Waquoit Bay National Estuarine Research Reserve Meteorological Metadata
January 2004-December 2004
Latest Update: **October 15, 2023**

I. Data Set & Research Descriptors

1) Principal Investigator(s) & contact persons

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2) Entry Verification

System I.

In late October 2003 a new CR10X program was installed. 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.

The meteorological information is sampled every 5 seconds from each instrument on the weather station and stored on a Campbell Scientific CR10X datalogger. Data are output to a file in three arrays: array 15 stores 15 minutes average , max and min data; array 60 stores hourly average, max and min data; and array 144 stores daily (24 hr) average, max and min data. The CDMO Data Logger (NERR_4.CSI) was loaded into the CR10X and controls the sensors. The CR10X then interfaces with the PC208W software supplied by Campbell Scientific.

In general, at the end of every month, in the first few days of the new month, the data are uploaded from the CR10X data logger and / or storage module to a personal computer (IBM compatible) and saved as a deployment or "monthly" raw data file (DATA000.dat) onto a separate hard drive and backed up onto the Waquoit Bay NERR server . The server data is itself backed-up everyday offsite by a server located at the Massachusetts Dept. of Conservation and Recreation headquarters in Boston, MA. Files are exported from the PC208W or LoggerNet in a comma-delimited format (.dat) and opened in Microsoft Excel for pre-processing with the EQWin format macro (EQWinFormat.xls) that was developed by the CDMO to reformat the header columns, insert station codes, insert a date column (mm/dd/yyyy), correct the time column format and reformat the data to the appropriate number of decimal places. The pre-processed file is then ready to be copied into the EQWin weather.equi file where data can be QA / QC checked and archived in a database. In practice at Waquoit Bay NERR, we also scan the raw data in both the earlier formats as well, just after uploading to look for significant time gaps and other gross anomalies, and similarly in the Excel format. EQWin queries, reports and graphs are used to look for outliers and other significant anomalies. Any anomalous or missing data are investigated and then noted below in the Anomalous / Suspect Data and Missing Data sections. Any Data corrections or substitutions (from real-time database or other source) are noted and any deleted data sections are noted in the Deleted Data sections.

The most common reported errors/anomalies noted in the monthly error reports in 2004 were:

1) 15 minute sample rainfall amount differences of over 5mm from previous sample.
2) Relative humidity over 100% .

In all cases in 2004, these two most commonly reported anomalies were found to be valid data and retained. All reported errors/anomalies are double checked, and where data truly appear anomalous, they are compared with other regional meteorological data for verification.

Chris Weidman, Research Coordinator, and Heather Tschaekofske, Research Assistant, error checked and compiled the meteorological data for 2004.

System II.

In March 2004, our meteorological station was linked to a Marisys [TR] system box, which allowed near real-time access to our meteorological data over the internet. All the real-time meteorological data since March 9, 2004 are archived at a CDMO server and available on the web (Note this is currently a separate database from data acquired through System I methods. The web address is still provisional and only accessible by authorized NERRs staff. The parameters available in this format are the following:

Air Temperature (C)
- 15 minute average (over previous 15 minute period)
- Maximum (1 min average in previous 15 minute period)
- Minimum (1 min average in previous 15 minute period)
- Time Maximum
- Time Minimum

Relative Humidity (%)
- 15 minute average (over previous 15 minute period)
- Maximum (1 min average in previous 15 minute period)
- Minimum (1 min average in previous 15 minute period)
- Time Maximum
- Time Minimum

Barometric Pressure (mb)
- 15 minute average (over previous 15 minute period)
- Maximum (1 min average in previous 15 minute period)
- Minimum (1 min average in previous 15 minute period)
- Time Maximum
- Time Minimum

Wind Speed
- 15 minute average (over previous 15 minute period)
- Maximum (1 min average in previous 15 minute period)
- Minimum (1 min average in previous 15 minute period)
- Time Maximum
- Time Minimum

Wind Direction
- 15 minute average (over previous 15 minute period)
- Standard Deviation (over previous 15 minute period)

Total Precipitation (mm)
- previous 15 minute total

Total Photosynthetically Available Radiation (PAR)
- previous 15 minute total (millimoles/ m2)

Note that the Marisys system flags data that fall outside the preset filter ranges. As this system has been in pilot mode throughout 2004, the flagged data are simply appended with a "BAD" at the end of a given sample value. Almost all of these flags are not indicative of "bad" data but simply the result of an inappropriately set filter threshold setting. These filter settings were finally improved, though not entirely corrected, in early December 2004. Data from this database can be obtained by contacting Chris Weidman at Chris.Weidman@state.ma.us.

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 half-hourly 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 CR10X to produce 15 minute, hourly and daily averages of those measurements of air temperature, relative humidity, barometric pressure, wind speed, and wind direction. Precipitation and PAR are recorded as a totals for each interval. As mentioned above, we generally upload data from theCR10X / storage module about once a month. However, it is noted that in 2004, due to a staffing shortage, no data were uploaded from late July 2004 until early December 2004. However, our real-time system indicated that accurate data were being collected for almost all of that time period. CR10X raw data are currently stored on 2 data storage modules capable in combination of storing about 4 or more months of data. The CR10X is also cabled directly to a desktop PC where the instantaneous 5 sec data are displayed (in a PC208W window) and can be viewed at anytime. All collected data is quality checked immediately after the monthly downloads. The error/anomaly reports and all monthly parameter graphs are printed and reviewed. Any error/anomaly messages are further investigated and the data is either corrected/deleted (if necessary) or commented on and left unchanged.

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 date stream indicates a malfunction. Also, once a month on upload day, we use a handheld Kestrel 4000, to run a comparative set of observations as a general check on the Campbell station sensors.

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^{o} 34.895 N, 70^{o} 31.511' 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 is 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 is mounted next to the CR10X in the laboratory. The rain gauge is located in an open field away from trees about 55 m northwest of the laboratory and tower at 41^{o} 34.908' N, 70^{o} 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 brush 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.

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.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
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	**9.5**
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	**11.2**
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	**100.8**
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	**135.0**

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, 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 m/s	Gust m/s	Wave ht	Baro	Air T	Water T
Jan mean	243 *(249)*	9.0 *(2.1)*	10.0	1.3	1013.1 *(1011)*	4.0 *(3.9)*	5.7 *(3.3)*

Jan min	----	1.4 *(0.0)*	1.5	0.3	986.1 *(980)*	-4.5 *(-4.7)*	4.5 *(0.6)*
Jan max	----	21.5 *(16.6)*	24.6	2.9	1031.6 *(1031)*	11.1 *(13.7)*	8.0 *(5.8)*
Feb mean	220 *(237)*	8.6 *(3.1)*	9.5	1.1	1016.0 *(1014)*	3.1 *(3.3)*	4.6 *(3.7)*
Feb min	----	0.6 *(0.0)*	0.7	0.3	995.7 *(992)*	-6.9 *(-9.7)*	3.6 *(1.0)*
Feb max	----	21.0 *(14.4)*	23.6	3.1	1037.6 *(1036)*	11.1 *(13.7)*	6.1 *(6.9)*
Mar mean	179 *(186)*	8.8 *(2.5)*	9.6	1.3	1020.3 *(1018)*	4.5 *(5.7)*	5.1 *(5.8)*
Mar min	----	0.4 *(0.0)*	0.5	0.4	998.0 *(998)*	-6.6 *(-5.5)*	4.4 *(3.2)*
Mar max	----	20.0 *(18.0)*	22.0	3.7	1038.8 *(1038)*	12.7 *(17.9)*	5.9 *(9.8)*
Apr mean	201 *(214)*	7.6 *(2.4)*	8.3	0.9	1018.4 *(1016)*	8.0 *(10.0)*	7.9 *(10.9)*
Apr min	----	0.4 *(0.0)*	0.5	0.2	997.6 *(995)*	-0.9 *(-2.0)*	5.6 *(6.7)*
Apr max	----	21.6 *(17.1)*	25.4	2.3	1039.5 *(1038)*	22.4 *(31.2)*	10.2 *(16.3)*
May mean	200 *(194)*	7.8 *(2.0)*	8.5	0.9	1016.5 *(1015)*	11.4 *(13.6)*	11.1 *(14.2)*
May min	----	0.2 *(0.0)*	0.7	0.3	993.2 *(990)*	5.3 *(2.4)*	9.1 *(10.4)*
May max	----	22.1 *(16.6)*	24.6	2.4	1028.4 *(1027)*	19.6 *(24.9)*	14.5 *(20.3)*
Jun mean	175 *(216)*	6.9 *(1.6)*	7.5	0.8	1016.0 *(1015)*	16.2 *(18.2)*	15.3 *(19.1)*
Jun min	----	0.0 *(0.0)*	0.0	0.4	998.2 *(996)*	9.7 *(5.9)*	13.6 *(14.9)*
Jun max	----	18.6 *(10.7)*	20.3	1.8	1033.6 *(1033)*	26.2 *(31.3)*	18.5 *(24.3)*
Jul mean	207 *(218)*	6.6 *(1.4)*	7.0	0.7	1014.8 *(1014)*	20.6 *(22.8)*	18.7 *(23.4)*
Jul min	----	0.0 *(0.0)*	0.0	0.4	1005.3 *(1004)*	15.7 *(11.2)*	16.0 *(21.5)*
Jul max	----	15.9 *(11.8)*	17.1	1.6	1024.8 *(1024)*	29.4 *(34.2)*	21.5 *(26.5)*
Aug mean	178 *(207)*	6.4 *(1.4)*	6.8	0.6	1017.5 *(1017)*	21.2 *(22.8)*	20.0 *(24.3)*
Aug min	----	0.1 *(0.0)*	0.3	0.3	1005.4 *(1006)*	15.6 *(11.7)*	18.1 *(20.6)*
Aug max	----	14.2 *(11.4)*	14.9	1.4	1034.4 *(1035)*	25.9 *(33.5)*	22.9 *(28.1)*
Sep mean	180 *(192)*	7.1 *(1.7)*	7.7	0.8	1017.7 *(1017)*	18.8 *(18.6)*	19.0 *(21.0)*
Sep min	----	0.2 *(0.0)*	0.5	0.3	988.3 *(992)*	12.6 *(7.8)*	17.7 *(19.0)*
Sep max	----	21.2 *(15.7)*	24.5	2.9	1033.1 *(1033)*	23.9 *(27.9)*	20.6 *(23.4)*
Oct mean	177 *(206)*	8.5 *(1.9)*	9.5	0.9	1019.0 *(1018)*	12.5 *(11.0)*	16.4 *(15.2)*
Oct min	----	0.7 *(0.0)*	1.1	0.2	995.1 *(995)*	2.8 *(-1.4)*	13.2 *(9.6)*
Oct max	----	19.9 *(13.2)*	23.0	3.3	1030.3 *(1029)*	22.0 *(24.9)*	19.2 *(21.3)*
Nov mean	204 *(241)*	10.1 *(2.5)*	11.2	1.3	1013.0 *(1012)*	8.0 *(6.7)*	11.3 *(9.0)*
Nov min	----	0.1 *(0.0)*	0.5	0.3	987.2 *(983)*	-5.0 *(-7.3)*	8.5 *(3.9)*
Nov max	----	20.6 *(15.8)*	23.0	3.2	1028.4 *(1028)*	17.2 *(21.1)*	13.3 *(14.2)*
Dec mean	246 *(254)*	9.6 *(2.8)*	10.7	1.2	1014.2 *(1013)*	2.6 *(1.1)*	6.3 *(3.3)*
Dec min	----	0.0 *(0.0)*	0.0	0.3	974.3 *(975)*	-8.0 *(-9.5)*	4.4 *(1.2)*
Dec max	----	21.4 *(17.2)*	24.6	3.1	1036.4 *(1035)*	12.7 *(13.0)*	9.6 *(6.7)*
Ann mean	201 *(218)*	8.1 *(2.1)*	8.9	1.0	1016.4 *(1015.0)*	10.9 *(11.5)*	11.8 *(12.8)*
Ann min	----	0.0 *(0.0)*	0.0	0.2	974.3 *(975)*	-8.0 *(-9.7)*	3.6 *(0.6)*
Ann max	----	22.1 *(18.0)*	25.4	3.7	1039.5 *(1038)*	29.4 *(34.2)*	22.9 *(28.1)*

Meteorological differences between the offshore Buzzards Bay Tower and our Waquoit Bay station are to be expected both 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, Solar Radiation), 2) Falmouth DPW (rainfall), 3) Otis Air Force Base (wind), and 4) Hyannis Airport (Temperature, Wind, Rainfall, Air Pressure, Relative Humidity). A comparison of daily data from WBNERR and Buzzards Bay Tower and Falmouth DPW is shown below for the Month of December 2001.

Waquoit Bay(WQB) vs Buzzards Bay Tower(BUZ) and Falmouth DPW(FAL): December 2001
Note: ppt is only measured once a day at Falmouth DPW.

DAY	WQB Temp	BUZ Temp	WQB Baro	BUZ Baro	WQB WSpd	BUZ WSpd	WQB WDir	BUZ WDir	WQB PPT	FAL PPT
1	15.4	14.8	1014.1	1015.7	2.8	10.3	244	200	0.762	0.000
2	9.3	11.5	1021.4	1019.8	1.3	7.0	319	296	0	0.000
3	7.8	8.8	1024.0	1025.7	1.6	5.6	267	268	0.254	0.000
4	11.1	10.6	1024.4	1024.9	1.0	8.0	251	245	0	0.508
5	13.6	12.1	1022.9	1025.7	1.0	6.0	211	216	0	0.000
6	15.0	13.5	1014.2	1020.0	2.4	8.9	239	224	0	1.016
7	11.3	12.5	1012.9	1013.2	1.1	7.0	288	257	1.27	0.000
8	4.7	8.3	1019.3	1019.0	1.1	7.0	10	214	2.54	13.208
9	2.7	3.9	1016.2	1016.3	2.2	9.2	356	74	15.24	0.508
10	4.9	3.4	1027.3	1026.7	1.5	6.1	245	265	0.254	0.000
11	8.3	8.9	1025.2	1026.5	1.1	6.2	21	138	3.302	0.000
12	7.6	7.4	1030.0	1029.9	1.5	9.3	43	31	0	0.508
13	10.7	8.3	1015.6	1024.6	1.4	5.6	151	83	4.064	2.540
14	11.7	10.9	1010.6	1013.6	1.5	7.4	251	239	4.826	0.000
15	6.2	9.6	1014.1	1009.4	3.4	8.4	331	200	0.508	0.762
16	0.6	2.1	1026.4	1026.4	2.0	10.1	329	333	0	0.000
17	3.3	3.6	1014.6	1025.2	1.3	4.1	43	98	6.604	19.812
18	6.8	8.9	990.9	997.5	3.3	8.8	314	218	28.702	10.668
19	6.2	5.7	1006.9	1002.6	2.5	13.2	290	284	0	0.000
20	7.3	8.7	1002.1	1006.8	3.2	5.6	322	213	0	0.000
21	2.9	4.6	1008.2	1005.1	4.2	13.4	314	289	0	0.000
22	0.3	0.9	1021.7	1019.7	2.7	11.9	325	324	0	0.000
23	2.6	1.9	1019.2	1024.1	0.9	5.2	258	314	0	0.000
24	9.2	9.2	1004.7	1011.6	1.8	7.1	189	168	19.304	10.160
25	2.1	4.5	1012.2	1009.2	1.3	8.8	302	276	0	5.080
26	1.3	2.8	1006.9	1014.0	0.6	3.9	9	160	2.54	6.350

27	-0.4	0.3	1000.0	1002.1	2.9	8.4	296	230	0.254	0.000
28	1.7	0.2	1002.8	1004.7	2.3	11.5	275	264	1.27	0.000
29	2.2	3.0	1004.0	1004.3	2.7	12.1	286	256	0	0.000
30	-0.1	0.7	1007.2	1007.5	3.4	10.2	284	278	0	0.000
31	-1.1	-1.1	1011.6	1011.6	3.0	11.6	287	270	0	0.000
Mean	5.97	6.47	1013.9	1015.6	2.0	8.32	237.1	223.4	91.694	72.078
SD	0.85	0.80	1.66	1.63	0.16	0.47	18.7	13.5		

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 2004, except for a 2 day period in mid-July when sensors were being calibrated.

Data were downloaded from the logger on the following dates:
1) 01/02/2004: for period 12/01/2003 15:15 to 01/02/2004 09:45
2) 01/30/2004: for period 01/02/2004 10:00 to 01/30/2004 15:00
3) 03/03/2004: for period 01/30/2004 15:15 to 03/03/2004 10:00
4) 04/07/2004: for period 03/03/2004 10:15 to 04/07/2004 13:15
5) 05/03/2004: for period 04/07/2004 13:30 to 05/03/2004 08:45
6) 07/21/2004: for period 05/03/2004 12:30 to 07/21/2004 15:15
7) 12/01/2004: for period 07/22/2004 10:45 to 12/01/2004 10:15
8) 01/06/2005: for period 12/01/2004 10:30 to 01/06/2005 11:15

As noted above data were also collected continuously in near real-time from 03/09/2004 thru the rest of the year – and archived on a server now at CDMO.

7) Distribution

According to the Ocean and Coastal Resource Management Data Dissemination Policy for the NERRS System-wide Monitoring Program,

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 the 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/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 Section 1 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 homepage) and online at the CDMO home page **http://cdmo.baruch.sc.edu**. Data are available in Excel, text and EQwin formats.

8) Associated researchers and projects

Not applicable at this time.

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

LiCor Quantum Sensor
Model #: LI-190SZ S/N Q12415
Stability: <±2% change over a 1 year period
Operating Temperature: -40 to +65 °C
Sensitivity: typically 5μA per 1000 μmoles $s^{-1}m^{-2}$
Light spectrum wavelength: 400 to 700 nm
Date of last calibration: 7/22/2004

Wind Monitor
Model #05103
Range: 0-60 m/s (130 mph), threshold: 0.5 m/s (1.1 kts)
(Note: from observation we note that the monitor seems to have a lower threshold than 0.5 m/s with the wind propeller spinning and values down to 0.1 m/s being measured).
Direction Range: 360°; Threshold Sensitivity: 0.5 m/s (1.1 kts) at 10° displacement
Calibration not required. Bearings replaced 7/21/2004

Temperature and Relative Humidity
Model #: HMP35C
Operating Temperature: -20 to +60°C
Temperature Measurement Range: -35 to +50°C
Temperature Accuracy: 0.5°C
Relative Humidity Measurement Range: 0 to 100%
RH Accuracy: ±2% RH, 0 to 90% or ±3% RH, 90-100%
Uncertainty of calibration: 0.3% RH
Date of last calibration: 7/22/2004

Barometric Sensor
Model #: PTP101B
Operating Range: 600-1060 hPa
Temperature: -40 to +60°C
Humidity: non-condensing
Accuracy: ±0.5 hPa
Stability: NA
Date of last calibration: 7/22/2004

Heated Tipping Bucket Rain Gauge
Model #: TR-525
Range: 0.1 mm
Accuracy: 1.0% at <10 mm/hour
Calibration not required. Check operation regularly and compare with nearby ppt stations

Storage Module
Model # SM4M
Storage capacity: 2 million low-resolution data values
Program storage: stores up to 8 program with a total capacity of 128 KB
Processor: Hitachi H8S
Operating system: 64 KB, flash memory based, user downloadable
Operating range: Temp: -35 to +65 degree C
Baud rates: 9600, 76800

Power requirements: 5 +/- 0.3 VDC @ 100 mA

Campbell Scientific CR10X datalogger and wiring panel has 128K flash memory (EEPROM), in which it stores the operating system and the actual weather program used to make the station operational. Additionally, there are 128K of SRAM, which it uses to run the program and store its measurements for final data storage.

10) Coded variable indicator and variable code definitions

Site definitions: CH=Carriage House

11) Anomalous Data

Arrays:
During 2022 all pre-2007 weather data were revisited by the CDMO. Historically those datasets included 15 minute, hourly (60), and daily data arrays (144). As directed by the NERRS Data Management Committee, the CDMO removed the hourly and daily data arrays leaving only the 15 minute data to make the entire NERRS SWMP weather dataset consistent in its reporting. All references to the 60 and 144 arrays were left in the metadata document as they may still provide valuable information, but users should be aware that they are largely no longer relevant. The updated datasets were uploaded to the database and made available through the various data applications at www.nerrsdata.org/get/landing.cfm throughout the fall of 2022.

COMMENT 1: 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.

COMMENT 2. Intense extra-tropical cyclones and hurricanes often affect the region and air values below 980 mb are not uncommon, especially in the autumn, winter and spring months.

COMMENT 3: A malfunctioning new data storage module (ironically with greater memory capacity) installed in early November 2003 resulted in the overwriting and loss of about two weeks of data every month of operation – roughly the first half of every month's data set. Unfortunately, the problem went undetected because of the new data management program changes –training on the new EQWIN system occurred in late January 2004 – until late March 2004 when the problem was detected.

COMMENT 4: Small negative PAR values sometimes occur at night. These small values are within the range of the sensors. The maximum signal noise error for the LIcor sensor is +/- 2.214 mmoles/m2 over a 15 minute interval. These data have been retained..

COMMENT 5: Relative Humidity data greater than 100% have been observed; these data are within the range of the sensor accuracy of +/- 3%. These data have been retained.

COMMENT 6: Sensors calibration occurred this year from 07/19/2004 14:00 until the morning of 07/22/2004 with everything back in operation by 10:45. Different sensors were out of operation at various times during this time while others continued in operation. The calibration event resulted in several categories of corrupted or incorrect data (anomalous -99999, missing data, and deleted data. (See note below in other remarks)

May 2004

a) Mean and min temperature data were reported as -99999 for the time period 05/24/2004 14:00. We suspect brief power loss due to thunderstorm and heavy downpour.

5/24/2004	14:00:00	15	-99999.0
5/24/2004	14:00:00	60	-99999.0
5/24/2004	24:00:00	144	-99999.0

b) 5/24/2004 14:00:00 15 13.0
5/24/2004 14:15:00 15 5.3

Above ppt outliers were supported as valid using nearby ppt records from Falmouth's Long Pond monitoring station, which indicate a total of 13.2 mm for that day, and we experienced a heavy downpour during a thunderstorm for that time period. See Comment 1. These data were retained.

July 2004

a) All following mean and min temperature data were reported as -99999 (See Comment 6).
07/19/2004 14:00 to 7/21/2004 08:15
07/21/2004 15:15

b) All following max temperature data are reported as -99999 (See Comment 6).
07/19/2004 14:15 to 7/19/2004 23:45
07/19/2004 24:00 to 7/21/2004 08:15
07/21/2004 15:15

c) All following mean and min RH data are reported as -99999 (See Comment 6).
07/19/2004 14:00 (15min and 60 min)
07/19/2004 15:30
07/19/2004 16:00 (60 min)
07/19/2004 24:00 (24 hr for 7/19)

d) All following mean and min Barometric Pressure data are reported as -99999 (See Comment 6).
07/19/2004 14:00 (15min and 60 min)
07/19/2004 15:30
07/19/2004 16:00 (60 min)
07/19/2004 24:00 (24 hr for 7/19)
07/21/2004 15:15

e) 7/2/2004 05:15:00 15 5.8

Above ppt outliers were supported as valid using nearby ppt records from Falmouth's Long Pond monitoring station, which indicate a total of 5.6 mm for that day. See Comment 1. These data were retained.

f) 7/28/2004 15:15:00 15 5.6

Above ppt outliers were supported as valid using nearby ppt records from Falmouth's Long Pond monitoring station, which indicate a total of 13.4 mm for that day. See Comment 1. These data were retained.

g) Some July RH data show values slightly above 100%. See Comment 5.

August 2004

a) Some August RH data show values slightly above 100%. See Comment 5.

b) 8/13/2004 19:15:00 15 8.1
8/15/2004 07:45:00 15 6.6
8/15/2004 08:00:00 15 10.7
8/15/2004 08:15:00 15 16.3
8/31/2004 06:30:00 15 7.6
8/31/2004 07:15:00 15 6.1
8/31/2004 09:00:00 15 9.7
8/31/2004 09:15:00 15 7.4

Above ppt outliers were supported as valid using nearby ppt records from Falmouth's Long Pond monitoring station, which indicate heavy ppt amounts of 10.4 mm for 8/13, 30.6 mm for 8/15 and 25.9 mm for 8/31. See Comment 1. These data were retained.

September 2004

a) Some September RH data show values slightly above 100%. See Comment 5.

b) 9/18/2004 11:30:00 15 6.1
Above ppt outliers were supported as valid using nearby ppt records from Falmouth's Long Pond monitoring station, which indicate heavy ppt amounts of 30.6 mm for 9/18. See Comment 1. These data were retained.

October 2004

Some October RH data show values slightly above 100%. See Comment 5.

November 2004

Some November RH data show values slightly above 100%. See Comment 5.

December 2004

Some December RH data show values slightly above 100%. See Comment 5.

12) Deleted Data

Arrays:
During 2022 all pre-2007 weather data were revisited by the CDMO. Historically those datasets included 15 minute, hourly (60), and daily data arrays (144). As directed by the NERRS Data Management Committee, the CDMO removed the hourly and daily data arrays leaving only the 15 minute data to make the entire NERRS SWMP weather dataset consistent in its reporting. All references to the 60 and 144 arrays were left in the metadata document as they may still provide valuable information, but users should be aware that they are largely no longer relevant. The updated datasets were uploaded to the database and made available through the various data applications at www.nerrsdata.org/get/landing.cfm throughout the fall of 2022.

January 2004

a) Owing to some missing data on 01/13/2004 the hourly data at 01:00 and the daily data for 01/13/2004 have been deleted.

May 2004

a) Owing to some missing data on 05/03/2004 the hourly data at 13:00 and the daily data for 05/03/2004 have been deleted.

July 2004

a) The following mean and min temperature data were corrupted and are incorrect owing to sensor disconnect during calibration (See Comment 6). These data (and associated times of min temp) were deleted.

07/19/2004 13:45

b) The following max temperature data were corrupted and are incorrect owing to sensor disconnect during calibration (See Comment 6). These data (and associated times of max temp) were deleted.

07/19/2004 13:45
07/19/2004 14:00 (15 min and 60 min)
07/19/2004 24:00 (24 hr for 07/19)

c) The following mean and min RH data were corrupted and are incorrect owing to sensor disconnect during calibration (See Comment 6). These data (and associated times of min RH) were deleted.

07/19/2004 13:45
07/19/2004 14:15 to 07/19/2004 15:15
07/19/2004 15:45 to 07/19/2004 16:00
07/19/2004 16:15 to 07/19/2004 23:45
07/19/2004 24:00 to 07/21/2004 08:15
07/21/2004 15:15

d) The following max RH data were corrupted and are incorrect owing to sensor disconnect during calibration (See Comment 6). These data (and associated times of max RH) were deleted.

07/19/2004 13:45 to 07/21/2004 08/15
07/21/2004 15:15

e) The following mean and min BP data were corrupted and are incorrect owing to sensor disconnect during calibration (See Comment 6). These data (and associated times of min BP) were deleted.

07/19/2004 14:15 to 07/19/2004 15:15
07/19/2004 15:45 to 07/19/2004 16:00
07/19/2004 16:15 to 07/19/2004 23:45
07/19/2004 24:00 to 07/21/2004 08:15

f) The following max BP data were corrupted and are incorrect owing to sensor disconnect during calibration (See Comment 6). These data (and associated times of max BP) were deleted.

07/19/2004 14:00 to 07/21/2004 08:15
07/21/2004 15:15

g) Owing to prior missing data on 07/22/2004, the hourly data at 11:00 and the daily data for 07/22/2004 have been deleted (See Comment 6).

13) Missing data

Arrays:
During 2022 all pre-2007 weather data were revisited by the CDMO. Historically those datasets included 15 minute, hourly (60), and daily data arrays (144). As directed by the NERRS Data Management Committee, the CDMO removed the hourly and daily data arrays leaving only the 15 minute data to make the entire NERRS SWMP weather dataset consistent in its reporting. All references to the 60 and 144 arrays were left in the metadata document as they may still provide valuable information, but users should be aware that they are largely no longer relevant. The updated datasets were uploaded to the database and made available through the various data applications at www.nerrsdata.org/get/landing.cfm throughout the fall of 2022.

January 2004

a) All meteorological data from 01/02/2004 10:15 to 01/13/2004 00:15 are missing due to a malfunctioning data storage module. See COMMENT 3.

b) Hourly RH max, RH min, Baro average, Baro max, Baro min, Wind spd average, Wind spd max, Wind spd min, Wind dir, Wind dir SD, PPT, and PAR are missing for 1/30/2004 15:00. This occurred at very end of file and may have resulted from interrupted calculation of hourly data during uploading.

May 2004

a) All met data are missing for the period from 05/03/2004 9:00 to 05/03 12:15. During this time period, trouble-shooting was being carried out with our real-time Marisys system and power-down of CR10X likely occurred.

July 2004

a) The following meteorological data (for all parameters) are missing due to sensor calibration (see Comment 6).

07/21/2004 08:30 to 07/21/2004 15:00
07/21/2004 15:30 to 07/22/2004 10:30

a) **Other remarks**

On 10/15/2023 this dataset was updated to include embedded QAQC flags for anomalous/suspect data. System-wide monitoring data beginning in 2007 were processed to allow for QAQC flags and codes to be embedded in the data files rather than detailed in the metadata alone (as in the anomalous/suspect, deleted, and missing data sections above). Prior to 2007, rejected data were deleted from the dataset so they are unavailable to be used at all, but suspect data were only noted in the metadata document. Suspect data flags <1> were embedded retroactively in order to allow suspect data to be easily identified and filtered from the dataset if desired for analysis and reporting purposes. No other flags or codes were embedded in the dataset and users should still refer to the detailed explanations above for more information.

Arrays:
During 2022 all pre-2007 weather data were revisited by the CDMO. Historically those datasets included 15 minute, hourly (60), and daily data arrays (144). As directed by the NERRS Data Management Committee, the CDMO removed the hourly and daily data arrays leaving only the 15 minute data to make the entire NERRS SWMP weather dataset consistent in its reporting. All references to the 60 and 144 arrays were left in the metadata document as they may still provide valuable information, but users should be aware that they are largely no longer relevant. The updated datasets were uploaded to the database and made available through the various data applications at www.nerrsdata.org/get/landing.cfm throughout the fall of 2022.

Precipitation:
During the initial years of NERRS SWMP weather data collection the CR10X programming was inconsistent in how precipitation values were recorded. For most reserves, zeros were not recorded when rainfall had not occurred between 2001-2003, instead no rainfall was represented by a blank cell. The CDMO verified which datasets were impacted by this issue for the 2001-2006 datasets and inserted zeros when the metadata indicated that no precipitation occurred and data were not missing for other reasons. In some cases, zero values for precipitation data were evaluated and removed where the metadata confirmed that no rainfall should have been in the dataset. The pre-2007 data did not go through a thorough QAQC process again at that time (in addition to previous QAQC); however, if discrepancies were noticed between what was documented in the metadata and what was in the dataset, additional updates may have been made. The updated datasets were uploaded to the database and made available through the various data applications at www.nerrsdata.org/get/landing.cfm throughout early 2023.

In June 2009, in order to repopulate data tables, the Centralized Data Management Office removed all -99999 from SWMP weather data files and replaced them with -99.

Below is text of email sent by R. Payne shortly after calibration completion 7/22/2004

```
19 July
1400EDT - Download stoarge module data to DATA054.DAT
~1440 EDT - Tower down
                        Cut off RH/AT sensor
~1500 EDT - Tower back up
~1500 EDT - Disconnect pressure sensor

20 July
Calibrate Vaisala HMP45ASP RH/AT sensor
```

Calibrate Vaisala PT101B BP sensor

21 July
0910 EDT - Tower down
Replace anemometer propellor shaft bearings
0925 EDT - Download DATA055.DAT, DATA056.DAT
Power down logger
Mount new Li-Cor calibrated PAR sensor
1020 EDT - Vaisala HMP45ASP RH/AT sensor mounted on tower
1045 EDT - Tower back up.
1100 EDT - Modified several holes in tower legs so that all six mounting bolts are useable.
1430 EDT - Neatened up logger box wiring. Rewired patch panel for HMP45ASP sensor.
Installed NERR_403 program. Contains new cal constants and new section for HMP45ASP.
BP, RH, AT numbers are wrong. Spent the rest of the afternoon struggling with the system

22 July
Made a couple of modifications to BP sensor. Added jumper to keep it up all the time. Changed program statement from excite-delay-SE to simple SE volts. This brought BP, RH, AT all within reasonable range.
1150EDT - System up and connected to network server.

The RH/AT sensor substitution was necessary because I inadvertently sliced a Campbell in-cable interface circuit board in two when I cut the sensor off the tower. I found a more recent sensor in my lab which has two voltage outputs and does not need am interface board. This was what I calibrated and installed. I don't know why the barometer caused funny results but I'm happier with the arrangement I wound up with.

b) Precipitation Totals

January	**2004**
15	0.5
18	14.5
28	3.6
Monthly Total	18.6

February	**2004**
3	11.9
6	37.6
7	5.6
18	13
21	3.3
Monthly Total	71.4

March	**2004**
4	1
5	0.5

6	13.7
8	4.1
11	12.7
16	12.2
17	3
18	1.3
19	7.1
20	3.3
21	12.2
25	1.8
26	0.3
27	6.6
28	0.3
31	5.6
Monthly Total	85.7

April **2004**

1	41.4
3	0.5
4	22.6
5	4.3
11	0.5
12	2.8
13	17.5
14	16
15	0.3
23	2
24	10.4
26	16
27	5.1
28	10.2
Monthly Total	149.6

May **2004**

2	1
3	9.7
4	9.1
5	0.3
9	2.3
19	0.5
22	0.3
23	0.5
24	18.5
26	3.6
27	4.1
28	26.4
Monthly Total	76.3

June **2004**

1	19.3

3	2.8
6	14
7	0.3
14	9.1
17	0.5
18	1.8
19	1.8
22	2.5
29	3
Monthly Total	55.1

July **2004**

2	8.6
5	12.4
11	0.8
13	6.9
14	1.5
28	21.3
29	0.5
Monthly Total	52.0

August **2004**

1	0.5
5	7.6
13	14.2
15	53.8
16	10.7
18	0.8
21	5.6
27	0.3
30	0.3
31	53.6
Monthly Total	147.4

September **2004**

7	0.5
9	0.5
14	0.3
15	6.4
16	10.9
18	40.1
28	36.8
29	83.6
1	0.5
Monthly Total	179.6

October **2004**

1	0.3

2	2
10	0.5
12	0.3
14	0.8
15	11.2
16	9.7
17	0.3
19	23.4
20	0.3
22	0.3
23	0.3
24	0.8
25	0.5
26	0.3
31	0.3
Monthly Total	51.3

November 2004

3	0.8
4	19.6
5	7.9
12	18.3
13	30.2
20	2.8
21	4.1
24	3.6
25	16
28	14
Monthly Total	117.3

December 2004

1	22.4
3	3.3
7	29.5
8	0.8
9	2.5
10	24.4
11	0.3
12	0.5
13	3.8
18	2.5
19	0.5
20	0.8
23	17.3
24	1.5
26	18.8
27	6.4
28	3
29	0.3
Monthly Total	138.6