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Six Years of Smart Controller Performance in Texas

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Abstract. *A smart controller testing facility was established by the Irrigation Technology Program at Texas A&M University in College Station in 2008. The objectives were to (1) evaluate smart controller testing methodology and to (2) determine their performance and reliability under Texas conditions using a six zone virtual Texas Landscape that reflects the type of landscape sites common to Texas. Annually a report is released detailing each controller's performance by irrigation amount on a yearly and seasonal basis. Controller performance is often observed to over-irrigate and be inconsistent throughout the seasons. This paper summarizes the performance of the smart controllers over the last six years. Overall, no controller has been consistently able to provide adequate amounts of water without over or under irrigating multiple landscape plants. Performance among controllers was observed to vary based on rainfall and the zone type for one or more seasons.*

Keywords. *Landscape Irrigation, Smart Controllers, Irrigation Scheduling, Water Conservation, Irrigation, Irrigation Technologies*

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Introduction

The term smart irrigation controller is commonly used to refer to various types of controllers that have the capability to calculate and implement irrigation schedules automatically and without human intervention. Ideally, smart controllers are designed to use site specific information to produce irrigation schedules that closely match the day-to-day water use of plants and landscapes. In recent years, manufacturers have introduced a new generation of smart controllers which are being promoted for use in both residential and commercial landscape applications.

However, many questions exist about the performance, dependability and water savings benefits of smart controllers. Of particular concern in Texas is the complication imposed by rainfall. Average rainfall in the state varies from 56 inches in the southeast to less than eight inches in the western desert. In much of the state, significant rainfall commonly occurs during the primary landscape irrigation seasons. Some Texas cities and water purveyors are now mandating smart controllers. If these controllers are to become requirements across the state, then it is important that they be evaluated formally under Texas conditions.

Materials & Methods

A smart controller testing facility was established by the Irrigation Technology Program of Texas A&M Agrilife Extension Service at Texas A&M University in College Station. Each controller was programmed according to the criteria describing six (6) virtual landscape as best allowed by the controller settings. As not all controllers allowed direct input of the defining landscape factors, professional judgement and/or initial calculations were needed to program these controllers. The controllers are connected to a data logger which records the start and stop times for each irrigation event and station (or zone). This information is transferred to a database and used to determine total runtime and irrigation volume for each irrigation event then summarized over seasonal periods.

Table 1. The controller name, type, communication method, and sensors attached of the controllers evaluated in this study. All controllers were connected to a rain shut off device unless equipped with a rain gauge.

Controller ID	Controller Name	Type	Communication Method	On-Site Sensors[1]	Rain Shutoff
A	ET Water	ET	Pager	None	✓
B	Rainbird ET Manager Cartridge	ET	Pager	Tipping Bucket Rain Gauge	
C	Hunter ET System	Sensor Based	-	Tipping Bucket Rain Gauge, Pyranometer, Temperature/ RH, Anemometer	
D	Hunter Solar Sync	Sensor Based	-	Pyranometer	✓
E	Rainbird ESP SMT	Sensor Based	-	Tipping Bucket Rain Gauge, Temperature	
F	Accurate WeatherSet	Sensor Based	-	Pyranometer	✓
G	Weathermatic Smartline	Sensor Based	-	Temperature	✓
H	Toro Intellisense	ET	Pager	None	✓
I	Irritrol Climate Logic	Sensor Based	-	Temperature, Solar Radiation	✓

[1] Rain shut off sensors are not considered as On-Site Sensors for ET Calculation or runtime adjustment

Each controller was assigned six stations, each station representing a virtual landscaped zone
(Table 2). These zones are designed to represent the range in site conditions commonly found in Texas, and to provide a range in soil conditions designed to evaluate controller

performance in shallow and deep root zones (with low/high water holding capacities). Since we do not recommend that schedules be adjusted for the DU (distribution uniformity), the efficiency was set to 100% if allowed by the controller.

Irrigation requirement was calculating using ETo from the TexasET Network weather station located on the campus of Texas A&M University.

Table 2. The Virtual Landscape which is representative of conditions commonly found in Texas.

	Zone 1	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**	**Zone 6**
Plant Type	Flowers	Turf	Turf	Ground-cover	Small Shrubs	Large Shrubs
Plant Coefficient (Kc)	0.8	0.6	0.6	0.5	0.5	0.3
Root Zone Depth (in)	3	4	4	6	12	20
Soil Type	Sand	Loam	Clay	Sand	Loam	Clay
MAD (%)	50	50	50	50	50	50
Adjustment Factor (Af)	1.0	0.8	0.6	0.5	0.7	0.5
Precipitation Rate (in/hr)	0.2	0.85	1.40	0.5	0.35	1.25
Slope (%)	0-1	0-1	0-1	0-1	0-1	0-1

Testing Periods

For the purposes of this analysis, controller performance was based on each year's summer period performance. The summer period varied by month and number of days each year. Each year's summer period was defined as follows:

- 2010: May 31 to August 20 (92 Days)
- 2011: August 8 to September 4 (28 Days)
- 2012: April 30 to September 30 (153 Days)
- 2013: July 29 to September 15 (49 Days)
- 2014: May 1 to September 14 (137 Days)

Recommended Irrigation

In this report, smart controller irrigation volumes are compared to the recommendations of the TexasET Network and Website generated using the *Landscape Plant Water Requirement Calculator* (http://TexasET.tamu.edu) on a weekly basis. This weekly water balance approach is used for the weekly irrigation recommendations generated by TexasET for users that sign-up for automatic emails.

The calculation uses the standard equation:

$$ET_C = (ET_O \times K_C \times A_f) - R_e \qquad \text{(Equation 1)}$$

where

ET_C = irrigation requirement

ET_O = reference evapotranspiration

K_C = crop (plant) coefficient

A_f = adjustment factor

R_e = effective rainfall.

Due to the lack of scientifically derived crop coefficients for most landscape plants, we suggest that users classify plants into one of three categories based on their need for or ability to survive with frequent watering, occasional watering and natural rainfall. Suggested crop coefficients for each are shown in Table 3.

In addition to a Plant Coefficient, TexasET users have the option of applying an *Adjustment Factor*. This can be used to make adjustments for site factors such as microclimates, allowable stress, or desired plant quality. For most home sites, a *Normal Adjustment Factor* (0.6) is recommended in order to promote water conservation, while an adjustment factor of 1.0 is recommended for sports athletic turf. Table 4 gives the adjustment factor in terms of a plant quality factor.

A weekly irrigation recommendation was produced using equation (1) following the methodology discussed above. The Af used are shown in Table 3. Effective rainfall was calculated using the relationships shown in Table 5.

Table 3. Landscape Plant Water Requirements Calculator Coefficients

Plant Coefficients		Example Plant Types
Warm Season Turf	0.6	Bermuda, St Augustine, Buffalo, Zoysia, etc.
Cool Season Turf	0.8	Fescue, Rye, etc.
Frequent Watering	0.8	Annual Flowers
Occasional Watering	0.5	Perennial Flowers, Groundcover, Tender Woody Shrubs and Vines
Natural Rainfall	0.3	Tough Woody Shrubs and Vines and non-fruit Trees

Table 4. Adjustment Factors in terms of “Plant Quality Factors.”

Maximum	1.0
High	0.8
Normal	0.6
Low	0.5
Minimum	0.4

Table 5. TexasET Effective Rainfall Calculator

Rainfall Increment	% Effective
0.0" to 0.1"	0%
0.1" to 1.0"	100%
1.0" to 2.0"	67%
Greater than 2"	0%

Results

Results of each controller's summer performance are summarized in Tables 6-11 by zone. Since controller ETo calculations vary among manufacturers and methods, controllers that applied +/- 20% of the irrigation recommendation were considered good performers in their given year. For a controller to pass the evaluation, it would need to consistently be within 20% for all zones.

<u>Controller Performance Zone 1</u>
No Controller Passed
One Controller was within 20% for three years
Two Controllers were not within 20% during the five years

<u>Controller Performance Zone 2</u>
No Controllers Passed
One Controller was within 20% for four years
Two Controllers were not within 20% during the five years

<u>Controller Performance Zone 3</u>
No Controllers Passed
One Controller was within 20% for four years
Three Controllers were not within 20% during the five years

<u>Controller Performance Zone 4</u>
No Controllers Passed
One Controller was within 20% for three years
Three Controllers were not within 20% during the five years

<u>Controller Performance Zone 5</u>
No Controllers Passed
One Controller was within 20% for three years
Two Controllers were not within 20% during the five years

<u>Controller Performance Zone 6</u>
No Controllers Passed
One Controller was within 20% for two years
Four Controllers were not within 20% during the five years

Irrigation amounts were normalized for comparison purposes by calculating each irrigation amount as a percentage of the irrigation requirement. Each zone's percentage of irrigation requirement was averaged for all five (5) years. Results of the five (5) year comparison are shown in Table 12. Based on this analysis, three (3) controllers had five (5) out of six (6) stations within 20% of the recommended irrigation per zone.

Table 6. Zone 1 Performance. Irrigation amount (inches) applied for each year. Yellow denotes values within +/- 20% of the irrigation requirements.

Controller	2010	2011	2012	2013	2014
A	13.14	N/A	22.00	8.32	20.63
B	15.90	3.63	20.33	5.81	20.34
C	2.45	4.74	15.67	5.02	10.26
D	3.80	12.13	55.31	18.72	47.67
E	10.66	5.81	25.92	9.34	22.25
F	3.35	4.79	24.90	8.12	21.91
G	4.17	4.32	18.50	8.50	19.60
H	20.87	5.50	23.69	10.29	20.83
I	NA	10.28	56.47	24.10	59.97
Irrigation Requirement	11.57	5.29	18.32	6.37	22.63

Table 7. Zone 2 Performance. Irrigation amount (inches) applied for each year. Yellow denotes values within +/- 20% of the irrigation requirements.

Controller	2010	2011	2012	2013	2014
A	10.11	N/A	14.28	5.73	13.04
B	8.96	2.14	10.55	2.96	3.63
C	1.72	2.99	7.59	2.39	4.50
D	2.08	7.14	35.11	10.97	26.53
E	6.59	3.45	14.66	5.62	12.47
F	3.15	N/A	18.70	6.65	15.83
G	1.70	2.32	10.54	5.38	11.38
H	6.82	3.53	15.18	6.59	13.35
I	NA	3.24	17.92	8.58	28.02
Irrigation Requirement	6.63	3.04	9.65	5.12	11.90

Table 8. Zone 3 Performance. Irrigation amount (inches) applied for each year. Yellow denotes values within +/- 20% of the irrigation requirements.

Controller	2010	2011	2012	2013	2014
A	7.28	N/A	10.83	4.45	9.84
B	6.64	1.59	7.65	2.18	15.27
C	0.76	1.49	4.58	1.07	2.24
D	1.66	5.60	26.90	8.63	20.91
E	3.44	2.18	7.80	2.88	6.42
F	2.57	N/A	22.91	7.28	19.55
G	1.35	1.85	7.90	4.04	8.53
H	4.97	2.44	10.53	4.57	9.26
I	NA	2.42	13.33	8.86	30.75
Irrigation Requirement	4.78	2.19	6.77	3.71	8.39

Table 9 Zone 4 Performance. Irrigation amount (inches) applied for each year. Yellow denotes values within +/- 20% of the irrigation requirements.

Controller	2010	2011	2012	2013	2014
A	6.33	N/A	9.28	3.74	7.85
B	4.74	1.13	5.46	1.56	10.90
C	0.83	1.23	4.13	1.21	1.95
D	1.18	3.86	16.72	5.86	14.46
E	2.32	1.29	4.60	1.79	4.02
F	1.15	N/A	8.44	2.65	7.00
G	0.94	1.28	5.46	2.78	5.89
H	3.01	1.86	7.99	3.47	7.03
I	NA	1.66	8.23	5.97	15.91
Irrigation Requirement	3.17	1.42	4.51	2.54	5.98

Table 10. Zone 5 Performance. Irrigation amount (inches) applied for each year. Yellow denotes values within +/- 20% of the irrigation requirements.

Controller	2010	2011	2012	2013	2014
A	6.30	N/A	9.45	4.19	8.40
B	4.55	1.58	6.20	1.50	N/A
C	1.20	1.85	4.68	1.21	1.15
D	0.27	5.16	22.35	7.82	19.28
E	4.19	2.42	6.60	2.43	4.14
F	1.83	N/A	13.51	4.23	11.26
G	1.15	1.57	7.66	3.91	8.27
H	5.20	2.52	10.86	4.71	9.55
I	NA	2.74	12.72	6.47	17.20
Irrigation Requirement	4.64	2.13	6.55	3.61	6.32

Table 11. Zone 6 Performance. Irrigation amount (inches) applied for each year. Yellow denotes values within +/- 20% of the irrigation requirements.

Controller	2010	2011	2012	2013	2014
A	4.17	N/A	7.50	3.32	6.66
B	0.00	1.58	3.55	0.00	N/A
C	0.00	0.55	0.57	0.00	0.00
D	0.13	2.33	11.19	3.57	8.65
E	0.00	0.00	0.00	0.00	0.00
F	1.17	1.60	8.67	2.70	7.27
G	0.73	0.92	2.94	1.68	3.71
H	2.13	1.09	4.70	2.04	4.13
I	NA	1.45	5.66	3.95	10.62
Irrigation Requirement	1.78	0.82	2.50	0.00	0.00

Table 12. Overall Performance. Irrigation amount (%) compared to irrigation requirements for each zone during 2010-2014. Yellow denotes values within +/- 20% of the irrigation requirements.

Controller	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
A	0.91	1.04	1.10	1.37	1.06	3.06
B	1.00	0.81	1.13	1.19	0.62	0.87
C	0.64	0.57	0.41	0.57	0.47	0.58
D	2.14	2.13	2.34	2.30	2.22	3.92
E	1.18	1.16	0.88	0.81	0.87	0.40
F	0.96	1.01	1.64	0.89	1.08	3.21
G	0.88	0.82	0.88	0.90	0.91	1.62
H	1.33	1.23	1.21	1.31	1.36	2.12
I	2.29	1.39	1.83	1.60	1.55	3.72

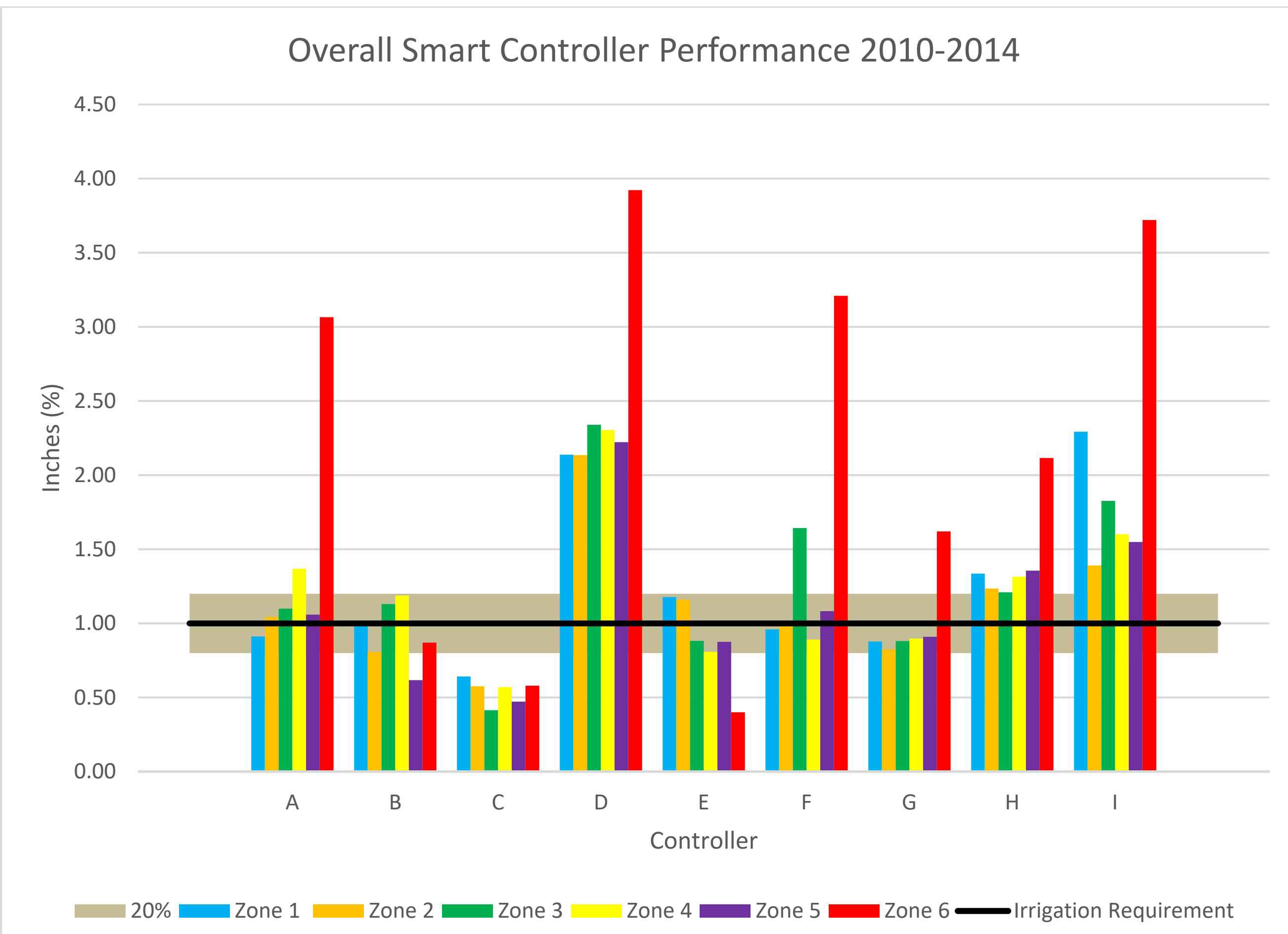

Figure 1. Normalized Overall Smart Controller Performance 2010-2014

Discussion and Conclusions

For a controller to pass our test, it would need to meet the irrigation requirements for all six zones. Of the nine (9) controllers tested, none successfully passed the test during any of the testing periods (years). Results over the last five (5) years have consistently shown that some of the controllers over-irrigate (i.e., apply more water than is reasonably needed). However, some manufacturers have updated their product firmware or sensors (some multiple times) since testing began in 2010 reducing the amount of over-irrigating.

Over the past six years since starting the evaluation of smart controllers, we have seen improvement in their performance. However, the communication and failures that were evident in our field surveys conducted in San Antonio in 2006 (Fipps, 2008) continue to be a problem for two out of nine controllers. In the past six years of bench testing, we have seen some reduction in excessive irrigation characteristics of controllers, however some controllers still have difficulty managing irrigations in some stations, particularly zone 6, which had the greatest amount of plant available water (e.g. 20 inch roots and clay soil or estimated 3.33 inches water storage potential).

Reasons for these excessive amounts are likely due to either insufficient account for rainfall or improper/inaccurate acquisition of ET data. Of the nine controllers evaluated, only three (3) were equipped with tipping bucket rain gauges capable of measuring rainfall event amounts (which credit back to the water balance), whereas the majority of controllers only have a rain shut off device. We believe improper accounting for rainfall to be the biggest variable causing excessive irrigation. Figure 1 supports this reasoning since the three controllers that did not apply excessive amount for zone 6 (or any zone on average) are also the same three controllers equipped with the tipping bucket style rain gauges. Based on these observations, accurate accounting (true measurement) of local rainfall is an important factor in evaluating a smart controller's performance and/or water conservation potential.

References

Swanson, Charles, and Guy Fipps. 2011. *Evaluation of Smart Irrigation Controllers: Year 2010 Results.* TR-401. College Station, TX: Texas Water Resources Institute.

Swanson, Charles, and Guy Fipps. 2012. *Evaluation of Smart Irrigation Controllers: Year 2011 Results.* TR-428. College Station, TX: Texas Water Resources Institute.

Swanson, Charles, and Guy Fipps. 2013. *Evaluation of Smart Irrigation Controllers: Year 2012 Results.* TR-443. College Station, TX: Texas Water Resources Institute.

Swanson, Charles, and Guy Fipps. 2014. *Evaluation of Smart Irrigation Controllers: Year 2013 Results.* TR-469. College Station, TX: Texas Water Resources Institute .