Smart Irrigation Controller Demonstration and Evaluation in Orange County Florida [Project #4227]

ORDER NUMBER: 4227

DATE AVAILABLE: June 2016

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OBJECTIVES

The objective of the "Smart Irrigation Controller Demonstration and Evaluation in Orange County, Florida" project was to evaluate the water savings potential of soil moisture sensors (SMS) and evapotranspiration (ET) irrigation controllers on residential and commercial properties on two distinct soil types: flatwood soils and sandy soils. The Water Research Foundation funded this project to further the scientific and technological knowledge of smart irrigation technologies. The objectives of this report are to document the considerable effort required to engage the public in this research, present the results, and make the findings available to water utilities, water management districts, conservationists, and other stakeholders.

BACKGROUND

The Smart Irrigation Controller Demonstration and Evaluation in Orange County, Florida, project began in January 2009 under the direction of Jacqueline W. Torbert, Manager of the Water Division at Orange County Utilities Department. The primary researcher was Dr. Michael Dukes of the University of Florida Agricultural and Biological Engineering Department. Funders included Orange County Utilities Department, the South Florida Water Management District, the St. Johns River Water Management District, and the Water Research Foundation. Two factors influenced Orange County Utilities' decision to take on this study: a sustainable groundwater withdrawal limit based on the year 2035 planning horizon, and the increased affordability of Smart Irrigation Technologies.

Orange County, Florida is a 903 square mile area located in Central Florida, and Orange County Utilities is one of the water utilities providing services to residents of, and visitors to, Orange County. Orange County Utilities serves the unincorporated areas within the County. As in most of Florida, the people of Orange County rely on fresh groundwater from the Floridan Aquifer

to meet urban, agricultural and industrial uses. Additionally, Orange County is located in an area of Central Florida where the boundaries of three water management districts converge, and is one of five counties included in the Central Florida Water Initiative (CFWI) Regional Water Supply Plan (RWSP). When the research on Smart Irrigation Technologies began, multiple utilities in the region, including Orange County Utilities, were withdrawing approximately 280 million gallons of water per day (mgd) from the Floridan Aquifer.

Groundwater withdrawal in this region is regulated by three water management districts: the South Florida Water Management District, the St. Johns River Water Management District, and the Southwest Florida Water Management District. In addition to their regulatory role, the water management districts develop water supply plans and have jointly developed the Central Florida Water Initiative (CFWI) Regional Water Supply Plan (RWSP). Their combined assessments and modeling results have determined that sustainable groundwater withdrawal from the Floridan Aquifer in the five-county CFWI region is 850 mgd and any additional groundwater withdrawal would result in harmful impacts to water resources and the natural systems that rely on those resources.

The CFWI planning efforts have estimated that the population will increase from 2.7 million people to 4.1 million people by the year 2035 (a 49% increase) and that water demand will increase from 800 mgd to 1,100 mgd. The 850 mgd sustainable withdrawal limit and the 1,100 mgd demand estimate results in a 250 mgd deficit. The projected deficit has prompted Orange County Utilities to pursue alternative water supplies as well as additional water conservation initiatives in order to provide a sustainable water supply to its customers.

Orange County Utilities' history of water conservation includes education, incentives and regulatory requirements designed to change behaviors and modify water use habits. Orange County Utilities has watering restrictions and an enforcement program to encourage conservation. The current practice in Orange County is to restrict irrigation to particular days of the week based on upon addresses and further restrictions on the number of times a customer can irrigate during the course of a week based on the time of year. Even with these restrictions, homes with an in-ground irrigation system use 50% of their consumption on landscaping and these systems typically apply 2–3 times more water than the landscape requires. It was time to re-evaluate fixed irrigation schedules based upon address and day of the week and consider allowances for weather-based Smart Irrigation Technologies. Before new regulations associated with Smart Irrigation Technologies could be recommended for implementation, Orange County Utilities needed to research the water use impact of these devices in the hands of the everyday user.

University of Florida Institute of Food and Agricultural Sciences (UF/IFAS) studies have shown that smart irrigation controllers have the potential to conserve water by efficiently scheduling irrigation. However, most of the work in Florida has been performed on tightly controlled research plots. The plot work has been valuable to assess the performance potential of these controllers, but these controllers are relatively complicated to set up and program correctly for efficient irrigation. Thus, it is not known how much feedback or interaction is needed by irrigation professionals to implement these devices to achieve their potential level of water conservation. By recruiting both residential and commercial property owners to participate in the study and incorporating two levels of contractor training and follow-up on controller operation and performance, this study was able to provide an authentic assessment of smart irrigation controller performance.

APPROACH

From over 7.5 million pieces of Orange County Utilities customer data, irrigation water uses were analyzed to isolate "over-irrigators" as potential participants for the study. The customer's irrigation was estimated by separating estimated indoor water use from the monthly total meter amount for each household. A theoretical irrigation requirement was calculated using a daily soil water balance equation for different landscape scenarios found among Orange County Utilities customers. Those customers who exceeded their corresponding theoretical irrigation requirement by 1.5 to 4.0 times were considered over-irrigators and were selected as potential cooperators for the study.

Pre-test questionnaires and site visits narrowed the participant pool to 167 residential properties across the Orange County Utilities service area in nine location clusters. Smart irrigation technology treatments were distributed within each location so that there were at least three replicates per treatment group and homes were spread across the two dominant general soil types, flatwoods soils and sandy soils, in Orange County. In addition to residential properties, non-residential properties with separate irrigation meters were identified and screened. To participate in the study, commercial properties had to have a separate irrigation meter, use potable water for irrigation, and be located in close proximity to the residential clusters. These criteria and the availability of monthly irrigation water use history narrowed the participation to four commercial properties across the two dominant soil types. These properties received evapotranspiration (ET) controllers with site-specific programming.

The two smart irrigation technology treatments evaluated were the RainBird ESP-SMT 4 Evapotranspiration Controller and the Baseline Water Tec S100 Soil Moisture Sensor. This equipment, backflow prevention devices, irrigation meters, and weather stations were installed between March 2011 and January 2012. Location clusters included some or all of the following treatments: evapotranspiration irrigation controller only (ET), soil moisture sensor only (SMS), evapotranspiration irrigation controller with educational training (ET+Edu), soil moisture sensor with educational training (SMS+Edu), and a comparison group that was monitored only. While the irrigation consumption data collected and analyzed for this study spanned a three year-period, it is worth noting that recruitment of residential cooperators and subsequent equipment installation for monitoring added a considerable amount of time to the project schedule.

Hourly irrigation consumption data was stored in Neptune T-10 Automatic Meter Reading devices and collected by Orange County Utilities on a monthly basis. The volume of irrigation was converted by the researchers to a depth using the irrigable area measured during the initial site visits. Irrigation was then totaled into weeks and averaged across treatments and statistical analyses were performed. In addition to making comparisons between treatments, irrigation was compared to the estimated irrigation needed to meet plant water needs. The irrigated area was assumed to be 100% turfgrass to allow for a generous allocation for comparison purposes. Because of this, monthly crop coefficients were selected for turfgrass in Central Florida. Turfgrass quality ratings were conducted seasonally throughout the treatment period and statistical analysis of the turfgrass quality results were conducted. Changes in turfgrass quality ratings between rating periods were modeled compared to the difference in cumulative irrigation application and cumulative irrigation required based on weather. Daily values of reference evapotranspiration for each weather station location were calculated.

For commercial properties, monthly meter readings from the outdoor water meter and newly installed water meters were provided from Orange County Utilities. By October 2014, 19

months of irrigation data was collected for the commercial properties. This data was compared to all historical irrigation data.

RESULTS/CONCLUSIONS

Location cluster was not significant to the statistical model during the study period. However, the soil type was significant, resulting in the need to separate results by soil type. The treatment effect was also significant indicating differences in irrigation applied by the various technologies and implementation approaches.

In the flatwoods soil locations, the comparison group had significantly higher weekly irrigation (averaging 0.91 inches) compared to all other treatments. Differences between the SMS treatment and the two ET controller treatments were not significant, averaging 0.76, 0.67, and 0.72 inches for ET, ET+Edu, and SMS, respectively. However, the ET treatment applied significantly more irrigation than the ET+Edu treatment. The SMS+Edu group, averaging 0.50 inches, had significantly less irrigation than all other treatments. The site specific settings as associated with the education component, appears to have significantly lowered the average irrigation application on flatwoods soils for both SMS and ET technologies.

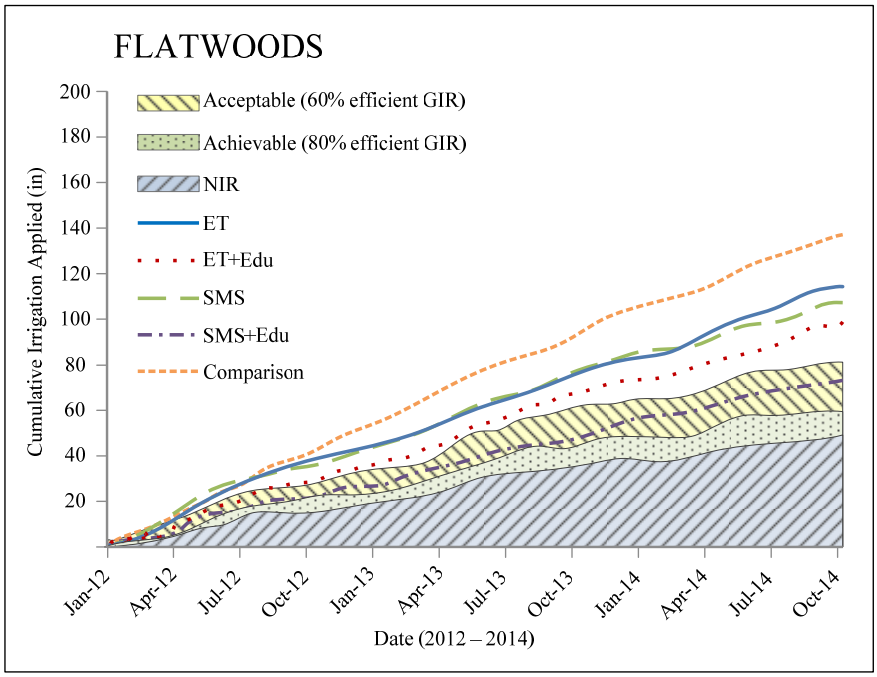

Figure ES.1. Cumulative irrigation for the study period averaged across locations for the flatwood soils

In the sandy soil locations, the comparison group had significantly higher weekly irrigation (averaging 1.21 inches) compared to all other treatments. The ET treatment irrigated significantly more (averaging 1.06 inches) than both SMS treatments and the ET+Edu treatment. Additionally, there were no significant differences between the remaining three treatments with weekly average irrigation application of 0.75, 0.75, and 0.70 inches for ET+Edu, SMS, and SMS+Edu, respectively. The education component has significantly lowered the average irrigation application for the ET technology only.

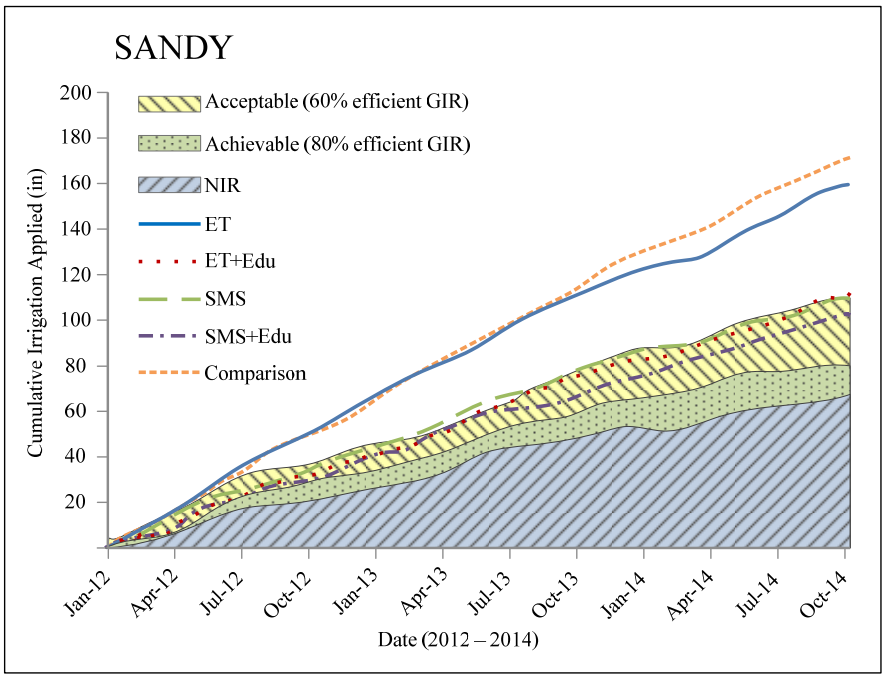

Figure ES.2. Cumulative irrigation for the study period averaged across locations for the sandy soils

On average, evapotranspiration irrigation controller treatments reduced irrigation by 18% across both sandy and flatwoods soils for the non-education group, and 32% for the education group. The soil moisture sensor technology reduced irrigation by 30% for the non-educational group and 42% for the educational group across both soils. The educational groups had a trend for less irrigation than their non-educational counterparts. A post-test survey showed that the level of irrigation knowledge did not differ between educational and non-educational treatment groups. Therefore, the study concludes that the educational groups irrigate less due to optimized controller settings with site specific parameters.

Among the four commercial properties, all of which were installed with evapotranspiration irrigation controller treatments, average irrigation was reduced across both soil types by 28%. Turfgrass quality ratings were taken quarterly and quality exceeded the minimum rating of five at all commercial properties throughout the study period.

The post-test survey was designed to be unique for each treatment group. Results provided data on water use, conservation attitudes, satisfaction with the residential use of SMS and ET controllers, as well as other aspects of the study. A range of 61% to 87% of participants in each treatment group considered themselves satisfied or very satisfied with their irrigation practices. Regarding satisfaction of yard appearance, survey participants that were either satisfied or very satisfied ranged from 61% to 77%. Finally, 65% - 81% of survey participants reported being satisfied or very satisfied with smart irrigation technology.

APPLICATIONS/RECOMMENDATIONS

Policy Changes

The results of the "Smart Irrigation Controller Demonstration and Evaluation in Orange County, Florida" project have demonstrated that smart irrigation controllers do conserve water for both residential and commercial properties that historically over irrigate by efficiently scheduling irrigation. Cooperators in the study were exempt from mandatory one and two-day-a-week irrigation restrictions imposed by the water management districts and enforced by Orange County. To realize the water conservation potential of smart irrigation technologies, it is recommended that alternatives to policy mandates such as irrigation restrictions based on days of the week be examined. This examination will likely result in state agency rule changes, modification of ordinances, and regulatory program implementation changes.

Economic Implications

Like many other parts of the country, Orange County Florida has emerged from the recession and is once again experiencing growth in the housing market. Many new homes are constructed with automatic in-ground irrigation systems. Modification to regulatory policies that allow flexibility when smart irrigation technology devices are installed may offer opportunities for developers to offer these devices in new home construction. Irrigation reductions of 18–42% should also be of interest to commercial enterprises as they endeavor to reduce overhead costs and improve their bottom line. Satisfaction expressed by customers with the technology may be of interest to irrigation technology providers and contractors as they look for additional methods to market their products.

Public Funding Allocation

Because optimized controller settings resulted in lower rates of irrigation application and high customer satisfaction, there may be opportunities for public-private partnerships between water management districts, water utilities, irrigation suppliers, and contractors for incentive programs for residential and commercial customers. Data provided in this study may help water management districts quantify water use savings as they consider funding awards for water conservation initiatives. The efficiency of smart irrigation technology to reduce wasteful watering may help water utilities extend their portfolio of water resources, including both potable and reclaimed water.

TAILORED COLLABORATION PARTNER

- Orange County Utilities