Chapter 10 Conservation Management Systems and Irrigation Planning

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FL652.1005a Irrigation Water Management Plan For Fixed-Solid Set Sprinkler Irrigation System

General

The example problem in this chapter is intended to cover the basic steps to follow in the development of an irrigation water management (IWM) plan for a permanent and solid-set sprinkler irrigation system. It is understood that one example cannot cover all situations and an IWM plan should be tailored to the individual site and the management expertise and desires of the irrigator.

Criteria

The requirements for an IWM plan are contained in Florida NRCS conservation practice standard, Irrigation Water Management, Code 449.

Example Problem

For this example problem, we will develop an IWM plan for the permanent/solid-set sprinkler irrigation system that was designed in Chapter FL6A.

Given:

Refer to Exhibit FL6A-1 for all the necessary information.

Solution:

Step 1. Provide the irrigator basic data such as:

- acres to be irrigated of each crop;
- water supply;
- irrigation flow rates;
- water quality;
- soil type;
- available water capacity (AWC);
- management allowable depletion (MAD);
- peak consumptive use rate;
- intake rate;
- irrigation efficiency; and,
- rooting depth.

This data is contained in the irrigation data sheets as shown in Chapter FL6A. In this example, this information was provided to the irrigator by providing the irrigator a copy of the design, Exhibit FL6A-1. If the irrigator does not have a copy of the design then this information should be obtained and provided to the irrigator.

Step 2. Discuss with the irrigator the need to measure soil moisture in order to determine the AWC of the soil to be irrigated. The various methods available to determine soil moisture should be discussed with the irrigator in such detail that a method can be selected to use. Once the irrigator chooses a method, work with the irrigator until they understand how to use the method. The irrigator in this example selected tensiometers to determine soil moisture content. The irrigator must be able to convert the tensiometer reading to percent of soil water depleted. This requires calibrating the tensiometers for the soil type.

Step 3. Provide the irrigator with information on the daily crop water requirements (i.e., peak consumptive use rate). Information on irrigation water requirements can be found in Chapter 4 of this guide or obtained from Table FL4-6 of Chapter 4. This example is for citrus in climatic zone 4. The irrigator should have an understanding that this information is estimated. The irrigator should also have an understanding of effective rainfall (i.e., that all rainfall is not available for use by the crop).

Step 4. The irrigator should have a method to determine when to irrigate (i.e., an irrigation scheduling procedure). The different methods should be explained to the irrigator in such detail that a method can be selected. The irrigator should be taught how to use the method selected in scheduling irrigation. In this example, the irrigator selected to use the results from the Florida NRCS computer workbook IWM. The results are summarized in Table 1 of the IWM plan, Exhibit FL10A-1. This is an estimated schedule. The irrigator should adjust scheduling as needed based on the soil moisture and the crop's response to irrigation.

Step 5. Provide the irrigator with the MAD before irrigation. MAD (in.) is based on a percentage of AWC to be depleted before irrigation. In this example, citrus has a rooting depth of 60 inches, so the AWC is 3.72 inches (0.062 in./in. x 60 in. = 3.72 in.). With a MAD of 30%, then the maximum allowed soil depletion before irrigation or MAD (in.) is: 3.72 in. x 0.30 = 1.12 inches. This was included in the IWM plan, Exhibit FL10A-1.

Step 6. The critical stages of growth where sufficient moisture is necessary for crop production should be provided to the irrigator. This information can be obtained from Chapter FL3 of this guide. The critical period for citrus is from fruit set (February – March) until such time when young fruit has reached more than 1-inch in diameter (June – July). During this time, the MAD should not exceed 30%. For the remainder of the year, MAD should not exceed 50%. This information was included in the IWM plan, Exhibit FL10A-1.

Step 7. The irrigator should know how much water to apply. The net amount to apply is determined by the AWC and MAD and will vary at different rooting depths (i.e., crop growth stages). The gross amount to apply is the net amount divided by the irrigation system efficiency. The irrigator should understand that the irrigation system is not 100% efficient in delivering water to the field and that they should divide the net amount by the irrigation efficiency to obtain the gross amount to apply. Irrigation efficiency was given on the irrigation data sheets as 75%. So for a MAD of 30%, the gross amount applied would be 1.12 in. ÷ 0.75 = 1.5 inches.

The irrigator should know the application rate (in./hr.) of the irrigation system in order to determine the time needed to apply the required water. In this example, the irrigator will also be using a second tensiometer installed at 18 inches to help fine tune the duration of irrigation.

Step 8. The irrigator should understand how to recognize erosion caused by irrigation and excess runoff of irrigation water and should be provided with ways to make adjustments to prevent runoff. The information provided will vary with each situation due to the variance in erosion potential of soils, land slope, soil intake rate, etc. A statement was made for this example and included in the IWM plan, Exhibit FL10A-1.

Step 9. The irrigator should be provided with a method of evaluating the performance of the irrigation applications. This would consist of explaining the reasons to evaluate the system and forms that would be helpful in evaluating the system. It may be necessary to work with the landowner on the first evaluation to demonstrate how to gather and interpret the data. Chapter 9 of this guide gives additional information on how to evaluate irrigation systems.

Exhibit FL10A-1. Irrigation Water Management Plan for Fixed Solid-Set Sprinkler Irrigation System

IRRIGATION WATER MANAGEMENT PLAN

DATE:	12/05
COOPERATOR:	T.O. Dry
LOCATION:	2 miles S of Sebring, W side of 27
FIELD NUMBER:	1
CROP:	Citrus
ROOTING DEPTH:	60”
AVAILABLE WATER CAPACITY (AWC):	3.72 inches
PEAK CONSUMPTIVE USE RATE:	0.19 inches/day
IRRIGATION SYSTEM RATE:	Solid Set Sprinklers with a 60’ x 60’ spacing, 5/32” diameter nozzle, 96’ wetted diameter and 4.72 gpm/sprinkler @ 45 psi
SPRINKLER APPLICATION RATE:	0.13 in./hr.
WATER SUPPLY:	8” diameter well
PREDOMINATE SOIL SERIES:	Lakeland fine sand
CURRENT MANAGEMENT PRACTICE:	None

RECOMMENDATIONS:

The most important aspect of irrigation water management is properly evaluating and monitoring the available soil moisture for the particular crop. Tensiometers will be used for determining soil moisture and when irrigation is needed.

The system is designed to provide irrigation water to meet peak consumptive use for citrus in field 1 provided the acreage grown is not increased beyond 20 acres.

Moisture should always be available above the Management Allowable Depletion (MAD) for the planned crops. The critical periods for adequate available water are from fruit set (February – March) until such time when young fruit has reached more than 1-inch in diameter (June – July). The soil moisture should be checked to determine how much irrigation water should be applied for each irrigation. If operated properly, irrigation can result in high crop production. The system should be managed to maintain a high moisture level in the root zone.

Observations of the leaf wilt, soil, tensiometer readings and weather conditions will indicate when irrigation is needed to maintain the desired moisture level. The Irrigation Scheduling Guide, Table 2, was developed with the Florida NRCS computer workbook IWM and indicates the approximate irrigation frequency. The estimated irrigation frequency is from 2 to 10 days. The estimated delay days for 1/4 inch of rainfall is 1 to 6 days. The Irrigation Scheduling Guide is based on general climatic and crop data providing a beginning schedule until adjustments are made. The actual need for irrigation will be determined by observing the soil and estimating the remaining moisture (tensiometers), observing leaf wilt, and weather conditions.

Exhibit FL10A-1. Irrigation Water Management Plan for Fixed Solid-Set Sprinkler Irrigation System (Cont'd.)

Generally, during the bloom and fruit set period, irrigation will be applied when the six-inch tensiometers reach 15 cb. During the remainder of the year, irrigation will be applied at 20 cb. These guidelines may be adjusted due to variations in the soil. The tensiometer readings will be confirmed and the irrigation schedule in Table 1 adjusted by close observations described above.

The approximate number of hours to operate the system for water to reach the depth of the root system is shown on Table 1 Irrigation Scheduling Guide. The schedule will be modified based on observations of the soil. A tensiometer will be used to determine the depth the water reaches in the soil.

The operating time that is shown in the Irrigation Scheduling Guide will be modified by using a tensiometer in the lower portion of the root system. An 18-inch tensiometer will be used. Operating time will be decreased if the 18-inch tensiometer drops below 10 cb and increased if readings rise above 15 cb during the bloom and fruit set period. During the remainder of the year, operating time will be decreased if the 18-inch tensiometer drops below 10 cb and increased if it rises above 20 cb. These guidelines may be adjusted for the soil type based on observations.

Based on the current uniformity and discharge rate, to replace 30% of the soil moisture to a depth of 60 inches, 11 hours, 45 minutes of irrigation are required. To replace 50% of the soil moisture to a depth of 60 inches, 19 hours, 45 minutes of irrigation are required. These estimates are to be confirmed or modified, based on observations of the soil.

The irrigation system should be checked periodically to ensure proper operation of the pump, pipeline, and sprinklers. Some puddling may occur during system operation. If significant puddling, runoff, or other irrigation-induced erosion occurs, the system should be operated for a shorter duration and the frequency of irrigation increased.

Check the condition of the crop to ensure that it looks consistent in color to determine adequacy and uniformity of irrigation. If application is not uniform, a system evaluation should be performed.

If there is change in the soil moisture monitoring method or irrigation method, the NRCS office in Sebring, Florida, should be contacted.

Exhibit FL10A-1. Irrigation Water Management Plan for Fixed Solid-Set Sprinkler Irrigation System (Cont'd.)

Table 1 - Irrigation Scheduling Guide

	---Irrigation---					---Rainfall---
	[1/] MAD	[1/] MAD	[2/] Gross Irrigation Depth	[3/] Operating Time	Irrigation Interval	Delay Days per 1/4 inch of rainfall
Month	(%)	Inches	Inches	Hrs: Min	Days	
January	30	1.12	1.48	11:45	20	4
February	30	1.12	1.48	11:45	17	4
March	30	1.12	1.48	11:45	13	3
April	30	1.12	1.48	11:45	11	2
May	30	1.12	1.48	11:45	8	2
June	30	1.12	1.48	11:45	7	2
July	50	1.86	2.49	19:45	12	2
August	50	1.86	2.49	19:45	12	2
September	50	1.86	2.49	19:45	14	2
October	50	1.86	2.49	19:45	18	2
November	50	1.86	2.49	19:45	24	3
December	50	1.86	2.49	19:45	32	4

[1/] *Management Allowable Depletion.*
[2/] *Application depth necessary to replace water used by crop assuming an application efficiency of 75%.*
[3/] *Time required for each irrigation unit.*

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FL652.1005b Irrigation Water Management Plan For Microirrigation System

General

The example problem in this chapter is intended to cover the basic steps to follow in the development of an irrigation water management (IWM) plan for a microirrigation system. It is understood that one example cannot cover all situations and an IWM plan should be tailored to the individual site and the management expertise and desires of the irrigator.

Criteria

The requirements for an IWM plan are contained in Florida NRCS conservation practice standard, Irrigation Water Management, Code 449.

Example Problem

For this example problem, we will develop an IWM plan for the microirrigation system that was designed in Chapter FL6B.

Given:

Refer to Exhibit FL6B-1 for all the necessary information.

Solution:

Step 1. Provide the irrigator basic data such as:

- acres to be irrigated of each crop;
- water supply;
- irrigation flow rates;
- water quality;
- soil type;
- allowable water capacity (AWC);
- management allowable depletion (MAD);
- peak consumptive use rate;
- intake rate;
- irrigation efficiency; and,
- rooting depth.

This data is contained in the irrigation data sheets as shown in Chapter FL6B. In this example, this information was provided to the irrigator by providing the irrigator a copy of the design, Exhibit FL6B-1. If the irrigator does not have a copy of the design then this information should be obtained and provided to the irrigator.

Step 2. Discuss with the irrigator the need to measure soil moisture in order to determine the AWC of the soil to be irrigated. The various methods available to determine soil moisture should be discussed with the irrigator in such detail that a method can be selected to use. Once the irrigator chooses a method, work with the irrigator until they understand how to use the method. The irrigator in this example selected tensiometers to determine soil moisture content. The irrigator must be able to convert the tensiometer reading to percent of soil water depleted. This requires calibrating the tensiometers for the soil type.

Step 3. Provide the irrigator with information on the daily crop water requirements (i.e., peak consumptive use rate). Information on irrigation water requirements can be found in Chapter 4 of this guide. This example is for citrus in climatic zone 4. The irrigator should have an understanding that this information is estimated. The irrigator should also have an understanding of effective rainfall (i.e., that all rainfall is not available for use by the crop).

Step 4. The irrigator should have a method to determine when to irrigate (i.e., an irrigation scheduling procedure). The different methods should be explained to the irrigator in such detail that a method can be selected. The irrigator should be taught how to use the method selected in scheduling irrigation. In this example, the irrigator selected to use the results from the Florida NRCS computer workbook IWM. The results are summarized in Table 1 of the IWM plan, Exhibit FL10B-1. This is an estimated schedule. The irrigator should adjust scheduling as needed based on the soil moisture and the crop's response to irrigation.

Step 5. Provide the irrigator with the MAD before irrigation. MAD (in.) is based on a percentage of AWC to be depleted before irrigation. In this example, citrus has a rooting depth of 42 inches, so the AWC is 1.47 inches (0.035 in./in. x 42 in. = 1.47 in.). With a MAD of 30%, then the maximum allowed soil depletion before irrigation or MAD (in.) is: 1.47 in. x 0.30 = 0.44 inches. This was included in the IWM plan, Exhibit FL10B-1.

Step 6. The critical stages of growth where sufficient moisture is necessary for crop production should be provided to the irrigator. The information can be obtained from Chapter 3, Table 3-1, of this guide. The critical period for citrus is from fruit set (February – March) until such time when young fruit has reached more than 1-inch in diameter (June – July). During this time, the MAD should not exceed 30%. For the remainder of the year, MAD should not exceed 50%. This information was included in the IWM plan, Exhibit FL10B-1.

Step 7. The irrigator should know how much water to apply. The net amount to apply is determined by the AWC and MAD. The gross amount to apply is the net amount divided by the irrigation system efficiency. The irrigator should understand that the irrigation system is not 100% efficient in delivering water to the field and that they should divide the net amount by the irrigation efficiency to obtain the gross amount to apply. Irrigation efficiency was given on the irrigation data sheets as 80 %. So for a MAD of 50%, the gross amount applied would be = 0.74 in. ÷ 0.80 = 0.93 inches. The irrigator should know the application amount (in.) of his irrigation system in order to determine the time needed to apply the required water. In this example, the irrigator will also be using a second tensiometer installed at 18 inches to help fine tune the duration of irrigation.

Step 8. The irrigator should understand how to recognize erosion caused by irrigation and excess runoff of irrigation water and should be provided with ways to make adjustments to prevent runoff. However, this is typically not a concern for microirrigation systems.

Step 9. The irrigator should be provided with a method of evaluating the performance of his irrigation applications. This would consist of explaining the reasons to evaluate the system and forms that would be helpful in evaluating the system. It may be necessary to work with the landowner on the first evaluation to teach them how to gather and interpret the data. Chapter 9 of this guide gives additional information on how to evaluate irrigation systems.

Exhibit FL10B-1. Irrigation Water Management Plan for Microirrigation

IRRIGATION WATER MANAGEMENT PLAN

DATE:	10/04
COOPERATOR:	Orange Tree Groves, Inc.
LOCATION:	1 mile south of Sebring
FIELD NUMBER:	8
CROP:	Citrus
ROOTING DEPTH:	42 in
PEAK CONSUMPTIVE USE RATE:	0.19 in/day
IRRIGATION SYSTEM:	4000 green emitters on a 15’ x 25’ spacing (1 emitter/tree)
WATER SUPPLY:	1200 gpm well
PREDOMINATE SOIL SERIES:	Astatula

Management Allowed Depletion (%)

The micro-sprinkler irrigation system will be operated to maintain the soil moisture in a range of field capacity to 30 percent depletion from fruit set (February – March) until such time when young fruit has reached more than 1-inch in diameter (June – July) and in a range of field capacity to 50 percent depletion during the remainder of the year.

Method Used to Determine When to Irrigate

Observations of the leaf wilt, soil, tensiometer readings and weather conditions will indicate when irrigation is needed to maintain the desired moisture level. The Irrigation Scheduling Guide, Table 2, was developed with the Florida NRCS computer workbook IWM and indicates the approximate irrigation frequency. The estimated irrigation frequency is from 2 to 10 days. The estimated delay days for 1/4 inch of rainfall is 1 to 6 days. The Irrigation Scheduling Guide is based on general climatic and crop data providing a beginning schedule until adjustments are made. The actual need for irrigation will be determined by observing the soil and estimating the remaining moisture (tensiometers), observing leaf wilt, and weather conditions.

Generally, during the bloom and fruit set period, irrigation will be applied when the six-inch tensiometers reach 15 cb. During the remainder of the year, irrigation will be applied at 20 cb. These guidelines may be adjusted due to variations in the soil. The tensiometer readings will be confirmed and the irrigation schedule in Table 2 adjusted by close observations described above.

Method Used to Determine Quantity of Water Needed

The approximate number of hours to operate the system for water to reach the depth of the root system is shown on the Irrigation Scheduling Guide. The schedule will be modified based on observations of the soil. A tensiometer will be used to determine the depth the water reaches in the soil.

Exhibit FL10B-1. Irrigation Water Management Plan for Microirrigation (Cont'd.)

The operating time that is shown in the Irrigation Scheduling Guide will be modified by using a tensiometer that reaches the bottom of the root system. An 18-inch tensiometer will be used. Operating time will be decreased if the 18-inch tensiometer drops below 10 cb and increased if readings rise above 15 cb during the bloom and fruit set period. During the remainder of the year, operating time will be decreased if the 18-inch tensiometer drops below 10 cb and increased if it rises above 20 cb. These guidelines may be adjusted for the soil type based on observations.

Based on the current uniformity and discharge rate, to replace 30% of the soil moisture to a depth of 42 inches, 5 hours, 30 minutes of irrigation are required. To replace 50% of the soil moisture to a depth of 42 inches, 9 hours of irrigation are required. These estimates are to be confirmed or modified, based on observations of the soil.

Application Rate

To maintain the current application rate, the system pressure will be maintained between 17 psi and 23 psi at the emitter. The emitter wetted pattern will be maintained at 18 feet diameter.

Table 1 - Irrigation Scheduling Guide

	---Irrigation---			---Rainfall---	
	MAD	**Operating Time [1/]**	**Irrigation Interval**	**Delay Days per 1/4 inch of rainfall**	**Maximum Delay**
Month	**(%)**	**Hrs: Min**	**Days**		**Days**
January	30	05:30	8	4	8
February	30	05:30	8	4	8
March	30	05:30	5	3	5
April	30	05:30	4	2	4
May	30	05:30	3	2	3
June	30	05:30	3	2	3
July	50	09:00	5	2	5
August	50	09:00	5	2	5
September	50	09:00	6	2	6
October	50	09:00	7	2	7
November	50	09:00	10	3	10
December	50	09:00	12	4	13

[1/] Operating time rounded to nearest 15 minutes.

Exhibit FL10B-1. Irrigation Water Management Plan for Microirrigation (Cont'd.)

Operation

The irrigation system should be checked periodically to ensure proper operation of the pump, pipeline, and emitters.

Check the condition of the leaves to determine adequacy and uniformity of irrigation. If application is not uniform, a system evaluation should be performed.

If there is change in the soil moisture monitoring method or irrigation method, the NRCS office in Sebring, Florida, should be contacted.

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FL652.1005c Irrigation Water Management Plan For Center Pivot Sprinkler Irrigation System

General

The example problem in this chapter is intended to cover the basic steps to follow in the development of an irrigation water management (IWM) plan for a center pivot sprinkler irrigation system. It is understood that one example cannot cover all situations and an IWM plan should be tailored to the individual site and the management expertise and desires of the irrigator.

Criteria

The requirements of an IWM plan are contained in Florida NRCS conservation practice standard, Irrigation Water Management, Code 449.

Example Problem

For this example problem, we will develop an IWM plan for the center pivot sprinkler irrigation system that was designed in Chapter FL6C.

Given:

Refer to Exhibit FL6C-1 for all the necessary information.

Solution:

Step 1. Provide the irrigator basic data such as:

- acres to be irrigated of each crop;
- water supply;
- irrigation flow rates;
- water quality;
- soil type;
- available water capacity (AWC);
- management allowable depletion (MAD);
- peak consumptive use rate;
- intake rate;
- irrigation efficiency and,
- rooting depth.

This data is contained in the irrigation data sheets as shown in Chapter FL6C. In this example, this information was provided to the irrigator by providing the irrigator a copy of the design, Exhibit FL6C-1. If the irrigator does not have a copy of the design then this information should be obtained and provided to the irrigator.

Step 2. Discuss with the irrigator the need to measure soil moisture in order to determine the AWC of the soil to be irrigated. The various methods available to determine soil moisture should be discussed with the irrigator in such detail that a method can be selected to use. Once the irrigator chooses a method, work with the irrigator until they understand how to use the method. The irrigator in this example selected the feel and appearance method of determining soil moisture content. The irrigator must be able to convert the soil moisture measurement to inches of water available to the crop. A form was prepared for convenience in converting the soil moisture measurement to AWC and was included in the IWM plan, Exhibit FL10C-1. Exhibit 9-1 of this guide shows how to convert the soil moisture measurement to AWC in inches for the major soil moisture measurement methods.

Step 3. Provide the irrigator with information on the daily crop water requirements (i.e., peak consumptive use rate). Information on irrigation water requirements can be found in Chapter 4 of this guide. If the planting and harvest dates are close to the dates shown in Table FL4-6 of Chapter 4, then that data can be given to the irrigator. This example is for corn in climatic zone 2. The planting and harvest dates are close to those shown in Table FL4-6. The irrigator should have an understanding that this information is estimated. The irrigator should also have an understanding of effective rainfall (i.e., that all rainfall is not available for use by the crop).

Step 4. The irrigator should have a method to determine when to irrigate (i.e., an irrigation scheduling procedure). The different methods should be explained to the irrigator in such detail that a method can be selected. The irrigator should be taught how to use the method selected in scheduling irrigation. In this example, the irrigator selected to use the checkbook method. This method uses the consumptive use data contained in Chapter 4, Table FL4-6, to create a plot of average daily consumptive use versus time. The curve was drawn for the irrigator and included in Exhibit 1 of the IWM plan, Exhibit FL10C-1. A moisture balance sheet (checkbook) was created as an example using this data and

included in Exhibit 2 of the IWM plan, Exhibit FL10C-1. An abbreviated explanation of how to use the selected method should be left with the irrigator. This was also included in the IWM plan.

Step 5. Provide the irrigator with the MAD before irrigation. MAD (in.) is based on a percentage of AWC to be depleted before irrigation. In this example, when the corn has a rooting depth of 12 inches the AWC is 0.67 inches (0.056 in./in. x 12 in. = 0.67 in.). With a MAD of 50%, then the maximum allowed soil depletion before irrigation or MAD (in.) is: 0.67 in. x 0.50 = 0.34 inches. When the corn has a rooting depth of 36 inches the AWC is 1.87 inches. The maximum allowed soil depletion prior to irrigation is 1.87 in. x 0.50 = 0.94 inches. This was calculated for various rooting depths and included in the IWM plan, Exhibit FL10C-1. The irrigator must determine the current rooting depth in order to properly schedule irrigations.

Step 6. The critical stages of growth where sufficient moisture is necessary for crop production should be provided to the irrigator. The information can be obtained from Chapter 3, Table 3-1, of this guide. The critical period for corn is from tasseling through silk stage until kernels become firm and this information was included in the IWM plan, Exhibit FL10C-1.

Step 7. The irrigator should know how much water to apply. The net amount to apply is determined by the AWC and MAD and will vary at different rooting depths (i.e., crop growth stages). The gross amount to apply is the net amount divided by the irrigation system efficiency. The irrigator should understand that the irrigation system is not 100% efficient in delivering water to the field and that they should divide the net amount by the irrigation efficiency to obtain the gross amount to apply. Irrigation efficiency was given on the irrigation data sheets as 85%. So for a 12 inch root depth, the gross amount applied would be 0.34 in. ÷ 0.85 = 0.40 inches. The irrigator should know the application rate of their irrigation system (in./hr) in order to determine the time needed to apply the required water. In the case of self-propelled irrigation equipment, operating adjustments should be made to apply the necessary irrigation amount. For center pivot systems a table should be developed to relate the dial setting to the gross water applied. Chapter FL6C of this guide gives a procedure for determining gross applications of center pivot systems. The dial setting for this system was computed and included in the IWM plan, Exhibit FL10C-1, showing the gross amount and net amount applied.

Step 8. The irrigator should be taught how to recognize erosion caused by irrigation and excess runoff of irrigation water and should be provided with ways to make adjustments to prevent runoff. The information provided will vary with each situation due to the variance in erosion potential of soils, land slope, soil intake rate, etc. A statement was made for this example and included in the IWM plan, Exhibit FL10C-1.

Step 9. The irrigator should be provided a method of evaluating the performance of their irrigation applications. This would consist of explaining the reasons to evaluate the system and forms that would be helpful in evaluating the system. It may be necessary to work with the landowner on the first evaluation to teach them how to gather and interpret the data. In this example, forms were included in the IWM plan, Exhibit FL10C-1. Plans were made to assist the irrigator in evaluating the irrigation system. Chapter 9 of this guide gives additional information on how to evaluate irrigation systems.

Exhibit FL10C-1. Irrigation Water Management Plan for Center Pivot Sprinkler Irrigation System

IRRIGATION WATER MANAGEMENT PLAN

DATE:	4/04
COOPERATOR:	Hurry I. Dry
LOCATION:	Bellville
FIELD NUMBERS:	1
CROP:	Corn
GROWING SEASON:	February 15 – June 20
ROOTING DEPTH:	36 in
PEAK CONSUMPTIVE USE RATE:	0.23 in/day
IRRIGATION SYSTEM:	Center pivot - 1314' span length, Pivot pressure = 38 psi, Capacity = 1100 GPM
WATER SUPPLY:	Well
PREDOMINANT SOIL SERIES:	Alpin sand

Table 1: Operating Times for Various Rooting Depths and 50%MAD

Crop	Rooting Depth (inches)	1/ AWC (in)	2/ MAD (in)	3/ Gross Application Irrigation (in)	Critical Irrigation Period	4/ Dial Setting	4/ Time per Revolution (hours)
Corn	12"	0.67	0.34	0.40	Tasseling through silk stage until kernels become firm	88	20.60
	24"	1.27	0.64	0.75		47	38.57
	36"	1.87	0.94	1.11		32	56.66

1/ *Available Water Capacity within the root zone (AWC).*
2/ *Management Allowable Depletion (MAD)*
3/ *Application depth necessary to replace water used by crop assuming an application efficiency of 85%*
4/ *Calculated from manufacturer's data. This should be re-calculated after checkout or evaluation.*

Exhibit FL10C-1. Irrigation Water Management Plan for Center Pivot Sprinkler Irrigation System (Cont'd.)

CURRENT MANAGEMENT PRACTICE: None

RECOMMENDATIONS:

The most important aspect of irrigation water management is properly evaluating and monitoring the available soil moisture for the particular crop. By observing moisture levels in the soil, the operator can determine how long and how much water to apply. The landowner will be using the feel and appearance method. See attached feel and appearance worksheets.

The system is designed to meet peak consumptive use for corn on 125 acres.

Moisture should always be available above the MAD for the planned crops. The critical period is from tasseling through silk stage until the kernels become firm. The soil moisture should be checked to determine how much irrigation water should be applied for each irrigation. Prior to planting, or soon thereafter, the 12 inch root zone should be brought up to field capacity. If operated properly, irrigation can result in high crop production. The system should be managed to maintain a high moisture level in the root zone.

For planned crop yield, irrigation should commence when the available soil moisture drops below the MAD and should continue until the soil reaches field capacity. See Table 1 for how long to operate the system for various rooting depths and a MAD of 50%.

The irrigation system should be checked periodically to ensure proper operation of the pump, pipeline and sprinklers. No puddling should occur in the system. A visual inspection should be performed during operation to determine if any puddling or other irrigation-induced erosion is occurring. If so, increase the speed of the center pivot and the frequency of irrigation until no erosion occurs.

Check the condition of the crop to see if there is growth and if the crop looks consistent in color and height to determine adequacy and uniformity of the irrigation system.

Table 2 can be used to determine the time required per revolution, gross application and net application for various dial settings.

If there is change in the soil moisture monitoring method or irrigation method, contact the NRCS field office in Jasper, Florida.

Exhibit FL10C-1. Irrigation Water Management Plan for Center Pivot Sprinkler Irrigation System (Cont'd.)

TABLE 2: Time Required per Revolution, Gross Application, and Net Application

Dial Setting	Time Required per Revolution-Hours	Gross Application inches	Net Application inches
100	18.13	0.35	0.30
90	20.14	0.39	0.33
80	22.66	0.44	0.37
70	25.90	0.50	0.43
60	30.21	0.59	0.50
50	36.25	0.70	0.60
40	45.32	0.88	0.75
30	60.42	1.17	1.00
20	90.64	1.76	1.50
10	181.27	3.52	2.99

Exhibit FL10C-1. Irrigation Water Management Plan for Center Pivot Sprinkler Irrigation System (Cont'd.)

Cooperator: Hurry I. Dry Field No. 1 Location: Bellville

Format for figuring the net amount of water needed for an irrigation using the feel and appearance method of soil moisture measurements.

1	2	3	4	5	6
Depth	**Soil Series**	**Available Water Capacity**	**Soil Water Content Before Irrigation**		**Soil Water deficiency**
feet	**Alpin texture**	**inches**	**percent**	**inches**	**inches**
0-1	coarse	0.67			
1-2	coarse	0.60			
2-3	coarse	0.60			
Total		1.87			

Column 1, the depth increment sampled.

Column 2, the soil texture of the sample.

Column 3, the available water capacity based on the texture of the sample.

Column 4, the percent of soil water content (remaining)

0-25% - AWC - Dry, loose, will hold together if not disturbed, loose sand grains on fingers with applied pressure.

25-50% - AWC – Slightly moist, forms a very weak ball with well-defined finger marks, light coating of loose and aggregated sand grains remains on fingers.

50-75% - AWC Moist, forms a weak ball with loose and aggregated sand grains, darkened color, moderate water staining on fingers, will not ribbon.

75-100% - AWC – Wet, forms a weak ball, loose and aggregated sand grains remain on fingers, darkened color, heavy water staining on fingers, will not ribbon.

100% - AWC – Wet, forms a weak ball, moderate to heavy soil/water coatings on fingers, wet outline of soft ball remains on hand.

Column 5, Column 3 x Column 4, the soil-moisture balance, inches.

Column 6, Column 3 - Column 5, soil-moisture deficiency or net irrigation requirement.

Fine sand and loamy fine sand soils

Percent available: Currently available soil moisture as a percent of available water capacity.

Available Soil Moisture Remaining	Appearance of soil
0-25 percent available	Dry, loose, will hold together if not disturbed, loose sand grains on fingers with applied pressure.
25-50 percent available	Slightly moist, forms a very weak ball with well-defined finger marks, light coating of loose and aggregated sand grains remains on fingers.
50-75 percent available	Moist, forms a weak ball with loose and aggregated sand grains on fingers, darkened color, moderate water staining on fingers, will not ribbon.
75-100 percent available	Wet, forms a weak ball, loose and aggregated sand grains remain on fingers, darkened color, heavy water staining on fingers, will not ribbon.
100 percent available	Wet, forms a weak ball, moderate to heavy soil/water coating on fingers, wet outline of soft ball remains on hand

Courtesy of the United States Department of Agriculture, Natural Resource Conservation Service, *Estimating Soil Moisture by Feel and Appearance* (Program Aid 1619)

Exhibit FL10C-2. Average Daily Consumptive Use Mass Curve for Corn in Climatic Zone 2

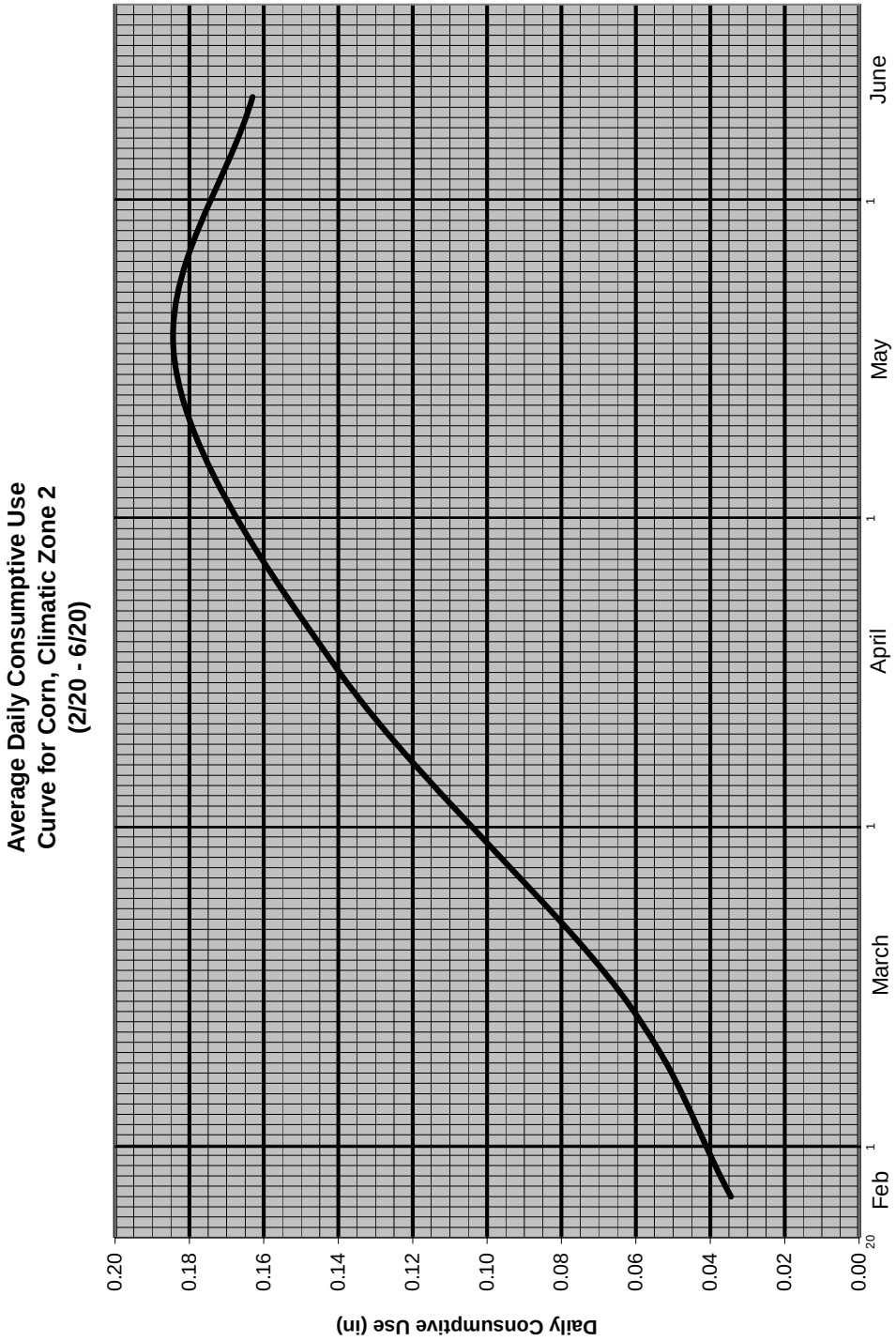


Exhibit FL10C-3. Moisture Balance Sheet for Scheduling Irrigation

Farm Hurry I. Dry Field No. 1 Crop Corn Month April Year 2004

County Hamilton Climatic Zone 2 Soil Type Alpin F.S.

Moisture Holding Capacity in Root Zone 1.87 inches

Net Moisture to Apply at Each Irrigation 0.94 inches (50% MAD)

Irrigate when balance is 0.93 inches

Date	Estimated Daily Consumptive Use, (in)	Rainfall (in)	Net Irrigation (in)	Daily Balance (in)	Remarks
Balance Brought Forward				1.78	Balance brought forward from March 31
1	0.10	0	0	1.68	
2	0.11	0	0	1.57	
3	0.11	0	0	1.46	
4	0.11	0	0	1.35	
5	0.12	1.5	0	1.87	Rain replenished root zone moisture.
6	0.12	0	0	1.75	1.87 inches is the maximum capacity.
7	0.12	0	0	1.63	
8	0.12	0	0	1.51	
9	0.13	0	0	1.38	
10	0.13	1.8	0	1.87	Rain replenished root zone moisture.
11	0.13	0	0	1.74	
12	0.13	0	0	1.61	
13	0.13	0	0	1.48	
14	0.14	0	0	1.34	
15	0.14	0	0	1.20	
16	0.14	0	0	1.06	
17	0.14	0	0.94	1.87	Gross irrigation of 1.1 inches at 85%
18	0.14	0	0	1.73	application efficiency.
19	0.15	0	0	1.58	
20	0.15	0	0	1.43	
21	0.15	0	0	1.35	Field moisture check, balance adjusted.
22	0.15	2.2	0	1.87	Rain replenished root zone moisture.
23	0.15	0	0	1.72	
24	0.16	0	0	1.56	
25	0.16	0	0	1.40	
26	0.16	0	0	1.24	
27	0.16	0.6	0	1.68	
28	0.16	0	0	1.52	
29	0.16	0	0	1.36	
30	0.17	0	0	1.19	
Totals	4.14	6.10	0.94		

Using the Average Daily Consumptive Use Curve and Moisture Balance Sheet

Step 1. Estimate the average daily consumptive use values from the graph by projecting vertically from the day of the month in question until intersecting the curve and then projecting horizontally to read the consumptive use. Record these values for each day of the month.

Step 2. Take soil moisture measurements at the beginning of the season and determine the initial soil moisture content.

Step 3. Take moisture measurements periodically during the growing season to verify soil moisture content or make adjustments as necessary.

Step 4. Knowing the moisture balance from the previous month, subtract the estimated consumptive use and add any effective rainfall and/or irrigation on a daily basis.

Step 5. Measure the rainfall using rain gauges. However, not all rainfall is effective and may exceed the amount required to fill the root zone to field capacity, resulting in some of it lost to deep percolation or runoff.

FL652.1005d Irrigation Water Management Plan For Traveling Gun Sprinkler Irrigation System

General

The example problem in this chapter is intended to cover the basic steps to follow in the development of an irrigation water management (IWM) plan for a traveling gun irrigation system. It is understood that one example cannot cover all situations and an IWM plan should be tailored to the individual site and the management expertise and desires of the irrigator.

Criteria

The requirements of an IWM plan are contained in Florida NRCS conservation practice standard, Irrigation Water Management, Code 449.

Example Problem

For this example problem, we will develop an IWM plan for the traveling gun sprinkler irrigation system that was designed in Chapter FL6D.

Given:

Refer to Exhibit FL6D-1 for all the necessary information

Solution:

Step 1. Provide the irrigator basic data such as:

- acres to be irrigated of each crop;
- water supply;
- irrigation flow rates;
- water quality;
- soil type;
- available water capacity (AWC);
- management allowable depletion (MAD);
- peak consumptive use rate;
- intake rate;
- irrigation efficiency; and,
- rooting depth.

This data is contained in the irrigation data sheets as shown in Chapter FL6D. In this example, this information was provided to the irrigator by providing the irrigator a copy of the design, Exhibit FL6D-1. If the irrigator does not have a copy of the design then this information should be obtained and provided to the irrigator.

Step 2. Discuss with the irrigator the need to measure soil moisture in order to determine the AWC of the soil to be irrigated. The various methods available to determine soil moisture should be discussed with the irrigator in such detail that a method can be selected to use. Once the irrigator chooses a method, work with the irrigator until they understand how to use the method. The irrigator in this example selected the feel and appearance method of determining soil moisture content. The irrigator must be able to convert the soil moisture measurement to inches of water available to the crop. A form was prepared for convenience in converting the soil moisture measurement to AWC and was included in the IWM plan, Exhibit FL10D-1. Exhibit 9-1 of this guide gives guidance on how to convert the soil moisture measurement to AWC in inches.

Step 3. Provide the irrigator with information on the daily crop water requirements (i.e., peak consumptive use rate). Information on irrigation water requirements can be found in Chapter 4 of this guide. If the planting and harvest dates are close to the dates shown in Table FL4-6 of Chapter 4, then that data can be given to the irrigator. This example is for watermelons in climatic zone 2. The planting and harvest dates are the same as those shown in Table FL4-6. The irrigator should have an understanding that this information is estimated. The irrigator should also have an understanding of effective rainfall (i.e., that all rainfall is not available for use by the crop).

Step 4. The irrigator should have a method to determine when to irrigate (i.e., an irrigation scheduling procedure). The different methods should be explained to the irrigator in such detail that a method can be selected. The irrigator should be taught how to use the method selected in scheduling irrigation. In this example, the irrigator selected to use the accumulated consumptive use mass curve. This curve was drawn for the irrigator and included in Exhibit 1 of the IWM plan, Exhibit FL10D-1. An abbreviated explanation of how to use the selected method should be provided to the irrigator. This was also included in the IWM plan.

Step 5. Provide the irrigator with the MAD before irrigation. MAD (in.) is based on a percentage of AWC to be depleted before irrigation. In this example, when the watermelons have a rooting depth of 12 inches, the AWC is 0.67 inches (0.056 in./in. x 12 in. = 0.67 in.). With a MAD of 50%, then the maximum allowed soil depletion before irrigation or MAD (in.) is: 0.67 in. x 0.50 = 0.34 inches. When the watermelons have a rooting depth of 36 inches, the AWC is 1.87 in. The maximum allowed soil depletion prior to irrigation is 1.87 in. x 0.50 = 0.94 inches. This was calculated for various rooting depths and included in the IWM plan, Exhibit FL10D-1. The irrigator must determine the current rooting depth in order to properly schedule irrigations.

Step 6. The critical stages of growth where sufficient moisture is necessary for crop production should be provided to the irrigator. The information can be obtained from Chapter 3, Table 3-1, of this guide. The critical period for watermelons is from blossom to harvest and this information was included in the IWM plan, Exhibit FL10D-1.

Step 7. The irrigator should know how much water to apply. The net amount to apply is determined by the AWC and MAD and will vary at different rooting depths (i.e., crop growth stages). The gross amount to apply is the net amount divided by the irrigation system efficiency. The irrigator should understand that the irrigation system is not 100% efficient in delivering water to the field and that they should divide the net amount by the irrigation efficiency to obtain the gross amount to apply. Irrigation efficiency was given on the irrigation data sheets as 65%. So for a 12 inch root depth, the gross amount applied would be = 0.34 in. ÷ 0.65 = 0.52 inches. The irrigator should know the application amount (in.) of the irrigation system in order to determine the time needed to apply the required water. In the case of a traveling gun irrigation system, travel speed adjustments should be made to apply the necessary irrigation amount. For this example, when the root depth is 12 inches, the travel speed would be 5.46 ft/min. in order to apply the required 0.52 inches. However, the travel speed would need to be decreased to 1.96 ft/min. to apply the required 1.45 inches (0.94 in. ÷ 0.65) when the root depth is 36 inches.

Step 8. The irrigator should understand how to recognize erosion caused by irrigation and excess runoff of irrigation water. The irrigator should be provided with ways to make adjustments to prevent runoff. The information provided will vary with each situation due to the variance in erosion potential of soils, land slope, soil intake rate, etc. A statement was made for this example and included in the IWM plan, Exhibit FL10D-1.

Step 9. The irrigator should be provided with a method of evaluating the performance of the irrigation applications. This would consist of explaining the reasons to evaluate the system and forms that would be helpful in evaluating the system. It may be necessary to work with the landowner on the first evaluation to show how to gather and interpret the data. In this example, forms were included in the irrigation water management plan, Exhibit FL10D-1. Chapter 9 of this guide gives additional information on how to evaluate irrigation systems.

Exhibit FL10D-1. Irrigation Water Management Plan for Traveling Gun Sprinkler Irrigation System

IRRIGATION WATER MANAGEMENT PLAN

DATE:	4/04
COOPERATOR:	T.O. Dry, Jr.
LOCATION:	T1N,R12E,S14, S.W. Jasper & S. of SR 6
FIELD NUMBER:	1
CROP:	Watermelons
GROWING SEASON:	March 15 – June 15
ROOTING DEPTH:	36 in
PEAK CONSUMPTIVE USE RATE:	0.19 in/day
IRRIGATION SYSTEM:	Cable tow traveling gun with a 418 ft. wetted diameter and 260' lane spacing using a Nelson 200 gun, 1.5-inch nozzle, 24 degree, at 85-psi nozzle pressure. Capacity = 460 GPM
WATER SUPPLY:	10” diameter well
PREDOMINATE SOIL SERIES:	Alpin sand

Table 1: Operating Times for Various Rooting Depths and 50% MAD

Crop	Rooting Depth (inches)	1/ AWC (inches)	2/ MAD (in)	3/ Gross application per irrigation (inches)	Critical Irrigation Period	4/ Travel Speed (ft/min)	4/ Time per 660' (hr.)
Watermelons	12”	0.67	0.34	0.52	Bloom to harvest	5.46	2.01
	24”	1.27	0.64	0.98		2.90	3.79
	36”	1.87	0.94	1.45		1.96	5.61

1/ *Available Water Capacity within the root zone (AWC).*
2/ *Management Allowed Depletion (MAD) of 50%.*
3/ *Application depth necessary to replace water used by crop assuming an application efficiency of 65%.*
4/ *Some travelers will not reach the higher travel speeds. In this case, use the fastest speed available to keep water waste to a minimum.*

Exhibit FL10D-1. Irrigation Water Management Plan for Traveling Gun Sprinkler Irrigation System (Cont'd.)

CURRENT MANAGEMENT PRACTICE: None

RECOMMENDATIONS:

The most important aspect of irrigation water management is properly evaluating and monitoring the available soil moisture for the particular crop. The feel and appearance method will be used for determining soil moisture and when irrigation is needed. See attached feel and appearance worksheets.

The system is designed to provide irrigation water to meet peak consumptive use for watermelons in field 1 provided the acreage grown is not increased beyond 40 acres.

Moisture should always be available above the MAD for the planned crops. The critical periods for adequate available water are from blossom to harvest. The soil moisture should be checked to determine how much irrigation water should be applied for each irrigation. Prior to planting, or soon thereafter, the 12 inch root zone should be brought up to field capacity. If operated properly, irrigation can result in high crop production. The system should be managed to maintain a high moisture level in the root zone.

For planned crop yield, irrigation should commence when the available soil moisture drops below the MAD and should continue until the soil reaches field capacity. See Table 1 for how long to operate the system for various rooting depths and a MAD of 50%.

The irrigation system should be checked periodically to ensure proper operation of the pump, pipeline, risers and traveling gun. A visual inspection should be performed during operation to determine if significant puddling, runoff or other irrigation induced erosion is occurring. If so, increase the speed of the traveling gun and the frequency of the irrigation until no erosion occurs.

Check the condition of the crop to ensure that growth is occurring and that the crop looks consistent in color and height to determine adequacy and uniformity of irrigation. If the application is not uniform, a system evaluation should be performed.

If there is change in the soil moisture monitoring method or irrigation method, the NRCS office in Jasper, Florida should be contacted.

Exhibit FL10D-1. Irrigation Water Management Plan for Traveling Gun Sprinkler Irrigation System (Cont'd)

Cooperator: _____ Field No. ____ Location: _____

Format for figuring the net amount of water needed for an irrigation using the feel and appearance method of soil moisture measurements.

1	2	3	4	5	6
Depth	**Soil Series Alpin**	**Available Water Capacity**	**Soil Water Content Before Irrigation**		**Soil Water deficiency**
feet	**texture**	**inches**	**percent**	**inches**	**inches**
0-1	Coarse	0.67			
1-2	Coarse	0.60			
2-3	Coarse	0.60			
Total		1.87			

Column 1, the depth increment sampled.

Column 2, the soil texture of the sample.

Column 3, the available water capacity based on the texture of the sample.

Column 4, the percent of soil water content (remaining)

0-25% - AWC - Dry, loose, will hold together if not disturbed, loose sand grains on fingers with applied pressure.

25-50% - AWC – Slightly moist, forms a very weak ball with well-defined finger marks, light coating of loose and aggregated sand grains remains on fingers.

50-75% - AWC Moist, forms a weak ball with loose and aggregated sand grains, darkened color, moderate water staining on fingers, will not ribbon.

75-100% - AWC – Wet, forms a weak ball, loose and aggregated sand grains remain on fingers, darkened color, heavy water staining on fingers, will not ribbon.

100% - AWC – Wet, forms a weak ball, moderate to heavy soil/water coatings on fingers, wet outline of soft ball remains on hand.

Column 5, Column 3 x Column 4, the soil-moisture balance, inches.

Column 6, Column 3 - Column 5, soil-moisture deficiency or net irrigation requirement.

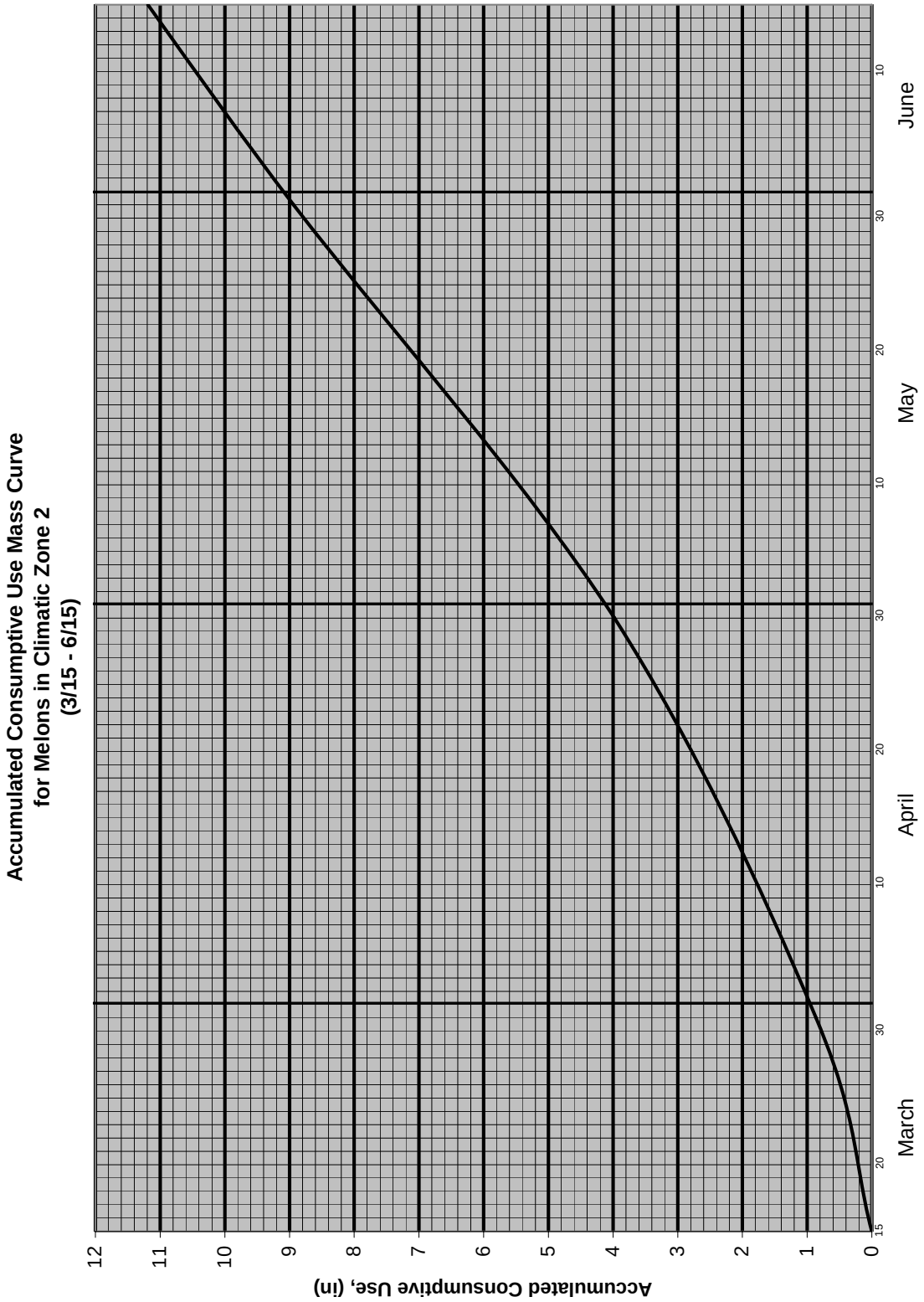
Fine sand and loamy fine sand soils

Percent available: Currently available soil moisture as a percent of available water capacity.

Available Soil Moisture Remaining	Appearance of soil
0-25 percent available	Dry, loose, will hold together if not disturbed, loose sand grains on fingers with applied pressure.
25-50 percent available	Slightly moist, forms a very weak ball with well-defined finger marks, light coating of loose and aggregated sand grains remains on fingers.
50-75 percent available	Moist, forms a weak ball with loose and aggregated sand grains on fingers, darkened color, moderate water staining on fingers, will not ribbon.
75-100 percent available	Wet, forms a weak ball, loose and aggregated sand grains remain on fingers, darkened color, heavy water staining on fingers, will not ribbon.
100 percent available	Wet, forms a weak ball, moderate to heavy soil/water coating on fingers, wet outline of soft ball remains on hand

Courtesy of the United States Department of Agriculture, Natural Resource Conservation Service, *Estimating Soil Moisture by Feel and Appearance* (Program Aid 1619)

Exhibit FL10D-2. Accumulated Consumptive Mass Curve for Watermelons in Climatic Zone 2



Using the Accumulated Consumptive Mass Curve

Step 1. Determine the current rooting depth. Using Table 2, determine the AWC and MAD for current rooting depth. Subtract the MAD from the AWC to determine the minimum root zone water balance.

Step 2. Make a soil-moisture measurement and determine the current soil-water content (SWC) for the current root zone.

Step 3. Determine the soil-moisture available prior to irrigation by subtracting the minimum root zone moisture balance to be maintained from the current SWC in the root zone.

Step 4. On the day the moisture measurement is made, project vertically from the curve the amount of the soil-moisture obtained in Step 3. Then project horizontally to the right until the curve is intersected. Project from the intersection of the curve vertically downward to determine the date of the next irrigation.

Step 5. If rainfall occurs before the scheduled irrigation, determine the amount of rainfall that is effective, add the effective rainfall to the remaining soil-moisture balance and plot this amount vertically on the day of the rainfall. Then project horizontally to the right until the curve is intersected. Project from the intersection of the curve vertically downward to determine the date of the irrigation.

Note that the value of the effective rainfall plus the root zone moisture balance above the curve cannot exceed 50% times the AWC for the current root zone.

Step 6. Make soil-moisture measurements periodically to verify or adjust irrigation schedule.

FL652.1005e Irrigation Water Management Plan For Subsurface – Flow Through Irrigation System

General

The example problem in this chapter is intended to cover the basic steps to follow in the development of an irrigation water management (IWM) plan for a subsurface irrigation system. It is understood that one example cannot cover all situations and an IWM plan should be tailored to the individual site and the management expertise and desires of the irrigator.

Criteria

The requirements of an IWM plan are contained in Florida NRCS conservation practice standard, Irrigation Water Management, Code 449.

Example Problem

For this example problem, we will develop an IWM plan for the flow through irrigation system that was designed in Chapter FL6E.

Given:

Refer to Chapter FL6E for all the necessary information.

Solution:

Step 1. Provide the irrigator basic data such as:

- acres to be irrigated of each crop;
- system type;
- water supply;
- irrigation flow rates;
- system capacity;
- water quality;
- soil type;
- available water capacity (AWC);
- peak consumptive use rate;
- intake rate;
- irrigation efficiency; and,
- root zone depth.

This data is contained in the irrigation data sheets as shown in Chapter FL6E. In this example, this information was provided to the irrigator by providing the irrigator a copy of the design, Exhibit FL6E-1. If the irrigator does not have a copy of the design then this information should be obtained and provided to the irrigator.

Step 2. Provide the irrigator with information on the crop water requirements - daily, monthly, and seasonal. This can be computed by methods mentioned in Chapter 4 of this guide. If the planting and harvest dates are close to the dates shown in Table FL4-6 of Chapter 4, then that data can be given to the irrigator. This example is for small vegetables in climatic zone 4. The planting and harvest dates are the same as those shown in Table FL4-6. This data was given to the irrigator. The irrigator should have an understanding that this information is estimated. The irrigator should also have an understanding of effective rainfall (i.e., that all rainfall is not available for use by the crop).

Step 3. Provide the irrigator information in order to determine the water table depth at which to irrigate. A water table is generally held at a constant elevation during a crop growing season, but can also be fluctuated. Water from a water table is supplied to plant roots by upward capillary water movement, or upflux through the soil profile. At the minimum system capacity, the irrigator should allow a *maximum* water table depth such that the upflux rate is twice the peak consumptive use. In this example, the peak consumptive use rate is 0.18 in/day with an upflux rate = 0.36 in/day (0.18 in/day * 2 = 0.36 in/day). The information can be obtained from Chapter 4, Table FL4-7, of this guide. This is the maximum depth the water table should be allowed to drop before irrigation. The NRCS approved SOILPREP computer program can be used to determine the maximum water table depth to irrigate based on upflux rates. See Table FL10E-1 for these values. Using interpolation, at a 28” water table depth, the rate of upflux is approximately 0.36 in/day. Provide the irrigator with this information. Typically for vegetable crops, the system shall be operated with the water table controlled within a range of 18 to 24 inches during crop establishment. It is recommended that the irrigator fluctuate the water table no more than 6 inches.

Step 4. The irrigator should have a method to determine how long to irrigate for and how many days until he/she has to irrigate again (i.e., an irrigation scheduling procedure). There are several factors to consider when determining an

irrigation scheduling procedure for subsurface irrigation systems including the soil type, system type, system's capacity, root zone depth, and the irrigator's preference. These factors should be discussed with the irrigator in such detail that the irrigator has an understanding of how to manage the operation of a subsurface irrigation system. For a flow-through or semi-enclosed system, the irrigator should irrigate until the water table is within 18 inches of the surface at the lower end of the field, between the field ditches. In this example, the irrigator chose to determine the depth to the water table by installing observation wells in the field and using a water table depth variation to determine the irrigation cycle. See Exhibit FL10E-1 for installation and monitoring instructions.

Step 5. The critical stages of growth where sufficient moisture is necessary for crop production should be provided to the irrigator. The information can be obtained from Chapter 3, Table 3-1, of this guide. The critical period for small vegetables is primarily from blossom through harvest.

Step 6. The irrigator should understand how to recognize erosion caused by irrigation and excess runoff of irrigation water. The irrigator should be provided with ways to make adjustments to prevent runoff. The information provided will vary with each situation due to the variance in erosion potential of soils, land slope, soil intake rate, etc. A statement was made for this example and included in the IWM plan, Exhibit FL10E-1.

Step 7. The irrigator should be provided with a method of evaluating the performance of the irrigation applications. This would consist of explaining the reasons to evaluate the system and forms that would be helpful in evaluating the system. It may be necessary to work with the landowner on the first evaluation to show how to gather and interpret the data. Chapter 9 of this guide gives additional information on how to evaluate irrigation systems.

Table FL10E-1. SOILPREP Output for Immokalee Fine Sand in Highlands, County.

Water Table Depth cm (in)	**Drained Volume cm (in)**	**Upflux Rate cm/hr (in/day)**
0.0 (0.0)	0.000 (0.00)	.5000 (4.7)
3.0 (1.2)	0.007 (0.00)	.5000 (4.7)
6.0 (2.4)	0.027 (0.01)	.5000 (4.7)
9.0 (3.5)	0.061 (0.02)	.5000 (4.7)
12.0 (4.7)	0.108 (0.04)	.5000 (4.7)
15.0 (6.0)	0.169 (0.07)	.5000 (4.7)
20.0 (7.9)	0.291 (0.11)	.5000 (4.7)
25.0 (9.8)	0.491 (0.19)	.5000 (4.7)
30.0 (12.0)	0.826 (0.33)	.5000 (4.7)
35.0 (13.8)	1.313 (0.52)	.5000 (4.7)
40.0 (15.7)	1.987 (0.78)	.5000 (4.7)
45.0 (18.0)	2.866 (1.13)	.4622 (4.32)
60.0 (24.0)	6.152 (2.42)	.0854 (0.80)
75.0 (30.0)	9.272 (3.65)	.0178 (0.17)
90.0 (35.4)	12.801 (5.04)	.0051 (0.05)
120.0 (47.2)	20.362 (8.02)	.0009 (0.01)
150.0 (59.0)	26.168 (10.30)	.0002 (0.0)
200.0 (78.7)	32.205 (12.68)	.0000 (0.0)
500.0 (196.9)	98.737 (38.87)	.0000 (0.0)
1000.0 (393.7)	100.000 (39.37)	.0000 (0.0)

Exhibit FL10E-1. Irrigation Water Management Plan for Subsurface – Flow Through Irrigation System

IRRIGATION WATER MANAGEMENT PLAN

DATE:	4/06
COOPERATOR:	T.O. Dry, Jr.
LOCATION:	Sebring, Highlands County
FIELD NUMBER:	1
CROP:	Small Vegetables
GROWING SEASON:	December 1 – March 31
ROOTING DEPTH:	18 in
PEAK CONSUMPTIVE USE RATE:	0.18 in/day
IRRIGATION SYSTEM:	Flow-through subirrigation system with 28 furrows of different lengths on 60-foot spacing requiring a total of 161 gpm. Well capacity = 300 GPM at 5 ft drawdown.
WATER SUPPLY:	6” diameter well
PREDOMINATE SOIL SERIES:	Immokalee fine sand

A flow-through subirrigation system is to be installed. A minimum water delivery rate of 7 gpm/acre shall be available in order that your irrigation system meets the peak water demand period of the crop. A system which is capable of delivering 10 gpm/acre gives you more management options and allows you to meet the peak water demand of the crop without running the pump for 24 hours a day.

The system shall be operated with the water table controlled within a range of 18 to 24 inches during crop establishment. Based on a peak consumptive use rate of 0.18 in/day, and a rate of upflux equal to 0.36 in/day, you should allow the water table depth to recede to no lower than 28 inches below the top of the bed.

The water table depth from the top of the bed shall be determined using observation wells placed within the field. The observation wells can be made from 4" PVC sand point (see enclosed observation well sheet) or with 4" drain tile with sock. The wells are approximately 40" long and installed in the ground until the top of the well is level with the top of the bed. Two observation wells shall be installed at the highest and lowest areas of the field.

The system shall be operated until the water table is approximately 18" from the top of the bed. This point will be reached after an outflow (tailwater) of 1 - 2 hours has occurred at the downstream end of the field. At that time, the system shall be turned off. When the water table recedes to a depth of approximately 24", the system shall be started again. Most of the water savings during the season will be possible during the early part of the season before the plants demand a great deal of water.

Exhibit FL10E-1. Irrigation Water Management Plan for Subsurface – Flow Through Irrigation System (Cont'd.)

Using a water table depth range to determine the irrigation cycle is more practical and more accurately reflects the plant water use than trying to establish a regular irrigation interval such as two days on/one day off.

Soil moisture feel and appearance can be used to determine when to irrigate as per enclosed measuring soil moisture content sheet. Irrigate when soil moisture is 50% or less. Shut off irrigation system based on experience. It is recommended that observation wells be used in conjunction with the feel and appearance method.

The operator should consider correlating results from water table observation wells with those from soil moisture feel and appearance.

The irrigation system should be checked periodically to ensure proper operation of the system and to identify any problems with the system layout. A visual inspection should be performed during operation to determine if there are excessive tailwater losses to the system or significant erosion is occurring in furrows or ditches. Tailwater losses can be reduced by installing water table control structures in outlet drainage ditches, or allowing the water table to fluctuate within an allowable range. Water erosion can be controlled by structures at the ends of laterals, reducing the irrigation stream, structures in open ditches, and/or changing system layout to reduce slope in direction of irrigation.

Check the condition of the crop to ensure that growth is occurring and that the crop looks consistent in color and height to determine adequacy and uniformity of irrigation. If the application is not uniform, a system evaluation should be performed.

If there is change in the soil moisture monitoring method or irrigation method, the NRCS office in Sebring, Florida should be contacted.

Fine sand and loamy fine sand soils

Percent available: Currently available soil moisture as a percent of available water capacity.

Available Soil Moisture Remaining	Appearance of soil
0-25 percent available	Dry, loose, will hold together if not disturbed, loose sand grains on fingers with applied pressure.
25-50 percent available	Slightly moist, forms a very weak ball with well-defined finger marks, light coating of loose and aggregated sand grains remains on fingers.
50-75 percent available	Moist, forms a weak ball with loose and aggregated sand grains on fingers, darkened color, moderate water staining on fingers, will not ribbon.
75-100 percent available	Wet, forms a weak ball, loose and aggregated sand grains remain on fingers, darkened color, heavy water staining on fingers, will not ribbon.
100 percent available	Wet, forms a weak ball, moderate to heavy soil/water coating on fingers, wet outline of soft ball remains on hand

Courtesy of the United States Department of Agriculture, Natural Resource Conservation Service, *Estimating Soil Moisture by Feel and Appearance* (Program Aid 1619)

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FL652.1005f Irrigation Water Management Plan For Subsurface – Underground Conduit Irrigation System

General

The example problem in this chapter is intended to cover the basic steps to follow in the development of an irrigation water management (IWM) plan for a subsurface irrigation system. It is understood that one example cannot cover all situations and an IWM plan should be tailored to the individual site and the management expertise and desires of the irrigator.

Criteria

The requirements of an IWM plan are contained in Florida NRCS conservation practice standard, Irrigation Water Management, Code 449.

Example Problem

For this example problem, we will develop an IWM plan for the underground conduit irrigation system that was designed in Chapter FL6F.

Given:

Refer to Chapter FL6F for all the necessary information.

Solution:

Step 1. Provide the irrigator basic data including:

- acres to be irrigated of each crop;
- system type;
- water supply;
- irrigation flow rates;
- system capacity;
- water quality;
- soil type;
- available water capacity (AWC);
- peak consumptive use rate;
- intake rate;
- irrigation efficiency; and,
- root zone depth.

This data is contained in the irrigation data sheets as shown in Chapter FL6F. In this example, this information was provided to the irrigator by providing the irrigator a copy of the design, Exhibit FL6F-1. If the irrigator does not have a copy of the design then this information should be obtained and provided to the irrigator.

Step 2. Provide the irrigator with information on the crop water requirements - daily, monthly, and seasonal. This can be computed by methods mentioned in Chapter 4 of this guide. If the planting and harvest dates are close to the dates shown in Table FL4-6 of Chapter 4, then that data can be given to the irrigator. This example is for small vegetables in climatic zone 4. The planting and harvest dates are the same as those shown in Table FL4-6. This data was given to the irrigator. The irrigator should have an understanding that this information is estimated. The irrigator should also have an understanding of effective rainfall (i.e., that all rainfall is not available for use by the crop).

Step 3. Provide the irrigator information in order to determine the water table depth at which to irrigate. A water table is generally held at a constant elevation during a crop growing season, but can also be fluctuated. Water from a water table is supplied to plant roots by upward capillary water movement, or upflux through the soil profile. At the minimum system capacity, the irrigator should allow a *maximum* water table depth such that the upflux rate is twice the peak consumptive use. In this example, the peak consumptive use rate is 0.18 in/day with an upflux rate = 0.36 in/day (0.18 in/day x 2 = 0.36 in/day). The information can be obtained from Chapter 4, Table FL4-7, of this guide. This is the maximum depth the water table should be allowed to drop before irrigation. The NRCS approved SOILPREP computer program can be used to determine the maximum water table depth to irrigate based on upflux rates. See Table FL10E-1 for these values. Using interpolation, at a 28" water table depth, the rate of upflux is approximately 0.36 in/day. Provide the irrigator with this information. Typically for vegetable crops, the system shall be operated with the water table controlled within a range of 18 to 24 inches during crop establishment. It is recommended that the irrigator fluctuate the water table no more than 6 inches.

Step 4. The irrigator should have a method to determine how long to irrigate for and how many days until he/she has to irrigate again (i.e., an irrigation scheduling procedure). There are several factors to consider when determining an

irrigation scheduling procedure for subsurface irrigation systems such as the soil type, system type, system's capacity, root zone depth, and the irrigator's preference. These factors should be discussed with the irrigator in such detail that the irrigator has an understanding of how to manage the operation of a subsurface irrigation system. For a flow-through or semi-enclosed system, the irrigator should irrigate until the water table is 18 inches deep at the lower end of the field, between the field ditches. In this example, the irrigator chose to determine water table depth by installing observation wells in the field and using a water table depth variation to determine the irrigation cycle. See Exhibit FL10F-1 for installation and monitoring instructions.

Step 5. The critical stages of growth where sufficient moisture is necessary for crop production should be provided to the irrigator. The information can be obtained from Chapter 3, Table 3-1, of this guide. The critical period for small vegetables is primarily from blossom through harvest.

Step 6. The irrigator should understand how to recognize erosion caused by irrigation and excess runoff of irrigation water. The irrigator should be provided with ways to make adjustments to prevent runoff. The information provided will vary with each situation due to the variance in erosion potential of soils, land slope, soil intake rate, etc. A statement was made for this example and included in the IWM plan, Exhibit FL10F-1.

Step 7. The irrigator should be provided with a method of evaluating the performance of the irrigation applications. This would consist of explaining the reasons to evaluate the system and forms that would be helpful in evaluating the system. It may be necessary to work with the landowner on the first evaluation to show how to gather and interpret the data. Chapter 9 of this guide gives additional information on how to evaluate irrigation systems.

Table FL10F-1. SOILPREP Output for Immokalee Fine Sand in Highlands, County.

Water Table Depth cm (in)	**Drained Volume cm (in)**	**Upflux Rate cm/hr (in/day)**
0.0 (0.0)	0.000 (0.00)	.5000 (4.7)
3.0 (1.2)	0.007 (0.00)	.5000 (4.7)
6.0 (2.4)	0.027 (0.01)	.5000 (4.7)
9.0 (3.5)	0.061 (0.02)	.5000 (4.7)
12.0 (4.7)	0.108 (0.04)	.5000 (4.7)
15.0 (6.0)	0.169 (0.07)	.5000 (4.7)
20.0 (7.9)	0.291 (0.11)	.5000 (4.7)
25.0 (9.8)	0.491 (0.19)	.5000 (4.7)
30.0 (12.0)	0.826 (0.33)	.5000 (4.7)
35.0 (13.8)	1.313 (0.52)	.5000 (4.7)
40.0 (15.7)	1.987 (0.78)	.5000 (4.7)
45.0 (18.0)	2.866 (1.13)	.4622 (4.32)
60.0 (24.0)	6.152 (2.42)	.0854 (0.80)
75.0 (30.0)	9.272 (3.65)	.0178 (0.17)
90.0 (35.4)	12.801 (5.04)	.0051 (0.05)
120.0 (47.2)	20.362 (8.02)	.0009 (0.01)
150.0 (59.0)	26.168 (10.30)	.0002 (0.0)
200.0 (78.7)	32.205 (12.68)	.0000 (0.0)
500.0 (196.9)	98.737 (38.87)	.0000 (0.0)
1000.0 (393.7)	100.000 (39.37)	.0000 (0.0)

Exhibit FL10F-1. Irrigation Water Management Plan for Subsurface – Underground Conduit Irrigation System

IRRIGATION WATER MANAGEMENT PLAN

DATE:	4/06
COOPERATOR:	T.O. Dry, Jr.
LOCATION:	Sebring, Highlands County
FIELD NUMBER:	1
CROP:	Small Vegetables
GROWING SEASON:	December 1 – March 31
ROOTING DEPTH:	18 in
PEAK CONSUMPTIVE USE RATE:	0.18 in/day
IRRIGATION SYSTEM:	Underground conduit subirrigation system with 8” mainline and 4” diameter drain laterals on 60-foot spacing with 30-inch drain tile depth. Well capacity = 150 GPM.
WATER SUPPLY:	4” diameter well
PREDOMINATE SOIL SERIES:	Immokalee fine sand

An underground conduit subirrigation system is to be installed. A minimum water delivery rate of 7 gpm/acre shall be available in order that your irrigation system meets the peak water demand period of the crop. A system which is capable of delivering 10 gpm/acre gives you more management options and allows you to meet the peak water demand of the crop without running the pump for 24 hours a day.

The system shall be operated with the water table controlled within a range of 18 to 24 inches during crop establishment. Based on a peak consumptive use rate of 0.18 in/day, and a rate of upflux equal to 0.36 in/day, you should allow the water table depth to recede to no lower than 28 inches below the top of the bed.

The water table depth from the top of the bed shall be determined using observation wells placed within the field. The observation wells can be made from 4" PVC sand point (see enclosed observation well sheet) or with 4" drain tile with sock. The wells are approximately 40" long and installed in the ground until the top of the well is level with the top of the bed. Two observation wells shall be installed at the highest and lowest areas of the field.

The system shall be operated until the water table is approximately 18" from the top of the bed. This point will be reached after an outflow (tailwater) of 1 - 2 hours has occurred at the downstream end of the field. At that time, the system shall be turned off. When the water table recedes to a depth of approximately 24", the system shall be started again. Most of the water savings during the season will be possible during the early part of the season before the plants demand a great deal of water.

Exhibit FL10F-1. Irrigation Water Management Plan for Subsurface – Underground Conduit Irrigation System (Cont'd.)

Using a water table depth range to determine the irrigation cycle is more practical and more accurately reflects the plant water use than trying to establish a regular irrigation interval such as two days on/one day off.

Soil moisture feel and appearance can be used to determine when to irrigate as per enclosed measuring soil moisture content sheet. Irrigate when soil moisture is 50% or less. Shut off irrigation system based on experience. It is recommended that observation wells be used in conjunction with the feel and appearance method.

The operator should consider correlating results from water table observation wells with those from soil moisture feel and appearance.

The irrigation system should be checked periodically to ensure proper operation of the system and to identify any problems with the system layout. A visual inspection should be performed during operation to determine if there are excessive tailwater losses to the system or significant erosion is occurring in furrows or ditches. Tailwater losses can be reduced by installing water table control structures in outlet drainage ditches, or allowing the water table to fluctuate within an allowable range. Water erosion can be controlled by structures at the ends of laterals, reducing the irrigation stream, structures in open ditches, and/or changing system layout to reduce slope in direction of irrigation.

Check the condition of the crop to ensure that growth is occurring and that the crop looks consistent in color and height to determine adequacy and uniformity of irrigation. If the application is not uniform, a system evaluation should be performed.

If there is change in the soil moisture monitoring method or irrigation method, the NRCS office in Sebring, Florida should be contacted.

Fine sand and loamy fine sand soils

Percent available: Currently available soil moisture as a percent of available water capacity.

Available Soil Moisture Remaining	Appearance of soil
0-25 percent available	Dry, loose, will hold together if not disturbed, loose sand grains on fingers with applied pressure.
25-50 percent available	Slightly moist, forms a very weak ball with well-defined finger marks, light coating of loose and aggregated sand grains remains on fingers.
50-75 percent available	Moist, forms a weak ball with loose and aggregated sand grains on fingers, darkened color, moderate water staining on fingers, will not ribbon.
75-100 percent available	Wet, forms a weak ball, loose and aggregated sand grains remain on fingers, darkened color, heavy water staining on fingers, will not ribbon.
100 percent available	Wet, forms a weak ball, moderate to heavy soil/water coating on fingers, wet outline of soft ball remains on hand

Courtesy of the United States Department of Agriculture, Natural Resource Conservation Service, *Estimating Soil Moisture by Feel and Appearance* (Program Aid 1619)

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