GSA Public Buildings Service

GSA

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# WIRELESS SOIL-MOISTURE SENSORS FOR IRRIGATION

## Wireless Moisture Sensors Show Potential for Water Savings, Warrant Further Study

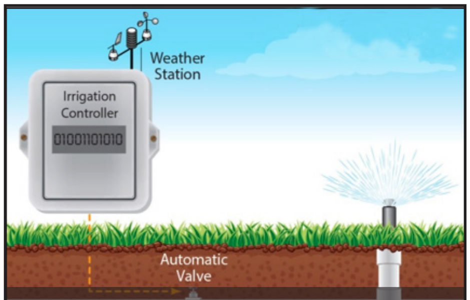
With severe drought in Western states and Executive Order 13693 calling for an annual 2% reduction in water use through 2025,[1] water conservation is more important than ever. Smart irrigation conserves water and can help meet federally mandated goals. Smart irrigation controllers provide an alternative to conventional timer-based systems, with demonstrated water savings of between 20% and 40%.[2] There are two types of smart irrigation controllers. Weather-based controllers use weather data to determine landscape water requirements, while sensor-based controllers use on-site sensors, such as those that detect moisture, to determine whether the landscape requires irrigation.

The Green Proving Ground (GPG) program commissioned the Pacific Northwest National Laboratory (PNNL) to assess a pre-commercial wireless implementation of a soil-moisture sensor-based system at the George C. Young Federal Building and U.S. Courthouse (Young Federal Building) in Orlando, Florida. Because of operational problems that compromised the assessment, results were inconclusive. Still, it was determined that soil-moisture sensor-based systems warrant further study. Unlike weather-based systems, they can determine landscape water needs for specific zones and thereby deliver only as much water as is needed to keep vegetation healthy.

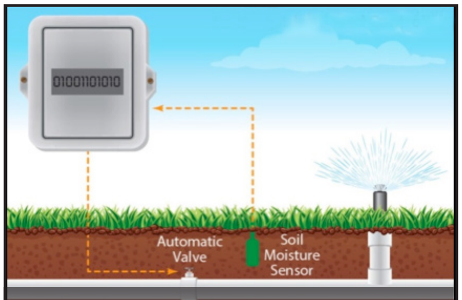
GPG
Green Proving Ground Program

The Green Proving Ground program leverages GSA's real estate portfolio to test innovative building technologies and provide recommendations on their deployment. The program helps GSA meet its sustainability goals with actionable data that informs investment decisions targeted at reducing energy- and water-use.

# INTRODUCTION



A. Weather-Based Controller



B. Soil-Moisture-Based Controller

### Smart Irrigation Control

A. Weather-based controllers use weather data to determine landscape water requirements using an on-site weather station, a nearby municipal weather station, or historical weather data.

B. Soil-moisture-based controllers use underground soil-moisture sensors to determine whether the area surrounding the sensor requires irrigation.

*"Soil-moisture technology can gauge the moisture content of individual landscape types in real time. Irrigation based on that kind of granularity can save water and keep vegetation healthy. Re-evaluation makes good sense."*

—KL McMordie Stoughton
Principal Investigator
Pacific Northwest National Laboratory

**PERFORMANCE SPECIFICATIONS**
Water Savings

**EXECUTIVE ORDER 13693**

Reduction in non-potable water for use in industrial, landscaping and agricultural applications by 2025, compared to 2010 baseline — **30%**

Reduction in potable water use (including landscaping) by 2025, compared to 2007 baseline — **36%**

**SMART-IRRIGATION**

Projected Water Savings — **20-40%**

## What Is This Technology?

**WIRELESS NETWORK GATHERS LOCAL SOIL-MOISTURE DATA FOR OPTIMAL IRRIGATION**

The irrigation control technology assessed during this GPG demonstration project uses a wireless communication network to gather real-time soil-moisture sensor data from predetermined irrigation zones. This information is used to control the irrigation system, with the objective of keeping soil within the predetermined zones at optimal moisture levels. In addition to monitoring and recording data from soil-moisture sensors and irrigation flow meters, the system analyzes, presents, and manages data with a web-accessible analytical software package, which can enable central management of multiple landscape areas.

## What We Did

**SYSTEM GATHERED MOISTURE DATA FROM 23 SEPARATE ZONES**

The wireless soil-moisture sensor irrigation control system was installed at the Young Federal Building in January, 2012. A flow meter was also installed to measure water flow to the irrigation system. Two independent controllers collected data and controlled irrigation events for 23 separate irrigation zones throughout the approximately one-acre site. The system recorded two sets of data. One set detailed watering events—total volume of water, date, time, duration, and type of watering event (manual or automatic)—the other soil-moisture content. PNNL compared the two data logs for a six-month period to determine whether the system was operating correctly, gauge irrigation water consumption, and ascertain where in GSA's real estate portfolio this technology might best be deployed. Referencing system costs, baseline water use, and assumptions about water savings potential, researchers also performed an economic analysis to determine cost-effectiveness.

# FINDINGS

**COMMUNICATION PROBLEMS IMPEDED DATA TRANSFER** During installation of the technology, it was discovered that the Young Federal Building's heavy concrete construction impeded the transmission of wireless signals. Repeaters were installed but communication problems continued throughout the course of the study.

**DISPARITIES IN SENSOR READINGS** There were large sensor reading disparities between zones with similar irrigation needs. This may indicate communication problems, sensor errors, or problems with moisture target settings used in the algorithm to trigger watering events.

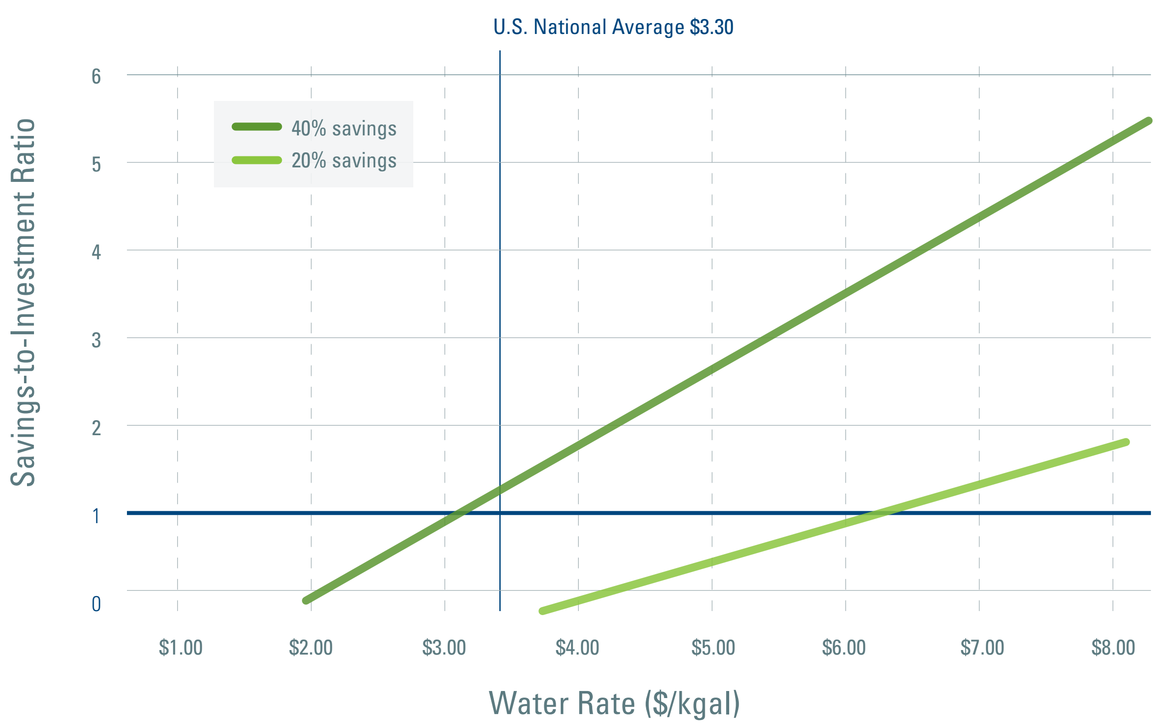
**LIFE-CYCLE COST EFFECTIVE AT AVERAGE U.S. WATER RATE, ASSUMING 40% WATER SAVINGS** Because of Orlando's very low local water rate of $1.06/kgal, the technology was not cost-effective at the time of the assessment. Assuming a 40% water savings, however, the technology becomes cost-effective at a water rate of $3.11/kgal, which is just below the U.S. national average of $3.30/kgal.

**FURTHER STUDY RECOMMENDED** Because of the potential for more precise measurement, increased water savings and lower costs, when compared with weather-based irrigation control, further evaluation of wireless moisture sensors for irrigation control is recommended. Also, the technology assessed was pre-commercial and product development continued after the assessment.

## Economic Assessment for Soil-Moisture Sensor Installation in Orlando

Cost-effective when Savings-to-Investment Ratio (SIR) is greater than 1

Assuming installed system cost of $4,500, annual costs of $680 and 773,700 gal/yr water use



# CONCLUSIONS

These Findings are based on the report, "Irrigation Controls Based on Wireless Soil Moisture Technology Assessment: George C. Young Federal Building and U.S. Courthouse, Orlando, FL," which is available from the GPG program website, www.gsa.gov/gpg

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## What We Concluded

**BECAUSE OF OPERATIONAL PROBLEMS LEADING TO AN INCONCLUSIVE ASSESSMENT, FURTHER EVALUATION IS RECOMMENDED**

The technology assessed during this Green Proving Ground program demonstration project was pre-commercial and operational problems during the assessment compromised the analysis, leading to incomplete results. Nonetheless, it was concluded that wireless soil-moisture based systems warrant further study. As drought conditions worsen (37% of the U.S. is currently experiencing drought[3]) and the need for water conservation increases, a technology that has the potential to be more efficient and cost-effective than weather-based systems is attractive. Also, the soil-moisture based system evaluated here has undergone further development since this evaluation. However, until the effectiveness of wireless soil-moisture technology is as thoroughly documented as weather-based technology, it is recommended that GSA continue to pursue integrated weather-based irrigation control.

## Recommendations for Further Research

- Choose a location with multiple-zone landscape and intermittent rain.
- Test the wireless signal transmission prior to technology implementation.
- Analyze zone soil type to understand the general constitution and soil-moisture retention so that the control system can be properly programmed.
- Install a dedicated irrigation flow meter that can measure water usage by irrigation zone before and after installation of the soil-moisture-based system. Monitor the system after installation to determine whether automatic watering events are triggered by a drop in soil-moisture levels to a minimum threshold level.
- Have the manufacturer commission the irrigation system and equipment prior to the installation of the new control system to make sure that all zone irrigation sprinklers are working properly.
- Train grounds maintenance managers on the operation and maintenance of the soil-moisture controller, including system programming, adjustments and override mode, and the on-line data system.

### Footnotes

[1] Executive Order 13693, https://www.whitehouse.gov/the-press-office/2015/03/19/executive-order-planning-federal-sustainability-next-decade.

[2] Dukes, MD. Water Conservation Potential of Landscape Irrigation Smart Controllers. American Society of Agricultural and Biological Engineers. ISSN 2151-0032. 2012.

[3] *The New York Times*, Mapping the Spread of Drought Across the U.S., http://www.nytimes.com/interactive/2014/upshot/mapping-the-spread-of-drought-across-the-us.html?_r=0&abt=0002&abg=0. Accessed 4/6/2015.