LONG-TERM SITE WIND DATA REPORT

Bishop and Clerks

January 1, 2005 – December 31, 2005

Prepared for

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NOTICE AND ACKNOWLEDGEMENTS

This report was prepared by the Renewable Energy Research Laboratory (RERL) at the University of Massachusetts, Amherst in the course of performing work sponsored by the Renewable Energy Trust (RET), as administered by the Massachusetts Technology Collaborative (MTC), pursuant to work order number 05-1. The opinions expressed in this report do not necessarily reflect those of MTC or the Commonwealth of Massachusetts, and reference to any specific product, service, process, or method does not constitute an implied or expressed recommendation or endorsement of it.

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EXECUTIVE SUMMARY

All the work presented in this Wind Data Report including installation and decommissioning of the meteorological tower and instrumentation, and the data analysis and reporting was performed by the Renewable Energy Research Laboratory (RERL) at the University of Massachusetts, Amherst.

This wind measurement station is installed on the Bishop & Clerks US Coast Guard (USCG) automated lighthouse, almost 3 miles south-southeast of Pt. Gammon on Cape Cod, MA. Installed in November of 2000, the wind monitoring station has been in continuous operation to this day. The two anemometers and wind vanes are mounted 15 m (49 ft) above the Mean Low Water Level.

This annual report covers the period January 1, 2005 – December 31, 2005. However, the data and graphs presented here only show data from January 1 – June 23. On June 23, the system at Bishop and Clerks lost the ability to transmit data due to lack of battery charge. This problem was compounded by the inaccessibility of the site, so the problem persisted through the end of 2005.

Between January 1 and June 23, the mean recorded wind speed at 15 m was 7.38 m/s (16.5 mph) and the prevailing wind direction was from the north-northeast. The average turbulence intensity at 15 m was 0.11, which is typical for this site. Over the entire year of 2005, the gross data recovery percentage (the actual percentage of expected data received) was 47.6% and the net data recovery percentage (the percentage of expected data which passed all of the quality assurance tests) was 46.9%. For the period when the system was reporting data (January 1 – June 23), the gross data recovery percentage was 100.0% and the net data recovery percentage was 98.7%. These indicate that, before the battery failed, the system was working well.

Additional information about interpreting the data presented in this report can be found in the Fact Sheet, "Interpreting Your Wind Resource Data," produced by RERL and the Massachusetts Technology Collaborative (MTC). This document is found through the RERL website:

http://www.ceere.org/rerl/about_wind/RERL_Fact_Sheet_6_Wind_resource_interpretation.pdf

* 1m/s = 2.237 mph

SECTION 1 - Station Location

Bishop & Clerks was originally a small island south of Hyannis in the 1800's. Over time, it has eroded down to a few exposed rocks. The concrete and stone base of the lighthouse is currently the largest remaining piece above water. The lighthouse is located within the three-mile state limit of Massachusetts' waters, at 41^0-34'-27.6" North, 070^0-14'-59.5" West (Figure 1). A photo of the lighthouse as it stands today can be seen at www.ceere.org/rerl/rerl_offshore.html. The wind monitoring station at Bishop and Clerks is located on the top of the USCG lighthouse facility. Relative to the Mean Low Water Level, the anemometry is mounted at a height of 15 m (49 ft).

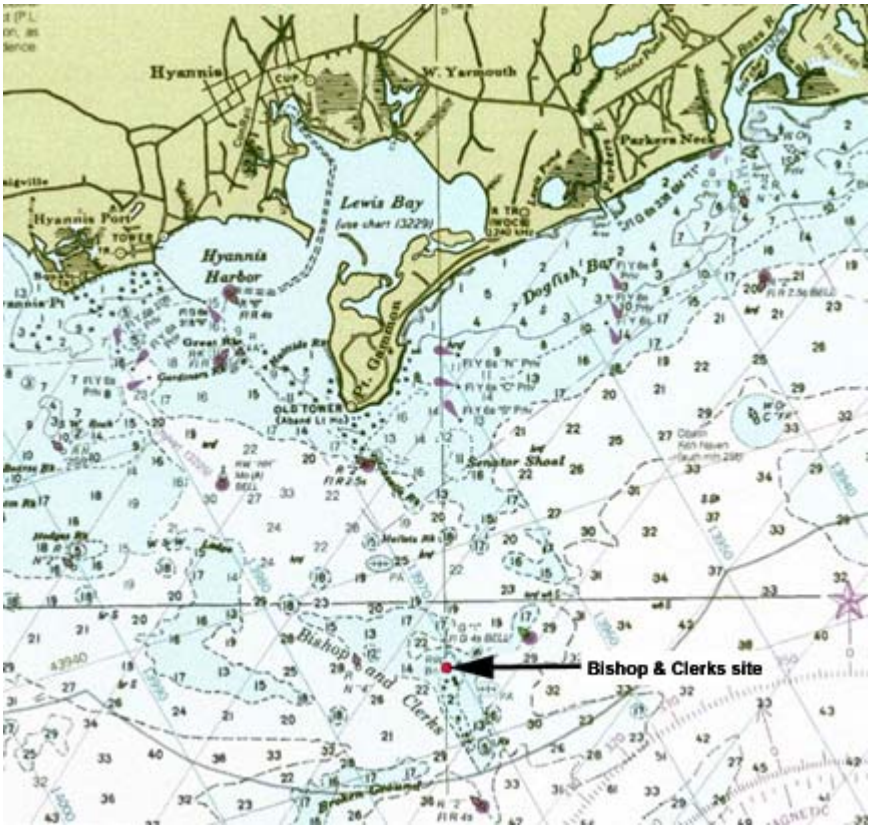

Figure 1 - Site location at Bishop & Clerks light

SECTION 2 - Instrumentation and Equipment

The wind monitoring equipment is mounted on a 12 ft long, 3" diameter, aluminum mast that is secured to the deck railing at the top of the lighthouse (Figure 2). All the remaining monitoring equipment comes from NRG Systems, and consists of the following items:

- Model 9300 Cellogger®, serial # 0258
- Electrical enclosure box with 5 watt PV panel
- Yagi directional antenna and mount
- 2 – #40 Anemometers, standard calibration (Slope - 0.765 m/s, Offset – 0.350 m/s)
- 2 - #200P Wind direction vanes
- 4 – Sensor booms, 43” length
- Lightning rod and grounding cable
- Shielded sensor wire

Figure 2 - Anemometry mast and data collection equipment at Bishop & Clerks

Limitations of this setup are that the mast height is low relative to the diameter of the lighthouse and the fact that the warning light and a PV panel mounted on top of the tower can interfere with the free flow of air. The mast height is limited by the stiffness of the railing. In fact, it was necessary to reinforce the free end of the railing to the USCG lighthouse PV panel brackets in order to use even the 12 ft mast (Figure 3) which otherwise shook severely in high winds.

Figure 3 - Railing stiffener connecting PV bracket to rail

The NRG 9300 system logger is equipped with a built-in cell phone so that the data can be transmitted weekly to a PC, located at the University of Massachusetts, Amherst. The logger samples wind speed and direction once every second. These are then combined into 10-minute averages, and along with the standard deviation for those 10-minute periods, are put into a binary file. These binary files are converted to ASCII text files using the NRG software BaseStation®. These text files are then imported into a database software program where they are subjected to quality assurance (QA) tests prior to using the data.

SECTION 3 - Data Collection and Maintenance

The following maintenance/equipment problems occurred during the year of 2005, and the following corrective action was taken:

- Sometime around December 11, 2004, the solar charging system that keeps the data logger battery charged stopped working properly. The cause of this failure has not yet been determined.

- In the week after June 23, the data logger battery voltage dropped to a voltage at which the data logger could not complete the weekly phone call to transmit data. From this data forward, no data were transmitted from the site.

- On July 13, a crew attempted to access the site to replace the batteries and repair the charging system. The door to the facility was found to be corroded shut and, as a result, the crew was not able to access the site or the system.

- The US Coast Guard, which owns the facility, tried to access the site by helicopter on August 24, but was not able to drop personnel onto the platform.

- By the middle of January, 2006, the US Coast Guard had cut the corroded door to allow access into the facility. When the weather allows and a crew is available, another repair attempt will be made.

- There were no equipment or maintenance problems to report.

No measurement of wind speed can be perfectly accurate. Errors occur due to anemometer manufacturing variability, anemometer calibration errors, the response of anemometers to turbulence and vertical air flow and due to air flows caused by the anemometer mounting system. Every effort is made to reduce the sources of these errors. Nevertheless, the values reported in this report have an expected uncertainty of about ± 2% or ± 0.2 m/s.

The data statistics summary table gives the wind characteristics for each month of 2005 and also gives the overall annual 2005 wind characteristics, including mean wind speed, maximum wind speed, average turbulence intensity, prevailing wind direction, and net data recovery for the anemometer at each level with the highest percentage of good data. A complete description of net data recovery is given in Section 4. The sensor statistics for each month and the entire year of 2005 are in APPENDIX A.

Data Statistics Summary

Date	Mean Wind Speed	Max Wind Speed	Turbulence Intensity	Prevailing Wind Direction	Good Data
Heights units	**15 m [m/s]**	**15 m [m/s]**	**15 m [ ]**	**15 m [ ]**	**15 m [%]**
Jan 05	8.56	22.44	0.10	W	97.7
Feb 05	8.29	24.83	0.10	NW	99.6
Mar 05	7.02	18.62	0.11	NNE	95.3
Apr 05	7.40	19.38	0.11	WNW	100.0
May 05	7.54	21.39	0.10	SW	99.4
Jun 05	- [a]	-	-	-	74.6
Jul 05	-	-	-	-	0.0
Aug 05	-	-	-	-	0.0
Sep 05	-	-	-	-	0.0
Oct 05	-	-	-	-	0.0
Nov 05	-	-	-	-	0.0
Dec 05	-	-	-	-	0.0
Jan 05 – Dec 05	7.38 [b]	24.83	0.11	NNE	46.8

[a] The data starting in June 2005 are missing due to a combination of loss of battery charge and the inaccessibility of the site. These issues will be dealt with as soon as possible.

[b] This row of summary data are the overall statistics for the site for the time the data were valid (January 1 – June 23). These are not comparable with annual average statistics.

The data reported in the Data Statistics Summary table are only based on the percentages of good data indicated; missing data may skew these values.

SECTION 4- Data Recovery and Validation

All raw wind data are subjected to a series of tests and filters to weed out data that are faulty or corrupted. Definitions of these quality assurance (QA) controls are given below under Test Definitions and Sensor Statistics. These control filters were designed to automate the quality control process and used many of the previous hand-worked data sets made at UMass to affect a suitable emulation. The gross percentage of data recovered (ratio of the number of raw data points received to data points expected) and net percentage (ratio of raw data points which passed all QA control tests to data points expected) are shown below for the reporting period January 1 to December 31, 2005.

Gross Data Recovered [%]	47.55
Net Data Recovered [%]	46.94

The low percentages here are due to a combination of loss of battery charge and the inaccessability of the site. The system was performing very well (percentages in the high 90s) until June, when the battery lost its charge. This situation will be remedied as soon as possible.

Test Definitions

All raw data were subjected to a series of validation tests, as described below. The sensors tested and the parameters specific to each sensor are given in the Sensor Performance Report that is included in APPENDIX A. Data that were flagged as invalid were not included in the statistics presented in this report.

MinMax Test: All sensors are expected to report data values within a range specified by the sensor and logger manufacturers. If a value falls outside this range, it is flagged as invalid. A data value from the sensor listed in Test Field 1 (TF1) is flagged if it is less than Factor 1 (F1) or greater than Factor 2. This test has been applied to the following sensors (as applicable): wind speed, wind speed standard deviation, wind direction, temperature, and solar insolation.

$$F1 > TF1 > F2$$

MinMaxT Test: This is a MinMax test for wind direction standard deviation with different ranges applied for high and low wind speeds. A wind direction standard deviation data value (TF1) is flagged either if it is less than Factor 1, if the wind speed (TF2) is less than Factor 4 and the wind direction standard deviation is greater than Factor 2, or if the wind speed is greater than or equal to Factor 4 and the wind direction standard deviation is greater than Factor 3.

$$\begin{gathered}(TF1 < F1) \\ \text{or } (TF2 < F4 \text{ and } TF1 > F2) \\ \text{or } (TF2 \geq F4 \text{ and } TF1 > F3)\end{gathered}$$

Icing Test: An icing event occurs when ice collects on a sensor and degrades its performance. Icing events are characterized by the simultaneous measurements of near-zero standard deviation of wind direction, non-zero wind speed, and near- or below-freezing temperatures. Wind speed, wind speed standard deviation, wind direction, and wind direction standard deviation data values are flagged if the wind direction standard deviation (CF1) is less than or equal to Factor 1 (F1), the wind speed (TF1) is greater than Factor 2 (F2), and the temperature (CF2) is less than Factor 3 (F3). To exit an icing event, the wind direction standard deviation must be greater than Factor 4.

$$CF1 \leq F1 \text{ and } TF1 > F2 \text{ and } CF2 < F3$$

CompareSensors Test: Where primary and redundant sensors are used, it is possible to determine when one of the sensors is not performing properly. For anemometers, poor performance is characterized by low data values. Therefore, if one sensor of the pair reports values significantly below the other, the low values are flagged. At low wind speeds (Test Fields 1 and 2 less than or equal to Factor 3) wind speed data are flagged if the absolute difference between the two wind speeds is greater than Factor 1. At high wind speeds (Test Fields 1 or 2 greater than Factor 3) wind speed data are flagged if the absolute value of the ratio of the two wind speeds is greater is greater than Factor 2.

$$[\ TF1 \le F3 \text{ and } TF2 \le F3 \text{ and } abs(TF1 - TF2) > F1\ ]$$
$$\text{or } [\ (TF1 > F3 \text{ or } TF2 > F3) \text{ and } (abs(1 - TF1 / TF2) > F2 \text{ or } abs(1 - TF2 / TF1) > F2)\ ]$$

Sensor Statistics

Expected Data Points: the total number of sample intervals between the start and end dates (inclusive).

Actual Data Points: the total number of data points recorded between the start and end dates.

% Data Recovered: the ratio of actual and expected data points (this is the *gross data recovered percentage*).

Hours Out of Range: total number of hours for which data were flagged according to MinMax and MinMaxT tests. These tests flag data that fall outside of an expected range.

Hours of Icing: total number of hours for which data were flagged according to Icing tests. This test uses the standard deviation of wind direction, air temperature, and wind speed to determine when sensor icing has occurred.

Hours of Fault: total number of hours for which data were flagged according to CompareSensors tests. These tests compare two sensors (e.g. primary and redundant anemometers installed at the same height) and flag data points where one sensor differs significantly from the other.

% Data Good: the filter results are subtracted from the gross data recovery percentage to yield the *net data recovered percentage*.

SECTION 5 - Data Summary

This report contains several types of wind data graphs. ***These graphs represent data from January 1 – June 23, 2005 only. They are included in this report to show the wind climate for that period but should not be used in comparison with annual data from this or other sites.*** The following graphs are included:

- Time Series – In Figure 4, 10-minute average wind speeds are plotted against time for all data starting on January 1, 2005 through June 23, 2005.

- Wind Speed Distribution – A histogram plot giving the percentage of time that the wind is at a given wind speed is shown in Figure 5. This distribution has a maximum between 6 and 7 m/s (13.4 and 15.7 mph).

- Monthly Averages – A plot of the average monthly wind speed for each month of data is shown in Figure 6. There is no data point shown for June because there were not enough data available for this month for a June data point to be meaningful. Typically for this site, May – August are the months with the lowest average wind speeds and November – January have the highest. Over the past 3 years, the average highs and lows have been around 9 m/s (20.1 mph) and 6.5 m/s (14.5 mph) respectively.

- Diurnal Average Wind Speeds – Figure 7 is a plot of the average wind speed for each hour of the day. This graph shows the typical diurnal trend for Bishop and Clerks—a fairly flat curve with slightly higher wind speeds in the afternoon.

- Turbulence Intensity – A plot of turbulence intensity as a function of wind speed is shown in Figure 8. Turbulence Intensity is calculated as the standard deviation of the wind speed divided by the 10-minute mean wind speed and is a measure of the gustiness of a wind resource. Lower turbulence results in lower mechanical loads on a wind turbine. Typical annual average wind speeds for this site are around 7.5 m/s (16.8 mph), which falls on the portion of the graph where the turbulence intensity curve has bottomed out, suggesting that, on average, this site experiences low turbulence intensities. For Bishop and Clerks, the average turbulence intensity was 0.11, which is typical for this site.

- Wind Rose – Figure 9 is a plot, by compass direction, showing the percentage of time that the wind comes from a given direction and the average wind speed in that direction at the 15 m level. This wind rose shows that, for the first half of the year, the prevailing wind direction at the 15 m level was from the north-northeast. For comparison, during the previous 3 years the annual prevailing direction has been from the southwest. The mean wind speed is essentially independent of direction, though there is a slight increase in mean speed from the north and northeast.

SECTION 6 - Graphs

Data for the wind speed histogram and wind rose are included in APPENDIX B.

Wind Speed Time Series

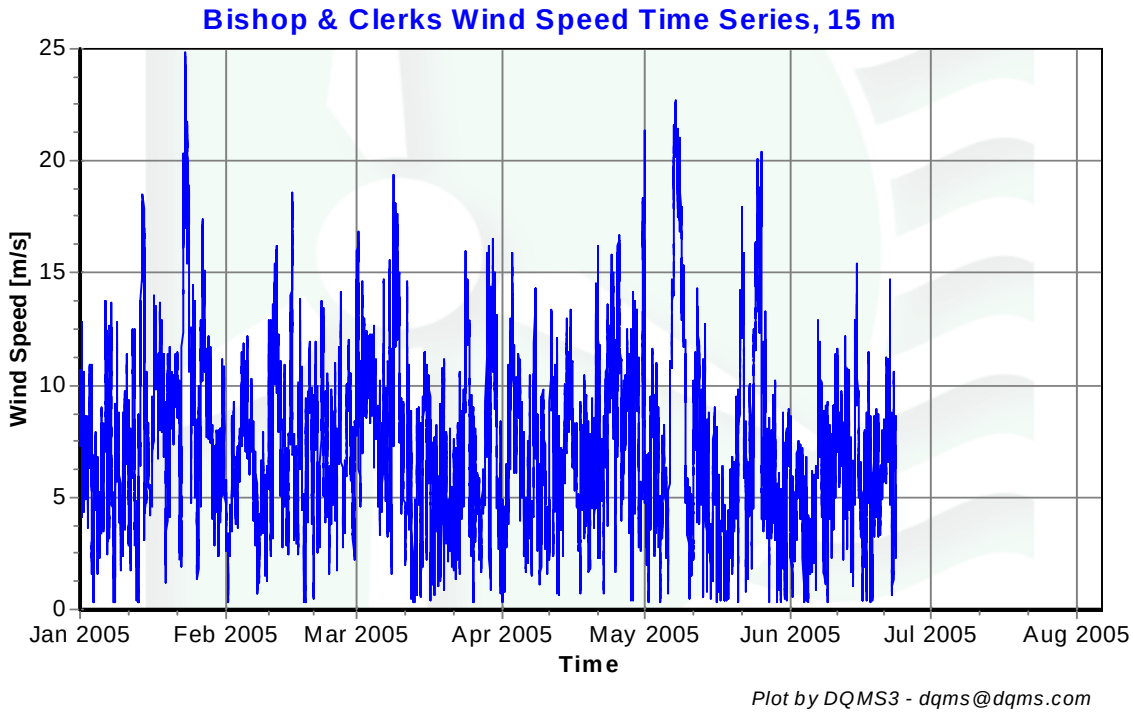

Figure 4 - Wind Speed Time Series, January 1, 2005 – June 23, 2005

Wind Speed Distribution

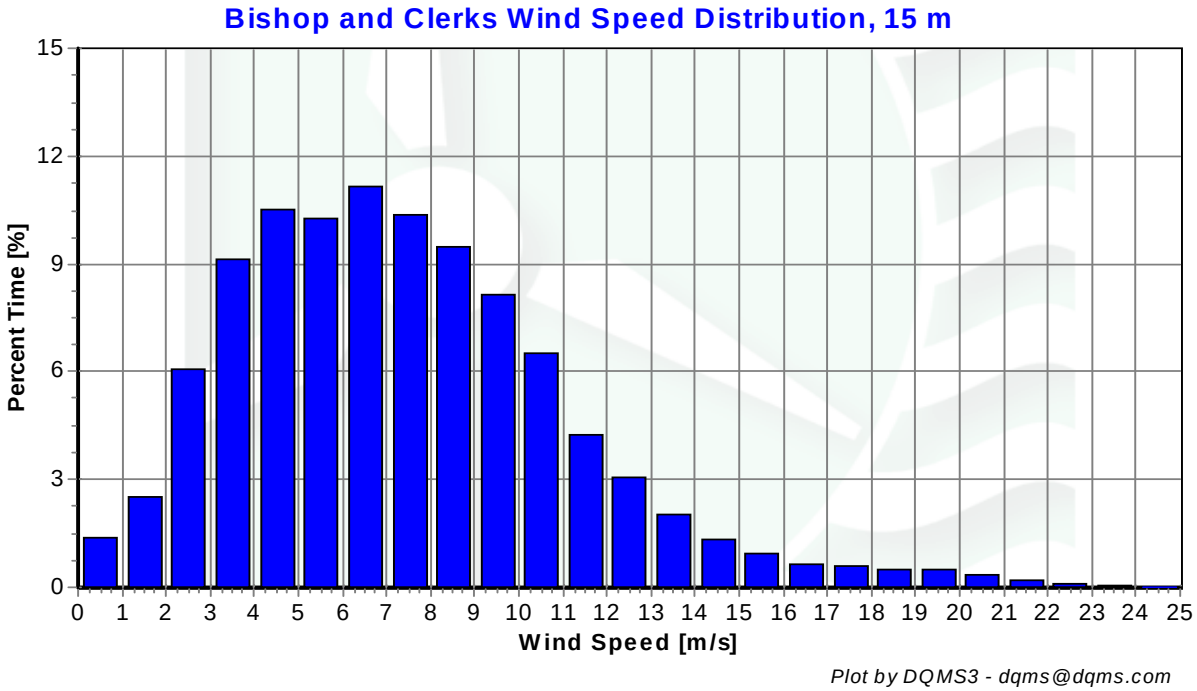

Figure 5 – Wind Speed Distribution, January 1, 2005 – June 23, 2005

Monthly Average Wind Speeds

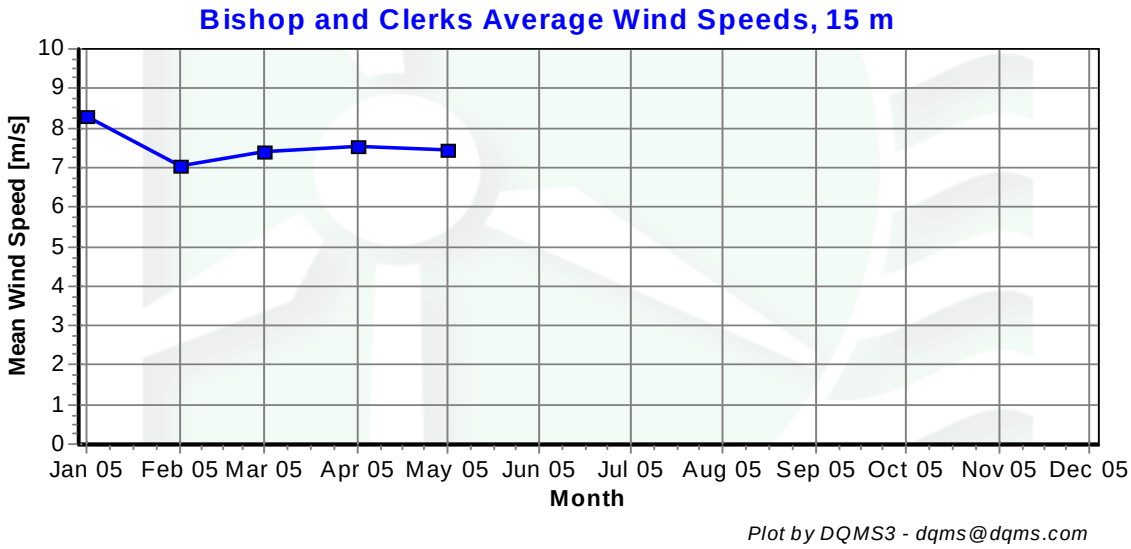

Figure 6 – Average Monthly Wind Speeds, January 1, 2005 – June 23, 2005

Diurnal Average Wind Speeds

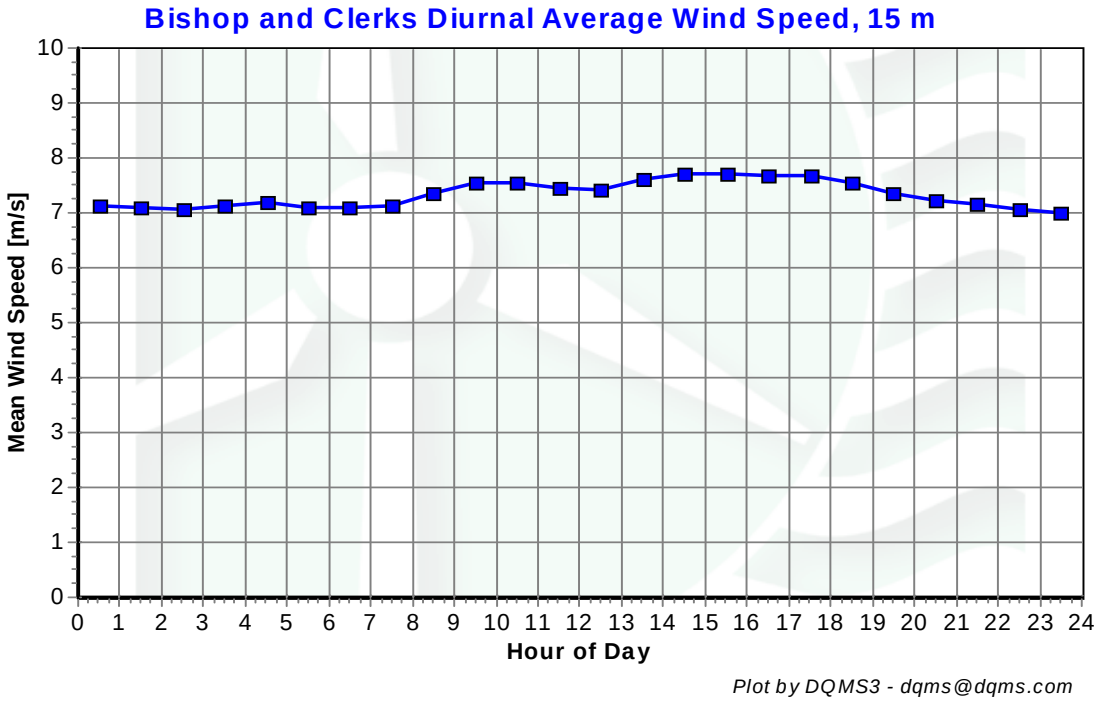

Figure 7 – Diurnal Average Wind Speeds, January 1, 2005 – June 23, 2005

Turbulence Intensities

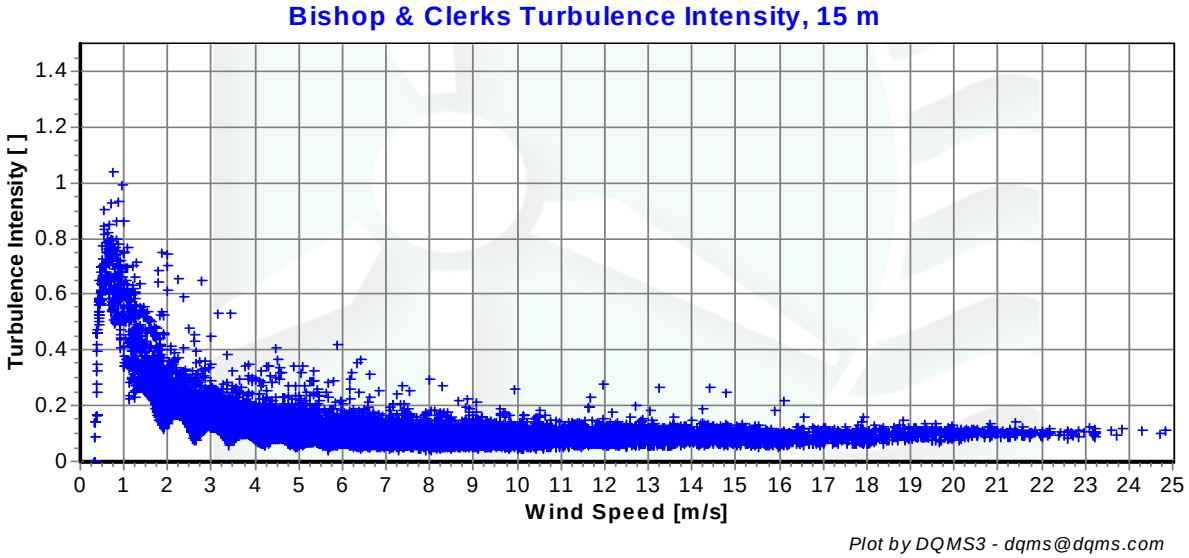

Figure 8 – Turbulence Intensity vs. Wind Speed, January 1, 2005 – June 23, 2005

Wind Rose

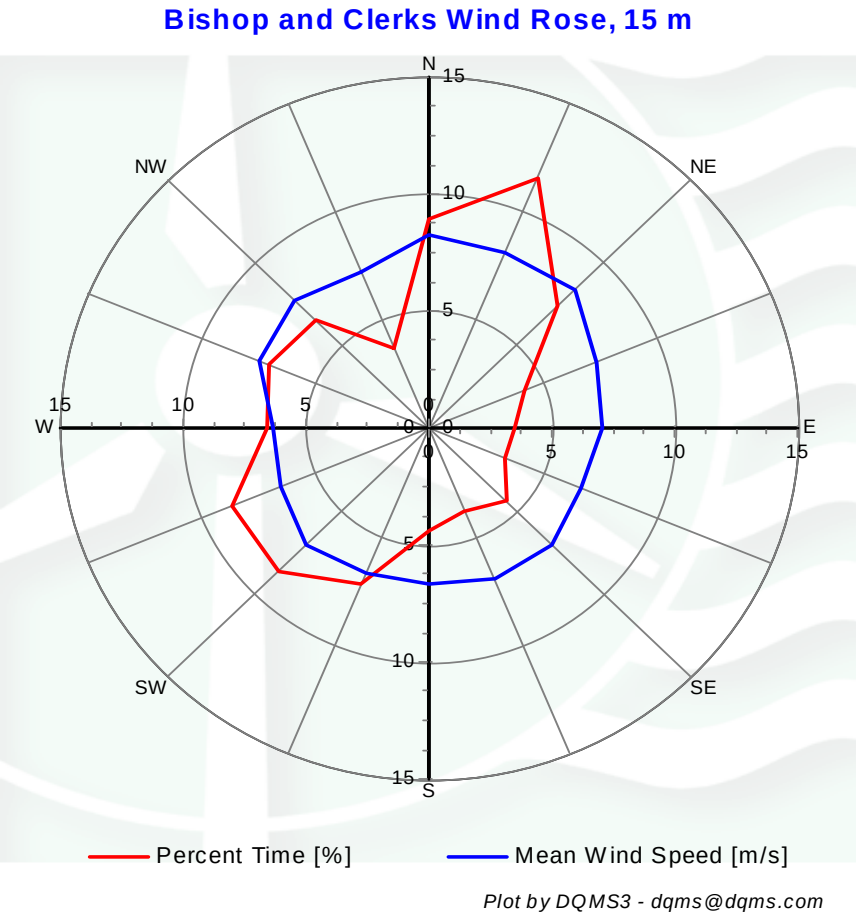

Figure 9 - Wind Rose, January 1, 2005 – June 23, 2005

APPENDIX A - Sensor Performance Report

Test Definitions

Test Order	Test Field1	Test Field2	Test Field3	Calc Field1	Calc Field2	Calc Field3	TestType	Factor 1	Factor 2	Factor 3	Factor 4
1							TimeTest Insert				
3	Itmp13aDEGC						MinMax	-30	60		
4	Batt13aVDC						MinMax	10.5	15		
10	Anem15aMS						MinMax	0	90		
11	Anem15bMS						MinMax	0	90		
12	Anem15yMS						MinMax	0	90		
20	AnemSD15aMS						MinMax	0	4		
21	AnemSD15bMS						MinMax	0	4		
22	AnemSD15yMS						MinMax	0	4		
30	Vane15aDEG						MinMax	0	359.9		
31	Vane15bDEG						MinMax	0	359.9		
32	Vane15yDEG						MinMax	0	359.9		
50	Turb15zNONE						MinMax	0	2		
200	VaneSD15aDEG	Anem15aMS					MinMaxT	0	100	100	10
201	VaneSD15bDEG	Anem15bMS					MinMaxT	0	100	100	10
300	Anem15aMS	AnemSD15aMS	Vane15aDEG	VaneSD15aDEG	Itmp13aDEGC		Icing	0.5	1	2	2
301	Anem15bMS	AnemSD15bMS	Vane15bDEG	VaneSD15bDEG	Itmp13aDEGC		Icing	0.5	1	2	2
400	Anem15aMS	Anem15bMS					CompareSensors	1	0.25	3	

Sensor Statistics: January 2005 – December 2005

Sensor	Expected Data Points	Actual Data Points	% Data Recovered	Hours Out of Range	Hours of Icing	Hours of Fault	% Data Good
Itmp13aDEGC	52560	24994	47.553	0	0	0	47.553
Batt13aVDC	52560	24994	47.553	0	0	0	47.553
Anem15aMS	52560	24994	47.553	0.333	52.667	16	46.766
AnemSD15aMS	52560	24994	47.553	0.333	52.667	16	46.766
Anem15bMS	52560	24994	47.553	0.167	69.167	9.167	46.657
AnemSD15bMS	52560	24994	47.553	0.167	69.167	9.167	46.657
Vane15aDEG	52560	24994	47.553	0.667	52.667	0	46.944
VaneSD15aDEG	52560	24994	47.553	0.667	52.667	0	46.944
Vane15bDEG	52560	24994	47.553	0.667	69.167	0	46.756
VaneSD15bDEG	52560	24994	47.553	0.667	69.167	0	46.756
Total	**525600**	**249940**	**47.553**	**3.667**	**487.333**	**50.333**	**46.935**

Sensor Statistics: January 2005

Sensor	Expected Data Points	Actual Data Points	% Data Recovered	Hours Out of Range	Hours of Icing	Hours of Fault	% Data Good
Itmp13aDEGC	4464	4464	100	0	0	0	100
Batt13aVDC	4464	4464	100	0	0	0	100
Anem15aMS	4464	4464	100	0	16.5	0.333	97.737
AnemSD15aMS	4464	4464	100	0	16.5	0.333	97.737
Anem15bMS	4464	4464	100	0	29.333	0	96.057
AnemSD15bMS	4464	4464	100	0	29.333	0	96.057
Vane15aDEG	4464	4464	100	0	16.5	0	97.782
VaneSD15aDEG	4464	4464	100	0	16.5	0	97.782
Vane15bDEG	4464	4464	100	0	29.333	0	96.057
VaneSD15bDEG	4464	4464	100	0	29.333	0	96.057
Total	**44640**	**44640**	**100**	**0**	**183.333**	**0.667**	**97.527**

Sensor Statistics: February 2005

Sensor	Expected Data Points	Actual Data Points	% Data Recovered	Hours Out of Range	Hours of Icing	Hours of Fault	% Data Good
Itmp13aDEGC	4032	4032	100	0	0	0	100
Batt13aVDC	4032	4032	100	0	0	0	100
Anem15aMS	4032	4032	100	0	2	1	99.554
AnemSD15aMS	4032	4032	100	0	2	1	99.554
Anem15bMS	4032	4032	100	0	4	0.167	99.38
AnemSD15bMS	4032	4032	100	0	4	0.167	99.38
Vane15aDEG	4032	4032	100	0	2	0	99.702
VaneSD15aDEG	4032	4032	100	0	2	0	99.702
Vane15bDEG	4032	4032	100	0	4	0	99.405
VaneSD15bDEG	4032	4032	100	0	4	0	99.405
Total	**40320**	**40320**	**100**	**0**	**24**	**2.333**	**99.608**

Sensor Statistics: March 2005

Sensor	Expected Data Points	Actual Data Points	% Data Recovered	Hours Out of Range	Hours of Icing	Hours of Fault	% Data Good
Itmp13aDEGC	4464	4464	100	0	0	0	100
Batt13aVDC	4464	4464	100	0	0	0	100
Anem15aMS	4464	4464	100	0.167	34.167	0.667	95.296
AnemSD15aMS	4464	4464	100	0.167	34.167	0.667	95.296
Anem15bMS	4464	4464	100	0.167	35.833	0	95.161
AnemSD15bMS	4464	4464	100	0.167	35.833	0	95.161
Vane15aDEG	4464	4464	100	0.667	34.167	0	95.318
VaneSD15aDEG	4464	4464	100	0.667	34.167	0	95.318
Vane15bDEG	4464	4464	100	0.333	35.833	0	95.139
VaneSD15bDEG	4464	4464	100	0.333	35.833	0	95.139
Total	**44640**	**44640**	**100**	**2.667**	**280**	**1.333**	**96.183**

Sensor Statistics: April 2005

Sensor	Expected Data Points	Actual Data Points	% Data Recovered	Hours Out of Range	Hours of Icing	Hours of Fault	% Data Good
Itmp13aDEGC	4320	4319	99.977	0	0	0	99.977
Batt13aVDC	4320	4319	99.977	0	0	0	99.977
Anem15aMS	4320	4319	99.977	0.167	0	0	99.954
AnemSD15aMS	4320	4319	99.977	0.167	0	0	99.954
Anem15bMS	4320	4319	99.977	0	0	0	99.977
AnemSD15bMS	4320	4319	99.977	0	0	0	99.977
Vane15aDEG	4320	4319	99.977	0	0	0	99.977
VaneSD15aDEG	4320	4319	99.977	0	0	0	99.977
Vane15bDEG	4320	4319	99.977	0	0	0	99.977
VaneSD15bDEG	4320	4319	99.977	0	0	0	99.977
Total	**43200**	**43190**	**99.977**	**0.333**	**0**	**0**	**99.972**

Sensor Statistics: May 2005

Sensor	Expected Data Points	Actual Data Points	% Data Recovered	Hours Out of Range	Hours of Icing	Hours of Fault	% Data Good
Itmp13aDEGC	4464	4464	100	0	0	0	100
Batt13aVDC	4464	4464	100	0	0	0	100
Anem15aMS	4464	4464	100	0	0	4.667	99.373
AnemSD15aMS	4464	4464	100	0	0	4.667	99.373
Anem15bMS	4464	4464	100	0	0	4.5	99.395
AnemSD15bMS	4464	4464	100	0	0	4.5	99.395
Vane15aDEG	4464	4464	100	0	0	0	100
VaneSD15aDEG	4464	4464	100	0	0	0	100
Vane15bDEG	4464	4464	100	0.333	0	0	99.955
VaneSD15bDEG	4464	4464	100	0.333	0	0	99.955
Total	**44640**	**44640**	**100**	**0.667**	**0**	**18.333**	**99.745**

Sensor Statistics: June 2005

Sensor	Expected Data Points	Actual Data Points	% Data Recovered	Hours Out of Range	Hours of Icing	Hours of Fault	% Data Good
Itmp13aDEGC	4320	3251	75.255	0	0	0	75.255
Batt13aVDC	4320	3251	75.255	0	0	0	75.255
Anem15aMS	4320	3251	75.255	0	0	9.333	73.958
AnemSD15aMS	4320	3251	75.255	0	0	9.333	73.958
Anem15bMS	4320	3251	75.255	0	0	4.5	74.63
AnemSD15bMS	4320	3251	75.255	0	0	4.5	74.63
Vane15aDEG	4320	3251	75.255	0	0	0	75.255
VaneSD15aDEG	4320	3251	75.255	0	0	0	75.255
Vane15bDEG	4320	3251	75.255	0	0	0	75.255
VaneSD15bDEG	4320	3251	75.255	0	0	0	75.255
Total	**43200**	**32510**	**75.255**	**0**	**0**	**27.667**	**74.87**

Sensor Statistics: July - December 2005

Due to the combination of loss of battery charge and inaccessibility of the site, the datalogger stopped reporting data on June 23, 2005. For this reason, there are no sensor statistics from July – December.

APPENDIX B - Plot Data

Wind Speed Distribution Data

Bin Center Wind Speed [m/s]	Percent of Time [%]
0.5	1.38
1.5	2.53
2.5	6.09
3.5	9.12
4.5	10.53
5.5	10.24
6.5	11.13
7.5	10.37
8.5	9.47
9.5	8.14
10.5	6.51
11.5	4.24
12.5	3.08
13.5	2.02
14.5	1.31
15.5	0.92
16.5	0.66
17.5	0.59
18.5	0.48
19.5	0.52
20.5	0.34
21.5	0.20
22.5	0.08
23.5	0.04
24.5	0.01

Table 1: Wind Speed Distribution, January 1, 2005 – June 23, 2005

Monthly Average Wind Speed Data

Date	Mean [m/s]
Jan 2005	8.56
Feb 2005	8.29
Mar 2005	7.02
Apr 2005	7.40
May 2005	7.54
Jun 2005	-
Jul 2005	-
Aug 2005	-
Sep 2005	-
Oct 2005	-
Nov 2005	-
Dec 2005	-

Table 2 - Wind Speed Averages

Diurnal Average Wind Speed Data

Hour of Day	Average Wind Speed [m/s]
0.5	7.14
1.5	7.10
2.5	7.05
3.5	7.12
4.5	7.18
5.5	7.11
6.5	7.09
7.5	7.14
8.5	7.35
9.5	7.55
10.5	7.56
11.5	7.46
12.5	7.43
13.5	7.60
14.5	7.71
15.5	7.72
16.5	7.69
17.5	7.68
18.5	7.54
19.5	7.35
20.5	7.21
21.5	7.17
22.5	7.07
23.5	7.00

Table 3 - Diurnal Average Wind Speeds, January 1, 2005 – June 23, 2005

Wind Rose Data

Direction	Percent Time [%]	Mean Wind Speed [m/s]
N	8.91	8.27
NNE	11.59	8.15
NE	7.35	8.41
ENE	4.17	7.39
E	3.52	7.05
ESE	3.31	6.67
SE	4.44	7.06
SSE	3.83	6.98
S	4.39	6.69
SSW	7.23	6.72
SW	8.67	7.02
WSW	8.68	6.49
W	6.60	6.38
WNW	7.06	7.46
NW	6.54	7.77
NNW	3.72	7.25

Table 4: Wind Rose, Time Percentage and Mean Wind Speed by Direction, January 1, 2005 – June 23, 2005