100.00
Sector Management	100.00	100.00	100.00	100.00	100.00	100.00
Substation maintenance	100.00	100.00	100.00	100.00	100.00	100.00
Topographic efficiency	100.64	92.40	98.12	104.81	98.31	106.26
Utility downtime	98.00	98.00	98.00	98.00	98.00	98.00
Total Losses	**17.22**	**19.86**	**15.35**	**9.10**	**16.15**	**9.56**

- **Array efficiency:** Array efficiency is the ratio of the net yield that considers topographic speed-ups and wake losses to gross yield, which also considers topographic speed-ups, but does not make allowances for wake losses.
- **Availability:**
  - **Turbine Availability**: Wind turbine manufacturers will specify an availability level to be covered in a warranty (this may be difficult to obtain for single turbine installations). This value assumes the turbine's availability is only at that warranty value.
  - **Grid Availability:** An estimate is made as to the amount of time the utility (or in this case, the electrical system of the plant) will be available to receive power from the project. All grid systems are off-line periodically for maintenance, and projects in more remote locations will be connected to weaker grid systems that are more prone to failure.

Losses for grid availability vary between 0.1 percent for very strong grid system to as high as 5 percent for weak systems (and even larger for systems outside the US). As Black & Veatch has no specific information on grid reliability in the project area, an estimated loss of 0.5 percent was assumed.

- **Electrical Efficiency:** Losses in the lines and electrical equipment prior to the plant's revenue meters are covered by this factor. Points of significant electrical losses in a wind energy project usually include the underground and overhead distribution lines connecting the turbines to a substation, and the substation's primary transformer. Typical electrical loss values range from as low as 1 percent to 10 percent or more, depending on the layout and equipment used.
- **High Wind Hysteresis:** When wind speeds exceed the operational range of a wind turbine, the turbine shuts down to protect itself. Such shut-downs normally require the turbine to remain offline for several minutes, regardless if the wind speed returns to the operational range. Sites with a significant number of these high wind events suffer lost energy due to this hysteresis effect, which is additional to the amount of time the average wind speeds remain above the cut-out wind speed. As the Project site does not have a significant number of high wind events on record, no losses due to this hysteresis effect were applied.
- **Icing and Blade Contamination:**
    - **Icing:** During winter storms, snow and ice will build on the wind turbine blades causing the same degradation as caused by dust and insects. While this contamination will build much faster than summer contamination, it is often cleared after a few hours of direct sunlight (even at continued subzero temperatures). Given the anticipated likelihood of several significant storms per winter, a loss of 1 percent was assumed for the lost energy due to icing.
    - **Blade Contamination:** Wind turbine performance is sensitive to the cleanliness of the turbine's blades. In areas of high dust or insects, contamination can build on the wind turbine blades that will limit the turbine's performance (causing losses up to 5 percent or more). Often the blades are cleaned by occasional rainfall, but in some areas periodic blade washing is required. As the plant is not an area of high dust, the potential for blade contamination is fairly low and due mostly to insects. As such, an annual loss of 1 percent was assumed for blade contamination.
- **Other Losses**
    - **Wake Effect:** This is the energy loss due to the effect one turbine will have on another, or the wake caused by any structure on the wind turbines.

- **Columnar Losses:** If a project of many wind turbines is arranged in rows, turbine manufacturers may require the shutdown of some turbines when the winds are coming from directions parallel to the rows. These losses will not apply to the options defined in this report.
- **Model Estimate:** Black & Veatch estimated the performance of potential wind turbines using manual calculations within a basic spreadsheet. While this approach can have significant uncertainties in complex terrain, it is believed to be fairly accurate for Brewster. Therefore, no losses were assumed due to wind model accuracy.

- **Power curve turbulence variation:** The wind turbine manufacturer will warranty a performance level from the turbine at a percentage of the power curve values (this may also be difficult to obtain for a single turbine installation.) Typical warranty levels are 95 to 97 percent of published power curve. However, industry practice is usually not to consider this as a potential loss, given most wind turbines operate at or slightly above their published power curves. For this study, Black & Veatch left the value as a 0 percent loss.
- **Sector Management :** This is an evaluation of whether the turbine is operational or not, taking into account the cut-in and cut-out wind speeds and sector management. Incident wind speed that includes any wake effects is used for this evaluation, and the design equivalent turbulence is set to zero if the turbine is not in operation.
- **Substation maintenance:** In order to perform substation maintenance, the tower must be shut down and will not produce power. Substation maintenance is usually scheduled for low-wind, low-load days following the seasonal variations of that site.
- **Topographic Efficiency:** This is the loss due to wind speed reductions between the met tower and turbine caused by the site's topography.
- **Utility downtime:** Events that require downtime on the part of the utility.

9.3 Production Estimates and Comparisons

Based on the wind analysis discussed in Section 4, Black & Veatch estimated the production for the Vestas V82

WAsP (the Wind Atlas Analysis and Application Program), an industry-standard computational wind analysis model developed by Risø National Laboratory in Denmark, was used to calculated the wind resource on the project site based on data from the Brewster met tower. The adjusted long-term average wind data was input into WAsP along with terrain data from the USGS Seamless National Elevation Dataset. WAsP then generated a wind resource grid, which provides a model for the varying wind resources across the areas of interest in the project.

Black & Veatch then utilized another computer modeling software package (WindFarmer, from Garrad Hassan) to estimate wind turbine performance. The same topographical, vegetation, and obstruction data was input to WindFarmer as was input to WAsP. Additionally, the turbine characteristics and layout were also defined. WindFarmer then estimated the annual energy generation of each turbine. These estimates include the impacts of terrain and the wake effects of other turbines into the estimate of each turbine's performance.

The resulting energy and capacity factor estimates for the three projects are shown in detail below. Since WindFarmer only estimates production on an annual basis, Black & Veatch estimated the monthly production breakdown through manual analysis of the met tower data.

9.4 Uncertainty Analysis

Based on the analysis detailed above and in Section 4, Black & Veatch has estimated the long-term average wind speed for Brewster to be 4.90 m/s at 49 meters above ground level, and 5.88 m/s at 80 meters. The corresponding long-term average production for the various turbine types and project options were presented as the Annual Average (P50) in Section 9.3. These values correspond to the 50 percent confidence value estimates, meaning that there is a 50 percent chance that the true long-term average wind speed is higher, and a 50 percent chance it is lower. To determine the sensitivity of the production to variations in wind speed, and to estimate the magnitude of variations possible, the following uncertainty analysis is performed.

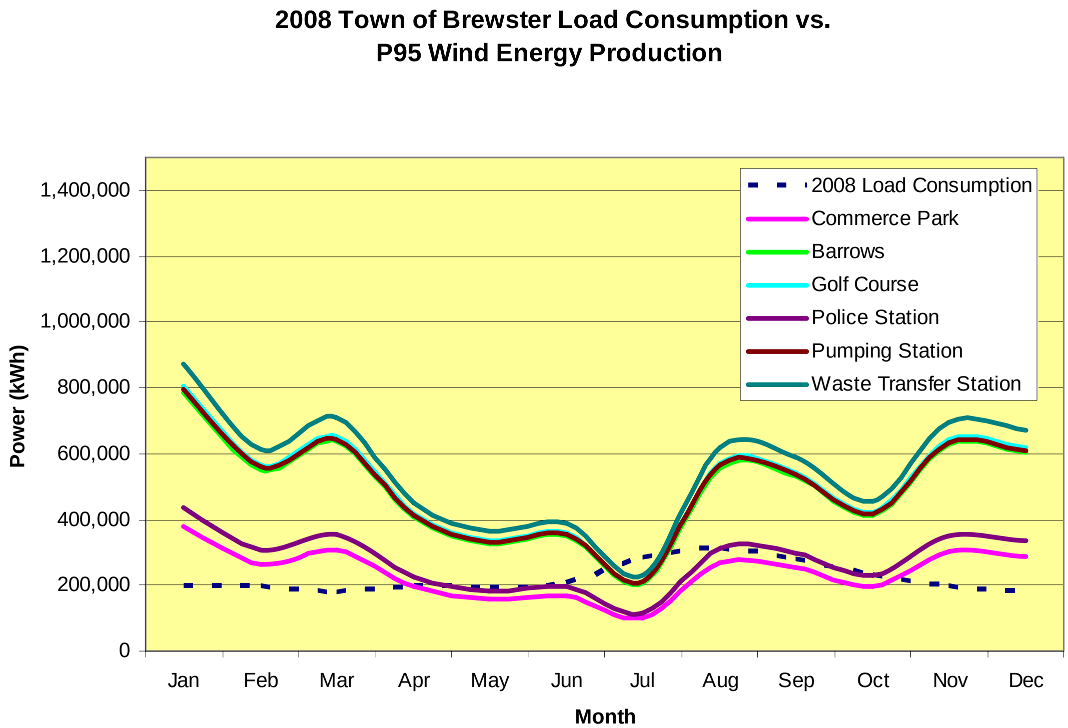
- **Long-term wind speed variability:** this is a measure for how well understood the long-term wind resource is, and is determined by the length of the long-term data set analyzed.
- **Correlation standard error:** this value is a measure of how well the on-site data correlated to the long-term data source.
- **Anemometer calibration:** this is the stated calibration of the primary anemometer used to measure the on-site wind resource (or in our case, the RERL Brewster met tower). For uncalibrated instruments, the standard accuracy of the anemometer published by its manufacturer is used. For instruments left installed past their calibration period, or for longer than one year for uncalibrated sensors, an increase in the calibration uncertainty may be applied for expected sensor degradation.
- **Topographic and wake modeling:** the models used to estimate the effects of topography and turbine wakes have uncertainty associated to them.
- **Wind variability:** this is a single year estimate of the long-term variability, signifying the uncertainty of estimating the "next year's" power production.

Table 9-3 shows the P50, P90, and P95 annual energy that are calculated from Combined Standard Error values based on uncertainty components for the project options. For each option, the true long-term annual average energy has a 50 percent chance of being greater than the P50 estimate, a 90 percent chance of being greater than the P90 estimate, and a 95 percent chance of being greater than the P95. These values can be used for sensitivity evaluations in a project pro forma or payback analysis.

Table 9-3. Energy Production Uncertainty Analysis.

Project Site	Barrows	Commerce Park	Golf Course	Police Station	Pumping Station	WTS
# Turbines	2	1	2	1	2	2
WTG Model	V82	V82	V82	V82	V82	V82
WTG Capacity (MW)	1.65	1.65	1.65	1.65	1.65	1.65
Site Capacity (MW)	3.3	1.65	3.3	1.65	3.3	3.3
Exceedence level – 1st Year						
P50 [GWh]	7.930	3.838	8.108	4.353	8.032	8.663
P90 [GWh]	6.419	3.088	6.570	3.565	6.497	7.097
P95 [GWh]	5.991	2.875	6.134	3.342	6.062	6.654
P50 [NCF]	27.43%	26.55%	28.05%	30.12%	27.78%	29.97%
P90 [NCF]	22.20%	21.36%	22.73%	24.67%	22.47%	24.55%
P95 [NCF]	20.72%	19.89%	21.22%	23.12%	20.97%	23.02%

Note:
NCF is net capacity factor, including the losses discussed in Section 9.2



10.0 General Project Cost Estimate

Black & Veatch prepared budgetary estimates for the installation of a wind energy project at a site in Brewster. The estimates considered the installation of one or two wind Vestas V82 turbines at a single site. The cost of the project is very much contingent on the interconnection method and the number of turbines. If the town is able to interconnect to the low voltage line with a simple connection, the overall cost is much lower. As mentioned in section 6, it is the expectation of Black & Veatch that interconnecting a project to the 115 kV transmission line or 23 kV transmission line would add significant costs in the form of upgrades to the existing infrastructure and likely necessitate a substation to be built. As such, the cost estimates provided in this section relies on the assumption that a single turbine can be connected to the local distribution line and pending further study, the addition of a second turbine is possible.

The estimates detailed on Table 10-1 are based on general pricing data from wind turbine vendors and the cost breakdown of a recent single wind turbine project. A detailed estimate has not been generated for this study, nor has Black & Veatch requested cost proposals from local construction contractors. This estimate is also not a bid from Black & Veatch to install this project for this price, but rather intended for study purposes only. These estimates also do not attempt to capture any internal Town of Brewster costs for any necessary engineering or project oversight.

The general total estimate for the installation of one V82 is about $4.8 million, or about $2,900 per kilowatt; the estimate for two V82's ranges between about $8.6 and $8.9 million, or about $2,600 to $2,700 per kilowatt. Readers may note the costs per kilowatt are higher than the often quoted industry model of $1,000 per kilowatt for wind farms. The reason for the higher cost is that all the study, engineering, construction mobilization, and permitting work must be amortized over only one or two turbines, while these costs are spread across many turbines for a larger wind farm. These prices also reflect the current exchange rate between the US Dollar and the Euro (which is the basis of the Vestas pricing). General increases in steel and concrete prices, and a large current demand for wind turbines in the U.S., have also increased the costs of wind energy projects; current costs for large wind energy projects are near $1,800 per kilowatt.

Table 10-1. Project Site Cost Estimate Comparison.

	Barrows	Commerce Park	Golf Course	Police Station	Pumping Station	WTS
Site Capacity(MW)	**3.30**	**1.65**	**3.30**	**1.65**	**3.30**	**3.30**
WTG Type	**V82**	**V82**	**V82**	**V82**	**V82**	**V82**
Number of WTG	**2**	**1**	**2**	**1**	**2**	**2**
WTG Capacity(MW)	**1.65**	**1.65**	**1.65**	**1.65**	**1.65**	**1.65**
Development and Project Management						
	$750,000	$750,000	$750,000	$750,000	$750,000	$750,000
Wind Turbines and Balance of Plant						
Engineering (BOP)	$179,000	$99,000	$179,000	$99,000	$179,000	$179,000
WT Procurement	$5,280,000	$2,640,000	$5,280,000	$2,640,000	$5,280,000	$5,280,000
BOP Construction						
Civil Works						
Site Clearing, Roads & Erosion Control	$143,500	$55,000	$121,875	$76,850	$244,060	$84,300
WT Crane Pads	$16,000	$8,000	$16,000	$8,000	$16,000	$16,000
Electrical works						
WT Transformers & Install	$190,000	$104,000	$208,000	$104,000	$208,000	$208,000
Collection System Cables & Install	$76,500	$18,000	$52,875	$32,850	$129,060	$15,300
Fiber Optic Cables, Equipment & Install	$12,000	$6,000	$12,000	$6,000	$12,000	$12,000
Structural Works						
WT Foundations	$500,000	$250,000	$500,000	$250,000	$500,000	$500,000
WT Installation						
Assembly	$700,000	$350,000	$700,000	$350,000	$700,000	$700,000
Electrical Install	$106,000	$68,000	$136,000	$68,000	$136,000	$136,000
Mechanical Completion	$30,000	$15,000	$30,000	$15,000	$30,000	$30,000
Project Management	$248,000	$124,000	$248,000	$124,000	$248,000	$248,000
Interconnection						
Studies	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000
Metering/NSTAR Equipment	$260,000	$130,000	$260,000	$130,000	$260,000	$260,000
Project Totals						
Development and Project Management	$750,000	$750,000	$750,000	$750,000	$750,000	$750,000
WT Procurement	$5,280,000	$2,640,000	$5,280,000	$2,640,000	$5,280,000	$5,280,000
Balance of Plant	$2,201,000	$1,097,000	$2,203,750	$1,133,700	$2,402,120	$2,128,600
Interconnection Cost	$410,000	$280,000	$410,000	$280,000	$410,000	$410,000
Total Project	***$8,641,000***	***$4,767,000***	***$8,643,750***	***$4,803,700***	***$8,842,120***	***$8,568,600***
	($/kW)	***($/kW)***	***($/kW)***	***($/kW)***	***($/kW)***	***($/kW)***
Development and Project Management	*$227*	*$455*	*$227*	*$455*	*$227*	*$227*
WT Procurement	*$1,600*	*$1,600*	*$1,600*	*$1,600*	*$1,600*	*$1,600*
Balance of Plant	*$667*	*$665*	*$668*	*$687*	*$728*	*$645*
Interconnection	*$124*	*$170*	*$124*	*$170*	*$124*	*$124*
Total Project	***$2,618***	***$2,889***	***$2,619***	***$2,911***	***$2,679***	***$2,597***

11.0 Preliminary Financial Analysis

The financial impacts of the project depend greatly on what project structure is chosen. The two project structures are discussed in the following section, each with different financial and legal considerations:

Single Turbine Project: Net-Metered – Town Owned
Two Turbine Project: Net-Metered – Town Owned

For the Town ownership options, Black & Veatch reviewed potential economic performance for the Brewster community wind project options using economic criteria established by MTC. This section provides an overview of the economic model, the economic assumptions, and the analysis results.

11.1 Economic Model Overview

The financial model consists of a spreadsheet-based, 20-year annual cash flow (pro forma) model. The model takes into account the project's capital and operating costs, performance characteristics (e.g., capacity factor), REC sales, and energy sales.

The project options discussed in Section 8 were evaluated using the financial model for a 100 percent debt to finance the project(s). For the 100 percent debt assumption, since there is no equity investment, only net present value (NPV) is calculated. The payback is the amount of time in years it takes for the revenues to pay for the initial investment. Discounted payback takes into account the time value of money, and discounts the future savings. Simple payback takes into account the non-discounted 20 year cash flows. Both incorporate interest on debt. In general, projects that result in a lower payback time periods are preferred to those with a higher payback. For all project options, a profitability index (cost/benefit ratio) is also calculated. All six options are involved installations and consist of arrangements net metering.

The results are driven by many assumptions made regarding project capital costs, operating costs, retail cost of energy, net-metering credits, REC values, and escalation of costs and revenues. Although this is a relatively simple economic model, in general, the results of the analysis should be sufficient to indicate general project viability, to differentiate between the various possible scenarios. If the project proceeds, it is recommended that a more detailed financial model be constructed to more accurately reflect the details of the project.

11.2 Cost and Performance Assumptions

The cost and performance assumptions for this study come from the cost estimates in the previous section (Table 11-1). Financial assumptions came from Black & Veatch estimates and standard financial assumptions provided by MTC. These assumptions are provided in Table 11-1 for the Town ownership scenario. This analysis includes a provision for Renewable Energy Certificate (REC) sales, assuming the MTC "standard financial offer" and a spot price of

$10/MWh after the offer expires. These renewable energy certificates represent the environmental value of the clean energy the turbines will produce.

Table 11-1. Economic Analysis Assumptions – Town Ownership.

Assumption	Value	Basis
Project Assumptions		
Annual Power Generation	Varies	Dependant on project option. See Section 6.
Annual Power Requirement	2,645 MWh	Town of Brewster – Total Load, All accounts.
Average Annual Cost of Power	$175/MWh	Town of Brewster – All Accounts
Average Annual Energy Costs	$463,248	Town of Brewster – All Accounts
Capital Costs, per kW	Varies	Dependant on project option. See Section 10.
Operations & Maintenance Costs, per Wind Turbine, years 1 and 2	$50,000	B&V estimate, based on MTC/Vestas Quotes
Operations & Maintenance Costs, per Wind Turbine, years 3 and on	$55,000	B&V estimate, based on MTC/Vestas Quotes
Fixed O&M Escalation	2.5%	B&V Estimate, based on project experience
Class III Virtual Net-Metering Credit	$187/MWh	B&V estimate/ Proposed Senate Act No. 2468
Brewster Financial/Economic Assumptions		
Debt Percentage	100%	Town of Brewster
Debt Interest Rate	4.5%	Town of Brewster
Debt Term	20 years	MTC
Energy Price Escalation	2.0%	B&V Estimate
Nominal Discount Rate	5.0%	MTC
Annual Inflation Rate	2.50%	B&V estimate
Financing Fee (% of issuance)	1%	B&V estimate
Insurance Costs	$0.998/MWh	B&V estimate
REC Price Assumptions		
REC Contract Rate (years 1-3)	$40/MWh	This is the standard offer from MTC for RECs
REC – Rate from year 4 on	$40/MWh	This rate runs until it reaches a maximum of $1.2 Million per MW
REC – Spot Rate	$10/MWh	Price of REC after standard offer runs out

11.3 Results

The results for Town Ownership project options are shown in Table 11-2. The results show the expected payback for each net metering project option to be about 0.1 years with a 490 to 865 percent return, depending on the project option selected.

Table 11-2. Financial Analysis Results.

Project Site	Barrows	Commerce Park	Golf Course	Police Station	Pumping Station	Waste Transfer Station
# Turbines	2	1	2	1	2	2
WTG Model	V82	V82	V82	V82	V82	V82
WTG Capacity (MW)	1.65	1.65	1.65	1.65	1.65	1.65
Site Capacity (MW)	3.3	1.65	3.3	1.65	3.3	3.3
Total Project Costs	$8,641,000	$4,766,850	$8,642,700	$4,803,150	$8,840,700	$8,570,100
20 Year Cash Flows	$15,883,800	$6,657,145	$16,571,705	$8,870,103	$15,920,409	$19,188,687
Discounted Cash Flows	$9,454,082	$3,693,858	$9,887,990	$5,315,533	$9,479,514	$11,533,067
Simple Payback	0.11 years	0.14 years	0.11 years	0.11 years	0.11 years	0.09 years
Discounted Payback	0.18 years	0.25 years	0.18 years	0.18 years	0.19 years	0.15 years
Internal Rate of Return	680%	490%	717%	697%	666%	865%
Net Present Value – 100% Debt	$8,920,778	$3,693,858	$9,334,007	$5,016,216	$8,943,078	$10,901,445
Profitability Index	109.40	81.57	113.29	109.58	106.17	133.25

12.0 Project Management Considerations

This project will not require an on-site operations or maintenance building. It is expected that any spare parts for the wind turbine can be stored within the Town's existing facilities. During the turbine's warranty period, turbine performance will be monitored remotely by the manufacturer who will be responsible for dispatching repair personnel as needed. It is likely the manufacturer will request the Town of Brewster to perform periodic visual inspections of the wind turbine, but maintenance and repair work will be performed by qualified technicians from the nearest large project. For the Vestas, this could be Meyersdale Wind Energy Project near Somerset, Pennsylvania, or Buffalo Mountain Wind Energy Project near Oak Ridge, Tennessee. Operations and maintenance arrangements will be determined with manufacturers during the turbine purchase negotiation.

When the warranty and service contract period expires, the Town of Brewster will have the option to continue to work with the turbine manufacturer, contract with a third party provider, or train plant personnel to perform these services. The best solution will depend somewhat on how many wind energy projects are installed in the region over the next few years. If an independent service provider or vendor service center is sited near Boston, obtaining a contract with that entity will likely be the most cost effective solution. Money for this contract was included in the pro forma analysis provided in Section 11.

Appendix A. Wind Resource Maps

Wind resource map of Massachusetts was downloaded from the New England Wind Map web site (http://truewind.teamcamelot.com/ne/).

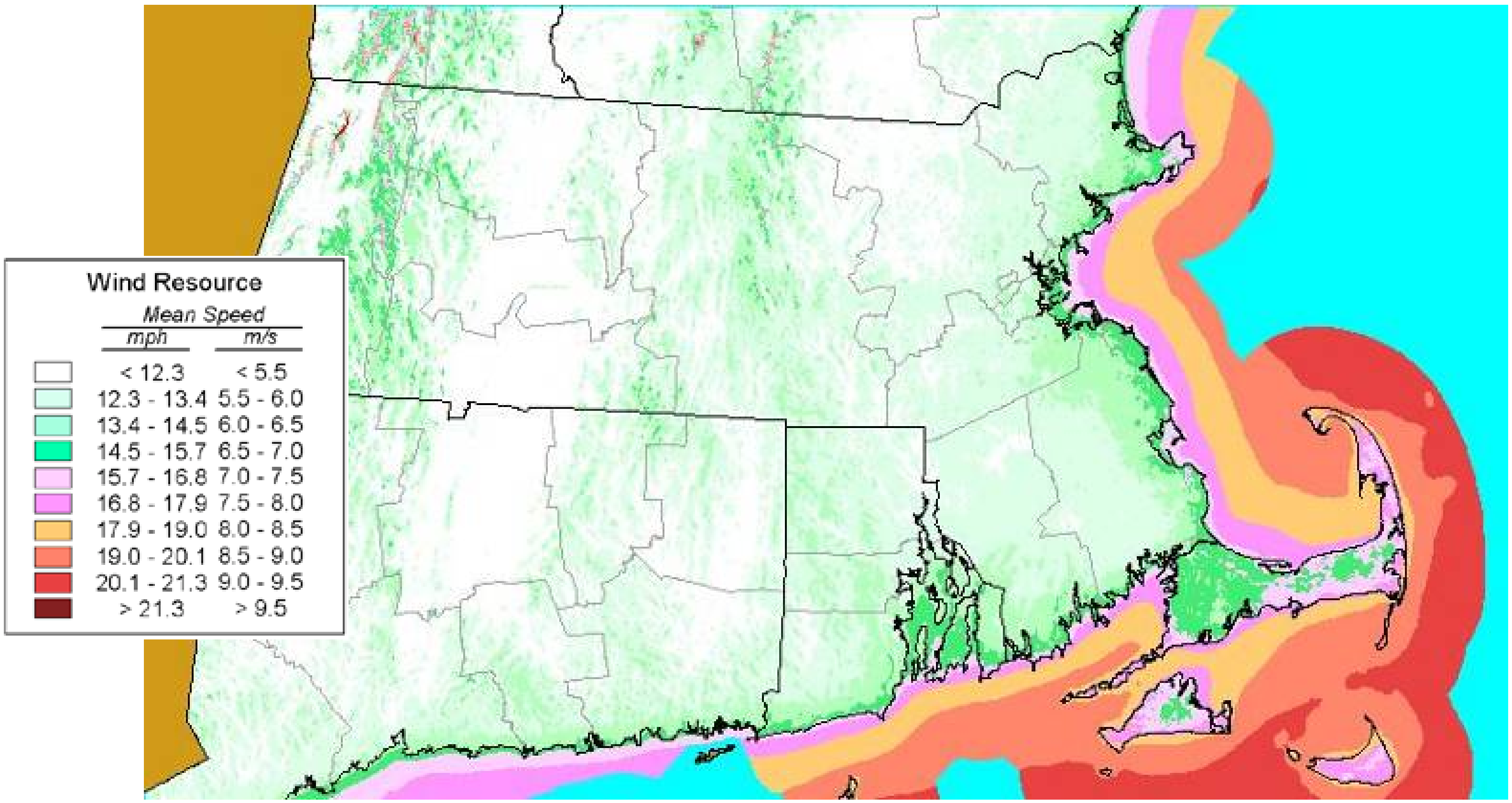


Figure A-1 Massachusetts Wind Resource Map

Appendix B. Core Habitats of Brewster

BioMap and Living Waters

Guiding Land Conservation for Biodiversity in Massachusetts

Core Habitats of Brewster

This report and associated map provide information about important sites for biodiversity conservation in your area.

This information is intended for conservation planning, and is not intended for use in state regulations.

Produced by:

Natural Heritage & Endangered Species Program
Massachusetts Division of Fisheries and Wildlife
Executive Office of Environmental Affairs
Commonwealth of Massachusetts

Produced in 2004

Revised January 2005

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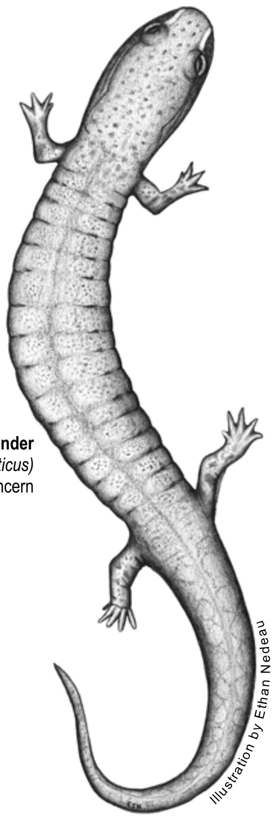
* Depending on the location of Core Habitats, your city or town may not have all of these sections.



Spring Salamander
(Gyrinophilus porphyriticus)
Species of Special Concern

Funding for this project was made available by the Executive Office of Environmental Affairs, contributions to the Natural Heritage & Endangered Species Fund, and through the State Wildlife Grants Program of the US Fish & Wildlife Service.

Natural Heritage & Endangered Species Program

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BioMap and Living Waters:
Guiding Land Conservation for Biodiversity in Massachusetts

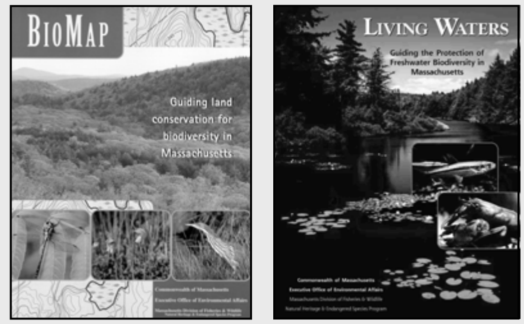
Introduction

In this report, the Natural Heritage & Endangered Species Program provides you with site-specific biodiversity information for your area. Protecting our biodiversity today will help ensure the full variety of species and natural communities that comprise our native flora and fauna will persist for generatons to come.

The information in this report is the result of two statewide biodiversity conservation planning projects, ***BioMap*** and ***Living Waters***. The goal of the BioMap project, completed in 2001, was to identify and delineate the most important areas for the long-term viability of terrestrial, wetland, and estuarine elements of biodiversity in Massachusetts. The goal of the Living Waters project, completed in 2003, was to identify and delineate the rivers, streams, lakes, and ponds that are important for freshwater biodiversity in the Commonwealth. These two conservation plans are based on documented observations of rare species, natural communities, and exemplary habitats.

What is a Core Habitat?

Both BioMap and Living Waters delineate ***Core Habitats*** that identify the most critical sites for biodiversity conservation across the state. Core Habitats represent habitat for the state's most viable rare plant and animal populations and include exemplary natural communities and aquatic habitats. Core Habitats represent a wide diversity of rare species and natural communities (see Table 1), and these areas are also thought to contain virtually all of the other described species in Massachusetts. Statewide, BioMap Core Habitats encompass 1,380,000 acres of uplands and wetlands, and Living Waters identifies 429 Core Habitats in rivers, streams, lakes, and ponds.



Get your copy of the ***BioMap*** and ***Living Waters*** reports! Contact Natural Heritage at 508-792-7270, Ext. 200 or email natural.heritage@state.ma.us. Posters and detailed technical reports are also available.

Core Habitats and Land Conservation

One of the most effective ways to protect biodiversity for future generations is to protect Core Habitats from adverse human impacts through land conservation. For Living Waters Core Habitats, protection efforts should focus on the ***riparian areas***, the areas of land adjacent to water bodies. A naturally vegetated buffer that extends 330 feet (100 meters) from the water's edge helps to maintain cooler water temperature and to maintain the nutrients, energy, and natural flow of water needed by freshwater species.

In Support of Core Habitats

To further ensure the protection of Core Habitats and Massachusetts' biodiversity in the long-term, the BioMap and Living Waters projects identify two additional areas that help support Core Habitats.

In BioMap, areas shown as ***Supporting Natural Landscape*** provide buffers around the Core Habitats, connectivity between Core Habitats, sufficient space for ecosystems to function, and contiguous undeveloped habitat for common species. Supporting Natural Landscape was

Natural Heritage & Endangered Species Program

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generated using a Geographic Information Systems (GIS) model, and its exact boundaries are less important than the general areas that it identifies. Supporting Natural Landscape represents potential land protection priorities once Core Habitat protection has been addressed.

In Living Waters, ***Critical Supporting Watersheds*** highlight the immediate portion of the watershed that sustains, or possibly degrades, each freshwater Core Habitat. These areas were also identified using a GIS model. Critical Supporting Watersheds represent developed and undeveloped lands, and can be quite large. Critical Supporting Watersheds can be helpful in land-use planning, and while they are not shown on these maps, they can be viewed in the Living Waters report or downloaded from www.mass.gov/mgis.

Understanding Core Habitat Species, Community, and Habitat Lists

What's in the List?

Included in this report is a list of the species, natural communities, and/or aquatic habitats for each Core Habitat in your city or town. The lists are organized by Core Habitat number.

For the larger Core Habitats that span more than one town, the species and community lists refer to the entire Core Habitat, not just the portion that falls within your city or town. For a list of all the state-listed rare species within your city or town's boundary, whether or not they are in Core Habitat, please see the town rare species lists available at www.nhesp.org.

The list of species and communities within a Core Habitat contains only the species and

Table 1. The number of rare species and types of natural communities explicitly included in the BioMap and Living Waters conservation plans, relative to the total number of native species statewide.

BioMap		
	Species and Verified Natural Community Types	
Biodiversity Group	**Included in BioMap**	**Total Statewide**
Vascular Plants	246	1,538
Birds	21	221 breeding species
Reptiles	11	25
Amphibians	6	21
Mammals	4	85
Moths and Butterflies	52	An estimated 2,500 to 3,000
Damselflies and Dragonflies	25	An estimated 165
Beetles	10	An estimated 2,500 to 4,000
Natural Communities	92	> 105 community types
Living Waters		
	Species	
Biodiversity Group	**Included in Living Waters**	**Total Statewide**
Aquatic Vascular Plants	23	114
Fishes	11	57
Mussels	7	12
Aquatic Invertebrates	23	An estimated > 2500

natural communities that were explicitly included in a given BioMap or Living Waters Core Habitat. Other rare species or examples of other natural communities may fall within the Core Habitat, but for various reasons are not included in the list. For instance, there are a few rare species that are omitted from the list or summary because of their particular sensitivity to the threat of collection. Likewise, the content of many very small Core Habitats are not described in this report or list, often because they contain a single location of a rare plant species. Some Core Habitats were created for suites of common species, such as forest birds, which are particularly threatened by habitat fragmentation. In these cases, the individual common species are not listed.

What does 'Status' mean?

The Division of Fisheries and Wildlife determines a status category for each rare species listed under the Massachusetts Endangered Species Act, M.G.L. c.131A, and its implementing regulations, 321 CMR 10.00. Rare species are categorized as Endangered, Threatened, or of Special Concern according to the following:

- ***Endangered*** species are in danger of extinction throughout all or a significant portion of their range or are in danger of extirpation from Massachusetts.
- ***Threatened*** species are likely to become Endangered in Massachusetts in the foreseeable future throughout all or a significant portion of their range.
- ***Special Concern*** species have suffered a decline that could threaten the species if allowed to continue unchecked or occur in such small numbers or with such restricted distribution or specialized habitat requirements that they could easily become Threatened in Massachusetts.

In addition, the Natural Heritage & Endangered Species Program maintains an unofficial ***watch list*** of plants that are tracked due to potential conservation interest or concern, but are not regulated under the Massachusetts Endangered Species Act or other laws or regulations. Likewise, described natural communities are not regulated any laws or regulations, but they can help to identify ecologically important areas that are worthy of protection. The status of natural communities reflects the documented number and acreages of each community type in the state:

- ***Critically Imperiled*** communities typically have 5 or fewer documented sites or have very few remaining acres in the state.
- ***Imperiled*** communities typically have 6-20 sites or few remaining acres in the state.
- ***Vulnerable*** communities typically have 21-100 sites or limited acreage across the state.
- ***Secure*** communities typically have over 100 sites or abundant acreage across the state; however excellent examples are identified as Core Habitat to ensure continued protection.

Legal Protection of Biodiversity

BioMap and Living Waters present a powerful vision of what Massachusetts would look like with full protection of the land that supports most of our biodiversity. To create this vision, some populations of state-listed rare species were deemed more likely to survive over the long-term than others.

Regardless of their potential viability, all sites of state-listed species have full legal protection under the Massachusetts Endangered Species Act (M.G.L. c.131A) and its implementing regulations (321 CMR 10.00). Habitat of state-listed wildlife is also protected under the Wetlands Protection Act Regulations (310 CMR 10.37 and 10.59). The ***Massachusetts Natural Heritage Atlas*** shows **Priority Habitats**, which are used for regulation under the Massachusetts Endangered Species Act and Massachusetts Environmental Policy Act (M.G.L. c.30) and **Estimated Habitats**, which are used for regulation of rare wildlife habitat under the Wetlands Protection Act. For more information on rare species regulations, see the *Massachusetts Natural Heritage Atlas*, available from the Natural Heritage & Endangered Species Program in book and CD formats.

BioMap and Living Waters are conservation planning tools and do not, in any way, supplant the Estimated and Priority Habitat Maps which have regulatory significance. Unless and until the combined BioMap and Living Waters vision is fully realized, we must continue to protect all populations of our state-listed species and their habitats through environmental regulation.

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Understanding Core Habitat Summaries

Following the BioMap and Living Waters Core Habitat species and community lists, there is a descriptive summary of each Core Habitat that occurs in your city or town. This summary highlights some of the outstanding characteristics of each Core Habitat, and will help you learn more about your city or town's biodiversity. You can find out more information about many of these species and natural communities by looking at specific ***fact sheets*** at www.nhesp.org.

Next Steps

BioMap and Living Waters were created in part to help cities and towns prioritize their land protection efforts. While there are many reasons to conserve land – drinking water protection, recreation, agriculture, aesthetics, and others – BioMap and Living Waters Core Habitats are especially helpful to municipalities seeking to protect the rare species, natural communities, and overall biodiversity within their boundaries. Please use this report and map along with the rare species and community fact sheets to appreciate and understand the biological treasures in your city or town.

Protecting Larger Core Habitats

Core Habitats vary considerably in size. For example, the average BioMap Core Habitat is 800 acres, but Core Habitats can range from less than 10 acres to greater than 100,000 acres. These larger areas reflect the amount of land needed by some animal species for breeding, feeding, nesting, overwintering, and long-term survival. Protecting areas of this size can be very challenging, and requires developing partnerships with neighboring towns.

Prioritizing the protection of certain areas within larger Core Habitats can be accomplished through further consultation with Natural Heritage Program biologists, and through additional field research to identify the most important areas of the Core Habitat.

Additional Information

If you have any questions about this report, or if you need help protecting land for biodiversity in your community, the Natural Heritage & Endangered Species Program staff looks forward to working with you.

Contact the Natural Heritage & Endangered Species Program:

by Phone 508-792-7270, Ext. 200

by Fax: 508-792-7821

by Email: natural.heritage@state.ma.us.

by Mail: North Drive
Westborough, MA 01581

The GIS datalayers of BioMap and Living Waters Core Habitats are available for download from MassGIS: www.mass.gov/mgis

Check out www.nhesp.org for information on:

- Rare species in your town
- Rare species fact sheets
- BioMap and Living Waters projects
- Natural Heritage publications, including:
  - Field guides
  - Natural Heritage Atlas, and more!

BioMap: Species and Natural Communities
Brewster

Core Habitat BM1226

Natural Communities

Common Name	Scientific Name	Status
Marine Intertidal: Flats		Secure

Plants

Common Name	Scientific Name	Status
Brackish Bulrush	*Scirpus cylindricus*	Watch Listed
Mitchell's Awned Sedge	*Carex mitchelliana*	Watch Listed
Oysterleaf	*Mertensia maritima*	Endangered
Seabeach Dock	*Rumex pallidus*	Threatened

Vertebrates

Common Name	Scientific Name	Status
Diamondback Terrapin	*Malaclemys terrapin*	Threatened

Core Habitat BM1241

Natural Communities

Common Name	Scientific Name	Status
Estuarine Intertidal: Saline/Brackish Flats		Vulnerable
Marine Intertidal: Flats		Secure
Maritime Beach Strand Community		Vulnerable
Maritime Dune Community		Imperiled

Plants

Common Name	Scientific Name	Status
American Sea-Blite	*Suaeda calceoliformis*	Special Concern
Oysterleaf	*Mertensia maritima*	Endangered

Invertebrates

Common Name	Scientific Name	Status
Coastal Heathland Cutworm	*Abagrotis nefascia benjamini*	Special Concern

Vertebrates

Common Name	Scientific Name	Status
Arctic Tern	*Sterna paradisaea*	Special Concern
Common Moorhen	*Gallinula chloropus*	Special Concern
Common Tern	*Sterna hirundo*	Special Concern
Diamondback Terrapin	*Malaclemys terrapin*	Threatened
Least Tern	*Sterna antillarum*	Special Concern
Northern Harrier	*Circus cyaneus*	Threatened
Pied-Billed Grebe	*Podilymbus podiceps*	Endangered
Piping Plover	*Charadrius melodus*	Threatened
Roseate Tern	*Sterna dougallii*	Endangered
Short-eared Owl	*Asio flammeus*	Endangered

Core Habitat BM1243

Plants

Common Name	Scientific Name	Status
Small Site for Rare Plant		

Core Habitat BM1245

Natural Communities

Common Name	Scientific Name	Status
Coastal Plain Pondshore		Imperiled

Plants

Common Name	Scientific Name	Status
Maryland Meadow Beauty	*Rhexia mariana*	Endangered
Plymouth Gentian	*Sabatia kennedyana*	Special Concern

Pondshore Knotweed	*Polygonum puritanorum*	Special Concern
Purple Milkweed	*Asclepias purpurascens*	Endangered
Redroot	*Lachnanthes caroliana*	Special Concern
Terete Arrowhead	*Sagittaria teres*	Special Concern
Two-Flowered Rush	*Juncus biflorus*	Watch Listed

Invertebrates

Common Name	Scientific Name	Status
New England Bluet	*Enallagma laterale*	Special Concern
Pine Barrens Bluet	*Enallagma recurvatum*	Threatened
Water-Willow Stem Borer	*Papaipema sulphurata*	Threatened

Vertebrates

Common Name	Scientific Name	Status
Bird Migration Habitat		-------------------
Eastern Box Turtle	*Terrapene carolina*	Special Concern

Core Habitat BM1247

Natural Communities

Common Name	Scientific Name	Status
Coastal Plain Pondshore		Imperiled

Plants

Common Name	Scientific Name	Status
Small Site for Rare Plant		

Core Habitat BM1249

Natural Communities

Common Name	Scientific Name	Status
Coastal Plain Pondshore		Imperiled

Plants

Common Name	Scientific Name	Status
Bushy Rockrose	*Helianthemum dumosum*	Special Concern
Maryland Meadow Beauty	*Rhexia mariana*	Endangered
Plymouth Gentian	*Sabatia kennedyana*	Special Concern
Terete Arrowhead	*Sagittaria teres*	Special Concern
Two-Flowered Rush	*Juncus biflorus*	Watch Listed

Invertebrates

Common Name	Scientific Name	Status
New England Bluet	*Enallagma laterale*	Special Concern

Core Habitat BM1251

Plants

Common Name	Scientific Name	Status
Small Site for Rare Plant		

Core Habitat BM1256

Plants

Common Name	Scientific Name	Status
Salt Reedgrass	*Spartina cynosuroides*	Threatened

Invertebrates

Common Name	Scientific Name	Status
Coastal Heathland Cutworm	*Abagrotis nefascia benjamini*	Special Concern
Straight-lined Mallow moth	*Bagisara rectifascia*	Special Concern

Vertebrates

Common Name	Scientific Name	Status
Piping Plover	*Charadrius melodus*	Threatened

Core Habitat BM1257

Plants

Common Name	Scientific Name	Status
Small Site for Rare Plant		

Core Habitat BM1265

Natural Communities

Common Name	Scientific Name	Status
Coastal Plain Pondshore		Imperiled

Plants

Common Name	Scientific Name	Status
Commons's Panic-Grass	*Dichanthelium ovale ssp. pseudopubescens*	Special Concern
Pondshore Knotweed	*Polygonum puritanorum*	Special Concern

Invertebrates

Common Name	Scientific Name	Status
New England Bluet	*Enallagma laterale*	Special Concern
Pine Barrens Bluet	*Enallagma recurvatum*	Threatened
Spatterdock Darner	*Aeshna mutata*	Special Concern
Water-Willow Stem Borer	*Papaipema sulphurata*	Threatened

Vertebrates

Common Name	Scientific Name	Status
Eastern Box Turtle	*Terrapene carolina*	Special Concern
Northern Parula	*Parula americana*	Threatened
Spotted Turtle	*Clemmys guttata*	Special Concern

Core Habitat BM1271

Natural Communities

Common Name	Scientific Name	Status
Coastal Plain Pondshore		Imperiled

Core Habitat BM1279

Plants

Common Name	Scientific Name	Status
Small Site for Rare Plant		

Core Habitat BM1281

Plants

Common Name	Scientific Name	Status
Small Site for Rare Plant		

Core Habitat BM1284

Natural Communities

Common Name	Scientific Name	Status
Coastal Plain Pondshore		Imperiled

Plants

Common Name	Scientific Name	Status
Plymouth Gentian	*Sabatia kennedyana*	Special Concern
Redroot	*Lachnanthes caroliana*	Special Concern

Core Habitat BM1287

Plants

Common Name	Scientific Name	Status
Small Site for Rare Plant		

Massachusetts Division of Fisheries and Wildlife
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http://www.nhesp.org

Core Habitat BM1288

Natural Communities

Common Name	Scientific Name	Status
Coastal Plain Pondshore		Imperiled

Plants

Common Name	Scientific Name	Status
Long-Beaked Bald-Sedge	*Rhynchospora scirpoides*	Special Concern
Plymouth Gentian	*Sabatia kennedyana*	Special Concern
Redroot	*Lachnanthes caroliana*	Special Concern
Terete Arrowhead	*Sagittaria teres*	Special Concern
Wright's Panic-grass	*Dichanthelium wrightianum*	Special Concern

Invertebrates

Common Name	Scientific Name	Status
Comet Darner	*Anax longipes*	Special Concern
New England Bluet	*Enallagma laterale*	Special Concern
Pine Barrens Bluet	*Enallagma recurvatum*	Threatened

Core Habitat BM1299

Plants

Common Name	Scientific Name	Status
Small Site for Rare Plant		

Core Habitat BM1304

Plants

Common Name	Scientific Name	Status
Small Site for Rare Plant		

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Core Habitat BM1226

This Core Habitat contains a large, impressive Marine Intertidal Flat community in Brewster, Orleans, and Eastham. This area is surrounded by high-quality estuarine communities that support rare seaside plants. The diversity of salt marshes, tidal creeks, and sandy uplands also support Diamondback Terrapins. Conservation of additional Diamondback Terrapin habitat is needed to help protect this species here.

Natural Communities

This Core Habitat contains a large, impressive Marine Intertidal Flat with some species of particular interest, including Brant, horseshoe crabs, and Diamondback Terrapins. The Marine Intertidal Flat community is found in areas protected from intense wave action. Although many flats have little to no vegetation, they are physically and biologically linked to other coastal marine systems. The majority of surrounding land here is occupied by high-quality estuarine communities including Salt Marshes, Eel Grass Beds, and Barrier Beaches.

Plants

Rare plant species adapted to seaside habitats, such as Seabeach Dock and Oysterleaf, are found within this Core Habitat.

Vertebrates

This Core Habitat surrounding the Namskaket/Herring River Marsh contains widespread salt marsh, extensive tidal creeks, beaches, and sandy uplands that support Diamondback Terrapins. At least three nesting sites in sandy uplands have been confirmed. Portions of the marshes, tidal creeks and uplands are protected for conservation, and protection of other suitable habitat is needed. Potential threats to this species include collisions with vehicles and degradation of foraging and nesting habitat.

Core Habitat BM1241

South Beach and South Monomoy Islands provide the most important breeding sites in the state for Piping Plovers, and South Monomoy Island also supports the state's largest Common Tern, Laughing Gull, Herring Gull, and Great Black-backed Gull colonies. The beaches and extensive sandflats and mudflats at North and South Monomoy Islands and South Beach Island collectively represent one of the most important shorebird migration stopover areas in New England. In addition, this Core Habitat encompasses large, high-quality natural communities, including Estuarine Intertidal Flats, Maritime Beach Strands, and Maritime Dune systems. These areas provide significant habitat for several rare moth species, two rare plant species, as well as Diamondback Terrapins. The Core Habitat encompasses Nauset Beach, South Beach, North and South Monomoy Islands, Sampson Island, Hog Island, Tern Island, Strong Island, Sipson Meadow, Sipson Island, Little Sipson Island, Pleasant Bay, Little Pleasant Bay (and associated inlets), and Chatham Harbor. Given their constantly changing configurations, the current extents of the beaches, especially South Beach Island, may not be reflected precisely in the Core Habitat.

Natural Communities

This long Core Habitat includes an exemplary barrier beach system. It includes five miles of good-quality Maritime Beach Strand with minimal disturbances located on the ocean side of a high-quality 2000-acre Maritime Dune system with natural vegetation, limited access, and no vehicle damage. Maritime Beach Strand communities are sparsely vegetated, narrow, wrack-strewn areas between the line of high tide and the foredunes. They are usually part of barrier beach systems and are found seaward of any dunes, but above daily high tides. Meanwhile, the Maritime Dune community consists of patches of herbaceous plants interspersed with areas of bare sand and shrubs. It occurs on windswept dunes within the salt spray zone, and often grades into shrubland or woodlands on more sheltered back dunes. Also included in this Core Habitat are the Estuarine Intertidal Saline/Brackish Flats along the shores of Monomoy Island. These flats are well-buffered within a complex of estuarine communities and are a rich area for migratory shorebirds and horseshoe crabs.

Plants

Two rare sea-beach plants, American Sea-Blite and Oysterleaf, are found within beach strand communities along the shores of Monomoy Island.

Invertebrates

This Core Habitat includes Monomoy Island (part of the Monomoy National Wildlife Refuge), which is protected coastal sandplain habitat for rare moths such as the Coastal Heathland Cutworm. It is likely that Monomoy Island is inhabited by additional rare coastal moth species, such as the Dune Noctuid moth, the Drunk Apamea moth, and other species.

Vertebrates

Barrier beaches and islands within this Core Habitat support several species of breeding coastal waterbirds and raptors, including: Piping Plovers, Least Terns, Common Terns, Roseate Terns, Black-crowned Night-Herons, Glossy Ibises, Snowy Egrets, Laughing Gulls, Herring Gulls, Great Black-backed Gulls, and, in some years, Black Skimmers, Arctic Terns, Short-eared Owls, and Northern Harriers. South Beach and South Monomoy Islands are notable as two of the most important breeding sites in the state for the Piping Plover. South Monomoy Island also supports the state's largest Common Tern, Laughing Gull, Herring Gull, and Great Black-backed Gull colonies, and is among the most important breeding sites for Black-crowned Night-Herons and Snowy Egrets. Potential threats to these coastal waterbird and raptor species include predation, human disturbance (including dogs), off-road vehicles, and habitat degradation caused by dune-building activities. Annual protection from these threats is needed.

The beaches and extensive sandflats and mudflats at North and South Monomoy Islands as well as South Beach Island collectively represent one of the most important shorebird migration stopover areas in New England. Uncommon species of marsh birds and waterfowl, including Pied-billed Grebe, Common Moorhen, and Gadwall, occasionally nest in wetlands on South Monomoy Island.

This Core Habitat also contains salt marsh, tidal creeks, beaches, dune areas, shallow waters, and sandy uplands that support Diamondback Terrapins. Thirty documented observations of nesting are known from the late 1970s and early 1980s. The land along the upper reaches of the bay is relatively undeveloped, but in areas of development, potential threats to this species include mortality caused by vehicles and degradation of foraging and nesting habitat.

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Core Habitat BM1245

This Core Habitat encompasses several clusters of Coastal Plain Ponds and wetlands that support rare damselflies, such as the New England Bluet and Pine Barrens Bluet, as well as the Water-willow Stem Borer moth. The pondshores here also support several populations of the beautiful and globally rare Plymouth Gentian. The Core Habitat's Pine-Oak woodlands provide habitat for a variety of birds, and the area may represent the best opportunity to protect the Eastern Box Turtle on Cape Cod. Much of this Core Habitat is protected within the Nickerson State Park, but further conservation of the remaining unprotected lands would help protect one of the largest areas of relatively unfragmented upland habitat remaining in the mid-Cape region.

Natural Communities

This Core Habitat includes several clusters of Coastal Plain Pondshore communities that have associated state-listed plant and animal species. Coastal Plain Pondshores are globally rare herbaceous communities of exposed pondshores with a distinct Coastal Plain flora. Water levels change with the water table, typically leaving an exposed shoreline in late summer where many rare species grow. Here one cluster is completely buffered by a natural landscape that has roads but little development. Another cluster is partially buffered by a natural landscape. Because there are multiple high-quality ponds in this Core Habitat, the habitat and long-term viability of the component species are greatly enhanced. However, most of the ponds in the cluster are within the zone of groundwater contribution to public water supply wells, which can contribute to lowering of pond levels. If water withdrawals are managed to mimic natural fluctuations, the impact on the natural community is lessened.

Plants

Two very high-quality populations and several smaller populations of the globally rare Plymouth Gentian occur along shores within this Core Habitat, as does a large, healthy population of Maryland Meadow Beauty.

Invertebrates

Wetlands within this Core Habitat such as Cliff Pond and the numerous small ponds peripheral to it, as well as Smalls, Mill, and Cahoon Ponds to the southwest, all provide habitat for rare damselflies such as the New England Bluet and the Pine Barrens Bluet, as well as for the Water-willow Stem Borer moth. All of these ponds are located within a large area of undeveloped and unfragmented landscape, allowing for unimpeded dispersal of rare damselflies, Water-willow Stem Borer moths, and other species.

Vertebrates

This large and relatively unfragmented Core Habitat contains significant habitat for Eastern Box Turtles, and may be one of the best places to preserve viable populations of this species on Cape Cod. This is also an important block of habitat for woodland and shrubland birds characteristic of Cape Cod, including the Eastern Towhee, one of the fastest declining songbirds in eastern North America. Given its location near the "elbow" of Cape Cod, this area provides important migration habitat for many species of landbirds.

Core Habitat BM1247

Natural Communities

This small Core Habitat contains a Coastal Plain Pondshore community that is part of a cluster of ponds associated with state-listed plant species. Coastal Plain Pondshores are globally rare herbaceous communities of exposed pondshores with a distinct Coastal Plain flora. Water levels change with the water table, typically leaving an exposed shoreline in late summer where many rare species grow. A small portion of the shoreline here is buffered by a natural landscape; the rest is surrounded by residential development. The area is not in a zone of groundwater contribution to public water supplies, and there are no adjacent cranberry bogs. The viability of the characteristic Coastal Plain Pond species is lessened by the clearing of the pondshore for recreation, but enhanced by the presence of nearby ponds and wetlands and the lack of large-scale water withdrawal.

Core Habitat BM1249

Natural Communities

This small cluster of Coastal Plain Pondshore communities of moderate quality is partially buffered by naturally vegetated land. Coastal Plain Pondshores are globally rare herbaceous communities of exposed pondshores with a distinct Coastal Plain flora. Water levels change with the water table, typically leaving an exposed shoreline in late summer where many rare species grow. Here the pond is separated from other pond clusters by residential development and an adjacent golf course. The multiple ponds in the area enhance the viability of the characteristic Coastal Plain Pond species, but development in the area may stress the habitat.

Plants

Three rare plant Species of Special Concern are found within this Core Habitat: Bushy Rockrose, Plymouth Gentian, and Terete Arrowhead. These plants are adapted to grow along the shores of Coastal Plain ponds.

Invertebrates

This Core Habitat includes Blueberry Pond, Salls Pond, and Widger Hole, all of which are habitat for the rare New England Bluet damselfly. Though surrounded by development, this Core Habitat is located less than 5 km from the population of the New England Bluet at Cliff Pond in Brewster, which may allow for dispersal of individuals between these two locations. Apparently only a very small fraction of this Core Habitat is protected.

Core Habitat BM1256

This Core Habitat, centered on Quivett Creek, contains a variety of habitats for rare plants and animals. It includes beaches that support breeding Piping Plovers, marshes that provide habitat for the Salt Reedgrass and rare moth species, as well as maritime habitats that support the Coastal Heathland Cutworm moth.

Plants

Two large, vigorous populations of Salt Reedgrass, a relative of the more common cordgrasses, are found within marshes of this coastal Core Habitat.

Invertebrates

Rare moth species occurring within this Core Habitat include the Coastal Heathland Cutworm, which inhabits the dunegrass grasslands and maritime shrublands, and the Straight-lined Mallow moth, which inhabits the marsh. It is likely that this Core Habitat supports additional rare coastal moth species, such as the Spartina Borer moth.

Vertebrates

The beaches of Quivett Neck and Coles Pond support breeding Piping Plovers. Potential threats to nesting coastal waterbirds include habitat alteration and loss, human disturbance, and predation. Annual protection from these threats is needed.

Core Habitat BM1265

This Core Habitat, spanning Brewster and Harwich, is one of the largest areas of unfragmented upland habitat remaining in this area of Cape Cod. It provides significant habitat for Eastern Box Turtles and important breeding habitat for birds that are characteristic of the region. The many Coastal Plain Pondshores and wetlands also provide habitat for rare species of damselflies, dragonflies, moths, and plants. With half of the Core Habitat protected as municipal watershed land, conservation of the remaining unprotected lands would help ensure the long-term viability of the rare species found here.

Natural Communities

This Core Habitat contains a Coastal Plain Pondshore community of moderate quality in Brewster. Coastal Plain Pondshores are globally rare herbaceous communities of exposed pondshores with a distinct Coastal Plain flora. Water levels change with the water table, typically leaving an exposed shoreline in late summer where many rare species grow. Recreational use of this pond has reduced the extent of pondshore vegetation. This pond may also be at risk from the effects of adjacent cranberry bogs and three nearby public water supply wells.

Plants

Commons's Panic-grass (Species of Special Concern) is scattered along dry cart paths and small clearings in this area.

Invertebrates

Coastal Plain Pondshores within this Core Habitat, including Lower Millpond, Upper Millpond, Walkers, Seymour, Hinckleys, Smith, Elbow, and Robbins Ponds, as well as numerous smaller kettlehole ponds and shallow, swampy wetlands, all provide habitat for rare dragonflies and damselflies including the Spatterdock Darner, the New England Bluet, and the Pine Barrens Bluet, as well as the Water-willow Stem Borer moth. All of these ponds are located within a large area of relatively undeveloped and unfragmented landscape, allowing for unimpeded dispersal of these and other invertebrate species.

Vertebrates

This Core Habitat comprises upland forest and small, scattered wetlands, ponds, and cranberry bogs. It contains significant habitat for Eastern Box Turtles and likely Spotted Turtles as well. Northern Parula warblers have also been noted in the area. The relative size of this Core Habitat in the increasingly developed mid-Cape area makes it important habitat for birds that breed in the pine-oak woodlands and barrens characteristic of Cape Cod.

Core Habitat BM1271

Natural Communities

This Core Habitat contains a Coastal Plain Pondshore community of moderate quality that is partially buffered by natural vegetation. Coastal Plain Pondshores are globally rare herbaceous communities of exposed pondshores with a distinct Coastal Plain flora. Water levels change with the water table, typically leaving an exposed shoreline in late summer where many rare species grow. Here the shore is used for swimming and other kinds of recreation, which have a detrimental impact on the plants and reduce the amount of habitat present. The fluctuation of the pond water levels is affected by its use as a cranberry bog reservoir. There are nearby water supply wells that may affect water levels in the pond during times of high demand. These artificial water fluctuations can have detrimental impacts on the rare plants and the natural community.

Core Habitat BM1284

Natural Communities

This Core Habitat includes a cluster of several Coastal Plain Pondshore communities that have partially undeveloped shorelines. They support many of the species that specialize in inhabiting peaty, sandy Coastal Plain pondshores. There are no cranberry bogs in the vicinity. They are within the areas of groundwater contribution to a public water supply well; during periods of high water demand, groundwater in these areas is lowered, reducing the water levels of nearby ponds. Repeated and excessive artificial lowering of the pond levels threatens the habitat of species dependent on Coastal Plain Ponds.

Plants

Two plant Species of Special Concern, Redroot and Plymouth Gentian, are found along pondshores in this Core Habitat.

Core Habitat BM1288

This Core Habitat in Dennis and Brewster contains a cluster of high-quality Coastal Plain Ponds, a globally rare type of natural community. These pondshore habitats and the surrounding forests support several rare species of plants, damselflies, and dragonflies. While part of this Core Habitat is on protected municipal watershed land, conservation of the remaining unprotected lands will help ensure the long-term viability of rare species inhabiting the area.

Natural Communities

This Core Habitat contains a cluster of Coastal Plain Pondshore communities that are in excellent condition and partially to well-buffered by surrounding natural vegetation; however, their hydrology may be affected by their proximity to two zones of groundwater contribution to public water supply wells. Coastal Plain Pondshores are globally rare herbaceous communities of exposed pondshores with a distinct Coastal Plain flora. Water levels change with the water table, typically leaving an exposed shoreline in late summer where many rare species grow.

Plants

Two outstanding populations of Long-Beaked Bald-Sedge, a tiny, brownish plant Species of Special Concern, occur within the sandy shorelines of this Core Habitat. A very large and robust population of Wright's Panic-grass is also found here, along with several other smaller populations.

Invertebrates

Coastal Plain Ponds within this Core Habitat, including Flax, Run, Simmons, Clay, Grassy, Bakers, and Pine Ponds, as well as numerous smaller ponds and surrounding forest all provide habitat for rare dragonflies and damselflies. Species found here include the Comet Darner, the New England Bluet, and the Pine Barrens Bluet. All of these ponds are located within a large area of relatively undeveloped and unfragmented landscape, allowing for unimpeded dispersal of dragonflies, damselflies, and other invertebrate species. This Core Habitat is just to the west of Core Habitat in Brewster and Harwich, allowing additional dispersal between these two areas.

Core Habitat LW053

Exemplary Habitats

Common Name	Scientific Name	Status
Lake/Pond Habitat		-------------------

Core Habitat LW280

Plants

Common Name	Scientific Name	Status
Resupinate Bladderwort	*Utricularia resupinata*	Threatened

Core Habitat LW344

Exemplary Habitats

Common Name	Scientific Name	Status
Lake/Pond Habitat		-------------------

Core Habitat LW346

Exemplary Habitats

Common Name	Scientific Name	Status
Lake/Pond Habitat		-------------------

Plants

Common Name	Scientific Name	Status
Acadian Quillwort	*Isoetes acadiensis*	Endangered

Core Habitat LW347

Exemplary Habitats

Common Name	Scientific Name	Status
Lake/Pond Habitat		-------------------

Core Habitat LW348

Exemplary Habitats

Common Name	Scientific Name	Status
Lake/Pond Habitat		-------------------

Core Habitat LW053

Ponds on the Atlantic Coastal Plain experience natural water level fluctuations and provide uncommon freshwater habitats for aquatic plants and insects with their acidic waters and sandy, cobble, or mucky pond bottoms. Rafe Pond is one of the few such ponds that has little or no development in its riparian areas and is removed from cranberry agriculture. While partially protected by conservation lands, the habitats within Rafe Pond may be threatened by development and water level drawdowns due to wells in the region.

Core Habitat LW280

One of only nine known populations of the rare Resupinate Bladderwort in the state inhabits the peaty margin of this Coastal Plain pond. This tiny plant is usually submerged underwater, and purple flowers are produced only when the habitat is exposed during periods of extremely low water. Bladderworts are carnivorous plants, trapping tiny aquatic animals in their pouch-like "bladders." Native freshwater plants like the Resupinate Bladderwort are an important component of aquatic communities, and warrant conservation attention if we are to maintain healthy freshwater ecosystems.

Core Habitat LW344

Ponds on the Atlantic Coastal Plain experience natural water level fluctuations and provide uncommon freshwater habitats for aquatic plants and insects with their acidic waters and sandy, cobble, or mucky pond bottoms. Higgins and Eel Ponds are examples of such ponds that have little or no development in their riparian areas and are removed from cranberry agriculture. Although protected within Nickerson State Forest, the habitats in Higgins and Eel Ponds may be threatened by water level drawdowns due to wells in the region.

Core Habitat LW346

Ponds on the Atlantic Coastal Plain experience natural water level fluctuations and provide uncommon freshwater habitats for aquatic plants and insects with their acidic waters and sandy, cobble, or mucky pond bottoms. Little Cliff Pond is one of the few such ponds that has little or no development in its riparian areas and is removed from cranberry agriculture. Its sandy pond bottom supports a population of the Endangered Acadian Quillwort, a primitive, submerged freshwater plant, which is so-named for its spiky, quill-like leaves rising from its base. Although protected within Nickerson State Forest, the habitats in Little Cliff Pond and its associated peripheral ponds may still be threatened by water level drawdowns due to wells in the region.

Core Habitat LW347

Ponds on the Atlantic Coastal Plain experience natural water level fluctuations and provide uncommon freshwater habitats for aquatic plants and insects with their acidic waters and sandy, cobble, or mucky pond bottoms. Cliff Pond is one of the few such ponds that has little or no development in its riparian areas and is removed from cranberry agriculture. Although protected within Nickerson State Forest, the habitats in Cliff Pond and its associated peripheral ponds may still be threatened by water level drawdowns due to wells in the region.

Core Habitat LW348

Ponds on the Atlantic Coastal Plain experience natural water level fluctuations and provide uncommon freshwater habitats for aquatic plants and insects with their acidic waters and sandy, cobble, or mucky pond bottoms. Ruth Pond is one of the few such ponds that has little or no development in its riparian areas and is removed from cranberry agriculture. Although protected within Nickerson State Forest, the habitats in Ruth Pond and its associated peripheral pond may be threatened by water level drawdowns due to wells in the region.

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Diamondback Terrapin

Malaclemys terrapin

State Status: **Threatened**
Federal Status: None

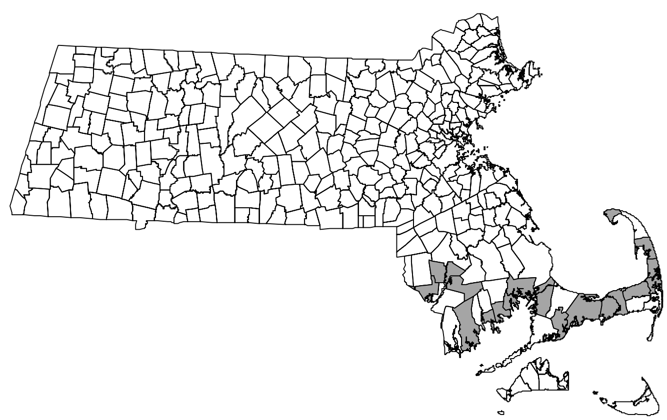
Photo by Bill Byrne

DESCRIPTION: The Diamondback Terrapin is a medium-sized salt marsh turtle. It has a wedge shaped carapace (top shell) variably colored in ash grays, light browns, greens and blacks. It has concentric ring patterns on the carapace and a pronounced ridged or bumpy mid-line keel. Both sexes have grayish to black skin, spotted with dark green flecks and light colored upper and lower jaw. This turtle has very large, paddle like hind feet that are strongly webbed. Sexual size dimorphism is prominent in this species. Adult females are considerably larger than males ranging from 15-23 cm (6-9 in.) in length, while males are 10-15 cm (4-6 in.). Hatchlings look like adults and are about 2.6 cm (1 in.) long.

SIMILAR SPECIES: There are no other brackish water species in Massachusetts. This is the most distinctive turtle in both appearance and its habitat use. It is not likely to be confused with any other turtle species resident within the Commonwealth. Occasionally casual observers may report Diamondback Terrapins as "sea turtle" sightings.

HABITAT IN MASSACHUSETTS: Diamondback Terrapins inhabit marshes which border quiet salt or brackish tidal waters. They can also be found in mud flats, shallow bays, coves, and tidal estuaries. Adjacent sandy dry upland areas are required for nesting.

RANGE: The Diamondback Terrapin (*Malaclemys terrapin terrapin*) is found along the Atlantic coast from Massachusetts south to Florida and along the Gulf coast from the Carolinas to Texas.



Distribution in Massachusetts
1980 - 2006
Based on records in Natural Heritage Database

LIFE CYCLE & BEHAVIOR: Diamondback Terrapins overwinter in the bottom of estuaries, creeks and salt marsh channels. In late spring, males and females gather to create mating aggregations in small, quiet coves along the coast. Salt marshes are critical wintering, foraging, and nursery areas. Egg-carrying females will make the journey upland and sometimes inland as much as a 0.4 km (1/4 mile) to lay eggs. Except when basking, males spend their time in water; females venture onto land normally twice a year for nesting, once in early June and once in July. Females travel from water's edge to nesting habitat usually at high tide to reach sites above the high water line. Hatchlings and juveniles are thought to hide out among the grasses in brackish water marshes.

Diamondback Terrapins feed on crabs, mollusks, crustaceans, insects, fish, and carrion. They forage in the water.

The Diamondback Terrapin is polygamous (each individual may breed with several others) and mates in the water. Females are capable of retaining viable spermatozoa for up to 4 years without subsequent matings. Females become sexually mature at 8 to 10 years of age (males mature earlier) and are known to live to 40, but this is likely to be an underestimation of longevity. A single female may lay 1-3 nests per year. The female digs a nest about 10-20 cm (4-8 in.) deep and then deposits a clutch of approximately 12 eggs. Most females exhibit nest site fidelity, where they return to the same nesting location year after year.

On Cape Cod, Diamondback Terrapins have been observed nesting during both day and night and on both vegetated and unvegetated uplands; in contrast, southern populations have reported nesting only during the day and only on vegetated dunes. Eggs laid in unvegetated areas, although more susceptible to wind erosion, receive more heat thereby decreasing incubation time. Diamondback Terrapins have temperature dependant sex determination; eggs will develop into males if temperatures are below 28º C (82º F) and at temperatures above 30ºC (86ºF) females will develop. At temperatures ranging from 28-30 ºC (82-86ºF), there will be a mixture of males and females.

Incubation of eggs in Massachusetts lasts between 59 and 116 days depending on temperature. It may take from 2 to 11 days after the eggs hatch for the young turtles to emerge and start the hazardous trip from the nest to the water. Part of this time may be spent rotating towards the sun in what is thought to be an orientation behavior. When the climate is unseasonably cold, some hatchlings may overwinter in their nests waiting until the following May to erupt from the sand.

ACTIVE PERIOD

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

THREATS: Diamondback Terrapin population declines have been documented in many areas with a number of factors contributing to these declines. This species was nearly wiped out by gourmet consumption around the turn of the 20^{th} century. Today, the harvest of Diamondback Terrapins is illegal in Massachusetts. However, other human activities continue to threaten this species.

Reduction of salt marsh habitat and alteration of water composition due to ditching, dredging and channelization, loss of sandy nesting habitats, and destruction of dune areas continue to contribute to the decline of the Diamondback Terrapin in Massachusetts. "Armoring" and sea-walling coasts thwart Diamondback Terrapin access to upland nesting areas.

One of the Diamondback Terrapins healthiest populations in Massachusetts is located on Cape Cod. Today this area is also heavily used for recreational activities. Human activity may disrupt nesting turtles and hatchlings. Off road vehicles increase the chances of disturbing, injuring or killing nesting females, crushing nests, and killing migrating hatchlings. When interrupted, females will abort nesting attempts which may have taken hours.

Additional causes of mortality are pollution and roads, as well as predation of eggs and hatchlings by predators whose unnaturally high populations are encouraged by high human densities. As air breathers, Diamondback Terrapins get trapped and drown in improperly discarded "ghost" netting, as well as by-catch in estuarine crab traps. Nesting females often must cross roads to get to appropriate nesting habitat.

MANAGEMENT RECOMMENDATIONS: Diamondback Terrapin habitat needs to be targeted for protection and management. NHESP records can be used to assess and prioritize areas based on the extent, quality, and juxtaposition of habitats and their predicted ability to support self-sustaining populations of Diamondback Terrapins. Given limited conservation funds, alternatives to outright purchase of conservation land for nesting habitat is an important component to the conservation strategy. These can include Conservation Restrictions (CRs) and Agricultural Preservation Restrictions (APRs). Another method of protecting large blocks of land is allowing the building of small or clustered roadside developments in conjunction with protecting large areas of unimpacted land.

Habitat management and restoration guidelines should be developed and implemented in order to create and/or maintain consistent access to nesting habitat at key sites. This is most practical on state-owned conservation lands (i.e. DFW, DCR). However, educational materials should be made available to guide private land-owners on the best management practices for Diamondback Terrapin habitat.

Alternative wildlife corridor structures should be considered at strategic sites on existing roads. In particular, appropriate wildlife corridor structures should be considered for bridge and culvert upgrade and road-widening projects within Diamondback Terrapin habitat. Efforts should be made to inform Mass Highways of key locations where these measures would be most effective for turtle conservation.

Educational materials need to be developed and distributed to the general public in reference to the detrimental affects of keeping native Diamondback Terrapins as pets, which is illegal in Massachusetts. Of equal concern is the release of pet store turtles (which could spread disease), leaving cats and dogs outdoors unattended (particularly during the nesting season), mowing of fields and shrubby areas, feeding suburban wildlife (which increases the numbers of natural predators to turtles), and driving ATVs in nesting areas from June-October. People can be encouraged, when safe to do so, to help Diamondback Terrapins cross roads (always in the direction the animal was heading); however turtles should never be transported to “better” locations. They will naturally want to return to their original habitat and likely need to traverse roads to do so.

Increased law enforcement is needed to protect our wild turtles, particularly during the nesting season when poaching is most frequent and ATV use is common and most damaging.

Diamondback Terrapins are an extremely elusive, non-migratory species. They can be easily extirpated by the unintended consequences of human activities before they are even identified as being present. Coastal residents are often surprised to learn their abutting estuary hosts a Diamondback Terrapin population.

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Brennessel, B. 2007. The Northern Diamondback Terrapin Habitat, Management and Conservation. Wheaton College, Norton, MA.

Lewis, D. 2002. Diamondback Terrapin Summary for Outer Cape Cod. Report to NHESP. Westborough, MA.

Updated: 2007

Midland Clubtail Dragonfly

Gomphus fraternus

State Status: **Endangered**
Federal Status: None

Natural Heritage & Endangered Species Program
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DESCRIPTION: The Midland Clubtail is a large, semi-aquatic insect in the order Odonata, suborder Anisoptera (the dragonflies). They are members of the family Gomphidae (the clubtails), a large, diverse group comprising nearly 100 species in North America. Clubtails are named for the lateral swelling at the tip of the abdomen (the seventh through ninth segments) that produces a club-like appearance. The extent of this swelling varies greatly, from extreme to non-existent, depending upon the species. The club is generally more pronounced in males. The purpose of the club is uncertain, but it may be used for displays, or it may serve an aerodynamic function. Clubtails are further distinguished from other dragonflies by their widely separated eyes, characteristics of their wing venation, and behavior. Many species are very elusive and are thus poorly known.

The Midland Clubtail is in the subgenus *Gomphurus*, a group of medium- to large-sized dragonflies characterized by having the broadest clubs of any of the Gomphidae. Midland Clubtails are dark brown dragonflies with pale yellow to greenish markings on the body and bright green eyes. The top of the thorax is marked with thick, pale stripes that form a rearward-facing U pattern. There are broad, pale, lateral stripes on the sides of the thorax. The pale thoracic markings are bright yellow in immatures but darken to a dull grayish-green in mature individuals. The dark abdomen has thin, yellow markings on the tops of segments one through eight, and yellow patches on the sides of the club. The face is plain, dull yellowish and the legs are blackish. The sexes are similar in appearance, though the females have thicker abdomens and a less developed, though still prominent, club.

Adult Midland Clubtails range in length from 1.9 to 2.1 inches (48 mm - 54 mm), with a wingspan averaging 2.7 inches (68 mm). The fully developed nymphs average about 1.2 inches in length (29 mm - 31.5 mm).

SIMILAR SPECIES: The Midland Clubtail is one of three species in the subgenus *Gomphurus* in Massachusetts. The other two, the Cobra Clubtail (*Gomphus vastus*) and Skillet Clubtail (*G. ventricosus*), are very similar in appearance. As in most clubtails, the shape of the male terminal appendages and hamules (located on the underside of the second abdominal segment) and the female vulvar lamina (located on the underside of the eighth and ninth abdominal segments) provide the most reliable means for identification. Midland Clubtails are the largest of the three *Gomphurus* species in the state, but have the narrowest club. They also have a small, yellow, triangular spot on the top of the eighth abdominal segment; Cobra Clubtails and Skillet Clubtails are entirely black on the top of the eighth segment. The Midland Clubtail has a plain yellow face, without the black cross-striping present on the Cobra Clubtail.

The nymphs can be distinguished by characteristics of the palpal lobes on the labium, as per the keys in Walker (1958), Soltesz (1996), and Needham *et al.* (2000).

HABITAT: Midland Clubtails inhabit medium to large-sized rivers and large, wind-swept lakes. They are only known from the Connecticut River in Massachusetts.

LIFE-HISTORY/BEHAVIOR: The recorded flight season extends from late May into mid-July. There are two main life stages, the aquatic nymph and flying adult. The nymphs spend at least a year, possibly more, maturing, undergoing several molts during this period. They burrow shallowly into the substrate and are voracious predators, feeding upon a variety of aquatic life. When ready to emerge from the water as the adult, the nymphs crawl out onto exposed rocks, emergent vegetation, partially submerged logs, or the steeper sections of river banks, where they emerge from the nymphal exoskeleton as adults (a process known as "eclosion"). Emergence generally takes place very early in the morning, presumably to reduce exposure to predation.

MIDLAND CLUBTAIL FLIGHT PERIOD

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

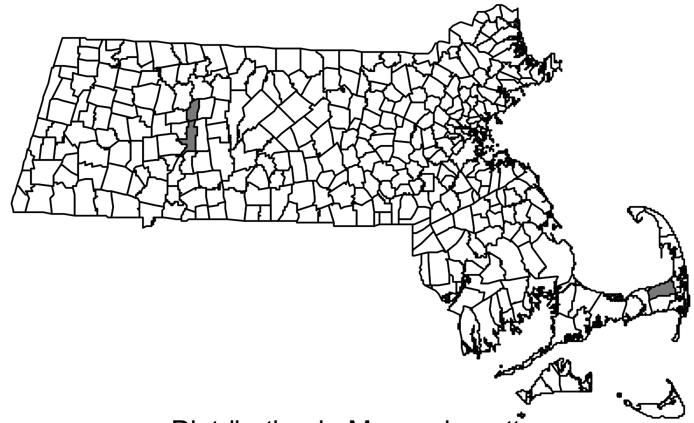
As soon as the freshly emerged (teneral) adults are dry and the wings have hardened sufficiently, they fly off to seek refuge in the vegetation of adjacent uplands, leaving their larval exoskeletons behind. These cast exoskeletons, known as exuviae, are identifiable to species and provide a reliable, useful means of determining the presence of a species. The immature dragonflies spend several days or more feeding and maturing in upland areas, before returning to their breeding habitats. Adult clubtails feed on aerial insects which they capture in short sallies from their perches.

When mature, the males return to the water where they can be found resting on sandy stretches of shoreline, or perched on overhanging vegetation. They periodically make flights out over the water, particularly over rapids and riffles, presumably to search for females. Females generally appear at water only for a brief period when they are ready to mate and lay eggs. When a male encounters a female, he attempts to grasp the back of her head with claspers located on the end of his abdomen. If the female is receptive, she allows the male to grasp her, then curls the tip of her abdomen upward to connect with the male secondary sexual organs located on the underside of the second abdominal segment, thus forming the familiar heart-shaped "wheel" typical of all Odonata - the male above, the female upside down underneath. In this position, the pair flies off to mate, generally hidden high in nearby trees where they are less vulnerable to predators. The duration of mating in Midland Clubtails has not been recorded, but in similar-sized odonates can range from several minutes to an hour or more.

Females oviposit by flying low over the water, periodically striking the surface with the tips of the abdomen to wash off the eggs. They seem to prefer the more turbulent areas of rivers and lakes for oviposition. It is not known how long the eggs of Midland Clubtails take to develop.

RANGE: Midland Clubtails range throughout northeastern North America from Maine, Quebec, Ontario, and Manitoba south to North Carolina, Tennessee and Missouri. In New England, the species has been recorded from Maine and from the Connecticut River in New Hampshire, Massachusetts, and Connecticut.

POPULATION STATUS IN MASSACHUSETTS: The Midland Clubtail is listed as an Endangered Species in Massachusetts. As with all species listed in Massachusetts, individuals of the species are protected from take (picking, collecting, killing, etc…) and sale under the Massachusetts Endangered Species Act. Midland Clubtails have been recorded a handful of times in Massachusetts along the Connecticut River. The species also has been found along the Connecticut River just south of the Massachusetts border in Connecticut. Further field work along the river, particularly those areas where the flow is swifter and riffles occur, will likely provide additional Massachusetts records. Whether the species inhabits other river systems in the state remains to be determined. A teneral female reportedly collected on Cape Cod in Brewster seems incongruous and requires confirmation.



Distribution in Massachusetts
1977 - 2002
Based on records in Natural Heritage Database

MANAGEMENT RECOMMENDATIONS: As for many rare species, the exact management needs of Midland Clubtails are not known. With most odonates water quality is critical to their well-being, and Midland Clubtails are undoubtedly no exception. Potential threats to the water quality of the Connecticut River include industrial and agricultural pollution, sewage overflow, salt and other road contaminant run-off, and siltation from construction or erosion. The impact of the disruption of natural flooding regimes by damming and water diversion projects on Midland Clubtails and other riverine species is unknown but may be considerable. Extensive use of the river by power boats and jet skis is a serious concern, particularly during the early summer emergence period of Midland Clubtails (as well as several other clubtail species). Many species of clubtails, as well as other riverine odonates, eclose low over the water surface on exposed rocks, emergent or floating vegetation, or steep sections of the river bank where they are imperiled by the wakes of high speed watercraft. Low-level recreational use from fisherman and canoeists probably has little impact on odonate populations, but should be monitored. The upland borders of these river systems are also crucial to the well-being of odonate populations as they are critical for feeding, resting, and maturation, particularly for the teneral adults. Development of these areas should be discouraged, and the preservation of remaining undeveloped upland should be a top priority.

REFERENCES:

Dunkle, S. W. 2000. Dragonflies Through Binoculars. Oxford University Press.
Needham, J. G., M. J. Westfall, Jr., and M. L. May. 2000. Dragonflies of North America. Scientific Publishers.
Nikula, B., J. L. Loose, and M. R. Burne. 2003. A Field Guide to the Dragonflies and Damselflies of Massachusetts. Massachusetts Natural Heritage and Endangered Species Program.
Soltesz, K. 1996. Identification Keys to Northeastern Anisoptera Larvae. Center for Conservation and Biodiversity, University of Connecticut.
Walker, E. M. 1958. The Odonata of Canada and Alaska, Vol. II. University of Toronto Press.

Updated May 2003

Natural Heritage
& Endangered Species
Program
Massachusetts Division of Fisheries & Wildlife
Route 135, Westborough, MA 01581
tel: (508) 792-7270, ext. 200; fax: (508) 792-7821
www.state.ma.us/dfwele/dfw/nhesp

Pine Barrens Bluet Damselfly

Enallagma recurvatum

State Status: **Threatened**
Federal Status: None

DESCRIPTION OF ADULT: The Pine Barrens Bluet is a small, semi-aquatic insect of the order Odonata, suborder Zygoptera (the damselflies), and family Coenagrionidae (pond damsels). Like most damselflies, Pine Barrens Bluets have large eyes on the sides of the head, short antennae, and four heavily veined wings that are held folded together over the back. The male's thorax (winged and legged section behind the head) is mostly blue with black stripes on the "shoulders" and top. The Pine Barrens Bluet has a long, slender abdomen, which is composed of ten segments. The abdominal segments are blue with an increasing amount of black distally through segment 7. Segments 8 and 9 are entirely blue, except segment 8 has a small horizontal black dash on each side of the segment. This mark can sometimes be absent. The top of segment 10 is black. Females have thicker abdomens than the males, and are generally brown where the males are blue, though older females may become quite bluish.

Pine Barrens Bluets average just over one inch (26mm to 29mm) in length.

SIMILAR SPECIES: The bluets (genus *Enallagma*) comprise a large group of damselflies, with no less than 20 species in Massachusetts. Identification of the various species can be very difficult and often requires close examination of the terminal appendages on the males (Nikula *et al.* 2003) or the mesostigmal plates (located behind the head) on the females (Westfall and May 1996). The Pine Barrens Bluet is most similar in appearance to the New England Bluet (*E. laterale*), a species of Special Concern in Massachusetts. Both are found at several of their known locations. The two species are most safely distinguished by the shape of the terminal appendages on the male and the mesostigmal plates of the females. The black dash on the sides of segment 8 is generally larger in the New England Bluet, however this feature is highly variable and should not be used for definitive identification.

HABITAT: Pine Barrens Bluets are regional endemics and appear to be restricted to coastal plain ponds. Their range coincides closely with the distribution of those ponds. Some of the common attributes shared by ponds inhabited by the Pine Barrens Bluet include: sandy shallow shores; large amounts of vegetation close to the shore, especially Military Rush (*Juncus militarus*); and yearly natural fluctuations in water levels. The nymphs are aquatic and live among aquatic vegetation and debris. The adults inhabit nearby uplands and emergent vegetation along the shore.

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LIFE-HISTORY/BEHAVIOR: The flight season of the Pine Barrens Bluet is generally restricted to the month of June, with emergence generally occurring during the last week of May. Adults are rarely seen after June. Although little has been published specifically on the life history of the Pine Barrens Bluet, it is likely similar to other, better-studied species in the genus. All odonates have three life stages: egg, aquatic nymph, and flying adult. The nymphs are slender with three leaf-like appendages extending from the end of the body which serve as breathing gills. They have a large, hinged lower jaw which they are able to extend forward with lightning speed. This feature is used to catch prey, the nymph typically lying in wait until potential prey passes within striking range. They feed on a wide variety of aquatic life, including insects and worms. They spend most of their time clinging to submerged vegetation or other objects, moving infrequently. They transport themselves primarily by walking, but are also capable of swimming with a sinuous, snake-like motion.

PINE BARRENS BLUET FLIGHT PERIOD

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Natural Heritage
& Endangered Species
Program
Massachusetts Division of Fisheries & Wildlife
Route 135, Westborough, MA 01581
tel: (508) 792-7270, ext. 200; fax: (508) 792-7821
www.state.ma.us/dfwele/dfw/nhesp

Scarlet Bluet Damselfly

Enallagma pictum

State Status: **Threatened**
Federal Status: None


© Blair Nikula

DESCRIPTION OF ADULT: The Scarlet Bluet is a small, semi-aquatic insect of the order Odonata, suborder Zygoptera (the damselflies), and family Coenagrionidae (pond damsels). Like most damselflies, Scarlet Bluets have large eyes on the sides of the head, short antennae, and four heavily veined wings that are held folded together over the back. The eyes are red with a small red spot behind each eye on the back of the head, which is black. The spots are connected by a thin red bar. The Scarlet Bluet has a long, slender abdomen, composed of ten segments. The abdominal segments are orange below and black above. The male's thorax (winged and legged section behind the head) is red with black stripes on the "shoulders" and top. Females are similar in appearance, but have a duller yellow thorax and thicker abdomens than the males.

Scarlet Bluets average just over one inch (26 mm to 29 mm) in length.

SIMILAR SPECIES: The Bluets (genus *Enallagma*) comprise a large group of damselflies, with no fewer than 20 species in Massachusetts. However, this is the only red Bluet in the Northeast; the majority of bluets are blue, with the exception of one yellow, one orange, and one red species. The Eastern Red Damsel (*Amphiagrion saucium*) is also red, but is smaller, and the abdomen is entirely red, unlike the Scarlet Bluet, whose abdomen is black above and orange below. The Orange Bluet (*E. signatum*) is also similar, but not as red, and the second to last abdominal segment is entirely orange, unlike the Scarlet Bluet, which is black above and orange below. The Vesper Bluet (*E. vesperum*) bears some resemblance, but is more yellow overall and the tip of the abdomen is blue.

HABITAT: Scarlet Bluets are found in acidic, sandy ponds (including coastal plain ponds) with floating vegetation, often with water lilies (*Nuphar* and *Nymphaea*). Nymphs are aquatic and live among the aquatic vegetation. Adults spend much of their time flying out over the water, alighting on lily pads. Before they are sexually mature, the adults inhabit nearby uplands.

LIFE-HISTORY/BEHAVIOR: The flight season of the Scarlet Bluet lasts from late June through August.

Although little has been published on the life history of the Scarlet Bluet, it is likely similar to other, better-studied species in the genus. All odonates have three life stages: the egg, the aquatic nymph, and flying adult. The nymphs are slender with three leaf-like appendages extending from the end of the body which serve as breathing gills. They have a large, hinged lower jaw which they are able to extend forward with lightning speed. This feature is used to catch prey, the nymph typically lying in wait until potential prey passes within striking range. They feed on a wide variety of aquatic life, including insects and worms. They spend most of their time clinging to submerged vegetation or other objects, moving infrequently. They transport themselves primarily by walking, but are also capable of swimming with a sinuous, snake-like motion.

Scarlet Bluets have a one-year life cycle. The eggs are laid during the early summer and probably hatch in the fall. The nymphs develop over the winter and spring, undergoing several molts. In early to mid-summer the nymphs crawl up on emergent vegetation and begin their transformation into adults.

SCARLET BLUET FLIGHT PERIOD

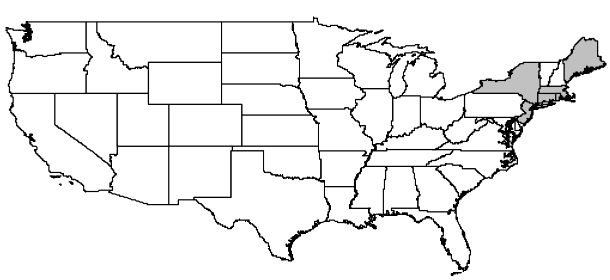
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

This process, known as emergence, typically takes a couple of hours, after which the newly emerged adults (tenerals) fly weakly off to upland areas where they spend a week or two feeding and maturing. The young adults are very susceptible to predators, particularly ants and spiders during emergence, and birds during the teneral stage. Mortality is high during these periods. The adults feed on a wide variety of smaller insects.

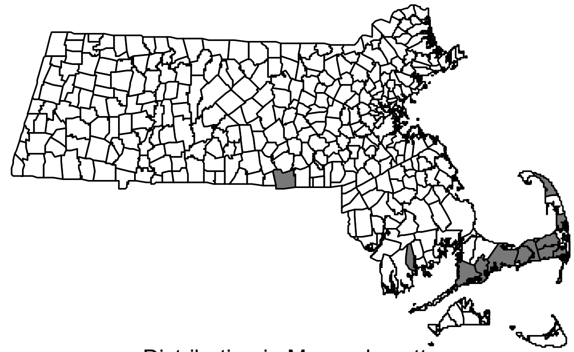
When mature, adults return to the wetlands. When they locate a female, the male attempts to grasp her behind the head with the terminal appendages at the end of his abdomen. If the female is receptive, she allows the male to grasp her, then curls the end of her abdomen up to the base of the male's abdomen where his secondary sexual organs ("hamules") are located. This coupling results in the heart-shaped tandem formation characteristic of all odonates. This coupling lasts for a few minutes to an hour or more. The pair generally remains stationary during this mating but, amazingly, can fly, albeit weakly, while coupled.

Once mating is complete, the female begins laying eggs (ovipositing) in aquatic vegetation, including the underside of lily pads, using the ovipositor on the underside of her abdomen to slice into the vegetation and deposit eggs. Although the female occasionally oviposits alone, in most cases the male remains attached to the back of the females head. This form of mate-guarding is thought to prevent other males from mating with the female before she completes egg-laying. The adult's activities are almost exclusively limited to feeding and reproduction, and their life is short, probably averaging only three to four weeks for damselflies like the Scarlet Bluet.

RANGE: The Scarlet Bluet is a regional endemic and has a very small range restricted to scattered locations in the northeastern United States from New Jersey to southern Maine.



Range of Species in US



Distribution in Massachusetts
1977 - 2002
Based on records in Natural Heritage Database

POPULATION STATUS IN MASSACHUSETTS: The Scarlet Bluet is listed as a Threatened Species in Massachusetts. The species is known mainly from southeastern portions of Massachusetts, primarily Barnstable and Plymouth counties. There are also a few records from south-central and possibly northeastern Massachusetts.

MANAGEMENT RECOMMENDATIONS: The major threat to the Scarlet Bluet is degradation and destruction of the wetlands which are its breeding and nymphal habitat. Threats include construction and development, artificial drawdown of pond water-level by groundwater pumping, and run-off from roadways and sewage. In addition, high-impact recreational use such as off road vehicles driving through pond shores, which may destroy breeding and nymphal habitat, and motor boats, whose wakes swamp delicate emerging adults, are threats. Since Scarlet Bluets, like many species of damselflies, spend a period of several days or more away from the pond maturing, it is important to maintain natural upland habitats adjoining the breeding sites for roosting and hunting. Without protected uplands the delicate newly emerged adults are more susceptible to predation and mortality from inclement weather.

REFERENCES:

Nikula, B., J. L. Loose, and M. R. Burne. 2003. A Field Guide to the Dragonflies and Damselflies of Massachusetts. Massachusetts Natural Heritage and Endangered Species Program.

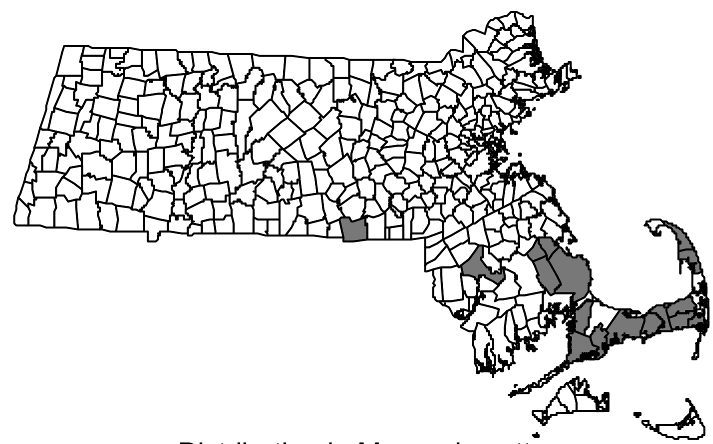
Walker, E. M. 1953. The Odonata of Canada and Alaska, Vol. I. University of Toronto Press.

Westfall, M. J., Jr., and M. L. May. 1996. Damselflies of North America. Scientific Publishers.

Pine Barrens Bluets have a one-year life cycle. The eggs are laid during the early summer and probably hatch in the fall. The nymphs develop over the winter and spring, undergoing several molts. In early to mid-summer the nymphs crawl up on emergent vegetation and begin their transformation into adults. This process, known as emergence, typically takes a couple of hours, after which the newly developed adults (tenerals) fly weakly off to upland areas where they spend a week or two feeding and maturing. The young adults are very susceptible to predators, particularly birds, ants, and spiders; mortality is high during this stage of the life cycle. The adults feed on a wide variety of smaller insects which they typically catch in flight.

When mature, the males return to the wetlands where they spend most of their time searching for females. When they locate a female, the male attempts to grasp her behind the head with the terminal appendages at the end of his abdomen. If the female is receptive, she allows the male to grasp her, then curls the end of her abdomen up to the base of the male's abdomen where his secondary sexual organs ("hamules") are located. This coupling results in the heart-shaped tandem formation characteristic of all odonates. This coupling lasts for a few minutes to an hour or more. The pair generally remains stationary during this mating but, amazingly, can fly, albeit weakly, while coupled.

Once mating is complete, the female begins laying eggs (ovipositing) in emergent grasses and rushes, using the ovipositor located on the underside of her abdomen to slice into the vegetation where the eggs are deposited. Although the female occasionally oviposits alone, in most cases the male remains attached to the back of the females head. This form of mate-guarding is thought to prevent other males from mating with the female before she completes egg-laying. The adult's activities are almost exclusively limited to feeding and reproduction, and their life is short, probably averaging only three to four weeks for damselflies like the Pine Barrens Bluet.

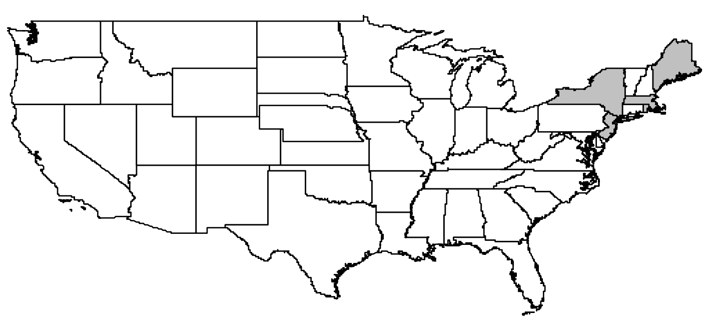


Distribution in Massachusetts
1977 - 2002
Based on records in Natural Heritage Database

RANGE: The Pine Barrens Bluet has a very small range restricted to scattered locations in the northeastern United States. It has been found only in Maine, Massachusetts, Rhode Island, New York and New Jersey.

POPULATION STATUS IN MASSACHUSETTS: The Pine Barrens Bluet is listed as a Threatened Species in Massachusetts. The species is known mainly from southeastern portions of Massachusetts, primarily Barnstable and Plymouth counties. Unlike the closely related New England Bluet, the Pine Barrens Bluet has occasionally been found in large numbers at some locations, though its overall range is more limited.

MANAGEMENT RECOMMENDATIONS: The major threat to the Pine Barrens Bluet is degradation and destruction of the wetlands which are its breeding and nymphal habitat. Threats include construction and development, artificial drawdown of pond water-level by groundwater pumping, and run-off from roadways and sewage. In addition, high-impact recreational use such as off road vehicles driving through pond shores, which may destroy breeding and nymphal habitat, and motor boats, whose wakes swamp delicate emerging adults, are threats. Since Pine Barrens Bluets, like many species of damselflies, spend a period of several days or more away from the pond maturing, it is important to maintain natural upland habitats adjoining the breeding sites for roosting and hunting. Without protected uplands the delicate newly emerged adults are more susceptible to predation and mortality from inclement weather.



Range of Species in US

REFERENCES:

Nikula, B., J. L. Loose, and M. R. Burne. 2003. A Field Guide to the Dragonflies and Damselflies of Massachusetts. Massachusetts Natural Heritage and Endangered Species Program.

Walker, E. M. 1953. The Odonata of Canada and Alaska, Vol. I. University of Toronto Press.

Westfall, M. J. ,Jr., and M. L. May. 1996. Damselflies of North America. Scientific Publishers.

Appendix C. Brewster Airspace Review

AVIATION SYSTEMS INC.

Date: NOV 28 2006

To: Aaron Bouchane
Massachusetts Tech Collaborative
75 North Drive
Westborough, MA 01581

ASI #: 06-N-0448.005
Client Site ID: Brewster
FAA #:

We are sending you herewith the following via:

☑ **US Mail** ☐ **Overnight** ☐ **Fax** ☑ **Email** ☐ **2nd Day**

☑ ASI FAR Part 77 Airspace Obstruction Report
☐ Search Area Study Report
☐ Copies of our filing(s) with FAA and/or State
☐ Responses from FAA and/or State
☐ ASI Opinion Letter
☑ Quad Chart
☑ See attachments for Airport Runway data and/or AM Stations(s)
☐ Certified Survey

Comments:

Sincerely,

Aviation Systems, Inc.

By:

2510 W. 237th Street • Suite 210 • Torrance, CA 90505
Tel: 310.530.3188 • Fax: 310.530.3850 • email: asi@aviationsystems.com • www.aviationsystems.com

AVIATION SYSTEMS, INC.
Phone: 310-530-3188 Fax: 310-530-3850
crisj@aviationsystems.com
www.aviationsystems.com

FAR PART 77 AIRSPACE OBSTRUCTION REPORT

To:
Aaron Bouchane
Massachusetts Tech Collaborative
75 North Drive
Westborough, MA 01581

Date: November 22, 2006

Location: South Brewster, MA
Client Case No: Brewster
ASI Case No: 06-N-0448.005

SUMMARY OF FINDINGS:

At this location any structure over 200 feet AGL will have to be filed with the FAA. A structure up to 232 feet AGL should receive a routine approval. A structure from 232 to 397 feet AGL should be approvable but require extended study. Refer to Findings and Comment Section for additional information.

SITE DATA:

Structure: Wind Turbine

Coordinates: 41°-44'-09.20" / 070°-01'-41.30" **[NAD 27]**
41°-44'-09.60" / 070°-01'-39.36" **[NAD 83]**

Site Ground Elevation: 112 ' **[AMSL]**
Studied Structure Height (with Appurtenances): 397 ' **[AGL]**
Total Overall Height: 509 ' **[AMSL]**

SEARCH RESULTS:

- The nearest public use or military air facility subject to FAR Part 77 is Chatham Muni Airport.
- The studied structure is located 3.27 NM / 19,883 feet NorthWest (325 ° True) of the Chatham Muni Airport Runway 24.
- Other public or private airports or heliports within 3 NM: ☑ None ☐ Printout attached
- AM radio station(s) within 3NM: ☐ None ☑ Printout attached

Highlighted AM stations on printout require notice under FCC Rules and Policy (Ref.: 47 CFR 73.1692).

FINDINGS

- **FAA Notice (Ref.: FAR 77.13 (a)(1); FAR 77.13 (a)(2) i, ii,iii):**
  - ☐ Not required at studied height.
  - ☑ Required at studied height.
  - ☑ The No Notice Maximum height is 200 feet AGL.

  IMPORTANT: Our report is intended as a planning tool. If notice is required, actual site construction activities are not advisable until an FAA Final Determination of No Hazard is issued.

- **Obstruction Standards of FAR Part 77 (Ref.: FAR 77.23 (a)(1),(2),(3),(4),(5)):**
  - ☐ Not exceeded at studied height.
  - ☑ Exceeded at studied height and Extended Study may be required.
  - ☑ Maximum nonexceedance height is 232 feet AGL.

- **Marking and Lighting (Ref.: AC 70/7460-1K, Change 1):**
  - ☐ Will not be required.
  - ☑ Will be required at studied height, if structure exceeds:
    - ☑ 200 feet AGL
    - ☐ Obstruction Standard

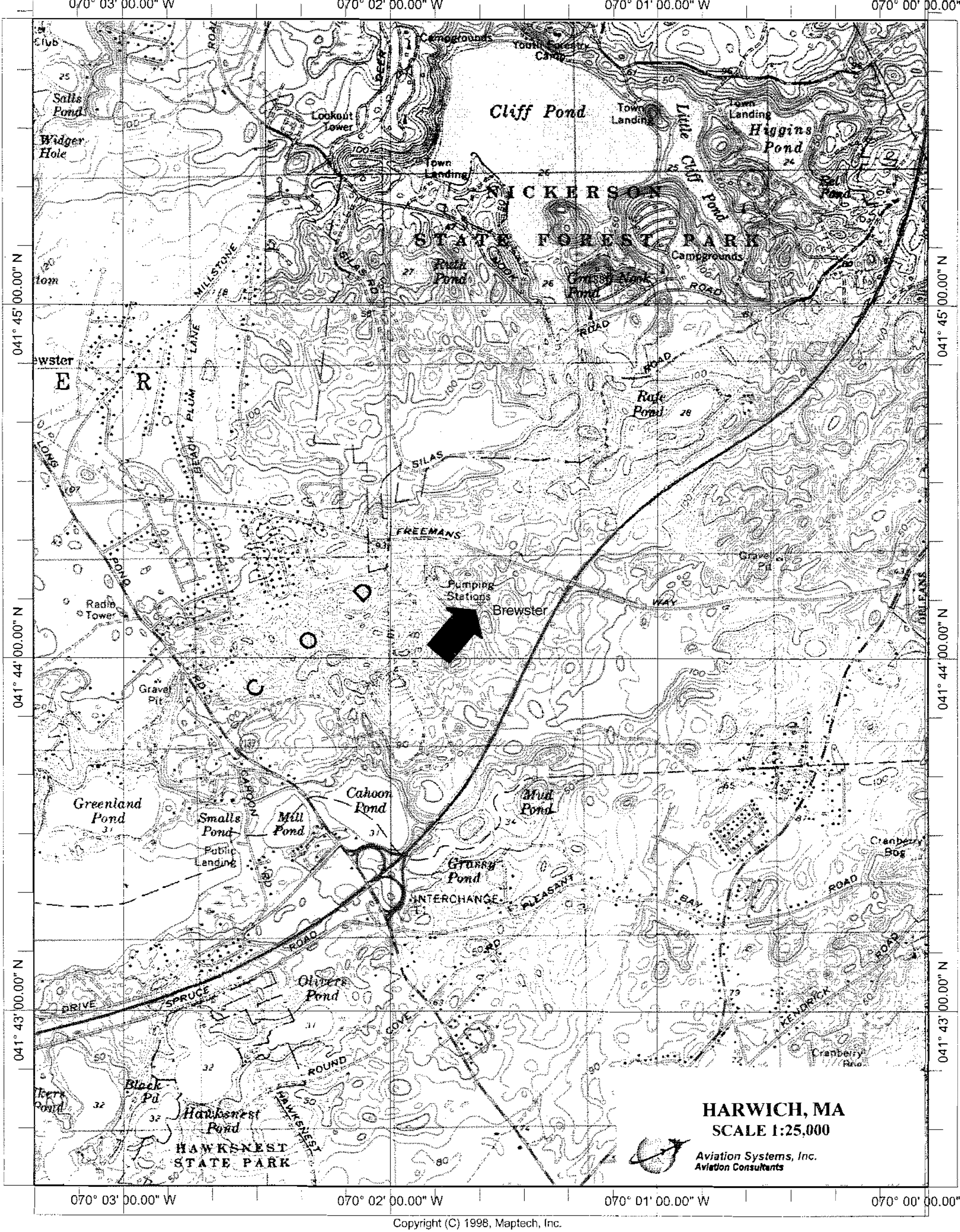
- **Operational Procedures (Ref.: FAR 77.23 (a)(3), (4); FAA Order 7400.2; FAA Order 8260.3B):**
  - ☑ Not affected at studied height (FAA should issue a Determination of No Hazard.)
  - ☐ Affected at studied height and the FAA will consider the studied structure to be a hazard to air navigation.
  - ☐ Maximum height that would not affect operational procedures is ____ feet AMSL.

Conclusions/Comments

- The North TRURO Joint Use Long Range Radar site is within 60 NM (57.28 NM) of the site.
- The Air Force has published a memo establishing the following policy: "The DOD/DHS Long Range Joint Program Office Interim Policy is to contest any establishment of windmill farms within radar line of site of the National Air Defense and Homeland Security Radars." Therefore, the FAA may object to this proposal, until an individual assessment is performed.
- The FAA may apply CAT D Traffic Pattern criteria to this site which would limit the structure to 306 feet AGL. We expect that CAT C criteria will be applied due to the short length of the Chatham Muni runway (3000 feet).

Actions:

ASI will file with FAA Region and State ☐ Yes ☑ No



070° 03' 00.00" W
070° 02' 00.00" W
070° 01' 00.00" W
070° 00' 00.00" W
041° 45' 00.00" N
041° 44' 00.00" N
041° 43' 00.00" N
Cliff Pond
Little Cliff Pond
Higgins Pond
NICKERSON STATE FOREST PARK
Campgrounds
Town Landing
Lookout Tower
Salls Pond
Widger Hole
Ruth Pond
Rafe Pond
Pumping Stations
Brewster
Radio Tower
Gravel Pit
CAPE COD
FREEMANS WAY
Greenland Pond
Smalls Pond
Mill Pond
Cahoon Pond
Mud Pond
Grassy Pond
Public Landing
INTERCHANGE
Olivers Pond
Black Pd
Hawksnest Pond
HAWKSNEST STATE PARK
Cranberry Bog
HARWICH, MA
SCALE 1:25,000
Aviation Systems, Inc.
Aviation Consultants

AM Stations

Search Latitude: 41-44-09 **Search Radius:** 3

Search Longitude: 070-01-41 **Height (MSL):**

Freq	Call Sign	State	City	Latitude	Longitude	Power KW	Domestic Status	Hours Of Oper	Antenna Mode	Complete Schedule	Last Update	Distance NM	Distance Feet	Bear
1170	WFPB	MA	ORLEANS	41-46-48N	070-00-36W	100	L	D	DAD	D		2.77	16,834	16.98

Federal Aviation Administration
Air Traffic Airspace Branch, ASW-520
2601 Meacham Blvd.
Fort Worth, TX 76137-0520

Aeronautical Study No.
2008-ANE-402-OE

Issued Date: 06/15/2008

Nils Bolgen
Massachusetts Technology Collaborative
75 North Drive
Westborough, MA 01581

**** DETERMINATION OF NO HAZARD TO AIR NAVIGATION ****

The Federal Aviation Administration has conducted an aeronautical study under the provisions of 49 U.S.C., Section 44718 and if applicable Title 14 of the Code of Federal Regulations, part 77, concerning:

Structure:	Wind Turbine South Pumping Station Site
Location:	Brewster, MA
Latitude:	41-44-01.37N NAD 83
Longitude:	70-01-37.93W
Heights:	443 feet above ground level (AGL)
	460 feet above mean sea level (AMSL)

This aeronautical study revealed that the structure does not exceed obstruction standards and would not be a hazard to air navigation provided the following condition(s), if any, is(are) met:

As a condition to this Determination, the structure is marked and/or lighted in accordance with FAA Advisory circular 70/7460-1 K Change 2, Obstruction Marking and Lighting, white paint/synchronized red lights - Chapters 4,12&13(Turbines).

It is required that FAA Form 7460-2, Notice of Actual Construction or Alteration, be completed and returned to this office any time the project is abandoned or:

_____ At least 10 days prior to start of construction (7460-2, Part I)
__X__ Within 5 days after the construction reaches its greatest height (7460-2, Part II)

This determination expires on 12/15/2009 unless:

(a) extended, revised or terminated by the issuing office.
(b) the construction is subject to the licensing authority of the Federal Communications Commission (FCC) and an application for a construction permit has been filed, as required by the FCC, within 6 months of the date of this determination. In such case, the determination expires on the date prescribed by the FCC for completion of construction, or the date the FCC denies the application.

NOTE: REQUEST FOR EXTENSION OF THE EFFECTIVE PERIOD OF THIS DETERMINATION MUST BE POSTMARKED OR DELIVERED TO THIS OFFICE AT LEAST 15 DAYS PRIOR TO THE EXPIRATION DATE.

This determination is based, in part, on the foregoing description which includes specific coordinates, heights, frequency(ies) and power. Any changes in coordinates, heights, and frequencies or use of greater power will void this determination. Any future construction or alteration, including increase to heights, power, or the addition of other transmitters, requires separate notice to the FAA.

This determination does include temporary construction equipment such as cranes, derricks, etc., which may be used during actual construction of the structure. However, this equipment shall not exceed the overall heights as indicated above. Equipment which has a height greater than the studied structure requires separate notice to the FAA.

This determination concerns the effect of this structure on the safe and efficient use of navigable airspace by aircraft and does not relieve the sponsor of compliance responsibilities relating to any law, ordinance, or regulation of any Federal, State, or local government body.

A copy of this determination will be forwarded to the Federal Communications Commission if the structure is subject to their licensing authority.

If we can be of further assistance, please contact our office at (770) 909-4329. On any future correspondence concerning this matter, please refer to Aeronautical Study Number 2008-ANE-402-OE.

Signature Control No: 568316-102201707 (DNE)
Michael Blaich
Specialist

Federal Aviation Administration
Air Traffic Airspace Branch, ASW-520
2601 Meacham Blvd.
Fort Worth, TX 76137-0520

Aeronautical Study No.
2008-ANE-401-OE

Issued Date: 06/15/2008

Nils Bolgen
Massachusetts Technology Collaborative
75 North Drive
Westborough, MA 01581

**** DETERMINATION OF NO HAZARD TO AIR NAVIGATION ****

The Federal Aviation Administration has conducted an aeronautical study under the provisions of 49 U.S.C., Section 44718 and if applicable Title 14 of the Code of Federal Regulations, part 77, concerning:

Structure:	Wind Turbine North Pumping Station Site
Location:	Brewster, MA
Latitude:	41-44-09.46N NAD 83
Longitude:	70-01-46.55W
Heights:	443 feet above ground level (AGL) 502 feet above mean sea level (AMSL)

This aeronautical study revealed that the structure does not exceed obstruction standards and would not be a hazard to air navigation provided the following condition(s), if any, is(are) met:

As a condition to this Determination, the structure is marked and/or lighted in accordance with FAA Advisory circular 70/7460-1 K Change 2, Obstruction Marking and Lighting, white paint/synchronized red lights - Chapters 4,12&13(Turbines).

It is required that FAA Form 7460-2, Notice of Actual Construction or Alteration, be completed and returned to this office any time the project is abandoned or:

_____ At least 10 days prior to start of construction (7460-2, Part I)
__X__ Within 5 days after the construction reaches its greatest height (7460-2, Part II)

This determination expires on 12/15/2009 unless:

(a) extended, revised or terminated by the issuing office.
(b) the construction is subject to the licensing authority of the Federal Communications Commission (FCC) and an application for a construction permit has been filed, as required by the FCC, within 6 months of the date of this determination. In such case, the determination expires on the date prescribed by the FCC for completion of construction, or the date the FCC denies the application.

NOTE: REQUEST FOR EXTENSION OF THE EFFECTIVE PERIOD OF THIS DETERMINATION MUST BE POSTMARKED OR DELIVERED TO THIS OFFICE AT LEAST 15 DAYS PRIOR TO THE EXPIRATION DATE.

This determination is based, in part, on the foregoing description which includes specific coordinates, heights, frequency(ies) and power. Any changes in coordinates, heights, and frequencies or use of greater power will void this determination. Any future construction or alteration, including increase to heights, power, or the addition of other transmitters, requires separate notice to the FAA.

This determination does include temporary construction equipment such as cranes, derricks, etc., which may be used during actual construction of the structure. However, this equipment shall not exceed the overall heights as indicated above. Equipment which has a height greater than the studied structure requires separate notice to the FAA.

This determination concerns the effect of this structure on the safe and efficient use of navigable airspace by aircraft and does not relieve the sponsor of compliance responsibilities relating to any law, ordinance, or regulation of any Federal, State, or local government body.

A copy of this determination will be forwarded to the Federal Communications Commission if the structure is subject to their licensing authority.

If we can be of further assistance, please contact our office at (770) 909-4329. On any future correspondence concerning this matter, please refer to Aeronautical Study Number 2008-ANE-401-OE.

Signature Control No: 568315-102201706 (DNE)
Michael Blaich
Specialist

Appendix D. Visual Simulations

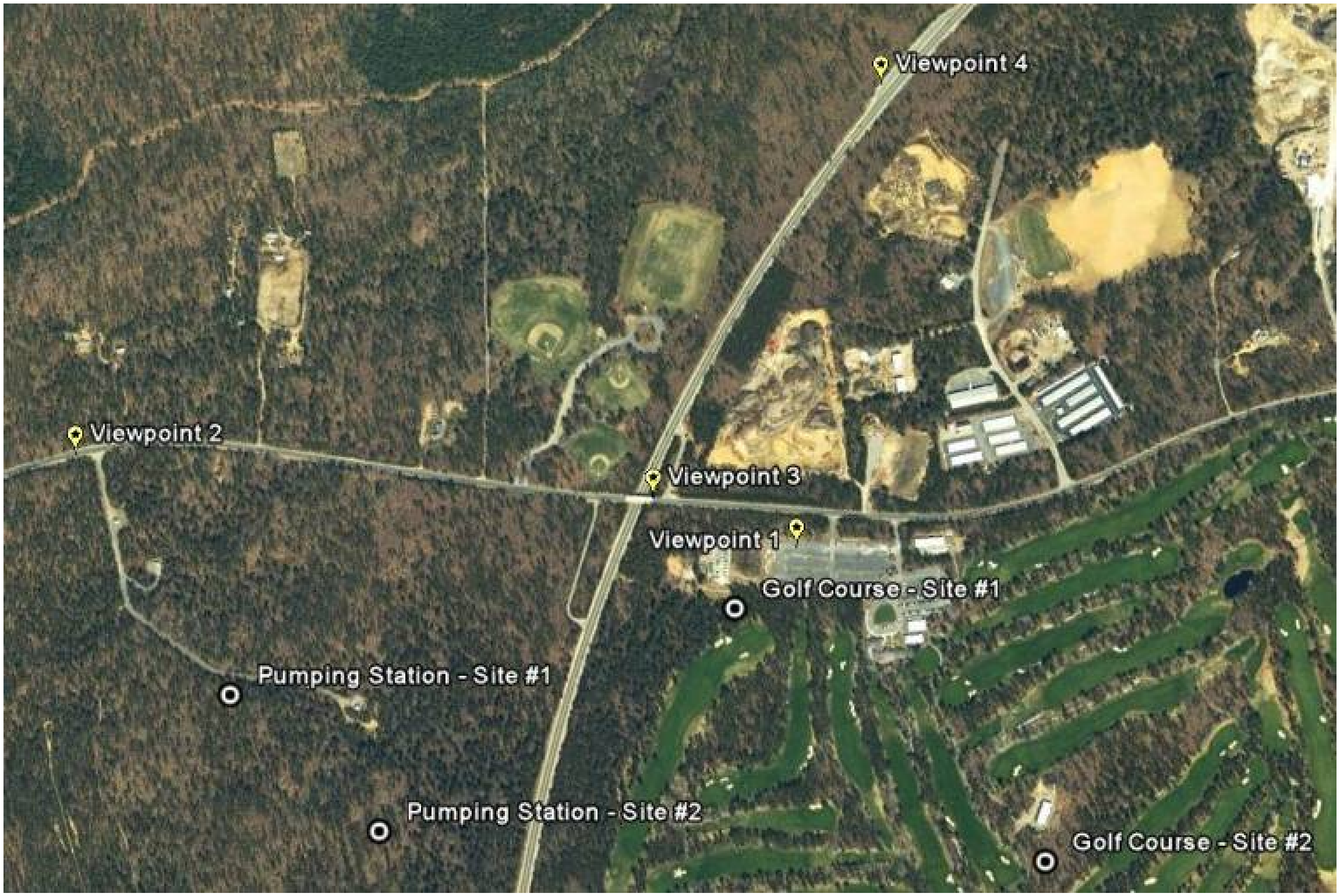


Figure D-1. Overview Map of Visual Simulation Views

Figure D-2. View 1: Large Wind Turbine near Golf Course Site #1

Figure D-3. Viewpoint 4 – Large Wind Turbine at Golf Course Site #1.

Figure D-4. Viewpoint 2 – Large Wind Turbines at Golf Course Sites #1 & #2.

Figure D-5. Viewpoint 8: Pumping Station Wind Turbine Site #2, off Highway 6.

Figure D-6. Viewpoint 1: Pumping Station Turbines Sites #1 and #2

Appendix E. List of Permits

Table E-1
List of Permits

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
FEDERAL						
COE	Section 10 Nationwide Permit	Construction activities in navigable waters of the US.	Construction	No	3 - 4 months	Required for construction in navigable waters of the US. Assume nationwide permit, if COE approval required.
COE	Section 404 Nationwide Permit	Discharge of dredge or fill material into US waters, including jurisdictional wetlands.	Construction	Maybe	3 - 4 months	Required only if wetlands will be filled on site or along off-site utility right-of-way. Assume nationwide permit, if COE approval required.
EPA	SPCC Plan	On site storage of oil > 1,320 gallons.	Construction	Maybe	3 months	Threshold may be exceeded due to construction equipment at site. Exceeding threshold not expected for operational activities.

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Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
FAA	Notice of Proposed Construction or Alteration	Construction of an object which has the potential to affect navigable airspace (height in excess of 200' or within 20,000' of an airport).	Construction	Yes	3 - 4 months	See Section 7.2.1
FERC	Exempt Wholesale Generator (EWG) Status	Selling electric energy at wholesale to a utility or other generator.	Construction	No	3 - 4 months	Assume no electricity will be sold to the grid.
FERC	Qualifying Facility Certification	Qualification for PURPA benefits for small power production facility using renewable resources < 80 MW.	Construction	No	Formal certification, 3 - 5 months. Self-certification, upon filing.	Assume no electricity will be sold to the grid.
EPA	NPDES Stormwater Construction General Permit	Discharge of stormwater from construction sites disturbing > 1 acre.	Construction	No	9 - 12 months	Requires joint approval with MDEP. Project will disturb < 1 acre.

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Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
USFWS	Migratory Bird Treaty Act Compliance	Activity with potential to harm migratory bird species	Construction	Maybe	1 - 2 months	Avian impact review or study required.
USFWS	Endangered Species Act Compliance	Confirmation of no impacts to threatened and endangered species.	Construction	Maybe	1 - 2 months	Consultation may be required if species and/or habitat onsite or along offsite utility interconnection right-of-way may be impacted. May be concerns about avian impacts from turbines.
FEDERAL	NEPA	Major federal action affecting the environment	Construction	Not likely	NA	Fatal flaw for schedule if triggered.
STATE						
MDPU/EFSB	Site Certification	Construction of an energy generating facility.	Construction	No	10 - 12 months	No electricity will be sold to the grid.
DOER	Application for Statement of Qualification pursuant to Massachusetts Renewable Portfolio Standard	Construction and operation of a new renewable energy facility proposing to sell energy to the grid	Construction	Likely	2 -3 Months	Project would be considered a Small Power Production Qualifying Facility with respect to selling power to utilities that are required under Massachusetts law to purchase electricity from

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Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
						certain classes of renewable energy and distributed generation facilities.
EOEA	MEPA Determination: Environmental Notification Form (or expanded form)	Alteration of more than 25 acres of land	Construction	Not likely	2 - 3 months	Must be filed if more than 25 acres of land will be directly altered or certain other criteria met. The three turbines for this project are expected to impact a total of less than 1 acre.
EOEA	MEPA Review: Environmental Impact Report	Alteration of more than 50 acres of land	Construction	No	6 - 9 months	Based on review of the Environmental Notification Form by the Secretary of Environmental Affairs. Required if more than 50 acres of land will be altered or other criteria met. Project will not meet 50 acre threshold.

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Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
EOEA	Protected Land Regulation Compliance	Activities on protected land	Construction	Maybe	1 - 2 months	EOEA Article 97 Policy and Massachusetts General Law Chapter 61 govern the use of protected land. Compliance with these laws is necessary for a successful EIR or ENF process. These laws may apply if the project requires access or easements on protected parkland or agricultural land. B&V assumes the land within the Brewster sites is not considered a protected land.
MDEP	Notice of Intent	Wetland alteration	Construction	Maybe	3 - 4 months	Same as form submitted to Boston Conservation Commission (refer to local permits). Wetland impacts from wind turbine construction are unlikely with the planned installation in existing WWTP parking lot or gravel areas adjacent to operations buildings.

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Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
MDEP	Noise Control Policy Compliance	Noise from wind turbine	Operation	Maybe	1 - 2 months	Policy discourages a broadband noise level greater than 10 dB(A) above ambient, or pure tone noise. Noise is not expected to be an issue as long as the project is properly evaluated and any necessary mitigation requirements are implemented.
MDEP	NPDES Individual Wastewater/Storm Water Discharge Permit	Wastewater discharge and storm water runoff during facility operation. NOTE: This program is jointly administered by EPA and MDEP.	Operation	No	9 - 12 months	Operation of a wind farm is not considered an industrial activity under the stormwater program.

Table E-1
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Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
MDEP	Massachusetts Clean Waters Act, Section 401 Water Quality Certification	Required for federal activities affecting state land.	Construction	Maybe	3 months	If less than 5,000 square feet of wetlands are altered, the OOC can be used for this. Necessary if Section 404 permit is required. Wetland impacts from wind turbine construction are unlikely with the planned installation in existing WWTP parking lot or gravel areas adjacent to operations buildings.
MDF&G Natural Heritage and Endangered Species Program	Notice of Intent	Wetland alteration	Construction	Maybe	3 - 4 months	Same as form submitted to Boston Conservation Commission and state DEP. Required if project is in "estimated habitat" of rare wildlife. Wetland impacts from wind turbine construction are unlikely with the planned installation in existing WWTP parking lot or gravel areas adjacent to operations buildings.

Table E-1
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Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
MDF&G Natural Heritage and Endangered Species Program	Conservation and Management Permit	Activities that could potentially affect threatened or endangered species.	Construction	Maybe	3 - 4 months	Required for any take of a state endangered species.
MDOH	General Access Permit	Alteration of state roads	Construction	Maybe	2 - 3 months	May be needed if project involves alterations to state roads.
MDOH	Wide Load Permit	Movement of oversize project equipment.	Construction	Maybe	2 - 3 months	May be necessary for transport of oversized equipment like turbine components or certain construction equipment.
ISO New England (and transmission line owner at interconnection point)	NEPOOL Interconnection System Impact Study and Facility Study	Transmission interconnection	Construction	No	9 - 12 months	No electricity will be sold to the existing grid.
EFSB	Transmission line approval	Transmission interconnection	Construction	No	2 - 3 months	No electricity will be sold to the grid.
MAC	Request for Airspace Review courtesy notice	Structures over 200 feet tall	Construction	Yes	3 - 4 months	Provide courtesy notification of any projects over 200 feet tall (similar to FAA review, but not a permit per se). Note

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Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
						that Logan is owned by MPA, and MAC has no jurisdiction over this airport.
MPA	Request for Airspace Review	Structures over 200 feet tall near airports	Construction	Maybe	3 - 4 months	Logan International Airport is in close proximity, approximately 1.5 miles from the site. May be concerns about the 400 foot turbine blade height if close to existing flight paths. If required, this review may be done concurrent with the FAA review.
MHC	Archeological and Historical Review	Activities that could potentially affect archeological or historical resources.	Construction	Yes	3 - 4 months	The site has a long history of Native American use and has also been used for various purposes more recently, including a Native American interment camp and a prison.
LOCAL						
Boston Redevelopment Authority	Planning review	New development	Construction	Yes	3 - 4 months	Makes recommendations to Zoning Commission and Board of Appeal after review of project.

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List of Permits

Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
Boston Zoning Commission	Zoning/Special Use permit	Construction of a wind farm outside the scope of current zoning regulations	Construction	Maybe	3 - 4 months	Reviews project for compliance with zoning code.
Zoning Board of Appeal	Variances from code	Project outside height limit	Construction	Maybe	3 - 4 months	Height or setback restrictions may require a variance.
Inspectional Services Department	Building and construction permits	New construction	Construction	Yes	3 months	Grants building permits and change in use or occupancy permits. Project application must receive a favorable decision from the Board of Appeal.
Inspectional Services Department	Certificate of Occupancy	Newly constructed facility addition	Operation	Yes	1 - 2 months	
Boston Area Planning Board	Approval of project	New development on existing facility	Construction	Yes	3 months	

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Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
Boston Conservation Commission	Order of Conditions	Wetland alteration	Construction	Maybe	3 - 4 months	Permit required if wetlands will be altered in any way. The permit application is a Notice of Intent and is also sent to the Massachusetts Department of Environmental Protection. If an area less than 5,000 square feet of wetland is altered, the OOC also serves as the project's Section 401 Water Quality Certificate. Wetland impacts from wind turbine construction are unlikely with the planned installation in existing WWTP parking lot or gravel areas adjacent to operations buildings.
Fire Marshal	Fire Code Approval	New development on existing facility	Construction	No	NA	Joint review as part of Inspectional Services Department.
Town of Brewster - Building Department	Building permit	New construction activity in Brewster	Construction	Yes	2 – 3 months	

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Agency	Permit	Regulated Activity	Required Project Phase	Applicable to Project	Expected Review Time	Comments/Issues
Town of Brewster - Planning and Zoning Department	Zoning/Site Plan Approval - Special Permit	Construction of a wind farm outside the scope of current zoning regulations	Construction	Maybe	3 – 4 months	Reviews project for compliance with zoning code.
Town of Brewster - Zoning Board of Appeals	Variances from code	Project outside height limit	Construction	Maybe	3 – 4 months	Height or setback restrictions may require a variance.

Notes:

Abbreviations:

COE - Army Corps of Engineers
DOE - Department of Energy
dB(A) - A-weighted decibel
EFSB - Energy Facility Siting Board
EOEA - Executive Office of Environmental Affairs
EPA - US Environmental Protection Agency
EWG - Exempt Wholesale Generator
FAA - Federal Aviation Administration
FERC - Federal Energy Regulatory Authority
ISO/NEPOOL - Independent System Operator/New England Power Pool
MDOH - Massachusetts Department of Highways
MDPU - Massachusetts Department of Public Utilities
MEPA - Massachusetts Environmental Policy Act
MHC - Massachusetts Historical Commission
MNHP - Massachusetts Natural Heritage Program
MPA - Massachusetts Port Authority
NEPA - National Environmental Policy Act
NPDES - National Pollutant Discharge Elimination System
NPS - National Park Service
OOC - Order of Conditions
PURPA - Public Utilities Regulatory Policy Act
SPCC - Spill Prevention, Control and Countermeasure

Table E-1 List of Permits						
Agency	**Permit**	**Regulated Activity**	**Required Project Phase**	**Applicable to Project**	**Expected Review Time**	**Comments/Issues**
MAC - Massachusetts Aeronautics Commission MDEP - Massachusetts Department of Environmental Protection MDF&G - Massachusetts Department of Fish and Game			USFWS - US Fish and Wildlife Service WWTP - Wastewater Treatment Plant			