Weather Reach

Landscape Water Management

Irrisoft

Weather Reach

Landscape Water Management

Irrisoft, Inc.
PO Box 6266
North Logan, UT 84341.6266

www.weatherreach.com

Voice: 435-755-0400
Fax: 435-755-0415

Rev 1/2004

1. Introduction

Landscape water managers are feeling the pressure to use water resources more wisely. The science and technology to improve management practices are available. Irrisoft is responding to the growing demand to provide improved irrigation control systems. The Weather Reach system provides the means to automate landscape irrigation system by using real-time weather conditions.

Weather-based control systems have been in use for decades in agriculture, on golf courses, parks, theme parks, campus and other large-scale operations. With the rising demand for improved technology and the cost of technology is now within reach of commercial and residential customers.

Automated control systems are meant to respond to the ever-changing need for water in the landscape. This is accomplished by controlling the irrigation system to provide the right amount of water needed to maintain a healthy landscape. Weather conditions cause water to evaporate from the soil, and to be used by the plant. To keep landscapes healthy and green lost water needs to be replaced. This training program integrates the science associated with landscape water use and control of irrigation systems.

Implementing automated controls requires a firm understanding of plant water use, the soils they live in and the irrigation system used to replace lost water. This course of study is broken down into four major areas:

- Plant Water Soil Relationships
- The Irrigation System
- Irrigation Scheduling
- Weather Reach Control

The demand for better landscape water management requires well designed, fine-tuned irrigation systems, a watering schedule that reacts to changing conditions, and continuous monitoring. There is a growing business opportunity ~~to~~ for landscape irrigation management services. This manual provides information fundamental to offering efficient water management products and services.

2. Plant Water Soil Relationships

Plants Need Water

Plants need water to transport nutrients through the plant, for cell development and temperature control. Available moisture moves from the root hairs to the leaves. As soil moisture levels drop the plants ability to draw moisture declines. If inadequate moisture is available or evaporation from the leaf surface exceeds the rate at which water can be moved upward then the plant goes into water related stress. Plants differ in their ability to respond to stress conditions. Prolonged moisture stress can result in permanent wilting or damage to the plant. To maintain a healthy landscape irrigation is required when soil moisture is depleted.

Evapotranspiration

Evapotranspiration is the primary cause of moisture depletion.

Evapotranspiration (ET) is the amount of water lost from the soil or leaf surface by evaporation and water used by the plants through transpiration. Evapotranspiration is typically expressed in inches of water per hour or day. Potential evapotranspiration losses can be estimated using meteorological data measured with a weather station. Weather parameters used to calculate ET include:

- Solar radiation
- Air temperature
- Wind speed
- Relative humidity

Solar radiation is the primary energy source influencing ET. Air temperature to a lesser extent also provides this energy. In dry conditions the vapor pressure deficit is greater which means ET will be higher compared to a humid environment. Wind replaces saturated air with drier air. Without wind the ET rate decreases. Evapotranspiration equations are based on a well-watered, well-maintained crop and serves as a reference to the potential for evaporation and transpiration.

Formulas to Calculate Evapotranspiration

Over the past 40 years methods have been refined to calculate ET using various methods.
Meteorological data from weather stations
Soil moisture sensors
Pan Evaporation
Atmometer (ET Gauge)

The scientific community and the irrigation industry accept an equation for ET defined by the Environmental and Water Resources Institute of the American Society of Civil Engineers, published in December 2001. The formula is referred to as the ASCE Standardized Evapotranspiration Equation. The formula is a result of years of research that has included the use of lysimeters.

A lysimeters is a highly accurate instrument to measure soil moisture content. A large container is filled with soil then planted and watered. The weight of the container is monitored and compared with rain and irrigation measurements to determine the amount of water lost from evaporation and transpiration.

The ASCE formula requires hourly weather data measurements for temperature, solar radiation, humidity and wind speed. The accuracy of the calculation depends on the quality of the weather data. Station location and sensor accuracy affect data quality. Weather data should be measured with high-quality stations that are located over grassed surfaces, in open well-watered settings and that have good quality control procedures in place.

Evapotranspiration calculations are based on a reference crop and are usually expressed as inches per hour, day, week or month. Reference ET data can be based on either grass or alfalfa. A calculated alfalfa reference ET is designated as ETo. It is the amount of water that an actively growing crop of alfalfa about 20 inches tall requires for optimum growth. Similarly grass reference ET is designated as ETos. And is the amount of water that an actively growing clipped cool-season grass 3 to 6 inches tall (such as tall fescue, Kentucky blue grass or perennial ryegrass) requires for optimum growth. The two references are not equivalent. Alfalfa reference (ETo) is typically 15 to 35% higher than the grass reference (ETos).

Specific Plant Water Use

Evapotranspiration from a cropped field is composed of transpiration from the crop and evaporation from the soil. The rate of evapotranspiration from the crop (ETc) depends on the type of crop, stage of growth, moisture content of the surface soil, and the amount of energy available to evaporate water. The reference crop evapotranspiration rate (ETos) is used to represent a baseline rate of evapotranspiration for a clipped grass. The evapotranspiration for other crops is computed relative to the reference crop evapotranspiration.

The factor that relates actual crop water use to reference crop evapotranspiration is called the crop coefficient (Kc).

Extensive crop coefficient research has been done for agricultural applications. In some parts of the country information is available for various turf types. Research for crop coefficient values for ornamental plants has recently started, but is essentially not available.

Plant growth stages during the growing season can affect crop coefficient values. The annual life cycle including establishment, development, through midseason and late-season to dormancy have different crop coefficient values.

Research and available information varies from region to region. For example in California the following information is published:

Month	Fescue	Bermuda
January	0.61	0.52
February	0.69	0.62
March	0.77	0.7
April	0.84	0.73
May	0.9	0.73
June	0.93	0.71
July	0.93	0.69
August	0.89	0.67
September	0.83	0.64
October	0.75	0.6
November	0.67	0.57
December	0.59	0.53

Walker, Robert E. and Gary F. Kah - “Landscape Water Management Handbook” - Office of Water Conversation, Department of Water Resources, State of California, - Version 3.1 September, 1987

Landscape Coefficients – (Taken from the Irrigation Association Best Management Practices – Landscape Irrigation Scheduling and Water Management, September 2003)

The use of a landscape coefficient (K_L) is a relatively new concept. The advantage of using K_L for landscapes instead of the traditional "crop coefficient" (Kc) is that the K_L value can be adjusted for the microclimate (Kmc) and planting density (Kd) impacts upon the plant water requirement as well as for the specific species

(Ks). However, K_L cannot be used if its Ks factor is unknown. In some regions of the country, only information on Kc may be available.

K_L is a dimensionless landscape coefficient that takes into account the specific water requirement of a landscape plant species and also the environment where the plant is growing. Environmental conditions include microclimate, such as shade or sun exposure, and density of planting. K_L is calculated from:

$$K_L = Ks \times Kmc \times Kd$$

Where:

K_L= Site-specific landscape coefficient.
Ks = Adjustment factor representing characteristics for a particular plant species.
Kmc = Adjustment factor for microclimate influences on the plant.
Kd = Adjustment factor for plant density.

For more details on determining a K_L factor refer to the Irrigation Association Best Management Practices or the Landscape Auditor training manual.

Whenever possible, use local sources of information to more accurately determine the water requirements of the landscape plantings.

Plant Water Requirement

The plant water requirement can be calculated based on Reference ET and a crop or landscape coefficient for a specific period of time.

$$ETc = ETo \times Kc \text{ or } K_L$$

Where:

ETc = Plant Water Requirement
ETo = Reference Evapotranspiration
Kc = Crop Coefficient
K_L = Landscape Coefficient

This is the amount of water lost from the landscape resulting in soil moisture depletion. Plants draw water from the soil reservoir. Once the soil reservoir level drops to an allowable level it must be replenished with either rain or irrigation.

Soils

Do we water plants, or do we refill a soil reservoir?

The soil is a habitat for soil organisms and plant roots. It functions as a storehouse for nutrients and a water reservoir. It contains and supplies water oxygen nutrients and mechanical support for plant growth. The amount of water the soil can hold is determined by soil properties. This amount determines how long a plant can be sustained before the soil moisture is replenished by irrigation or rain. Soil properties are important to proper operation and management of irrigation systems. These properties include soil texture, intake characteristics, water holding capacities and capillary movement.

Soil texture

Soil texture refers to the proportion of sand, silt, and clay found in the soil profile. It defines the fineness or coarseness of a soil. Fine textured soils generally hold more water than coarse textured soils. Medium textured soils actually have more available water for plant use than some clay soils. The size and shape of individual soil particles such as sand, silt, or clay describes the soil texture. Soil texture largely determines the amount of water that can be stored in a soil, as well as soil infiltration rate and soil permeability. Soil infiltration rate is the rate at which water enters the soil. Permeability is the rate at which water moves through the soil. A soil texture class is defined by the relative amounts of sand, silt or clay in a particular soil.

The USDA Soils Manual includes the following general definitions of soil textural classes in terms of field experience. These definitions are also specifically used in estimating soil-water content by the feel and appearance method.

Sand – Sand is loose and single-grained. The individual grains can be readily seen and felt. Squeezed in the hand when dry, sand falls apart when pressure is released. Squeezed when moist, it forms a cast, but crumbles when touched.

Sandy loam – A sandy loam is soil containing a high percentage of sand, but having enough silt and clay to make it somewhat coherent. The individual sand grains can be readily seen and felt. Squeezed when dry, a sandy loam forms a cast that falls apart readily. If squeezed when moist, a cast can be formed that bears careful handling without breaking.

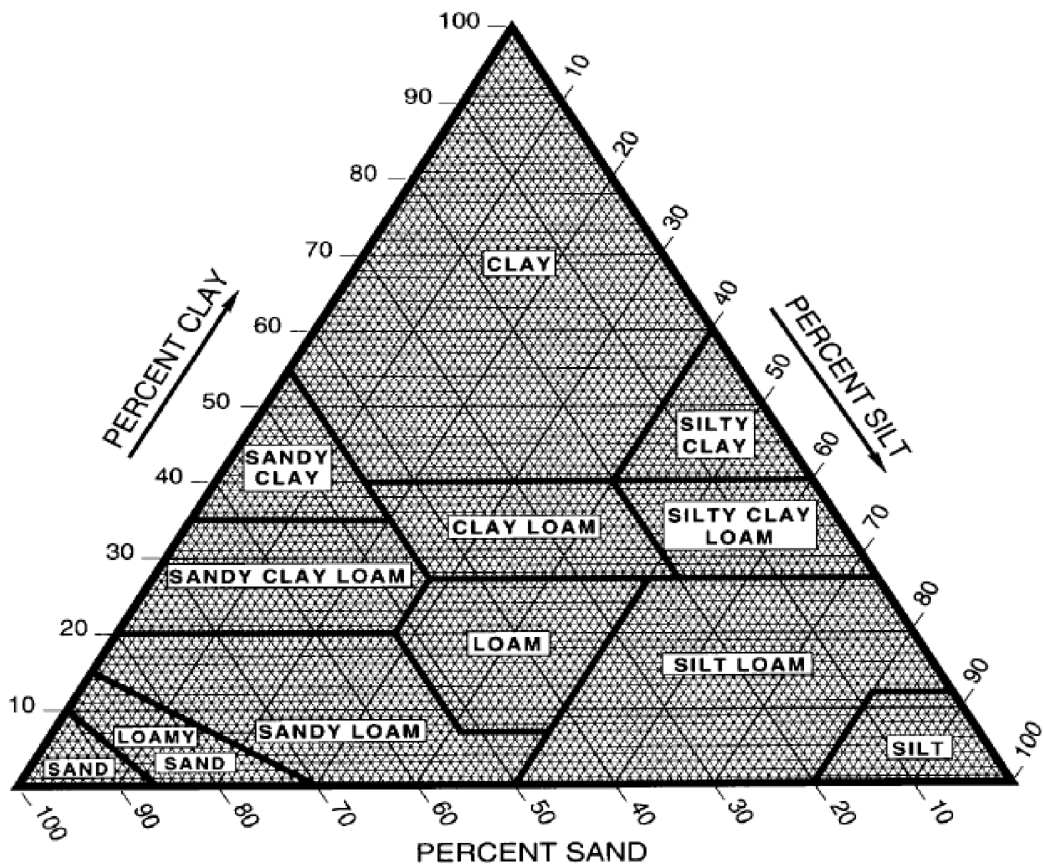
Loam- A loam is a soil having a relatively even mixture of different grades of sand, silt, and clay. It is friable with a somewhat gritty feel, but is fairly smooth and slightly plastic. Squeezed when dry, it forms a cast that bears careful handling, and the cast formed by squeezing the moist soil can be handled freely without breaking.

Silt loam – A silt loam is soil having a moderate amount of find sand with a small amount of clay. Over half of the particles are silt size particles. When dry, a silt loam appears cloddy, but the lumps can be readily broken. When pulverized, it feels soft and floury. When wet, the soil runs together readily and puddles. Either dry or moist, silt loam forms a cast that can be handled freely without breaking. When moist and squeezed between thumb and finger, it does not ribbon, but has a broken appearance.

Clay loam – A clay loam is moderately fine-textured soil that generally breaks into clods or lumps that are hard when dry. When the moist soil is pinched between the thumb and finger, it forms a thin ribbon that breaks readily, barely sustaining its own weight. The moist soil is plastic and forms a cast that bears much handling. When kneaded in the hand, clay loam does not crumble readily, but works into a heavy compact mass.

Clay – Clay is fine textured soil that usually forms very hard lumps or clods when dry and is very sticky and plastic when wet. When moist soil is pinched between thumb and finger, it forms a long flexible ribbon. Some clays that are very high in colloids are friable and lack plasticity at all moisture levels.

Organic - Organic soils vary in organic matter content from 20 to 95 percent. They generally are classified on the degree of decomposition of the organic deposits. The terms muck, peat, and mucky peat are commonly used. Muck is well-decomposed organic material. Peat is raw, undecomposed, very fibrous organic material in which the original fibers constitute all the material.



A soils lab can determine soil type and provide additional details regarding that may be useful. A quick way to determine soil composition is to put a soil sample in a jar with water with a couple drops of dish detergent, shake and allow the soil particles to settle. Sand particles settle first followed by silt then clay. Compare the percentages of each type of soil and then use the chart to estimate the soil composition.

Intake characteristics

Soil intake/water infiltration is the process of water entering the soil at the soil surface. Infiltration rates change during the time water is applied, typically becoming slower with elapsed time. Soil intake characteristics directly influence the length of run times that provides a uniform and efficient irrigation without excessive deep percolation or runoff. For irrigation with sprinklers, application rates vary according to the type of sprinkler or spray head. With impact heads, application rates are much slower because water is not applied to the entire area of coverage continuously. Water on the ground surface is at a single point only with each head rotation. With spray heads, the area of coverage is receiving water continuously, causing much higher rates of application.

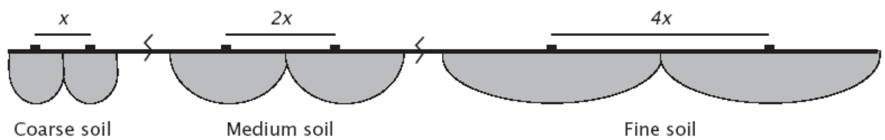
Infiltration rates are affected by soil texture, compaction, moisture content and slope. The following chart provides average soil intake rates.

Soil Textural Class	**Average Soil Intake Rate (in./h)**
Clay	0.1
Silty Clay	0.15
Clay Loam	0.2
Loam	0.35
Sandy Loam	0.4
Loamy Sand	0.5
Sand	0.6

Soil Conservation Service Nation Engineering Handbook, September 1997

Capillary Movement

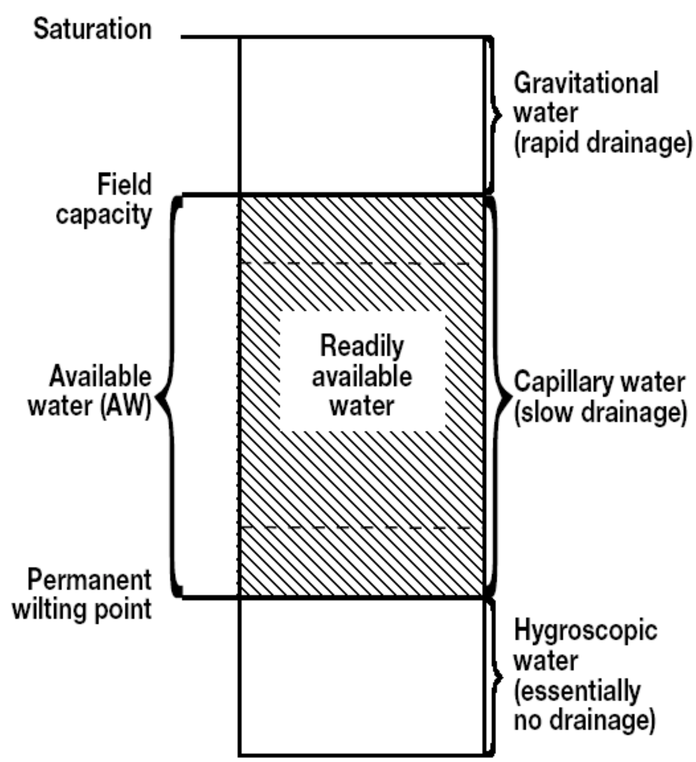
Once water enters the soil it can move in all directions. Gravitational drainage pulls it downward. Capillary movement can either be both upward and laterally. Soil texture affects capillary movement. Lateral movement compared to percolation depth can be estimated as a ratio. Course soils 1:1, medium soils 2:1 and fine soils 4:1.



Chapter 2 discusses the distribution of water by the irrigation system. Once water is in the soil, lateral movement distributes water more evenly to the plants. Soil characteristics and root depth affect the extent of lateral movement. This should not be an excuse to accept irrigation systems with poor distribution uniformity.

Soil Moisture Holding Capacities

Soil is a reservoir. The soil profile consists of inorganic soil particles and organic materials. The density or compaction of these materials affects the left over space known as pore space. Pore space contains either air or water. The composition of soil particles affects the amount of pore space. Measurements of soil moisture content range from saturation to oven dry.



General Conditions

Saturation – 100% of the pore space is filled with water. All oxygen has been displaced. Excess water drains, accumulates on the surface or runs off.

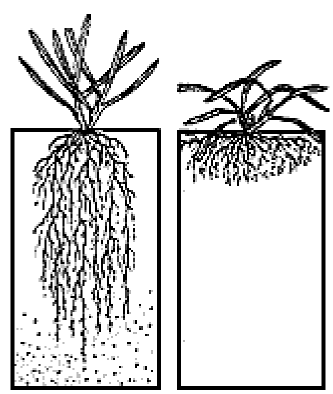
Field Capacity – This is the amount of water a well-drained soil holds after ample irrigation or heavy rain, when the rate of downward movement due to gravity has substantially decreased, usually one to three days after soil saturation. Generally fine textured soil holds more water than course-textured soils. Because it may take a day or two for saturated soil to reach field capacity, some of the water is available for plant consumption.

Permanent Wilting Point – This is the soil water content at which most plants cannot extract sufficient water to prevent permanent tissue damage.

Available Water Holding Capacity – This is the amount of water held between field capacity and permanent wilting point. The Soil Conservation Service Nation Engineering Handbook provides tables to estimate moisture content based on basic soil types.

Plant Specific Conditions

Root Zone Depth – The active root zone is the soil depth from which the plant extracts most of its water needs. Rooting depth and the resulting total Available Water Holding Capacity control the length of time plants can go between irrigations or effective rainfall events before reaching moisture stress. If more water is applied than the root-zone soil reservoir can retain the soil becomes saturated. Water may be lost to percolation below the root zone or run-off. Saturated soils lack oxygen necessary for healthy plants.



The deeper the plant roots are, the more soil-water storage is available for plant use.

Plant Available Water –This is the amount of water available to the plants when at field capacity. It is expressed in inches and is based on the available water holding capacity and the effective root zone depth.

Management Allowable Depletion (MAD) – This is the maximum percentage of plant available water that the irrigation manager allows to be depleted from the soil before irrigation is applied. Usually the value for MAD is chosen so that the plants can utilize water from the soil moisture reservoir with little or no stress. The Irrigation Association has published a Best Management Practices that provides a guide to the MAD percentages based on soil texture class. The average management allowed depletion is 50%. Soil conditions and management objectives affect the percentage.

Allowable Depletion – This is the desired amount of water to be depleted from the root zone before applying irrigation based on the MAD percentage and plant available water. It is expressed in inches of water.

The following chart combines soil type, available water holding capacity, root-depth and management allowable depletion. It can be used as a guide to determine the allowable depletion.

Allowable Depletion

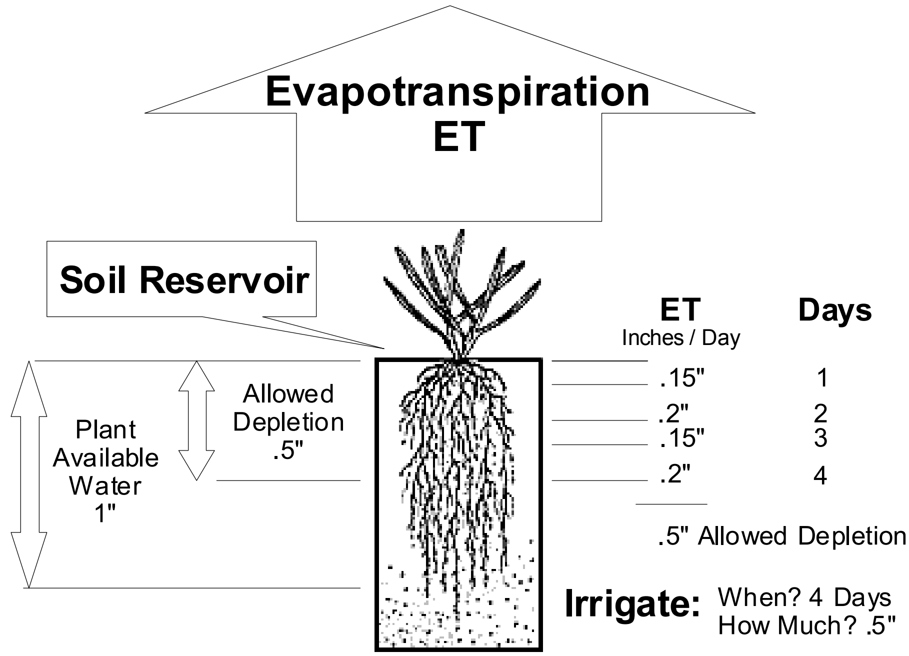
Soil Type	Available Water* Inch / Inch	Calculated Allowable Depletion	Root Depth in Inches					
		MAD %**	2	4	6	8	12	18
Sand	0.02	60%	0.02	0.05	0.07	0.10	0.14	0.22
Fine Sand	0.06	60%	0.07	0.14	0.22	0.29	0.43	0.65
Loamy Sand	0.07	60%	0.08	0.17	0.25	0.34	0.50	0.76
Sandy Loam	0.12	50%	0.12	0.24	0.36	0.48	0.72	1.08
Sandy Clay	0.16	50%	0.16	0.32	0.48	0.64	0.96	1.44
Loam	0.17	50%	0.17	0.34	0.51	0.68	1.02	1.53
Sandy Clay Loam	0.15	50%	0.15	0.30	0.45	0.60	0.90	1.35
Silty Loam	0.20	50%	0.20	0.40	0.60	0.80	1.20	1.80
Clay Loam	0.20	50%	0.20	0.40	0.60	0.80	1.20	1.80
Silt	0.17	50%	0.17	0.34	0.51	0.68	1.02	1.53
Silty Clay Loam	0.20	50%	0.20	0.40	0.60	0.80	1.20	1.80
Silty Clay	0.16	40%	0.13	0.26	0.38	0.51	0.77	1.15
Clay	0.15	30%	0.09	0.18	0.27	0.36	0.54	0.81

* Soil Conservation Service Nation Engineering Handbook, September 1997

** Irrigation Association Best Management Practices – Landscape Irrigation Scheduling and Water Management, September 2003

Note: Actual allowable depletion depends on soil composition, compaction, chemistry, temperature and plant characteristics, etc. Therefore, the above values are estimates, but can be used as a basis for determining initial irrigation schedules.

Rocky conditions reduce the available water holding capacities by 70%
Organic Content increases available water holding capacities up to 10%
Compaction can reduce available water holding capacities by 20%



Effective Rain

Not all rainfall is available to the plants. Effective rainfall depends on the amount, intensity and duration of each rain event, soil type and its available water holding capacity, intake rate, plant type and root depth, and the amount of moisture in the root zone prior to the rain event.

Soil Intake – Soil type, surface cover and slope all affect intake rate. When rain falls faster than can be absorbed into the soil there is the potential for run-off.

Soil Moisture Holding Capacities – Soil type and rooting depth affect soil moisture holding capacities.

Current Soil Moisture Content –The soil moisture content when a rainfall event occurs determines how much water will bring the soil moisture level to field capacity. Rainfall that percolates below the root-zone is unavailable to the plant. Once the soil reaches saturation levels it may take 2-3 days before draining to field capacity. Depending on ET rates this moisture may be available to the plants.

Irrigation Requirement

The irrigation requirement is based on the plant water requirement minus effective rainfall. Soil moisture depletes over time because of evapotranspiration. Rain also occurs over time. The need to irrigate is based on a combination of accumulated ETc minus effective rainfall. The industry refers to this as the soil moisture balance or the Checkbook method of irrigation management. Four factors affect the soil moisture balance.

- Moisture loss by evapotranspiration
- Drainage below the root-zone
- Effective rain
- Irrigation

Irrigation should occur only when the plants truly need it and cannot readily get it from the root zone.

To maintain healthy plants soil moisture should be depleted to a manageable level before irrigating. If watering always occurred daily, based on the irrigation requirement, deep root systems are not developed. Less frequent and deeper watering encourages healthy roots, which improves stress tolerance in the summer.

$$IR = ET - ER$$

Where:

IR = Irrigation Requirement
ETc = Crop specific ET
ER = Effective Rain

The irrigation requirement is accumulated as a balance of depleted soil moisture.

USDA – National Engineering Handbook – Plant Water Soil Relationships

Water Balance Accounting Procedures

The water-accounting procedure is based on two fundamental concepts, namely:

1. If there is an adequate supply of soil water, evapotranspiration rate for a given crop depends on the climatological evaporative demand.
2. If the soil water content of a soil is known at a given time, the water content at any later time can be computed by adding irrigation or rainfall and subtracting ET during the elapsed period.

Within recent years, reasonably reliable daily ET data have become available from climatic stations at strategic locations. This information is frequently available through one or more news media sources or computer linkage. By knowing the daily values at a site for rainfall events, ET, and
net irrigation amount, the daily balance can be computed and compared to the amount of available water that can be depleted safely before an irrigation is required.

Computation is started when the soil is at field capacity or a known water content. Following a heavy rain or an irrigation, the soil may be at field capacity, but this should be verified in the field. The soil water content should always be verified at the starting time. At a given time of the day, each morning if convenient, the available water in the soil is computed by subtracting the previous day's ET from the previous morning's balance. The previous day's irrigation or rainfall is added to the previous morning's balance. When the daily balance reaches the point at which soil water is depleted to the predetermined allowable limit, it is time to irrigate. Ignoring application efficiency, the net amount of water to be replaced in the soil by irrigation is the amount that brings the soil water content up to FC. To arrive at the balance on the morning following irrigation, this amount is added. The balance is then computed daily until another irrigation is indicated. Should an irrigation amount not be adequate to return the profile to field capacity, the profile available water content is set to the actual amount present. This tactic is used in humid areas to more efficiently utilize rainfall should it occur shortly after an irrigation application and to reduce the leaching of nutrients into the ground water.

The water retention properties of table l- 13 can be used to illustrate the procedure. Suppose a crop rooting depth is 26 inches, the total plant available water is 3.66 inches for this depth in the Hinckley loamy sand. If a crop is allowed to deplete 60 percent of the amount, 2.2 inches of allowable depletion can occur before soil water must be replenished. A water balance accounting procedure for these conditions is shown in table 1-14.~-

When rainfall or irrigation takes place in excess of the amount needed to bring the soil back to FC, the extra amount is assumed to percolate below the root zone; the daily balance is recorded as the FC level. Should high intensity rains cause runoff before the soil is filled to FC, it will be necessary to either estimate or measure the effective rainfall percolating into the soil that is available for plant use. This amount is added to achieve the daily balance.

210-VI, NEH 15-1, 2ndEdition, Dec. 1991 I-51

Irrigation Requirement Balance

The irrigation requirement is computed and added to the balance. Once the irrigation requirement reaches the allowed moisture depletion level it is time to irrigate. The following example uses a .5" allowable depletion level before allowing irrigation.

Date	ETc	Effective Rain	Irrigate	Irrigation Requirement Balance
4/1/2003	0.28	0.13		0.15
4/2/2003	0.27			0.42
4/3/2003	0.21		0.50	0.13
4/4/2003	0.16	0.04		0.25
4/5/2003	0.19			0.44
4/6/2003	0.14		0.50	0.08
4/7/2003	0.15			0.23
4/8/2003	0.18			0.41
4/9/2003	0.18		0.50	0.09
4/10/2003	0.19			0.27
4/11/2003	0.20			0.47
4/12/2003	0.22		0.50	0.19
4/13/2003	0.23			0.42
4/14/2003	0.21		0.50	0.14
4/15/2003	0.17	0.20		0.11
4/16/2003	0.16	0.11		0.16
4/17/2003	0.18			0.34
4/18/2003	0.21		0.50	0.04
4/19/2003	0.11	0.01		0.14
4/20/2003	0.19			0.33
4/21/2003	0.17			0.50
4/22/2003	0.21		0.50	0.21
4/23/2003	0.13			0.34
4/24/2003	0.17		0.50	0.01
4/25/2003	0.23			0.24
4/26/2003	0.27		0.50	0.01
4/27/2003	0.24			0.25
4/28/2003	0.26		0.50	0.01
4/29/2003	0.27			0.28
4/30/2003	0.24		0.50	0.02

Summary

The soil is a reservoir that holds water. Soil conditions affect the soil moisture holding capacities. Plant roots draw water from the soil. Weather conditions and the type of plant influence the amount of water drawn from the soil as a result of evaporation and transpiration. When soil moisture is depleted to an allowable level it is time to irrigate. Soil conditions must be understood to mitigate run-off.

Review Questions

1. Soil texture refers to the distribution of what types of soil particles? ______________________________________

____

2. Describe each of these terms as they relate to soil moisture content:

Saturation: ____

____

____

Field Capacity: ____

____

____

Permanent Wilting Point:____

____

____

3. Using the Available Water Holding Capacity chart what is the available water in 6" of Silty Loam soil?

____

4. What is the relationship between Root Zone Depth and Plant Available Water? ____________________________

____

____

5. Soil moisture should only be depleted to an allowable level. What is the percentage of water that managers would typically allow to be depleted from the soil? ____________ The abbreviation for this value is? _________________

6. Given a 6" root depth in a Sandy-Clay soil, what is the estimated allowable moisture depletion level? ___________

7. Identify the three factors that cause soil moisture to be depleted from the root zone? ____________________

____

8. What two energy sources affect evapotranspiration? ____

9. How does wind affect evapotranspiration? ____

____

____

10. What affect does humidity have on evapotranspiration? ____

____

____

11. How are crop coefficients applied to reference evapotranspiration rates? _________________________

____

____

12. What is the formula to calculate the irrigation requirement? ___________________________________

____

13. What is the relationship between soil moisture balance and allowable depletion? __________________

____

____

3. The Irrigation System

Irrigation systems refill the soil reservoir to provide water to sustain healthy landscapes.

In the previous chapter the method for determining the irrigation requirement was explored. To sustain the landscape an irrigation system needs to deliver the required amount of water. If more water is applied than needed, water is wasted. This can affect plant health and have adverse affects on the environment. If the irrigation system fails to deliver enough water, the plants suffer.

Irrigation systems are a complex arrangement of sprinkler heads, valves and piping systems. Typically an automated control system is connected to the valves to operate the system. There are many factors that affect how well the irrigation system delivers water to the landscape. To properly control the irrigation system the amount of water delivered by the system in a given period of time needs to be quantified. In addition the accuracy or efficiency of the system needs to be qualified.

Sprinkler performance is measured in inches per hour and the efficiency of the system is expressed using a distribution uniformity factor. This chapter will look at sprinkler application rates and distribution uniformity.

Units

First there are several key units of measure relative to water that need to be defined:

Depth

Inches – Water is also measured in inches

- Measured rain
- Evapotranspiration – Plant water loss from evaporation and transpiration
- Sprinkler application is expressed in inches per hour. Also referred to as precipitation rate.

Volume

Gallons – The volume of water is typically measured in gallons.

Cubic Feet – Water volume may also be measured in cubic feet. One cubic foot contains 7.48 gallons.

Acre Feet – One acre-foot of water is the amount of water covering one acre at depth of 1 foot. It is equal to 43560 cubic feet or 325,851 gallons of water.

Sprinkler Systems

Gallons per minute – The rate of flow in piping systems, through valves and out of sprinkler heads is typically expressed in gallons per minute.

Water Pressure – Water for sprinkler systems is carried in pressurized piping systems. Water pressure is measured in pounds per square inch (PSI). At times it is expressed in feet of head.

As PSI increases the flow rate out of a sprinkler increases.

Distance – Sprinkler heads are spaced to spread water over a given area. Head spacing and the size of the area covered by the sprinklers affect how fast water is applied.

How many inches in a gallon of water?

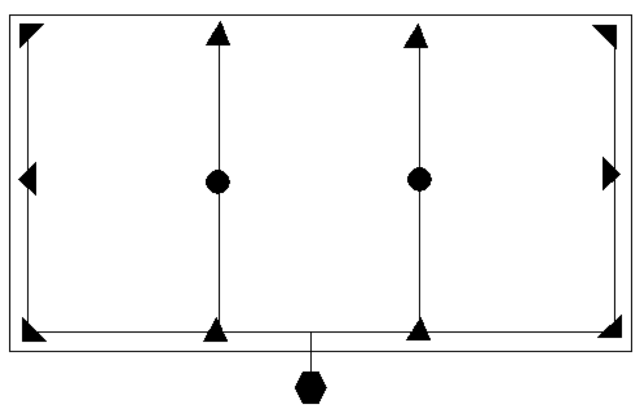
1 cubic foot of water contains 7.48 gallons

1 cubic foot of water may be spread over 24 square feet ½" deep

How much water does an irrigation system apply?

Consider the following sprinkler system:

Spray head zone watering an area 30' x 45'



Using industry standard spray heads at 30 PSI the total gallons per minute in this system is:

4 - 15' quarter heads	4 x .92 GPM =	3.68 GPM
6 - 15' half heads	6 x 1.85 GPM =	11.1 GPM
2 - 15' full heads	2 x 3.7 GPM =	7.4 GPM
		22.18GPM

Given a valve run time of 20 minutes

22.18 GPM X 20 minutes = 444 gallons

Convert gallons to Cubic feet

444 / 7.48 = 59 cubic feet

Sprinkler coverage area

30 x 45 = 1350 square feet

The 591 gallons (79 cubic feet) of water is spread (divided) over an 1800 square feet area

59 CF/1350 SF = .044 feet

Convert to inches

.044 X 12(Inches in a foot) = .53”

Sprinkler Precipitation Rate

The capabilities of the sprinkler system must be known so that the irrigation schedules can control the irrigation system in response to the plant water requirement. Sprinkler application rate or precipitation rate is typically expressed in inches of water applied in a one-hour period. For a sprinkler zone it is the average or a gross precipitation rate. Precipitation rates do not account for weaknesses in distribution uniformity. There are two principles that control precipitation rates:

- Sprinkler output
- Sprinkler layout

Sprinkler output is a controlled by the size of the nozzle opening and water pressure. Given the same pressure, sprinklers with larger nozzles will put out more water. As pressure increases water is forced out of the nozzle at a higher rate. Manufacturers publish sprinkler nozzle performance information in the catalog. When looking at catalog data choose the correct sprinkler and nozzle size. It is also important to the water pressure at the sprinkler. Here are two examples of catalog data for sprinklers:

Standard Angle Rain Curtain Nozzle Performance

Pressure psi	Nozzle	Radius ft.	Flow (GPM)	Precip. (in/h) Square	Precip. (in/h) Triangular
25	1.5	33	1.12	0.20	0.23
	2.0	35	1.50	0.24	0.27
	2.5	35	1.81	0.28	0.33
	3.0	36	2.26	0.34	0.39
	4.0	37	2.91	0.41	0.47
	5.0	39	3.72	0.47	0.54
	6.0	39	4.25	0.54	0.62
	8.0	36	5.90	0.88	1.01
35	1.5	34	1.35	0.22	0.26
	2.0	36	1.81	0.27	0.31
	2.5	37	2.17	0.31	0.35
	3.0	38	2.71	0.36	0.41
	4.0	40	3.50	0.42	0.49
	5.0	41	4.47	0.51	0.59
	6.0	43	5.23	0.54	0.63
	8.0	43	7.06	0.74	0.85
45	1.5	35	1.54	0.24	0.28
	2.0	37	2.07	0.29	0.34
	2.5	37	2.51	0.35	0.41
	3.0	40	3.09	0.37	0.43
	4.0	42	4.01	0.44	0.51
	5.0	45	5.09	0.48	0.56
	6.0	46	6.01	0.55	0.63
	8.0	47	8.03	0.70	0.81
55	1.5	35	1.71	0.27	0.31
	2.0	37	2.30	0.32	0.37
	2.5	37	2.76	0.39	0.45
	3.0	40	3.47	0.42	0.48
	4.0	42	4.44	0.48	0.56
	5.0	45	5.66	0.54	0.62
	6.0	47	6.63	0.58	0.67
	8.0	50	8.86	0.68	0.79
65	1.5	34	1.86	0.31	0.36
	2.0	35	2.52	0.40	0.46
	2.5	37	3.01	0.42	0.49
	3.0	40	3.78	0.45	0.53
	4.0	42	4.83	0.53	0.61
	5.0	45	6.16	0.59	0.68
	6.0	48	7.22	0.60	0.70
	8.0	50	9.63	0.74	0.86

15 Standard

SERIES 30° trajectory

Nozzle	Pressure psi	Radius feet	Flow gpm	Precip.■ in/h	Precip.▲ in/h
15F	15	11	2.60	2.07	2.39
	20	12	3.00	2.01	2.32
	25	14	3.30	1.62	1.87
	30	15	3.70	1.58	1.83
15TQ	15	11	1.95	2.07	2.39
	20	12	2.25	2.01	2.32
	25	14	2.48	1.62	1.87
	30	15	2.78	1.58	1.83
15TT	15	11	1.74	2.07	2.39
	20	12	2.01	2.01	2.32
	25	14	2.21	1.62	1.87
	30	15	2.48	1.58	1.83
15H	15	11	1.30	2.07	2.39
	20	12	1.50	2.01	2.32
	25	14	1.65	1.62	1.87
	30	15	1.85	1.58	1.83
15T	15	11	0.87	2.07	2.39
	20	12	1.00	2.01	2.32
	25	14	1.10	1.62	1.87
	30	15	1.23	1.58	1.83
15Q	15	11	0.65	2.07	2.39
	20	12	0.75	2.01	2.32
	25	14	0.83	1.62	1.87
	30	15	0.93	1.58	1.83

Figure 31a: Nozzle performance (U.S. Standard Units)

Sprinkler layout is a combination of head spacing and layout pattern. Typical layout patterns are square, triangular and rectangular. Often heads laid out in a rectangular or triangular pattern will be closer together. Given the same nozzle size, as head spacings increase, precipitation rate decreases.

There are several ways to estimate the application rate for sprinklers:

- Manufacturers catalog data
- Precipitation rate formulas
- Field measurements of actual sprinkler performance using catch cans

Manufacturers catalog data – Most manufacturers provide sprinkler performance information in product catalogs. This information is meant as a guide and assumes the sprinklers are installed a specific spacings. Actual field conditions may vary which will affect the precipitation rate.

Going back to the example, use sprinkler catalog performance data to calculate the amount of water applied in 20 minutes.

Standard spray head catalog precipitation rate is 1.58” per hour.

In 20 minutes 20 / 60 = .333 hours

1.58” per hour x .333 hours (20 minutes) = .52” of water

Either way it is calculated spray heads at 30 PSI spaced at 15’ apart apply about 1/2” of water in 20 minutes. This does not account for uneven distribution of water, which will be discussed later.

Precipitation Rate Formula

Use the following formula to calculate the average precipitation rate for sprinklers.

PR = (96.3 X GPM) / Area

Where:

PR = Average precipitation rate expressed in inches per hour.
96.3 = Constant to resolve the units of measure (GPM & Area).
GPM = Total gallons per minute of water applied to an area.
Area = Total square foot area where the water is being distributed.

This formula can be applied in several ways.

1. For example, two readings were taken from an irrigation meter fifteen minutes apart. The difference of the readings was 375 gallons. A zone being irrigated with spray heads had an area of 1500 square feet. The average flow rate (GPM) is 375 gallons in 15 minutes or 375 / 15 = 25 GPM.

1.6 inches per hour = (96.3 x 25) / 1500

2. Using catalog data obtain the GPM for the sprinklers watering an area. Measure the area and run the calculations. Using the above example:

1.58 inches per hour = (96.3 x 22.18) / 1350
GPM = 22.18
Area = 1350

3. It is not necessary to include all the heads in an area. Consider the area watered by 4 heads and the amount of water each head applies to the area. For example, a 4 quarter-pattern sprinklers that output 5.5 GPM each would have a total zone GPM of 22 (5.5 GPM x 4 sprinklers). These heads water a rectangular area measuring 45’ by 50’. (45 x 50 = 2,250 square feet)

.94 inches per hour = (96.3 x 22) / 2250

If they were half heads the area would be the same but the GPM would be cut in half. The precipitation rate would be .47” per hour.

The Rain Bird Landscape Irrigation Design Manual, page 44 has additional examples.

Field measurements

A more accurate approach is to place catch cans in a given area then operate the sprinklers for a specific period of time and measure the results. Containers need to be placed in a grid on the turf so that they catch a good representation of the sprinkler system output. To determine the application rate, use the average depth of water computed for all containers. The application rate is determined from the following simple formula:

$$PR = (V_{avg} / T) / 60$$

Where:

PR = Average precipitation rate expressed in inches per hour.
V_{avg} = Average volume of all containers (in inches)
T = Sprinkler operating time in minutes
60 = Constant to convert results to inches per hour

The process is described in more detail in the Irrigation Association Certified Landscape Irrigation Auditor training manual. There is also information provided by the Bureau of Reclamation, Upper Colorado Region, Water Conservation Office. They published a scheduling guide that details a field measurement process. See chapter 2 in “Landscape Irrigation Simplified - A handbook for Landscape Irrigation Practitioners”.

Drip Irrigation systems

The average precipitation rate for drip systems can also be computed.

$$PR = (231 \times GPH) / (S \times S)$$

Where:

PR = Average precipitation rate expressed in inches per hour.
231 = Constant to resolve the units measure (GPH & Area).
GPH = Emitter flow rate in gallons per hour
S = Emitter spacing in inches

As an example, if 1 GPH emitters are spaced 18” apart on 18” rows the average precipitation rate would be calculated by:

$$.72 \text{ inches per hour} = (231 \times 1) / 18 \times 18$$

Valve Run-Time

Precipitation rates are used to determine valve run-time. From the previous section the process to determine the irrigation requirement has been defined. Run-times are based on the amount of time it takes to apply the amount of water needed based on the irrigation requirement. The run-time formula is:

RT = IR x (60 / PR)

Where:

RT = Valve run-time in minutes
IR = Irrigation requirement in inches
60 = Constant to convert units (hours to minutes)
PR = Precipitation rate in inches per hour

For example if the irrigation requirement is .5” and the precipitation rate is 1.6” per hour the run-time is calculated by:

19 minutes = .5 x (60 / 1.6)

Distribution Uniformity

Distribution uniformity is the measure of the uniformity of irrigation water distribution over a sprinkler zone. The industry typically uses a lower-quarter DU formula. Distribution Uniformity is based on the ratio of the average amount of water applied to a given area compared to the lowest one-fourth of measured water applied by the sprinklers, expressed as a percentage. When distribution uniformity goes down, the ability to water efficiently also decreases. Poor distribution uniformity requires over watering some areas to adequately water areas with weak coverage. Distribution Uniformity is influenced by many elements including:

Head Layout & Spacing – Sprinklers should be evenly spaced and follow the manufacturers design criteria. Head to head spacing provides for overlap that improves uniformity.

Head Alignment – Crooked heads or heads set too low will not distribute the water evenly.

Nozzle Design – Nozzle engineering and manufacturing has a major affect on distribution uniformity.

Nozzle Size – The nozzles in a zone of sprinklers should be sized proportionally so the precipitation rate from all sprinklers is matched.

Head Operating Pressure – Nozzle pressure affects water droplet size. Droplet size and velocity affects the distance of throw.

Wind – Despite all the efforts of designers, manufacturers, installers and maintenance crews the wind can quickly disrupt distribution uniformity. In high-wind areas there are several things that can be done to compensate for windy conditions. Spacings should be closer. Use low angle trajectory sprinkles. Select nozzles and operating pressures that keep the droplet size larger. Smaller droplets are more easily blown away.

Physical Obstructions – Any obstruction either inside or outside the sprinkler that interferes with the stream of water can affect uniformity.

Slope – Distribution is also influenced by slope. Water from sprinklers may go further or fall short depending on ground conditions.

Catch-can test

The distribution uniformity is measured by conducting a catch-can test and comparing the average of the lower quarter of the samples with the overall average of samples. Good distribution uniformity is indicated by the average values of the lower quarter being similar to the overall average.

The lower quarter distribution uniformity (DU_{LQ}) is calculated with the following method:

1. Place all catch cans within the fully irrigated area. See that all zones that contribute to the area are operated during the test. The volumes of water caught by containers must be measured soon after the test to reduce losses by evaporation.
2. List the catch-can volumes in order from smallest to largest.
3. Determine the catchment values for the one-fourth of the cans containing the least amount of water.
4. Calculate the average catchment volume of these cans (V_{LQ}).
5. Calculate the average catchment volume for all the cans (including the low quarter) (V_{avg}).
6. Calculate the lower quarter distribution uniformity (DU_{LQ}). It is expressed as a percentage:

$$DU_{LQ} = V_{LQ} / V_{avg}$$

Where:

DU_{LQ} = Lower Quarter Distribution uniformity
V_{LQ} = Average volume of catchments from ¼ of the cans with the lowest volume
V_{avg} = Average volume of all catchments

For example, an audit was conducted on a zone and multiple catch-can volumes were gathered. The catch-can volumes were ordered from lowest to highest volume. The average volume of the one-fourth of the cans containing the lowest volumes was 19 ml. The average volume for all the cans was 27.25 ml. The lower quarter distribution uniformity is calculated as:

$$70\% = 19 / 27.25$$

Run Time:	60
Catch Can Area:	3
Catchment in Milliliters	
1	18
2	20
3	25
4	28
5	29
6	30
7	32
8	36
Total Volume:	218
# of Catch Cans:	8
Average Volume:	27.25
LQ Ave Volume:	19.00
Precipitation Rate:	**0.55**
DU_{LQ}:	**70%**

The following chart from the Irrigation Association provides a guide to the levels of Distribution Uniformity found in the field:

Type of Zone	Excellent	Very Good	Good	Fair	Poor
Fixed Spray	75%	65%	55%	50%	40%
Rotor	80%	70%	65%	60%	50%

Run Time Multipliers

Distribution uniformity provides and indicator of how evenly water is applied within a given zone. Dry-spots are typically a result of poor distribution uniformity. Less water is applied to a “dry-spot” compared to a green healthy area. There are two approaches to dealing with a dry-spot. First, take the necessary steps to improve sprinkler coverage. Second, add additional valve run-time to the zone. This is often the first solution, because it is easy, but it is important to recognize that the balance of the zone will be over-watered to get the “dry-spot” enough water.

There has been research to help guide irrigation schedulers to utilize measured distribution uniformity and apply it to valve run-time. The research takes into account distribution uniformity and the potential for lateral movement in the soil. A catch-can test for distribution uniformity measures the effectiveness of the sprinklers to deliver water to the soil surface. Soil moisture uniformity is not the same as sprinkler distribution uniformity. Water moves laterally from wet soil to dryer soil. The formula to estimate the valve run-time multiplier is:

RTM = 100 / (38.6 + (.614 x DU_{LQ})

Where:
RTM = Run-time Multiplier
38.6 = Constant
.614 = Constant
DU_{LQ} = Lower Quarter Distribution uniformity

The following table provides run-time multipliers based on the above formula:

DU_{LQ}	Run Time Multiplier
95%	1.03
90%	1.07
85%	1.10
80%	1.14
75%	1.18
70%	1.23
65%	1.27
60%	1.33
55%	1.38
50%	1.44
45%	1.51
40%	1.58
35%	1.66

The run-time multiplier is used to calculate the Total Run Time as follows:

RT_{TOT} = RT x RTM

Where:
RT_{TOT} = Total valve run-time to meet the irrigation requirement
RT = Run-time based on Irrigation Requirement and Average Precipitation Rate
RTM = Run Time Multiplier calculated or taken from the chart

There are many factors that affect soil moisture movement. The use of this research provides a basis to closely estimate the zone run-time. The science and research provides a good foundation from which to start but there are many other factors that are difficult to quantify. Once implemented, field observation and adjustments will be needed.

Runoff

Precipitation (from rain or sprinklers) rate exceeds soil infiltration rate the accumulated surface water is subject to run-off.

Runoff not only wastes water but it caries with it chemicals, soil particles and other pollutants to rivers and streams and can also affect our coastal regions. Runoff from irrigation systems should be controlled. There are several steps that can be taken:

- Avoid over-spray
- Install check-vales to prevent low-head drainage
- Do not over water
- Operate sprinklers with multiple cycles

There is potential for runoff when water originating from sprinklers applies water to a sloped landscape area when the application rate exceeds the soil intake rate of the soil. Thatch and mulch layers will retain some surface water that will percolate into the soil.

To minimize runoff, sprinkler zone run-time may to be divided into multiple cycles (also called cycle starts or repeat cycles) with a soak time between the cycles. There are two ways to determine a maximum cycle time, the "observation" method or the "basic intake rate" method.

Observation Method

Cycle Time - Begin by observing the landscape while irrigating a representative station/zone of the hydrozone. Note the total elapsed time until runoff is visible. Divide this run time into the base run time and round up to determine the whole number of required cycle starts.

Soak Time- Run a cycle or two and allow the water to infiltrate into the soil between cycles for a period of time that is greater then the cycle run time. Then run another cycle. If excessive runoff or surface accumulation is visible before the cycle finishes, then increase the soak time between cycles.

Basic Intake Rate Method

There is a new process coming out of the Center for Irrigation Technology (CIT) that can be used to estimate a maximum cycle time and a minimum soak time. It uses a formula that considers; soil type, the intake rate of the soil, slope and precipitation rate. The formula compares the precipitation rate with the soil intake rate. When the precipitation rate exceeds the soil intake rate surface water accumulates. The scheduler can use a chart that contains allowed surface accumulation based on soil type and slope. Surface conditions affect the amount of surface water that can be held before runoff. This approach can be used as a starting reference but results should be verified with field observation.

Soil Textural Class	Allowable Surface Accumulation				Average Soil Intake Rate (in./h)
	0 to 3%	4 to 6%	7 to 12%	13% <	
Clay	0.20	0.16	0.12	0.08	0.1
Silty Clay	0.21	0.17	0.13	0.09	0.15
Clay Loam	0.23	0.19	0.14	0.10	0.2
Loam	0.26	0.21	0.15	0.11	0.35
Sandy Loam	0.29	0.22	0.16	0.12	0.4
Loamy Sand	0.32	0.23	0.18	0.13	0.5
Sand	0.35	0.25	0.20	0.14	0.6

Maximum Cycle Time

Max = 60 x ASA / (PR – SI)

Where:

Max = Maximum cycle time in minutes
60 = Constant to convert hours to minutes
ASA = Allowable Surface Accumulation (from chart or field observations)
PR = Precipitation rate in inches per hour (see section 2)
SI = Average Soil Intake Rate (from chart)

For example, given a loam soil with a 5% slope and spray heads operating at 1.6 inches per hour the maximum rain time would be calculated as:

10 Minutes = 60 x .21 / (1.6 – .35)

Minimum Soak Time

Min = 60 x ASA / SI

Given the same conditions as above the minimum soak time would be calculated as:

36 Min = 60 x .21 / .35

Review

To calculate the net run-time the following steps are needed:

1. Determine the irrigation requirement.
2. Calculate the average precipitation rate.
3. Measure or estimate the Distribution Uniformity.
4. Determine the run-time multiplier.
5. Calculate the run-time and apply the run-time multiplier.
6. Determine the maximum cycle time to avoid run-off.

Summary

The irrigation system delivers water to the landscape. For controller settings to be effective the performance of the system must be quantified. The quality or efficiency of the system should also be known as well so the results can be adjusted to deal with inefficiencies. An ET-based control system manages the irrigation system by calculating water lost from the landscape, measured in inches and then replaces lost water using the irrigation system.

Review Questions

1. What unit of measure is used to measure rainfall, evapotranspiration and sprinkler application? _______________

2. List three ways precipitation rates can be determined and rank the accuracy of the three methods:

- ____
- ____
- ____

3. Calculate the precipitation rate for a zone of full circle sprinklers laid out in a square pattern spaced 35' apart. Each sprinkler puts out 6 gallons per minute. ____

4. List at least 5 factors that affect distribution uniformity: ____

____

____

5. What is relationship between Distribution Uniformity and valve run-time? ______________________________

____

6. For a spray head system with very good coverage how much does the valve run-time need to be adjusted to compensate for weaknesses in uniformity? ____

7. Calculate the net valve run-time for a zone under the following conditions:

Precipitation Rate = .85 inches per hour
DU_{LQ} = 70%
Irrigation Requirement = .6

_____________________How often should the above zone be set to run? ______________________________

14. List three ways runoff can be reduced: ____

____

____

4. Irrigation Scheduling

An irrigation schedule is meant to bring all requirements together to control how long and how often systems should operate. The schedule is the basis for programming the irrigation controller. The needs of the landscape are combined with the capabilities of the irrigation system. Then any site-specific limitations must be considered. An irrigation scheduler may need to make adjustments and compromises to deal with inadequacies of the irrigation system.

Site Data Collection

To properly create am irrigation schedule there are four key site conditions that should be evaluated:

- Landscape / soil conditions
- Irrigation system capabilities
- Controller capabilities
- Irrigation system deficiencies

Landscape / Soil Conditions

The objective of an irrigation schedule is to meet the plant water requirements. The following information should be gathered during a site inspection:

- Plant types
- Root depth
- Planting density
- Soil Conditions
- Slope
- Facility use needs
- Maintenance needs
- Local watering restrictions
- Time period available for watering

Irrigation System Capabilities

The capabilities of the irrigation system need to be understood. During the site visit evaluate each of the zones; consider each of the following items:

- Record information about each sprinkler zone:
    - Station number and controller assignment
    - Description of area being watered
    - Type of plants watered
    - Precipitation rate
    - Distribution Uniformity
    - Valve size / flow rate – this is needed if there are hydraulic limitations that need to be considered.
    - Slope
    - Exposure
    - Zone specific soil conditions
- Water pressure
- Size of mainline

Controller Capabilities

Note the capabilities of the irrigation controller(s). Note the features available in the controller:

- Make and Model
- Controller location
- Number of stations
- Condition
- Maximum and minimum run-times
- Station timing resolution – station timing should be in at least one-minute intervals
- Number of programs
- Number of start times per program
- Watering day control options
  - Days in the calendar
  - Odd / Even
  - Skip Days control
- Water budget %
- Cycle and Soak
- Installed sensors
- Working battery backup
- If there is an irrigation schedule programmed in the controller, record the current schedule.

Irrigation System Deficiencies

Before implementing an irrigation schedule, the system should be inspected to identify potential problems. It is much better to correct a potential problem rather than having to go back and fix a problem. When irrigation systems are controlled to closely follow the actual plant water requirement water is saved. Often using less water improves the health of the landscape, but over-watering may have covered up system inefficiencies. As water use is reduced the weaknesses in the irrigation system will become more apparent.

An irrigation schedule cannot solve all problems. It is much better to correct problems early rather than waiting for a call.

Inspect each zone and consider the following when evaluating the system:

- Distribution uniformity- Zones with a DU less than 60% should be modified as necessary
- Automatic valve operation
- Operating pressure
- Tilted heads
- Low heads
- Obstructions
- Plugged nozzles
- Nozzle size and adjustment

- Arc alignment
- Over-spray
- Low head drainage
- Leaks
- Drainage or surface accumulation
- Compaction

The Irrigation Schedule

"The schedule should be based on plant water need and changing weather conditions. The number of irrigations per week and/or the run time of each station zone should be based on the plant type (species factor), microclimate, plant density, soil type, slope, microclimate exposure, root zone depth, watering window, and other factors. The frequency of irrigation should be based on allowing the soil moisture to deplete to an allowable depletion limit. Scheduling should supply no more than the amount of water needed to bring the soil moisture back to field capacity." Landscape Irrigation Scheduling and Water Management, September 2003 - Prepared by the Water Management Committee of The Irrigation Association.

There are only two factors in the control system that affects the amount of water that is applied by the sprinkler system:

- **Station run-time** determines how long the sprinklers operate. The capabilities of the sprinkler zone i.e. precipitation rate and distribution uniformity determine how much water is applied in a given time. The objective is to refill the root-zone back to field capacity once soil moisture has been depleted to an allowable level. This means that station run-times can be kept at a constant level. The allowable depletion amount can be used to determine station run-time.

  Advanced control systems can vary the station run-time based on ET. The station precipitation rate is entered and the run-time is calculated based on the last irrigation event, precipitation rate and ET.

- **Frequency** will vary due to changing weather conditions including rainfall.

To create an irrigation schedule all the data that has been collected will be needed. There four steps to follow:

- **Assign stations to a program**
- **Determine watering days**
- **Calculate station run-time**
- **Select cycle start times**

Assign stations to a program

Stations should be grouped into hydrozones. A hydrozone is grouping of plants with similar water (and environmental) requirements. The primary consideration when establishing hydrozones is plant type. The next key factor is rooting depth and soil type. Exposure and slope conditions can also be considered. Now assign hydrozones to programs in the controller.

There may be times with complex landscapes that there may be more hydrozones than are available on the controller. This may require using a controller with more capabilities or adding another controller. In some cases hydrozones can be combined into a one program. When this occurs scheduling decisions should be made based on the worst-case condition and use station run-time to make adjustments.

Hydraulic limitations of the system may require that stations be grouped in different programs.

Determine watering days

The days available for watering must be identified. Given days may not be available due to maintenance schedules, facility use, watering restrictions or some other condition. Demand-based irrigations schedules work best with the least amount of restrictions.

Watering frequency for the hydrozone is based on allowable depletion, consider soil type and rooting depth. Refer to the Allowable Depletion table on page 11.

A source of current ET needs to be identified. This program is geared to implement a Weather Reach Receiver as the ET source. Without an automated source for ET another source should be identified. The information may be available on local websites, from University Extension services, local weather reports, newspapers or historical almanacs. Often ET from these sources will be provided as a weekly value.

To calculate the watering frequency use the following method:

Days = IR / AD

Where:

Days = Number of watering days in the period – Round up to nearest whole day
IR = Irrigation Requirement for a given period of time (Week or month)
AD = Allowable Depletion

For example given an ETc of 1.65” for a week less .25” of rain and an allowable depletion of .5” the following number of watering days is needed for the week:

3 Days = 1.4 / .5

Calculate Station Run-time

Chapter 3 covers the details to calculate station run-time. The run-time should apply enough water to refill the root-zone. When using a fixed run-time based on allowable depletion the irrigation requirement is managed by changing the frequency of irrigation. The runtime is based on the precipitation rate, allowable depletion and the run-time multiplier to adjust for weaknesses in the system's distribution uniformity.

The following chart provides a quick reference to run-times based on different allowable depletion values:

Minutes of Valve run-Time			
Precipitation Rate - Inches per Hour	**Allowable Depletion Inches of water**		
	0.35"	**0.5"**	**0.65"**
2.00	11	15	20
1.75	12	17	22
1.50	14	20	26
1.25	17	24	31
1.00	21	30	39
0.90	23	33	43
0.80	26	38	49
0.70	30	43	56
0.60	35	50	65
0.50	42	60	78
0.40	53	75	98
0.30	70	100	130

This chart does not account for distribution uniformity.

Multiple Cycles

Multiple start times will be needed to minimize run-off when precipitation rates exceed infiltration rate. Use the following process to determine the number of cycles.

$$N = RT_{TOT} / Max$$

$$RT_{NET} = RT_{TOT} / N$$

Where:

N = Number of cycles – Round up.
RT_{TOT} = Total valve run-time to meet the irrigation requirement.
RT_{NET} = Net valve run-time for each cycle.
Max = Maximum cycle time in minutes before run-off begins.

For example given a total run time of 36 minutes and a maximum cycle time of 10 minutes to avoid run-off the total number of cycles and the run time for each cycle is:

3.6 (round up to 4) = 36 / 10

9 = 36 / 4

Number of cycles = 4
Run-time per cycle = 9

Select cycle start times

There are several factors to consider when determining the program start times.

- **Total watering time** - Add up the total run-time of all zones.
- **Facility use** – When does irrigation need to be completed? When can it start?
- **Time window available for irrigation** – Are there any time-of-day watering restrictions?
- **Multiple cycles** – Use more than one start-time to minimize run-off. To determine the number of start times, identify the station requiring the most number of start times. Use this number of start times to recomputed the net cycle run-time for each zone.
- **Hydraulic limitations** – When operating more than one valve at a time the hydraulic capabilities of the system need to be considered.
- **Overlapping start-times** – Some controllers will either stack program start times so they run in sequentially or are set to overlap to allow concurrent operation. Take into account hydraulic limitations and programming options when programming the start times for each program.

Work sheets

The following worksheets can be used to prepare an irrigation schedule. Station specific information is needed to make the calculations.

Station Worksheet

Project Name: Date:

1	Zone Number				
2	Location				
Plant Water Requirement					
3	Plant Type				
4	Soil Type				
5	Root Depth				
6	Allowable Depletion				
7	Kc or KL KL = Ks x Kmc x Kd				
8	Ks-Species Factor				
9	Kmc - Microclimate Factor				
10	Kd- Density Factor				
11	Hydrozone				
Irrigation System					
12	Sprinkler Type				
13	Precipitation Rate PR = (96.3 X GPM) / Area				
14	Run Time RT = IR x (60 / PR)				
15	Distribution Uniformity				
16	Slope				
17	Run Time Multiplier				
18	Adjusted Run Time				
19	Maximum Run Time				
20	Minimum Soak Time				
21	Number of Cycles				
22	Run Time per Cycle				

Use the information from the controller-programming sheet to complete the irrigation schedule.

Controller Programing Worksheet

			Program A	Program B	Program C	Program D
Weather Reach Settings		Water Days	S M T W T F S	S M T W T F S	S M T W T F S	S M T W T F S
"A" ET Threshold		Cycle Days				
"A" % ET Adjust		Start Times				
"B" ET Threshold		1				
"B" % ET Adjust		2				
Time Window Start		3				
Time Window Length		4				
		5				
		6				
		7				
		8				

Stations							
	Location	WR-7 A or B	Sprinkler Type	Run-Time	Run-Time	Run-Time	Run-Time
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
			Total Run-Time				

Summary

An irrigation manager combines the plant water requirements, soil reservoir capacities, irrigation system capabilities and facility use. In simple terms a schedule has three variables:

- Valve Run-Time
- Cycle Start Time
- Watering Days

Plant health and responsible use of the water resource are all at stake. Irrigation schedules should be planned and not based solely on reaction to the results. All too often irrigation schedules are only changed when the landscape is drying out or water starts ponding on the surface.

Review Questions

Complete the scheduling worksheet and prepare an irrigation schedule:

Schedule Worksheet

Project Name: Sample Date:

1	Zone Number	1	2	3	4
2	Location	Front Yard	Front Yard	Park Strip	Front Yard
Plant Water Requirement					
3	Plant Type	Turf	Turf	Turf	Shrub
4	Soil Type	Loam	Loam	Loam	Loam
5	Root Depth	6	6	6	12
6	Allowable Depletion				
7	Kc or KL KL = Ks x Kmc x Kd				
8	Ks-Species Factor				
9	Kmc - Microclimate Factor				
10	Kd- Density Factor				
11	Hydrozone				
Irrigation System					
12	Sprinkler Type	Spray Heads	Rotor	Spray Head	Drip
13	Precipitation Rate PR = (96.3 X GPM) / Area	1.6	0.85	1.8	0.66
14	Run Time RT = IR x (60 / PR)				
15	Distribution Uniformity	60%	70%	55%	90%
16	Slope	3%	10%	5%	3%
17	Run Time Multiplier				
18	Adjusted Run Time				
19	Maximum Run Time				
20	Minimum Soak Time				
21	Number of Cycles				
22	Run Time per Cycle				

Controller Programing Worksheet

			Program A	Program B	Program C	Program D
Weather Reach Settings		Water Days	S M T W T F S	S M T W T F S	S M T W T F S	S M T W T F S
"A" ET Threshold		Cycle Days				
"A" % ET Adjust		Start Times				
"B" ET Threshold		1				
"B" % ET Adjust		2				
Time Window Start		3				
Time Window Length		4				
		5				
		6				
		7				
		8				

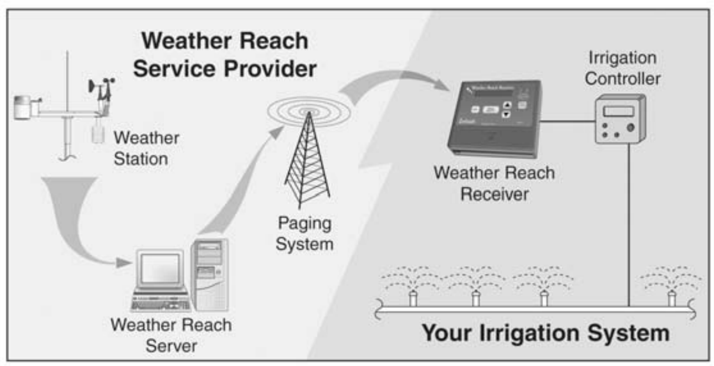
Stations							
	Location	WR-7 A or B	Sprinkler Type	Run-Time	Run-Time	Run-Time	Run-Time
1							
2							
3							
4							
5							
6							
			Total Run-Time				

5. Weather Reach Control

Weather Reach System Overview

A Weather Reach Receiver can assist an irrigation controller to water based on current weather conditions. A Weather Reach Receiver is not an irrigation controller, but an accessory to a controller. A local Weather Reach Service Provider (WRSP) retrieves weather data from local weather stations then broadcasts the information via a paging radio frequency. The data contains the most recent conditions including:

- Temperature
- Humidity
- Wind
- Rainfall
- Solar Energy



Weather Reach Receivers use weather information to calculate evapotranspiration (ET), which is the amount of water lost from the soil from evaporation and the water used by the plant by transpiration.

ET Outputs

The WR-7 has four different ways that ET can be integrated with an irrigation control system:

- **ET Enable** – The "common" output of a controller is interrupted until a programmed ET threshold is reached to control irrigation frequency based on ET. The ET threshold value equals the amount of water applied by the irrigation controller in a 24–hour period.
- **ET Trigger** – When an ET threshold is reached the Weather Reach Receiver trips a relay to signal an irrigation controller that irrigation is needed.
- **ET Pulse** – The Weather Reach Receiver outputs a switch closure for every 0.01" of ET to compatible ET-based irrigation controllers.
- **RS-232** – Compatible irrigation controllers directly access ET and weather data from a WR-7 via a serial port, and then initiate irrigation "decisions" based on the data provided.

The type of irrigation controller will determine which ET output is needed.

Additional Features

In addition the Weather Reach Receiver has the following options:

- **Rain Pulse Output** - One switch contact for each 0.01” of rainfall.
- **Rain Tip In** – Monitors an on-site tipping bucket rain gauge.
- **Weather Interrupts** – Interrupts irrigation if certain weather conditions exist.
    - Low Temperature
    - High Wind Speed
    - Rain fall

Advanced Control Systems

There are several ET-based control systems on the market. All of them are dependent on a source for ET. These systems can use the Weather Reach Receiver as an ET source. The implementation of these systems is too broad to include in this guide. Irrisoft has Application Notes that provide the details needed to implement the Weather Reach Receiver as and ET source. The programming and site integration of those systems is available from the manufacturers of those systems.

Activation

A Weather Reach Receiver must be activated before it will operate. It is recommended that activation be done before installation. Activation is done using the Weather Reach Activation software that operates on a personal computer. The Weather Reach Receiver must be connected to the PC during the activation process. There are four things accomplished in the activation process:

1. **Select a Weather Reach Service Provider (WRSP)** – The WRSP manages the network of weather stations. The pager settings are unique to each WRSP. For the Weather Reach Receiver to work properly the pager must be programmed or activated to work with the desired WRSP.
2. **Select Weather Station** – Weather stations are assigned a "Weather Region Code" select the station that most closely represents the conditions of the site.
3. **Enter warranty information** - Warranty registration with Irrisoft Inc. is taken care of when the device is activated.
4. **Program Settings** – There are a number of site-specific settings needed for proper operation of the Weather Receiver.
5. **Activation Report** – All the information gathered during the activation process and entered in the Weather Reach Receiver is available on a printout generated by the activation software

For more information on the activation process, refer to the Weather Reach Receiver Activation software Users Guide and the Weather Reach Receiver Users Guide.

Installation

Refer to the Weather Reach Receiver users guide for details associated with proper installation. The following points are key points to remember.

Mounting

It is best to install the Weather Reach Receiver adjacent to the irrigation controller. The WR-7 is NOT weather resistant. Install indoors or in a weather resistant enclosure. An optional outdoor enclosure designed for the WR-7, is available. Use the model WR-OE a WR-7 outdoor enclosure, a heavy duty, lockable fiberglass NEMA 4X cabinet.

Provide Power

WARNING - To prevent electrical shock make sure the power supply is OFF before connecting wires to any of the devices. Electrical shock can cause severe injury or death.

All electrical connections and wire runs must be made in accordance with local building codes.

The power requirement is 12 to 28 Volts AC or 12 to 35 Volts DC and draws a maximum 0.1 Amp max. Remove the lower access panel to get at the plug-in power connection. Power for the WR-7 can come from one of two sources:

Option 1

The WR-7 comes with a power cable that can be connected to a 24-volt AC source within the irrigation controller. The current draw is less than one standard valve solenoid. Check the controller owner's manual to verify that accessory devices can be powered from the controller power supply.

Option 2

Use a WR-PS – plug-in power supply transformer. This plugs into a standard a 110-volt AC outlet.

Grounding

Connect a 14-gauge, or larger, ground wire to the ground wire lug. GROUNDING IS REQUIRED for surge, equipment, and personal protection.

Wire Connections

The ET mode and selected options affect the wiring schemes; determine ET output to determine which wiring method is needed.

- ET Enable
- ET Trigger
- ET Pulse
- RS-232

Wiring diagrams can be found in the Weather Reach Receiver Users Guide for each of the ET outputs.

Users Guide and Cue Card

Install the cue card and provide the users guide to the operator.

Program the Irrigation Controller

The irrigation controller needs to be setup with specific settings to work with the Weather Reach Receiver. For RS-232 or ET pulse output options refer to the controller users guide. The Weather Reach Receiver is a data source and the controller must be programmed to work with the data.

ET Enable

The most frequently used output is the ET Enable. Because the controller common is routed through the WR-7 it can control the irrigation frequency of irrigation for the valves connected to the common. Enter the prepared irrigation schedule into the controller. Set the controller to water everyday, leave selected days OFF as needed. The Weather Reach Receiver manages the watering days.

Time Window

During activation the Time Window was programmed. Verify the programmed Time Window in the Weather Reach Receiver corresponds to the controller programmed start times and overall watering time.

Check to see that the current time on the Weather Reach Receiver is the same as the irrigation controller.

ET Threshold

When the irrigation requirement reaches the ET Threshold irrigation is allowed. The program in the controller is allowed to water. It is essential that the programmed valve run-times activate the valves long enough to apply the same amount of water as the ET Threshold. If the ET Threshold is set to allow irrigation after .5" of soil moisture depletion then the irrigation system needs to apply .5". Verify that the sprinkler system applies enough water to refill the root zone.

Set ET Balance for A & B

The initial setting of the ET Balance affects the first ET Enabled watering cycle. Consider the irrigation needs of the site; average daily ET, ET Threshold, the last irrigation day and estimate the desired day for the next ET Enabled watering. To assure watering will occur at the next scheduled start time set the ET Balance higher than the ET Threshold. As long as the Time Window is currently closed then the irrigation suspended light will go off.

Automatic Control

Once the Weather Reach Receiver is activated, installed, and the controller is set it will manage irrigation frequency.

Irrigation Requirement Balance

As weather data is received each hour ET is calculated. ET is added to the irrigation requirement balance. Once ET accumulates in the irrigation requirement balance to the threshold setting irrigation is enabled. The A & B indicators light are on when the irrigation requirement balance is less than the threshold. When the light is off, irrigation is enabled, allowing the controller's programmed cycle to operate. When irrigation occurs the irrigation requirement balance is automatically adjusted. The threshold value is subtracted from the irrigation requirement balance.

The Weather Reach Receiver detects the electrical current that would be activating an automatic control valve. This current detection system is used to verify the irrigation cycle ran. If the controller has been programmed with a specific day-of-the-week turned off, and the WR-7 has enabled irrigation for that day, the controller will not energize the valve so no current will activate the valve. The current sensor in the Weather Reach Receiver uses this information to determine if it the system has watered. When no current is detected the irrigation balance is not adjusted so irrigation will occur the following day.

Rain

Effective measured rain is subtracted from the irrigation requirement balance. Rainfall measurements will either be recognized from the local on-site rain collector (if installed) or from the weather data broadcast.

The soil holding setting creates a limit to on the irrigation requirement balance. Rain is subtracted from the irrigation requirement. In heavy rains soil moisture goes above field capacity. The soil holding setting is the saturation limit above field capacity. Accumulated rain in the irrigation balance will never exceed this value. It creates a negative limit to the irrigation requirement balance.

Example

Review the following example of the irrigation balance. The ET threshold is set at .5”. The soil holding is set to .25. Notice that the balance does not drop below -.25 on 4/26/03. Of the 1.2” of rain only .76” was effective rain

Date	ETc	Effective Rain	Irrigate	Irrigation Requirement Balance
4/1/2003	0.28	0.13		0.15
4/2/2003	0.27			0.42
4/3/2003	0.21		0.50	0.13
4/4/2003	0.16	0.04		0.25
4/5/2003	0.19			0.44
4/6/2003	0.14		0.50	0.08
4/7/2003	0.15			0.23
4/8/2003	0.18			0.41
4/9/2003	0.18		0.50	0.09
4/10/2003	0.19			0.27
4/11/2003	0.20			0.47
4/12/2003	0.22		0.50	0.19
4/13/2003	0.23			0.42
4/14/2003	0.21		0.50	0.14
4/15/2003	0.17	0.20		0.11
4/16/2003	0.16	0.11		0.16
4/17/2003	0.18			0.34
4/18/2003	0.21		0.50	0.04
4/19/2003	0.11	0.01		0.14
4/20/2003	0.19			0.33
4/21/2003	0.17			0.50
4/22/2003	0.21		0.50	0.21
4/23/2003	0.13			0.34
4/24/2003	0.17		0.50	0.01
4/25/2003	0.23			0.24
4/26/2003	0.27	1.20		-0.25
4/27/2003	0.24			-0.01
4/28/2003	0.26			0.25
4/29/2003	0.27		0.50	0.02
4/30/2003	0.24			0.26

Time Window

The Time Window plays several important functions:

1. Current Detection – The current detection system, used to verify the irrigation cycle ran, is only active during the programmed Time Window. This is so the WR-7 does not count a manual watering, which may have been run during the day, as the complete irrigation cycle.

2. The ET Enable control condition is locked in when the Time Window opens and will not change until the Time Window closes. This prevents an irrigation cycle from being enabled part way through a cycle.

   For example: Given a controller is programmed to start at 9:00 at night and the Time Window opens at 8:00. If at 8:00 the irrigation balance was at .48 and the threshold were at .5" irrigation would not occur. If at 11:00 the irrigation requirement balance reached .52" then irrigation would not start, it would be enabled for the following day.

When the Time Window is open the display flashes the message "Time Window Open" on the home screen.

Weather Interrupt

If weather conditions from the last broadcast met the interrupt settings the, weather interrupt switch opens, suspending irrigation. Irrigation will remain interrupted as long as the condition is met.

Operation

Refer to the Weather Reach Receiver Users Guide for detailed instructions to program and operate the WR-7 based on the chosen ET mode and optional features.

- Display
- Indicator Lights
- Control Buttons
- Menus

Settings

The settings were programmed during activation. The settings can be reviewed and adjusted, as site conditions require. For more information refer to the Weather Reach Receiver Users Guide.

Summary

A Weather Reach Receiver provides real-time ET-based control to landscape irrigation systems. There are multiple interfaces available for it to provide control to a variety of applications. As with all control systems if set correctly it will be a great tool.

The irrigation management style used by the ET enable output follows the best management practice recommended by the Irrigation Association. The watering frequency should be managed to promote a deeper healthier root system.

Review Questions

1. What does a Weather Reach Receiver do? ______________________________

____

2. What are the four ET outputs available on a Weather Reach Receiver, model WR-7? Explain each application:

____

____

____

____

____

____

____

3. Where does a Weather Reach Receiver get its power? ______________________________

____

4. Why does a Weather Reach Receiver need to be grounded? ______________________________

____

5. How does a Weather Reach Receiver obtain an ET value? ______________________________

____

____

The following questions apply when using the ET Enable control method:

6. Explain the purpose of the Time Window: ______________________________

____

____

7. Explain the ET Threshold: ____

____

8. List four factors that affect the Irrigation Requirement Balance: ________________________________

____

____

____

____

9. What happens when the Irrigation Requirement Balance reaches the ET Threshold? ____________________

____

10. What two settings are used to define "Effective Rain"? ______________________________________

____

____

11. If the controller was programmed with a given day off, and irrigation is enabled for that day, what will the Weather Reach Receiver do? ____

____

____

12. What historical events are logged in the Status Menu? ______________________________________

____

____

13. Why are is there an A & B threshold and balance? ____

____

____

6. System Monitoring

Site Visit & Follow-up

Schedule a follow-up site visit. The first visit should be in a few days and after the first ET Enabled irrigation event has occurred. Complete the Installation Follow-up report. Make additional periodic visits to inspect the landscape and evaluate the results programmed settings. Make adjustments to the irrigation controller program, Weather Reach Receiver settings or the irrigation system to respond to the needs of the landscape.

The installation follow-up form can be used to document the conditions, status and settings observed during a site visit.

Weather Reach Receiver

Installation Follow-up Report

Customer:	Contact:	Phone:
Date Installed:	Installer:	Phone:
Controller Start times:	Days set to irrigate:	

Date: WR-7 Date & Time: Inspected by:
Indicator Lights - A: ☐ On ☐ Off **B:** ☐ On ☐ Off **Alert:** ☐ On ☐ Off
If Alert on, current message: Time Window Status: ☐ Open ☐ Closed
Mode: ☐ Auto ET ☐ Off ☐ Default ET ☐ Override – Hours:
Weather Info: Rain – Last 24 hours: Last 7 Days **ET** – Last 24 hours: Last 7 Days:
ET A Threshold: Balance: **ET B** Threshold: Balance:
Status: Irrigate A Counter: Irrigate B Counter:
Last Irrigate A: Last Irrigate B:
Last Broadcast: Last Interrupt: Cause:
Broadcast Crop Coefficient: Missed Data: hrs in: days
Condition of the landscape:
Notes & Adjustments:

Fine Tuning the System

The system will require monitoring and adjustments.

When an irrigation schedule is implemented it is based on all available information. Control systems are not 100% set it and forget it. The system needs to be monitored. When water management styles bring water use closer to actual need there is less margin for error. Weaknesses in the system will become apparent. Many components make up an irrigation system, when a problem arises the cause needs to be identified and corrected.

Remember the variables when evaluating and troubleshooting problems with the system.

- **Sprinkler Performance –** A control system manages the delivery system. If sprinkler coverage is not adequate, using the control system to compensate will lead to over watering which can impact the health of the landscape.
- **ET –** Calculated ET is a reference value. It will change as weather conditions change. Specific crops or site conditions may vary but they will vary in relation to reference ET. Use the percentage adjustments to adjust ET for site specific needs. Lowering the percentage will reduce the amount of water applied.
- **Frequency –** The ET Threshold drives the frequency of watering based on ET. To increase the frequency, lower the ET Threshold.
- **Run-Time –** Valve run-times must be set to apply enough water to refill the soil root-zone reservoir to field capacity.
- **Effective Rain Settings** – The irrigation requirement is equal to ET minus effective rain. Rainfall that runs off or percolates below the root-zone is not available to the plant. If effective rain settings are not correct the system may resume watering too early or not soon enough after a rain event.

Soil Probe

A soil probe is a good tool to use to evaluate the effectiveness of the irrigation schedule. After a nights watering check the soil to see if the water soaked down to the desired level. Adjust the run-times as needed.

Having a deeper root system develops drought tolerance and a healthier landscape. Less frequent, deep watering will develop the roots. This is a gradual process. Over time the valve run-time can be increased while increasing the ET Threshold.

Visual Inspection

Observe the condition of the landscape, it can provide important clues that can help fine-tune the system.

Problems may show up at different levels. Observe the following condition when considering making changes to the system:

- **Dry Spots** – A small area within a zone will show stress if there is a sprinkler coverage issue. First evaluate sprinkler coverage and make adjustments as needed. The run-time may need to be increased. See the section on run-time multipliers when deciding how much to change.
- **Dry or over-watered zones** – If most or all of a sprinkler zone is not being watered correctly there may need to be a change in the settings. In most cases adjusting the valve run-time should solve it.
- **Dry or over-watered site** – If many zones or the entire site is not being watered properly do a complete system check to verify that all components are working properly. Confirm those valve run-times are applying the amount of water needed to bring the soil moisture levels back to field capacity. Evaluate ET Threshold settings. To water more often, lower the threshold setting.

In some cases the problem may be a combination of issues requiring more in-depth analysis.

Manual Watering

If the controller needs to be operated manually and the Weather Reach Receiver A & B indicator lights are on, the manual override button must be used. When the button is pressed the lights go out and irrigation is enabled. The irrigation requirement balance is not adjusted by a manual watering. Each time this button is pressed an additional hour is added to the override mode.

Water Tonight

If conditions require that a complete automatic irrigation cycle is needed at the normal scheduled time look at the current irrigation requirement balance. If the balance is lower than the threshold the indicator light will be on. The irrigation requirement balance can be adjusted. To raise the balance, press the Menu button, to move the cursor position to the balance. Use the up arrow to raise the balance greater than the threshold. This will enable the next scheduled irrigation cycle to operate.

Landscape Establishment Period

When a landscape is first planted, sod is laid or seed was just planted the water needs are much different. There is very little soil reservoir capacity because roots are not established. During this period the water manager should control the irrigation system based on field observations. The landscape is vulnerable, soil moisture levels are unknown and roots are not established.

After initial establishment, ET–based control can assist in the developing a healthy root system. The principles covered in chapter two apply. Because root systems are shallow the allowable depletion value will be smaller, watering will be more frequent and run-times shorter. During establishment monitor root development and increase the irrigation threshold. The controller run-times will need to be increased. This will decrease frequency and increase watering depth. This process will take one or two growing seasons. For discussion purposes establishment will be broken down into initial establishment

Summary

Irrigation control systems are not to be set and forgotten. An irrigation system is complex combination of sprinkler heads, piping systems, valves and electronics that is designed installed and managed to meet the plant water requirement. There are too many things that can go wrong. When the system fails to maintain a healthy landscape the entire system needs to be evaluated to determine the cause and then take whatever action is need to correct the problem.

Review Questions

1. Can you install a Weather Reach Receiver, set it and forget it? ______________________________

2. What setting should be changed to increase the frequency of watering? ______________________________

____

3. The scope of a problem observed on site should be narrowed to focus on a solution. What three levels of problems could be encountered? ____

____

4. What is the best way to fix a dry spot? ____

____

5. What should be changed if a zone is being over or under watered? ______________________________

____

6. What do you look for when the entire site is not being watered correctly? ________________________

____

____

____

7. Business Opportunities

Due to a growing population and given a limited nature of our water resource and delivery systems, the cost of water will keep going up. Many property owners consider a water bill to be a utility that they have no control over. It is paid automatically.

People change only when they get uncomfortable.

Study after study has shown that outdoor water use is typically twice what is needed to sustain a healthy landscape. But tell someone they are using twice what they need, and they probably won't believe you. The fact is; most water waste occurs when people are not thinking about it. Spring and fall watering habits are the source of most of the waste. Leaving the system on while it is raining also wastes water. There are also cool cycles every season when the water requirement goes down. In the late summer months the days are still hot, but not as long and the nights begin to cool off. The need for water begins to go down, but these subtle changes are often ignored.

Bottom line, most landscapes are over-watered.

What are the cost implications of over-watering?

- Higher water bills or electricity if pumping
- Plants may be killed
- Plant diseases
- Mosquito habitat
- Environmental impact of wasted water running off causing erosion and pollution

What is the cost of labor associated with reprogramming controllers? There is a direct relationship between the number of times a controller is reprogrammed and over watering. The more times a controller is adjusted to respond to the plant water requirement the lower the water bill. There is a labor cost associated with the site visit, evaluation and reprogramming. When scheduling systems are automated the labor costs go down.

The savings potential with improved water management lies in three areas:

- Water savings
- Labor
- Landscape maintenance

Who stands to benefit? Those sites where these costs are reduced to a level to offset the cost of implementing improved management systems.

Service Opportunities

There is a big difference between an irrigation system installer and a landscape water manager. Installers dig trench, fit pipe, run wire, set valves and heads. A landscape water manager understands the plant water requirements, uses the irrigation system to deliver water to the landscape by using advanced control systems that respond to changing conditions. To do the job the following services need to be done:

- Assess current site conditions associated with the landscape
  - Plant water requirements
  - Soil Conditions

After assessing current landscape conditions make recommendations for improvements such as soil amendments, mulches, changes in landscape plantings

- Evaluate the irrigation system
  - Perform an audit to determine irrigation system efficiency.
  - Do sprinkler zones correspond to plant hydrozones?
  - Is irrigation water kept on site, consider over-spray and run-off issues.
  - Does the control system adequately respond to changing water requirements?

Identify weaknesses in the system and determine a course of action to make improvements to the system. This would probably include updating the irrigation system controls to include Weather Reach.

- Evaluate current irrigation schedules
  - Compare present management practice to current Best Management Practices.

Generate and implement an irrigation schedule and program to monitor the system during the season.

There are several funding sources for water management services:
- Water savings
- Labor savings
- Rebate programs offered by water agencies
- Government grants

Return on Investment (ROI)

The ROI period is directly related to the cost of water and the current over-use. Water agency and university studies all reach the same conclusion. Landscapes are over watered by typically 20 to 60% plus.

Why?

- Irrigation controllers are to often set and forgotten.
- Schedule adjustments are based on reaction to visual inspection.

Labor costs

What is the cost of reprogramming controllers? The technician performing this service should be a trained professional. It should not be the job of low cost laborer.

Save Money

Determine the annual water requirement based on ET and the landscaped area. Then compare to actual usage. Look at the current water rate structure, projected increases and penalties to calculate the savings.

ETc* for Salt Lake City, Utah 4/15/02 to 10/15/02	25.6”
Less Effective Rain Fall 4/15/02 to 10/15/02	6.5”
Landscape Water Requirement	19.1”
Adjusted Irrigation Requirement**	25.5”
Documented average irrigation***	50”
Savings Potential	24”

* Average seasonal crop coefficient .7
** Sprinkler efficiency .75
*** 3-year homeowner average (1999-2001) for residential sites in Salt Lake County Water Check Program.

Potential Annual Water Savings

Given a 24” reduction in water use:

Landscape Area	Gallons SAVED	Cost of Water per 1,000 gallons				
		$1.00	**$2.00**	**$3.00**	**$4.00**	**$5.00**
0.1	**65,170**	$65	$130	$196	$261	$326
0.25	**162,926**	$163	$326	$489	$652	$815
0.5	**325,851**	$326	$652	$978	$1,303	$1,629
1	**651,703**	$652	$1,303	$1,955	$2,607	$3,259
2	**1,303,406**	$1,303	$2,607	$3,910	$5,214	$6,517
5	**3,258,515**	$3,259	$6,517	$9,776	$13,034	$16,293

Features and Benefits

When is a feature a benefit?

The Weather Reach system has many features. Not every feature is important to all users. The key to successful sales is to identify the benefits that are most important to the customer and assure them that the product has the features needed to achieve the benefit.

The following chart can help you understand many of the features and benefits but do no overwhelm a customer with everything.

Feature	Benefit
Irrigation is based on ET.	Healthy landscape. Water savings.
The system operates automatically.	Saves labor.
Optional on-site rain collector.	Exact rainfall amounts are used to control the irrigation.
Weather information is updated hourly.	Irrigation is controlled based on real-time conditions.
Weather data comes from a high quality regional weather station.	No weather station to maintain. Accurate data.
Four ET outputs	Adapts to almost any controller.
Weather Interrupt	Prevents unneeded irrigation.
Displays current weather conditions.	User can see the conditions affecting landscape water use.
Measured rain is used to calculate the irrigation requirement.	Saves water.
ET Threshold controls watering frequency.	Promotes deep healthy roots.
Responds to changes in the weather.	Gets plants the water they need.
A & B ET Enable Control.	Lawn and shrub areas are watered separately.
Adjustable ET Threshold	Works with differing site conditions.
Irrigation balance can be manually adjusted.	The user has control to water when needed.
Effective rain settings.	Recognizes the rain that is useful for the plants.
Manual Override.	User can always operate the system when needed.
Current sensor detects irrigation.	The Weather Reach Receiver knows when a specific day is programmed to not water.
Time Window	Allows complete watering to occur.
Landscape adjustment percentages.	Site specific control
Status log showing how many times the system watered and when.	The user knows what the Weather Reach Receiver is doing.
Default ET	There is a backup in the event there is a problem.
Wind adjustment percentage	Fine-tune the system to deal with local wind conditions.

Summary

Good businesses find and fill needs. The end user needs to see the benefit of the goods and services being offered. The cost benefit analysis needs to show a reasonable return on the investment. Healthy landscapes are important to people. There is an emotional, feel good, need that must be understood. Can they trust that the changes made to the landscape will not affect the appearance?

The bottom line is the public wants healthy landscape that uses the water resource responsibly.

8. Supplemental Material

Worksheets

- WR-7 Activation Worksheet
- Site Information by Station Worksheet
- Controller Programming worksheet
- Site Inspection / Follow-up worksheet
- Weather Reach Receiver Installation Follow-Up Form

Check Lists / Quick Reference

- Weather Reach Receiver Installation Checklist
- Weather Reach Receiver Menu Card

Weather Reach Resource CD Contents

- Application Notes
  - Rain Master DX2 Evolution
  - Rain Master Eagle
  - Rain Bird IM
  - Rain Bird Maxicom
  - Signature Controls
  - Toro Sentinel
- Weather Reach Graphics
  - Logo
  - Weather Reach Receiver
  - Poster
- Installation Details
  - AutoCAD 11
  - AutoCAD 2000
  - DXF
  - JPG
  - PDF
- Literature
  - Effective Water Management
  - ET 106 Weather Station
  - ET-based Control Savings Potential
  - Weather Reach Introductory Piece – B&W
  - Weather Reach Introductory Piece – Color
  - Site Weather Reach Server
  - Weather Reach System White Paper
  - Weather Reach Receiver Model WR-7

- Manuals
  - Weather Reach Receiver Model WR-7 Users Guide
  - Weather Reach Receiver Menu Card
  - Weather Station Maintenance
- Power Point Presentations
  - Overviews
  - Installation
- Specifications
  - Specifications WR-7
- Supplemental Resources
  - Estimating Irrigation Water Needs of Landscape Plantings - University of California Cooperative Extension - California Department of Water Resources
  - IA Landscape Irrigation Scheduling and Water Management - Sept 2003
  - Irrigation Water Requirements - USDA - SCS - National Engineering Handbook
  - Landscape Irrigation Simplified handbook - A handbook for Landscape Irrigation Practitioners - May 8, 2002 - 1Created by the Bureau of Reclamation, Upper Colorado Region, Water Conservation Office - Salt Lake City, UT.
  - Plant Water Soil Relationships - USDA - SCS - National Engineering Handbook
  - Rain Bird Irrigation Design Manual
  - Scheduling Methods Using ET as a Management Tool - Brent Q. Mecham - Northern Colorado Water Conservancy District Loveland, Colorado
  - Soils chapter - National Engineering Handbook
- Training Materials
  - Landscape Water Management Manual
  - Landscape Water Management Power Point Presentation
  - Landscape Water Management – Handout
- Worksheets and Checklists
  - Checklist - Weather Reach Server setup
  - Checklist - WR-7 Installation
  - Controller Programming Worksheet
  - Site Information by Station Worksheet
  - Weather Reach Receiver Installation Follow-Up Form
  - WR-7 Activation Worksheet

9. Sources

Certified Landscape Irrigation Auditor – Training manual published by the Irrigation Association – August 2001

"A guide to Estimating Irrigation Water Needs of Landscape Plantings in California" University of California Cooperative Extension - California Department of Water Resources

The Irrigation Association "Turf and Landscape Irrigation Best Management Practices" – Draft - September 2003

The Irrigation Association Best Management Practices – "Landscape Irrigation Scheduling and Water Management" – Draft- September 2003

United States Department of Agriculture – Soil Conservation Service - Part 623 – National Engineering Handbook – "Chapter 2 Irrigation Water Requirements" – September 1993

United States Department of Agriculture Soil Conservation Service - National Engineering Handbook Irrigation Chapter 1 "Soil-Plant-Water Relationships" – December 1991

United States Department of Agriculture Soil Conservation Service - National Engineering Handbook Irrigation Chapter 2 "Soils" – September 1997

"Landscape Irrigation Simplified" - A handbook for Landscape Irrigation Practitioners - May 8, 2002 - 1Created by the Bureau of Reclamation, Upper Colorado Region, Water Conservation Office, Salt Lake City, UT, www.uc.usbr.gov/progact/waterconsv/index.html

Scheduling Methods Using ET As a Management Tool - Brent Q. Mecham - Northern Colorado Water Conservancy District Loveland, Colorado