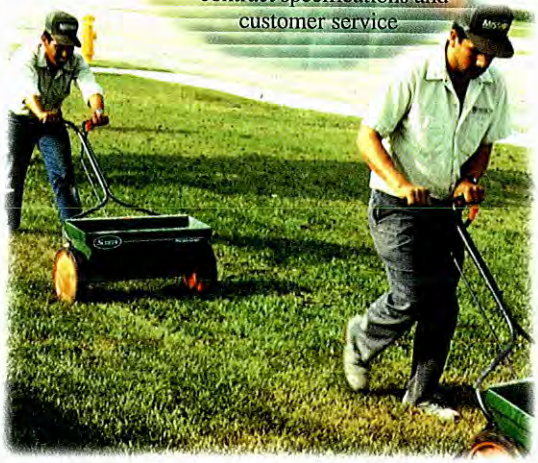
CHAPTER 5 Optimizing Landscape Water Efficiency

This chapter describes more specific horticultural information contractors can consider to help make a site water and resource efficient. The techniques and practices are intended to supply the contractor with more site knowledge, produce a healthier landscape, prevent problems before they occur and help save valuable labor time. *Recommendations for your specific sites may vary due to local soil, weather, landscape design, water prices, etc.*

Use this information in combination with other horticultural research to determine the best care for your landscape.

This chapter is:

- A guide to management techniques that can save contractor's time and save (or make) money
- Designed to help produce healthier and more attractive landscapes with less resources
- Intended to help contractors identify ways to improve site profits, contract specifications and customer service



The Best Maintenance Practices (BMPs) for a Water and Resource Efficient Landscape are identified as:

I. Sound Cultural Practices
II. Preventive Irrigation Maintenance
III. Water Budget Irrigation Scheduling

I. Cultural Practices: It All Starts With the Soil

"There are conditions of urban soils that present the most difficult problems to landscape professionals."

The Landscape Below Ground

Every discussion of how to achieve a healthy, attractive and efficient landscape starts below ground level with the soil. Every water and resource efficient landscape needs the site's soil to provide essential elements for plants to be successful. The water and resource efficient landscape is the site that receives only the amount of water plants need for healthy growth, receives fertilizer only when it is lacking, and restores a more natural balance by recycling organic material into the soil.

Every commercial landscape and home garden, it seems, has its own set of soil conditions that make site management a challenge. The complaints most often heard are: "hardpan," "run-off," "compaction," "nutrient deficiency," "yellow leaves," "surface roots," and on and on. Stop complaining. Get to know and understand the site's soil. Start with a soil test.

Test the Soil

Typical landscape contracts call for regular fertilizer applications regardless of the needs of the soil. The regular over application of fertilizer, particularly nitrogen, starts a cycle of more rapid growth, higher water use and increased labor requirements for the contractor. Do the plants and soil really need the fertilization as specified by most contracts? A field soil test, prior to fertilizer applications, will tell the site manager if nutrients are really needed. A laboratory soils test is appropriate to help analyze for more complex site problems. A field soils test or lab test is inexpensive when compared to the purchase and application of fertilizers. Soil testing is also very effective when compared to the labor time and dump fees associated with increased plant growth resulting from excessive fertilizers.

One city has written the use of soil testing before applying fertilizers into landscape maintenance contracts. The result has been a reduction of fertilizer applications from five times per year to two. The savings to the city comes in the form of lower fertilizer costs, reduced water need (from excessive growth) by the plants and reduced green waste production. With the aid of a soil test,

contractors gain ongoing knowledge of the site, reduce labor time for unnecessary work, avoid overstimulating plant growth, reduce dump fees and save wear on machinery and vehicles.

Use a soil test to verify the need and justify the cost of the time and labor it takes to apply fertilizer to the landscape. This sophistication and the professionalism, on the part of the landscape contractor, improves the image of the company in the eyes of the customer. Performing a soil test and using the results shows the client that you are spending their money wisely.

Using a Soil Probe

Getting to know the site's soil requires the use of a test to measure chemical and fertility levels. A soil probe is a field tool that offers fast and easy access to knowing the soils moisture content, plant root depth and health (especially in turf), the presence of hardpan layering and depth of water penetration in relation to the plant root zone. The use of a soil probe provides direct information a supervisor, irrigator and field hand need to help make management decisions that produce a water efficient landscape.

Make a soil probe standard equipment and require all site supervisors and irrigators to use probes daily. Soil probes are the quickest and least expensive way to monitor what is happening below ground. The combination of periodic soil testing and the use of a soil probe increases the knowledge the contractor has about the site and how to best manage the soil to insure the plant roots have the environment they need to be healthy.

What to Order in a Basic Soil Test:

A field soil test should look for nitrogen and pH. With a basic laboratory soil test, the following elements should be examined: nitrogen, phosphorus, potassium, calcium, magnesium, salts (sodium, SAR) & pH

A typical laboratory soils test as described above may cost approximately $25.

Properties of Soils:

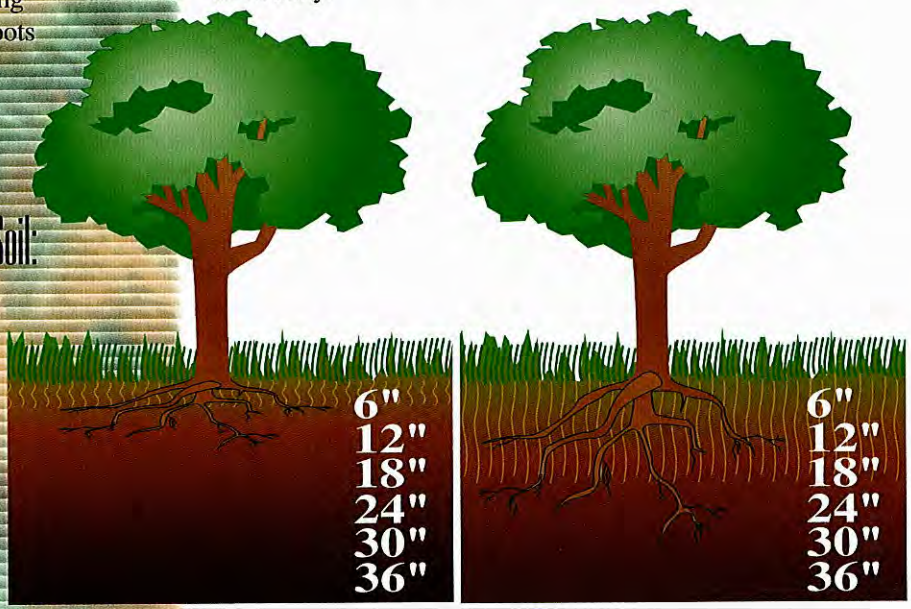
Sandy Soil – fast drainage, low nutrient holding capacity, difficult to compact, allows deep root growth, fast water penetration rate, low water holding capacity

Loam Soil – good nutrient holding capacity, good structure, good drainage, good water infiltration rate, moderate to good water holding capacity

Clay Soil – high nutrient holding capacity, little pore space for roots (especially when wet), slow water infiltration rate, high compaction potential, high water holding capacity

What Plants Need From Soil:

- Soil with adequate pore space
- Deep, penetrable soil profile
- Good soil structure with uniform texture throughout the soil profile
- Moderate water holding capacity
- Adequate drainage
- pH in an acceptable range



Urban Soil

Slow water infiltration; compaction; limited air spaces; shallow roots; water saturation from poor drainage

Good Soil

Air spaces; bacterial action; some moisture deep into the soil profile; ability to drain excess water

Soil Probes and Water Savings

Home sites in Orange County were studied to see if use of a soil probe saved landscape water. The study was conducted during the three highest irrigation months, July, August and September. The monthly water use of the test homes was averaged over the last 5 years and compared to the 3 test months of 1997. A group of neighboring homes water use, without the benefit of soil probes, was evaluated for the same period as a control group. The water use was weather normalized.

The study results showed that during July, August and September of 1997, water use at the soil probe test homes decreased 14.7%. The water use at the control homes (no soil probes) increased 9.2%. The difference between homes using soil probes versus homes not using soil probes was 23.9% in water use.

The findings of the study established that the use of soil probes, before irrigating, to monitor soil moisture can save significant water in the landscape. (See appendix II for soil probe references.)

What Urban Soils Often Provide:

- Compaction with limited air space for roots
- Nutrient imbalances (salts, low iron, boron)
- Low or no organic material
- Low micro-bacterial activity
- Layers of different soil textures and/or hardpan (limiting the movement of water)
- Slow water infiltration
- Poor drainage

The CLCA Landscape Standards Committee

recommends the use of soil probes to test for subsoil moisture for trees, shrubs and groundcovers on a bimonthly schedule. Soil probes should be used on a regular basis to "evaluate actual soil moisture levels and irrigation schedules."

Common Site/Soil Problems:

- Contractors inherit sites with poor soils, inefficient irrigation systems and difficult hydrozones
- Typical maintenance habits, such as high water applications and excessive fertilization contribute to common landscape problems
- Maintenance contracts that do not encourage resource efficient practices
- Customers consistently wanting to cut back on landscape maintenance contracts/ expenditures (perception of landscape as a low value asset)

The Solutions:

Work with the customer on a site program that includes:

- Analyze maintenance actions for it's time, cost and landscape success (plant health and attractiveness)
- Add up the costs of resources used for a site (water and fertilizer, etc.)
- List the complaints associated with the site landscape and time, money and resources spent to correct the problems
- Compare the above with using a preventative maintenance, resource efficient customer service approach

Water Infiltration and Penetration

The soils of urban landscapes are typically compacted through the construction process, from traffic and use. Water, where the infiltration rate is slow, has a difficult time penetrating compacted soils. Much of the water applied beyond the soils infiltration rate becomes wasted water run-off. Customers literally pay for water running down the street. Urban soils, with slow water infiltration rates, limited water penetration ability, that receive under or over-watering often have shallow and surface rooting plants.

How do you determine if water penetration is a problem? The common practice is to dig a hole, fill it with water and wait to see how long it takes to soak into the ground. The slower the water soaks into the ground, the more difficult that soil is to irrigate and move water down into the root zone. Another method is to use a soil probe. First, if you can't drive the probe into the soil, chances are that water and plant roots are also not able to penetrate the soil. If the probe stops a few inches below the surface, it's another sign that water and roots will also have difficulty going deeper than a few inches. If the probe goes into the ground easily and the soil core is seen to be fully wet, the soil should be allowed to dry (50% depletion rate is generally recommended) before irrigating again. At the saturation point, additional water becomes run-off or moisture below the root zone and is no value to the landscape and costly to the customer. Use consistent site monitoring with a hand soil probe to know when it is time to turn the water on or off.

Root Depth

The depth of plant roots in the soil is a function of the soil texture, whether sand, silt or clay, the pore space available, plant genetics and the water penetration into the soil. If water can penetrate deeply and adequate air is

present, roots can follow. By growing deeper, roots fill a greater soil area which increases the potential reservoir of water available to the plants. Root depth then becomes a mechanism that helps make plants healthier and the landscape more water efficient. The value of building deep roots is illustrated in the following example:

A high-tech commercial business development consists of large expanses of turf (95% of the site acreage) and evergreen trees, intended to present an attractive and sought-after location for businesses. The Tall Fescue landscape was well designed, the top few inches of soil amended and had state-of-the art irrigation equipment of the late 1980's. The predominant soil of the area is clay. By all indications, the 128 acres of business complex landscapes should have been performing well and be attractive within a 100% ET water budget.

Organic material for turf aeration

Within a few years of installation, most of the site was receiving 50%-100% more water than University of California turf research suggests should be applied. At the same time the turf showed consistent summer "hot spots," stress or burn patterns.

The turf stress occurred even with the high amounts of irrigation. The timing could not have been worse. The area was in the middle of an extended drought (1987-93). The state's economic recession was firmly in place and landscape contracts were under pressure to be reduced. High water bills were the cause of great stress for the customer and the contractor. The contractor was subject to significant criticism for high water bills and poor turf appearance from the developer and property manager.

Raising irrigation heads to clear fast-growing turf

Soil probe checking for root and moisture depth

What was happening? At the first signs of turf stress, the contractor turned up the water. When the weather continued to be hot and the turf continued to burn, increasing the water was the only maintenance response. The common practice of applying monthly, high nitrogen fertilization continued (under the premise that more fertilizer and more water would make the problem go away). Nothing short of flood irrigation worked. Some turf areas actually received 200 inches of water in a climate area that called for 48 inches annually.

The cost of the water drove the land owner, water district and a landscape consultant to take a systematic look at how best to manage this site in a cost effective and attractive way. The findings were:

- Clay soils were saturated with water
- Compaction and/or lack of soil oxygen was increased by over watering
- Nitrogen fertilizers contributed to fast top growth but little root development
- Tall Fescue turf had 1.5"-2.0" deep roots
- The top 2" of soil would dry out in a single hot summer day, causing consistent turf stress, even with a previous night's irrigation
- Tree roots surfaced due to compaction
- Turf, due to high fertilization and water, would grow rapidly, blocking spray heads
- Irrigation heads had sunk in the wet soil, causing blockage of spray heads
- Irrigation heads were not straight or well maintained
- Irrigation heads were clogged
- Water run-off occurred within 2 minutes of irrigation run-times
- Irrigation cycles were set for 7-10 minutes

By analyzing the site, from the soil and root zone, to the weekly cultural practices, the "numbers" presented a clear picture of the site challenge. A new set of maintenance guidelines needed to be developed. The sites' water efficient turf maintenance program emerged to include the following:

- Aerate 3 times per year (early spring, late spring, early fall) to open up compacted soils for increasing turf root depth
- Add organic top dressing immediately after every aeration to increase biological activity in the soil
- Eliminate high doses of nitrogen fertilizer and replace it with a slow release balanced fertilizer with iron (to maintain deep green turf color)
- Use of mulching mowers and grasscycling to moderate turf water and nutrient needs
- Apply specific aeration and top dressing to turf "hot spots" to allow for greater water penetration
- Apply a preventative irrigation maintenance program (routinely checking and adjusting low, blocked or clogged heads)
- Irrigation to move water deep into the soil, then let the soil dry to 50% field capacity moisture level to allow oxygen exchange
- Irrigation as per weather (ET) changes, including reading meters weekly, using irrigation scheduling software and soil probing to check moisture and turf rooting
- Irrigation with short run times of 2-3 minutes per cycle to minimize water run-off

The result, over the 128 acre business park, is a healthier, more attractive landscape that meets water budgets. Turf roots have grown to a depth of 5-6". Turf is irrigated 50% less during summer and the overall water use is down 56% when compared to past years. The presence of turf stress or "hot spots" has been significantly reduced. All these improvements came about because of attention paid to the three "best maintenance practices" for a water efficient landscape; (1) Sound cultural practices, (2) Preventive irrigation system maintenance, and (3) Scheduling irrigation as per ET. Water bills were reduced 75% while visual appearance, and turf health, were greatly improved. The customer has the valuable marketing asset (the landscape) they desire, maintained with better appearance at a lower cost.

The message from this example is clear. Manage the soils with proper cultural practices, use the right amount of water and do not cut corners on preventive maintenance. The landscape, in turn, will be water efficient, cost effective and more attractive. For the contractor and the customer, these practices amount to nothing more than quality customer service.

Example Site Water Costs/Reduction Through the Program Above

1992	1993	1994	1995	1996
$523,275	$244,581	$240,999	$134,036	$133,313

**1996 had a higher ET than any other year shown with average rainfall, yet achieved the lowest water bills during the period.*

Aeration – Making Turf More Water Efficient

Soils under turf are often compacted soils. Compaction limits root growth and depth. For turf with 2" deep roots, increasing the root area 1" increases the area from which turf can pull water by 33%. Aeration of the soil, at the right time of year, provides a more favorable environment for deeper root growth.

Aeration to help build deeper turf roots

Aerate soils when the turf roots are most actively growing. The first aeration of the year should be started as soon as the rain and temperature allow. In early spring, turf roots are starting up growth as the soil temperature warms. Late spring or early summer is the next aeration opportunity. At those times, turf roots are still expanding. Cool season grasses slow or stop root growth expansion during the hot summer months and aeration has little positive impact. Aerate again in late September or early October to coincide with cool season turf root activity. Warm season grasses may

need only a single aeration since they have a shorter growing season and more vigorous roots. (However, nitrogen applications can help extend the green color of warm season grass into the late fall.)

Mulch, Mulch and More Mulch

One of the surest ways to save water in the landscape is to use mulch. The consistent use of organic mulch creates an interface with soil that shields the soil surface from the sun that bakes and hardens the top of the soil. By covering the soil surface, mulch helps water penetration into the soil. The water saving function of mulch is that it insulates the soil to reduce evaporation. Mulch also reduces weed growth in planter areas. The use of mulch can more than off-set the labor cost of weeding. Find a reliable source of shredded, thoroughly composted, organic mulch and use it for every tree, shrub and ground cover area in every landscape, including slopes. (Note: keep mulch away from the base of plants to avoid trunk rot potential.)

Mulch that is shredded does stay in place on hillsides. CalTrans shown mulching miles of freeway landscapes.

Grasscycling: Mulch for the Turf

Grasscycling simply creates mulch for turf areas. Research has shown that grasscycling, the practice of using mulching mowers and leaving the grass clippings in the turf, reduces evaporation and returns nitrogen to the soil.

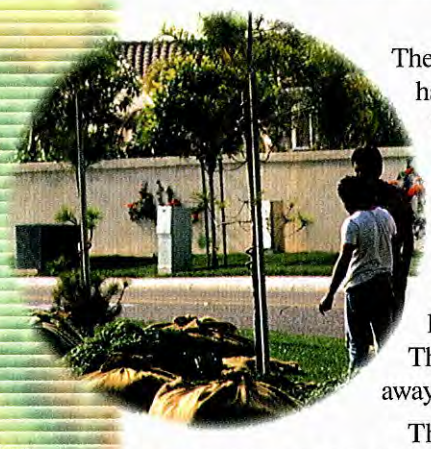
New Site Soil Preparation

- Stockpile the site's topsoil for use after construction is completed
- Generally, plant trees and shrubs in the native soil. Roots will extend well beyond the original planting hole. Since soil cannot be uniformly amended throughout the area that will eventually be filled by the roots of the trees and shrubs, save time and money by putting trees and shrubs directly into well tilled native soil.
- Apply mulch to a 2-4' layer on the soil surface around trees, shrubs and ground covers. Keep mulch a few inches away from the base of plants to reduce the potential of trunk and root rots.
- Completely mix in amendment in turf and ground cover planting areas as deep as possible

(Left) Mulch covers drip irrigation. (Above) Mulch gives more attractive appearance than barren soil.

Problem:

- Typical landscape maintenance contracts specify monthly or bimonthly fertilization for turf. The high application of nitrogen invites a cycle of higher water use, more labor and more fertilizer, making the site water and resource intensive (i.e., costly).



Solution:

- Rewrite contracts to include higher quality services, i.e. soil testing, aeration, dethatching and mulching
- Use soil tests to determine the nutrient needs of the site before fertilizing
- Use slow-release fertilizers and mulching mowers to help produce "green" grass without excessive growth

The demand for grasscycling has increased for two reasons. The first is State Assembly Bill 939 which mandates that the waste stream going to landfills must be cut by 50% by the year 2000. Generally, 25%-30% of all landfill material is green waste. This material must be diverted away from landfills by law.

The second reason to use grasscycling is the ability to reduce evaporation from lawns and gain "free" nitrogen from the microbiotic breakdown of the clippings. By using a mulching mower, the grass clippings are ground into a fine material that does not lay on the surface of the grass,

but drops down among the grass leaves. (The fallen clippings form a kind of mulch above the grass stems and act as an insulation to reduce evaporation.) As the clippings break down they give off moisture, cooling the grass leaves, and release nitrogen for plant uptake.

Contrary to conventional wisdom, mulched grass clippings **do not** cause thatch build-up in turf. Thatch is caused by a build-up of plant shoots, stems and rhizomes. Mulched grass clippings break down fast and do not build thatch in turf. Use grasscycling as a means of saving labor while improving the quality of turf at the same time. (For more information on grasscycling, contact your local Cooperative Extension office. See Appendix V.)

II. Preventive Irrigation Maintenance Program

Water efficiency cannot be achieved by simply turning the water down (not if you want to keep the landscape attractive and keep the job). An inventory and prioritized action item list of irrigation system repairs and upgrades is needed and the action items must be implemented. Only then can water efficiency begin.

To be water efficient, month by month, the same action item list should be used as part of a preventive maintenance program for every site. Taking care of a site's irrigation system makes good business sense. It is a prime component of the customer's landscape asset. A preventative maintenance program will save time compared to a crisis management approach that takes over when "hot spots" occur, or when irrigation equipment fails and water bills go sky high. Plan ahead and look for problems before they happen. Check for the following problems:

(Above) Pop-up spray head that does not reach above the grass. (Right) All heads were repaired or replaced with higher pop-ups. This retrofit costs less than over-watering.

- Sprinkler heads spaced too far apart
- Mismatched heads
- System distribution and uniformity
- System operating pressure and pressure regulation needs
- Sprinkler throw and arc
- Height of heads in relation to turf and other plants
- Tilting heads
- Clogged heads
- Sunken heads
- Low head drainage and the need for check valves

All heads have "sunk" and/or are low due to thatch build-up.

All of these items will affect water application, system uniformity and efficiency. These same items affect plant health, appearance and customer satisfaction. Avoid customer complaints and dissatisfaction by practicing consistent preventive maintenance and fixing problems before they cost you the contract.

III. Water Budget Irrigation Scheduling:

"Plants need the right amount of water at the right time and at the right place."
Gardening for Dummies

How Much Water Do Plants Need?

Different plant species need different amounts of water. No one gets it right all the time. How do you know how much water to apply to a landscape?

1. Use a soil probe to "see and feel" the moisture level in the soil and in the plant root zone
2. Monitor the weather (ET) and keep a weekly chart
3. Track the amount of water being applied to the site and compare the actual use with the local ET
4. Apply only the water lost by the plants to evapotranspiration (see the estimated water need of plants in Appendix V, WUCOLS)

Plants need water based on (1) their unique physiological requirements, (2) root volume depth and mass, (3) in relation to local environmental factors, such as light, temperature, wind and humidity. More roots at a deeper level enable plants to pull water from a larger soil area, increasing plant health, efficiency and even drought tolerance. A plants physiology and water use capabilities are referred to as their crop coefficient (Kc) or plant factor. For a listing of common landscape plants and their estimated water requirements, see Appendix V.

California Irrigation Management Information System (CIMIS) weather station measuring daily ETo.

Generally, plants can be classified in simple ranges of low, medium and high water users. Plant water need varies, even among species from the same genus. Cool season fescue grass represents the reference (ETo) for ornamental landscape plants. CIMIS weather stations, and other private manufacturer systems, measure the water transpired/evaporated by cool season fescue grass. The measurement refers to its maximum evapotranspiration rate, written as 100% or 1.0 of ET.

New plantings with smaller root mass at shallow soil depths may require more water and more frequent irrigations for establishment. Mature plants can perform at the lower end of the listed plant factor levels. Soil type and slopes have little impact on a plant's water need, though the site's

The Problems:

- The soil surface looks dry. Both the home gardener and the landscape professional react by turning up the water. But, does the plant really need more water?

Or:

- A watering schedule is programmed into a controller. This is done without evaluating the soil moisture and/or health of the plant materials. Water is applied to the landscape without knowing how much is really needed. The schedule remains unchanged for months or all year.

The Solution:

- Use a soil probe to determine the moisture content below the soil surface. It is a reliable way to tell if the soil is wet or dry (DO NOT rely on looking at the soil surface for soil moisture information)
- Observe the plants, feel for leaf turgidity, look at leaf color and wilting as signs of stress, etc.
- Find out how much water is being applied to the landscape (read the water meter weekly or after a typical stations run cycle; turn the ccfs into inches of water). Compare the actual use on the site to local weather (ET) in inches or ccfs. Turn the difference into a percentage and adjust the site controllers accordingly. A real site example is:

  Site Area: 1 acre

  Weekly ET: .84 inches/acre (30.5 ccfs for the week)

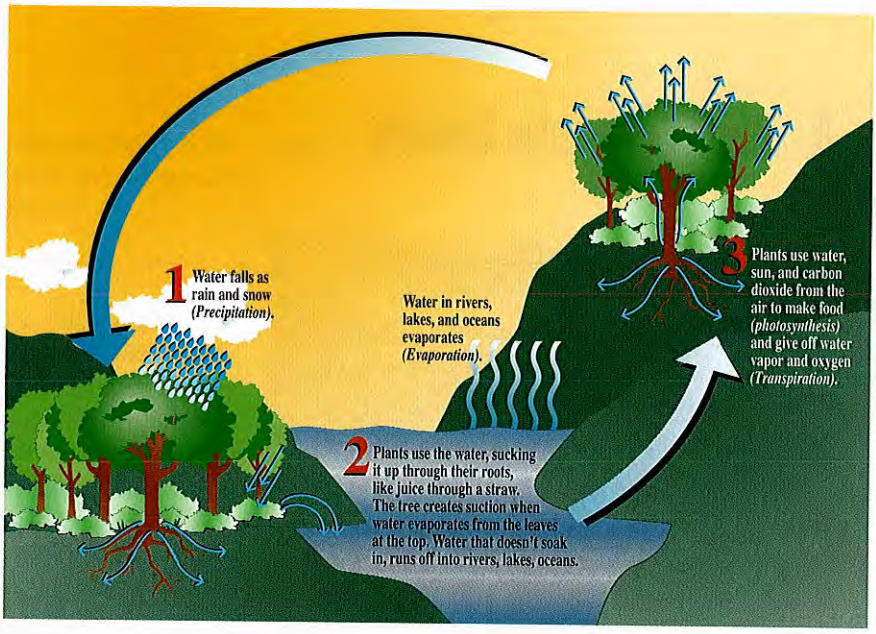
  Actual Weeks Water Application: 1.15 inches (41.7 ccfs)

  Water budget equation:

  $$\frac{\text{(30.5 ccf) (.75 Kc) (1 acre)}}{\text{(.80 IE)}} = \text{28.6 ccf/week}$$

  Actual Water Use: 9,800 gallons, or 31% overwatering for the week

(Below) University research plot determining plant water needs (Kc)



Soil probes help water managers assess irrigation schedule impacts in the soil.

soil certainly impacts how easily water gets into the plant root zone and how long it remains in that zone.

Landscape contractors are constantly presented with site variables that complicate efficient water management. They include:

- Micro-climates of sun and shade
- Multiple species plantings (such as trees in turf)
- Heat islands (parking lots, streets, buildings, etc.)
- Poorly designed irrigation systems (systems not separated between micro-climates or turf and shrub areas, spacing, pressure and head blockage, etc.)

Among the best options for addressing such problems are consistent use of soil probes to monitor soil moisture and tracking the local ET and matching it to watering schedules. Keep the customer informed of the site problems. As water costs rise, contractors can develop cost/benefit analyses to show customers how much upgraded irrigation systems and/or plant material upgrades would cost in relation to continuing to pay existing expenses. If the savings justifies the costs, new business and a more water efficient landscape can be created by the contractor.

General Plant Factors (estimated water needs) Compared to Reference ET (100%)

- **Turf** – High/Medium High, Cool Season Turf – 80%-100% or (.8 - 1.0), Warm Season Turf – 60%-80% (.6 - .8)
- **Groundcovers** – Medium/Medium High, – 50% - 80% or (.5 - .8)
- **Shrubs** – Medium/Low, 50% or (.5)
- **Trees** – Medium/Low, 50% or (.5)
- **Natives** – Low, 50% or below (.5 and lower)
- **Annuals** – Medium/High, 60%-100% or (.6 - 1.0)

Source: U.C. Cooperative Extension

CIMIS–Current & Historical Weather Station Sites

Evapotranspiration (ET) is the combined process of evaporation from the soil and plant surfaces and transpiration of water through plant materials. Contact your local Cooperative Extension office or the Department of Water Resources (DWR) for local ET information.

Contact your local water district to obtain sources of weather information.

Stn #	Station Name	Nearby City	County	Start Date	End Date
90	Alturas	Alturas	Modoc	4/23/89	
125	Arvin-Edison	Arvin	Kern	3/22/95	
134	Barstow NE	Barstow	San Bernardino	1/8/97	
60	Barstow	Barstow	San Bernardino	11/20/86	2/20/92
35	Bishop	Bishop	Inyo	2/4/83	
54	Blackwells Corner	Blackwells Corner	Kern	10/19/86	
135	Blythe NE	Blythe	Riverside	1/16/97	
36	Blythe	Blythe	Riverside	3/13/83	8/12/88
47	Brentwood	Brentwood	Contra Costa	11/18/85	
73	Hollywood Hills	Burbank	Los Angeles	3/4/88	9/14/93
41	Calipatria/Mulberry	Calipatria	Imperial	7/17/83	
29	Cantua Creek	Cantua Creek	Fresno	1/2/83	7/23/85
19	Castroville	Castroville	Monterey	11/18/82	
118	Cathedral City	Cathedral City	Riverside	12/7/95	
12	Durham	Chico	Butte	10/19/82	
82	Claremont	Claremont	Los Angeles	4/13/89	
32	Colusa	Colusa	Colusa	1/13/83	
11	Bakersfield/Bonanza	Conner	Kern	9/29/82	4/17/86
20	Corcoran	Corcoran	Kings	11/22/82	4/9/86
123	Suisun Valley	Cordelia	Solano	8/18/94	
88	Cuyama	Cuyama	Santa Barbara	5/20/89	
110	Newberry Springs	Dagget	San Bernardino	2/21/92	12/27/96
6	Davis	Davis	Yolo	7/17/82	
121	Dixon	Dixon	Solano	9/20/94	
122	Hastings Tract	Dixon	Solano	3/28/95	
87	Meloland	El Centro	Imperial	12/12/89	
74	Escondido	Escondido	San Diego	4/26/88	
131	Fair Oaks	Fair Oaks	Sacramento	4/18/97	
124	Panoche	Firebaugh	Fresno	7/27/95	
7	Firebaugh/Telles	Firebaugh	Fresno	9/22/82	
2	FivePoints/ WSFS USDA	Five Points	Fresno	6/7/82	
100	Fremont	Fremont	Alameda	8/29/91	
1	Fresno/F.S.U. USDA	Fresno	Fresno	6/7/82	9/25/88
80	Fresno State	Fresno	Fresno	10/3/88	
108	Gerber Dryland	Gerber	Tehama	3/11/91	
8	Gerber	Gerber	Tehama	9/22/82	
43	McArthur	Glenburn	Shasta	10/31/83	
133	Glendale	Glendale	Los Angeles	8/7/96	
94	Goleta Foothills	Goleta	Santa Barbara	7/7/90	
53	Greenfield	Greenfield	Monterey	10/10/86	10/23/91
120	Guadalupe	Guadalupe	Santa Barbara	12/24/93	
76	Betteravia	Guadalupe	Santa Barbara	12/18/87	7/1/93
92	Kesterson	Gustine	Merced	10/13/89	
51	Healdsburg	Healdsburg	Sonoma	8/24/86	3/28/94
126	San Benito	Hollister	San Benito	6/9/94	
106	Sanel Valley	Hopland	Mendocino	2/1/91	
85	Hopland FS	Hopland	Mendocino	9/23/89	
75	Irvine	Irvine	Orange	10/7/87	
21	Kettleman	Kettleman City	Kings	11/19/82	
113	King City-Oasis Rd.	King City	Monterey	6/12/93	
23	King City	King City	Monterey	11/19/82	12/23/85
9	Lamont	LaMont	Kern	9/29/82	4/10/89
93	Lamont	Lamont	Kern	2/4/90	10/3/94
22	Caruthers	Laton	Kings	11/18/82	6/6/88
86	Lindcove	Lindcove	Tulare	5/31/89	
42	Lodi	Lodi	San Joaquin	10/16/83	
102	El Dorado	Long Beach	Los Angeles	10/24/90	
56	Los Banos	Los Banos	Merced	6/28/88	
26	Lost Hills	Lost Hills	Kern	11/29/82	8/13/86
46	MacDoel	MacDoel	Siskiyou	11/11/85	6/11/86
138	Famoso	Macfarland	Kern	4/9/97	
70	Manteca	Manteca	San Joaquin	11/12/87	
84	Browns Valley	Marysville	Yuba	4/13/89	
31	McFarland/ Kern Farms	McFarland	Kern	1/11/83	3/8/93
17	El Centro	Meloland	Imperial	11/8/82	5/27/87
40	Mendota/ MuriettaUSDA	Mendota	Fresno	6/14/83	4/15/92
10	Bakersfield/Greenlee	Mettler Station	Kern	10/1/82	4/16/86
71	Modesto	Modesto	Stanislaus	6/25/87	
109	Carneros	Napa	Napa	3/11/93	
77	Oakville	Napa	Napa	3/1/89	
30	Nicolaus	Nicolaus	Sutter	1/3/83	
128	Salton Sea East	Niland	Imperial	11/17/94	
63	Novato	Novato	Marin	7/1/86	3/5/97
136	Oasis	Oasis/Indio	Riverside	1/7/97	
49	Oceanside	Oceanside	San Diego	3/11/86	
14	Orland (inactive)	Orland	Glenn	10/30/82	4/21/87
61	Orland	Orland	Glenn	5/13/87	
129	Pajaro	Pajaro	Monterey	9/13/95	
55	Palm Desert	Palm Desert	Riverside	5/26/87	4/11/94
72	Palo Verde	Palo Verde	Imperial	9/8/87	
39	Parlier	Parlier	Fresno	5/23/83	
101	Piru	Piru	Ventura	8/27/91	
13	Camino	Placerville	El Dorado	10/19/82	
81	Shenandoah Valley	Plymouth	Amador	5/11/90	
78	Pomona	Pomona	Los Angeles	3/14/89	
97	Port Hueneme	Port Hueneme	Ventura	2/16/91	
98	Ramona	Ramona	San Diego	4/20/91	
34	Rancho California	Rancho California	Riverside	1/21/83	11/25/86
62	Temecula	Rancho California	Riverside	11/25/86	
25	Rancho Mirage	Rancho Mirage	Riverside	11/22/82	11/20/85
140	Twitchell Island	Rio Vista	Sacramento		
44	U.C. Riverside	Riverside	Riverside	6/2/85	
115	Gonzales	Salinas	Monterey	6/18/93	
116	Salinas North	Salinas	Monterey	6/18/93	
37	USDA Salinas	Salinas	Monterey	4/11/83	7/27/92
89	Salinas South	Salinas	Monterey	9/5/92	
127	Salton Sea West	Salton City	Imperial	11/21/94	
45	San Diego	San Diego	San Diego	6/9/85	4/27/89
66	San Diego	San Digeo	San Digeo	4/27/89	
69	San Jose	San Jose	Santa Clara	6/8/87	
112	San Ardo	San Lucas	Monterey	6/18/93	3/13/95
52	San Luis Obispo	San Luis Obispo	San Luis Obispo	4/2/86	
107	Santa Barbara	Santa Barbara	Santa Barbara	4/7/93	
67	Goleta	Santa Barbara	Santa Barbara	2/17/88	4/7/93
104	De Laveaga	Santa Cruz	Santa Cruz	9/28/90	
38	Santa Maria	Santa Maria	Santa Barbara	5/3/83	
99	Santa Monica	Santa Monica	Los Angeles	12/11/92	
58	Santa Paula	Santa Paula	Ventura	7/30/87	2/15/91
83	Santa Rosa	Santa Rosa	Sonoma	2/11/89	
64	Santa Ynez	Santa Ynez	Santa Barbara	11/21/86	
68	Seeley	Seeley	Imperial	5/29/87	
5	Shafter/USDA	Shafter	Kern	6/1/82	
114	Arroyo Seco	Soledad	Monterey	6/18/93	
28	Soledad	Soledad	Monterey	1/4/83	2/11/87
79	Angwin	St. Helena	Napa	5/11/89	12/27/96
15	Stratford	Stratford	Kings	10/29/82	
57	Buntingville	Susanville	Lassen	6/22/86	
59	Tehachapi	Tehachapi	Kern	7/29/86	8/23/90
130	Temecula East	Temecula	Riverside	7/1/95	11/5/96
137	Temecula East II	Temecula	Riverside	2/20/97	
24	Thermal (inactive)	Thermal	Riverside	11/22/82	3/3/86
50	Thermal	Thermal	Riverside	7/22/86	
105	Westlands	Tranquility	Fresno	4/17/92	
48	Tulelake	Tulelake	Siskiyou	2/3/86	9/30/93
91	Tulelake FS	Tulelake	Siskiyou	4/12/89	
117	Victorville	Victorville	San Bernardino	2/1/94	
33	Visalia/ICI Americas	Visalia	Tulare	1/5/83	
65	Walnut Creek	Walnut Creek	Contra Costa	7/22/87	
111	Green Valley Road	Watsonville	Santa Cruz	5/29/92	
16	San Juan	Watsonville	Monterey	10/23/82	8/24/95
3	Beach / Santa Cruz CO	Watsonville	Santa Cruz	5/30/82	8/25/86
4	Webb / Santa Cruz CO	Watsonville	Santa Cruz	5/30/82	4/29/88
95	Watsonville	Watsonville	Santa Cruz	9/13/89	7/24/95
18	Westmorland	Westmorland	Imperial	11/11/82	4/9/86
103	Windsor	Windsor	Sonoma	12/14/90	
119	Putah Creek	Winters	Solano	8/21/93	1/25/95
27	Zamora	Woodland	Yolo	12/5/82	
96	Woodside	Woodside	San Mateo	10/31/90	1/24/94

The Water Budget

Plants need to replace the amount of water lost through evapotranspiration, or ET. More water than (ET) times the plant factor (Kc) should be considered wasted water. Excess water only contributes to soil, root, nutrient and erosion problems. Excess water becomes expensive as a commodity and causes hidden costs for the customer and the community.

The water budget is one of the contractor's tools for achieving efficient water use, plant health and improved customer service for every site. Too much water is costly to the customer and produces an unhealthy landscape.

When to water a landscape is just as important as how much to water. Every site differs in soil type, plant materials, root zone depth, irrigation system output and efficiency, environmental factors and microclimates. It is difficult to predict when or how often to water. But, by tracking the water applied to the site, comparing that amount to the ET and using a soil probe to monitor actual field conditions, a contractor can determine site specific parameters for when and how much to water. Remember, irrigation is needed to replace water lost to evapotranspiration. No more water than (ET) times the plant factor, or (Kc), are needed by plants. Any more water is not beneficial to the landscape.

Water Budget Equation

(ET) x (Kc) x (LA) = Site Water Budget

ET – Local evapotranspiration rate

Kc – Site plant factor or crop coefficient

LA – Landscape area

Note: Irrigation inefficiency must be factored into the site water budget equation as shown below: (I.E. stands for percent Irrigation Efficiency)

$$\frac{(ET) \times (Kc) \times (LA)}{(IE)} = \text{Site Water Budget}$$

****If irrigation efficiency is below 75% then water could be considered wasted. Systems should be upgraded to improve efficiency.***

How Much Water is a Site Using – Tracking Site Water Use

Water can not be counted as savings without knowing how much water is actually being used on a site and what the water need, or water budget, is for the landscape. The same information is needed whether it's a separately metered landscape or a mix-metered site. A metered site has monthly water use data available on the water bill. A meter serving both inside and outside water use can be sub-metered to determine actual landscape use. Another method to determine how much water an unmetered site is using in the landscape is to analyze a bill during a rainy month, when outside irrigation is shut off, to determine typical inside water use. The rainy month interior water use number becomes a baseline for site water demand. Monthly landscape irrigation appears as water used over and above the baseline (interior use).

(Top left) A soil probe can be used to monitor actual soil moisture. (Top right) Weekly meter readings show how much water is being applied. It can also identify leaks or system malfunctions. (Above) The irrigation system uniformity must be known to determine the water budget. (Left) Adjust controllers consistently as weather changes.

Water histories are used on weekly site walks.

Actual Site Water Use Compared to Landscape Water Budget:

Landscape Area – 1.17 acres
(no plant material changes during this time period)

Historical ET – 48.2 inches/year

	1990 Use/ET (inches)	1993 Use/ET (inches)	1995 Use/ET (inches)
Jan	9.8 / 2.1	0.6 / 1.9	1.0 / 1.6
Feb	5.7 / 2.4	0.0 / 2.2	0.0 / 1.9
Mar	7.9 / 3.4	0.0 / 3.8	0.0 / 3.6
Apr	10.4 / 4.9	2.7 / 5.8	2.9 / 5.6
May	8.7 / 5.3	5.3 / 5.9	5.7 / 4.3
Jun	12.4 / 5.8	3.2 / 6.2	3.0 / 5.1
Jul	7.6 / 6.3	5.9 / 5.5	5.3 / 6.7
Aug	13.1 / 6.5	5.7 / 6.2	7.4 / 6.6
Sept	8.2 / 4.9	3.7 / 4.3	6.9 / 5.1
Oct	9.4 / 3.6	3.3 / 3.4	6.5 / 3.7
Nov	8.0 / 2.7	3.3 / 2.7	5.8 / 2.5
Dec	8.4 / 1.99	1.3 / 2.4	3.7 / 1.9
Totals	Use / ET	Use / ET	Use / ET
	109.6 / 49.9	35.0 / 50.3	48.2 / 48.6
	54% over budget	30% under budget	annual use right on budget

Conversions:

Choose the unit of measurement for specific needs, i.e. use inches as it relates to ET and irrigation application rates, or use CCF as it relates to water billing units for the customer.

Inches to CCF - $\frac{\text{(inches) (435.6)}}{12}$ = CCF 1 ccf = 748 gallons

CCF to Inches - $\frac{\text{(ccf) (12)}}{435.6}$ = inches 1 inch (of water) = 36.3 ccf

Comparing Actual Water Used to Landscape Water Budget Needs

The example at left is an actual, separately metered, landscape site. This table compares the actual water used on the site to the actual weather for the same month.

Conclusions/analysis from the site irrigation history:

The water use history of this site is consistent with landscape meters across the state. Too little water is likely used in the spring and early summer months, while too much water is applied in the fall and winter months.

- Based on site size (1.17 acres) and plant materials (60% turf, 40% trees and shrubs) the site requires approximately 100% of ET for one acre of turf for optimum plant health
- Water use, in 1990 (before local water budgets and incentive pricing), was 54.4% higher than the evapotranspiration rate (ET)
- Water use in 1993 was 30% under irrigated with plant health maintained (showing the low water use potential for this landscape during a drought period)
- Water use in 1995 was, in practical terms, identical to the evapotranspiration (ET) requirements of the plant materials on the site
- The landscape is often under irrigated in the early spring, and over irrigated in the fall
- 1990 use wasted at least 1.6 million gallons of water not required by the landscape
- Significant learning by the contractor has taken place to be able to irrigate as per the weather
- Agency water budget and pricing programs motivated the customer and contractor to become efficient water managers
- Customer water bills were reduced significantly without any reduction or change in landscape health and appearance

Tracking a sites water use in comparison to its water needs (ET) is accepted as the method for measuring water efficiency on a site by site basis. With the water use analysis, the contractor has a powerful tool to educate staff and the customer as to the job being done as well as the potential to improve the site. For example, contractors should get paid for the service of tracking water use; get paid for the service of quickly changing irrigation schedules as weather changes; get paid for the service of identifying water leaks quickly and get paid for the service of saving water and lowering water bills for the customer. A water use history/comparison becomes the foundation for development of specific plans for irrigation system upgrades, plant renovation and /or modifications to the maintenance contract specifications. This information helps create "new" business of retrofitting and renovating paid for with water savings.

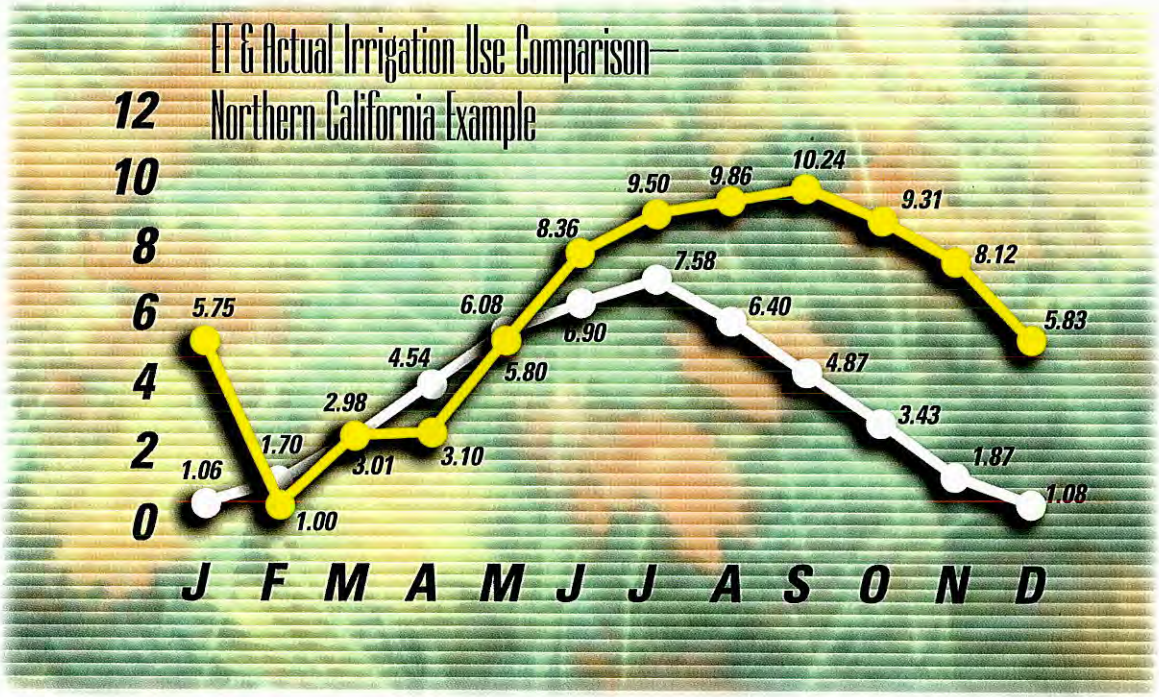
Seasonal Water Use

How Hot Is It for Plants?

The use of a water budget serves to evaluate landscape irrigation as it relates to actual weather conditions and plant water needs. An alarming trend is seen statewide. Irrigation scheduling does not match actual weather conditions. The result of inaccurate irrigation scheduling costs customers money on water bills and weakens plant health in the landscape.

Landscape water use histories show, generally, underwatering in the spring and early summer months, with overwatering in the fall and winter months (rains impact actual water need.) Irrigation that does not match weather conditions can create shallow rooted turf, stunted trees, increase disease potential and cause high water bills for customers. The following charts show the typical landscape water use pattern:

How often is this site checked? Reading a meter and comparing it to actual ET could help discover this problem before the water bill comes.



Overwatering from June through January shows poor irrigation scheduling habits, even irrigating during rainy months.

Adjust controllers according to actual weather.

Problem:

Landscapes are irrigated by how "hot" it feels to the maintenance staff. Landscapes are underwatered in the spring, when it feels cool, and over irrigated in the fall when temperature and/or winds make it feel hot to people.

Solution:

Monitor the daily, weekly and monthly ET to "know" the actual impact of weather on plants. Use a soil probe to monitor soil moisture. Use a schedule based on actual weather for turning water up or down.

How Hot is it for Plants II –

Spring

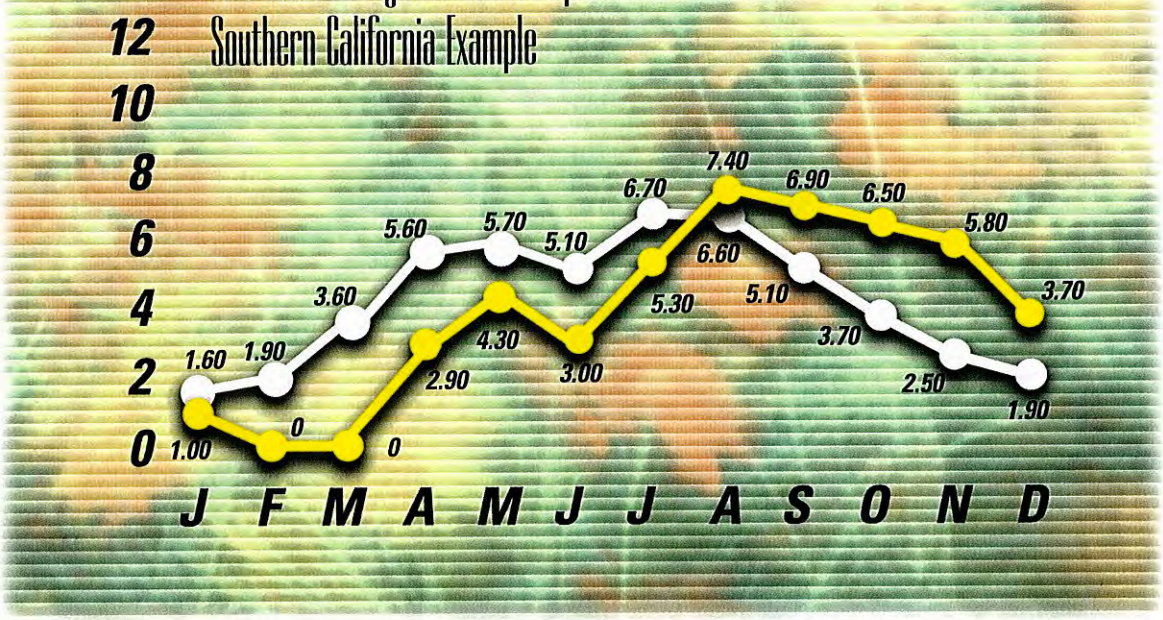
Plants need water in spring during the fast root growth stage. Too little water during spring will shorten roots and cause stress during the summer hot months. Use ET to get adequate water deep into the soil. Use irrigation, with rains, to keep the soil moist (not saturated) to build deep root systems.

Fall

The days are shorter, the nights cooler, the sun is lower on the horizon (less solar radiation) and the physiological water needs of plants is decreasing. Weather and plant needs combine to mean that less water is needed by plants even though it may still feel hot to people.

Know the irrigation system, the time it takes for water to run-off, the water needs of the plants and the soil moisture to avoid this scene.

ET & Actual Irrigation Use Comparison– Southern California Example



ACTUAL Site Water Use (inches)

ET (Evapotranspiration, inches)

Over and under reaction to weather changes and rains are typical. Weather changes can be dramatic and need to be tracked for efficiency.

Why do landscapes receive inaccurate seasonal irrigation? A northern California study suggests that there is a disincentive for landscapes to be irrigated to match the weather. Changing irrigation clocks is time consuming and not a priority for contractors. After all, they do not pay the water bill.

Inaccurate seasonal irrigation is simply the inability or inattention to change controllers to match the weather (ET). How often should controllers be changed? As often as significant weather changes dictate. The graph below shows the weekly changes in weather over 3 consecutive years. The percent change is listed in the right-hand column. Weather changes dramatically. Schedules should change to benefit plants.

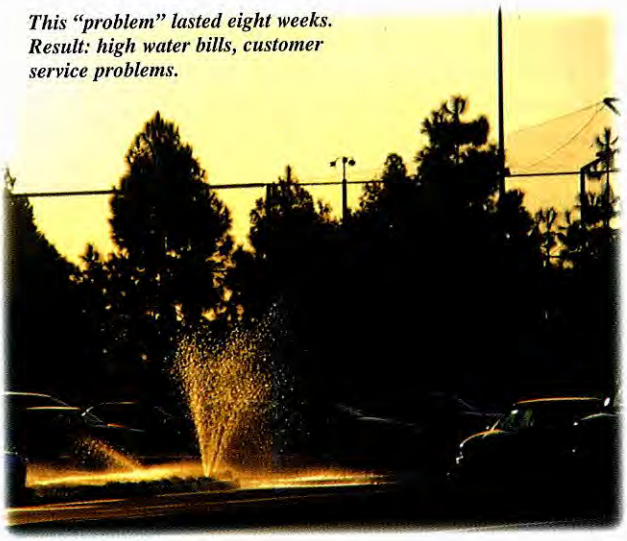
How Weather (ET) Changes Weekly – 3 Year Comparison

- This year's schedule may not work for next year
- Landscape health improves with accurate watering

What To Do:

- Read water meters
- Use a soil probe
- Track actual ET
- Make appropriate controller changes as weather changes

Week	Year 1 *ccf's per week*	Year 2 *ccf's per week*	Year 3 *ccf's per week*	Percent Change
1	9.08	19.60	9.96	81.68
2	13.07	19.60	4.15	125.88
3	11.62	26.50	1.66	187.33
4	12.34	18.88	9.96	64.98
5	29.77	16.70	6.92	128.39
6	21.42	23.23	17.76	26.29
7	17.79	24.32	11.91	61.27
8	18.15	18.88	17.42	8.04
9	18.88	22.87	11.91	61.27
10	33.03	25.41	7.17	118.24
11	35.57	25.77	10.55	104.41
12	32.67	34.12	29.61	14.04
13	23.23	28.31	13.61	67.69
14	33.76	31.58	52.37	52.99
15	41.75	35.94	50.02	33.07
16	41.02	41.75	54.27	29.01
17	50.82	35.94	50.02	32.64
18	47.19	29.77	56.63	60.32
19	48.28	33.76	50.43	37.75
20	50.46	16.70	56.04	95.08
21	40.66	40.66	56.04	33.59
22	53.72	30.49	34.05	58.93
23	45.52	45.74	43.60	4.76
24	52.64	36.66	58.03	43.51
25	53.72	43.20	48.42	21.71
26	62.07	62.80	60.11	4.36
27	52.27	53.36	61.09	15.87
28	52.27	53.00	60.78	15.37
29	49.01	51.91	66.38	31.15
30	35.94	47.19	69.83	66.47
31	40.66	49.01	68.11	52.19
32	52.64	55.18	66.81	24.34
33	50.82	60.62	67.25	27.58
34	49.73	54.45	63.37	24.42
35	49.01	47.92	65.52	32.50
36	46.10	44.65	60.79	31.95
37	42.83	49.01	47.98	13.26
38	23.60	39.57	41.86	52.16
39	32.67	35.94	36.75	11.62
40	40.29	30.13	34.37	29.09
41	22.87	32.31	35.73	42.44
42	19.97	33.40	25.52	51.07
43	31.22	27.95	23.48	28.09
44	35.21	21.78	26.20	48.43
45	29.40	23.96	13.48	71.45
46	19.24	15.61	18.79	20.30
47	25.05	24.32	14.40	50.10
48	21.78	23.23	15.65	37.49
49	26.14	16.70	19.04	45.77
50	13.07	16.70	9.69	53.29
51	11.98	11.98	10.24	15.26
52	27.59	13.79	14.12	74.59
Total Yearly	1799.59 ccf	1722.85 ccf	1858.98 ccf	
Historical ET	1749 ccf or 48.2 inches of water for cool season turf (30 yr. average)			
Difference from 30 Year avg.	3.25% above average	1.16% above average	6.65% above average	



This "problem" lasted eight weeks. Result: high water bills, customer service problems.

Controllers should be changed if weather changes. And weather will change. Don't guess. Become water managers that "know" how much water to apply to the landscape. Develop site by site water budgets; track site use and compare it to the changing weather and set clocks according to actual weather and plant needs. Use soil probes, weather stations and the Internet to get the information you need. Get paid for that knowledge and service. Market that ability to attract new clients.

Contractors should be paid for efficient water management. If weekly meter readings and controller adjustments are performed, that service should be factored into site contracts. Show the customer that paying for **quality water management will cost less than paying higher water bills** on sites with neglected controllers.

Landscape Irrigation and Drought

Drought inevitably brings water cut-backs, renewed conservation, even water rationing, that directly effects the commercial landscape and home garden. The green industry should not only expect and anticipate drought cycles (as they are normal for California), but treat the growing state population, and its impact on water supplies, as a never ending drought. The California Department of Water Resources (DWR) predicts "chronic" water shortages soon after the year 2000. That prediction assumes normal rainfall and snow pack. That sounds like water shortages, conservation, and maybe even water rationing every single year out into the future.

During past droughts, typical public policy has been to seek cutbacks in landscape water use first. Plants, like people, need a certain amount of water for their physiological requirements. The landscape, like a business or a bank account, has a value. Plants and landscapes help make a healthy and attractive home, and help create the property values in a community. How then, do we maintain the landscape asset during a drought, or any type of water shortage?

First, the contractor must know the water budget of every site. By knowing the site water budget, based on optimum plant performance, the contractor can reduce irrigation to lower, subsistence levels. While landscape aesthetics may suffer, the customer's landscape asset can be retained through a water shortage.

Problem:

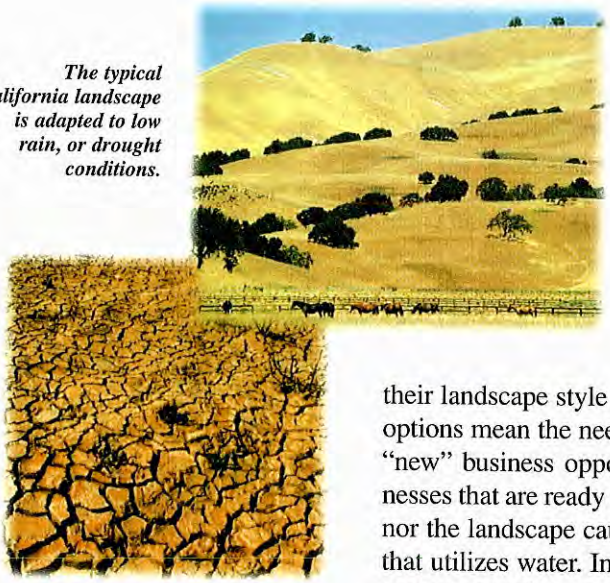
Drought increases chronic water shortage projections; 17 of the last 30 years have been critical, dry or below normal precipitation years

Green Industry Goal:

Minimize impact of water shortages or drought years on landscapes and business

Solutions:

Make landscapes water efficient; partner with public agencies on customer incentive programs; support the development of recycled water; learn the water limits of your landscapes; prioritize the most valuable parts of each landscape for using water and be prepared to manage sites with limited water



The typical California landscape is adapted to low rain, or drought conditions.

The key during a drought is to measure how much water is being used versus how much water is needed by a landscape. If the site uses water above an accepted budget allowance, water can be saved and the landscape maintained. If a site is already efficient, the landscape contractor has the water use data that provides the answer to how far the landscape can go. Be prepared, with water budget knowledge, to help the customer maintain their valuable property asset, the landscape, during a drought.

Drought may also influence customers to change their landscape style or to use more sophisticated irrigation technologies. Both options mean the need for green industry and contractor assistance and offers a "new" business opportunity. Change is always an opportunity for those businesses that are ready and responsive to the marketplace. Remember, neither you nor the landscape cause drought and you shouldn't feel guilty about a business that utilizes water. Instead, be prepared to help serve customer needs and solve customer problems related to water shortages and conservation mandates.

Using Recycled Water in the Landscape

Reclaimed or recycled water is a major, potential source of water that can be used directly on landscapes. In the city of Irvine, California, 80% of commercial, city, school, golf course and homeowner association landscape acres use recycled water. The community landscapes are viewed as drought resistant, not because of the types of plants in use, but because the source of the recycled water is constant, come rain or drought. Sewage water is treated to a tertiary level (as described in the California Water Code, Title 22) and is determined to be safe for use by the California Department of Health. Local county health departments permit the use of tertiary treated recycled water for a variety of uses. Recycled water, for example, can be used for swimming, which assumes gulping of the water and for use on agricultural crops. The use of recycled water for landscaping expands the water supply in a way that directly benefits the green industry.

Green industry businesses should become aware of any local recycled water projects or plans, and support efforts to expand the use of recycled water in California (For more information, contact the WateReuse Association.). If recycled water is available in your area, the supplying agency will provide water quality reports that list the constituents and quality of the water. The elements you need to be aware of for plant health are boron, chloride, sodium, nitrates, the sodium absorption ratio (SAR), the electrical conductivity (EC) and the overall total dissolved salts (TDS).

(Above) Recycled water use in a nursery.

(Right) Purple pipe designated for recycled water use.

Remember, with population growth alone, California is heading toward consistent water shortages in the next century. Where will landscapes get the water they need? Recycled water is perhaps the best and most cost-effective new source of water for landscapes.

Misconceptions about Recycled Water:

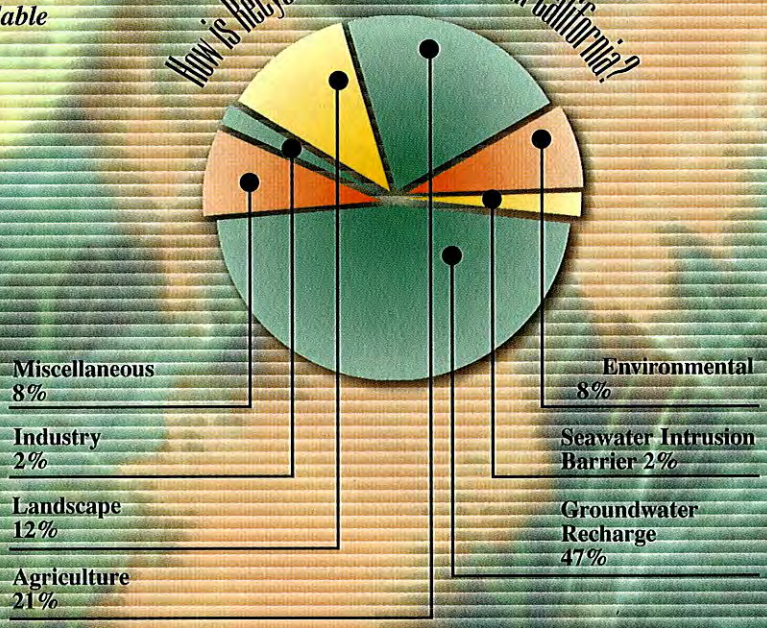
- It smells
- It will damage plants
- It clogs irrigation systems
- It leads to salt build-up in the soil
- It's unsafe for human contact

Reality of Recycled Water:

- Recycled water has been used right up to the front door of homes in associations, in schools and parks for at least the past 30 years. Recycled water is also used in nurseries to grow ornamental container stock. Recycled water is safe for people and plants when used in landscapes.
- Recycled water, based on actual use in landscapes and from tests at Marin Water District and U.C. Davis, does not damage or hinder landscape plant growth. Studies show that recycled water may actually increase landscape plant growth due to the higher concentrations of nitrogen occurring in the water.
- In areas where recycled water has been used on landscapes for 30 years, no soil salt build-up has been found, even in areas with typically heavy clay soils
- Tertiary treated recycled water is being used with all types of irrigation equipment, including drip and sub-surface irrigation, with no more problems than the same equipment has when the source is potable drinking water.
- Recycled water is used on agricultural crops across the state. Studies show that recycled water is totally safe for crops grown for human consumption.
- Nurseries that use recycled water have never reported any adverse health impact with workers in close contact with recycled water.

The bottom line is that recycled water is safe to use for landscapes and significantly increases the supply of water available for landscapes.

How is Recycled Water Being Used in California?



Hidden Cost of Over-Watering

It is true that too much water can damage the landscape and kill more plants than under-watering ever does. Over-watering may stunt plant growth, may help bring on chlorosis, leaches nutrients from the soil, makes nutrients unavailable to plants, contributes to shallow rooting and soil compaction. Those are obvious horticultural problems caused by over-watering. There are other, more costly problems:

- High costs to customers for water not needed by plants
- Degradation of asphalt in streets and parking lots
- Pollutants washed into other water bodies (streams, estuaries, bays and ocean) from water run-off
- Damage to fences, hardscapes and building structures

The combination of hidden costs make over-watering costly to customers and communities. For example, one city analyzed all maintenance costs in the public works department. It found that significant dollars were being spent every year to repair street potholes and asphalt. The major cause of the street problems were coming from the over spray and water run-off from the adjacent streetscapes. Even relatively new landscapes and irrigation systems contributed to the problem. The answer for the city was to find a more cost effective way to irrigate valuable community landscaping and save streets at the same time. The city solutions included:

- New street landscape design guidelines with emphasis on efficient irrigation technology and plants that require less water
- Making routine street upgrades that include landscape and irrigation renovations to eliminate overspray and run-off
- Landscape maintenance specifications that have been rewritten to incorporate ET water budgeting as the accepted irrigation scheduling method, and to make landscape irrigators responsible for high water use penalties

Population increases will mean water shortages even in non-drought years.

(Right) Efficient landscapes can be attractive and colorful.

(Below) Low-water-use and low-maintenance home landscapes fit customer desires.

The public is looking for unique and efficient plants.

The Bottom Line

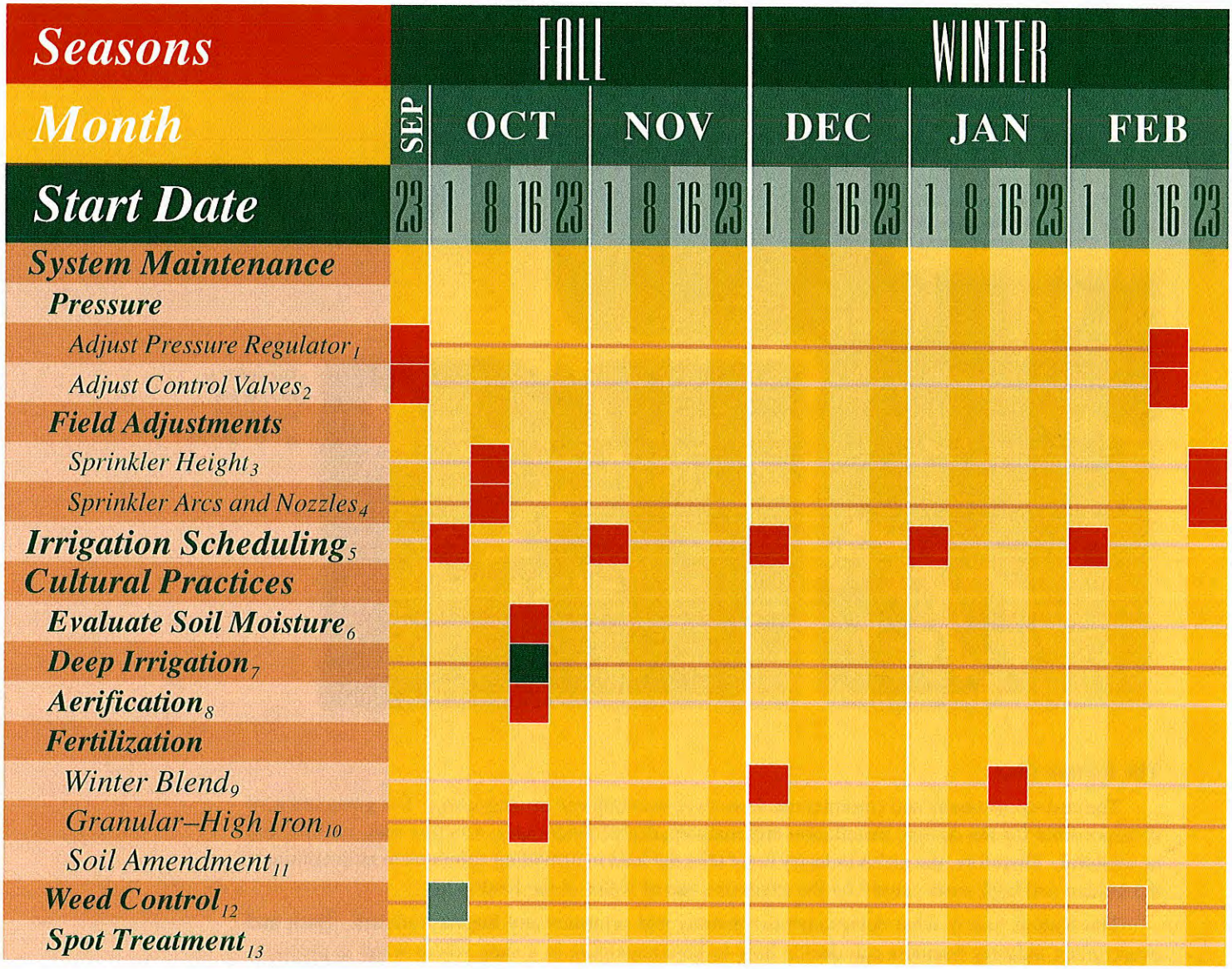
The cost to customers and communities from over-watering can be staggering. The green industry is responsible for the design, installation and maintenance of landscapes, whether they are efficient or wasteful. Therefore, the green industry must take the lead in providing solutions to help eliminate the hidden and high costs caused by the excessive use of water in the landscape.

The bottom line is what determines the actions and priorities any business makes. Each and every green industry business can decide how to be competitive in a state where water is precious. It is the hope of the groups that commissioned and produced this guide that the information presented here will assist you to: (1) be better informed, (2) have greater confidence to provide a water efficient landscape for your customers, (3) market your services and abilities to increase business in a state with a future of water limits.

This guide book is based on positive examples of what the green industry has to offer and can do for customers faced with water budgets in California. Hopefully, this effort will inspire readers to seek out the information they need from local experts, schools and public agencies. To address state water demand and supply circumstances, public needs will change. Business will need to adapt and change to keep pace. Businesses' profit when market forces drive change and the business is ready to serve the new need.

Be ready. Prepare now and establish your business as a leader that performs for the customer. The future is clear. Water will be key to California prosperity, environment and quality of life. The green industry can provide quality service to every water customer by striving for water efficiency on each and every site. Use this guide, university information, local colleges, public agencies and the services of specialized green industry consultants to reach water efficiency in every landscape.

Integrated Management Program Calendar Example



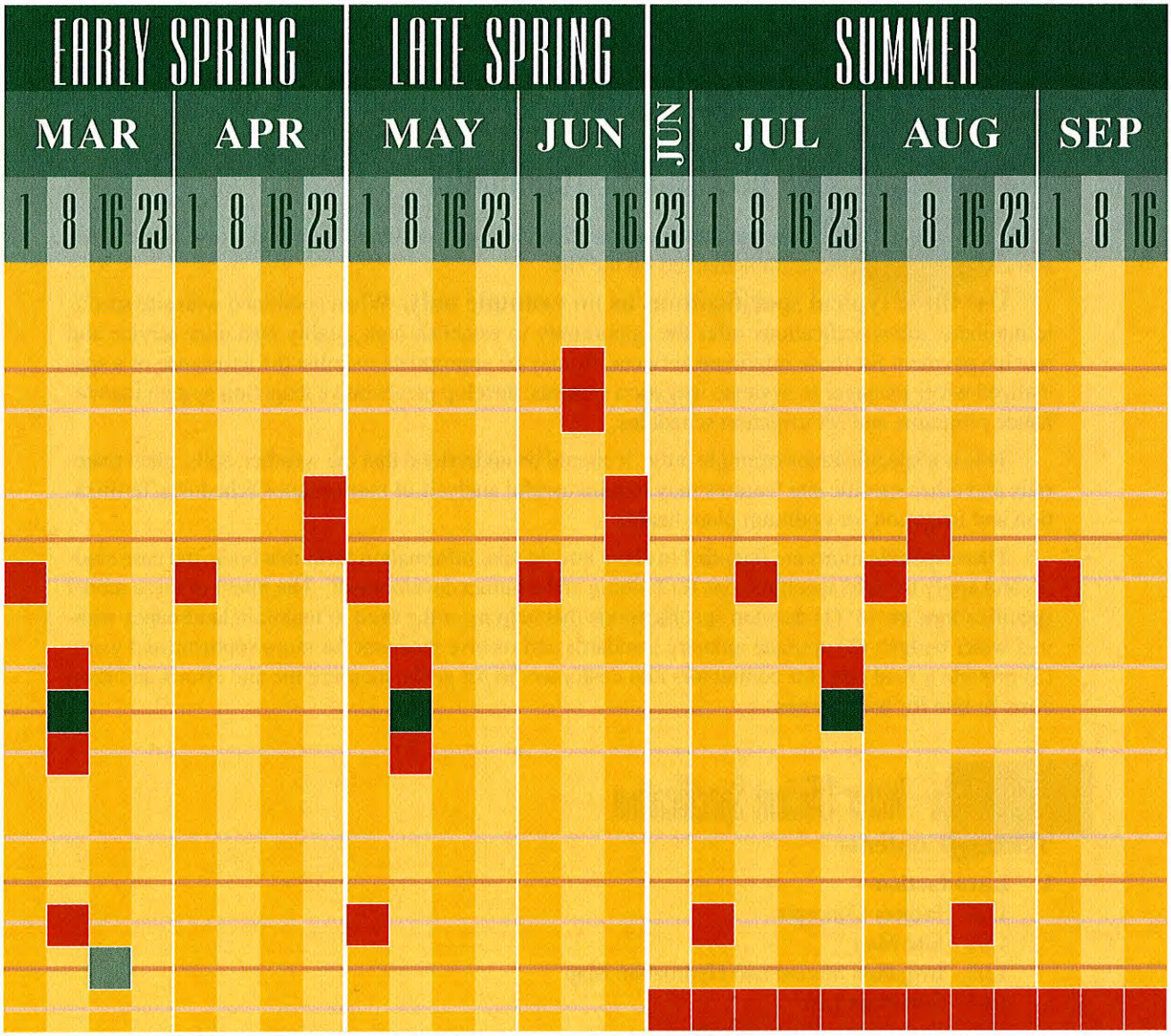
Recommended

When Needed

Bermuda, Kikuya When Needed

Pre-Emergent When Needed

1. Adjust pressure regulator so that the system operating pressure is equal irrigation design pressure shown on irrigation plans or not more than 20% above pressure required to maintain sprinkler head operating pressure at the worst hydraulic condition.
2. Adjust control valve throttling device so that farthest and highest sprinkler head operates at the manufacturer's optimum operating pressure or as indicated on the irrigation plans.
3. Adjust sprinkler heads in turf areas so that the top of the sprinkler head is flush to 1/4" above finish grade. For shrub and ground cover areas adjust riser height to avoid interference from adjacent plant foliage.
4. Make sure sprinkler arcs and nozzles are appropriate for the intended landscape type. Size nozzle for intended spacing.
5. Adjust irrigation schedules monthly. Reprogram controllers as needed to meet actual evapo-transpiration requirements.



6. Determine depth of soil moisture and overall soil moisture content with a soil probe.
7. Irrigate turf to 6" depth before aerification and after fertilization.
8. Aerify at least 2-1/2" deep no more than 48 hours before fertilization.
9. Apply winter blend fertilizer with nitrate nitrogen w/potassium (22-3-9).
10. Apply granular material with approximately equal amounts of N and Fe (9-9-9).
11. Apply soil amendments combining 1/4" screen high-quality humus at 200lbs/1,000 sq.ft. and inorganic material for increased water holding capacity.
12. Prevent weed with pre-emergent. Remove unwanted grass weeds such as bermuda, kikuya with chemical spray. Replant with seed or sod. Control established broadleaf weeds with overall spray.
13. Treat dry areas that do not respond to irrigation system maintenance through aerification and soil amendments.

Source: Pagano and Barry (1996)