REDUCING WATER USE ON TWIN CITIES LAWNS THROUGH RESEARCH EDUCATION AND OUTREACH

University of Minnesota Extension

Extension
Turfgrass Science

CLEAN WATER LAND & LEGACY AMENDMENT

METROPOLITAN COUNCIL

January 2019

The Council's mission is to foster efficient and economic growth for a prosperous metropolitan region

The Metropolitan Council is the regional planning organization for the seven-county Twin Cities area. The Council operates the regional bus and rail system, collects and treats wastewater, coordinates regional water resources, plans and helps fund regional parks, and administers federal funds that provide housing opportunities for low- and moderate-income individuals and families. The 17-member Council board is appointed by and serves at the pleasure of the governor.

On request, this publication will be made available in alternative formats to people with disabilities. Call Metropolitan Council information at 651-602-1140 or TTY 651-291-0904.

Irrigation Systems Demonstration Project

Introduction

Lawn irrigation practices have become a concern due to water quantity and quality issues with irrigation being a significant source of freshwater withdrawals in the Twin Cities Metro Area (TCMA). Our previous collaborative work with the Metropolitan Council identified opportunities for maximizing water use efficiency in the home landscape, including conducting irrigation audits and utilizing irrigation technologies such as rain sensors, soil moisture sensors, and smart controllers (Metropolitan Council project number: 15I103). This report summarizes results from an irrigation systems demonstration project on the University of Minnesota (UMN) St. Paul Campus. During 2018, postdoctoral associate Dr. Dan Sandor continued working on 2nd-year evaluations of ongoing projects from the previous project, and developed and provided outreach education at regional and state events. Currently, Dr. Sandor has initiated an irrigation systems demonstration and research project at the Minnesota Landscape Arboretum and is developing curriculum and educational materials for events in 2019 and 2020.

Materials and Methods

During the fall of 2016 and spring of 2017, an irrigation systems demonstration trial was established at the turfgrass research farm on the UMN St. Paul campus. Six different irrigation systems were designed and installed to assess the various amounts of water use for each irrigation system technology (Table 1). A non-irrigated plot was also established for control purposes. Each system represented a typical homeowner irrigation system determined from survey and assessment data in a previous project (Metropolitan Council project number 15I103). Each system was installed as a 1,156-ft^2 Kentucky bluegrass lawn and managed to maintain visual turfgrass quality at an acceptable level (Fig. 1). All treatments were mowed at 2.5 inches twice weekly and fertilized with 2.0 pounds of nitrogen fertilizer June through September (1.0 pound beginning of June, and 0.5 pound once in August and in September). The trial ran from July 15 to October 19 in 2017 and from June 4 to October 5 in 2018.

The irrigation treatments included various technologies to determine the amount of water savings observed by each technology (Table 1) and included a rain sensor, a soil moisture sensor, and several different smart controllers. All of the treatments were programmed to apply 0.33” of water on odd days, representative of a typical irrigation frequency for this region, and would either adjust program runtimes (smart controllers), or bypass scheduled irrigation altogether (rain sensor or soil moisture sensor) based upon the given technology, thus affecting the actual volume of water applied. The smart controllers collected weather data to adjust irrigation schedules by either using Wi-Fi to connect to local weather stations or by using a wireless connection to an on-site weather sensor. All of the technologies were evaluated against an irrigated control treatment, which used the same automated irrigation without using any smart or sensor-based technology (0.33” of water was applied odd days). A manually irrigated control treatment was also included, where 0.33” of irrigation was only applied as needed based on visual turf quality. This demonstration study also featured a non-irrigated treatment that was only watered from natural rainfall, to allow for observation of visual differences in aesthetic quality between irrigated and non-irrigated turf.

Table 1. Irrigation systems evaluated in the demonstration project.

Irrigation Treatment	**Sensor or Technology**	**Irrigation Program**
Irrigated Control, Controller A	Standard irrigation timer	0.33” odd days
Smart Controller B	Smart irrigation controller, uses Wi-Fi to obtain regional ET data	0.33” odd days
Smart Controller C + Rain Sensor	Smart irrigation controller, uses Wi-Fi to obtain regional ET data, treatment included a wireless rain sensor	0.33” odd days
Non-Irrigated	n/a	Natural rainfall only
Smart Controller D	Smart irrigation controller, uses on-site, wireless, add-on weather station sensor	0.33” odd days
Manually Irrigated, Controller E	Manually irrigated on an “as-needed” basis only	0.33” manually
Soil Moisture Sensor + Controller F	Standard irrigation timer with a soil moisture sensor	0.33” odd days

Figure 1. The project location at the turfgrass research farm on the UMN St. Paul campus. The irrigation treatments were a regular time-based Controller A (1), Smart Controller B (2), Smart Controller C + Rain Sensor (3), a non-irrigated plot (4), Smart Controller D (5), a manually-irrigated plot (6), and Soil Moisture Sensor + Controller F (7).

Results and Discussion

There were a number of rainfall events during both trial periods and 2017, on average, was slightly cooler than 2018 (Fig. 2). Overall, none of the automatically irrigated treatments exhibited unacceptable turfgrass quality. The manually irrigated treatment had a slight decline below acceptable turfgrass quality for a very brief period (two or three days) in 2017 and 2018, but the turfgrass recovered quickly upon being irrigated. The non-irrigated treatment, watered from natural rainfall only, steadily declined in quality during periods of infrequent rainfall and/ or drought, as the lawn would slowly decrease in color. However, once the drought stress was alleviated and rainfall occurred, the turfgrass quickly recovered to an acceptable level of turfgrass quality (Fig. 3). This demonstrated the inherent drought resistance and recuperative ability of turfgrasses and supported the belief that very little irrigation is required due to the frequent number of rainfall events in the Twin Cities Metro Area (TCMA) during the summer. Residents in the TCMA who are considering installing an irrigation system may be surprised to learn of the positive impact of frequent rainfall events in a properly managed lawn.

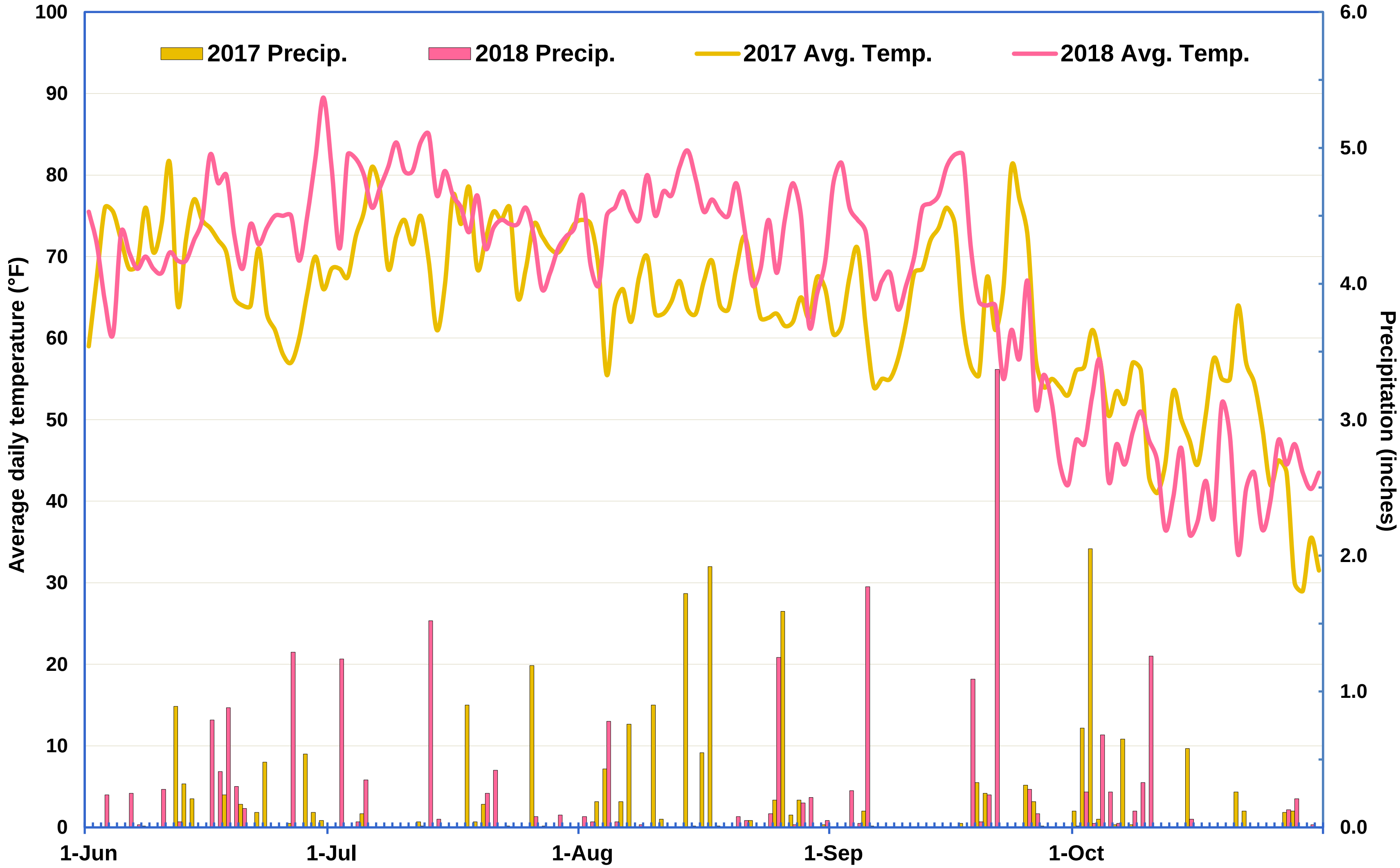

Figure 2. Average daily temperature and daily precipitation in 2017 and 2018. The 2017 trial ran from June 5 to October 19 and the 2018 trial ran from June 4 to October 5. This data was recorded from a NOAA weather station (GHCND: USC00218450) located on the St. Paul Campus.

Figure 3. Above: the unirrigated plot of Kentucky bluegrass in late August after approximately three weeks of high temperatures (77°F daily average) and very little rainfall (0.2 inches total). Bottom: the unirrigated plot two weeks later after a period of milder temperatures (72°F daily average) and frequent rainfall (2.1 inches total) had occurred.

Reductions in water use were observed under manually irrigated and smart controller / soil moisture sensor irrigation treatments compared to the irrigated control (Table 2; Figs. 4 and 5). The manually irrigated treatment used the least amount of water in both years which could likely be attributed to the frequent number of rainfall events during the trial periods (Table 2; Figs. 2 and 4). Irrigation occurred on only six and nine days total in 2017 and 2018, respectively. The soil moisture sensor reduced water use by the second-largest amount in both trials and resulted in similar reductions in water each year (Table 2; Figs. 4 and 5). It is important to understand that unlike smart controllers, soil moisture sensors bypass scheduled irrigation altogether and do not make runtime adjustments in the irrigation program runtime. The frequency in which soil moisture sensors bypass scheduled irrigation is affected by the moisture threshold setting; in this study the moisture threshold was set at 7 on the user-interface of the soil moisture sensor. This threshold can be adjusted (+/-) based upon end-user preferences. Soil moisture will also be influenced by soil texture and environmental conditions. During the study there were some periods where the soil moisture sensor exhibited lower visual turfgrass quality than the smart controller treatments; however, the soil moisture sensor did not exhibit unacceptable turfgrass quality during the trial periods. Proper installation and calibration of a soil moisture sensor is critical in making an irrigation schedule more water efficient.

Table 2. Water use and reduction (%) of various irrigation technologies and manual irrigation compared to irrigated control during 2017 and 2018.

Irrigation Treatment	2017 Water Use†	Reduction	2018 Water Use‡	Reduction
	-- gallons (inches) --	-- % --	-- gallons (inches) --	-- % --
Irrigated Control	12,962 (18.0)		14,323 (19.9)	
Smart Controller B	8,732 (12.1)	33	11,276 (15.6)	21
Smart Controller C + Rain Sensor	3,173 (4.4)	76	7,341 (10.2)	49
Smart Controller D	5,160 (7.6)	60	7,855 (10.9)	45
Manually Irrigated	1,197 (1.7)	91	2,144 (3.0)	85
Soil Moisture Sensor + Controller F	2,207 (3.1)	83	2,310 (3.2)	84

† 2017 trial ran from July 15 to October 19 (97 days). It is likely some irrigation ran that was unaccounted for and was not part of the scheduled program (such as following fertilizer applications or for demonstration purposes).

‡ 2018 trial ran from June 4 to October 5 (124 days).

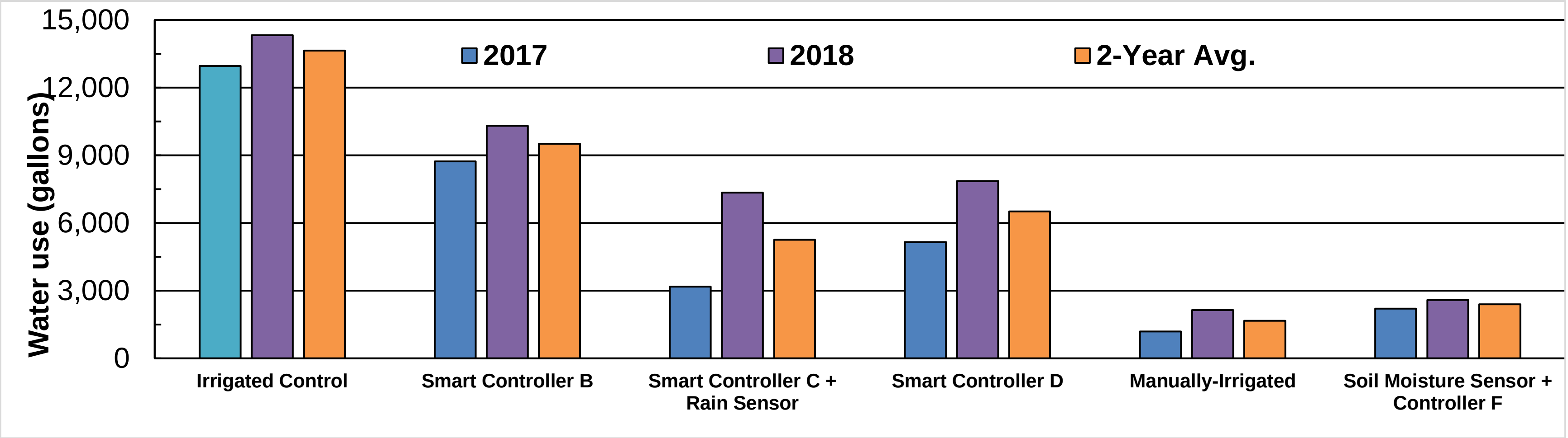

Figure 4. Water use (gallons) of various irrigation technologies and manual irrigation compared to irrigated control during 2017 and 2018. 2017 trial ran from July 15 to October 19 (97 days). It is likely some irrigation ran that was unaccounted for and was not part of the scheduled program (such as following fertilizer applications or for demonstration purposes). 2018 trial ran from June 4 to October 5 (124 days).

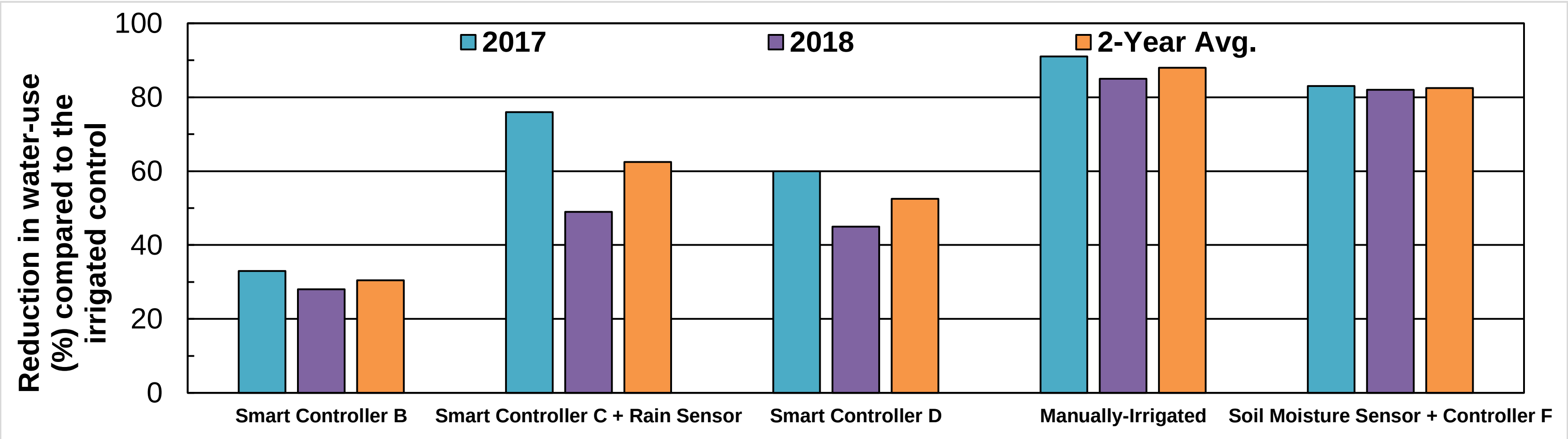

Figure 5. Reduction (%) of various irrigation technologies and manual irrigation relative to the irrigated control during 2017 and 2018. 2017 trial ran from July 15 to October 19 (97 days). It is likely some irrigation ran that was unaccounted for and was not part of the scheduled program (such as following fertilizer applications or for demonstration purposes). 2018 trial ran from June 4 to October 5 (124 days).

Smart controller D reduced water usage by an average of 53% between the two trial years (Table 2; Fig. 5) and maintained good communication with the on-site wireless weather sensor to make adjustments to the irrigation program runtime. The on-site wireless weather sensor was located within three feet of the smart controller and was unobstructed by shade or any structure limiting air movement. The rain sensor on the device appeared to be working properly during both years. It is likely an end user or homeowner may not be able to install the sensor in such close proximity to the smart controller at a residential or commercial property. End users also must be certain to properly install the sensor in an area that is unimpeded by natural or artificial restrictions of light, air, and other factors (e.g., under roof awnings / overhangs, gutters, etc.). Such impediments can influence the sensor's capabilities to efficiently schedule irrigation for the lawn's water requirements.

Smart controller C + rain sensor and smart controller B used Wi-Fi to connect to local weather stations in the area to obtain various weather data to adjust the program run times. These two treatments varied in their water savings, which could be a result of a malfunctioning rain sensor and inconsistent connections to Wi-Fi during 2017 and part of 2018. Smart controller C + rain sensor decreased water use by 76% in 2017. Even though water usage was reduced by a large amount during this time, acceptable turfgrass quality was not compromised. In early July 2018 it was determined that the rain sensor had stopped functioning properly (i.e., behaving as if it was continually wet) and therefore prevented any irrigation from occurring. On July 10 the rain sensor was disabled; however, it is unknown the duration to which the broken rain sensor affected water usage. It is likely that the rain sensor had been preventing irrigation from occurring in the 2017 trial period given the high reduction in water usage (Table 2; Fig. 4), and therefore likely that more water would have been used for irrigation had the rain sensor been working properly. Once the rain sensor was disabled, the irrigation program was only affected by the smart controller's Wi-Fi connection. The smartphone app that adjusts and programs smart controller C was convenient in terms of its use and understanding the program options and adjustments. Additionally, updates to the app did not seem to affect the irrigation program. Smart controller B reduced irrigation by approximately 27%, which was the lowest reduction amount during both trial periods. The low reduction in water savings could be attributed to the intermittent connection with Wi-Fi and difficulties in troubleshooting connectivity issues. Additionally, updates to the smart controller B smartphone app would sometimes affect the irrigation program settings, which in turn would affect the water savings until the program was readjusted. The turfgrass did not exhibit unacceptable turfgrass quality during either trial period.

Implications and Conclusions

Though relatively affordable, rain sensors are not effective for providing significant, consistent reductions in water usage. Minnesota state law (statute 103G.298) requires any irrigation system installed after 2003 to have a technology for interrupting operation during periods of sufficient moisture. Since 2003 there have been new technologies developed, such as smart controllers and soil moisture sensors, which have demonstrated greater effectiveness in reducing water use. Moreover, previous research has documented the sensitive nature and degradation of rain sensors after one to three years of use and recommended the replacement of the rain sensor at least every three years. Therefore, in order to more efficiently save water, one must consider upgrading their controller + rain sensor to a smart controller or adding a soil moisture sensor to their system.

There were some limitations in evaluating these technologies, which likely contributed to some of the findings of this project. Smart controllers typically utilized in residential and light-commercial properties (e.g., a restaurant, bank, store, etc.) are intended to work with Wi-Fi networks using a single-sign-on connection (i.e., password-only connection). In June 2018 it was determined that our smart controllers were not consistently connected to the UMN Wi-Fi due to the campus Wi-Fi network requiring a username and a password to establish a connection. This issue was resolved by purchasing a mobile Wi-Fi hotspot device (Verizon MiFi Jetpack), which provided continual Wi-Fi communication to the controllers. A different mobile hotspot device had been utilized for a portion of 2017; however, the operational period of that device is unknown. Due to manufacturer changes to that device, we installed the Jetpack in 2018. Wi-Fi communication issues of this nature would likely not be an issue in a residential setting where single sign-on connections are frequently utilized.

It is important to bear in mind that water savings will likely be affected if wireless network connectivity is interrupted or disabled for an extended period of time (greater than 24 hours) as smart controllers are collecting daily weather data to adjust scheduled program runtimes. One advantage of smart controller D is that it uses wireless communication with its on-site weather station sensor, which does not require access to a Wi-Fi network to adjust the irrigation program. This would be of great benefit for consumers who may not own a smart phone or have access to Wi-Fi and/or in locations where Wi-Fi connectivity may be poor. Additionally, using an on-site weather station can help fine-tune adjustments for site-specific water requirements, compared to using Wi-Fi to connect to off-site weather stations that may be miles away in some cases.

Another concern is the function or nature of smart controllers as relatively new technologies and, consequently, the manufacturers' continual updates of the corresponding application (app) on a smart phone. App updates may affect the water savings due to changes in program settings or options. Additionally, water savings adjustments and settings made by the smart controller app may not account for recommended best management practices for lawn irrigation, such as irrigating infrequently during the week (e.g., once or twice weekly). It is important that manufacturers provide options for infrequent irrigation schedules, without significantly reducing the water savings potential of the smart controller.

Overall, it is important that homeowners and property managers consider upgrading their irrigation systems by installing a smart controller and/or using a soil moisture sensor to reduce unnecessary watering while maintaining good lawn quality. Homeowners who are deciding on whether or not to install an irrigation system may consider not to, as rainfall in the TCMA appears sufficient to maintain the turf at an acceptable quality for a majority of the summer. The decision to utilize drought-resistant Kentucky bluegrass cultivars and/or more drought-resistant turfgrass species altogether, such as tall fescue or fine fescues, should be carefully weighed before considering installing an irrigation system. A research study, similar to this demonstration project, is currently being installed at the Minnesota Landscape Arboretum, where arboretum visitors will be able to learn first-hand about smart irrigation tools and technologies. The findings of the research study will be submitted for publication in a peer-reviewed journal in 2020, and research findings will be presented at local, state, and national meetings and conferences. To our knowledge, it will be perhaps the only research study to date evaluating smart controllers and soil moisture sensors in cool-season lawns, which would serve as a great value for homeowners and turfgrass managers in the Midwest and northern parts of the nation.

390 Robert Street North
Saint Paul, MN 55101-1805

651.602.1000
TTY 651.291.0904
public.info@metc.state.mn.us
metrocouncil.org

Follow us on:
twitter.com/metcouncilnews
facebook.com/MetropolitanCouncil
youtube.com/MetropolitanCouncil