SOUTH MOUNTAIN WEATHER STATION:
HISTORY, DATA SUMMARIES, AND CONTINUED OPERATION

Prepared for
ESTANCIA BASIN WATERSHED HEALTH,
RESTORATION AND MONITORING STEERING COMMITTEE

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INTRODUCTION

The South Mountain Weather Station (SMWS) (Figure 1) was installed to provide meteorological and soil moisture and temperature data as part of a watershed health and restoration program overseen by the Estancia Basin Watershed Health, Restoration and Monitoring Steering Committee (EBWHRMSC). EnviroLogic, Inc. (EnviroLogic) installed the SMWS in September 2006 to initiate site-specific monitoring of rainfall and soil water content at various soil depths. The SMWS is within the Edgewood Soil and Water Conservation District, on the private property of David King, near South Mountain, Santa Fe County, New Mexico, approximately 19 km (12 miles) north of the town of Edgewood (Figure 3). The assumed intent of EnviroLogic was to assess water infiltration through soil depths, relate that to meteorological variables, and then compare two measured locations to determine the effects of forest thinning projects on groundwater recharge.

The meteorological station measures precipitation, wind speed and direction, air temperature, humidity, and solar radiation. Soil moisture and temperature probes are situated at various depths at two locations with distinct vegetation structure types: one site within a piñon-juniper stand, and one site in an adjacent open area consisting of short-grasses. Envirologic referred to these locations as “Tree” and “Meadow,” respectively. The Tree location (Figure 4) is situated approximately 30 m (98 feet) northeast of the SMWS within a grouping of one-seed juniper (*Juniperus monosperma*) and piñon pine (*Pinus edulis*) trees. The Meadow location (Figure 5) is situated approximately 11 m (36 feet) northwest of the SMWS, in vegetation dominated by blue grama grass (*Bouteloua gracilis*) and broom snakeweed (*Gutierrezia sarothrae*). At each location, two distinct methods were implemented for placing the soil moisture and temperature probes: a trench and a borehole. For more information on the depths and methods of the soil probe placements, see Appendix A.

SWCA Environmental Consultants (SWCA) is now responsible for the management of the SMWS and the maintenance, summation, and distribution of the data collected at this station. This report summarizes the efforts undertaken to compile, assimilate, critique, and display the collected data. Additionally, this report contains recommendations for modifications of the data collection protocols, as well as a list of all components (Appendix B), and a manual outlining maintenance and calibration procedures for the weather station and its components (Appendix B).

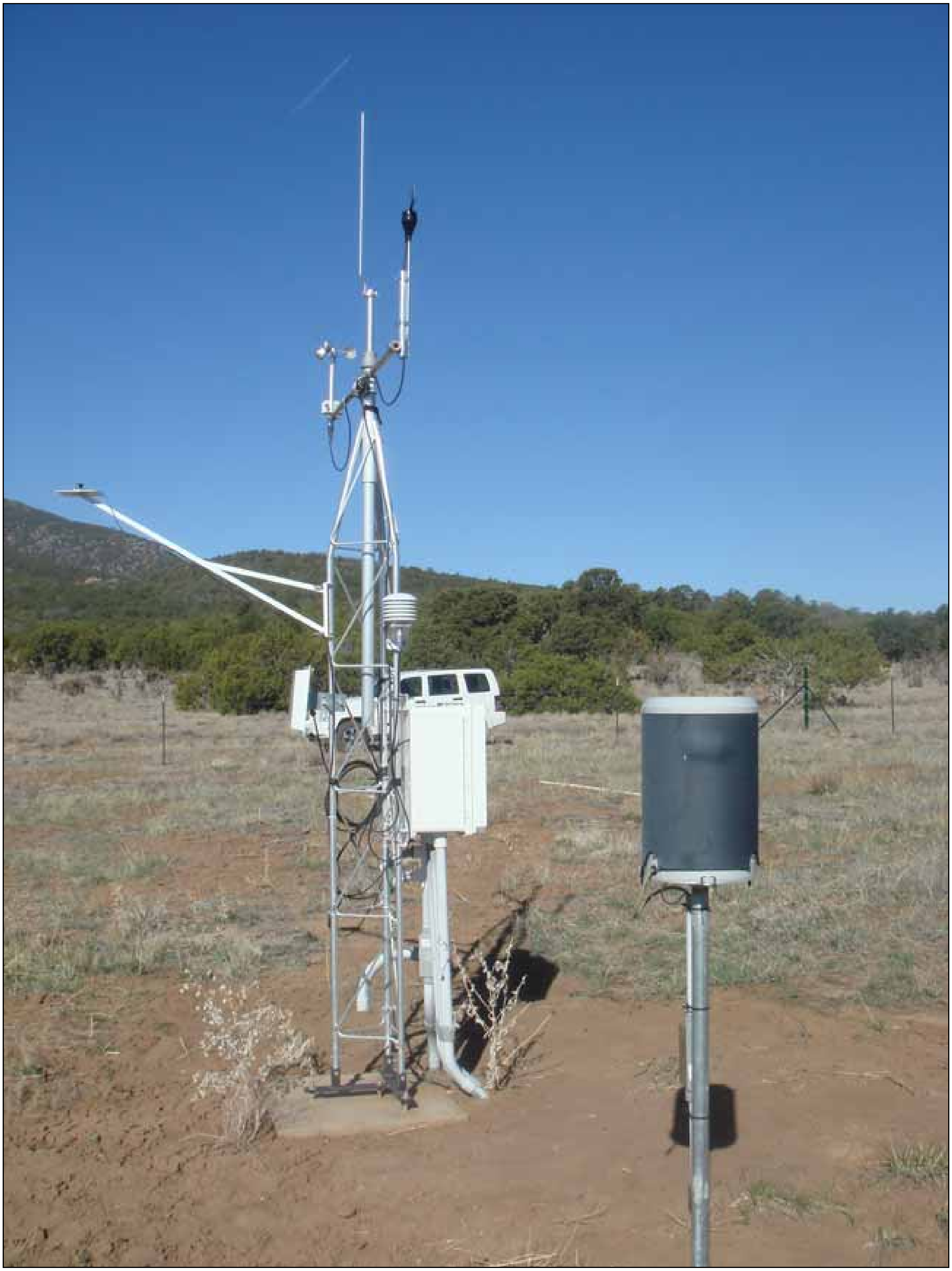


Figure 1. South Mountain weather station.

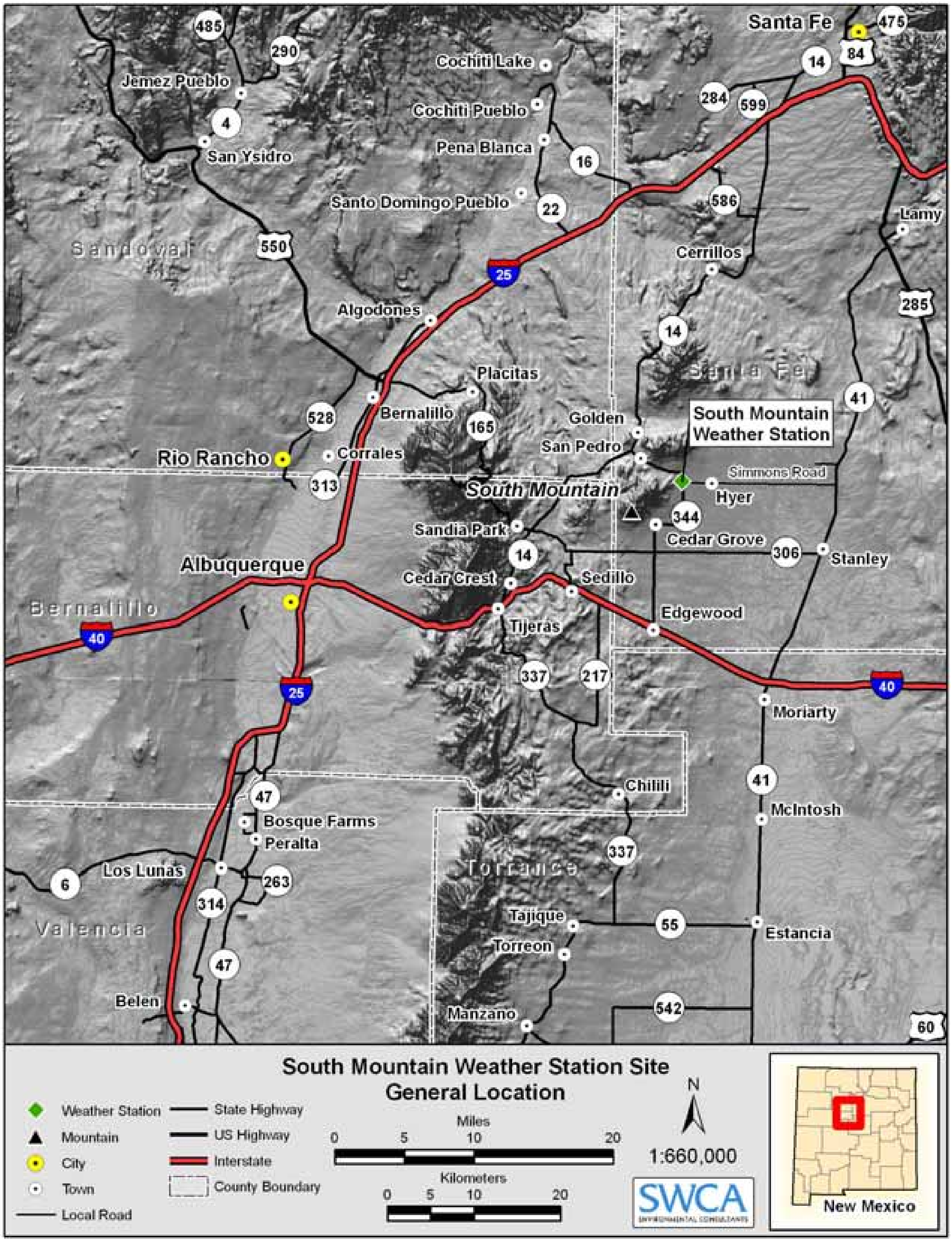


Figure 2. Location of the South Mountain Weather Station, near South Mountain and Edgewood, Santa Fe County, New Mexico.

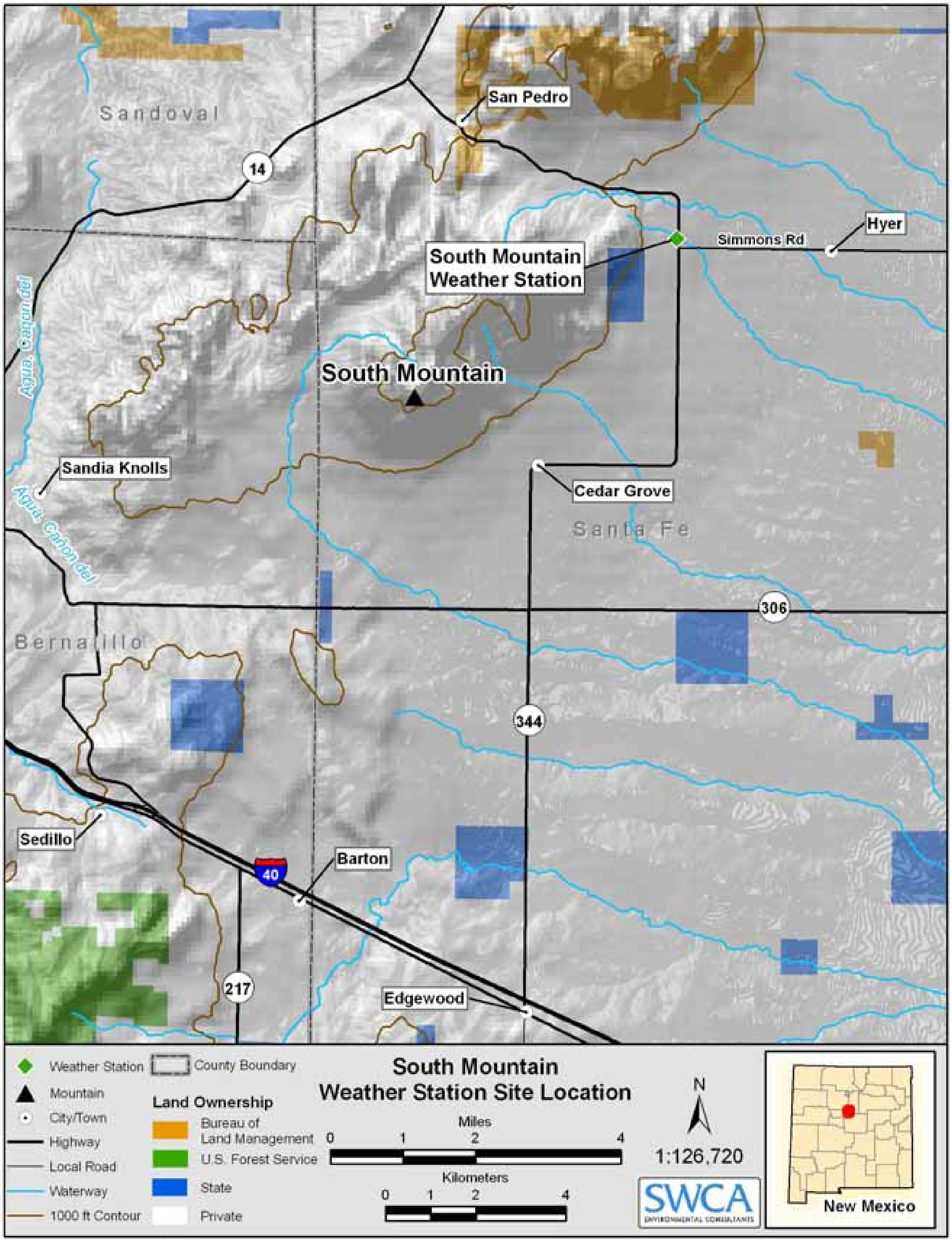


Figure 3. Location of the South Mountain Weather Station, near South Mountain and Edgewood, Santa Fe County, New Mexico.

Figure 4. Tree area.

Figure 5. Open, or Meadow area.

METHODS

Data from the time period of September 2006 to January 2008 for the SMWS was obtained by SWCA from EnviroLogic in April 2008. SWCA was charged with the evaluation, compilation, and analysis of this data for the EBWHRMSC.

The data from the SMWS were presented by EnviroLogic on three CD-ROMs. The CDs were labeled with the approximate date-range of data contained on that CD. Copies were immediately made of these CDs, and the files were grouped into two folders, labeled “Original Copies” and “Working Copies.” All subsequent work has been conducted in the “Working Copies” folder, leaving the original raw data as obtained from EnviroLogic untouched.

Data evaluation and analysis was first conducted on the atmospheric data. The files were renamed to better reflect the contents (date range and origin) of those files. For example, in the file named “South_Mtn_Monitoring_Station_2006_09_12-2007_01_20 (Disk One),” the tab titled “Weather Station” was used to create a new spreadsheet entitled, “Simplified” Sheet One. In the new file, columns were renamed, some were hidden, and others were removed. This was done to create a more manageable data set.

The selected parameters, which were then analyzed and graphed, included:

- maximum wind speed in miles per hour (mph)
- average wind speed in mph
- average air temperature in degrees Fahrenheit
- maximum air temperature in degrees Fahrenheit
- minimum air temperature in degrees Fahrenheit
- relative humidity (in percent)
- total precipitation in inches

For the average values, the mean was calculated for that 10-minute data set.

Graphs were then created for some of these parameters based on the data in the modified tables. To do this, fields with no recorded data, (recorded as -9999 and -9998) were recoded to read No Data. This step was necessary in order to prevent Microsoft Excel reading these items as data values, which would skew subsequent graphs. However, the drawback of this approach was that “no data” items were read by Excel as a zero when making graphs. For this reason, the reader should ignore those values that read “no value” in any output graphs.

DESCRIPTIONS AND INCONSISTENCIES IN DATA SETS

Immediately upon receipt of the data, work was conducted to evaluate the data sets, their layout, and their consistency. As is common with dataloggers on remote devices, several issues were identified that reduce the managerial utility of the data set; below is a list of identified “flaws.” It should be noted that a complete audit of the data sets was not conducted. The 10-minute intervals created a data set so large that a line-by-line analysis is not possible without spending considerable resources. Instead, a random evaluation was conducted, in which a data row or column was chosen at random and reviewed for data gaps and consistencies. Despite this more limited data evaluation process, it is possible to gage the general quality and utility of the data sets.

Some of the major flaws with the data sets are outlined below:

- The time interval was inconsistent even within a given data column. The data were programmed to arrive in uniform 10-minute intervals. On many occasions this was the case, however in some instances the data were recorded once per hour. Occasionally the time interval had changed, altering the hour in which data were recorded. This inconsistency made it difficult to summarize the data based on time.

- In several places, data rows were missing—the data set was not reporting “No Data,” rather, the entire data field was missing.

- Not all data were recorded in all data sets for the same data cell. For example, Relative Humidity was not recorded in the Disk Three 2007 data set; however, it was recorded in the data set on Disk One. This raises the question of how these data were entered into the spreadsheets by EnviroLogic.

- With the wide range of data, it was impossible to tell whether all data are consistent across all data sets for each given cell. In some instances, data had been rounded in the data columns on one data set, and remained in decimal form on another data file representing the same data.

- The greatest constraint with the data collected and reported by EnviroLogic was the large number of data gaps (Figure 6). In several places, gaps of over 100 data points (records) existed for several data parameters. This is likely the result of equipment malfunction, but it makes data aggregation and summary problematic.

Rain_in_Tot inch	WS_mph miles/hour	WS_mph_Max miles/hour	WS_mph_Min miles/hour	WS_mph_Avg miles/hour	WindDir miles/hour	WindDir_Avg miles/hour	WindDir_Max miles/hour	WindDir_Min miles/hour
0.00	6.78	-9999.00	-9999.00	6.42	-9999.00	-9999.00	-9999.00	-9999.00
0.00	6.31	-9999.00	-9999.00	6.10	-9999.00	-9999.00	-9999.00	-9999.00
0.00	6.67	-9999.00	-9999.00	5.75	-9999.00	-9999.00	-9999.00	-9999.00
0.00	4.22	-9999.00	-9999.00	4.89	-9999.00	-9999.00	-9999.00	-9999.00
0.00	7.32	-9999.00	-9999.00	6.06	-9999.00	-9999.00	-9999.00	-9999.00
0.00	3.68	-9999.00	-9999.00	5.73	-9999.00	-9999.00	-9999.00	-9999.00
0.00	3.92	-9999.00	-9999.00	4.11	-9999.00	-9999.00	-9999.00	-9999.00
0.00	2.97	-9999.00	-9999.00	2.64	-9999.00	-9999.00	-9999.00	-9999.00
0.00	3.45	-9999.00	-9999.00	3.75	-9999.00	-9999.00	-9999.00	-9999.00
0.00	4.16	-9999.00	-9999.00	4.47	-9999.00	-9999.00	-9999.00	-9999.00
0.00	3.80	-9999.00	-9999.00	3.64	-9999.00	-9999.00	-9999.00	-9999.00
0.00	2.31	-9999.00	-9999.00	3.29	-9999.00	-9999.00	-9999.00	-9999.00
0.00	3.39	-9999.00	-9999.00	2.73	-9999.00	-9999.00	-9999.00	-9999.00
0.00	2.49	-9999.00	-9999.00	2.67	-9999.00	-9999.00	-9999.00	-9999.00
0.00	2.91	-9999.00	-9999.00	3.01	-9999.00	-9999.00	-9999.00	-9999.00
0.00	0.00	-9999.00	-9999.00	1.87	-9999.00	-9999.00	-9999.00	-9999.00
0.00	1.42	-9999.00	-9999.00	0.81	-9999.00	-9999.00	-9999.00	-9999.00
0.00	4.82	-9999.00	-9999.00	3.54	-9999.00	-9999.00	-9999.00	-9999.00
0.00	3.62	-9999.00	-9999.00	3.79	-9999.00	-9999.00	-9999.00	-9999.00
0.00	2.01	-9999.00	-9999.00	2.74	-9999.00	-9999.00	-9999.00	-9999.00
0.00	0.00	-9999.00	-9999.00	0.21	-9999.00	-9999.00	-9999.00	-9999.00
0.00	3.33	-9999.00	-9999.00	2.85	-9999.00	-9999.00	-9999.00	-9999.00
0.00	3.51	-9999.00	-9999.00	3.55	-9999.00	-9999.00	-9999.00	-9999.00
0.00	3.39	-9999.00	-9999.00	3.33	-9999.00	-9999.00	-9999.00	-9999.00
0.00	3.98	-9999.00	-9999.00	3.53	-9999.00	-9999.00	-9999.00	-9999.00
0.00	2.19	-9999.00	-9999.00	2.60	-9999.00	-9999.00	-9999.00	-9999.00
0.00	2.07	-9999.00	-9999.00	2.23	-9999.00	-9999.00	-9999.00	-9999.00

Figure 6. Example of the large data gaps that existed in some data sets (the data come from the file, "South_Mtn_Monitoring_Station#1_data-020607." The red cell color was added by EnviroLogic).

RESULTS

DATA FILES: SEPT 2006–JAN 2008

On the CD accompanying this report, the data are presented in three folders. The “Original Copies” folder contains the data from September, 2006 to January, 2008 in the form in which they were received from EnviroLogic. The folder labeled, “Working Copies” contains the spreadsheets used to generate the graphs for this report. These spreadsheets have been modified from the originals, including the hiding of some data columns, the renaming of columns, and in some cases, the aggregation of some data fields to different temporal intervals to complete the analysis of the data. The folder labeled, “Raw Data from the Weather Station” contains the data in the form in which they were derived from the South Mountain Weather Station. These data are in “.DAT” files, and are only available for the data off-loaded from SMWS by SWCA since April, 2008. Those recent data since April 2008 will be presented in a quarterly report to the EBWHRMSC in August of 2008.

CLIMATE GRAPHS SEPT 2006–JAN 2008

Summary graphs were created based on 10-minute data intervals for maximum temperature or average temperature (whichever was the more complete data set for a given time period—with such short sampling intervals the variance between the two values is minimal), maximum and average wind speed, average relative humidity, and precipitation. In many cases, summary graphs using longer time intervals, such as monthly totals, or monthly mean data are likely more meaningful. Monthly graphs were created for total monthly precipitation and for the minimum, maximum, and mean air temperature (Figure 7–Figure 23).

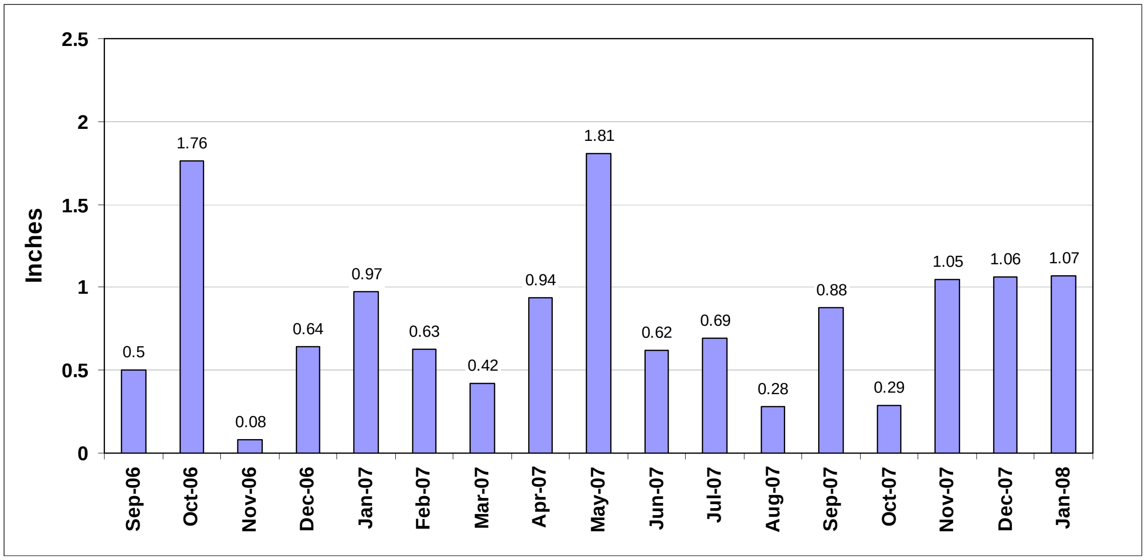


Figure 7. Total monthly precipitation (inches), September 2006–January 2008.

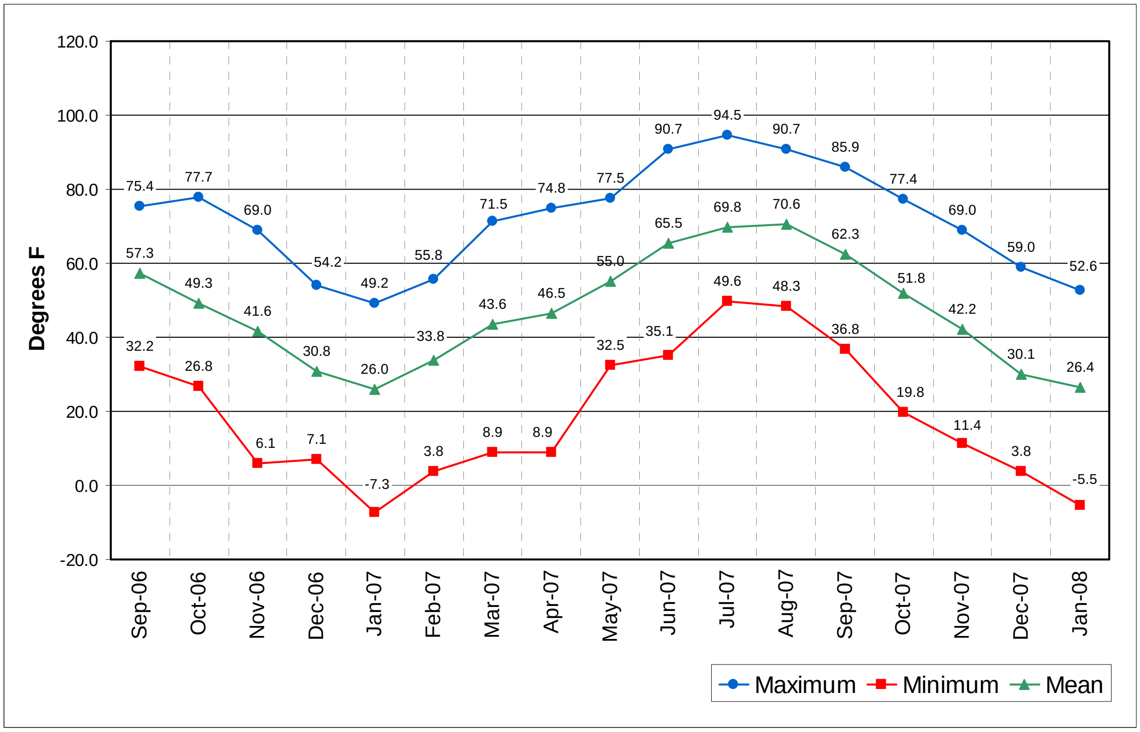


Figure 8. Monthly average temperatures, September 2006–January 2008.

2006 Daily Temperature and Precipitation Data

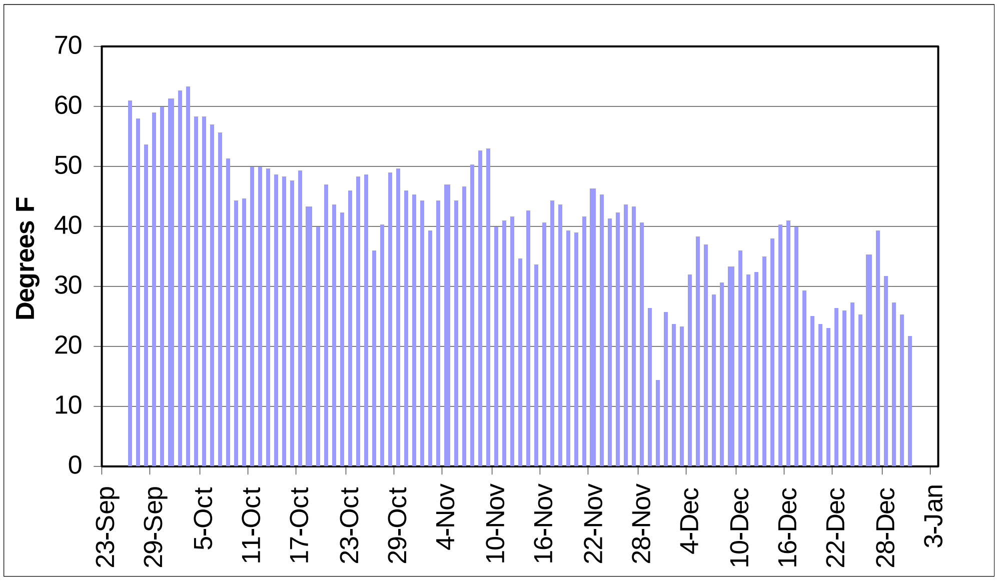


Figure 9. Daily average air temperature (degrees Fahrenheit), September–December 2006.

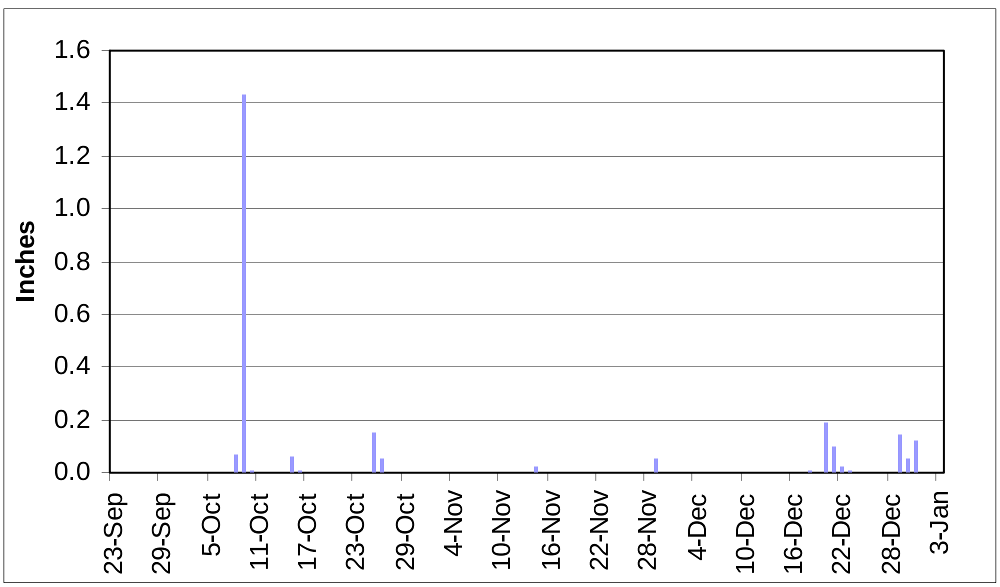


Figure 10. Daily precipitation totals (inches): September–December 2006.

2007 WEATHER AND SOIL MOISTURE DATA

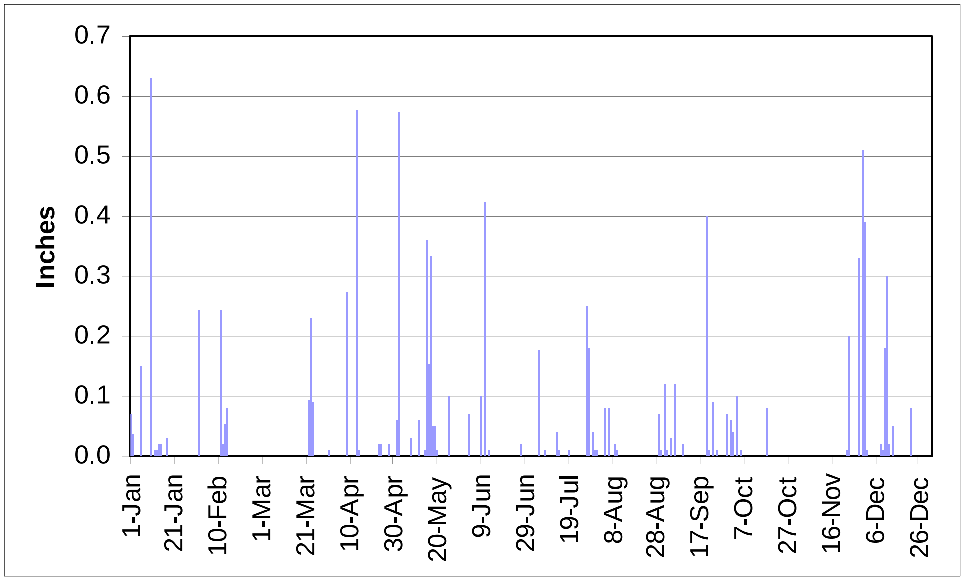


Figure 11. Daily precipitation totals, January–December 2007.

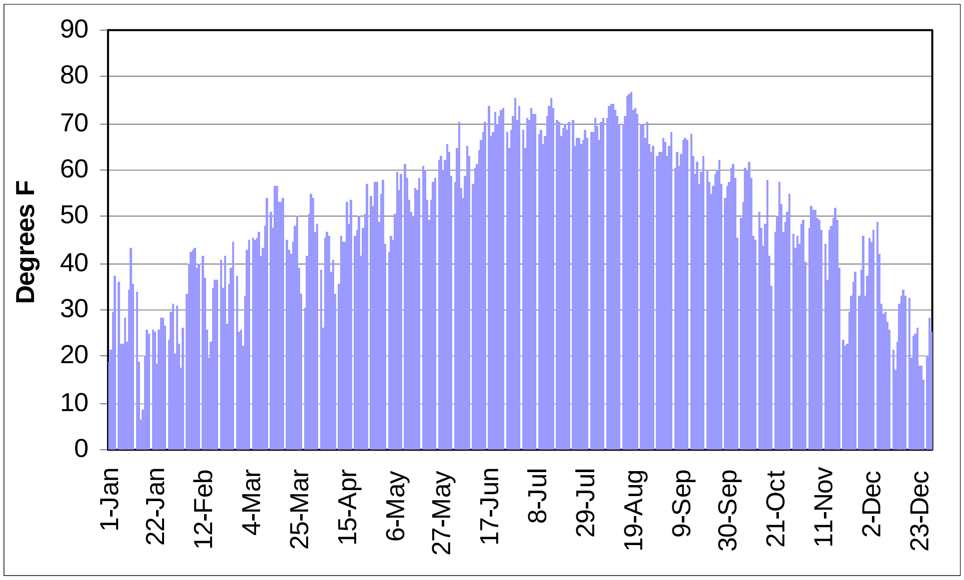


Figure 12. Daily average air temperature (degrees Fahrenheit), January–December 2007.

2008 Daily Precipitation and Temperature Graphs

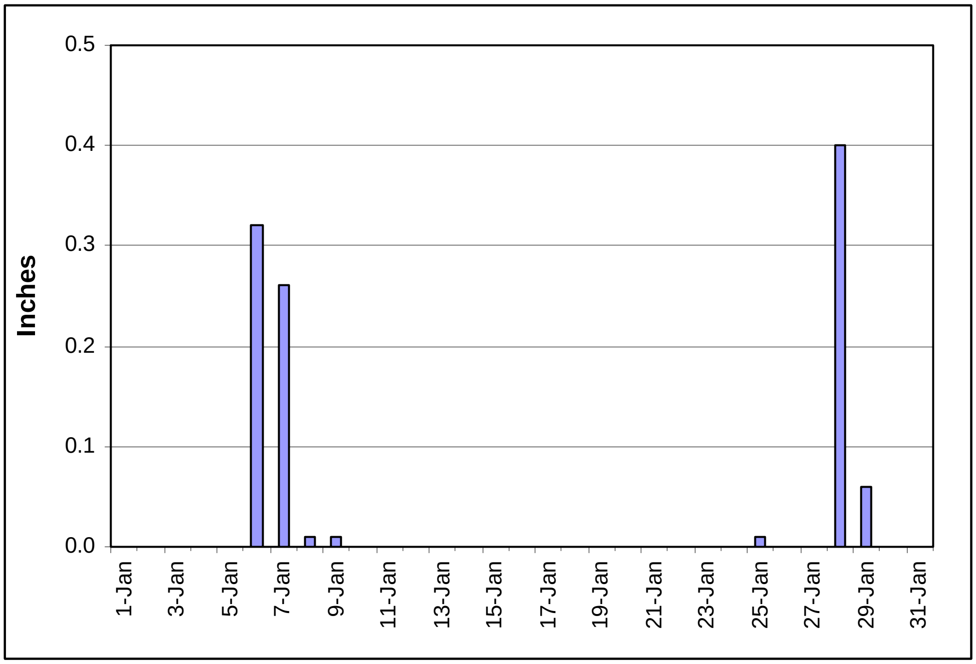


Figure 13. Daily total precipitation (inches), January 2008.

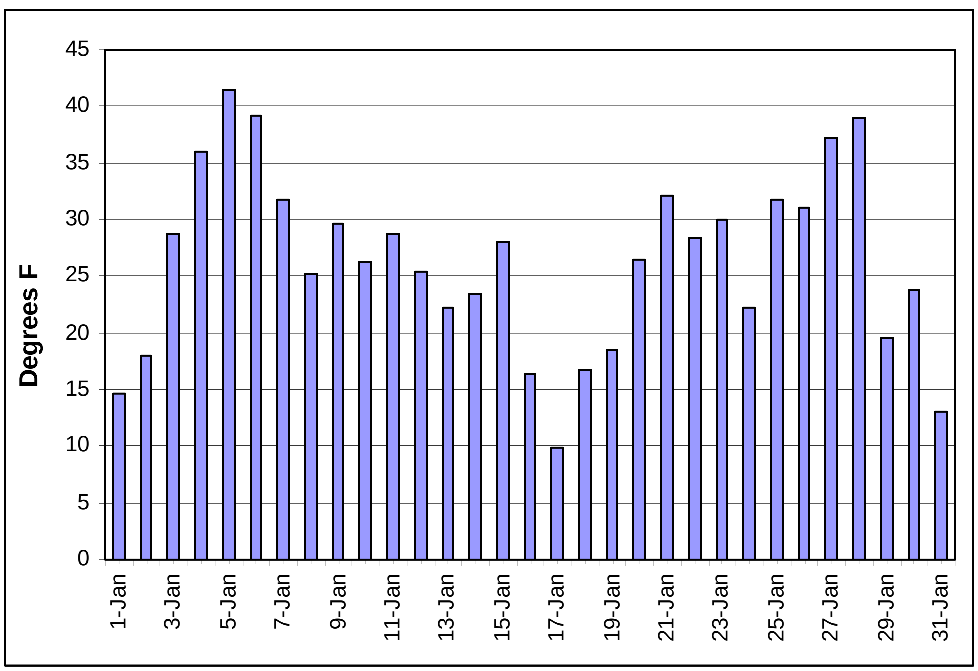


Figure 14. Daily average temperature (degrees Fahrenheit), January 2008.

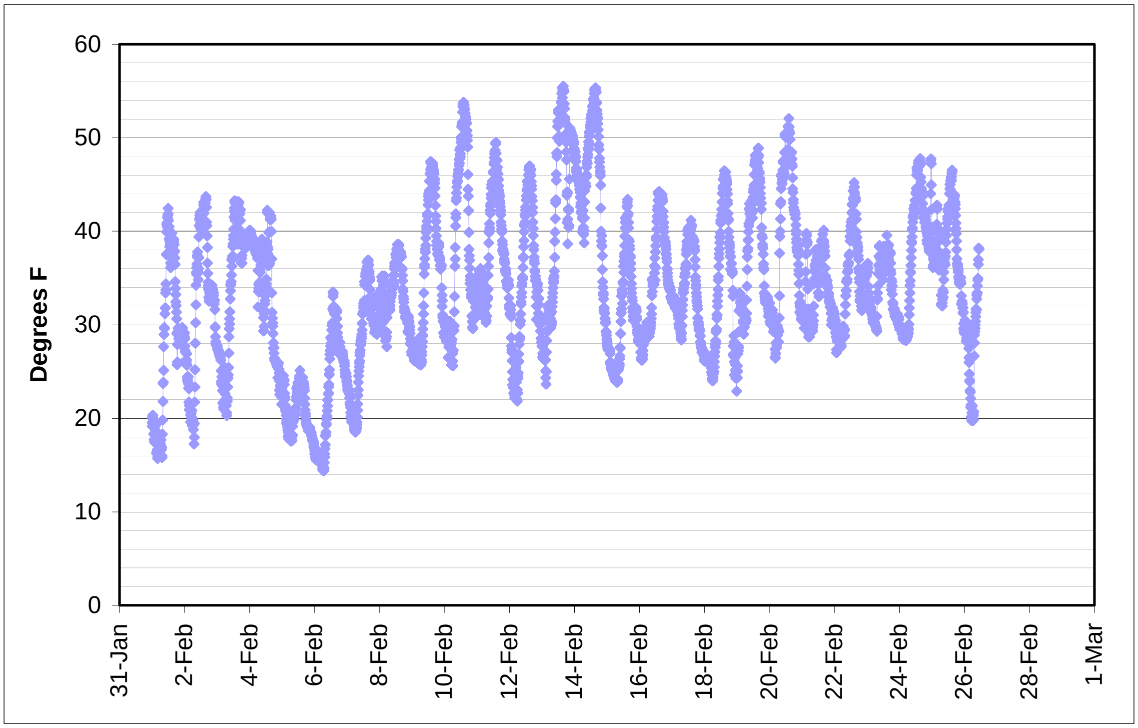


Figure 15. Maximum temperature (degrees Fahrenheit), February 2008.

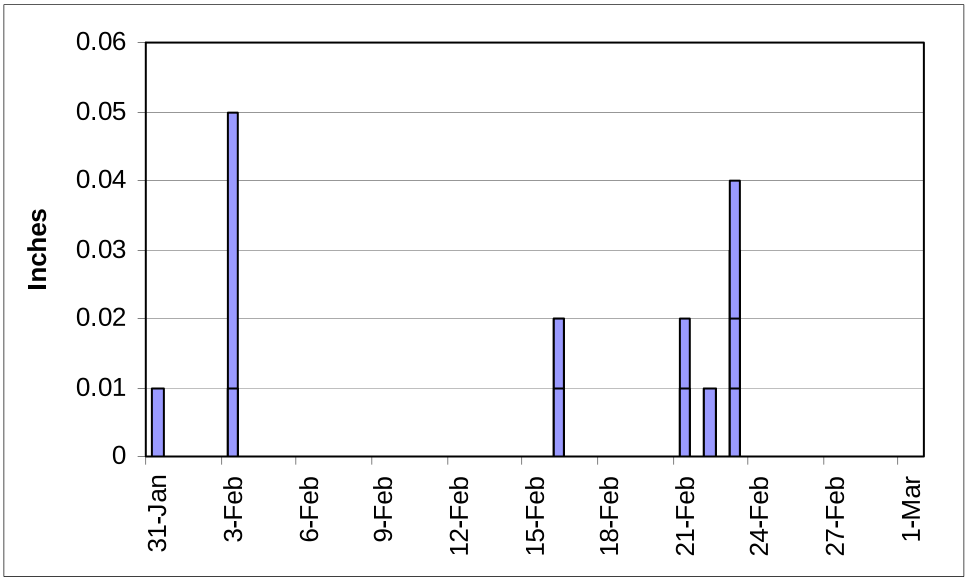


Figure 16. Precipitation (inches), February 2008.

2006–2008 Wind Speed Data

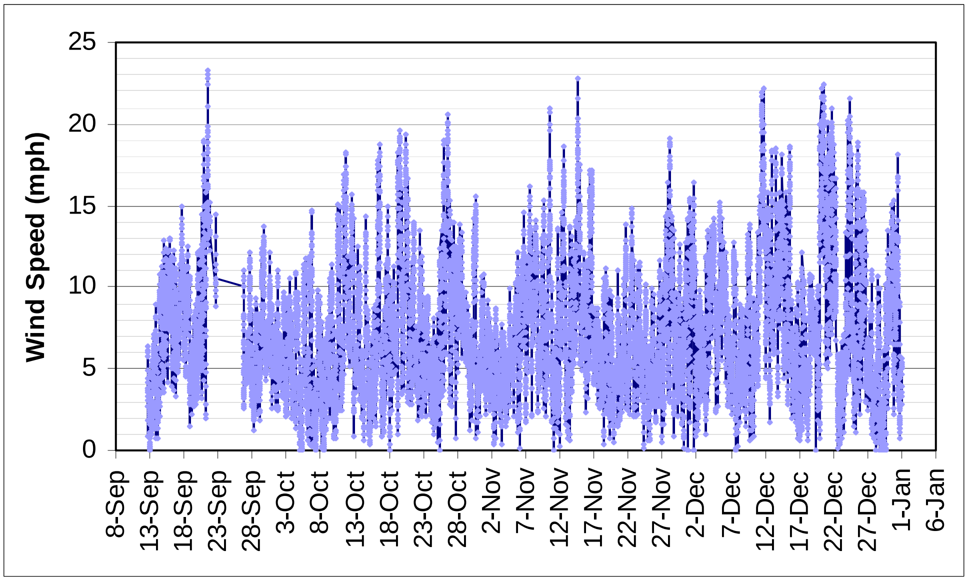


Figure 17. Average wind speed (wind speed averaged over each 10-minute interval), 2006.

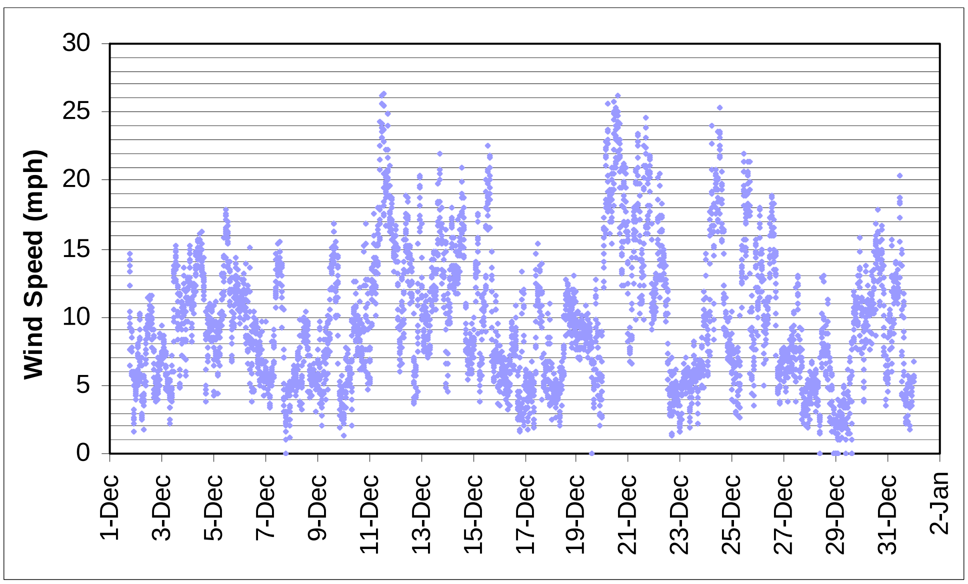


Figure 18. Maximum wind speed, 2006.

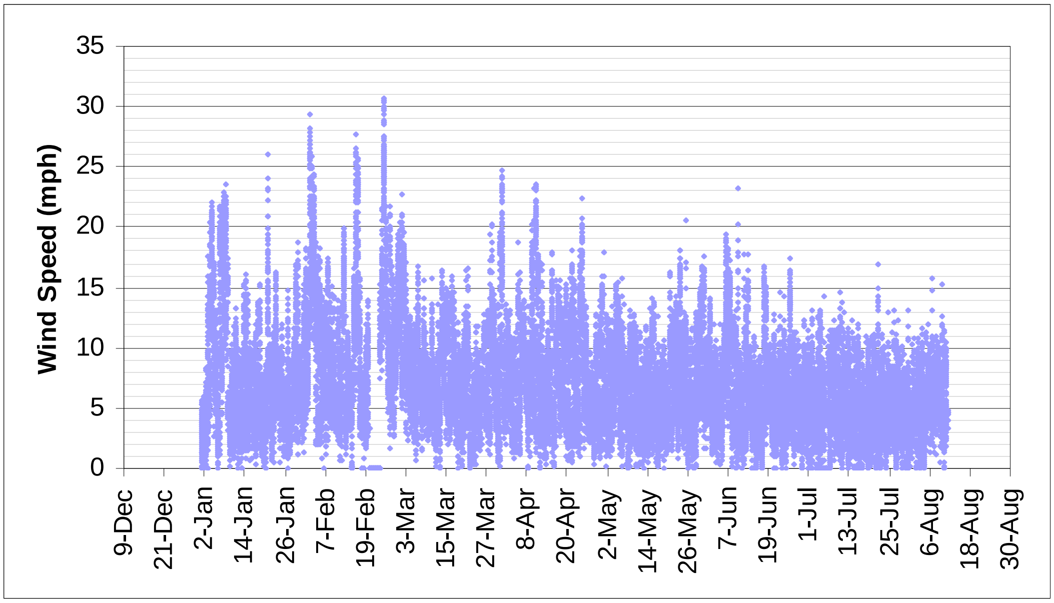


Figure 19. Average wind speed, January 2007.

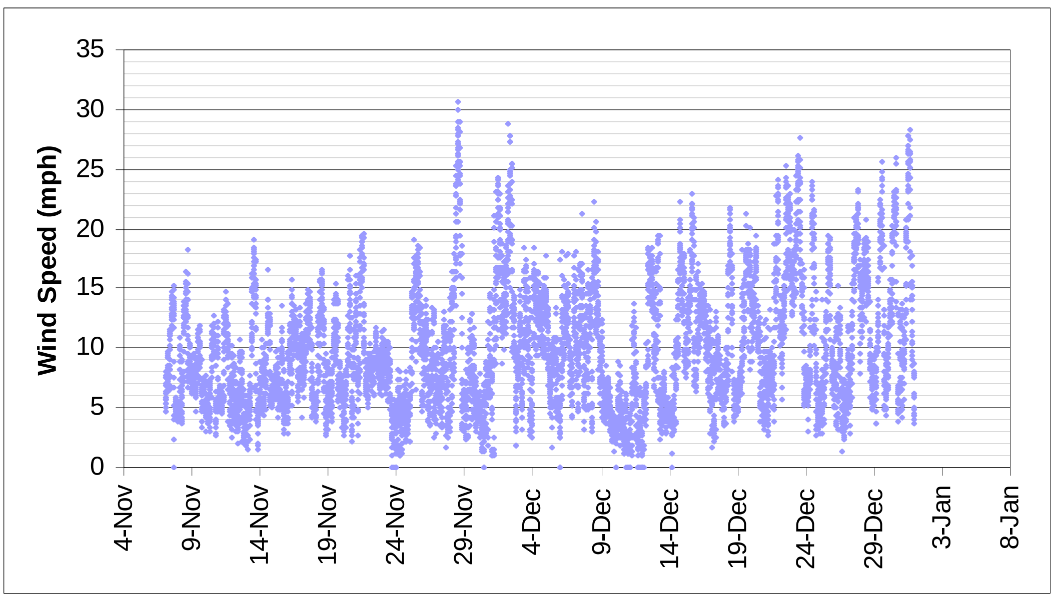


Figure 20. Maximum wind speed, 2007.

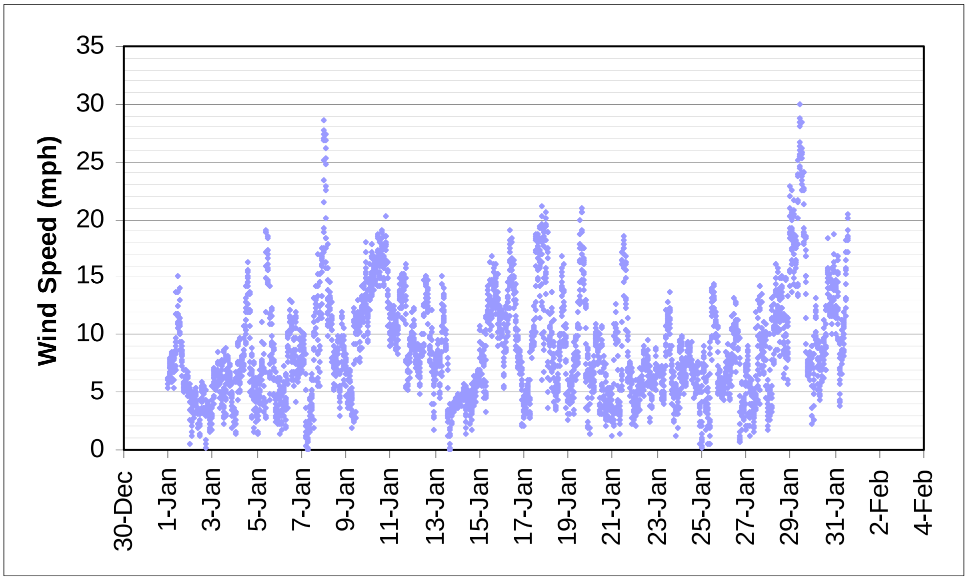


Figure 21. Average wind speed, January 2008.

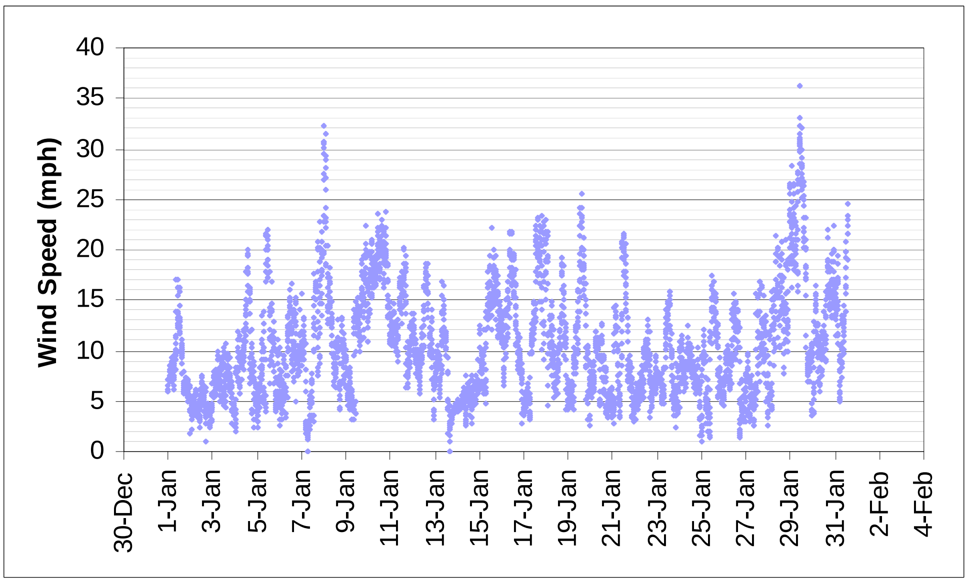


Figure 22. Maximum wind speed, January 2008.

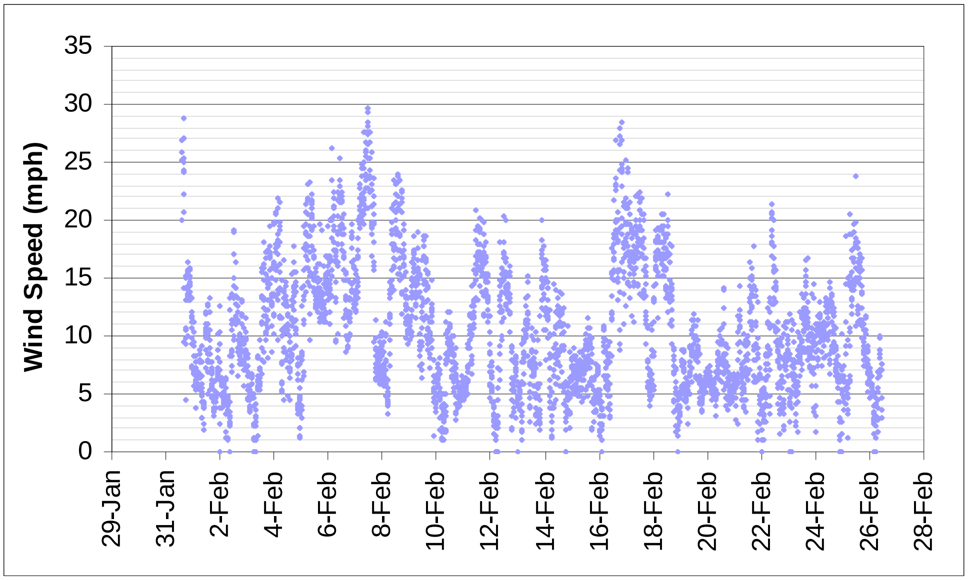


Figure 23. Mean wind speed, February 2008.

SOIL MOISTURE DATA

The soil moisture data sets were then reviewed and their content analyzed. A cursory review revealed that these data sets were more intact and more consistent than the atmospheric data. For example, time intervals were consistent across the data sets with fewer large data gaps. However, the data recording was not consistent; for example, the date in which the various soil moisture sites first began to read data varied.

A more thorough audit of the data, again using a random approach, showed the data are more consistent than the atmospheric data across the three CDs of data. Nonetheless, several data gaps exist in even the most complete set of data (Disk Three).

Summary graphs were created for the soil moisture data. Due to the size of the data set, several groundwater fields were chosen for this analysis. The data fields chosen for both the Meadow and Tree sites were: 4” trench, 1’ trench, 3’ trench, 6’ trench, 22’ 2 1/8” borehole (Meadow site only), and 21’6” borehole (Tree site only). Several graphs were created including soil moisture for each data point. Due to the size of the data set (approximately 56,000 data fields for each of the sites exists for 2007), this set of graphs was difficult to read. In an attempt to create easier to read graphs, graphs of monthly mean values were created (Figure 24–Figure 31).

SOIL MOISTURE 2006-2008 AT MEADOW AND TREE SITES

All values are in percent water per unit soil volume.

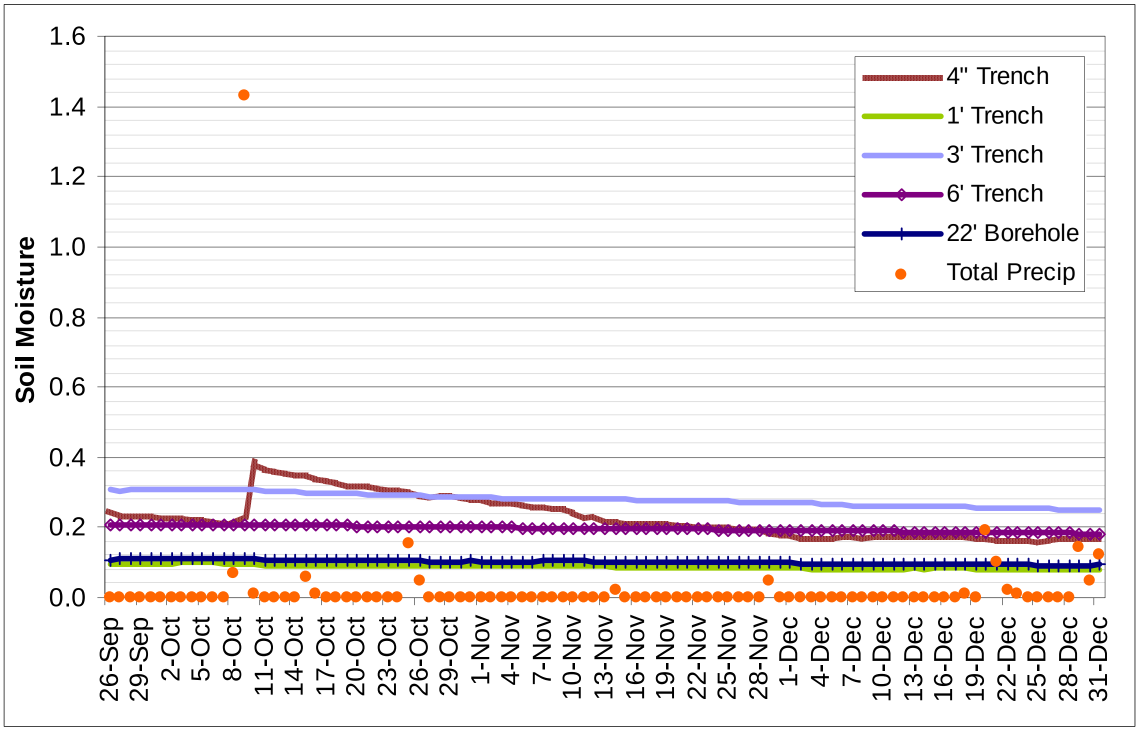


Figure 24. Monthly soil moisture for Meadow site, October–December 2006.

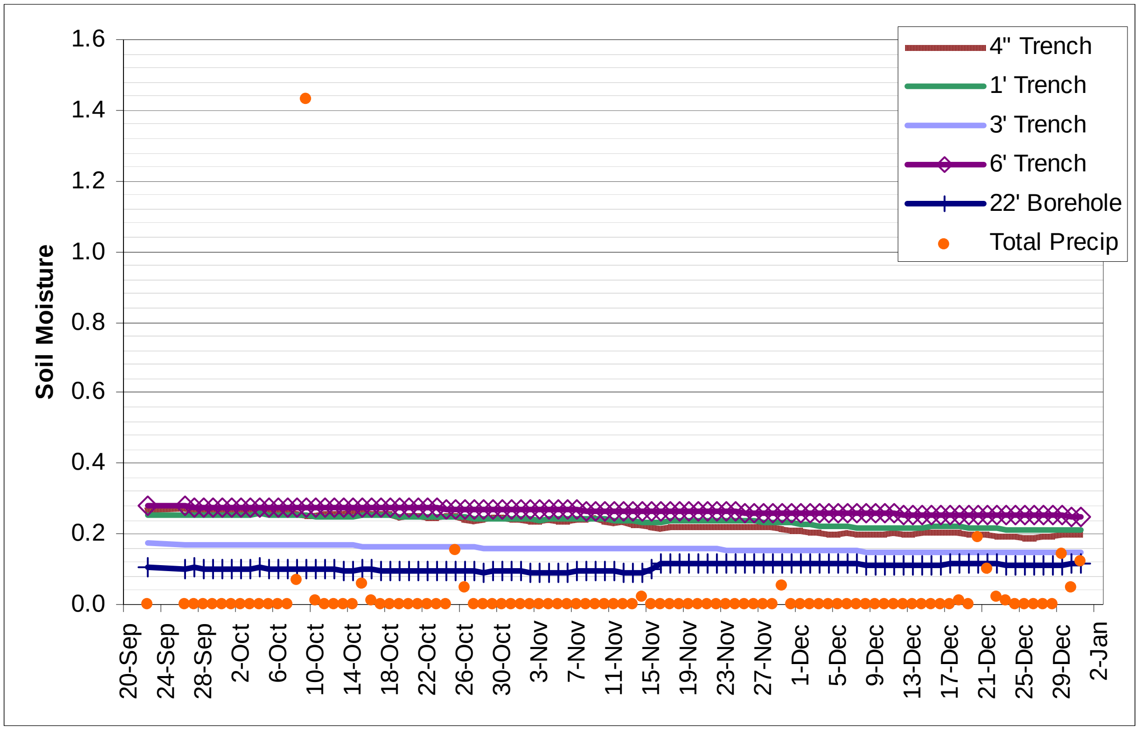


Figure 25. Monthly soil moisture for Tree site, September–December 2006.

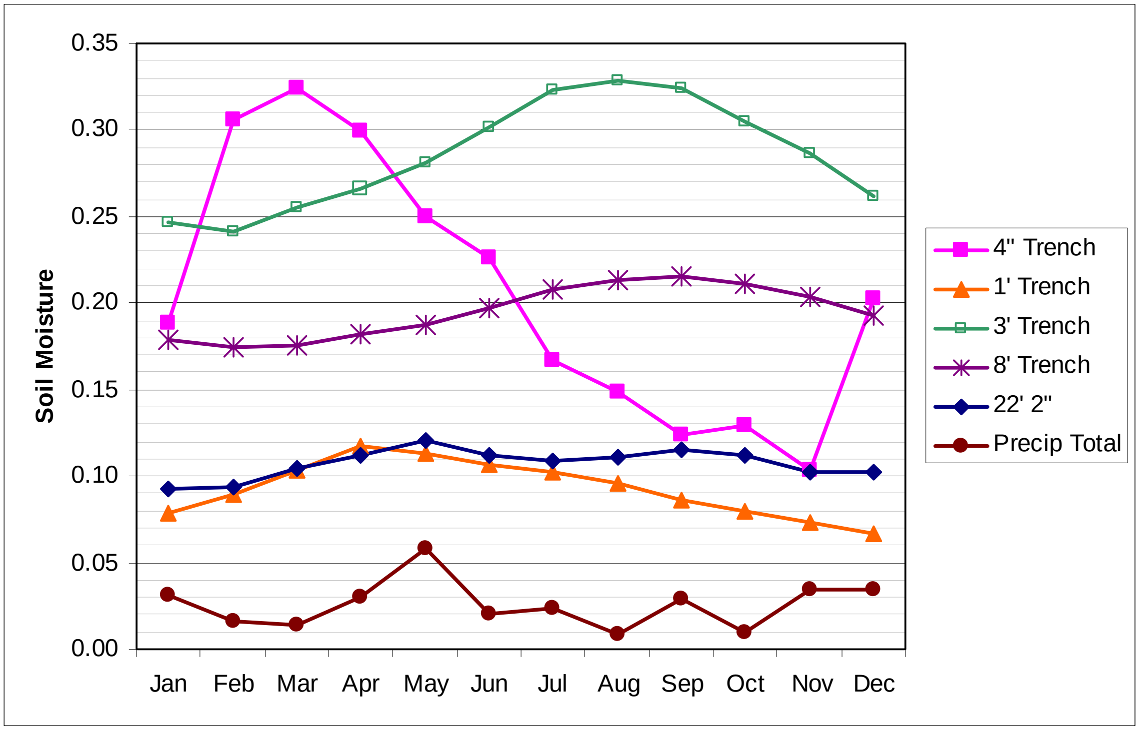


Figure 26. **Monthly mean soil moisture for Meadow site, January–December 2007.**

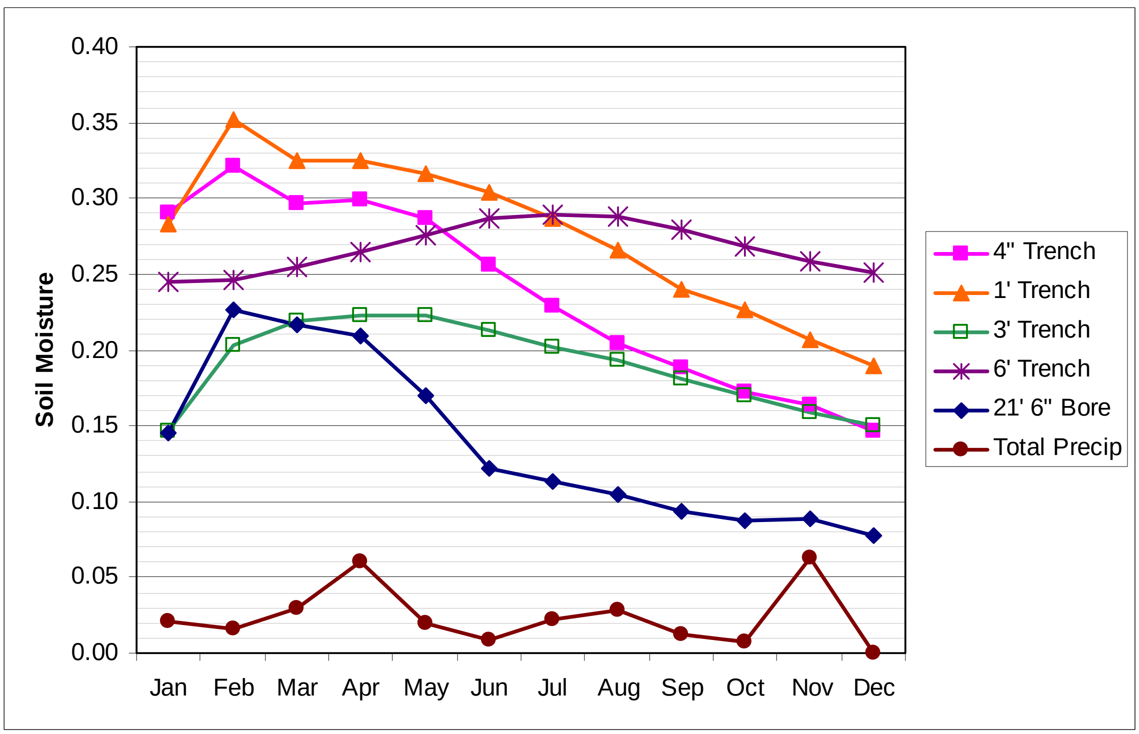


Figure 27. **Monthly mean soil moisture for Tree site, January–December 2007.**

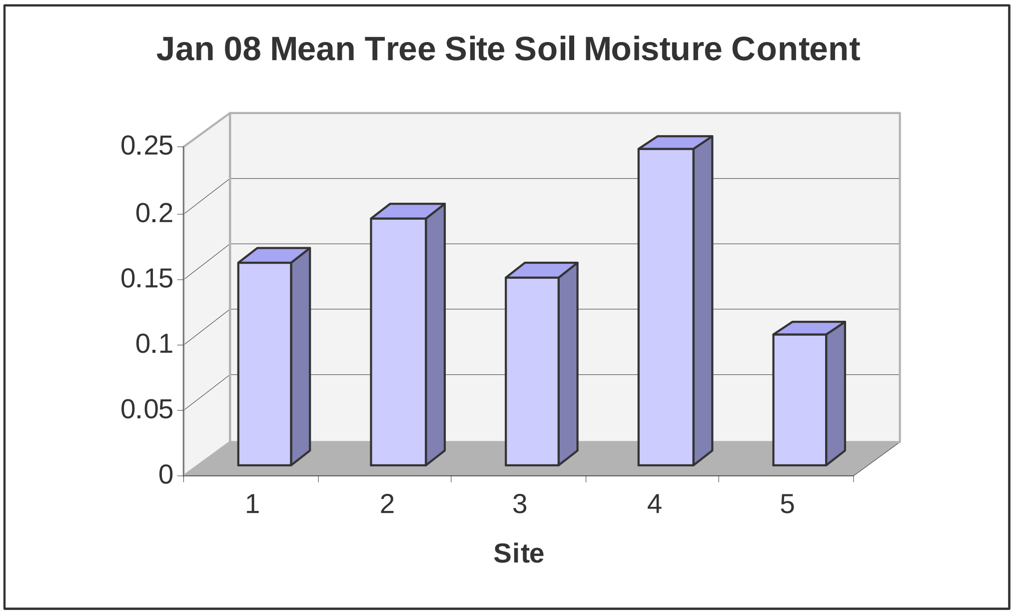


Figure 28. Mean soil moisture content for Tree site, January 2008.

1: 4" Trench 2: 1' Trench 3: 3' Trench
4: 6' Trench 5: 21'6" Borehole

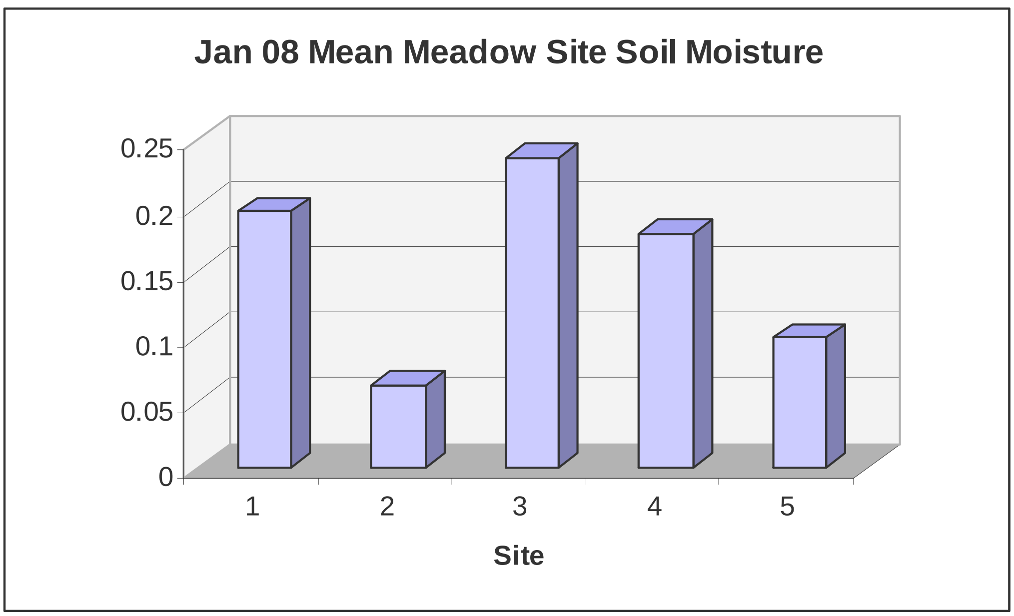


Figure 29. Mean soil moisture content for Meadow site, January 2008.

1: 4" Trench 2: 1' Trench 3: 3' Trench
4: 6' Trench 5: 21'6" Borehole

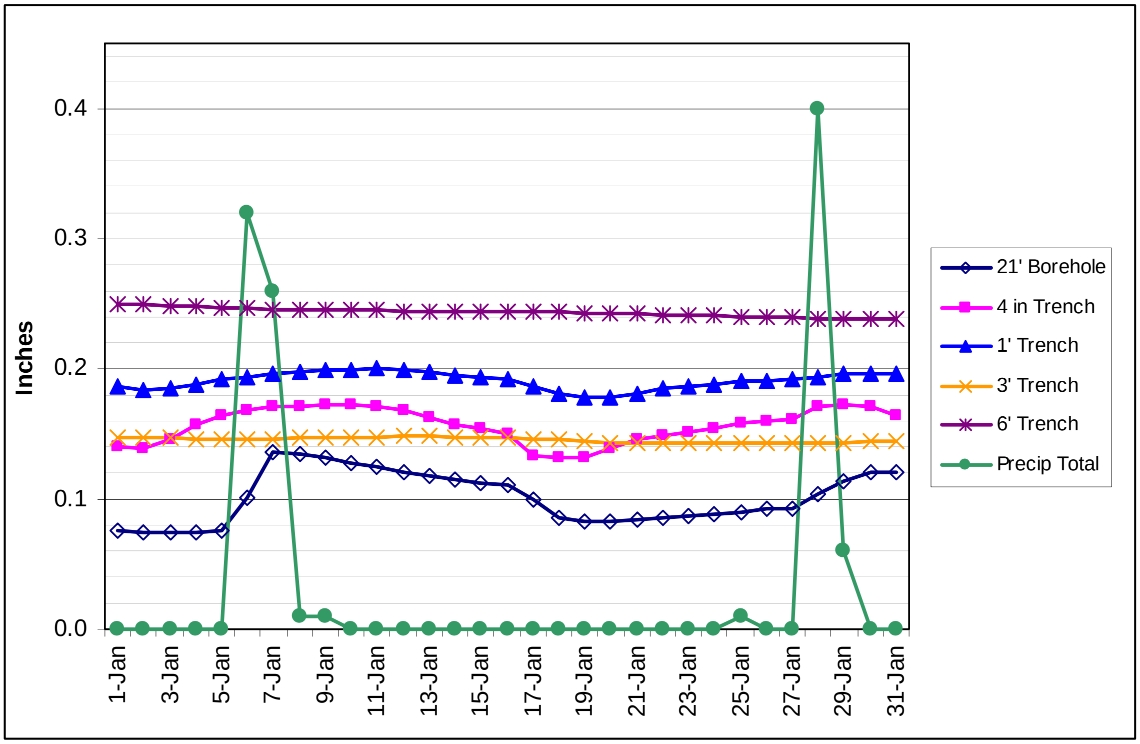


Figure 30. Soil moisture for Tree site, January 2008.

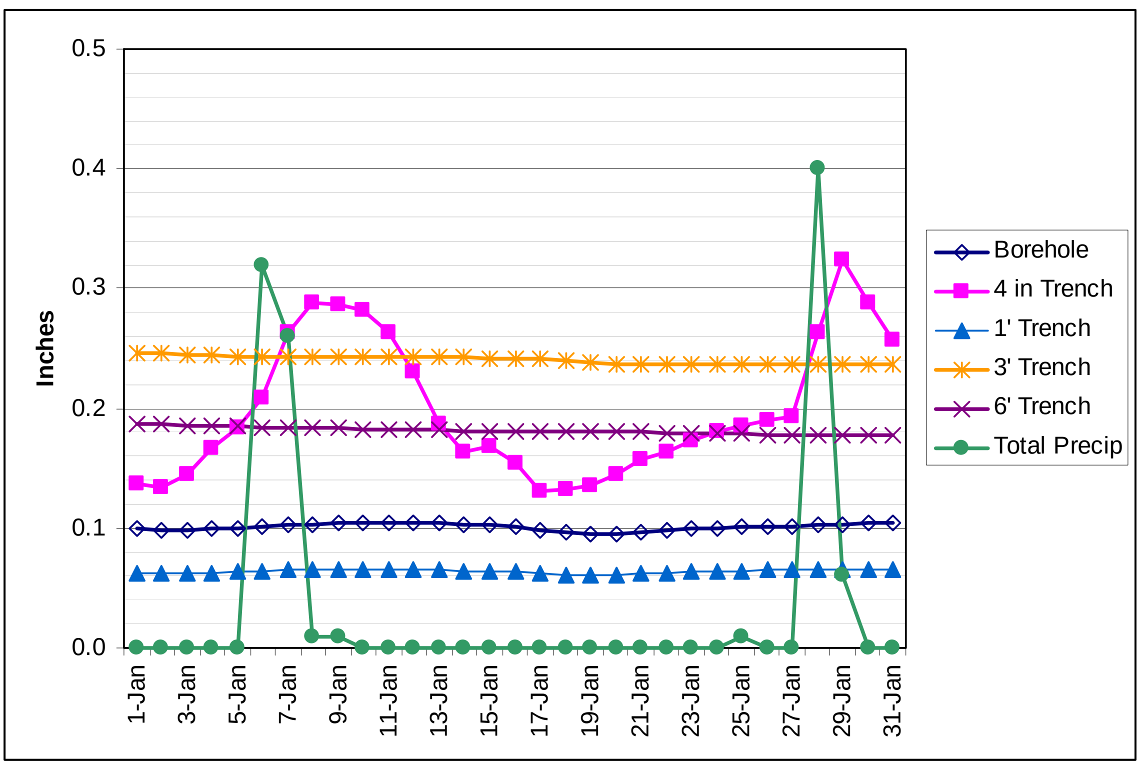


Figure 31. Soil moisture for Meadow site, January 2008.

COMPILING SOIL AND ATMOSPHERIC DATA

To study the interplay of precipitation and soil moisture, the data from the selected sites in the soil moisture data sets was graphed in relation to the precipitation data from the atmospheric data sets. To do this, the files were exported into Microsoft Access, and the data columns were aggregated by date; from this, daily means were derived. The results were then exported back into Excel in order to create graphs showing the relationship between these variables (Figure 32–Figure 33).

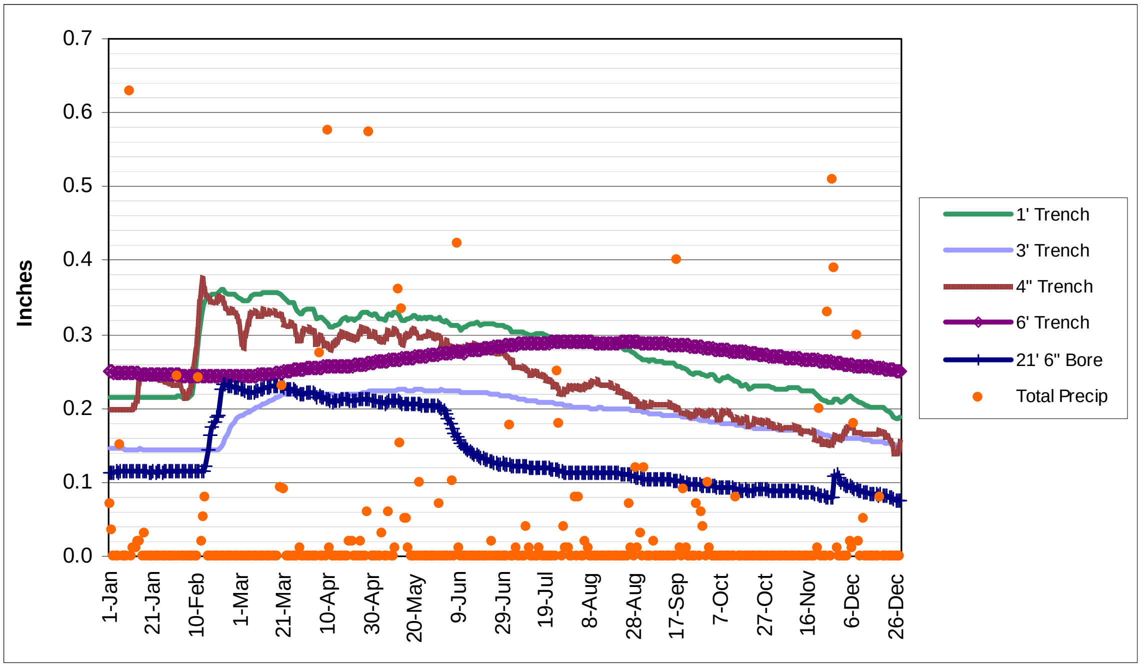


Figure 32. Tree site daily soil moisture levels and precipitation, 2007.

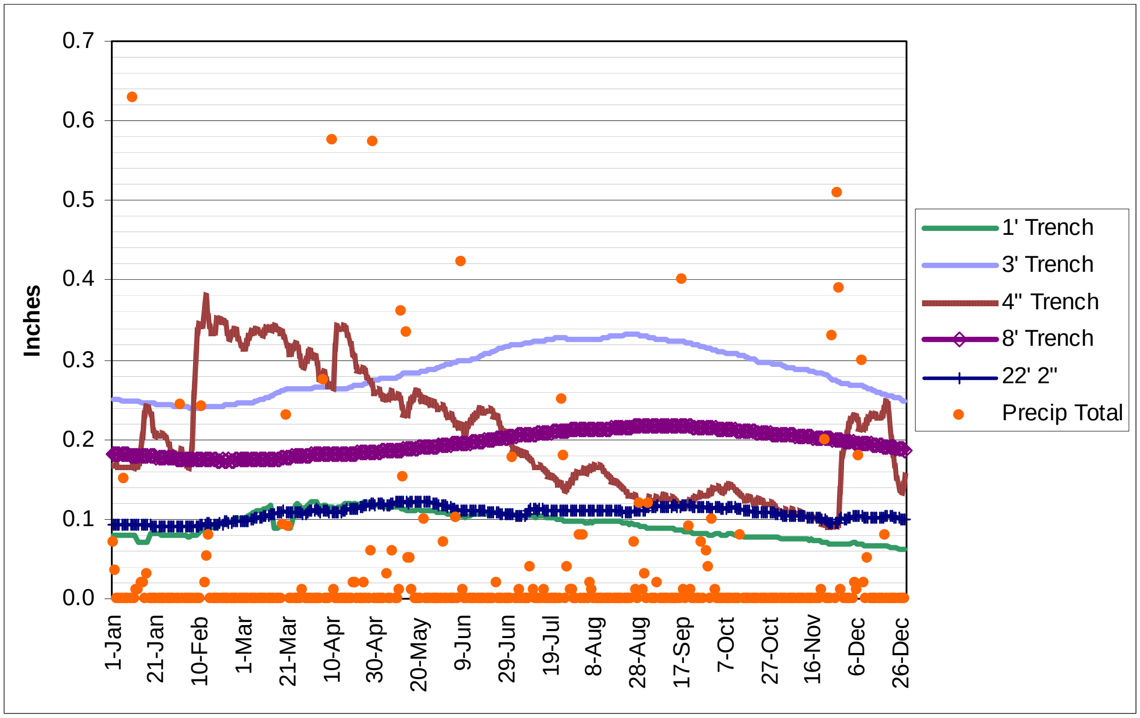


Figure 33. Meadow site daily soil moisture levels and precipitation, 2007.

When evaluating the soil moisture data at both the Tree and Meadow locations, with precipitation overlaid on the graph, there are no strong correlations between precipitation and soil moisture levels. The strongest correlations exist at the sensors closest to the surface level: the 4" and 1' trenches.

SUMMARY OF APRIL 2008 TO PRESENT DATA

Data from the time period of April 8, 2008, to July 1, 2008, for the SMWS was obtained by SWCA on July 1, 2008. SWCA was charged with the evaluation, compilation, and analysis of this data on behalf of the Edgewood, Claunch Pinto, and East Torrance Soil and Water Conservation Districts. Below is the summary of the reviewed data.

The data were obtained by manual download at the weather station site—the wireless data retrieval function on the weather station was not functioning. The data were retrieved in .dat files; these were then imported in Excel. Two copies of the data were created and placed in different folders; one folder was called "Original Copy" and remains untouched, serving as a duplicate of the original data. The other folder was labeled "Working Copy."

The data were reviewed for inconsistencies and missing data. This data set contained far fewer "data gaps" than the September 2006–January 2008 time period data. Summary graphs were created for basic climate parameters, including average temperature (based on 10-minute time intervals), max wind speed, average wind speed, precipitation, and relative humidity. Graphs were created overlaying precipitation and soil moisture content for both the Tree and Meadow sites (Figure 34–Figure 39).

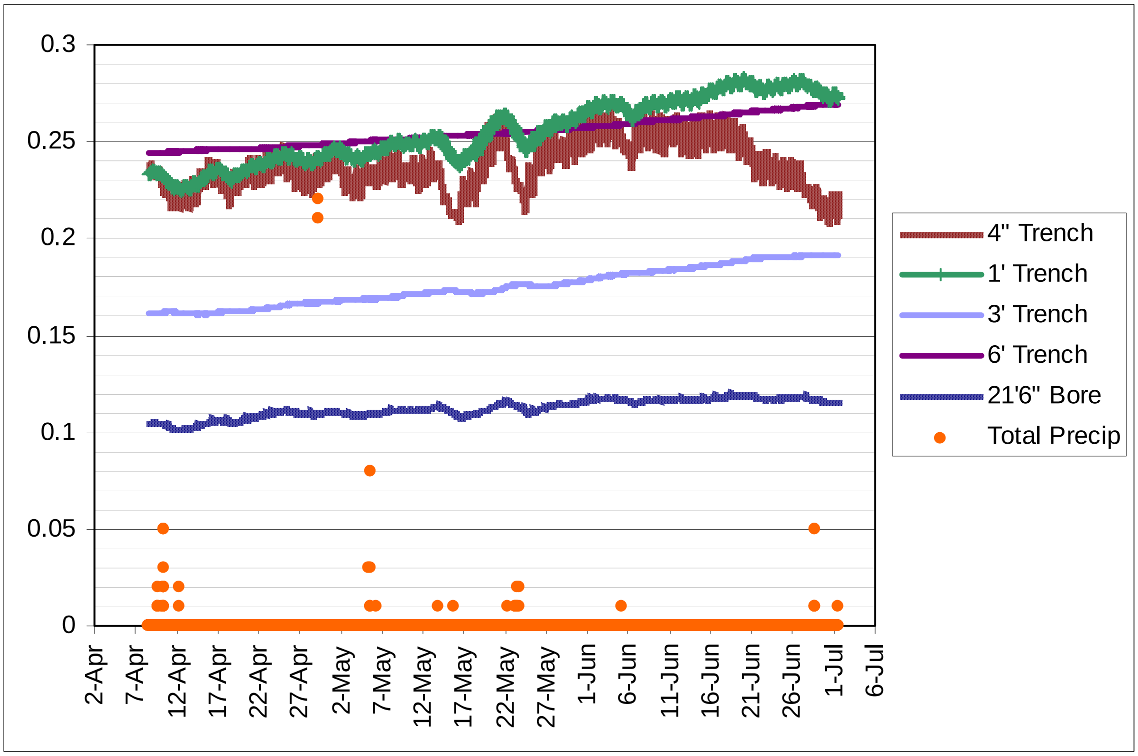


Figure 34. Tree site soil moisture levels and precipitation, April–July 2008.

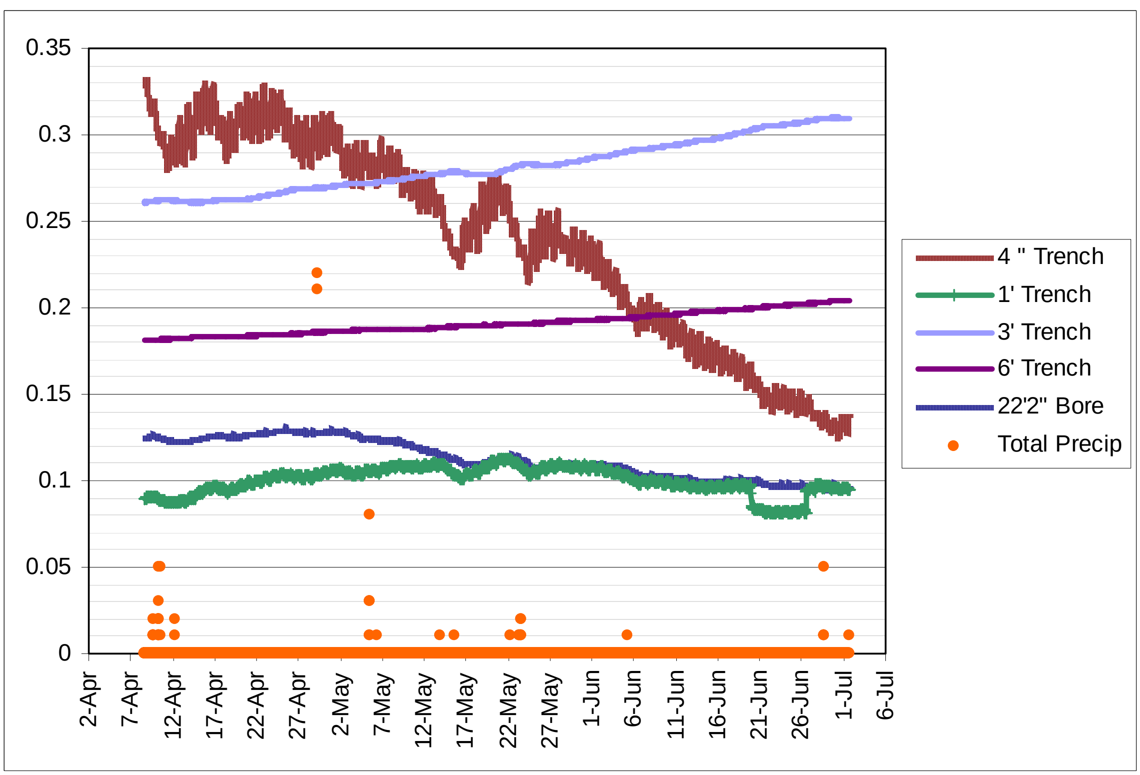


Figure 35. Meadow site soil moisture levels and precipitation, April–July 2008.

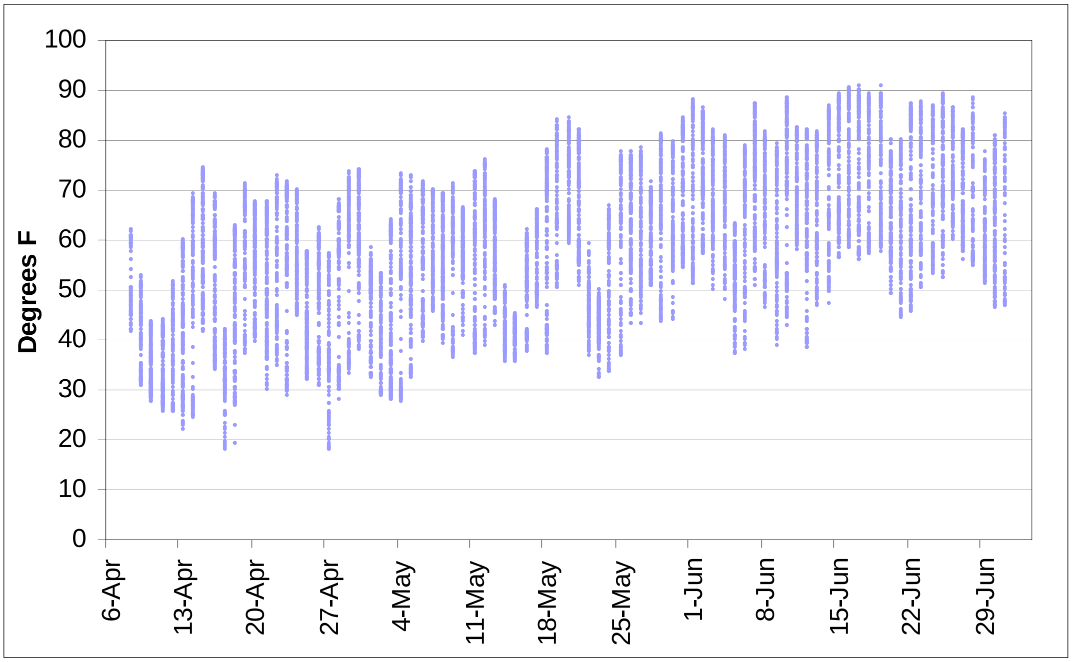


Figure 36. Temperature data, 10-minute intervals (Fahrenheit), April–July 2008.

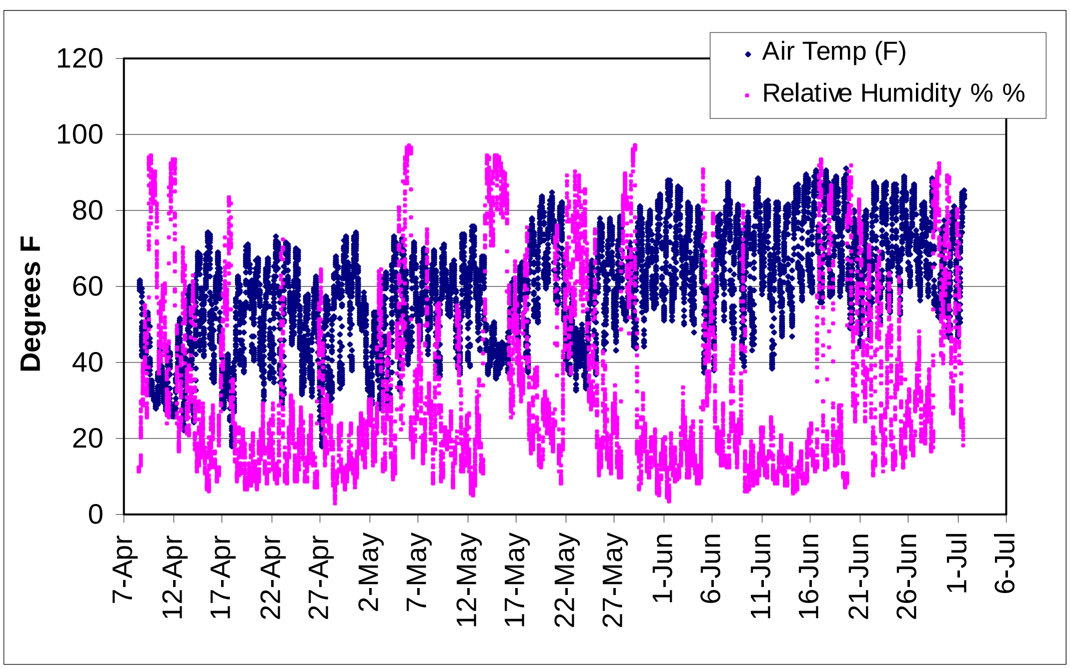


Figure 37. Temperature data and relative humidity, April–July 2008.

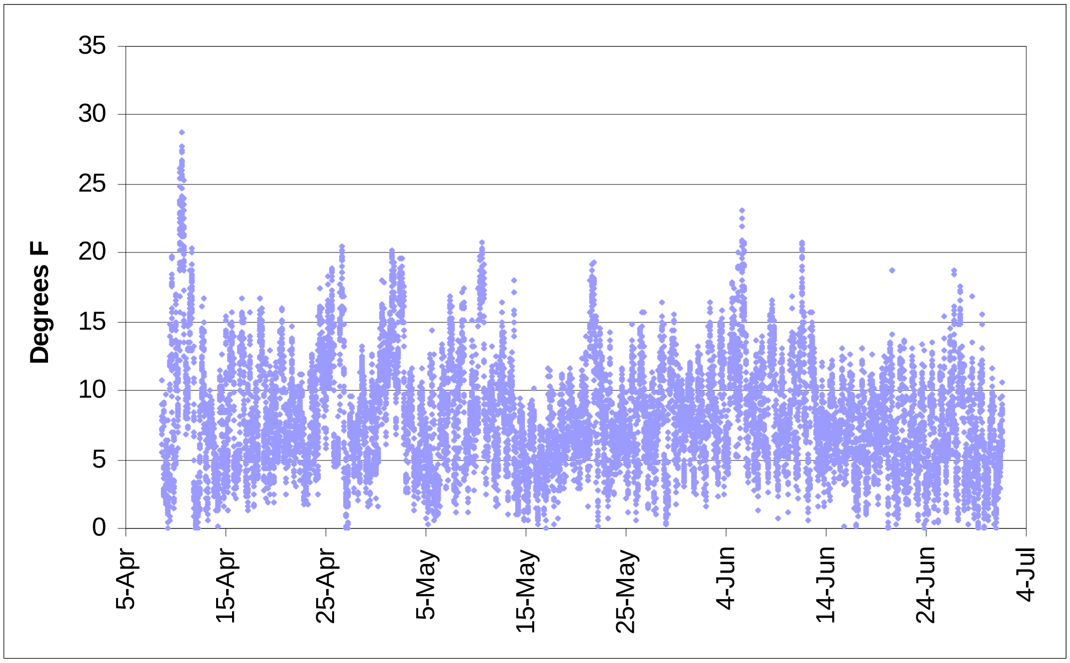


Figure 38. Maximum wind speed, April–July 2008.

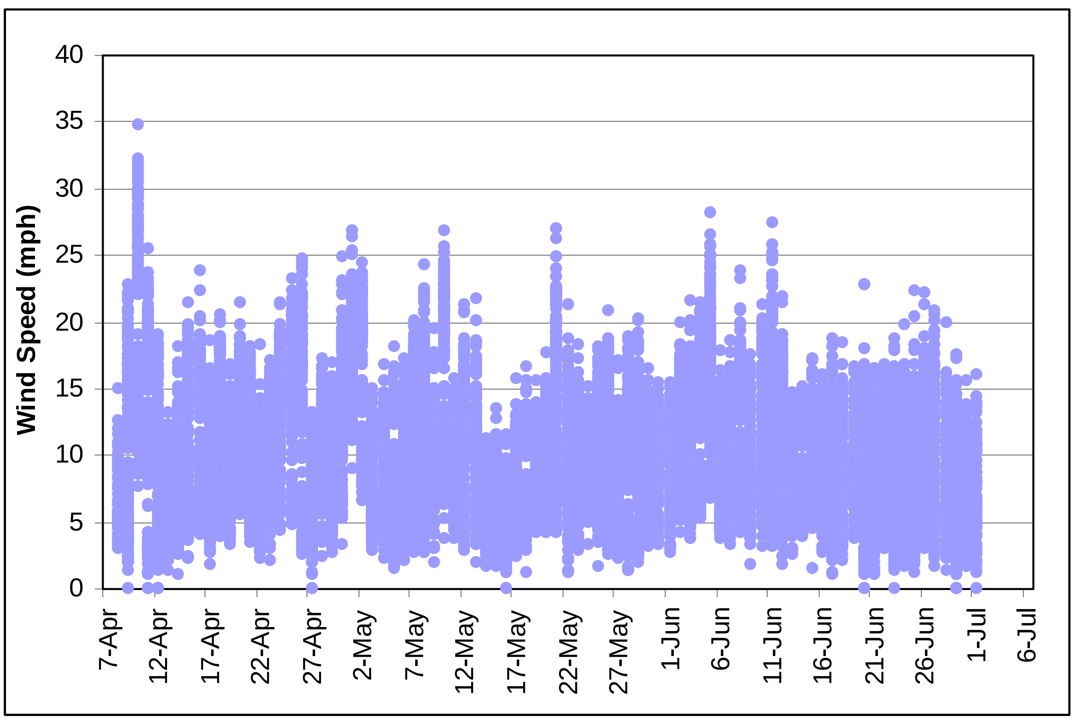


Figure 39. Average wind speed, April–July 2008.

The overlay of precipitation and soil moisture showed little correlation between precipitation and soil moisture levels during the April–July time period. The difference between the Tree and Meadow sites was more pronounced at the 4” and 1’ trench levels, but it is unclear how much of the this variance can be explained by the difference over and above the spatial variances between the sites.

DISCUSSION

As outlined above, the data received from EnviroLogic contained several large data gaps (the -9999 data fields represent fields with no data available) that make full analysis problematic (see Figure 5). The 10-minute sampling intervals resulted in a cumbersome data set to analyze, and lack of consistent time intervals further hindered consistent analysis (Figure 40). Aggregating data to daily and monthly values provides easier-to-analyze information with adequate temporal resolution for most decision-making purposes.

SWCA staff met with Josh Hanks, a representative of Intermountain Environmental, a regional distributor for Campbell Scientific to evaluate the condition of the SMWS. The Campbell representative thought the overall condition of the station was very good with no immediate needs for significant repair. SWCA was advised on necessary maintenance and calibration of the various components. This feedback was used in the design of the maintenance manual, which outlines necessary steps required to ensure that the weather station and its components function properly (Appendix B). The maintenance of the SMWS will be conducted by SWCA and field technicians from the Edgewood, Claunch Pinto, and East Torrance Soil and Water Conservation Districts. A specific schedule of routine maintenance will be finalized after the EBWHRMSC has reviewed the maintenance manual.

Data retrieval will be conducted via a wireless transfer when possible. The weather station contains a wireless router allowing remote downloading of data. If the wireless function is unavailable, SWCA will send a field technician to the weather station to manually download the data. Data retrieval will occur every three months, so quarterly reports can be conducted and submitted to the EBWHRMSC. Upon collection, the raw data will be analyzed for large data gaps. Frequent download of data and its evaluation will alert SWCA staff to any equipment malfunctions. If any data parameters are not being recorded, SWCA will promptly visit the site and contact the necessary equipment vendors to correct the problem as expeditiously as practicable.

Starting with the July 1, 2008 data, SWCA proposes to create Excel and Access templates in which to enter and store future data. A data entry template is being designed to ensure that information collected in the future is input into spreadsheets in a uniform manner. This template will include the fields required to conduct a thorough analysis of both weather and soil moisture data. Reducing the raw data to a more concise data sheet will allow for easier analysis and easier identification of missing data. Utilizing Access will allow for aggregation of data, so monthly totals and means can be tabulated more easily. After data are imported into Access, they will be analyzed in an effort to ensure all data columns and fields are present.

The collected data along with a summary report will be provided to EBWHRMC. Data will be distributed to the New Mexico Forest and Watershed Restoration Institute for web posting, and to each conservation district office. The raw data will be provided to EBWHRMC through an ftp site. The summary report will contain graphs showing mean and maximum values for various weather records. Soil moisture levels will be shown for both the Tree and Meadow locations, and will be shown in relation to precipitation levels.

TIMESTAMP TS	RECORD RN	Batt_Volt Volts	Batt_Volt_Min Volts	Batt_Volt_Max Volts	Rain_in_Tot inch	WS_mph miles/hour	WS_mph_Max miles/hour	WS_mph_Min miles/hour	WS_mph_Avg miles/hour
1/1/08 0:00	7916	12.83	12.83	12.83	0	5.204	7.172	5.204	6.221
1/1/08 0:10	7917	12.83	12.83	12.83	0	5.711	5.89	4.817	5.431
1/1/08 0:20	7918	12.83	12.83	12.83	0	5.413	6.188	5.025	5.762
1/1/08 0:30	7919	12.83	12.83	12.83	0	6.069	6.606	5.025	5.988
1/1/08 0:40	7920	12.83	12.83	12.83	0	6.904	7.351	6.188	6.641
1/1/08 0:50	7921	12.82	12.82	12.83	0	6.606	6.844	6.218	6.623
1/1/08 1:00	7922	12.82	12.82	12.82	0	6.427	7.232	6.218	6.662
1/1/08 1:10	7923	12.82	12.82	12.82	0	7.083	7.083	6.248	6.671
1/1/08 1:20	7924	12.82	12.82	12.82	0	6.725	7.232	6.248	6.743
1/1/08 1:30	7925	12.82	12.82	12.82	0	7.232	7.56	6.635	7.127
1/1/08 1:40	7926	12.82	12.82	12.82	0	7.828	7.828	6.784	7.259
1/1/08 1:50	7927	12.81	12.81	12.82	0	7.112	8.1	7.112	7.628
1/1/08 2:00	7928	12.81	12.81	12.81	0	8.01	8.54	7.291	7.888
1/1/08 2:10	7929	12.81	12.81	12.81	0	7.083	8.6	7.083	7.765
1/1/08 2:20	7930	12.81	12.81	12.81	0	7.083	7.619	6.367	7.142
1/1/08 2:30	7931	12.8	12.8	12.81	0	7.053	7.589	6.158	7.035
1/1/08 2:40	7932	12.8	12.8	12.8	0	7.679	8.01	6.606	7.42
1/1/08 2:50	7933	12.8	12.8	12.8	0	7.917	8.36	7.172	7.837
1/1/08 3:00	7934	12.79	12.79	12.8	0	8.13	8.87	7.619	8.13
1/1/08 3:10	7935	12.79	12.79	12.79	0	8.99	8.99	7.172	8.03
1/1/08 3:20	7936	12.78	12.78	12.79	0	9.11	9.32	7.023	8.24
1/1/08 3:30	7937	12.78	12.78	12.78	0	8.16	8.99	7.47	8.51
1/1/08 3:40	7938	12.78	12.78	12.78	0	8.19	8.42	7.917	8.25
1/1/08 3:50	7939	12.77	12.77	12.78	0	7.619	8.75	6.546	7.604
1/1/08 4:00	7940	12.77	12.77	12.77	0	7.947	8.13	6.128	7.378
1/1/08 4:10	7941	12.77	12.77	12.77	0	8.1	8.51	6.456	7.557
1/1/08 4:20	7942	12.76	12.76	12.77	0	6.516	7.858	6.218	7.151
1/1/08 4:30	7943	12.76	12.76	12.76	0	5.741	7.112	5.741	6.749

Figure 40. Example of data from the SMWS files found on the CD included with this report.

RECOMMENDATIONS

Two steps should be taken to ensure the data gathered by the SMWS is useful, concise, and meaningful. The goal is to create standardized data storage, retrieval, and analysis methodology that will yield consistent outputs and provide adequate detail for various decision making functions. First, a relational database should be constructed in Access or another similar program. This will allow for automatic data reports and analyses of preset parameters. For example, a report could be made that gives the date, duration, and intensity of every recorded rainfall event, and another report could present the five windiest days in April. The database could also be set to present analyses; for example, the correlation among soil moisture, air temperature, and solar radiation after precipitation. Second, SWCA proposes to change many of the measurement parameters established by EnviroLogic by reprogramming the datalogger. Below is a list of proposed changes.

DATALOGGER PARAMETER: CHANGES

Timestamp: Currently measured in 10-minute intervals. Propose to change to hourly intervals. This is a typical measurement interval for most meteorological stations.

Record Number: No Change

Battery Voltage: This is a discrete measurement at the exact time the logger takes the time stamp. Propose to remove due to redundancy. The important measurements for battery voltage are minimum and hourly average. By measuring the minimum voltage the batteries condition can be assessed, and by comparing that to the hourly average we can measure voltage draw conditions.

Battery Voltage Minimum: No Change

Battery Voltage Maximum: Propose to remove. See Battery Voltage.

Battery Voltage Average: Propose to add.

Rain in Total: No Change

Wind Speed: This is a discrete measurement at the exact time the logger takes the time stamp. Propose to remove due to redundancy. The important measurements for wind speed are average and maximum. Average wind speed over the hourly interval gives us an idea of typical wind speed and maximum wind speed gives us a measurement of gusts.

Wind Speed Maximum: No Change

Wind Speed Minimum: Propose to remove. See Wind Speed

Wind Speed Average: No Change

Wind Direction: This is a discrete measurement at the exact time the logger takes the time stamp. Propose to remove due to redundancy. The only important measurement for wind direction is average. With average hourly wind speed and direction appropriate descriptions can be made of wind conditions and water evaporation.

Wind Direction Maximum: Propose to remove. See Wind Direction.

Wind Direction Minimum: Propose to remove. See Wind Direction.

Wind Direction Average: No Change.

Solar Radiation: This is a discrete measurement at the exact time the logger takes the time stamp. Propose to remove due to redundancy. Only an hourly average is necessary to compute evaporation rates. Daily accumulated solar radiation may be useful in future calculations.

Solar Radiation Average: No Change

Accumulated Solar Radiation: No Change

Air Temperature: This is a discrete measurement at the exact time the logger takes the time stamp. Propose to remove due to redundancy. Minimum, maximum, and hourly average air temperatures are sufficient to describe climatic conditions.

Air Temperature Maximum: No Change

Air Temperature Minimum: No Change

Air Temperature Average: No Change

Relative Humidity: This is a discrete measurement at the exact time the logger takes the time stamp. Propose to remove due to redundancy. Hourly average relative humidity is sufficient to describe climatic conditions.

Relative Humidity Maximum: Propose to Remove. See Relative Humidity.

Relative Humidity Minimum: Propose to Remove. See Relative Humidity.

Relative Humidity Average: No Change

Soil Moisture: This is a discrete measurement at the exact time the logger takes the time stamp. Propose to remove due to redundancy. Hourly soil moisture measurements are more than sufficient for assessing soil moisture trends.

Soil Moisture Average: No Change

Soil Moisture Measurement Time: This is a measurement that can be used to normalize readings taken in different types of soil. Because these moisture probes will never move this measurement is useless. Propose to remove.

Soil Temperature: This is a discrete measurement at the exact time the logger takes the time stamp. Propose to remove due to redundancy. Hourly soil temperature measurements are more than sufficient for measuring soil temperature trends.

Soil Temperature Average: No Change.

APPENDIX A
SOUTH MOUNTAIN WEATHER STATION: DEVICE AND RECORDED DATA DESCRIPTIONS

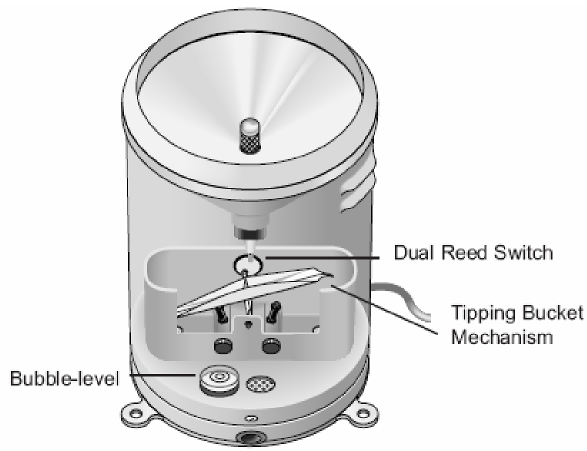
The following is a description of each component of the South Mountain Weather Station (SMWS) (Figure A.1). Technical descriptions and instrument diagrams are adapted from technical literature distributed by each manufacturer.

Figure A.1. The South Mountain weather station.

Parameter: Precipitation

CS700 Tipping Bucket Rain Gauge
Manufactured by Campbell Scientific, Inc.

The tipping bucket rain gauge measures precipitation. Any rain that falls in the funnel at the top is focused into the center of the gauge where it triggers a switch for every 0.25 mm of water that flows through it.



Transparent view of CS700 shows tipping bucket mechanism

By counting the number of times the switch is triggered the gauge can determine the total precipitation to the closest quarter of a millimeter (about one hundredth of an inch). After measurement the water flows through the bottom of the gauge back into the system. This rain gauge model is designed to measure extremely heavy rainfall events, accurately measuring rainfall up to 700 mm per hour (almost 28 inches).

The tipping bucket rain gauge's funnel aperture should be checked and cleaned of debris monthly, and checked for accuracy and re-leveled once a year. An explanation of these procedures can be found in the SMWS Maintenance Manual.

At the SMWS, the rain gauge is installed (per specifications provided by the manufacturer) on a steel post approximately 1 m (3.3 feet) above the ground. It is located on the site 3 m (10 feet) northeast of the instrument tower.

Parameter: Wind Speed

014A Anemometer
Manufactured by Met One Instruments, Inc.
Distributed and Warranted by Campbell Scientific, Inc.

The anemometer measures wind speed, but not wind direction. It consists of three aluminum cups in an array mounted to spin on a stationary base.

During each revolution of the cups, a switch is opened and closed twice. Wind speed is measured by converting the frequency of switch closures to meters per second or miles per hour (mph). The anemometer can measure winds speed of up to 100 mph with an accuracy of 0.25 mph, but has a starting threshold of 1 mph; it measures from 1 to 100 mph in quarter mph increments or 0 mph (no wind).

The anemometer should be visually inspected every six months, the bearings replaced after 18 months, and a complete factory overhaul performed every 36 months. An explanation of these procedures can be found in the SMWS Maintenance Manual.

The anemometer is located on the instrument tower attached to a cross-arm approximately 3 m (10 feet) above ground level.

Parameter: Wind Direction

#200P Wind Direction Vane
Manufactured by NRG Systems, Inc.

The wind direction vane measures wind direction, but not speed. It consists of a thermoplastic base and a stainless steel-tipped thermoplastic rudder which has full and free rotational capability.

The wind direction vane operates using a potentiometer (essentially a dial) that transmits a specific electrical potential for any direction within the 360 degree range. For example, if the wind is blowing from the north the potentiometer should transmit 0 volts, which translates into 0 degrees (N), but if the wind shifts to the east the potentiometer transmits approximately 3.75 volts which translates to 90 degrees (E).

The wind direction vane is rated by the manufacturer for 50 million revolutions, which under normal operating conditions will take between 2 and 6 years to complete. After this interval the manufacturer recommends replacement rather than a costly overhaul and recalibration.

The wind direction vane is located on the instrument tower attached to a cross-arm opposite the anemometer approximately 3 meters (10 feet) from ground level.

Parameters: Air Temperature, Relative Humidity

CS215-L Air Temp/Relative Humidity Sensor
Manufactured by Campbell Scientific, Inc.

The CS215-L Air Temp/Relative Humidity Sensor measures both ambient air temperature and relative humidity in one unit. Because air is actually a mixture of water vapor and air, relative humidity is a ratio of the two and is thus represented as a percentage. The technical definition is the ratio of the *partial pressure* of water vapor in the mixture to the saturated *vapor pressure* of water at a given temperature.

The sensor will accurately read air temperatures from -40 to 70 degrees Celsius (˚ C) (-40 to 158 degrees Fahrenheit [˚ F]) and relative humidity from 0 to 100 percent.
Contact with direct solar radiation would cause the temperature sensor to overheat and give false readings, so the sensor is placed inside a radiation shield. The radiation shield consists of several down turned plates stacked on top of each other, which allows free exchange of the ambient air and air inside of the shield.

The temperature/relative humidity sensor has a filter that covers the sensor element which requires monthly cleaning and inspection. The filter is replaced periodically dependent on its condition. The sensor element itself must be replaced annually; both of these procedures are outlined in the SMWS Maintenance Manual.

The sensor is located inside the radiation shield on the instrument tower about 2 m (6.6 feet) above ground level.

Parameter: Solar, Lunar, and Background Radiation

LI200X Pyranometer
Manufactured by Li-Cor Biosciences, Inc.
Distributed and Warranted by Campbell Scientific, Inc.

The pyranometer measures the density of intercepted radiation from the sun and moon as well as background radiation from stars. This pyranometer measures radiation intensity in average kilowatts per meter squared and total megajoules per meter squared over a specified time period; for the SMWS that time period is 10 minutes. These two measurements allow calculations of water evaporation rates and cloud cover.

It is important that the pyranometer be level with the ground surface, and not be shaded by the instrument tower. For this reason it is fixed to a cross-arm that projects south of the tower, and is mounted on a leveling base.

The pyranometer sensor surface should be cleaned with a blast of compressed air monthly and the leveling checked regularly. The pyranometer also requires a biannual factory recalibration.

Parameter: Soil Temperature

108 Temperature Probe
Manufactured by Campbell Scientific, Inc.

The 108 temperature probe measures the soil temperature at the SMWS in several locations at several depths. Probes were placed in four sites: a tree borehole, a tree trench, a meadow borehole, and a meadow trench. The depths are as follows.

Meadow Borehole	Meadow Trench	Tree Borehole	Tree Trench
26.125 inches	24 inches	17 inches	24 inches
146.125 inches	60 inches	136.5 inches	60 inches
266.125 inches		258 inches	

The soil temperature probes are waterproof and constructed to withstand pressure and can remain buried for many years without the need for calibration or maintenance. Probes can measure between -5˚ and 95˚ C (23˚ F –203˚ F).

Parameter: Soil Moisture

ECHO Probe EC-5
Manufactured by Decagon Devices, Inc.

And

CS616-L Water Content Reflectometer
Manufactured by Campbell Scientific, Inc.

Two types of soil moisture probes are installed at the SMWS, although they are very similar and work using the same concepts. A soil moisture probe determines a measurement called volumetric water content, which is represented as a percentage. The probes consist of two closely spaced metal rods that measure the conductivity between them. Because water is more conductive than soil, the probes measure a voltage that then calculates into a percentage of water per unit soil volume. This is done very accurately to a measurement of ±2.5%.

The probes are designed to remain in their placement until failure, and no calibration or maintenance is needed. Like the soil temperature probes, the soil moisture probes are located at four sites: a tree borehole, a tree trench, a meadow borehole, and a meadow trench. These are the same sites as the soil temperature probes. The depths are as follows:

Meadow Borehole	Meadow Trench	Tree Borehole	Tree Trench
26.125 inches	4 inches	17 inches	4 inches
146.125 inches	8 inches	136.5 inches	8 inches
266.125 inches	12 inches	258 inches	12 inches
	18 inches		18 inches
	25 inches		26 inches
	36 inches		36 inches
	54 inches		54 inches
	72 inches		72 inches

APPENDIX B
SOUTH MOUNTAIN WEATHER STATION
MAINTENANCE MANUAL

SOUTH MOUNTAIN WEATHER STATION:
MAINTENANCE MANUAL

Prepared for
ESTANCIA BASIN WATERSHED HEALTH, RESTORATION AND MONITORING STEERING COMMITTEE

c/o CLAUNCH-PINTO SOIL AND WATER CONSERVATION DISTRICT
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SWCA Project No. 12996
July 16, 2008

SOUTH MOUNTAIN WEATHER STATION MAINTENANCE MANUAL

The South Mountain Weather Station (SMWS) is located within the Edgewood Soil and Water Conservation District, on the private property of David King, near South Mountain, Santa Fe County, New Mexico, approximately 19 km (12 miles) north of the town of Edgewood (Figure B.1). The purpose of the weather station was to monitor ambient rainfall and other weather parameters, and soil moisture and temperature at various subsurface soil depths to understand the relationships between rainfall and water yield to the watershed over time. One set of soil moisture sensors was placed under a juniper tree (Figure B.2), and another set in an adjacent open area (Figure B.3). SWCA Environmental Consultants assumed operation of the SMWS in April, 2008. Part of the operation of the SMWS is maintenance of the weather station and its various components. This document provides a description of routine maintenance needed for the SMWS, and includes a description of the components.

The following provides a summary of the maintenance schedule for the components that make up the South Mountain Weather Station. Technical information is taken from Manufacturer Instruction Manuals. For more information, consult the Campbell Scientific Instruction Manual for the specific component.

Component	Maintenance	Recalibration
CR1000 Datalogger	Desiccant packs	Can be recalibrated every three years
AM16/32B Multiplexer (4x16 model)	Desiccant packs	
CS700-L Tipping Bucket Rain Gauge	Monthly	Yearly calibration check; factory recalibration
014A Anemometer	Biannually	Factory overhaul every three years
NRG #200P Wind Direction Sensor	Periodic inspection	Replacement 2–6 years depending on use
CS215-L Air Temp/Relative Humidity Sensor	Monthly	Yearly sensor element replacement
41303-5A Gill Radiation Shield	Periodic inspection	
LI200X Pyranometer	Monthly	Factory recalibration every two years
LI200X Leveling Base	Periodic inspection	
CM225 Mounting Stand	None	
108 Temperature Probe (4-wire)	Remove debris	
ECHO Probe EC-5	None	Recalibration if in sandy soil
CS616-L Water Content Reflectometer	None	
Radio Antena	Periodic inspection	
UT10 Instrument Tower	Periodic inspection	

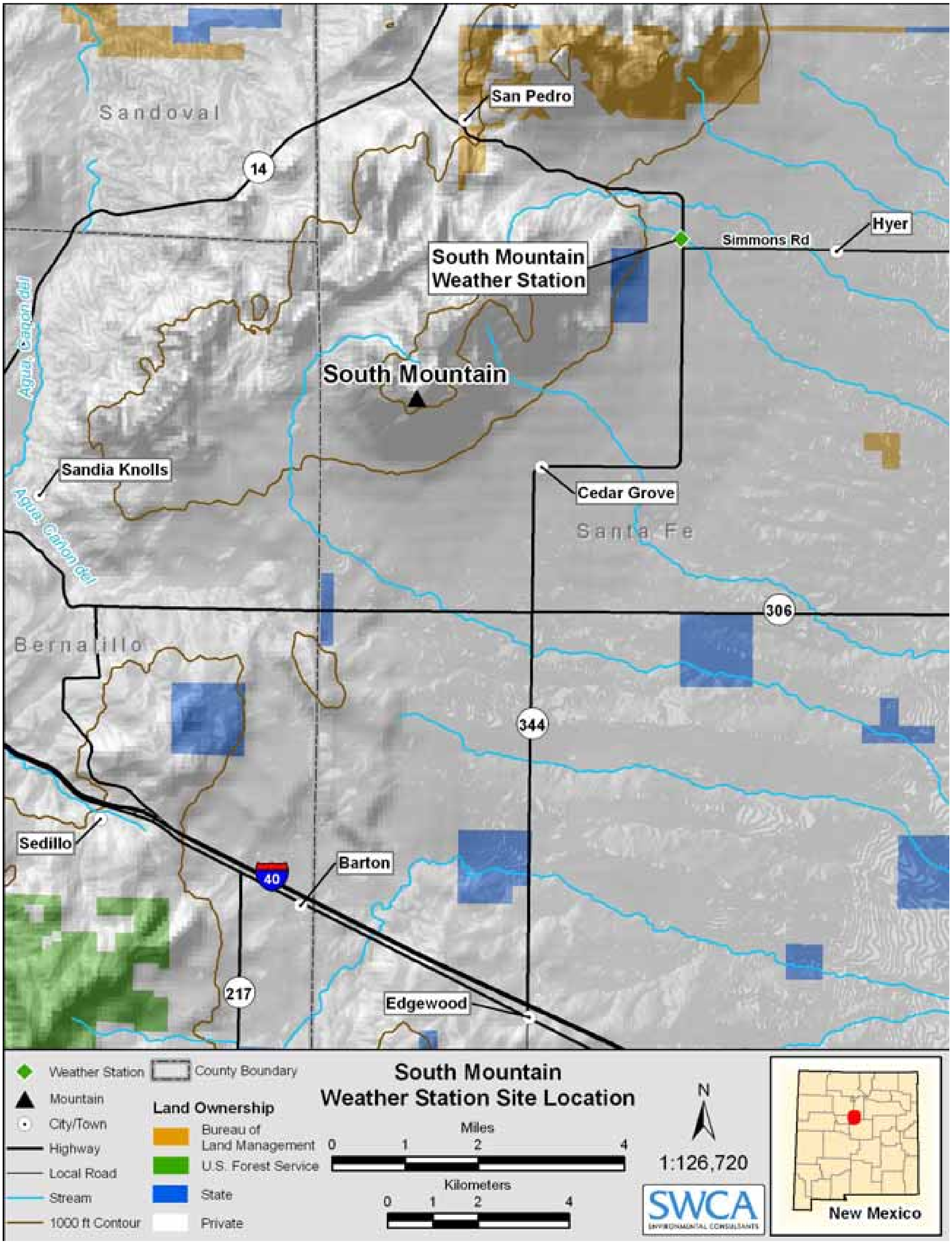


Figure B.1. Location of the South Mountain Weather Station near Edgewood, New Mexico.

Figure B.2. Meadow site.

Figure B.3. Tree site.

CR1000 DATALOGGER

The datalogger is located inside the enclosure (Figure B.4). The desiccant packs should be replaced as needed. The moisture card in the enclosure will indicate when replacement is necessary. The datalogger can be recalibrated every three years if deemed necessary. To recalibrate, contact Campbell Scientific to obtain a Return Materials Authorization.

Figure B.4.. Datalogger enclosure.

AM 16/32 B MULTIPLEXER (4X16 MODEL)

The multiplexer is susceptible to corrosion in high relative humidity. Desiccant packs should be used inside the enclosure and can be obtained from Campbell Scientific. Operators should also ensure that air movement is not restricted through the enclosure if lead batteries are used as power, as this creates risk of explosion.

CS700-L TIPPING BUCKET RAIN GAUGE

At each site visit, the operator should clear all debris from the collection funnel, debris screen, siphoning mechanism, and tipping bucket assembly (Figures B.5 and B.6). The operator should also ensure that the tipping bucket is able to move freely and that the data logger is recording every bucket tip.

The sensor is factory calibrated and does not require recalibration unless damaged. A calibration check is, however, recommended every 12 months that should include:

1. Remove the housing assembly from the base by removing the three screws and lifting housing upward.
2. Check the bubble level to ensure rain gauge is level
3. Pour water through the inner funnel to wet the bucket surfaces. Using a graduated cylinder, slowly pour 314 cubic centimeters of water over a 15-minute period into the collection funnel. This volume of water is equal to 0.39 inches of rainfall.
4. After the water has passed through the rain gauge, the tipping bucket should have tipped 39 times.
5. If the rain gauge fails to record the correct number of tips, return the unit to Campbell Scientific for recalibration.

Figure B.5. Rain bucket with insulation.

Figure B.6. Rain bucket funnel (from above).

014A Anemometer

Every 6 to 12 months, the operator should visually check the anemometer cups for cracks and breaks and ensure that each arm is securely attached to the cup assembly hub (Figure B.7). The vent hole should also be checked for obstructions. After periods of heavy wind the operator should check for slow cup rotation; this indicates that the bearings may need to be replaced. Sensor bearings should be replaced on a 12- to 24-month cycle. Every 24 to 36 months the manufacturer recommends a complete factory overhaul of the sensor. The operator should contact Met One Instruments, Inc., for recalibration and overhaul details.

Met One Instruments, Inc.
479 California Avenue, Grants Pass, OR 97526, (541) 471-7111

Figure B.7. Anemometer.

NRG #200P WIND DIRECTION SENSOR

The wind direction sensor (Figure B.8) should be inspected periodically for cracks or breaks. It should be replaced every 2 to 6 years depending on assessed condition. No manual is available for this instrument.

FigureB.8. Wind direction vane.

CS215-L AIR TEMP / RELATIVE HUMIDITY SENSOR

The CS215-L probe (Figure B.9) requires minimal maintenance. The operator should conduct monthly checks to remove dust and debris from around the radiation shield and the white filter on the end of the sensor. The filter can be cleaned with distilled water or replaced. The filter should not be over-tightened when replaced. The CS215-L sensor should be replaced annually in order to ensure accurate readings.

Figure B.9. Air temperature and relative humidity sensor (with radiation shield).

41303-5A GILL RADIATION SHIELD

The shield (see Figure B.9) should be inspected periodically for cracks or breaks. Debris should be removed from the shield during each site visit. No manual is available for this instrument.

LI200X PYRANOMETER

The level of the pyranometer (Figure B.10) should be checked on a monthly basis. Dust and debris should also be removed from the sensor head using a blast of compressed air or soft bristle brush. The drain hole next to the surface of the sensor should be clear at all times. Care should be taken to not scratch the surface of the sensor during maintenance.

Figure B.10. Pyranometer with arm.

LI200X LEVELING BASE

The leveling base should be checked for position every month. The base should be inspected periodically for cracks or breaks and debris and dust removed during each site visit. No manual is available for this instrument.

CM225 MOUNTING STAND

The mounting stand should be inspected periodically for cracks or breaks.

108 TEMPERATURE PROBE

The 108 temperature probe requires minimal maintenance. Monthly checks should be made of the radiation shield to remove debris. Calibration is deemed unnecessary. For more information refer to specific component Campbell Scientific Instruction Manual.

RADIO TOWER

Periodic inspection is recommended to ensure the radio tower is firmly connected to the UT10 Instrument Tower. No manual is available for this instrument.

CS616-L WATER CONTENT REFLECTOMETER

Based on the manual, significant site-specific calibration is required for proper function of the reflectometer. Once calibrated, the unit does not require periodic maintenance.

ECHO PROBE EC-5

The ECHO Probe is calibrated to work in most soils, but the manual suggests that soils with a high sand content and/or soils with high salinity levels should be recalibrated. It does not provide a sand content threshold; depending on the location of the probe, it may make sense to run the calibration process outlined in the manual.

UT10 INSTRUMENT TOWER

The UT10 Instrument Tower (Figure B.11) requires less maintenance than the instruments that it supports. With that said, some work should be completed to ensure that it is working properly. A visual inspection should be conducted every time a visit is paid to the tower; the inspector should conduct a thorough examination looking for any structural issues on the tower itself. The connection between the tower and its base should also be examined, ensuring the anchor bolts are tight. The connection between the tower and the ground rod should also be examined to ensure a strong connection. The examiner should also bring a compass or global positioning system (GPS) unit and check that the wind vane is calibrated to true north.

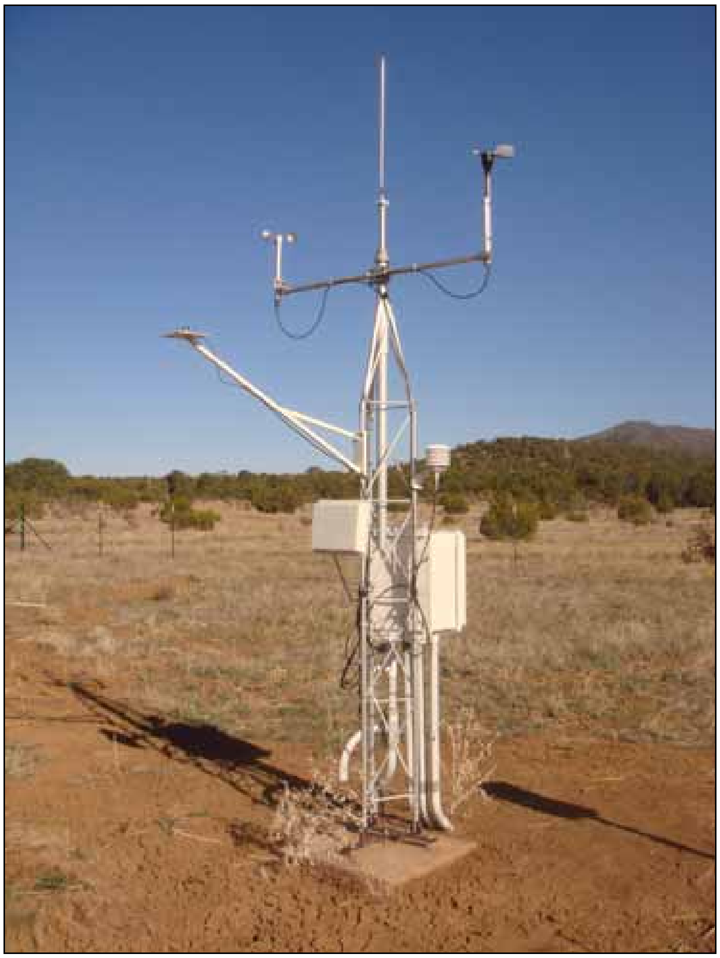


Figure B.11. UT10 Instrument Tower.

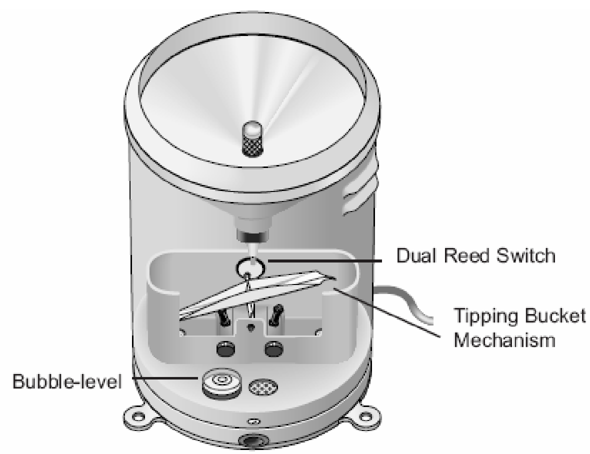
SOUTH MOUNTAIN WEATHER STATION: DEVICE DESCRIPTIONS

The following is a description of each component of the South Mountain Weather Station (SMWS). Technical descriptions and instrument diagrams are adapted from technical literature distributed from each manufacturer.

PARAMETER: PRECIPITATION

CS700 Tipping Bucket Rain Gauge
Manufactured by Campbell Scientific, Inc.

The tipping bucket rain gauge measures precipitation. Any rain that falls in the funnel at the top is focused into the center of the gauge where it triggers a switch for every 0.25 mm of water that flows through it.



Transparent view of CS700 shows tipping bucket mechanism

By counting the number of times the switch is triggered the gauge can determine the total precipitation to the closest quarter of a millimeter (about one hundredth of an inch). After measurement the water flows through the bottom of the gauge back into the system. This rain gauge model is designed to measure extremely heavy rainfall events, accurately measuring rainfall up to 700 mm per hour (almost 28 inches).

The tipping bucket rain gauge's funnel aperture should be checked and cleaned of debris monthly, and checked for accuracy and re-leveled once a year. An explanation of these procedures can be found in the SMWS Maintenance Manual.

At the SMWS the rain gauge is installed (per specifications provided by the manufacturer) on a steel post approximately one 1 m (3.3 feet) above the ground. It is located on the site 3 m (10 feet) northeast of the instrument tower.

PARAMETER: WIND SPEED

014A Anemometer
Manufactured by Met One Instruments, Inc.
Distributed and Warranted by Campbell Scientific, Inc.

The anemometer measures wind speed, but not wind direction. It consists of three aluminum cups in an array mounted to spin on a stationary base.

During each revolution of the cups, a switch is opened and closed twice. Wind speed is measured by converting the frequency of switch closures to meters per second or miles per hour (mph). The anemometer can measure winds speed of up to 100 miles per hourmph with an accuracy of 0.25 mph, but has a starting threshold of 1 mph; it measures from 1 to 100 mph in quarter mph increments or 0 mph (no wind).

The anemometer should be visually inspected every six months, the bearings replaced after 18 months, and a complete factory overhaul performed every 36 months. An explanation of these procedures can be found in the SMWS Maintenance Manual.

The anemometer is located on the instrument tower attached to a cross-arm approximately 3 m (10 feet) above ground level.

PARAMETER: WIND DIRECTION

#200P Wind Direction Vane
Manufactured by NRG Systems, Inc.

The wind direction vane measures wind direction, but not speed. It consists of a thermoplastic base and a stainless steel-tipped thermoplastic rudder which has full and free rotational capability.

The wind direction vane operates using a potentiometer (essentially a dial) which that transmits a specific electrical potential for any direction within the 360 degree range. For example, if the wind is blowing from the north the potentiometer should transmit 0 Volts which translates into 0 Degrees (N), but if the wind shifts to the east the potentiometer transmits approximately 3.75 volts which translates to 90 Degrees (E).

The wind direction vane is rated by the manufacturer for 50 million revolutions, which under normal operating conditions will take between 2 and 6 years to complete. After this interval the manufacturer recommends replacement rather than a costly overhaul and recalibration.

The wind direction vane is located on the instrument tower attached to a cross-arm opposite the anemometer approximately 3 meters (10 feet) from ground level.

PARAMETERS: AIR TEMPERATURE, RELATIVE HUMIDITY

CS215-L Air Temp/Relative Humidity Sensor
Manufactured by Campbell Scientific, Inc.

The CS215-L Air Temp/Relative Humidity Sensor measures both ambient air temperature and relative humidity in one unit. Because air is actually a mixture of water vapor and air, relative humidity is a ratio of the two and is thus represented as a percentage. The technical definition is the ratio of the *partial pressure* of water vapor in the mixture to the saturated *vapor pressure* of water at a given temperature.

The sensor will accurately read air temperatures from -40 to 70 degrees Celsius (˚ C) (-40 to -158 degrees Fahrenheit [˚ F]) and relative humidity from 0 to 100 percent.

Contact with direct solar radiation would cause the temperature sensor to overheat and give false readings, so the sensor is placed inside a radiation shield. The radiation shield consists of several down turned plates stacked on top of each other, which allows free exchange of the ambient air and air inside of the shield.

The temperature/relative humidity sensor has a filter that covers the sensor element which requires monthly cleaning and inspection. The filter is replaced periodically dependeant on its condition. The sensor element itself must be replaced annually; both of these procedures are outlined in the SMWS Maintenance Manual.

The sensor is located inside the radiation shield on the instrument tower about 2 meters (6.6 feet) above ground level.

PARAMETER: SOLAR, LUNAR, AND BACKGROUND RADIATION

LI200X Pyranometer
Manufactured by Li-Cor Biosciences, Inc.
Distributed and Warranted by Campbell Scientific, Inc.

The pyranometer measures the density of intercepted radiation from the sun and moon as well as background radiation from stars. This pyranometer measures radiation intensity in average kilowatts per meter squared and total megajoules per meter squared over a specified time period; for the SMWS that time period is 10 minutes. These two measurements allow calculations of water evaporation rates and cloud cover.

It is important that the pyranometer be level with the ground surface, and not be shaded by the instrument tower. For this reason it is fixed to a cross-arm which that projects south of the tower, and is mounted on a leveling base.

The pyranometer sensor surface should be cleaned with a blast of compressed air monthly and the leveling checked regularly. The pyranometer also requires a biannual factory recalibration.

PARAMETER: SOIL TEMPERATURE

108 Temperature Probe
Manufactured by Campbell Scientific, Inc.

The 108 tTemperature probe measures the soil temperature at the SMWS in several locations at several depths. Probes were placed in four sites:; a tree borehole, a tree trench, a meadow borehole, and a meadow trench. The depths are as follows.

Meadow Borehole	Meadow Trench	Tree Borehole	Tree Trench
26.125 iInches	24 Iinches	17 Iinches	24 Iinches
146.125 Iinches	60 Iinches	136.5 Iinches	60 Iinches
266.125 Iinches		258 Iinches	

The soil temperature probes are waterproof and constructed to withstand pressure and can remain buried for many years without the need for calibration or maintenance. They Probes can measure between -5˚ and 95˚ C (23˚ F -–203˚ F).

PARAMETER: SOIL MOISTURE

Echo ECHO EC-5 Probe EC-5
Manufactured by Decagon Devices, Inc.

And

CS616-L Water Content Reflectometer
Manufactured by Campbell Scientific, Inc.

Two types of soil moisture probes are installed at the SMWS, although they are very similar and work using the same concepts. A soil moisture probe determines a measurement called volumetric water content, which is represented as a percentage. The probes consist of two closely spaced metal rods which that measure the conductivity between them. Because water is more conductive than soil, the probes measure a voltage that then calculates into a percentage of water per unit soil volume. This is done very accurately to a measurement of ±2.5%.

The probes are designed to remain in their placement until failure, and no calibration or maintenance is needed. Like the soil temperature probes, the soil moisture probes are located at four sites:; a tree borehole, a tree trench, a meadow borehole, and a meadow trench. These are the same sites as the soil temperature probes. The depths are as follows:

Meadow Borehole	Meadow Trench	Tree Borehole	Tree Trench
26.125 iInches	4 Iinches	17 iInches	4 iInches
146.125 Iinches	8 iInches	136.5 Iinches	8 iInches
266.125 iInches	12 Iinches	258 iInches	12 Iinches
	18 iInches		18 iInches
	25 iInches		26 iInches
	36 iInches		36 iInches
	54 iInches		54 iInches
	72 iInches		72 iInches