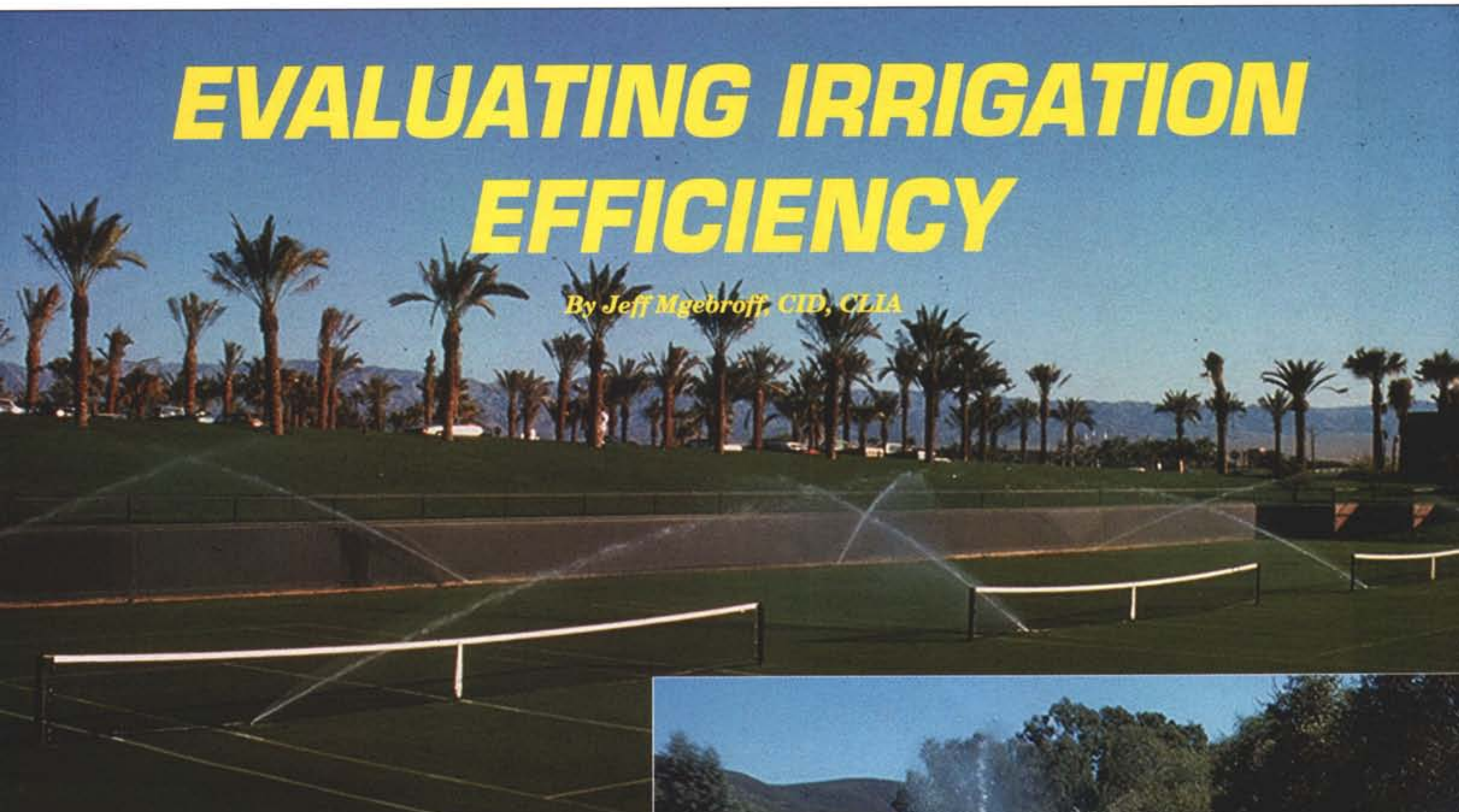
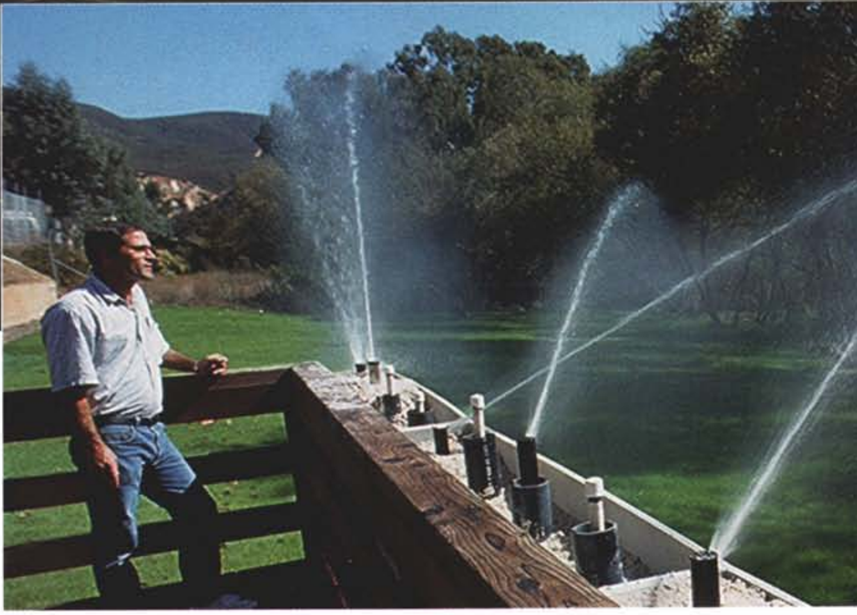
EVALUATING IRRIGATION EFFICIENCY

By Jeff Mgebroff, CID, CLIA





Above: Efficient irrigation coverage of grass tennis courts at La Quinta in Palm Springs, CA. Right: Outdoor sprinkler testing facility. All photos courtesy Hunter Industries.

Efficiency, as it relates to irrigation, is a measure that consists of many different factors. Generally speaking, irrigation efficiency deals with the overall operation of an irrigation system. There are various factors, both within the system and environment, which effect the smooth operation of irrigation systems.

How Much, How Fast

Knowing how long to run a given system is crucial to irrigation efficiency. This is scheduling, and proper scheduling requires the answers to two basic questions:

1. *How much water needs to be applied?*

2. *What is the rate at which the water should be applied?*

The amount of water to apply in landscape irrigation is generally measured in inches. This is sometimes known as the demand. This demand is based on evapotranspiration (ET), a rather fancy word that can be broken down into two parts; "evapo," meaning the amount of evaporation due to climatic factors, and "transpiration," meaning the amount of water a given plant will transpire or sweat. ET values are available from various sources such as universities and extension services.

The rate of speed at which water should be applied is measured in inches per hour. This is commonly referred to as the "precipitation rate" and can be calculated by using the flow of a given sprinkler and the distance at which the sprinkler is spaced.

The following are typical precipitation rate ranges for several common sprinklers spaced in a conventional manner: spray heads, 1.5 to 2.25 inches per hour; rotating stream heads, .6 to .9 inches per hour; and rotor heads, .2 to .8 inches per hour.

Determining a schedule is similar to planning an automobile driving trip—to determine how long the trip will take, one needs to know the distance to be traveled and the speed. It is not much different for irrigation scheduling. To figure out individual watering times, take the ET and divide it by the average precipitation rate for an individual valve. The result is a system run time in hours, which can easily be converted to minutes.

Environmental And Physical Factors

There are other factors that must be considered when discussing the efficiency of an irrigation system. Among these are water demands of specific plants, seasonal climatic changes (remember, ET is seasonal), microclimates such as shaded and open areas, and elevation differences.

The water demand of each plant is different. For example, a warm-season turf will require less water during a given season than a cool-season turf.

It's important to keep in mind that ET is actually a base value that was created from a base plant material, alfalfa. This is nice if your crop is alfalfa, but not so great if your crop is the grass on a sports field or a golf green. Therefore, to make these values more useful, "crop coefficients" have been established for several kinds of plants from shrubs to turf. These crop coefficients can be considered multipliers, which multiplied by the base ET will yield specific ET values for a range of different plants. For example, warm-season turf traditionally has a crop coefficient of .60. This means that warm-season turf would require 60 percent of the base ET value. Other crop coefficients can be obtained from extension services.

Elevation changes, commonly referred to as slopes, can also affect scheduling and therefore irrigation efficiency. The steeper the slope, the more likely it is that the water will run off from the area it was originally intended to irrigate. If this happens, the water is being applied at a higher rate than the soil can take it in. This is one reason why slopes lend themselves to shorter, multiple run times. A similar situation will occur in flat areas, with the result being standing water instead of runoff.

Of course, both of these conditions are considered inefficient. Knowing how much water the ground can retain in a given amount of time—called the "soil intake rate"—is vital for proper scheduling. The goal is to apply water at a rate that is less than or equal to the soil intake rate.

Soil intake rates are chiefly affected by the size of the particles that make up

Above: Irrigation at Mile High Stadium in Denver, CO. Left: Single line tests are used by sprinkler manufacturers to help determine uniformity.

a given soil. These particles are described as sands, silts, clays, or a relative combination of the three. In sandy soils, particles are usually large enough to see with the human eye. Because they are so large, they do not compact as tightly as silts or clays. This means there is more space between the particles to allow water to move through the soil. That's good news if the goal is drainage, but bad news if the goal is to retain water in the soil, as in the case of water soluble fertilizers. Conversely, clay soils have microscopic particles that compact much easier. Loam, another common term used to describe soils, refers to soils with particles between sands and clays and are usually considered most desirable.

It is important to note that there is a general misconception that soil intake rates are constant or fixed. This not the case. In fact, these rates decrease during the duration of the irrigation cycle, and clay soil intake rates decrease more rapidly than sand soil intake rates.

Sprinkler Uniformity

Few people would dispute the fact that the objective of irrigation is to apply water over a given area as evenly as possible. It makes sense that this would have a large bearing on the efficiency of an irrigation system. Sprinkler uniformity is how the industry gauges this objective. High uniformity indicates even distribution and low uniformity indicates uneven distribution.

The three most commonly used uniformity statistics are Chritiansen's Uniformity Coefficient (C.U.), Distribution Uniformity (D.U.), and the Scheduling Coefficient (S.C.). C.U. values provide an overall measure of how the precipitation rate varies throughout an irrigated area. D.U. values provide a measure of the relationship between the precipitation rate in the driest 25 percent of the irrigated area and the average precipitation rate of the entire area. S.C. values provide a measure of the relationship between the precipitation rate in the driest area and the average precipitation rate of the entire area.

Both C.U. and D.U. values are expressed as percentages. A value of 100 percent indicates perfect uniformity. Decreasing C.U. or D.U. values indicate less uniformity. S.C. is expressed as a ratio rather than a percentage. An S.C. value of 1.0 indicates perfect uniformity. Increasing S.C. values indicate less uniformity.

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Each of these three uniformity statistics has been shown to provide valuable information concerning uniformity. The D.U. and S.C. are especially meaningful when emphasis is placed on the significance of the dry area, as in the case of landscape irrigation. It is important to note that although each of these statistics can be used independently, it is preferable to use them concurrently to achieve the most accurate determination of uniformity.

In order to calculate each statistic, precipitation rate values must be obtained. There are two primary testing methods that are used to obtain these values.

The first is known as a "single line test," where a sprinkler is located at one end of a row of similar catchments placed at two-foot intervals. The sprinkler applies water over the catchments to obtain precipitation rate values at each catchment location. A set of precipitation rate values for a given sprinkler is referred to as a "sprinkler distribution profile." These profiles are the "building blocks" that can be used to simulate spacing patterns and determine the associated uniformity statistics. This method is conducive to research and development of sprinkler heads, individual sprinkler evaluations, and irrigation system design considerations. There are two software programs that have the ability to create these profiles from a test and compute uniformity statistics. One, called "SPACE" (Sprinkler Profiles and Coverage Evaluation) is from the Center for Irrigation Technology (CIT) in Fresno, CA. The other, Water Distribution Software, is from Hunter Industries in San Marcos, CA.

The second method of obtaining precipitation rate values is known as a "grid test," where a series of overlapping sprinklers are used instead of a single sprinkler. In a grid test, similar catchments are placed in a pattern between the overlapping sprinklers. Again, precipitation rate values are found for each of the catchments, which are located based on the on the sprinklers' spacing and layout configuration. These values are then used to calculate the uniformity statistics.

Unlike the single line test, the grid test lends itself more to system field evaluations such as water audits. However, like the first method, the grid test uses the aforementioned computer programs to determine these statistics.

For some reason, uniformity and efficiency are often used interchangeably in reference to irrigation systems. This is incorrect and should be avoided. As stated earlier, uniformity is just one factor that determines irrigation efficiency. It is also one factor over which sprinkler manufacturers and system designers have some control. It is true that certain factors, such as climate, are impossible to control. Many others, however, such as proper scheduling can be determined by sports turf managers and superintendents.

It is crucial for all sectors of the green industry to be a least aware, if not completely knowledgeable, of all the factors that comprise irrigation efficiency. If we ignore these factors, the precious resource the industry depends on for survival will continue to be wasted. ❑

Editor's note: Jeff Mgebroff is the technical services manager for Hunter Industries in San Marcos, CA.