

# **FINAL WIND DATA REPORT**

**Upper Cape Cod Regional Technical School  
Bourne, MA**

July 30, 2004 – August 4, 2005

Prepared for

Massachusetts Technology Collaborative  
75 North Drive  
Westborough, MA 01581

by

Melissa L. Ray  
Anthony L. Rogers  
Anthony F. Ellis

August 29, 2005

**Renewable Energy Research Laboratory**  
University of Massachusetts, Amherst  
160 Governors Drive, Amherst, MA 01003

[www.ceere.org/rerl](http://www.ceere.org/rerl) • (413) 545-4359 • [rerl@ecs.umass.edu](mailto:rerl@ecs.umass.edu)



## **NOTICE AND ACKNOWLEDGMENTS**

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.

Further, MTC, the Commonwealth of Massachusetts, and RERL make no warranties or representations, expressed or implied, as to the fitness for particular purpose or merchantability of any product, apparatus, or service, or the usefulness, completeness, or accuracy of any processes, methods or other information contained, described, disclosed, or referred to in this report. MTC, the Commonwealth of Massachusetts, and the contractor make no representation that the use of any product, apparatus, process, method, or other information will not infringe privately owned rights and will assume no liability for any loss, injury, or damage directly or indirectly resulting from, or occurring in connection with, the use of information contained, described, disclosed, or referred to in this report.

# TABLE OF CONTENTS

Notice and Acknowledgments .....	1
Table of Contents .....	2
Table of Figures .....	2
Executive Summary .....	3
SECTION 1 – Station Location .....	4
SECTION 2 - Instrumentation and Equipment.....	4
SECTION 3 - Data Collection and Maintenance.....	5
Data Statistics Summary .....	6
SECTION 4 - Significant Meteorological Events .....	6
SECTION 5 - Data Recovery and Validation.....	7
Test Definitions.....	7
Sensor Statistics .....	8
SECTION 6 - Data Summary .....	10
SECTION 7 - Graphs.....	11
Wind Speed Time Series.....	11
Wind Speed Distribution.....	12
Monthly Averages.....	13
Diurnal Average Wind Speeds.....	14
Turbulence Intensities.....	15
Wind Roses .....	16
APPENDIX A - Sensor Performance Report .....	17
Test Definitions.....	17
Sensor Statistics .....	18
APPENDIX B - Plot Data.....	19
Wind Speed Distribution Data .....	19
Monthly Average Wind Speed Data.....	20
Diurnal Average Wind Speed Data.....	21
Wind Rose Data .....	22

# TABLE OF FIGURES

Figure 1 - Site location at Upper Cape Cod Regional Technical School, Bourne, MA .....	4
Figure 2 - Wind Speed Time Series, July 30, 2004 – August 4, 2005.....	11
Figure 3 - Wind Speed Distribution, August 2004 – July 2005.....	12
Figure 4 - Monthly Averages, August 2004 – July 2005.....	13
Figure 5 - Diurnal Average Wind Speed, August 2004 – July 2005 .....	14
Figure 6 - Turbulence Intensity vs. Wind Speed, August 2004 – July 2005 .....	15
Figure 7 - Wind Rose, August 2004 – July 2005.....	16

## 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.

Wind monitoring equipment was first installed at the Upper Cape Cod Regional Technical School in Bourne, MA, on July 30, 2004. Two sets of two anemometers and one wind vane were mounted at 50 m (164.1 ft) and 39 m (128.0 ft), and an additional vane and anemometer were mounted at 20 m (65.6 ft). The equipment was taken down on August 4, 2005, after completing a full calendar year of wind measurements. For this time period, the gross data recovery percentage (the actual percentage of expected data received) was 100.00 % and the net data recovery percentage (the percentage of expected data which passed all of the quality assurance tests) was 97.22 %. The slightly lower net data recovery is mainly due to multiple icing events during the winter.

This final data report summarizes the wind data collected between July 30, 2004 and August 4, 2005. The mean speed at 50 m over this time period was 5.48 m/s (12.28 mph\*). The highest monthly mean wind speed during the year at 50 m was in April 2005 at 5.99 m/s (13.42 mph) and the lowest was 4.80 m/s (10.75 mph) in July 2005. The prevailing wind direction in the spring, summer, and fall was southwest and in the winter it was northwest. The mean wind speed for the 365-day period of August 1, 2004 to July 31, 2005 was 5.49 m/s (12.30 mph) at 50 m.

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](http://www.ceere.org/rerl/about_wind/RERL_Fact_Sheet_6_Wind_resource_interpretation.pdf)

\* 1 m/s = 2.24 mph

## SECTION 1 – Station Location

The Bourne station is located at the Upper Cape Cod Regional Technical School in Bourne, MA. The tower base is located at NAD 27, 41° 44' 35.9" North, 070° 34' 25.3" West (Figure 1). The elevation at the station is approximately 130 feet above sea level.

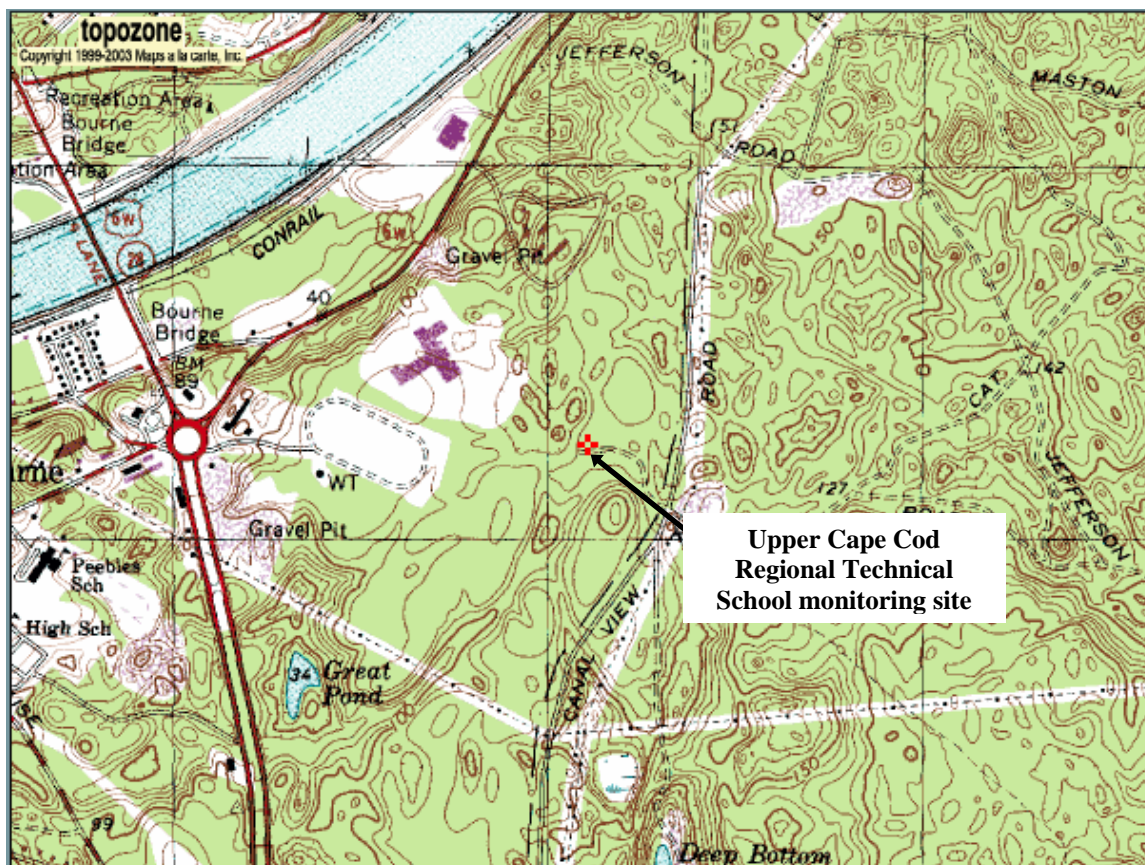


Figure 1 - Site location at Upper Cape Cod Regional Technical School, Bourne, MA

[www.topozone.com](http://www.topozone.com)

## SECTION 2 - Instrumentation and Equipment

The wind monitoring equipment is mounted on a 50 m (164.0 ft) Second Wind tower. All the remaining monitoring equipment comes from NRG Systems, and consists of the following items:

- Symphonie Data Logger
- Electrical enclosure box
- 5 – #40 Anemometers, standard calibration (Slope - 0.765 m/s, Offset – 0.350 m/s). Two anemometers are located at 50 m (164.1 ft), two at 39 m (128.0 ft) and one at a height of 20 m (65.6 ft).
- 3 - #200P Wind direction vanes. They are located at heights of 50 (164.1), 39 (128.0) and 20 m (65.6 ft) each.
- 5 – Sensor booms, 54” length
- Lightning rod and grounding cable
- Shielded sensor wire

The data from the Symphonie logger is mailed to the University of Massachusetts, Amherst on a regular basis. The logger samples wind speed and direction once every two seconds. 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**

Data collection began on July 30, 2004 and ended when the measurement tower was taken down on August 4, 2005. Data cards were manually removed from the logger and mailed to staff at RERL approximately once a month, except for the last month when the card was removed by RERL staff. In December 2004, more than 10% of the data was flagged for icing, so no statistics are reported for December. No other problems with the data were encountered during the yearlong measurement campaign and no maintenance operations were needed or performed on the equipment.

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.

### Data Statistics Summary

Date	Mean Wind Speed	Max Wind Speed	Turbulence Intensity	Prevailing Wind Direction	Mean Wind Speed	Max Wind Speed	Turbulence Intensity	Prevailing Wind Direction	Mean Wind Speed	Max Wind Speed	Prevailing Wind Direction
Heights, units	50 m, [m/s]	50 m, [m/s]	50 m, [ ]	50 m, [ ]	39 m, [m/s]	39 m, [m/s]	39 m, [ ]	39 m, [ ]	20 m, [m/s]	20 m, [m/s]	20 m, [ ]
Aug 2004	5.06	13.3	0.21	SW	4.66	12.5	0.22	SW	3.34	9.6	225
Sep 2004	5.1	16.6	0.18	SW	4.54	15	0.2	SW	3.17	10.1	225
Oct 2004	5.52	13.7	0.19	NE	4.96	12.6	0.21	NE	3.47	9.5	45
Nov 2004	5.66	16.7	0.18	NNW	5.1	15.9	0.2	NNW	3.65	13	NW
Dec 2004	---	---	---	---	---	---	---	---	---	---	---
Jan 2005	5.8	22.1	0.19	NW	5.22	20.3	0.22	NW	3.92	15	NW
Feb 2005	5.49	15.7	0.18	NNE	4.92	14.2	0.21	NNE	3.6	11.2	NNE
Mar 2005	5.67	16.7	0.18	WNW	5.13	16.1	0.2	W	3.86	14	WNW
Apr 2005	5.99	14.9	0.19	SSW	5.45	13.9	0.22	SSW	3.97	11.3	SW
May 2005	5.65	19.8	0.2	NNE	5.18	18.1	0.23	NNE	3.82	13.5	NNE
June 2005	5.25	12.4	0.2	SSW	4.82	11	0.22	SSW	3.6	8.3	SW
July 2005	4.8	12.1	0.19	SW	4.32	11.1	0.22	SW	3.18	8.1	SW
<b>Aug 2004 – July 2005</b>	<b>5.49</b>	<b>22.1</b>	<b>0.19</b>	<b>SW</b>	<b>4.96</b>	<b>20.3</b>	<b>0.21</b>	<b>SW</b>	<b>3.6</b>	<b>15</b>	<b>SW</b>

### **SECTION 4 - Significant Meteorological Events**

The following significant meteorological events occurred during the measurement period:

- 12/26/2004 – Winter storm.
- 1/22/2005 – Winter storm.
- 1/23/2005 – Storm surge.
- 2/24/2005 – Heavy snow.
- 3/01/2005 – Winter storm.
- 3/08/2005 – High winds.

The wind conditions were close to average for the rest of the year.

Sources:

<http://www.erh.noaa.gov/box/MonthlyClimate2.shtml>,

<http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms>

## SECTION 5 - 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 QA controls are given below under Test Definitions and Sensor Statistics. 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.

Gross Data Recovered [%]	100.00
Net Data Recovered [%]	97.22

The high Gross Data Recovery Percentage is an indication that the logger was recording and transmitting perfectly. Icing conditions during the winter and spring resulted in the lower net data recovery, but the sensors were otherwise functioning properly. Once the tower was taken down, the slopes and offsets of all five of the anemometers were compared to a calibrated anemometer in the UMass, Amherst, wind tunnel. These tests verified that the performances of the anemometers did not degrade during the yearlong measurement period and that they were accurately calibrated when they were first installed on the tower.

### 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: wind speed, wind speed standard deviation, wind direction, and temperature.

$$F1 > TF1 > F2$$

**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.

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

**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 less 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.

$$\begin{aligned} & [ TF1 \leq F3 \text{ and } TF2 \leq F3 \text{ and } \text{abs}(TF1 - TF2) > F1 ] \\ & \text{or } [ (TF1 > F3 \text{ or } TF2 > F3) \text{ and } (\text{abs}(1 - TF1 / TF2) > F2 \text{ or } \text{abs}(1 - TF2 / TF1) > F2) ] \end{aligned}$$

### 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. It should be noted that, while this test is tuned to detect sensor icing events, it is possible for the conditions that are representative of icing to occur at other times. The error due to this possibility is considered to be insignificant.

**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 6 - Data Summary

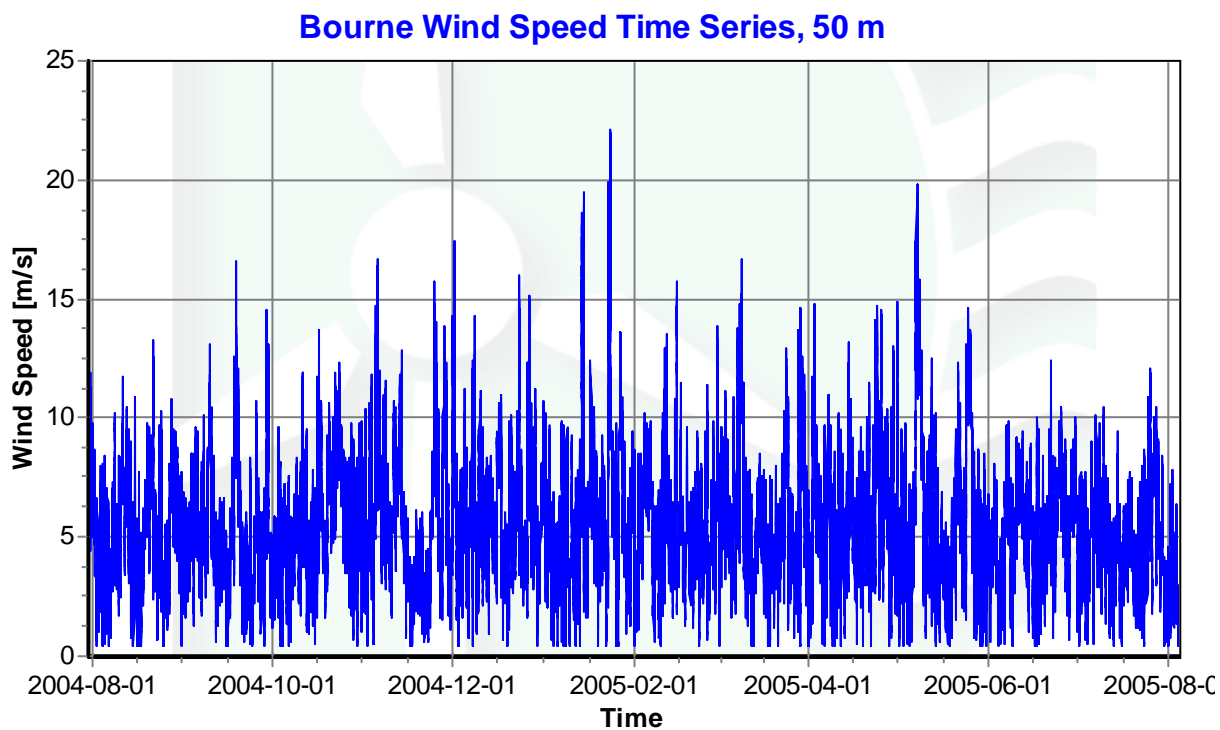
This report contains several types of wind data graphs. Unless otherwise noted, each graph represents data at a height of 50 m (164.1 ft) for the year of measurement from August 2005 through July 2005.

- Time Series – In Figure 2, 10-minute average wind speeds are plotted against time for all data starting on July 30, 2004 at 5:00 PM through August 4, 2005 at 6:50 AM. During this time, highest measured wind speed of 22.1 m/s (49.5 mph) was measured in January 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 3. This plot shows that the wind speeds ranged between 4 and 5 m/s (8.9 and 11.2 mph) 18.42 % of the time.
- Monthly Averages – A plot of the average monthly wind speed for each month of data is shown in Figure 4, starting in August 2004 through July 2005. This graph shows that for Bourne, the highest average monthly wind speed of 5.99 m/s (13.42 mph) was in April 2005. The winter months of December 2004 and January 2005 also have high wind speeds. The lowest was in July 2005, with an average wind speed of 4.8 m/s (10.75 mph).
- Diurnal Average Wind Speeds– Figure 5 is a plot of the average wind speed for each hour of the day. The hourly average varied between 4.92 and 6.2 m/s (11.02 and 13.89 mph), with the highest average speeds between 1 PM and 3 PM. The lowest average wind speeds were between 6 AM and 7 AM.
- Turbulence Intensity – A plot of turbulence intensity as a function of wind speed is shown in Figure 6. Turbulence Intensity is calculated as the standard deviation of the wind speed divided by the wind speed and is a measure of the gustiness of a wind resource. Lower turbulence results in lower mechanical loads on a wind turbine. In general, turbulence intensities range from 0.1 to 0.4; for Bourne, the average turbulence intensity over the entire year was 0.19.
- Wind Rose – Figure 7 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. This wind rose shows the prevailing direction from the southwest. Wind blew from this direction 14.55 % of the time with a mean wind speed of 5.9 m/s (13.22 mph). Wind blew from the north-northeast 9.45% and it had the highest mean wind speed by direction at 6.47 m/s (14.49 mph).

## SECTION 7 - Graphs

Data for the wind speed histograms, monthly and diurnal average plots, and wind roses are included in APPENDIX B.

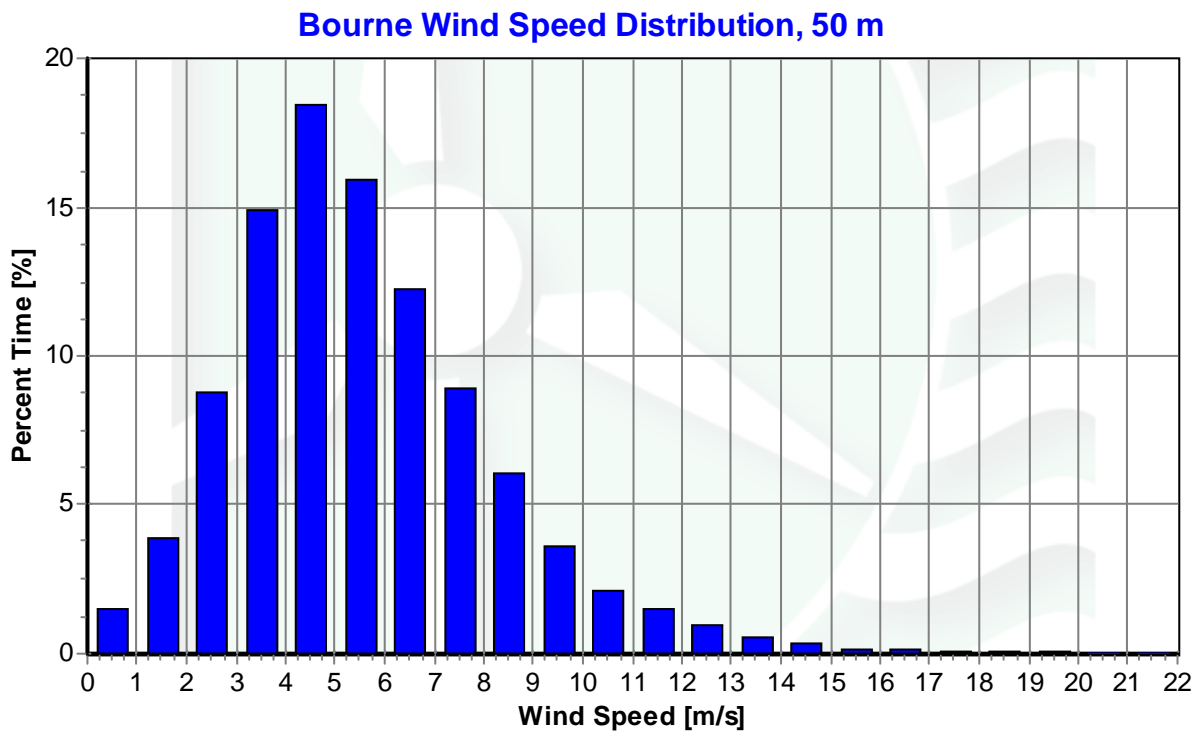
### Wind Speed Time Series



*Plot by DQMS3 - dqms@dqms.com*

**Figure 2 - Wind Speed Time Series, July 30, 2004 – August 4, 2005**

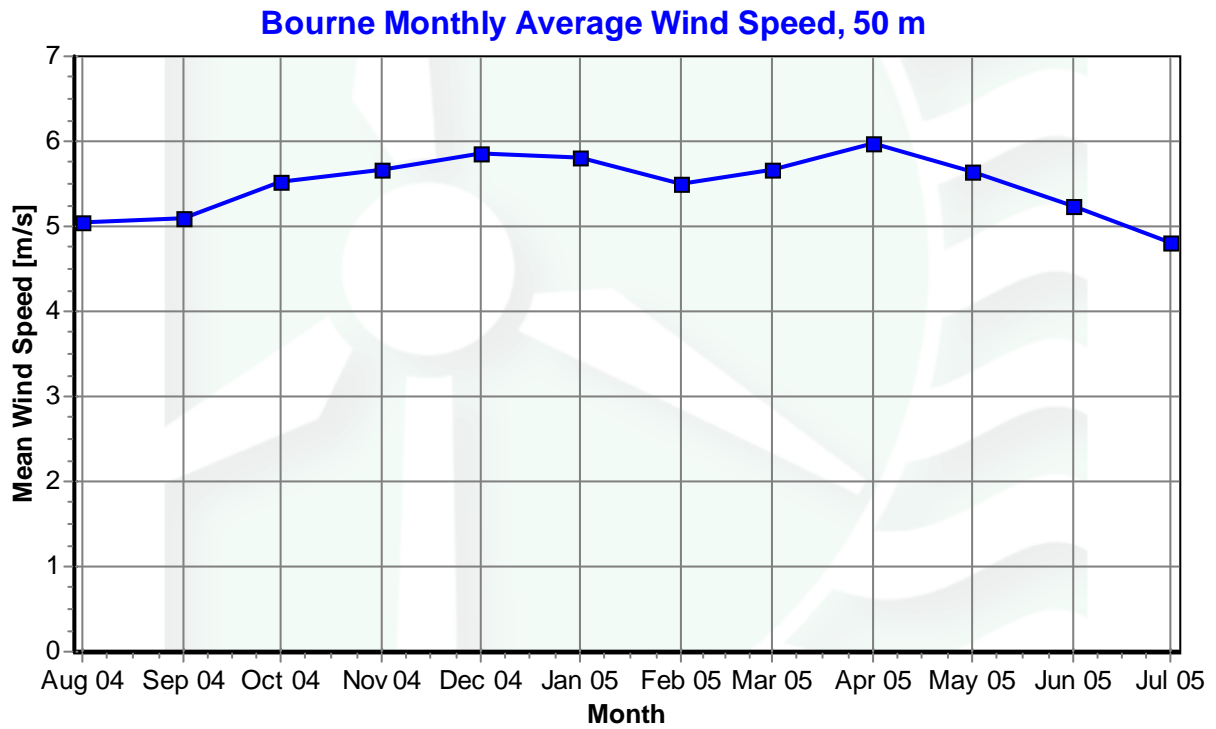
## Wind Speed Distribution



*Plot by DQMS3 - dqms@dqms.com*

**Figure 3 - Wind Speed Distribution, August 2004 – July 2005**

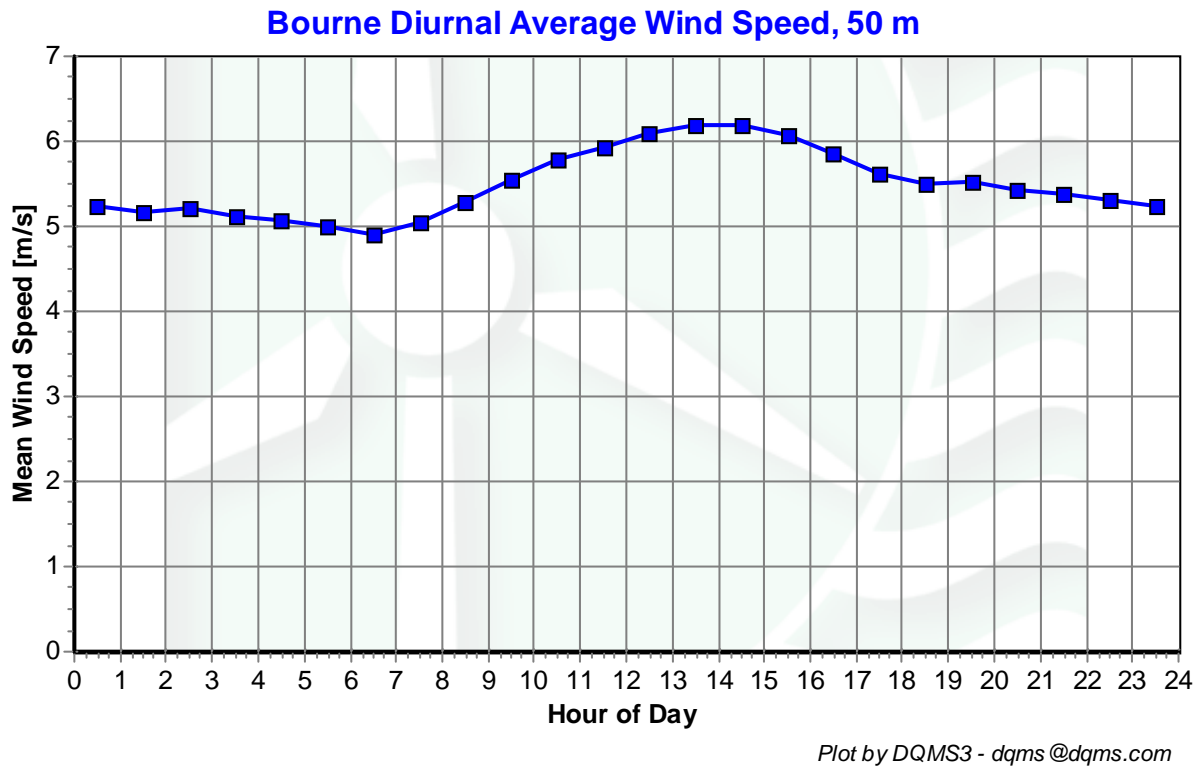
## Monthly Averages



Plot by DQMS3 - dqms@dqms.com

**Figure 4 - Monthly Averages, August 2004 – July 2005**

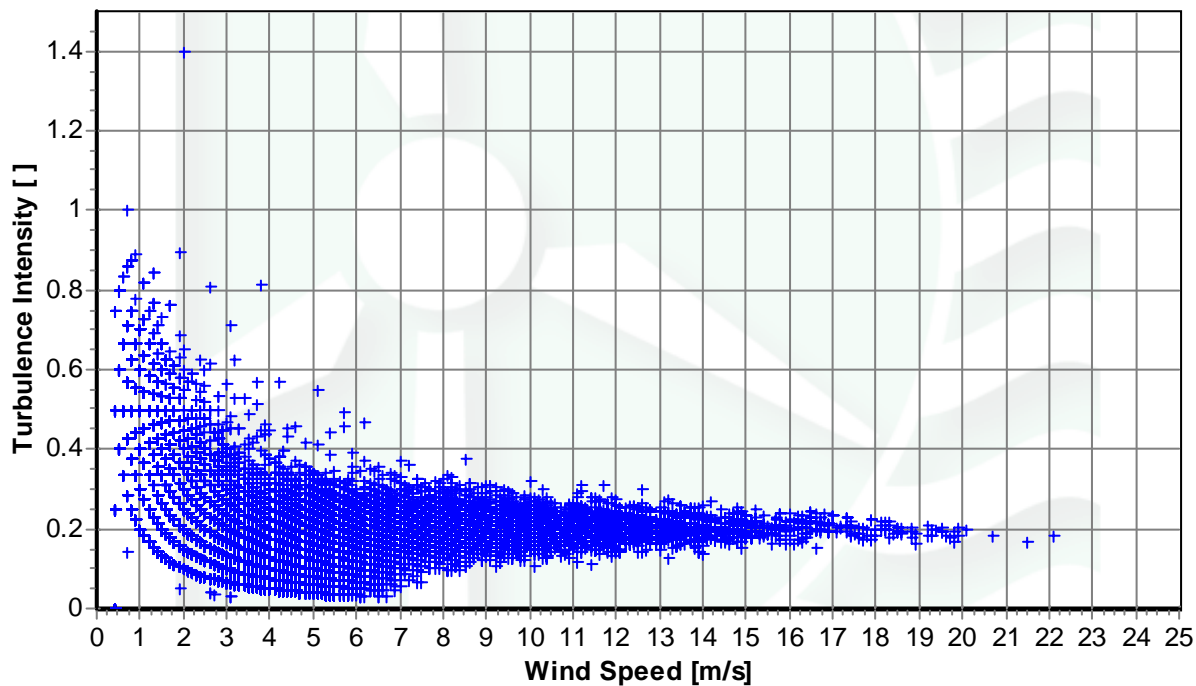
## Diurnal Average Wind Speeds



**Figure 5 - Diurnal Average Wind Speed, August 2004 – July 2005**

## Turbulence Intensities

### Bourne Turbulence Intensity, 50 m



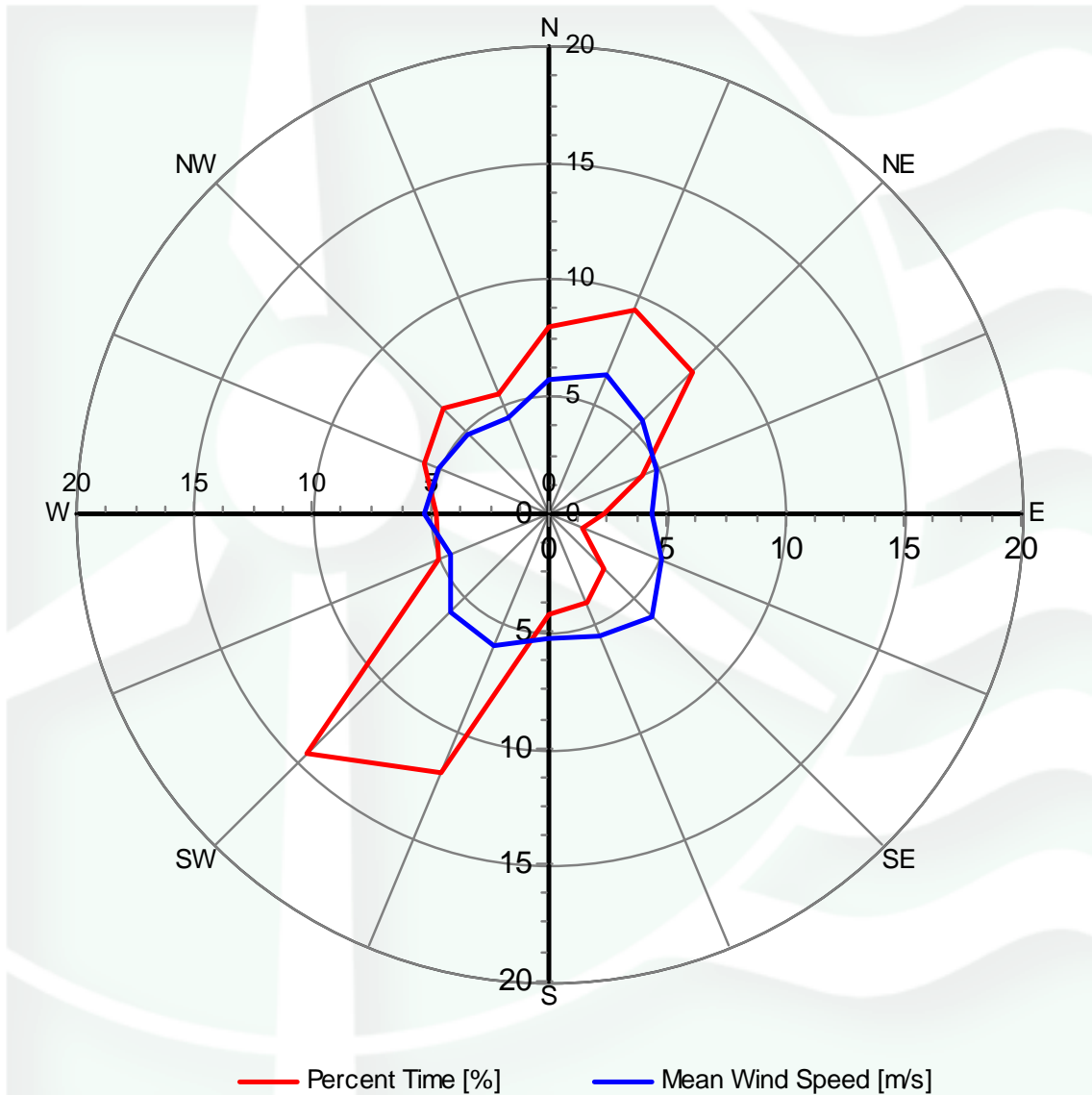
Plot by DQMS3 - dqms@dqms.com

Figure 6 - Turbulence Intensity vs. Wind Speed, August 2004 – July 2005



## Wind Roses

### Bourne Wind Rose, 50 m



Plot by DQMS3 - dqms@dqms.com

Figure 7 - Wind Rose, August 2004 – July 2005

# APPENDIX A - Sensor Performance Report

## Test Definitions

Test Order	TestField1	TestField2	TestField3	CalcField1	CalcField2	TestType	Factor1	Factor2	Factor3	Factor4
1						TimeTest Insert				
2	Etmp2aDEGC					MinMax	-30	60		
3	Etmp2aDEGC					MinMax	-30	60		
4	Etmp2aDEGC					MinMax	-30	60		
5	EtmpSD2aDEGC					MinMax	-30	60		
10	Anem50aMS					MinMax	0	90		
11	Anem50bMS					MinMax	0	90		
12	Anem39aMS					MinMax	0	90		
13	Anem39bMS					MinMax	0	90		
14	Anem20aMS					MinMax	0	90		
15	Anem50yMS					MinMax	0	90		
16	Anem39yMS					MinMax	0	90		
20	AnemSD50aMS					MinMax	0	4		
21	AnemSD50bMS					MinMax	0	4		
22	AnemSD39aMS					MinMax	0	4		
23	AnemSD39bMS					MinMax	0	4		
24	AnemSD20aMS					MinMax	0	4		
25	AnemSD50yMS					MinMax	0	4		
26	AnemSD39yMS					MinMax	0	4		
30	Vane50aDEG					MinMax	0	359.9		
31	Vane39aDEG					MinMax	0	359.9		
32	Vane20aDEG					MinMax	0	359.9		
50	Turb50zNONE					MinMax	0	2		
51	Turb39zNONE					MinMax	0	2		
60	Wshr0zNONE					MinMax	-100	100		
70	Pwr50zWMS					MinMax	0	5000		
71	Pwr39zWMS					MinMax	0	5000		
200	VaneSD50aDEG	Anem50yMS				MinMaxT	0	100	100	10
201	VaneSD39aDEG	Anem39yMS				MinMaxT	0	100	100	10
202	VaneSD20aDEG	Anem20aMS				MinMax	0	100	100	10
300	Anem50aMS	AnemSD50aMS	Vane50aDEG	VaneSD50aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
301	Anem50bMS	AnemSD50bMS	Vane50aDEG	VaneSD50aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
302	Anem39aMS	AnemSD39aMS	Vane39aDEG	VaneSD39aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
303	Anem39bMS	AnemSD39bMS	Vane39aDEG	VaneSD39aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
304	Anem20aMS	AnemSD20aMS	Vane20aDEG	VaneSD20aDEG	Etmp2aDEGC	Icing	0.5	1	2	10
400	Anem50aMS	Anem50bMS				CompareSensors	1	0.25	3	0
401	Anem39aMS	Anem39bMS				CompareSensors	1	0.25	3	0

500	Amax50aMS					MinMax	0	90		
501	Amax50bMS					MinMax	0	90		
502	Amax39aMS					MinMax	0	90		
503	Amax39bMS					MinMax	0	90		
504	Amax20aMS					MinMax	0	90		
510	Amin50aMS					MinMax	0	90		
511	Amin50bMS					MinMax	0	90		
512	Amin39aMS					MinMax	0	90		
513	Amin39bMS					MinMax	0	90		
514	Amin20aMS					MinMax	0	90		
520	Vmax50aDEG					MinMax	0	359.9		
521	Vmax40aDEG					MinMax	0	359.9		
522	Vmax20aDEG					MinMax	0	359.9		
530	Vmin50aDEG					MinMax	0	359.9		
531	Vmin39aDEG					MinMax	0	359.9		
532	Vmin20aDEG					MinMax	0	359.9		

### Sensor Statistics

Sensor	Expected Data Points	Actual Data Points	% Data Recovered	Hours Out of Range	Hours of Icing	Hours of Fault	% Data Good
Anem50aMS	53220	53220	100	2.667	294.833	4	96.601
AnemSD50aMS	53220	53220	100	2.667	294.833	4	96.601
Anem50bMS	53220	53220	100	4.833	271.333	11.333	96.759
AnemSD50bMS	53220	53220	100	4.833	271.333	11.333	96.759
Anem39aMS	53220	53220	100	4.333	304.167	33.167	96.148
AnemSD39aMS	53220	53220	100	4.333	304.167	33.167	96.148
Anem39bMS	53220	53220	100	4.5	309.167	37.667	96.039
AnemSD39bMS	53220	53220	100	4.5	309.167	37.667	96.039
Anem20aMS	53220	53220	100	3.5	146.167	0	98.313
AnemSD20aMS	53220	53220	100	3.5	146.167	0	98.313
Vane50aDEG	53220	53220	100	2.333	295	0	96.648
VaneSD50aDEG	53220	53220	100	2.333	295	0	96.648
Vane39aDEG	53220	53220	100	2.5	339.833	0	96.141
VaneSD39aDEG	53220	53220	100	2.5	339.833	0	96.141
Vane20aDEG	53220	53220	100	3	146.167	0	98.318
VaneSD20aDEG	53220	53220	100	3	146.167	0	98.318
Etmp2aDEGC	53220	53220	100	0.667	0	0	99.992
EtmpSD2aDEGC	53220	53220	100	0	0	0	100
<b>Total</b>	<b>957960</b>	<b>957960</b>	<b>100</b>	<b>56</b>	<b>4213.333</b>	<b>172.333</b>	<b>97.218</b>

## APPENDIX B - Plot Data

### Wind Speed Distribution Data

Bin Center Wind Speed [m/s]	Percent of Time [%]
0.5	1.48
1.5	3.9
2.5	8.74
3.5	14.87
4.5	18.42
5.5	15.94
6.5	12.27
7.5	8.88
8.5	6.05
9.5	3.57
10.5	2.14
11.5	1.49
12.5	0.92
13.5	0.57
14.5	0.32
15.5	0.15
16.5	0.11
17.5	0.06
18.5	0.05
19.5	0.03
20.5	0.01
21.5	0.02
22.5	0
23.5	0
24.5	0

**Table 1 - Wind Speed Distribution**

### Monthly Average Wind Speed Data

<b>Date</b>	<b>10 min Mean [m/s]</b>
Aug 2004	5.06
Sep	5.10
Oct	5.52
Nov	5.66
Dec	5.87
Jan 2005	5.80
Feb	5.49
Mar	5.65
Apr	5.99
May	5.65
Jun	5.25
Jul	4.80

**Table 2 - Wind Speed Averages**

### **Diurnal Average Wind Speed Data**

<b>Hour of Day</b>	<b>Average Wind Speed [m/s]</b>
0.5	5.23
1.5	5.16
2.5	5.21
3.5	5.11
4.5	5.08
5.5	5.01
6.5	4.92
7.5	5.04
8.5	5.28
9.5	5.55
10.5	5.79
11.5	5.94
12.5	6.09
13.5	6.20
14.5	6.19
15.5	6.07
16.5	5.85
17.5	5.61
18.5	5.50
19.5	5.51
20.5	5.43
21.5	5.37
22.5	5.31
23.5	5.24

**Table 3 - Diurnal Average Wind Speeds**

### Wind Rose Data

<b>Direction</b>	<b>Percent Time [%]</b>	<b>Mean Wind Speed [m/s]</b>
<b>N</b>	7.97	5.74
<b>NNE</b>	9.45	6.47
<b>NE</b>	8.55	5.66
<b>ENE</b>	4.32	4.94
<b>E</b>	2.35	4.34
<b>ESE</b>	1.58	5.17
<b>SE</b>	3.37	6.17
<b>SSE</b>	4.11	5.68
<b>S</b>	4.34	5.31
<b>SSW</b>	12.04	6.14
<b>SW</b>	14.55	5.90
<b>WSW</b>	5.05	4.53
<b>W</b>	4.75	5.29
<b>WNW</b>	5.74	5.04
<b>NW</b>	6.33	4.81
<b>NNW</b>	5.50	4.45

**Table 4 - Wind Rose, Time Percentage and Mean Wind Speed by Direction**