



Landscape Irrigation Simplified¹

A handbook for
Landscape Irrigation Practitioners

(May 8, 2002)



Checking contents of container after the test.

¹Created by the Bureau of Reclamation, Upper Colorado Region, Water Conservation Office, Salt Lake City, UT, www.uc.usbr.gov/progact/waterconsv/index.html

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CHAPTER 1 - THE BASICS

Introduction

Approximately 50 to 70 percent of the water used for urban purposes is used on landscapes. Preliminary results of numerous water audits conducted by Utah State University Extension in Salt Lake County and surrounding counties suggest that the typical landscape manager (professional or homeowner) applies about twice as much water as the landscape requires. Experience shows the major factors that, individually or in combination, result in over-irrigating landscapes include:

- Irrigations that occur more frequently than required by the landscape.
- Irrigations that apply more water than can be infiltrated into the soil effectively.
- Irrigation systems that are poorly designed or inefficient, with sprinklers improperly placed, out of adjustment, or in need of repair.

Except for poorly designed or improperly placed sprinkler systems, the above problems can be corrected quite easily with little or no cost to the homeowner or landscape manager. Three requirements must be met to irrigate landscapes efficiently. They are:

- 1. The sprinkler system must distribute the water evenly.**
- 2. The sprinkler system must apply the proper amount of water at a rate that can be completely infiltrated into the soil without runoff.**
- 3. Individual irrigation events must be scheduled to meet actual plant water needs.**

“Landscape Irrigation Simplified” or LIS provides a package of tools and techniques for improving landscape irrigation efficiencies. This handbook describes two approaches. LIS provides information and options appropriate for the landscape irrigation practitioner (landscape irrigation manager, irrigation system designer, irrigation system installer, etc.). LIS is intended for the landscape professional or homeowner that desires the greatest precision and efficiency without employing more expensive monitoring and control systems. Some shortcuts are included specifically for the typical homeowner. They are much simpler to use because they provide fewer options and require fewer choices while still achieving acceptable results.

Why Homeowners Should Irrigate Their Landscapes Properly

Landscapes are typically over-irrigated. Proper landscape irrigation has many benefits. These include:

Personal Benefits

- Reduction in water bill—could be significant depending on current water rates.
- Better appearance and health of landscape. Seventy percent of plant problems diagnosed by Extension Service have been linked to poor irrigation practices.
- Less time maintaining the landscape each week—more time for doing something else.
- Less fertilizer—this will save time and money.
- Less spraying of pesticides—this will save time and money also.

Social Benefits

- Proper irrigation saves water that could be used other places, or stored for future use.
- Proper irrigation could delay the need for costly, new water supplies and/or treatment and delivery facilities.
- Proper irrigation protects the environment. Applying less water will allow the applied fertilizers and pesticides to work properly by not washing them down storm drains or into the ground water.
- Proper irrigation reduces costs associated with excessive runoff. Prolonged runoff from over-irrigation can weaken the foundation materials supporting concrete and asphalt pavements resulting in costly repairs

The Process

The process for achieving efficient outdoor water use involves several relatively simple steps. In general, these steps include:

Step 1. Evaluate the sprinkler performance. A sprinkler performance evaluation consists of placing some containers on the lawn area, turning on the sprinklers for a period of time, and observing the amount of water collected in the containers. This usually requires 10 to 20 containers, depending upon the size of the lawn area being evaluated. The containers are set out in a grid pattern in the lawn area. Once the sprinklers have been run for a period of time, the depth of water in the containers is measured and recorded. The Distribution Uniformity (DU) is then calculated. A DU of less than 0.7 indicates problems with the sprinkler system. If the DU is less than 0.7, the sprinkler system should be inspected to identify obvious problems. If necessary, repairs or adjustments are made (See Chapter 6), the containers are emptied, and the system is run again. The new readings are then used to calculate the DU. If the sprinkler system is performing satisfactorily, compute the application rate. Otherwise, continue to tune up the sprinkler system and repeat the test.

The **Homeowners Shortcut** is a simplification of the above procedure and requires the use of only four containers. Four containers are set out in a grid in the area to be evaluated. Once the containers have been placed, the sprinkler system is run for a specified period of time and the depth of water in the containers is observed or measured and recorded. If the amount of water in each container is not about the same, the sprinkler system should be inspected and tuned up (See Chapter 6). The test should then be repeated. "Chapter 2 - Evaluating Sprinkler Performance" describes the performance evaluation process in more detail.

Step 2. Set the sprinkler controller to apply the desired amount of water each irrigation event without causing runoff. LIS uses the application rate determined as part of the sprinkler performance evaluation described above. You must know the desired amount to apply each irrigation event as well as the soil type. The soil type is an indicator of how fast water can soak in. Soil type also determines how fast the water can be applied and how deep a specific application amount will soak in. The required soaking depth depends upon the depth of the plant roots. Settings may differ for various sprinkler zones because of different application rates or soil types. "Chapter 3 - Setting the Sprinkler Controller" provides in-depth discussions of several options for setting the sprinkler controller.

The **Homeowners Shortcut** uses a default application amount of 1/2-inch (5/8-inch for warmer climates). The four containers described above are used to determine how long to run the sprinklers each irrigation. The run times can be adjusted to eliminate runoff.

Step 3. Schedule irrigation events to coincide with changing plant water needs. Plant water needs are the least in the spring and fall when temperatures are cooler. Water needs are the greatest during the heat of the summer. Properly scheduled irrigations will have the largest interval between irrigations during the spring and fall. Likewise, intervals will be the shortest during the summer. "Chapter 4 - Scheduling Irrigations" describes several options for scheduling irrigations and explains in some detail how to use each option.

You should frequently observe the condition of the landscape to identify potential problems with sprinkler system performance. Occasional irrigations may be added under unusually hot conditions. Rain storms or prolonged cool periods could delay or postpone an irrigation.

Remember, if there are dry spots, check the sprinklers first to be sure they are operating correctly and applying water evenly. Next, check for soil or disease problems. Don't just automatically increase the sprinkler run time to apply more water.

CHAPTER 2 - EVALUATING SPRINKLER PERFORMANCE

Introduction

Not all sprinklers apply the same amount of water in the same amount of time nor do they perform with the same level of efficiency. It is, therefore, essential to determine how much water is being applied and how evenly the sprinkler system is applying water. The uniformity of water application is expressed by a factor called “distribution uniformity” (DU). The DU can help identify and resolve problems that reduce a sprinkler system’s operating efficiency. The application rate, also called the precipitation rate, is defined as the depth of water that can be applied in one hour (in/hr). The application rate is essential for setting the sprinkler system’s controller to apply the proper amount of water each irrigation event. The sprinkler performance evaluation process for determining these two parameters is described below.

Equipment Required

Ten to 20 small containers, a watch, a ruler, a pocket calculator, a writing pad, and pencil are the only items required. The containers can be any straight-walled container like soup or vegetable cans, open-topped milk cartons, rain gauges or similar devices, or performance evaluation cups² designed by Reclamation (see Figure 1). These are preferred because they provide direct readout of the application amount, minimizes the required computations, and shortens run times while wasting less water. Tuna fish cans are not recommended. They can produce inaccurate results because they are shallow and can lose water due to splashing.



Figure 1.
Suitable test containers

Layout Containers

Containers are placed in a grid on the turf so that they catch a good representation of the sprinkler system output. Containers placed at the mid-points between the sprinkler heads seem to work well. Any containers placed near sprinkler heads should be at least four feet away from the head. When using more than four containers, a minimum of two containers should catch the output from each sprinkler head. Make a sketch of the layout showing the location of the sprinkler heads and containers. This will help locate any problem sprinkler heads after the test has been run. To save time, the location of the sprinkler heads may be plotted on the layout sketch while the sprinklers are operating (see Figure 2).

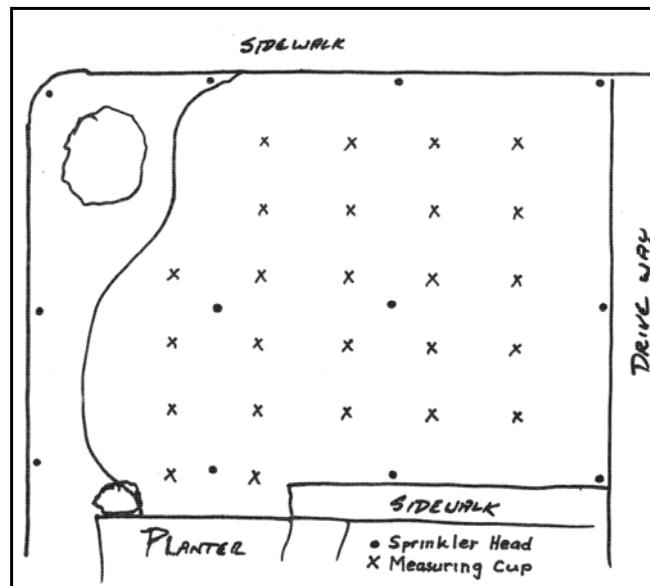


Figure 2
Sample Layout Sketch

²Performance Evaluation Cups are available from local Utah State University Extension Offices.

Operate the Sprinkler System

Once the containers are placed and noted on the layout sketch, the sprinkler system is turned on for a specific time period. Low output sprinklers like gear drive or impact sprinklers may require 30 minutes or more to collect a measurable amount of water in the containers. High output spray heads may only require about 10 minutes. Operating time can be reduced to about 6 minutes for high-output spray heads and 12 minutes for low-output spray heads when using the performance evaluation cups. These cups improve the resolution of the graduated scale. You should be aware if the area being evaluated is irrigated by two, overlapping sprinklers that run at different times. If this is the case, both sprinklers should be run for the same amount of time before checking the containers. After the sprinkler has run for the desired amount of time, either measure the amount of water in each container or read it directly from the performance evaluation cups and record the measurements on the layout sketch. A blank computation form, found in Appendix A, is provided for recording the reading and making the necessary computations.



Figure 3
Performance Evaluation in Progress

Compute the Distribution Uniformity (DU)

The DU is a measure of how uniform or evenly the sprinkler heads apply water. The DU would be 1.0 in a system where the sprinklers apply exactly the same amount of water to all parts of the turf area—a situation that probably never occurs. If the DU is 0.5, for instance, some areas of the turf are receiving twice as much water as other areas. In this situation, either some areas of the turf would be over watered or brown spots would develop where areas of the turf did not receive enough water.

Add all of the measurements and divide the total by the number of containers to determine the average depth of water in each container.

$$\text{Average depth of water in inches (AVG)} = \frac{\text{Cup1} + \text{Cup2} + \text{Cup3} + \dots}{\text{Total Number of cups}}$$

Now, identify the “lowest quarter” readings. If you placed 12 containers, these would be the 3 lowest readings. Add up the readings for the lowest quarter and divide by the number of readings to obtain the lowest quarter average depth.

$$\text{Lowest Quarter Average depth of water in inches (LQA)} = \frac{\text{LQCup1} + \text{LQCup2} + \text{LQCup3} + \dots}{\text{Number of lowest readings}}$$

Determine the DU by dividing the lowest quarter average depth (LQA) by the average depth (AVG) for all containers.

$$\text{DU} = \frac{\text{LQA}}{\text{AVG}}$$

A DU of .65 to .70 is acceptable. A DU of less than about .65 indicates that there may be problems with the sprinklers or sprinkler layout. Examine the numbers recorded on the layout sketch and locate the numbers that are considerably higher or lower than the average depth of application you computed. The sprinklers closest to the abnormally high or low readings should be checked. Does the offending sprinkler(s) appear to be working properly or does it appear to be clogged or improperly spaced? Can the sprinkler be adjusted to produce more or less water? Can the nozzle be changed to a larger or smaller size? Is the sprinkler the same type or manufacture as surrounding sprinklers? Chapter 6 gives some additional suggestions for tuning up the sprinkler system. You should try to clean or adjust sprinklers,

change nozzles, or replace or move sprinklers to improve the DU of the system.

Once you have tuned up the sprinkler system, empty all of the containers and re-run the test for the same amount of time as you ran it initially. Record the new measurements on the layout sheet. Re-calculate the overall average application depth, the lowest quarter average application depth, the DU, and the application rate to see what improvement has been made in the system uniformity. If the new DU is within acceptable limits, you are done tuning up the sprinkler system. If not, you may need to try to make additional repairs or adjustments to the system if they can be done with reasonable effort and cost. It is important that the sprinkler system be as efficient as possible at this time, otherwise, it will continue to waste water.

Compute the Application Rate

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:

$$\text{Application Rate} = \frac{\text{AVG}}{\text{Sprinkler run time in minutes}} \times 60 \text{ minutes/hour}$$

The computed application rate could range from as low as 0.2-inches/hour for low output gear drive sprinklers to as high as 4.0-inches/hour for high output brass spray heads.

Considerations for Manually-moved Hose and Sprinkler

Procedures for evaluating a manually-moved hose and sprinkler are very similar to those described above. Containers are placed on the area to be evaluated following the previous suggestions. The sprinkler is set where it would normally be placed during a typical irrigation and is run for a short period of time; possibly 5, 10, or 15 minutes depending upon the output of the sprinkler. The sprinkler is then moved to each position in the normal irrigation pattern and run again for the same length of time. The containers are left in place undisturbed until the entire irrigation pattern has been completed. The location of each container and each sprinkler set should be noted on the layout sketch. After the sprinkler has been run at each location in the normal irrigation pattern, the containers are read. The average depth of application, the application rate, the lowest quarter average depth of application, and DU are calculated as described above.

A DU of about .65 to .70 or higher suggests that the normal irrigation pattern is acceptable. If the DU is lower, consider altering the irrigation pattern or trying other types of sprinklers. If the irrigation pattern is altered or a different sprinkler is selected, empty the containers and repeat the test.

Example 1 - Performance Evaluation: Twenty five containers are placed in a grid on the turf so that they catch a good representation of the sprinkler system output. Figure 2 shows a sketch of the layout showing the location of the sprinkler heads and containers. The system was run for 6 minutes. Figure 4 shows the readings plotted on the layout sketch. Figure 5 shows the calculations made to determine the DU and application rate.

The DU = **.41**

The application rate = **1.96-inch/hour**.

The DU of .41 indicates that there are some problems with the sprinklers. The low readings in the upper left portion of the layout sketch suggest which sprinklers could be causing problems. An examination of the sprinklers identified the problems which were subsequently repaired. The cups were emptied and the test repeated for 6 minutes. Figure 6 shows the readings from both the first and second tests. Note that the low readings have increased. Figure 7 shows the calculations made to determine the DU and application rate.

The DU = **.85**

The application rate = **2.27-inch/hour**.

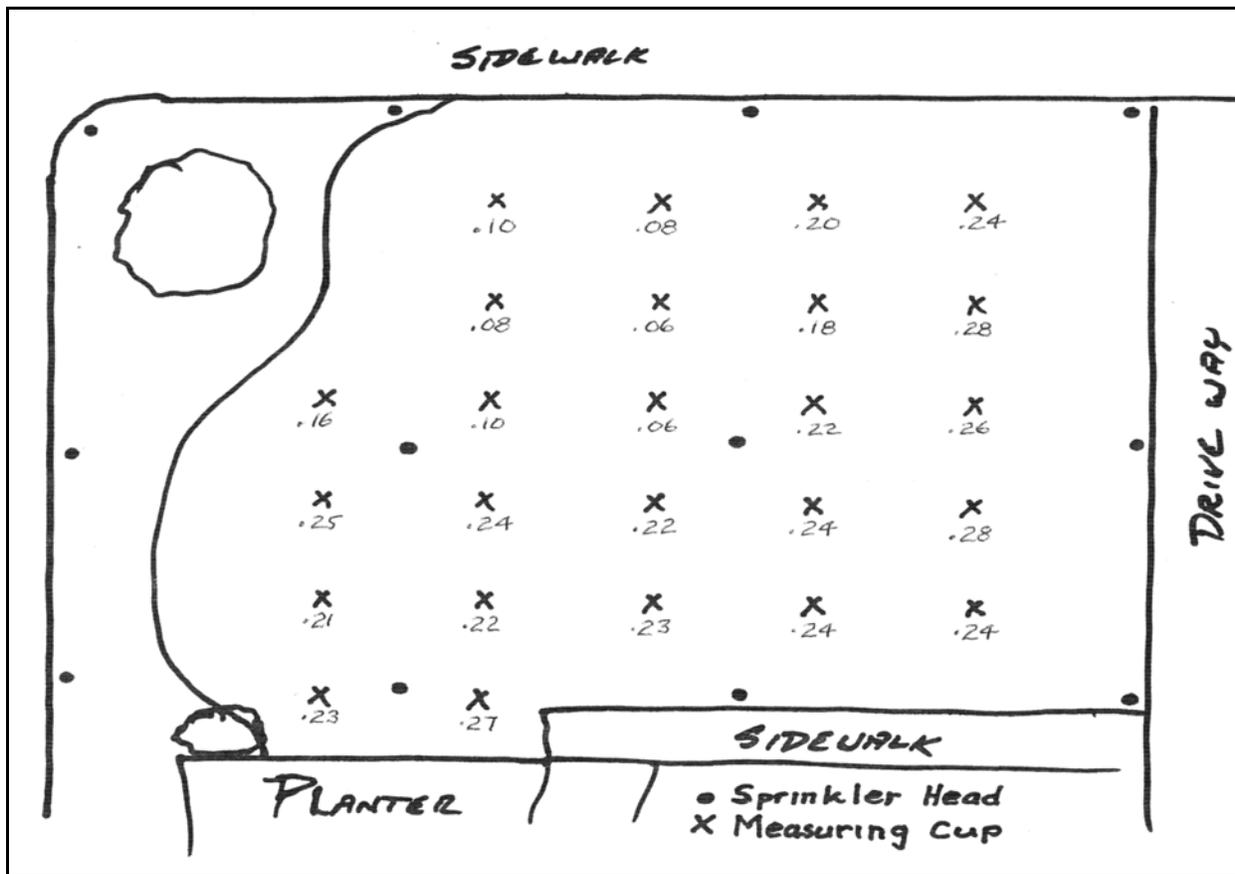


Figure 4
Catch Cup Readings Recorded on the Layout Sketch

Figure 5
Landscape Irrigation Simplified
Performance Evaluation Worksheet

Location (front yard, side yard, back yard, etc.): Front Yard - 1st Run

Run time (minutes) [a]: 6 minutes Number of containers or readings [b]: 25

Compute Distribution Uniformity

Container Readings
(arranged smallest to
largest)

1. .06

2. .06

3. .08

4. .08

5. .10

6. .10

7. .16

8. .18

9. .20

10. .21

11. .22

12. .22

13. .22

14. .23

15. .23

16. .24

17. .24

18. .24

Instructions: Transfer information in blanks to appropriate boxes.

$$\text{Average depth (inches)[d]} = \frac{\text{Total, all readings[c]}}{\text{Total Number of readings[b]}} = \frac{[c] \boxed{4.91}}{[b] \boxed{25}} = [d] \underline{.196} \text{ in.}$$

$$\text{Lowest Quarter[e]} = \frac{\text{Number of readings[b]}}{4} = \frac{[b] \boxed{25}}{4} = [e] \underline{6.25 \text{ or } 6} \text{ readings}$$

Add up the first [e] readings in the column and enter the number here [f]

$$\text{Lowest Quarter Average[g]} = \frac{\text{Total, lowest quarter[f]}}{\text{Lowest quarter Number[e]}} = \frac{[f] \boxed{0.48 \text{ in.}}}{[e] \boxed{6}} = [g] \underline{0.08} \text{ in.}$$

$$\text{Distribution Uniformity[h]} = \frac{\text{Lowest Quarter Average[g]}}{\text{Average depth[d]}} = \frac{[g] \boxed{0.08 \text{ in.}}}{[d] \boxed{.196 \text{ in.}}} = [h] \underline{.41}$$

Compute Application Rate

$$\text{Application Rate[i]} = \frac{\text{Average depth (inches)[d]} \times 60 \text{ minutes/hour}}{\text{Sprinkler run time (minutes)[a]}}$$

$$\text{Application Rate[i]} = \frac{[d] \boxed{.196} \times 60 \text{ minutes/hour}}{[a] \boxed{6 \text{ min.}}} = [i] \underline{1.96} \text{ in./hr.}$$

Amount to Apply Each Irrigation

	<u>If your soil is</u>	<u>and your root depth is</u>	<u>apply this amount of water</u>
19. <u>.24</u>	Sand	< 6 inches	1/2 inch
20. <u>.25</u>	Sand	6 to 10 inches	3/4 inch
21. <u>.26</u>	Sand	> 10 inches	1 inch¹
22. <u>.26</u>	Silt	< 4 inches	1/2 inch
23. <u>.27</u>	Silt	4 to 8 inches	3/4 inch
23. <u>.27</u>	Silt	> 8 inches	1 inch¹
24. <u>.28</u>	Clay	< 3 inches	1/2 inch
25. <u>.28</u>	Clay	3 to 6 inches	3/4 inch
25. <u>.28</u>	Clay	> 6 inches	1 inch¹

Total [c] 4.91

¹Preferred or normal application amount

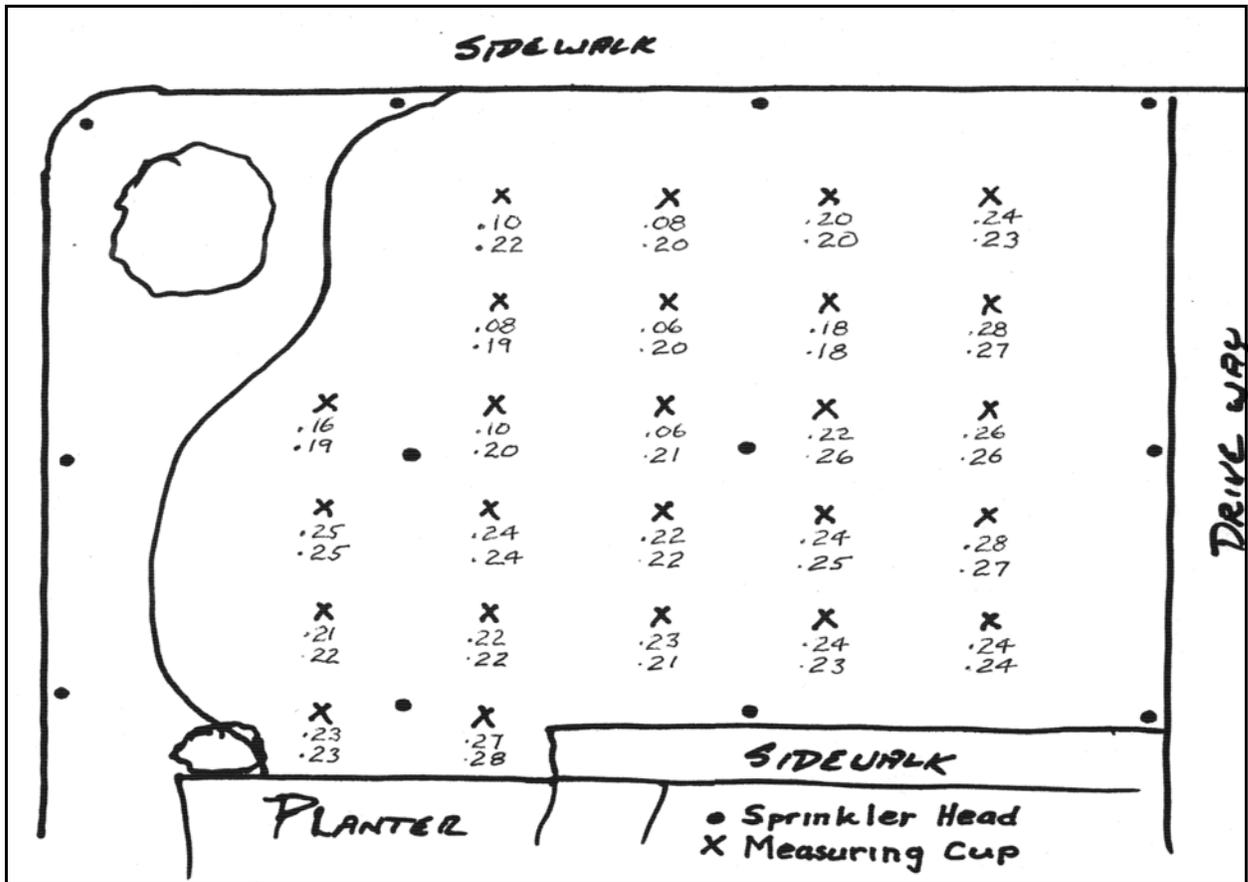


Figure 6
Catch Cup Readings from the First and Second Runs Recorded on the Layout Sketch

Figure 7
Landscape Irrigation Simplified
Performance Evaluation Worksheet

Location (front yard, side yard, back yard, etc.): Front Yard - 2nd Run

Run time (minutes) [a]: 6 minutes Number of containers or readings [b]: 25

Compute Distribution Uniformity

Container Readings
(arranged smallest to largest)

1. .18

2. .19

3. .19

4. .20

5. .20

6. .20

7. .20

8. .21

9. .21

10. .22

11. .22

12. .22

13. .22

14. .23

15. .23

16. .23

17. .24

18. .24

Instructions: Transfer information in blanks to appropriate boxes.

$$\text{Average depth (inches)[d]} = \frac{\text{Total, all readings[c]}}{\text{Total Number of readings[b]}} = \frac{[c] \text{ } \boxed{5.67}}{[b] \text{ } \boxed{25}} = [d] \text{ } \underline{.227 \text{ in.}}$$

$$\text{Lowest Quarter[e]} = \frac{\text{Number of readings[b]}}{4} = \frac{[b] \text{ } \boxed{25}}{4} = [e] \text{ } \underline{6.25 \text{ or } 6 \text{ readings}}$$

Add up the first [e] readings in the column and enter the number here [f]

$$\text{Lowest Quarter Average[g]} = \frac{\text{Total, lowest quarter[f]}}{\text{Lowest quarter Number[e]}} = \frac{[f] \text{ } \boxed{1.16 \text{ in.}}}{[e] \text{ } \boxed{6}} = [g] \text{ } \underline{.193 \text{ in.}}$$

$$\text{Distribution Uniformity[h]} = \frac{\text{Lowest Quarter Average[g]}}{\text{Average depth[d]}} = \frac{[g] \text{ } \boxed{.193 \text{ in.}}}{[d] \text{ } \boxed{.227 \text{ in.}}} = [h] \text{ } \underline{.85}$$

Compute Application Rate

$$\text{Application Rate[i]} = \frac{\text{Average depth (inches)[d]} \times 60 \text{ minutes/hour}}{\text{Sprinkler run time (minutes)[a]}}$$

$$\text{Application Rate[i]} = \frac{[d] \text{ } \boxed{.227} \times 60 \text{ minutes/hour}}{[a] \text{ } \boxed{6 \text{ min.}}} = [i] \text{ } \underline{2.27 \text{ in./hr.}}$$

Amount to Apply Each Irrigation

	<u>If your soil is</u>	<u>and your root depth is</u>	<u>apply this amount of water</u>
19. <u>.25</u>	Sand	< 6 inches	1/2 inch
20. <u>.25</u>	Sand	6 to 10 inches	3/4 inch
21. <u>.26</u>	Sand	> 10 inches	1 inch¹
22. <u>.26</u>	Silt	< 4 inches	1/2 inch
23. <u>.27</u>	Silt	4 to 8 inches	3/4 inch
23. <u>.27</u>	Silt	> 8 inches	1 inch¹
24. <u>.27</u>	Clay	< 3 inches	1/2 inch
25. <u>.28</u>	Clay	3 to 6 inches	3/4 inch
25. <u>.28</u>	Clay	> 6 inches	1 inch¹

Total [c] 5.67

¹Preferred or normal application amount

The system is now functioning properly. An application rate of about 2.3-inch/hour should be used for programming or setting the sprinkler controller.

Homeowners Shortcut

The Homeowners Shortcut uses a very simple performance test based upon observation, not mathematics. To check the distribution pattern, you will need at least 4 containers like those described above.

A) Place the 4 or more containers in a grid pattern over the lawn area to be checked.

B) Run your sprinklers for a period of time (at least 10 minutes) over the lawn. If you have overlapping sprinklers that run at different times, run both sets of sprinklers. Check each container and see if the amount of water in each is about the same. Make a note of those containers (areas) that have more or less water than average.

Try the following suggestions to apply water more evenly:

- Set the sprinklers to run for longer or shorter periods of time if they are on different valves.
- Check and repair clogged, damaged, or broken sprinkler heads. Also look for sprinklers that may be set into the ground too deeply or tilted. Sprinklers should be vertical and should not be obstructed by surrounding grass, plants, or other objects.
- Sprinklers running on the same line or valve should be the same model and have the right nozzle to cover the desired area.

C) After making adjustments, empty the containers and try the test again. Continue to make adjustments and run the test until the system is applying water as evenly as possible.

CHAPTER 3 - SETTING SPRINKLER CONTROLLER RUN TIMES

Introduction

Most experts now recommend applying more water less frequently instead of the short-duration, frequent irrigations that are so common. This improves plant vigor and improves the efficiency of the irrigation. ***The preferred application is 1.0 inch each irrigation event, applied between the hours of 6:00 p.m. and 9:00 a.m. to avoid the heat of the day when evaporation is the greatest.*** Avoiding irrigations during the heat of the day is more difficult with a manually-moved hose and sprinkler because of the time required to repeatedly move the sprinkler. Even so, every effort should be made to avoid irrigating during the hottest part of the day. Some communities may prohibit irrigating during the heat of the day.

The amount of water applied during an irrigation event is dependent upon the application rate and the run time. ***Where infiltration rates are low, multiple run cycles may be required to avoid excessive runoff.*** Multiple run cycles should be separated by soak cycles lasting about an hour each. The run-time settings on the controller are critical to achieve efficient landscape irrigation applications. The following discussion explains how to set the run time.

Choosing the Amount to Apply

The amount to apply is generally governed by the depth of the roots (existing or target depth) and the water holding capacity of the soil. Under normal growing conditions, turf root systems will be deeper in sandy soils than in clay soils, partly because there is less oxygen at depth in clay soils than in sandy soils. The root systems will be about 6 inches deep in clay soils, about 9 inches deep in silty soils, and about 12 inches deep in sandy soils. In some instances, roots may be found deeper. More frequently, less than ideal conditions will cause shallower root systems.

Use 1.0-in per application or best judgement. One inch will usually fill the normal turf root zone. It will penetrate about 6 inches in clay soils, 9 inches in silty soils, and 12 inches in sandy soils. Where the turf has been irrigated frequently with short-duration irrigations, the plants may not have an established root system or adequate plant vigor to withstand the change to less-frequent irrigations. In this case, it would be preferable to start with 0.5-inch applications repeated at more frequent intervals. After a few weeks, the applications could be increased to 0.75-inch per irrigation event and then later increased to 1.0-inch per irrigation event and the irrigation schedules are adjusted accordingly. This approach would also be appropriate for recently seeded turf or annual plantings. Some sandy soils have a very low holding capacity. The lower application amounts (0.5-inch or 0.75-inch) would be appropriate for these soils as well. Application amounts of 0.5-inch, 0.75-inch, and 1.0-inch work best when the average high temperatures are 90° - 100° F. If there are 25 or more days above 100° F each year (like St. George, UT), application amounts of 0.6-inch or 0.9-inch, etc. per irrigation event will produce greater efficiencies.

There may be some instances when you want to tailor the amount to apply to the existing or target root depth and the holding capacity of the soil. Use a soil probe or shovel to determine the depth of the existing root system. You should consider using the normal root depths discussed above if the existing roots are shallower than normal and there are no abrupt soil changes or other conditions that would limit root depth.

If the soil type is known, you can determine the amount to apply by multiplying the root depth (in inches) by the available moisture shown below. Table 6 shows a more detailed list of soil types.

<u>Soil Type Group</u>	<u>Available Moisture (inches per inch of depth)</u>
Coarse, sandy soils	0.084
Medium, silty soils	0.125
Fine, clay soils	0.167

For a 6-inch root zone in a fine, clay soil, the amount to apply would be 6-inch x 0.167 = 1.002-inch or 1.0-inch.

The amount to apply can still be determined if the soil type is unknown by using a simple infiltration test. You will apply a known amount of water to a soil sample to determine how deep the water penetrates. You will need a 10- to 12-inch. deep container with parallel sides and a wide top. The container should be transparent

or translucent so that you can observe how deep the water soaks into the sample. Smaller diameter containers will require less soil to fill the container.

First, prepare some measured volumes of water for the test. Fill the container with two or three inches of water. Mark the water level on the side of the container. Measure down from the mark 0.5-inch and place another mark. Pour the marked amount of water into a small cup. This represents 0.5-inch of water. Now, measure down from the lower mark 0.25-inch. Pour this marked amount of water into another small cup. This represents 0.25-inch of water. Repeat the process by measuring down from the lowest mark another 0.25-inch. You should have one cup representing a 0.5-inch application and two cups representing 0.25-inch applications. Empty the remaining water from the container.

Add about one inch of soil to the container and tamp it firmly. Add another inch of soil and tamp it. Continue adding and tamping soil until the container is filled to about one inch from the top.

Carefully pour the contents of the small container representing a 0.5-inch application on top of the compacted soil. Note the time that the water is added. It could take from one-half hour to several hours for the water to soak in. When the water has completely soaked into the soil, note the time and observe how deep the water has penetrated. If the water has not penetrated to the desired root depth, additional water will be required. Carefully pour the contents of the container representing a 0.25-inch application onto the soil and note the time. You have now applied a total of 0.75-inch of water. Again, check the depth the water has soaked into the soil and record the time as soon as the water is completely soaked in. If water has not soaked to the desired depth, add the next 0.25-inch of water. A total of 1.0-inch of water has now been applied. Record the time when this last increment of water completely soaks in and observe how deep the water has soaked. This should be close to the desired root depth. If it is not, estimate how much water would be required to get to the desired depth and add this to the amount already applied. The total will be the application amount that will be used to set the controller.

Compute the infiltration rate. Divide the total amount of water added to the container by the time (in hours) required to completely soak in. For example, it took about 5.5 hours for a total of 1.0-inch of water to completely soak in. The infiltration rate is 1.0-inch / 5.5-hours = 0.18-inch/hour. The infiltration rate can suggest a representative soil type. Below is a list of ranges of infiltration rates for representative soil types. From the list, an infiltration rate of 0.18-inch/hour would be representative of fine, clay soil.

<u>Infiltration Rate (in/hr) Range</u>	<u>Representative Soil Type</u>
0.10 - 0.35	Fine, clay soil
0.35 - 0.75	Medium, silty soil
0.75 - 1.00	Coarse, sandy soil

Determining Controller Settings

The settings used to program the controller will determine the amount of water that will be applied each time an irrigation event occurs. These settings can be determined different ways.

First, tables are provided for use in determining controller settings for a range of application rates and soil type groups. Two tables are provided—one for application amounts of 0.50-inch, 0.75-inch, and 1.00-inch and another for 0.60-inch and 0.90-inch applications.

Table 1a will help you determine the required number of run cycles and run times. Table 1a shows the cycle run times for the three soil type groups and applications of .5-, .75-, and 1.0-inch of water under each soil group. Cycle run times have been computed for a large range of application rates. Table 1b shows similar information for application amounts of 0.6-inch and 0.9-inch.

To use the tables, identify your particular soil type group (or use clay soil as the default option) and locate the desired application amount (e.g., .5-, .75-, or 1.0-inch applications) for the landscape. Now locate the application rate in the left column of the table. The application rate was determined as part of the sprinkler performance evaluation. Follow the row across the table until it intersects with the columns containing the desired application amount and soil type group. The first number shown at the intersection of the row and column is the number of run cycles required and the second number is the number of minutes that should be set as the cycle run time on the controller. Follow the controller manufacturer's instructions for setting the number of cycles and run times. These settings should not change except for minor adjustments to fine-tune

Table 1a
Sprinkler Controller Settings Required to Apply 0.5, 0.75, or 1-inch of Water

Application Rate (in/hr)	Number of Run Cycles and Run Times Per Cycle in Minutes Required for Each Irrigation Event																	
	Coarse Sandy Soils						Medium Silty Soils						Fine Clay Soils					
	.5 Inch Application		.75 Inch Application		1.0 Inch Application)		.5 Inch Application		.75 Inch Application		1.0 Inch Application		.5 Inch Application		.75 Inch Application		1.0 Inch Application	
	No. run cycles	Min. per cycle	No. run cycles	Min. per cycle	No. run cycles	Min. per cycle	No. run cycles	Min. per cycle	No. run cycles	Min. per cycle	No. run cycles	Min. per cycle	No. run cycles	Min. per cycle	No. run cycles	Min. per cycle	No. run cycles	Min. per cycle
0.20	1	150	1	225	1	300	1	150	2	113	2	150	3	50	4	56	5	60
0.30	1	100	1	150	1	200	1	100	2	75	2	100	3	33	4	38	5	40
0.40	1	75	1	113	1	150	1	75	2	56	2	75	3	25	4	28	5	30
0.50	1	60	1	90	1	120	1	60	2	45	2	60	3	20	4	23	5	24
0.60	1	50	1	75	1	100	1	50	2	38	2	50	3	17	4	19	5	20
0.70	1	43	1	64	1	86	1	43	2	32	2	43	3	14	4	16	5	17
0.80	1	38	1	56	1	75	1	38	2	28	2	38	3	13	4	14	5	15
0.90	1	33	1	50	1	67	1	33	2	25	2	33	3	11	4	12	5	13
1.00	1	30	1	45	1	60	1	30	2	23	2	30	3	10	4	11	5	12
1.20	1	25	1	38	1	50	1	25	2	19	2	25	3	8	4	9	5	10
1.50	1	20	1	30	1	40	1	20	2	15	2	20	3	7	4	8	5	8
1.70	1	18	1	26	1	35	1	18	2	13	2	18	3	6	4	7	5	7
2.00	1	15	1	23	1	30	1	15	2	11	2	15	3	5	4	6	5	6
2.50	1	12	1	18	1	24	1	12	2	9	2	12	3	4	4	5	5	5
3.00	1	10	1	15	1	20	1	10	2	8	2	10	3	3	4	4	5	4
4.00	1	8	1	11	1	15	1	8	2	6	2	8	3	3	4	3	5	3

Table 1b
Sprinkler Controller Settings Required to Apply 0.6 or 0.9-inch of Water

Application Rate (in/hr)	Number of Run Cycles and Run Times Per Cycle in Minutes Required for Each Irrigation Event											
	Coarse Sandy Soils				Medium Silty Soils				Fine Clay Soils			
	0.6 Inch Application		0.9 Inch Application)		0.6 Inch Application		0.9 Inch Application		0.6 Inch Application		0.9 Inch Application	
	No. run cycles	Min. per cycle	No. run cycles	Min. per cycle	No. run cycles	Min. per cycle	No. run cycles	Min. per cycle	No. run cycles	Min. per cycle	No. run cycles	Min. per cycle
0.20	1	180	1	270	2	90	2	135	3	60	5	54
0.30	1	120	1	180	2	60	2	90	3	40	5	36
0.40	1	90	1	135	2	45	2	68	3	30	5	27
0.50	1	72	1	108	2	36	2	54	3	24	5	22
0.60	1	60	1	90	2	30	2	45	3	20	5	18
0.70	1	51	1	77	2	26	2	39	3	17	5	15
0.80	1	45	1	68	2	22	2	34	3	15	5	14
0.90	1	40	1	60	2	20	2	30	3	13	5	12
1.00	1	36	1	54	2	18	2	27	3	12	5	11
1.20	1	30	1	45	2	15	2	23	3	10	5	9
1.50	1	24	1	36	2	12	2	18	3	8	5	7
1.70	1	21	1	32	2	11	2	16	3	7	5	6
2.00	1	18	1	27	2	9	2	14	3	6	5	5
2.50	1	14	1	22	2	7	2	11	3	5	5	4
3.00	1	12	1	18	2	6	2	9	3	4	5	4
4.00	1	9	1	14	2	5	2	7	3	3	5	3

the system for peak performance.

Example 2: The sprinkler performance evaluation shows the system has an application rate of 0.7-inch/hour. It is irrigating a medium, silty soil. The desired application amount chosen for the landscape is 1.0-inch of water each application. On Table 1a, locate the application rate of .70-inch/hour. Read across the table to the 1.0-inch application under medium, silty soils. The first number indicates that 2 run cycles will be required. The second number indicates that the run time for each run cycle will be 43 minutes. Remember to program in a soak cycle of about 1 hour between each run cycle to ensure water is going into the soil and not running off.

There may be some instances when Tables 1a and 1b do not fit local situations. The following discussion explains a process for customizing the controller settings. To use this method you must know the application rate of the sprinkler system, the desired application amount for each irrigation event, and the infiltration rate of the soil.

Example 3: The sprinkler's application rate is 0.9-inch/hour and the sprinkler system is intended to apply 1.0-inch per irrigation event. The soil infiltration rate has been determined to be 0.75-inch/hour. This is just midway between the infiltration rates of medium, silty soils and coarse, sandy soils.

Number of cycles = application rate ÷ infiltration rate

Number of cycles = 0.90-inch/hour ÷ 0.75-inch/hour = 1.2 cycles. 1.2 is greater than 1 so use 2 cycles.

Total run time = (application amount ÷ application rate) x 60 minutes/hour

Total run time = (1.0-inch ÷ 0.9 inch/hour) x 60 minutes/hour = 66.67 minutes

Cycle run time = total run time ÷ number of cycles

Cycle run time = 66.67 minutes ÷ 2 cycles = 33.33 minutes/cycle. Use 33 or 34 minutes per cycle.

Resolving Runoff Problems

One case requiring fine tuning would occur if runoff is noted before the run cycle finishes. Record the elapsed time from when the cycle begins to when runoff is first noted and reduce the elapsed time by 3 minutes. This is the maximum cycle time that will avoid runoff. Now that the cycle time has been shortened, you will need to provide additional cycles. Determine the total run time by multiplying the number of cycles shown in Tables 1a and 1b by the minutes per cycle. Now divide the total run time by the shortened cycle time and round the result up to the next whole number. This will be the new number of cycles required. To determine the new run time, divide the total run time by the new number of cycles. Reprogram the controller with the new number of cycles and cycle run time.



Figure 8
Excessive Runoff

Example 4: Like the previous example, the sprinkler system has an application rate of 0.7-inch/hour, is irrigating a medium, silty soil, and applies 1.0-inch each irrigation event. According to Table 1a, this should require 2 run cycles with a duration of 43 minutes each. However, runoff is observed after the sprinklers have been running for about 35 minutes. To avoid runoff, the recommended run time is 32 minutes (35 minutes - 3 minutes).

Total run time of each irrigation is 2 cycles x 43 minutes/cycle = 86 minutes.

To determine the new number of cycles, use total run time ÷ recommended run time/cycle =
86 minutes ÷ 32 minutes/cycle = 2.7 cycles,
or rounded up to the next whole number = 3 run cycles.

The run time for each cycle = the total run time ÷ number of cycles =
86 minutes ÷ 3 cycles = 29 minutes/cycle.

Considerations for Manually-moved Sprinklers

For manually-moved sprinklers, follow the procedures described above to determine the cycle run time. To avoid either under- or over-irrigating, use a kitchen timer or alarm clock/watch to signal when to move the sprinkler. Set the timer for the cycle run time as soon as the water is turned on. The timer should be reset with the appropriate cycle run time each time the sprinkler is moved.

If runoff is a problem, the best strategy is to determine the number of run cycles and cycle run time as discussed above. If this strategy is too burdensome, consider a sprinkler with a lower application rate.

Homeowners Shortcut

Most areas of Utah have average high temperatures of 90° - 100° F. The suggested irrigation application is ½ inch of water each irrigation. Where there are 25 or more days above 100° F each year (e.g., St. George, Ut.), ⅝ inch irrigation applications are suggested.

A) In your 4 containers, measure and mark the appropriate depth as suggested above. Note that the ½ inch line on the special water measuring cups is just above the measured markings on the side. The ⅝ mark is at the bottom of the “MADE IN USA” label.

B) Turn on your sprinklers and time how long it takes for water to reach the marks in each container. With overlapping sets of sprinklers, split the run time equally between both sets of sprinklers. Figure the average run time for all containers.

C) If you see water running off your lawn, three or more soak cycles are recommended. Irrigate for three or more cycles allowing 1-hour in between each cycle. This will prevent water from running off the lawn.

Example 5: If your sprinklers take 21 minutes to apply ½ inch of water, you would use three 7-minute cycles (21 minutes ÷ 3 cycles). Run your sprinklers for 7 minutes each cycle and wait one hour in between each cycle.

CHAPTER 4- SCHEDULING IRRIGATION EVENTS

Introduction

The process for improving landscape irrigation efficiency is not complete until you understand how to schedule irrigation events. The attached graph in Figure 8 shows that daily turf water-use or evapotranspiration (ET) is the least in the spring and fall and the greatest in mid-July. As a result, the spacing between irrigation events will be the greatest in the spring, decrease to the shortest interval in mid-July, and increase again in the fall. This applies to both permanent sprinkler irrigation systems and manually-moved sprinklers. Using this information, preset irrigation schedules can be developed for the entire growing season. Another more accurate approach is to use the daily ET, which can be obtained from a variety of published sources. This, however, requires regular monitoring or the use of an ET controller. Procedures for scheduling irrigations with both the calendar method and the daily ET method are presented here. These methods require that a constant amount of water will be applied at each irrigation event. **Again, the preferred application is 1.0 inch for each irrigation event, applied between the hours of 6:00 p.m. and 9:00 a.m. to avoid the heat of the day when evaporation is the greatest.**

The long-term averages of daily ET have been used to develop optimum irrigation schedules. These schedules most closely match the day-to-day water needs of the turf. Table 2 shows a typical optimum irrigation schedule. The optimum irrigation schedule differs for various application amounts. In this case, Table 2 shows the optimum irrigation schedule for a 0.5-inch irrigation application. It shows the beginning and ending dates when each irrigation interval is applicable. Even though a 1.0-inch application is preferred, the table for the 0.5-inch application has been shown to save space. Table 2 shows about 24 intervals while the 1.0-inch irrigation schedule has about twice as many.

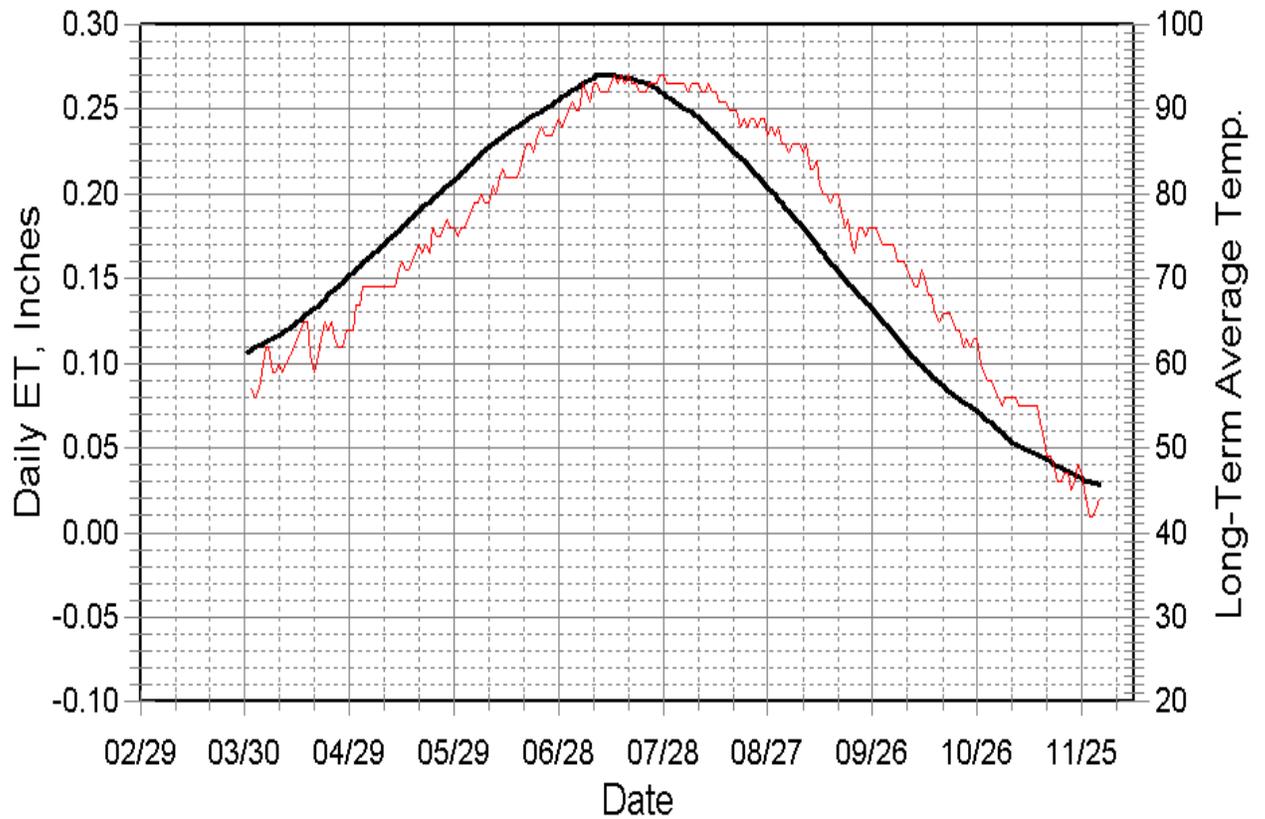
The optimum irrigation schedule is very complex with as many as 48 different intervals occurring throughout the irrigation season. This would be a very difficult schedule for most irrigation managers to use. The optimum irrigation schedule has been simplified into a more easily used monthly irrigation schedule. The simplification only sacrifices a small amount of efficiency. A typical monthly irrigation schedule is shown in Table 3. This table shows the irrigation interval that is appropriate for each month during the growing season. This table shows schedules for 0.5-inch, 0.75-inch, and 1.0-inch irrigation applications

Tables 2 and 3 are for typical situations. Appendix B contains optimum turf irrigation schedules for about 35 specific locations throughout the State of Utah. Appendix C contains monthly turf irrigation schedules for the same 35 locations. Tables for other locations outside of Utah are also being prepared.

The tables can be used for setting the proper irrigation interval on the controller. They can also be used to determine the number of days until the next irrigation event when starting the events manually. Procedures differ slightly for automated or manual operation. For automated operation, the tables indicate the dates to reset the controller for the next appropriate irrigation interval. For manual operation, the tables indicate the number of days that can elapse before the next required irrigation.

Table 2 Optimum Turf Irrigation Schedule 0.50" Application	
Date of Most Recent Irrigation	Days to Next Irrigation
04/01 - 04/02	10
04/03 - 04/07	9
04/08 - 04/13	8
04/14 - 04/20	7
04/21 - 04/29	6
04/30 - 05/12	5
05/13 - 06/04	4
06/05 - 08/09	3
08/10 - 08/29	4
08/30 - 09/09	5
09/10 - 09/16	6
09/17 - 09/20	7
09/21 - 09/24	8
09/25 - 09/28	9
09/29 - 09/30	10
10/01 - 10/03	11
10/04 - 10/05	12
10/06 - 10/06	13
10/07 - 10/08	14
10/09 - 10/11	15
10/12 - 10/14	16
10/15 - 10/23	17
10/24 - 10/31	18

Daily Turf ET & High Temperature Salt Lake City & Vicinity



— Daily ET — Daily High Temp.

Figure 9

Caution! The tables are based upon long-term (30-year) averages. Unusual warm conditions may require an occasional irrigation a day earlier than scheduled. Rain storms or cool periods may allow postponing or skipping an irrigation. Frequently check the condition of the landscape to be sure that the schedules reflect actual conditions.

Month	Irrigation Interval, Days between Irrigations		
	0.5-in. Appl.	0.75-in. Appl.	1.0-in. Appl.
April	6	9	12
May	4	6	8
June	3	4	6
July	3	4	6
August	3	5	6
September	6	9	12
October	10	15	20

Example 6: This example describes how to use Table 3 to determine the irrigation interval when manually operating the system. The system is applying 1.0-inch each irrigation event. The most recent irrigation occurred on June 15. For a 1.0-inch application, Table 3 shows that During June, the irrigation interval is 6 days. Thus, the next irrigation should occur on June 21 (June 15 + 6 days = June 21). Assuming that the irrigation occurred on June 21, the table shows that the irrigation interval to the next irrigation would be 6 days or the following irrigation would be due on June 27 (June 21 + 6 days = June 27).

There may be some cases when it would be desirable to use daily ET data rather than predetermined schedules to determine when to irrigate the landscape. First, daily ET data can be used as a real-time method for scheduling irrigation events based upon actual daily water use. This method is generally more precise than the predetermined schedules. Second, daily ET data can be used when the daily high temperature deviates significantly from normal and causes the preset schedules to become inaccurate.

In the **first case**, daily ET amounts are used to schedule irrigations. This is a “bookkeeping” process to track the amount of available moisture remaining at the end of the day. Daily ET values are often published in the media or can be obtained from various web sites. The bookkeeping process begins when an irrigation event occurs where a known amount of water is applied. Each day the daily ET is subtracted from the running balance of available moisture. When the running balance reaches zero, it is time to irrigate again.

Example 7: On June 10, a 1.0-inch irrigation was applied. On June 11, the daily ET was .13-inch so the running balance was .87-inch (See Figure 10). On June 12, the daily ET was .14-inch and the running balance was .73-inch. Then on June 13, the daily ET was .12-inch and the running balance was .61-inch. The process continues until June 17 when the running balance is not enough to satisfy another day’s ET. An irrigation should occur during the evening of June 17 or early morning on June 18. Following the irrigation, the running balance is 1.01-inch and the process continues.

In the **second case**, use of the preset irrigation schedule is temporarily suspended during periods when daily high temperatures are abnormally high or low. Procedures described in Example 7 are followed to schedule irrigations. When daily high temperatures return to near normal, the use of preset irrigation schedules can be resumed.

Be sure to monitor the condition of the landscape closely while following the recommended irrigation schedule. If dry spots persistently appear before the next scheduled irrigation, verify performance of the sprinkler system.

At this point, you are ready to more efficiently use precious water supplies.

Daily Water Use “Bookkeeping”

Application Amount = 1.0-inch per application

<u>Date</u>	<u>Daily ET</u>	<u>Balance</u>	<u>Notes</u>
6/10	+1.00	1.00	Irrigated at 9:00 pm
6/11	-0.13	0.87	
6/12	-0.14	0.73	
6/13	-0.12	0.61	
6/14	-0.16	0.45	
6/15	-0.14	0.31	
6/16	-0.15	0.16	
6/17	-0.15	0.01	
6/17	+1.00	1.01	Irrigated at 9:00 pm
6/18	-0.16	0.85	
6/19	-0.16	0.69	
6/20	-0.15	0.54	
6/21	+0.30	0.84	Rain, effective precipitation = 0.3-inch

Figure 10
Sample “Bookkeeping” Computations

Special Considerations for Odd- or Even-day Irrigation Restrictions

The preferred strategy for irrigating landscapes is to maintain a constant application from irrigation event to event while adjusting the interval between events to account for seasonal changes in daily ET or water requirement. However, some local ordinances limit the irrigation of landscapes to even-numbered or odd-numbered days. Under these conditions, the interval is based on a 2-day interval—every other day. This method is not recommended because it is neither horticulturally correct nor water efficient. However, here is a strategy to help you be as efficient as possible and still comply with the ordinance.

In this strategy, the recommended application is still 1.0-inch per irrigation event. You need to determine the preferred irrigation interval using one of the irrigation scheduling options to determine the preferred irrigation date. Choose the nearest mandated date to the preferred date. This could be either 1 day earlier or 1 day later than the preferred date. If the earlier date is chosen, some water will be wasted. The later date could result in some possible plant water stress. You will need to regularly observe the condition of the landscape to determine which choice is preferable. By following this procedure, you will not be as efficient as if there was complete control over the management of the landscape irrigations, but irrigation efficiencies can be improved considerably.

Example 8: Irrigations are limited to even-days only. The controller is set to apply 1.0-inch per irrigation event and the last irrigation occurred on June 10. By using one of the scheduling options, it was determined that the next preferred irrigation would be on June 15 but irrigations are only permitted on June 14 or 16. You must now choose when to irrigate, recognizing the potential for wasting water or experiencing some possible plant water stress.

Adjusting Irrigation Schedules for Rain

Rain storms, depending upon the amount of precipitation, can delay the need for irrigations. The effective precipitation may not be the total amount of precipitation. High rain-fall intensities coupled with low soil infiltration rates could significantly reduce the effective precipitation. The effective precipitation could be as low as the hourly infiltration rate of the soil multiplied by the duration in hours of the rainfall event.

To make adjustments for rainfall, the following conditions must be fulfilled. These conditions include:

1. Rainfall must be measured at or near the site.

2. The duration of the rainfall must be known.
3. An approximate estimate of the daily ET must be available.

The entire amount of rainfall may not be effective in meeting plant water needs. If the amount of the storm is less than .25-inch, the rain can be ignored. If there are signs of runoff, the effective precipitation will be less than the measured precipitation. To determine the effective precipitation, the intensity of the rainfall must be known (amount of rain in inches ÷ storm duration in hours). If the intensity is greater than the soil infiltration rate (.5-inch/hour for silty soils and .2-inch/hour for clay soils), the effective precipitation will be the soil infiltration rate multiplied by the duration of the storm in hours. The duration is the time when rainfall occurred.

Divide the amount of effective precipitation by the daily ET. This will be the number of days to postpone the next scheduled irrigation event. If this number is less than about 0.6 or 0.7, there probably was not enough effective rain to change the schedule. If the effective precipitation ÷ ET is greater than 0.7, round the number to the nearest whole number and add that to the original scheduled date to get the next irrigation date. The condition of the landscape should be checked frequently, especially the last few days before the next scheduled irrigation. Again, the full amount of the rain storm may not penetrate the root zone. The irrigation interval may not be as long as computed and the next irrigation could be required before it is expected.

Example 9: The preferred irrigation is scheduled for June 20. The reported daily ET is about .15-inch/day. On June 18, it rained .75-inch in 1.5 hours. The precipitation intensity is .75-inch / 1.5 hours or .5-inch/hour. The soil is a clay soil with an infiltration rate of .2-inch/hour. The precipitation intensity is greater than the soil infiltration rate. The effective precipitation, then, is the soil infiltration rate multiplied by the rainfall duration (.2-inch/hour X 1.5 hours) or .3 inches. Dividing .3-inch by .15-inch/day equals 2 days. The new irrigation date would be June 22 (June 20 + 2 days).

When using the **Daily ET** method for scheduling irrigations, effective precipitation is treated just like another irrigation. Figure 10 illustrates this using the effective precipitation shown in the above example.

Homeowners Shortcut

This approach uses the same calendar irrigation schedule shown above. Since each irrigation applies 1/2-inch (or 5/8-inch) only the table for the 1/2-inch (or 5/8-inch) application applies. This schedule is based upon average or normal weather conditions. Unusual warm conditions may require an occasional irrigation a day earlier than scheduled. Rain storms or cool periods may allow postponing or skipping an irrigation. Table 5 shows homeowner's irrigation schedules for about 35 locations in the State of Utah.

Table 4 Typical Monthly Irrigation Schedule for the Homeowner	
Month	Interval
Startup Until April 30	Once every 6 days
May	Once every 4 days
June	Once every 3 days
July	Once every 3 days
August	Once every 3 days
September	Once every 6 days
October 1 to Shutdown	Once every 10 days

Table 5
Homeowner's Irrigation Schedules for Selected Locations in the State of Utah

Location	Application inches	Irrigation Interval/Days between Irrigations								
		March	April	May	June	July	August	September	October	November
Beaver	1/2		5	4	3	3	3	5		
Blanding	1/2		5	4	3	3	4	5		
Box Elder	1/2		7	4	3	3	3	6	12	
Cache Valley	1/2		6	4	3	3	4	6	12	
Daggett County	1/2		6	4	3	3	3	5	11	
Davis County	1/2		6	4	3	3	3	5	9	
Duchesne County	1/2		6	4	3	3	4	5	10	
Emery County	1/2		6	4	3	3	3	4	7	
Enterprise	1/2		5	4	3	3	3	5	10	
Escalante	1/2	8	5	4	3	3	4	5	7	
Garfield	1/2		8	4	3	3	4	5		
Green River	1/2		5	4	3	3	3	4	7	
Hanksville	1/2		5	3	3	3	3	4	7	
Heber	1/2		7	4	3	3	4	5	10	
Iron County	1/2		5	4	3	3	3	4	7	
Juab County	1/2		6	4	3	3	3	6	10	
Kanab	1/2	8	5	3	3	3	4	5	7	
Milford	1/2		6	4	3	3	3	4	8	
Millard	1/2		5	4	3	3	3	5	9	
Moab	1/2	7	5	4	3	3	3	4	6	
Monticello	1/2		7	4	4	3	4	5	8	
Morgan	1/2		7	5	3	3	4	5	9	
Ogden	1/2		6	4	3	3	3	6	10	
Orderville	1/2		6	4	3	3	3	5		
Roosevelt	1/2		6	4	3	3	3	5	10	
Sanpete County	1/2		6	4	3	3	3	5	8	
Scipio	1/2		6	4	3	3	3	5	9	
Sevier County	1/2		6	4	3	3	3	5	9	
Salt Lake County	1/2		6	4	3	3	3	6	10	
St. George	5/8	8	5	4	3	3	3	5	7	10
Summit County	1/2		7	5	4	4	4	6		
Tooele	1/2	12	6	4	3	3	3	5	9	
Utah County	1/2		6	4	3	3	3	6	10	
Vernal	1/2	11	6	4	3	3	3	5	9	
Wendover	1/2	9	6	4	3	3	3	5	8	
State Composite	1/2	9	6	4	3	3	3	5	9	10

CHAPTER 5 - DETERMINING SOIL CHARACTERISTICS

Introduction

Some limited information on soil characteristics is necessary to properly manage a landscape irrigation program because the soil characteristics help determine how plants behave and how water is absorbed. Typical soils range from coarse, sandy soils to fine, clay soils with a wide range in between. Sandy soils allow for deeper root penetration and rapid infiltration of irrigation water. Finer, clay soils infiltrate water much slower, provide for less root penetration, and hold more water than the coarser soils. Three general groups of soils include:

- Coarse, sandy soils: Infiltration rate of a coarse soil is about 1.5-inches per hour. The available water is about .084-inches per inch of soil depth which means it can provide about 1-inch of water in 12-inches of soil.
- Medium, silty soils: Infiltration rate of a medium silty soil is about 0.5-inches per hour. The available water is about .125-inches per inch of soil which means it can provide about 1-inch of water in 8-inches of soil.
- Fine, clay soils: Infiltration rate of a fine soil is about 0.2-inches per hour. The available water is about 0.167-inches per inch of soil which means it can provide about 1-inch of water in 6-inches of soil.

There are several options for determining soil types. The quickest but least precise is the “feel method.” A more precise method involves the use of a soil triangle. The most precise method is to send the soil sample to a professional soils laboratory for analysis.

Determining Soil Characteristics

Default Soil Type: This option is for those who need a quick approach to starting an irrigation program. This should be considered “entry level” and the least precise approach. No testing or analysis is required. A soil type of fine, clay soil is assumed as a default. It is chosen as a default because it has the lowest infiltration rate of all soil types. A sprinkler system set to correctly apply water to a clay soil will be equally effective on other soil types.

Feel Method: The “feel method” can provide adequate information to properly program a sprinkler controller or manage a hand-moved sprinkler.

A small handful of soil is slowly moistened and kneaded in the hand until it appears wet. Use the descriptions below to determine which soil group most accurately describes your soil sample.

- Coarse, sandy soils: Forms a weak ball, leaves a light to heavy soil/water coating on the fingers, produces a wet outline of the soft ball on the hand when squeezed, and feels gritty when rubbed between the thumb and forefinger.
- Medium, silty soils: Forms a soft ball, free water appears briefly on soil surface after squeezing or shaking the ball, leaves a medium to heavy soil/water coating on fingers, and feels slick when rubbed between the thumb and forefinger.
- Fine, clay soils: Forms a soft ball, free water appears on soil after squeezing or shaking the ball, leaves a thick soil/water coating on fingers, and feels slick and sticky when rubbed between the thumb and forefinger.

Soil Gradation Analysis: A simple soil gradation analysis uses a jar and soil triangle to determine the soil type. It can provide a more refined estimate of the soil infiltration rate and available moisture than can the other methods.

This method requires a soil sample, a glass jar with water-tight lid, water, and a liquid dish detergent. The size of the soil sample depends upon the size of the glass jar. A quart mason jar will work and will require about 1 to 1-1/2 pints of soil. Smaller jars like the tall, skinny jars used to package some brands of olives will also work and will require much smaller soil samples.

The jar should be filled between 1/2 to 2/3 with loose soil. Large clumps of soil should be broken up by hand. Fill the jar to within about 1-inch of the top with water and add a few drops of liquid dish detergent. The detergent is added to help the soil particles disburse. Place the lid tightly on the jar and shake the jar vigorously for several minutes. Continue shaking the jar until all of the small clumps have broken up. Set the jar on a table top or other flat surface where the soil particles can settle. Let the jar sit undisturbed until the soil particles have settled—this may take a few hours.

When the soil particles have settled, measure the total height of the soil column in the jar. Likewise, measure the thickness of the sand, silt, and clay layers. The sand layer will be the layer of coarse particles at the bottom of the jar. The silt will be the layer of very fine particles on top of the sand layer. The clay will be the top layer in the soil column. Next, calculate the percentages of sand, silt, and clay in the jar.



Figure 11
Identification of Soil Components

Finally, use the soil triangle shown in Figure 12 to determine the soil type.

Locate the appropriate percentages of sand, silt, and clay and find the point where they intersect. The different soil types are shown in specific regions of the triangle. The example shown in Figure 11 contains 70 percent sand, 20 percent silt, and 10 percent clay. Using Figure 12, the intersection of these percentages indicates that the sample in the jar is a sandy loam soil.

This method provides a more precise method for determining soil types since it can identify one of 12 soil types whereas the feel method can only identify one of three general groups. From Table 6, coarse, sandy soils correspond with sand; medium, silty soils correspond to silty clay loam; and fine clay soils correspond to silty clay.

If you have difficulties determining your soil type, schedule your irrigations for a clay soil. This is the most limiting soil type but it can be used to schedule irrigations for all soil types.

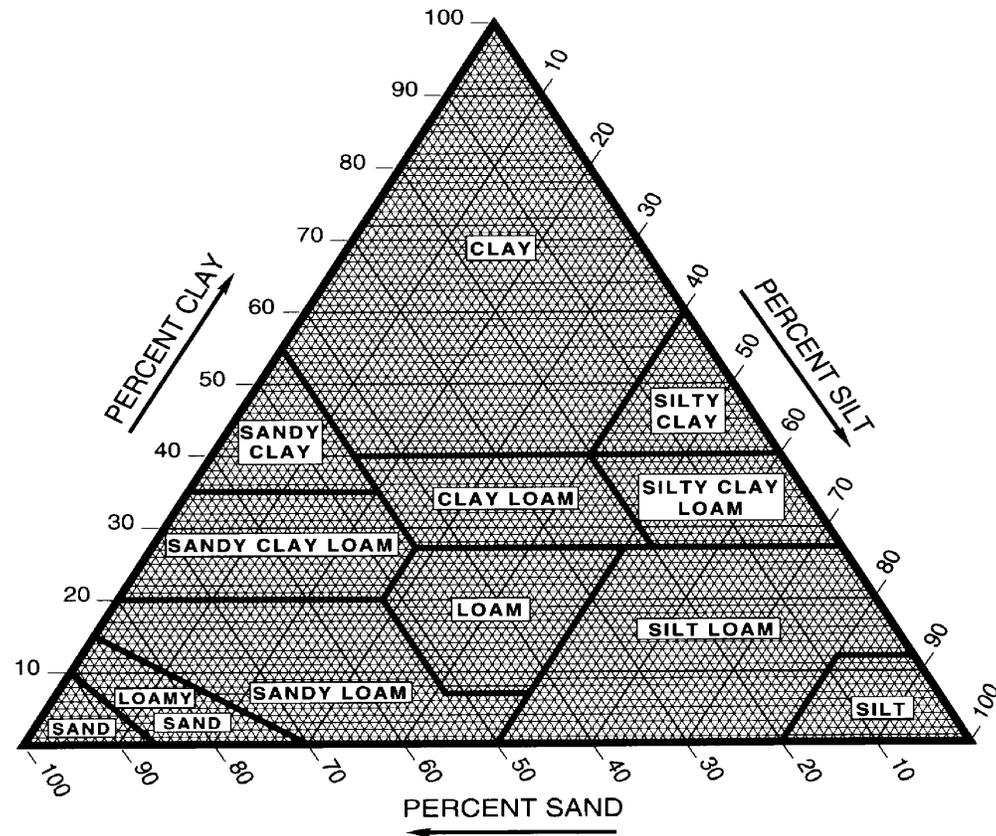


Figure 12 - Soil Textural Class

**Table 6
TYPICAL CHARACTERISTICS OF DIFFERENT SOILS**

Type of Soil	Infiltration Rate (in./hr.)	Available Water (in./in. of depth)
Coarse Sand	1.0 +	.01 - .03
Loamy Sand	0.4 - 1.5	.06 - .08
Sandy Loam	0.3 - 1.25	.11 - .13
Loam	0.5 - 0.7	.16 - .18
Silt and Silt Loam	0.5 - 0.7	.16 - .21
Sandy Clay Loam	0.1 - 0.5	.14 - .16
Silty Clay Loam	0.1 - 0.5	.14 - .16
Clay Loam	0.1 - 0.5	.19 - .21
Sandy Clay	0.1 - 0.4	.15 - .17
Silty Clay	0.1 - 0.2	.15 - .17
Clay	0.1 - 0.2	.14 - .16

Source: Part 652, Irrigation Guide; Natural Resources Conservation Service

CHAPTER 6 - TUNING UP THE SPRINKLER SYSTEM

A DU of 0.75 to 0.70 is acceptable. A DU of less than about 0.65 indicates that there may be problems with the sprinklers or sprinkler layout.

Examine the numbers recorded on the layout sketch and locate the numbers that are considerably higher or lower than the average depth of application you computed. The sprinklers and sprinkler layout closest to the abnormally high or low readings should be checked.

1. Does the offending sprinkler(s) appear to be working properly or does it appear to be clogged or improperly spaced?
Malfunctioning sprinklers have a huge impact on uniformity. Clean clogged heads, replace broken heads, or move heads to a uniform spacing.
2. Can the sprinkler be adjusted to produce more or less water?
Some heads have an adjustment screw to change the amount of water the sprinkler puts out, others have interchangeable spray nozzles.
3. Can the nozzle be changed to a larger or smaller size?
Nozzles should be sized to the amount of area covered by that particular sprinkler ie: a full head should put out twice as much water as a half head, and a half head should put out twice as much water as a quarter head.
4. Is the sprinkler the same type or manufacture as surrounding sprinklers?
Heads from different manufactures, even though the specifications may be similar, have different application rates.
5. You should try to clean or adjust sprinklers, change nozzles, or replace or move sprinklers to improve the DU of the system.

In most cases simple adjustments or repairs can greatly improve your DU. However; some cases may require redesigning the system.

The following photographs illustrate common sprinkler problems.

Common Sprinkler Problems



Broken Sprinkler Heads



Partially Plugged Sprinkler Head



Broken Head



Head Not Fully Extended



Tilted Sprinkler Head



Head out of Alignment -
Spraying Road and Sidewalk



Obstructed Sprinkler Head



Pressure too High



Poor Design



Cold and Windy Conditions