

**Field Guide to  
Proper Installation,  
Calibration, and Maintenance of  
Soil Moisture Sensor  
Control Systems  
in Residential Florida Landscapes  
2007**



Produced for  
the St. Johns River Water Management District  
by  
The University of Florida Program for Resource Efficient Communities

**DISCLAIMER:**

The University of Florida does not in any way endorse specific brands of soil moisture sensor control systems. This document only endorses specific best practices for proper installation, calibration, and maintenance of soil moisture sensor control systems.

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# I. Introduction

## A. The Role of the Modern Soil Moisture Sensor in Florida

Water is an extremely valuable, yet seriously stressed resource in Florida. Nevertheless, in-ground time-controlled irrigation systems that use potable water are standard in the landscapes of newly built homes. Ideally, homeowners adjust their irrigation time clocks in response to seasonal weather patterns. However, homeowners often make no adjustments, leaving their time clocks set at fixed watering levels regardless of plant water requirements. As a result, residential irrigation systems frequently apply significantly more water than landscapes require.

Conventional irrigation time clocks used in residential landscapes allow irrigation at scheduled times for specified periods of time. For example, a controller can be scheduled to initiate a 15-minute irrigation event every Monday and Friday at 6:00 AM. These time clocks do not account for weather conditions and will irrigate at the scheduled time even if it is raining. To minimize this unnecessary irrigation, Florida Statute 373.62 requires that all newly-installed residential irrigation systems have an add-on rain shutoff device (rain sensor) that bypasses time-scheduled irrigation events during, and for a period after, rain events. While rain sensors improve the water-use efficiency of time-controlled irrigation systems, time clocks are still programmed based on estimates of landscape water needs rather than actual landscape conditions.

Soil moisture sensor (SMSs) controllers measure soil moisture content where it is most vital to plants: in the active root zone. SMS systems connect to conventional irrigation time clocks and check soil moisture content prior to scheduled irrigation events. If the SMS controller determines that soil moisture content is above a user-defined set-point, the irrigation cycle is bypassed. This allows SMS controllers to not only bypass irrigation during rainy periods, but also to minimize irrigation when plants do not require additional water. A properly working SMS controller does not stress plants or decrease turfgrass quality because it allows the irrigation system to apply the amount of water actually needed to meet plant water requirements.

Figure 1 shows the circuit created by a SMS control system. If moisture is above the set-point, the circuit in the SMS controller is left open and no irrigation occurs. If the soil moisture is below the set-point the circuit is closed and the scheduled irrigation even occurs.

Different SMS technologies are used to measure soil moisture content in residential landscapes. One is an improved granular matrix sensor (GMS) technology, which has been used in agricultural irrigation systems for decades. Some modern soil moisture sensors use electrical conductivity to measure soil moisture content. Two types of SMSs use this technology: a time domain transmissivity (TDT) sensor and a time domain reflectometry (TDR) sensor. All sensor types are discussed in general terms in this field guide.

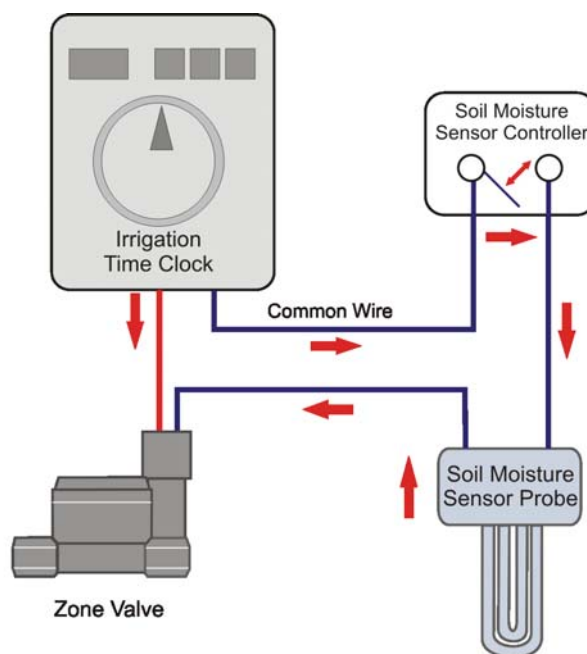


Figure 1. General diagram of an irrigation system with a soil moisture sensor (SMS) control system.

## Useful Terms

**Evapotranspiration (ET)** – A combination of water transpired from vegetation and evaporated from the soil and plant surfaces. Also known as consumptive use.

**Field capacity** – The moisture remaining in the soil following wetting and gravitational drainage until water has ceased drainage.

**Irrigation zone** – An area in a landscape that is irrigated by a single zone (solenoid) valve.

**Net irrigation requirement** – The amount of water needed to replace water lost through evapotranspiration, minus the amount of rainfall that contributes water to the plant root zone (i.e. effective rainfall).

**Plant water requirement** – The amount of water needed to replace water lost through evapotranspiration.

**Representative area** – An area possessing the average qualities of the irrigation zone(s) controlled by the SMS control system.

**Soil Moisture Sensor** - The soil moisture sensor probe that is installed in the ground within the root zone.

**Soil Moisture Sensor Controller** - Collective term sometimes used for the entire SMS system.

## *B. University of Florida Research*

Beginning in 2004, a research group in the Agricultural & Biological Engineering Department at the University of Florida (UF) initiated a series of ongoing studies on soil moisture sensors (SMSs) in turfgrass. These studies have been conducted in both highly-controlled research facilities and in homeowner landscapes. To date, all studies have shown that SMS controllers produce substantial water savings in comparison to conventional time clocks and rain sensors, while maintaining acceptable turf quality.

## Study 1

In the first study, in a controlled research environment in Gainesville, FL (2004-2005) four SMS controllers were tested:

- Acclima RS500,
- RainBird MS-100,
- WaterWatcher DPS-100, and
- Irrrometer 200SS-5.

Rainfall during this study period was average to above average, resulting in high sensor-based water savings. Treatments were compared to a 2-day-per-week time-based irrigation schedule based on Dukes and Haman (2002a), using no sensor technology. All four SMS controller treatments applied less irrigation water than the time-based schedule with no sensor (Table 1). Three of the SMS controllers (Acclima RS500, RainBird MS-100, and WaterWatcher DPS-100) significantly outperformed a rain shut-off device set at ¼" (6 mm): the SMS-controlled irrigation application reduction ranged from 70% to 92% while rain sensors averaged a 34% savings (Cardenas-Lailhacar, in press).

**Table 1: Water Savings In Wet Conditions in a Research Setting**

Treatment	Percentage of Water Saved
2 days/week without sensor	0%
2 days/week with rain sensor	34%
2 days/week SMS average	72%

\* SMS = Soil moisture sensor

Two other sensors, the BaseLine WaterTec S100 and the Lawn Logic LL-1004, have been added to ongoing research at the Gainesville, FL facility.

## Study 2

In the second study at a controlled research environment in Citra, FL (2006), two SMS controllers were tested: the Acclima RS500; and the LawnLogic LL-1004. Rainfall during this study was below average, resulting in lower SMS-controlled water savings compared to Study 1 savings. These water savings ranged from 10% to

**Table 2: Water Savings In Dry Conditions in a Research Setting**

Treatment	Percentage of Water Saved
2 days/week without sensor	0%
2 days/week with rain sensor	10–23%
2 days/week SMS average	10–28%

\* SMS = Soil moisture sensor

28% (Table 2). Rain sensors saved 11% to 23% compared to the conservative irrigation schedule (Shedd et al., 2007).

## Study 3

The third study tested one sensor controller, the Acclima RS500, on residential landscapes in the City of Palm Harbor, FL. Preliminary results show that sensors are successful for irrigation water-use savings at the single family home level. From June 2006 through March 2007, homes with soil moisture sensors demonstrated water savings of 51% compared to homes with an irrigation time clock only (Haley and Dukes, 2007).

## Disclaimer

Procedures for proper installation, calibration, and maintenance vary by SMS brand. Generally, each manufacturer's installation manual provides adequate instructions for effective installation and these manuals should be referenced for specific instructions, especially for wiring, calibration, and troubleshooting. Valuable lessons have been learned during testing conducted at the University of Florida (UF) that can provide additional guidance. This field guide describes these lessons and other information required for general best practices. However, installers and maintenance professionals should always refer to the most current manufacturer's installation manual for model-specific instructions.



## II. Installation

There are four main installation steps outlined here. These are:

1. Establish the sensor location
2. Install the sensor
3. Install the controller
4. Connect the wiring

### ***Step 1: Establish the Sensor Location***

SMSs are most effective when placed in a location representative of the zone(s) that the sensor is controlling. If one sensor is being used for the entire landscape (the sensor is controlling multiple zones), the average water requirement of the entire landscape should be considered as the baseline. If multiple sensors are being used in one landscape (i.e. one sensor per zone), each sensor should be placed in an area representative of the specific zone it is controlling.

When used to control an entire irrigation system with only one sensor, SMS controllers should be installed in an irrigation zone for turfgrass. Instructions in this field guide focus on landscapes comprised primarily of turfgrass. Typically, turfgrass will need more frequent irrigation than most other plant types in a landscape. Therefore, if turfgrass watering requirements are met, other plants in the landscape will receive sufficient irrigation, presuming that all irrigation zones are properly designed and scheduled for the associated plant materials. Care must be taken before using SMS control systems on stress prone plants such as some annuals. If SMS controllers are being used for landscape plants, trees, or other types of groundcover, installers should refer to the manufacturer's installation manual for location instructions and specifications.

Variations in soil type and condition, adjacent land use, shading, and drainage patterns all can cause a sensor to read an unrepresentative soil moisture content, which can result in too much or too little irrigation. If one area does not represent the average condition of the SMS-controlled area, SMS placement in that location should be avoided.

**Location in the landscape** – Soil moisture sensors should be placed at the driest location relative to the average of the SMS-controlled zone(s). These driest locations may include:

1. areas with significant sun exposure
2. lot-specific high elevation points

**Depth in the ground** – Sensor probes should be placed within the root zone, in contact with relatively undisturbed soil that is representative of the irrigated landscape area. Contact with disturbed soil with a higher (or lower) amount of void space will likely result in unrepresentative soil moisture content readings. However, if the soil in the entire landscape is disturbed (i.e., fill material used to elevate and level a new construction site), a disturbed area would be representative.

A. Optimal Installation Areas

The following are optimal areas for sensor installation:

- **In the turfgrass root zone** (Figure 2), if turfgrass is used as the representative plant type.

*Purpose:* Provide sufficient irrigation to the area with the greatest water requirement. Generally, turfgrass will have the highest water requirement relative to other landscape plants. If the turfgrass requirements are met, other plant water requirements should also be met, presuming that all irrigation zones are properly designed and scheduled for the associated plant materials.

- **In a relatively sunny area**, if full sun is representative of the landscape.

*Purpose:* Provide sufficient irrigation to the area with the greatest water requirement. Often, landscapes have turfgrass lawns in full sun. These areas have higher evapotranspiration (ET) rates and therefore, higher water requirements. Also, in new landscapes, these areas may have poor soil that does not hold water well.

- **In the driest representative area possible**, considering all other factors.

*Purpose:* Provide sufficient irrigation to the area with the greatest water requirements. While other areas might receive more water than required, the sensor should not be installed in an area where it will bypass irrigation events necessary to meet the landscape's water requirements as a whole.

- **In the center of the irrigation zone**, or in an area receiving an average, or slightly less than average, amount of irrigation relative to other irrigated areas in the landscape.

*Purpose:* Ensure that the SMS is not located in an area with a greater than average soil moisture content. In some cases, irrigation distribution may be nonuniform and sensor placement in an area with higher relative irrigation could result in too many bypassed irrigation events, preventing plants in some areas from receiving the irrigation needed to meet their water requirement.



Figure 2. Bermudagrass root zone.

B. Areas to Avoid – General

When establishing the SMS location, certain areas and site conditions should be avoided.

INSTALL the sensor at least 5 feet away from:	To avoid:
• a property line .....	irrigation overspray from a neighbor's yard
• an impervious surface.....	runoff from impervious surfaces and compacted soil around impervious surfaces
• a structure (e.g., house, porch, shed, etc.) .....	compacted soil, shade, and runoff
• a depression/swale .....	naturally high soil moisture content areas
INSTALL the sensor at least 3 feet away from:	To avoid:
• a plant bed .....	higher runoff, shade, and unrepresentative plant roots

## C. Areas to Avoid – High Moisture

Some areas in the landscape can have a higher moisture content due to increased water inflow or reduced water outflow. For example, directed stormwater runoff can cause an area to have a higher moisture content, while shade can cause the same effect by reducing evapotranspiration. These areas with a higher moisture content relative to the surrounding landscape should be avoided.

### INSTALL the sensor at least 5 feet away from:

### To avoid:

- |                                                       |                                                                                                    |
|-------------------------------------------------------|----------------------------------------------------------------------------------------------------|
| • a downspout .....                                   | areas with higher amounts of inflowing stormwater relative to the rest of the landscape            |
| • an overhang .....                                   | areas with higher or lower amounts of inflowing stormwater relative to the rest of the landscape   |
| • a hose bib .....                                    | areas with higher amounts of inflowing water relative to the rest of the landscape                 |
| • an air conditioner condensate line .....            | areas with higher amounts of inflowing water relative to the rest of the landscape                 |
| • the dripline of a tree canopy .....                 | areas with a lower ET rate and higher moisture content (unless SMS is specifically used for trees) |
| • a shaded north side of the home (if possible) ..... | areas with a lower ET rate and higher moisture content                                             |

## D. Areas to Avoid – Disturbed Sites and Soils

In some areas it is difficult to tell if the soil has been, or will be, compacted. Installers should use their best knowledge of the landscape history and projected use to determine the SMS location. If it is known that the soil has been, or will be, compacted in one particular area, the SMS should be installed elsewhere.

### INSTALL the sensor at least 4 feet away from:

### To avoid:

- |                             |                                                 |
|-----------------------------|-------------------------------------------------|
| • a construction road ..... | compacted soils and runoff from compacted soils |
|-----------------------------|-------------------------------------------------|

### INSTALL the sensor at least 3 feet away from:

### To avoid

- |                                                                                           |                                                                                                                                                                                          |
|-------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| • an area with plant debris (e.g., tree stump) .....                                      | compacted soils and materials intermixed with soils that are unrepresentative of the landscape as a whole                                                                                |
| • an area with fill dirt (if fill dirt is unrepresentative of the entire landscape) ..... | soils that are unrepresentative of the landscape as a whole                                                                                                                              |
| • buried material (e.g. cable, water or sewer line) .....                                 | soils and materials that will result in a soil moisture reading that is unrepresentative of the landscape as a whole or that may be disturbed in the future due to maintenance or repair |

*Note:*

- Check with local building codes before digging and installation of the irrigation system.
- See Appendix A for a condensed table containing these priorities for determining SMS installation location.

## E. Landscape Examples

To better understand how these rules should be applied, three different landscape installation examples are shown on the following pages. The three depicted conditions are:

1. a typical landscape,
2. a Florida Water Star<sup>SM</sup> landscape, and
3. a preserved vegetation landscape.

In all three examples:

1. Green dotted areas are *optimal* locations for SMS placement.
2. Blue striped areas are *secondary* locations that might be appropriate in some cases.
3. Red wavy areas are *not suitable* SMS locations.

Drawings are not to scale, to emphasize landscape features.

*Note:* Specific site features and conditions could preclude installation in areas that appear to be optimal or secondary installation locations. Always perform a site inspection to determine if any site specific conditions make an area less suitable for sensor probe installation.

### In a Typical Landscape

Figure 3 depicts a lot with typical landscaping characterized by large turfgrass areas (greater than 60% of the entire landscape) and very few trees. There are many optimal sensor locations in this landscape, and it should be relatively easy to determine the best location within a short period of time. A newly developed landscape of this type will have fill material that must be considered during SMS installation.

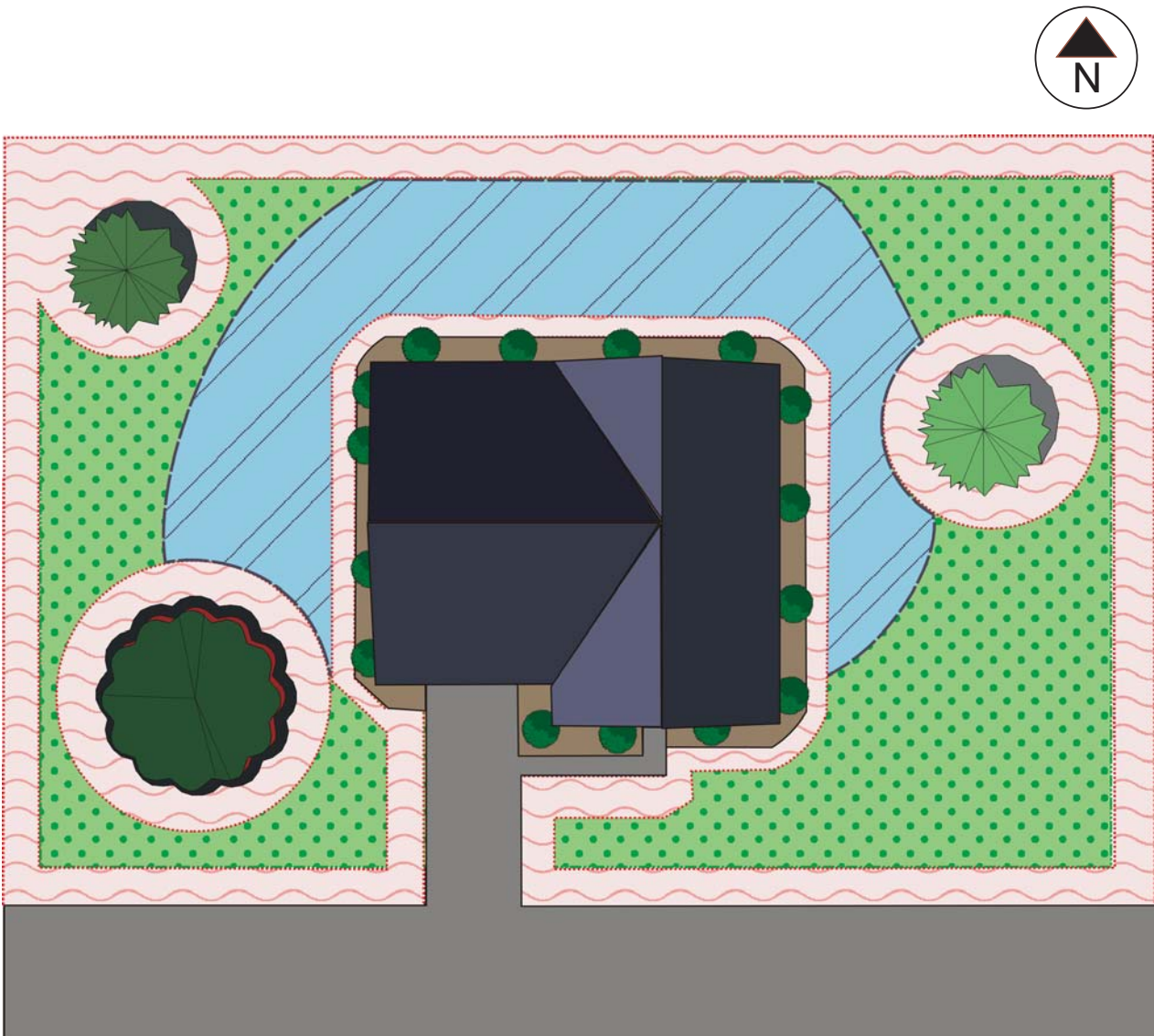


Figure 3. Example of a typical residential landscape.

#### Legend

- Green dotted areas: **Optimal** locations for SMS placement.
- Blue striped areas: **Secondary** locations that might be appropriate in some cases.
- Red wavy areas: **Not suitable** SMS locations.



## In a Florida Water Star<sup>SM</sup> Landscape

Figure 4 depicts a hypothetical Florida Water Star landscape, composed of 60% or less turfgrass and 40% or greater planting beds, natural areas, or drought tolerant groundcovers. Reduced turfgrass area decreases the number of *optimal* SMS locations. There are optimal areas in the front yard, but fewer such areas exist throughout the Florida Water Star landscape, compared to the typical landscape. Selection of a sensor location in this type of landscape might require more attention than in a typical setting.

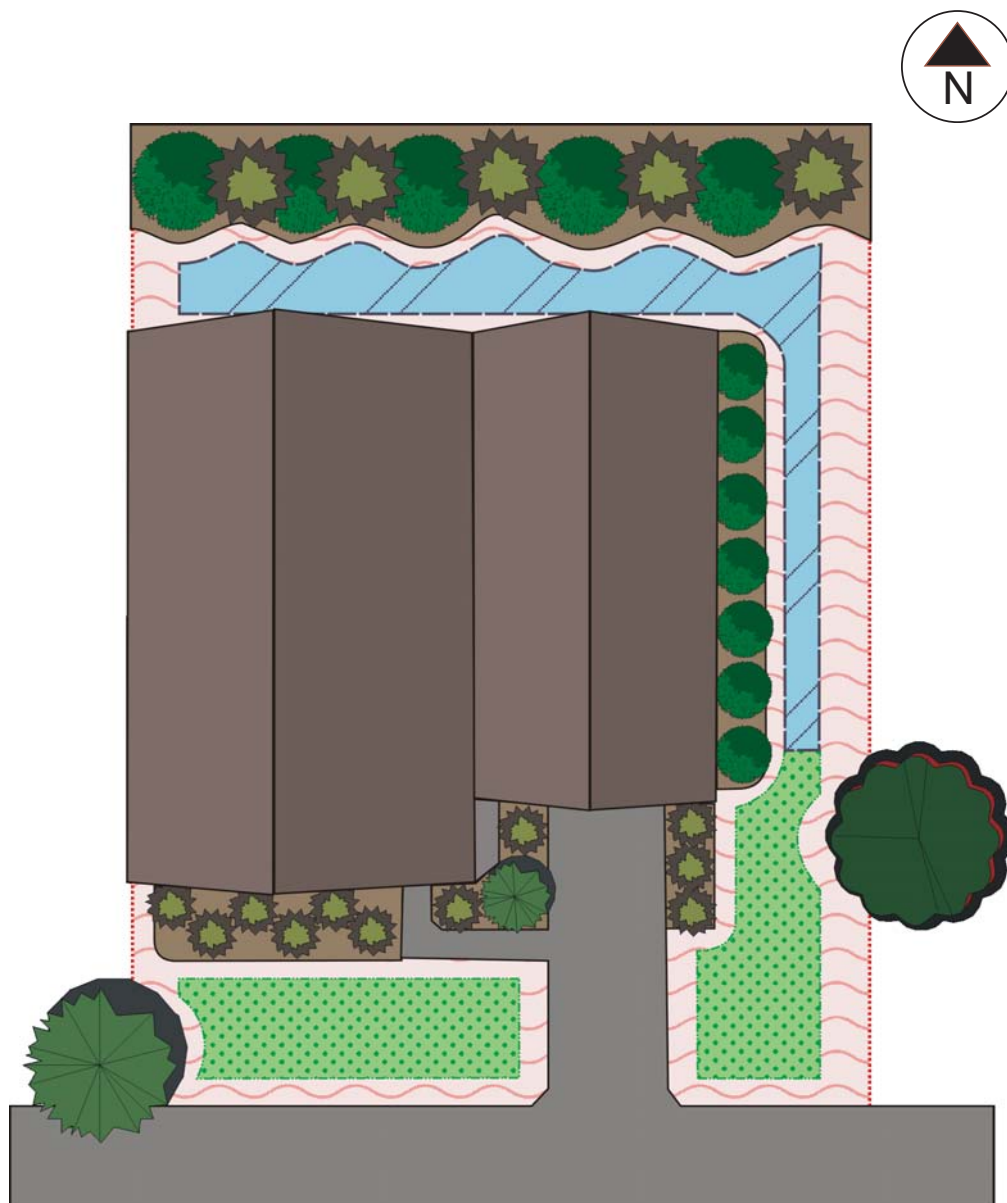


Figure 4. Example of a Florida Water Star (water efficient) landscape.

### Legend

- Green dotted areas: **Optimal** locations for SMS placement.
- Blue striped areas: **Secondary** locations that might be appropriate in some cases.
- Red wavy areas: **Not suitable** SMS locations.

### In a Preserved Vegetation Landscape

Figure 5 depicts a landscape with a high percentage of preserved vegetation. This landscape has more shaded areas, less turfgrass, and potentially higher soil moisture content. Because of the landscape layout, the optimal areas for SMS installation might be considered secondary areas in other landscapes. However, the goal is to place the SMS in a representative area. If the landscape only has secondary areas, the SMS should be installed in an area that will ensure all areas receive adequate irrigation.

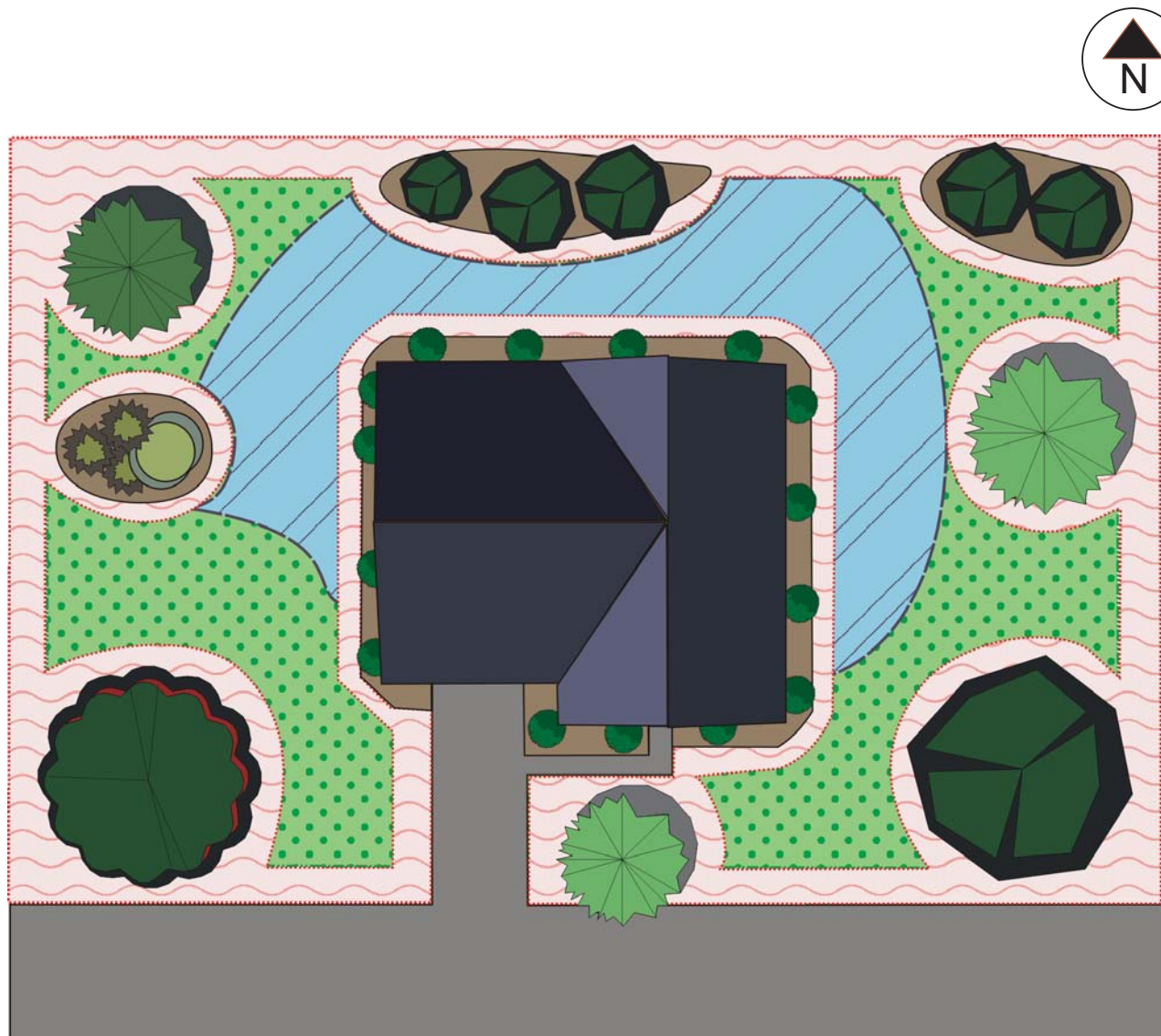


Figure 5. Example of a landscape with preserved vegetation.

#### Legend

- Green dotted areas: **Optimal** locations for SMS placement.
- Blue striped areas: **Secondary** locations that might be appropriate in some cases.
- Red wavy areas: **Not suitable** SMS locations.

## F. Include SMS Location in New Landscape Plans

Specifying the SMS location in the landscape and irrigation design plan prior to installation can help streamline the installation process and reduce human error in the field. If the location is predefined, the installer will spend less time surveying the landscape to determine an optimal sensor location. Nevertheless, the predefined location should be checked according to the Step 1: “Establish Sensor Location” instructions to ensure that unforeseeable factors do not make the area a poor choice for a SMS location.

## G. Mark and Measure the Sensor Location

Documentation of the sensor location can make future maintenance easier by providing a record of the SMS location to future homeowners, irrigation contractors, and maintenance professionals. Foremost, the SMS installer should specifically mark the sensor location on a copy of the as-built irrigation plan and display the plan adjacent to the irrigation timer. Additionally, installers should measure and record the distance and approximate angle from the SMS to two permanent points in the landscape (triangulation).

## Step 2: Install the Sensor

Because a sensor’s installation orientation depends upon its type, size, and shape, installers should always refer to the manufacturer’s installation manual during installation of the sensor. Until more research data regarding sensor installation become available, the sensor should be installed in the turfgrass root zone. In new landscapes with turfgrass, the SMS will often be installed prior to installation of the turfgrass sod. In this case, the sensor should be buried in the soil to a depth of approximately 3" and the turfgrass sod laid on top. For installation in existing turfgrass, an area of sod must be removed for SMS installation, and a trench must be dug into the adjacent sod to run the SMS wiring. The following installation instructions suggest that a wiring trench be dug after SMS installation. It is perfectly reasonable to dig the hole for the SMS and the trench at the same time and then install the sensor and wiring.



Figure 6. Square point ditching shovel required for SMS installation.

- Note:*
- Always use a square-point ditching shovel for SMS installation (Figure 6).
  - Always check for proper system operation before burying the sensor probe and wiring.



## A. Sensor Types

At the time of this writing, three types of residential sensor probes are commercially available in Florida: (1) flat, (2) node, and (3) rod. Installation procedures vary by type.

### 1. Flat sensor probes

Two types of long, flat sensor probes are commonly found. Sensors with this type of probe typically use time domain transmissivity (TDT) to measure soil moisture content. Orientation should occur as follows:

**Exposed wave guides** – If the sensor probe is long, flat, and has exposed rounded wave guides (steel rods), it should be installed horizontally with the wide side facing up (Figure 7).

**Encased wave guides** – If the sensor probe is long, flat, and has a solid surface encasing the wave guides, it should be installed horizontally with the thin side facing up (Figure 8).



Figure 7. Probe with exposed wave guides.

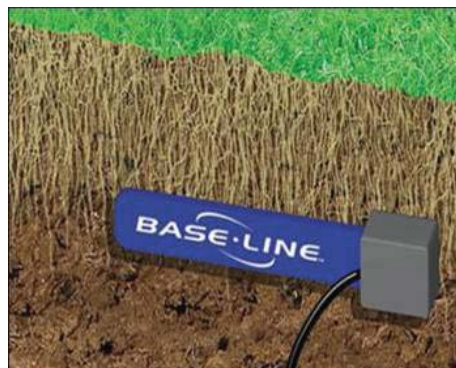


Figure 8. Probe with encased wave guides. (Photo courtesy of Base Line)

### Flat Probes in New Landscapes

In landscapes with new turfgrass sod being installed, the sensor should be buried approximately 3" deep in the soil and the turfgrass sod placed on top of the soil as follows:

1. Dig an 8" by 8" hole, 3" deep.
2. Insert the sensor into the bottom of the hole according to the sensor orientation specifications (Figure 9).
3. Dig the trench for the wiring connection (See Section B), connect wiring according to the manufacturer's installation manual, and check for proper SMS controller functioning.
4. Fill in the hole and trench, completely covering the sensor and wiring.
5. Mark the sensor location with a flag to prevent damage during the sod installation.
6. Install the turfgrass sod, pressing firmly over the sensor.

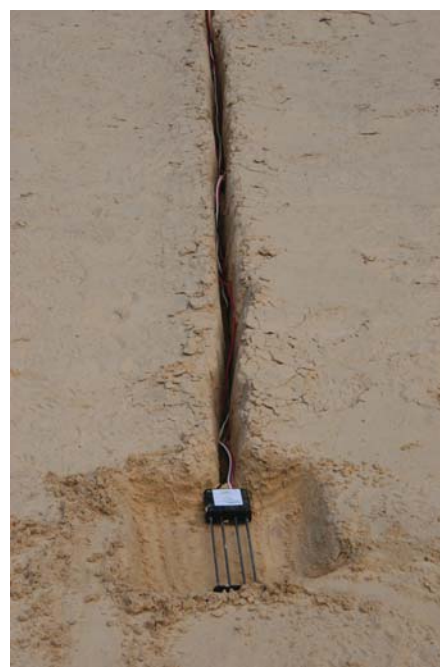


Figure 9. Installation of flat probe SMS in new landscape (bare soil).

## *Flat Probes in Existing Landscapes*

Two methods can be used to install flat sensors in existing landscapes.

Option 1: Bury the SMS in a shallow hole by rolling back a square of turfgrass.

1. Using a square ditching shovel, cut a square piece of turfgrass to a depth of 3" that is large enough to cover the entire probe (Figure 10).
2. Remove the square of turfgrass and soil by rolling it back, exposing the soil underneath (Figure 11).



*Figure 10. Cutting a square of turfgrass large enough to cover entire probe.*



*Figure 11. Turfgrass square rolled back.*

3. Place the sensor on top of the soil and gently press it into the soil (Figure 12).
4. Dig the trench to run wiring (See Section B), make the connections according to the manufacturer's specifications, and check for proper SMS controller functioning.
5. Roll the turfgrass back on top of the sensor (Figure 13).



*Figure 12. SMS installed in root zone by "roll back" method.*



*Figure 13. Turfgrass rolled back over sensor.*



6. Gently compact the turfgrass and soil plug, making sure that there are no channels that will allow water to seep in and pool around the SMS (Figure 14). Additional soil can be added on top of the sensor location so that it may wash into any remaining gaps.



*Figure 14. Gently compacting the turfgrass area.*

- Option 2: Slide the SMS into the sidewall of a hole by cutting the turfgrass roots.
  1. Dig an 8" by 8" hole, 6" to 8" deep, ideally creating a plug that can be pulled out whole (Figure 15).
  2. Horizontally cut the turfgrass roots in an area large enough to fit the sensor into the wall of the hole at a depth of approximately 3" using a "metal slicing tool" and mallet (Figure 16).



*Figure 15. Removal of turfgrass and soil plug.*



*Figure 16. Root cutting procedure preparing soil for SMS installation.*

3. In its specified orientation, slide sensor into cut area within the root zone (Figure 17).
4. Gently compact the soil above the sensor to ensure that there is sufficient contact between the sensor probes and the soil (Figure 18).



Figure 17. SMS installed within root zone.



Figure 18. Compaction of soil around sensor to reduce void space and ensure adequate connection between SMS and soil.

5. Dig the trench to run wiring (See Section B), make the connections according to the manufacturer's specifications, and check for proper SMS controller functioning.
6. Replace the removed turfgrass and soil plug (Figure 19).



Figure 19. Soil and turfgrass plug replaced, covering SMS prior to burying wire.

7. Gently compact the turfgrass and soil plug, making sure that there are no channels that will allow water to seep in and pool around the SMS. Additional soil can be added on top of the sensor location so that it may wash into any remaining gaps.

## 2. Node Probes

SMSs with node probes should be installed vertically within the root zone. Sensors with this type of probe typically use granular matrix technology to measure soil moisture content. Because this type of sensor might have additional specifications, always refer to the manufacturer's installation manual. Figure 20 shows a granular matrix sensor (GMS) being installed in a new landscape.

## 3. Rod probes

If a sensor has rod probes, it should be installed with all probes angled down at approximately 45 degrees to the ground. This allows the probes to read soil moisture content in the most active portion of the root zone. Sensors with these types of probes typically use time domain reflectometry (TDR) to measure soil moisture content.



Figure 20. Irrrometer Watermark SMS being installed in a new landscape.

### Rod Probes in New Landscapes

In landscapes with new turfgrass sod, the sensor probes should be inserted into a shallow hole and the turfgrass laid on top.

1. Dig a 4" by 4" square hole, 2" deep.
2. Insert sensor into the bottom of the hole at a 45 degree angle.
3. Dig the trench to run wiring (See Section B), make the connections according to the manufacturer's specifications, and check for proper SMS controller functioning.
4. Fill in the hole, completely covering the sensor.
5. Mark the sensor location with a flag to prevent damage during the sod installation.
6. Install the turfgrass sod.

## ***Rod Probes in Existing Landscapes***

In a landscape with existing turfgrass, the SMS should be inserted in the turfgrass root zone in the sidewall of a hole.

1. Dig an 8" by 8" square hole, 6", ideally creating a plug that can be pulled out whole.
2. Insert the sensor probes down into the root zone in the soil of the hole's sidewall at a 45 degree angle (Figure 21) at a depth of approximately 2-3". If the rods were inserted at a 2" depth they would reach to a depth of approximately 4".
3. Step on the turfgrass and soil above the SMS to ensure that the probes are in sufficient contact with the soil.
4. Dig the trench to run wiring (See Section B), make the connections according to the manufacturer's specifications, and check for proper SMS controller functioning.
5. Replace the turfgrass plug.
6. Gently compact the turfgrass and soil plug, making sure that there are no channels that will allow water to seep in and pool around the SMS. Additional soil can be added on top of the sensor location so that it may wash into any remaining gaps.



*Figure 21. LawnLogic SMS partially inserted into turfgrass root zone of undisturbed soil.*



## B. Run Sensor Cable to Zone Valve

Connecting the SMS wiring requires digging a trench, the length of which varies from installation to installation. Wiring provided in the installation kit is typically long enough for the connection between the SMS and the irrigation valve or SMS controller. If necessary, additional wiring should be added to allow for SMS installation in an optimal location. Depending on the circumstances, the trench digging process can be either mechanical or manual. For simplicity, instructions here discuss wiring the SMS to an irrigation valve.

*Note:* Inadvertent cutting of the wiring is one of the greatest threats to SMS operation. It is highly recommended that all in-ground wiring be encased in conduit to protect it from being severed.

### Mechanical Digging in New Landscapes

If the SMS is being installed in a newly developed landscape, it commonly will be installed prior to turfgrass installation. In this case, a mechanical device, such as an earthsaw or a chain trencher, can be used to dig the wiring trench. A mechanical trencher creates a deeper trench (8" to 12") that will further protect the wiring from being cut by aerators, edgers, shovels, and other landscape maintenance devices. While the trench might be deeper in this case, the soil moisture sensor probe should still be installed in the root zone at a depth of approximately 3".

1. After establishing the sensor location, mark the location with a flag.
2. Determine where the connection between the SMS and the valve will be made and mark it with a flag.
3. Dig the trench between the two flags to a depth of 8" to 12".
4. Install the SMS at the end of the newly dug trench to the recommended 3" depth.
5. Insert the wiring into the bottom of the trench until it reaches the point where the connection to the irrigation valve will be made.
6. Make the proper wiring connections according to the manufacturer's specifications and check for proper SMS controller functioning.
7. Fill in the trench completely.

*Note:* If the irrigation system and the SMS are being installed at the same time, the irrigation trench can be used for running the SMS wiring. Additionally, wiring should be placed underneath the irrigation pipes for further protection. Not all sensors are wired the same and connections should be made according to the manufacturer's specifications.

## Manual Digging In Existing Landscapes

Two manual digging methods, lift trench and slit trench, can be used for running wiring in existing landscapes.

### *a. Lift Trench Method*

A lift trench is made by inserting a square ditching shovel at a 45-degree angle to the ground surface, and while the soil is lifted, inserting the wiring underneath. This method is appropriate when no conduit is being used and there is little risk of cutting the wire. It is relatively simple and reduces the chances of killing turfgrass above the trench.

1. Insert square ditching shovel into the soil at a 45-degree angle, to a depth of 6" (Figure 22).
2. Lift the shovel to a 90-degree angle, or where there is enough room to insert the SMS wiring at a depth of 6" in the bottom of the trench (Figure 23).



*Figure 22. Beginning lift trench.*



*Figure 23. Lifting shovel within the lift trench to create room for SMS wiring.*

3. While the shovel is still in the trench, insert the wiring into the trench to a depth of 6", only running the wire halfway across the shovel head (Figure 24).
4. Repeat Steps 1-3 until the wiring reaches the irrigation valve.
5. Make wiring connections according to manufacturer's specifications and check for proper SMS controller functioning.
6. Step on the top and the edge of the turfgrass and soil to close the trench. Compact the entire length of the trench until it is completely closed (Figure 25).



*Figure 24. Placing sensor wires while continuing lift trench*



*Figure 25. Closing lift trench*



### ***b. Slit Trench Method***

A slit trench is a wedge made in the ground. This method can be slightly more time consuming than the lift trench method, while also leaving a line of dead turf after installation. However, this method should be used when running wiring through conduit for additional protection (Figure 26). When manually digging a trench the slit trench method including conduit is recommended.

1. Insert a square ditching shovel into the ground at a 90 degree angle.
2. While standing on both sides of the shovel head, rock the shovel, spreading the soil to a depth of approximately 6 inches.
3. Continue Steps 1 and 2 until the trench reaches from the SMS to the irrigation valve.
4. Insert the wiring through a section(s) of conduit long enough (in total) to protect the wires' entire length.
5. Insert the wiring and conduit into the bottom of the trench, making sure that the wiring reaches from the SMS to the irrigation valve or SMS controller.
6. After a working connection is made according to manufacturer's specifications, step on both sides of the opening in order to completely close the entire trench.



*Figure 26. A conventional slit trench, which should only be used when placing wiring in conduit.*

## ***Step 3: Install the Controller***

There are two recommended locations for a SMS controller:

- Adjacent to the irrigation timer on an interior wall of a non-conditioned space (e.g., garage).
- Adjacent to the irrigation timer in a weatherproof housing on the exterior of the home.

*Note:* Do not install the SMS controller outside without a weatherproof housing and ultraviolet (UV) protection from the sun.

After determining the SMS controller location, install it on the wall adjacent to the timer. Make sure it is not blocked when the timer door is open. Installers should always refer to the manufacturer's specifications when installing the SMS controller.

## Step 4: Connect the Wiring

Figure 27 shows a general wiring configuration between the SMS, the irrigation valve, the SMS controller, and the irrigation timer. This does not depict the wiring configuration for all sensors and installers should *always* refer to the manufacturer's specific wiring diagram and instructions when making wiring connections.

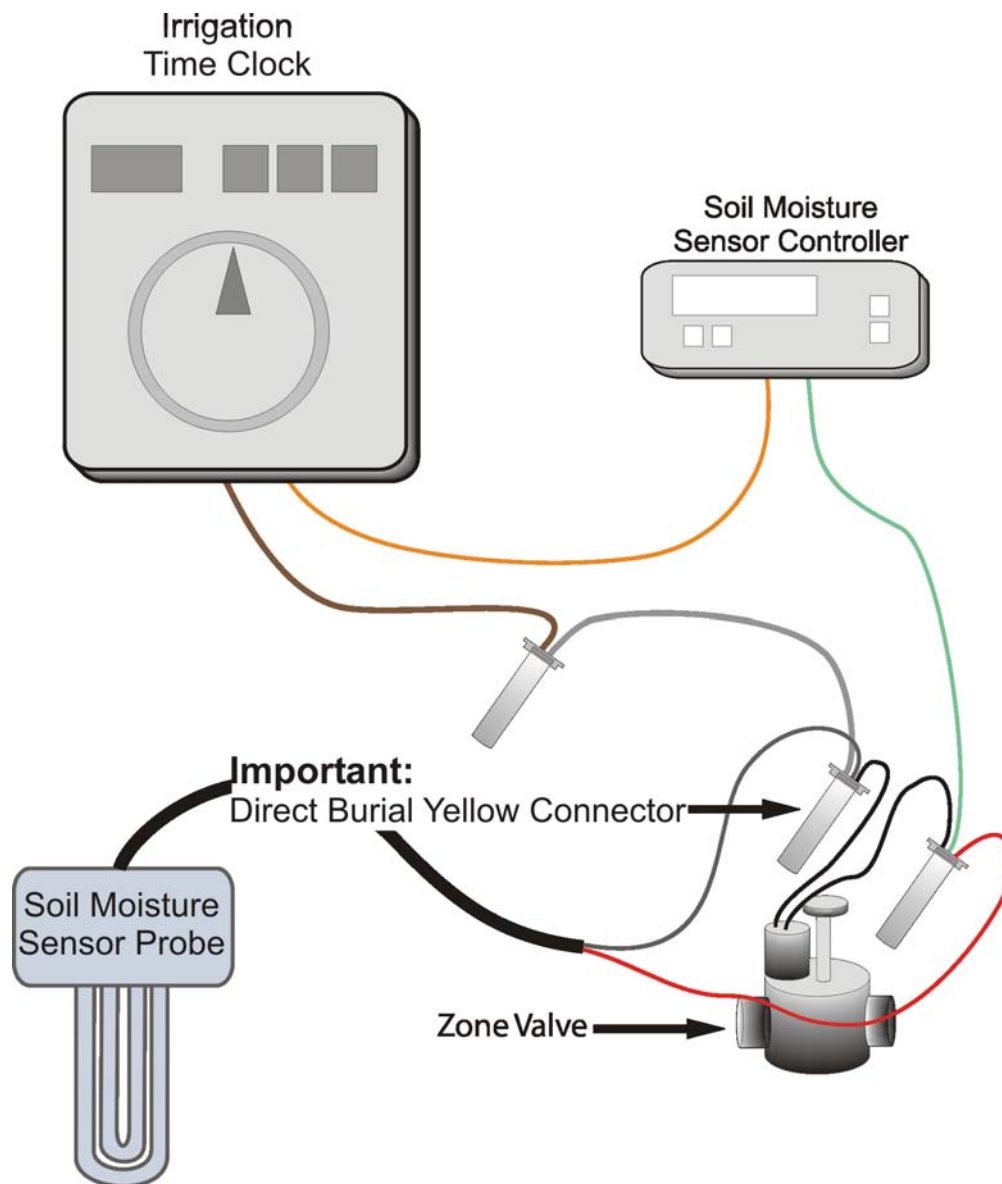


Figure 27. Example of a general wiring configuration for a SMS-controlled irrigation system.

## A. Connect Sensor to Zone Valve

Generally, sensors can be wired either to an irrigation valve or directly to the SMS controller. If possible, it is recommended that SMSs be wired to the nearest zone valve to facilitate sensor installation in the most representative area.

Wiring configurations vary among brands. Installers should *always* refer to specific wiring diagrams in the manufacturer's installation manual. Figures 28 through 32 show a connection being made between a sensor and a zone valve.

*Note:* Direct burial yellow or red (DBY or DBR) connectors should be used on all connections between the sensor and the zone valve to prevent moisture intrusion and to provide a secure connection.



Figure 28. Direct burial yellow (DBY) connector.



Figure 29. Uncover the irrigation zone valve box.



Figure 30. Disconnect the existing wiring connection between the irrigation timer and zone valve.



Figure 31. Prepare the soil moisture sensor and zone valve for connection.



Figure 32. Connect the wires from the soil moisture sensor to the zone valve.



Figure 33. Enclose all wire nuts in direct burial connectors.



## B. Connect SMS Controller to Irrigation Timer

The connections from the SMS controller to the irrigation timer also vary by brand and should always be done according to specifications in the manufacturer's installation manual. Figures 33 through 36 show a Lawn Logic LL-1004 controller being wired to an irrigation time clock.

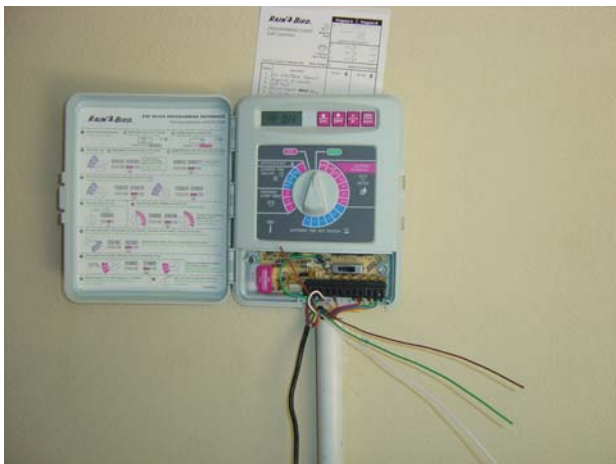


Figure 34. Open irrigation timer, exposing wires to be connected to SMS controller.

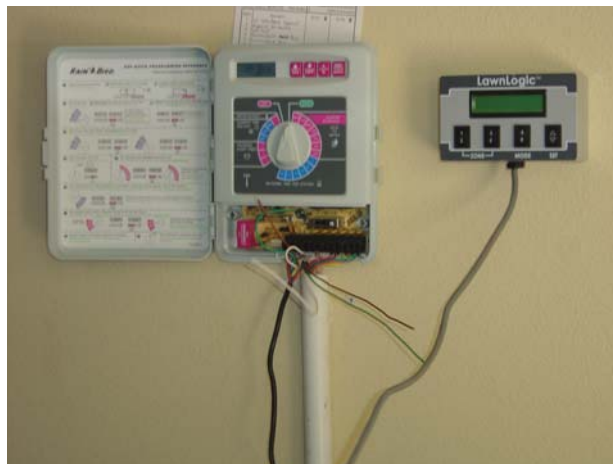


Figure 35. Install SMS controller adjacent to the irrigation timer on the side opposite the timer door hinges.



Figure 36. Connect SMS controller wiring to the irrigation timer wiring.

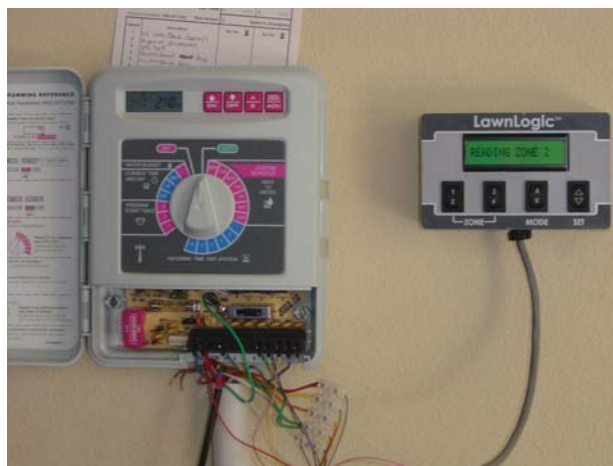


Figure 37. Power the SMS controller and the irrigation timer and check for proper functioning.

## III. Calibration

### Step 1: Establish Controller Set-point

Prior to calibration and set-point establishment, it is necessary to determine how much water can be held in the root zone where the SMS is buried. To achieve this, the installer should saturate the area immediately around the SMS location. 24 hours after saturation, the controller will read a certain soil moisture content that will be close to field capacity (i.e., no further water drainage below the root zone). Generally, the recommended soil moisture set-point is 75% of the field capacity. Two primary methods for establishing field capacity, bucket and irrigation, are recommended. A third method, calibration after a significant rainfall, can be used in situations where rainfall occurs shortly after sensor installation.

- Option 1. Bucket method

1. Pour a 5 gallon bucketful of water directly over the installed and connected SMS (Figure 37).
2. Wait 24 hours.
3. Perform the calibration according to the manufacturer's specifications.

- Option 2. Irrigation method

1. Specify a watering cycle period according to Appendix B that will apply 1" of water to the zone where the sensor is installed.
2. Manually start the irrigation system for the zone where the SMS is located by pressing the manual start button (Figure 38).
3. Wait 24 hours from the end of the irrigation cycle.
4. Perform the calibration according to the manufacturer's specifications.

- Option 3. Post rainfall method

1. Wait 24 hours from the end of a significant rainfall event (1" or more).
2. Perform the calibration according to the manufacturer's specifications.

**Note:** The soil surrounding the sensor *should not* receive any water during the 24-hour post-saturation period. If rainfall occurs during this period, then the soil will not be at field capacity at the end of 24 hours and the procedure must be repeated once the soil dries.



Figure 38. Establishing the controller set-point—bucket method. Arrow points to sensor location.



Figure 39. Manual start of the irrigation time clock to saturate area around SMS for calibration.

## Step 2: Calibration

*Always* refer to the manufacturer's specifications for detailed SMS controller calibration procedures. Calibration instructions are brand-specific and cannot be adequately specified in general terms.

### Timing with Plant Establishment

In new landscapes, plants (including turfgrass) are typically installed about the same time as irrigation systems. During establishment, plants have their highest water requirements as they develop their root system. The St. Johns River Water Management District irrigation rules state: "Irrigation of new landscape is allowed at any time of day on any day for the initial 30 days and every other day for the next 30 days for a total of one 60-day period, provided that the irrigation is limited to the minimum amount necessary for establishment" (SJRWMD).

Two SMS calibration issues arise during a plant establishment period. First, the irrigation system will be set to meet the water requirements of newly installed plants and the SMS controller will be turned off during this period. Second, plant root depth and soil qualities in the root zone will change significantly during establishment. As a result, the controller should be calibrated post-establishment when the irrigation timer is reset for normal operation.

### Manufacturer Recommended Set-Points

*Always* refer to the manufacturer's installation manual for specific set-point recommendations. Generally, a SMS controller should be set at an initial soil moisture set-point equivalent to 75% of field capacity. Table 3 shows volumetric moisture content (VMC) settings for several field capacity VMCs.

Table 3: Recommended SMS Controller Set-Points				
Field Capacity	10%	15%	20%	25%
Moisture Setting (Threshold)	8%	11%	15%	19%

## Irrigation Time Clock Scheduling

The irrigation time clock, not the SMS controller, initiates scheduled irrigation events. It is extremely important that the irrigation time clock be set for an irrigation schedule appropriate for the irrigation system, location, plant need, season, and your water management district's requirements. Appendix B contains recommended irrigation scheduling for Florida turfgrasses. To establish the run time for a particular zone, use the following procedure:

1. Determine your region (e.g., Central Florida)
2. Determine the season (e.g., autumn)
3. For each zone, determine the appropriate application rate. (e.g., 0.5 in/hr for typical rotors, 1.5 in/hr for typical spray heads) (See: Dukes and Haman, 2002a).
4. Determine the appropriate run time for each zone according to Appendix B (e.g., 85 minutes for a zone with an application rate of 0.50 in/hr during autumn months).
5. Program the specific run time into the irrigation timer for each zone.
6. Repeat for each zone until all zones have been programmed appropriately.

*Note:* For additional assistance in setting you irrigation time clock see the Florida Automated Weather Network (FAWN) Urban Irrigation Scheduler at: [http://fawn.ifas.ufl.edu/tools/urban\\_irrigation/](http://fawn.ifas.ufl.edu/tools/urban_irrigation/)





## IV. Maintenance

Currently, SMS control system manufacturers do not specify routine maintenance procedures. A properly working SMS controller should not result in excessive irrigation application. If the system is applying excessive amounts of irrigation, it needs to be inspected by an irrigation contractor. The principle maintenance task described here is monitoring of the irrigation system's functioning.

*Note:* As previously mentioned, to improve monitoring and maintenance of the SMS, the sensor location should be marked on an as-built design plan displayed next to the irrigation timer.

### A. Evaluate Soil Moisture Sensor Functioning

#### Step 1: Review water bill/meter

The water bill should be reviewed to estimate how much water is being used for irrigation. For new homes, initial irrigation is likely to be higher for plant establishment, and water consumption should be compared with water use for a similar existing landscape. After extended occupancy, it will be possible to compare current water use with past water use. In existing homes, it is fairly straightforward to compare irrigation between pre and post-SMS installation conditions.

For a complete evaluation tool, the following should be known:

1. Amount of water used for irrigation as reported in the monthly utility bill.
2. Irrigated landscape area taken either from an irrigation plan or estimated based on the lot and house size.

#### a. Estimate monthly outdoor water use

##### *Single Meter*

If one meter combines monitoring of domestic indoor water use and outdoor irrigation water use, the two uses should be separated. Two methods can be used for this calculation.

**Method 1.** Assume the average Floridian uses 53 gallons per day indoors (Marella, 2004, p. 15). Multiply this by the number of people in the household to calculate indoor domestic water use.

Formula:      53 gallons /day × \_\_\_\_ people in household × \_\_\_\_ days in month  
= monthly indoor water use

**Method 2.** Calculate the monthly domestic indoor use based on the water bill during a period of low net irrigation requirement (winter months). If the irrigation timer is set properly, irrigation during those winter months should be near zero, and total consumption can act as a baseline for monthly domestic indoor water consumption throughout the year. To determine monthly outdoor water use subtract the monthly indoor use from the monthly total water use.

Formula: \_\_\_\_ total monthly water use - \_\_\_\_ monthly indoor use = \_\_\_\_ monthly outdoor use

## Dual Meter

If an independent water meter is installed to record irrigation consumption, calculating SMS performance is relatively straightforward. The only required calculation is estimation of the irrigated landscape area (ft<sup>2</sup>).

### b. Compare to Appendix C

Appendix C contains monthly recommended net irrigation volume in gallons by region. Net irrigation is calculated by subtracting average rainfall from historical evapotranspiration (ET). To compare your monthly irrigation application to the net irrigation requirements in Appendix C, take the following steps:

1. Determine your region (e.g., Central Florida).
2. Determine the season (e.g., autumn).
3. Estimate your irrigated landscape area in square feet (e.g., 2,000 ft<sup>2</sup>).
4. Find the recommended net irrigation volume in gallons from Appendix C based on steps 1-3 (e.g., 4,300 gallons)
5. Compare this recommendation to the amount of monthly outdoor water use from your utility bill (e.g., 4,000 gallons). Be careful that the amount of water from your bill is one month as some utilities bill on a bimonthly basis.
6. If you are applying excessive amounts of irrigation volume compared to the recommended net irrigation volume, the SMS control system should be inspected by an irrigation contractor. (In this example, irrigation volume is reasonable. Check again the following month.)

## Step 2: Manual Start

Another method for monitoring the SMS controller function is a manual start of the irrigation time clock. This is done by pressing the irrigation time clock's manual start button when irrigation is unnecessary (the SMS controller is in bypass mode). When the manual start is pressed, the irrigation system should not come on. If a watering cycle *is* activated under these conditions, there is a problem with the system's functioning and an irrigation contractor should be contacted (Figure 39).



Figure 40. Manual start of irrigation timer while SMS controller is “On Hold” to test proper operation.

## Step 3: Observation

In some instances, observation of plant "health" can indicate whether the SMS control system is functioning properly. Visual evidence can tell you if the landscape is getting either too much or too little water. Certain conditions, as shown in Table 4, are caused by too much or too little irrigation. Too much irrigation can mean that the SMS is not working properly, or that the set-point is too high. Too little irrigation typically indicates that the set-point is too low. Also, it is important to remember that over- or under-irrigation can result from improper scheduling.

Table 4. Methods for Testing Soil Moisture Sensor Functioning			
Method	Possible Cause of Failure		
	Malfunction	Threshold	Schedule
1. Review of water bill/meter	X	X	X
2. Manual system activation	X		X
3. Check for wet/dry areas			
→Wet	X	X	X
Fungus	X	X	X
Dollar weed	X	X	X
→Dry		X	X
Chinch bugs		X	X

## B. Other Information

### Periodic Recalibration

SMS controller set-points can be increased or decreased periodically to achieve a homeowner's desired irrigation results. Reasons for this periodic recalibration could be seasonal weather variation, water table variation, improper sensor location, or site alteration. If the system is installed properly and the landscape has not been altered, recalibration is only recommended once a year as part of a routine annual irrigation system maintenance program. Annual recalibration should be done beginning with Step 1 in Section III (Calibration) of this field guide.

### Other Considerations

Fertilization companies often activate a watering cycle after fertilizer application. A SMS controller might be turned off at this time to prevent it from bypassing the irrigation system. *The SMS controller must be turned back on.* Instructions for these and other professionals (e.g. pest control) should be included in materials displayed next to the irrigation timer.

### Sensor and Controller Replacement

Contact your distributor for replacement components. If they are unable to meet your needs, contact the manufacturer directly.



## V. Troubleshooting

A. SMS control systems have troubleshooting procedures that are typically model-specific, and operators should *always* refer to the manufacturer's installation manual for troubleshooting guidance.

### ***Important Reminders***

- Be certain that the sensor is connected to the valve controlling irrigation in the sensor's location.
- Make sure the correct wire is connected to the sensor zone terminal on the irrigation timer.
- Make sure all in-ground wiring connections are enclosed within a direct burial connector.
- Make sure the circuit connecting the sensor, zone valve, SMS controller, and time clock is properly connected (i.e. no short circuit).



## VI. References and Resources

### A. Irrigation Scheduling

- Augustin, B. J. (2000). Water Requirements of Florida Turfgrasses. BUL200, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL. Available: <http://edis.ifas.ufl.edu/pdffiles/EP/EP02400.pdf>
- Dukes, M. D. and Haman, D. Z. (2002a). Operation of residential irrigation controllers. CIR1421, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL. Available: <http://edis.ifas.ufl.edu/AE220>
- Florida Automated Weather Network (FAWN) Urban Irrigation Scheduler. [http://fawn.ifas.ufl.edu/tools/urban\\_irrigation/](http://fawn.ifas.ufl.edu/tools/urban_irrigation/)
- St. Johns River Water Management District. (2006). Summary of Lawn and Landscape Irrigation Rule and Exceptions. Available: [http://www.sjrwmd.com/programs/outreach/conservation/irrigation\\_rule/index.html](http://www.sjrwmd.com/programs/outreach/conservation/irrigation_rule/index.html)

### B. General Irrigation

- Dukes, M. D. and Haman, D. Z. (2002b). Residential irrigation system rainfall shutoff devices. ABE325, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Fla. Available: <http://edis.ifas.ufl.edu/AE221>
- Haley, M. B., M. D. Dukes, and G. L. Miller. (2007). Residential irrigation water use in Central Florida. *Journal of Irrigation and Drainage Engineering* 133(2), 427–434.

### C. UF Soil Moisture Sensor Research

- Cardenas-Lailhacar, B., M. D. Dukes, and G. L. Miller. (in press). Sensor-based automation of irrigation on bermudagrass, during wet weather conditions. *Journal of Irrigation and Drainage Engineering*.
- Dukes, M. D., B. Cardenas-Lailhacar, G. L. Miller. (2005). Residential Irrigation Based on Soil Moisture. *Resource* June/July, 4–6.
- Dukes, M. D., B. Cardenas-Lailhacar, S. Davis, M. B. Haley, M. Shedd. (2007). Smart Water Application Technology (SWAT) Evaluation in Florida. *Proceedings of the American Society of Agricultural and Biological Engineers (ASABE) Annual International Meeting, 2007*. Minneapolis, Minnesota.
- Haley, M, and M. D. Dukes. (2007). Evaluation of sensor-based residential irrigation water application. *ASABE 2007 Annual International Meeting, Minneapolis, Minnesota, 2007*. ASABE Paper No. 072251.
- Shedd, M., M. D. Dukes, and G. L. Miller. (2007). Evaluation of evapotranspiration and soil moisture-based irrigation control on turfgrass. *Proceedings of the ASCE EWRI 2007 World Environmental & Water Resources Congress 2007*. Tampa, Fla.

### ***D. Water Efficiency***

Florida Water Star. [http://sjr.state.fl.us/programs/outreach/conservation/water\\_star/water\\_star.html](http://sjr.state.fl.us/programs/outreach/conservation/water_star/water_star.html)

Marella, R.L. (2004). Water withdrawals, use, discharge, and trends in Florida, 2000. U.S. Geological Survey Scientific Investigations Report 2004-5151.



## VII. Appendices

### *Appendix A: Where to Install a Soil Moisture Sensor (SMS)*

#### **Prerequisites for Placement:**

- Within the root zone of turfgrass
- In sunniest area possible
- Within the driest area possible considering all other factors
- Within the center of an irrigation zone

#### **Main Areas to Avoid:**

#### **Minimum Distance Away**

- |                                                    |      |
|----------------------------------------------------|------|
| • Away from structures (house, garage, shed, etc.) | 5 ft |
| • Away from a property line                        | 5 ft |
| • Away from depressions/swales                     | 5 ft |
| • Away from impervious surfaces                    | 5 ft |
| • Away from plant beds                             | 3 ft |

#### **High Moisture Areas to Avoid:**

- |                                                |      |
|------------------------------------------------|------|
| • Away from an overhang                        | 5 ft |
| • Away from an air conditioner condensate line | 5 ft |
| • Away from a hose bib                         | 5 ft |
| • Away from north (shaded) side of the home    | 5 ft |
| • Away from tree canopy                        | 5 ft |
| • Away from a downspout                        | 5 ft |

#### **Disturbed Areas to Avoid:**

- |                                                        |      |
|--------------------------------------------------------|------|
| • Away from construction roads                         | 4 ft |
| • Away from areas with plant debris (i.e., tree stump) | 3 ft |
| • Away from areas with fill dirt                       | 3 ft |
| • Away from buried materials                           | 2 ft |

## Appendix B: Irrigation scheduling per irrigation event for Florida turfgrasses (min)

Season	North	Central	South	Season	North	Central	South
<b>0.50 in/hr</b>				<b>1.50 in/hr</b>			
Winter	5	25	50	Winter	0	10	15
Spring	75	110	80	Spring	25	35	25
Summer	80	95	100	Summer	25	30	35
Autumn	55	85	65	Autumn	20	30	20
<b>0.75 in/hr</b>				<b>1.75 in/hr</b>			
Winter	0	15	35	Winter	0	5	15
Spring	50	70	55	Spring	20	30	25
Summer	55	65	65	Summer	25	25	30
Autumn	40	55	45	Autumn	15	25	20
<b>1.00 in/hr</b>				<b>2.00 in/hr</b>			
Winter	0	15	25	Winter	0	5	15
Spring	40	55	40	Spring	20	25	20
Summer	40	45	50	Summer	20	25	25
Autumn	30	45	35	Autumn	15	20	15
<b>1.25 in/hr</b>				Season = Month w/ highest net requirement			
Winter	0	10	20				
Spring	30	44	30				
Summer	35	40	40				
Autumn	25	35	25				

- Events occur twice per week
- 60% system efficiency
- Calculated from historical ET and effective rainfall
- Numbers rounded for convenience

*Adapted from: Augustin, 2000; and Dukes and Haman, 2002a*

## Appendix C: Monthly Net Irrigation Requirements for Florida

**Table 1: Monthly Net Irrigation Requirements for North Florida**

Net Irrigation Requirement (Historical ET - Rainfall)						
	Volume (gallons) of Irrigation per Irrigated Area (sq. ft.)					
Season	Application (Inches)	Irrigated Area (sq. ft.)				
		2,000	4,000	6,000	8,000	10,000
Spring	3.70	4,600	9,200	13,800	18,500	23,000
Summer	3.21	4,000	8,000	12,000	16,000	20,000
Autumn	3.51	4,400	8,800	13,100	17,500	21,900
Winter	1.44	1,800	3,600	5,400	7,200	9,000
Annual Total	11.86	14,800	29,600	43,300	59,200	73,900

- Requirements are for Gainesville, FL
- Seasons are the months with the highest irrigation requirement
- Spring = May
- Summer = June
- Autumn = September
- Winter = December

*Adapted from Augustin, 2000*

**Table 2: Monthly Net Irrigation Requirements for Central Florida**

Net Irrigation Requirement (Historical ET - Rainfall)						
		Volume (gallons) of Irrigation per Irrigated Area (sq. ft.)				
Season	Application (Inches)	Irrigated Area (sq. ft.)				
		2,000	4,000	6,000	8,000	10,000
Spring	4.73	5,900	11,800	17,700	23,600	29,500
Summer	4.68	5,800	11,700	17,500	23,300	29,200
Autumn	3.41	4,300	8,500	12,800	17,000	21,300
Winter	1.19	1,500	3,000	4,500	6,000	7,400
Annual Total	14.01	17,500	35,000	52,500	69,900	87,400

- Requirements are for Orlando, FL
- Seasons are the months with the highest net irrigation requirement.
- Spring = May
- Summer = August
- Autumn = September
- Winter = November

*Adapted from Augustin, 2000*

**Table 3: Monthly Net Irrigation Requirements for South Florida**

Net Irrigation Requirement (Historical ET - Rainfall)						
	Volume (gallons) of Irrigation per Irrigated Area (sq. ft.)					
Season	Application (Inches)	Irrigated Area (sq. ft.)				
		2,000	4,000	6,000	8,000	10,000
<b>Spring</b>	4.12	5,100	10,300	15,400	20,500	25,700
<b>Summer</b>	4.06	5,100	10,100	15,200	20,200	25,300
<b>Autumn</b>	2.96	3,700	7,400	11,100	14,800	18,500
<b>Winter</b>	2.07	2,600	5,200	7,700	10,300	12,900
<b>Annual Total</b>	13.21	16,500	33,000	49,400	65,800	82,400

- Requirements are for Ft. Myers, FL
- Seasons are the months with the highest irrigation requirement
- Spring = May
- Summer = August
- Autumn = November
- Winter = December

*Adapted from Augustin, 2000*