SWAT Testing:
Proposed Rain Sensor Protocol

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Outline

- Florida Central Ridge residential irrigation research
- Smart Controller research at UF
- Current rain sensor (RS) research at UF
- Proposed RS protocol

FLORIDA CENTRAL RIDGE RESIDENTIAL IRRIGATION RESEARCH

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T1

T1 = Existing landscape and irrigation, only monitored, 75% turfgrass

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T2

T2 = T1, but with a reduced irrigation schedule

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T3

T3 = T2 irrigation schedule and 65% of microirrigated ornamentals

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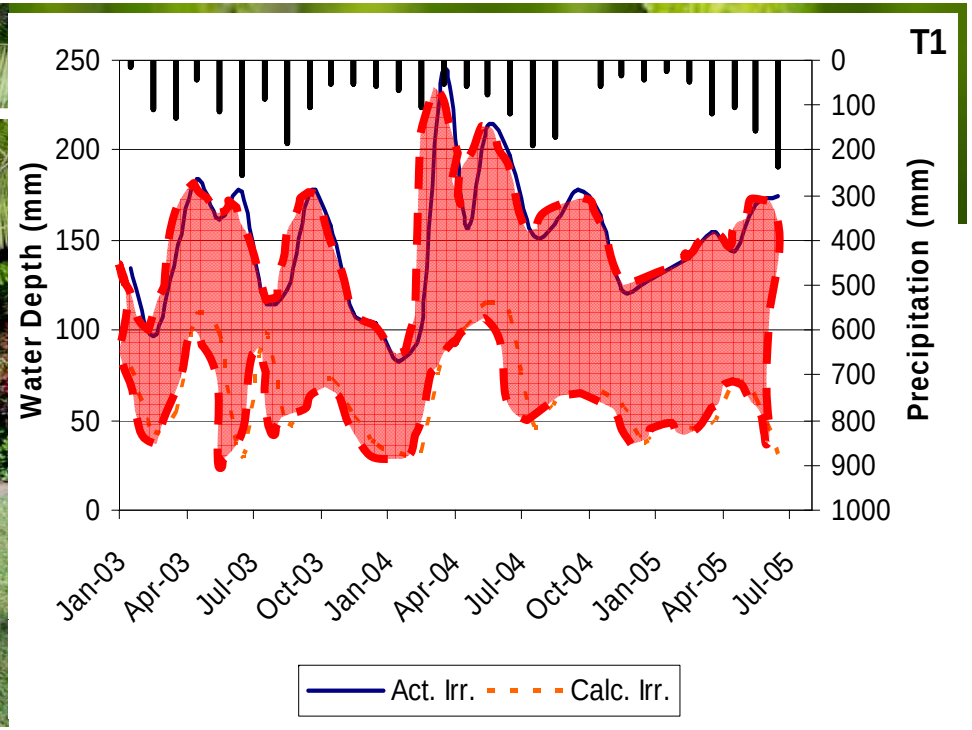
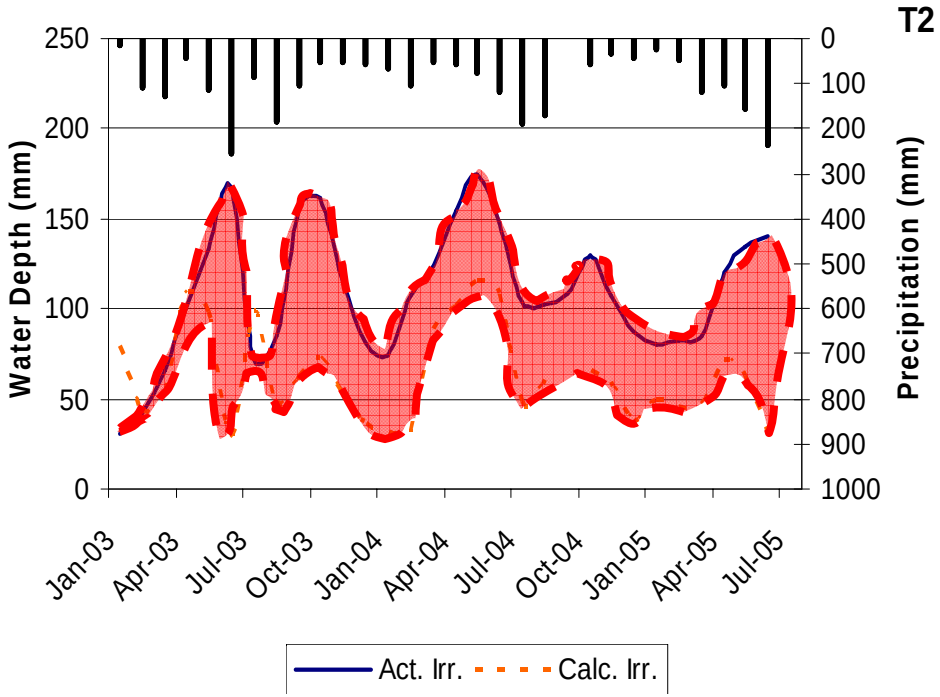
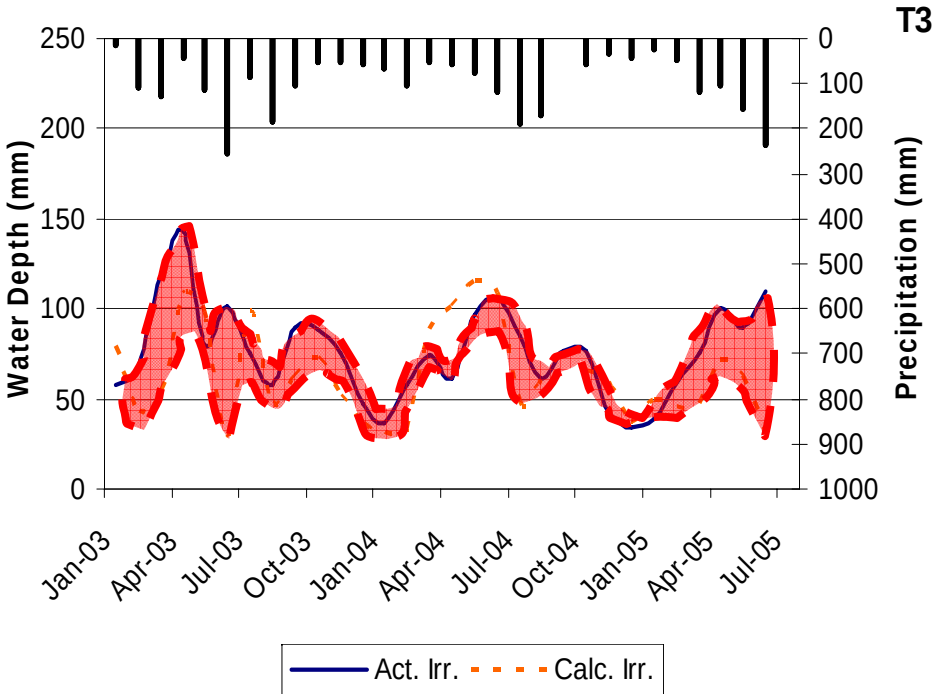
Irrigation Water Use - Conclusions

Significant reductions in water use (30% and 50%) can be achieved by irrigation scheduling (T2) and scheduling + landscape changes (T3)







SMART CONTROLLER TESTING AT UF

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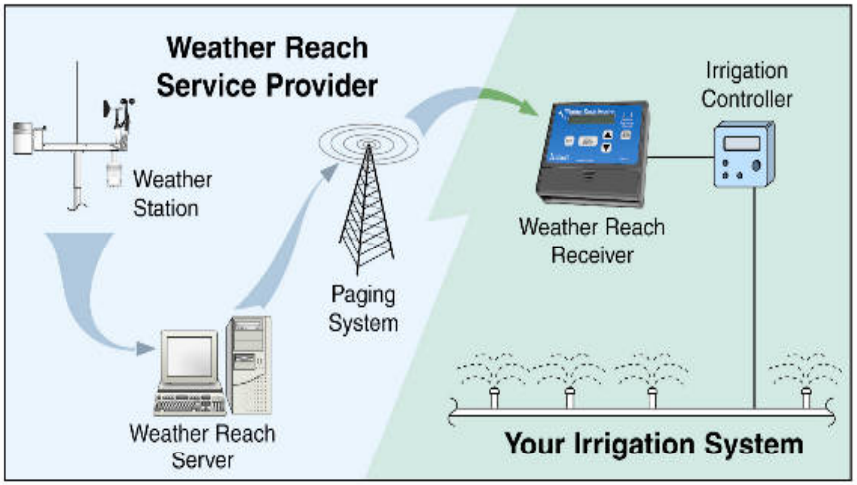
Smart Controller Testing

Soil moisture sensors (SMS)



Evapotranspiration (ET) based controllers

Current Landscape Irrigation Research

- SMS plots, Phase I, Gainesville (ABE Turfgrass Research Facility)
- SMS on cooperating homes Pinellas Co, Phase II
  - SWFWMD, FNGLA, FDACS, Pinellas Co Utilities
- SMS plots & ET controllers, Citra (Turfgrass Research Unit)
  - FNGLA, FTGA/GCSAA
- ET controller plots, GCREC Hillsborough Co.
  - Hillsborough Co Water, FDACS, FNGLA

Landscape Irrigation Research in Negotiation

- SMS plots & cooperating homes, Phase III
  - SWFWMD, FNGLA, FDACS, Pinellas Co Utilities
- Turfgrass, ornamental, mixed landscape crop coefficients and water requirements
  - SWFWMD, SJRWMD

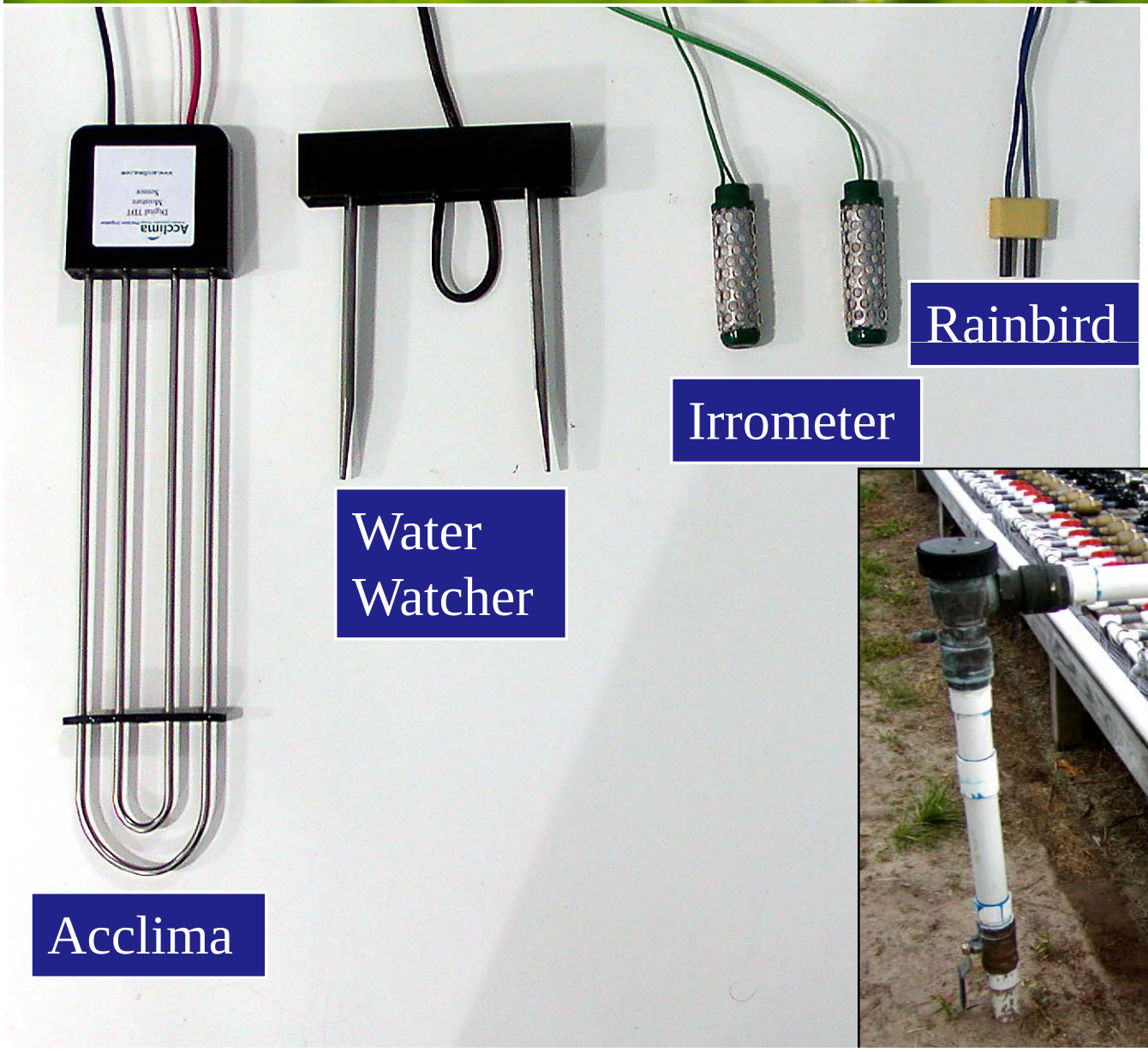
Soil Moisture Sensor Plots, Phase I, Gainesville

- 1 d/wk four brands SMS
- 2 d/wk four brands SMS
- 7 d/wk four brands SMS
- Time 2 d/wk with RS
- 60% of time 2 d/wk with RS
- Time 2 d/wk without RS
- Non-irrigated

3 SMS frequencies

Comparisons

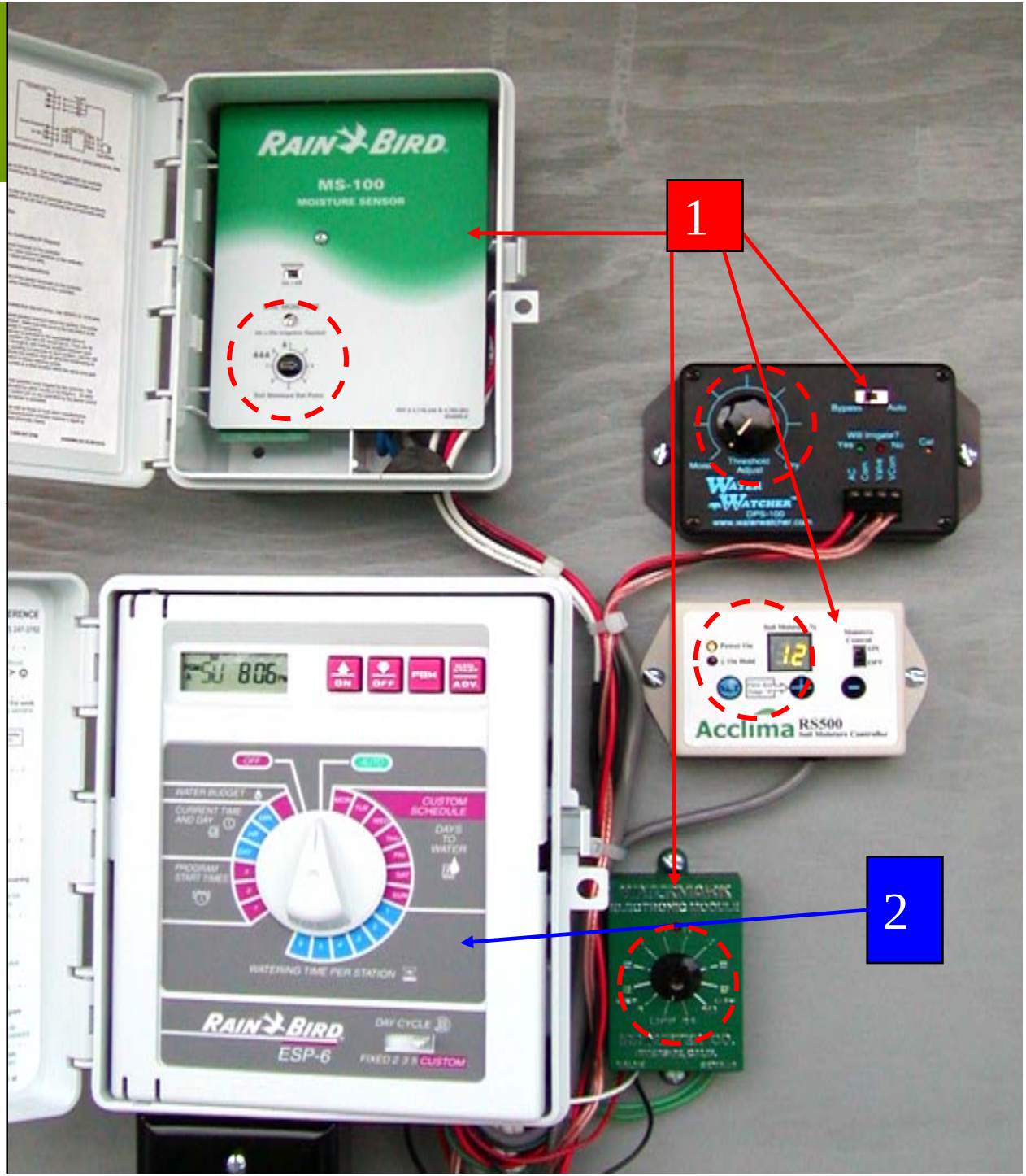
Soil Moisture Control Sensors



SMS Controllers in Experiment

1: Sensor Controllers

2:Timer



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Expanding Disk Rain Sensor

Set at 6 mm

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TIME vs. SMS Control 2004+05

Treatment	TOTAL (mm)*	Savings compared to 2-WORS (%)
2-WORS	1514	0
2-WRS	995	34
2-DWRS	623	59
Sms Avg	420	72

WORS = Without Rain Sensor

WRS = With Rain Sensor

DWRS = 60% of With Rain Sensor

Sms = Soil Moisture Sensors

Avg = Average

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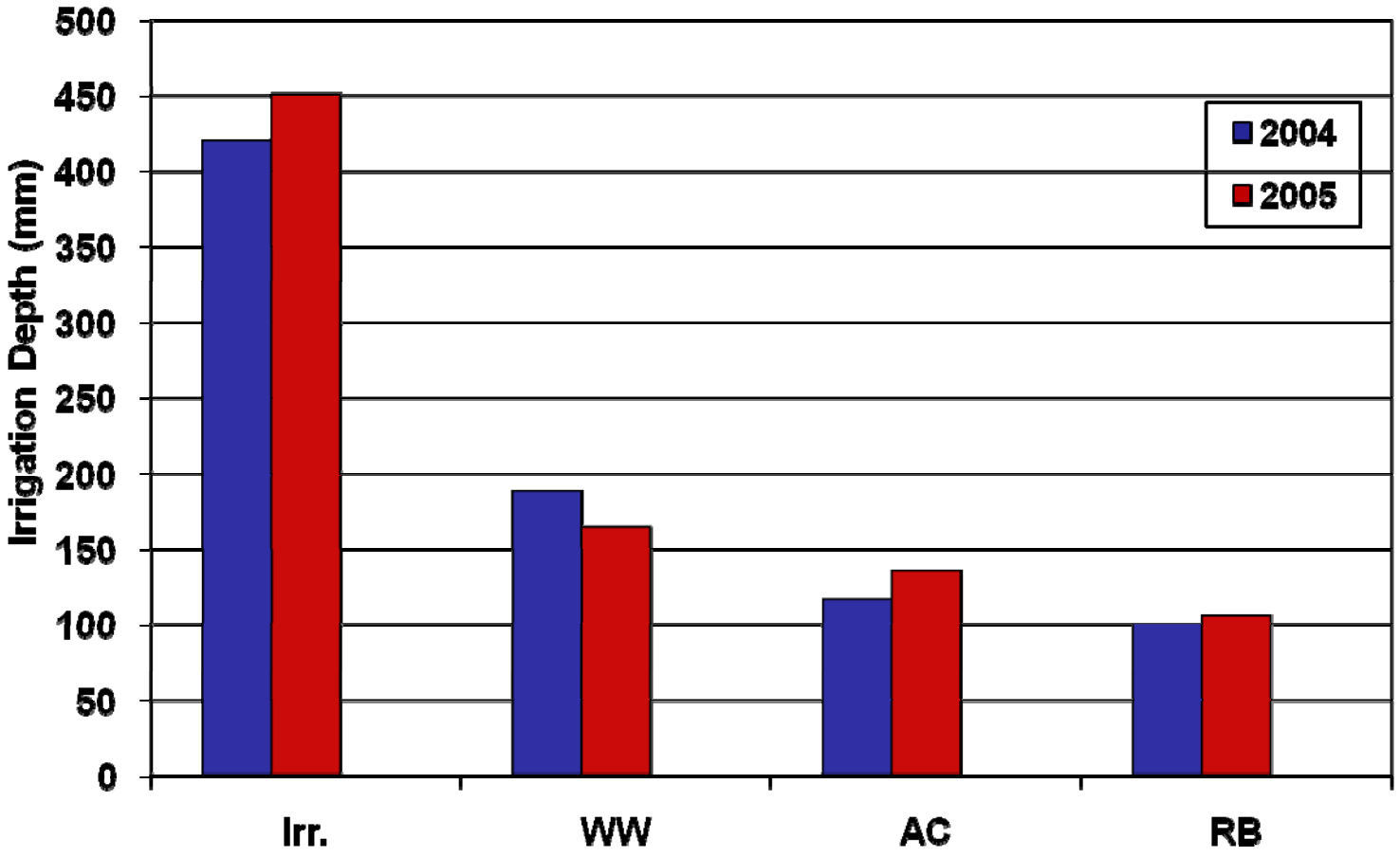
Sensor Brand Performance



SMS Test Conclusions Under Rainy Conditions

- Significant differences in turfgrass quality among treatments were not detected → no irrigation was necessary
- WRS 34%< WORS → importance & benefit of rain sensor
- SMS savings: 69-92% (excluding brand IR).
- 7 d/wk frequency used less irrigation than 1 or 2 d/wk by taking advantage of rainfall

CURRENT RAIN SENSOR RESEARCH AT UF

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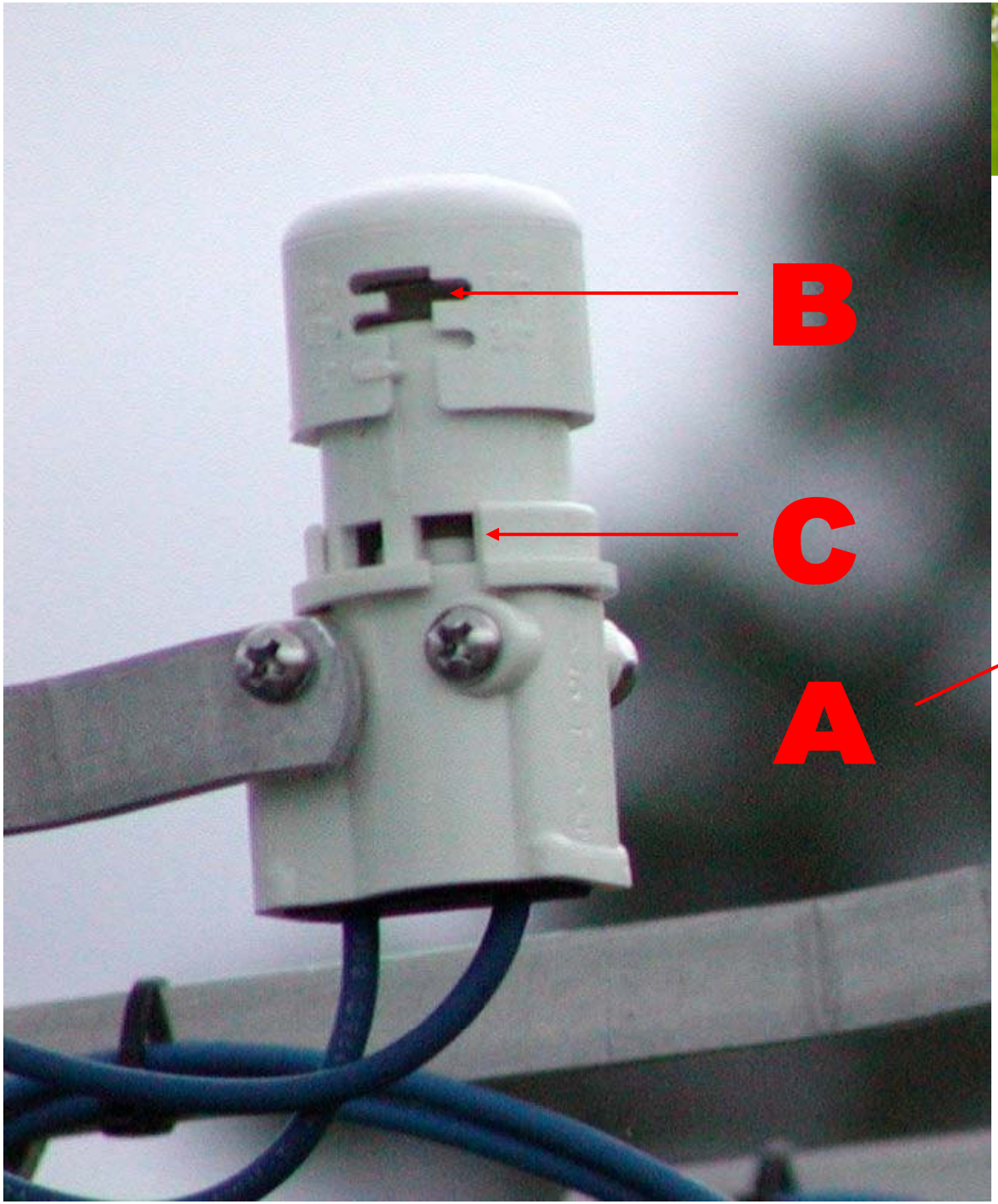
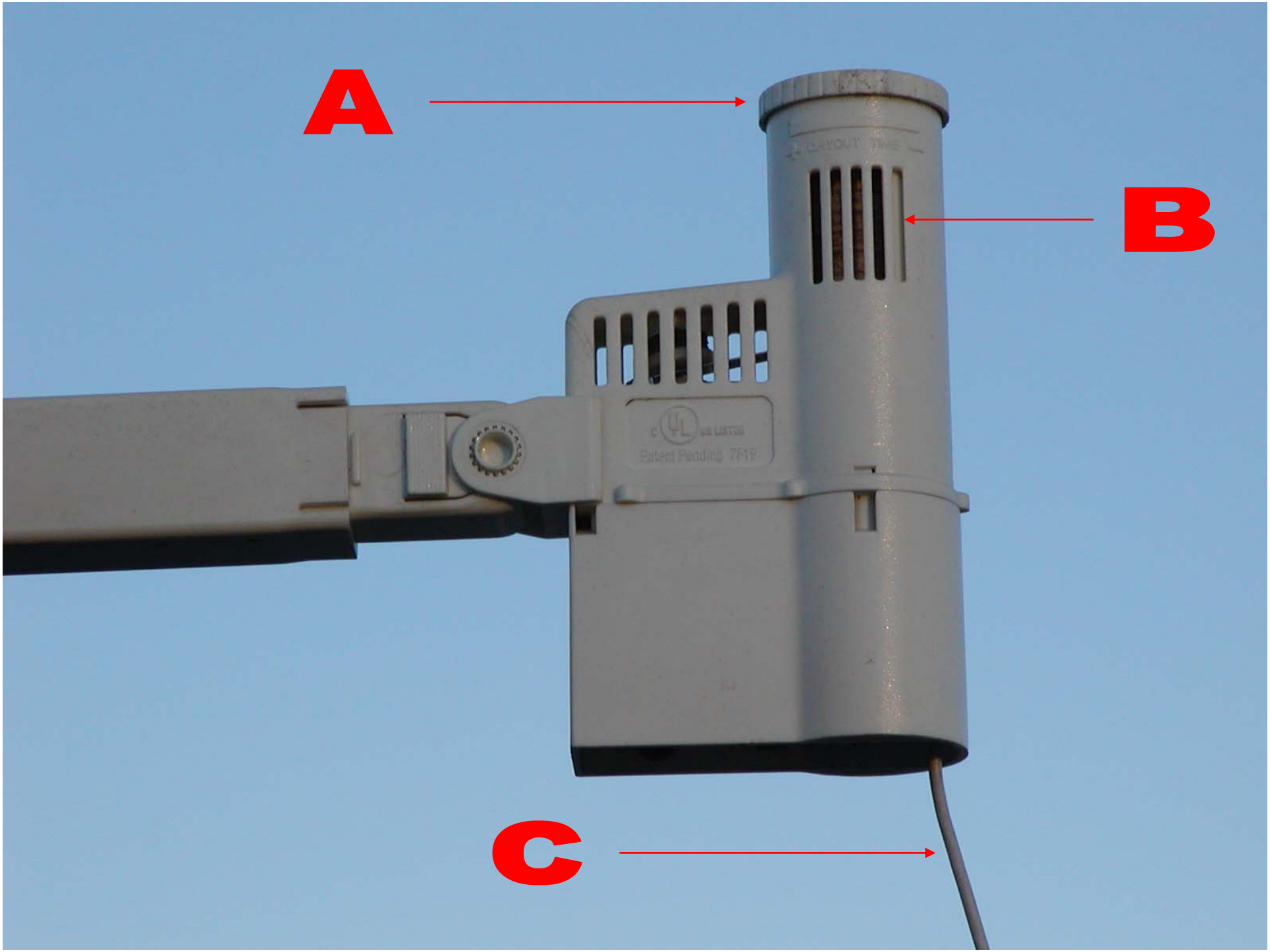
Existing Rain Sensor (RS) Testing

- Two RS types
  - Hunter Mini-Click (3, 13, 25 mm)
  - Hunter Wireless Rain-Click
- Natural rainfall
  - 25 Mar – 31 Dec 2005
- Datalogger data collection
- Weather data
  - Tipping bucket rainfall
  - Temp, RH, Rs, Wind


B
C
A


A
B
C

Objectives

1. Evaluate two commercially available expanding disk RS-types with respect to:
   - rainfall depth before they switch to bypass mode,
   - accuracy of set point,
   - number of irrigation cycles bypassed, and
   - dry out period.
2. Quantify the amount of water that RSs could save compared to a time-based irrigation schedule without RS.
3. Estimate the payback period of RSs at different set points.

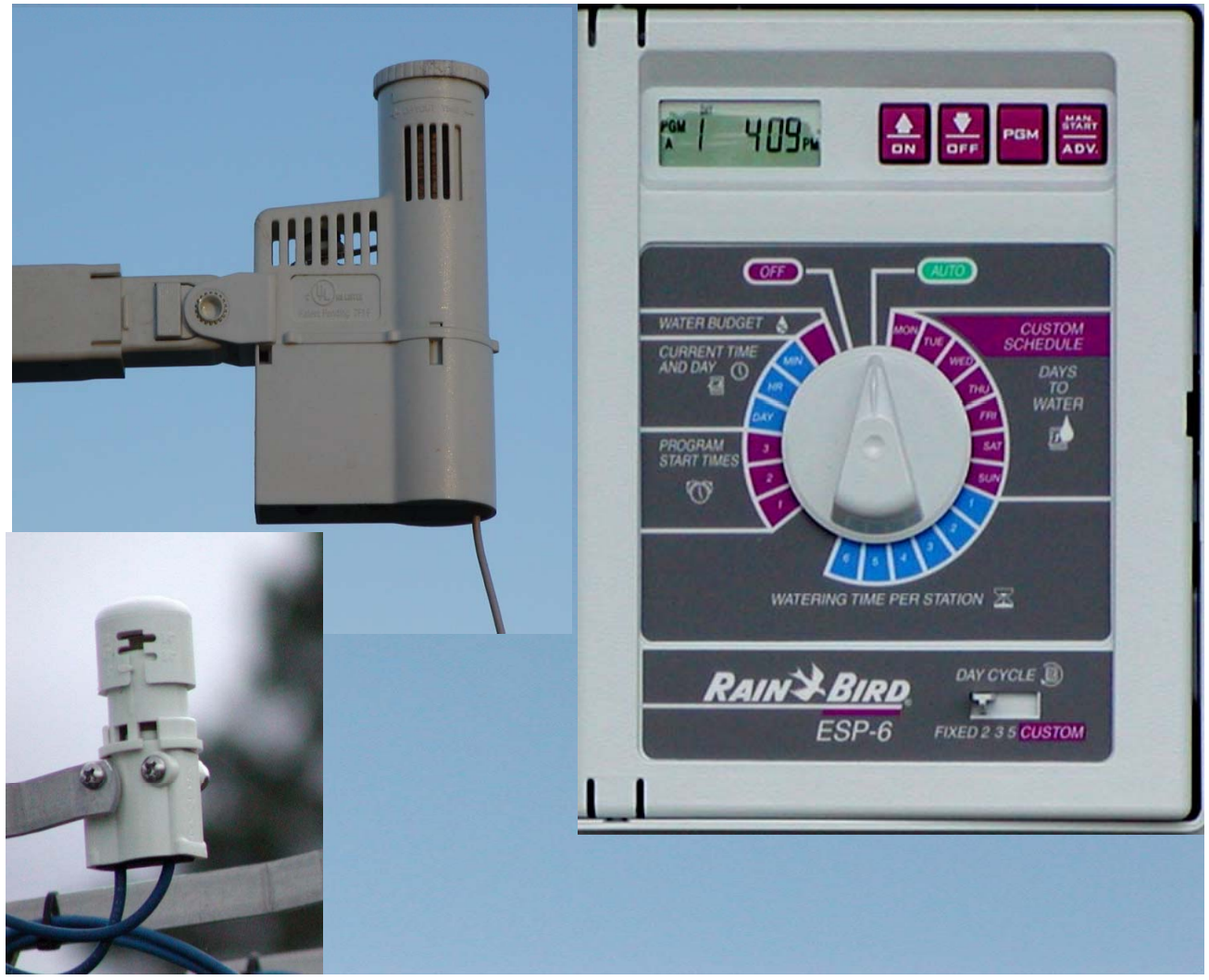
Materials & Methods

- **Location:**

  On campus, UF, Gainesville, Florida

- **Data collection:**

  25 Mar. - 31 Dec., 2005 (282 days)



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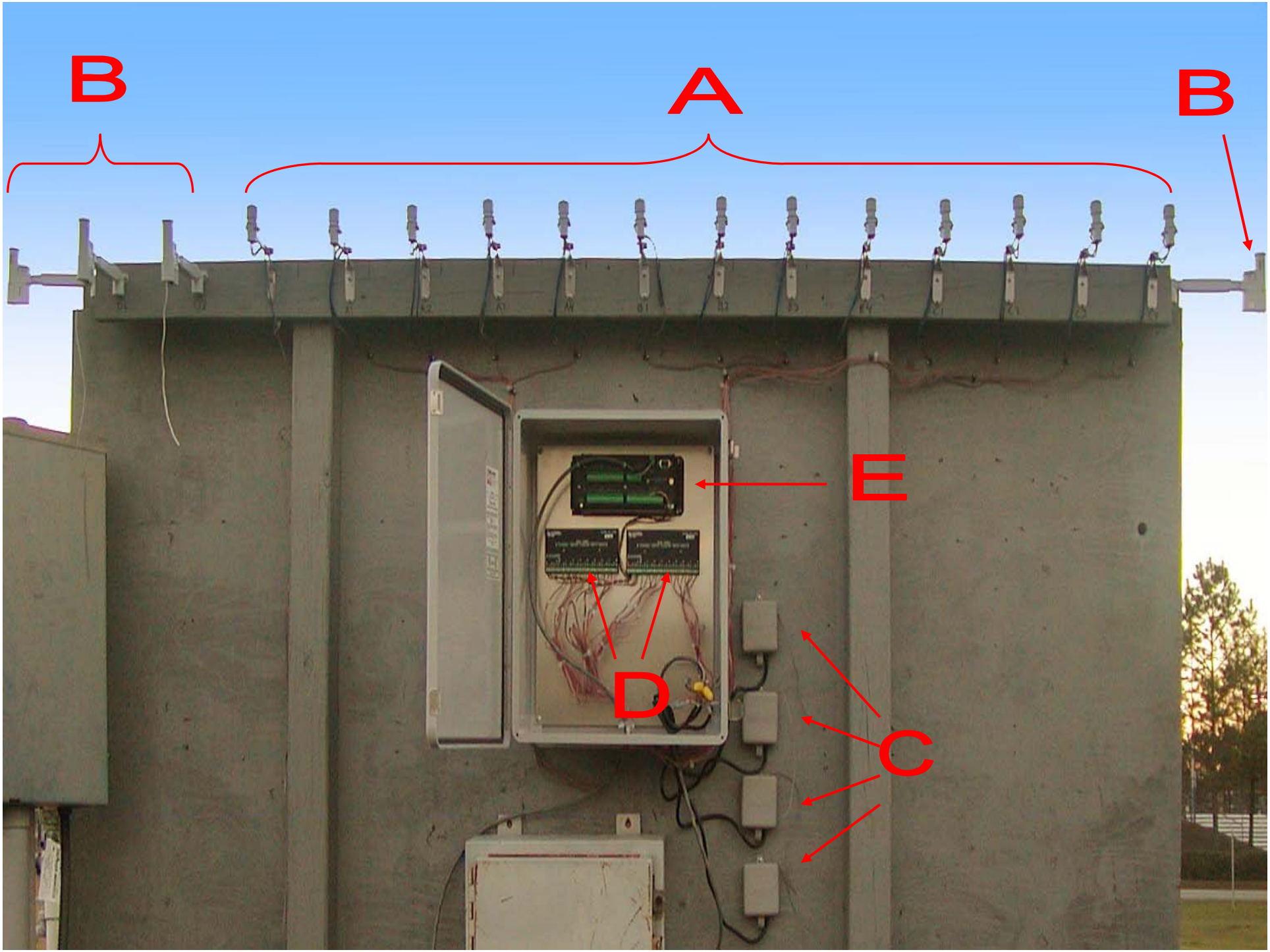
B
A
B
E
D
C

Weather Station

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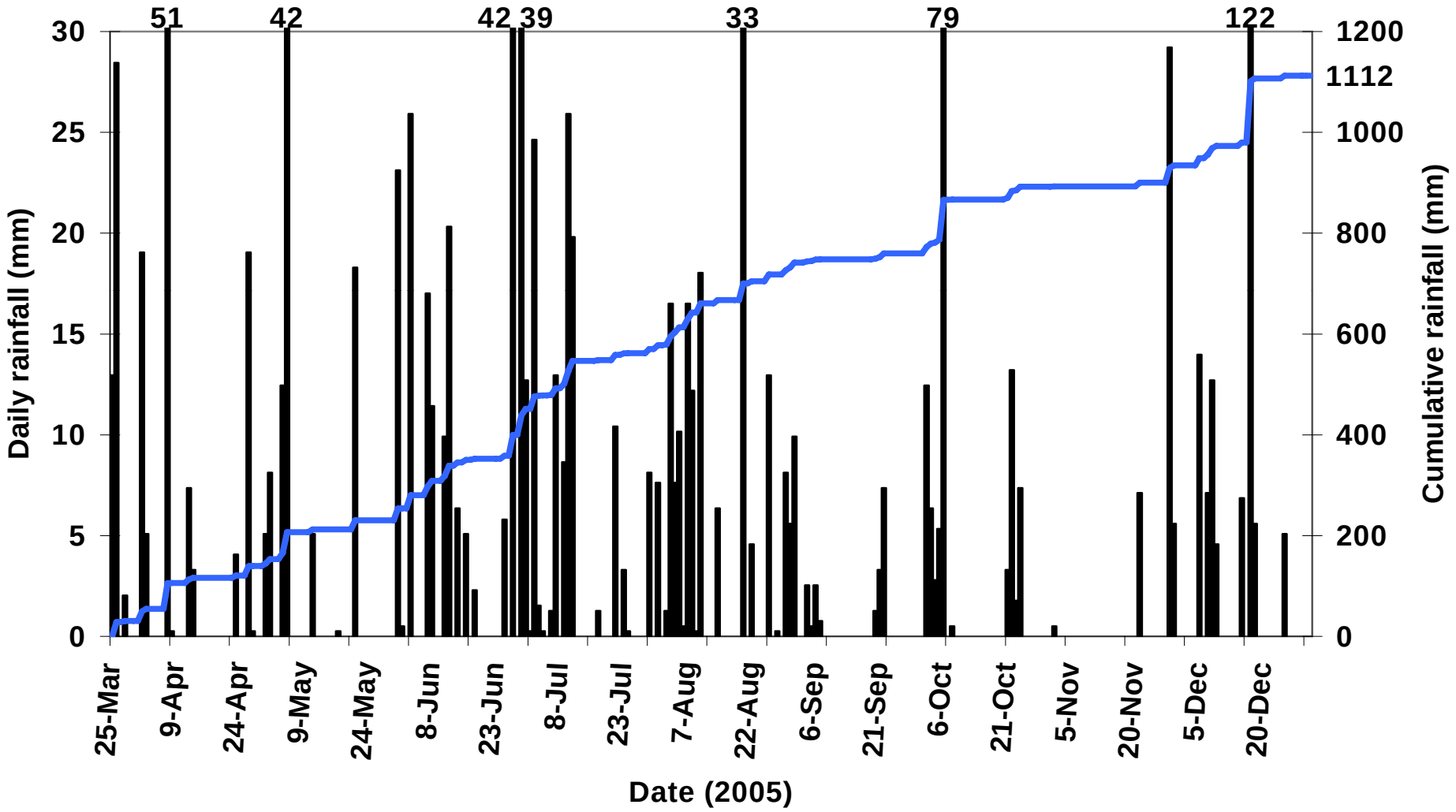
WL
3-MC
13-MC
25-MC

Daily & Cumulative Rainfall



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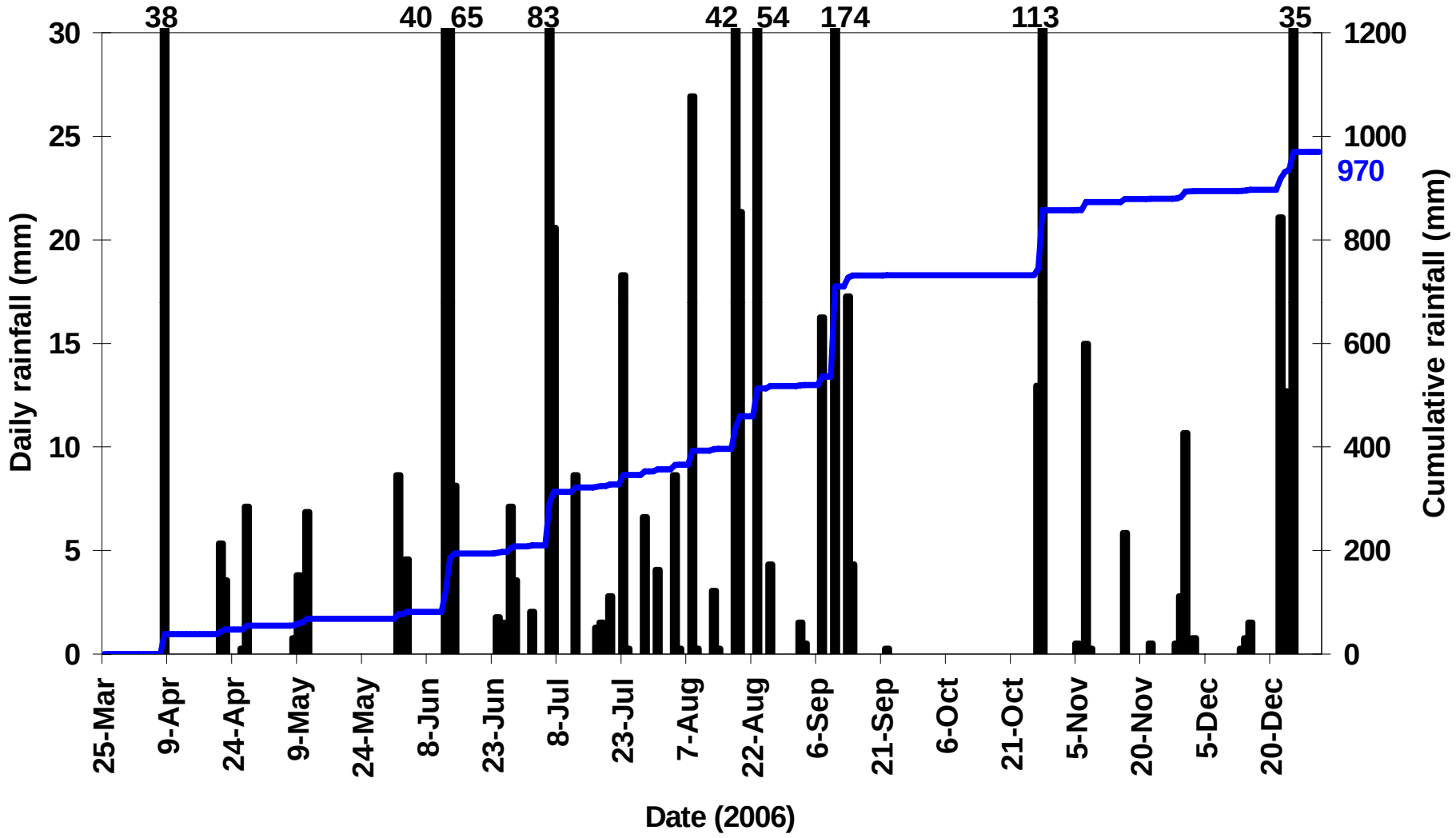
Daily & Cumulative Rainfall



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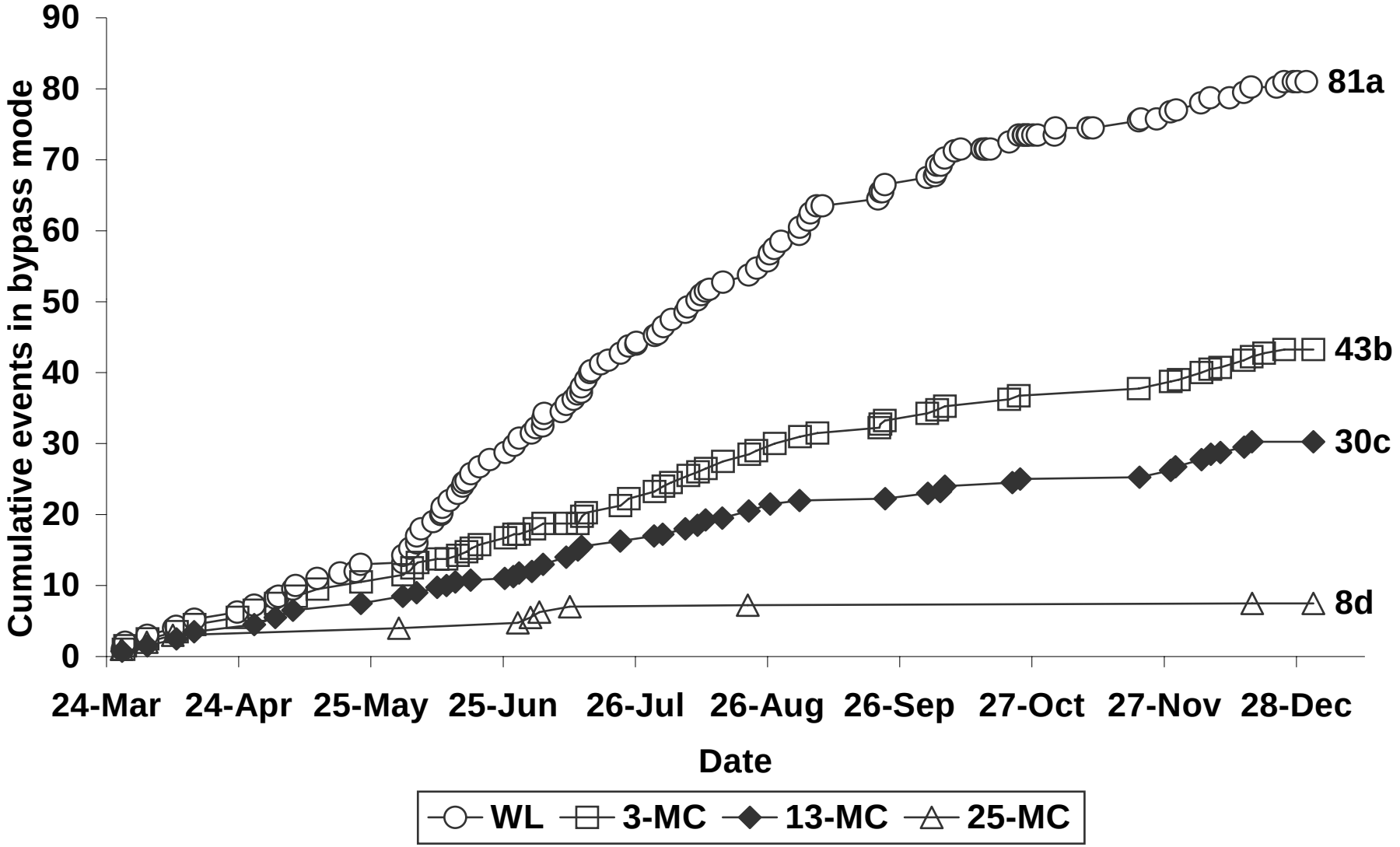
Rain Sensor Accuracy

Treatment	Set point (mm)	Rainfall depth (mm)	Accuracy (%)
3-MC	3	3.4	88
13-MC	13	10.0	77
25-MC	25	24.5	98
WL	---	1.4	---[z]

[z] Because these instruments do not declare a specific set point, no accuracy can be calculated.

Cumulative Times Sensors Switched to Bypass - Averages



Different letters indicate a significant difference by Duncan's Multiple Range Test (P<0.05)

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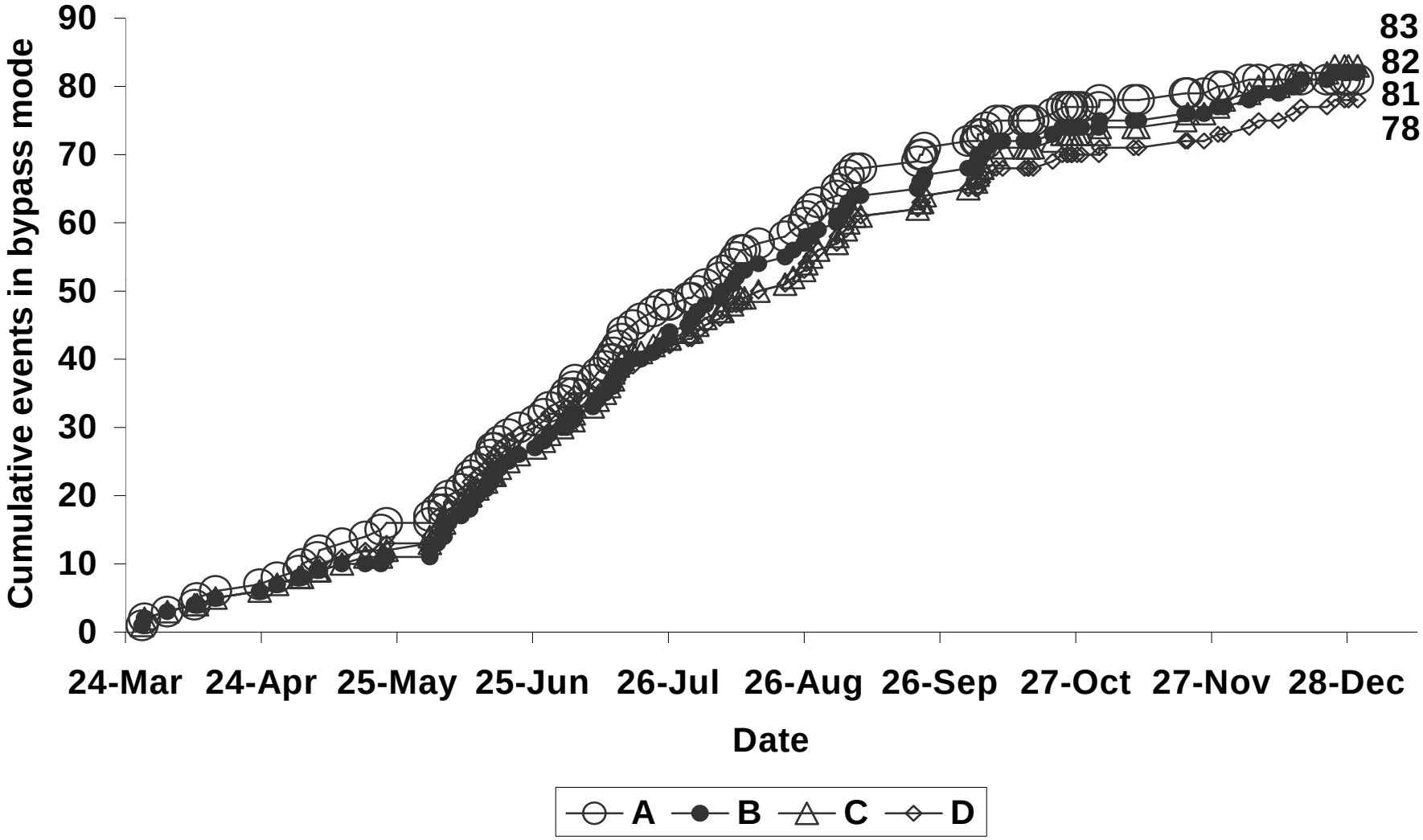
Cumulative Times Sensors Switched to Bypass – WL Replicates



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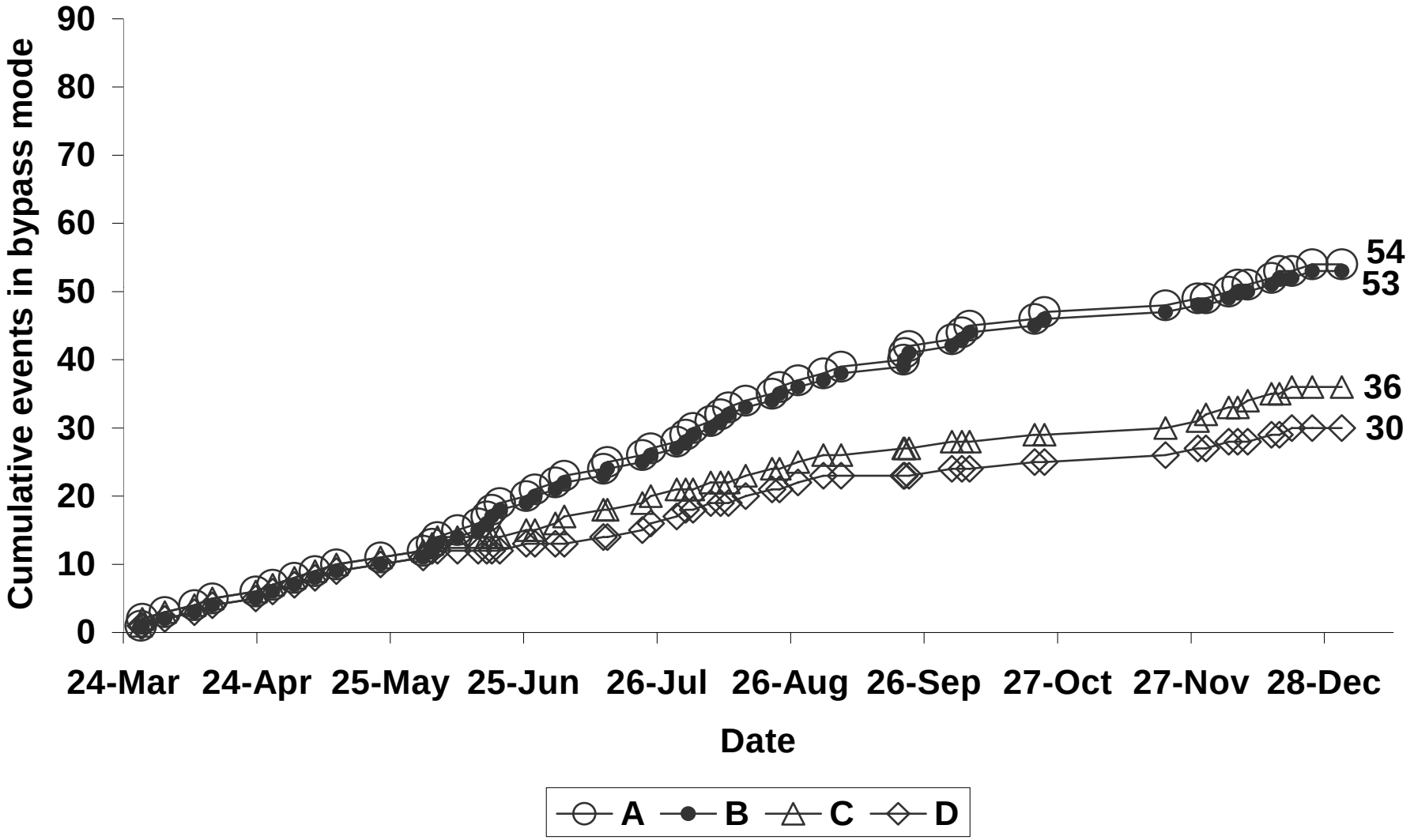
Replicates indicated by A-D.

Cumulative Times Sensors Switched to Bypass – 3-MC Replicates



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Replicates indicated by A-D.

Large Rainfall Events not Bypassed by some Replicates

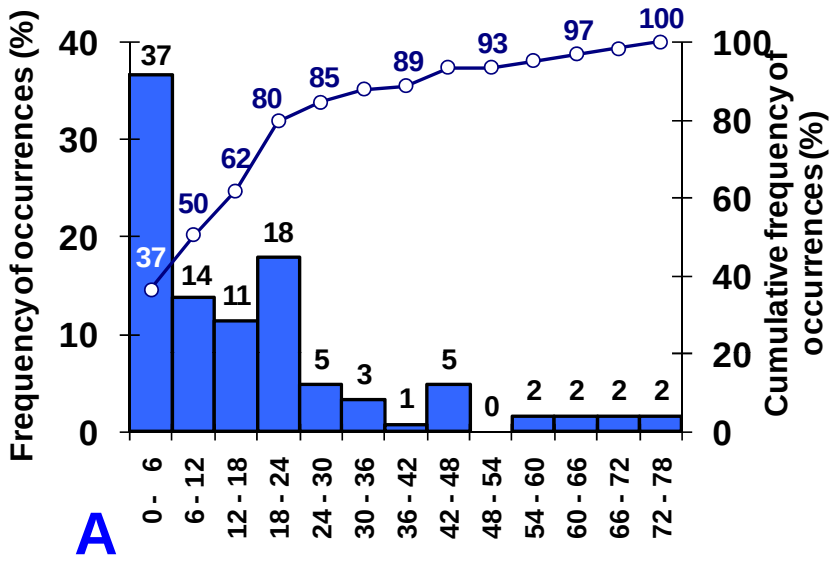
Date	Rainfall (mm)	Treatments		
		3-MC	13-MC	25-MC
26-Mar	29		3, 4	
1-Apr	19		3, 4	
5-May	42		3, 4	
7-Jun	17	3, 4		
8-Jun	11	3, 4		
12-Jun	20	3, 4	2, 4	
27-Jun	42			3
29-Jun	39			4
2-Jul	25	3, 4	2, 3, 4	
3-Aug	16	3, 4		
7-Aug	17	3, 4		
8-Aug	12	3, 4		
10-Aug	18	3, 4		
20-Aug	33			1, 2, 3
6-Oct	79	3, 4	3, 4	1, 2, 3, 4
17-Dec	122	3, 4	2, 4	1, 2, 3

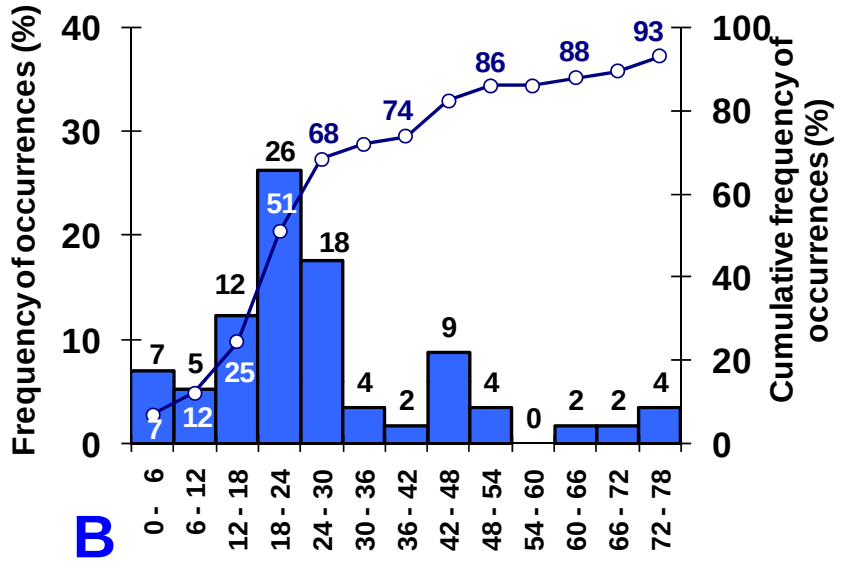
Hours After Rain Stopped, and 3-MC Switched to Bypass

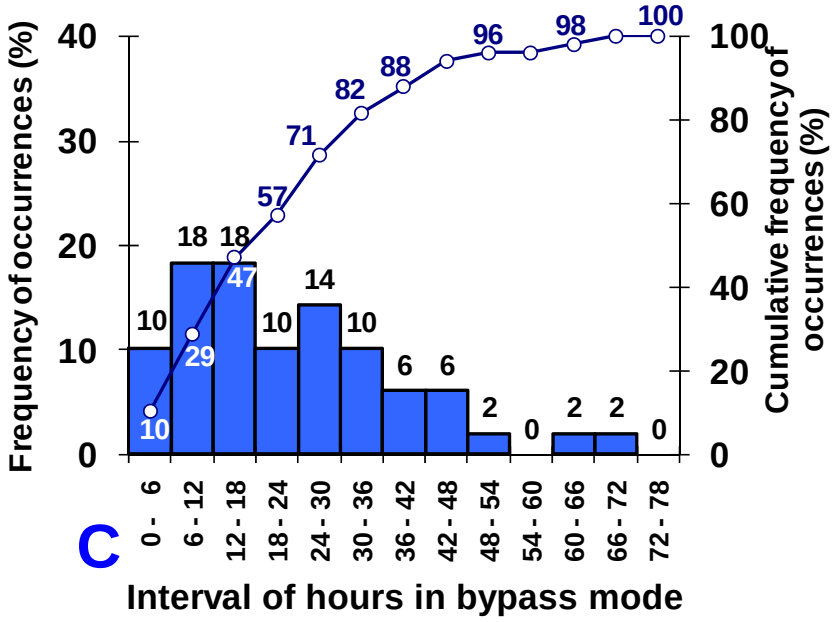
Date	Replicate (h)			
	1	2	3	4
3-Jul				6
1-Aug			6	
21-Sep	6	4		
30-Nov			18	
10-Dec			X	
16-Dec			18	
20-Dec			X	X

X = more than 24 h.

Dry Out Period







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Potential Water Savings Compared to a Time-based Schedule Without a RS

Treatment	Irrigation Depth (mm)	Water savings	
		(mm)	(%)
No rain sensor	818	0	0
WL	455	363	44
3-MC	573	245	30
13-MC	676	142	17
25-MC	793	25	3

Conclusions

- RS were relatively accurate
- Variability of MC sensors was high
- Some rain events were not detected
- Switched to bypass after rain had stopped, for many hours
- WL sensors were the most sensitive
- Can result in water savings and payback of < 1 year
- Settings < 13 mm had highest water conservation potential

PROPOSED RAIN SENSOR PROTOCOL

Protocol Testing

- Quantify the operation and functionality of climate-based controllers
  - Evapotranspiration (ET) controllers
  - Soil Moisture Sensor (SMS) controllers
- Proposed Rain Sensor (RS) testing
  - Phase I: Equipment functionality, accuracy, precision, variation
  - Phase II: Water conservation potential
    - Dry out period
    - Effect on turfgrass quality
    - Effect on soil moisture content variability

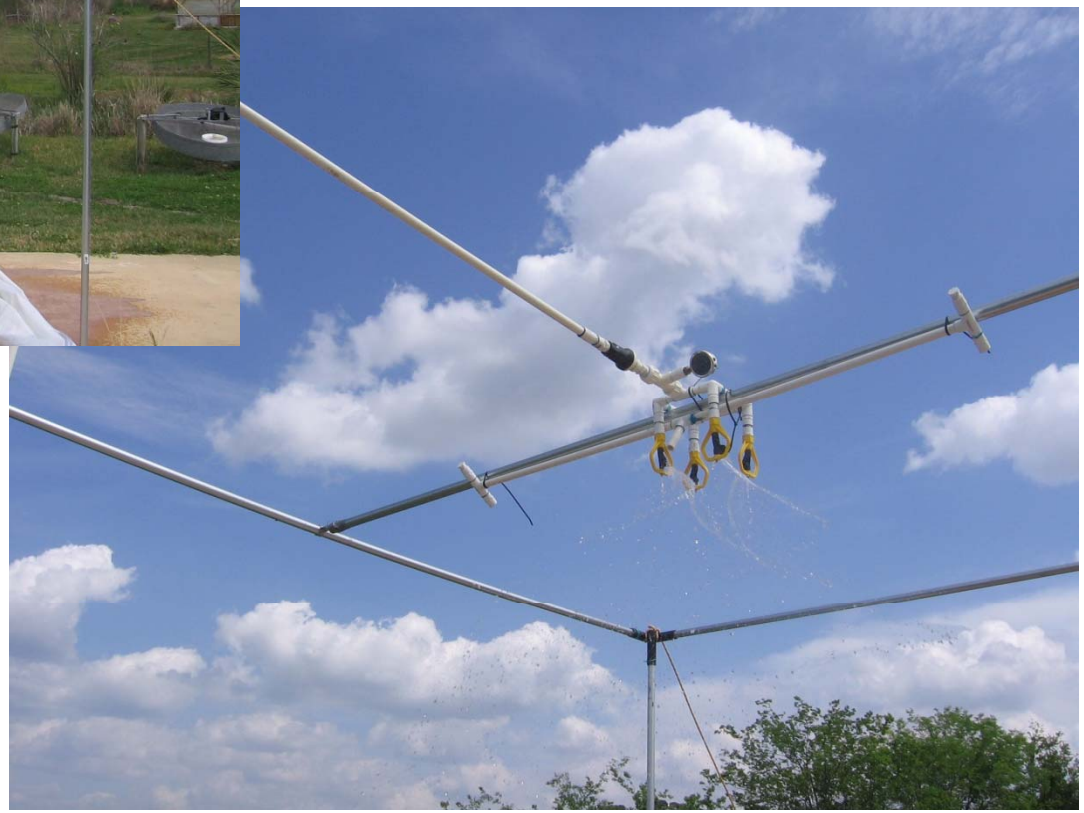
Proposed Protocol

- Tests device functionality for bypassing rainfall
  - Accuracy of set point
  - Precision of set point
  - Variability of individual sensors
- Does not test water conservation potential directly
  - Water conservation potential depends on climate

Procedures

- Rain simulator (standardized)
  - Control over application amount and uniformity
  - Constant intensity
  - No wind influence

Rain Simulator



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Procedures

- Rain simulator (standardized)
  - Control over application amount and uniformity
  - Constant intensity
  - No wind influence

- Testing
  - 8 set point replicates
  - 8 device replicates

Procedures (cont'd)

- Dry out period
  - Depends on regional climate
  - Depends on weather on site during testing (i.e. time of year)
  - Phase I: will be accelerated to shorten test time
- Intensity
  - Fixed intensity simulated rainfall (~20 mm/hr)
  - Rain intensities during testing:

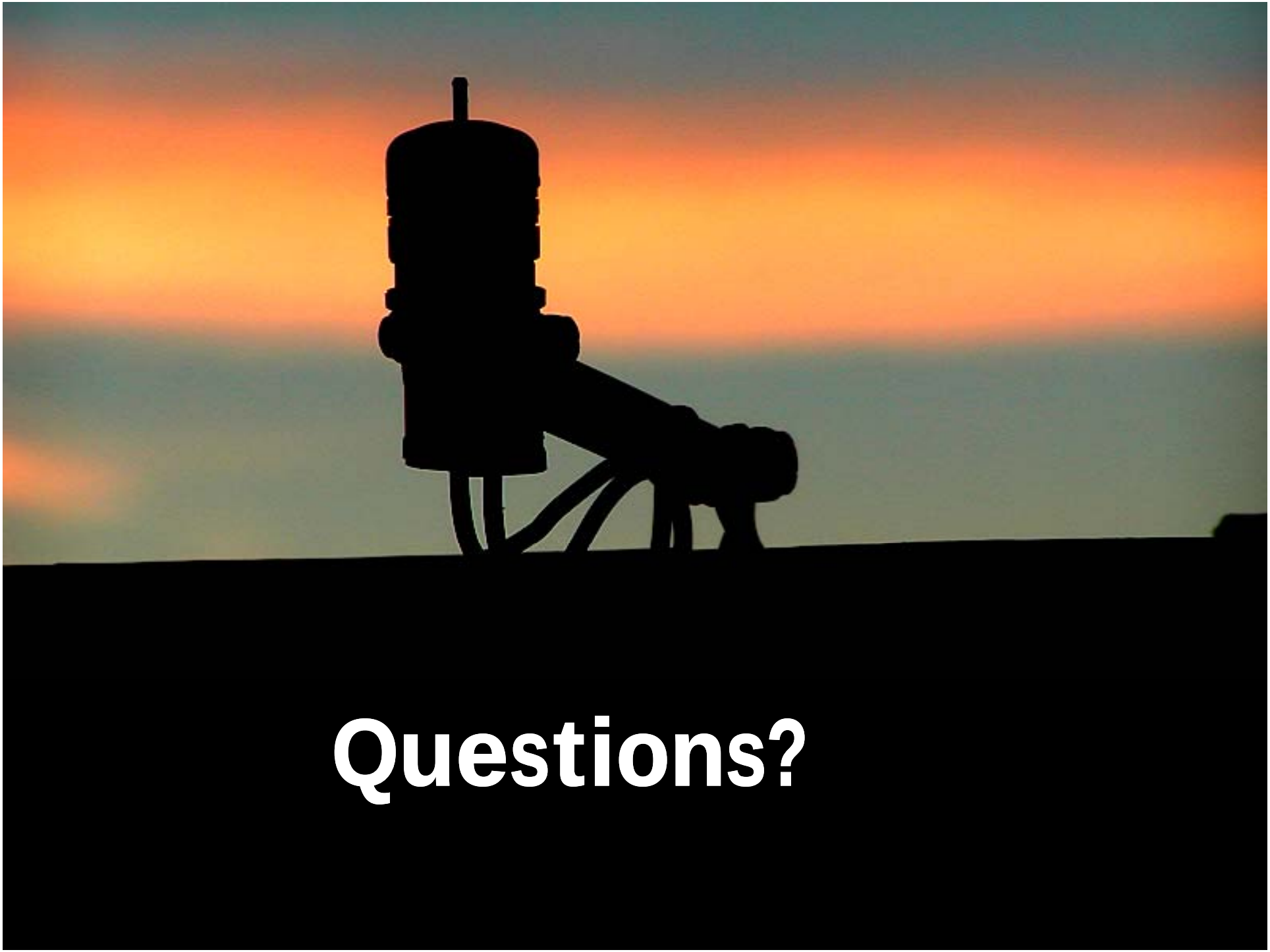
    <1 mm/hr to > 75 mm/hr

Report

- Accuracy
  - Closeness of measurement to a true value
- Precision
  - Comparison of multiple measurements to each other
    - Repeatability
- Variability
  - Coefficient of variation, CV
    - Measure of dispersion or variability across devices
- Anomalies or unexplained behavior

Comments

- Testing of five thresholds on one sensor will take ~ 6 months
- Testing of one threshold will take ~ 1.5 months
- Cost: Depends on number of sensors/thresholds to be tested


Questions?