

# **WEATHERPAK<sup>®</sup> -2000**

## **User Manual**

November 1, 1999

### **COASTAL ENVIRONMENTAL SYSTEMS**

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**IMPORTANT NOTES****DO CALL/FAX US IF YOU HAVE QUESTIONS OR PROBLEMS**

Call Coastal Environmental Systems if any troubles arise or if you have any questions pertaining to the equipment. Our telephone number is 206-682-6048 and the FAX number is 206-682-5658. Refer to the model number (WEATHERPAK® -2000) and the serial number of the WEATHERPAK® which can be found by looking under the radiation shield on top of the unit.

**DO WASH OFF CHEMICALS OR DEBRIS WHILE THE WEATHERPAK® IS ASSEMBLED** to prevent getting water in the connectors. The WEATHERPAK® is water-resistant when assembled.

**DO FOLLOW THE MAINTENANCE SCHEDULE.**

**INCORRECT WIND SPEED WILL RESULT IF THE PROPELLER NUT IS NOT TIGHT.**

**DO NOT OPEN THE WEATHERPAK®.** It is purged with desiccant bags to seal out all the moisture. Opening it may allow moisture to foul the electronics and will invalidate the warranty.

**DO NOT PICK UP THE WEATHERPAK® BY THE WIND VANE.** This is a durable but sensitive wind sensor and it can be broken if it is used to lift the entire unit.

**DO NOT REMOVE THE ANTENNA FROM THE WEATHERPAK®.** If the WEATHERPAK® is activated without the antenna, the radio can be damaged.

The WEATHERPAK is designed to be completely automatic. When power is applied, if no terminal intervention occurs, the system will automatically initialize itself and begin sampling according to its predetermined schedule. The WEATHERPAK has a hardware clock accurate to about 5 seconds per day and an EEPROM portion of memory where sampling variables and system parameters are stored. Data are time marked with date/time.

All transient protection sensor signals and power lines are protected from transients and EMI by circuitry inside the WEATHERPAK. EMI filters are single pole RC filters (100 ohm and 0.1 microfarads). Transient protection is by 18 volt tranzorb diodes. If for any reason -- lightning, RF interference, power surge -- the computer program is corrupted and the sampling loop is broken, then a watchdog timer will reset the entire system and the WEATHERPAK will go into its autoboot routine.

***DEPENDING ON YOUR CONFIGURATION THIS USER MANUAL CONTAINS INFORMATION THAT MAY NOT APPLY TO YOUR SPECIFIC WEATHERPAK.***

## INSTALLATION

This section will offer generalized advice on the siting and installation of a WEATHERPAK and its associated sensors. All installations are unique with their own set of problems, so care and attention are required. Coastal Environmental Systems will be happy to provide special advice for your application.

Select an exposed site, removed from obstructions and more than 3 meters above the ground or the prevailing terrain. The wind pattern around a building or other obstacle is highly disturbed for a considerable distance, so the site should be as. A rule of thumb is that the sensors should be placed at a height 1½ times the nearby obstacles or that they are placed at a distance away of ten times the height.

### Erecting a Tower

The WEATHERPAK mounts on the quick release mount which is threaded on the bottom with a 1½ inch NPT male pipe thread. The quick release mount must be securely mounted to withstand wind loading and vibration at the installation site. Standard 1½ inch NPT pipe fittings can be used. We recommend that fittings be assembled with an anti-seizing compound to facilitate disassembly. If you use a free standing tower we recommend that you also use guy wires to support the WEATHERPAK in high winds. The guy wires attach just below the quick release mount.

### Quick Release Mount

The quick release mount can be threaded into the tower and fully secured before the tower is erected. ***Keep the protective PVC cap in the quick release whenever the WEATHERPAK is not connected.*** This prevents sand or water from getting onto electrical contacts. Keep the cap in a safe place and always replace it if the WEATHERPAK is removed for maintenance. When removing the PVC cap, be sure the quick release is clean and dry. During the removal, any water or dirt that has collected on top of the cap can fall into the mount.

### Cables and Connectors

Problems with cables and connectors cause at least 40% of all system failures. Our recommendation is “do it right the first time.” Take special care of external cables and connectors. Air pressure differences from wind or differential heating of instruments can cause cables to vent air into sensors and connectors; wind can force sand or moisture into the most insignificant interstices; and solar radiation is destructive to plastics and paint.

Below is a list of considerations:

1. ***Protect external connectors.*** Molded neoprene oceanographic connectors are probably the only connectors that do not need extra protection. Any other types, including MS-style environmental connectors, must be protected. We recommend that you wrap them in self-vulcanizing rubber tape followed by an outer wrap of black electrical tape (environmental grade). Use only the highest quality wrapping tape -- tape is cheap insurance.
2. ***Consider conduit.*** Conduit is good insurance. It protects cables from sunlight and abrasion. Animals love to chew on cables. Human beings may also harm cables.
3. ***Dorn fittings.*** Dorn fittings (also called compression fittings) are cable pass-through fittings, which use a rubber stopper to squeeze the cable. The Dorn fitting should be the proper size to snugly squeeze the cable -- when it is tight, you cannot pull the cable through the fitting. A small bit of silicone grease on the cable in the stopper is added protection. Dorn fittings are an excellent means of getting watertight security at a reasonable price, but they are not perfect. As we said earlier, cables “breathe”, so a Dorn fitting is no more than a straw into your electronic enclosure unless care is taken to block the cable. Alternatively, breather holes are often provided to allow the pressure difference to equilibrate.
4. ***Oceanographic connectors.*** For the best and most reliable system, use molded oceanographic connectors. With these expensive connectors, you will have perfect seals for indefinite periods.

### Compass

Observe the following cautions:

- Make sure there is no disturbing metal or other magnetic material around.
- Re-check the site routinely for new magnetic contamination. On a buoy, ice, or other remote site this is rare, but at an industrial or urban site you can expect problems.

In a semi-permanent or permanent fixed site, we advise that you do not use the compass, but instead survey in the WEATHERPAK to the proper alignment. In doing so, bear in mind that the alignment pin on the quick release and the alignment box on the wind sensor are at ***relative South***.

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## COMMUNICATION SETUP

### Introduction

The WEATHERPAK has a set of menus which are used to change the data collection schedule, upload logged data, display and change communications parameters, and display and change system parameters and values. You can reach the menus connecting a terminal (test set) directly to the user interface communications port on the front of the WEATHERPAK; any terminal or computer with RS232 input will do.

A PC or AT running a terminal program such as CROSSTALK or MIRROR is ideal. You can also use the Microsoft WINDOWS® terminal program to communicate with the WEATHERPAK; or even a dumb terminal with an RS-232 serial port. Coastal Environmental Systems can provide terminal software for this task.

Most terminal emulation programs have a "capture" mode that lets you save the session on a disk file. This practice is highly recommended as it provides a reference if any questions about operation or setup arise.

### Connecting the Terminal

To communicate with the WEATHERPAK, your terminal must be connected to the user interface communications port on the front of the WEATHERPAK.

Set the terminal as follows:

- Baud rate = 9600 (you can change and save this) (Radio Base Stations use 1200 Baud)
- Start bits = 1
- Stop bits = 1
- Data bits = 8
- Parity = none

### Powering up the WEATHERPAK

Power is supplied via the umbilical cable. The system requires 11-18 VDC. The mean current drain is 20 mA and the peak current required is 80 mA.

### Automatic Bootup Sequence

The WEATHERPAK commences operation when power is applied to it. The program commences by setting all default parameters. The parameter EEPROM memory is read into RAM. This memory contains parameters such as sampling rates, calibration coefficients, and state flags.

If a terminal is connected while the power is applied you will see something similar to the following message after about 5 seconds:

```
Watchdog Reset
Zeno 3200 V1.50 Nov 27 1994 14:36:30
Copyright (C) Coastal Environmental Systems, 1994.
System Time = 94/11/28 12:26:50
Initializing (approximately 8 seconds) . . ./
Sampling . . . Type 'U' To Enter The User Menus.
```

---

## WEATHERPAK®-2000 USER MODE

### Introduction

The WEATHERPAK®-2000 User Mode lets you:

- change communications settings;
- change system settings such as the clock time;
- change the data collection schedule;
- upload logged data.

Type **U** to enter the User Menu. The WEATHERPAK will display the following menu structure.

```

USER MENU
(C) Communications Menu           (T) Test Menu
(F) System Functions Menu        (Z) Zeno Program Menus
(S) Sample Period Menu          (H) Help
(D) Data Retrieval Menu         (Q) Quit
  
```

### Changing and saving settings

The configuration of your WEATHERPAK is held in EEPROM. This means that the settings are retained, even when the system powered down. When you power up the WEATHERPAK, the settings are read from EEPROM into RAM; the WEATHERPAK operates according to the configuration in its RAM.

When you change any settings in the User Mode, the new configuration is held in RAM, and takes effect immediately. However, if the system is powered down, the settings in RAM will be lost -- the old configuration will take effect the next time the system boots. To save settings to EEPROM -- making them permanent until the next change -- you need to enter **E** from any of the sub-menus.

**Type E within any sub-menu to save all settings to EEPROM.  
You will lose any unsaved settings when the system powers down.**

The WEATHERPAK continues data collection while you are in the User Mode. If there is no terminal activity for approximately three minutes, the WEATHERPAK will exit the User Mode. You should save any settings you wish to keep to EEPROM before quitting the User Mode -- you will lose any unsaved settings when the system powers down.

### Help facilities

Context-sensitive on-line help is available through two commands. By entering **Hn**, where **n** is a number, you obtain help on line item **n**. For example, in the System Functions Menu, **H5** gives you help on line item 5 -- Add Compass To Vane. Remember to type **<RETURN>** or **<ENTER>** after any command.

By entering **HX**, where **X** is a command, you obtain help on that command. For example, entering **HQ** in the User Menu gives you information on the Quit option.

### Communications settings

The communications parameters for your WEATHERPAK have been factory set. We do not recommend that they be changed. If you do wish to alter these settings (through the Communications Menu), you should be aware that the WEATHERPAK COM3 port is the one connected to your terminal.

### Changing System settings

The System Functions Menu covers a number of miscellaneous functions, such as:

- setting the system clock;
- calibrating the internal thermistor;
- finding your software version number;
- adding the compass reading to the measured direction when doing a wind vector average.

Type **F**, followed by **<RETURN>** or **<ENTER>**, from the main menu to enter the system **FUNCTIONS** menu. The WEATHERPAK user interface is not case sensitive -- **f** will also work. Once you are within the user interface, you must type **<Enter>** or **<Return>** at every command

```

SYSTEM FUNCTIONS MENU
(Cn/m) Change Item n to Value m   (E) Save Parameters To EEPROM
(D)  Display System Clock         (U) User Menu
(S)  Set System Clock             (Q) Quit
(V)  Program Version              (H) Help
(T)  Calibrate Internal Temperature

Item 1: 0 (Primary Unit/Experiment ID, 0 to 9999)
Item 2: 0 (Secondary Unit/Experiment ID, 0 to 9999)
Item 3: 1 (Data Dump Format)
Item 4: 1 (Real Time Output Format)
Item 5: 0 (Add Compass to Vane, 0 = NO, 1 = YES)
Item 6: 0 (Compass Offset in degrees, -180 to 180)
Item 7: 0 (Barometer Elevation in meters, 0 to 5000)

```

### Change Item n to Value m

Enter Cn/m to **CHANGE** the value of line item n to value m. For example, type **C1/3**, followed by **<RETURN>** or **<ENTER>**, to set the primary unit/experiment ID number to 3. If you wish to make this change permanent, you should then enter **E** to save the setting to EEPROM.

The different line items have the following meaning.

**Primary Unit/Experiment ID:** This item affects the real time output messages output by the WEATHERPAK during data collection. You may have seen these messages on the terminal before entering the User Menu. The values of this unit ID number, and unit ID number 2 are attached to these messages, to let you identify the source of the message. For example, they let you identify a single WEATHERPAK in a multi-site system; or they can be used to define the current system configuration.

**Secondary Unit/Experiment ID:** This is a second unit identifier, used together with the primary unit/experiment ID.

**Data dump format:** The format of the data messages you receive from the WEATHERPAK at the terminal when using the Data Retrieval menu. The formats are defined in the table overleaf.

**Real time output format:** This item affects the messages transmitted by the WEATHERPAK during normal data collection.

**Add compass to vane:** Controls whether or not the WEATHERPAK adds the compass value to the measured wind direction (the vane) when doing a wind vector average. This is described in more detail in Appendix 0.

**Compass offset:** This value is added to the compass measurement, to compensate for local variations in magnetic North. If you have no compass, this option has no effect. More details are given in Appendix 0.

**Barometer elevation:** The elevation above sea level. This quantity is used to correct the barometric pressure reading to sea level.

System settings		
Line	Quantity	Values available
1	Primary Unit/Experiment ID	0 to 9999
2	Secondary Unit/Experiment ID	0 to 9999
3	Data dump format	1 Space delimited 2 Comma delimited 3 Match the real time output format
4	Real time output format	0 None (output message suppressed) 1 ASCII characters, width dependent on data values, comma separated 2 ASCII characters, width as factory configured, no automatic separators
5	Add compass to vane	0 No 1 Yes
6	Compass offset (degrees)	-180 to +180
7	Barometer elevation (meters)	0 to 5000

#### System date and time

Options **D** and **S** respectively let you **DISPLAY** and **SET** the current date (format YY/MM/DD) and time (format HH:MM:SS) on the system clock to the nearest second. If you set the clock, the new setting is saved immediately: you do not have to type **E** to save the new setting, since it is not held in EEPROM. Be sure to use the “/” format for dates, and “:” for time.

#### Internal Temperature Calibration

Option **T** lets you calibrate the internal Temperature. You will be prompted to enter the current ambient air temperature -- measured with an accurate temperature probe placed near the WEATHERPAK electronics. If you move the WEATHERPAK to the probe, rather than the probe to the WEATHERPAK, you must give the internal thermistor time to equilibrate at the new temperature -- 15 minutes is usually adequate for this. The temperature can be specified in units of **FAHRENHEIT** (example input: **72.5F**), **CENTIGRADE** (**23.2C**), or **KELVIN** (**295.6K**). If you recalibrate the thermistor, the new calibration is saved immediately to EEPROM: you do not have to type **E** to save the new calibration.

**Changes to the system clock and internal thermistor are saved immediately -- without typing E**

#### Other commands

Option **V** gives you the current software **VERSION** number.

**Please note the software version before calling Coastal's customer service**

Option **E**, as already described, saves changes to **EEPROM**.

Option **U** returns you to the **USER** Menu.

Option **Q** lets you **QUIT** directly from the current menu. Any changes made will remain in RAM, but will not be saved to EEPROM. You can return to the previous configuration by powering down and then re-powering your WEATHERPAK.

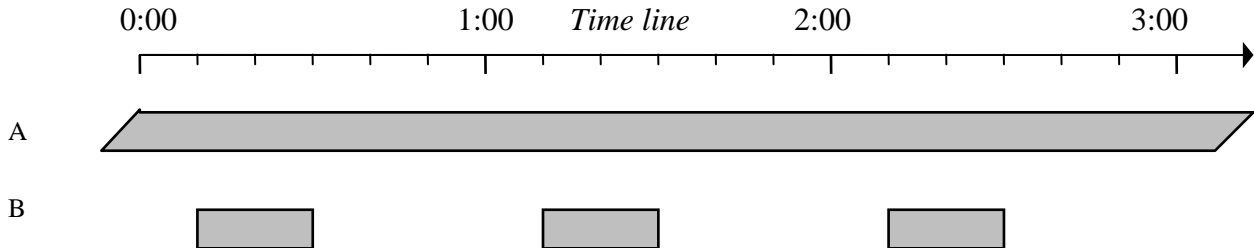


**Changing the data collection schedule**

A wide range of sensor sampling schemes are available from the Weatherpak. Examples are:

- A. the sensors can be sampled continuously, with no gaps;
- B. the Weatherpak can take samples from ten past until half past each hour.

The following time line illustrates these schemes -- a period of 3 hours is shown. The light grey areas indicate that sensors are being sampled.



The Weatherpak uses the same data collection schedule for all of the sensors. For the two cases listed above, you would set up the following schemes within the Sample Period Menu:

- A. start a sampling period each hour, minute or second, and let that period last one hour, minute or second;
- B. start a sampling period each hour, at 10 minutes past the hour, and let that period last 20 minutes.

Enter **S** from the User Menu to enter the **SAMPLE** Period Menu.

```

SAMPLE PERIOD MENU
(Cn/m) Change Item n To Value m      (Q) Quit
(E)   Save Settings To EEPROM        (H) Help
(U)   User Menu

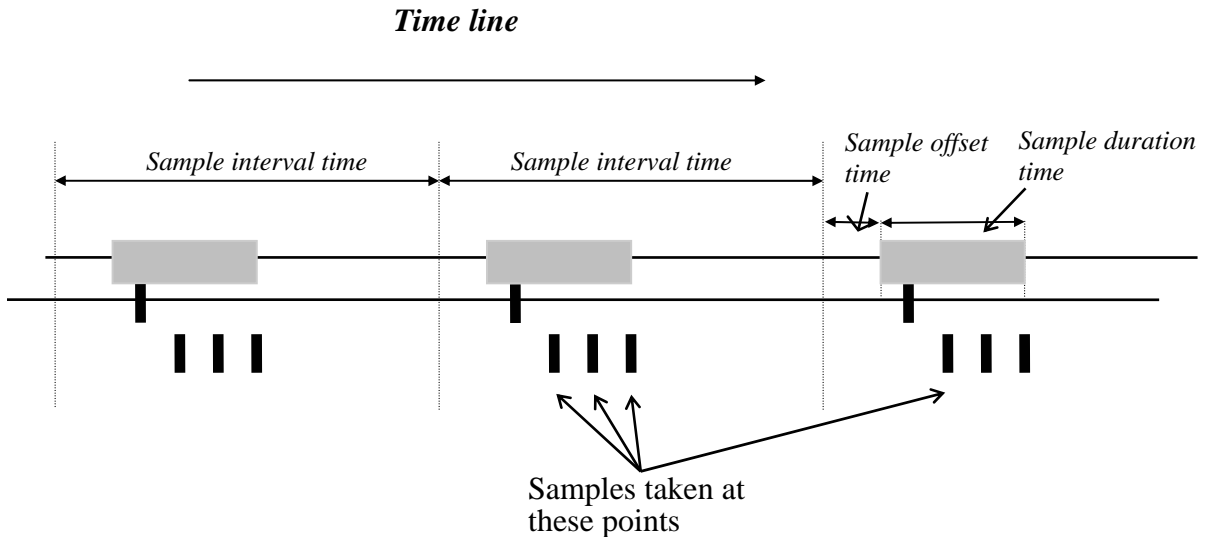
Item 1: 3600 (Sample Interval Time in seconds)
Item 2: 1200 (Sample Duration Time in seconds)
Item 3: 600  (Sample Time Offset in seconds)
    
```

The three variables are as follows:

- the sample interval time is the time elapsing between the start of successive sampling periods (i.e., one hour or 3600 seconds in case B above);
- the sample duration time is the time for which the sampling actually takes place within each sample interval (i.e., 20 minutes or 1200 seconds in case B above);
- the sample time offset defines the time at which the sampling begins, relative to a round number of sampling periods -- 10 minutes in case B above.

Sample period settings		
Line	Quantity	Values available
1	Sample interval $T_{int}$ (seconds)	1 to 86400 (24 hours)
2	Sample duration time $T_{dur}$ (seconds)	1 to $T_{int}$
3	Sample time offset $T_{off}$	0 to $T_{int} - T_{dur}$

The following time line illustrates the three variables, with case B in mind. Sampling takes place within the time periods marked gray.



The sample interval always starts, as far as possible, at an even time -- for example, if the sample interval time is one hour then the sample intervals start on the hour. The sensor outputs are sampled throughout the sample duration time.

A wide range of sensor sampling schemes are available from the WEATHERPAK. Examples are: the sensors can be sampled continuously, with no gaps; the WEATHERPAK can take samples from ten past until half past each hour.

### Inspecting Raw Data

The Test Menu lets you inspect raw data as it is measured -- without any averaging or other processing. The data can be inspected either before or after conversion to engineering units. Enter **T** from the user menu to reach the **TEST** Menu.

```

TEST MENU
(R) Display Raw Sensor Data      (H) Help
(S) Display Scaled Sensor Data  (U) User Menu
(Q) Quit
  
```

You cannot change anything from the Test Menu.

- R** Display **RAW** sensor data. The terminal will display, as it is measured, raw data from each sensor. The values are displayed before conversion to engineering units -- for example, volts for analog sensor inputs.
- S** Display **SCALED** sensor data. The terminal will display, as it is measured, scaled data from each sensor -- in engineering units.

### Exiting the User Interface Mode.

The WEATHERPAK continues to collect data while you are in the User Interface mode. If there is no terminal activity for approximately five minutes, the WEATHERPAK will time-out, exit the User Interface mode, and resume displaying the data sample lines. To manually exit the User Interface Mode, select **Q** to **QUIT** from any menu.

### Uploading logged data from the WEATHERPAK

The Data Retrieval Menu lets you upload and inspect data being collected by the WEATHERPAK. Type **D** from the user menu to enter the **DATA** retrieval menu. The WEATHERPAK stores sensor data as a set of data records: each data record consists of a time stamp and one or more processed sensor data values. You may have seen the processed sensor data values being output to the terminal before entering the User Menu.

#### DATA RETRIEVAL MENU

```
(A) Show Records AFTER Specified Time (C) Compute Data Logging Capacity
(B) Show Records BETWEEN TimeSpan (D) Delete All Data Records
(Ln) Show Last n Records (N) Show Number of Records Logged
(*) Show All Data Records (U) User Menu
(@n) Show n Unmarked Records (Q) Quit
(M) Mark Recently Shown Data (H) Help
```

You cannot change anything from the data retrieval menu. The following data retrieval commands are available.

- A** Show records **AFTER** specified time. This option lets you examine a fixed number of records, starting at a given time. For example, you may wish to examine the next 3 records logged after 3 p.m. You will be prompted to enter the start time, and the number of records to be displayed. Be sure to enter the start and end times in the format “YY/MM/DD HH:MM:SS”; for example, 94/11/28 14:45:00. Hit the space bar to halt the display; you will be prompted for confirmation.
- B** Show all records **BETWEEN** timespan. This option lets you examine all records logged between a defined start and end time -- you will be prompted for the start and end time if you make this choice. Be sure to enter the start and end times in the format “YY/MM/DD HH:MM:SS”; for example, 94/11/28 14:45:00. Hit the space bar to halt the display; you will be prompted for confirmation.
- C** Compute data logging **CAPACITY**. The terminal will show the total memory available for data storage, the total number of data records that can be stored, and the total time taken to fill the data logging memory.
- N** Show **NUMBER** of records logged. The terminal will show the number of data records that have been collected and stored in memory. This value must be less than or equal to the data logging capacity.
- D** **DELETE** all data records from the data logging memory. You will be prompted for confirmation.
- Ln** Show the **LAST n** data records. For each data record, the terminal will show the date and time stamp, followed by the logged, processed, sensor data values. The display will look something like this (assuming relative humidity and air temperature are being measured). The detailed format of the display (e.g., whether commas or spaces separate the data values) can be changed from the System Functions menu (choose **S** from the user menu). Hit the space bar to halt the display; you will be prompted for confirmation.

```
> L3
Hit The Space Bar To Halt The Log Data Output.
DATE TIME RH AT
94/04/15 4:43:38 86.4 78.6
94/04/15 4:43:40 86.4 78.6
94/04/15 4:43:42 86.4 78.6
```

- @n** Show **n** unmarked records. The data retrieval menu lets you “mark” logged records as already having been read. The first time you enter **@n**, the WEATHERPAK will display the oldest **n** records. If you subsequently enter **M**, these records will be marked as read. You will no longer be able to access these records using the **@n** command, although they will be accessible using the **L** (show last records), **J** (show records between specified times), and **K** (show records after a specified time) commands. The next time you enter **@n**, the WEATHERPAK will display the oldest unmarked **n** records.
- M** **MARK** recently shown data. This command marks as read the last set of records displayed using the **@n** command. This command will work irrespective of when the last **@n** command was used -- even if you have left and re-entered the user interface in the mean time.
- \*** Show all data records. You will see all the records logged to date sequentially, in the same format as the above. Hit the space bar to halt the display; you will be prompted for confirmation.

---

## GLOSSARY

**ALOHA:** Aerial Location of Hazardous Atmospheres

**ASCII:** American Standard Code for Information Interchange.

**Autoboot:** Automatic bootup.

**Base Mount:** A shortened name for the “quick-release base mount”, the device which holds the WEATHERPAK and provides electrical interface.

**Boot or Bootup:** When a computer initializes itself and automatically starts operation of a program when the power is turned on or after a warm reset.

**Byte:** A group of eight bits of computer information.

**CAMEO:** Computer Aided Management of Emergency Operations

**Declination:** See Variation.

**Dorn Fittings:** Compression fittings that allow an electronic cable to penetrate a casing wall and maintain a hermetic seal.

**EEPROM:** Electronically Erasable Programmable Read-Only Memory--- allow programmable setting of system parameters that is preserved when all power is removed.

**Magnetic declination:** See Variation.

**Magnetic variation:** See Variation.

**RAM:** Random Access Memory -- memory for data storage and program operation. RAM can be written to and read by addressing from the microprocessor.

**RC Filter:** An analog low-pass filter made of resistors and capacitors.

**Resolution:** The smallest amount of change in a measured quantity that can be discerned in a measurement. Unless stated otherwise, resolution implies the “exported resolution” which is the least resolvable change in the final datum. As an example, temperature might be reported to 0.1 °C but the actual measurement and internal processing might maintain 0.01 °C resolution. In this case, the resolution would be 0.1 °C. (sometimes written ±0.1 °C).

**RFI:** Radio Frequency Interference -- any noise that enters into a system from external sources.

**RS232:** The most common computer serial interface standard.

**Tranzorb:** A special diode semiconductor device that will acts as a short to high-voltage transients. It is installed on electrical input or output connections to protect a device from corona or electrical transients such as lightning.

**Variation:** Also magnetic variation and deviation. At most points on the Earth, the direction to true north varies from the direction to magnetic north by some number of degrees. This difference is called the **magnetic declination**. When the local magnetic anomalies are added to the declination, the result is called the **magnetic variation** or simply the **variation**. Either term, declination or variation, is correct although surveyors generally prefer the term declination and navigators the term variation.

Aeronautical and marine charts give variation as isogonic lines, or lines of constant magnetic variation. Variation changes with time, and the charts usually give the rate of change. In some areas, such as the Arctic, the charts note that compass measurements are unreliable. For the highest accuracy, it is important to use up-to-date charts. When a compass needle points east of true north it is due to **easterly variation**. This is the case for most of the continental U.S.A. The correction from magnetic to true direction for an easterly variation is a positive correction. As an example, in Seattle WA the variation is approximately 22° and a compass reading of 0° Magnetic corresponds to a true direction of 22° True. Alternatively, a **western variation** results in a negative correction.

**Vector Averaging:** The technique for averaging a wind or ocean current by converting each measured speed and direction pair to a corresponding pair of x-y coordinates for averaging. The coordinates are summed over an averaging interval and their final average is computed at the end of the averaging time. Vector averaging removes the errors that occur when direction cycles from 359° to 0°.

**Warm Reset:** A system reset whereby the computer is reset and restarted but all peripherals remain powered.

**Watchdog Timer:** A special countdown timer whose function is to cold or warm reset a system if its computer program stops operating. Often during lightning or intense RFI a computer RAM will be corrupted and the program will “crash”.

---

**MATHEMATICS OF WIND MEASUREMENTS**

**Wind direction is the compass angle from which  
the wind is blowing**

Many different wind statistics are in common use. Vector averaging of some sort is necessary for reliable wind direction estimates. You cannot simply average the vane measurement directly without risking grave errors. As an example if the wind blew half the time from 359° and the other half from 1°, the simple vane average would yield a mean direction of 180°!

The compass bearing can be added to the vane measurement for each sample. If the vane direction measurement relative to the sensor is  $\theta_s$  and the measured corrected compass angle is  $\alpha$ , the instantaneous wind direction relative to true north is  $\theta_i = \theta_s + \alpha$ . If you know the magnetic declination  $\delta$  at your site, you should input it to the WEATHERPAK, using the System Functions Menu (section 0). However, if there are contaminating magnetic objects in the vicinity of your WEATHERPAK, or if the compass is not installed, then the wind monitor must be aligned as closely as possible to true north. The flag Add Compass To Vane, also set in the System Functions Menu, should be set to 0 (false) in this case.

The different wind statistics available are described below. They are all based upon the same measurements: the wind speed  $s$  and direction  $\theta$  (including the compass bearing) are measured typically once per second (the rate can be factory set). From these, the WEATHERPAK calculates the following quantities for each measurement  $i$ :

$$\begin{aligned}x_i &= \sin \theta_i; \\y_i &= \cos \theta_i; \\u_i &= s_i x_i; \\v_i &= s_i y_i;\end{aligned}$$

giving  $x_i$  and  $y_i$ , the unit vector components corresponding to east and north respectively, and  $u_i$  and  $v_i$ , the wind speed vector components. The vector components are summed over the averaging period, and the vector averages are computed at the end of the averaging interval:

$$\begin{aligned}X &= \frac{1}{N} \sum_{i=1}^N x_i; \\Y &= \frac{1}{N} \sum_{i=1}^N y_i; \\U &= \frac{1}{N} \sum_{i=1}^N u_i; \\V &= \frac{1}{N} \sum_{i=1}^N v_i.\end{aligned}$$

**Vector Average Wind Speed and Direction**

The  $U$  and  $V$  terms are used to compute the vector average wind speed  $S_V$  and direction  $\theta_V$ :

$$\begin{aligned}S_V &= \sqrt{U^2 + V^2}; \\ \theta_V &= \arctan(U, V).\end{aligned}$$

The arctangent notation  $(U, V)$  means that the signs of  $U$  and  $V$  are used to determine the exact angle in the range of 0-360°.

### Scalar Average Wind Speed

The mean speed  $S_S$  is computed from the speed measurements alone:

$$S_S = \frac{1}{N} \sum_{i=1}^N s_i.$$

Scalar wind is a measure of the wind regardless of its direction. Yamartino showed<sup>1</sup> that wind gustiness and direction fluctuation will lead to a scalar wind that is always larger than the vector average wind.  $S_S$  is usually only a few percent greater than  $S_V$  and it serves as a backup measurement if the compass or vane fails and  $S_V$  is invalidated.

### Standard Deviation of Wind Direction, Sigma-Theta

The standard deviation  $\sigma_\theta$  of the wind direction is based on the time series of wind direction measurements,  $\theta_i$ , and the average wind direction,  $\theta_V$ . A formal definition of  $\sigma_\theta$  is:

$$\sigma_\theta^2 = \frac{1}{N} \sum_{i=1}^N \Delta_i^2 - \left[ \frac{1}{N} \sum_{i=1}^N \Delta_i \right]^2,$$

where all measurements are in radians:  $\Delta_i$  is defined such that each  $|\Delta_i|$  is the smaller of  $|\theta_i - \theta_V|$  and  $2\pi - |\theta_i - \theta_V|$ . Calculating this exactly requires two passes over the data: first to calculate  $\theta_V$ , and then to find  $\sigma_\theta$ .

Coastal Environmental Systems uses a single pass method because data can be processed in real time without storing all the wind samples in memory. Yamartino compared several single pass computations and showed that the most accurate equation -- used in Coastal Environmental System analysis -- is:

$$\sigma_\theta = \arcsin \left[ \varepsilon \left( 1 + b\varepsilon^3 \right) \right],$$

where:

$$\varepsilon^3 = 1 - (X^2 - Y^2);$$

$$b = \frac{2}{\sqrt{3}} = 0.1547.$$

### Maximum Wind Speed

Maximum winds (gusts) are determined during each individual averaging period. Gust information is important for risk studies of damage to constructions and buildings. The duration of the gust is an important consideration and is often related to the intended application. Some applications require information about extreme values of the shortest gusts (1 second duration), while in other cases, the damaging gusts are those that engulf the entire structure (5-10 seconds duration). Fortunately, with little error, there is a technique for relating extreme gust measurements taken for one duration to extreme gusts of other durations<sup>2</sup>. The gust duration  $D$  in the WEATHERPAK can be factory set to values between 1 and 5 seconds.

In the Coastal Environmental Systems wind algorithm, a  $D$ -second running average of the speed measurements is applied to the data as it is collected. At the time of each measurement the average of the circular buffer is computed and compared against the maximum value up to that time. When the current "gust" measurement exceeds the stored maximum, the maximum value is updated.

<sup>1</sup> Yamartino, R.J. (1984) A Comparison of Several "Single-Pass" Estimators of the Standard Deviation of Wind Direction. *Journal of Climate and Applied Meteorology*, 23, 1362-1366.

<sup>2</sup> Beljaars, A.C.M. (1987) The Influence of Sampling and Filtering on Measured Wind Gusts. *Journal of Atmospheric and Oceanic Technology*, 6, 613-626.

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## WEATHERPAK-2000 FOR HAZMAT RESPONSE

The WEATHERPAK® -2000 can be configured for HazMat Spill Response. In this configuration the system measures the air temperature and the speed, direction and stability class of the wind. As an option, it can measure barometric pressure and relative humidity. Information is sampled every 2 seconds and then computed into a 5-minute running average. The data is then transmitted to you every 30 seconds for an updated line of data.

A WEATHERPAK® -2000 is suitable for extremely portable use when mounted on a van or a portable tower. It can also be mounted at a fixed site, such as an industrial plant.

The WEATHERPAK® was designed with the following unique features for use in hazardous materials response:

- A built-in electronic compass allows the WEATHERPAK® to be set up in any orientation – it will automatically determine true North and give you true wind direction.<sup>1</sup>
- Set-up time is under two minutes.
- When the unit is assembled, there are no electrical connections that can spark.
- The housing is constructed of 6061-T6 aluminum that is non-corrosive and will not spark if dropped or struck.
- The housing is sealed and dried with desiccant to protect the electronics against moisture. This means that the WEATHERPAK® can easily withstand decontamination procedures.
- A beeper in the tower sounds when battery replacement is required because of low voltage in the battery pack.<sup>2</sup>
- All of the electronics are grounded at a single point to protect the WEATHERPAK® against unexpected large voltages and radio interference.

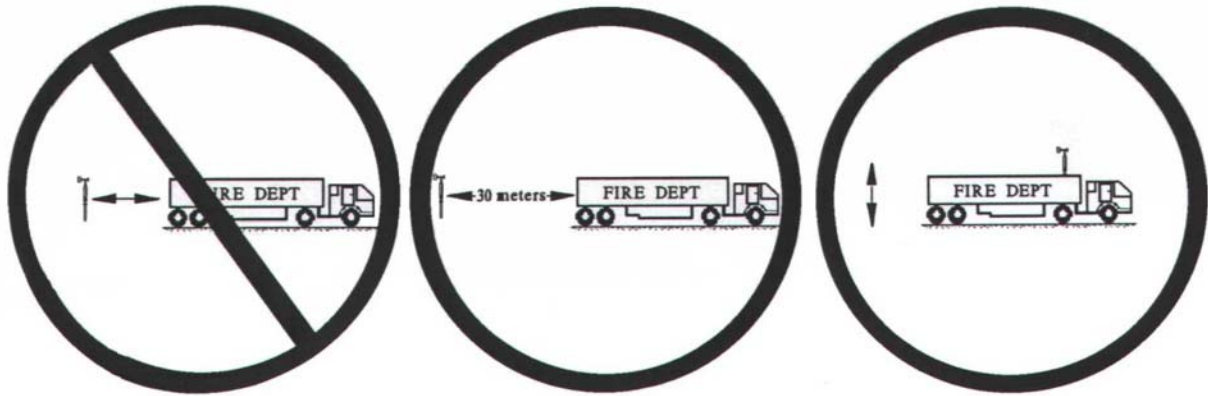
<sup>1</sup> The variation of true North from magnetic North is entered into your WEATHERPAK® for your location. It is easily changed, but should not be done so without first consulting Coastal Environmental Systems.

<sup>2</sup> The WEATHERPAK® must be installed for the beeper to function.

### Installation

#### Siting Considerations

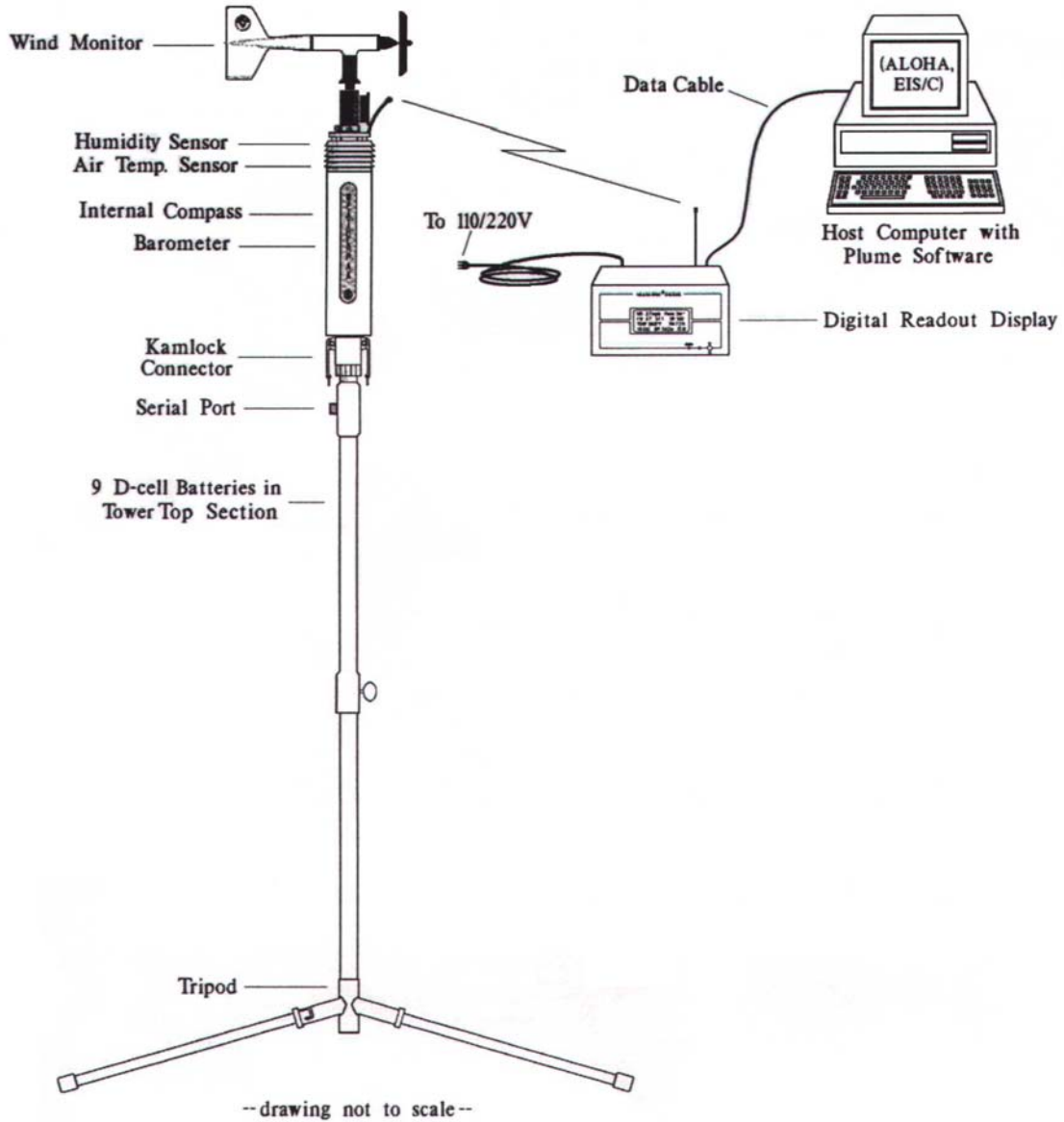
- a) **Compass Measurements** – Remember that the WEATHERPAK® contains an electronic fluxgate compass for automatic North alignment. Like any compass, it can make an error if located too close (**laterally**) to large amounts of steel or other magnetic material. (In other words, on top of a van is OK, but next to it is not an ideal location.) Try to place the WEATHERPAK® at least 30 meters from large vans, busses, cranes, etc.
- b) **Wind Measurements** – Select as exposed a site as is possible. The wind pattern around a building or other obstacle is disturbed for a considerable distance. If the WEATHERPAK® is placed immediately North of your vehicle and the wind is coming from the South, an erroneous wind direction and speed reading will result.
- c) **Radio Transmissions** – Locate the WEATHERPAK® as close as safety permits within 2 miles of the receiving unit. Do not attempt to transmit through structures containing steel, or through hills. Reception range will vary depending on radio signal path.



Placement on top of vehicles is okay



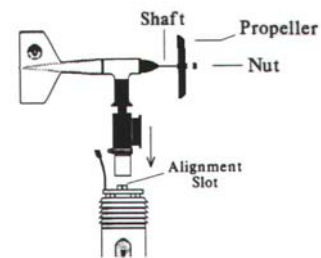
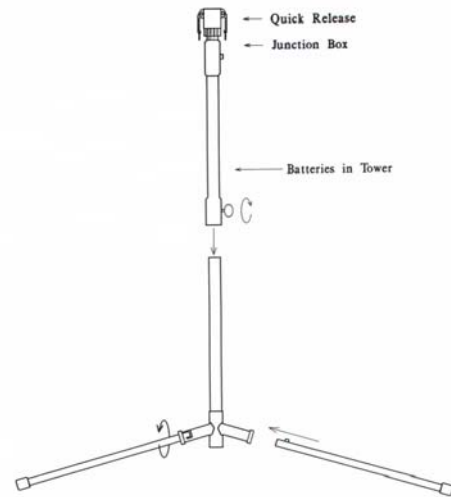
### Tripod Mount



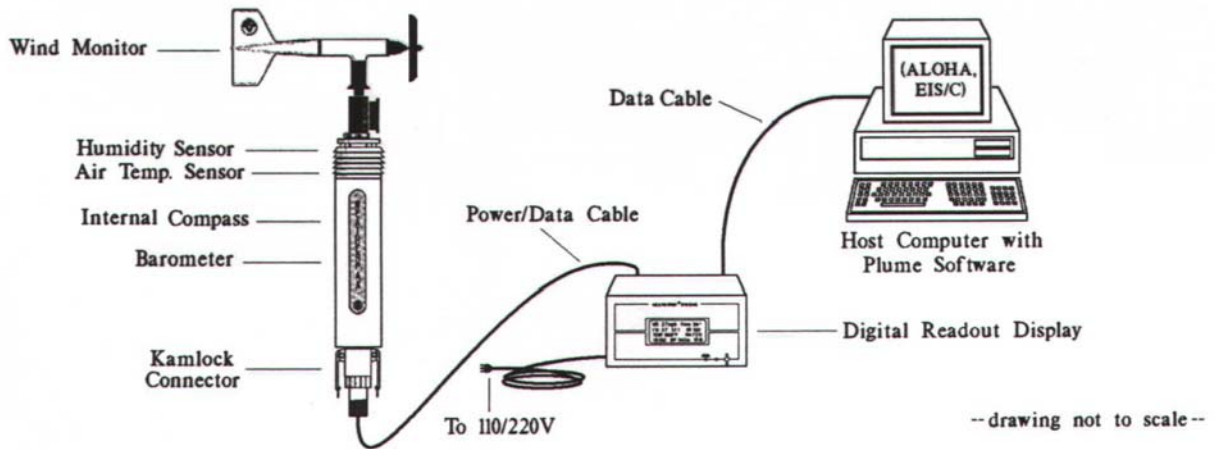
The WEATHERPAK® -2000TRx with tower

## Tripod Mount Setup

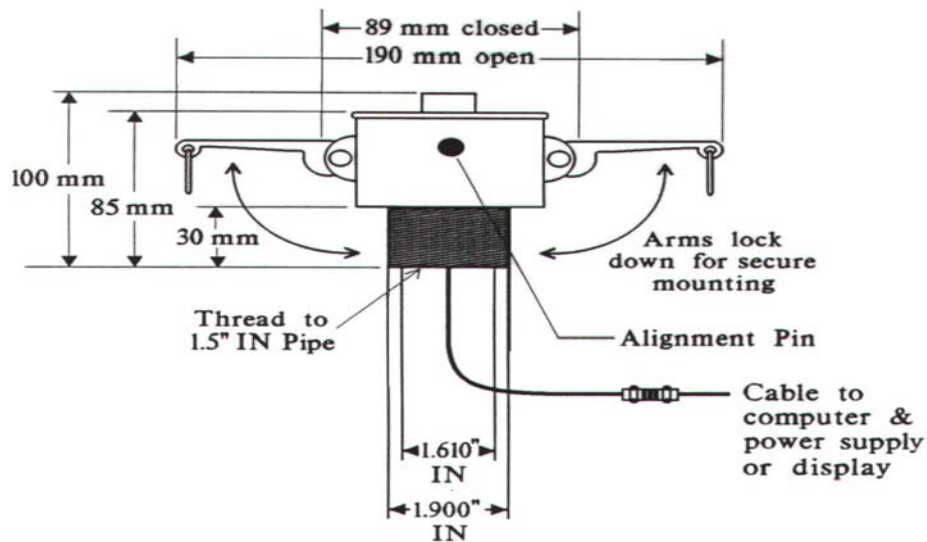
- 1) Lock the legs on to the bottom section of the tower forming the tower tripod base.
- 2) Remove the wind vane from the case. Place the propeller on the front shaft screw the nut into place on the propeller shaft to secure the propeller.
- 3) Plug the wind vane into the top of the WEATHERPAK®. There is an alignment pin and slot inside the connector to assure a proper and aligned fit.  
*Be certain that the wind vane is plugged all the way in.*  
*DO NOT rotate the wind vane when installing or removing.*
- 4) Align the slot on the WEATHERPAK® with the guide pin on the quick release and push straight in. (DO NOT “screw” the WEATHERPAK® onto the quick release.) This is a good sealed fit and may require an extra push - then **push the arms of the clamp down** to assure a tight fit. DO NOT rotate the WEATHERPAK® or tower when installing or removing.
- 5) Place the entire unit -- tower top and WEATHERPAK® – onto the tripod and securely tighten the tower locking knob.
- 6) The WEATHERPAK® is now running and is sampling. When the WEATHERPAK® is removed from the Quick Release, it will stop sampling and shut itself off.



### Van Mount Setup

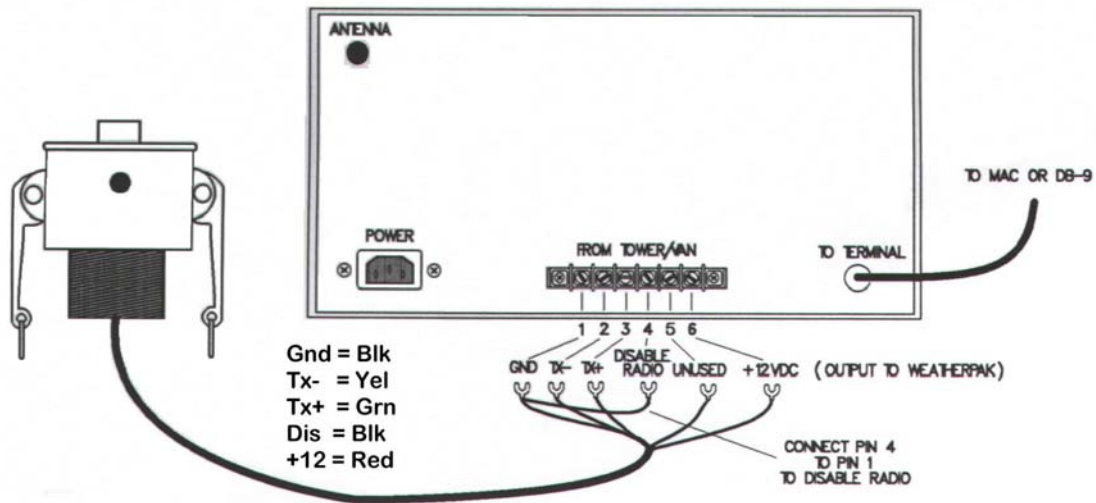


- 1) Remove the wind vane from the case. Place the propeller on the front shaft screw the nut into place on the propeller shaft to secure the propeller.
- 2) Plug the wind vane into the top of the WEATHERPAK<sup>®</sup>. There is an alignment pin and slot inside the connector to assure a proper and aligned fit. **Be certain that the wind vane is plugged all the way in. DO NOT rotate the wind vane when installing or removing.**
- 3) Align the slot on the WEATHERPAK<sup>®</sup> with the guide pin on the quick release and push straight in. (DO NOT "screw" the WEATHERPAK<sup>®</sup> onto the quick release.) This is a good sealed fit and may require an extra push - then **push the arms of the clamp down** to assure a tight fit. DO NOT rotate the WEATHERPAK<sup>®</sup> or tower when installing or removing.
- 4) The WEATHERPAK<sup>®</sup> is now running and is sampling. When the WEATHERPAK<sup>®</sup> is removed from the Quick Release, it will stop sampling and shut itself off.
- 5) The Van Mount Quick Release is permanently mounted on a vehicle. Coastal supplies a 1-1/2" female SPT.



Van Mount Quick Release

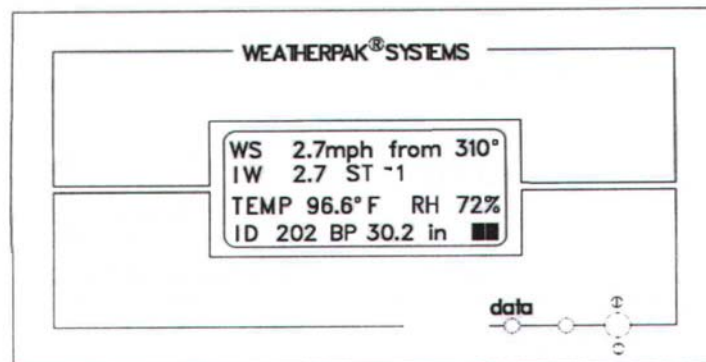
**Receiver Display Box**



Receiver box rear panel connections.

**Internal Switches**

The following internal switches change the functions of the RX Box Display only. Serial data will not be affected by switch settings. **IMPORTANT NOTE: DO NOT** open the receiver/display box without permission from Coastal Environmental Systems Customer Service, as doing so may void your warranty. Always disconnect the A/C power cord before opening the box. The receiver box contains many static sensitive parts which can be inadvertently damaged by improper handling. **DS1** Unused (remains off); **DS2** Standard = off / Metric = on, **DS3** Degrees = off / Ordinal points = on, **DS4** Unused (remains off), **DS5** English = off / French = on



DW 20452R

EXAMPLE Receiver front panel

The example is interpreted as follows: The five minute average wind (**WS**) is 2.7 miles per hour and is coming from 310 degrees. The instantaneous – one second wind speed (**IW**) is 2.7 miles per hour. The stability (**ST**) will range from -1 to 100. The -1 is a default reading for the first 5 minutes. After that it will range from 1 to 100. The higher the ST number, the more unstable the wind is with a corresponding wider area of concern. The air temperature (**TEMP**) is 96.6 degrees Fahrenheit. The relative humidity (**RH**) is an option. The **ID#** is unique to your WEATHERPAK®. The barometric pressure (**BP**) in inches is an option.

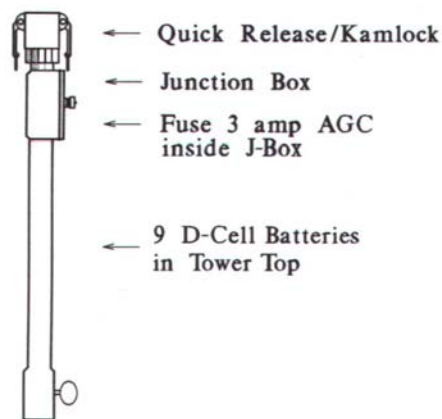
### Low Power Indicators

1. A beeper will sound in the tower. The WEATHERPAK® must be installed.  
*Dead batteries will not activate the beeper.*
2. A “T” will flash on the Receiver front panel
3. The battery voltage reads below 11.0 on the “Processed Sam Data: screen

There are low power warning indicators which will flash in the lower right corner of the display. A **flashing “R”** indicates that the Receiver batteries are low. R warning flash starts  $\cong 11.5$  VDC. Receiver lights go out  $\cong 10.5$  VDC. If the receiver lights go out, plug the receiver into a wall outlet, then reset the receiver by flipping the power switch off then back on. This will recharge the batteries. Batteries last = approximately 2 hours. Recharge time = approximately 1 hour. A **flashing “T”** indicates that the batteries in the tower are low and need replacing.

### Replacing tower batteries and fuse

The WEATHERPAK® has nine alkaline D cell batteries which are located in the top section of the tower, as shown in the figure below. The batteries can be replaced with standard alkaline batteries. Make sure that the replacement batteries are of the same type. There is an in-line fuse located in the tower junction box (see figure below.)



Replacing the batteries

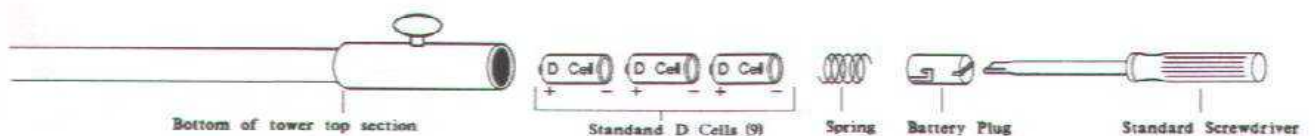


Figure 11. Replacing the batteries (2)

You will need a large screwdriver to replace the batteries. The battery “plug” is slotted. With the screwdriver, **PUSH** (the plug is held in place by a spring) and rotate the plug clockwise. The plug will come out followed by a spring and the batteries. Slide the new batteries in (positive end first) and replace the spring and plug.

To check the new voltage, set up the WEATHERPAK® and get the ALOHA plume model running. Then pull down the [MISC] menu to “Processed Sam data”. One of the items shown is battery voltage (see figure 10 on page 14.) It should read about 13 to 15 volts. The tower low voltage beeper will go off when the battery voltage reaches 11 volts.

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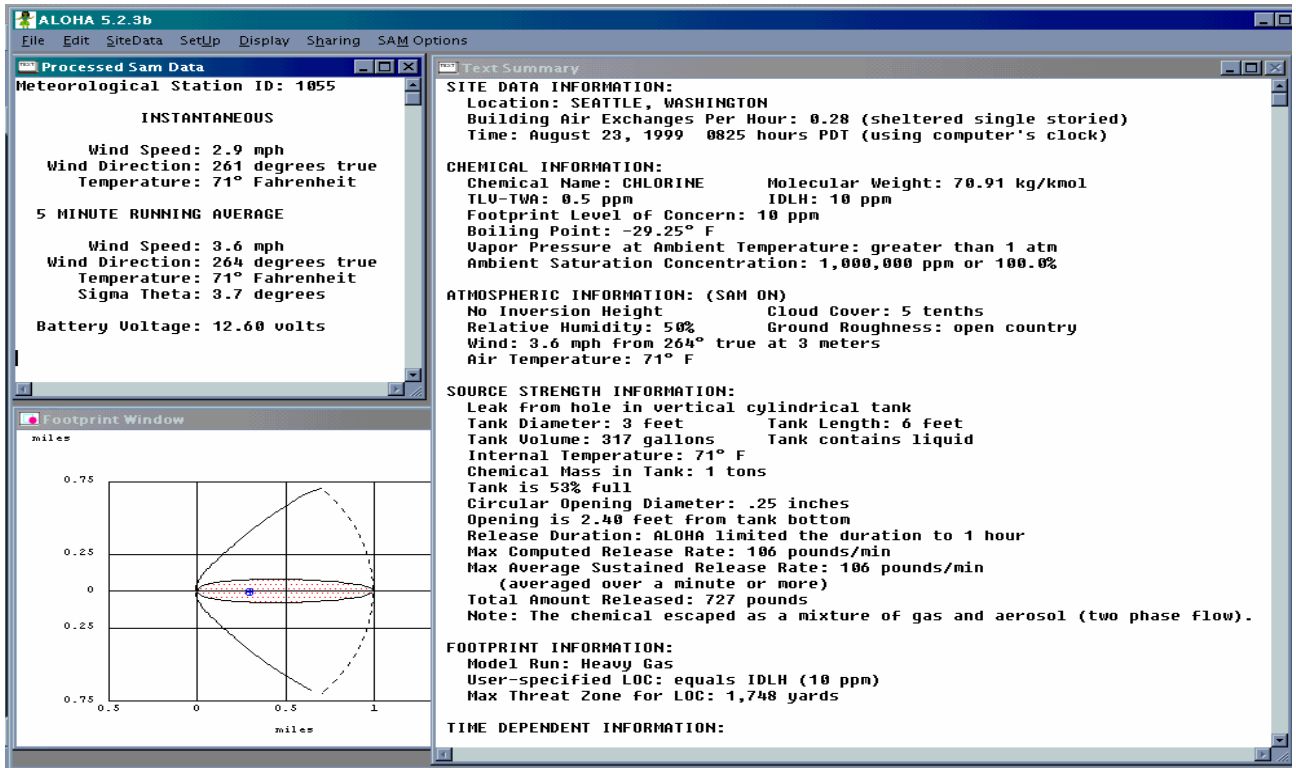
## Plume Modeling Software

With the WEATHERPAK set-up and operational and the Receiver/Display box connected to your computer, real-time data is available to run air dispersion plume modeling software.

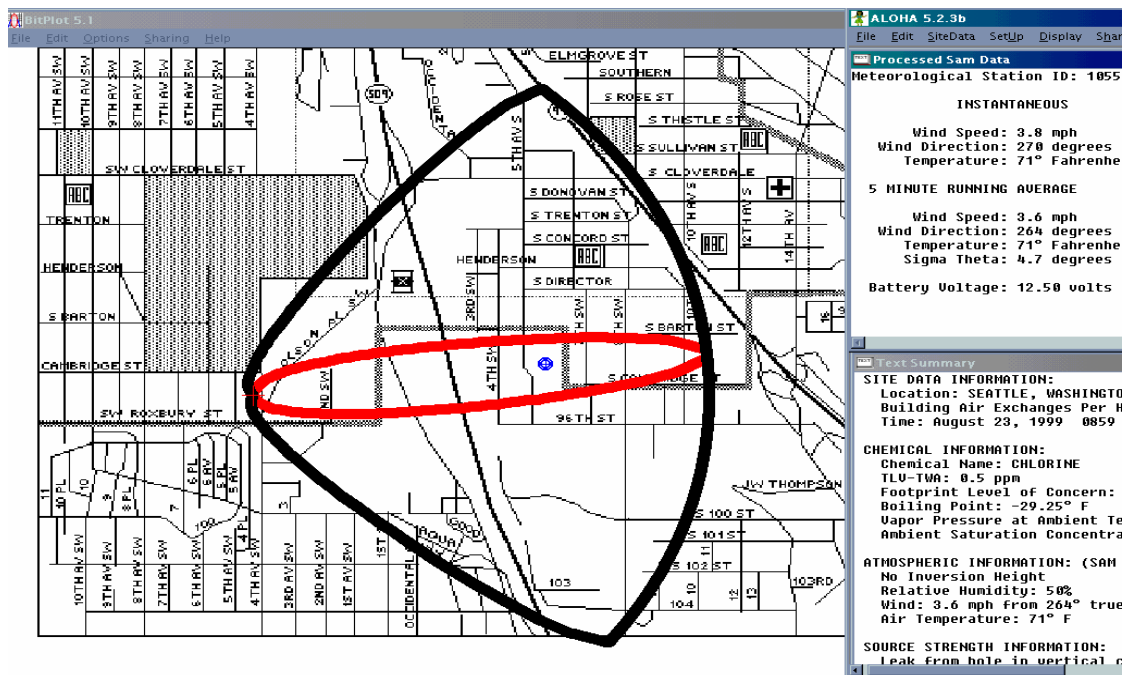
**IMPORTANT NOTE:** Some versions of ALOHA (including 5.2.1) need to be upgraded in order to work with a Station for Atmospheric Measurement (SAM); the WEATHERPAK is a SAM. The US EPA provides CAMEO/ALOHA software support and information at their website <http://www.epa.gov/ceppo/cameo/support.htm>. To upgrade, go to Updates and Utilities which exits to <http://www.nsc.org/ehc/cam/fixitlib.cfm> scroll down to ALOHA UPDATES 5.2.2. These addresses change periodically – we'd appreciate knowing any changes you encounter.

The following is a brief outline on using the system to produce an ALOHA plume model on a PC operating Windows 95. There is a general assumption that the user is familiar with ALOHA and that the program is properly loaded on the user's computer. Please consult the ALOHA user's manual for additional details and program limitations.

1. Open ALOHA by clicking on its desktop icon, or selecting it from the Programs menu
2. A series of dialogue boxes will appear including important notes on program limitations.
3. A Text Summary window will appear with information summarizing the event.
4. Confirm that your Site Data information is correct. If required, use the SiteData pull-down menu to change it.
5. Using the pull-down menu SetUp/Chemical select the chemical (chlorine, for example).
6. Using the pull-down menu SetUp/Atmospheric/SAM Station a series of dialogue boxes will appear requiring user observations or assumptions. Relative humidity data is not captured automatically and can be hand-entered using data from the Receiver/Display box.
7. Using the pull-down menu SAMOptions select Processed Data. The WEATHERPAK delivers data in the proper format for ALOHA to use. A Processed SAM Data window will appear. If the WEATHERPAK has been collecting data for less than five minutes a warning message will be displayed in both the Text Summary and Processed SAM Data windows.
8. Before allowing selection of the source of the leak (tank, pipe, direct etc.), ALOHA requires the SAM station to record five minutes worth of data. Using the pull-down menu SetUp/Source select the source of the leak (tank, for example); a series of dialogue boxes will appear requiring user observations or assumptions.
9. Use the Display/Footprint pull-down menu to show the plume footprint. A footprint is required before plotting the plume onto a street map. Refer to the ALOHA manual for interpretations and explanations on selecting locations within the plume footprint.
10. Optional graphs: Use the Display pull-down menu to produce graphs for source strength release rate, concentration, and dose.
11. Use the Display/Tile Windows to show multiple windows on the same screen; reposition and re-size as needed. Display/Stack will organize and stack the windows for quick access.
12. To plot the plume onto a street map, use the Sharing pull-down menu. As weather conditions change the plume size and position will change shortly after the WEATHERPAK provides updated data. Note: some software versions require that the ALOHA window overlay the map window in order for the map-plume to update automatically.



The WEATHERPAK takes a sensor sample approximately every 1-2 seconds and calculates a five minute running average and sends updated data approximately every thirty seconds. "INSTANTANEOUS" data is captured just prior to the thirty-second update. By comparing the "5 MINUTE RUNNING AVERAGE" and "INSTANTANEOUS" data, the user can get a good idea of changing conditions. The WEATHERPAK calculates "Sigma Theta", or air mixing, and produces a Stability Class value used by the plume model. The battery voltage is also transmitted. Note: If voltage is below 11.0 the batteries in the WEATHERPAK tower should be replaced.



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## Aloha Operation

If you pull down the “SAM Options” from the Main menu and select “Raw data”, something like the following line of data will appear:

**421, 0.9, 225, 1.0, 23.9, 1.0, 226, 23.9, 14,0, 1917, 999, 46, 2536**

This is showing you exactly what the WEATHERPAK® is sending. Notice that most of these numbers are present in the “Processed Sam Data” on the previous page. The difference is that there are no labels and there are some additional numbers. Also, this raw data is in metric units (millibars, m/s, C), whereas the processed data is in standard English units (inches, m.p.h., F.)

The first number is the unique ID number (Serial #) of your WEATHERPAK®. If you do not have a WEATHERPAK® display screen, then this is how to identify your WEATHERPAK®. If you have a WEATHERPAK® display screen, the ID number appears on it.

Two “checksums” are performed to ensure that the message sent was correct. The computer adds up the “ASCII value” of the data line (each letter and number and comma, etc., has a numerical value universal to all computers) to make sure that the computer got the same number that the WEATHERPAK® transmitted.

### Data line interpretation

The data line fields are as follows:

**ID, MW, MD, ST, AT, SI, DI, TI, BV, CKSUM1, BP, RH CKSUM2**

**ID** – WEATHERPAK® identification number

**MW** – 5 minute averaged wind speed in meters per second

**MD** – 5 minute averaged wind direction in degrees

**ST** – Stability class in degrees

**AT** – 5 minute averaged air temperature in degrees Centigrade

**SI** – Instantaneous wind speed in meters per second

**DI** – Instantaneous wind direction in degrees

**TI** – Instantaneous air temperature in degrees Centigrade

**BV** – Battery voltage in volts

**CKSUM1** – First checksum

**BP** – Barometric pressure in millibars

**RH** – Relative humidity in percent

**CKSUM2** – Second checksum



## TROUBLESHOOTING

**Do not take the WEATHERPAK® or the Receiver box apart;** this will void the warranty. If the procedures below do not solve the problem, call Coastal Environmental Systems.

### Is the WEATHERPAK® on?

Once the WEATHERPAK® is set up, it turns itself on, and starts sampling and transmits data every 30 seconds. If it does not:

- Check that the WEATHERPAK® is properly secured in the quick release – reseal firmly.
- Check the power connection to the WEATHERPAK®, or
- Check the tower batteries and fuse.

### Is the Receiver/Display Box on?

The display light should be on and the display characters visible. If this does not occur, do the following:

- Be sure the receiver unit is plugged in and turned on.
- Check the power light on the front panel. It should be lit.
- If it is not lit, check for power at the outlet the RX Box is plugged into.
- Check the cable connections from the WEATHERPAK® to the receiver,

### Receiver/Display Box Data light not flashing?

Every 30 seconds (approximately), the data light will flash signifying that the WEATHERPAK® is updating the display. If the light does not flash, then do the following:

- Be sure the receiver unit is plugged in and turned on.
- Check the power light on the front panel, it should be lit.
- Check to see if the WEATHERPAK® is “line of sight” (less than 2 miles, and not transmitting through hills, or steel walls, etc.)
- Be sure you are not trying to transmit through structures containing lots of steel.
- Check to see if both antennas are connected (WEATHERPAK® and receiver.)
- Unclamp, remove, wait 10 seconds, then replace the WEATHERPAK® on the tower (this resets it.)
- Check to see if the low battery beeper in the tower is beeping.
- Check that the batteries in the tower are properly aligned and are the correct voltage.
- Check the power connection to the WEATHERPAK®.
- Check the cable connections from the WEATHERPAK® to the receiver

### Wind speed off?

- Check that the propeller is turning. There is a minimum threshold of about 2.5 MPH.

### Propeller is turning, wind speed reads zero?

- Make sure that the wind monitor has been pushed down all the way on to the WEATHERPAK®.

### Wind direction off?

For this job you need a partner. Have your partner go to the wind monitor and hold the vane so the propeller points in a known direction. Does the display read correctly? If not:

- Make sure that the wind monitor has been pushed down all the way on to the WEATHERPAK®. There is an alignment pin and slot inside the connector to assure a proper and aligned fit; make sure that the pin is in the slot. See Tower Mount Setup.

### Other sensor readings off?

- Contact Coastal Environmental Systems. The WEATHERPAK® may be broken or require maintenance.

### There is data at the display but there is either no data or erroneous data at the computer?

- Check all the connections from the receiver to the computer.

### Error messages while running plume modeling?

Typically, these are not related to the WEATHERPAK®, they are coming from the plume modeling software.

- ALOHA version 5.2.1 will not work with weather stations, free upgrades are available
- Consult your CAMEO/ALOHA manual.
- Contact the US EPA for help with CAMEO/ALOHA software.
- Coastal is NOT an authorized CAMEO/ALOHA representative; however, we may be able to help.

## MAINTENANCE

Routine maintenance is required on the WEATHERPAK® every 12 months. This maintenance is to ensure that the overall system and its sensors are working and performing to specifications. The actual service varies, based on the sensors installed in your model of WEATHERPAK®. For example, a WEATHERPAK® –2000 should have the wind, compass, air temperature (and, optionally, the barometric pressure and relative humidity) sensors tested to their stated specifications. In addition, the entire WEATHERPAK® should be examined for any wear, damage or other non-conforming variances.

## SYSTEM DESCRIPTION, SCHEMATICS AND CONFIGURATION

Your WEATHERPAK®-2000 Weather Station is made up of the following major components:

WIND MONITOR	S1104W	RM Young 05103
	S1145W	RM Young AQ
		Handar Sonic
AIR TEMPERATURE	S1074W	YSI 44203
		YSI 44304
RELATIVE HUMIDITY		VAISALA 50U – 3%
		Hygrometrics – 4%
		VAISALA Hmm20D – 2%
BAROMETER	S1081W	IC Sensor 1220A
		Setra 270
PYRANOMETER	S1114	Licor 200 SZ
		Eppley 8-40
		Eppley PIR
DATA STORAGE MEMORY		1 MB
OPERATING SOFTWARE	S1288	ZENOSOFT version 1.966
	S1329	MET EXPERT
DATA COLLECTION SOFTWARE	S1341	INTERCEPT Network 3.34B
	S1137	INTERCEPT 3.34B
	S1140	INTERCEPT Format Editor 2
TOWER	S1125W	3 Meter Tripod Tower
		3 Meter Universal Tower
	S1118W	10 Meter Universal Tower

RADIO		S1064W	2 Watt 467.8
RADIO RECEIVER			
RADIO RECEIVER/DISPLAY BOX		S1016	
RECEIVER/DISPLAY BOX		S1011	
CABLE LENGTH			