Interpreting Watermark Sensor / Hansen AM 400 Data Logger Readings

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Introduction

The Watermark granular matrix sensor is essentially an electrical resistance block, surrounded by sand of a specific size, contained by a stainless steel mesh. Water in the soil comes to equilibrium with the pores in the sand and the gypsum block. The electrical resistance of the block is related to the soil matric potential (the energy the plant must exert to remove water from the soil), expressed in centibars (cb). A potential near zero indicates that the soil is nearly saturated, and therefore almost no energy is required to remove water. As the soil dries due to plant water use or evaporation, the centibar readings rise. When the readings reach a threshold value unique for each plant and soil texture, irrigation is required or the plant will be excessively water-stressed. Approximate volumetric soil water content can also be obtained from soil-specific water content vs. matric potential relationships. Many users glue a length of ½ inch PIP PVC pipe to the base of the sensor as an aid in installation and removal, and as a way to protect the sensor cable.

The Hansen AM 400 data logger is designed to function specifically with watermark sensors to determine, display, and record soil matric potential values from six sensors. The sensors are connected to the data logger with 4-pair CAT 3 or CAT 5e data cable. Sensors can be located up to 1000 feet from the data logger, and can be placed at any location and depth, as desired. A typical installation might be sensors at 1, 2, and 3 feet at two locations within the field. In this arrangement, the 1- and 2-foot sensors are used for irrigation scheduling, and the 3-foot sensors are used to indicate either inadequate irrigation (drying over time) or excess irrigation (a sudden increase in soil moisture after an irrigation). With the default interval of 8 hours, the data logger can display the previous 5 weeks' data for each sensor. This allows both current readings and long-term patterns in water content to be displayed on demand in the field without a required download to another device. When configured in the 8-hour reading interval, the data logger has sufficient storage to store data for an entire field season without downloading.

Sensor Installation

Proper sensor installation is the most critical factor in achieving success with this system. Because soil water moves in and out of the sensor pores as the soil wets and dries, good soil/sensor contact must be maintained. Three installation techniques have been used to achieve good contact. In the first, a soil probe nearly the same diameter as the sensor is used to excavate a hole to the desired depth. A slurry, composed of excavated soil and water, is added to the hole to about a 4-inch depth. The sensor is then inserted to depth, and soil firmed around the PVC pipe at the soil surface.

The second method involves excavating a larger diameter hole with a soil auger, installing the sensor at the correct depth, and refilling and compacting the soil in the hole to give proper contact. This method works better in rocky soil and gives excellent contact. However, care must be taken to prevent over-compaction of the area surrounding the sensor, which will cause the soil to respond in a different manner and will not be representative of field conditions.

The third method, which is effective for moist soil in shallow installations, is to drive a pointed steel rod with a diameter slightly smaller than that of the sensor into the ground. The rod is removed, a small amount of water added to the hole to help establish good soil contact, and the sensor inserted to the correct depth. Again, local compaction due to insertion of the rod may modify soil properties. Additional information on sensor installation is available in University of Idaho CIS 1140 “Sugarbeet Irrigation Management Using Watermark Moisture Sensors”

Data Interpretation

Current values: Watermark readings of near zero are common in the top foot following an irrigation. The soil is nearly saturated and will drain to field capacity in about 1 day on sandy soils and in 2-3 days for silt loam and clay soils. Field capacity for sandy soils is about 10 cb and 25-30 cb for silt loam, etc. Relationships between watermark readings, percent available water, and water required to refill 1 ft to field capacity are shown in Tables 1-5. General interpretations of watermark or tensiometer readings for water-sensitive and other crops are given on the right side of Tables 1-5.

Trends Over Time

One of the advantages of having multiple readings over a short period of time is the ability to detect additional soil water information. A number of examples are shown below for June 2003 winter wheat data at Kimberly. Note that soil moisture stayed constant in the second and third foot until about June 18, indicating no water use or recharge until that time. Irrigation was stopped on this plot on June 24, so the crop began using water from the second foot as the first foot dried out.

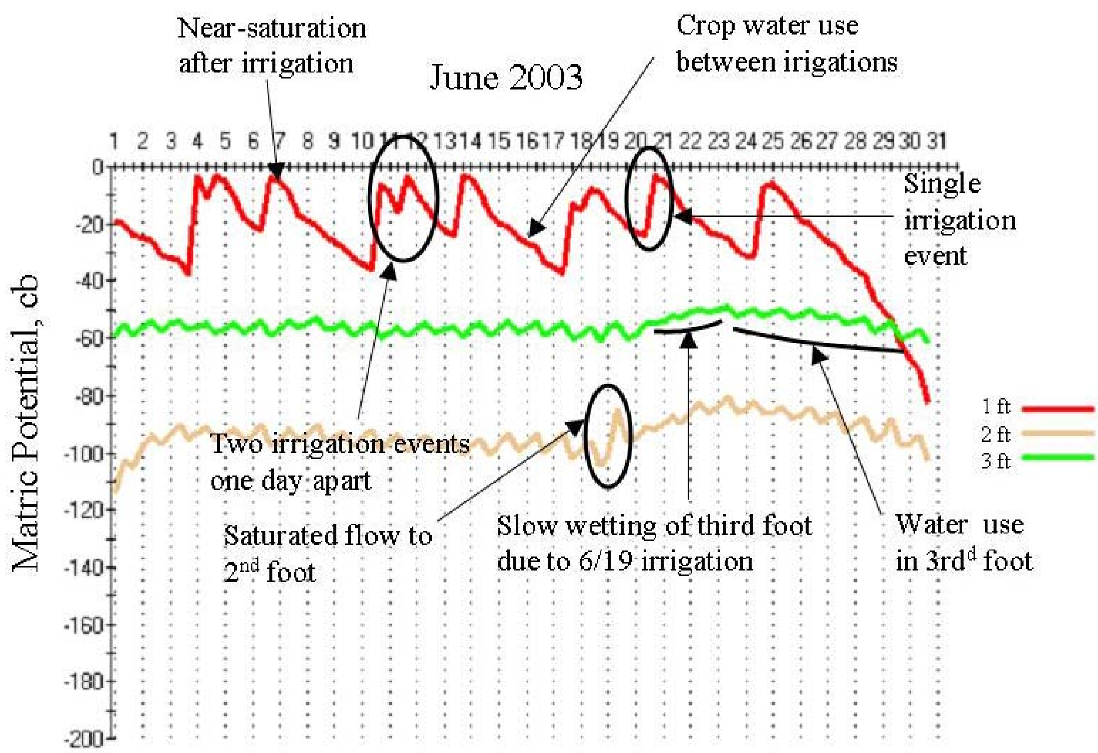

Table 1. Relationship between watermark or tensiometer readings and percent available soil water for a sandy loam soil.

Sandy Loam (1.67 in/ft):

Percent Available Soil Water	Water-mark Reading cbars	Inches to refill 1 ft of soil **pivot or linear**	Inches to refill 1 ft of soil **hand or wheel line**
100	10	0	0
85	12	0.32	0.36
80	14	0.42	0.48
75	16	0.52	0.6
70	18	0.63	0.72
65	20	0.73	0.84
60	24	0.84	0.95
55	27	0.94	1.07
50	30	1.04	1.19
40	43	1.25	1.43
30	71	1.46	1.67
Percent Available Soil Water	Water-mark Reading cbars	Inches to refill 1 ft of soil **pivot or linear**	Inches to refill 1 ft of soil **hand or wheel line**

Sandy Loam (1.67 in/ft):
(Potatoes, Mint, Onions, Dry Beans)
0 Saturated soil
0-10 Leaching Possible
10-24 Best Crop Growth
>24 Crop Water Stress

Sandy Loam (1.67 in/ft):
(Alfalfa, Beets, Grain, Corn, Pasture)
0 saturated soil
0-10 Leaching Possible
10-30 Best Crop Growth
>30 Crop Water Stress

Table 2. Relationship between watermark or tensiometer readings and percent available soil water for a Light-Textured Silt Loam soil.

Light-Textured Silt Loam (1.97 in/ft):

Percent Available Soil Water	Water-mark Reading cbars	Inches to refill 1 ft of soil **pivot or linear**	Inches to refill 1 ft of soil **hand or wheel line**
100	10	0	0
85	12	0.32	0.36
80	14	0.42	0.48
75	16	0.52	0.6
70	18	0.63	0.72
65	20	0.73	0.84
60	24	0.84	0.95
55	27	0.94	1.07
50	30	1.04	1.19
40	43	1.25	1.43
30	71	1.46	1.67
Percent Available Soil Water	Water-mark Reading cbars	Inches to refill 1 ft of soil **pivot or linear**	Inches to refill 1 ft of soil **hand or wheel line**

Light-Textured Silt Loam (1.97 in/ft):
(Potatoes, Mint, Onions, Dry Beans)
0 Saturated soil
0-10 Leaching Possible
10-25 Best Crop Growth
>25 Crop Water Stress

Light-Textured Silt Loam (1.97 in/ft):
(Alfalfa, Beets, Grain, Corn, Pasture)
0 Saturated soil
0-10 Leaching Possible
10-40 Best Crop Growth
>40 Crop Water Stress

Table 3. Relationship between watermark or tensiometer readings and percent available soil water for a Heavier-Textured Silt Loam soil.

Heavier-Textured Silt Loam (2.25 in/ft):

Percent Available Soil Water	Water-mark Reading cbars	Inches to refill 1 ft of soil **pivot or linear**	Inches to refill 1 ft of soil **hand or wheel line**
100	10	0	0
85	12	0.32	0.36
80	14	0.42	0.48
75	16	0.52	0.6
70	18	0.63	0.72
65	20	0.73	0.84
60	24	0.84	0.95
55	27	0.94	1.07
50	30	1.04	1.19
40	43	1.25	1.43
30	71	1.46	1.67
Percent Available Soil Water	Water-mark Reading cbars	Inches to refill 1 ft of soil **pivot or linear**	Inches to refill 1 ft of soil **hand or wheel line**

Heavier-Textured Silt Loam (2.25 in/ft):
(Potatoes, Mint, Onions, Dry Beans)
0 Saturated soil
0-30 Leaching Possible
30-62 Best Crop Growth
>62 Crop Water Stress

Heavier-Textured Silt Loam (2.25 in/ft):
(Alfalfa, Beets, Grain, Corn, Pasture)
0 Saturated soil
0-30 Leaching Possible
30-75 Best Crop Growth
>75 Crop Water Stress

Table 4. Relationship between watermark or tensiometer readings and percent available soil water for a Loam soil.

Loam (1.41 in/ft):

Percent Available Soil Water	Water-mark Reading cbars	Inches to refill 1 ft of soil **pivot or linear**	Inches to refill 1 ft of soil **hand or wheel line**
100	10	0	0
85	12	0.32	0.36
80	14	0.42	0.48
75	16	0.52	0.6
70	18	0.63	0.72
65	20	0.73	0.84
60	24	0.84	0.95
55	27	0.94	1.07
50	30	1.04	1.19
40	43	1.25	1.43
30	71	1.46	1.67
Percent Available Soil Water	Water-mark Reading cbars	Inches to refill 1 ft of soil **pivot or linear**	Inches to refill 1 ft of soil **hand or wheel line**

Loam (1.41 in/ft):
(Potatoes, Mint, Onions, Dry Beans)
0 Saturated soil
0-20 Leaching Possible
20-45 Best Crop Growth
>45 Crop Water Stress

Loam (1.41 in/ft):
(Alfalfa, Beets, Grain, Corn, Pasture)
0 Saturated soil
0-20 Leaching Possible
20-58 Best Crop Growth
>58 Crop Water Stress

Table 5. Relationship between watermark or tensiometer readings and percent available soil water for a Fine Sand.

Fine Sand (0.6 in/ft):

Percent Available Soil Water	Water-mark Reading cbars	Inches to refill 1 ft of soil **pivot or linear**	Inches to refill 1 ft of soil **hand or wheel line**
100	10	0	0
85	12	0.32	0.36
80	14	0.42	0.48
75	16	0.52	0.6
70	18	0.63	0.72
65	20	0.73	0.84
60	24	0.84	0.95
55	27	0.94	1.07
50	30	1.04	1.19
40	43	1.25	1.43
30	71	1.46	1.67
Percent Available Soil Water	Water-mark Reading cbars	Inches to refill 1 ft of soil **pivot or linear**	Inches to refill 1 ft of soil **hand or wheel line**

Fine Sand (0.6 in/ft):
(Potatoes, Mint, Onions, Dry Beans)
0 Saturated soil
0-10 Leaching Possible
10-18 Best Crop Growth
>18 Crop Water Stress

Find Sand (0.6 in/ft):
(Alfalfa, Beets, Grain, Corn, Pasture)
0 Saturated soil
0-10 Leaching Possible
10-25 Best Crop Growth
>25 Crop Water Stress