EFFICIENT WATER USE ON TWIN CITIES LAWNS THROUGH ASSESSMENT, RESEARCH, AND DEMONSTRATION

Objective 1 Report

University of Minnesota Extension Turfgrass Science

METROPOLITAN COUNCIL

December 2016

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Efficient Water Use on Twin Cities Lawns through Assessment, Research, and Demonstration

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December 31st, 2016

Summary

Minnesotans cherish their land of 10,000 lakes but may not connect the dots as to the relationship between their actions at home and the impact on the state's water. Outdoor water use in the Twin Cities Metro Area (TCMA) has come under the spotlight recently due to concerns related to water quantity and quality. In the TCMA, approximately 20% of all treated drinking water is used outdoors, with a majority of this being used on lawns and landscapes. The goal of this project is to recommend water use efficiency measures in the home landscape by conducting assessments, research, and demonstration around the smart use of irrigation.

Objective 1 of this project involved conducting an irrigation survey of residents in the TCMA, and conducting irrigation audits of 60+ residents that completed the survey. Survey results and irrigation audit data provide insight into how irrigation systems are currently being operated in the TCMA.

Introduction

Nationally, water use in the home landscape accounts for nearly one-third of all residential water use, totaling nearly nine billion gallons per day (EPA, 2013). Lawns are the single largest irrigated area in the United States, accounting for over 40 million irrigated acres, or four times the irrigated acreage of corn (Milesi et al., 2005). In the TCMA, approximately 20% of treated drinking water is used outdoors (City of Minnetonka, 2012) and monthly summer water use is nearly three times greater than monthly winter use (Metropolitan Council, 2014), attributable to outdoor watering.

TCMA outdoor water use has become a concern due to local water quantity and quality issues and seasonal droughts. For instance, White Bear Lake, the second largest lake in the Twin Cities, had lost more than one fourth of its water volume in the last decade due to increased groundwater pumping around the region (Freshwater Society, 2013). This trend, coupled with climate change, may continue as urbanization increases. A University of Minnesota Extension survey conducted in 2013 found that approximately 81% of surveyed homeowners in Minnesota watered their lawns at some point throughout the growing season (n = 1119) (unpublished data). For those who did not water their lawns, 47% and 25% cited environmental and price concerns, respectively, as reasons for not irrigating. In a 2015 survey of Minnesota Master Gardeners, 26% of respondents indicated that they have an irrigation system, but how they operate it can vary (n = 129) (unpublished data). Some respondents operate their irrigation systems manually by turning it on and off depending on lawn water needs, while others rely on automatic operation. Over 55% of the respondents with irrigation systems have rain sensors installed, and 8% have soil moisture sensors. This data indicates a significant number of outdated systems or systems that would benefit from upgraded sensor technology. According to Minnesota Statute 103G.298, enacted in 2003, "All automatically operated landscape irrigation systems shall have furnished and installed technology that inhibits or interrupts operation of the landscape irrigation system during periods of sufficient moisture. The technology must be adjustable either by the end user or the professional practitioner of landscape irrigation services." This applies to irrigation systems installed after 1 July 2003.

Irrigation sensor technology continues to improve as manufacturers place more of an emphasis on water conservation. In addition to rain sensors, which deactivate irrigation systems when rainfall events occur, soil moisture sensors and smart irrigation controllers are becoming more common. Soil moisture sensors may be more beneficial for reducing landscape water use than rain sensors because they measure actual volumetric soil moisture content. Additionally, smart irrigation controllers have the ability to make daily adjustments based on plant water demands (evapotranspiration) and seasonal weather fluctuations. These upgrades are becoming more economical for homeowners with irrigation systems, although use is still not widespread. Manufacturers are also designing more efficient irrigation sprinklers, such as the *IrriGreen sprinkler* (*irrigreen.com*) which automatically adjusts water distribution patterns to irrigate irregularly-spaced areas, and the *Toro* Company's (*toro.com*) matched precipitation rate nozzles which apply uniform depths of water across a lawn.

The University of Minnesota Turfgrass Science Extension Program focuses heavily on water conservation in the home landscape. Our approach to this effort has included surveying the public about water use, identifying and developing drought tolerant grasses, and educating the public about water conservation. This project with the Metropolitan Council builds on our previous work by studying outdoor water use at the homeowner level through the assessment of irrigation practices and irrigation systems.

The objectives of this project are to: 1) survey and conduct assessments of lawns in the 7-county TCMA, and 2) conduct research, demonstration, and education related to water conservation in the home landscape.

Irrigation Survey

Overview

In the spring of 2016, an irrigation survey was created in Qualtrics survey software and distributed to homeowners across the TCMA via city and county newsletters, social media and mass media. The 22-question survey included questions related to homeowner's irrigation practices and lawn preferences, and homeowners answered different sets of questions depending on whether they had an irrigation system or not. To encourage participation in this survey, we conducted a drawing in which respondents could win one of ten $50 Visa gift cards.

In total, we received 931 responses to the survey and 745 fully completed surveys. The survey was distributed to two distinct groups: general public and avid gardeners, accounting for 758 and 171 responses, respectively. Table 1 outlines the distribution of survey respondents across the 7-county TCMA. Avid gardeners were emailed the survey if they subscribed to the University of Minnesota Yard and Garden News Blog. Visit the *Yard and Garden News Blog* (*http://blog-yard-garden-news.extension.umn.edu/*). Where responses between the two groups were the same, we combined the results.

One of the initial questions on the survey asked whether the respondent had an irrigation system or not which allowed us to split the respondents into two distinct groups: (1) those with irrigation systems and (2) those who manually water their lawns with a hose and sprinkler. Where applicable, we will discuss these groups separately.

Table 1: Survey respondent distributions by county

County	# of respondents	% of total respondents
Anoka	39	6.4%
Carver	11	1.8%

County	# of respondents	% of total respondents
Dakota	72	11.8%
Hennepin	260	42.7%
Ramsey	69	11.3%
Scott	12	2.0%
Washington	146	24.0%

Summary of Survey Results

- Approximately 63% of the 931 respondents in the TCMA have an irrigation system.
- The installation of irrigation systems is more common on large suburban lawns than small urban lawns.
- Over 70% of the respondents with irrigation systems live on a site that was developed more than 10 years ago, which suggests that the systems may be dated and in need of upgrade.
- On average, 15% of homeowners in the TCMA hire a contractor to perform some type of lawn care service.
- Lawn health and curb appeal are more important to survey respondents than water conservation.
- 70% of those who own an irrigation system operate it on their entire lawn, whereas 60% of those that water manually do so on 75% or less of their lawn.
- 30% of respondents do not know how much water they apply each week.
- 25% of respondents with an irrigation system run it on an automatic schedule without sensor technology.
- Over 40% of irrigation system owners operate their systems on an every other day schedule.
- Almost 50% of respondents with an irrigation system do not have it audited.

Residence Type

More than 92% of survey respondents live in a single-family home located on either a city or suburban lot; this is a good representation of the typical type of residence where irrigation systems would be used. The remaining 8% of respondents were distributed among townhomes, condos or apartments, and larger acreage properties, such as farms (Figure 1). The residence type distribution was essentially the same between the general public and the avid gardener groups. Survey results indicate irrigation systems are utilized on all residence types however, subsequent results indicate that lawn size may have an influence on watering method.

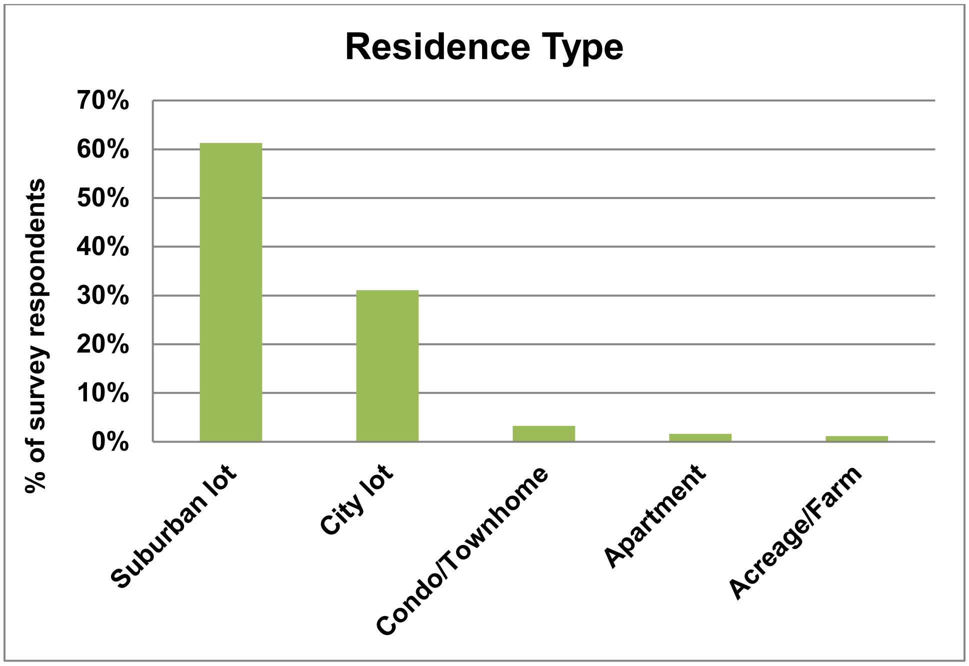


Figure 1: Survey respondent residence type (n=929)

Age of Properties

Results from the survey revealed that 28% of homes with an irrigation system have been developed in the last 10 years; less than 5% of those that water manually indicated that their site was developed in the last 10 years (Figure 2). This suggests a greater trend for the installation of irrigation systems at new homes. Over 70% of the respondents with irrigation systems live on a site that was developed more than 10 years ago, which suggests that the systems may be dated and in need of an upgrade. Over the last 10 years, irrigation system technology has rapidly evolved with the introduction of smart irrigation controllers, wireless sensors, and new sprinkler technologies. Additionally, from our observations in conducting irrigation audits, residential landscapes can change greatly over time as new construction occurs, designs are changed, and plants mature; these changes can impact the efficiency of irrigation practices in a large way. For example, we have observed many irrigation sprinklers being blocked by new or maturing plants which redirects the stream of water away from the intended target. We also witnessed sidewalks and patios installed without first removing or relocating the sprinklers, resulting in issues such as leaking pipes and watering impervious surfaces.

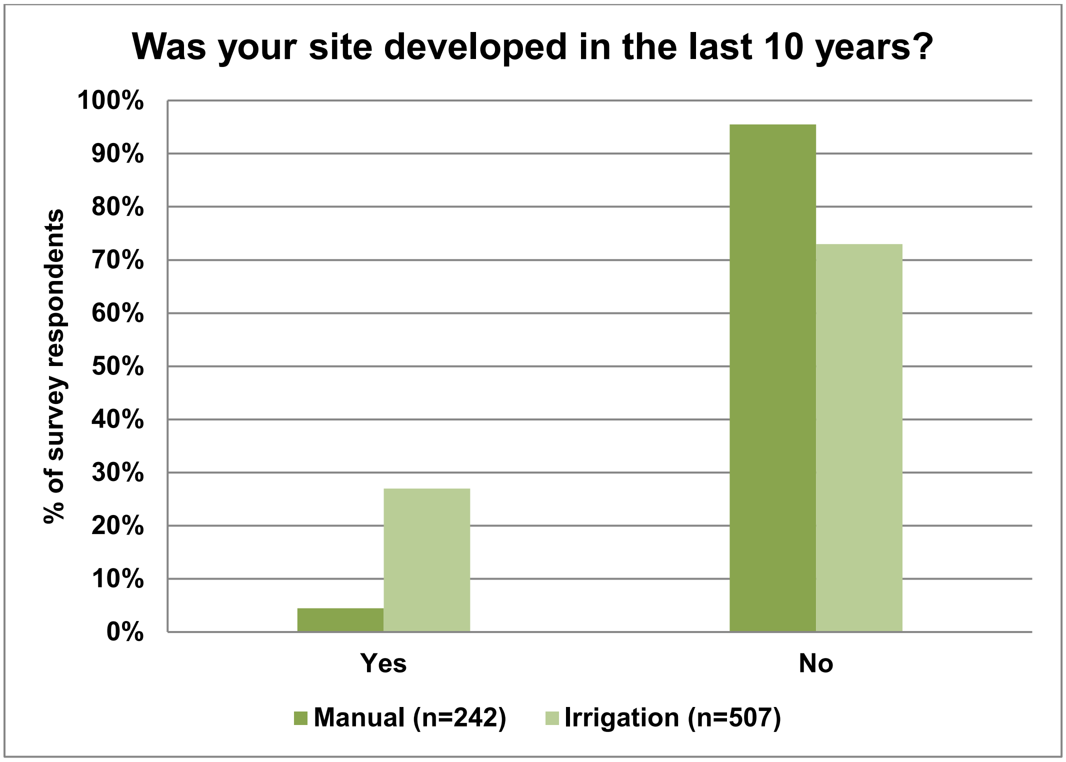


Figure 2: Responses to the question "Was your site developed in the last 10 years?"

Amendments to Soil Prior to Lawn Construction

A good quality soil is the foundation for healthy lawns and will influence irrigation use. For residents in the TCMA, we recommend adding amendments to native soils that are low in organic matter, compacted or sandy. Sandy soils will drain rapidly and will require more frequent irrigation; the opposite is true for heavy, compacted soils. Compacted soils will limit root growth and therefore can minimize access to water by turfgrass. Many cities and counties will recommend adding amendments, such as black dirt, prior to the installation of a lawn and this is generally a useful recommendation. When asked the question "*Were any of the following soil amendments added to the site before, during or after construction?*", approximately 70% of the respondents indicated that an amendment of black dirt, organic matter, or sand was added to their soil to improve the quality of the lawn (Figure 3). An overwhelming majority (73%) mentioned that the amendments were applied over the existing soil versus incorporating (tilling) them into the soil (data not shown). Layering amendments on the surface can create issues with rooting and soil moisture infiltration, and therefore we feel that homeowners must be educated on the proper amendments and layering depths for this practice. In most cases, amendments should be tilled into the existing soil, whereas new soil should be layered on the surface in a sufficient depth (6-8 inches) to encourage root growth and lawn health. Through Extension consultations, we have observed many homeowners spreading a thin layer (2-3 inches) of black dirt prior to seeding or sodding, and this practice should be avoided. The overall response to this question was low and this indicates that over half of our main survey respondents do not know whether anything was added to their soil prior to them purchasing the property.

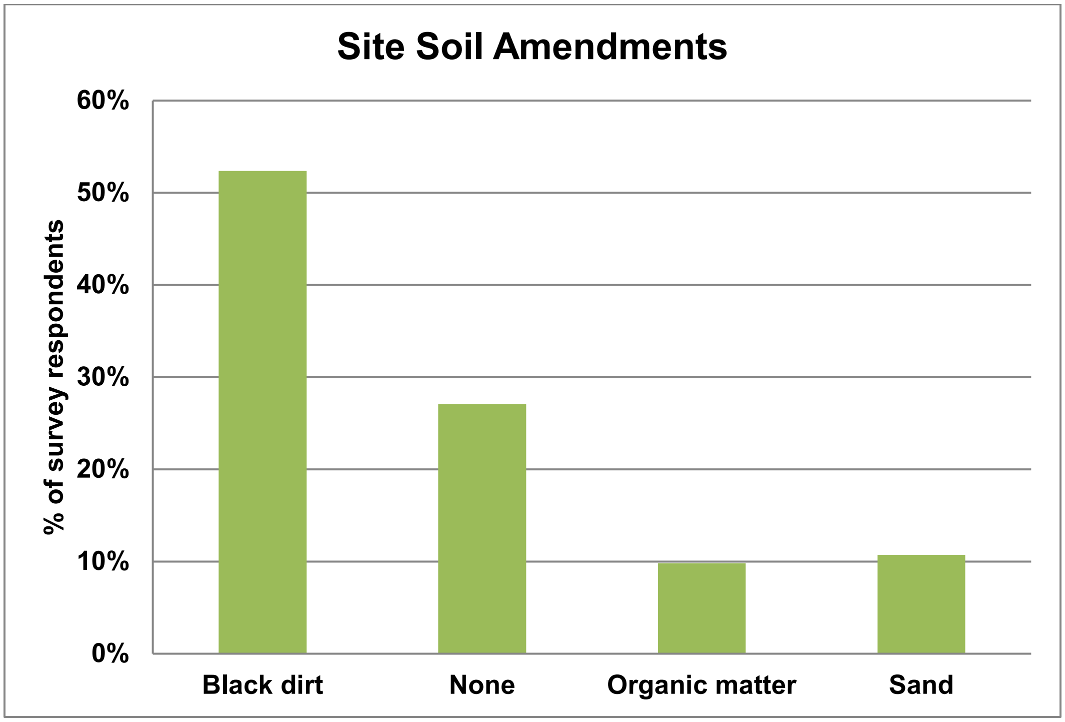


Figure 3: Survey responses (n=336) to the question "Were any of the following soil amendments added to the site before, during or after construction?"

Lawn Size

Lawn sizes varied from less than 5,000 ft^2 (typical size of a small urban lawn) to 15,000 ft^2 or more. Generally, most respondents who manually water have lawns that are 10,000 ft^2 or less, whereas most respondents who own an irrigation system have lawns that are 10,000 ft^2 or greater (Figure 4). This is consistent with results reported by Bremer et al. (2015) who observed that homeowners with large lots (>14,000 ft^2) were twice as likely to have an irrigation system compared to homeowners with smaller lots (<9,000 ft^2). This information is useful in directing education and outreach efforts towards suburban homes with larger lawns because they have a greater tendency to have an irrigation system installed and they are irrigating larger areas; this group potentially has the most to gain from targeted education efforts.

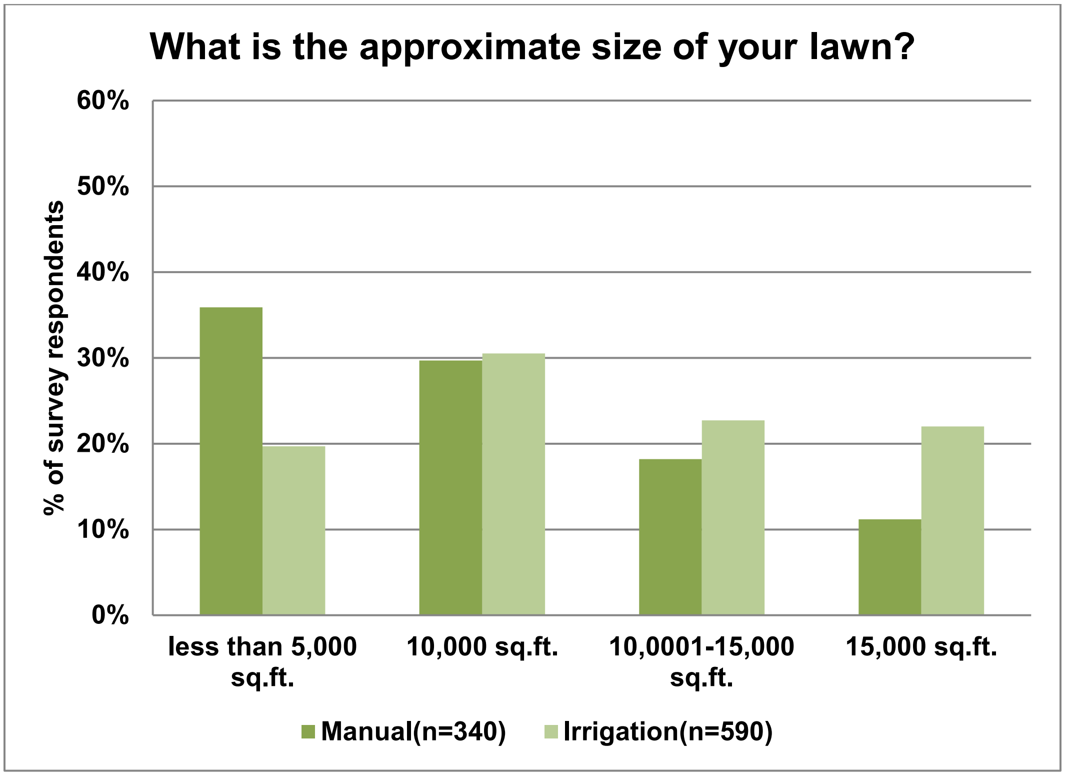


Figure 4: Survey responses to the question "What is the approximate size of your lawn?" for manual and irrigation groups

Contractor Services

Hiring a company to provide lawn care service is common in the TCMA, with companies contracting for services such as mowing, fertilizing, and aerating. On average, 15% of homeowners in the TCMA hire a contractor to perform some type of lawn care service. When comparing the responses between the manual and irrigation groups, one can see that the irrigation group has a greater tendency to hire contractors (Figure 5), and the most common service performed is weed control, followed by mowing (Figure 6); the differences between these groups is small. These data indicate that most homeowners maintain their lawns themselves and therefore education should be targeted at the homeowner level.

Figure 5: Survey responses to the question "Do you hire a contractor?" for manual (n=338) and irrigation groups (n=587)

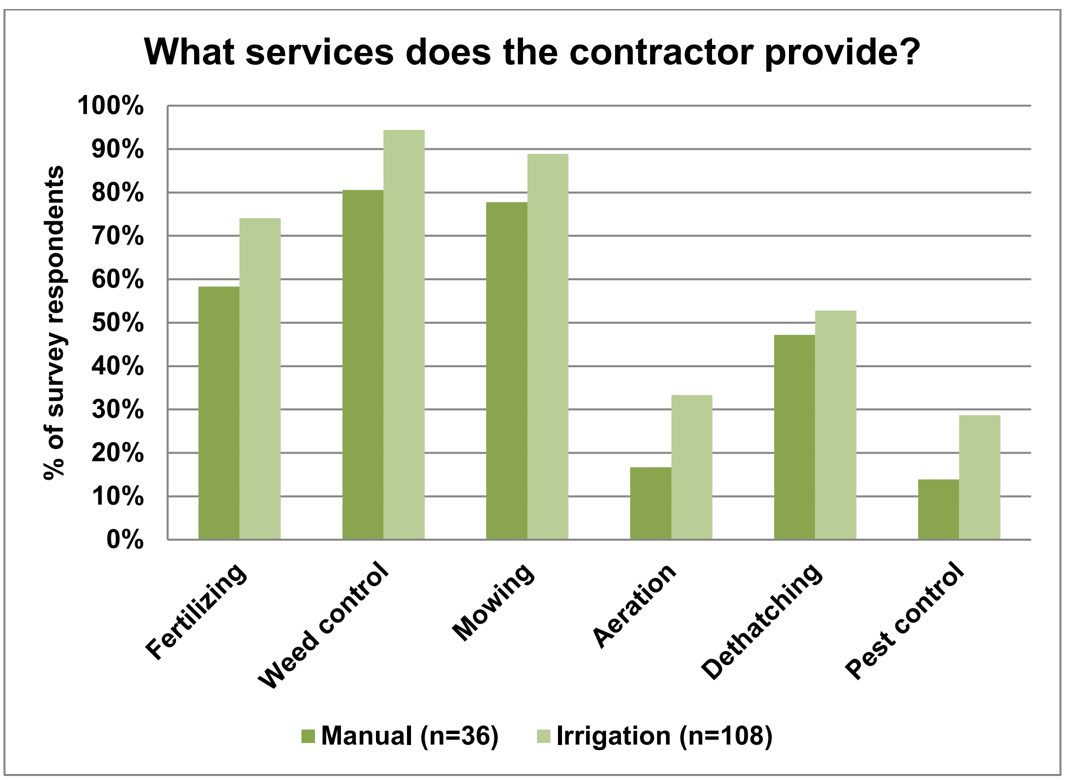


Figure 6: Survey responses to the question "What services does the contractor provide?" for the manual and irrigation groups

Lawn Goals

People maintain lawns for different reasons and can have a variety of goals in mind when caring for their lawns. When asked the question, "*Which of the following goals do you desire to achieve for your lawn?*", an overwhelming majority of respondents indicated that lawn health (83% of respondents) and curb appeal (77% of respondents) are most important to them. These responses were consistent among the manual and irrigation groups as well as the general public and avid gardener groups. Combined responses from these groups are included in Figure 7. Less than 50% of the respondents indicated that conserving water was a goal of theirs, which indicates a lack of awareness of the reasons to conserve water in the "Land of 10,000 Lakes." These results are consistent with a study conducted by Bremer et al. (2012) where neighborhood appearance ranked "very important" with homeowners and water conservation was only "somewhat important."

Additionally, only 38% of respondents use their lawn for some type of recreation. This means that the 62% of homeowners that don't recreate on their lawns could achieve the same curb appeal goals with lower maintenance, aesthetically pleasing grasses that are not typically recommended in situations with sustained traffic and recreation.

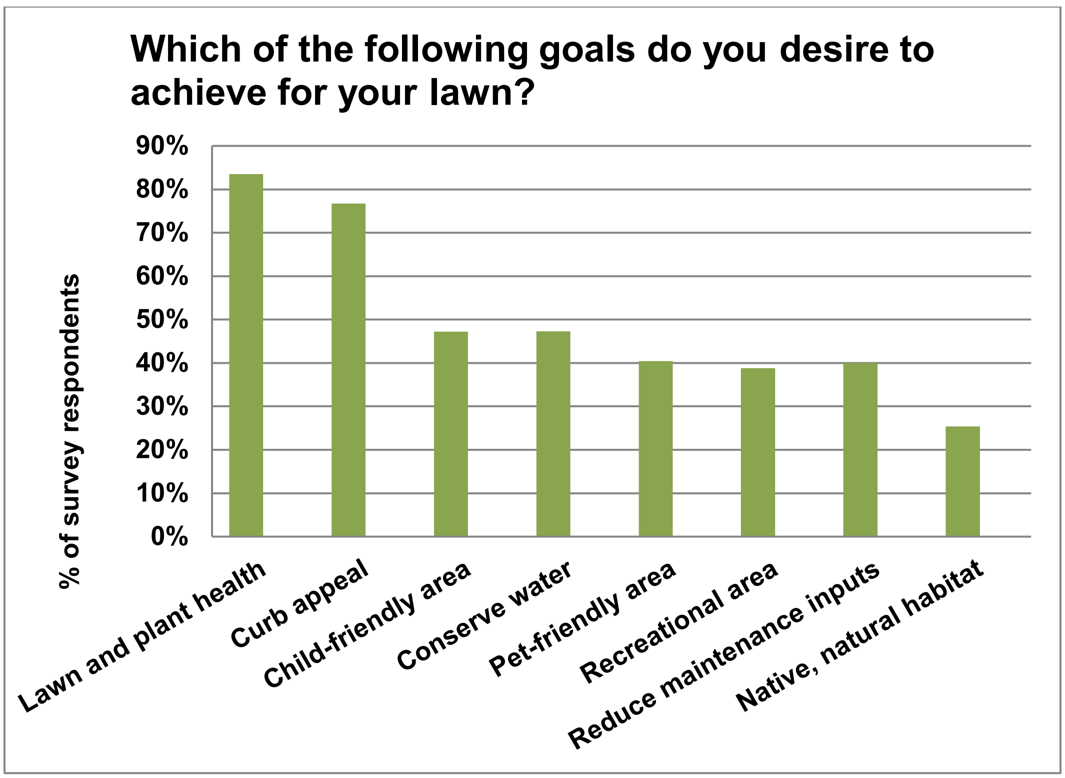


Figure 7: Survey responses to the question "Which of the following goals do you desire to achieve for your lawn?" (n=930)

Irrigation System Use

Results from the survey indicate that 63% of the respondents in the TCMA have an irrigation system and only 37% do not (Figure 8). While these results are surprising, and the authors acknowledge the potential for bias with this type of survey, these results are consistent with other studies across the nation. In 2013, Lawn and Landscape Magazine surveyed 555 homeowners across the nation, finding that 51% have an irrigation system (Bowen, 2013). Additionally, in 2005, the Tampa Bay, FL Water Authority reported that 70% of its single-family homes have automatic irrigation systems and this percentage was expected to continue to increase (Tampa Bay Water, 2005). Those with in-ground irrigation systems have a tendency to water more frequently than a homeowner without an irrigation system (Bremer et al., 2012).

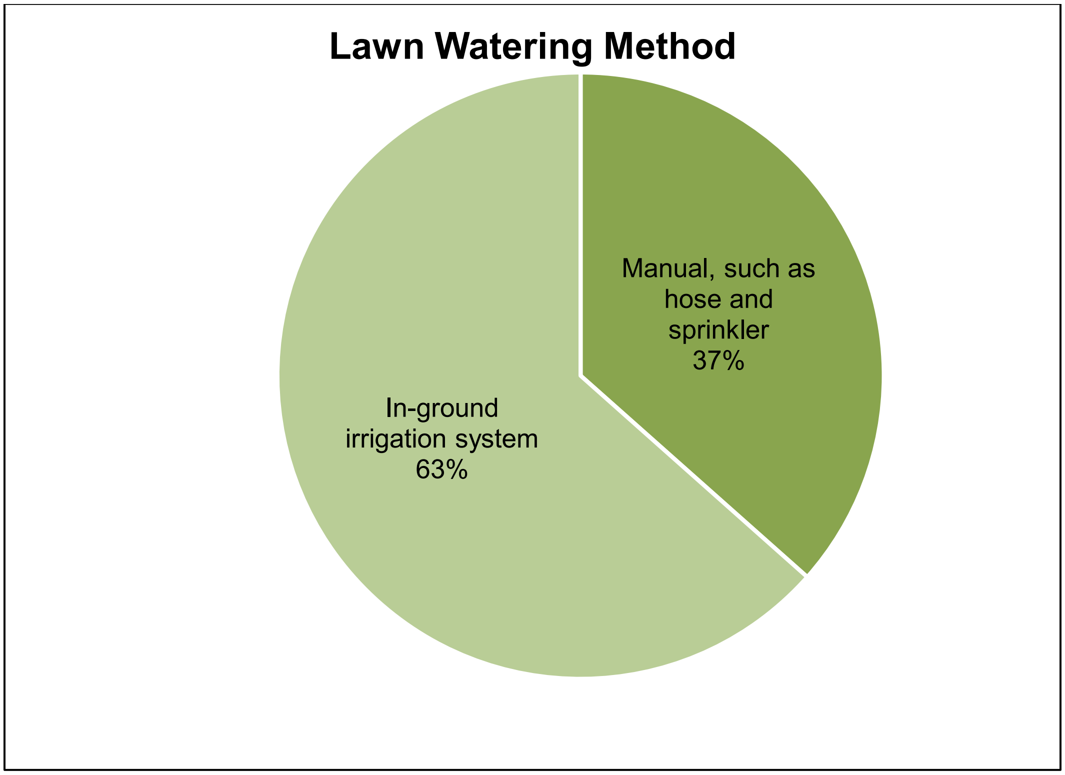


Figure 8: Distribution of survey respondents with in-ground irrigation systems versus those who water manually (n=931)

While on average 63% of respondents have an in-ground irrigation system, the results vary greatly based on the county of residence. In general, homeowners in suburban counties tend to have a higher percentage of irrigation systems than those in more densely populated, urban counties (Table 2). Fifty-five percent of respondents in Hennepin County have an irrigation system and 39% in Ramsey County have irrigation systems, while over 70% of respondents in more suburban counties of Anoka, Dakota, and Washington have irrigation systems. This confirms previous results indicating that the installation of in-ground irrigation systems is more common on larger, suburban lots. Unfortunately, we did not generate enough survey responses from Carver and Scott counties to make defensible conclusions about the percent of irrigation systems in these locations.

Table 2: County distributions of residents with and without irrigation systems

County	Irrigation	% of total	Manual	% of total
Anoka	30	76.9%	9	23.1%
Carver	7	63.6%	4	36.4%
Dakota	57	79.2%	15	20.8%
Hennepin	143	55.0%	117	45.0%
Ramsey	27	39.1%	42	60.9%
Scott	8	66.7%	4	33.3%
Washington	103	70.5%	43	29.5%

Level of Importance for Installing an Irrigation System

As part of the survey, participants with irrigation systems were asked to indicate the level of importance for installing an irrigation system from the list as shown in Table 3. Ninety-three percent of respondents listed “Lawn health” as important or very important; interestingly, 33% of survey respondents do not know how much water they apply to their lawn. Seventy percent or more of survey respondents indicated that all of the reasons listed in Table 3 were “important” or “very important”.

Table 3: Level of importance for installing an irrigation system

Reason for installing irrigation system	Not important	Somewhat important	Important	Very important
Lawn health (n=395)	1.3%	5.6%	38.5%	54.7%
Promote property value (n=391)	9.2%	20.2%	41.9%	28.6%
Save time (n=395)	6.3%	16.2%	35.2%	42.3%
Watering efficiency (n=392)	2.3%	9.9%	39.5%	48.2%

Irrigation System Age

The age of an irrigation system will influence water efficiency and older systems often have outdated technology that will influence water use. Approximately 55% of the survey respondents indicated that their irrigation system was installed within the last 10 years and 36% have a system that is 10 to 20 years old. Less than 10% of the respondents have an irrigation system that is 20 years old or greater (Figure 9). The results indicate that approximately 45% of the respondents that have irrigation systems could benefit from upgrading sprinklers and controller or sensor technology; assuming they haven’t made any of these changes already.

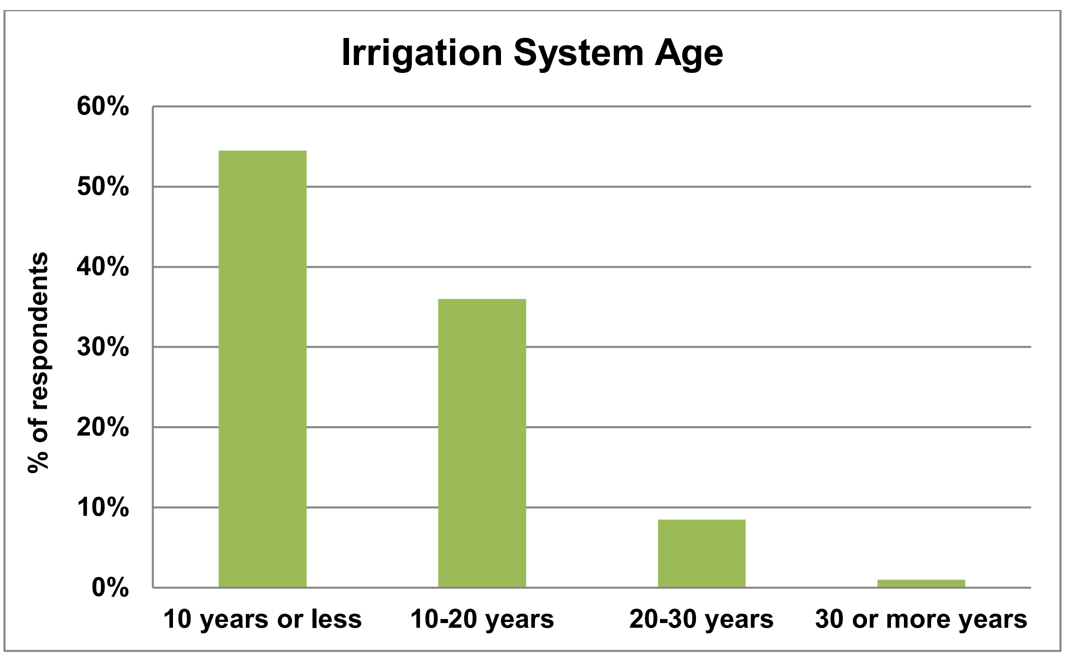


Figure 9: Irrigation system age across the TCMA (n=519)

Irrigation Controller Manufacturers

Residents of the TCMA utilize as many as nine different brands of irrigation controllers to operate their irrigation systems. Irrigation controllers manufactured by Hunter Industries are the most common, with 37.5% of respondents indicating that they have this type of controller (Figure 10). This is consistent with our observations from site visits. Interestingly, Rachio controllers, which have smart phone controller technology, are in place at over 16% of the homes surveyed. Rachio controllers allow a user the ability to directly link their controller with a local weather station and operation can easily be performed from a smart phone; homeowners can track water usage and savings on the smartphone application. Rainbird and Toro controllers are installed at approximately 20% of the homes surveyed, and the remaining respondents have one of five other brands.

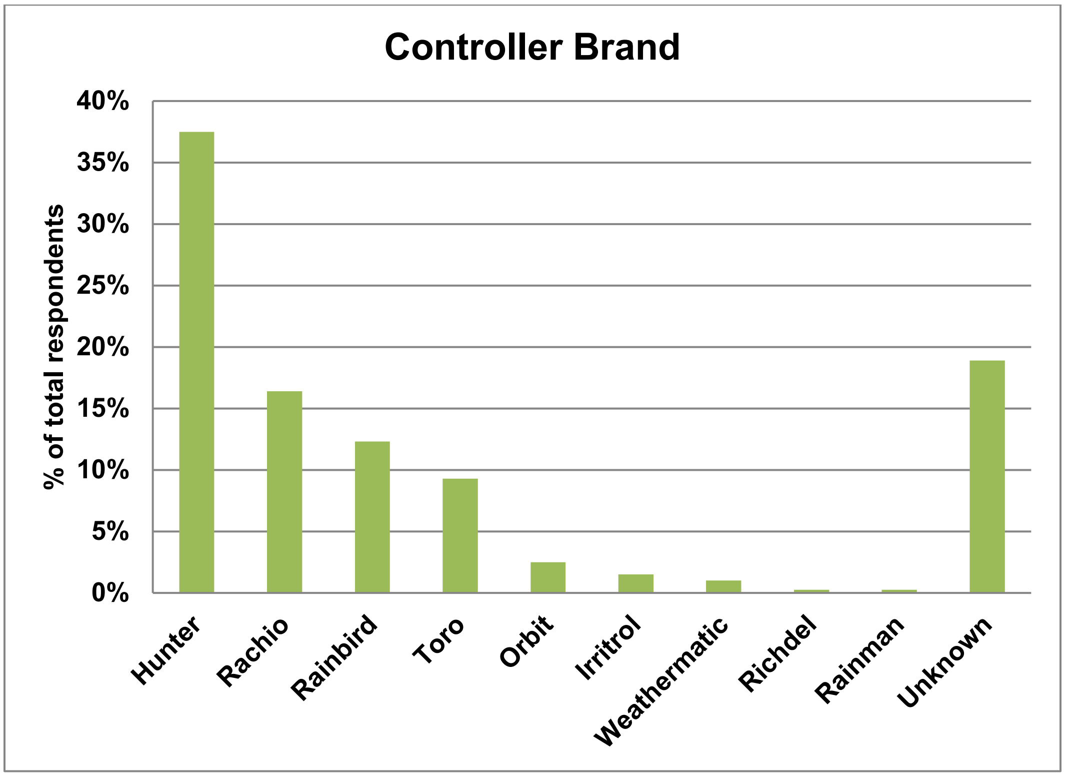


Figure 10: Irrigation controller brands of survey respondents (n=397)

Lawn Area Irrigated and Depth of Water Applied

Respondents who water manually cover smaller areas of their lawns compared to those who own irrigation systems. About 65% of manual watering respondents do so on three-fourths of their lawn or less, whereas almost 70% of those who own an irrigation system water their entire lawn (Figure 11). These data demonstrate an opportunity to save a significant amount of water by educating homeowners on the importance of adjusting their irrigation controllers to irrigate only high priority areas (for example, only the front yard).

When asked how many inches of water they attempt to irrigate on a weekly basis, there were only minor differences between those that water manually and those with irrigation systems (Figure 12); although 90% of manual waterers only irrigate if the lawn looks dry or if there has been a lack of rainfall, more than 60% of respondents with irrigation systems water on an automatic cycle (with or without sensors). Approximately 35% of the respondents indicated that they irrigate to a depth of 0.5 to 1.0 inches and this would be the ideal target for most lawns

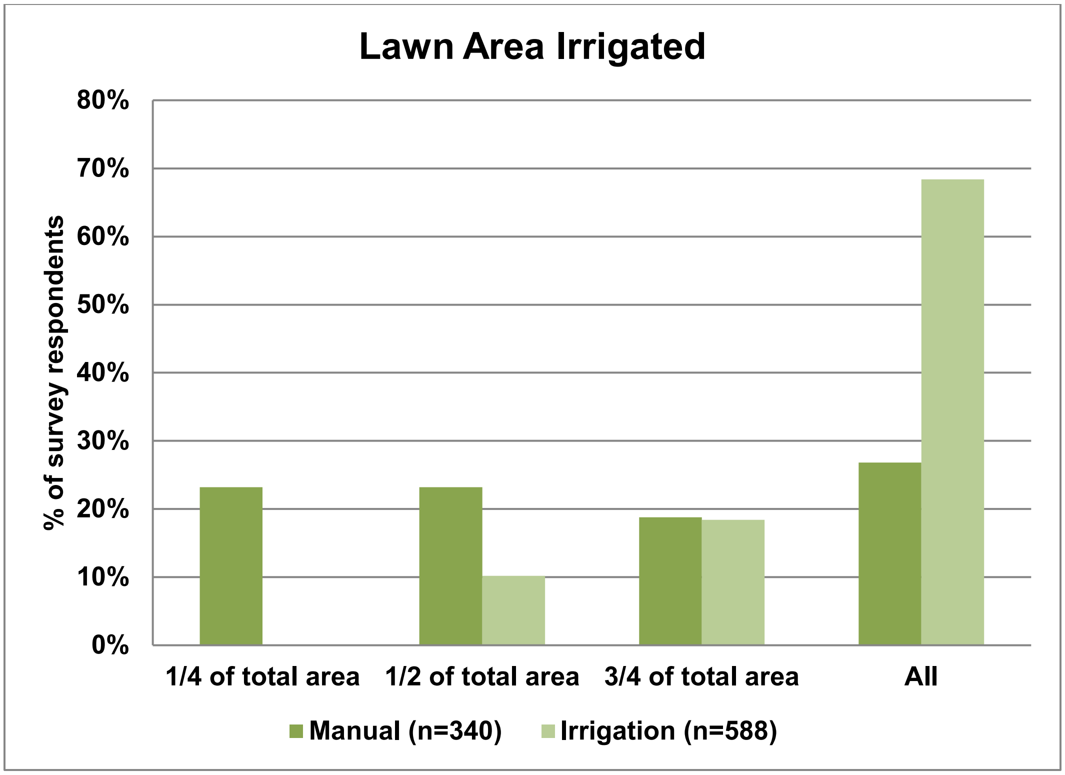


Figure 11: Area of lawn irrigated during each watering cycle

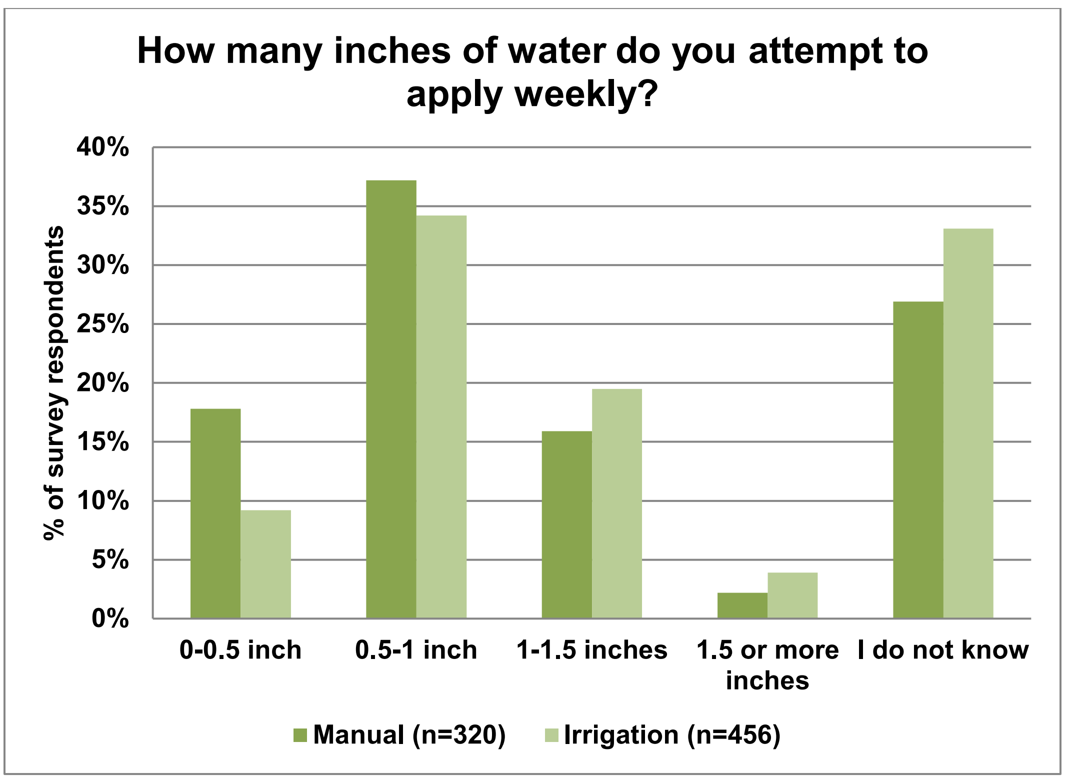


Figure 12: Inches of water applied on a weekly basis

in Minnesota based on the evapotranspiration demands of cool-season turfgrasses (University of Minnesota Extension, 2016). Respondents who water manually have a greater tendency to water less than 0.5 inches per week than those with irrigation systems. Approximately 20% of respondents irrigate with 1.0 inch or more per week, whether they irrigate manually or with an irrigation system, and 30% do not know how much water they apply each week. These results demonstrate that at least 50% of respondents may be either overwatering or may be less concerned with the amount of irrigation that is being applied to their lawns. Education programs should aim to educate these homeowners on the proper water requirements for cool-season grasses grown in Minnesota.

When to Water and Scheduling Irrigation

Only 34% of those with irrigation systems have it turned off and operate the system when the grass appears dry or there has been a lack of rainfall (Figure 13). Most respondents (90%) who manually water also use this as a determining factor (Figure 14). A quarter of respondents with an irrigation system run it on an automatic schedule without sensor technology. For the when-to-water criteria, we observed different response trends between the general public and the avid gardener group, so the data are presented separately. Overall, the general public has a lower tendency to use irrigation sensors (e.g., rain or soil moisture sensor) and they rely more on automatic programs compared to the avid gardener group; this is likely a reflection of the lack of general public awareness about sensor technologies and how to install these devices. Our best recommendation for the operation of irrigation systems with water conservation in mind is to turn it on only when the lawn shows signs of drought or to utilize sensor technology on an automatic system.

The time of day watering is performed varied between respondents who manually water and those who use an irrigation system. Manually watered lawns are irrigated 46% in the evening, 28% in the morning, and 23% whenever it is convenient (Figure 15). Lawns watered by irrigation systems are irrigated 18% in the evening, 80% in the morning, and only 1% whenever it is convenient. **Early morning is the best time to irrigate a lawn in Minnesota because at this time evaporation demands are low and the influence of wind is less of a factor.** Daytime irrigation is inefficient due to evaporation and wind deflection, and nighttime watering will encourage shallow rooting and disease due to the extended duration of leaf wetness. Clearly, manual watering homeowners need to be educated on the proper time of day to water, while most respondents with irrigation systems are operating them at the correct time. We caution homeowners from setting irrigation programs for too early in the morning, however, and suggest that they schedule programs for a time when they are awake and able to see the irrigation system running; this has the potential to increase a homeowner's awareness of when their irrigation system runs and if there are any leaks or sprinklers out of adjustment.

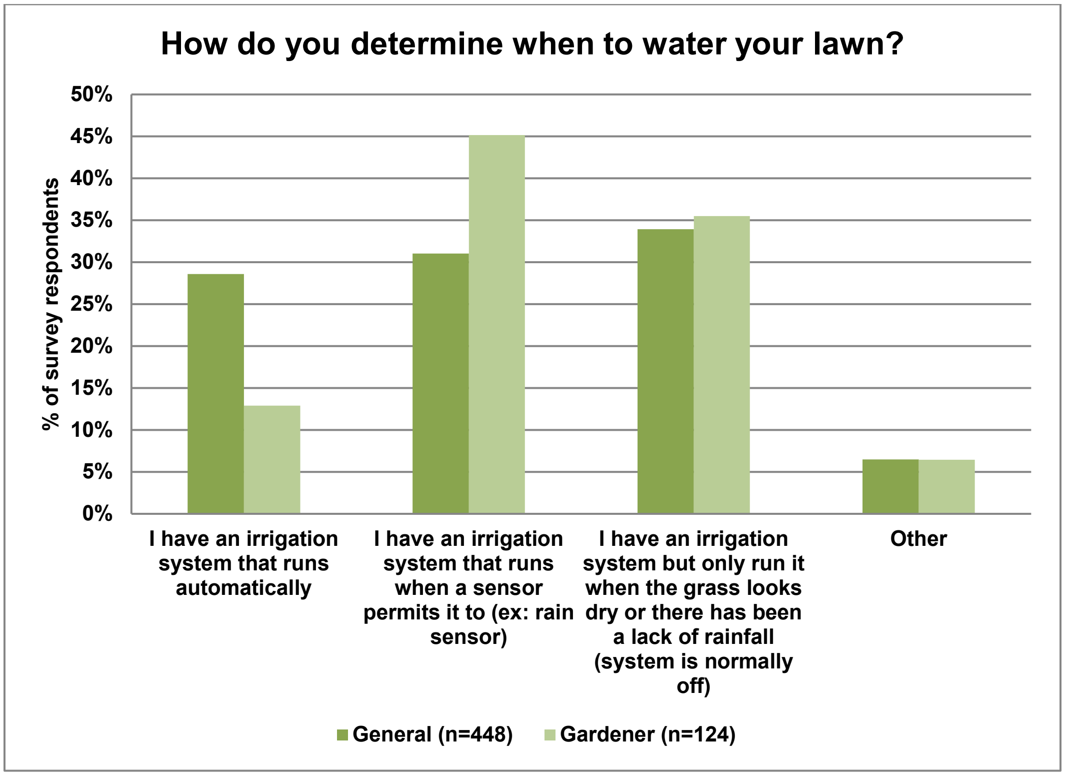


Figure 13: Survey responses to the question "How do you determine when to water your lawn?" This question was only asked to those with in-ground irrigation systems

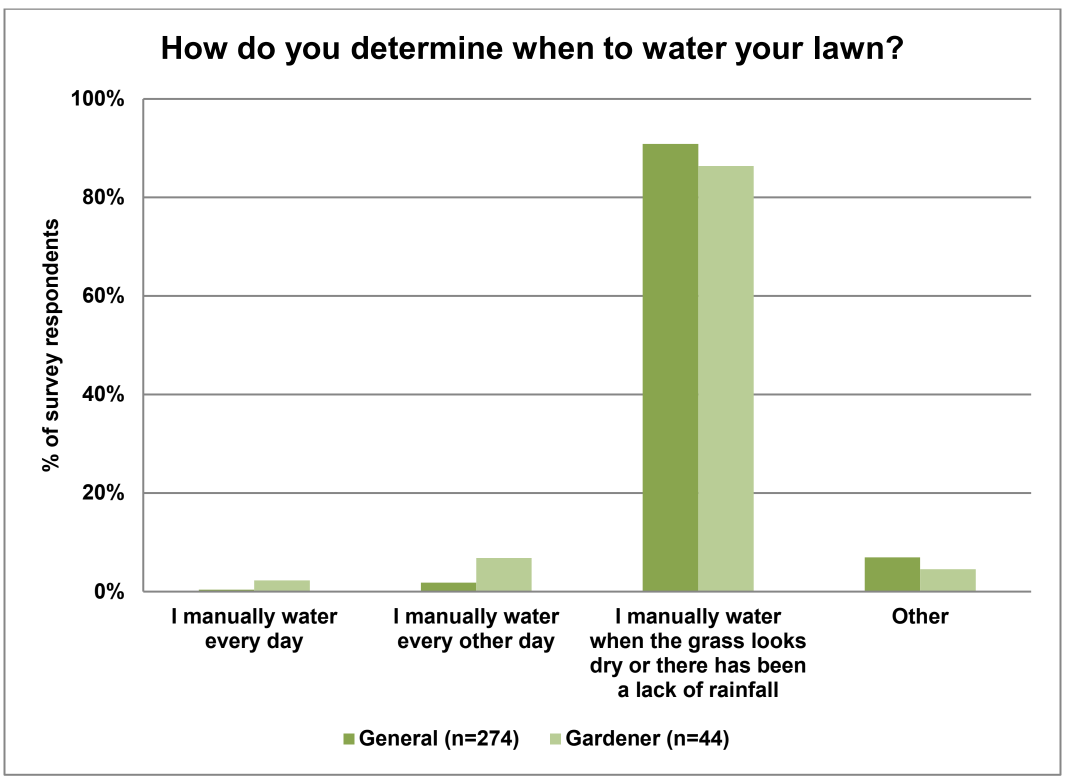


Figure 14: Survey responses to the question "How do determine when to water your lawn?" This question was only asked to those that manually water their lawns

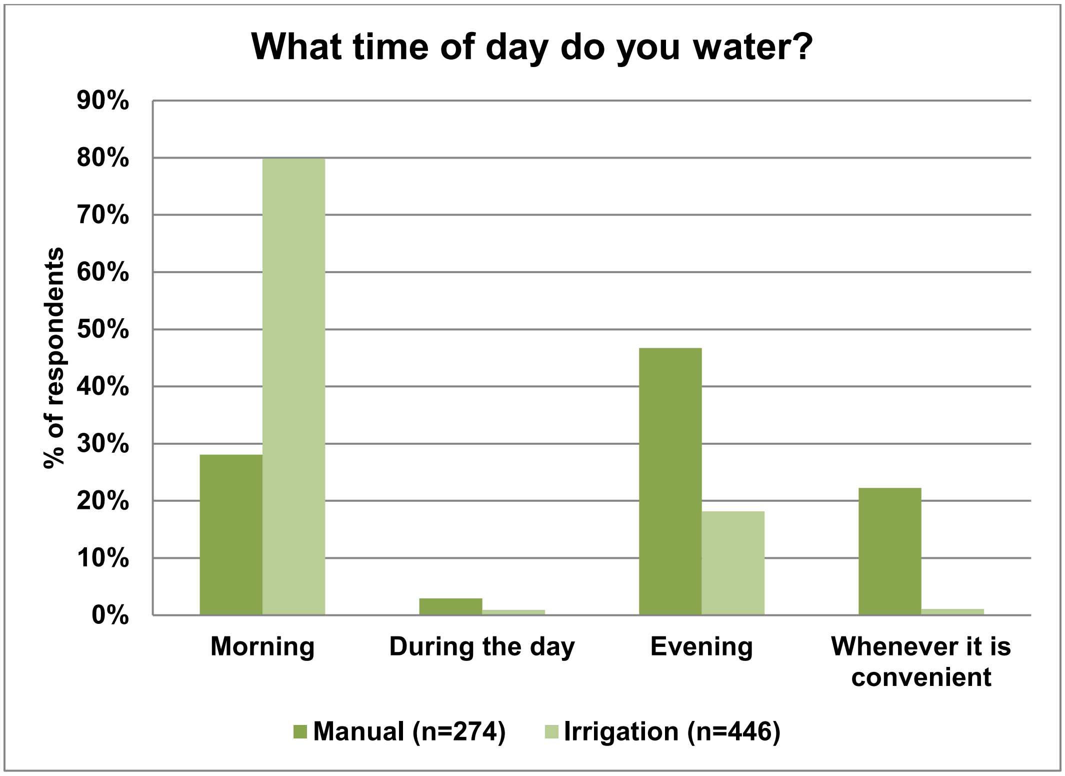


Figure 15: Survey responses to the question "What time of day do you water?"

Irrigation scheduling tends to be driven by city water restrictions, as 42% of respondents with an irrigation system water their lawns every other day; only 33% with in-ground irrigation systems turn their system on manually when the lawn looks dry and or adjust irrigation programs based on seasons (Figure 16). Four percent of the respondents water their lawns on a daily basis. Daily or every other day irrigation is often unnecessary due to frequent precipitation and the seasonal variation in plant water demands. In general, we suggest that homeowners operate their irrigation systems on an infrequent basis by applying irrigation volumes to wet sufficient depths in the soil profile (6-8 inches) and, withholding irrigation until the lawn shows signs of drought; this will encourage deeper rooting and therefore a larger reservoir in the soil for turfgrass to withdraw water from. Light, frequent irrigation encourages shallower rooting (due to constant moisture at the surface) and consequently, a smaller soil water reservoir. Overall, we feel that one weekly irrigation application is the **maximum** level of frequency that would be required to maintain a healthy, attractive lawn in Minnesota, assuming that soil is healthy and proper cultural practices, such as fertility and mowing, are carried out.

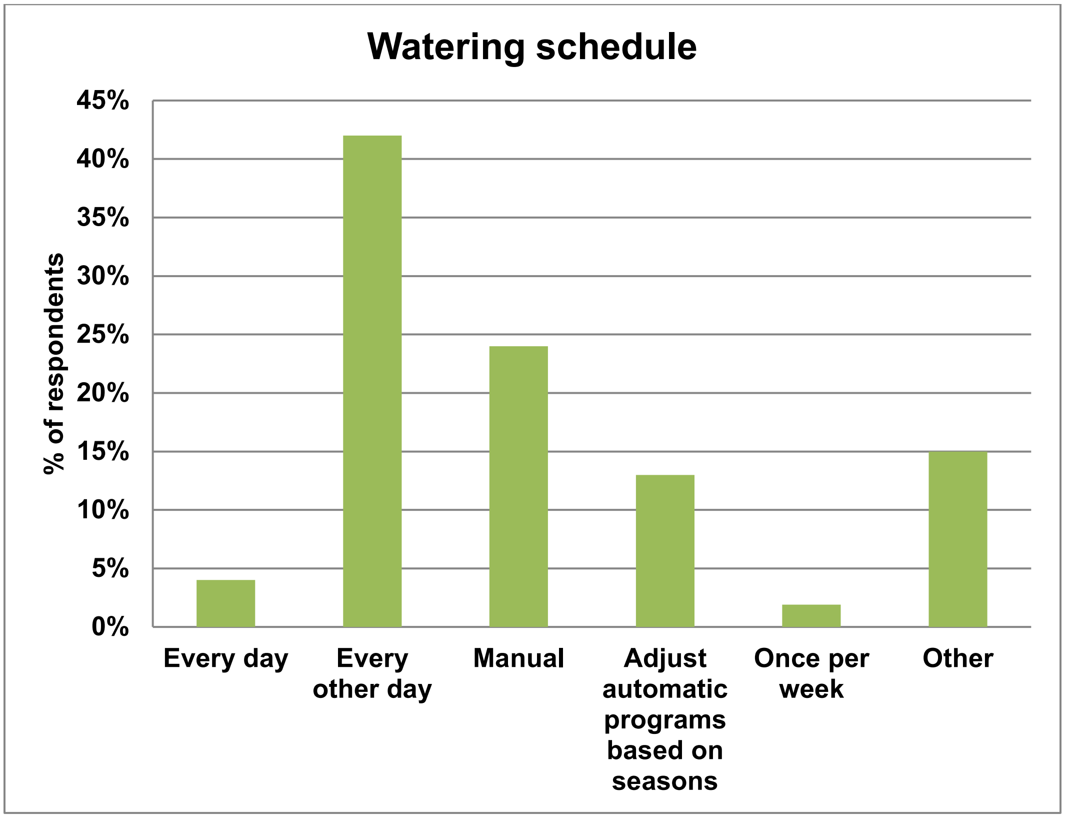


Figure 16: Watering schedule for respondents with irrigation systems (n=519)

Irrigation System Auditing

Irrigation system auditing is a critical practice to ensure that irrigation is being applied as efficiently as possible. Auditing includes checking irrigation components for proper function (e.g., leaking sprinklers), and measuring precipitation rates and sprinkler distribution uniformity. Simple audits may involve only checking and replacing broken sprinklers or resetting arcs, whereas comprehensive audits take more time and require catch cans to measure water volumes. Irrigation audit guidelines are available from the Irrigation Association. Visit the *Irrigation Association website*.

Results from the survey indicate that irrigation audits are either performed yearly (45%) or not at all (47%) (Figure 17). From our observations in conducting irrigation audits, the lack of auditing results in a significant loss of water whenever the irrigation system runs. Irrigation systems should be inspected for leaks on a yearly basis and complete audits should take place every 2-3 years. At least 47% of our survey respondents could benefit from learning the importance of having an irrigation audit performed on their irrigation system, and this will most certainly result in water savings.

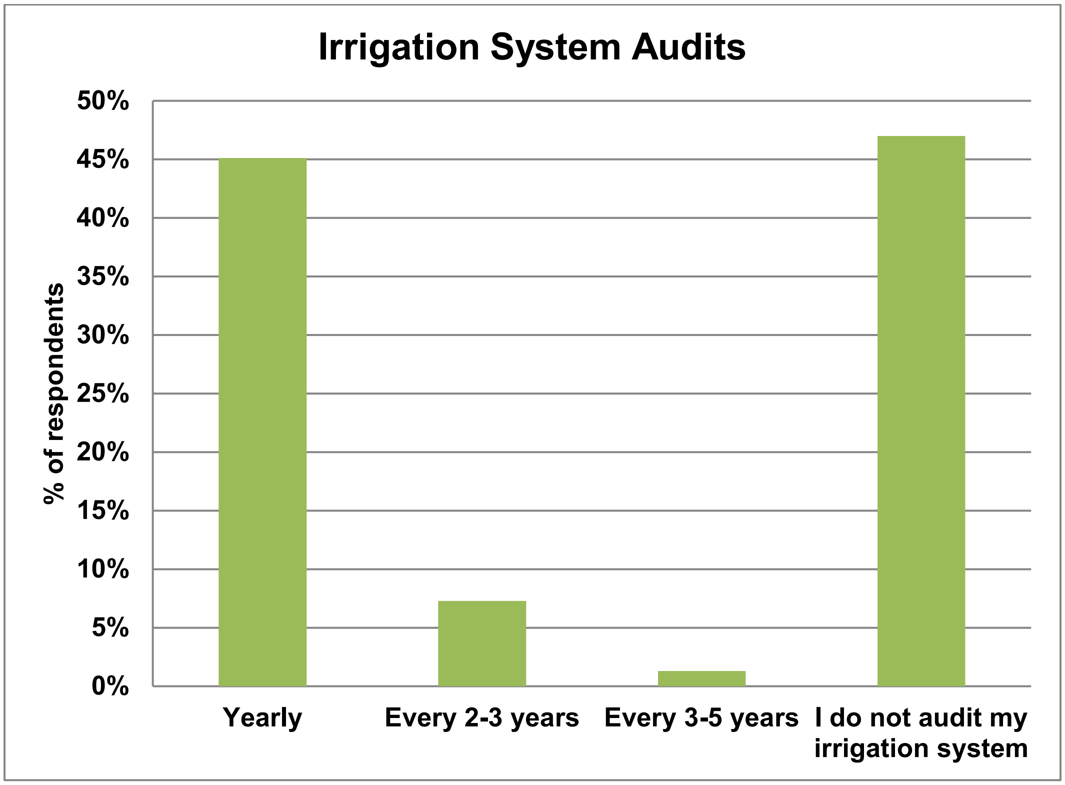


Figure 17: Frequency of irrigation audits performed by survey respondents (n=519)

Awareness of Water Source

Water sources in the TCMA vary from ground and surface water, and can be supplied by municipalities or from private wells. Less than 10% of either the manual or irrigation system groups are irrigating from private wells, and over 90% of respondents are supplied with water from their local municipality (Figure 18). Those that water manually are less likely to know where their water comes from (19%) compared to those with irrigation systems (8%). Understanding where water comes from must be a key piece of education and outreach efforts, as this establishes the connection between individual homeowners and the broader community and ecosystem.

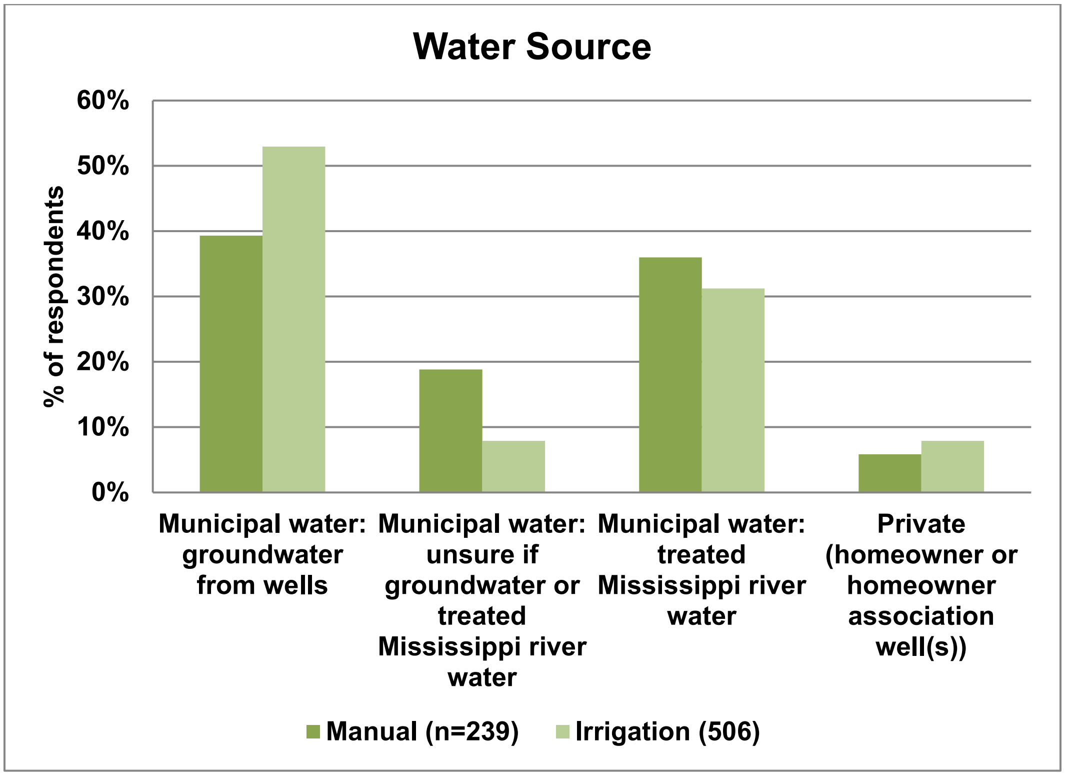


Figure 18: Survey responses to the question "What type of source supplies water to your residence?"

Awareness of Irrigation Restrictions

Recently, many cities have imposed watering restrictions for outdoor use to aid in managing water demands during peak times and to reduce overall water use. Watering restrictions will vary from city to city depending on the goals and the water supply capacity. Only 8% of survey respondents did not know whether restrictions were in place in their city (Figure 19). This is consistent with results reported by Sisser et al. (2016) who found a high homeowner awareness of municipal lawn ordinances. It is encouraging to see a large homeowner awareness of local ordinances and we acknowledge the benefits of these ordinances in helping municipalities manage water demands, however, we feel that homeowners on odd/even day watering bans have a tendency to set automatic irrigation programs based on this schedule when it often would not be required. We have observed this through site visits and consultations.

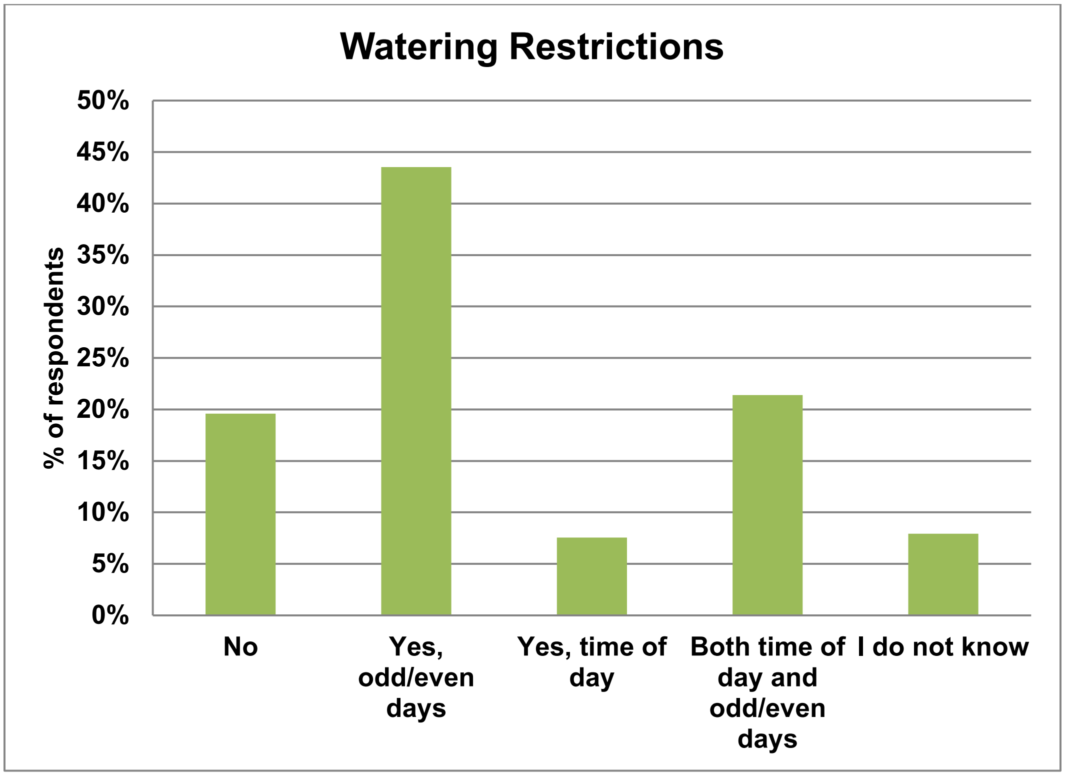


Figure 19: Survey responses to the question "Does your city/municipality impose water restrictions?" (n=781)

Willingness to Adopt Water-Saving Devices

In an effort to gain a better understanding of homeowner's willingness to adopt new technologies, survey participants were asked to rate their likelihood of adding water saving components to their system. The responses from the survey are outlined in Table 4 below. Remarkably, between 13-41% of participants responded either "Not likely" or "Not at all" to the likelihood of installing water saving components to their irrigation system. Rain sensors were reported as the highest percentage (52.5%) of currently used water saving components whereas soil moisture sensors (1.4%) were the least used. With the advancement of technology, water saving components for irrigation systems have drastically improved and have become more economical and readily available. The purchase and installation of most of these components is minimal in comparison to the potential dollars saved on a homeowner's water bill. Additionally, 15 cities in the TCMA are currently offering a rebate for the purchase of water-saving devices for irrigation systems in a water efficiency grant through the Metropolitan Council.

Table 4: Respondent willingness to adopt water-saving devices

Water saving component	Highly likely	Somewhat likely	Not likely	Not at all	Currently have
Smart Controller (n=518)	24.3%	28.8%	12.9%	6.2%	27.8%
Rain Sensor (n=518)	18.7%	15.4%	7.9%	5.4%	52.5%
Soil Moisture sensor (n=518)	31.1%	42.3%	17.6%	7.7%	1.4%
Smart phone watering technology (n=517)	23.8%	25.0%	24.0%	16.2%	11.0%
Irrigation flow meter (n=515)	19.2%	35.7%	30.1%	11.5%	3.5%

Homeowner Assessments and Irrigation Audits

Overview

In conjunction with the survey distribution as part of Objective 1, we conducted 62 homeowner assessments and irrigation audits in 21 different cities within the 7-county TCMA (Table 5 and Figure 20). The goal was to collect data from residents with irrigation systems to determine water use patterns, irrigation system inefficiencies, age of irrigation systems, as well as overall homeowner lawn care preferences and practices. Locations were selected from survey respondents that indicated their residence had an irrigation system and were willing to participate in the assessment. Homeowners were contacted via Doodle Scheduler, allowing them to select a day and time for the assessment. Individual homeowner assessments took approximately 2 ½- 3 hours to complete, however we notified residents that they only needed to be present for the initial 15-20 minutes in order for us to complete the intake questionnaire. The complete assessment form is included at the end of the report as Attachment 1.

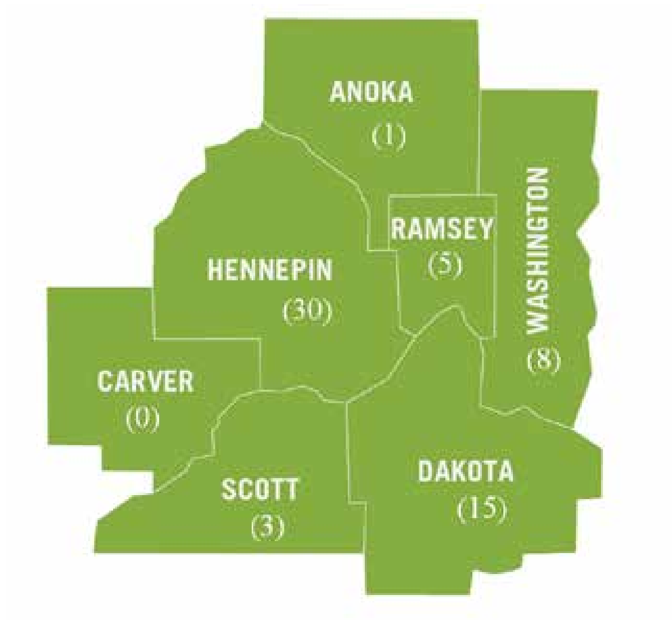
Summary of Homeowner Assessments

- 62 site visits were conducted in 21 different cities within the 7 county TCMA.
- Kentucky bluegrass was the most universally found species comprising of 73% of lawns.
- Over 50% of homeowners operated their systems on an every other day schedule.
- The average homeowner irrigates 500 ft^2 of impervious surfaces.
- 75% of audits revealed at least 1 leaking sprinkler head and 27% revealed 5 or more leaking heads.
- Rotor precipitation rates ranged from 0.27”-1.58”/hr and averaged 0.61”/hr.
- Fixed spray precipitation rates ranged from 0.46”-2.73”/hr and averaged 1.41”/hr.
- Over 25% of the total rotor stations audited measured in the poor (<50%) range, the average distribution uniformity (DU) was 58% (fair).
- Nearly 28% of the fixed spray stations audited measured poor (<40%) DU, the average was 46% (fair).
- Hunter brand irrigation components were the most frequently identified at site visits.
- Over 30% of sites visited either had a rain sensor that was inoperable or none at all.

Table 5: Distribution of site visits by city and county

City	County	Total visits
Coon Rapids	Anoka	1
Apple Valley	Dakota	5
Burnsville	Dakota	1
Eagan	Dakota	1
Hastings	Dakota	3
Mendota Heights	Dakota	1
Rosemount	Dakota	4
Brooklyn Park	Hennepin	14
Eden Prairie	Hennepin	3
Edina	Hennepin	5
Golden Valley	Hennepin	2
Minneapolis	Hennepin	5
St. Louis Park	Hennepin	1

City	County	Total visits
New Brighton	Ramsey	1
Roseville	Ramsey	1
St. Paul	Ramsey	1
Vadnais Heights	Ramsey	1
White Bear Lake	Ramsey	1
Savage	Scott	3
Cottage Grove	Washington	2
Woodbury	Washington	6



http://www.streetworksmn.org/about/outreach-workers-mpls-st-paul/

Figure 20: Twin Cities 7 County Metro Area Map site visit distribution

General Maintenance Practices

Homeowners were asked about the function of their lawn, maintenance practices and quality expectations during the assessment. Lawn function responses included aesthetics, recreation, soil stabilization as well as combinations of several functions. The majority of homeowners fertilized their lawn at least one time per season and utilized some form of weed control. With the exception of one homeowner that used a reel type mower, rotary push or rider mowers were most commonly used. It was noted that several homeowners were willing to adopt a reduced maintenance program as long as the lawn quality wasn't compromised. Quality expectations ranged from pristine and well-manicured to average or below average. We feel that our assessments provided a good representation of homeowners with in-ground systems across the TCMA.

Turfgrass Species Distribution

Turfgrass species were identified using the grid-intersect method as described by Gaussoin and Branham (1989) by randomly placing a 25 count grid on the lawn at three locations for each site. Individual species were recorded at the point directly beneath each gridline intersection for a total of 75 counts per site. The data shown in Figure 21 focuses only on the turfgrass species that were identified;

on average lawns across the TCMA were composed of only 2.1% grassy and broadleaf weedy species such as quackgrass, dandelion and white clover. Kentucky bluegrass (KBG), a relatively high maintenance turfgrass, was the most common species, covering 73% of lawns that were assessed. Fine fescue, a low maintenance and drought resistant turfgrass, was found covering 11.5% of lawns. Broadleaf and grassy weed species that were recorded included; dandelion, creeping charlie, woodsorrel, purslane, knotweed, crabgrass, quackgrass, and nutsedge.

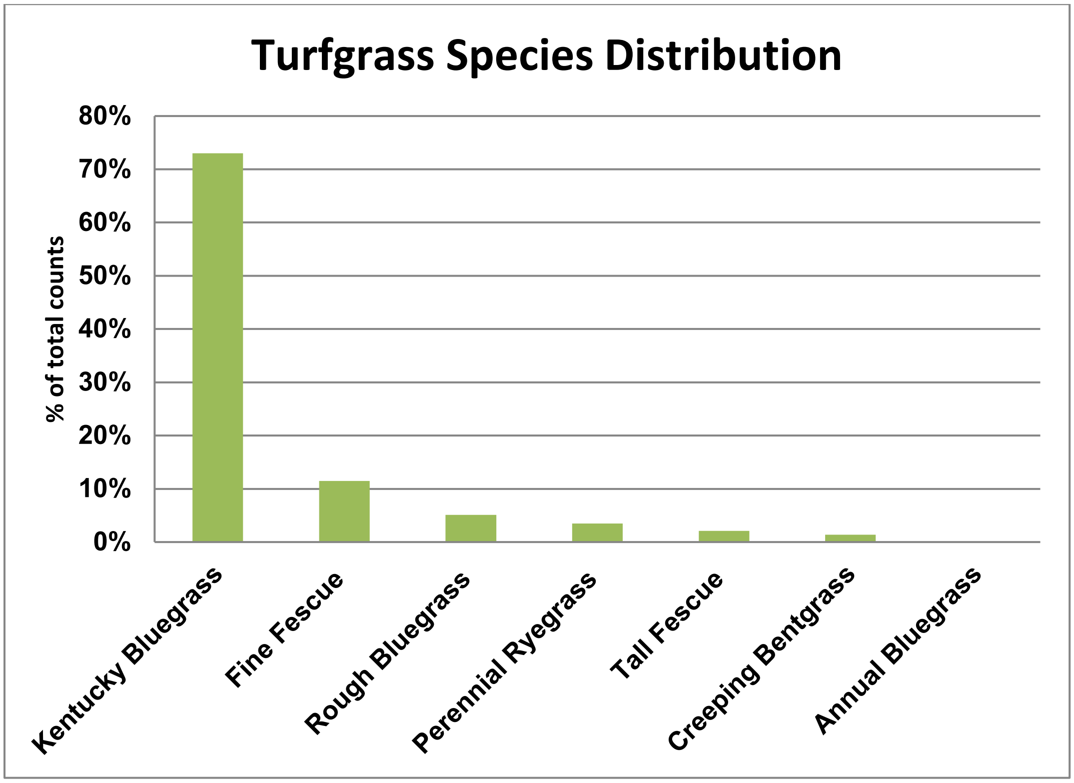


Figure 21: Distribution of turfgrass species from site visits

Mowing Height

Mowing heights were documented based on the homeowner's familiarity with their mower setup or our measurements of lawn height after the most recent mowing event. Mowing heights for all 62 lawn assessments are presented in Figure 22. Mowing heights ranged from 1.5 to 4 inches. The overall average of mowing heights across all lawns measured was 2.8 inches. We often encourage homeowners to maintain their lawns at a height of 3 inches or higher to promote root growth. **Height of cut plays a very important role in determining the maintenance needs of a lawn. Generally, as the lawn height of cut increases, maintenance and input levels decrease. This is primarily due to the fact that higher mowing heights promote deeper rooting.** Fortunately, less than 10% of homeowners maintained their lawns at a height of less than 2.5 inches. The majority of homeowners reported that they mow their lawn once per week, however they noted that with the amount of precipitation this summer mowing was required more frequently.

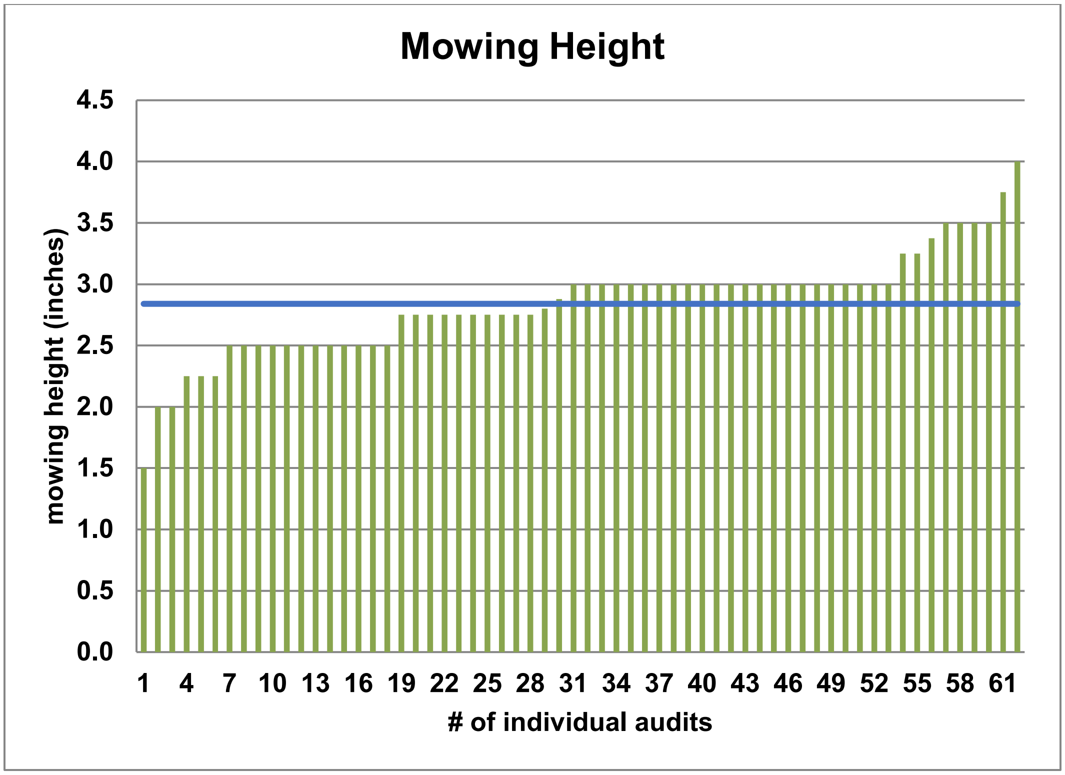


Figure 22: Distribution of homeowner mowing heights

Soil Properties

Soil samples were taken and later analyzed from each property. Soil texture and percent soil organic matter (SOM) were determined by the University of Minnesota Soil Testing Laboratory. Of the 62 properties, 34 have soil texture classified as a sandy clay loam and 24 have clay loams (Figure 23 and 24). These texture classifications range from 20-40% clay and 20-80% sand. Clay particles collectively have a large surface area enhancing water retention, but reducing water infiltration rates. Infiltration of moisture in a home lawn is an important ecosystem service. If a soil cannot infiltrate water at the same rate it is being applied either through irrigation or rainfall, then surface runoff becomes a concern.

The SOM present also varied, but most properties have high levels (Figure 25). Soil organic matter across the 62 properties evaluated ranged from 2.1-9.4%. Similarly to clay content, high levels of SOM enhance soil water retention, reducing the need for regular watering, however water infiltration rates at the properties evaluated were generally greater than 3 inches per hour, indicating adequate drainage (data not shown).

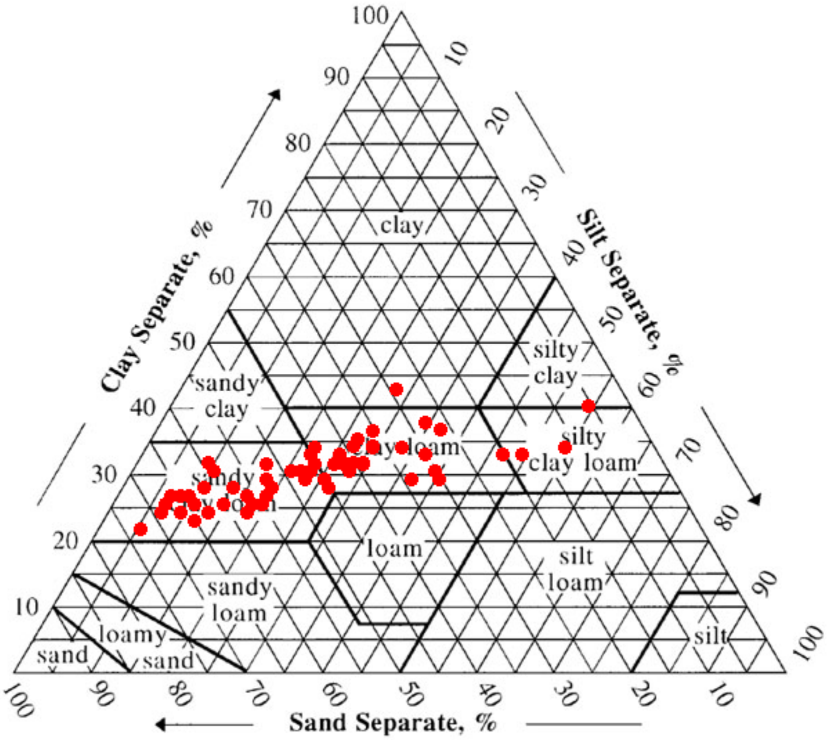


Figure 23: Distribution of soil textures across 62 properties in the TCMA

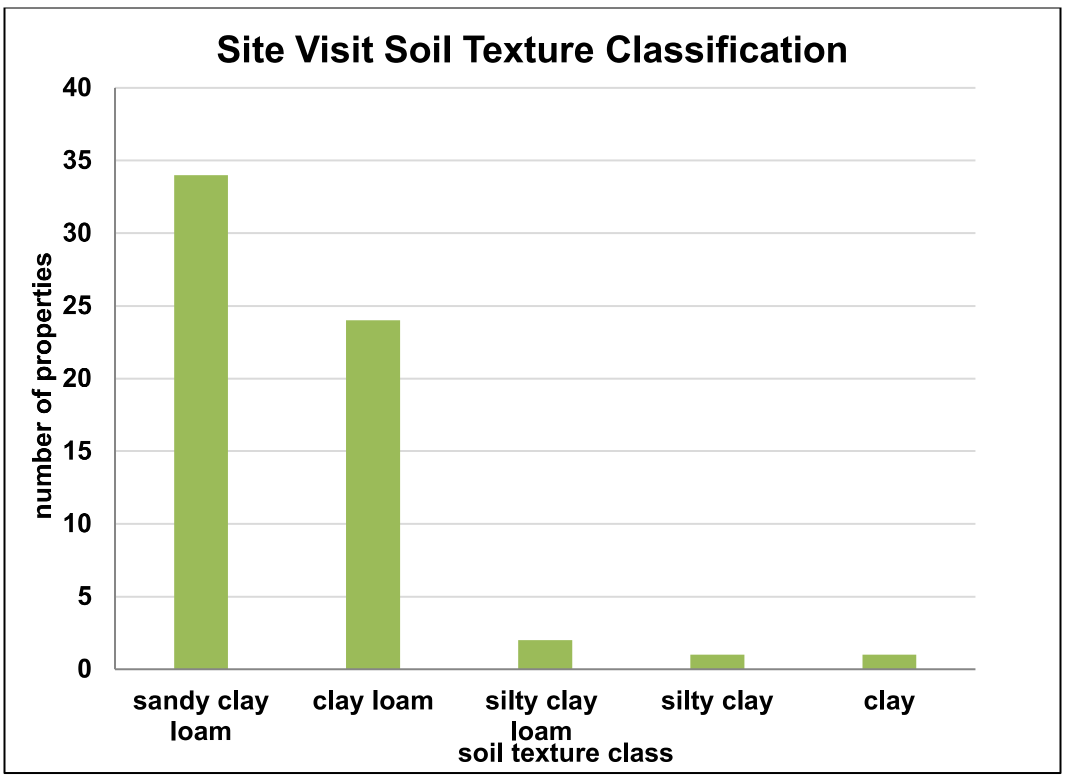


Figure 24: Soil texture classifications for 62 properties acros the TCMA

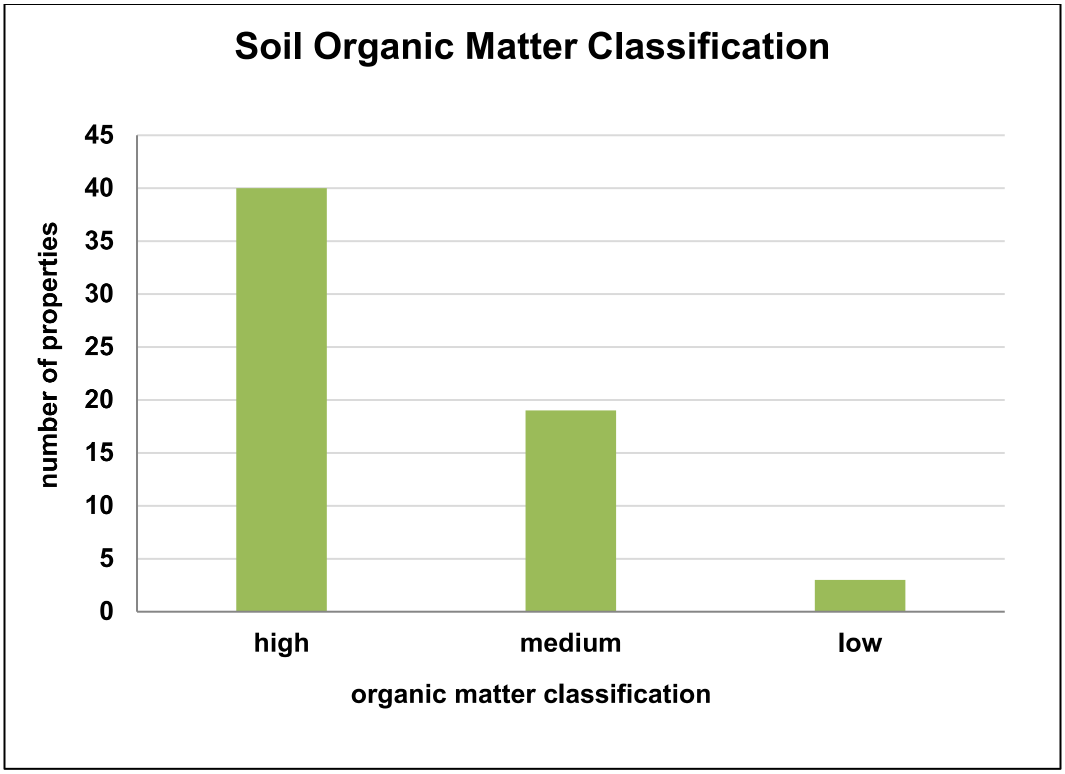


Figure 25: Soil organic matter classification for 62 properties in the TCMA

Soil compaction decreases porosity and ultimately reduces water movement through the profile and inhibits root growth. Penetration of a 0.5-inch cone into the top six inches of the soil profile was performed to determine compaction levels at ten random points of each property (Figure 26). The pressure (bar) needed to penetrate the topsoil was measured using a penetrometer. The point at which root inhibition may occur is at 20.6 bar (Duiker, 2002). Notably 78% of the penetrometer readings were greater than this threshold, which suggests most lawn areas visited have some compaction and are not performing at their full potential.

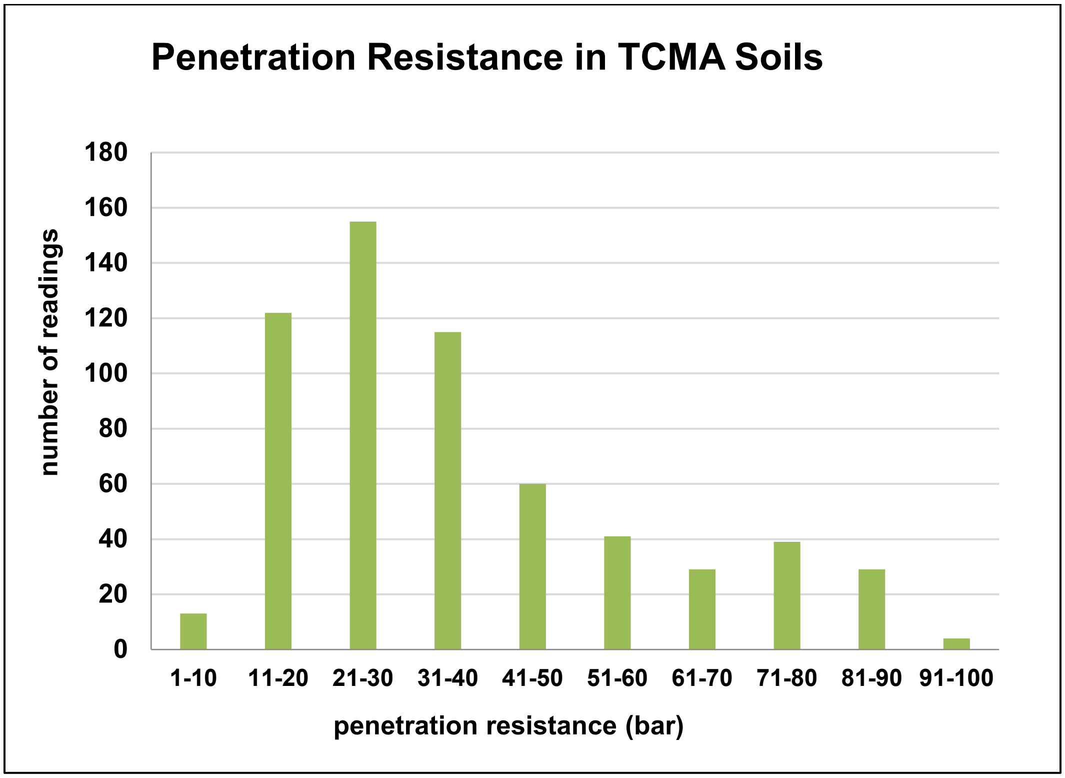


Figure 26: Penetration resistance (compaction) of 62 properties across the TCMA

Irrigation Frequency

In order to gain a better understanding of homeowner's irrigation practices we asked about the frequency at which they operated their system; we also visually verified that schedule during our inspection of the irrigation controller prior to operating the system. The results are shown in Figure 27. One-third of homeowners operated their systems manually, this included "normally off" responses, and this is consistent with results from the irrigation survey. Alarmingly, 57% of homeowners operated their systems on an every other day schedule; this suggests that many homeowners are either programming their controllers based on city water restriction guidelines or do not adjust their programs after the initial startup.

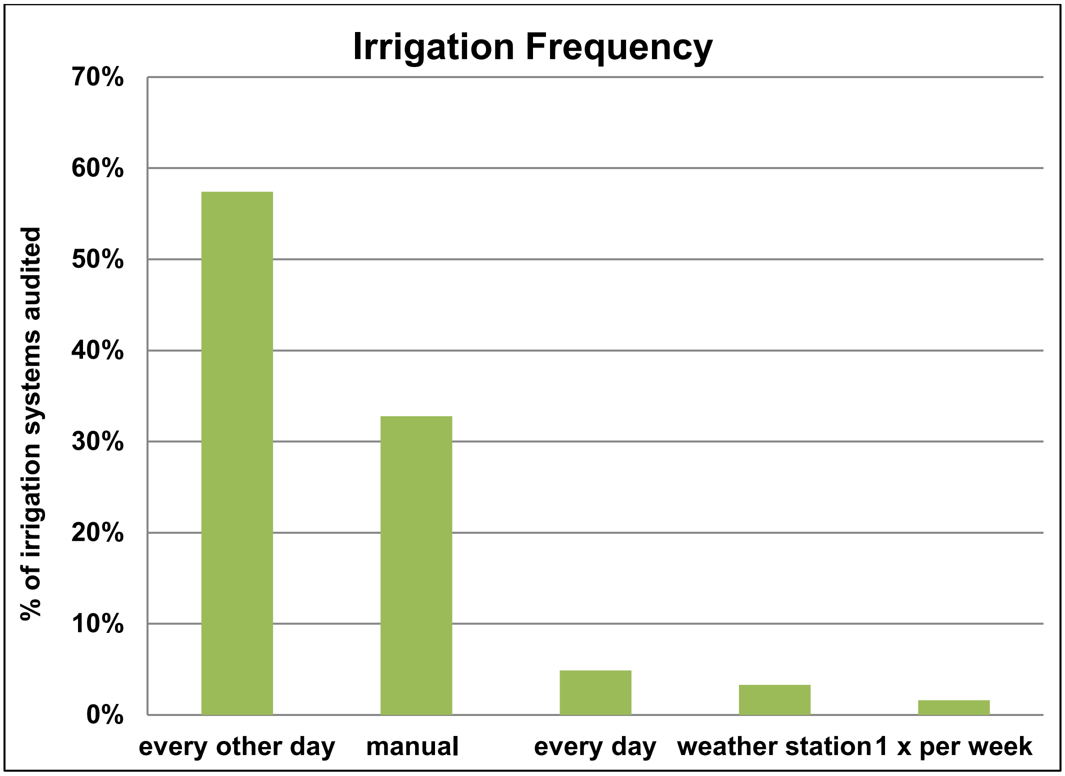


Figure 27: Irrigation schedule frequency (n=62)

Irrigation Applied to Impervious Surfaces

During the irrigation audit process, we measured and recorded any impervious surface area that was wet after each station was operated. Impervious surfaces were identified as any artificial surface such as driveways, sidewalks, roads, etc. (Figure 28). Irrigation of impervious surfaces provides no benefit to plant growth and a majority of this water is lost through runoff into storm drains or from evaporation on these surfaces. Figure 29 displays the distribution of the data from the 62 assessments. Nearly 32,000 ft^2 of irrigated impervious surface was measured, with an average for all homes of 500 ft^2. Eighty-seven percent of the sites audited recorded 100 ft^2 or more, with the highest totaling 1,703 ft^2. One multi-unit facility audited measured 6,446 ft^2 of impervious surface being watered.

Figure 28: Wet road surface due to improperly adjusted rotor head

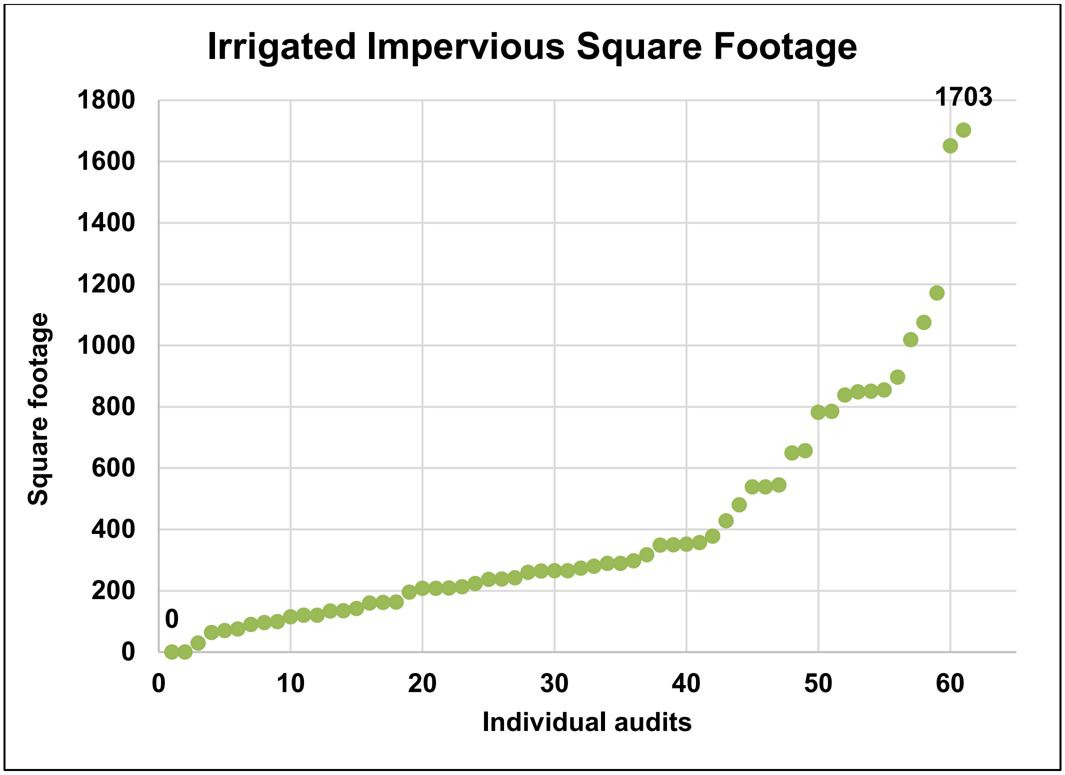


Figure 29: Distribution of impervious surface area being watered

Irrigation Sprinkler Leaks

In an effort to determine the efficiencies of the irrigation systems audited, the function of all sprinklers was documented. While each station was in operation, each individual head was visually inspected for any sign of leaks, arc or adjustment issues. The data in Figure 31 indicates the quantity of leaking sprinklers and the number of audits that each quantity was recorded. Seventy percent of audits revealed at least one leaking sprinkler, while at 27% of the audits we discovered five or more leaking sprinklers per site. At two sites we discovered as many as fifteen leaking sprinklers. An irrigation system with a leak as small as 1/32nd of an inch in diameter (about the thickness of a dime) can waste over 6,000 gallons of water per month (EPA, 2016).

Figure 30: Example of leaking rotor head

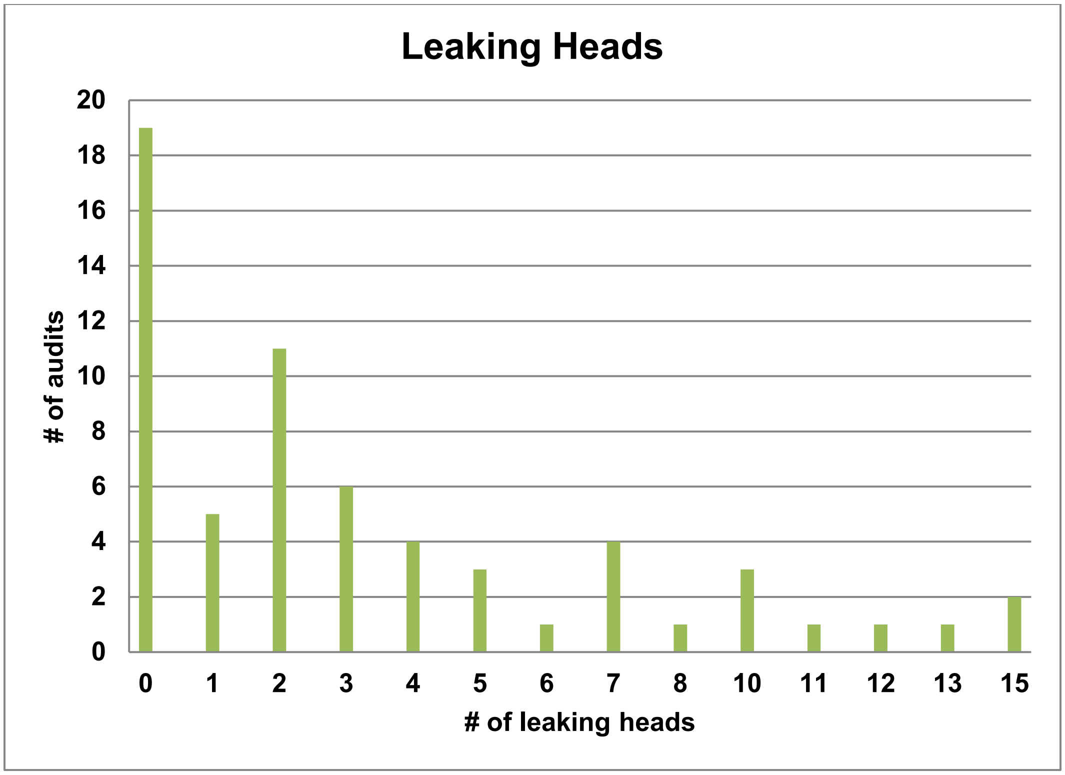


Figure 31: Distribution of leaking heads

Precipitation Rates

Precipitation rate, also known as application rate, refers to the depth of water being applied to a given area. Rates are measured in inches per hour and take into account the average irrigation depth of all sprinklers in a particular zone. Matched precipitation is achieved when all of the sprinklers in a zone apply the same amount of water to the designated area. Sprinkler spacing, nozzle type, nozzle size and arc adjustment are all factors that have an effect on the precipitation rate for an irrigation zone. Rotor sprinklers are generally installed in larger areas and on a wider design spacing, typically 25 to 30 feet apart. Precipitation rates for rotors were calculated after conducting the catch can tests (minimum of 24 cans per zone), where each station was operated for a minimum of 20 minutes and water depths were recorded. Values were recorded for 67 total rotor stations across the TCMA, typically one or two stations per site. Rotor sprinklers were the most commonly found sprinkler, this is likely due to the size of the sites that were audited and the versatility of this sprinkler type. The range of recorded precipitation rates was 0.27-1.58 inches per hour with the average being 0.61 inches per hour (Figure 33). In many cases, homeowners are only concerned with the minutes that their irrigation system runs. However, minutes of run time are not transferrable from one property to the next due to the wide range of precipitation rates. This further justifies the need for auditing irrigation systems.

Figure 32: Catch can test used to measure rotor and fixed spray uniformity

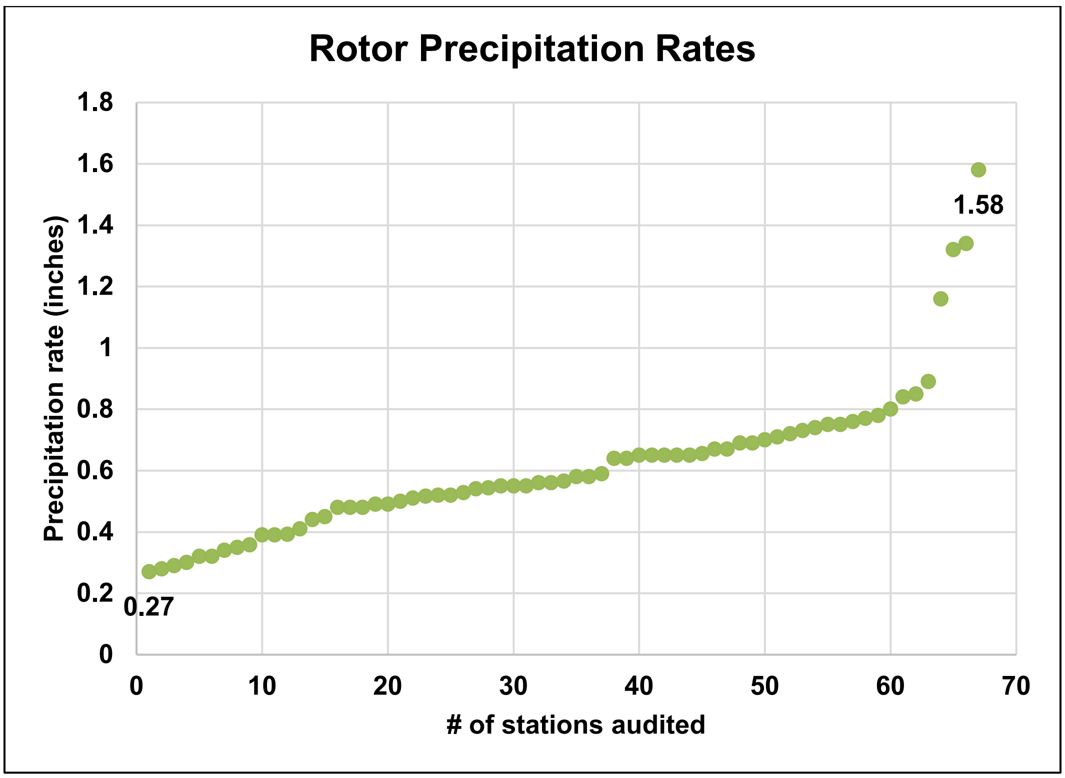


Figure 33: Distribution of rotor precipitation rates

Precipitation rates were also recorded for 46 fixed spray stations, typically one or two stations per site. Fixed spray sprinklers are often installed in smaller areas and at a narrower spacing, generally between 8 to 15 feet apart. Precipitation rates were calculated after conducting the catch can test, where each station was operated for 10 minutes and water depths were recorded. The range of recorded rates was 0.46-2.73 inches per hour with the average being 1.41 inches per hour; this is over twice the amount applied by rotors (Figure 34).

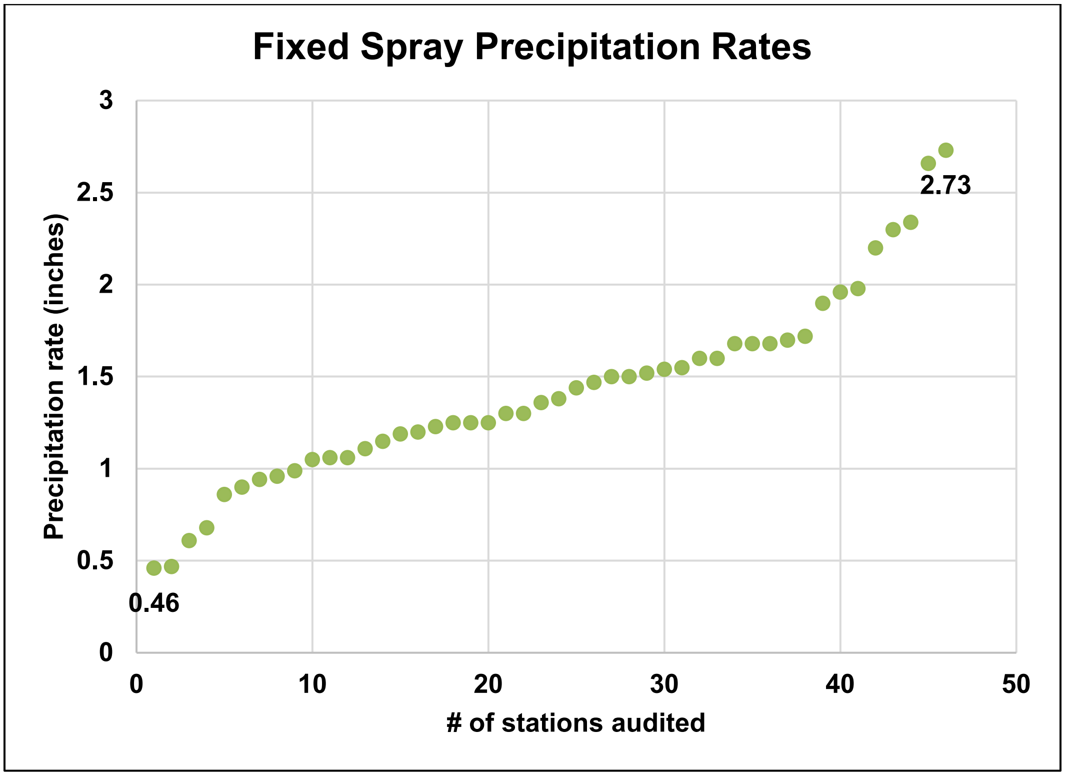


Figure 34: Distribution of fixed spray precipitation rates

Uniformity of Irrigation Systems

Distribution uniformity (DU) is a measure of how evenly water is being applied to a given area. Uniformity is measured as a percentage, with 100% indicating a perfect DU. Uniformity was calculated after performing the *catch can test* and recording the water depths for each can. The DU percent was calculated by determining water depths in the lowest quartile for the number of cans used, usually six as we typically used twenty-four cans per station, and dividing that by the overall average depth in all cans. For example, if the average of the six lowest cans was 0.5 inches and the overall average was 1.0 inch, then the distribution uniformity would be 50%. This is a standard calculation for DU and is further explained in the audit guidelines of the Irrigation Association (Irrigation Association, 2009). Acceptable rotor DU ranges vary and have been debated over the years. We referenced a report titled "Using Distribution Uniformity to Evaluate the Quality of a Sprinkler System" and developed the following categories: <50%-poor, 51%-64%-fair, 65%-74%-good, and 75%+-excellent (Mecham, 2004). Thirty-four percent of the rotor stations recorded a fair DU, while only 13% measured excellent. Over a quarter of the total stations audited measured in the poor (<50%) range, and the average DU was 58% (Figure 35). Some common mistakes that we found included; poor head spacing, incorrect nozzle size, mixing of head type, poor arc adjustment, and excessive heads irrigating a given area; all of these have an impact on uniformity. We feel that with proper design and regular irrigation auditing, it is very practical to maintain DU ranges above 65%.

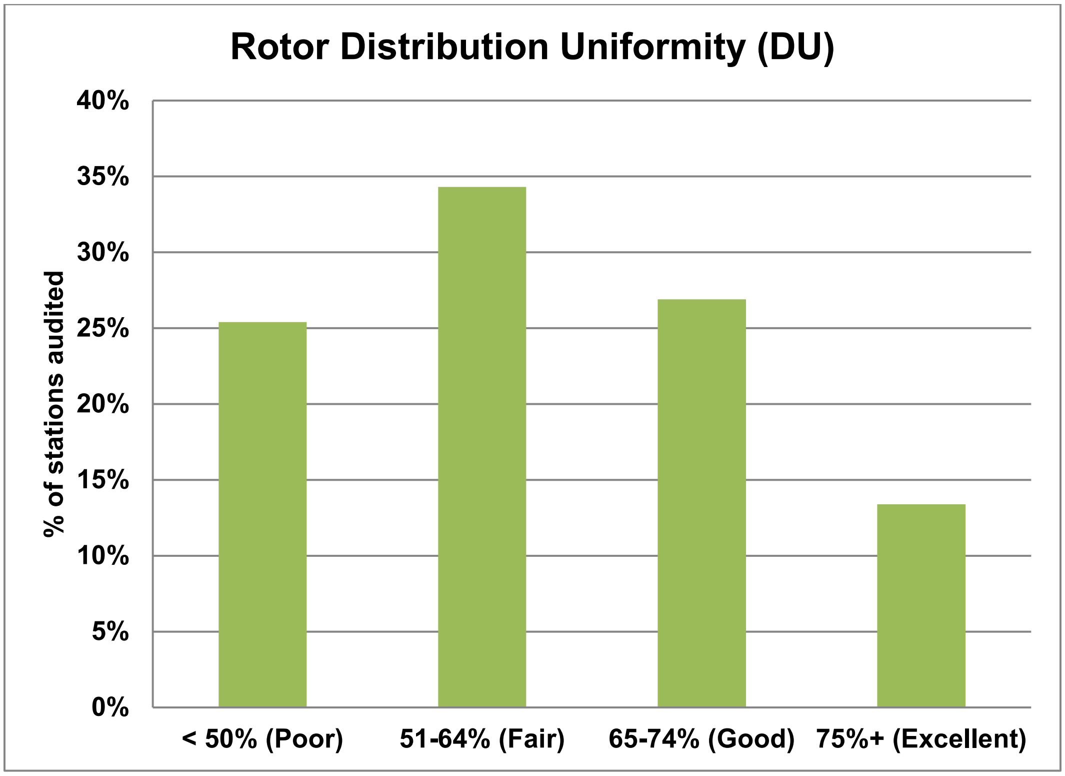


Figure 35: Rotor DU percentages (n=67)

Fixed spray DU values were calculated exactly the same way as for the rotor stations. Referencing the same report, we developed the following DU ranges: <40%-poor, 41%-54%-fair, 55%-69%-good, and 70%+-excellent. Forty percent of the audited fixed-spray stations were operating in the fair category and 0% were excellent. Nearly 28% of the stations audited measured poor (<40%) DU (Figure 36). Fixed-spray station audits revealed the need for significant improvements in design, installation and maintenance.

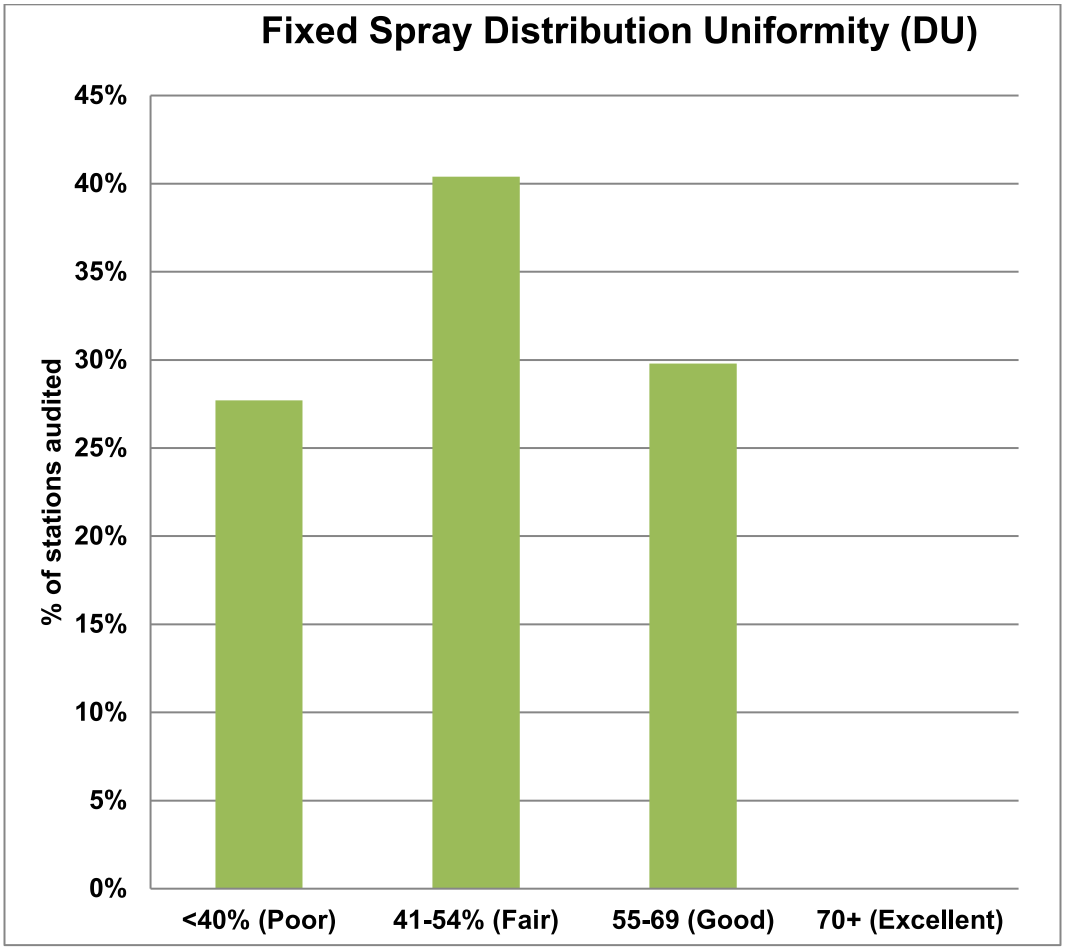


Figure 36: Fixed spray DU percentages (n=46)

Irrigation System Components

Irrigation systems are comprised of a few major components that, when combined, make up the working system. The major working devices within an irrigation system include a controller, valves, sprinklers and any additional water saving components. Similar to the survey, we documented the various brands of controllers, and also sprinkler heads and the presence of water saving devices. Five different controller brands were discovered and controllers from Hunter Industries were the most frequently found; nearly 50% of the systems assessed utilize this brand. There appears to be an encouraging trend towards the use of more advanced technology as about 10% of the sites utilized weather based controllers. Rachio, one of the newest brands to enter the market, was part of a controller upgrade program in the community of Woodbury and was found at five lawn assessments there. We also observed several properties with operational controllers dating back at least 20 years (Figure 37). For the minimal cost of a new controller and considering the fact that 15 cities are offering rebates, there is a strong case for updating controller technology that is 20 years old. Figure 38 displays the various controller brands and their distribution.

Figure 37: Dated irrigation technology (Rainbird RC 1260)

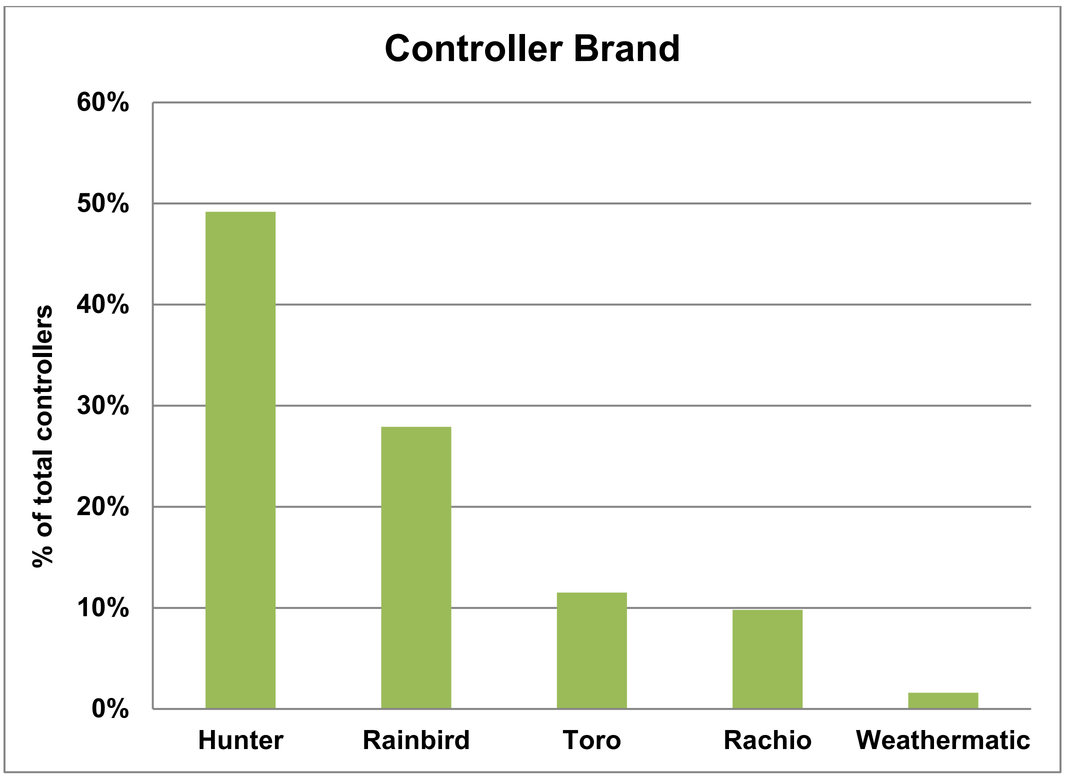


Figure 38: Controller brand distribution from site visits (n=62)

Similarly to the brands of controllers, Hunter was most frequent sprinkler brand found throughout our site visits (Figure 39). Several sites utilized a mix of sprinkler brands, sometimes as many as four different ones. All of the brands that we discovered included both rotor and fixed spray head types. Orbit and K-Rain are less recognized brands and are known as more affordable options compared to the more notable brand names. The Hardie brand sprinklers are no longer available as the company was acquired by Toro in 1996. In the past, brands such as Hunter, Rainbird, and Toro were only available through irrigation supply distributors, but more recently can be found at big box stores such as Home Depot and Menards.

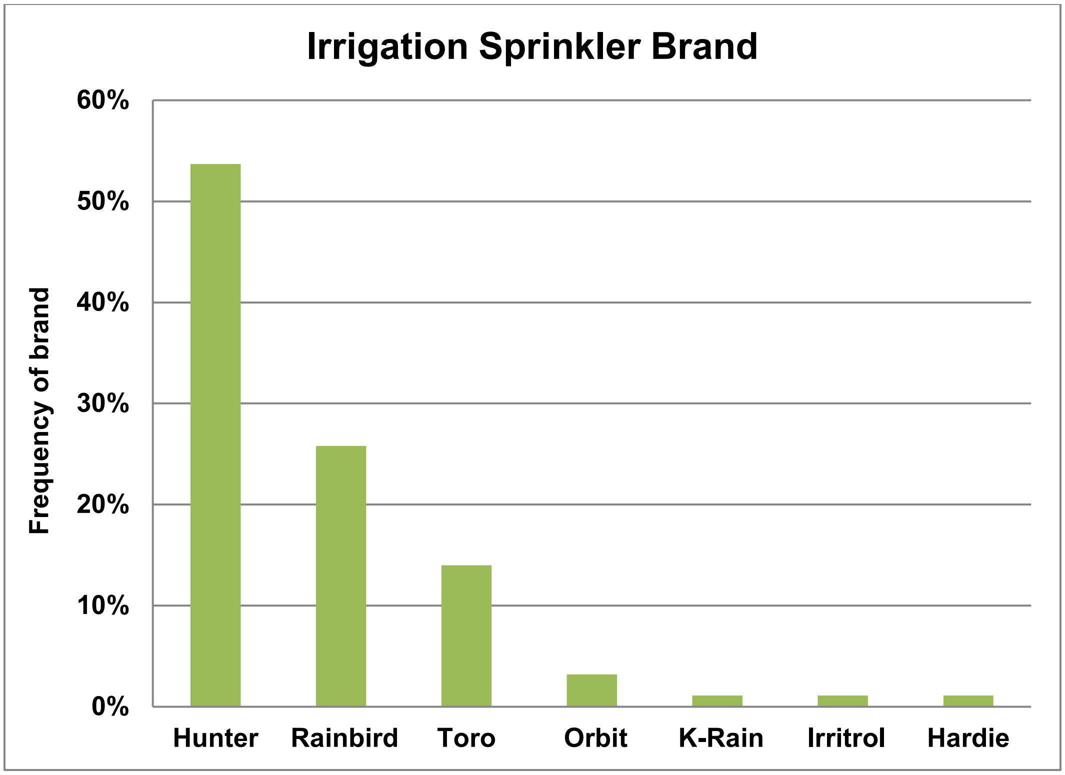


Figure 39: Irrigation head brand distribution

A relatively common component for increasing water savings on an irrigation system, rain sensor data was recorded as part of the audit process. Homeowners were asked if their system was equipped with a rain sensor and whether it was functional or not. We verified the presence and condition both visually and operationally. Approximately 32% of sites that we visited either had a device that was inoperable or none at all. With the increasing emphasis on water efficiency we emphasized the importance of either repairing or installing a new device. Figure 41 contains the rain sensor data results.

Figure 40: Example of a broken and non-functional rain sensor

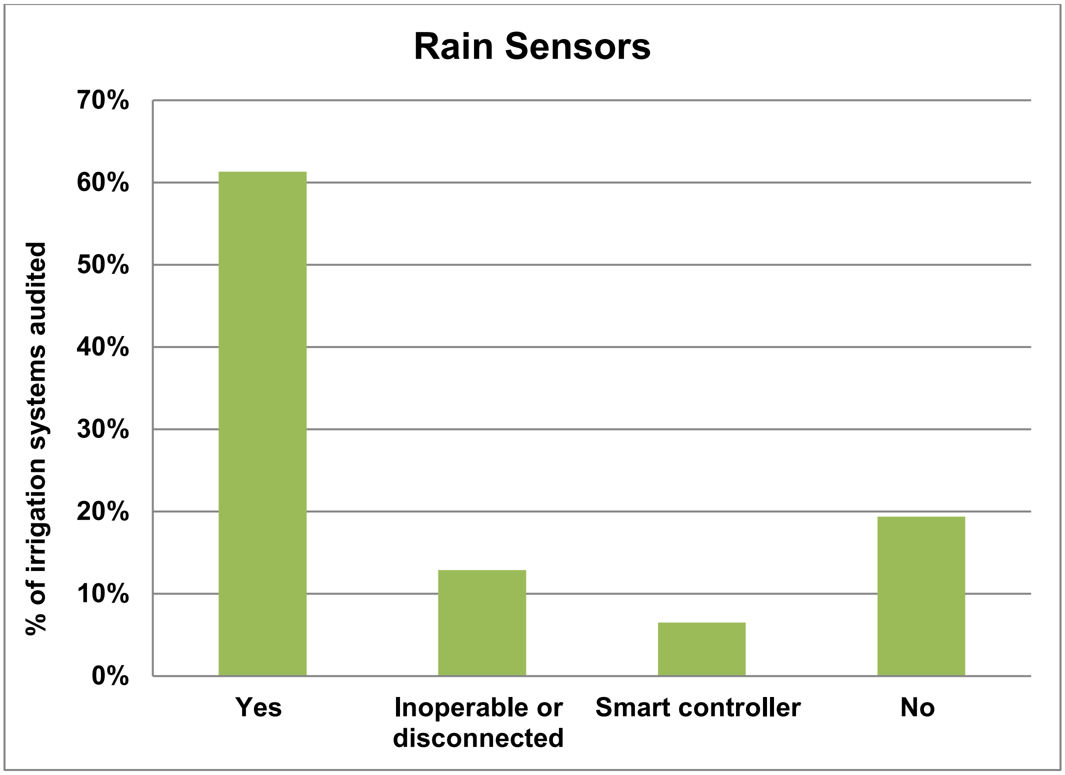


Figure 41: Rain sensor distribution (n=62)

Conclusions

As outdoor water use is a perennially debated topic nationally, our objective was to investigate residential usage locally in the 7-county TCMA. The University of Minnesota Turfgrass Science Extension Program strives to be at the forefront of efficient water use within the residential landscape. After analyzing the results from the survey and our site visits it has become more apparent that research and education are needed on the topic of water conservation. During a record-breaking year in which the TCMA recorded over 30 inches of rain during the growing season, some people may find it absurd that anyone would operate their irrigation system at all. As survey data revealed, 25% of irrigation systems are operated automatically every other day and are void of any sensor technology, raising our concern that water is viewed as limitless resource. When polled about the goals for their lawns, less than 50% of survey respondents listed conserving water; however, 77% selected curb appeal as a primary goal. Audit results revealed leaking heads at 70% of the sites, and with nearly 50% of homeowners never auditing their systems, it is not surprising that TCMA summer water use is three times greater than winter use. Further validating the necessity for irrigation systems to be regularly audited was the determination of an average of 500 ft^2 of impervious surfaces being watered at each individual property. It is apparent that irrigation systems are not being audited and thist has made a significant impact on the overall water usage in the TCMA.

Objective 2 update

Significant progress has been made with the construction and implementation of the site for the irrigation demonstration as stated in Objective 2. At our research facility located on the St. Paul campus preparation is underway for the irrigation research plots. The site has been renovated, the irrigation valves and pipe have been installed. These systems will be fitted with upgrades such as soil moisture sensors, smart irrigation controllers, and drip irrigation lines. Our research will track water use and lawn quality based on automatic and manual scheduling. From this research we will make recommendations for irrigation system upgrades and scheduling that will reduce water use on lawns. In addition, 30 consumer turfgrass seed mixtures have been seeded at our rain out shelter site to perform the two-month acute drought trial (Attachment 2). This will allow us to make practical recommendations on the existing mixtures that provide the best drought tolerant characteristics.

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