THE UNIVERSITY OF GEORGIA
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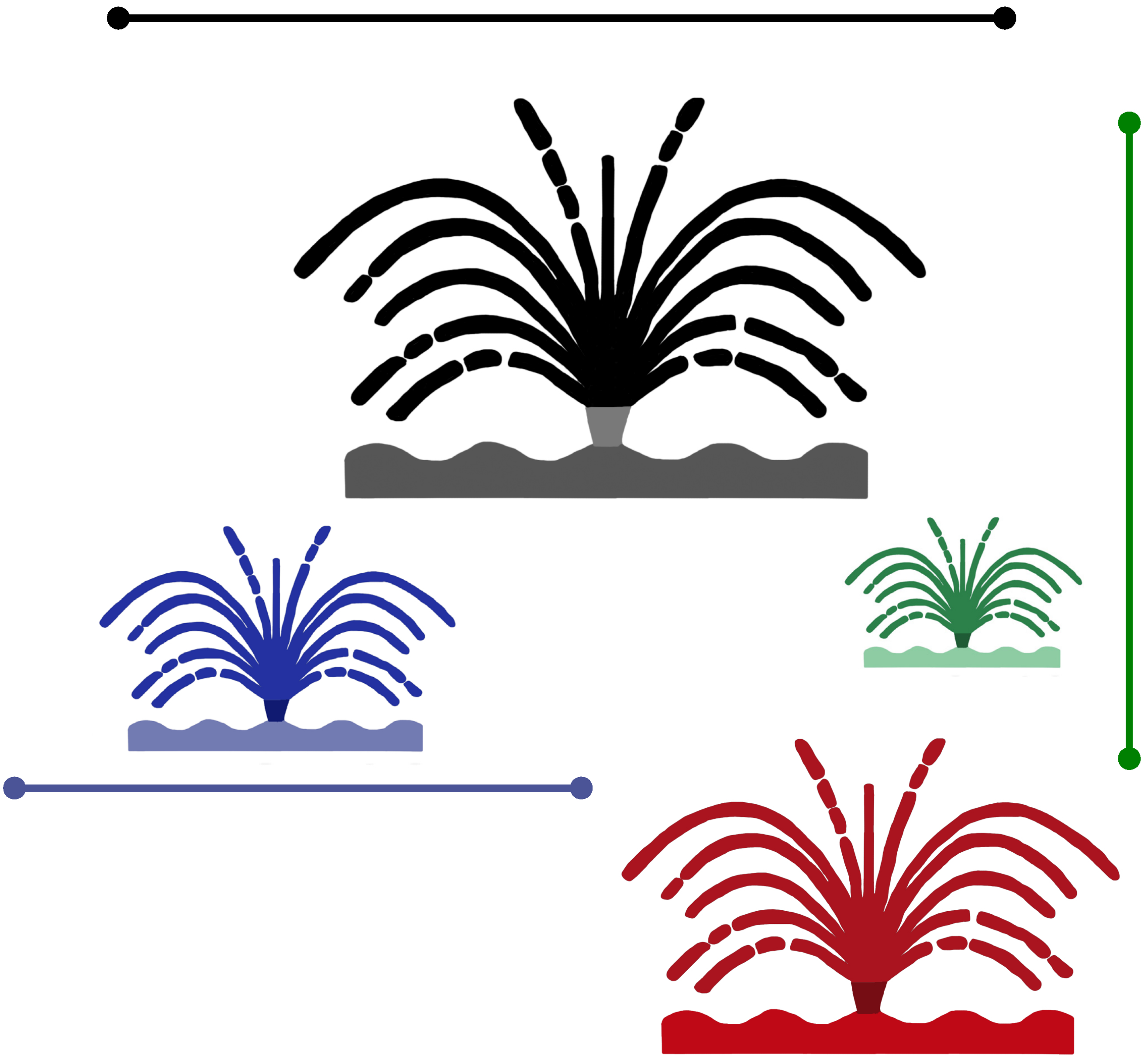
Landscape and Turf Irrigation Auditing:

A Mobile Laboratory Approach for Small Communities



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ABSTRACT

A landscape irrigation auditing approach is introduced for small communities where funding is insufficient for a full-time irrigation auditing service component of a water conservation program. The overall objective for the program is to help small communities use their available water resources more efficiently. Landscape irrigation is a major component of water use in many communities, so the implementation of a cost-effective program can be economically viable for communities with limited available funding. The combination of contacts, auditing, and reporting information are designed to achieve the highest potential for success in understanding and implementing water conservation practices in urban landscapes. The approach was tested during a pilot study in Douglas, Georgia. Resulting irrigation system and management alternatives indicated at least a 20 percent reduction in expected irrigation water use if all proposed recommendations are implemented across the community. Recommended incentive approaches are provided to encourage adoption of water conservation alternatives.

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D.L. Thomas, K.A. Harrison, M.D. Dukes, R.M. Seymour, F.N. Reed[1]

Introduction

Landscape irrigation is one of the first water resource uses to be affected by designated drought or water restriction conditions. Odd/even watering (based on the last digit of an address), time periods of allowable water use (such as no outside watering between 10 a.m. and 6 p.m.), and complete outside water use restrictions are logical approaches that communities have used to help manage limited water resources.

In large cities, personnel and funds may be allocated to encourage improved approaches to outside water use. However, many small communities lack the funds to hire personnel to help with their outside water management and must revert to "system-wide bans." Outside watering bans have a direct and long-term potential impact on some of our most dynamic and thriving industries: landscape plant nurseries, turf/sod operations, and commercial landscape management firms.

In Georgia, statewide outside watering restrictions were implemented in 2000 for the first time in history. Outside watering restrictions have been in place in Florida for several years. These restrictions ban irrigation between 10 a.m. and 4 p.m. and may restrict irrigation to once or twice weekly. The combination of an extended drought, rainfall patterns that do not conform with land-scape plant water needs, and sandy soils in many areas that reduce the available water for landscape plants have all contributed to an increasing need for irrigation and better management of water. Georgia and Florida citizens, accustomed to plentiful water and inefficient water use practices, are now aware of the need for improved conservation.

Landscape irrigation is notoriously inefficient because irrigation systems can rarely be designed, installed and maintained at the highest level attainable (unless available funds are not limited and dedicated personnel are responsible for maintaining the irrigation system efficiency). Baum *et al.* (2002) indicated very low irrigation uniformity (one parameter associated with irrigation system efficiency) values for landscape irrigation systems that were evaluated in Florida.

The overall information provided in this landscape irrigation auditing extension program is not new. In fact, any community interested in improving its landscape irrigation can find good resources to help manage landscape water use if they are willing to take the time and investigate alternatives. A large percentage of homeowners and business owners are unfamiliar with current efficient landscape irrigation technologies. The need to provide a mechanism for direct investigation and information transfer associated with good landscape irrigation practices is vital.

The opportunity to tap the extensive information and technology alternatives for urban landscapes and landscape irrigation, and to package this information in a comprehensive approach that is oriented toward small communities, provides a foundation for a good extension program.

This bulletin presents an approach for improving landscape irrigation efficiency, with alternatives to save water that could be implemented by Cooperative Extension Service personnel or other groups. A pilot study to evaluate the approach was implemented in Douglas, Georgia, a town of about 11,000 residents in the southern part of the state. This bulletin discusses the experience with the pilot study to illustrate the approach and will evaluate how much water savings might result. Computer software for analysis and presentation of audit data was created to facilitate the process. This software is currently available as shareware through the Georgia Cooperative Extension Service.

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[1]**D.L. Thomas**, Professor and Head, Biological and Agricultural Engineering Department (BAE), Louisiana State University and LSU AgCenter, Baton Rouge, LA 70803 (former Professor at the University of Georgia), **K.A. Harrison**, Senior Public Service Associate, University of Georgia (UGA), BAE, College of Agricul-tural and Environmental Sciences (CAES) Tifton Campus, Tifton, GA 31794; **M.D. Dukes**, Assistant Professor, University of Florida, Agricultural and Biological Engineering Dept., Gainesville, FL 32611; **R.M. Seymour**, Public Service Assistant, UGA, BAE, CAES Griffin Campus, Griffin, Ga.; and **F.N. Reed**, Senior Public Service Associate and Extension Coordinator (retired), Coffee County, Ga.

Output from the software is presented in this bulletin.

Procedures

The mobile laboratory approach recommended in this bulletin is designed as a resource to small communities. A mobile laboratory can move into a community for a short period of time, conduct evaluations and make reports, and then move on to another community. Figure 1 illustrates the steps that were ultimately implemented (after some trial and error) to achieve the goals of the auditing program. Since the program is designed to be mobile, a team is expected to spend two to three months working closely with a community (depending on the size of the community).

The ability to have mobile team members be "in a community" indicates the commitment of the sponsoring and funding organizations toward the needs of that community. The mobile laboratory approach (personnel and equipment) should ideally be funded through some type of state appropriation. Specific recommendations that are tailored to a community can improve overall water use and provide incentive programs for the future. In addition, many water purveyors or communities are required to develop and implement a water conservation plan as a part of their permit renewal process.

Developing the Initial Team and Local Liaison

The team and the local liaison are essential to the success of the program. A team needs to include at least two members, with three being ideal. Personnel associated with the auditing team would greatly benefit by being certified through an appropriate irrigation auditor program. Understanding irrigation, ways to troubleshoot those systems, and appropriate procedures for the actual audit process are included in such programs. The Irrigation Association offers nationwide training for their Certified Landscape Irrigation Auditor (CLIA) program (Irrigation Association, 2002). This program is in conjunction with the Center for Irrigation Technology at California State University (with support from irrigation specialists across the nation). The Irrigation Training and Research Center at California Polytechnic and State University at San Luis Obispo, Cal., provides training programs for auditing landscape irrigation systems as well (ITRC, 2002).

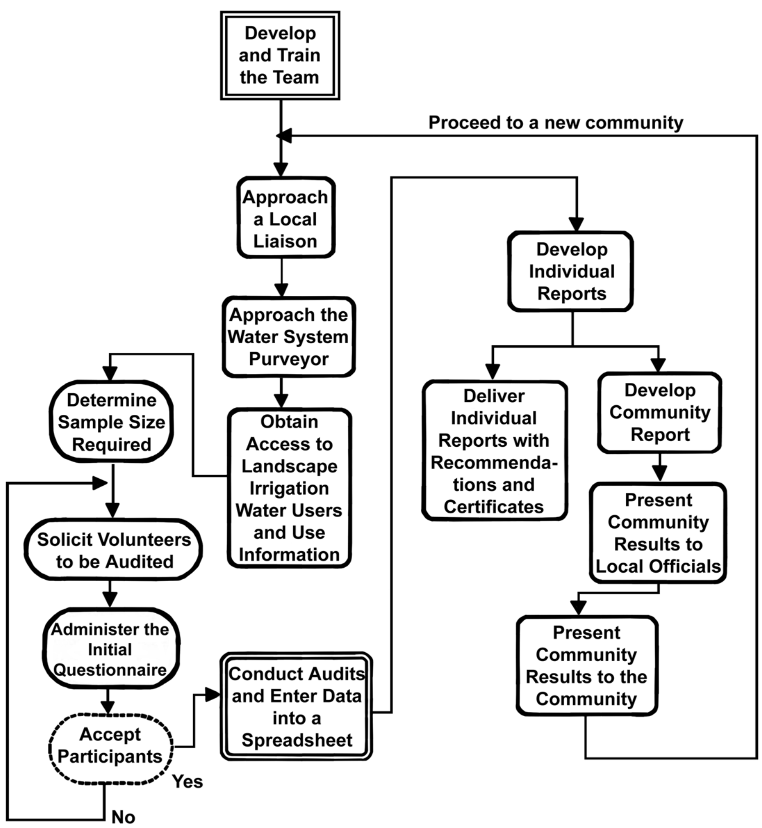

Figure 1. Illustration of the mobile landscape irrigation audit process.

For the southeast region of the United States, a County Extension Agent is a logical choice for the local liaison. This person should have an interest in water conservation. The knowledge of a local county extension agent can include essential contacts and the potential for acceptance of the ideas (local politics). If a local extension agent is not available, someone from the local Soil and Water Conservation District, Natural Resources Conservation Service, or a Resource Conservation and Development Council may be good alternatives. Local water management district water conservation personnel are good contacts in Florida.

Having the mobile audit team in good communication with a local person is essential for "buy-in" (by the local community for the process being used) and potential success of the effort. In addition, the participation of a local agency can create a local contact person who is knowledgeable about landscape irrigation practices and about particular constraints to different approaches. A representative from the water system purveyor may be a good local liaison, but individuals may be reluctant to volunteer without some incentive. If the water sys-tem purveyor is the primary choice for a local liaison, participation in the program can be directly tied to positive or negative impacts on a water bill.

Approaching the Water System Purveyor

The organization that is involved in distributing the water to customers is an essential component to the success of a landscape auditing program. Since their direct revenues are usually associated with the amount of water being distributed, the idea of "reducing" that water use is not always met with a positive response and willingness to cooperate. It is important to assure the local water system purveyor that recommendations will include approaches to maintaining their economic viability while reducing overall water use. One long-term incentive is that the water supply infrastructure should last for a longer period of time.

The water system purveyor can provide critical data that is necessary to evaluate the level of outside water use, either by direct results from outside water use meters or by comparing summer-time water use with winter-time values. It is important to remember (when documenting results) that outside water use must be associated with an area of water application to assess the efficiency of those water applications.

The water system purveyor can help determine how many outside water users are present in the community. A sample size of between 5 and 10 percent is considered adequate to evaluate the community water use. This range of sample size has been used extensively as a statistically valid representation of the population (Thomas, 2003).

Enlisting Volunteers for Auditing

Trying to obtain volunteers implies that you must make direct contacts. If the community requires separate meters for outside water use, a letter can be sent to each customer (in combination with the water system purveyor). This letter can contain information about the program, who is doing the activity, what is to be expected of the participants, and what they will receive in return (Appendix A on page 13 for example). The personal audit information of each water user should be kept confidential. However, they should understand that their information will be used to create a community report. The community report will provide an evaluation of overall outdoor water use issues and solutions that can be applied to the many water users who were not audited.

If a community does not have separate water meters for outside irrigation, the initial contact with potential participants requires a different strategy. A community- or county-based meeting is one recommended approach to initiate the audit program (using standard mass-media contact approaches). This meeting can provide essential information about current water resources, the need for everyone to be involved in conservation (not just the big water users), the audit process, why it will be important to consider water saving alternatives, and who would be involved in the audit program. Partnering with a successful community seminar associated with landscaping is a viable approach to reach volunteers. "Incentives" could be provided by the water system purveyor (or other group) to encourage community meeting attendance.

In this bulletin, "incentives" are positive and negative. We have encouraged positive approaches to participation, but the typical response of some communities may require some negative incentives.

Examples of positive incentives for attending a first meeting could include a small water rebate for a coming month, a coupon to be used with excessive future water bills and rain gauges to help determine water use. The rain gauges could be provided by a local irrigation dealer or landscape contractor in the community. Brochures about landscape water use, landscape planting (Xeriscaping®, etc.), mulching, etc., could also be available at this initial meeting. Potential negative incentives could be an added charge to a water bill if participants with outside irrigation do "not" attend one of the meetings associated with a proposed program.

Questionnaires

Two questionnaires were developed for use with the audit program. The first questionnaire would normally be administered by the local liaison working with the team prior to visiting the individual irrigation system (Appendix B, page 14). It determines the working condition of the irrigation system, whether design and layout information could be available at the time of the audit, sets a time/appointment for the actual audit, and records good directions to the site. If the system is not currently in good working order, the audit can be postponed until the system is operational. Interest of water users can be solicited by mail (such as with water bills).

The first questionnaire can be administered by telephone, after a person has indicated that he or she is interested in participating in the audit program. Alternatively, this questionnaire can also be administered in conjunction with the first community contact session. Those who are willing to participate in the audit program can fill out the first questionnaire.

One essential component for administering the first questionnaire is the audit team's schedule of availability. This schedule is essential to make sure the audit team and the potential participants are both available at the same time. If potential participants do not have scheduling information, the local liaison can follow up with a schedule.

The second questionnaire is used during the actual audit (Appendix B). This questionnaire collects critical information about the system: number of rotating sprinkler heads, nozzles on those heads, zones with mixed irrigation types (typically spray nozzles in combination with rotating sprinklers), zone operating times, any observed maintenance or design problems, and questions to evaluate the "irrigation knowledge" of the water user. By having this question-naire available during the audit, the person being audited is required to be present. Their presence im-proves the educational opportunity and enables rapid feedback on obvious problems.

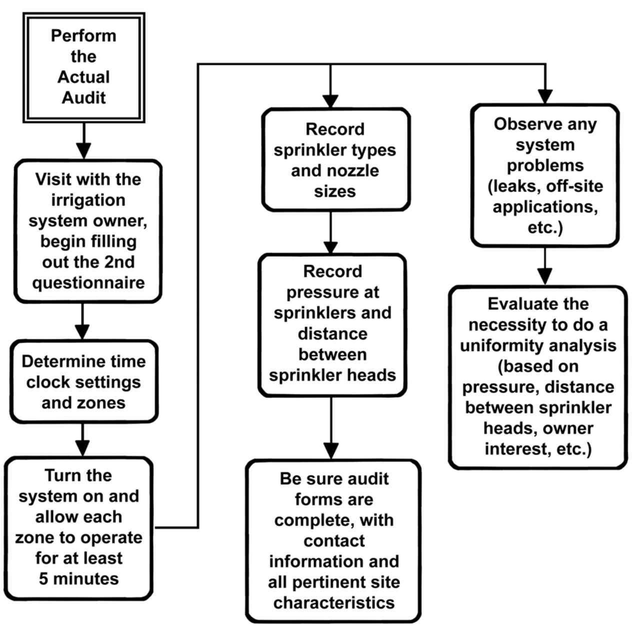

Figure 2. Basic steps during the on-site irrigation audit.

Figure 3. Shirt logo used for the water auditing team.

The Audit

After a time is scheduled for the team to meet the water user, the audit team visits the site and evaluates the irrigation system. The basic steps during that process are illustrated in Figure 2. A logo/shirt is suggested to help identify the audit team. This may be a more logical necessity if the audit team is not continuously escorted by a local liaison. Our initial perception was that many individuals may be reluctant to visit with the audit team until they are confident of the group's identity (Figure 3). This same logo is potentially available for other universities, states and organizations (replace UGA with another organization name) by contacting the authors.

During the audit, the system is operated through each zone. One member of the team records the zone information (sprinkler types, number of sprinklers, nozzle sizes, areas covered, full- and part-circle) while another team member observes individual sprinklers for off-site applications, other maintenance problems, and pressure conditions (near and far sprinklers). A pitot-tube pressure gauge can be used to measure pressure conditions if this component appears to be a problem. All information is recorded on data sheets to be sure important information is not neglected. A third team member can question the water user while recording information about the time clock. In many cases, digital pictures can be taken during the actual audit to illustrate problems or good characteristics of the irrigation system. These images can be catalogued by site to help

Figure 4. Water team member visiting with a homeowner.

explain particular characteristics to the water user in their individual report.

The person responsible for operating the landscape irrigation system is an essential partner during the audit and should be present (Figure 4). His understanding of the irrigation system operation is necessary to evaluate user information. Many of the expected problems can be observed directly on site during the audit. In most cases, the water user can be provided with information to make initial changes for direct water saving and to improve water use efficiency, prior to receiving a formal report.

Uniformity Analysis

A uniformity analysis can be performed on a selected number of irrigation audit sites (Figure 5). The uniformity of water application is a concern for both rotating sprinklers and spray heads (Baum *et al.,* 2002). A *Uniformity Analysis* provides a number that indicates the consistency of water application over an area of interest (Smajstrla, 1997). If the water user indicates the presence of "wet" or "dry" spots during irrigation, a uniformity analysis is useful for visual and quantitative analysis of the problems. In most cases, a uniformity analysis may not be necessary (due to the time required). The uniformity analysis includes installing catch cups on a grid interval. More than one irrigation zone may be required to water the particular area, but the purpose is to demonstrate to the water user whether water is being applied evenly across the irrigation area.

The computer program used for the uniformity analysis is available from the University of Georgia (Harrison, 2002). This uniformity analysis program provides the three basic uniformity calculations used most often in analyzing irrigation systems: the Christiansen uniformity coefficient (CU), low quarter DU, and Heerman-Hein equation (Keller and Bleisner, 1990; ASAE, 1994), and is applicable to solid set and center pivot irrigation systems (landscape and agricultural applications). The Heerman-Hein equation is only provided for analysis of uniformity on center pivot irrigation systems and would not be used for landscape system uniformity analysis. The three different uniformity calculations are provided because different groups tend to like or use a particular formula. For our analysis, a low quarter DU of at least 80 percent or a CU of at least 85 percent were considered adequate (Keller and Bliesner, 1990).

The program provides an area for recording comments about the irrigation system and a color-coded graphical display of the uniformity results. Those areas where the water application is 20 percent below the average and 20 percent above the average are designated in red and blue, respectively. Areas near the average are displayed in green. The program can be run from the Windows® operating system and is available on a compact disc. An example of the output is provided in Appendix C (page 18).

Loss Analysis

The determination of losses for each individual irrigation system component or management alternative can be made on a simple spreadsheet. The spreadsheet approach allows all audit results to be catalogued and summarized from a single site (examples in Appendix D, page 20). A spreadsheet can be organized by pages based on individual audit information (identification), rotors, spray heads, and general management conditions. The columns needed are a function of the problems being analyzed. For example, the most common rotor problems may include rotor sizes and nozzles, water pressure, flow rate, the operating schedule (from the time clock), and the area of coverage. These parameters can be recorded in an area associated with

Figure 5. Installing catch-cups for a uniformity analysis at one of the audit sites.

current conditions. Standard calculations of application amounts (depth and volume) are adjusted to a per-week basis to allow incorporation of odd/even watering schedules.

The spreadsheet allows different nozzles, times of application and spacings to be evaluated for potential water savings in an area associated with “changes.” Maintaining individual worksheets for each individual component allows determination of community or “total audit” effects of particular water saving alterna-tives. It is important that “current/actual” conditions be fixed in the spreadsheet to reduce the possibility of making recommended changes that are not reflected in the efficiency or water saving results.

One problem with this spreadsheet approach is for those irrigation systems where sprinklers have been replaced over time with different sprinkler heads. In many cases, systems that have been in for many years will require replacement of sprinkler heads. Invariably, the exact same sprinkler head is not available locally. In most cases, the sprinklers that are present over most of the irrigated area are represented in the data sheet. If a system has a significant number of sprinkler heads of more than one type, separate lines can be added on the spreadsheet.

All loss calculations in our analysis are based on “expected” water applications at the high water use period (usually mid-summer but can be spring – the period with less rainfall). Peak demand periods tend to stress a water system and available water supplies. Additional recommendations need to be provided for seasonal adjustments to the overall water use, but these generalized recommendations can be included in both the individual and community reports (not in the spreadsheet).

Reports

Prepare an individual report for each audit site. This report contains general information that relates to most irrigation systems as well as specific information on the system being audited. For example, some water saving technologies can be illustrated (such as rainfall cut-off switches). Particular off-site application or maintenance problems can also be identified. Specific recommendations for the irrigation system (nozzle changes, time of application within a zone, etc.) are described for calculating direct water savings. These potential water savings are reported to the water user as a way to encourage changes in the system (see Appendix E on page 21 for an example of an individual report).

Recommendations are indicated for changes that should be implemented when a major repair is warranted. Zones with too many sprinklers, mixed spray heads and rotors, and time clock problems would require significant (and potentially costly) modifications. Making these changes when the system already needs repairs is a logical alternative.

A community report is necessary to illustrate the overall water savings that could be expected by instituting water saving alternatives (see Appendix F, page 25). Most results can be reported in percentages with direct reference to potential gallons saved during a period of time. The opportunity to save water should include alternatives to maintain income for the water purveyor. Recommendations for nozzles to be available for retrofitting rotating sprinklers, rain gauges to help keep track of current conditions, and other water saving practices can be provided in the community report as potential incentives to achieving actual reductions in water use for the community.

Acknowledging Participation

It is essential to acknowledge the support provided by the community and the sacrifice made by the participants in allowing the team to do an audit. Award certificates for appropriate community leaders (City Manager and Water System Coordinator) and each of the individual operators and homeowners. Maintaining the contact and good-will associated with the audit process is essential to the follow-up necessary to help a community implement the recommendations.

The Douglas, Georgia Case Study

Background

A pilot study of the mobile landscape irrigation auditing program was conducted in Douglas, Georgia (Coffee County). Douglas is located at coordinates 31º 31' N and 82º 50' W in south Georgia; it is between Albany and Savannah. Ground water is the primary source for the drinking and landscape water supply. Water is supplied from the Upper Floridan aquifer with pumps located about 35 m below the ground surface. Douglas had about 186 total outside water use meters (in 2002). All households do not have outside water meters. This metering approach may not be typical for many small communities. Total city water use (excluding industry) is about 7,570 m^3 per day (2 million gallons per day, mgd), which implies about 0.69 m^3 (182 gallons) are used per person per day. This amount may not seem extravagant. However, estimates of average per capita consumption throughout the United States range from 0.38 m^3 (100 gallons) per day (Wade, 1998) to 0.58 m^3 (153 gallons) per day (Gleick, 1996). Most organizations recommend about 0.38 m^3 (100 gallons) per day are "necessary" to maintain a good quality of life.

The city of Douglas uses a block rate structure for their water users (Table 1). The current block rate structure does not specifically encourage water savings since the cost per volume decreases with increased usage. Most water users with operating irrigation systems would be in blocks 3, 4 or 5, depending on the area being irrigated. For example, a 1,350 m^2 (⅓ acre or 14,500 ft^2) irrigation area that is irrigated 38 mm (1.5 inches) per week would be expected to use about 200 m^3 (53,500 gallons) in a month during the summer. Water use would include block 5, with a resulting $59.00 water bill for outside water use for that month. The cost to the user, revenue to the water system purveyor, and relative impact of increased costs versus water saved must all be determined for "proposed" water reductions to become "actual" water reductions.

Table 1. Block rate pricing structure for monthly water use in Douglas, Ga.

Block	Rate, $/1,000 gal.*	Description, gal.* used	Potential Monthly Bill, $
1.	$6.68+	≤4,000	$6.68
2.	$1.26	4,000 to 10,000	$14.24
3.	$1.08	10,000 to 20,000	$25.04
4.	$1.02	20,000 to 50,000	$55.64
5.	$0.89	50,000 to 100,000	$100.14
6.	$0.79	100,000 to 200,000	$179.14
7.	$0.71	>200,000	>$179.14

*For SI conversion, use 3.8 liters/gallon
+This is a base charge regardless of amount used below 4,000 gal.

Procedures

Audits were performed on 14 different systems in the community (>7 percent sample). The selection was based entirely on those who requested an audit after receiving a notice in the mail. Half of the audits were on commercial or municipal sites, the rest were residential customers. Most of the irrigation systems evaluated were in the form of standard landscape irri-gation devices (rotors, spray heads and drip). Only one audit included a large traveling gun (hose tow) system, which was used for sport turf irrigation.

The Douglas community was operating under an odd/even watering restriction (based on address) when the audit was performed. Water users were allowed to irrigate every other day. A 6-hour time period (4 p.m. to 10 p.m.) was designated across the state of Georgia to eliminate/reduce home water use every day. Many communities in Georgia and surrounding states have instituted additional constraints. Most time-clocks were set to allow irrigation during early morning hours (within the water use restrictions), thus reducing expected losses due to evaporation. Unfortunately, early morning hours (12 a.m. to 5 a.m.) tend to encourage other potential losses. Offsite applications, maintenance problems (broken sprinklers), and small leaks (if the evidence of the leak is not substantial) are not easily observed during early morning operation periods.

The water saving opportunities listed below are based on "potential" water savings during peak summer use periods with no supplemental rainfall. Obviously, if rainfall occurs or the period is associated with the fall, winter or spring seasons, the water use required would be less, and the potential water savings would be less for the system and management changes.

Results

Water Saving Opportunities

The largest problem observed within the audits was *selection of nozzles in rotating sprinklers*. Regardless of whether sprinklers were old or new, nozzles were not sized according to the area of coverage by the rotating sprinklers. For sprinklers that were operating over part circles, the same nozzles were typically used as those in the full circle sprinklers. This is not a problem if all full circle sprinklers are on the same zone, all part circle sprinklers are on a different zone, and the operating times are adjusted accordingly. Results from the Douglas community tests indicate that nearly 24 percent of the water used on rotating sprinklers could be saved by using the proper nozzles (based on those systems tested, with no other changes in operating schedules). This percentage translates into nearly 151 m^3 (40,000 gallons) of water per week (during peak summer water use periods) that could be saved on the 14 systems tested, by using proper nozzles. For the individual systems tested, the water savings due to nozzle changes ranged from 0 to 45 percent.

Operating time was another concern illustrated from the irrigation audit results. In most cases, spray heads tend to put out three to five times the water application rate on a given area as compared to drip or rotating sprinklers. If the time is not adjusted for the different spray head rates, those areas will receive a much higher application of water. For those systems with spray head problems (60 percent of those systems with spray heads), about 19 percent of the water used through spray heads could be saved by adjusting the time to conform to a “recommended” amount that was consistent with the rotating sprinkler amounts. Turf needs about 32 mm (1.25 in. via irrigation or rainfall) per week during peak water demand periods (Tyson and Harrison, 1995; Wade *et al.,* 2000) in south Georgia. This water savings percentage translated into more than 18.9 m^3 (5,000 gallons) of water saved per week during peak summer use periods for the systems tested.

On one system, the operating time per irrigation was 180 minutes (with rotors). If this system is operated on an odd/even irrigation schedule, the application amount per week is nearly 50 mm (2.0 inches). Reducing the zone time to 120 minutes per irrigation saves about 18 m^3 (4,700 gallons) per week on this system alone.

Off-site applications were a real problem in some areas. Spray heads and rotating sprinklers applied water on roads, sidewalks, driveways and parking lots; hitting nearby bushes and trees (significantly affecting the pattern); and even putting water into a swimming pool. Recommendations to save water were based on converting some full circle rotating sprinklers to part circle. Water savings based on off-site applications are “real” based on any application scenario because this water is not being used for any beneficial plant response. Off-site applications represented a relatively small percentage of the overall water use, but they are the primary concern when addressing public perceptions about irrigation system efficiency.

For one system tested, changing a full circle sprinkler to a 270 degree coverage would save about 0.8 m^3 (210 gallons) per week. For another system, changing a full circle sprinkler to a half circle sprinkler amounted to about 0.4 m^3 (100 gallons) per week in water savings. This analysis was based on the current operating time set to provide 12.7 mm (0.5 inches) of water per week. All of the above savings were based on the current irrigation schedule (time of application in a zone) and the particular nozzles being used.

Changes were also recommended *based on the season*. In the majority of the audits, no direct effort was made by the water user to reduce water applications during the fall, winter or spring. In some cases timing was modified if areas were too wet. Rarely were the seasonal adjust features (water budgeting) used on time clocks. The potential for educational efforts to help water users more effectively use their time clocks was evident in almost all audit situations.

All reports contained a recommendation for the installation of a rainfall shutoff or soil moisture sensor. Some sensors can turn the system off when it starts raining. Other sensors monitor the soil moisture and will prevent the system from operating if the soil water conditions are adequate. In Florida, rainfall shutoff sensors are required. This is not the case in many other states, including Georgia.

Efficiency Improvements, but More Water Needed

In some cases, water application recommendations were provided to help meet potential plant water needs. Some irrigation systems were not providing sufficient water to meet plant water requirements at peak summer conditions. Recommendations that increase the amount of water applied to a particular area would lead to increased efficiency but also increased water use. Obviously, if the water user is satisfied with the condition of the turf and landscape plants, these recommendations should not be implemented (indicated in their report). Schools are one typical irrigation system location that may not need as much water during the summer (if schools are not in session). Maintenance during the summer should be low and appearance may not be as important (low application amounts may be acceptable). Unfortunately, the climate in the southern United States encourages the encroachment of drought-tolerant weeds if sufficient water is not available to the turf.

Application amounts for rotors seemed to be low for a large percentage of the systems evaluated (50 percent of those tested). These systems were putting out less than 15 mm (0.6 in.) over a week (based on applications “every other day”). Some of these sites may have low water application rates because of anticipation of rainfall. Unfortunately, when it does not rain for extended periods, the water supply is insufficient for most turf types. These application amounts may need to be adjusted based on the stresses observed on turf and landscape plants. The amount applied can easily be corrected by adjusting operating time(s) per zone. However, this would result in increased water use for those particular systems.

Alternative Water Rate Structures

The largest concern by the water purveyor was the potential loss in revenue associated with water use reductions. By modifying the water rate structure, the loss in revenue can be offset to address those persons making the changes. We estimated that most irrigators would be in blocks 3, 4 and 5 based on their schedule and irrigated area.

What if the block water rate structure described in Table 1 were “readjusted” to penalize those who use more water (inclining water rate structure)? For example, the water rate for blocks 3, 4 and 5 could be increased ($/1,000 gal.) to encourage outside water users to use less water (Table 2). Income to the water purveyor would not be reduced, since those wishing to use more water would pay an increased rate. The example presented previously indicated a cost of $59.00 per month to use about 200 m^3 (53,500 gallons). If the water user reduced outside water use by 20 percent (to about 160 m^3 or 42,800 gallons), the water bill would be about $58.86 (Table 1). If the user did not choose to reduce water use, the water bill would be about $75.25.

Table 2. Block rate pricing structure for monthly water use in Douglas, Ga.

Block	Rate, $/1,000 gal.*	Description, gal.* used	Potential Monthly Bill, $
1.	$6.68⁺	≤4,000	$6.68
2.	$1.26	4,000 to 10,000	$14.24
3.#	$1.36	10,000 to 20,000	$27.84
4.#	$1.41	20,000 to 50,000	$70.14
5.#	$1.46	50,000 to 100,000	$143.14
6.	$0.79	100,000 to 200,000	$222.14
7.	$0.71	>200,000	>$222.14

*For SI conversion, use 3.8 liters/gallon
⁺This is a base charge regardless of amount used below 4,000 gal.
#Potential increasing rate structure for primary irrigation water users.

Positive incentives, such as reduced water rate structures by the implementation of water saving alternatives, could also be used to encourage reduced water use. However, the opportunity to maintain a water bill near the previous level by saving water was considered a very good incentive.

Summary and Conclusions

A new mobile landscape irrigation auditing program was developed for small communities in the southeastern United States, and was tested in a pilot study in Douglas, Georgia. Fourteen individual systems were audited (>7 percent of outside water meters). Fifty percent of the audit sites were municipal or commercial sites and 50 percent were residential. For the audited systems, at least 950 m^3 (250,000 gallons) per week were estimated to be used if all systems were operating on an “every other day” irrigation schedule during peak water use periods. If all recommendations for water savings were implemented on these systems, about 190 m^3 (50,000 gallons) per week (20 percent) would be saved. All potential water savings were based on a combination of system and management alternatives toward applying less water if they were currently exceeding recommended amounts (per week).

Some audited sites were applying less water than is recommended for turf and landscape plants (during the hot part of the summer). Irrigation efficiencies and possibly health of turf and landscape plants could improve by applying more water.

In practically all irrigation audit situations no seasonal adjustments were being made to reduce water applications during the fall, winter, and spring seasons of the year. The need for improved education on irrigation and operating system alternatives was obvious.

The audit program represents a real, potentially viable method of improving water use for small communities. The potential to use water more efficiently and save water under drought conditions is necessary to the future of the landscape and turf industries, and the quality of life and quality landscapes expect.

The proposed procedures provide limited alternatives for potential water savings. Other approaches, such as deficit irrigation (putting out less water than is needed by plants), encouraging the use of low water use landscape plants (such as Xeriscaping®), rebates on water bills after implementing water saving approaches, etc., can encourage even greater water savings and higher levels of participation.

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APPENDIX A. Example letter to potential participants

The University of Georgia
College of Agricultural and Environmental Sciences
Cooperative Extension Service

City of Douglas
"Working Together To Serve You Better"

Irrigation Water Audits in Landscapes

You are receiving this special notice because you have been identified as an outside water user (since you have a separate water meter for irrigation). Everyone has been impacted by the ongoing drought. The Georgia Department of Natural Resources has imposed statewide watering guidelines to help with the drought conditions. Consequently water use outside the home is becoming a " critical issue" in water conservation talks and is being blamed for many of the problems associated with shortages and potential wasting of water.

The Biological and Agricultural Engineering Department of the University of Georgia (UGA) would like to implement a pilot program which is aimed toward you, the landscape/outside water user. *Basically, we are interested in saving water through more efficient irrigation practices, rather than "cutting off your water supply."* This pilot program will include performing what is called "water audits" on a random sample of landscape irrigation systems in your community. These audits are designed to more adequately explain the water conditions that currently exist in the landscape irrigation area. This data will be used to develop a program on a statewide basis. We have selected the Douglas water system as a pilot community.

What will the audit require of me? The audit is usually a "two step" visit. The first step is to meet with you and determine as much information as possible about the type of irrigation you have and how you manage the irrigation. This will involve mostly answering questions about the irrigation system and will require about 30-45 minutes of your time. Once it has been determined that the irrigation system can be tested, the actual field audit will be conducted. The actual field audit will require that the irrigation system be operated for about 30 minutes and UGA personnel will collect the necessary field data. A report will be developed that includes information like recommended operating schedules, uniformity of application, and maintenance. This report will be discussed with you on an individual basis, and a copy will be provided to you for planning purposes (in case there are suggested changes for your system that you may wish to implement). A complete audit may require up to a half day.

The good news is that there is no charge for this audit! All the information gathered will be held as confidential and will not be associated with an individual name. We do plan to provide a "community report" to Douglas which describes the most consistent practices/ideas for saving water. Since this is a pilot program, the participation will be limited to the first XX-XX systems who sign up. At this time, the pilot program is scheduled to get started around the first week in September. If you would be willing to volunteer your landscape irrigation system for a water audit, please fill out and return the lower portion of this page. You will be contacted by Rick Reed to schedule your audit. If you have questions, please feel free to call: XXXX, Coffee County Extension Service at XXX-XXXX or XXXXXXX, City of Douglas at XXX-XXXX.

- -

Yes; I would like to volunteer as a participant in the UGA landscape water audit program.

Name: ________________________________

Address: ________________________________

Telephone: ________________________________

Please return to: City of Douglas
P. O. Box XXX
Douglas, GA XXXXX

APPENDIX B. Questions to ask prior to and during the initial landscape irrigation visit

Questions to ask during the phone conversation when setting up appointments:

Identify who you are, and what you are calling about.

Intro? Something like: Landscape irrigation is one of the first uses that is affected when water supplies are limited, or restrictions are put in place. If we can improve the efficiency of water use in landscape irrigation, we can potentially have more water available for current and future uses.

1. **Make sure of name, address, telephone number:**

   Name: ______________________________

   Address: ____

   Telephone no.: ____________________________

2. It would help us greatly in planning your direct audit if we had your past history of water use. Realizing that any recommendations are designed to "improve" water use over what you have done in the past, do you have any problem with team members from the University of Georgia seeing your water bill?

   Yes No

3. How much area (square feet) are you *irrigating*? Or do you know the dimensions of your *lot*? X ft by Y ft
   ____ (circle above, put down units, sq. ft, acres, etc.)

4. What kind of irrigation system do you have? (Buried/permanent, portable, rotating sprinklers, spray heads, drip/micro) — Circle all that apply — If the system is PORTABLE, ask the next two questions:

   4b. What are the weekly water requirements for your landscape plants and lawn?

   landscape plants ____________(inches/week) lawn ____________ (inches/week)

   4c. What is your operating schedule?

   ____

   ____

   ____

5. Is your irrigation system currently in working order?

   Yes No Don't Know

   If answer is "No," what would it take to make it "operational"? Note: system must be operational before we can schedule a site visit.

   If answer is "Don't know," does someone else (such as a landscape contractor) operate/manage/maintain your system for you? Yes No

6. Will you participate in the audit program? Yes No

7. Is there (or do you have) a schematic/plan for the irrigation system? Yes No

   If "yes," can you have it available at the time of the site visit? Yes No

8. Is there a specific time (2 to 3 hours) between Date 1 and Date 2 (preferably during the week) that a team from the University of Georgia could visit with you about your landscape irrigation system?

   Date and time of the audit:

   Date:____________________ Time: ___________________

9. During the visit, team members will ask additional questions about your irrigation system and may do a direct measurement of water application uniformity. A confidential report will be provided to you about your system. The information from your system will be used with other audits for a general report to the city of Douglas. The main interest is to help you and the community use water more efficiently and hopefully save water both now and into the future.

   If so, what are driving (or special) instructions to get to the house/site? (use noted landmarks)

   ____

   ____

   ____

   ____

10. If a landscape company is used (*yes* to question 5b) and the homeowner is interested in participating in the audit program (*yes* to question 6), the homeowner is offered the opportunity to invite the landscape contractor to be present during the audit. Will landscape company be invited to be present?

    Yes No

11. Would you be interested in an audit of "in home" water use? Yes No

12. If something comes up, and the schedule needs to be changed, please call my office number.

Information Recorded by: ____________________ (Initials) Date:____________________

Questions to be asked during the landscape irrigation audit:

Name: ______________________________ City: ______________________________

Installation and Maintenance:

1. If there was a plan (question #7 from above), can we get it now?
2. What made you decide to install the irrigation system?

   Wanted my yard to be pretty all year round
   Didn't want to mess with moving sprinklers around
   Didn't have time to irrigate any other way
   ____

3. What outside sources did you use for information to make your decision? ______________________

   ____

4. Is there anything (other than price) that you considered when installing the system?

   Examples: product reliability, maintenance, management time required, etc.

   ____

   ____

5. Did you hire someone to install the irrigation or did you do it yourself? Hire Yourself

6. What maintenance has been performed and why was it done?

   Example: Head replacement, added sprinklers, new timeclock, etc.

   ____

   ____

7. What improvements would you like to see in your system? **OR** If you had it to do over again what would you change?

   ____

   ____

   ____

8. How old is the system? ______________ years

9. Are you aware of any problems with the system (like water in the street)?

   ____

   ____

Scheduling:

10. What are the weekly water requirements for your landscape plants and lawn?

    landscape plants __________(inches/week) lawn __________ (inches/week)

11. What is your operating schedule? Note: Compare verbal answer with actual timeclock settings. Will need to go "zone by zone" with owner if system is manually operated.

____

____

____

12. Based on information from the telephone interview, you "are"/"are not" using a landscape contractor/lawn maintenance company. Check all the following that apply if they "are"

___Initial time clock setting
___Repair/replace damaged or broken heads
___Seasonal clock/controller adjustment
___Annual system check

Field Evaluation by UGA (do not ask homeowner):

13. What types of irrigation are used?

____

____

____

Working knowledge of irrigation system? Yes No

14. If you had to prioritize water for different uses, how would you rank the following (personally): Use 1-5, where 1 is the most important to you. (Given to the homeowner on a card?)

___ Home use including drinking water
___ Landscape irrigation
___ Agricultural irrigation
___ Industry
___ Recreation

Information Recorded by: _________________________ (Initials) Date:_______________________

APPENDIX C. Example output from the uniformity analysis program.

```
                       SOLID SET IRRIGATION SYSTEM REPORT
================================================================================
Date of Test: xx-xx-xx
File: C:\Program Files\ISAAC\XXXX.Coffee.ssd
Report Date: xx/xx/xxxx                   Report Time: 4:59:46 PM
================================================================================
Test Conducted For:                       For Further Information Contact:
XXXX                                      Kerry Harrison
                                          University of Georgia
XXXX                                      P.O. Box 1209
Douglas, GA                               Tifton, GA 31793
                                          kharriso@uga.edu
XXX-XXX-XXXX                              229-386-3442
Coffee County
================================================================================
Field Information
Field Name: Zones 1 & 2                   Estimated Area:
Soil Type: Sandy Loam                     Soil Slope: 0-1 Percent
Common Tillage: Other/Unknown
Crop Rotation: Turgrass
Comments:

================================================================================
System Information
Sprinkler:            Other
Sprikler Age :        1 year
Sprinkler Spacing:    33 x 25
Estimated Flow Rate: 2.3
Measured Flow Rate :
Estimated Pressure:   25
Measured Pressure:
Leaks Observed:       False
Operation Times:      Nighttime Only

Comments:

================================================================================
Average Depth = 0.06 inches
Application Rate = 0.17 inches per hour

Coefficients of Uniformity:
Christiansen Method       CU = 82%
Low Quarter Distribution  CU = 70%
================================================================================
```

APPENDIX C. *Continued*

Uniformity Analysis - Representative Layout
(Note: values that are high are displayed in blue, values that are low are displayed in red. Values near the average are displayed in green)

Y Axis \ X Axis	1	2	3	4	5	6	7	8
1	0.04	0.06	0.04	0.03	0.02	0.03	0.06	0.06
2	0.07	0.07	0.05	0.04	0.03	0.05	0.06	0.05
3	0.06	0.06	0.06	0.06	0.05	0.05	0.06	0.06
4	0.05	0.06	0.06	0.06	0.06	0.06	0.05	0.04
5	0.05	0.06	0.07	0.07	0.07	0.06	0.05	0.05
6	0.06	0.09	0.08	0.08	0.06	0.05	0.05	0.05

\+ denotes relative sprinkler head location

==

If there are specific points in the fields where improvements may be needed they will be indicated on the report by either red (for low) or blue (for high). These points recorded a variation greater than 20% from the average. Check sprinklers at or near these points for proper operation. Items to look for include proper rotation (if the sprinkler rotates), worn nozzles, clogged nozzles and leaks that may have been collected by the data collection cups.

The low quarter DU is an indication of the percentage of water that the lowest 25% of the data gets compared to the average amount of water collected (all the data). In your particular situation it means that the amount of water collected by the lowest 25% of the data was 70% of the average amount of all the data collected. A low quarter uniformity close to 100% means the system has less variability in its output or uniformity.

==
Comments:
Head observed to be not operating in Zone 2. This is probable explanation for "dry spot" between zone 1 & 2
==

APPENDIX D. Example spreadsheet pages used in the data management

ROTORS										Area
Site	Zone	No.	Brand	Descrip.	Nozzle	Nozzle	Spacing		Radius	Area
				Deg.	Size	Rate, gpm	ft	ft	ft	sq. ft
34-U01	Front	0	Nelson	90	4	3	30	40	na	1200
34-U01	Front	22	Nelson	180	4	3	30	40	na	1200
34-U01	Front	1	Nelson	270	4	3	30	40	na	1200
34-U01	Front	15	Combo	360	4	3	30	40	na	1200
34-U01										

ROTORS			Current Conditions, Application Rates				Recommendations		Application Rates After Recommendations					Water	Total
Site	Run time	Appl./ week	Rate	Rate	Rate	Total	Nozzle	Nozzle	Rate	Rate	Rate	Total	Saved	Saved	Saved
	Min	No.	in/hr	in/day	in/week	gal/week	Change	Rate, gpm	in/hr	in/day	in/week	gal/week	gal/week	%	gal/week
34-U01	20	3.5	0.96	0.32	1.12	0	3	0.8	0.26	0.09	0.30	0	0		
34-U01	20	3.5	0.48	0.16	0.56	4620	4	1.5	0.24	0.08	0.28	2310	2310		
34-U01	20	3.5	0.36	0.12	0.42	210	5	2	0.24	0.08	0.28	140	70		
34-U01	20	3.5	0.24	0.08	0.28	3150	na	3	0.24	0.08	0.28	3150	0		
34-U01						7980						5600		30	2380

SPRAYS										
Site	Zone	No.	Brand	Descrip.	Nozzle	Nozzle	Spacing		Radius	Area
				Deg.	Size	Rate, gpm	ft	ft	ft	sq. ft
34-U01	1	1	Toro	360	15	3	15	15	na	225
34-U01	1	26	Toro	180	15H	1.5	15	7.5	na	112.5
34-U01	2	1	Toro	180	15H	1.5	15	7.5	na	112.5

SPRAYS			Current Conditions, Application Rates				Recom.	Application Rates After Recommendations					Water
Site	Run time	Appl./ week	Rate	Rate	Rate	Total	Operating Time	Rate	Rate	Rate	Total	Saved	Saved
	Min	No.	in/hr	in/day	in/week	gal/week	(min)	in/hr	in/day	in/week	gal/week	gal/week	%
34-U01	20	3.5	1.28	0.43	1.50	210	15	1.28	0.32	1.12	158	53	25
34-U01	20	3.5	1.28	0.43	1.50	2730	15	1.28	0.32	1.12	2048	683	25
34-U01	20	3.5	1.28	0.43	1.50	105	20	1.28	0.43	1.50	105	0	0

APPENDIX E. Example report to an individual participating in the audit.

Location: XXXXXX XXXXXX, in Douglas, Georgia; Coffee County
Date of Audit: October 25, 2001
Team: K. Harrison, D. Thomas, R. Bennett, V. Perez, R. Reed
For more information Contact:
Rick Reed, Coffee Co. Extension Director, 384-1402, or
The Landscape and Turf Irrigation Audit Team, Tifton, GA, 229-386-3377

The following report describes alternatives for improving the water use efficiency of landscape and turf irrigation practices for *XXXXXX XXXXXX, in Douglas, Georgia.* **Improving water use efficiency** implies that water that is used for irrigation will be used properly and to the best benefit for plants and turf. The following report is designed to analyze the existing system, indicate positive characteristics, and provide recommendations for potential improvement for the future. Management and system recommendations are for the benefit of the water user. Some information is expected to be used in a consolidated report for the community.

Positive Characteristics of the Irrigation System

The landscape irrigation system at *XXXXXX XXXXXX* appears to be meeting the objectives of most irrigation systems, "keeping the grass relatively green, keeping landscape plants alive, and meeting irrigation objectives at a reasonable cost with reasonable water use." If the current system is "meeting the needs," very few recommendations will be provided to help *conserve* water or energy. Some recommendations, however, will hopefully improve the water use efficiency. The unique relationship between the school and the community (especially Mr. Bill) has allowed a system to be installed and operated at a minimal expense. This is a very beneficial approach which can be an example for many public facilities.

General Irrigation System Characteristics

Landscape irrigation systems can include a combination of rotating sprinklers (or rotors), spray heads and drip components. **Rotating sprinklers** include impact and gear driven approaches to moving a stream of water over an area being irrigated. **Spray heads** (pop-up and other) typically have a set pattern (full-circle, half-circle, side-spray, etc.) over a small, well-defined area that needs water.

Typically, irrigation zones may include a combination of full-circle and part-circle sprinklers. If a zone includes both full- and part-circle sprinklers, and the **nozzles** (the part at the exit of the sprinkler that controls the flow of water) are the same then the water application rate will be different. For example, a half-circle sprinkler will put out twice as much water to a given area as compared to the full-circle sprinkler if both have the same nozzle. Full-circle sprinklers that are located improperly can also cause water to be applied "off-site" (into roads or other areas where water is not desired) which is a waste of water and a potential hazard.

Drip irrigation in the landscape allows watering of individual plants or beds more efficiently. A drip system can include individual tubing and emitters, tubing with in-line emitters, or misters (small spray-type emitters). Drip tubing with in-line emitters can be used on close-spaced landscape plantings (such as beds of flowers) and drip tubing with attached emitters on spaghetti tubing can be used for wider-spaced landscape plantings (such as shrubs and trees).

Irrigation System Recommendations

The following recommendations are based on "what may be changed now" and "what is recommended to be changed later" as the system/sprinklers require more complete repair or replacement. Additional recommendations are provided to indicate the relative costs of the making the changes.

Landscape Beds

In some areas (near the sign, the large bed in the center), sprinklers may be operating on an area where you do not truly wish to have "everything" irrigated. Operating a sprinkler on a landscape area with spaced plants and mulch encourages grass and weeds to grow because water is available outside of the landscape plant needs. This can create an added mainte-

Figure 6. Full-circle sprinkler operating too close to the road.

Figure 7. Example of drip tubing with in-line emitters.

Figure 8. Distributor for landscape drip with emitters attached through spaghetti tubing.

Figure 9. Water is being applied across the sign with a rotating sprinkler. Drip may be an alternative.

nance burden because you are watering the unwanted grass and weeds! *This was evident near the sign at the front of the school.* One alternative is the installation of drip lines within the beds to allow water application only to the areas of concern (where the plants are).

The *XXXXXX XXXXXX* irrigation controller has another available zone if a drip zone were to be added. It is important that a drip zone be operated a sufficient amount of time to meet water needs of the plants. Fortunately, the sprinklers around the beds can be re-oriented to water only the grass if a drip zone is added. If these sprinklers are changed to a partial circle, the nozzles need to be adjusted to reflect that change.

The area near the sign *at XXXXXX XXXXXX* and the road seems to have problems with dry grass and grass within the juniper plants. By using a "low water use," and "low growing" juniper (or other plant), the sprinklers could be readjusted to miss this area, thus reducing maintenance (grass problems in the bed) and water use.

Sprinkler Zones and Nozzle Sizes

Sprinklers designed to "pass/rotate over" an area have a particular nozzle size that affects the rate of water application (within a particular pressure range). If a zone contains sprinklers that operate over full circles and partial circles, nozzle sizes need to be changed to provide "a similar amount of water" over the irrigation area. For example, a Toro S-700 sprinkler operating at 30 psi with a #6.0 nozzle is designed to put out 4.6 gallons per minute (suggested for full-circle operation). If this same sprinkler were to be used for only 180° (half-circle), then a #3.0 nozzle should be used (2.6 gallons per minute). If this same sprinkler were only used for a 90° (¼ circle) a #1.5 nozzle should be used (1.2 gallons per minute). Each sprinkler manufacturer has a set of nozzles which allow the rate to be changed for different partial circles.

Number of Sprinklers in a Zone

An irrigation system can supply only so much water (based on the size of the supply line, and the initial pressure in the irrigation system). The reason for using different zones is to keep the irrigation lines at a reasonable size (lower cost) while still maintaining the pressure. If the number of sprinklers in a zone is too large, then the pressure to the system cannot be maintained within the optimum operating pressure. If the pressure is too low, ALL the sprinklers and sprinkler patterns can be affected. Sprinklers that "stream" water (droplets do not break up) are evidence of low pressure. If an area is not being covered well by the existing sprinklers, care must be taken before adding a sprinkler to that zone if the pressure is already low.

Uniformity of Water Application

Irrigation uniformity is a measure of the similarity in the depth of water being applied over an area. If the spacing of sprinklers is not as recommended, pressure is off, or sprinklers are not operating properly, some areas will receive more water than others. By improving the uniformity, irrigations can be scheduled consistently for the best performance of the irrigation system and the landscape.

For the *XXXXXX XXXXXX* system, some sprinklers are spaced about 30 feet apart while others are 40 feet apart. Based on a measured pressure of between 20 and 26 psi, the sprinklers should be spaced within about 30 feet of each other for full head-to-head coverage. **Head-to-head coverage** is recommended for the best opportunity for uniform water application with sprinklers.

Figure 10. Low pressure on a sprinkler creates "donut" shaped patterns because droplets do not break up.

Management Characteristics

Since this system contains both rotating sprinklers and spray heads, it is important to understand "how much water" is applied to a given area by each type. Typically, spray heads apply four to five times the water to a given area as compared to a rotating sprinkler. This is a direct function of the area where water is being applied and the amount of water coming out of the sprinkler. At *XXXXXX XXXXXX*, at least one zone has a combination of sprinklers and a spray head.

The current operating schedule for the irrigation system is 20 minutes per zone, every other day (meeting the community requirements of odd/even watering based on the last digit of the address). This operating schedule indicates that about 0.08 inches of water is being applied each irrigation for the full circle sprinklers. This amounts to 0.28 inches of water being applied during a week. Under high water use periods for our climate conditions, turf/grass can be expected to require between 1.0 and 1.5 inches of water per week.

For the spray zones, about 1.5 inches of water is being applied per week based on the same 20 minute operating schedule.

Under the current management at *XXXXXX XXXXXX*, the small amount of water being applied to the sprinkler areas is barely penetrating the soil. This low rate will encourage root growth near the top of the soil (especially during times without rainfall). "Shallow root" condition can be a problem if the irrigation system fails for only a few days. Plant health (including turf) may also be affected since roots are more susceptible to disease and insect pressures if they are only near the top of the soil profile.

Management Recommendations

The irrigation system at *XXXXXX XXXXXX* currently operates in the early morning hours, which is very good. Less water is lost to evaporation at this time (usually lower evaporation and wind), and more water is available to plants for encouraging deeper root growth. Care should be taken to avoid extended wetting periods which can also promote disease and insect problems.

The time schedule for the zones should be modified based on the season. For winter months, about 0.5 inches per week is reasonable (a time set of ≈45 minutes per irrigation, on an odd/even day irrigation schedule for sprinkler zones for this system). During the late fall and early spring, about 1.0 inches per week is reasonable (time set of ≈75 minutes for sprinkler zones). During the summer months, about 1.25 inches per week is reasonable (time set of ≈90 minutes for sprinkler zones).

Rainfall Cut-off Switch

One alternative which can be effective for the irrigation system (to help prevent extra water being applied during periods with sufficient rainfall), is to install a rainfall cut-off switch. Switches are available that can sense the soil or a rainfall event and keep the system turned off until water is required. A rainfall cut-off switch can be effective in saving all the water during an irrigation if sufficient rainfall has occurred. It is also useful because it may be difficult to remember to turn the irrigation system on and off if it is operating at night or early morning hours. Your local irrigation dealer can provide information on appropriate alternatives.

Rain Check

Figure 11. Example switch that can cut off the irrigation system when the cup is full after a rain.

Maintenance of the Irrigation System

Maintenance of the irrigation system involves checking the sprinkler heads, making sure the patterns are not putting water in roads, and that all irrigation components are working properly. It is recommended that the irrigation system be checked at least twice per year by a qualified irrigation specialist. This service will help prevent small problems that result in large water losses over a period of time.

Some of the irrigation components are located in areas of high traffic (near sidewalks and curbs). These components need to be properly installed (correct height), but no amount of installation planning will completely reduce the potential for irrigation system damage due to traffic or yard maintenance. Periodic system checks can help reduce water losses due to broken spray heads, sprinklers, etc.

Summary of Recommendations

1. Readjust the time for each irrigation zone based on season. The 20 minute time schedule for both the sprinklers and spray zones creates greatly different water application amounts. For example, (see table below) during summer months, increase the time on the sprinklers to about 90 minutes per zone while irrigating under spray nozzles only 20 minutes. *(Minimal cost to implement)*

Season	Water typically required per week for turf (≈in.)	Time required per irrigation (this system, odd/even schedule) (≈min.)	
		Areas under Sprinklers/rotors	Areas under Sprays
Summer	1.25	90	20
Spring and Fall	1.0	90	15
Winter	0.5	45	7

2. Make sure nozzles that are partial-circle and nozzles that are full-circle on the same zone are matched. The local irrigation dealer or irrigation installer can determine the best nozzle alternatives. Remember, if a larger nozzle is placed in the full circle sprinklers, application rates (time of operation) need to be reduced accordingly. *(Minimal cost to implement)*
3. Add a drip zone for the bed areas (as time and funds permit). This recommendation would include readjusting the patterns (and perhaps nozzles) on the sprinklers around the beds. Care must be taken to be sure the quality of water is good. Drip systems are more susceptible to plugging of the emitters if the quality of water is poor. An in-line filter may be required to help prevent emitter plugging. By using drip irrigation in the beds, water can be applied directly to the landscape plants, thus reducing weed and grass pressure throughout the beds. *(Significant cost to implement)*
4. Make sure sprinklers are spaced properly and consistently. This recommendation would include some modification of the location of sprinkler heads or a change in the actual head. This change could be instituted when sprinklers malfunction and need to be replaced. Care must be taken to not add too many sprinklers into an existing zone (in case pressure will be too low). *(Significant cost to implement)*

Potential Water Savings

Using the current irrigation schedule, and readjusting the nozzles (for the partial circles) as recommended above would save *nearly 8,000* gallons of water per week. If the irrigation schedule is increased (during hot summer months), an additional 15,000 gallons of water would be required per week.

If the landscape areas are converted to drip irrigation, significant water savings can be achieved. For example, a small landscape plant may require 2 gallons of water per day during summer months (or 14 gallons per week). If a sprinkler is used that covers the entire area around the plant, over 3 times that amount of water would be applied (based on a plant spacing of 3 feet *and the current irrigation schedule)*.

Potential $ Savings

Water savings are usually directly proportional to $ saved. Based on the water rate structure for Douglas, about $1 can be saved for every 1,000 gallons saved.

In this case, recommendations may actually “increase” water use (for improved water use efficiency). Under those circumstances, the system and schedule should be closely maintained to ensure water is used efficiently. Water that is used more efficiently can translate into decreased grounds maintenance costs, and reduced costs to replace landscape plants.

APPENDIX F. Example Community Report

Final Report
Landscape and Turf Irrigation Auditing Program
University of Georgia

Location: Douglas Community, Coffee County, Georgia
Date of Audit: August 14, 2002
Team: K. Harrison, D. Thomas, R. Bennett, V. Perez, R. Reed, T. Whitley
For more information Contact:
XXXX XXXX, Coffee Co. Extension Director, XXX-XXXX, or
The Landscape and Turf Irrigation Audit Team, Tifton, GA, XXX-XXX-XXXX

The following report describes final results and recommendations for the Douglas community landscape irrigation auditing program. During that program, at least 7 percent of outside water meters were audited. Audited sites included a combination of residential (50 percent), municipal, and commercial sites. For the sites tested, at least 250,000 gallons of water per week were estimated to be used if all systems are operating on an "every other day" schedule, during the peak water use period. If all recommendations for water savings were to be implemented on these sites, at least 50,000 gallons of water would be saved per week (20 percent of water used). This figure is based on water "savings" recommendations, and not recommendations that may include using more water to meet plant needs where too little water is being used currently.

The process used in the auditing is described in the attached paper that was presented at the International ASAE meeting, to a group of engineers involved in irrigation and landscape systems (Thomas *et al.,* 2002).

The following recommendations are those that could be implemented on a community-wide program. Obviously, "potential" water savings are not realized until some incentive program has been implemented to encourage water savings.

Recommendations

New Block Water Rate Structuring

The implementation of any water savings approach can have a detrimental impact on revenues associated with the water system purveyor. Under those conditions, it is logical to *develop an improved water rate structure that encourages water users to be more conservative*. This recommendation is more palatable to a community if the community (and community leadership) is involved in creating a new structure. Obviously, we (University of Georgia) do not understand all the customers and customer base for the community. However, an "increasing block" water rate structure through certain ranges has been shown to encourage conservation of water, while maintaining revenues. By increasing the cost per 1,000 gallons for those blocks where the excessive water users (for outside irrigation) fall, it becomes a direct incentive for customers to be more efficient. Those customers who do not wish to conserve will contribute an increasing amount to the water structure.

Operating Time for Irrigation Systems

The current "odd/even" watering restrictions will save water. However, it is important to understand how much water plants need, and how those needs change from season to season. Many of the irrigation systems tested have time clocks that will allow *water budgeting or seasonal adjustments.* These features allow easy reduction in irrigation water use during the fall, winter and spring when plants require less water.

Unfortunately, very few of these features are being used by those in the pilot program. In most cases and for your climatic conditions, plants and turf require about 0.5 inch per week during winter months, about 1.0 inch per week during fall and spring, and 1.25 inches per week during summer months. *The ability to readjust irrigation during periods when plants require less water is essential to an overall water conservation plan.* **For fall and spring, at least 20 percent of irrigation water can be saved (when compared to summer months). In winter, at least 60 percent of water can be saved as compared to summer months, if the irrigation systems are operating! For one system tested, a reduction in operating time to recommended rates would result in 4700 gallons of water being saved per week!**

Spray heads (pop-ups in turf and landscape areas) put out four to five times the amount of water over a given area as compared to rotating sprinklers (those that pass over an area by a gear-driven or impact device). Drip irrigation (micro spray heads and trickle devices) tend to put out water at a similar rate to the rotating sprinklers. *All operating schedules need to be adjusted to reflect the amount of water put out by the different irrigation system types.* **For the systems tested, reducing the operating time for spray head zones was estimated to save between 0 and 50 percent of the water used through the spray heads (average of 20 percent).**

Nozzle Selection for Rotating Sprinklers

Rotating sprinklers are designed to operate over a particular area. In some cases those areas may be partial circles, while in other areas, the sprinklers operate through a complete circle. In most every irrigation system where a combination of partial and full circle sprinklers were used, the nozzles were not selected to achieve similar application amounts. For example, a rotating sprinkler that operates full circle will have a particular nozzle (say a #6). If that same type sprinkler is present on the same zone and it operates only a half circle, it will put out twice the amount of water over the application area if the nozzle is the same (a #6). However, nozzles are available to adjust the application amount (cut it in half) so that sprinklers are putting out the same amount of water to a given area, regardless of whether it is operating over a partial or full circle. **For the systems tested, water savings ranged from 0 to 37 percent (average 20 percent).**

In some cases, irrigation system owners have "increased" the operating time, because some areas are dry (full circle sprinkler areas) as compared to partial circle areas. In those cases, more water is being applied to the partial circle areas than can be taken up by plants.

One way of helping correct the problem is to work with landscape companies and sprinkler manufacturers to provide replacement nozzles for the community. That way, a small investment in time, parts, and effort can achieve significant water savings.

Uniformity of Application

Irrigation systems are designed to try and put out the same amount of water over an area, usually to achieve a uniform look to the turf/grass (all of it is green). If the system has been poorly designed (sprinklers spaced too far apart for example), sprinklers are not operating properly, the pressure available to the sprinklers is too high (not a major problem in Douglas) or too low (a problem in some areas), then the amount of water reaching the ground will be different across a landscape area. In those cases, owners tend to water to the driest area in the yard. That means that some areas are receiving too much water. The need to make sure that the system is operating properly and effectively is important to water conservation. We did several uniformity analyses in the community. The typical problem encountered was sprinklers spaced too far apart based on the available pressure and sprinkler type. In some cases, sprinklers may need to be added to achieve better uniformity, but care must be taken to not reduce the pressure to the system by adding too many sprinklers. In other cases, an additional zone may be required to maintain pressure and improve coverage. The problems associated with improper nozzle selection on rotating sprinklers causes direct problems with the uniformity. Correcting the nozzle size can help solve many of the uniformity problems. **Direct water savings through improved uniformity was difficult to estimate for the limited number of uniformity evaluations per-formed during this pilot study.**

One additional concern is related to the uniformity of application under spray heads. Spray heads are notoriously non-uniform in their water application because nozzles clog very easily. A properly designed and maintained spray head area is essential to uniform water application and water conservation (Baum *et al.,* 2002).

Off-Site Applications

Off-site applications are when water is applied to an area with no plants (sidewalks, driveways, roads, parking lots) or to plants that are not desirable to be irrigated (neighboring woods). We observed several irrigation systems that were in need of maintenance or redesign to reduce the amount of water being applied to paved areas. Many of the irrigation systems were operating during early morning hours, so the off-site applications may not be easy to spot. *Running the system periodically during daylight hours can help reduce the problems with off-site applications.* Remember, every drop of water that is applied to a paved area is a drop that can be saved! **Estimated water savings due to correction of off-site applications ranged from 0 to 5 percent for the systems tested.**

One other off-site application that is not as obvious is the use of rotating sprinklers to irrigate large landscape beds. In most landscape beds, plants are spaced widely with mulch between plants. The use of drip irrigation in landscape beds can allow water to be applied directly to the desired plants. Changing rotating sprinkler zones into drip zones can also reduce weed problems in landscape beds (reduce cost of overall maintenance).

Leaks and System Maintenance

Several systems had obvious leaks. A leak will cause a combination of problems in a landscape irrigation area. Leaks put too much water in a particular area which can be detrimental to plants, and can cause soggy or wet conditions. Leaks typically are included in off-site applications because excess water ends up in "non desirable" areas. Leaks also have a direct impact on the pressure available to other sprinklers or application devices. A large leak in a drip area can cause the rest of the drip area to improperly function. **For one system tested, the leaks were estimated to be about 5 gpm (5 percent of water being applied).**

Periodic maintenance checks are recommended to reduce leaks and other maintenance problems. Customers can be reminded twice each year (newspaper, public service announcements, reminders with their water bill) to have their irrigation systems checked.

Mixing Different Irrigation Devices on the Same Zone

If spray heads and rotating sprinklers are mixed on a zone, then some areas are receiving a great deal more water than other areas! Remember, spray heads are designed to apply four or five times the water to a given area as compared to rotating sprinklers or drip. It is impossible to have an efficient operating system if water cannot be applied at the same rate. Spray heads and other irrigation devices should be separated into different zones. **For the systems tested, 15 percent had**

spray heads and rotating sprinklers mixed on the same zone.

Using Plants with Low Water Requirements

As new landscape systems are put in place, and as customers make changes in existing landscape plantings, the opportunity exists to use turf and plants that require less water. The use of native vegetation, Xeriscaping®, and other appropriate techniques (new turf cultivars, larger landscape beds), can reduce the overall water requirements in the landscape. Many nurseries, landscape companies, and the Cooperative Extension Service can provide information on different plants and their water requirements. In many cases, a customer needs to only "ask" how much water a plant will require prior to making a purchase!

Acknowledgments

The University of Georgia, Landscape Irrigation Auditing Team appreciates the cooperation of the Douglas community during this pilot study. Without your interest and cooperation, this project could not have occurred and would not have had the breadth of participation.

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Conclusions

We, the Landscape Irrigation Auditing group, believe that the citizens of Georgia deserve alternatives to "cutting off your water." There is a new office of water conservation within the Department of Natural Resources with a coordinator that will be working toward improved water conservation initiatives for the entire state. We believe that small communities deserve direct and usable options that fit within their economic and social structure. This pilot study will remain a pilot study until sufficient support is provided to transfer these same type opportunities to other communities across the state.

Landscape irrigation water conservation implies that all citizens can be involved in water conservation. We cannot assume that "someone else" (like the farmer) needs to save water, but not me. Everyone needs to do their part toward conserving water for the future generations.

The approaches provided in this study work hand-in-hand with the Home*A*Syst program implemented through the Cooperative Extension Service. The ability to save water within the home or business while saving water "outside" creates a complete water conservation ethic that can become a good habit!

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