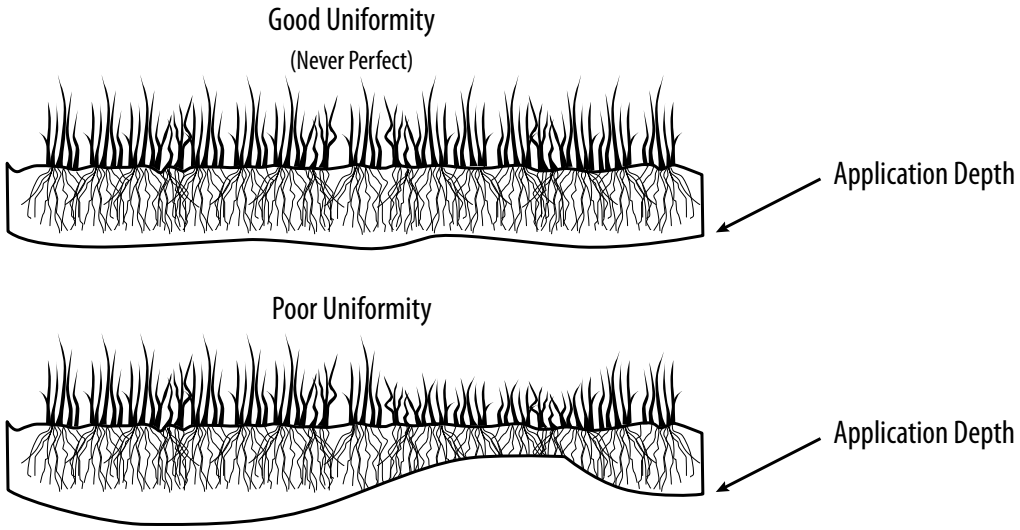
Overview

The efficiency of an irrigation system is dictated by many factors, including human, mechanical, and environmental components. Implementing mechanisms and practices that increase an irrigation system's efficiency could save a property more than half of its outdoor water use. In landscapes around the country, a significant amount of water is lost from evaporation, wind, or runoff due to improper irrigation system design, installation, and maintenance. Eliminating this waste requires trained professionals, appropriate irrigation schedules, and efficient technologies. Additionally, the landscape itself (e.g., plant palette, soil type, etc.) plays a role in irrigation water use and provides the potential for additional water savings. See *Section 5.2: Landscaping* for more details.

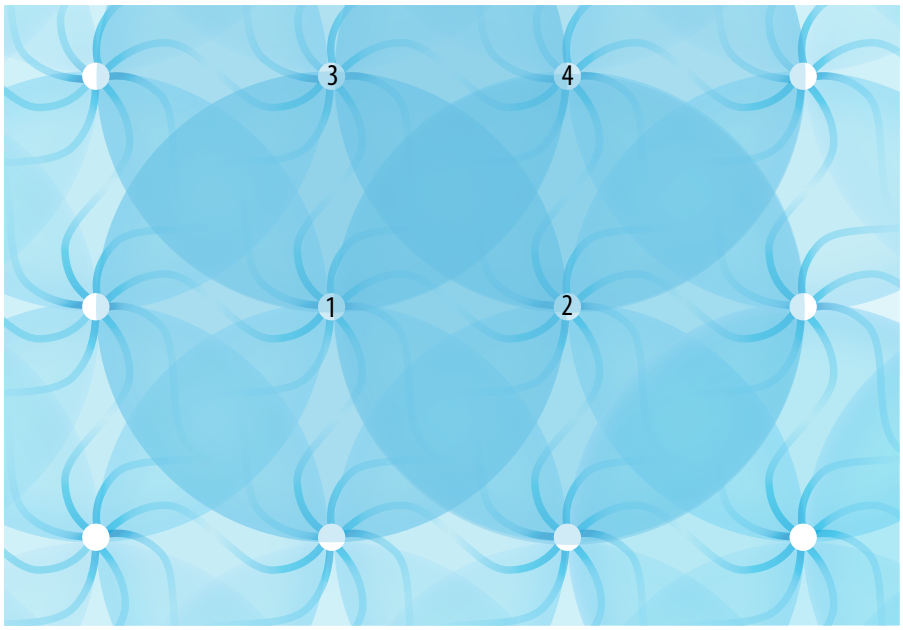
One of the most important concepts associated with irrigation system efficiency is distribution uniformity, or how evenly water is applied over the landscape. This concept is illustrated in Figure 5-2.[25] Extra water is often applied if the system is not distributing water in a uniform manner. Without proper distribution, the landscape is watered to keep the driest spot green, over-irrigating other areas. Figure 5-3 provides an illustration of head-to-head coverage, which is a practice to increase distribution uniformity. Using this practice, each sprinkler head (depicted with numbers 1 through 4 in Figure 5-3) is positioned so that its spray arch just touches the head of each surrounding sprinkler. This ensures that there is sufficient overlap and no areas are without coverage.

Figure 5-2. Good and Poor Distribution Uniformity



[25] Irrigation Association (IA). Falls Church, Virginia.

Figure 5-3. Example of Head-to-Head Coverage Spray Pattern



In addition to considering how evenly water is applied, it is equally important to consider the irrigation schedule, which dictates the amount and timing of the water applied. Landscape water needs change with the seasons, and so should the irrigation schedule. Many landscapes are watered at the same level all year, which is unnecessary. Over-watering can damage plants more than under-watering and can also damage streets, curbs, other paving, and building foundations.

Not only do proper design, installation, and maintenance of an irrigation system play a significant role in landscape water efficiency, but there are also a variety of irrigation technologies that can help reduce water use. For example, drip irrigation is a highly efficient method of application because it directs water to plant roots at a low flow rate, avoiding water lost to wind or runoff. This technology uses between 20 to 50 percent less water than conventional in-ground sprinkler systems.[26] There are also efficient types of sprinkler heads that distribute water in larger droplets, avoiding wind drift and increasing distribution uniformity. The Southern Nevada Water Authority (SNWA) estimates water-efficient sprinkler technologies can reduce water use by as much as 30 percent when compared to standard pop-up sprinklers.[27] Additionally, scheduling technologies relying on weather data, soil moisture, or other onsite conditions apply water only when needed.

To capitalize on the water savings potential from these scheduling technologies, the U.S. Environmental Protection Agency's (EPA's) WaterSense® program published a specification to label weather-based irrigation controllers. WaterSense labeled weather-based irrigation controllers (WBICs)[28] are independently certified to meet plants' watering needs without over-watering.

[26] Gleick, Peter H., et al. Pacific Institute. 2003. *Waste Not, Want Not: The Potential for Urban Water Conservation in California*. Page 8.
[27] Solomon, K.H., et al. 2007. *Performance and Water Conservation Potential of Multi-Stream, Multi-Trajectory Rotating Sprinklers for Landscape Irrigation*. Applied Engineering in Agriculture. 23(2):153-163.
[28] U.S. Environmental Protection Agency's (EPA's) WaterSense program. WaterSense Labeled Irrigation Controllers. www.epa.gov/WaterSense/products/controltech.html.

WaterSense has evaluated a number of studies conducted by a variety of organizations that cover numerous WBIC brands. Results from these studies indicate a range of overall savings from 6 to 30 percent. Individual site savings can vary beyond these overall numbers, depending upon the watering habits prior to installing the WBIC. In some cases, site water use can increase if the facility was practicing deficit irrigation before installing a WBIC. In a 2009 comprehensive study, first-year savings were shown to be approximately 6 percent.[29] For a limited subset of controllers in this study that were tracked for three years, overall savings were shown to be 16 percent in the third year after installation. In full consideration of the findings of these numerous studies, WaterSense anticipates seeing overall water savings of approximately 15 percent after proper installation of WBICs, when compared to systems that use a clock timer with manual programming.[30]

The key to saving irrigation water is to combine efficient irrigation practices with efficient technologies. Additional details on many of these principles, practices, and technologies can be found in the Irrigation Association's (IA's) Landscape Irrigation Scheduling and Water Management and Turf and Landscape Best Management Practices[31] documents.

Operation, Maintenance, and User Education

There are several best practices a facility can consider to optimize an irrigation system's efficiency, such as ensuring irrigation professionals are properly educated on water-efficient practices and that existing irrigation systems are properly operated and maintained.

Irrigation Professional Education

Consider the following to ensure irrigation professionals have a strong understanding of the principles of water-efficient irrigation:

- Ensure existing professionals or staff managing the irrigation system become familiar with water-efficient irrigation practices through partnerships, classes, seminars, and/or published guidance documents. Encourage professionals or staff managing the system to:
    - Become certified through a WaterSense labeled irrigation certification program with an emphasis on water efficiency.[32]
    - Consult the local water utility, community colleges, or agricultural services for courses or seminars on water-efficient irrigation practices.
    - Review technical guidance documents provided by local cooperative extension services and irrigation trade associations.

[29] Mayer, Peter, et al. The Metropolitan Water District of Southern California and the East Bay Municipal Utility District. July 1, 2009. *Evaluation of California Weather-Based "Smart" Irrigation Controller Programs*. www.aquacraft.com/node/32.
[30] EPA's WaterSense program. November 3, 2011. *WaterSense Specification for Weather-Based Irrigation Controllers Supporting Statement*. Page 12. www.epa.gov/watersense/partners/controller_final.html.
[31] IA. Best Practices & Standards: Turf & Landscape Irrigation Best Management Practices. www.irrigation.org/Resources/Turf___Landscape_BMPs.aspx.
[32] EPA's WaterSense program. Professional Certification Program. www.epa.gov/WaterSense/outdoor/cert_programs.html.

- When hiring new irrigation professionals to work with the system, inquire about their water-efficiency certification or specific training that promotes efficient irrigation. For example, professionals certified by WaterSense labeled irrigation certification programs[33] have demonstrated knowledge in water-efficient irrigation.

Irrigation System Operation

In addition to periodically reviewing all irrigation service agreements to emphasize the operation of a water-efficient system, verify that the irrigation schedule is appropriate for climate, soil conditions, plant materials, grading, and season as follows:

- Irrigation schedules should be updated based on changing weather conditions and as part of regular maintenance. Require the irrigation professional and/or auditor to deliver options for automating schedule changes based on changing weather conditions. Installing and properly programming WaterSense labeled WBICs[34] or soil moisture sensors can provide this capability.
- Certain soil types or steep slopes could increase the chance of surface runoff. Irrigation events may need to be separated into multiple applications depending upon landscape conditions. This is commonly known as a "cycle and soak" methodology. If currently installed irrigation controller(s) are not capable of such programming, consider using more current technology.
- Generally, it is better to apply water in larger amounts, but less frequently, resulting in deep watering. A less frequent but more intense schedule encourages the growth of deep roots, resulting in healthy plants. Note that soil type plays a role in creating this type of schedule and should be taken into consideration.
- Incorporate a water budget, which can be used as a performance standard for water use. A budget provides a specified amount of water that should be applied to the landscape and can be used as a comparison to the property's actual water use.

Irrigation System Maintenance

Irrigation systems require regular maintenance to ensure optimal performance. Consider the following key system maintenance tips:

- Require a full audit of the irrigation system every three years by a qualified irrigation auditor, such as a professional certified by a WaterSense labeled program.[35] IA provides audit guidelines.[36] A full audit should include an in-depth assessment of the irrigation system, its performance, and schedule. In addition, the audit should expose deficiencies that have occurred from either system changes and/or landscape changes. The audit is an opportunity to identify appropriate, new technologies as well. An audit should analyze the distribution uniformity of the system to ensure it is at least 65 percent. A distribution uniformity of

[33] *Ibid.*
[34] EPA's WaterSense program. WaterSense Labeled Irrigation Controllers, *op. cit*.
[35] EPA's WaterSense program. Professional Certification Program, *op. cit*.
[36] IA. Technical Resources: Irrigation Audit Guidelines. www.irrigation.org/Resources/Audit_Guidelines.aspx.

65 percent is equal to a rating of "very good" for fixed spray heads, according to IA.[37] To help ensure consistent uniformity, require that replacement equipment is compatible with existing equipment and made by the same manufacturer.

- In addition to a full audit every few years, the system should be periodically monitored for effectiveness throughout the year. Ask the irrigation professional or staff managing the system to ensure certain sprinkler components are placed and adjusted so that they water the cultivated plants and not the pavement or other hardscape. Verify that irrigation system pressure is within manufacturer specifications.
- Request that irrigation professionals or staff managing the system include immediate reporting and repair of problems in maintenance programs, and require regular maintenance routines as part of the overall irrigation maintenance program.
- Install a dedicated water meter for the irrigation system to measure the amount of water applied to the landscape. Some water utilities offer an interruptible rate for the service or will not apply sewer charges to water used for irrigation. The irrigation professional or staff managing the system should keep a record of trends in irrigation water use as part of the maintenance program.

Retrofit Options

If retrofitting an irrigation system, consider the following options to decrease landscape water use.

Weather-based irrigation controller

Irrigation System Controllers and Sensors

An existing irrigation system can be optimized by the following retrofits to the controls or components:

- Consider replacing existing irrigation system controllers with a more advanced control system that waters plants only when needed. There are many available technologies using weather or soil moisture information to schedule irrigation according to plant needs. The following are a few options to discuss with the service provider, auditor, or consultant/designer:
  - WaterSense labeled WBICs[38] can be added to an existing system. These products are independently certified to minimize irrigation excess and maximize irrigation adequacy, while also providing other performance and user features. In order to work effectively, these WBICs must be installed and programmed properly, taking into account facility-specific landscape conditions and the irrigation system installed.

[37] IA. March 2005. *Landscape Irrigation Scheduling and Water Management*. Pages 1-22. www.asla.org/uploadedFiles/PPN/Water%20Conservation/Documents/LISWM%20Draft.pdf.

[38] EPA's WaterSense program. WaterSense Labeled Irrigation Controllers, *op. cit*.

  - Soil moisture sensors can be inserted into the soil to measure moisture. They can be connected to an existing system, enabling irrigation as needed by plants.

- Consider installing rain-sensing technology to prevent irrigation from taking place during periods of sufficient moisture. Many cities and some states require rain-sensing technology by law. Check with the state or city on relevant mandates.
- Consider installing other sensors to cut down on wasted water. For example, wind-sensing technology interrupts irrigation cycles in the presence of significant wind. Freeze-sensing technology prevents irrigation during freeze conditions. Flow rate-monitoring equipment can interrupt irrigation if excess flow is detected (i.e., caused by broken pipes, fittings, emitters, sprinklers, etc.).
- If managing a large property, consider installing complete central control systems that use demand-based controls to enable a water manager to centrally operate and manage multiple irrigation systems at multiple locations with various means of communication.

Irrigation System Hardware

In addition to retrofitting the control system to decrease water use, a facility can consider retrofitting irrigation system hardware as follows:

- Consider retrofitting a portion of the spray heads that water trees, shrubs, or plant beds with low-flow, low-volume irrigation, also called micro-irrigation or drip irrigation. Many plant beds do not require the spray heads traditionally used to water turf areas.
- Consider exchanging existing sprinkler heads with more efficient heads designed to minimize water lost to wind and distribute water in a more uniform manner. Sprinklers with a fine mist are susceptible to water waste from wind drift. Also, some sprinklers do not apply water evenly over the landscape. Consider pressure-regulating heads with matched precipitation and/or multi-trajectory rotating spray heads as water-efficient sprinkler head options.
- Pay attention to sprinkler head spacing during replacement to ensure the heads have matched trajectories and offer head-to-head coverage.
- Retrofit other water-using devices on the property to use water more efficiently. For example, attach shut-off nozzles to handheld hoses to make sure water is going directly to the plants rather than dripping on the ground.

Replacement Options

If replacing an irrigation system, there are as many opportunities to increase its efficiency during the phases of system design and installation as there are during system operation and maintenance. Hiring qualified irrigation professionals and ensuring a well-designed system are key to ensuring water savings from an irrigation system replacement.

Qualified Irrigation Professionals

Select an irrigation installation and maintenance professional that has been certified by a WaterSense labeled program[39] or otherwise has experience in water efficiency. In addition, consider the following:

- If using onsite staff, encourage them to become certified through a WaterSense labeled certification program that focuses on water efficiency.
- Upon completion of new irrigation systems, use a qualified irrigation auditor, such as one certified by a WaterSense labeled program,[40] to audit the system and ensure the installed system's performance meets the design intent. The auditor can then make minor adjustment recommendations as needed.

System Design Considerations

When replacing an irrigation system, recommend that the system be designed, installed, and maintained according to technical guidance published by local co-operative extensions or IA. Following industry best practices helps the irrigation professional address water-efficient techniques from design through installation and proper maintenance. Visit IA's website for further technical guidance and information related to the most widely known irrigation best practices.[41] In addition, consider the following:

- Design the system for maximum water application uniformity (i.e., distribution uniformity). As noted above, aim for a distribution uniformity of at least 65 percent. Request the following of the designer:
  - Ensure no direct distribution of water over impermeable surfaces or non-target areas.
  - Maximize sprinkler distribution uniformity by following manufacturer recommendations for head spacing and design the system with head-to-head coverage.
- Create irrigation hydrozones by placing plants with similar water needs together. Also consider varying soil conditions, sun/shade/wind exposure, slope, and other site specifics that could impact watering needs.
- Consider installing the following components for optimal water efficiency:
  - Drip/micro-irrigation for all areas suitable for such technology.
  - High-efficiency sprinkler heads for turf and other areas that require spray irrigation.
  - Check valves in all sprinklers to retain water in lateral pipes between cycles.
  - Demand-based irrigation controls (i.e., weather- or sensor-based controls).

[39] EPA's WaterSense program. Professional Certification Program, *op. cit*.
[40] *Ibid*.
[41] IA. Technical Resources. www.irrigation.org/Resources/Technical_Resources.aspx.

- Rain, freeze, and wind sensors to interrupt irrigation during unfavorable weather conditions.
- Flow rate-monitoring equipment that can interrupt irrigation if excess flow is detected.

- Use alternative sources of water (see *Section 8: Onsite Alternative Water Sources*) where environmentally appropriate and local regulations allow. Keep in mind that while alternative sources are an additional way to save water in a landscape, efficiency should come first. Apply all the principles above to build the optimal, efficient system, and then consider using alternative sources.

Savings Potential

Irrigation water savings can be achieved through proper design, installation, and maintenance, combined with efficient technologies. In addition, the landscape itself (e.g., plant palette, soil type, etc.) plays a role in irrigation water use and provides potential for additional water savings (see *Section 5.2: Landscaping* for more details).

In order to consider irrigation system improvements and their associated savings, it is important to first understand how much water is being applied to the landscape. Dedicated irrigation meters track irrigation water use and allow facilities to document actual savings.

The WaterSense Water Budget Tool,[42] developed by EPA to support residential landscapes associated with WaterSense labeled new homes, can be used to see how relative water needs adjust by changing the plant palette and associated irrigation type. For example, replacing a large turf area irrigated by spray heads with plant beds irrigated by drip irrigation could significantly reduce water use. The Water Budget Tool allows a landscape professional to alter the irrigation type in a virtual setting, analyzing the relative water savings associated with each design change. The tool, however, is not intended to estimate actual savings; it is meant to evaluate the relative water savings achieved with different palette and technology choices.

Savings from implementing any of these technologies are dependent upon the system as a whole, including the landscape and climate, and, therefore, are landscape-specific. Following are a few examples of savings realized from implementing water-efficient technologies in the landscape:

- Installing drip irrigation uses 50 percent less water than conventional in-ground sprinkler systems.[43]
- Water-efficient sprinkler technologies can reduce water use by as much as 30 percent when compared to standard pop-up sprinklers.[44]

[42] EPA's WaterSense program. The WaterSense Water Budget Tool. www.epa.gov/WaterSense/water_budget/.
[43] Gleick, Peter H., *op. cit*.
[44] Solomon, K.H., et al., *op. cit*.

- Properly installing a WaterSense labeled WBIC may reduce irrigation water use by 15 percent.[45]
- A project in Florida demonstrated a savings of 13,567 gallons every time a rain sensor prevented an irrigation event on half an acre of landscape.[46]

Additional Resources

EPA's WaterSense program. The WaterSense Water Budget Tool. www.epa.gov/WaterSense/water_budget/.

EPA's WaterSense program. *Resource Manual for Building WaterSense Labeled New Homes*. www.epa.gov/WaterSense/docs/newhome_builder_resource_manual508.pdf.

EPA's WaterSense program. Meet Our Partners. www.epa.gov/watersense/meet_our_partners.html.

EPA's WaterSense program. Watering Wisely. www.epa.gov/watersense/outdoor/waterwisely.html.

EPA's WaterSense program. WaterSense Labeled Irrigation Controllers. www.epa.gov/watersense/products/controltech.html.

Irrigation Association. Best Practices & Standards: Turf & Landscape Irrigation Best Management Practices. www.irrigation.org/Resources/Turf___Landscape_BMPs.aspx.

Irrigation Association. March 2005. *Landscape Irrigation Scheduling and Water Management*. www.asla.org/uploadedFiles/PPN/Water%20Conservation/Documents/LISWM%20Draft.pdf.

Irrigation Association. Technical Resources: Irrigation Audit Guidelines. www.irrigation.org/Resources/Audit_Guidelines.aspx.

[45] EPA's WaterSense program. November 3, 2011, *op. cit.*
[46] Dukes, Michael D. and Haman, Dorota Z. University of Florida IFAS Extension. August 2002. *Residential Irrigation System Rainfall Shutoff Device*. edis.ifas.ufl.edu/ae221.