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-UPDATE-

IA SOIL MOISTURE SENSOR PROTOCOL TO MANAGE IRRIGATION EVENTS

By

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It is estimated that typical residential landscapes apply 30 to 40% more water than is required by the plants.

Introduction

- The Irrigation Association (IA) through its Smart Water Applied Technology ™ (SWAT)™ effort has been a pioneer in developing an independent third party testing protocol designed to evaluate control systems that "automatically" adjust irrigation events.

- This nationally recognized effort initially focused on "smart" climatologically-based controllers but more recently developed a second protocol for Soil moisture based controllers as well.

Introduction cont'd…

- This presentation will discuss the methods and outcomes derived from utilizing the new IA protocol based on soil moisture sensor response curves used to manage irrigation events.

- We plan to discuss the areas of comparability and limitations of results to those produced by "smart" climatologically-based controllers.

“SMART” Soil Moisture Sensor (SMS) based controllers

Phase Ⅰ: Laboratory Screening

SMS Based Protocol

- Over the past 10 years, the Center for Irrigation Technology, CSU Fresno, has been working closely with water purveyors statewide and the Irrigation Association as part of their “Smart Water Application Technology” (SWAT) to develop the SMS based protocol.

- ✓ **Phase 1-** Lab Test for the sensors.
- ✓ **Phase 2-** Virtual Test of the Controller w/sensor

Phase 1:Sensor Testing

- Following extensive review and revisions by industry personnel, academics and water purveyors, a **“Soil Moisture Sensor Based Controller Protocol”** is available for application on commercially available moisture sensors.

http://www.irrigation.org/gov/swat_drafts-soil/

Objective of Phase 1

- Apply 8th Draft Protocol to test the ability of sensors to provide reliable results during multiple wetting cycles for various soil types, soil temperature and water salinity levels.

Materials and Methods

Manufacturer submits 20 sensors & 3 read-out devices

Laboratory Tests :

- Sensors were setup in rectangular boxes filled with soil of known bulk densities.
- Initial soil properties : texture; oven dried; EC less than 2 dS/m; and pH=6.8

Fig1: Oven Dried soils being weighed.

Fig2: Sensor being placed in the box.

Methods cont'd...

- Soil was wetted up to saturation from the bottom of the box to limit air entrapment.
- Allowed to free drain to field capacity.
- Weighed periodically to determine the gravimetric and volumetric water content.

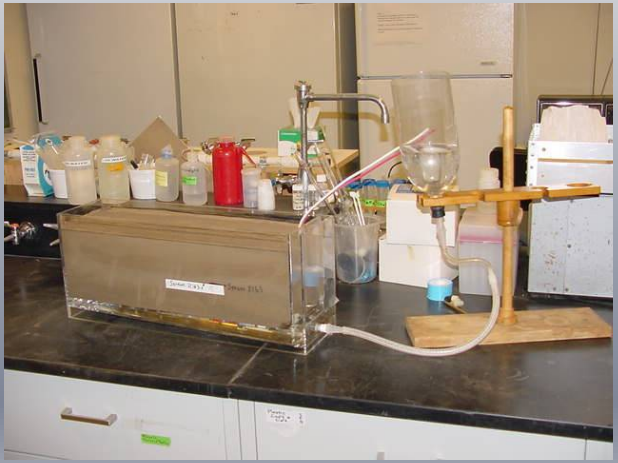


Fig3: Wetting of the soils box.

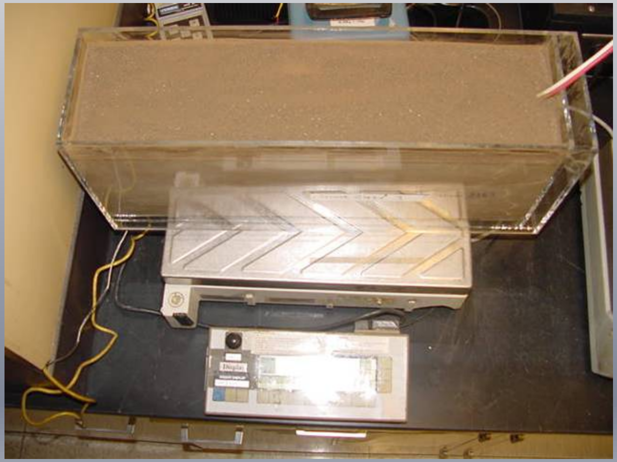


Fig4: Soil box being weighed.

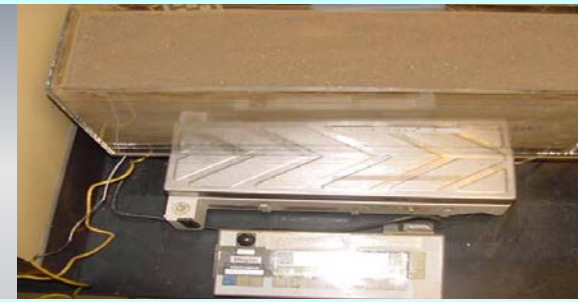
Methods cont’d

- Tests conducted at average 15° C, 25° C and 35 °C >and one below freezing conditions: -5° C
- Sensors were subjected to application of DI and saline water of 2.5 and 5.0 dS/m
- Calculated volumetric soil moisture were compared with values obtained from computer readouts.

Oven Dried soil being weighed.

Example of Sensor and datalogger

Wetting of the soil box



Soil boxes being weighed

Soil boxes in environmental chamber

Downloading data

Methods cont'd

Sub-Clause	Subject of Test	No. of tests	Days
7.2.1	Calibration in a fine textured soil with 0dS/m water	3	35
7.2.2	Calibration in a medium textured soil with 0dS/m water	3	25
7.2.3	Calibration in a coarse textured soil with 0dS/m water	3	20
7.3.1	Calibration at 15°C with 0dS/m water	2	25
7.3.2	Calibration at 35°C with 0dS/m water	2	25
7.3.3	Test for freezing (-5°C)susceptibility with 0dS/m water	2	45
7.4.1	Calibration when wetted with water with a conductivity of 2.5 dS/m on a fine textured soil	2	35
7.4.2	Calibration when wetted with water with a conductivity of 5 dS/m on a fine textured soil	2	35
7.5.1	Calibration when wetted with water with a conductivity of 2.5 dS/m on a coarse textured soil	2	20
7.5.2	Calibration when wetted with water with a conductivity of 5 dS/m on a coarse textured soil	2	20
7.6.1	Verification of performance when the sensor is subjected to standard conditions for a total of six wet/dry cycles in a medium textured soil.	2	140

Table 1: Summary of number of days needed to complete tests outlined in SWAT 4th Draft Testing Protocol.

Methods cont'd

Class	Sand	Silt	Clay
Coarse (Loamy Sand)	85%	5%	10%
Medium (Sandy Loam)	70%	15%	15%
Fine (Clay)	45%	10%	45%

Table 2: Soil Textures for Coarse, Medium and Fine Soils

Example Output from *Phase* / Protocol

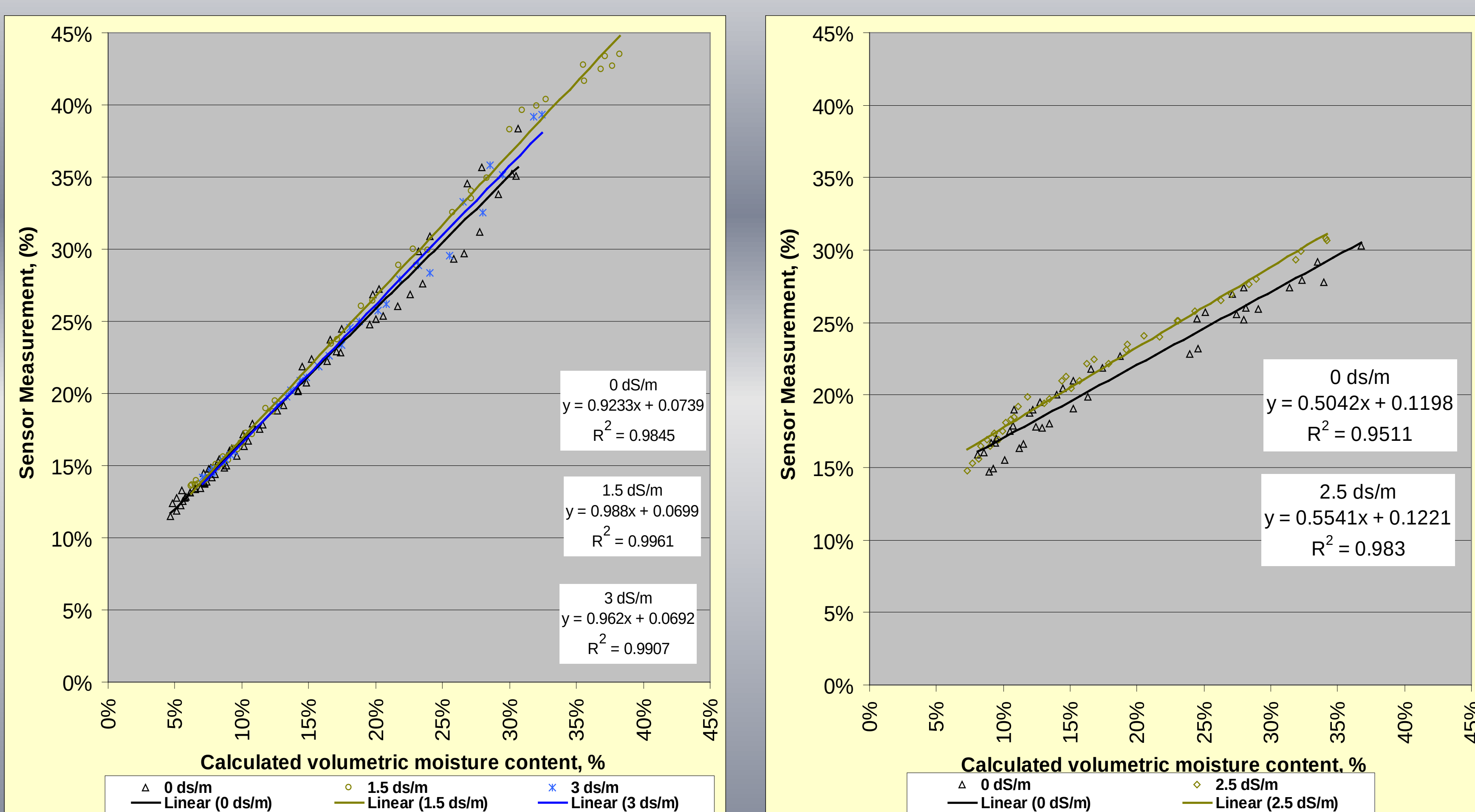


Figure 5: Relationship between volumetric water contents measured with a **Time Domain Transmissivity (TDT)** based soil moisture sensor (Y-axis) and that calculated using the gravimetric water content and bulk density of the soil (X-axis) for Coarse Textured soils using draft 4 and 8 protocol.

Results

- To date 8 sensors have completed testing under phase 1.
- Currently 2 more sensors are being tested.
- Summary result of testing can be found at:

http://www.irrigation.org/swat/control_sensor/

Phase II: Virtual Landscape

Objectives of Phase 2 Protocol

- The objective of this protocol is to evaluate how well current soil moisture technology integrates into a practical control system that meets the agronomic needs of the turf and landscape plants.
- This is the first step in an evaluation procedure that must also eventually include other secondary considerations that affect market acceptance.

Introduction

- This protocol is designed to test the efficacy of a soil moisture sensor-based controller suitable for use with residential and light commercial irrigation systems under the following conditions:
  - ✓ The system must function without human intervention.
  - ✓ The system must provide high levels of irrigation adequacy and scheduling efficiency
  - ✓ Function over a wide range climate, plant material, topology, soils and water quality.

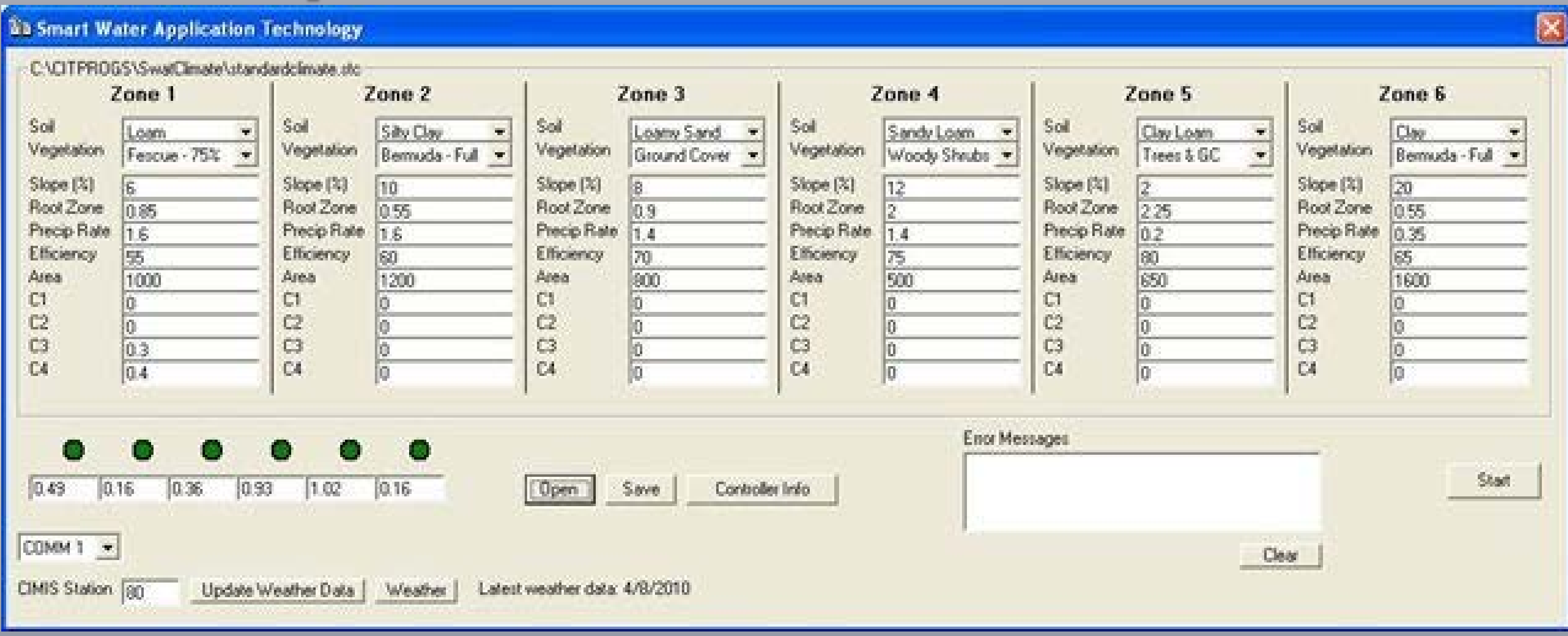
Materials and Methods

- This evaluation is accomplished by creating a "virtual electronic" landscape.
- The virtual electronic landscape is subjected to representative climate and six different zones.
- The six different zones mimic various soil texture; temperature; water quality; slope; exposure to sun; root zone storage & depth; vegetation; crop coefficient; irrigation system; precipitation rate; application efficiency & area.

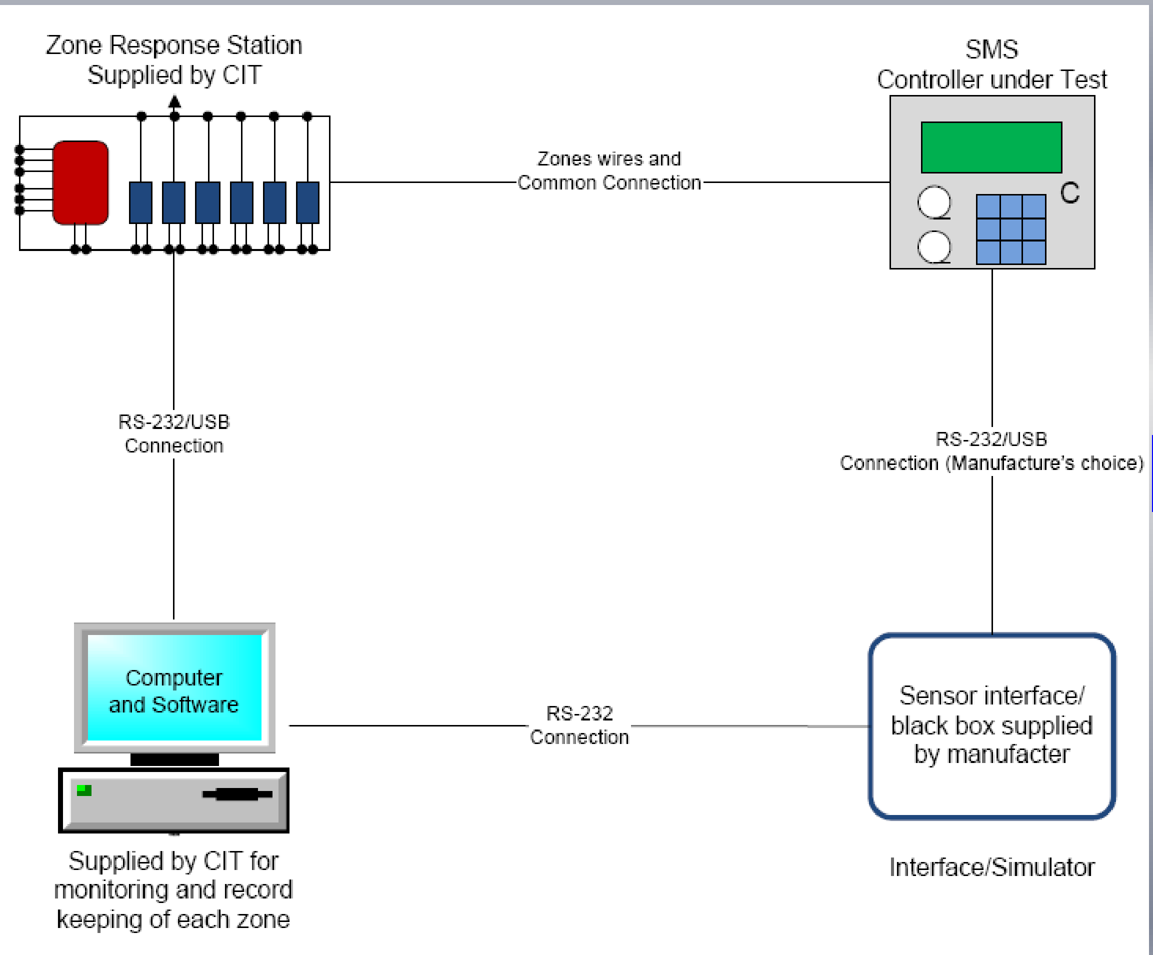
Materials and Methods cont'd…

- Phase I response curves data is used during this evaluation.
- An electronic computer interface to create the virtual electronic yard.
- A properly sited weather station with quality assurance data will be used to provide the moisture balance calculation required for this evaluation.

Zone Inputs


Smart Water Application Technology
C:\CITPROGS\SwatClimate\standardclimate.stc
Zone 1
Soil Loam
Vegetation Fescue - 75%
Slope (%) 6
Root Zone 0.85
Precip Rate 1.6
Efficiency 55
Area 1000
C1 0
C2 0
C3 0.3
C4 0.4
Zone 2
Soil Silty Clay
Vegetation Bermuda - Full
Slope (%) 10
Root Zone 0.55
Precip Rate 1.6
Efficiency 60
Area 1200
C1 0
C2 0
C3 0
C4 0
Zone 3
Soil Loamy Sand
Vegetation Ground Cover
Slope (%) 8
Root Zone 0.9
Precip Rate 1.4
Efficiency 70
Area 800
C1 0
C2 0
C3 0
C4 0
Zone 4
Soil Sandy Loam
Vegetation Woody Shrubs
Slope (%) 12
Root Zone 2
Precip Rate 1.4
Efficiency 75
Area 500
C1 0
C2 0
C3 0
C4 0
Zone 5
Soil Clay Loam
Vegetation Trees & GC
Slope (%) 2
Root Zone 2.25
Precip Rate 0.2
Efficiency 80
Area 650
C1 0
C2 0
C3 0
C4 0
Zone 6
Soil Clay
Vegetation Bermuda - Full
Slope (%) 20
Root Zone 0.55
Precip Rate 0.35
Efficiency 65
Area 1600
C1 0
C2 0
C3 0
C4 0
0.49 0.16 0.36 0.93 1.02 0.16
Open
Save
Controller Info
Error Messages
Start
Clear
COMM 1
CIMIS Station 80
Update Weather Data
Weather
Latest weather data: 4/8/2010

Phase II: Schematics



Irrigation Association - Smart Water Application Technology
Climatologically Based Controllers
Evaluation Protocol: 7th Draft (November, 2006)
International Center for Water Technology

Project Identification

Manufacturer	Black Box 1
Model Number	
Serial Number	
Evaluated By	JO
Date	October 1, 2010 - October 30, 2010
Weather Station	CIMIS 80
Reference No.	
Comments	

Input Data

Parameter	Zone #1	Zone #2	Zone #3	Zone #4	Zone #5	Zone #6
Soil Type	Loam	Silty Clay	Loamy Sand	Sandy Loam	Clay Loam	Clay
Vegetation	Fescue - 75%	Bermuda - Full	Ground Cover	Woody Shrubs	Trees & GC	Bermuda - Full
Slope, %	6.0	10.0	8.0	12.0	2.0	20.0
Root Zone Stor., in.	0.85	0.55	0.90	2.00	2.25	0.55
Precip Rate, in./h	1.60	1.60	1.40	1.40	0.20	0.35
Efficiency, %	55	60	70	75	80	65
Area, SQ-Ft	1000	1200	800	500	650	1600
Soil Intake Rate, in./h	0.35	0.15	0.50	0.40	0.20	0.10
ASA, in.	0.25	0.16	0.26	0.24	0.26	0.10
Max. Run Time, min.	12.0	6.6	17.3	14.4	N/A	24.0

Evaluation Summary

ETo, in.	3.64	3.64	3.64	3.64	3.64	3.64
ETc, in.	1.79	2.21	1.98	1.43	2.26	2.21
Gross Rainfall, in.	0.64	0.64	0.64	0.64	0.64	0.64
Net Rainfall, in.	0.52	0.52	0.52	0.52	0.52	0.52
Eff. Rainfall, in.	0.52	0.52	0.52	0.52	0.43	0.52
Gross Irr., in.	2.82	1.84	2.59	2.03	8.08	1.69
Direct Runoff, in.	0.00	0.00	0.00	0.00	0.00	0.00
Soak Runoff, in.	0.08	0.06	0.07	0.07	0.00	0.05
Effective Irr., in.	1.38	1.07	1.80	1.40	6.36	0.99
Deficit, in.	0.00	0.46	0.00	0.00	0.00	0.58
Surplus, in.	0.00	0.00	0.00	0.00	3.51	0.00
Irr. Adequacy, %	100.0	79.1	100.0	100.0	100.0	73.8
Sch. Eff., %	94.4	94.6	96.2	95.2	44.9	95.1
Overall Eff., %	51.9	56.8	67.4	71.4	35.9	61.8
Rainfall Eff., %	100.0	100.0	100.0	100.0	82.7	100.0
Cur. Moist. Bal., in.	0.61	0.18	0.71	1.51	2.25	0.18

Results and Discussion

<u>**Phase I:**</u>

- From the experiments conducted to date, most correlation equations for medium and coarse textured soils were obtained using a liner equation (r^2 range 0.99 to 0.60)
- In some cases: For fine textured soil a polynomial equation was obtained for best results.

Results and Discussion cont'd…

Phase II:

- Three different SMS Technology based controllers were tested. The following overall efficiency ranges were recorded:
  - ✓ Irrigation Adequacy: 100 to 73.8 %
  - ✓ Scheduling Efficiency: 100 to 25%
  - ✓ Overall Efficiency: 100 to 70%
  - ✓ Rainfall Efficiency: 100 to 80%

Conclusion and Future Work

- Using the technique of Virtual testing the test time will be reduced to 1 month or until the minimum rainfall requirement of 0.4 inches and reference ET of 2.5 inches is met.
- Most of the technical issues with regards to phase I testing protocol has been resolved and accommodated in the recent draft.
- All three electronic computer interface were build with different specification by each SMS manufacturer as a result we had to constantly change our testing system to accommodate these boxes.

Conclusion and Future Work

- The test data shown here are from the beta test, which is the first of its kind and hence bulk of the time was spent in integrating the various parts together and make it work.
- Future tests will emphasize on getting reasonable efficiency numbers, now that we have a better understanding of the whole system.
- And hence at this time the efficiency numbers from this beta test should not be compared with efficiency numbers obtained using the climatologically based controllers.

Thank You!

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