

## I. Data Set & Research Descriptors

### 1) Principal Investigator(s) & contact persons

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### 2) Entry Verification

System I: CR1000, CR10X

The initial weather station and CR10X program was installed in late October 2003. The old program (ner30.csi) was revised (NERR\_4.CSI) to standardize the program for all sites. The revision was necessary to meet new data reporting requirements of CDMO to eliminate instantaneous data sample reporting, add cumulative daily rainfall and additional sensors. Starting July 12, 2006 at 17:45, WBNERR weather station was changed from the CR10X Datalogger to a CR1000 Datalogger and associated software program. The sensors for Air Temperature (C), Relative Humidity (%), Barometric Pressure (mb), Wind Speed, Wind Direction, Total Precipitation (mm), Total Photosynthetically Available Radiation (PAR), and Total Solar Radiation (SoRAD – available from the reserve) remain the same. See section 9: Sensor specifications, operating range, accuracy, date of last calibration for sensor specifications.

The meteorological information is sampled every 5 seconds from each instrument on the weather station and stored on a Campbell Scientific CR1000 data logger. Data are output to a file in three file formats: CR1000\_A5Min.dat stores 5 minute data; CR1000\_GOESout.dat stores 15 minute averages that are transmitted hourly for Satellite upload; and CR1000\_SWMP.dat files stores the 15 minute average and total data that is submitted to CDMO on a quarterly basis for primary QAQC review. The CDMO Data Logger (NERR\_4.CSI) was loaded into the CR1000 and controls the sensors. The CR1000 then interfaces with the LoggerNet software supplied by Campbell Scientific.

Presently, data are uploaded from the CR1000 data logger to a personal computer (IBM compatible). Files are exported from LoggerNet in a comma-delimited format and uploaded to the CDMO where they undergo automated primary QAQC and become part of the CDMO's online provisional database. During primary QAQC, data are flagged if they are missing or out of sensor range,. The edited file is then returned to the Reserve where it is opened in Microsoft Excel and processed using the CDMO's NERRQAQC Excel macro. The macro inserts station codes, creates metadata worksheets for flagged

data, and graphs the data for review. It allows the user to apply QAQC flags and codes to the data, append files, and export the resulting data file to the CDMO for tertiary QAQC and assimilation into the CDMO's authoritative online database. For more information on QAQC flags and QAQC codes, see sections 11 and 12

Chris Weidman, Research Coordinator and MaryKay Fox, Assistant Research Coordinator, error checked and compiled the meteorological data.

#### System II.

In July 2006, our meteorological station was linked to a NOAA GOES<sup>®</sup> satellite system, which allowed near real-time access to our meteorological data over the internet. A Campbell Scientific data telemetry equipment is used at this station to transmit to the NOAA GOES satellite, NESDIS ID #3B022462. The transmissions are scheduled hourly and contain four (4) datasets reflecting the fifteen minute data sampling interval. The telemetry is "Provisional" data and not the "Authentic" Dataset used for long term monitoring and study.

#### System III

On February 10th, 2005, a new EPLAB<sup>®</sup> Black and White Pyranometer was installed. It was mounted on the same structure as the PAR instrument approximately within one meters distance. This Pyranometer is an Eppley 10-and 50-junction 180<sup>°</sup> pyrliometer originally introduced by Kimball and Hobbs in 1923. The detector is a differential thermopile with the hot-junction receivers blackened and the cold-junction receivers whitened. The element is of radial wire-wound-plated construction with the black segments coated with 3M black and the white segments with Barium Sulfate. Built in temperature compensation with thermistor circuitry is incorporated to free the instrument from the effects of ambient temperature. A precision ground optical glass hemisphere of Schott glass WG295 uniformly transmits energy from 285 to 2,800 millimicrons. This hemispherical envelope seals the instrument from the weather, but is readily removable for instrument repair. The cast aluminum case carries a circular spirit level and adjustable leveling screws. Also supplied is a desiccator, which can be inspected readily. **Total Solar Radiation data are not currently available from the CDMO, but are available from the Reserve.**

### 3) Research objectives

The principal objectives are to record meteorological information for the Waquoit Bay NERR's site that can be used 1) as a vital reference of atmospheric data for various research projects at the reserve -- an integral part of our general NERR mission is to provide a platform for estuarine research, 2) to give meteorological context (atmospheric-forcing) for our fifteen minute SWMP water quality data, and other long-term environmental monitoring programs at the Reserve (including nutrients and shoreline change), 3) to observe and characterize important events, such as storms, heat and cold waves, droughts and heavy rainfalls, and 4) to detect trends and characterize climate variability over the long-term.

### 4) Research Methods

The Campbell Scientific weather station samples every 5 seconds continuously throughout the year. These data are used by the CR1000 to produce 15 minute averages of those measurements of air temperature, relative humidity, barometric pressure, wind speed, and wind direction. Precipitation and PAR are recorded as totals

for each interval. As mentioned above, we generally upload data from the CR1000 storage module about once a month. CR1000 raw data are currently stored on one data storage module capable of storing about 3 months of data. The CR1000 is also cabled directly to a desktop PC where the instantaneous 5 sec data are displayed (in a LoggerNet window) and can be viewed at any time. All collected data is quality checked immediately after the monthly downloads.

Campbell Scientific data telemetry equipment was installed at the WQB Carriage House meteorological station on July 2006 and transmits data to the NOAA GOES satellite, NESDIS ID #3B022462. The transmissions are scheduled hourly and contain four (4) data sets reflecting fifteen minute data sampling intervals. Upon receipt by the CDMO, the data undergoes the same automated primary QAQC process detailed in Section 2 above. The “real-time” telemetry data become part of the provisional dataset until undergoing secondary and tertiary QAQC and assimilation in the CDMO’s authoritative online database. Provisional and authoritative data are available at <http://cdmo.baruch.sc.edu>.

The 15-minute data are collected in the following formats for the CR1000:

Averages from 5-second data:

Air Temperature (°C), Relative Humidity (%), Barometric Pressure (mb),  
Wind Speed (m/s), Wind Direction (degrees), Battery Voltage (volts)  
Maximum and Minimum Air Temperature (°C) and their times from 5-second data  
(these data are available from the Reserve)  
Maximum Wind Speed (m/s) and time from 5-second data  
Wind Direction Standard Deviation (degrees)

Totals:

Precipitation (mm), PAR (millimoles/m<sup>2</sup>), and Cumulative Precipitation (mm)

Sensors on the weather station are inspected monthly for damage or debris. The heated rain gauge tends to collect debris and is cleaned out every few days, particularly before and after major storms events. Sensors are removed and calibrated on an annual basis depending on the particular sensor, unless the real-time data stream indicates a malfunction. Also, once a month on upload day, we use a compass and utilize a Weather Station monitoring system (with a wind sensor) to run a comparative set of observations as a general check on the Campbell station sensors.

Recommended calibration frequency for the MET station sensors:

- Temperature/Humidity- yearly recalibration
- Rain Gauge- yearly recalibration
- Wind Speed/Direction- yearly or every 2 years (depending on the sensor)
- Barometric Pressure- every 2 years recalibration
- PAR- every 2 years recalibration
- CR1000-every 5 years (required beginning 2014, one year initial grace period)

## **5) Site Location and character**

The weather station is located on a 24-acre parcel of Reserve land that includes the Reserve headquarters at 41° 34'54.12 N, 70° 31' 30.36 W. Wind (speed and direction), temperature and relative humidity sensors are mounted on a 10-m aluminum tower next to the Carriage House, which houses our grounds facilities, classroom and laboratory. The tower is surrounded on three sides by an open parking area; its attached probes stand approximately 2.5 m above the roof peak of the adjacent building and are separated from any trees by at least 30 m. A crushed shell parking area (bleach white in color) is located directly to the south and west of the tower, with the building and its roof

peak to the northeast. The tower base is 10.39 m above sea level (NGVD), approximately 100 m north from Waquoit Bay's northern shoreline. The location is most well exposed to winds from the west and south (southeast clockwise to northwest). The LiCor (PAR) sensor and EPLAB Pyranometer (Total Solar Radiation) are mounted about 10 m away on an extended aluminum arm at a height of 3 m above the ground level and is well exposed at all times to the sun in both winter and summer. The air pressure sensor, which is mounted next to the CR1000 in the laboratory, is approximately 1.5meters in height above ground level. . The rain gauge is located in an open field away from trees about 55 m northwest of the laboratory and tower at 41° 34.908' N, 70° 31.546' W and 11.2 m above sea level (NGVD).

As for its general setting, the Waquoit Bay National Estuarine Research Reserve (WBNERR) is located in the northeastern United States on the southern coast of Cape Cod, Massachusetts. Climatically, this region is considered temperate maritime, and experiences relatively mild winters and cool summers relative to the rest of New England because of its exposed oceanic location. Typical of the mid-latitudes (41 N), prevailing winds are from the southwest, while storm winds tend to be from the east.

The area is adjacent to one of the world's most active regions for cyclogenesis (extra-tropical cyclone formation) off the East coast of North America. These generally winter season storms are most frequent (almost weekly) from late October until late April and are locally called Nor'easters because of the NE wind direction typical to the area during the period of peak wind speeds. These storms generally develop rapidly as secondary lows off the mid-Atlantic coast (Carolinas to New Jersey) and track northeastward passing Cape Cod either directly overhead, or to the southeast or northwest. These winter season storms are important agents of coastal erosion and shoreline alteration in the region, particularly for easterly facing coasts.

Hurricanes are also important phenomena in the region. Most years, during the period from July to November, the Cape experiences some interaction with a passing tropical storm. About once every decade the area experiences a nearby landfall, with winds exceeding hurricane threshold (>33 m/s), usually from the southerly quarter. Hurricanes are particularly important agents of change for the Cape's southern coastal areas, and can have profound effects on local estuaries, including Waquoit Bay. Typically, barrier beach over-wash (with salt marsh burial) and breaching (with new tidal inlet formation) occur during these extreme events.

|                | Jan  | Feb  | Mar  | Apr  | May  | Jun  | Jul  | Aug  | Sep  | Oct  | Nov  | Dec  | Annual       |
|----------------|------|------|------|------|------|------|------|------|------|------|------|------|--------------|
| Ptown Temp (C) | -0.6 | -1.1 | 1.7  | 6.7  | 11.7 | 17.2 | 20.6 | 20.0 | 17.2 | 12.2 | 6.7  | 1.7  | <b>9.5</b>   |
| WQB Temp (C)   | 0.0  | 3.3  | 5.7  | 10.0 | 13.6 | 18.2 | 22.8 | 22.8 | 18.6 | 11.0 | 6.7  | 1.1  | <b>11.2</b>  |
| Ptown Ppt (cm) | 9.9  | 8.7  | 9.4  | 9.0  | 7.5  | 7.0  | 6.8  | 8.1  | 8.4  | 8.7  | 8.1  | 9.2  | <b>100.8</b> |
| WQB Ppt (cm)   | 12.5 | 5.6  | 14.5 | 10.7 | 13.4 | 8.1  | 1.4  | 6.5  | 13.8 | 8.2  | 19.9 | 20.4 | <b>135.0</b> |

**Average temperature and rainfall conditions for the period 1882-1960 for Provincetown (about 50 km to the northwest) (Ptown) are shown in the table below in comparison with Waquoit Bay (WQB) monthly values for 2002.**

Note: The temperatures for Waquoit Bay on the southwest corner of Cape Cod vs. for Provincetown on the northeast corner are likely to be a bit warmer in spring and summer and a bit colder in autumn and winter. Provincetown is on a very small peninsula a couple of miles wide, surrounded by colder (in Summer) Gulf of Maine waters, while Waquoit Bay is closer to the mainland of New England and is bathed by the warmer shelf waters of southern New England. Also, these averages do not include the period since 1960. The last two decades, in particular, have been known to be among the warmest recorded (last 150 years), though that may be compensated in part by the historically cold periods of mid-1960s and mid-1970s.

Meteorological data from Waquoit Bay NERR can also be compared to that from other nearby meteorological stations. These stations are located at Otis Air Force Base (10 km to the north), Falmouth Water Department-Long Pond (8 km to the west), Woods Hole Oceanographic Institution–Quisset Campus (13 km to the southwest), Hyannis Airport (23 km to the northeast), and Buzzards Bay Texas Tower (41 km to the southwest) – this latter station being a particularly valuable reference site because it is offshore and weatherward (southwest) with at least 15 km of unobstructed open water around it and it also records other useful sea surface parameters (wave height and direction, and ocean temperatures). We frequently compare our observations with data from the NOAA offshore tower at the entrance to Buzzards Bay (Temperature, Wind, and Air Pressure) because its current (within the hour) and archived measurements are available online (website). A comparison of monthly data for 2002 between the Buzzards Bay Tower and Waquoit Bay SWMP data is shown in the table below:

#### **Buzzards Bay Tower and Waquoit Bay (data) Monthly Meteorological Statistics for 2002**

**Note: Water temps in Waquoit Bay are from Menauhant SWMP Station**

| Month               | Wdir         | Wspd<br>m/s    | Gust<br>m/s | Wave<br>ht | Baro             | Air T           | Water T       |
|---------------------|--------------|----------------|-------------|------------|------------------|-----------------|---------------|
| <b>Jan<br/>mean</b> | 243<br>(249) | 9.0 (2.1)      | 10.0        | 1.3        | 1013.1<br>(1011) | 4.0 (3.9)       | 5.7 (3.3)     |
| <b>Jan min</b>      | ----         | 1.4 (0.0)      | 1.5         | 0.3        | 986.1 (980)      | -4.5 (-<br>4.7) | 4.5 (0.6)     |
| <b>Jan max</b>      | ----         | 21.5<br>(16.6) | 24.6        | 2.9        | 1031.6<br>(1031) | 11.1<br>(13.7)  | 8.0 (5.8)     |
|                     |              |                |             |            |                  |                 |               |
| <b>Feb<br/>mean</b> | 220<br>(237) | 8.6 (3.1)      | 9.5         | 1.1        | 1016.0<br>(1014) | 3.1 (3.3)       | 4.6 (3.7)     |
| <b>Feb min</b>      | ----         | 0.6 (0.0)      | 0.7         | 0.3        | 995.7 (992)      | -6.9 (-<br>9.7) | 3.6 (1.0)     |
| <b>Feb max</b>      | ----         | 21.0<br>(14.4) | 23.6        | 3.1        | 1037.6<br>(1036) | 11.1<br>(13.7)  | 6.1 (6.9)     |
|                     |              |                |             |            |                  |                 |               |
| <b>Mar<br/>mean</b> | 179<br>(186) | 8.8 (2.5)      | 9.6         | 1.3        | 1020.3<br>(1018) | 4.5 (5.7)       | 5.1 (5.8)     |
| <b>Mar min</b>      | ----         | 0.4 (0.0)      | 0.5         | 0.4        | 998.0 (998)      | -6.6 (-<br>5.5) | 4.4 (3.2)     |
| <b>Mar max</b>      | ----         | 20.0<br>(18.0) | 22.0        | 3.7        | 1038.8<br>(1038) | 12.7<br>(17.9)  | 5.9 (9.8)     |
|                     |              |                |             |            |                  |                 |               |
| <b>Apr<br/>mean</b> | 201<br>(214) | 7.6 (2.4)      | 8.3         | 0.9        | 1018.4<br>(1016) | 8.0<br>(10.0)   | 7.9<br>(10.9) |

|                 |           |             |      |     |               |             |             |
|-----------------|-----------|-------------|------|-----|---------------|-------------|-------------|
| <b>Apr min</b>  | ----      | 0.4 (0.0)   | 0.5  | 0.2 | 997.6 (995)   | -0.9 (-2.0) | 5.6 (6.7)   |
| <b>Apr max</b>  | ----      | 21.6 (17.1) | 25.4 | 2.3 | 1039.5 (1038) | 22.4 (31.2) | 10.2 (16.3) |
|                 |           |             |      |     |               |             |             |
| <b>May mean</b> | 200 (194) | 7.8 (2.0)   | 8.5  | 0.9 | 1016.5 (1015) | 11.4 (13.6) | 11.1 (14.2) |
| <b>May min</b>  | ----      | 0.2 (0.0)   | 0.7  | 0.3 | 993.2 (990)   | 5.3 (2.4)   | 9.1 (10.4)  |
| <b>May max</b>  | ----      | 22.1 (16.6) | 24.6 | 2.4 | 1028.4 (1027) | 19.6 (24.9) | 14.5 (20.3) |
|                 |           |             |      |     |               |             |             |
| <b>Jun mean</b> | 175 (216) | 6.9 (1.6)   | 7.5  | 0.8 | 1016.0 (1015) | 16.2 (18.2) | 15.3 (19.1) |
| <b>Jun min</b>  | ----      | 0.0 (0.0)   | 0.0  | 0.4 | 998.2 (996)   | 9.7 (5.9)   | 13.6 (14.9) |
| <b>Jun max</b>  | ----      | 18.6 (10.7) | 20.3 | 1.8 | 1033.6 (1033) | 26.2 (31.3) | 18.5 (24.3) |
|                 |           |             |      |     |               |             |             |
| <b>Jul mean</b> | 207 (218) | 6.6 (1.4)   | 7.0  | 0.7 | 1014.8 (1014) | 20.6 (22.8) | 18.7 (23.4) |
| <b>Jul min</b>  | ----      | 0.0 (0.0)   | 0.0  | 0.4 | 1005.3 (1004) | 15.7 (11.2) | 16.0 (21.5) |
| <b>Jul max</b>  | ----      | 15.9 (11.8) | 17.1 | 1.6 | 1024.8 (1024) | 29.4 (34.2) | 21.5 (26.5) |
|                 |           |             |      |     |               |             |             |
| <b>Aug mean</b> | 178 (207) | 6.4 (1.4)   | 6.8  | 0.6 | 1017.5 (1017) | 21.2 (22.8) | 20.0 (24.3) |
| <b>Aug min</b>  | ----      | 0.1 (0.0)   | 0.3  | 0.3 | 1005.4 (1006) | 15.6 (11.7) | 18.1 (20.6) |
| <b>Aug max</b>  | ----      | 14.2 (11.4) | 14.9 | 1.4 | 1034.4 (1035) | 25.9 (33.5) | 22.9 (28.1) |
|                 |           |             |      |     |               |             |             |
| <b>Sep mean</b> | 180 (192) | 7.1 (1.7)   | 7.7  | 0.8 | 1017.7 (1017) | 18.8 (18.6) | 19.0 (21.0) |
| <b>Sep min</b>  | ----      | 0.2 (0.0)   | 0.5  | 0.3 | 988.3 (992)   | 12.6 (7.8)  | 17.7 (19.0) |
| <b>Sep max</b>  | ----      | 21.2 (15.7) | 24.5 | 2.9 | 1033.1 (1033) | 23.9 (27.9) | 20.6 (23.4) |
|                 |           |             |      |     |               |             |             |
| <b>Oct mean</b> | 177 (206) | 8.5 (1.9)   | 9.5  | 0.9 | 1019.0 (1018) | 12.5 (11.0) | 16.4 (15.2) |
| <b>Oct min</b>  | ----      | 0.7 (0.0)   | 1.1  | 0.2 | 995.1 (995)   | 2.8 (-1.4)  | 13.2 (9.6)  |
| <b>Oct max</b>  | ----      | 19.9 (13.2) | 23.0 | 3.3 | 1030.3 (1029) | 22.0 (24.9) | 19.2 (21.3) |
|                 |           |             |      |     |               |             |             |
| <b>Nov mean</b> | 204 (241) | 10.1 (2.5)  | 11.2 | 1.3 | 1013.0 (1012) | 8.0 (6.7)   | 11.3 (9.0)  |
| <b>Nov min</b>  | ----      | 0.1 (0.0)   | 0.5  | 0.3 | 987.2 (983)   | -5.0 (-7.3) | 8.5 (3.9)   |

|                 |              |                |      |     |                    |                |                |
|-----------------|--------------|----------------|------|-----|--------------------|----------------|----------------|
| <b>Nov max</b>  | ----         | 20.6<br>(15.8) | 23.0 | 3.2 | 1028.4<br>(1028)   | 17.2<br>(21.1) | 13.3<br>(14.2) |
|                 |              |                |      |     |                    |                |                |
| <b>Dec mean</b> | 246<br>(254) | 9.6 (2.8)      | 10.7 | 1.2 | 1014.2<br>(1013)   | 2.6 (1.1)      | 6.3 (3.3)      |
| <b>Dec min</b>  | ----         | 0.0 (0.0)      | 0.0  | 0.3 | 974.3 (975)        | -8.0 (-9.5)    | 4.4 (1.2)      |
| <b>Dec max</b>  | ----         | 21.4<br>(17.2) | 24.6 | 3.1 | 1036.4<br>(1035)   | 12.7<br>(13.0) | 9.6 (6.7)      |
|                 |              |                |      |     |                    |                |                |
| <b>Ann mean</b> | 201<br>(218) | 8.1 (2.1)      | 8.9  | 1.0 | 1016.4<br>(1015.0) | 10.9<br>(11.5) | 11.8<br>(12.8) |
| <b>Ann min</b>  | ----         | 0.0 (0.0)      | 0.0  | 0.2 | 974.3 (975)        | -8.0 (-9.7)    | 3.6<br>(0.6)   |
| <b>Ann max</b>  | ----         | 22.1<br>(18.0) | 25.4 | 3.7 | 1039.5<br>(1038)   | 29.4<br>(34.2) | 22.9<br>(28.1) |

Meteorological differences between the offshore Buzzards Bay Tower and our Waquoit Bay station are to be expected because of a separation of about 40 km and because of the site geographies (offshore vs. coastal land). Wind direction values generally are higher for Waquoit Bay versus Buzzards Bay Tower, meaning a more westward and northward component at the Waquoit Bay site. This is an expected result of winds encountering greater friction over land than over water causing the wind to turn more to the right over land. Average wind speeds are notably lower at Waquoit Bay by about a factor of four. Somewhat lower wind speeds are expected again because of the greater surface friction and topography encountered at land versus offshore stations, but a factor of four appears to us to be unusually large. We have verified our Wind Monitor wind speeds using a hand-held Kestrel, but our wind speeds are also lower by a factor of 2-3 compared with other nearby land stations (Otis Air Base and Hyannis Airport). The Buzzards Bay station is noted for its very high (often the highest) wind speeds recorded for even nearby offshore sites, so the fact that it has some “outlier” characteristics relative to other regional stations is to be noted. As for local topographic effects at Waquoit Bay, the site (as noted above) is about 100 m from a 6 m bluff and the surrounding area is forested with tree canopies topping out at about 10 m., so the wind sensors no doubt experience a fairly turbulent (gusty) wind stream. In contrast maximum wind speeds at Waquoit are not so different (80%) from Buzzards Bay Tower values strongly indicating that the Waquoit wind sensor is calibrated correctly and that the winds at Waquoit show more variability. Air pressure values between stations track closely with Waquoit showing only a slightly lower average of about 1 mb. Air Temperatures also track closely, with the expected land/ocean contrasts of Waquoit’s land site showing more extreme hot and cold values, and with colder averages in the winter and warmer averages in the summer. Water temperatures also show a similar though more subdued set of contrasts between stations.

Other stations which are also used for reference are 1) the Woods Hole Oceanographic Institution in Woods Hole (Temperature, Air Pressure, and Solar Radiation), 2) Falmouth DPW (rainfall), 3) Otis Air Force Base (wind), and 4) Hyannis Airport (Temperature, Wind, Rainfall, Air Pressure, Relative Humidity) and Menauhant Yacht Club weather station operated and maintained by Dr. Richard Taylor

## 6) Data collection period

Weather data has been collected at the Waquoit Bay NERR Carriage House since December 2001. The current weather station has been operational since this date.

Data were collected continuously for the entire year in 2012 from 1/1/2012 00:00 through 12/31/2012 23:45, except for when sensors were calibrated, or when sensors were removed due to failure.

## **7) Distribution**

NOAA/ERD retains the right to analyze, synthesize and publish summaries of the NERRS System-wide Monitoring Program data. The PI retains the right to be fully credited for having collected and processed the data. Following academic courtesy standards, the PI and NERR site where the data were collected will be contacted and fully acknowledged in any subsequent publications in which any part of the data are used. Manuscripts resulting from this NOAA/OCRM supported research that are produced for publication in open literature, including refereed scientific journals, will acknowledge that the research was conducted under an award from the Estuarine Reserves Division, Office of Ocean and Coastal Resource Management, National Ocean Service, National Oceanic and Atmospheric Administration. The data set enclosed within this package/transmission is only as good as the quality assurance and quality control procedures outlined by the enclosed metadata reporting statement. The user bears all responsibility for its subsequent use/misuse in any further analyses or comparisons. The Federal government does not assume liability to the Recipient or third persons, nor will the Federal government reimburse or indemnify the Recipient for its liability due to any losses resulting in any way from the use of this data.

NERR weather data and metadata can be obtained from the Research Coordinator at the individual NERR site (please see Principal investigators and contact persons), from the Data Manager at the Centralized Data Management Office (please see personnel directory under the general information link on the CDMO home page) and online at the CDMO home page <http://cdmo.baruch.sc.edu/>. Data are available in comma separated format.

## **8) Associated researchers and projects**

The Waquoit Bay Meteorological Station located at the Carriage House satisfies the weather data collection requirement of a broader nationwide program, the System-Wide Monitoring Program (SWMP). Within the SWMP, additional required parameters include water quality and nutrient monitoring.

1) Water quality monitoring involves continuous measurements of water temperature, specific conductivity, salinity, dissolved oxygen (percent saturation and concentration in mg/L), depth, pH, turbidity, and chlorophyll fluorescence. These measurements are taken every 15 minutes and stored on a submersible YSI multi-parameter sonde (i.e., data logger). Sondes are rotated every 2-3 weeks for cleaning and calibration.

2) To meet the nutrient sampling requirements of the SWMP, monthly grab samples, in tandem with a 24-hour ISCO water sampler, are collected and processed for various nutrient compounds. The chemical analyses mainly focus on levels of nitrogen, phosphorous, and carbon in the water column.



## II. Physical Structure Descriptors

### 9) Sensor specifications, operating range, accuracy, date of last calibration

Photosynthetically Active Radiation (PAR)  
LiCor Quantum Sensor  
Model #: LI-190SZ  
Stability:  $<\pm 2\%$  change over a 1 year period  
Operating Temperature:  $-40$  to  $+65^{\circ}\text{C}$   
Sensitivity: typically  $5\mu\text{A}$  per  $1000\mu\text{moles s}^{-1}\text{m}^{-2}$   
Light spectrum wavelength:  $400$  to  $700\text{ nm}$   
Serial Number: Q45963  
Date of last calibration: 09/09/2011  
Multiplier:  $-264.77$   
Dates of Sensor Use: 09/09/2011 – 04/18/2016

Total Solar Radiation (SoRAD)  
EPLAB Pyranometer  
Model #: 8-48  
Stability:  $>1\%$  over 5 years ( $0.2\%$  per year)  
Operating Temperatures:  $\pm 1.5$  percent constancy from  $-20$  to  $+40^{\circ}\text{C}$   
Sensitivity:  $11$  microvolts/watt meter $^{-2}$  approximately  
Impedance:  $350$  ohms approximately  
Response Time:  $5$  seconds ( $1/e$  signal)  
Linearity:  $\pm 1$  percent from  $0$  to  $1400$  watts meter $^{-2}$   
Serial Number: 9698  
Installed November 15<sup>th</sup>, 2005  
Calibrated 3/26/2008  
Dates of Sensor Use: 03/26/2008 - current as of 12/31/2012

Wind Speed/Wind Direction  
Model #05103  
Range:  $0$ - $60\text{ m/s}$  ( $130\text{ mph}$ ), threshold:  $0.5\text{ m/s}$  ( $1.1\text{ kts}$ )  
(Note: from observation we note that the monitor seems to have a lower threshold than  $0.5\text{ m/s}$  with the wind propeller spinning and values down to  $0.1\text{ m/s}$  being measured).  
Direction Range:  $360^{\circ}$ ; Threshold Sensitivity:  $0.5\text{ m/s}$  ( $1.1\text{ kts}$ ) at  $10^{\circ}$  displacement  
Serial Number: unknown  
Date of Last Calibration: 08/01/2011, new bearing 06/27/2012  
Dates of Sensor Use: 08/01/2011 – 06/27/2012, 06/27/2012 - 12/04/2015

Temperature and Relative Humidity  
Model #: HMP35C  
Operating Temperature:  $-20$  to  $+60^{\circ}\text{C}$   
Temperature Measurement Range:  $-35$  to  $+50^{\circ}\text{C}$   
Temperature Accuracy:  $0.5^{\circ}\text{C}$   
Relative Humidity Measurement Range:  $0$  to  $100\%$   
RH Accuracy:  $\pm 2\%$  RH,  $0$  to  $90\%$  or  $\pm 3\%$  RH,  $90$ - $100\%$   
Uncertainty of calibration:  $0.3\%$  RH  
Serial Number: unknown  
Date of Last Calibration: 08/1/2011  
Dates of Sensor Use: 08/03/2011 – 06/27/2012

Serial Number: A4940008

Data of Last Calibration: 06/25/2012  
Dates of Sensor Use: 06/27/2012-12/04/2015

Barometric Pressure  
Model #: PTP101B  
Operating Range: 600-1060 hPa  
Temperature: -40 to +60°C  
Humidity: non-condensing  
Accuracy:  $\pm 0.5$  hPa  
Stability: NA  
Serial Number: PTA427  
Date of Last Calibration: 08/01/2011  
Dates of Sensor Use: 07/14/2010 - 06/27/2012

Serial Number: P5240006  
Date of Last Calibration: 06/27/2012  
Dates of Sensor Use: 06/27/2012 - 06/07/2016

Precipitation  
Heated Tipping Bucket Rain Gauge  
Model #: TR-525  
Range: 0.1 mm  
Accuracy: 1.0% at  $< 10$  mm/hour  
Serial Number: C1521  
Direct calibration: 09/04/2011  
Dates of Sensor Use: 09/09/2011 – 06/06/2016

The CR1000 has two MB Flash EEPROM that are used to store the Operating System. Another 128 K Flash is used to store configuration settings. A minimum of 2 MB SRAM is (4 MB optional) is available for program storage (16K), operating system use, and data storage. Additional storage is available by using a compact flash card in the optional CFM100 Compact Flash Module. This station was installed on 7/12/2006.

Additional CR1000 specification can be found at:  
[http://www.campbellsci.com/documents/lit/s\\_cr1000.pdf](http://www.campbellsci.com/documents/lit/s_cr1000.pdf).

CR1000 Serial Number: 5287  
Date CR1000 Calibrated: unknown  
Date CR1000 Installed: 07/12/2006 – 06/07/2016

CR1000 Firmware Version (s): CR1000.Std.14, date of update unknown

CR1000 Program Version(s): WQBCHMET\_V5\_110907.CR1

## **10) Coded variable indicator and variable code definitions**

Site definitions: CH=Carriage House  
Station code: wqbchmet

## **11) QAQC flag definitions**

QAQC flags provide documentation of the data and are applied to individual data points by insertion into the parameter's associated flag column (header preceded by an F\_). During primary automated QAQC (performed by the CDMO), -5, -4, and -2 flags are

applied automatically to indicate data that is above or below sensor range, or missing. All remaining data are then flagged 0, as passing initial QAQC checks. During secondary and tertiary QAQC 1, -3, and 5 flags may be used to note data as suspect, rejected due to QAQC, or corrected.

|    |                                   |
|----|-----------------------------------|
| -5 | Outside High Sensor Range         |
| -4 | Outside Low Sensor Range          |
| -3 | Data Rejected due to QAQC         |
| -2 | Missing Data                      |
| -1 | Optional SWMP supported parameter |
| 0  | Passed Initial QAQC Checks        |
| 1  | Suspect Data                      |
| 2  | Open - reserved for later flag    |
| 3  | Open - reserved for later flag    |
| 4  | Historical Data: Pre-Auto QAQC    |
| 5  | Corrected Data                    |

## 12) QAQC code definitions

QAQC codes are used in conjunction with QAQC flags to provide further documentation of the data and are also applied by insertion into the associated flag column. There are three (3) different code categories, general, sensor, and comment. General errors document general problems with the CR1000, sensor errors are sensor specific, and comment codes are used to further document conditions or a problem with the data. Only one general or sensor error and one comment code can be applied to a particular data point, but some comment codes (marked with an \* below) can be applied to the entire record in the F\_Record column.

### General Errors

|     |                                                       |
|-----|-------------------------------------------------------|
| GIM | Instrument Malfunction                                |
| GIT | Instrument Recording Error, Recovered Telemetry Data  |
| GMC | No Instrument Deployed due to Maintenance/Calibration |
| GMT | Instrument Maintenance                                |
| GPD | Power Down                                            |
| GPF | Power Failure / Low Battery                           |
| GPR | Program Reload                                        |
| GQR | Data Rejected Due to QA/QC Checks                     |
| GSM | See Metadata                                          |

### Sensor Errors

|     |                                                      |
|-----|------------------------------------------------------|
| SDG | Suspect due to sensor diagnostics                    |
| SIC | Incorrect Calibration Constant, Multiplier or Offset |
| SIW | Incorrect Wiring                                     |
| SMT | Sensor Maintenance                                   |
| SNV | Negative Value                                       |
| SOC | Out of Calibration                                   |
| SQR | Data rejected due to QAQC checks                     |
| SSN | Not a Number / Unknown Value                         |
| SSM | Sensor Malfunction                                   |
| SSR | Sensor Removed                                       |

### Comments

|     |                                                 |
|-----|-------------------------------------------------|
| CAF | Acceptable Calibration/Accuracy Error of Sensor |
| CDF | Data Appear to Fit Conditions                   |

CML Snow melt from previous snowfall event  
CRE\* Significant Rain Event  
CSM\* See Metadata  
CCU Cause Unknown  
CVT\* Possible Vandalism/Tampering  
CWE\* Significant weather event

### 13) Comments on Data

Data are missing due to equipment or associated specific sensors not being deployed, equipment failure, time of maintenance or calibration of equipment, or repair/replacement of a sampling station platform. Any NANs in the dataset stand for “not a number” and are the result of low power, disconnected wires, or out of range readings. If additional information on missing data is needed, contact the Research Coordinator at the reserve submitting the data.

Small negative PAR values are within range of the sensor and are due to normal errors in the sensor and the CR1000 Datalogger. The Maximum signal noise error for the Licor sensor is +/- 2.214 mmoles/m<sup>2</sup> over a 15 minute interval.

Relative Humidity data greater than 100 are within range of the sensor accuracy of +/-3%.

Data recorded for all parameters (with the exception of cumulative precipitation) at the midnight timestamp (00:00) are the 15 minute averages and totals for the 23:45-23:59 time period of the previous day. Cumulative precipitation data at the midnight timestamp (00:00) are the sum of raw (unrounded) precipitation data from 00:00 to 23:59 of the previous day. Summing each individual 15-minute total precipitation value from the same period will result in small differences from cumulative precipitation due to rounding. It is especially important to note how data at the midnight timestamp are recorded when using January 1st and December 31st data.

**As of 12/04/2014 the CDMO has removed all Total Solar Radiation data for 2008-2012. Please contact the WQB NERR for more information about or to request those data.**

All PAR data were rejected for 2012. PAR data from 1/1/2012 - 12/31/2012 were collected as 15 minute averages instead of 15 minute totals. Although the data were rejected, users interested in PAR averages for 2012 may still find the data useful when looking at trends.

- a) Pyranometer Data (SoRAD): WQBNERR has been collecting Total Solar Radiation data since November 16<sup>th</sup>, 2005 at 3:15pm, initially as an experimental basis. See section 9: Sensor specifications, operating range, accuracy, date of last calibration for detailed information on the Pyranometer instrumentation. **All Total solar Radiation was removed from the dataset as of 12/4/2014. Please contact the WQB Reserve for more information or to request the data.**
- b) 15 min sample rainfall amount differences of over 5mm in 15 minutes can occur during storms and indicate intense ppt bursts during thunderstorms or frontal passages.
- c) Logger data missing from 01/10/2012 10:30 – 01/20/2012 22:45 and 03/15/2012 17:15 – 05/03/2012 19:30. Data stored on location did not have these dates so data downloaded from CDMO (GOES Data submittal). MaxTemp and MaxTempTime, MinTemp and MinTempTime, Max WSpdTime (included during 03/15/2012 – 05/03/2012), and voltage are not included in the telemetry file. These data are considered suspect, <1> [GIT] (CSM) and any missing parameters or gaps in the telemetry data are also coded with GIT, <-2>[GIT] (CSM). Any NAN's in the telemetry data are rejected.

- d) The MET station tower was lowered on 06/25/2012 from 12:55 – 13:07 in order to remove the temperature/relative humidity sensor for calibration. All parameters with sensors on the tower, (temperature/relative humidity, barometric pressure, and wind) were rejected at 13:30 and 13:15 while the tower was down. PAR data were already rejected. Temperature and relative humidity were rejected from 06/25/2012 13:15 - 06/27/2012 13:45 due to the sensor removal for calibration and maintenance. The tower was lowered again on 06/27/2012 13:30 – 14:10 to reinstall the temperature/rh sensor and to swap the barometric pressure sensor. The wind sensor bearings were also replaced from 13:30 – 14:10 while the tower was down. All parameters with sensors affected by lowering the tower were rejected 06/27/2012 13:30 – 13:45 and all parameters were missing 14:00 – 14:30. A new program was uploaded 06/27/2012 14:45 followed by a station power down at 15:00; however, it was not the correct program version for the newly installed BP sensor and NaNs were recorded until 09/21/2012 14:45. The updated program was installed on 09/21/2012 15:30.

#### Local National Weather Service Reporting Station.

Since December 2002, in the SW corner of the Reserve, at the outlet of Eel River and located at the Menauhant Yacht Club, a National Weather Service Reporting Station in East Falmouth has been recording local 24 hour weather conditions (Data Garrison <https://datagarrison.com/>). Dr. Doc Taylor records daily observations at 0700 and 1900 for the following weather parameters: Temperature (°F; minimum and maximum), Precipitation (inches; rain and melted snow, snow fall, initial and endpoint times of events), Sky Conditions and Wind Direction (mph; gusts). WBNERR compares its weather data with this station and other local weather stations which include Hyannis Airport (<http://www.wunderground.com/cgi-bin/findweather/getForecast?query=02601#History>), and WHOI Climate Reports (<http://cis.who.edu/science/PO/climate/index.cfm>). A complete monthly data set from the East Falmouth Reporting Station is available by contacting WBNERR Research Coordinator.