THE UNIVERSITY OF GEORGIA
COOPERATIVE EXTENSION
Colleges of Agricultural and Environmental Sciences & Family and Consumer Sciences

# Best Management Practices for Landscape Water Conservation

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# Introduction

**Clint Waltz and Gary Wade**

Landscape water conservation Best Management Practices (BMPs) are practices that integrate plant selection, plant adaptation, irrigation, cultural and management practices, and a change in the acceptable expectations of plant performance under sub-optimal water conditions. The primary objective of these BMPs is to reduce landscape water use — not just during periods of drought, but throughout the entire growing season. Water conservation is an improvement in water use efficiency, not the temporary responses to periodic drought. BMPs are designed to be economical, practical, and sustainable while maintaining a healthy, functional landscape — a landscape that capitalizes on the environmental benefits of plant systems.

Georgia, like the rest of the United States, has a growing thirst for water. It is essential to human life, the health of ecosystems, and Georgia's economic development. Figure 1-1 illustrates how Georgia's demand for public supplied water, ground water, and surface water has increased over the past 50 years, from 130 million gallons per day (Mgd) in 1950 to more than 1,250 Mgd in 2000 (Fanning, 2003a).

Publicly supplied water is water withdrawn, treated, and distributed by public and private water suppliers for normal household uses, landscape maintenance, and commercial uses, including restaurants, hotels, retail stores, hospitals, prisons and colleges. In 2000, 98 percent of Georgia's industries relied on their own water resources (Fanning, 2003a). Publicly supplied water is commonly referred to as "municipal" water supplied by local county or private utilities. Seventy-eight percent of the public supply water in Georgia comes from surface water, such as reservoirs and rivers, while 23 percent comes from ground water and aquifers.

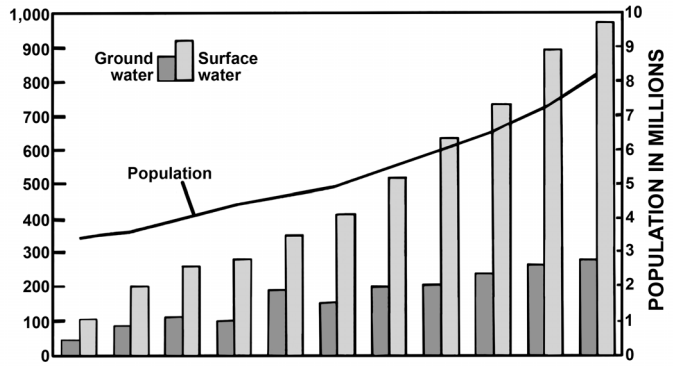


**Figure 1-1.** Demands on Georgia's water supply and population increase since 1950.

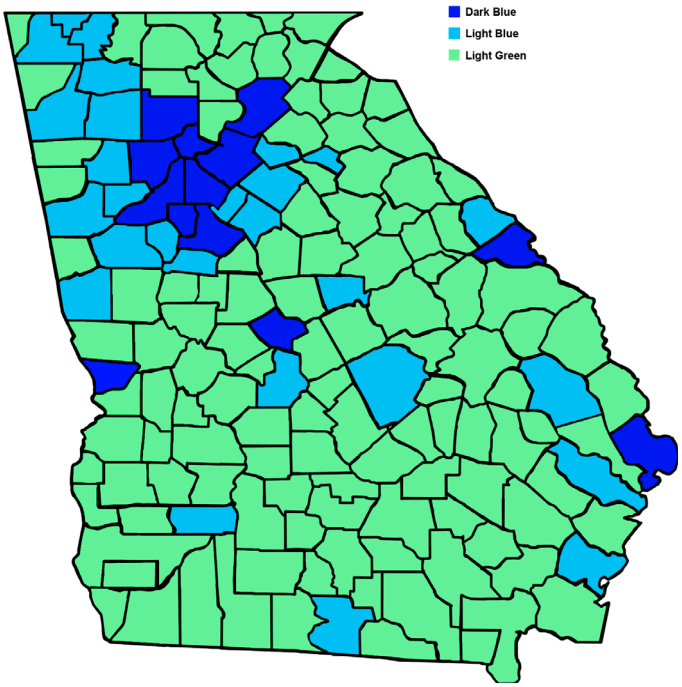


**Figure 1-2. Georgia's most populous counties, 2003.** Dark blue counties account for ½ of Georgia's population, while dark blue + light blue counties account for more than ⅔ of Georgia's population. Population is highest in and around urban areas.

Increasing demand for public water is directly related to increasing population (Figure 1-1), and an increase in the number of public and private water suppliers (Fanning, 2003b). From 1950 to 2000, Georgia's population grew by 40 percent. Another 16-percent increase is projected by 2010 (Bachtel, 2003).

People relocating to Georgia are moving to urban areas for improved goods, services, schools and health care. Unfortunately, from the water supply standpoint, population is not evenly distributed throughout the state (Figure 1-2). In fact, more than half of Georgia's population resides in 12 urban counties, while two-thirds of the population lives in just 40 of the state's 159 counties (Bachtel, 2003).

Table 1-1 shows population and water demand in 2000 and projected population and water demand in 2030 for five counties in northeast Georgia. Similar

**Table 1-1. Population and water demand projections for five northeast Georgia counties.**

| County | 2000 Population (# people) | 2030 Projected Population (# people) | % Change | 2000 Water Demand (Mgd) | 2030 Projected Water Demand (Mgd) | % Change |
|---|---|---|---|---|---|---|
| Barrow | 46,144 | 173,750 | +277 | 5.03 | 23.68 | +371 |
| Clarke | 101,489 | 181,340 | +79 | 13.67 | 25.26 | +85 |
| Jackson | 41,589 | 138,480 | +233 | 3.67 | 15.88 | +333 |
| Oconee | 28,225 | 51,870 | +84 | 2.46 | 9.56 | +289 |
| Walton | 60,687 | 213,880 | +252 | 7.17 | 27.91 | +352 |
| **Total** | **276,134** | **757,320** | **+174** | **31.00** | **102.29** | **+230** |

**Source:** Northeast Georgia Regional Development Center.

statistics can be obtained for most counties in and around urban areas in Georgia.

Unlike arid regions of the United States where annual rainfall may be less than 5 inches, most areas of Georgia receive 45 to 55 inches of rain annually (Table 1-2 and Figure 1-3 on page 5). Summer drought is common in Georgia, however, when significant rainfall amounts may be 30 or more days apart. These periods of limited rainfall increase demand on pubic water supply systems.

During the summer months, municipal water use outdoors increases between 30 percent to 50 percent, probably for outdoor recreational purposes (e.g. swimming pools), utility purposes (e.g. car washing and pressure washing), and for lawns and landscapes. Figure 1-4 (page 5) shows a typical monthly demand cycle on a metro-Atlanta utility.

Population growth and increased demand for water in combination with seasonal drought has resulted in water restrictions or bans on outdoor irrigation in many areas of Georgia, even during years of normal rainfall. In 2004, the Georgia Department of Natural Resources (DNR) adopted guidelines for outdoor water use; visit www.state.ga.us/dnr/. These guidelines serve as a basis for local water purveyors and municipalities to regulate water use. Local restrictions may vary and may even be more restrictive than those of the state. Residents and professionals should become familiar with the DNR guidelines and, more importantly, their local outdoor water use rules and restrictions.

The state guidelines outline four drought response levels, each with specific restrictions and exemptions. The four levels and a few applicable restrictions include:

- Declared Drought Response Level One – Outdoor water use may occur on scheduled days within the hours of 12 a.m. to 10 a.m. and 4 p.m. to 12 a.m.
  - Scheduled days for odd-numbered addresses are Tuesday, Thursday, and Sunday.
  - Scheduled days for even-numbered addresses are Monday, Wednesday, and Saturday.
- Declared Drought Response Level Two – Outdoor water use may occur on scheduled days within the hours of 12 a.m. to 10 a.m.
  - Scheduled days for odd- and even-numbered addresses are same as Level One.
- Declared Drought Response Level Three – Outdoor water use may occur on the scheduled day within the hours of 12:00 a.m. to 10:00 a.m.
  - The scheduled day for odd-numbered addresses is Sunday.
  - The scheduled day for even-numbered addresses is Saturday.
- Declared Drought Response Level Four – No outdoor water use is allowed other than for activities exempted by the guidelines or the EPD Director.

Similarly, the "Georgia Drought Management Plan" was drafted by state government in 2003 (www.gaepd.org/Documents/index_water.html). It proposes "pre-drought strategies, implemented before drought, for the purposes of preparedness, mitigation and monitoring, and drought responses, which are short-term actions, implemented during drought, according to the level of severity." Water use restrictions proposed by this plan can be addressed through the implementation of BMPs for water conservation in urban landscapes.

No doubt, water conservation is a concept that must be adopted as water resources become more limited. Water conservation should be institutionalized across all industries, including the green industry, production agriculture, pulp and paper, and manufacturing, just to

**Table 1-2. Historical rainfall data (1961-1990) for five locations in Georgia.**

| | Precipitation (inches) for five Georgia locations | | | | | |
|---|---|---|---|---|---|---|
| **Month** | **Lafayette** | **Blairsville** | **Jeffersonville** | **Savannah** | **Georgetown** | **Average** |
| January | 5.41 | 5.15 | 4.90 | 3.58 | 5.26 | 4.86 |
| February | 5.12 | 5.20 | 4.97 | 3.38 | 5.04 | 5.77 |
| March | 6.49 | 6.24 | 4.92 | 3.83 | 5.51 | 5.40 |
| April | 4.50 | 4.74 | 3.70 | 3.09 | 3.71 | 3.95 |
| May | 4.81 | 7.80 | 3.69 | 4.22 | 3.98 | 4.30 |
| June | 4.17 | 4.32 | 3.91 | 5.41 | 4.56 | 4.47 |
| July | 5.33 | 4.85 | 4.96 | 6.31 | 5.48 | 5.39 |
| August | 3.49 | 4.41 | 4.01 | 7.02 | 3.67 | 5.22 |
| September | 5.13 | 4.24 | 3.46 | 4.41 | 3.36 | 4.12 |
| October | 3.54 | 3.70 | 2.41 | 2.24 | 2.29 | 2.83 |
| November | 4.74 | 4.52 | 3.05 | 2.23 | 3.35 | 3.58 |
| December | 5.44 | 4.87 | 4.66 | 3.01 | 4.82 | 4.56 |
| **Total** | **58.17** | **57.04** | **48.64** | **48.73** | **51.03** | **54.45** |

**Source:** Georgia Automated Environmental Monitoring Network (http://www.GeorgiaWeather.net)

**Figure 1-3.** To provide perspective of rainfall across Georgia, data for five locations were evaluated.

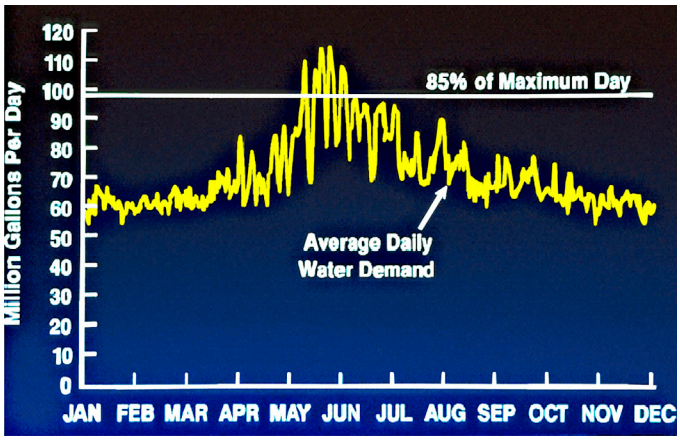


**Figure 1-4.** Daily water demand on a metro-Atlanta utility. Source: Cobb-Marietta Water Authority, 2000.

name a few. Furthermore, the aesthetic, sociological, and environmental benefits of landscapes also must be recognized by water authorities and policy makers. Policies that value a landscape will not only reduce water consumption, they can accentuate the environmental and societal benefits.

Landscapes can have a positive influence on human behavior characteristics such as improved ability to concentrate and self-discipline (Taylor et al., 2001).

Views of "nature" have been correlated to more effective, self-disciplined lives in inner city girls who had an open view of natural settings or landscapes from their homes or apartments. This life style is thought to translate into improved academic achievement and fewer destructive tendencies such as juvenile delinquency and teenage pregnancy. While landscapes mitigate environmental concerns, the influences on the human psyche are just beginning to be understood.

Turfgrass, an integral component of the landscape, plays a significant role in reducing water runoff and mitigating stormwater problems in urban and suburban environments with significant areas of impervious surfaces such as parking lots, sidewalks, and driveways. A healthy turfgrass root zone will:

- Help improve soil structure and reduce soil compaction, leading to greater infiltration of rain or irrigation water into the root zone. These waters percolate through the soil and contribute to ground water recharge;
- Help improve soil processes that facilitate the biodegradation (breakdown) of various types of pollutants and air contaminants;
- Encourage soil-building processes through decomposition of organic matter and formation of humus, which contributes to easier lawn care with fewer fertilizer, pest control, or water inputs.

Furthermore, recent research (Bandaranayake et al., 2003) indicates that turfgrass systems help rid the atmosphere of greenhouse gases, like carbon dioxide ($CO_2$), which contribute to global warming. Turfgrasses, like all plants, use the carbon requiring process of photosynthesis to produce their own "food." Studies have shown golf course putting greens and fairways store nearly a ton of carbon (C) per acre per year, with effects lasting for 31 to 45 years (Elstein, 2003). Interestingly, these data are comparable to carbon sequestration rates of lands placed in federal Conservation Reserve Programs. Because of the high productivity and lack of soil disturbances in turfgrass systems, golf courses, home lawns, athletic fields, and other grassed areas serve as effective, long-term "traps" for $CO_2$ while providing aesthetic, economic, and recreational benefits.

To meet Georgia's growing demands for water resources, the focus must be on how to use water more efficiently without sacrificing environmental quality. This objective can be achieved through proper plant selection and installation, and the use of landscape management practices that accentuate a plant's natural ability to survive despite a temporary deprivation of required resources (e.g. nutrients and water).

By employing proper techniques in landscape design, installation, and routine maintenance, water use in the landscape can be more efficient and, therefore, reduce the amount of water used. The purpose of this publication is to provide BMPs for landscape design, planting installation, effective use of irrigation systems, proper turfgrass maintenance, and guidance of irrigation practices. When combined, all these practices become an integrated approach to achieve landscape water conservation. The practices presented in this publication can be used by landscape professionals, homeowners, water purveyors, municipalities, and state regulatory agencies to improve water use efficiency while maintaining a healthy and attractive landscape.

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# BMPs for Water Conservation in Landscape Design

**David Berle and Gary Wade**

- Select plants that match the existing light conditions; they will grow better and require less water.
- Match surface and soil drainage conditions to plant moisture requirements.
- Select plants that grow well in the temperature ranges of the area.
- Select plants that are regionally adapted to the average rainfall of the area.
- Preserve established vegetation growing on a site; it has an extensive root system and requires less irrigation water than newly planted trees and shrubs.
- Space plants according to their mature size to reduce competition for water.
- Concentrate seasonal color in small, high impact areas to reduce overall water requirements.
- Avoid constructing raised beds under trees due to root competition for available water.
- Develop a landscape plan BEFORE designing an irrigation system.
- Incorporate shade trees into the landscape to reduce evaporative water loss.
- Select and group plants according to their water needs and drought tolerance.
- Divide the landscape into water-use zones.
- Avoid small, irregular-shaped island plantings in turfgrass areas because they are difficult to irrigate.
- Consider irrigation sprinklers when designing turfgrass areas and planting beds.
- Move or eliminate plants not suited to the existing site conditions and irrigation.

## Introduction

Conserving water should be a goal when establishing new landscapes, as well as when retrofitting existing landscapes. When designing a new landscape, you need to make many decisions, including how the landscape will be used, how it should look, what trees and shrubs already exist, which plants are appropriate, and what colors and textures to use. All of these decisions will have an impact on the appearance of the landscape, as well as how much water will be required to maintain it.

Landscaping of commercial sites is different from residential landscaping. Not only do budgets vary, but goals for appearance and maintenance are often different. For example, apartment complexes and shopping centers focus on drawing in visitors while minimizing maintenance. Home landscape design focuses more on creating environments and outdoor spaces that meet the needs of the client.

Homeowners often try to duplicate commercial designs with showy flower beds, entrance plantings, and large turfgrass areas. These practices may work well on a larger property, but they look out of place on a residential scale and can result in wasted water resources.

Regardless of land use, a water-conserving landscape design should re-evaluate traditional landscape practices while incorporating sound water management practices. This does not require special skill or knowledge, only a new way of thinking that considers the overall effects of design decisions on water use.

Be aware of design-related mistakes that can directly influence the water requirements of a landscape. Rethinking design techniques will help reduce water use without sacrificing the quality or beauty of the landscape design.

## Site Characteristics Affecting Water Use

- Select plants that match the existing light conditions; they will grow better and require less water.

When observing a landscape plan, it is easy to imagine the big circle labeled "oak" as a mature specimen. Oak trees can grow to heights of more than 50 feet and cast a large shadow. However, if the oak is planted at the same time as the rest of the landscape plants, it is not likely to cast much of a shadow during its first years. The ultimate goal may be to have shade-loving plants growing under a grand oak tree, but establishing a shaded environment may take several years. In this situation, select plants that might prefer some shade but will tolerate full sun while waiting for the shade tree to grow.

The reverse is true when planting under existing shade trees. Mature trees such as pecans and oaks not only cast a large shadow, they also have roots that compete aggressively with nearby plants for nutrients and water. Contrary to popular belief, most tree roots extend out well beyond the limbs of the tree.

All plants require a certain amount of sunlight to grow properly and flower. Some require more than others. Plants listed as requiring full sun generally need 6 to 8 hours of full, direct sun. Although the plant may grow with less light, plant form, leaf shape, and flowering habit will likely be affected. Sun-loving plants grown under shaded conditions tend to have bigger leaves, spindly stems, and fewer flowers. Plants adapted to full sun in cooler temperature zones often must have a certain amount of shade just to survive in warmer climates. A good example is the rhododendron (*Rhododendron catawbiense*), which flourishes in full sun in the northern United States but must have some shade in Georgia to grow.

Shade-loving plants grown in full sun, however, require additional water to survive and may not grow properly. If they receive more than 4 hours of direct sunlight, they may wilt or even exhibit leaf scorch. Match the light conditions of the site to the light requirements of plants to reduce the need for supplemental water.

- Match surface and soil drainage conditions to plant moisture requirements.

The amount of water in the soil can either be a problem or an asset in terms of plant survival. Determining the movement of water across the site surface and into the ground is critical to plant selection. For instance, dry areas may benefit from water redirected from sidewalks, gutters, or foundation drains during rain, but using drought tolerant plants in dry areas may be the best solution.

If poor soil drainage is the problem, make corrections prior to planting. Soil drainage is determined by topography, soil texture, and the presence of sub-surface hardpans. Removing and replacing the existing soil is often tried; this often proves unsuccessful because quality topsoil is hard to find, and the interface of the new and existing soil is critical to drainage. Depending on soil texture, amending a native soil with too little sand can actually reduce the soil drainage. For example, improving drainage of a clay soil with sand would require a sand content greater than 70 percent.

Mounding soil to create raised beds improves soil drainage, but if the drainage problem is caused by topography, a raised bed may not work. Any time new soil is added, take care to mix the two soils together to prevent drainage problems caused by layering effects. If a hard-

pan is causing the problem, using a piece of machinery to break up the impermeable layer will improve drainage. French drains, subsurface drainage systems, or other engineered systems are often required to correct drainage problems. These practices can be incorporated into the design by means of a false creek bed or gravel walk, but they can add considerable expense to a landscape project. It is easier and cheaper to select plants adapted to specific drainage situations than to remedy serious drainage problems. When drainage work beyond surface grading is required, consult with someone experienced in successfully treating such problems.

- Select plants that grow well in the temperature ranges of the area.

The United States has been divided into zones for both cold hardiness and heat tolerance. Reference books and plant labels frequently list the cold hardiness zone for ornamental plants (www.usna.usda.gov/Hardzone/ushzmap.html). Nursery growers, retailers, and landscape designers use the cold hardiness information as a guide to indicate how well an ornamental plant performs in a given location. Figure 2-1 shows the hardiness zones in Georgia. This information is based on the average date of the last and first frosts of the season. A heat zone map has recently been developed, which classifies plants according to their tolerance of temperatures above 86 degrees F. Figure 2-1. USDA plant hardiness zone map for Georgia.

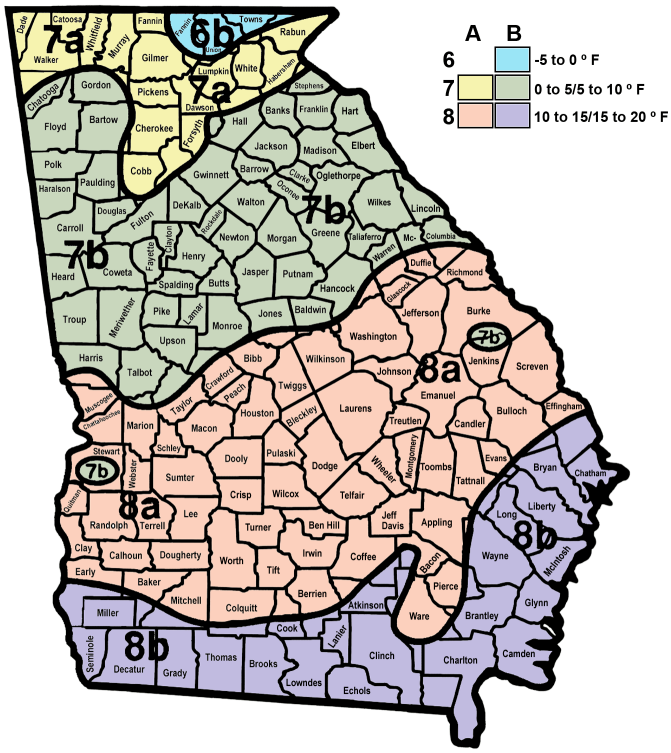


**Figure 2-1.** USDA plant hardiness zone map for Georgia.

Cold and heat tolerance directly affect a plant's water requirement. For example, a plant listed for hardiness zone 7 will survive in zone 8, but it will require more water and possibly more shade to survive. In a large parking lot, radiant heat temperatures soar well above the average air temperature of the area. As a result, the transpiration rate increases and plants require more water than normal. Although most ornamental plants will tolerate higher air temperatures, root growth is often stunted when the soil temperatures get extremely warm. Stunted root growth translates into poor plant development.

- Select plants that are regionally adapted to the average rainfall of the area.

Every region of the country is known for growing certain plants. Some plants are natives to the area, others are not. Some plants are salt tolerant. Others grow well in heavy clay soils. Plants suited to the regional conditions will grow better and use less irrigation water.

Much debate in recent years has been over the use of native versus non-native plants in the landscape. Some government agencies and municipalities have gone so far as to mandate the exclusive use of native plants on public lands. While there are many philosophical arguments for and against the use of native plants, from a water conservation point of view, a plant's parentage does not matter. Selecting the best plant for the specific site conditions, regardless of its parentage, provides the best outcome.

Sometimes, a new variety discovered or developed in a particular region will be better suited to that region than the native species. Look for regionally adapted cultivars that have been evaluated for your area. A good example is red maple, the cultivar *Acer rubrum* 'October Glory,' which was selected because it is more heat tolerant than most of the other available cultivars.

## Design Principles Affecting Water Use

- Preserve established vegetation growing on a site; it has an extensive root system and requires less irrigation water than newly planted trees and shrubs.

Whenever possible, preserve native vegetation and avoid disturbing it. Existing plants have well-established root systems that have adapted to the moisture extremes of the region. Mature trees also provide immediate shade that would take many years for newly planted trees to provide. It is important to identify valuable plants prior to site work and to install protective barriers to preserve the native vegetation, which can later be incorporated into the new landscape design.

- Space plants according to their mature size to reduce competition for water.

Densely planted shrubs are not only unattractive but require more water and maintenance. Densely planted shrubs encourage moisture-related problems around foundations and crawl spaces by reducing air flow. Overcrowding also increases the water requirements of plants since they compete for available moisture. Additionally, the dense canopies are havens for insects and diseases. The foundation of a building, with its "green necklace" of plants wrapped around it, is the most commonly overplanted area (Figure 2-2).

Many clients want an "instant landscape" and insist on spacing plants closer than their mature size indicates. Changes to the landscape plan are often made during installation because smaller plants just "look too far apart." It is not uncommon to see foundation shrubs such as dwarf yaupon holly (*Ilex vomitoria* 'Nana') planted as close as 24 inches, even though its mature width can reach 48 inches. A good reference book, *Manual of Woody Landscape Plants,* lists the mature spread of plants and is a useful guide in determining proper spacing.

- Concentrate seasonal color in small, high impact areas to reduce overall water requirements.

Most annuals used in seasonal color displays are shallow-rooted plants and have high water requirements. Showy color beds have become a common practice in today's landscape. They draw attention, and add excitement and visual interest into the landscape. The vivid color, not the size, of the planting attracts attention.

Concentrating color in small, highly visible areas saves water, time, and money. Tall, colorful plants, such as canna lilies (*Canna* sp.) can be used to make a planting stand out. Bold colors such as red and orange help smaller flower beds attract attention. Perennial plants, flowering shrubs, or shrubs with colorful foliage can be used in or around a flower bed to add height and depth to a small planting. Herbaceous perennials and shrubs tend to have more extensive root systems than annuals, are less costly to maintain, and are more water efficient than shallow-rooted annuals.

Locate flower beds where they will provide the greatest impact yet be close to available water sources. Another alternative to large in-ground flower beds is to use large containers placed in high impact locations. By using containers large enough for adequate root growth and by carefully selecting plants for container conditions, high-impact color can be achieved that requires less water than in-ground beds.

**Figure 2-2.** "Green necklace" around foundation of building.

- Avoid constructing raised beds under trees due to root competition for available water.

Creating raised beds under trees can be harmful to tree roots and ultimately results in root competition for moisture. Large trees have extensive root systems that compete with adjacent plants for water and nutrients.

A common remedy is to create a raised bed under the tree by adding several inches of new soil over the existing grade. This practice is harmful to the tree because it restricts the amount of oxygen and nutrients reaching the tree roots. When placed around the trunk, it may also promote wood decay. If the tree survives, its roots will eventually grow into the added soil and compete once again for water and nutrients.

- Develop a landscape plan BEFORE designing an irrigation system.

Irrigation systems work more efficiently and use less water if designed after the planting plan has been determined. In the rush to complete a new home or commercial building, irrigation systems are often installed prior to developing a landscape plan. This is particularly true in subdivisions that have covenants requiring the installation of a certain amount of turfgrass, plants, and an irrigation system. After moving in, the homeowner decides to supplement the initial landscape planting and finds that existing sprinklers are not located properly and timers do not have expansion capacity.

Planning for future irrigation needs is easy if done before installing the irrigation system. Larger timers can be used to accommodate future zones. PVC sleeves can be placed under paved surfaces to provide easy access for future water lines, and control valves can be placed in

an in-ground box adjacent to areas for future planting. The irrigation system should fit the landscape plan instead of dictating the landscape design.

- Incorporate shade trees into the landscape to reduce evaporative loss.

Large trees provide shade, reduce stormwater runoff, stabilize soil, reduce evaporative water loss, and reduce summer air conditioning needs. Place shade trees on the south and west sides of a building to block the sun but at least 20-30 feet away from the building, so the tree will not cause future damage from falling limbs or brushing against the building.

Consider grouping several shade trees together to create a shaded bed for plants. It may take several years to turn a sunny area to shade, so wait until the trees have grown enough to provide shade before planting underneath them. Most oaks and maples are excellent choices for shading the landscape. Several different species and cultivars are adapted to Georgia. A listing of plants can be found on the Georgia Cooperative Extension website at: http://pubs.caes.uga.edu/caespubs/pubcd/B625.htm.

- Select and group plants according to their water needs and drought tolerance.

Grouping plants with similar water requirements in the landscape allows more precise irrigation design and water management. All plants require a certain amount of water to grow to maturity. Some plants, such as yucca (*Yucca filamentosa*), can tolerate periods of limited rainfall. Others, like viburnum (*Viburnum* sp.) and rhododendron (*Rhododendron catawbiense*), require a steady supply of either rain or irrigation to survive. Some plants, such as Bald cypress (*Taxodium distichum*) and Virginia sweetspire (*Itea virginica*), can tolerate standing water for extended periods. When making a final plant selection, list the plants and group them according to irrigation needs. Look for alternatives when moisture-requiring plants are specified for non-irrigated areas. Understanding the individual needs and tolerances of plants will help in selecting and grouping plants in the landscape.

- Divide the landscape into water-use zones.

Divide the landscape into three water-use zones: high, moderate, and low. High water-use zones are highly visible areas of the landscape, such as the entrance to the property or building. In these zones, plants are irrigated as needed to promote optimum growth and aesthetic appearance.

Moderate water-use zones are transition zones, bridging the high and low water-use zones. In these areas, established plants are watered only when they show signs of moisture stress. Plants that require some irrigation during periods of limited rainfall, such as dogwoods (*Cornus florida*), azaleas (*Rhododendron* sp.), and hydrangeas (*Hydrangea macrophylla*), could be planted in moderate water-use zones. Low water-use zones are low impact areas or background areas viewed from a distance. Beds of mulch or drought tolerant plants would be used in low water-use zones because they are not irrigated once established.

- Avoid small, irregular-shaped island plantings in turfgrass areas because they are difficult to irrigate.

Isolated islands of individual trees or shrubs in the middle of turfgrass are difficult to irrigate properly and contribute to a disorganized design. Because turfgrass is a tough competitor for water and nutrients, landscape plants perform better if planted in larger groupings with a sufficient amount of mulch around them. The bed line of the mulched area can then be used to tie the plants together visually and help create unity in the landscape. For a large solitary tree, provide an adequate amount of mulch to cover as much of the tree root zone as possible. The mulched area should match the width of the root ball at planting time, and then gradually expand as the tree canopy expands. Make allowances in the landscape plan for extending the mulch area, either by leaving enough room for expansion or by planning to incorporate the trees into larger mulched beds as they grow.

Grouping plants is not only a good design practice, it also reduces water use by allowing more efficient irrigation layout. Mulched areas under grouped plants are a better environment for root growth. To create order in the landscape, arrange plants in groups of three, five, or seven. Group plants with similar colors, textures, or shapes. This helps unify the landscape. Mulched areas with wide, curved bed lines create a more natural or informal look in the landscape. When carefully selected and spaced properly, plants within mulched areas can be watered separately from adjacent turfgrass areas. This helps conserve water.

- Consider irrigation sprinklers when designing turfgrass areas and planting beds.

Limitations of irrigation sprinkler patterns can affect the water available to irrigate a landscape. For example, most irrigation sprinkler heads water in a circular pattern, so lawn areas should be designed with smooth, flowing curves to match the available irrigation distribution patterns. Sharp-angled, irregularly shaped, and small rectangular areas often receive too much or too little water, because irrigation sprinkler heads are not designed to cover every possible shape that can be drawn on paper. While irrigation should not dictate the entire design, consideration of available sprinkler patterns will

help prevent misuse of water. Designing turfgrass areas that match available sprinklers can also help reduce problems such as watering sidewalks and streets, or accidentally watering adjacent mulched areas.

For herbaceous plants and shrub installations, it makes sense to arrange the plants according to height in order to take advantage of the upward angle of most irrigation sprinklers. A large plant located along the edge of a bed will block the stream of water, preventing the plant behind it from receiving the proper amount of water. Plantings adjacent to buildings often require sprinklers to be placed on risers in the back of the planting in order to prevent irrigation water from contacting the building. An alternative in this situation is to install drip irrigation.

- Move or eliminate plants not suited to the existing site conditions and irrigation.

When landscapes are designed and installed without regard to site conditions or water conservation practices, problems can occur. Some plants may require frequent watering to survive, while others are over-watered. When this happens, it may be necessary to relocate some plants and replace others. Most landscape plants can be successfully transplanted when they are dormant. If plants are too large to move, they may have to be left in place to fend for themselves or removed if they become unattractive. Unattractive plants can be cut down to the ground and treated with an herbicide to prevent re-sprouting. Then a more appropriate plant can be placed in its spot.

# BMPs to Improve Water Conservation through Proper Landscape Installation and Maintenance

**Robert Westerfield and Gary Wade**

Research has shown that proper selection, installation and maintenance of ornamental plants can greatly increase their survivability and performance in the landscape. Follow sound planting and care procedures for ornamentals to help conserve water in the landscape. Properly sited plants that have been carefully planted and maintained usually require less irrigation and are less prone to diseases and insects. The following BMPs will help conserve moisture and will also promote overall health and vigor of the ornamental plants.

- Plant woody ornamentals and herbaceous perennials in the fall and winter; there will be less demand for water and nutrients by the top, allowing more energy and food for root growth. While the crown of a plant shuts down for winter, the roots continue to grow. A plant installed during cooler temperatures suffers less stress because this allows the plant time to develop a strong root system before dry, hot weather hits.
- Prepare the planting bed properly by deep tilling to a depth of 8 to 12 inches. When planting individual plants, dig a wide planting hole to provide a favorable rooting environment. A large planting hole and deep tilling will allow roots to expand more easily and the plant will develop a strong root system, better able to sustain the plant during times of drought.
- Add appropriate amendments to the planting bed, when necessary, to improve the physical properties of the soil, such as water retention, water infiltration, or drainage and/or to enhance the mineral content and microbial activity. Soil amendments (e.g. organic matter, compost) contribute to an overall healthier plant environment, allowing easier root development and fewer soil related problems.
- Avoid placing granular general-purpose fertilizers in the planting hole. These products can dehydrate and damage the roots of plants. Only slow-release fertilizer should be added to the planting hole if fertilizer is needed. General purpose fertilizer can be applied to the planting surface as indicated by a soil test after roots have become established.
- Give special care to seasonal color beds because of their high demand for water and maintenance. Plant seasonal color on well amended, raised beds to develop a healthier and more water efficient landscape.
- Apply 3 to 5 inches of mulch on the soil surface after planting to conserve soil moisture and help maintain a uniform soil temperature, while preventing weeds that compete with plants for light, water, and nutrients. Fine-textured mulches prevent evaporative water loss better than coarse-textured mulches. For best water efficiency, mulch out to the drip line of plants but do not pile mulch deeply against the trunks of trees and shrubs.
- Wait until you see moisture stress symptoms before irrigating. An abnormal gray-green color or obvious wilting indicate that a plant needs water. Water only when plants truly require it to help develop a deep, strong root systems and prepare plants to survive during drier periods.

- Irrigate at night or early in the morning to conserve moisture and to avoid evaporative loss of water. Water between the hours of 9 p.m. to 9 a.m. to conserve moisture and help prevent disease problems.
- Water deeply to encourage strong, healthy root systems that are water-efficient. Avoid light, frequent irrigation that encourages shallow rooting. Infrequent but thorough watering is the best formula to a healthy landscape. Water long enough to penetrate the soil to a depth of 6 to 8 inches.
- Test soil to provide the best gauge for fertilization requirements of the landscape. A healthy landscape is more water efficient. Proper nutrition enables plants to better use available water and to conserve it during dry periods. Over-fertilization increases plant stress during times of drought.
- Use slow-release fertilizers to provide a more even uptake of nutrients by the plant, resulting in a more uniform, water-efficient growth rate. Slow-release fertilizers are actually more cost efficient, decrease the chance of root burn, and allow the plant a season's source of nutrition.
- Avoid over-fertilization. Over-fertilization can cause excessive plant growth and additional water requirements.
- Avoid fertilizing during periods of limited rainfall or high temperatures. Additional fertilizer can cause root burn and other damage on drought stressed plants.
- During times of prolonged drought, cut back annual and perennial flowers several inches to reduce moisture loss. Reduction in the plant's overall canopy will cut down on water loss through transpiration.

## Installation

- Plant woody ornamentals and herbaceous perennials in the fall and winter; there will be less demand for water and nutrients by the top and more energy and food avail-able for root growth.

Correct planting procedures are essential to establishing a water efficient landscape. Fall is the ideal time to plant most woody trees, shrubs, vines, and ground covers as well as herbaceous perennials. Temperatures are moderate and less stressful to plants than the hot temperatures of late spring and summer. Plants require less frequent irrigation and are less likely to suffer sun scorch or heat-related stress. In addition, fall-planted ornamentals continue to develop a strong root system even after their tops have gone dormant. Fall and winter establishment will benefit the plant tremendously the following spring as the well-established root system can readily funnel water and nutrients to the above-ground growth. Ornamental plants that have a cold requirement (e.g. flowering bulbs) or are sensitive to frosts and freezes, such as annuals, are best planted according to recommended planting dates.

- Prepare the planting bed properly by deep tilling. When planting individual plants, dig a wide planting hole to provide a favorable rooting environment.

An ideal soil for optimal plant health contains air space for good drainage and good water holding capacity. It contains some organic mineral matter that supplies nutrients and improves soil structure and texture. A poorly drained and compacted soil can stunt root systems and may result in wasted water through runoff and evaporation. A poorly drained soil can also lead to disease problems later, shutting down a plant's ability to function properly.

Deep tilling the entire planting bed to a depth of 8 to 12 inches is one of the best and most cost effective ways to improve the planting site. Tilling will break up and loosen the existing soil, allowing easier plant root penetration and water infiltration. Deep tilling will help establish a plant more quickly with a healthier root system that can handle moisture extremes.

**Tip –** Check soil drainage by digging a hole approximately 15 inches deep by 15 inches in diameter and filling it with water. If water is left standing in the hole after 1 hour, the site may be poorly drained. If water remains in the hole for several hours, site and soil improvements are needed.

When planting solitary plants in undisturbed soil, make the planting hole as large as possible. Dig the hole at least twice the size of the diameter of the root ball. Set the top of the root system level with the soil surface, or slightly higher if the soil is prone to settling. Planting too deeply will result in root suffocation, and shallow planting may result in root death from dehydration.

Before planting balled-and-burlapped plants, cut the wire or cord around the trunk and pull back the burlap from the top one-third of the root ball. These can serve as an impediment to root growth if left in place. When planting container grown plants that are root bound, use a knife to make four to six shallow, vertical slits around the root ball and spread out the root system within the planting hole. This will allow water to readily penetrate the root ball while encouraging new root growth.

- Add appropriate amendments to the planting bed, when necessary, to improve the physical properties of the soil. This improves water retention, water infiltration, drainage, and enhancement of mineral and microbial content.

Most Georgia soils are low in organic matter, so it is usually beneficial to incorporate an organic amendment such as compost during the tilling process. Apply at least 4 inches of the amendment on the soil surface and thoroughly incorporate it into the native soil to a depth of 12 inches.

There are two broad types of soil amendments: organic and inorganic. Organic amendments come from something that is or was alive. Inorganic amendments are either mined or man-made. Examples of organic amendments are compost, peat moss, manure, and biosolids.

Organic amendments improve the water retention, oxygen infiltration, and nutrient-holding capacity of a soil. They also provide good environments for beneficial fungi and bacteria, earthworms, and other living organisms that improve nutrient availability and aeration of the soil.

Examples of inorganic amendments are vermiculite, perlite, pea gravel, shale, and sand. They are typically used to improve soil drainage. Unlike organic amendments, these products have little nutritional value.

Hydrogels are synthetic polyacrylamide or starch-based organic compounds capable of holding several hundred times their weight in water. They improve the water-holding capacity of soil while improving soil aeration as they swell and shrink according to fluctuation in soil moisture. In the landscape industry, they are used in containerized plantings and seasonal color beds, but their effectiveness and economic viability for use in shrub and tree planting remains questionable.

Other considerations when selecting soil amendments include:

- carbon to nitrogen (C:N) ratio;
- how long the amendment will last in the soil (coarser type amendments typically will last longer than fine ones);
- cost and availability;
- salt content and effect on soil pH.

- Avoid placing granular general-purpose fertilizers in the planting hole; they can dehydrate the roots of plants.

Granular general-purpose fertilizers such as 10-10-10, 8-8-8 or 16-4-8 are chemical salts and may burn the tender roots of newly planted ornamentals. hey may actually dehydrate the roots and cause the plant to demand more water in the planting hole. Use general-purpose fertilizers on the soil surface once the plant is established. Spread the fertilizer away from the base of the plant out to the drip line area. Do not pile the fertilizer to one side of the root system as this might burn roots as well.

In general, fertilizers are not a necessary ingredient in the planting hole. The plant will have enough stored energy in its roots to get established. One exception to this rule is seasonal color plantings. It's a common practice in the landscape industry to place slow-release fertilizer in the planting hole beneath annuals and perennials. This assures a season-long supply of nutrients and results in stronger growth compared to broadcast application.

**Tip –** Research has shown that amendments added to individual planting holes are not helpful and can, in fact, be harmful to the plant. They may act like a sponge, holding too much moisture in the hole. They may also encourage the roots to stay within the confines of the hole instead of growing outward into the native soil. Backfill these plants with the native soil without adding any amendments.

**Tip –** Do not add sand to clay soils. Depending on soil texture, amending a native soil with too little sand can actually lower the drainage below what it was initially. Adding sand to improve drainage will only work if enough sand is added to bring the sand content to a level greater than 70 percent.

- Give special care to seasonal color beds because of their high demand for water and maintenance.

Seasonal color beds are short-lived, shallow-rooted, and demand a uniform supply of water and nutrients for optimum growth. Amended beds are essential to promote good health and water transfer for annuals. On new beds, add 4 inches of organic matter to the soil surface and incorporate it to a 12-inch depth.

Raise the planting bed approximately 10 to 15 inches above grade to assure good drainage and improve the visual appeal of the planting. Raised beds assure good infiltration and movement of water in the soil, prevent possible water-logged conditions, and result in a healthier rooting environment.

A slow-release fertilizer added to the planting hole gives a uniform nutrient supply throughout the season and a healthy fibrous root system that makes best use of available water. Additional fertilizer may be needed to provide nutrition throughout the growing season.

- Apply 3 to 5 inches of mulch on the soil surface after planting to conserve moisture and help maintain a uniform soil temperature, while preventing weeds that compete with plants for light, water, and nutrients. Fine-textured mulches prevent evaporative water loss better than coarse-textured mulches.

Mulches have many benefits in the landscape. They hold moisture in the soil, prevent weeds, inhibit certain soil-borne foliar diseases, insulate the roots of plants from temperature extremes, and provide a protective barrier around the plant to keep lawn mowers or string trimmers away. They also provide a pleasing background contrast for plants.

Common mulches include pine straw, pine bark nuggets, hardwood chips, and cypress shavings. Fall leaves are also a good mulch, provided they are shredded prior to use. Grass clippings are not good mulch unless they are composted first, because they tend to mat down and inhibit the flow of water and nutrients into the soil. They may also introduce weeds into the planting bed.

Inorganic mulches such as rock, gravel, or marble are good soil insulators, but they are not good choices for Georgia landscapes because they absorb and radiate heat in the planting bed, increasing water loss from plants.

Apply mulches 3 to 5 inches deep. When mulching trees, remember that the root system of a mature tree may spread two to three times the canopy width, so mulch as large an area as possible.

Landscape fabrics are sometimes used under organic mulches to prevent weeds and to serve as an added barrier to moisture loss. Make sure these fabrics are free from soil on top as weeds may germinate. Do not use landscape fabrics in areas that tend to stay wet for long periods of time.

**Tip –** Too much mulch around plants is a barrier to oxygen, water, and nutrients and may encourage diseases or rodent damage.

## Irrigation

- Watch for moisture stress symptoms before deciding to irrigate. An abnormal gray-green color or obvious wilting are good indicators that a plant needs moisture.

Most healthy established woody ornamental plants in the landscape can survive weeks without supplemental irrigation. In fact, over-watering during periods of limited rainfall and the root rot which results has killed more plants than drought.

The best guide in determining when to water is the plant itself. Wilting or a pale grayish-green color are the most common symptoms of moisture stress. Some plants, such as annuals and herbaceous perennials, may need water more often than woody ornamentals because of their limited root system. By targeting irrigation to only those plants in the landscape that need water, you not only save water, time, and money, you also avoid potential disease or insect problems from over-watering.

- The best time to irrigate is at night or early in the morning to conserve moisture and to avoid evaporative loss of water.

Irrigating during mid-day results in evaporative water loss and inefficient use of water. Irrigating between 9 p.m. - 9 a.m. avoids evaporative water loss.

- Deep watering encourages strong, healthy, water-efficient root systems. Avoid light, frequent irrigation that encourages shallow rooting.

Frequent, light irrigations encourage shallow rooting. As a result, roots dry out more quickly and the plant's demand for water increases.

When irrigating, apply enough water to wet the soil to a depth of 8 to 10 inches to promote deep root growth. Remember to change irrigation frequency and amount according to changes in rainfall patterns. Make certain automated systems have a rain sensor that prevents them from operating during rain.

Apply water slowly using a hand-held hose, drip or trickle irrigation, micro-sprinklers, or an ooze hose. The amount and frequency of irrigation depend on the type of plant, the soil type, and the time of year. Plants in sandy soils normally require more frequent irrigation than those growing in clay soils.

**Tip –** Approximately 1 inch of water is required to wet clay soils to a depth of 8 inches.

## Fertilization

- A soil test provides the best gauge for fertilization requirements of the landscape. A healthy landscape is more water efficient.

Soil sampling through the local county Extension office is the best and most affordable way to assess the fertilizer needs of plants. In addition, a soil test is the only scientific way to determine whether lime is needed to adjust soil pH. Applying lime without a soil test may cause nutritional problems. Plants cannot use fertilizer properly unless the pH is adjusted correctly.

Proper nutrition promotes optimum plant growth and resistance to diseases, insects and environmental problems. Plants receiving proper nutrition also will be more water efficient. They have a healthier, larger root system that can better sustain the plant during periods of limited rainfall.

- Slow-release fertilizers provide a more even uptake of nutrients by the plant, resulting in a more uniform growth rate. Excess nitrogen or high nitrate fertilizers cause rapid growth and an increased demand for water.

Because slow-release fertilizers are coated and release nutrients over time, plants grow at an even rate instead of in bursts of new growth. This results in a more water-efficient plant. There is also less chance of salt injury from slow-release fertilizers, as the protective coating only releases a small amount at a time.

Slow-release fertilizers may also be more cost effective than traditional soluble fertilizers because they supply nutrients over an extended period.

- Avoid over-fertilization. Excessive fertilizer can be harmful to the plant's water efficiency and health, and to the environment.

Fertilizers are salts, and excess amounts can damage plants by drawing water from the roots. Plant cells in the roots begin to dehydrate and collapse, resulting in plant roots being "burned" or dried out to a point where they cannot recover.

Over-fertilizing can cause water quality problems as excess fertilizer enters storm drains, and eventually streams and rivers, through run-off and leaching. Leaching is the effect of nutrients being washed through the lower soil layers and into the groundwater supply.

The frequency of fertilization depends on the type of plants, the age of the plants, and the type of fertilizer used. In general, most established woody ornamentals need only one application of slow-release fertilizer per year. Annuals benefit from light, monthly applications of a water-soluble fertilizer or the use of a slow-release fertilizer product. Newly planted ornamental trees and shrubs may benefit from light additions of fertilizer applied in three applications during the growing season (March, May and July).

- Avoid fertilizing during periods of limited rainfall or high temperatures.

Plants absorb fertilizer when they are actively growing. Fertilize most plants during the early spring from the time they break dormancy until they taper off in their growth in fall and go dormant. It is a good idea to irrigate immediately after an application of fertilizer.

During periods of drought, reduce the amount of fertilizer applied and the frequency of application in non-irrigated areas as plants may be stressed and do not need to increase their canopy from nutrient uptake.

## Pruning

- During times of severe drought, cut back annual and perennial flowers to reduce moisture loss.

If irrigation is impossible because of public watering restrictions, cutting back herbaceous annuals and perennials that are wilting will reduce the water loss from leaves by taking pressure off the root system. Be sure to provide mulch to help keep moisture in the soil.

- Maintain pruning equipment in good order to improve the health and water efficiency of plants.

Dull hand-pruners will not cut cleanly and will cause cut branches to be frayed. Frayed branches will not recover as quickly as those cut cleanly by sharp blades and will allow more water loss. In addition, poorly cut branches may be a site for disease penetration that can weaken the plant.

Learn to sharpen tools properly with a stone, and keep them clean and oiled. Buy the best tools you can afford.

## Additional References

### Web sites:

http://www.caes.uga.edu/departments/hort/extension/index.html

http://ohioline.osu.edu/lines/hygs.html

http://www.hgic.umd.edu/

http://www.gaurbanag.org

### Books:

*Georgia Gardener's Guide,* by Erica Glasener and Walter Reeves

*Your Florida Landscape,* by Dr. Robert Black and Dr. Kathleen Ruppert

*Month by Month Gardening in the South,* by Don Hastings and Chris Hastings

*The American Horticultural Society – Pruning and Training,* by Christopher Brickell and David Joyce

# BMPs for Landscape Irrigation System Water Conservation

**Rose Mary Seymour and Kerry Harrison**

- Base the irrigation system design on the site landscape design, water use zones, and water use of the matured landscape.
- Divide irrigation zones according to water supply amount available.
- Use appropriate applicators for the plant materials and to fit the irrigated area for each zone.
- System design should fit the site's soil type, topography, and climate.
- System design should consider the time available for applying irrigation.
- Installation should follow the irrigation design specifications and component manufacturer's specifications.
- Upon completion of the irrigation system installation, conduct a field performance audit to determine distribution uniformity and precipitation rates for each zone.
- Use a separate or secondary meter for the irrigation system.
- Size meters, pipe, and pumping systems for optimal performance.
- Use lower trajectory sprinklers to minimize wind and evaporative losses.
- Include rain shutoff and other sensor devices as appropriate for site conditions.
- Provide a system controller that has flexibility and capacity.
- Use soil moisture sensing based or real-time weather based control for irrigation management.
- Use the short cycle feature for low permeability soils or steep slopes to prevent runoff.
- Perform a thorough irrigation system inspection annually.
- Repair or replace damaged or worn components in a timely manner, preferably before the next irrigation application.
- Conduct a field performance audit on an irrigation system every 5 years.
- As plants grow and mature, trim or remove vegetation that blocks applicator pattern to preserve the intended distribution of irrigation water.
- Carry out a regular winterization of the irrigation system if it will not be used for an extended period of time in the winter.

## Introduction

The water conservation practices in this chapter can reduce water waste from landscape irrigation systems. Along with providing efficient water use and uniform distribution of water in the landscape, irrigation systems must have economic installation costs and operating costs, and be simple to operate and adjust. There are many local codes and state laws that the irrigation installer and designer must know to create an efficient design and to install an irrigation system correctly. Many of the codes, laws, rules, and regulations do not pertain directly to water use efficiency, but some do, and those will be discussed.

The water conservation practices in this chapter are considered the primary responsibility of landscape irrigation designers, installers, and commercial landscape maintenance personnel. The landscape industry also has a responsibility to provide education to customers and to assist the customer or owner/operator in operating an irrigation system efficiently. Practices and suggestions are included for providing customers with tools and information that will enable them to do their part in efficient irrigation practices.

Irrigation system design, installation, and maintenance should be performed by licensed, certified and, when appropriate, bonded professionals. While Georgia does not have certification requirements for irrigation professionals, the Irrigation Association (IA) (http://www.irrigation.org) has a national certification program. To become certified, irrigation professionals can contact the IA or the Georgia Irrigation Association (http://www.gairr.org). Contact information for these two sources can be found at the end of the chapter. Certification indicates that a contractor or maintenance company is competent and takes a professional approach to providing services.

## Irrigation System Design

- Base the irrigation system design on the actual site landscape design, water use zones, and water use of the matured landscape.

Efficient irrigation design begins with a good landscape design. The landscape design should be the basis for the irrigation system design whether the landscape is put in place before the irrigation system or after. Unfortunately, it is much too common for a new development with similar lot sizes to install irrigation systems with a "one size fits all" approach. While this approach usually costs less in design and installation costs, it is the surest way to create poor efficiency and uniformity of irrigation systems because of the variability from lot to lot in soils, topography, landscape design, and microclimate influences.

Irrigation system design should include specifications of the manufacturer, model number, and nozzle size for each applicator. A drawing of the system layout with all valves, irrigation zones, control equipment, and points of connection labeled should also be included. The layout should include key landscape features such as trees,

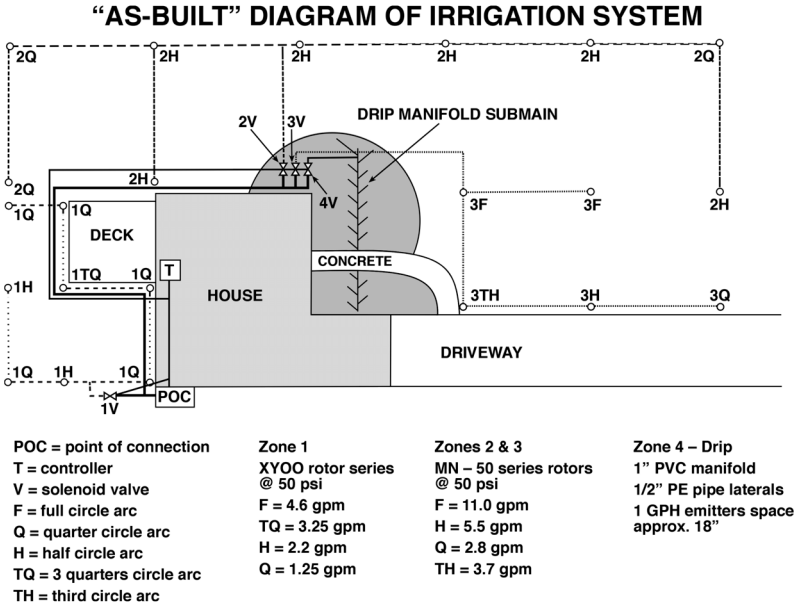


**Figure 4-1.** This "as-built" diagram would be adequate for owner/operator maintenance and management of the irrigation system. The specifications of gallons per minute information will be needed for sizing replacement nozzles correctly.

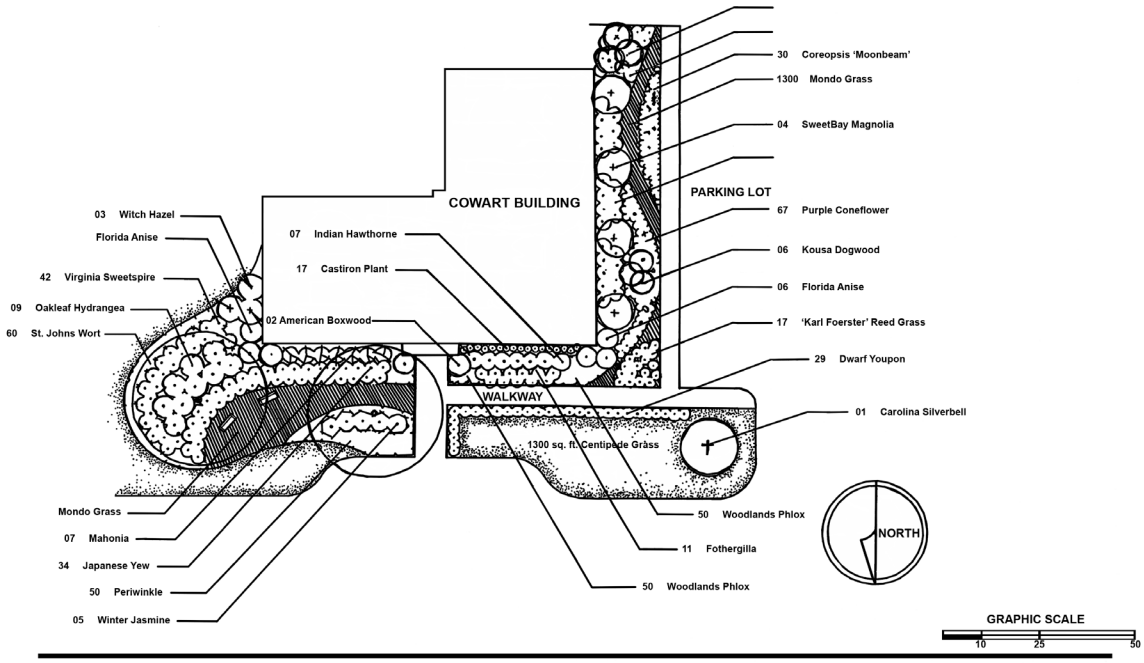


**Figure 4-2.** Landscape design layout.

fences, and buildings so the installer and owner/operator can easily locate components of the system according to the layout.

In the design documents provided to the customer, the designer should diagram the area of each irrigation zone, the location of all points of connection, control sensors, valves and sprinkler applicators, and areas where drip irrigation will be used. Other information to have in the design document for each irrigation zone is water-use zone and plant materials, soil types, root zone depths used for design, estimated precipitation rates, expected distribution uniformity, area square footages, and gallons per minute flow rate for each valve and applicator. Figure 4-1 is an example of a good and simple design diagram to provide an owner/operator.

Group plant materials into water-use zones in the landscape design. A water-use zone is an area of the landscape with all the plants having similar water requirements. If the landscape is laid out in water-use zones, then the irrigation system can be designed to allow independent control of irrigation for the different water use zones. Figure 4-2 shows a landscape design layout.

The water-use zones are designated as high, moderate and low use zones. Once plants are established, the low water-use zones should not need irrigation. However, these plants will need irrigation during the establishment phase. The moderate and high water-use zones will need similar irrigation coverage and uniformity of application, but will be run on different schedules that suit the needs of the plant material for each water-use zone. For more information on water-use zones, refer to Chapter 2 of this publication or to Georgia Cooperative Extension Bulletin B-1073 at http://pubs.caes.uga.edu/caespubs/pubcd/B1073.htm.

Irrigation systems in landscapes are presumed to have a lifetime of 15-20 years. Base the water supply and irrigation zone layout on the water needs of the mature landscape, so the system will be able to apply sufficient water for the lifetime of the system. It is much easier and less stressful to plants to run a larger irrigation system less frequently, and for shorter periods of time, while the landscape is young rather than trying to add additional water capacity or re-zone the system as the landscape matures and ages.

**Figure 4-3.** Poor design and/or installation of the applicator location wastes water because the sprinkler pattern is blocked by a tree 35 inches from the applicator.

During the design process, consider the mature landscape, shrubs, and trees so irrigation equipment is not blocked or hindered. Take this into account as the applicators are put in place in the design. Figure 4-3 shows an example of an irrigation system design that did not plan for the landscape design correctly. The irrigation head is completely blocked for part of its application arc by a tree.

- Divide irrigation zones according to water supply amount available.

Water for irrigation can be pumped from an on-site well or storage, or it may come from a municipal supply line. Whatever the source, the water supply delivers a limited volume and pressure where the irrigation system is connected. An irrigation zone is a set or grouping of irrigation applicators isolated from the rest of the irrigation system by a control valve. The valve is used to start or stop irrigation. The area covered by an irrigation zone is limited by the amount of water that can be delivered to the zone from the water supply. A large contiguous area may be divided into two or more irrigation zones since the water supply does not have a sufficient flow rate to irrigate the whole area at the required operating pressure.

- Use appropriate applicators for the plant materials and to fit the irrigated area for each zone.

Many kinds of irrigation application devices can be used in landscapes. Irrigation zones may be differentiated in the design process because different application devices or different management is needed from one area to the next. Keeping different kinds of application devices separated into different irrigation zones allows each zone to be operated in a way that is consistent with the application rate for similar application devices.

**Figure 4-5.** These two rotor applicators have over-lapping radius of throw to get a more even broadcast application of the irrigation water.

The two main categories of irrigation application devices are sprinkling type applicators or micro-irrigation applicators. Sprinkling application devices spread water in a broadcast manner over the whole area to be irrigated, mimicking rainfall, while micro-irrigation devices do not broadcast water over an entire area. To spread water evenly over an area, sprinkle application devices must have overlap of their water streams. Micro-irrigation application devices, also called drip irrigation, apply water directly to the root zone areas of plants, minimizing the wetted area of the soil surface. They do not have overlapping wetting patterns.

**Figure 4-4.** Spray applicators are pop-up style heads that will let the applicators recede below the turfgrass when irrigation stops.

**Figure 4-6.** The pop-up rotator applicator has several individual small moving streams rather than the one large stream of a rotor applicator.

Sprinkle applicators can be sprays or sprinklers. Spray applicators do not have any movement of the water streams that form the pattern, or wetted area, of the spray, and have no moving parts in the spray head. Figure 4-4 is a picture of spray applicators operating in a landscape. Sprinklers have moving water streams broadcasting water over an area that forms the pattern of the sprinkler. Sprinkler types include rotor, impact, and rotator style movements of the water streams. Figure 4-5 and 4-6 picture a rotor and rotator applicator, respectively. Most sprinkler or spray applicators can be housed in pop-up canisters that recede below the soil level when not applying water. They may also be placed on top of a riser, a vertical length of pipe, to provide broadcast application above taller plants. Table 4-1 has a summary of some key characteristics of sprinkle type applicators. Note that the water application rates and pattern sizes of the different sprinkling applicators vary considerably. The differences in the various applicator types require that they be managed differently and that they be laid out in a design differently. Their differences make them suitable for different kinds of landscape areas.

**Table 4-1. Characteristics of different sprinkling application devices.**

| Application Characteristics | Sprays | Rotors & Impacts | Rotators |
|---|---|---|---|
| Radius of throw | 3-15 ft | 15-80 ft | 16-30 ft |
| Operating pressures | 15-45 psi | 25-90 psi | 25-55 psi |
| Precipitation rates | 1-2.5 in/hr | 0.3-0.75 in/hr | 0.37-0.47 in/hr |
| Flow rates | 0.1-5 gpm | 3-22 gpm | 0.3-4.3 gpm |
| Uses | Smaller & odd shaped areas | Larger & simple shaped areas | Areas with widths & lengths >8 ft |

Micro-irrigation devices include drip emitters, inline emitters in rigid lateral pipe, drip tape, micro-sprinklers, and micro-sprays. The most common micro-irrigation device in landscapes is the drip emitter, which is installed along a lateral pipeline laid on the surface of the ground. Drip emitters are positioned along lateral pipelines where needed to drip water over the root zone of individual plants. Figure 4-7 shows a drip emitter that has been installed into a lateral pipe. Semi-rigid polyethylene pipe laterals have inline emitters embedded at regular intervals such as 12 inches within or along one side of the pipe. Drip tape is a flatter, more flexible polyethylene hollow "tape" with emitting devices evenly spaced along the tape. Drip tape and inline emitter piping

**Figure 4-7.** A drip emitter connected to a pipe lateral at each plant will provide water directly to the soil surface. This emitter and lateral are on the ground surface and would usually be covered by a layer of mulch.

can be buried or be placed at the soil surface. Micro-sprays and micro-sprinklers have low volume application rates similar to drip emitters, but the low volume of water is spread out over a larger area than with drip emitters. Micro-sprinklers are similar to micro-sprays except they have moving parts and water streams. Figure 4-8 is a picture of a micro-spray that is not applying water. Neither micro-sprays nor micro-sprinklers are designed to have overlapping water patterns like other sprinkling application devices. These micro-sprays or micro-sprinklers are needed where soils have a low water holding capacity and high permeability, so that the water applied does not move below the root zone without adequately refilling a large area of the root zone.

Some plant materials such as herbaceous perennials and woody plants are more amenable to drip irrigation, while turfgrass areas will be better suited to the broadcast application of sprinkler irrigation. The appropriate system for herbaceous annuals depends on their spacing and growth habit. Where there are steep slopes and plant materials other than turfgrass, drip irrigation is a better system since it will apply water slowly and prevent runoff. For turfgrass on steep slopes, low application rate sprinklers are preferred.

The designer should choose applicators such that impervious surfaces are not irrigated. Spray applicators come in many shapes to accommodate difficult spaces. Both sprays and sprinklers can have arcs that are less than 360 degrees to prevent watering impervious areas. Most sprinklers and sprays come in standard one-quarter, one-third, half, three-quarter, and full circle arcs. There are also sprinklers and sprays with adjustable arcs for spaces that need more or less than the standard arc sizes.

**Figure 4-8.** This is a micro-spray applicator positioned above a mulch layer by a plastic stake driven into the soil. Micro-sprays and micro-sprinklers must be above the mulch layer so the mulch will not inhibit their water spray or sprinkling patterns.

When these partial or adjustable arc applicators are used, the flow rate of the nozzle should be proportionately less than a comparable full circle nozzle flow rate based on the ratio of the reduced arc area to the full circle area.

For more information on different kinds of applicators, please refer to Georgia Cooperative Extension Service Bulletin 894 at http://pubs.caes.uga.edu/caespubs/pubcd/B894.htm .

Any irrigation device requires a certain operating pressure and flow rate. The operating pressure results from the static pressure at the upstream start of the irrigation system minus the pressure losses in the delivery lines and equipment of the irrigation system. Static pressure is the pressure measured when there is no flow, i.e. reading a pressure gauge just behind or at a closed valve is the static water pressure at that valve.

Where a municipal water supply is the irrigation source, new land development downstream along the municipal supply can mean reduced static pressure in the upstream pipes. For this reason, the system design should factor in a 10 percent reduction in static pressure of the water supply to accommodate future expansion of the supply system.

To ensure adequate pressure for all applicators, analyze pressure losses due to distribution and topography for each irrigation zone throughout the system to ensure applicators at locations with the least pressure are adequately pressurized. Careful choices in the layout of distribution lines can reduce the amount of pressure difference among the applicators within an irrigation zone, which will provide a more uniform distribution of water to the applicators.

If the actual operating pressure is higher than appropriate for the applicators, the system uniformity will be compromised. Pressure regulators are needed where excess pressures would occur. High pressures are common at the base of steep slopes.

- System design should fit the site's soil type, topography, and climate.

A good design includes obtaining direct knowledge of site conditions and not relying only on plot plans to generate a design. Taking measurements on site to verify actual pressure and flow rate is necessary for proper sizing of equipment. Also, base design on the soils at the site with adaptations made for soil variability around the site. While at the site, the designer should record possible microclimate variations. Important things affecting microclimate include the topography, shade from buildings and other structures, impervious areas, and soil conditions. The plant materials, the soil type, and microclimate influences will dictate different water needs for different areas. The soil type and site topography influence how the irrigation water will infiltrate into the soil and the potential for runoff problems around the site.

Precipitation rate is defined as the depth of water applied per hour. This rate of water applied is comparable to rainfall rate. Ideally, an irrigation zone's precipitation rate would not exceed the ability of the soil to absorb and retain the water applied during one application. For sprinkler zones in high clay content soils, heavily compacted soils, or on steep slopes, it may not be feasible to have a precipitation rate less than the basic infiltration rate. At such sites, low application rate is important, but flexibility of the control equipment is also needed to prevent runoff. The irrigation system controls should allow for intermittent water application for a series of cycles during one application event. Irrigation can be applied for repeated short intervals, switching the water between several irrigation zones. This allows the water to infiltrate between irrigation cycles, preventing the runoff that would occur with one long application period.

Typical weather conditions affect the changes in water needs with changing seasons. Hotter, drier, and windy climate conditions will mean higher water use for the plants in a landscape. Climates where maximum temperatures are not as high or do not persist will have lower water needs for plants. Because humid air is already close to saturation with water vapor, humid conditions limit the transpiration rate of plants. As a result, plants use less water in humid conditions than they would at the same temperature and sunlight levels in a drier climate.

Topography can also affect the pressure within the system. The site topography must be considered in

laying out irrigation zones. Steep areas can be isolated for better management in irrigation zones separate from zones for flatter areas. This allows for better pressure control and better irrigation management for topography differences. Flat areas at the base of a steep area may receive some runoff from the steep area and will need less irrigation water.

As part of a complete design, it is recommended that the designer include an average water use budget for the months that irrigation is typically required based on the local climate conditions. The expected monthly irrigation water usage is based on the historical evaporation or evapotranspiration for a given location. Table 4-2 on page 26 has an example average water use budget worked out for Atlanta weather and a typical sandy clay loam soil of that area. This budget does not take into account average precipitation. To deal with rainfall variability, a rain shutoff sensor and a controller set up with the water use budget will prevent over-watering. For more information on how to calculate the average water use budget, see Sidebar 4-1. Because an irrigation control system is often initially set to establish a new landscape, an average water use budget based on evapotranspiration provides a reasonable estimate for irrigation frequency and run-time once the landscape is established.

For more information on planning an irrigation system for the landscape, please refer to Georgia Cooperative Extension Bulletin 894 at http://pubs.caes.uga.edu/caespubs/pubcd/B894.htm.

- System design should consider the time available for applying irrigation.

Landscapes may have times when they are being used and irrigation is impractical. Irrigation systems should not be operating when the landscape areas are needed. For many soil types, traffic produces more damage and/or compaction when soils are near or at saturation. The destruction of the soil structure affects the health of the turfgrass, so there should be a period of little or no traffic immediately after irrigation water is applied. The required water supply flow rate should be adequate to provide no less than 70 percent of the peak water demand during the time available for application.

Another time constraint in Georgia is the mandatory watering schedule for the state. (See http://www.conservewatergeorgia.org for details of the mandated watering schedule for Georgia.) The state requires all commercial and residential landscape irrigation to follow a weekly alternate day schedule (Chapter 1). Therefore, an irrigation system must be able to apply all irrigation water that might be needed under peak water demands in three days or fewer per week.

**SIDEBAR 4-1: Example of Calculating an Irrigation Schedule for One Month**

**GIVEN:** Centipedegrass in the city of Atlanta on a sandy clay loam soil; a sprinkler irrigation system that applies 0.45 inch per hour net precipitation rate. (Net application means that the efficiency of the system is factored into the precipitation rate.) Calculate the water schedule and time of application for July.

**ASSUME** that centipedegrass requires about 5.4 inches of water from rain or irrigation in July. (The value of 5.4 inches was determined by looking at the historical evapotranspiration (ET) average for Atlanta at **http://www.griffin.uga.edu/aemn/**, the Georgia Automated Environmental Network. The average monthly ET was calculated to be 6.4 inches for July. Centipedegrass growing in Georgia has a crop coefficient of 0.85 for July, so 6.4 x 0.85 = 5.4).

**THE ROOT ZONE** for centipedegrass can be 2 to 8 inches deep; assume 8 inches. A sandy clay loam soil will hold about 2 inches of water available for plants per 1 foot of soil, so the 8-inch root zone for centipedegrass can store a total of about 1.33 inches of water for plant use. The root zone should be refilled when about 50 percent of the available water has been evaporated or transpired, so 1.33 x 0.5 = 0.67 inch of water to refill the root zone.

Ideally, an **IRRIGATION APPLICATION** would apply 0.67 inch of water to refill the root zone when evaporation and transpiration have used that amount. To apply the 5.4 inches needed in July will require 8 irrigation events (5.4inches ÷ 0.67 inch = 8.1, rounded to 8). Since there are 31 days in July, a schedule for irrigation that applies water evenly through the month would require irrigations 4 days apart (31/8 = 3.9 rounded to the nearest number of days). To apply 0.68 inch will take 1.5 hours or 91 minutes (0.68 inches/0.45 inches per hour = 1.5 hours).

In Georgia, a **WATERING SCHEDULE REQUIREMENT** allows irrigation only 3 days out of each week. For most places, this means that even-numbered addresses can water only on Monday, Wednesday and Saturday, and odd-numbered addresses can water only on Tuesday, Thursday and Sunday. This adds an additional constraint to the generic schedule already developed. With the state required watering schedule, irrigations cannot be spread evenly with 4 days between applications. The closest schedule to our calculated schedule would water twice a week, every other watering day available, i.e. Monday — Saturday — Wednesday — Monday, resulting in a 4- or 5-day interval between irrigations.

Determine a similar schedule for each month of the year, and adjust a controller monthly.

**Reference for Crop Coefficient for centipedegrass:**

Carrow, R.N. 1995. Drought resistance aspects of turfgrasses in the southeast: evapotranspiration and crop coefficients. *Crop Sci.* 35:1685-1690.

**Table 4-2. Irrigation schedule developed for sandy clay loam with Atlanta historical weather data.**

This schedule does not factor rainfall into application amounts or timing. The table includes a schedule for centipede turfgrass and for a bed of woody ornamentals. The centipede turfgrass is assumed to have an 8-inch active root zone requiring 0.67 inch net application to refill the root zone at 50 percent depletion, and to refill the 18 inches of root zone for the woody ornamentals bed would take 1.5 inches net application. For more details on how the schedule, run-time, and net application are calculated, see Sidebar 4-1.

| | | Centipede Turfgrass | | | | Woody Ornamentals | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | $ET_R$ (Inches) | $K_C$ | $ET_A$ (Inches) | Interval between Applications (Days) | Run-time Sprinkler (Minutes) | $K_C$ | $ET_A$ (Inches) | Interval between Applications (Days) | Run-time Sprinkler (Minutes) | Volume to Apply, Drip Irrig (Gal/week) |
| January* | 0.9 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| February* | 1.5 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| March | 3.0 | 0.85 | 2.6 | 8 | 91 | 0.70 | 2.1 | 30 | 300 | 1.2 |
| April | 4.4 | 0.85 | 3.7 | 5 | 91 | 0.70 | 3.1 | 15 | 300 | 1.8 |
| May | 6.0 | 0.85 | 5.1 | 4 | 91 | 0.70 | 4.2 | 10 | 300 | 2.4 |
| June | 6.5 | 0.85 | 5.5 | 4 | 91 | 0.70 | 4.6 | 10 | 300 | 2.7 |
| July | 6.4 | 0.85 | 5.4 | 4 | 91 | 0.70 | 4.5 | 10 | 300 | 2.6 |
| August | 5.5 | 0.85 | 4.7 | 4 | 91 | 0.70 | 3.9 | 10 | 300 | 2.2 |
| September | 3.8 | 0.85 | 3.2 | 6 | 91 | 0.70 | 2.7 | 15 | 300 | 1.6 |
| October | 2.7 | 0.85 | 2.2 | 9 | 91 | 0.70 | 1.9 | 30 | 300 | 1.1 |
| November* | 1.2 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| December* | 0.5 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| **Annual Total** | **42.4** | | **32.4** | | **728** | | **27** | | **2,400** | **67.8** |

* For Atlanta in these months, the evapotranspiration is minimal and usually there is excess rainfall, so no irrigation is needed.
$ET_R$ = Reference Evapotranspiration Estimate, inches.
$K_C$ = Crop Cooefficient.
$ET_A$ = Actual Plant Evapotranspiration Estimate, inches.

## Installing the Irrigation System

- Installation should follow the irrigation design specifications and component manufacturer's specifications.

When the contractor or installer and the designer for an irrigation system are not the same person, there should be interaction between the two as the system is being installed. If issues arise during installation that the contractor sees as problematic with the design, the contractor should consult with and get approval from the designer to make the appropriate changes.

Landscape designs and irrigation systems get modified at the time of installation for many reasons. It is important for the irrigation designer to be consulted prior to any changes to the design on paper to ensure that the change is within design performance specifications.

For example, when installing an irrigation system into an established landscape, the trenching close to large trees needs to be minimized to prevent damage to the trees. The undue stress of disturbing the root system of an established tree will reverse any benefits that an irrigation system might provide. This is the kind of decision that may not be addressed on the drawing board. But the installer will be able to recognize obstructions to the irrigation system created by the landscape that may not have been apparent during planning.

The designer should visit the site during installation to check for adherence to the design. Particular issues that the designer should check include:

- Service meter and backflow prevention assembly.
- Main line and other pipe sizes and layout.
- Valves and control wires.
- Irrigation system controller.
- Application devices and other water conserving devices specified in the design.

Before installation operations begin, the contractor or installer needs to verify that the point of connection (POC) flow rate, and static and dynamic pressures meet the design criteria. Neglect of this check at the outset can waste money and time for the installer when the system

does not work as expected. The installer is also responsible for making sure that the installation is in accord with the design specifications and the equipment manufacturer's published performance standards.

- Upon completion of the irrigation system installation, conduct a field performance audit to determine distribution uniformity and precipitation rates for each zone.

A field performance audit provides a measure of distribution uniformity and the actual precipitation rate of the system as installed. Precipitation rate and uniformity are needed to estimate accurate application time for each of the irrigation zones. This audit may be carried out by the installer or by a third party auditor.

An "as-built" set of drawings as shown in Figure 4-1 should be provided to the owner of the system that includes all system layout and component changes from the original design. At a minimum, the "as-built" set of drawings needs to include a site map showing the location of each POC, water meter, backflow prevention device, controller(s), irrigation zone valves, and irrigation zones served by each valve.

Either the designer, contractor, or installer should spend some time with the owner or operator of the irrigation system to make sure they are aware of:

- Irrigation scheduling recommendations for the landscape.
- Location of the controller, valves, sensors, pressure regulators, backflow device, metering device, and application devices.
- Operational requirements of the controller including advanced programming capabilities.
- Maintenance requirements for the system components.
- Product warranties and documentation of operating instructions for all equipment.

In the end, the most efficient irrigation system design with the most flexible controller does not conserve water unless the end user understands the basics of the irrigation system, the water requirements of plants, and the effect of weather conditions on need for irrigation. In Georgia, irrigation water is only a supplement to rainfall, which is the main source of water for landscapes. Conserving water with an irrigation system takes more time and more effort than conserving water without an irrigation system, and the owner should recognize this reality.

The irrigation schedule should include the expected monthly run-time of each irrigation zone in minutes. The run-time is based on the expected plant water requirement, effective rainfall, system precipitation rate, distribution uniformity, estimated application efficiency and the area of the sprinkler zones. The monthly minutes of run-time then need to be translated into a program that is entered into the controller for each month. To do this, divide the monthly station zone run-time into irrigation events. Next, divide the irrigation events into repeat cycles where needed to avoid runoff. See Sidebar 4-1 for an example of these calculations.

## Equipment Considerations

- Use a separate or secondary meter for the irrigation system.

Having a separate meter dedicated to the irrigation system allows for more accurate management of the irrigation system and makes it easier to find leaks, preventing waste of water. Initially, the separate irrigation meter will cost more than a combined meter. Depending on the local cost of water and wastewater treatment, the separate meter may have a quick payback period due to cost savings of water and sewer charges. Some local laws and codes do not allow separate supply metering for irrigation, so check with the local building codes office. If separate supply meters are not allowed, then it may be permissible to add an in-line meter dedicated to the irrigation system. This in-line meter will be no more expensive and will provide guidance for irrigation management.

If the water supply is a pumped source such as a well, then an in-line meter is also recommended. It is difficult to evaluate whether water is being used efficiently if there is no way to know how much water is being used for irrigation. Over time, the amount of water that a pump supplies and the system pressure will change with wear and age. Having a flow meter allows for adjustment for the symptoms of age.

- Size meters, pipe, and pumping systems for optimal performance.

For municipal water supplies, the maximum safe flow rate should be determined based on these three rules.

- The maximum allowable pressure loss through the meter should be less than 10 percent of the static pressure at the meter.
- The maximum flow rate through the meter should not exceed 75 percent of the maximum safe flow rate through the meter.
- The velocity of water through the service line supplying the meter should not exceed 7.5 feet per second (fps).

The design should allow for a reduction of 10 percent in the static pressure of the water supply to accommodate possible expansion in the supply network.

Use of an alternative water source rather than potable water conserves drinking water. With any alternative water source for pressurized irrigation, a pumping system will be needed to adequately pressurize the water. The alternative source and the pumping system must be able to provide sufficient pressure and flow rate to provide all of the irrigation zones with uniform application.

The distribution system is made up of the pipes, valves, and fittings that carry water from the supply to the applicators. The size and lengths of pipes will be dictated by the supply pressure and volume, pressure requirements of application devices, elevation changes, and distance that water must travel to reach each irrigation zone. To create a uniform application within a zone, pipes should be sized such that the variation in operating pressure among application devices within the same zone is 10 percent or less. Water velocities should not exceed 5 fps throughout the distribution pipes. Pressure regulators can keep low pressure applicators or applicators in low areas from having operating pressures that are too high. Thrust blocks and air release valves should be specified in the appropriate parts of the distribution system to eliminate system damage due to pressure surges.

For more information on landscape irrigation system components, planning an irrigation system, and pipe sizing, see Georgia Cooperative Extension Bulletin 894 at http://pubs.caes.uga.edu/caespubs/pubcd/B894.htm.

- Use lower trajectory sprinklers to minimize wind and evaporative losses.

Sprinklers with lower trajectories usually will have smaller diameters for a particular nozzle size and flow rate, and they also reduce the evaporative losses because water drops do not travel in the air as high or as far. The benefits of low trajectory sprinklers must be weighed against the increased number of applicators needed when the diameter of throw is less.

- Include rain shutoff and other sensor devices as appropriate for site conditions.

Any automated irrigation control system should have a rain shutoff sensor to stop irrigation if there is significant rainfall at the site. There are also other sensors that can stop irrigation due to freezing temperatures and/or wind conditions. These are not needed at all locations, while the rain shutoff sensor is applicable in almost any climate. Figure 4-9 is an example of a rain shutoff sensor.

**Figure 4-9.** A wireless rain shutoff device. The wireless style is more expensive but much less costly to install.

Rain shutoff sensors are relatively inexpensive and can be easily installed in current automated irrigation systems and new irrigation system designs. There are several mechanisms used by the sensors for determining how long the irrigation system should be turned off. Most can be adjusted for a certain amount of rainfall before the irrigation system is shut down. Rain shutoff sensors can be wired into the electrical controls or they can be wireless. The wireless sensors do not require the installer to have training in low voltage electrical installation to install them.

- Provide a system controller that has flexibility and capacity.

The irrigation control system should be only as complex and flexible as the system requires. The controller needed depends on the number of irrigation zones, variability of application devices in different zones, variability of water use zone water needs, soil variability, and local outdoor watering restrictions or guidelines. Minimum recommendations for an automated control system include:

- Three independent programs.
- Station run times from 1 to 200 minutes.
- Four start times per program.
- Odd/even and weekly interval programming capability up to 30 days.
- Water budgeting from 0-100 percent by 10 percent increments by program.
- 365-day calendar.
- Non-volatile memory or battery back-up.
- “Off,” “Auto” and “Manual” operation modes without disturbing programs.
- Rain shut-off device capability.
- Circuitry to signal when a station is shorted or a power failure has occurred.

- Use soil moisture sensing based on real-time weather based control for irrigation management.

Soil moisture sensors can be used to monitor soil moisture and suspend irrigation if the moisture reserve in the root zone is adequate. To do this, a separate common wire from the controller to each water-use zone station valve is required to allow for soil moisture sensor-based control of each water use zone.

Weather data measured on site and used to calculate water requirement can also be used to control irrigation application timing. Both real-time weather data and real-time soil moisture data are also available from satellites. This satellite data can be used to control irrigation systems and apply water only when the weather or soil moisture dictates a need. See Chapter 6 for additional information.

## Irrigation System Maintenance and Management

- Use the short cycle feature for low permeability soils or steep slopes to prevent runoff.

The more flexible irrigation control systems allow water to be applied in several cycles for one application. Cycling the water "on" and "off" within a water use zone prevents runoff by allowing extra time for water to infiltrate between cycles. This is necessary when the infiltration rate of the soil is lower than the applicator's precipitation rate or the irrigation zone is on a steep slope.

- Perform a thorough irrigation system inspection annually.

An irrigation system must be maintained so its performance remains consistent with the design specifications. Maintenance of the system should sustain an efficient and uniform distribution of the water. The maintenance contractor, owner, manager, or irrigation contractor needs to establish a periodic maintenance schedule for inspection and reporting performance conditions to the end-user (or owner) of the irrigation system. A map of irrigation zones is useful for writing down needed repairs and maintenance. At minimum, this thorough inspection should be done each spring. Inspection and reporting should include:

- Reviewing the system components to be sure they meet the original design criteria.
- Verifying that the backflow prevention device is working correctly.
- Verifying that the water supply pressure is within 10 percent of the design specifications.
- Verifying that pressure regulators are adjusted for desired operating pressure.
- Examining filters and cleaning filtration elements.
- Verifying proper operation of the controller, including confirmation of the correct date/time input and functional back-up battery.
- Verifying that sensors used in the irrigation system are working properly and are within their calibration specifications.
- Adjusting valves for proper flow and operation.
- Adjusting valve flow regulators for desired closing speed.
- Verifying that sprinkler and spray heads are properly adjusted. This includes checking the nozzle size, arc, radius, and height with respect to slope.
- Verifying that the applicators and risers are perpendicular to the actual slope.
- Verifying that other kinds of application devices such as drip emitters or drip tape are not clogged and have the expected flow rates.
- Repairing or replacing broken hardware and pipe; restoring the system to its design specifications.

- Repair or replace damaged or worn components in a timely manner, preferably before the next irrigation application.

Repairs need to be completed in a timely manner to support the integrity of the irrigation design and to minimize the waste of water. A visual inspection of irrigation systems should occur weekly or bi-weekly, depending on the size of the system.

Ensure that the replacement hardware used for system repairs matches the existing hardware and is in accordance with the design and installation plan. This is difficult if the owner or manager of the system has not been provided a complete set of design and installed specifications for the system. The repairs to a system should be tested and the end-user (or owner) notified of any deviations from the original design. Record any substantial changes made to the original design in the design plan records and drawings.

- Conduct a field performance audit on an irrigation system every 5 years.

A field performance audit is recommended every 5 years if proper maintenance is carried out on the system during that time. For a system that has not been maintained, the system should have an initial inspection and repairs made and then a field performance audit performed to test the system. Figure 4-10 (page 30) pictures a catch can layout for a performance audit to be performed on a turfgrass area.

Irrigation systems change with age, and any changes may reduce system uniformity. The original uniformity of the system is likely to change slowly over time for many reasons that cannot be controlled through regular maintenance, such as water supply pressure changes. A field performance audit will indicate if uniformity has declined and whether changes need to be made to the system. To adjust for changes in the system, irrigation management decisions need to be updated once the audit

**Figure 4-10.** Catch cans are laid out in a uniform grid for this version of an irrigation system performance audit.

is complete. The calibration of any sensor equipment that signals the control of the system should also be checked.

- As plants grow and mature, trim or remove vegetation that blocks the applicator pattern to preserve the intended distribution of irrigation water.

As the landscape matures, plants may interfere with applicator patterns. An easy solution is to trim vegetation that interferes with irrigation distribution, but sometimes trimming can upset the landscape's proportions. Another possibility is to add additional sprinklers or other hardware as required to compensate for blocked spray patterns or changes in the irrigation needs of the landscape. When making such changes, be sure system modifications do not cause landscape water demand to exceed the hydraulic capacity of the system.

- Carry out a regular winterization of the irrigation system if it will not be used for an extended period of time in the winter.

Freezing water and soil can damage irrigation system components. The best way to minimize damage due to freezing is to drain water from the system before freezing occurs. The irrigation controller should be turned off or set to a "rain" setting, if appropriate, to keep the main valve from opening. The main control valve, usually between the point of connection and the first irrigation zone, should be closed to stop water from entering the irrigation system in the winter. The valves for each zone should be opened to release all of the upstream water after the main control valve has been shut. Then pipes within the irrigation zones should be drained.

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# BMPs for Turfgrass Water Conservation in Landscapes

**Clint Waltz**

- Use a turfgrass that is best adapted to its region or microclimate. Plant selection and adaptation are the most important factors in planning, planting, and maintaining a lawn for water conservation. A properly selected grass species or cultivar is more likely to thrive and need fewer inputs (e.g. water, fertilizer, pesticides, etc.). Selection and adaptation include the influence of environmental factors as well as the ability of the turfgrass plant to withstand periodic dormancy.
- Irrigate each unique microclimate/zone within the landscape separately according to the needs within the microclimate or zone.
- Modify the root zone. Improvement in either the chemical or physical characteristics of the soil can reduce turfgrass irrigation needs by enhancing infiltration of rainfall, increasing soil moisture retention and promoting deeper rooting to reduce water leaching beyond the root zone. This practice involves understanding Georgia's soils. The water and nutrient holding capacity of the sandy soils in Coastal Georgia have different needs than the clay soils of the Piedmont and need to be modified or managed accordingly.
- Employ cultural practices that encourage minimal water use and accentuate root growth. These practices can be subdivided into four major categories: fertility, mowing, cultivation (i.e. aerification, top dressing, and vertical mowing), and pest management. Each component can affect turfgrass water use, and the interrelationship among practices can influence water uptake and use.
- Prior to irrigation, determine the need for supplemental water by checking the moisture level of the soil in the turfgrass root zone or using the turfgrass plant as an indicator of moisture stress. Allow plant factors to indicate a need for supplemental water. Apply only the amount of water the turfgrass needs to wet the root zone.
- Manage extrinsic stresses, like traffic. To reduce water use, maintain turfgrass stand density and promote survival during periods of drought stress, wear must be minimized. A thinned, weakened turfgrass will require more water for basic maintenance of physiological processes and recovery than a turfgrass that has ample cover despite being drought stressed.

## Introduction

Turfgrasses are the primary vegetative covers on airports, athletic fields, cemeteries, churches, commercial buildings, golf courses, home lawns, schools, parks, and roadsides. Healthy grass is an aesthetic asset, and a growing body of scientific evidence points to positive environmental and health contributions from lawns and other turfgrass areas. While turfgrasses are typically thought of for recreation and aesthetic value, they also provide a valuable environmental service by preventing soil erosion, the most common water polluting agent in Georgia, from wind and rain. Furthermore, turfgrass as a permanent vegetative cover can reduce runoff from rainfall, improve soil absorption and infiltration of water, and filter contaminates from polluted water.The Best Management Practices (BMPs) for turfgrass water conservation can be employed by all levels, from the well-trained turfgrass professional to the homeowner. The BMPs in this chapter are basic agronomic tools that will improve the overall health of the turfgrass plant and, in turn, will condition the grass to better withstand seasonal and prolonged drought.

- Use a turfgrass that is best adapted to its region or microclimate.

Plant selection and adaptation are the most important factors in planning, planting, and maintaining a lawn for water conservation. A properly selected grass species or cultivar is more likely to thrive and need fewer inputs (e.g. water, fertilizer, pesticides, etc.). Selection and adaptation includes the influence of environmental factors (e.g. temperature and shade) and the ability of the turfgrass plant to withstand periodic dormancy. Selecting the proper turfgrass is perhaps the most important factor in developing and maintaining an attractive and problem-free lawn. Base turfgrass selection on environmental conditions, turfgrass quality or appearance desired, and maintenance requirements. Environmental conditions to consider include temperature and moisture, shade adaptation, soil pH, and fertility. It is also important to realize that all turfgrasses have good and bad features. Base your selection on which turfgrass most nearly meets the criteria considered. Using grasses that have been genetically bred for an intended purpose or geographic region further enhances the turfgrass plant's ability to survive specific stresses. Through years of research, several turfgrass cultivars have been developed by The University of Georgia to suit Georgia's climate and conditions (e.g. 'TifSport' bermudagrass www.TifSport.com, and 'TifBlair' centipedegrass, www.TifBlair.com).Turfgrasses can be divided into two basic groups, cool-season grasses and warm-season grasses. Cool-season grasses grow well during the cool months of spring and fall when temperatures average 60-75 degrees F. They may undergo stress, become dormant, or be injured during the hot months of summer, and may require significantly more water than the warm-season grasses. These grass species are best adapted to the Georgia Piedmont and Mountain regions (Table 5-1). Warm-season grasses grow best during the warm months when temperatures reach 80-95 degrees F in the spring, summer, and early fall. They grow vigorously during this time and become brown and dormant in winter. These grasses can be grown statewide (Table 5-2). Environmental stresses include prolonged exposure to shade, drought, high temperatures, salinity, and cold temperatures. Furthermore, the microclimate in which the turfgrass is growing greatly impacts metabolic and morphological characteristics that are responsible for water use. For example, plants growing in the shade grow slower and, therefore, generally require less water than those in sunny environments. Management of environmental stresses falls into two primary categories: 1) selection of the most stress tolerant species or cultivar for a particular area, and 2) proper cultural and management practices to alleviate effects of the stress.

**Table 5-1. Adaptation and characteristics of cool-season turfgrasses relative to Georgia.**

| | Fine Fescue[s] | Kentucky Bluegrass[s] | Tall Fescue[s] |
|---|---|---|---|
| **Region Best Adapted:** | Mountains & Piedmont | Mountains | Mountains & Piedmont |
| **Adaptation** | | | |
| Heat hardiness | P - F | P - F | G |
| Cold hardiness | VG | VG | VG |
| Drought resistance | G | F - G | G |
| Sun tolerance | P - G | VG | F - G |
| Shade tolerance* | VG | G | G |
| Salt tolerance | P | P | F |
| Wear tolerance | F - G | G | G |
| Establishment rate** | Fast | Medium | Fast |
| Optimal soil pH range | 4.5-7.6 | 5.5-7.6 | 5.4-8.0 |

Key: E = Excellent, VG = Very Good, G = Good, F = Fair, P = Poor, VP = Very Poor
[s] Can be seeded
* Turfgrasses need at least 4 hours of direct sunlight per day.
** Establishment rate depends on planting date, seeding rate and environmental conditions.

**Table 5-2. Adaptation and characteristics of warm-season turfgrasses relative to Georgia.**

| | Bahiagrass[s] | Bermudagrass (common)[s] | Bermudagrass (hybrid)[v] | Carpetgrass[s] | Centipedegrass[sv] | Seashore Paspalum[v] | St. Augustinegrass[v] | Zoysiagrass[sv] |
|---|---|---|---|---|---|---|---|---|
| **Region Best Adapted:** | Statewide, excluding mountains | Statewide | Statewide | Coastal Plain | Statewide | Coastal Plain | Coastal Plain | Statewide |
| **Adaptation** | | | | | | | | |
| Heat hardiness | VG | E | E | E | G | E | E | E |
| Cold hardiness | F | P | F | VP | F | P | P | VG |
| Drought resistance | E | E | E | P | G | E | G | G |
| Sun tolerance | VG | E | E | G | VG | E | VG | VG |
| Shade tolerance* | G | VP | VP | P | G | P | VG | G |
| Salt tolerance | P | G | G | P | P | E | E | G |
| Wear tolerance | E | E | E | P | P | G | P | G |
| Establishment rate** | Slow to medium | Fast | Fast | Slow | Slow | Fast | Medium | Very slow |
| Optimal soil pH range | 6.5-7.6 | 5.1-7.1 | 5.1-7.1 | 4.7-7.1 | 4.0-6.1 | 5.5-7.5 | 6.1-8.1 | 4.6-7.6 |

Key: E = Excellent, VG = Very Good, G = Good, F = Fair, P = Poor, VP = Very Poor.
[s] Can be seeded.
[v] Vegetatively propagated.
* Turfgrasses need at least 4 hours of direct sunlight per day.
** Establishment rate depends on planting date, establishment rate and environmental conditions.

Additionally, environmental stresses can lead to increased weed, disease, or insect problems. These pests can compete with the turfgrass for water reserves or weaken the plant such that water uptake and use are severely impaired. Although these problems can be treated with chemical pesticides, the primary cause of the problem is typically an improper plant for the location or improper maintenance practices. A healthy turfgrass that is adapted to its surroundings is capable of resisting many pest problems. For long-term correction of these problems, either the grass needs to suit the environment or the environment needs to be altered. General practices that reduce environmental stresses include:

- Irrigate when the grass needs water.

Light and frequent irrigations lead to shallow root systems, while deep and infrequent irrigations stimulate deeper rooting. Over-irrigation leads to the failure of many lawns by increasing fungal problems and limiting the root system to the top few inches of the soil.

- Mow at proper heights.

Mowing below recommended heights removes a larger portion of the shoot tissue available for photosynthesis. This inhibits the ability of the grass to support itself or recover from injury. Using an improper mowing height is all too common; refer to Table 5-6 for proper mowing heights for grasses adapted to Georgia.

- Moderate nitrogen fertilization.

Nitrogen encourages the plant to form new tissue and grow. When nitrogen is applied in excess, the grass becomes more vulnerable to stresses. Fewer carbohydrate reserves are then available for recovery or avoidance of other problems.

- Irrigate each unique microclimate/zone within the landscape separately according to the needs within the microclimate or zone.

Most landscapes include shaded areas, with shade coming from either trees or buildings. Shade can have an effect on turfgrass growth, depending on the degree and duration of shade. In many landscape settings, grass will receive enough light for adequate growth even if an area is shaded during portions of the day. In some situations, however, a grassed area may be shaded for most or all of the day, making it difficult for the grass to obtain either adequate intensity or duration of light for growth. When the shade is from nearby trees, maintaining an acceptable turfgrass cover is compounded by competition from the tree for water and nutrients. Under shaded conditions, grasses will have elongated leaf blades and stems as they attempt to obtain sunlight by outgrowing plants next to them. This reduces the overall health and vigor of the turfgrass plant.

Trying to grow turfgrass in areas of heavy shade typically thins the grass canopy, thereby, exposing bare

ground that is conducive for weed growth and increases water losses through evaporation. More water is lost to the atmosphere by evaporation from exposed soils than those which have some type of ground cover (e.g. turfgrass, ornamentals, or mulch). Under conditions of heavy shade, it is generally not advisable to grow turfgrass. Consider other ground covers or mulch for these sites. For areas receiving moderate amounts of shade, however, certain species and cultivars are able to maintain suitable growth. Specific management practices also will encourage better turfgrass health under theses conditions.

Some species are particularly well suited for use in shaded areas. Within these species, certain cultivars sometimes maintain considerable advantages when grown in a shaded environment. Included in these species are:

**St. Augustinegrass** (*Stenotaphrum secundatum*): In general, this grass has the best shade tolerance of all the warm-season species. Although this grass has shade tolerance, it will also perform well in full sunlight. St. Augustinegrass cultivars that exhibit shade tolerance include 'Delmar,' 'Raleigh,' 'Mercedes,' 'Palmetto,' and 'Seville.' 'Floratam,' 'Floratine,' and 'Floralawn' exhibit moderate shade tolerance.

**Zoysiagrass** (*Zoysia* sp.): This warm-season grass has moderate shade tolerance and, like St. Augustinegrass, will do well in full sunlight. Generally, any cultivar of zoysiagrass will tolerate light to moderate shade.

**Turf-type Tall Fescue** (*Festuca arundinacea*): Because this grass is a cool-season species, it is best adapted to the climatic conditions of north Georgia. It has good shade tolerance and can easily be established from seed.

## BMPs for Turfgrass Grown in Shade Environments

- Reduce irrigation duration and frequency to turfgrass grown in shaded environments.

Because evapotranspiration demands are less, water usage is substantially reduced in shaded environments. If the irrigation system covers areas partially shaded and partially in sun, consider removing the irrigation heads from the shaded areas and irrigate by hand when rainfall is inadequate. If the shade is from nearby trees, the grass may undergo drought stress due to competition from tree roots. In these situations, using practices that encourage deep rooting of the grass and expanding ornamental bedlines are practices that can be employed.

- Increase the mowing height for grasses growing in the shade.

For instance, if you normally cut St. Augustinegrass or tall fescue at a 3.0 inch height, increase the cutting height to 4.0 inches. The increased mowing height allows for more leaf area to intercept as much available light as possible. In addition, leaf blades will be longer and narrower in the shade, and a lower cutting height will cause an excessive reduction in leaf length, which is harmful to the grass. Higher mowing heights will also promote deeper rooting, which is one of the key mechanisms of stress tolerance for turfgrasses.

- Reduce fertilizer applications to turfgrass growing in the shade.

Turfgrass grows more slowly in shaded environments, which reduces fertility needs. Too much nitrogen fertilizer depletes carbohydrates and produces a weaker turfgrass system. If you normally apply 4 pounds of nitrogen per 1,000 square feet yearly, apply 2 to 3 pounds for turfgrass growing in the shade. In shaded environments, limit any single fertilizer application to no more than 0.5 pounds of nitrogen per 1,000 square feet.

- Consider other ground covers.

Turfgrass is not always the best plant. Consider lirope (*Lirope* spp.), mondo grass (*Ophiopogon* spp.), Asiatic jasmine (*Trachelospermum asiaticum*), etc., for these areas. The listing of species and specific cultivars varies with time. Consult your local county Extension agent for updated recommendations for best adapted cultivars. The key to a successful landscape is the "right plant in the right place."

## Site Preparation

- Modify the root zone.

Improvement in either the chemical or physical characteristics of the soil can reduce turfgrass irrigation needs by enhancing infiltration of rainfall, increasing soil moisture retention, and promoting deeper rooting to reduce water leaching beyond the root zone. This practice involves understanding Georgia's soils.

From a classification standpoint, Georgia has relatively few soil types. However, due to the warm, humid climatic zone in which Georgia is located, the soils vary greatly. To improve water conservation, amending native soils prior to planting can be beneficial during the short establishment process and for long-term sustainability of the landscape. The water and nutrient holding capacity of the sandy soils in Coastal Georgia have different needs than the clayey soils of the Piedmont and, therefore, need to be modified or managed accordingly. Sandy soils have

little moisture or nutrient holding capacity. While the addition of some clay can improve water and nutrient holding capacity, it also makes the soil more prone to compact under traffic and normal use. In general, changing textural (percent sand, silt, and clay in a soil) and physical characteristics is more difficult than modifying the chemical characteristics, but these changes can be made to improve soils across Georgia. Furthermore, the organic matter content can have a tremendous effect on moisture and nutrient retention. Georgia's soils have relatively low organic matter contents and are considered highly leached.

For successful establishment and long-term health of turfgrasses, proper soil preparation is critical. Whether planting by seed, sprigs, stolons, or sod, the soil should be prepared similarly. The following steps are necessary for proper soil preparation.

**Take Soil Samples –** Soil sampling prior to establishment provides valuable recommendations for needed amendments such as fertilizer and lime. Adjusting the soil environment so chemical, nutritional, and physical properties are conducive for root growth can improve water use by the plant and reduce the need for irrigation once the grass is established. For more information on collecting soil samples, visit http://pubs.caes.uga.edu/caespubs/pubcd/L99.htm or contact your county Extension agent.

**Rough Grading –** If extensive grading is necessary, remove the topsoil, set aside, and replace it after the rough grade is finalized. Topsoil is the fertile soil with good tilth for root growth and proper drainage. A minimum of a 1 to 2 percent slope (1 to 2 foot drop in elevation per 100 linear feet) provides good surface drainage and minimizes the likelihood of saturated soils, which inhibit root growth. If, during this process, the subgrade soil becomes compacted by machinery, alleviate the compaction by deep tillage (6 to 8 inches). A physical hindrance from compacted soil can decrease the root zone depth and prevent water uptake from lower reserves. Also, avoid excessive slopes when feasible.

**Replace Topsoil –** Once the subgrade is established, spread 8 to 10 inches of topsoil over the subgrade. On steep slopes or where rock outcrops exist, 12 inches of topsoil are ideal for proper maintenance.

**Add Fertilizer, Lime, or other Nutrients –** Once the topsoil is spread and graded, add fertilizer and lime as indicated by the soil test report. Lime and fertilizer should be thoroughly mixed with the top 4 to 6 inches of topsoil. Generally, Georgia's soils are acidic, which makes the use of a liming agent (i.e. calcitic or dolomitic limestone) to increase the soil pH a common practice.

If the soil test report indicates a deficiency of calcium (Ca) or sulfur (S), gypsum (calcium sulfate) can be added to the soil. The calcium in gypsum is also helpful in neutralizing high levels of aluminum (Al). Unlike lime, gypsum does not affect soil pH. However, gypsum applications have been shown to reduce soil crusting, increase water infiltration, and improve the overall structure of the soil. Crusting, poor internal drainage, and weak soil structure are common characteristics of Piedmont soils. Although gypsum is relatively inexpensive, a potential source is from the recycling of scrap wallboard (sheet-rock) used in residential construction. Ground scrap wallboard can be beneficial in piedmont and coastal soils but, to maximize its benefits, ground wallboard should be incorporated into the upper 4 to 12 inches of soil. For more information on the use of scrap wallboard, refer to University of Georgia Cooperative Extension Special Bulletin #1223 and University of Georgia Cooperative Extension Circular #857.

**Add Organic Matter –** If organic matter is needed, add 1 to 3 cubic yards per 1,000 square feet of lawn area. Materials such as peat moss, well-rotted sawdust (at least 6 to 8 years old; the carbon to nitrogen ratio of the material should be below 40 to 1), or leaf litter serves well as organic material (Table 5-3). On heavy soils, add 8 to 10 cubic yards of sand per 1,000 square feet of lawn. All these materials should be mixed thoroughly with the native soil to a depth of 6 to 8 inches.

**Table 5-3. Soil amendments and their rate of application for soil incorporation.**

| Amendment | Volume (cubic yd) per 1,000 $ft^2$ | Depth (in.) before incorporated 6-8 in. deep in soil | C:N |
|---|---|---|---|
| Composted sludge[1] | 3 to 6 | 1 to 2 | |
| Sawdust[2] | 3 to 6 | 1 to 2 | 225:1 |
| Composted yard trimmings | 3 to 6 | 1 to 2 | 27:1 |
| Sphagnum peat moss | 3 | 1 | |
| Rotted farm manure[1] | 3 | 1 | 13:1 |

[1] With composted sludge and farm manure, do not apply additional nitrogen at establishment.
[2] Sawdust should be composted for 6 to 8 years to reduce any phytotoxic substances. Also, additional nitrogen may be required with the use of sawdust. Apply 2 lbs of actual nitrogen for each cubic yard of sawdust to aid decomposition and to ensure an adequate supply of nitrogen for the grass.

- Employ cultural practices that encourage minimal water use and accentuate root growth.

The cultural practices can be sub-divided into four major categories: fertility, mowing, cultivation (i.e. aerification, top dressing, and vertical mowing), and pest management. Each component can affect turfgrass water use, and the interrelationship among practices can influence water uptake and use.

After weather, cultural practices are the most important factors in determining how well an agronomic or horticultural program per-forms. The amount of water, fertilizers, or pesticides required for landscape maintenance is often directly related to the frequency and use of cultural practices. Cultural practices are management tools that improve the soil and environmental growing conditions for the plant, so stresses due to any number of factors are minimized or alleviated. Each component individually can affect turfgrass water use. In addition, the interrelationships between the practices can influence water uptake and use.

## Fertilization

Inadequate nutrition results in thin, weak plants that may be more susceptible to weeds, insects, and diseases. Certain diseases, such as rust and dollar spot, also occur in turfgrass maintained under low nutrient conditions. Over-fertilization can cause excessive growth of leaves, stems, and roots, which can result in increased water use, more maintenance, turfgrass decline, and increased susceptibility to pests. Therefore, understanding the fertility needs of specific turfgrass species is critical to a healthy sod.

Time fertilizer applications to maximize plant utilization and minimize environmental impacts. Weak plants may require a higher than normal nitrogen rate or other nutrients to get the turfgrass back to a healthy condition. Recognize that both quick- and slow-release fertilizers can fit into a sound management program. Table 5-4 is a suggested fertility program for turfgrasses grown in Georgia.

A basic understanding of the soil beneath the turfgrass is of tremendous benefit to developing a fertility program. A soil's physical and chemical properties can be obtained from published soil survey reports for each county in Georgia, see the local county Extension agent for additional information. Georgia's soils range from sands and sandy loams along the coastal regions and south Georgia to heavier soils that contain more clay in the Piedmont regions of north Georgia. In either case, Georgia's soils are well weathered and have poor nutrient holding capacity. However, they respond well to fertilization, which makes them conducive for growing many turfgrass species. Chemical properties such as soil pH; lime requirement; extractable levels of phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg); and selected micronutrients such as manganese (Mn), copper (Cu), and zinc (Zn) can be determined through soil testing. Soil samples are not analyzed for nitrogen (N) because it is highly mobile within the soil profile. Reliable relationships between turfgrass growth and soil test nitrogen have not been developed, so turfgrass N fertilization is based on the requirements of the individual turfgrass species being grown. Additional information on soil testing for turfgrasses can be found on the University of Georgia Turfgrass website (www.GeorgiaTurf.com).

## Mowing

Proper mowing has a tremendous effect on the appearance and water use of a lawn. Good mowing practices enhance turfgrass density, texture, color, root development, and drought and wear tolerance. Height of cut, frequency of cut, and type of mower used are all important factors to consider when mowing. Furthermore, dull mower blades tear leaves (Figure 5-1) instead of cutting them, thus reducing water efficiency, producing a poor appearance, reducing plant growth, increasing susceptibility to diseases and insects, and increasing fuel consumption.

Growth rates and mowing heights have the most influence on mowing frequency. The optimum mowing height is determined by the growth habit of the turfgrass species (Table 5-5). A grass that spreads along the soil surface, like bermudagrass and zoysiagrass, can usually be mowed lower than an upright-growing, bunch-type grass like tall fescue.

**Figure 5-1.** Torn grass leaf from mowing with a dull mower blade.

**Table 5-4. Suggested fertility program for Georgia lawns.**

| Turfgrass | J | F | M | A | M | J | J | A | S | O | N | D | Total lbs of N/1,000 $ft^2$/yr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bermudagrass, common & hybrid | | N° | | C | N | N | N | C | | | N° | | 2-4 |
| Carpetgrass | | | | C | | | | C | | | | | 1-2 |
| Centipedegrass | | | | C | Fe | | Fe | C | | | | | 1-2 |
| Seashore Paspalum | | | | C | N | N | N | C | | | | | 2-4 |
| St. Augustinegrass | | | | C* | C* | C* | C* | C* | | | | | 2-4 |
| Zoysiagrass | | N° | | | C | N | | C | | | N° | | 2-4 |
| Tall Fescue & Kentucky Bluegrass | | | C | | | | | | | C | N | | 1-3 |

C = Apply complete fertilizer (e.g. 16-4-8) at 1.0 lb N/1,000 $ft^2$ for high maintenance lawns or ½ lb N/1,000 $ft^2$ for low maintenance lawns. To improve winter hardiness, an additional potassium application may be needed at 1 lb K/1,000 $ft^2$ in late August through mid-September. Phosphorus is typically not needed on established centipedegrass lawns unless recommended by soil test results.

N = Water soluble inorganic nitrogen source (e.g. ammonium nitrate or ammonium sulfate) is applied at 1.0 lb N/1,000 $ft^2$ for high maintenance lawns or ½ lb N/1,000 $ft^2$ for low maintenance lawns.

Fe = Apply iron to provide green color without stimulating excessive shoot growth. Ferrous sulfate (2 oz in 3 to 5 gal of water per 1,000 $ft^2$) or chelated iron source may be used.

° = Fertilizing at this time is only for lawns overseeded with ryegrass.

* = To reduce chinch bugs and gray leaf spot problems on St. Augustinegrass, use a slow-release N source.

**Note:** Total yearly nitrogen rates are suggested guidelines. Actual rates depend on the desired aesthetics and location. Those desiring optimum aesthetics, located on sandy soils or with longer growing seasons in the Coastal Plain, may choose the higher rates. Fertilizing centipedegrass in excess of 2 lbs N/1,000 $ft^2$ yearly often causes excessive thatch, which may be a contributing factor to the phenomena of "centipede decline," and is not recommended.

Turfgrass undergoes physiological stress with each mowing event, particularly if too much leaf tissue is removed in a single mowing. The effects of this "scalping" can produce long-term damage to the turfgrass and leave it susceptible to moisture, insect, and disease stresses. Additionally, this upsets the balance between the grass shoots and roots.

**Table 5-5. Mowing calculations for ⅓ rule.**

| Desired Height | Mow when turfgrass is: |
|---|---|
| ----------inches ---------- | |
| 1 | 1⅜ |
| 1½ | 2 |
| 2 | 2⅝ |
| 3 | 4 |

As a general rule, mow a grass often enough so no more than one-third of the leaf blade is removed at any one mowing. For example, if a tall fescue lawn is mowed at a height of 3.0 inches, it should be mowed when it grows to a height of 4.0 to 4.5 inches (Table 5-5). If the grass becomes too tall between mowings, raise the cutting height, then gradually lower it until the recommended height is reached. Following this practice will minimize the effect of mowing and help maintain a high percentage of leaf surface area necessary for growth and root development.

**Table 5-6. Mowing height – lawn grasses in Georgia.**

| Grass | Mower | Height (inches) | Frequency (days) |
|---|---|---|---|
| Bermudagrass | | | |
| Common | Rotary or reel | 1-2 | 5-7 |
| Hybrid | | 0.5-1.5 | 3-4 |
| Centipedegrass | Either | 1-2 | 5-10 |
| St. Augustinegrass | Rotary | 2-3 | 5-7 |
| Seashore Paspalum | Either | 1-2 | 5-7 |
| Zoysiagrass | Reel | 0.5-2 | 3-7 |
| Tall Fescue | Rotary | 1.5-3 | 5-7 |

During stress periods, such as summer heat, it is a good idea to slightly raise the height of cut. This is especially helpful to the cool-season grasses because it reduces stress. Research indicates that grasses maintained at higher mowing heights have deeper root systems and improved drought tolerance. Also, raising the mowing height of warm-season grasses as fall

approaches will help the grass survive the winter months. It should be noted that "higher mowing heights" means increasing the height of cut to the maximum recommendation for a particular grass. For example, during periods of drought the height of cut for hybrid bermudagrass should be increased to 1.5-inches, the maximum recommended height for this species (Table 5-6). After drought or heat stress is alleviated, lower the height of cut gradually.

Research has shown that returning grass clippings to the lawn, sometimes referred to as "grasscycling," does not increase thatch build-up. A thatch layer is an accumulation of dead plant material at the soil surface composed of turfgrass stems, rhizomes, stolons, and roots. Thatch prevents penetration of water into the soil, harbors insects and disease organisms, and leads to a shallow-rooted grass that is susceptible to heat, cold and drought stresses.

Clippings are mostly water with significant nutrient value, and they decompose rapidly. In fact, grasscycling will recycle plant nutrients, reduce fertilizer requirements, and improve soil structure by increasing soil organic matter. The rate of thatch development can be minimized by following proper mowing, irrigation, and fertilization practices. If clumping occurs, distribute by re-mowing, lightly raking, or using a power blower. In cases where clipping are so thick that sunlight does not reach the growing turfgrass, consider collecting the clippings.

For more information on grasscycling, visit http://pubs.caes.uga.edu/caespubs/horticulture/grasscycling.html.

## Best Mowing Practices for Turfgrass Water Conservation

- Check the mower for adjustment to the proper mowing height for the grass.
- Mow with a sharp blade to prevent leaf tearing, which encourages excess water loss and weakens the plant.
- Never remove more then one-third of the foliage at one time.
- Adjust cutting height by setting the mower on a driveway or sidewalk and using a ruler to measure the distance between the ground and the blade.
- Practice grasscycling and return the clippings.
- Compost if you must collect clippings. Use the compost as a soil modifier or mulch. If pesticides have been used on the turfgrass, check the label for composting restrictions.

**Figure 5-2.** Vertical mower.

## Cultivation

Cultivation of turfgrasses includes vertical mowing, coring, and topdressing. These operations reduce surface compaction and thatch accumulation, improve soil aeration and water infiltration, and promote root growth. All these benefits produce vigorous, healthy turfgrass and encourage water conservation.

Vertical mowing or dethatching helps keep turfgrasses healthy by removing the dead vegetation from the thatch layer. This dead material is lifted to the surface by the blades of the vertical mower (Figure 5-2). This operation should be done in two directions at right angles for bermudagrass and zoysiagrass.

Vertical mowing is best done when the grass is actively growing and soil temperatures are consistently above 65 degrees F. It may be done prior to green-up, but waiting to vertical mow during green-up can be very risky because the grass can be damaged significantly as it begins to grow. Take care not to remove too much from St. Augustinegrass and centipedegrass lawns because they do not have underground runners to rejuvenate new plants. Even though zoysiagrass does have underground runners, it can also be injured by excessive thinning.

Coring relieves soil compaction and increases air and water movement into the soil (Figure 5-3). This practice is particularly useful on clayey soils, common in the Piedmont. Sandy soils can benefit from coring also. Additionally, coring stimulates decomposition of thatch and organic matter. Proper coring is best accomplished with a power aerator equipped with hollow tines or spoons that remove a soil core 2 to 3 inches deep and ½ to ¾ inch in diameter.

**Figure 5-3.** Extraction of soil cores helps to relieve soil compaction and increases air and water movement into the turfgrass root zone.

Coring is best accomplished during periods of active plant growth and when the soil is moist, which allows deep penetration. Coring, also called "aeration," corrects soil problems and may be the most effective cultural practice.

Topdressing is a management practice used to speed thatch decomposition, to reduce surface compaction, and to smooth the surface. Topdressing involves spreading a thin layer of topsoil or other soil mix on the soil surface. The topdressing material should have a texture and composition similar to that of the underlying soil. Topdressing rates range from ½ to 2 cubic yards of material per 1,000 square feet. This produces a layer from 1/8 to 5/8 inch thick. However, it is important that distinct layers are not formed. The topdressing material is usually worked into the turfgrass by dragging, raking or brushing.

Fertilization a week or two prior to cultivation stimulates rapid turfgrass recovery and promotes a healthy, vigorous turfgrass. Do not dethatch or core during a period of heavy weed germination, or appropriate weed control measures will be necessary. Interestingly, coring has not been shown to reduce the efficacy of previously applied preemergence herbicides.Figure 5-2. Vertical mower.

## Integrated Pest Management (IPM)

Although the use of pesticides to control diseases, insects, nematodes, and weeds remains an integral part of turfgrass management, promoting a healthy and vigorous turfgrass with good plant density is the best method of minimizing pest problems and improving water conservation. Pests either weaken the turfgrass, which leads to bare ground and losses of soil moisture, or compete with turfgrass for needed water and nutrients. It is the impact of pest pressure that influences the efficiency of turfgrass water usage. Therefore, the management of turfgrass pests can improve turfgrass water conservation by restricting water losses to the atmosphere and reducing competition for resources.

## BMPs for Turfgrass Water Conservation

- Properly identify the pest problem prior to any pesticide application.
- Apply pesticides correctly and according to label instructions.
- Calibrate distribution equipment (i.e. sprayers and spreaders) before each pesticide application.
- Make applications when environmental conditions are most favorable. Make applications when conditions for drift are minimal and avoid application when heavy rain is imminent.
- If the label calls for "watering-in," or activating the pesticide, irrigate as directed.
- Granular applications should be targeted away and removed from impervious surfaces and bodies of water.
- Always follow the label for proper disposal of pesticide containers; triple rinse and render unusable.

Cultural practices themselves do not control pests, but they help produce a healthy vigorous stand of turfgrass more resistant to pest problems.

## Irrigation

- Prior to irrigation, determine the need for supplemental water by checking the moisture level of the soil in the turfgrass root zone or by using the turfgrass plant as an indicator of moisture stress.

Allow plant factors to indicate a need for supplemental water. Apply only the amount of water the turfgrass needs to wet the root zone. For many plants and crops, there are growth periods when water is critical to physiological and reproductive processes. For most homeowners and turfgrass managers, fruit set and seed production are not important processes. Basically turfgrass needs water to maintain growth. The exception to this is during establishment, when water requirements would be the greatest. Once established, turfgrass requires relatively little water for survival (Table 5-7). In fact, research conducted in Georgia supports the recommendations that turfgrass requires approximately 1 inch of water per week.

Newly seeded, sprigged, or sodded lawns will require frequent irrigation intervals. Seed and sprigs will need to be kept moist but not saturated during the initial establishment period. Often multiple (four or five) irrigations

per day will be necessary, especially if the temperature is high, the humidity is low, or the wind is blowing. This watering regime can continue for 2 to 3 weeks until a root system is developed, at which time the frequency can be reduced but the duration should increase to encourage deeper water penetration into the soil profile. Under favorable conditions, most lawns are considered established after the third mowing, which could occur as soon as 1 month following initial establishment. Because more plant material and root system accompanies sodded turfgrass, this process is typically shortened and it is reasonable to expect a sodded lawn to be established in 30 days. If seedlings, sprigs, or sod are allowed to dry out, loss of turfgrass and a poor stand would be expected.

**Table 5-7. Daily water use of turfgrasses grown in Georgia (Carrow, 1995).**

| Turfgrass | Mean ET (in/d) | Drought Resistance |
|---|---|---|
| Common bermudagrass | 0.12 a[1] | Very high |
| 'Tifway' bermudagrass | 0.12 a | Very high |
| 'Raleigh' St. Augustinegrass | 0.13 ab | High |
| Meyer zoysiagrass | 0.14 ab | Moderate - Low |
| Rebel II tall fescue | 0.14 ab | Moderate - Low |
| K-31 tall fescue | 0.15 b | Moderate |
| Centipedegrass | 0.15 b | High |

[1] Means followed by the same letter are not significantly different.

Once established, a minimal amount of wilt should be allowed prior to applying irrigation. When grasses wilt, they take on a dull purplish cast and leaf blades begin to fold or roll. These are normal defense mechanisms that the turfgrass uses to conserve water. Contrary to what some believe, these are not the first signs of turfgrass death. With observation and experience, a turfgrass manager can look for the first signs of wilt, off color, foot-printing (evidence of foot-tracks after someone walks across a lawn), and leaf rolling, and then determine the optimum number of days between irrigations.

In Georgia's climate, where drought conditions are erratic and inconsistent from year to year, both warm- and cool-season grasses can be allowed to enter a drought-induced dormancy. In this situation, grasses adapted to Georgia may become dormant in the absence of natural rainfall but, once adequate water is again available, the grass resumes growth. Many home lawns do not have irrigation systems and are allowed to dry during drought periods, yet the grasses in these lawns green-up once weather conditions are conducive for growth. During periods of severe moisture stress, supplemental irrigation is necessary for survival of some turfgrass species. Irrigation should be judicious, applied when water can be optimized, and used to minimally sustain the turfgrass plant during these conditions.

Excessive or over-watering may increase weeds, insects, and diseases. For example, over-watering during cooler months can encourage weed growth. Conversely, other pests thrive under extremely dry conditions and will compete with desirable plants. Chinch bugs and spurge are examples of pests that attack turfgrass when the soil is too dry. A balance is necessary to keep the landscape strong and healthy.

Too much water from over-irrigation or poor drainage can cause additional problems. Plant roots can be deprived of oxygen in waterlogged conditions. The consequence is the turfgrass root system is damaged when roots die and can no longer uptake water and nutrients. Shortly after root loss, browning of turfgrass leaf tips and edges are the signs of a declining plant. Far too often, this problem is misdiagnosed as drought stress and water is added, further exacerbating the situation. The simple cure is taking the time to probe the soil profile. If the soil is wet, withhold irrigation.

It is not uncommon to find irrigation systems set to apply light daily sprinklings. This type of irrigation scheduling can be just as harmful as over-watering. Frequent light applications wet just the upper 1 inch or less of the soil. While turfgrass roots can grow to depths of 3 feet, most roots are in the upper 6 to 12 inches. Water applied from light frequent irrigations never reaches the roots growing at the lower depths and encourages shallow rooting. It is optimal for irrigation to be applied in two to three equal applications per week, depending on the soil type and infiltration rate, for a total of 1 inch of water per week. This practice promotes water infiltration deeper in the root zone and improves moisture retention. To achieve depth control of watering, an irrigation audit should be performed and the automatic irrigation system reprogrammed. An additional benefit to this watering practice is retaining nutrients in the root zone, where the turfgrass plant can use any applied fertilizer and the nutrients are not leached into the groundwater.

Turfgrasses growing in sandy soils, which have a limited capacity to retain moisture, can benefit from supplemental irrigation during periods of low rainfall. Even during rainy periods, evapotranspiration (water loss from plants and soil) occurs between showers and may mandate supplemental water, especially during establishment.

Determining and controlling the rate, amount, and timing of irrigation-water application can minimize soil

erosion, runoff, and fertilizer and pesticide movement. The irrigation system's application rate should not exceed the infiltration rate of the soil. This will prevent surface pooling and maximize efficiency of water percolation. Various sensors can be integrated into automated irrigation systems to improve water application, use, and conservation. Rain shutoff sensors are used to prevent systems from activating during rainfall (Figure 4-9). These sensors are relatively inexpensive and currently available for most automated irrigation systems. Soil moisture sensors can be employed to guide turfgrass managers or trigger an automated system to activate based on the moisture status of the soil (see Chapter 6). If soil reserves are adequate, sensors delay the system from irrigating until moisture becomes limiting.

Timing of irrigation is also important. There is a rule of thumb to "never put your grass to bed wet." Watering in the early morning is ideal because there is less wind and the temperatures are low, so evaporative losses are minimized. Morning watering also reduces the time the turfgrass canopy stays wet and conducive for disease infestation. Wet the soil to a depth of 8 to 12 inches. Soil types affect the amounts of water needed to wet soil to a desired depth. Consult your county Extension agent for specific information regarding the soil characteristics in your area.

## Extrinsic Stresses

- Manage stresses, like traffic.

To reduce water use, maintain turfgrass stand density, and promote survival during periods of drought stress, minimize wear. A thinned, weakened turfgrass will require more water for basic maintenance of physiological processes and recovery than a turfgrass that has ample cover despite being drought stressed. Proper management of extrinsic stresses, like traffic and plant competition, help reduce water use by maintaining turfgrass stand density and promoting survival during periods of drought stress.

In areas of heavy traffic, turfgrass stands benefit from periodic changes in pedestrian flow. These changes can be short in duration (i.e. 2 to 5 days) but significant in improving long-term grass health. Alleviating wear stress gives the turfgrass an opportunity to recover while producing new shoots and roots. It should be noted that alternating traffic patterns alone is generally not enough to prevent turfgrass decline in high use areas. These practices coupled with multiple core cultivations are commonly necessary in the heavily trafficked areas. In extreme cases, where excessive foot traffic causes worn spots or paths to develop, grassed areas can be replaced with a mulched path or a stepping stone walk.

**Figure 5-4.** Influence of tree roots on turfgrass drought stress.

Competition for water from surrounding plants, especially trees with shallow root systems that extend well away from the drip-line (e.g. sweet gum, maple, and others), can induce turfgrass drought due to water removal by the tree (Figure 5-4). The selection and implementation of cultural practices that encourage deep rooting help improve the competitive ability of the turfgrass. The most practical solution is to extend the mulch line and not attempt to grow grass so near a highly competitive plant species.

# Emerging and Existing Technologies for Landscape Water Conservation

**Clint Waltz and Gary Wade**

As water conservation and usage become more important issues, individuals will be forced to make more judicious use of water resources. Professional landscape and turfgrass managers will have to justify the use and volume of water and forego the days of indiscriminate irrigation. Since soil in the root zone acts as a storage reserve for water, an understanding of the soil moisture status is essential for efficient irrigation practices. Many methods to schedule or guide irrigation have been used. Some methods are qualitative (based on visual inspection), while others are quantitative (measured directly with instruments).

The method most commonly used for assessing moisture status is visual inspection. An early symptom of moisture stress is "wilt," a physiological condition that occurs when the cells within the plant lose turgor pressure. Before plants wilt, they usually change from a healthy green color to a bluish hue. As wilt progresses, the leaves of some plants will turn a purplish-black color. In the case of severe moisture stress, turfgrass will turn a brown straw-like color. If detected early and sufficient irrigation applied, many turfgrass species will regain turgor pressure and the green color will return within a few days. In the case of prolonged drought, turfgrass may enter into an induced dormancy, at which time growth will continue only when water is no longer limited.

Other characteristics of wilt on turfgrasses include narrowing of the leaf blade and an increase in the turfgrass canopy temperature. At the onset of moisture stress, a temperature increase can be detected by placing one hand on green grass and the other hand on stressed grass, much as a parent would check a child for fever. While visual and sensual assessments are quick and relatively easy, they are purely qualitative and more subject to error.

A physical measurement of water is a quantitative assessment of the plant moisture status or water content within the root zone. There are many quantitative methods of measuring plant and soil moisture status. Some are destructive (i.e. require destroying a part of the plant or removing a core from the soil) and take time to generate needed information. New technologies have been developed and are currently being investigated that are non-destructive and can be assessed in real time.

Researchers have continually shown that efficient water management can be achieved by using a reliable device to guide irrigation. The use of instrumentation, or sensors, permanently buried into the root zone is an old concept of determining soil moisture status. New technologies are making soil moisture measurement more accurate and convenient. Various types of instruments measure moisture content, including porous blocks, thermal dissipation blocks, tensiometers, and dielectric constant probes. Each instrument has positive and negative attributes. Permanently buried sensors can be valuable tools in the decision process of when to irrigate and how much water to apply.

Contemporary sensors coupled with data logging equipment can archive data and maintain a historical record of water use. This feature will allow managers to document water use and provide quantitative data to water authorities for future water planning.

## Probes for Water Conservation

### Tensiometers

When compared to a set irrigation schedule, Morgan and Marsh (1965) reported that irrigation guided by tensiometers installed at two depths (5 cm and 12.5 cm) in a clay loam soil could reduce water use by 83 percent. On bermudagrass, Augustin and Snyder (1984) were able to use 42 percent to 95 percent less water using tensiometer-guided irrigations compared to plots that received daily irrigation. Improved root vigor and depth were also observed when tensiometers were used to guide irrigation practices. Morgan et al. (1966) reported less compaction under tensiometer-guided irrigation compared to set irrigation schedules. Appropriate irrigation practices can also influence nutrient leaching. In a sandy soil, Snyder et al. (1984) observed a reduction in nitrogen leaching under tensiometer-guided irrigations.

### Dielectric Probes

A new technology used to measure soil moisture is the measurement of the soil dielectric constant (DC). The DC of dry soil ranges from 2 to 5, while the accepted DC value for water is 78. Evaluating the difference between

dry soil and water, soil moisture content can be determined. Greater moisture contents cause higher DC values while lower DC readings indicate reduced moisture content. Two basic types of probes measure DC, time domain reflectometry (TDR) probes and capacitance probes (CP).

Time domain reflectometry is a technique that provides reliable, instantaneous readings. TDR operates by emitting an electromagnetic pulse from a source through a wire into two parallel probes in the soil. An instrument is used to measure the return speed of the pulse to the source. The time for the pulse to travel down the wire, through the probes, and return to the source is a function of the DC of the media surrounding the probes, soil for example. The DC is directly related to the amount of moisture in the surrounding soil. When the soil contains moisture, the return time is slowed due to the high DC of water.

Like TDR, CP measure water content based on soil DC. Capacitance probes can be buried in the soil, are small [about twice the size of a golf ball (Figure 6-1)], and are easily integrated into automated data collection systems. As a result, CP can provide real-time moisture information so managers can quickly and accurately assess moisture in individual landscapes. To further improve soil moisture readings, some CPs also measure soil salinity and temperature along with DC. With further research and advancements in technology, CP may prove to be an economically justifiable tool for guiding irrigation practices in turfgrass areas.

### Other Probes

Other types of probes have been used to determine soil water content. Freeland et al. (1990) used parallel, bare wire ends to measure soil resistivity, which was converted to soil moisture content. While this technique is inexpensive, rapid, and useful in measuring relative moisture contents, sensors are sensitive to fluctuating soil temperatures, compaction, and soil salinity.

**Figure 6-1.** Commercially available capacitance probe.

Song et al. (1998) used a dual probe heat-pulse technique to measure soil moisture in laboratory packed columns seeded with 'Kentucky 31' tall fescue. The dual-probe heat-pulse technique is nondestructive, easily automated, and not sensitive to soil bulk density. However, the accuracy is subject to soil temperatures and low water content.

Another type of probe used to measure soil moisture is thermocouple psychrometers. This technique is based on measuring the relative humidity of a sample and relating it to water potential. Unfortunately, due to temperature differentials when buried in the upper 12 inches of soil, the reliability of thermocouple psychrometers was compromised (Brown and Oosterhuis, 1992). Although very sensitive, this technique is not practical because a calibration curve is required and it shows a lack of reliability in shallow soils.

## Environmental Guided Irrigation

### Evapotranspiration (ET)

Another method used to guide irrigation is based on estimated daily evapotranspiration rates. Evapotranspiration is the combined loss of water through plant surfaces and evaporation of water from the soil. Local weather information (i.e. temperature, relative humidity, wind velocities, solar radiation, etc.) is used in an equation to estimate the amount of moisture lost through ET. Irrigation is then applied to compensate for the moisture lost.

Several ET models are used to guide turfgrass irrigation. Fry et al. (1997) found turfgrass species, mowing height, and nitrogen fertility can influence the accuracy of ET models. Certain models may also provide more accurate estimates in one part of the country compared to another. When the proper information is used, ET can be an effective method of managing water resources. However, using ET to guide irrigation requires the input of many factors and site specific calibration.

In Irvine, California, ET data from local weather stations is used by a water provider to develop site specific water allocations, called "water budgets," for customers. The formula is rather complicated and involves knowing not only evapotranspiration, but also a crop coefficient, the efficiency of the irrigation system, and the landscaped area of the property (Equation 6-1). It also requires the property to be on a separate meter for monitoring outdoor water use. The utility uses a conservation rate structure to reward customers who use less than their allocated water budget and penalize those who use more than they are allocated. A customer who uses

**Equation 6-1. Irvine water district water budget equation.**

$$\text{Site Water Budget} = (ET \times K_c \times LA) / IE$$

ET = evapotranspiration
$K_c$ = crop coefficient
LA = landscape area
IE = irrigation efficiency

less water than allocated may receive a rebate on their water bill, while those who exceed their allocation by more than 200 percent may experience a bill as much as eight times higher than the base rate. For this community, their conservation pricing structure has resulted in a 45 percent reduction in residential water use.

Irrigation controllers that receive ET data directly from weather stations via a satellite link are on the market. The controller automatically calculates an irrigation schedule based on local weather data and landscape characteristics, and then sets the most efficient watering schedule for the site. When a rainfall shutoff sensor (Figure 4-9) is coupled with this controller, the controller manages the irrigation system. Once a landscape is established, the landscape parameters set in the controller may need to be adjusted to improve water-use efficiency. Once the site characteristics are optimized, no human intervention is needed.

Although personal sensory methods for assessing water for turfgrass will always be employed, instrumentation will become a more important part of irrigation scheduling to more accurately justify irrigation water use. As technology improves and water restrictions are levied, professionals and homeowners will have to justify water usage. A tool that provides reliable soil moisture status and records daily water status will be of potential benefit. Of the probes discussed, capacitance probes may offer an affordable option to guide water usage with a high degree of accuracy. Because of their small size, they do not interfere with standard cultural practices. Continued research will likely show these probes can improve water conservation and reduce the common deleterious effects of improper water management (i.e. soil compaction and nutrient leaching).

**Figure 6-2.** The Weather Track controller receives ET data and automatically schedules irrigation.

## Rainwater Harvesting

Rainwater harvesting is an old concept gaining renewed interest. Thomas Jefferson harvested rainwater from the roof of his Monticello estate and stored it in a cistern for use in his home and on the farm.

Today, rainwater harvesting is practiced on tropical islands where fresh water is limited or unavailable. It is also used in the arid regions of the United States. Due to abundant annual rainfall and common summer drought, practical application of rain harvesting in the southeastern United States is limited. Harvesting water during rainy periods, then reusing it during dry periods, can minimize or eliminate the reliance on public water supplies for outdoor irrigation. Rainwater harvested from roofs is not considered gray water.

Rainwater harvesting involves collecting water from roofs and hardscape surfaces such as driveways (Figure 6-3), storing it in a tank, and then pumping it via irrigation to the landscape as needed. Tremendous amounts of water can be harvested from roofs (Table 6-1).

**Table 6-1. Roof catchment potential of a 2,500 ft$^2$ asphalt shingle roof.**

| Rainfall amount (inches) | Volume harvested (gallons) |
|---|---|
| ¼ | 355.3* |
| ½ | 710.6 |
| ¾ | 1,065.9 |
| 1 | 14,212.0 |

* See Sidebar 6-1 for how to calculate the volume of water harvested from a roof.

One of the greatest impediments to rainwater harvesting in Georgia is sufficient storage capacity. A 1,400 gallon tank (Figure 6-4) installed below ground can be filled to capacity during a 1-inch rainfall (Table 6-1). Furthermore, installing a large tank below ground requires the excavation of a hole the size of a small swimming pool. This may be undesirable to the property owner and causes considerable soil disturbance. Above-

**Figure 6-3.** Water is harvested from roofs and hardscape surfaces into an underground storage tank.

**Figure 6-4.** A fluted underground PVC storage tank that holds approximately 1,400 gallons.

**Figure 6-5.** Above-ground tanks are difficult to conceal, particularly in a residential landscape.

**Side Bar 6-1. Example calculating the volume of water from a roof.**

**Basic Equation:**

Roof catchment = roof area ($ft^2$)
× catchment coefficient
× gallons per cubic foot (7.48 gal/$ft^3$)
× rainfall (ft)

How much water can be collected from a ¼-inch rainfall onto a 2,500 $ft^2$ roof with asphalt shingles?

- ✓ Catchment coefficient of asphalt shingles = 0.95
- ✓ 1 $ft^3$ of water is equivalent to 7.48 gallons
- ✓ ¼-inch = 0.02 ft

Roof catchment =
2,500 $ft^2$ × 0.95 × 7.48 gallons/$ft^3$
× 0.02ft = 355.3 gallons

ground tanks can be used, but they are not visually appealing and difficult to conceal (Figure 6-5).

## Alternative Water Sources

Like rainwater harvesting, another strategy for water conservation is to irrigate using non-potable water sources such as runoff collected in ponds, effluent (also referred to as treated wastewater and reclaimed water), grey water, poor quality ground water, seawater, or blended seawater. Treated wastewater does not require treatment up to the level of potable water, yet may still be an acceptable water source for irrigation of landscape plants. Turfgrass irrigation water quality guidelines are similar to those used for other crops with some refinement (Duncan et al., 2000; Huck et al., 2000). Use of alternative water sources, especially reclaimed wastewater, can reduce demands on potable water while providing an irrigation resource during periods of drought.

Similar to an overall water conservation program, the integration of the BMPs is essential to the success of using reclaimed wastewater for landscape irrigation, particularly in nutrient management. Some beneficial nutrients are typically associated with treated wastewater. Reclaimed water generally contains more nutrients than potable water, and these nutrients can occur in appreciable amounts. An added benefit to using wastewater is that managers may be able to reduce fertilization applications and expense due to the application of "free" nutrients being delivered through the irrigation lines.

To maintain a balanced fertilization program, the nutrient additions from the wastewater must be considered as part of the on-going fertilization program. Furthermore, water quality can change during the year and can vary from source to source; reclaimed water quality in urban environments can be different than reclaimed water quality in rural areas.

While use of reclaimed wastewater can be a significant component in water conservation practices, the treated water should be properly managed to prevent extraordinary problems. Depending on concentration and level of use, nitrogen and phosphorus loads can influence algae and aquatic weed growth in reservoirs. Additionally, reclaimed water can contain chemical constituents like salts, sodium, and nutrients that could have adverse effects on plants and soils. Specifically in Coastal Georgia, use of water affected by salt-water intrusion may create complex soil problems. Typically, these problems are site-specific and require a high degree of management to prevent and mitigate adverse impacts.

For these reasons, periodic water quality tests are valuable to help adjust fertilizer applications, monitor seasonal variations, and gain an appreciation for the quality of reclaimed water. A good water quality test

determines the particulate, biological, and nutrient load of the wastewater. For quality control and regulatory purposes, water treatment facilities test their wastewater routinely. But for an independent analysis, The University of Georgia Agriculture Services Laboratory (http://aesl.ces.uga.edu) can test water quality. If water quality remains rather consistent, annual testing may suffice. Consult your county Extension agent for further information. For turfgrass water quality guidelines visit www.TurfgrassWater.com

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# The Economic Benefits of Landscape Water Conservation

**Gary L. Wade**

In addition to the numerous environmental benefits of water-saving landscape practices discussed in this publication, water-wise landscapes also are economical. Landscape professionals, water purveyors, and elected officials can all capitalize on the concept of saving money while protecting the environment. All it takes is a simple cost/benefit model using local water and sewage costs. This chapter provides an example of such a cost/benefit model.

The first step is to determine the cost of water and sewage for the city in which a client's landscape is located. This can be done by contacting the municipality or water purveyor and asking for the water and sewage rate structure for the area; this is public information. Table 7-1 shows water and sewage cost per 1,000 gallons for 10 cities in Metro Atlanta during 2004. These cities were chosen for this model because they all have a "uniform" rate structure, which means that the price of water and sewage is directly proportional to the amount of water used.

**Table 7-1. Water and sewage cost per 1,000 gallons for 10 cities in Metro Atlanta.**

| | Costs* | | |
|---|---|---|---|
| City | Water | Sewage | Water + Sewage |
| | $ | | |
| Canton | 3.71 | 3.71 | 7.42 |
| Cartersville | 2.43 | 2.73 | 5.16 |
| Cumming | 2.53 | 2.12 | 4.65 |
| Dallas | 4.25 | 4.25 | 8.50 |
| Fairburn | 3.96 | 3.86 | 7.82 |
| Fayetteville | 2.40 | 1.65 | 4.05 |
| Lawrenceville | 3.50 | 3.68 | 7.18 |
| McDonough | 3.94 | 3.75 | 7.69 |
| Norcross | 4.92 | 2.55 | 7.47 |
| Villa Rica | 4.00 | 4.50 | 8.50 |
| **Average** | **3.56** | **3.28** | **6.84** |

* 2004 Water and Wastewater Rate Structure, Metropolitan North Georgia Water Planning District. For comparison purposes, all costs are for residential properties outside the city limits, having a uniform rate and structure. Monthly base cost is not included because the customer pays this cost regardless of volume used.

If a property is within the city limits, the client usually receives both monthly water and sewage bills. Sewage cost is assessed by the gallon and is based on water usage, although some counties add on an extra charge for storm water abatement. Most counties have a base charge for water and sewage, plus a volumetric charge per 1,000 gallons. For this model, the base charge per month is not included because the client would have to pay this cost regardless of the volume of water used.

The next step is to calculate projected annual cost of water and sewage per 1,000 $ft^2$ of landscape. To do this, the landscape should be divided into three water-use zones according to the Xeriscape™ principles: high, moderate and low. High water-use zones are limited areas in a landscape where plants are provided supplemental irrigation as needed to maintain optimum growth and performance. Plants in the moderate water-use zones are watered only when they show signs of stress. Low water-use zones, the largest area in a Xeriscape, are not irrigated, once established, and are watered by natural rainfall (Figure 7-1, page 48). In an ideal Xeriscape, not more than 10 percent of the landscaped area is zoned for high water use, 30 percent or less is zoned for moderate water use, while 60 percent or more is assigned to low water-use zones.

To estimate water usage, it is necessary to make some assumptions as to how much irrigation water could potentially be used in each of the water-use zones (Table 7-2, page 48). A number of Georgia Cooperative Extension publications state that turfgrass generally requires 1 inch of water (623 gallons per 1,000 $ft^2$) per week during the growing season for optimum growth. Although this recommendation fails to compensate for soil type, existing soil conditions, temperature and rainfall patterns, it is a standard recommendation that assures a thorough wetting of the top 12 inches of soil, which encourages deep rooting.

Using the calculated water requirement by water use zone (Table 7-2) and the average water and sewage rates (Table 7-1), projected annual water and sewage cost per 1,000 $ft^2$ can be determined (Table 7-3, page 49). The data in Table 7-3 show that, for each 1,000 square feet of landscaped area converted from high water use to low water use, $85.23 can be saved annually on water and sewage cost. Likewise, for each additional 1,000 $ft^2$ of

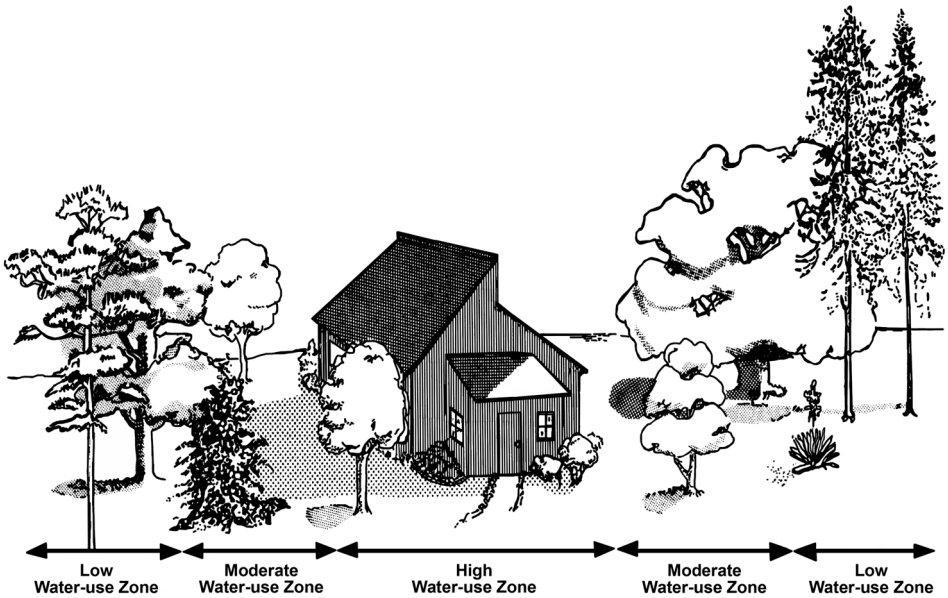


**Figure 7-1.** Typical water-use zones in Xeriscape™ design.

**Table 7-2. Projected water demand on municipal source[z].**

| | |
|---|---|
| **High Water-use Zone:** | **Assumption:** 2 inches of water/month from March to October (growing season), then 1 inch of water/month from November to February.<br>March – October: 623 gal[y]/1,000 $ft^2$ x 2 inches = 1,246 gal/1,000 $ft^2$/mo x 8 mo = 9,968 gal/1,000 $ft^2$<br>November - March: 1 inch of water/1,000 $ft^2$/mo = 623 gal x 4 mo = 2,492 gal/1,000 $ft^2$<br>**Total Water Use: 9,968 gal + 2,492 gal = 12,460 gal/1,000 $ft^2$/yr** |
| **Moderate Water-use Zone:** | **Assumption:** 1 inch of water/month from March to October, then no irrigation from November to February.<br>March - October: 623 gal/1,000 $ft^2$/mo x 8 mo = 4,982 gal/1,000 $ft^2$<br>**Total Water Use: 4,982 gal/1,000 $ft^2$/yr** |
| **Low Water-use Zone:** | **Assumption:** No supplemental irrigation throughout the year. |

[z] To allow a rainfall credit, this model assumes the high water-use zone would receive 1 inch of water per week or 4 inches per month, on average, with 2 inches from natural rainfall and the remaining 2 inches from municipal supplies. The moderate zone allows 2 inches per month, with 1 inch from rainfall and 1 inch from municipal supplies. Rainfall is variable but, for the purposes of this model, the basic assumption is that half of the monthly water need of the plants is satisfied by rainfall.

[y] 1 inch of water = 623 gal/1,000 $ft^2$.

moderate water-use area converted to low water use, $34.08 can be saved each year. These data do not take into account summer surcharges that are applied by some water purveyors for summer water use that exceeds an average winter use rate. Surcharges vary by city and range from 25 percent to 100 percent of the average winter rate.

Landscape professionals are encouraged to use similar analyses to justify water conservation retrofits to clients. For example, if a residential property (½-acre lot) contains 15,000 $ft^2$ of landscaped area (trees, shrubs, turfgrass, and flowers), and as little as 20 percent (3,000 $ft^2$) of it is converted from a high water-use zone to a low water-use zone, a $255.69 annual savings on water and sewage bills would be realized based on this model. Add to this the savings realized through the reduction of other inputs such as fertilizers, pesticides, and labor, and the annual savings could be well over $500.

Another way to use this model is to present various landscape retrofit options and to compare their installation costs to the savings realized on water and sewage (Tables 7-4 and 7-5, page 50). Table 7-5 compares the cost of various retrofit scenarios to that of water and sewage cost savings and shows the estimated time for a total return on investment. The pine straw retrofit will pay for itself in as little as 17 months. The other options are a little more costly, but still the annual savings in water and sewage will pay for the Asiatic jasmine retrofit in 6.7 years and the juniper retrofit in 5.7 years. Although this may seem like a long time for a total return on investment, the annual yield on the Asiatic jasmine investment would be 15.2 percent, while the juniper investment would yield an 18 percent return each year, which is much better than most financial investments today. Furthermore, the time for return on this investment will likely decrease significantly as water rates increase and summer surcharges are imposed. Finally, one strong selling point for water-wise retrofits is that landscapes do not depreciate – they appreciate the value of a property.

Although this chapter has emphasized landscape retrofits for water conservation, it would be misleading to tell clients they have to spend money to save money. In some landscapes, significant water savings can be realized simply by changing existing irrigation practices. For instance, the landscape may have certain plants under irrigation that do not require supplemental irrigation. Perhaps a few irrigation heads can be capped without any noticeable reduction in quality of the adjacent plants. Another option may be to relocate plants from areas where they require water to areas where their water demand is reduced. Canna lilies, for instance, on a hot western exposure may be moved to an area of lower elevation on an eastern exposure, where they are shaded from the afternoon sun while taking advantage of the natural drainage on the site. These types of low-cost changes build a client's trust and confidence.

**Table 7-3. Projected annual water and sewage cost per 1,000 $ft^2$ by water-use zone.**

| | Costs* | | |
|---|---|---|---|
| **Water-use Zone** | **Water** | **Sewage** | **Water + Sewage** |
| | ---------- $ ---------- | | |
| High | 44.36 | 40.87 | 85.23 |
| Moderate | 17.74 | 16.34 | 34.08 |

* Computed from average water and sewage cost in Table 7-1 (e.g. high water-use zone projected water use: 12,460 gal/1,000 $ft^2$ x $3.56/1,000 gal = $44.36.

**Table 7-4. Cost to retrofit 1,000 ft$^2$ of landscaped area with pine straw, Asiatic Jasmine, or Prince-of-Wales Juniper.[Z]**

**Pine Straw**
Pine straw @ $3/bale
20 bales/1,000 ft$^2$ x $3/bale = $60
+ Labor (2 man hours @ $10/hr) = $20
Total Direct Cost = $80
$80 + $16 (20% overhead) + $24 (25% profit) = $120
**Total Bid Price/1,000 ft$^2$ = $120**

**Asiatic Jasmine**
Asiatic Jasmine @ 24-inch centers = 250 plants/1,000 ft$^2$
Liner plants (2¼-inch pots) @ $0.75/plant = $187.50
+ 20 Bales of pine straw @ $3/bale = $60
+ Labor (11 man hours @ $10/hr) = $110
Total Direct Cost = $375.50
$375.50 + $71.50 (20% overhead) + $111.75 (25% profit) = $558.75
**Total Bid Price/1,000 ft$^2$ = $558.75**

**Prince-of-Wales Juniper**
Horizontal-type junipers @ 4-ft centers = 63 plants
110, 1-gal plants @ $3/plant = $189
+ 20 Bales of pine straw @ $3/bale = $60
+ Labor (6.5 man hours @ $10/hr) = $65
Total Direct Cost = $314
$314 + $62.80 (20% overhead) + $94.20 (25% profit) = $471
**Total Bid Price/1,000 ft$^2$ = $471**

[Z]Labor and material costs may vary. Industry average data was used for these calculations.

**Table 7-5. Client costs of various landscape retrofits compared to annual water and sewage cost savings per 1,000 ft$^2$ of high water-use zone and projected time for return on investment.**

| Option | Client Cost ($) | Est. Time for Return on Investment* |
|---|---|---|
| Pine Straw | 120.00 | 17 months |
| Asiatic Jasmine Groundcover[‡] | 558.75 | 6 years, 8 months |
| Prince-of-Wales Juniper[‡] | 471.00 | 5 years, 8 months |
| Annual Water + Sewer Cost Savings | 85.23 | |

* Two months added to each estimated return on jasmine and juniper to allow an 8-week establishment period during which the plants are watered regularly.
[‡] Model assumes that, once these plants are established, they are not irrigated.

## Water Allocation Forecasting

Water purveyors can use a model similar to the one above to forecast how much water a property needs and to gauge billing accordingly. As stated earlier in this chapter, if a landscape follows the Xeriscape principles, then not more than 10 percent of the landscaped area would be high water-use zones (irrigated routinely), 30 percent or less of the total area would be moderate water-use zones (irrigated on demand), while 60 percent or more of the landscaped area would be low water-use zones (not irrigated). Therefore, on a ½-acre landscape, this would equate to 2,178 $ft^2$ of high water use (43,560 $ft^2$ / acre × 0.5 (½-acre) × 0.10 (10%)). Likewise, 6,534 $ft^2$ (21,780 $ft^2$ × 0.30 (30%)) would be allowed for moderate water use. The remaining area, 13,068 $ft^2$ (60% of the total area), would be zones for low-water use and provided no supplemental irrigation. With these assumptions and the data from Table 7-2, water can be allocated to this landscape according to Table 7-6.

The ½-acre landscape in this model would be allocated 6,785 gallons/mo. from municipal supplies from March to October and 1,356 gallons/mo. from November to February. Since this model also assumes that at least 2 inches of additional rainfall occurs each month from March to October and 1 inch of rainfall per month from November to February, there is no need to make the model more complicated by allowing a rainfall credit each month according to actual rainfall, although it could be done by delayed billing and using local weather data. When rainfall is plentiful and customers do not use their allocated amount of water, they are given a rebate, credit, or some other incentive for saving water. On the other hand, if their monthly water use exceeds their monthly allocation, a surcharge is assessed. For this model to work, one would simply need to know the property size of the water customer (data can be obtained from the assessor's office). The landscape would also have to be on a separate meter so that only outdoor water use is monitored.

In summary, water-wise landscapes not only offer many environmental benefits, they also are an economically practical investment that pays dividends. Landscape designers, landscape contractors, and water purveyors are encouraged to develop their own set of economic incentives for water conservation. Saving money while saving time and protecting the environment make water-wise landscapes a smart investment and a very marketable concept.

**Table 7-6. Projected monthly water allocation for a ½-acre landscape.**

| | | Monthly Allocation* | |
|---|---|---|---|
| **Water-use Zone** | **Area Irrigated ($ft^2$)** | **Mar. – Oct.** | **Nov. – Feb.** |
| | | ---------- Gallons | ---------- |
| High | 2,178 | 2,714 | 1,356 |
| Moderate | 6,534 | 4,071 | 0 |
| Low | 0 | 0 | 0 |
| **Total** | **8,712** | **6,785** | **1,356** |

* Example calculation: From Table 7-2, high water-use zones = 1,246 gal/1,000$ft^2$/mo = 1.246 gal/$ft^2$/mo [2,178 $ft^2$ (irrigated area) x 1.246 gal/$ft^2$ = 2,714 gal).

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## Suggested Reading


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