WaterScout SM100 Soil Moisture Sensor

Catalog # 6460

Spectrum

Technologies, Inc.

CONTENTS

This manual will familiarize you with the features and operation of your new WaterScout SM100 Soil Moisture Sensor. Please read this manual thoroughly before using your instrument. For customer support, or to place an order, call Spectrum Technologies, Inc. at (800)248-8873 or (815) 436-4440 between 7:30 am and
5:30 p.m. CST, FAX at (815)436-4460, or E-Mail at info@specmeters.com.
www.specmeters.com

Spectrum Technologies, Inc. at 12360 S. Industrial Dr. East Plainfield, IL 60585

General Overview

Thank you for purchasing a WaterScout SM100 Soil Moisture Sensor.

The sensor is made up of two electrodes that function as a capacitor, with the surrounding soil serving as the dielectric. An 80 MHz oscillator drives the capacitor and a signal proportional to the soil's dielectric permittivity is converted to the output signal. The dielectric permittivity of water is much greater than air, soil minerals and organic matter. So, changes in water content can be detected by the sensor circuitry and correlated to the soil's moisture content.

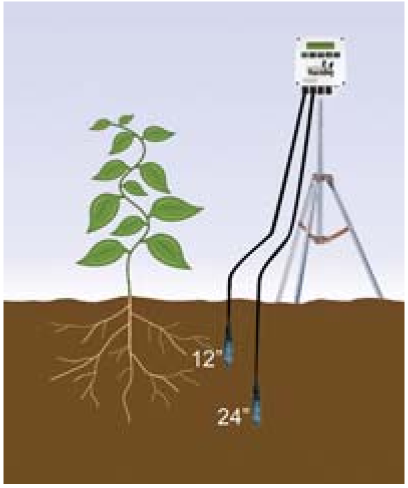
The SM100, in conjunction with a Soil Sensor Reader or a WatchDog weather station, will give you a better idea of how fast soil water is being depleted in different areas of your field. By keeping track of your field's soil moisture status between irrigations, you can better schedule irrigations and evaluate the effectiveness of rain and irrigation water. Regular monitoring will give you an accurate picture of this process over time. Download the accumulated data at your convenience. SpecWare will present data in graphical and tabular form. Use the software to view daily, monthly and yearly reports.

Specifications

Standard Interface	WatchDog weather station, WatchDog mini station, FieldScout Soil Sensor Reader
Connector	2.5mm stereo pin
Range	0% VWC to saturation
Power	3 to 5V @ 6 to 10mA
Output	Analog voltage proportional to excitation voltage (0.5 to 1.5 Vfor a 3V excitation)
Oscillator Frequency	80 MHz
Resolution	0.1% VWC
Accuracy	3% VWC @ EC < 8 mS/cm
Sensing Area	2.4in. (6cm) x 0.8in (2cm) x 0.1in (0.3cm)
Cable length	6 and 20ft. extendable up to 50ft.

Sensor Placement

The sensors should be located in the effective root zone and at locations that will give a representative picture of the soil water status of the field. Areas of the field planted to different crops or with significant differences in factors such as topography or soil type should be considered unique soil moisture environments. Selecting a site which receives the least amount of water from the irrigation system will tell you when that area becomes critically dry and is in need of attention. Typically, one or two sensors should be installed in the root zone. A single sensor should be placed in the middle of the root zone. When two sensors are installed at a single site, it is recommended to place one sensor at the top of root zone and a second at the bottom. An advantage of installing multiple sensors is it allows you to see how well irrigation and rainwater is moving through the soil profile.



The SM100 is most sensitive to the soil adjacent to the sensor. Therefore, good contact between the soil and sensor is important. Stones and air pockets next to the sensor will affect the accuracy of the readings. Because it is sensitive to differences in dielectric permittivity, care should be taken not to install the sensor in or near metal.

Hardware /Software Compatibility

There are some restrictions on which equipment is compatible with the WaterScout and how many sensors can be connected to a single unit. These are outlined below.

Software
Requires SpecWare version 9.0 Build 202 or greater.

Soil moisture sensor reader
Non data-logger. Reads one sensor at a time. Requires firmware version 3 or greater.

2000-series mini stations (2400, 2425, 2450, 2475)
Require firmware version 1.9 or greater. Models with serial number 2310 or greater were manufactured to accommodate the SM100 on all available channels. Compatible stations will have a “w” in the manufacturing code that accompanies the serial number. Stations with earlier serial numbers can accommodate only one SM100.

2000-series weather stations
(models 2550, 2700, 2900)
Require firmware version 6.1 or greater. Models with serial number 2310 or greater were manufactured to accommodate the SM100 on all available channels. Compatible meters will have a “w” in the manufacturing code that accompanies the serial number.
(model 2800)
Similar to other weather stations, but requires firmware version 2.4.

Early 2000-series weather stations
2000-series weather stations with serial numbers earlier than 2310 can accommodate only two SM100's. The limitation is that only one sensor can be on ports C through F. The other sensor can be on ports A or B (or G or H in the case of a model 2800 station). Earlier versions of the 200-series mini stations can accommodate one SM100 sensor. The firmware requirements for SM100-compatible stations still apply.

Original WatchDog weather stations (models 525, 550, 600, 700, and 900) and 200- and 400- series purple loggers
Incompatible

Checking the Sensor

The calibration equation for the SM100 was developed using mineral soils. Therefore the sensor will not give a value of 100% in water. To check if the sensor electronics are still functioning properly, they may be checked in the following media:

<u>Air</u>
In air, the sensor should read a VWC of 0%.

<u>Water</u>
In distilled water, the sensor should read a VWC of about 48%.

<u>Saturated Playground Sand</u>
Add water to playground sand until the surface glistens and no additional water can permeate the sand. The sensor should read a VWC of about 29%.

Installation

The most important consideration for installing the sensors is maintaining good contact between the sensor and the soil. This ensures optimum performance.

Surface Installation

If the sensor is being installed near the surface such that the molding and cable will remain above the soil surface the sensor can usually be pushed directly into the soil. Do not strike the sensor with a hammer or other blunt instrument as this could damage the sensor electronics. If the soil is very hard, a small slit can be dug into the soil with a knife or shovel to allow easier insertion. Pushing that same implement into the ground surrounding the sensor will improve the contact between soil and sensor.

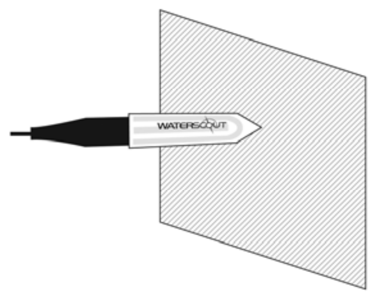
Deep Installation

Vertical Orientation

To install the sensor in a vertical orientation, dig an access hole to the desired depth. This can be done with a soil sampler, auger or metal rod. If possible, it is recommended that the hole be at a slight angle. This will reduce the effect of water channeling down to the sensor via the sensor cable.

The sensor blade is 3/4” while the molding is 5/8”. Therefore, there is a small lip on either side of the molding. This allows the sensor to be installed with a pipe or tube. An insertion tool can be made from ½” Class 315 PVC pipe. However, any material that fits over the molding and butts up against the base of the sensor may be used. The advantage of an insertion tool is that it allows the sensor to be pushed into undisturbed soil at the bottom of an access hole. If the fit between the sensor and the insertion tool is excessively snug, a dowel rod can be used to ensure the sensor is not withdrawn from the access hole along with the insertion tool. If the native soil at the depth of insertion is especially hard or gravel/stone-laden, it may be necessary to return a small amount of native soil into the access hole, tamp it sufficiently and use the insertion device to push the SM100 into the packed soil. The access hole should then be carefully backfilled with native soil and tamped down to eliminate air pockets.

Horizontal Orientation



Digging a small hole or trench in the soil allows the sensors to be installed horizontally. The sensors are pushed directly into the exposed face of undisturbed soil. To limit the effect of water moving vertically through the soil profile, the sensors should be installed so the flat face is perpendicular the soil surface. For the same reason, if sensors are installed at multiple depths, they should be offset from one another.

Removal

Care should be taken when removing a sensor that is firmly embedded in soil. Pull on the molding only. Pulling on the cable risks damaging the wiring.

Volumetric Water Content

The WaterScout SM100 measures volumetric water content. The volumetric water content (VWC) is the ratio of the volume of water in a given volume of soil to the total soil volume. At saturation, the volumetric water content (expressed as a percentage) will equal the percent pore space of the soil.

In-field soil moisture content will range from air-dry to saturation. However, plants cannot extract all the water in a saturated soil and can extract none of the water in an air-dry soil. Instead, two other moisture content levels, **field capacity** and **permanent wilting point** are often used to indicate the upper and lower limit of **plant available water**. Field capacity is defined as the condition that exists after a saturated soil is allowed to drain to the point where the pull of gravity is no longer sufficient to remove any additional water. Water draining from a soil profile cannot, in general, be taken up by plant roots. On the opposite end of the spectrum, permanent wilting point is the highest moisture level at which an indicator plant cannot recover turgor after being placed in a humid environment.

Irrigation should be scheduled somewhere between these two extremes. One rule of thumb is to apply water when half the plant available water has been depleted. However, individual circumstances may dictate a more conservative or liberal approach. Figure 1 illustrates the plant available water range for the 12 USDA-defined soil textures. Keep in mind that these numbers are merely guidelines and will vary for individual soils.

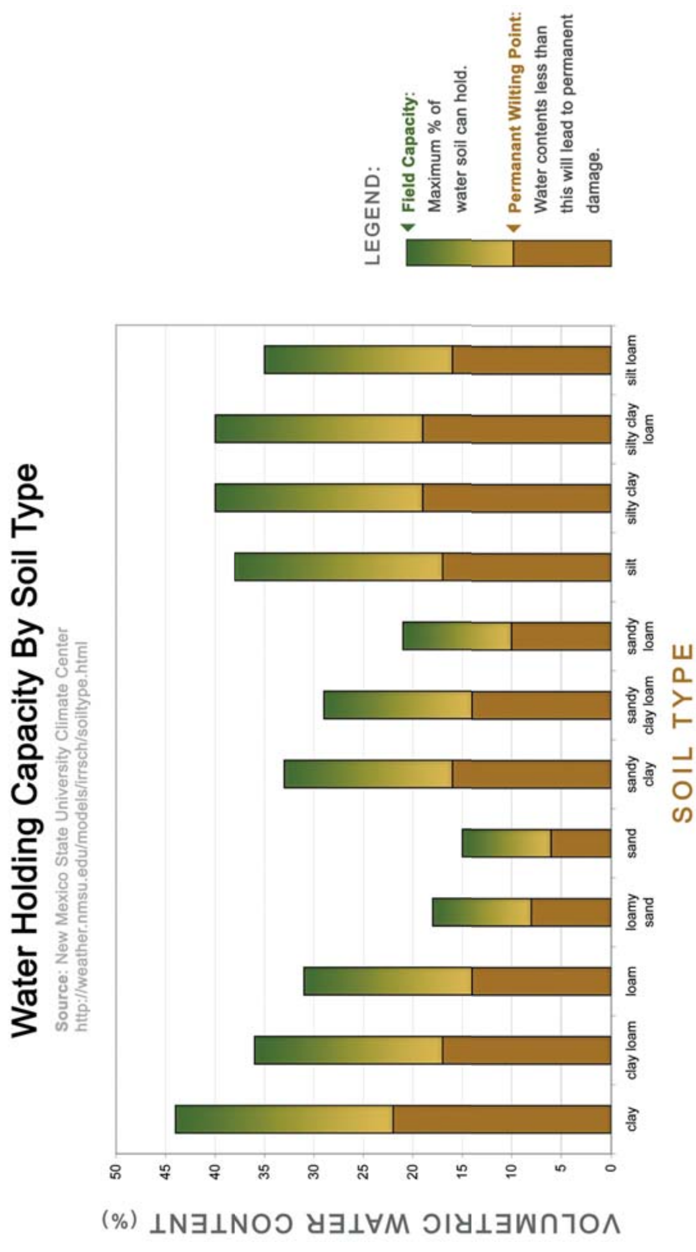

Water Holding Capacity By Soil Type
Source: New Mexico State University Climate Center
http://weather.nmsu.edu/models/irrsch/soiltype.html
VOLUMETRIC WATER CONTENT (%)
50
45
40
35
30
25
20
15
10
5
0
clay
clay loam
loam
loamy sand
sand
sandy clay
sandy clay loam
sandy loam
silt
silty clay
silty clay loam
silt loam
SOIL TYPE
LEGEND:
Field Capacity: Maximum % of water soil can hold.
Permanant Wilting Point: Water contents less than this will lead to permanent damage.

Figure 1.

Soil-Specific Calibration

In some instances, greater accuracy is desired than can be obtained from a general calibration equation. In this case, it is necessary to perform a calibration on your unique soil. Essentially, a relation needs to be developed that relates the meter's electronic reading to the actual volumetric water content (VWC). This will require that some other method be used to measure the VWC. VWC data can be measured in a lab setting by measuring the weight of a perforated soil column of known volume that is saturated, drained and dried. This method is preferred because the soil structure is not altered during the testing procedure. This procedure requires a weighing scale, a soil container with a height slightly greater than the WaterScout sensor (2 inches) and, depending on the ambient drying conditions, can take several weeks to complete. The procedure is briefly outlined below. WaterScout readings can be taken either with the Soil Sensor Reader or a WatchDog weather station. In either case, the device should be set to raw (or A/D) mode.

1. Build a small container to hold the soil from a non-metallic material such as PVC. The sensitive volume of the sensor is not large so the container diameter does not have to be very big. In fact, soil-moisture gradients will form in the container as it dries so, unless several sensors will be used in the calibration, a small container will provide the best results. Cap the bottom of the container and drill holes in the cap and on the container's sides that will allow water to permeate and drain as well as facilitate drying but will not allow soil to spill or leak out. Drilling the holes at a slight downward angle will minimize spillage.

2. Measure the mass of the empty container and the sensor or sensors being used in the calibration.

3. Determine the volume of the container. This can be done geometrically or by measuring the volume of sand needed to completely fill the container.

4. Fill the container with air-dry, sieved soil.

5. Take a reading of the sensor in air, install the sensor in the dry soil, and take the air-dry reading.

6. Place the container (with sensor installed) in a larger receptacle and add distilled water around the OUTSIDE of the container until the water level reaches the top of the container. Allow the container to completely saturate. Take a sensor reading.

7. Transfer the container to the scale and measure the mass. It is advisable to have a tray to hold the container to keep water from spilling on the bench. Be sure to tare out the weight of the tray.

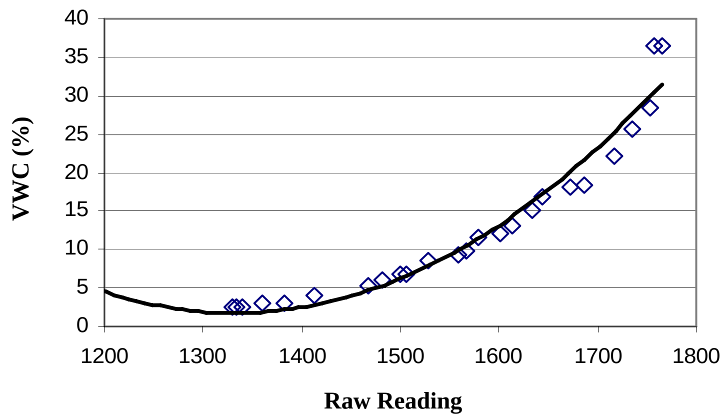
At this point, the procedure is to simply allow the container to dry while periodically taking simultaneous weight and sensor readings. Initially, the container will dry rapidly and 2 or 3 readings per day may be appropriate. As the container gets dryer, it will dry more slowly and the frequency of measurements will decrease. When the container returns to its air-dry value, the soil should be removed, oven-dried at 105 ºC for 24 to 48 hours and allowed to cool in a sealed container before measuring the oven dry weight (ODWt).

The volumetric water content at each data point is calculated as follows:

1) $VWC_i = 100*(m_i - m_{dry})/(\rho_w*V_{tot})$

m_i = mass of soil at a given point during drydown (grams)
m_{dry} = mass oven-dry dry soil (grams)
V_{tot} = total soil volume (ml)
ρ_w = density of water (1g/ml)

These calculations can easily be set up in a spreadsheet. The final step is to perform a regression between the raw data and the calculated VWC values. Regression analysis can then be performed on raw sensor data and the calculated VWC values to develop an equation to convert from measured readings to actual VWC.



A calibration curve can also be obtained by gradually wetting a pre-measured amount of soil with known increments of water. Care must be taken to return the soil to its original bulk density before a sensor reading is made.

Warranty

The WaterScout SM100 Soil Moisture Sensor is warranted to be free from defects in materials and workmanship for a period of 1 year from the date of original purchase. During the warranty period, Spectrum will, at its option, either repair or replace products that prove to be defective. This warranty is void if the product has been damaged by customer error or negligence, or if there has been an unauthorized modification.

Returning Products to Spectrum

Before returning a failed unit, you must obtain a Returned Goods Authorization (RGA) number from Spectrum. You must ship the product(s), properly packaged against further damage, back to Spectrum (at your expense) with the RGA number marked clearly on the outside of the package. Spectrum is not responsible for any package that is returned without a valid RGA number or for the loss of the package by any shipping company.

Spectrum Technologies, Inc.
12360 S. Industrial Dr. East
Plainfield IL 60585
(800) 248-8873 or (815) 436-4440
Fax (815) 436-4460
E-Mail: info@specmeters.com
www.specmeters.com

Spectrum

Technologies, Inc.

12360 S. Industrial Dr. East
Plainfield, IL 60585
(800) 248-8873 or (815) 436-4440
FAX: (815) 436-4460
E-Mail: info@specmeters.com
www.specmeters.com