Irrigation

Irrigation is the application of additional water beyond rainfall for support of plant growth. It is a common practice wherever and whenever rainfall is not enough to meet plant water needs at some point during its growing season. Irrigation also ensures enough water for plants to take up nutrients, leach damaging salts from the root zone, apply chemicals, flush a system, aid seed germination, and modify the microclimate. Irrigating with just enough water to refill the root zone, or when a plant demands water to avoid stress or damage is key to optimum plant growth. Applying too much or too little water to nursery or landscape plants can damage plant health from either flooded or dry root zones. Too much water also wastes water, time and money by leaching nutrients and pesticides below the root zone. Wise use of water is good stewardship of a scarce resource.

Water Issues

A water study released in late 2016 presents a broad overview of development and water demand through the year 2070. The Florida 2070 / Water 2070 report assesses whether sufficient water will be available to "meet the needs of people, agriculture and the environment" within approximately 50 years. During that time, Florida's population is projected to grow from the current 20 million residents to 35 million, and water use is projected to increase by 50%. This joint project of the Florida Department of Agriculture and Consumer Services, University of Florida GeoPlan Center, and 1000 Friends of Florida is a tool intended to foster informed discussions on how public policy and personal choices made today will impact water availability for future generations. Fundamentally, the report suggests two options to address future water demand: 1) increase supply via alternatives such as water reclamation and desalinization, or 2) reduce demand via water conservation and increased efficiency.

Focusing on the second option, the Florida 2070 / Water 2070 report concluded the single most effective strategy to reduce water demand is significant reduction in the amount used for landscape irrigation. This individual effort would conserve water and reduce water bills. Community infrastructure costs associated with supplying water and addressing sewage and stormwater would also be significantly reduced.

While this may sound alarming to the landscape and nursery industry, the Florida 2070 / Water 2070 report does offer a series of recommendations that encompass principles of two major programs already in existence. The first is ***Florida Water Star*** (FWS), a statewide water conservation certification program for new and existing homes as well as commercial developments. The program is a partnership between the St. Johns River Water Management District, the South Florida and Southwest Florida water management districts and the Florida Green Building Coalition. FNGLA administers the FWS landscape and irrigation professional exam. The second is ***Florida-Friendly Landscaping™*** (FFL), a joint program of the University of Florida/IFAS and the Florida Department of Environmental Protection. FFL encourages the use of low maintenance plants and environmentally sustainable practices. FNGLA is an active member of the FWS and FFL advisory councils and supports the goal of both programs to help increase public and personal conservation efforts.

Rather than solely pushing to deliver higher irrigation system efficiencies, the water conservation strategies presented in the Florida 2070 / Water 2070 report call for a much more comprehensive approach seeking ways to increase efficient irrigation, raise consumer education and heighten professionalism within the landscape industry. FNGLA has aggressively positioned landscape members and the industry-at-large to demonstrate how the landscape and horticulture profession can effectively play a leading role in helping reduce future water demand. As such, this chapter provides a compilation of irrigation system design, installation and management principles and practices representing the combined efforts of state agencies, water management districts, regulatory authorities and university recommendations to conserve and protect water resources in Florida (Figure 10-1).

Irrigation System Design

The state of Florida, and each of the 67 counties within, have different regulations and requirements concerning licensing, design and approval of an irrigation system. Irrigation system design is a complex issue that should be carried out only by trained professionals. These professionals must use existing standards and criteria, as well as the manufacturer's recommendations, to design the most appropriate system for a particular location. In many communities, construction, design documents and permits require the signature and seal of a registered design professional.

Figure 10-1. Zoned irrigation in a residential landscape setting.

Optimally, an irrigation system should be designed to meet a site's peak water requirements. The system should also have enough flexibility to adapt to various water demands and local restrictions, plus allow for operating modifications to meet seasonal irrigation changes. Most importantly, since turf and landscape areas have different irrigation requirements, irrigation systems MUST be designed to service both these areas with separate zones to meet each area's individual water needs. Each ***hydrozone*** should be based on consideration of available flow rate, cultural use of the area, type of vegetation irrigated (turf, shrubs, etc.), type of sprinkler or emitter, and soil characteristics (Figure 10-2).

The components of an irrigation system consist of the water supply, water conveyance system, distribution devices, and control mechanisms. The proper selection, design and installation of these components optimizes their use and decreases any off-site impacts. The design must also account for different site characteristics and topographies.

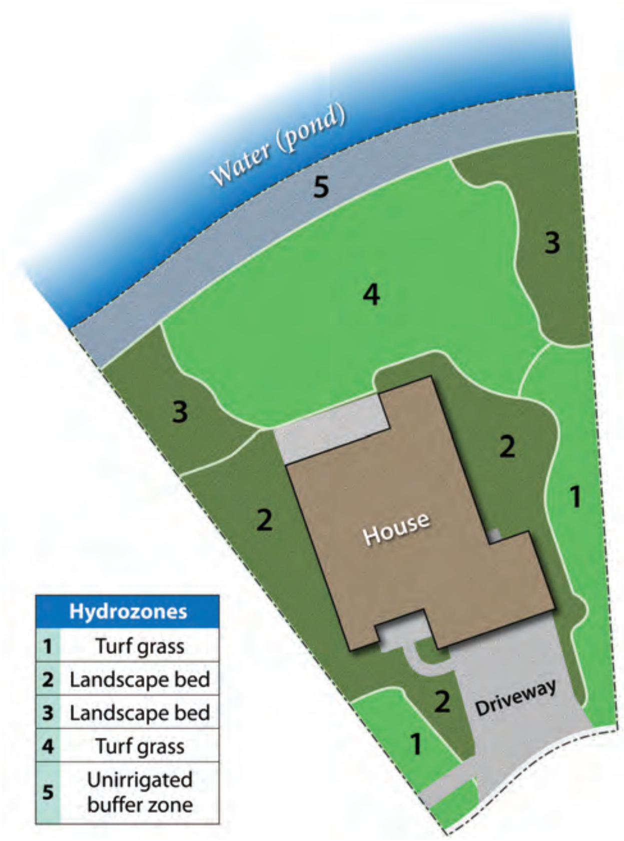


photo by florida water star^{sm}, st. johns river water managment district

Figure 10-2. Landscape irrigation separated by hydrozones.

Water Supply

Water supply includes the water source, pump, filters, and valves of a system. Many ***water sources*** are available for landscape irrigation, including potable wells or municipal supplies, rainwater collected from cisterns, storm water or other surface water, and reclaimed water. Use of the lowest quality water source is encouraged whenever feasible to preserve drinking water supplies. Some form of filtering is recommended when lower quality water sources are used to prevent the irrigation system from getting clogged with solid particles. Sediment will usually pass through larger-sized sprinkler nozzle openings, but pop-up rotating nozzles may still become clogged with grit and debris. Drip emitters and microsprayers have much smaller outlets that can easily be plugged by small particles. Consequently, water provided to a drip system must be properly filtered.

Reclaimed water, also known as recycled water or reuse water, is former domestic wastewater that has been disinfected and treated to remove solids and certain impurities. It can be safely used to irrigate turf and most other landscape plants. All reclaimed water piping, heads, valves, fixtures, etc. are required by law to be color coded purple (Figure 10-3) and labeled "*Do not drink this water.*"

Figure 10-3. Purple reclaimed water pipe.

Reclaimed water often contains nutrients (nitrogen and phosphorus) that can be considered part of the fertilizer needs of the landscape. Occasionally, reclaimed water contains elevated levels of salts that can harm sensitive landscape plants. Azaleas (*Rhododendron* spp.) and crape myrtles (*Lagerstroemia* spp.) are two common landscape plants used in Florida that are especially sensitive to high salt levels. Higher than normal salt levels in reclaimed water may occur near the coast because of the influence of seawater.

Any potential problems associated with using reclaimed water on landscape plants can usually be avoided by irrigating only when necessary, growing salt tolerant plant species, and minimizing the use of overhead sprinkler irrigation so that water with high salt levels does not contact plant foliage. Reclaimed water providers can furnish detailed information about the levels of nutrients and salts in local reclaimed water. Be sure to incorporate the results into landscape nutrient and irrigation management plans.

Water Conveyance and Distribution

Water is conveyed from the water supply through the mainline, lateral lines, and spaghetti or drip tubing used in low volume microirrigation. Distribution devices provide a means through which water is discharged from the water conveyance system. These devices include impact, oscillating or rotary sprinklers, sprayers with fixed patterns, or drip emitters (Figure 10-4).

Distribution devises and pipe sizes should be designed for uniform, optimum coverage. Distribution equipment (sprinklers, rotors and microirrigation devices) in a given zone must have the same precipitation rate. ***Precipitation rate*** (PR) is the rate at which the system applies water to the landscape expressed in depth of water per hour of operation (inches per hour or inches per minute).

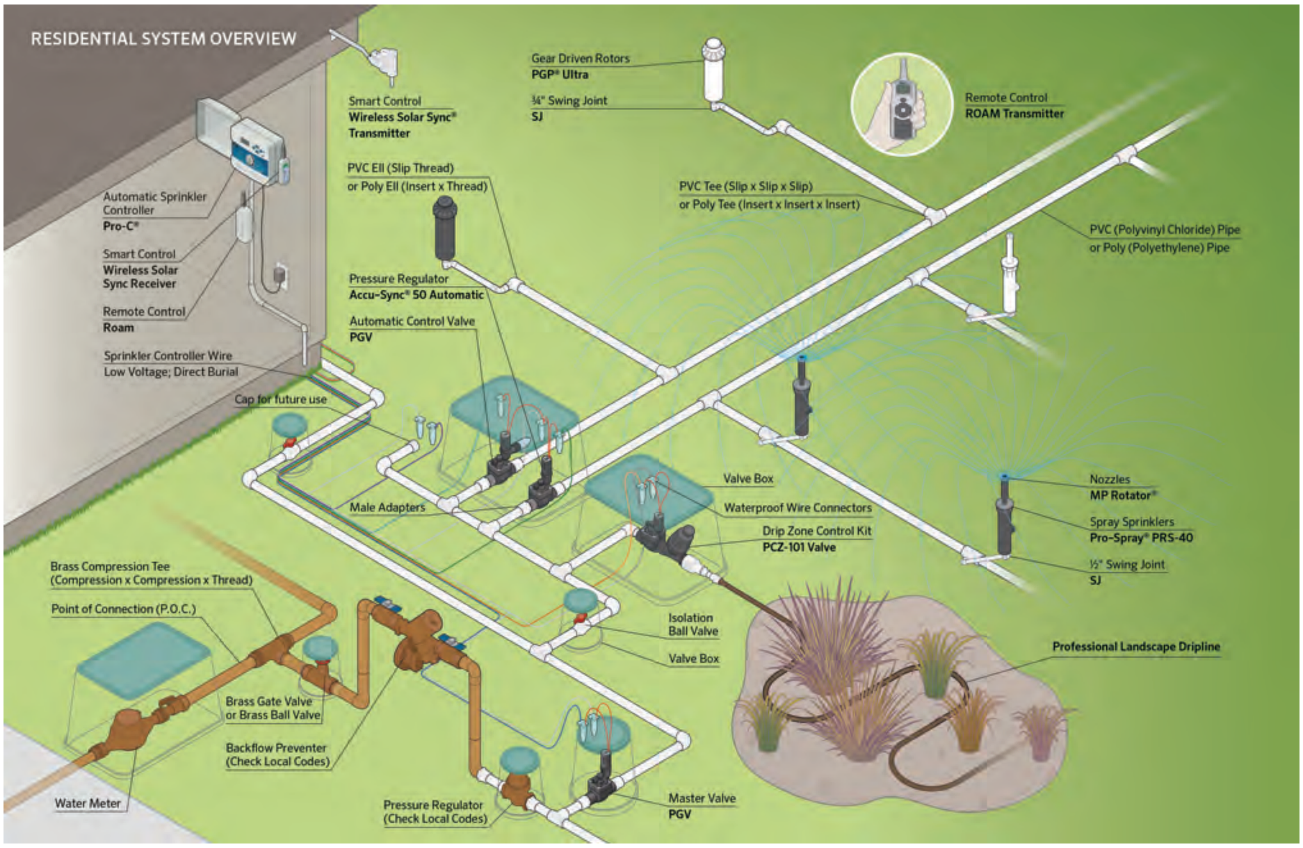


photo by hunter industries

Figure 10-4. Overview of residential irrigation system components including water meter, backflow preventer, manual valves, piping to zones, solenoid valves, sprinker heads, controller and rain sensor. Note the same type sprinklers, rotors or microirrigation devices are used in any given zone. Graphic used with permission of Hunter Industries.

Control Mechanisms

A ***controller*** is the timing mechanism that signals automatic valves to open and close on a preset program or based on soil moisture sensor readings (Figure 10-5). It is the brain of the sprinkler system. Controllers should have the following minimum capabilities:

1) Ability to be programmed in minutes, by day of week, season and time of day.
2) Ability to accommodate multiple start times and programs.
3) Automatic shut off after adequate rainfall.
4) Ability to maintain time during power outages for a minimum of three days.
5) Operational flexibility to meet applicable year-round requirements for water conservation and temporary water shortage restrictions.

Control components include ***valves*** for controlling the flow of water. Various valves allow for on-off control, adjustment of the flow rate through the system, and prevention of back flow. They can also be used for pressure relief or as a safety device. In general, valves can vary from simple manual on-off devices to sophisticated control equipment that acts as water metering instruments.

Check valves (Figure 10-6) are valves that limit flow in the pipe network to one direction and prevent backflow (a flow in the reverse direction). A check valve is also a component that increases the resistance of sprinkler pop-up mechanisms and prevents water from weeping out when the system shuts off.

Since 1990, the Florida Building Code has required that residential irrigation systems have a backflow preventer. The state requires that homeowners have backflow preventers evaluated every two years by a certified backflow tester to maintain compliance with environmental regulations designed to protect the quality of public drinking water supplies. Additionally, any landscape or nursery irrigation system into which chemicals or fertilizers are injected must be equipped with an antisiphon (backflow) device adequate to protect against contamination of the water supply.

Since 1991, Florida law has required an operating ***rain sensor*** device or switch on all automatically controlled irrigation systems. This device should override the irrigation cycle when adequate rainfall has occurred. Rain shut-off devices and rain gauges should be placed in open areas to assure accurate readings.

Flow sensors are used to measure the amount of water flowing through an irrigation system in gallons per minute (***gpm***). In a typical situation, the flow sensor will transmit the information to a ***flow meter*** (Figure 10-7). Flow meters should be placed where there is a straight enough run of pipe both downstream and upstream to prevent turbulence and bad readings. Where used in residential or commercial landscapes, flow meters are installed to separately account for water used

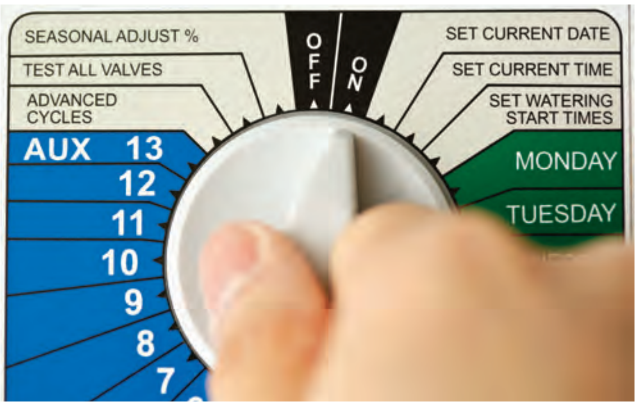


Figure 10-5. Automated irrigation system controller with the ability to accomodate multiple programs, start times and days of the week including quick adjustments for seasonal changes.

Figure 10-6. Backflow prevention device (check valve).


photo by creative commons

Figure 10-7. Inline water meter to measure water flow.

in irrigation. Water registered on this meter should not be assessed a sewer charge as incurred when using potable water supplies.

Types of Irrigation Systems

The type of irrigation method for delivering water to plants plays a large role in the amount of water used and the effectiveness of the irrigation system. The primary types of irrigation systems are overhead sprinkler, microirrigation or drip, and subirrigation systems that may be used in greenhouse production or interior plantings.

Overhead Sprinkler Systems

Overhead sprinkler systems (Figure 10-8) spray water into the air above and around plant foliage in a broadcast pattern. Water droplets from these systems are large enough to fall through the canopy to the soil or growing substrate. Sprinkler nozzles are designed to function at a certain pressure and discharge rate, which determines the diameter of water throw.

Overhead irrigation is efficient for larger turfgrass areas. It is also commonly used for watering smaller, one to three-gallon container plants placed close together in nursery production, even though water is lost from falling on the ground between containers. Overhead sprinklers are only 70% to 75% efficient in water delivery because evaporation occurs in the air, from the plant foliage, and from the ground surface. The circular pattern of application also makes it difficult to achieve a high degree of uniformity in delivering water to all plants. This is especially true when sprinkler heads are placed in rectangular spacing patterns necessary for irrigating most landscaped and nursery production areas.

Uniform coverage of irrigation water is important to prevent areas from being overwatered or underwatered. Sprinkler heads do not distribute water evenly throughout the radius of coverage. As the distance from a sprinkler head increases, the amount of water reaching the ground decreases due primarily to evaporation and wind action. The best way of providing uniform water distribution over an area is to plan the spacing of sprinkler heads so that water from one head overlaps the water sprayed from the heads next to it. This overlapping in coverage from one head to another achieves the most uniform water coverage and water conservation.

Figure 10-8. Overhead irrigation system in nursery production.

The most common reason for inaccurate irrigation is lack of uniform coverage. Sprinklers should be placed ***head-to-head*** to achieve maximum uniformity. This means that the distance between sprinkler heads is equal to the ***spray radius*** of the heads. For example, if the spray radius of sprinkler heads in a zone is 15 feet, the heads should be spaced 15 feet apart. This also means that sprinklers are required in all corners to achieve uniform coverage.

Microirrigation Systems

One of the most efficient and effective watering methods currently available for landscape purposes and large container plant production is microirrigation, which includes both ***drip*** and ***microspray*** irrigation (Figure 10-9). Low-pressure emitters (that is, nozzles that drip, spray, or sprinkle) are attached to small plastic tubing and are designed for slow release of water to smaller areas, frequently to the soil around individual plants.

Since microirrigation applies water to individual containers or plants near the growing substrate surface, it infiltrates quickly. Thus, less water is used than in overhead watering systems. The pumping station and pipe size requirements are also smaller for a drip system than for overhead, resulting in relative cost savings. Both water and nutrients can be delivered efficiently. Evaporation is greatly reduced with low volume irrigation, so the application efficiency may be as great as 90% to 95%. Therefore, water conservation and energy conservation are accomplished by using microirrigation.


photo by creative commons

Figure 10-9. Microirrigation system in greenhouse production.

Microirrigation systems (also known as low volume irrigation) can have many benefits, including

- Decreased water loss from evaporation, wind and runoff.
- Minimized pest problems, such as weeds and diseases, by applying water to the root area of the plant.
- Increased water application efficiency when retrofitting inground sprinkler systems.
- Flexibility in meeting the variable water needs of new, maturing and established plants.
- Minimized erosion when watering plants on steep slopes.
- Compliance with local water conservation codes and ordinances.

A risk with microirrigation is clogged emitters, regardless of the style, from poor water quality. Clogging can be reduced if filters are installed in the system. Filtering well water and surface water is strongly recommended. Another very common risk with microirrigation is the use of inaccurate numbers of emitters or the improper placement of emitters required to support the plant's water needs. This problem is compensated for by running the drip zone longer, which makes the system inefficient.

Subirrigation Systems

Subirrigation systems are an environmentally responsible alternative used to conserve water and reduce fertilizer use. They are used by greenhouse growers and in the interior plantscape. In subirrigation systems, water and nutrient solutions provided at the base of a container rise by capillary action through holes in the bottom, which is then absorbed by the growing media. After adequate absorption, the solution is returned to a storage tank to be recycled. These systems are adaptable to crops grown in pots or flats. Several basic types of subirrigation systems are used for potted plants in greenhouses.

A ***capillary mat system*** places pots on a thick mat that is kept constantly wet with a nutrient solution. The mat is placed on a level bench over a layer of plastic. Water is supplied from drip tubes laid on top of the fabric. Water is absorbed into containers as needed by capillary action. Other systems incorporate watertight benches, troughs or floor systems through which water and nutrient solutions can be circulated for bottom watering.

Subirrigated planters (Figure 10-10) are specially adapted containers used in the interior landscape. Water is introduced from a bottom reservoir and is subsequently soaked into the media through capillary action, usually with the aid of a wick and sometimes regulated by a sensor tip. This creates the opportunity to automate watering, and makes subirrigated planters popular for indoor plantings. One disadvantage of the closed system in these containers is that soluble salts cannot be flushed into the lower soil profile, causing build up over time.

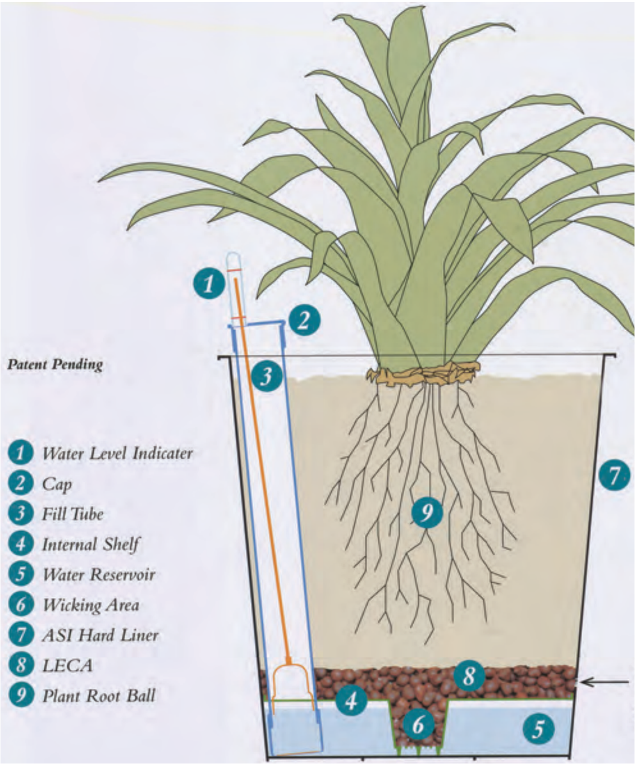


photo courtesy of architectural supplements

Figure 10-10. Concept of subirrigation in interior planters. When indicated by a float gauge, water is added to a hidden reservoir beneath the planter. Water is drawn into the growing media through wicking material submerged in the water reservoir as needed by capillary action.

Advantages of subirrigation systems include water and nutrient conservation because solutions are contained and recycled; uniform water application is also provided to all containers, foliage remains dry, thus reducing potential disease problems, and less labor input is possible. A few disadvantages include the high cost of initial system installation and the possibility of an increased presence of disease in recycled water.

Consequences of Improper Design

There are many possible consequences of the improper design of irrigation systems (Figure 10-11) including factors relating to

1) Public health if backflow prevention systems are not properly designed or installed.
2) Waste of natural resources including water, chemicals, and the energy required for pumping if systems are not properly designed and thus water cannot be applied uniformly.
3) Pollution of water supplies if poor system design results in nonuniform water or chemical applications and leaching of chemicals into water supplies.
4) Operator safety if components are not properly selected and installed.
5) Cost of irrigation if total annual fixed and operating costs are not considered.

Figure 10-11. Poorly designed irrigation systems waste resources.

6) Replacement costs from plant damage if a poorly designed irrigation system cannot meet water demand.

7) Reduction in system life expectancy if components are not properly selected and installed for the operating conditions expected of each individual system.

To avoid problems with poorly designed systems, all of these factors must be considered when irrigation systems are designed.

Irrigation System Installation

The only professionals who should manage irrigation system installation are appropriately qualified individuals who are properly bonded and insured, as well as correctly certified or licensed. These individuals must follow the designer's plans and use recognized standards and criteria, such as those established by the Florida Building Code in Appendix F – Plumbing, and approved by the American Society of Agricultural and Biological Engineers (ASABE), Florida Irrigation Society (FIS), Irrigation Association (IA), USDA Natural Resources Conservation Service (NRCS), or the manufacturer's recommendations. The designer must approve any changes to the system prior to installation.

All underground cables, pipes, and other obstacles must be identified, and their locations flagged before construction. To prevent system failures, waste, and property damage, construction materials must meet appropriate quality standards, such as those established by ASABE, the American Society of Civil Engineers (ASCE), or the American Society of Testing Materials (ASTM). Standard safety practices must be followed during construction, including site cleanup, before the job is complete.

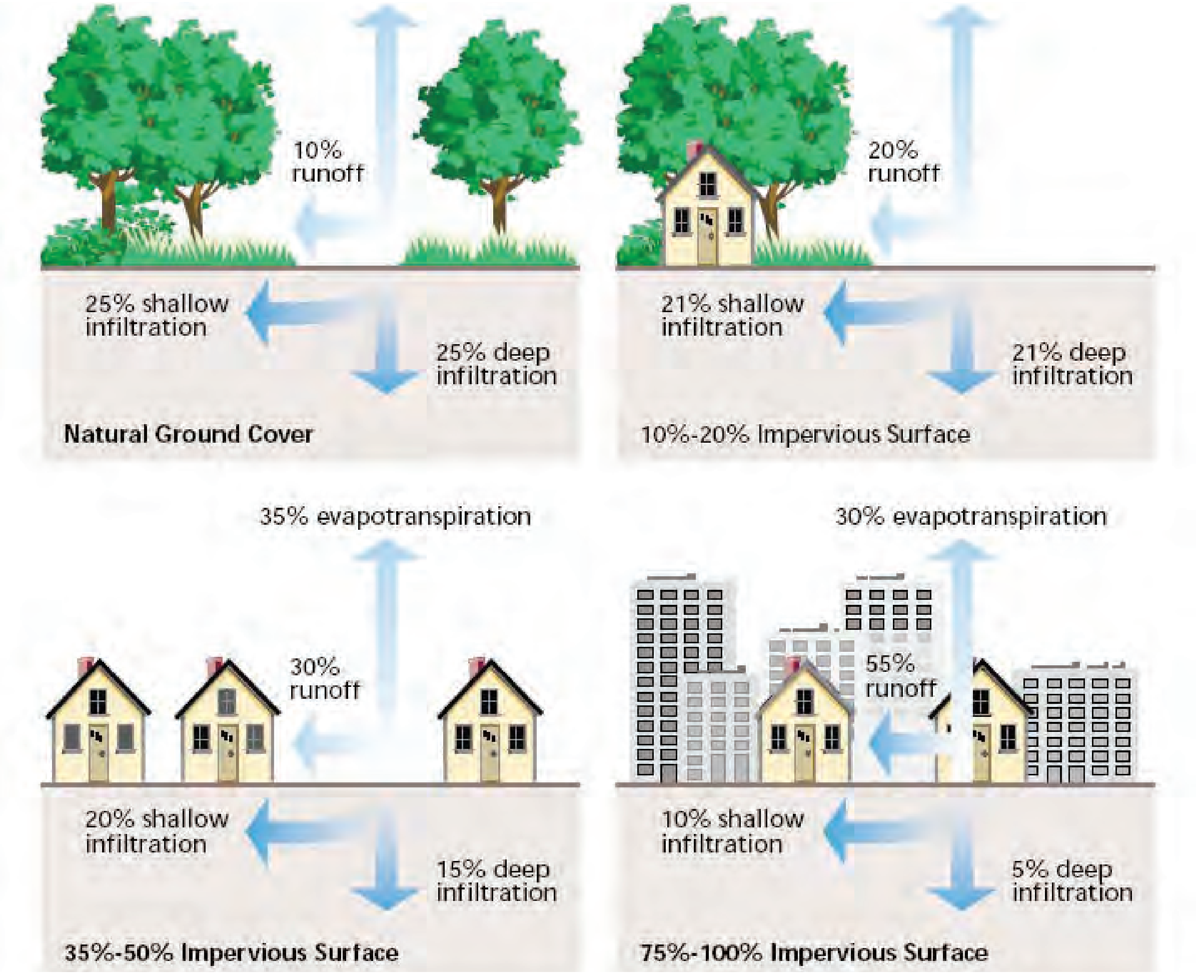


photo by university of florida

Figure 10-12. Groundwater recharge comparisons relative to development and imperious surface percentages.

Permitting & Regulations

Because periods of rainfall are irregular, supplemental irrigation must be used to produce and manage ornamental plants. In the past, the natural environment retained much of the annual summer rainfall and water was readily available. However, with increased development, drainage, asphalt and concrete, natural retention of water has been greatly reduced, thus diminishing the ability to recharge groundwater supplies (Figure 10-12).

Since Florida is faced with an ever-increasing problem of decreasing water supply, many agencies have jurisdiction over irrigation projects before, during and after construction. For example, Florida's five water management districts, the Florida Department of Health (FDOH), Florida Department of Environmental Protection (FDEP), and local governments will likely require permits. To prevent potential fines, it is important to follow all regulatory requirements and secure the appropriate permits.

Besides water use permits, the water management districts have special drought/water shortage restrictions that govern the amount and timing of irrigation. It is important to know the restrictions for a site and to set timers/controllers to those conditions. Since water shortage restrictions change with the severity of a drought, it is important to be aware of and to abide by current restrictions.

To follow permitting and regulatory guidelines for all irrigation projects, the irrigation contractor should:

- Contact local and state regulatory agencies (such as the county, city, FDEP, water management districts, and health department) to determine current irrigation regulations and criteria.
- Obtain required permits before construction.
- Abide by all permit conditions and current water restrictions when operating the irrigation system.
- Obtain any desired regulatory variances before irrigating.

At the end of construction, owners should be provided with a copy of the as-built plans (Figure 10-13), operating manuals, warranties and written instruction on how to change the irrigation system's controllers. Recommended operating schedules for both plant establishment and supplemental irrigation of mature plants should also be included. The owners are then responsible for abiding by permitted conditions and observing water restrictions.

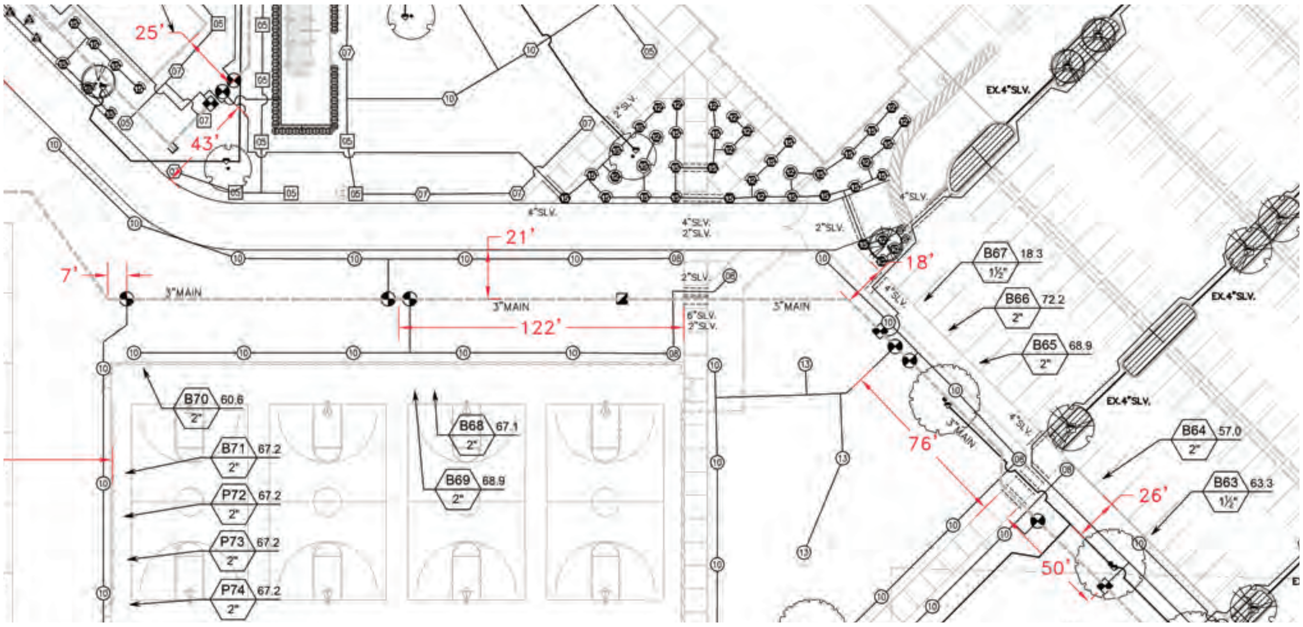


Figure 10-13. Sample as-built irrigation plans.

photo by michael prevost, design psi

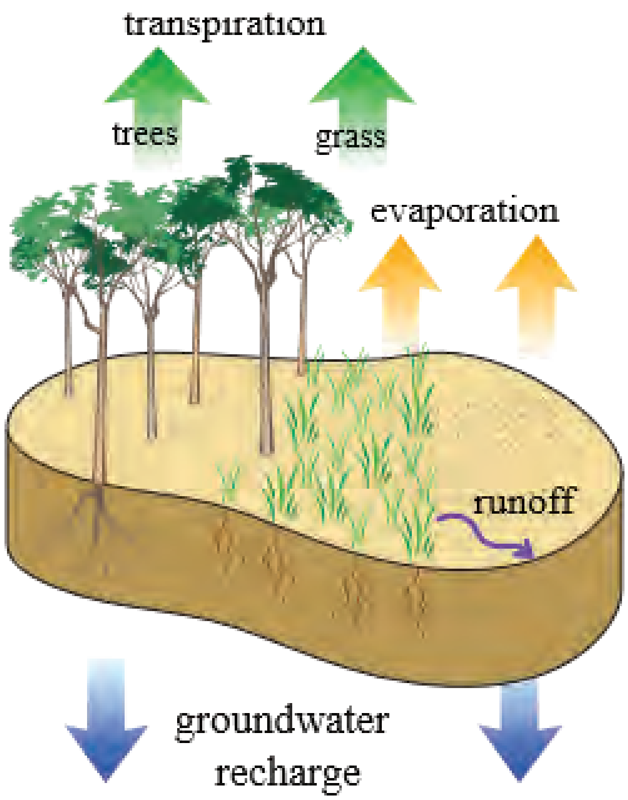


photo by m. w. toews, wikimedia commons

Figure 10-14. After rainfall or irrigation, water is lost to evapotranspiration (evaporation + transpiration), runoff and leaching into soil. Some water is taken up by plant roots, only to be transpired during growth processes.

Irrigation Management

Irrigation management is arguably the most important and most overlooked aspect of a landscape. It is the cornerstone of water conservation and reduction of nonpoint source pollution. Irrigation management encompasses the amount of water applied and the frequency of application, as well as selection of the most efficient method. Proper irrigation accounts for ***plant water demand*** (estimated water use based on temperature, humidity, wind, light and season) and the amount of water the plant can access in its root zone (based on recent rainfall and soil characteristics).

Plant water demand is equal to the water used during typical plant growth. ***Evapotranspiration*** (ET) is a term used to describe the water consumed by plants over a period of time. ET is water loss occurring from the combined processes of ***evaporation*** and ***transpiration***. Evaporation occurs when water changes to vapor on either soil or plant surfaces. Transpiration refers to water lost through the leaves of plants (Figure 10-14).

Evapotranspiration varies with plant properties (such as size, leaf type, and physiology) and with the growing season or weather conditions. Plants use more water during periods of active growth, flowering or fruiting, and during hot, dry weather. Though still needed, water use is less during colder months when turfgrass and landscape plants are not actively growing. Additionally, many established, drought tolerant landscape trees and shrubs require little or no irrigation, provided soils or other barriers do not obstruct root development.

Excess irrigation beyond plant water demand in both landscapes and nurseries is a major problem. It wastes water, causes off-site damage, and also pollutes groundwater through leaching and surface water through runoff. In addition to squandering a valuable natural resource, money is wasted when water percolates below root zones with no benefit to the plant, thus increasing the end user's water bill and fuel costs associated with pumping the water.

Average Potential Evaporation (ETp) Levels

MONTH	***Northern Florida ETp (inches / day)***	***Southern Florida ETp (inches / day)***
January	0.07	0.09
February	0.10	0.12
March	0.13	0.15
April	0.17	0.19
May	0.19	0.20
June	0.19	0.19
July	0.18	0.19
August	0.17	0.17
September	0.15	0.16
October	0.12	0.14
November	0.09	0.11
December	0.06	0.09

Figure 10-15. Daily ETp averages each month in Florida regions.

Irrigation Scheduling

Florida's average rainfall is 50 to 60 inches annually, which would be enough to maintain any landscape if evenly distributed over the year. Unfortunately, rainfall is highest during summer months, but falls to less than one half of summer peak during the winter when plant water demand may still exist. As a result, irrigation scheduling without understanding plant water use or changing seasonal weather often results in excess irrigation during wet summers and water stress during the winter.

Since rainfall varies from location to location, the proper use of rain gauges, rain shutoff devices, flow meters, soil moisture sensors, and/or other irrigation management devices should be incorporated into the operation plans of the site's irrigation. There are two approaches to deciding when and how much to irrigate a landscape. The most direct is ***soil water sensors*** that detect when the plant has used up available root zone water. Root zone water sensors are more effective in helping to determine when to irrigate, but less so in determining how much. The other approach is estimating plant water demand based on ***potential evapotranspiration*** (ETp) calculated from weather inputs such as temperature, wind, humidity, and sunlight.

photo by nw district, ifas, university of florida

Figure 10-16. One of the visual signs that turfgrass needs irrigating is the evidence of remaining footprints.

Calculated ETp rates are available for specific regions through the Florida Automated Weather Network (FAWN) at http://fawn.ifas.ufl.edu. ETp values should be used only as a general guideline, not an exact water demand for specific crops. However, the information can be used for irrigation scheduling and monthly controller adjustments when site-specific information is not available. The table on the previous page in Figure 10-15 lists average turfgrass water requirements relative to ETp by month for north and south Florida. In this case, the southern part of the state is considered the area below a diagonal from north of Tampa to south of Daytona Beach (the approximate pathway of Interstate 4).

Frequency

If mechanical or electronic devices are not available for irrigation management, plant observation can help determine when plants should be irrigated. Visual indicators, such as changes in color, curling of leaves and ultimately wilting can be used as guidelines to determine when to irrigate. Some plants react to water stress by changing leaf orientation; for example, with adequate water, leaves may be perpendicular to the sun. However, when little water is available, leaves may turn away from or parallel to the sun to reduce transpiration. Delay in foliar growth, flowering or fruit development is also an indicator that the plant could be experiencing water stress. Irrigation should be applied before or as soon as

- Grass has a dull, bluish-gray coloring.
- Foot tracks remain in the grass (Figure 10-16).
- Turfgrass leaf blades are folded in half on at least one-third of the site.
- Soil samples from the root zone are dry and crumbly.
- Foliage on landscape plants is dull colored.
- Indicator landscape plants (such as impatiens and azaleas) have drooping leaves.

By the time visual symptoms are evident, irrigation water may have been withheld too long for most plants and some damage from water stress is inevitable. In the early stages of plant establishment, irrigation water should be applied before water stress symptoms are evident.

Another indicator of water demand is leaf temperature. If leaves are cool during the hot part of the day, plants are not suffering from water stress. However, if the leaves are warm, irrigation is needed. Special devices (infra-red thermometers) have been developed to measure leaf temperature in relation to air temperature, but they must be calibrated for specific conditions before being used to determine the irrigation schedule.

Application Timing

When possible, irrigation should be timed to increase ***application efficiency*** (how much gets in the root zone) by watering at night or in the early morning when the wind, sun, and temperature are lowest, and humidity is high. This timing reduces losses to evaporation and wind that occur later in the day. On a typical summer afternoon, evaporation loss from irrigation can reach 40% to 50% of water applied through an overhead sprinkler.

Several irrigation management techniques can improve plant health and reduce water use. Delayed (less frequent) irrigation, called ***deficit irrigation***, often promotes root development and increases drought tolerance by postponing irrigation until just as wilt is observed. Deficit irrigation calls for managing irrigation quantities, so there is always soil storage available to take advantage of any possible rainfall. However, newly installed landscape plants often need frequent irrigation, but at lower amounts, to keep plants with limited root systems healthy.

The University of Florida's Institute of Food and Agricultural Sciences (UF/IFAS) has published studies on how to establish shrubs in Florida landscapes. UF/IFAS concludes that shrubs are considered established when they are able to survive and grow without irrigation. Most shrubs can survive on rainfall alone once roots have grown to the edge of the foliage canopy. This root growth normally occurs within 20 to 28 weeks after planting if irrigation guidelines provided in the table below (Figure 10-17) are followed and normal rainfall occurs.

When to irrigate is calculated from weather inputs, and how much to irrigate is a preset determined by the end user. Ideally, irrigation scheduling is based on site specific situations characterized by soil conditions, light environment (sun versus shade), and exposure orientation (north, south, east, west).

Regardless of the methods used to determine when to irrigate, the point is to be consistent and use some method other than setting an automated irrigation timer and never adjusting for changing weather and plant growth. Remember, plant water use changes with seasonal variations and with a maturing landscape.

Water Volume

An ***irrigation event*** should apply enough water to penetrate the average depth of the plant root system and refill the root zone in landscapes, or to reach the bottom of the container for nursery and greenhouse plants. For deep-rooted plants, water only needs to penetrate to the underlying moist soil, but that amount of water depends on soil type (sand, silt, or clay) and depth of rooting.

Irrigation Schedule for Establishing Shrubs in Well Drained Soil
(based on shrubs planted from 3-gallon plastic containers with smooth sides)

LOCATION	***Irrigation schedule for vigor***	***Irrigation schedule for survival***
North Florida	every 2-4 days	every 8 days
Central Florida	every 2-4 days	every 8 days
South Florida	every 2 days	every 4 days

Figure 10-17. Suggested irrigation timing for shrub establishment. *Source: University of Florida, IFAS.*

Proper management of irrigation water requires a determination of how much water the system uses. Measurement of flow rate will help ensure the irrigation system is operating properly. For example, low flow rates may indicate the need for pump repair or adjustment, partially closed or obstructed valves or pipelines, or clogged drip emitters. High flow rates may indicate broken pipelines, defective valves, too many zones operating simultaneously, or eroded sprinkler nozzles.

Water meters (flow meters), properly selected and maintained, can be the most accurate and easiest method for measuring water flow. Water meters (Figure 10-7) can be used to

- Improve irrigation water use efficiency by allowing accurate measurement of water applied.
- Determine pumping plant efficiency, allowing water to be supplied as inexpensively as possible.
- Detect potential well, pump or irrigation system problems.

Sprinkler Irrigation

When using overhead sprinklers, irrigation volume is commonly expressed in ***acre-inches***. Application of an acre-inch of water means enough water applied evenly over the area being irrigated so that, if it were all on top of the area at one time, it would measure one inch deep.

Depth units (***inches***) are used to refer to the amount of water required for irrigation because soil water holding capacity is typically measured in inches (of water) per foot (of soil depth). For example, an inch of water applied to sandy soils normally penetrates about 12 inches deep, while an inch of water applied to a loam soil or soil mix will only penetrate about six inches. Using this information, a pot six inches deep should have approximately ½ inch of water applied and a plant with an average root depth of a foot should have an inch of water applied.

However, to prevent excess irrigation and promote deeper rooting, research suggests applying no more than ½ to ¾ inch of water at any single irrigation event. A healthy, drought and stress tolerant lawn and landscape can be created by thoroughly watering the root zone, then allowing the soil to dry before the next irrigation cycle. Overwatering promotes weed growth, disease and fungus, plus inhibits root system development.

Another approach used in residential and commercial landscapes is to assume that on average one inch of water wets the top 12 inches of sandy soil. Because most roots grow in the topmost six inches of soil, ½ to ¾ inch of water is needed for replenishment every two to three days during periods of active growth, and every 10 to 14 days during less active growth periods. This water can come from rainfall or be provided by the irrigation system.

Use the ***catch can method*** (Figure 10-18) to determine how much water is actually applied and to see if uniform watering is occurring across the landscaped area. Place seven to ten wide-mouthed, flat-bottom cans, jars, cups or other straight-sided containers throughout the zone to be irrigated. Irrigate each zone as normal, then measure the depth of water in each can. Use the average of these measurements to determine the time required to apply ¾ inch of water in each irrigation zone.

photo by joy dorst

Figure 10-18. Conduction of catch can test to determine watering amount and distribution uniformity.

Schedule for Overhead Irrigation Efficiency

Head type	***Setting***	***Summer***	***Fall***	***Winter***	***Spring***
Spray	Ideal	25 min	15 min	0 min	20 min
	Range	20 – 30 min	10 – 20 min	0 – 10 min	15 – 20 min
Rotor	Ideal	45 min	30 min	< 10 min	40 min
	Range	40 – 60 min	20 – 40 min	0 – 20 min	35 – 55 min
Information provided by the St. Johns River Water Management District					

Figure 10-19. Suggested run times for spray and rotor type irrigation sprinklers based on estimated plant water demand.

General guidelines for residential and commercial irrigation system run times in the table above (Figure 10-19) are based on the type of head used in each irrigation zone. Use these estimated times and the catch can method to determine operating times. Landscape beds usually need less water than grass, often half the amount. A well-established shrub bed may not need any additional water other than rainfall, and it may be possible to cap the irrigation heads in these areas.

Microirrigation

Irrigation systems operate most efficiently if they do not wet plant foliage. In general, plants do not use water applied to the foliage. Microirrigation delivers small quantities of water (measured in gallons per hour or ***gph***) directly to the mulch and soil through plastic tubing on or below the ground surface at or close to the root system of the plant. Wetting only the root zone saves water because less is subject to evaporation. Microirrigation can be applied at any time of the day due to the lower flow rate and closer proximity to the root system.

The selection of emitter types (drip emitters or spray jets) in a given location is important to assure adequate coverage. With ***drip emitters*** (Figure 10-20), water moves laterally in sand only 10 to 12 inches from the emitter. Drip emitters are ideal when such precision is desirable in containers or for narrow strip plantings, such as along hedgerows. Because drip emitters are sometimes placed under mulch or buried in the soil, clogging may occur that is difficult to detect. In addition to clogging, it is hard to know whether the system is irrigating excessively due to damaged tubing or some other problem. A regular visual inspection is required to make sure that drip emitters and the overall system are functioning properly.

photo by hunter industries

Figure 10-20. Example of a drip emitter.

photo by hunter industries

Figure 10-21. Example of a microsprinkler.

Spray jets (either microsprayers or microsprinklers) are more desirable than drip emitters for most landscape applications. Because microsprinklers (Figure 10-21) can cover larger areas, fewer emitters are needed. Not only is their action visible, but the greater flow rate of water through spray jets (10 to 20 gallons per hour versus the drip emitter's 0.25 to 2 gallons per hour) also makes them less susceptible to clogging. Microsprayers create a fan-shaped distribution of fine water droplets. These fan application patterns perform well when used for directional spray and confined area applications. Some manufacturers have added spinner devices to create a sprinkler effect. Microsprinkler spinner heads have more uniform water distribution than fan spray jets and can provide excellent coverage. Since microirrigation emitters and spray jets deliver water at such varying rates (inches per hour), application times will also vary. Irrigation operating schedules should be adjusted appropriately.

To properly maintain the microirrigation system

Figure 10-22. Bricked lined swale in an urban setting for drainage. Additional brick and plants are placed to slow water flow.

- Periodically inspect plants for signs of overwatering or underwatering, such as wilting and/or changes in leaf color; adjust emitters or timer/controller as necessary.
- Check the soil wetting patterns around individual plants to ensure that at least half of the root zone area is covered. Whole root zone coverage is preferable.
- Inspect and clean filters and emitters on a regular basis. Flush the system every two months to discharge debris.
- As plants grow, inspect emitters and move them away from the original planting area.
- Reset the irrigation controller seasonally to adjust to changes in plant water needs.
- When replacing parts, use only parts specified by the equipment manufacturer.

Irrigation Runoff

Water is a carrier for nearly all pollutants. The most important irrigation management issue in sustainable nursery production and landscape management is containment of water, fertilizer or pesticide runoff. Runoff also contributes to erosion and sedimentation problems. Nutrient leaching and surface runoff are heavily dependent on the irrigation amount, method and timing. Precisely managing irrigation inputs to keep moisture primarily in the plant's root zone will significantly reduce these impacts.

When designing the layout of a nursery or landscape, pay particular attention to retention of as much water as possible from both irrigation and rain. To the extent possible, runoff or discharge should be exposed to filtering systems to help remove pollutants from the water before it leaves the nursery site or landscape basin. Ditches planted with grass or lined with rock to slow water flow (Figure 10-22), or tile systems that direct water to a pond or other holding area can collect runoff water. Water and some of the nutrients used can be recycled by pumping water back out of the holding tank or pond after impurities like sand and silt settle out.

Irrigation System Maintenance

Proper maintenance extends the life of an irrigation system and helps it perform optimally. Maintenance begins with visual observation of the system and plants. Perform weekly checks for leaks, broken/cracked lines, proper rotation, and damaged sprinkler heads. Check for obstacles that may interfere with irrigation uniformity. Brown spots, unnaturally green grass, certain types of weeds, and soggy spots are also indicators of problems.

Common ***irrigation efficiency*** problems include leaks, sprinkler head plugging, poor irrigation uniformity caused by nozzle wear, and poor system pressure. Some problems (such as repairing leaks and replacing nozzles) can be fixed at a minimal cost, while others (such as poor system design) might be very costly. Nonetheless, problems need to be corrected as soon as possible to prevent leaching of fertilizers or chemicals and/or wasting water. In the long term, investments made to improve the irrigation system will pay off in the form of reduced fertilizer or chemical costs and lower water bills.

While some irrigation system problems are easily fixed, they have to be identified to be repaired. The most important part of maintaining an irrigation system is conducting regular inspections while the system is operating. Some of the problems commonly found when checking irrigation systems are:

Figure 10-23. Leaking popup sprinkler head.

- Clogged sprinklers.
- Leaking sprinklers and valves, resulting in wasted water (Figure 10-23).
- Missing nozzles.
- Pipe leaks or breaks (Figure 10-24).
- Overspray onto sidewalks, streets or buildings (Figure 10-25).
- Sprinklers obstructed by plants or other objects, resulting in poor distribution uniformity.
- Design problems, resulting in turf and landscape areas being overwatered or underwatered if not zoned separately. Turf and landscape beds should always be in separate zones.

Damaged or defective systems should be repaired as soon as possible, preferably before the next scheduled irrigation. Replacement parts should always be the same type and have the same operating characteristics as the original components (nozzle size, pressure,

Figure 10-24. Broken irrigation pipe.

Figure 10-25. Adjusting sprinkler heads to avoid overspray.

UMIL Problem Codes and Description of Problems	
Pressure / Application Rate	
1	Undersized pump for number and type of sprinkler heads or emitters
2	Pressure loss between pump and sprinklers/emitters due to inadequate pipe size
3	Higher pressure than manufacturer's specifications
4	Lower pressure than manufacturer's specifications
5	Low pressure due to water supply
6	Different pressure between manifolds
7	Small wetted area
8	Application rate greater than soil infiltration rate (ponding)
9	Air in pipelines
10	Turf and landscape area irrigated in the same zone
11	Pressure variation due to elevation differences
Emitters / Sprinklers	
20	Mixed sprinkler/emitter sizes and unmatched application rates in the same zone
21	Mixed sprinkler/emitter brands or types in the same zone
22	Poor emitter/sprinkler uniformity due to worn orifice
23	Poor overlap due to improper sprinkler/emitter alignment or spacing
24	Various riser heights in same zone
25	Emitter/sprinkler spacing varies in same zone
26	Missing/malfunctioning emitters or sprinklers
27	Missing/malfunctioning pressure gauge/regulator/filter
Maintenance—Irrigation System	
30	Leaks and broken valves, pipe, laterals lines (poly tubing), emitters, sprinklers
31	Clogged filter or filter screen
32	Sprinkler heads not properly adjusted, causing overflow on paved areas
33	Clogged emitters/nozzles (due to biological, chemical, or physical factors)
34	Leaning sprinklers/emitters causing nonuniform distribution
35	Malfunctioning valves
Maintenance—Landscape	
40	Stream of water blocked by vegetation
41	Variable crop spacing and stage of growth
42	Poor drainage, requiring water control
Operation / Management	
50	Operating time too long
51	Operating time too short
52	Operating time too frequent
53	No rain shutoff device
54	No soil moisture measuring device or rain gauge
55	No irrigation water management plan

Figure 10-26. Urban mobile irrigation lab (UMIL) visual inspection checklist. *Source: Palm Beach Soil and Water Conservation District.*

throw diameter, arc, etc.). Otherwise, the replacement might cause more harm than the bad component.

Application efficiency is a component of irrigation system efficiency and indicates how well a system is providing water to the plant's root system. Irrigation application efficiency is defined as the amount of water delivered to an area compared to the amount of water beneficially used. The application efficiency percentage indicates how much of the applied water is stored in a plant's root zone.

In some areas of the state, the water management district or other local agencies may provide either mobile irrigation lab (MIL) or urban mobile irrigation lab (UMIL) services to evaluate a system and make recommendations to improve the irrigation system's efficiency. Recommendations on the improvement of existing irrigation systems, as well as education on water conservation, irrigation planning and irrigation management are provided. Some Water Management Districts have also partnered with communities to provide residential Urban Irrigation Efficiency Programs. These programs have several levels of evaluation, including

1) Visual inspection.
2) Pressure and flow check.
3) Distribution uniformity.

Visual inspections are conducted to determine if the system is in disrepair (leaks, broken sprinkler heads, etc.) or has poor coverage. If the system is found to be in poor condition, the other levels of evaluation are not carried out until the repairs are made. Pressure and flow checks on individual sprinkler heads or emitters are carried out next. Irrigation auditors usually calculate the application rate of an irrigation zone by running the zone for a set time and recording the volume observed from the water meter, then converting the amount to depth over the zone's irrigated area.

The auditor has a list of codes to describe problems seen in the irrigation system inspection (Figure 10-26). Any one residence may have multiple problem codes. Analyzing the frequency or number of times an irrigation maintenance problem occurs will provide a list of the most common irrigation maintenance problems in the residential irrigation system. Knowing the most common problems should increase awareness, leading to prevention or corrective action of the problem areas and reduction of water wasted by inground irrigation systems.

Distribution Uniformity

The irrigation ***application (distribution) uniformity*** is a critical function of irrigation system efficiency, as it indicates how uniformly water is distributed over a wetted area (Figure 10-27). Greater application uniformity occurs when spacing is adequate and sprinkler nozzles are matched. Poor application uniformity leads to localized overirrigation or underirrigation. Lack of application uniformity can lead to brown spots in the turfgrass, fertilizer and/or pesticide leaching or runoff, and waste of irrigation water.

In most cases, uniformity problems can be easily corrected. Once uniformity problems have been addressed, savings in electricity, fuel and watering costs can be realized. Poor uniformity in overhead sprinkler systems can be due to numerous factors, such as: a) improper pipe diameters; b) improper operation pressure; c) improper sprinkler heads and nozzles; d) inadequate sprinkler overlap; e) wind; f) changes in system components with time, such as pump efficiency, pressure regulation, or nozzle size; and g) nozzle clogging.

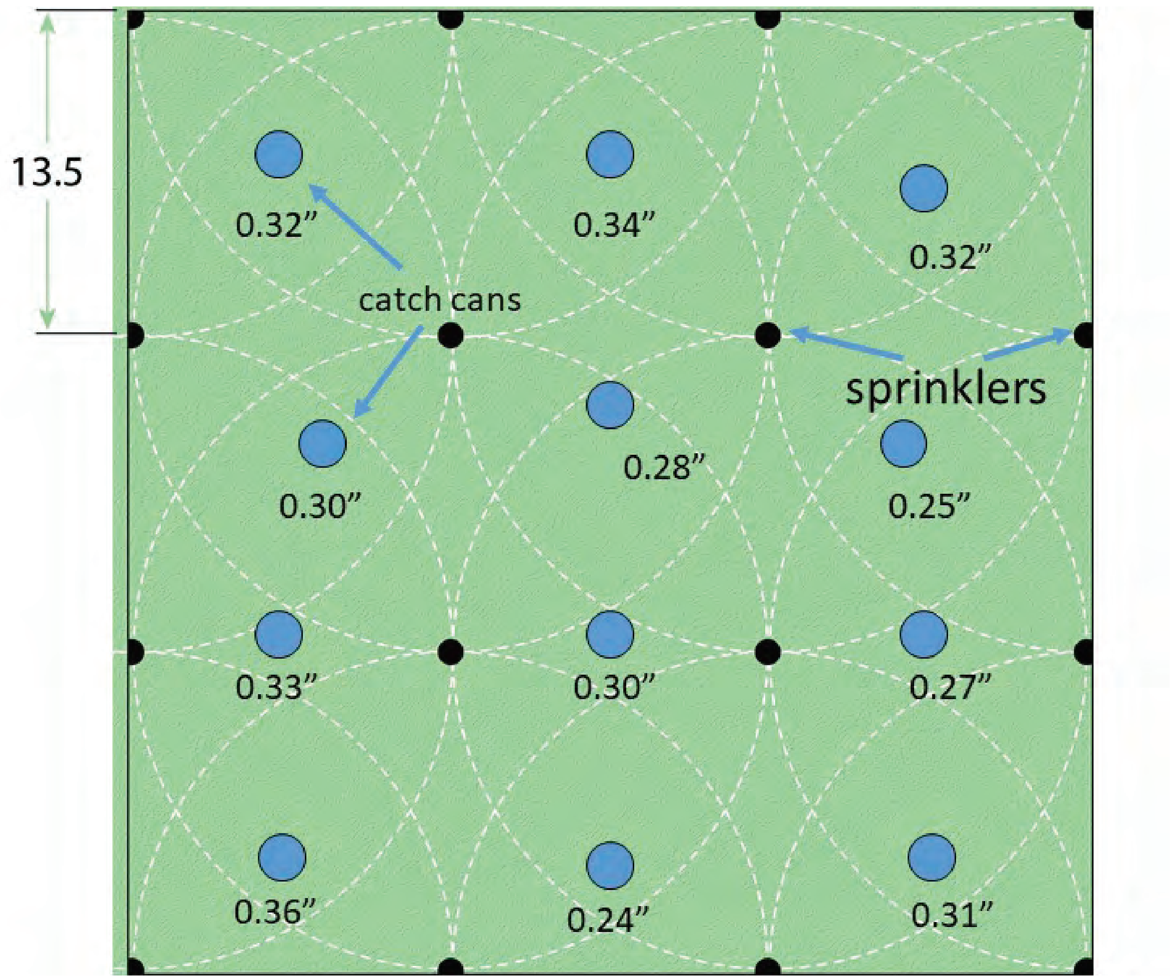
Figure 10-27. Example of uniform irrigation application.

There are several methods for determining distribution uniformity (DU). The most common method is referred to as the ***catch can test***, which was described in a previous section. With containers in place, the system is turned on for a fixed amount of time, ideally in quarter-hour increments, so determination of the amount per hour is easier. The water collected in each container is measured and recorded. If irrigation is uniform, the amount of water should be close to the same in each container.

The ***percentage of distribution uniformity*** is calculated by dividing the average depth of water collected in the lowest quarter of containers with the average depth of the water in all containers (see a practical example on the next page while using the illustration in Figure 10-28). The Irrigation Association has published a range and rating of distribution uniformities for different irrigation methods. For impact sprinkler systems, 70% to 80% is considered very good uniformity, and anything above 80% is excellent as indicated in Figure 10-29.

Irrigation systems should be designed to achieve optimal uniformity. Checking uniformity close to the pump and far away from the pump and in each zone with different irrigation infrastructures or delivery systems is recommended annually. Nonuniform systems may contribute to leaching and runoff, hence potential contamination of groundwater.

Emission uniformity, as opposed to distribution uniformity, is used for microirrigation systems. It is calculated by comparing the volume of water delivered from the emitters to the statistical differences in the total volume. An emission uniformity of 90% or higher is considered excellent.



graphic of head to head spacing by st johns river water management district;

Figure 10-28. Illustration of catch can placement under overhead sprinklers with head to head spacing. After irrigation is run for a set period of time (15 minutes, 30 minutes, or one hour), the depth of water in each can is measured and recorded for further calculations to determine distribution uniformity. (SJRWMD graphic modified to include catch cans).

Calculating Distribution Uniformity

Suppose 12 straight sided catch cans have been placed in the illustrated irrigation zone (Figure 10-28). The depth of water collected in these cans after running the system for one hour is presented below each can. The average application rate in this zone is the average depth collected in the cans.

Catch Can Data of All Cans	
Can Numbers	***Inches / Hour***
#1	0.36"
#2	0.24"
#3	0.31"
#4	0.33"
#5	0.30"
#6	0.27"
#7	0.30"
#8	0.28"
#9	0.25"
#10	0.32"
#11	0.34"
#12	0.32"
TOTAL	3.62"

The average water depth per can is:

Total in/hr ÷ Total number of cans

3.62 in/hr ÷ 12 = 0.30 in/hr

In order to calculate distribution uniformity (DU), the lowest one-fourth or quarter of the measurements are selected. This is known as the ***lower quarter DU***. The other value that must be known is the average depth of application during the test, which was calculated above.

Catch Can Data OF LOWER QUARTER	
Can Numbers	***Inches / Hour***
#2	0.24"
#6	0.27"
#8	0.28"
#9	0.25"
TOTAL	1.04"

The average low quarter depth is

1.04 in/hr ÷ 4 cans = 0.26 in/hr

Distribution uniformity (DU) =
(average low quarter depth ÷ overall average depth)

The distribution uniformity of the zone is

0.26 ÷ 0.30 = 0.8866 or 86.7%

Irrigation Management BMPs

The use of irrigation best management practices (BMPs) promotes proper irrigation system design, construction, and management. This leads to reduced water use, the protection of aquatic resources, better plant development, economic savings for the end user, and efficient fertilizer use.

The nursery and landscape industry is committed to minimizing any potential environmental impact associated with container or greenhouse production and landscape management. In addition to best management practices, there may be state, regional or local rules such as those governing wetlands, consumptive uses of water, environmental resource permitting, or occupational licenses, etc. that apply to irrigation operations. Irrigation managers should contact local water management districts and government regulatory authorities before starting expansion of an existing operation or any new construction.

The fundamental best management practices for irrigation management include:

- Irrigation rates and quantities should not exceed the maximum ability of the soil to absorb and hold the water applied in any one application.
- Use properly calibrated flow meters, soil moisture sensing devices, rain shutoff devises, and the visual observation of irrigation runoff or puddles to manage irrigation.
- Proper cultural practices should be employed to promote healthy, deep root development and reduce irrigation requirements.
- When possible, the irrigation schedule should coincide with other cultural practices (such as the application of fertilizer, herbicides, or other chemicals).
- When fertilizing (other than when watering restrictions apply), irrigate with ¼ inch following fertilization to avoid the loss of nitrogen and increase uptake efficiency.

Distribution Uniformity Percentages *Rating of Lower Quarter Distribution Uniformity (DULQ) for Sprinkler Zones*					
Type of Zone	***Excellent***	***Very Good***	***Good***	***Fair***	***Poor***
Fixed Spray	75%	65%	55%	50%	40%
Rotor	80%	70%	65%	60%	50%
Impact	80%	70%	65%	60%	55%
Information adapted from Predicting and Estimating Landscape Water Use. The Irrigation Association, Oct. 2001.					

Figure 10-29. Evaluation of overhead irrigation system distribution uniformity.

More than ½ inch of water may cause some nitrogen to be leached past the root zone. If water restrictions apply, irrigate as allowed.

- Irrigation controllers/timers should be reset seasonally to account for plant growth requirements and local climatic conditions.
- Where applicable, distribution, emission and application uniformities should be tested annually.
- Perform regular inspections to identify leaks, broken rain sensors or sprinkler heads and other system malfunctions.
- Implement a preventative maintenance program to replace worn components before they cause water, fertilizer or chemical waste.
- Replace or repair all broken or worn components before the next scheduled irrigation.

Summary

Management is the key to any irrigation system. Given Florida's limited water resources, in combination with a rapidly growing population, wise irrigation practices will play an essential role in providing a sustainable water future for our state. Proper landscape design and irrigation system standards can help save significant amounts of water and money, plus achieve both attractive landscapes and protection of Florida's natural resources.

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