Wednesday is NOT a Good Reason to Irrigate **Bruce Carleton – The City of Moreno Valley**

We in the landscape industry owe much to those that pioneered the irrigation industry, they being the growers of agricultural commodities. Many of the chemical tools we use in managing healthy, attractive landscapes come from their work. Further, many of the irrigation parts we work with were adaptations of agriculture parts. Until the development of the gear driven rotor, it was pretty much a one-way street; we did all the taking.

Once upon a time, most landscape systems were laid out like agriculture systems; the acreage was smaller but they had one thing in common, they both began at a gate valve. Manual irrigation systems were common into the '70's, especially residential systems. While considered a total bother by many who managed them, they had one advantage that no one appreciated; typically the plants thrived.

Back to the Future

I recognize the impracticality inherent in this approach to current-day commercial maintenance, but let's look at what was sacrificed when the horticulture community parted ways with our agricultural heritage in terms of irrigation scheduling. The key element to successful water management in the production agriculture setting is carefully managing the irrigation interval. In a field of Alfalfa the grower doesn't wander about wondering how long to irrigate the crop, the key element is when to start the pump. This equates to deciding how best to manage the irrigation interval. They make this decision through experience and the use of a shovel, or some other device to check the moisture content of the soil that supports the crop.

Although we are not growing Photinia to maximize vegetative production (likely, just the opposite), we do influence the health and appearance of the ornamentals under our care precisely by how well we manage the soil profile in terms of moisture. The innovation that revolutionized landscape management (the automated controller) also placed an obstacle in our path, one that has yet to even be recognized by many in the trade.

The nature of the obstacle is this; we have been numbed to the importance of whether irrigation is actually needed at a site each Wednesday (and Monday, Friday and probably Saturday as well!). The needs of the plants have been set aside to maximize the convenience for those maintaining the system. The calendar has become the inflexible dictator of when the landscape would receive irrigation, whether it needed some or not. In reality, we are likely placing undue stress on the plants when we fail to consider how our irrigation practices affect the plant physiologically.

Know The Law

Most plants can tolerate extremely frequent irrigation if the soil is reasonably well drained; so what's the problem you may think. There are two results of this attitude that will run you afoul of what I call *the law of landscape management*. Simply stated this law says that any poorly conceived or implemented action (or lack of action) will have unpleasant ripple effects.

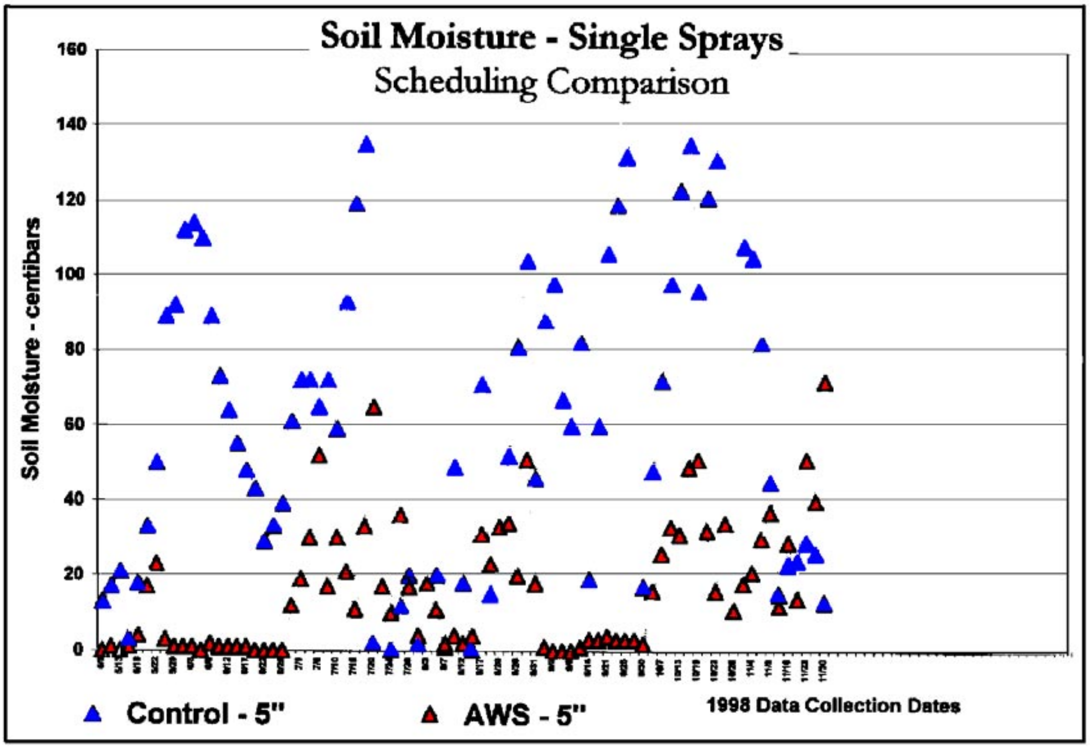
First, suppose there is a mainline break or other interruption in supply (the term drought comes to mind) which means you can't give the plants the daily dousing they've come to rely upon. The plants have adapted to the 'bath tub' irrigation schedule by establishing all the absorptive root hairs at the soil surface where they can get everything they need. Here, and nowhere else, can the roots find moisture AND air. Since they have an effective root depth of about two inches, this zone is quickly depleted of moisture by the plant and direct evaporation. It won't take long before the plants show the effects of even a brief interruption in irrigation.

Second, this attitude will become costly as more focus is placed on water consumption by governmental and supply agencies. Anyone who manages a site that falls under the guidelines of AB 325 (the landscape conservation ordinance mandated by the California state legislature in the early '90's) already has a flavor for what commercial maintenance will be like in the future. There is a process beginning in the California State Legislature to revisit AB 325 and make it more conservative, and influence more total acreage (older landscapes will likely be included) to help address the pending water shortage facing California with the loss of 'surplus' Colorado River water.

Since abandoning irrigation controllers is not an option, how can we improve our performance by using the controller more wisely? That is the dilemma I faced in Moreno Valley six years ago when tasked to improve the conservation performance of nearly 70 small parkway systems that were too small and scattered to be feasibly controlled with a central control system.

The first avenue explored was the use of 'canned' irrigation schedules generated by a software program developed for the California Department of Water Resources. A comparative study was constructed to measure the performance of the computer schedules versus 'artistic' scheduling done by an experienced technician. Both approaches were monitored to measure water use, turf quality and soil moisture levels during the seven heaviest irrigation months.

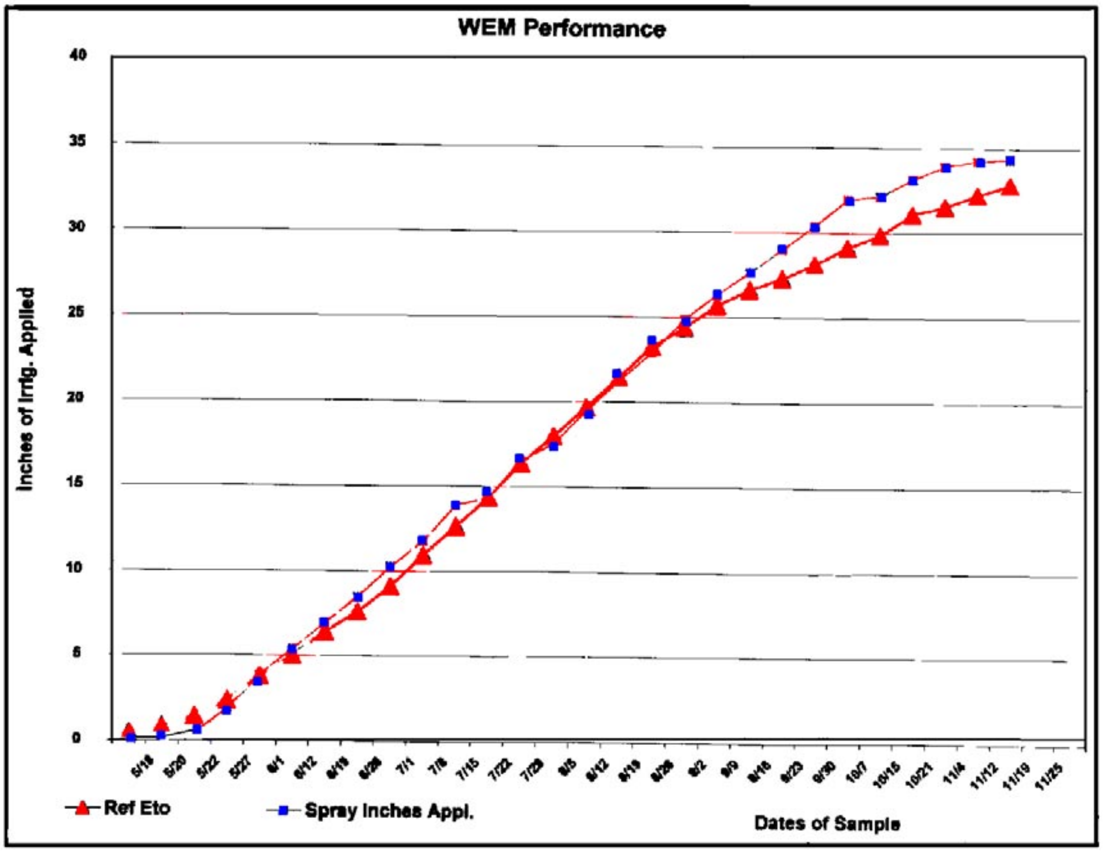
We used Watermark^{TM} moisture sensors to measure the moisture content of the soil profile at the 5 and 10-inch depths. We found that typically the computer scheduled sites (denoted as AWS) irrigated too often, particularly in the spring and fall months. The profile was near saturation below the 5-inch depth for periods up to two weeks at a time. Clearly water was being applied before the profile could even begin to dry out enough to approach field capacity, let alone the wilting point. Not surprisingly, this approach applied an average of 118% of ETo (over three sites); not exactly the level of conservation I had hoped for.



Conversely, the manual schedules (control) had the opposite problem, for most of the summer the soil at was at, or above, the wilting point at the 5-inch depth. Very small, frequent water applications were made so that below 2 inches into the soil profile, there was essentially no available water. Despite this apparently meager irrigation program, 101% of ETo was applied. So while the 'wing-it' approach proved more conservative, the root zone was in rather precarious shape through much of the irrigation season. So for different reasons both scheduling approaches resulted in shallowly rooted turfgrass, and less than optimum growing conditions for the roots.

Paradigm Shift

As a part of this study we equipped two out of the way valves with the Watermark™ moisture management hardware (WEM). We found that at the end of the study these valves were irrigating very efficiently, tracking with reference evapotranspiration (ETo) with amazing accuracy. But best of all, we paid almost no attention to these two isolated areas and seldom changed the irrigation schedule through the entire growing season.



Although this result was based on only two valves, this approach clearly warranted further consideration; particularly in light of the less than adequate performance of the 'canned' schedules that I had hoped would become the foundation of our water management program.

Like many in the trade, I too had a less than pleasant experience with an older soil moisture control system that showed up in the Southern California market in the 80's. And while there are some legitimate concerns associated with the use of soil moisture sensors, I have found that modern systems have evolved that can lessen these risks.

While our comparative study demonstrated that fundamentally, the hardware could perform well, there were some application conflicts that we encountered as we considered a more aggressive pilot project. A more serious effort took shape meant to evaluate how the system would perform in the real world, over the long haul.

Building A Better Mousetrap

One of my first concerns was the possibility of having the system over-ridden for testing, and then left that way at the end of the test. If only highly responsible people have access to the system, this may never be an issue. Since typically these systems are common interrupts, it is usually necessary to over-ride the sensors to test the system. This problem was defeated by installing a relatively inexpensive mechanically timed switch, such as those used in public facilities in lieu of normal toggle light switches so lights wouldn't be left on for hours. This was dubbed the 'egg timer' by staff and allowed us to protect the system from human forgetfulness.

Another common knock on sensors is that you can't properly represent a large area with a small patch of ground. This has not proven to be a major obstacle for our program, although the more diverse the landscape is, the more sensors that must be employed. One advantage enjoyed in the case of Moreno Valley is that parkway landscapes tend to be repetitive as a rule. This tendency toward monotony bodes well to success as it means finding a 'representative' sensor site is easier to do. If a site is properly hydro zoned in terms of irrigation layout, then the task of placing sensors is not particularly difficult.

Perhaps the biggest challenge is in planter beds, since the sensor must be within the active root zone of the plant(s) being monitored, while also being in a location that receives full irrigation applications. Obviously a sensor cannot be placed at the crown of a mature Wheeler's Pittosporum (at least with overhead irrigation), nor so far away from the ornamental that root influence on the sensor is lost. Fortunately, most established ornamentals have a root zone that exceeds the 'drip line' of the plant by a significant amount.

Our program is based on having the field wiring for the sensors protected by electrical conduit to keep any furry rodents from wreaking havoc with the sensor circuits. This is very easy to accomplish with new construction where open trenches allow the sensors to be located anywhere on the site. Under retrofit conditions, the wiring is obviously the big obstacle to installation. A vibratory plow or slit trencher can facilitate these projects on longer runs. Sensors can be placed more than 2000 feet from the control module if adequately sized wire is used. See manufacturers recommendations as a very long wire run adds resistance to the circuit that can affect the accuracy of the equipment.

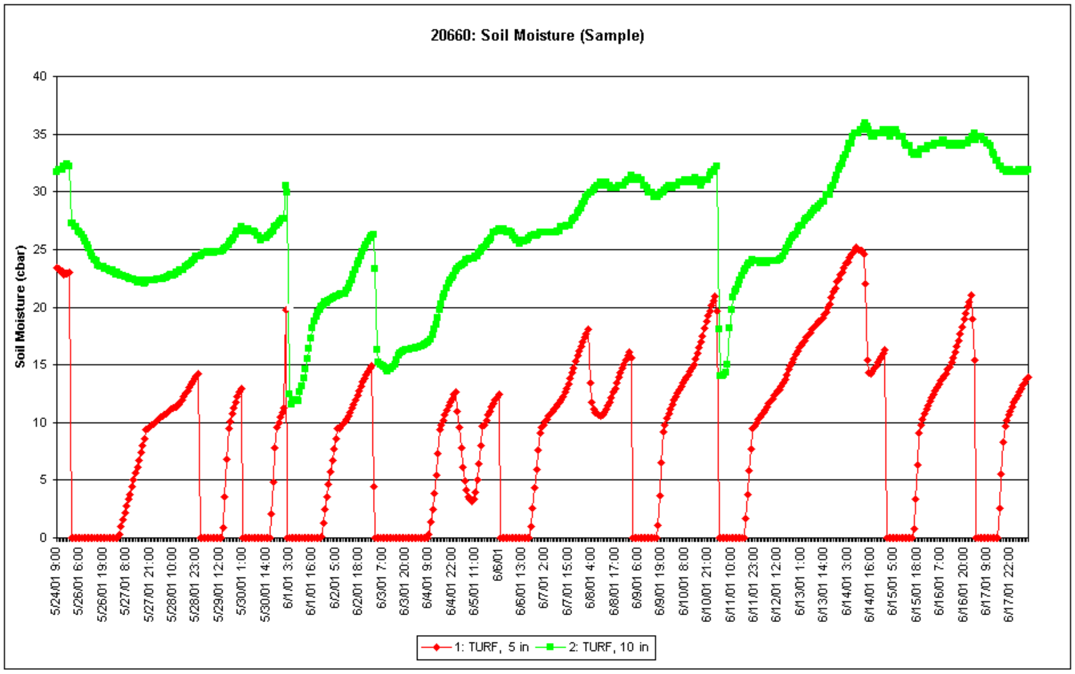
Perhaps the most obvious difference in managing a soil driven control system is how the controller is scheduled. The basic structure of the schedule changes dramatically. Currently the prime focus is on tweaking the run time to try to meet the ever-changing water needs of the plant. As was illustrated above, this is often not the best approach from the perspective of the root. The soil moisture approach turns the process around by switching the main focus toward tailoring the timing of irrigation events to the needs of the landscape. By introducing the hardware, the problem of guessing which nights to water is eliminated. The controller must be set to attempt to irrigate every night (except prior to mowing of course). This may or may not be a big change from normal for an irrigator. The other part of the equation is the runtime; this value will stop changing from month to month, eliminating the need to guess about how to tweak it.

Fill'er up!

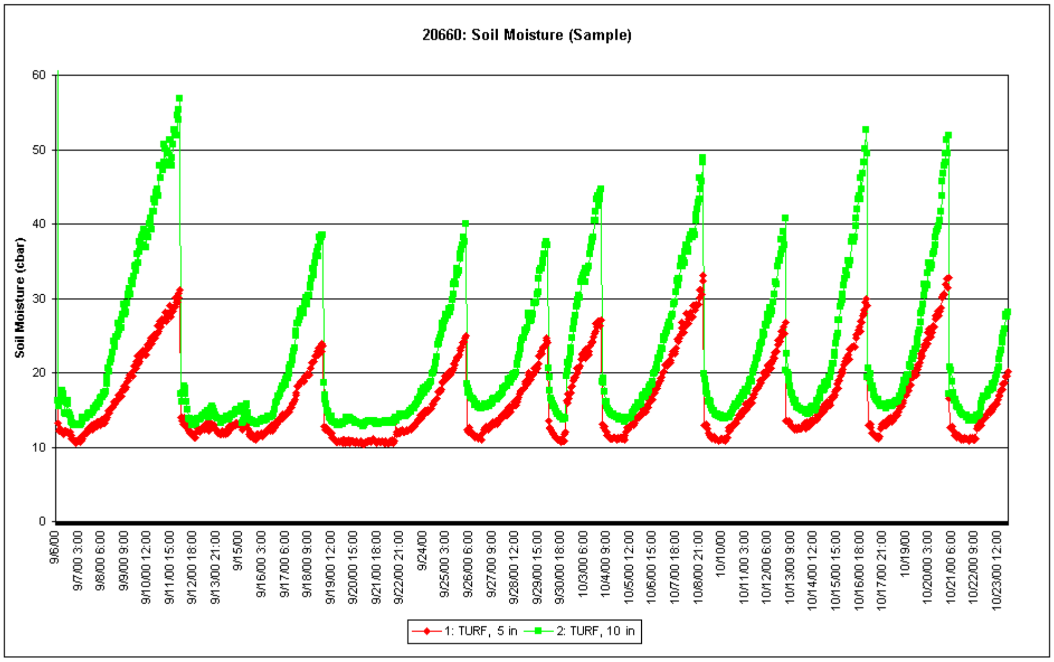
The underlying philosophy of interval driven irrigation is this, fully hydrate the root zone so the plants can exploit as large a volume of soil as possible. This accomplishes two things. First, we encourage the development of an extensive root system; more roots lead to more robust and durable plants. The impact of a temporary loss of irrigation will be greatly minimized. Second, when practiced on a regular basis, thorough irrigation helps facilitate root zone leaching, and encourages the proliferation of beneficial soil organisms that ultimately can improve the soil structure.

I'll use a car analogy to illustrate the process. The soil is to a plant what the fuel tank is to an engine. The soil is the 'tank' where water is stored until absorbed by the plant. Our first objective is to determine how much water must be applied to 'fill the tank'. Once we learn that value, it makes sense that we apply that much water each time it needs to be filled. Thus the valve run time becomes essentially a static value.

Now the run time part of the irrigation equation is satisfied (specifics will be covered below) and the challenge becomes knowing when that 'refueling' should occur. This is where the sensors and control hardware come into play. By tuning the interval with the control module it is possible to tailor the interval to real-time site conditions. The following charts were derived from data logger feedback.



This chart tracks soil moisture trends (in centibars of tension) for an established turf area (fescue) after retrofitting with the moisture control hardware. Note that moisture was not reaching the deeper portion of the soil profile after irrigation. At the same time, the shallow portion of the root zone was remaining soggy for two or more days at a time. This indicates that two adjustments are needed. First, the irrigation interval must increase. This is accomplished by increasing the set point on the control module. To drive moisture deeper into the profile, more runtime was added to the schedule on the clock.



The indicated adjustments had a beneficial result, eliminating the excess shallow moisture while improving deep profile moisture reserves. By monitoring soil moisture on a continuous basis, it is possible to use the base irrigation schedule and the control module to establish irrigation practices that provide consistently beneficial root zone moisture conditions. And these benefits occur regardless of the time of year and without monthly manipulation of the runtime or water budget. It is not essential to constantly log sensor data to derive benefit, but the fine-tuning process is accelerated if your system is so equipped.

Time is on Your Side

There are two ways to set up a base irrigation schedule to use with sensors. A theoretical approach that uses software to determine an approximate runtime based on a collection of field data and irrigation system performance. Some manufacturers have such a tool available. The Watermark™ system features WaterPerfect™ software, an excel spreadsheet, that is designed to work in concert with that manufacturer's hardware. The other is more labor intensive, but can be very accurate (without the use of even a calculator).

Briefly, the software approach involves using field measurements of soil texture, root zone dimensions, sprinkler precipitation rate (PR) and distribution uniformity to project how much runtime will be needed to fully hydrate the root zone of the landscape in question. If you have site audit data on hand (and the necessary technology) this can be a simple way to get going.

If you don't have a stomach for the math, fear not, there is another method just for you, the empirical approach. All you need is a soil probe and a watch. Evaluate the soil profile with the probe to determine if the soil profile is in need of irrigation. Depending upon the season, this may be two days since the last irrigation or two weeks. The key is probing down to see how deeply active roots exist, and whether you can squeeze any free water out of the sample. If you can extract water, the plants will likely also be able to. This is a rather subjective approach, and it will take daily observation to find the right time to conduct your test (I warned you this would be labor intensive!).

When the time is right, simply start irrigation for the area where you predict you will set a sensor. Note the time and constantly observe the system during irrigation. Two key pieces of information will be derived. First, determine how long each valve can run continuously without any run off (if more than one valve serves an area, alternate between them). Second, determine how many total minutes of irrigation are needed to drive water deep enough to sustain roots at the low end of the effective root zone. By probing the soil periodically during irrigation you can determine how many minutes the valve(s) must run to deliver enough water to hydrate *the entire* root zone. Note that you will likely need to interrupt irrigation periodically (at least with spray systems) to prevent ponding and run off. On sandy soils a cycle and soak approach may not be necessary. Keep good notes as this will define your cycle length and soak allowance. Once your probing shows that water has moved to a desired depth into the root zone, you have defined the optimum runtime for the valve(s).

If you have a very repetitive landscape, that same data can be used for several valves. However, if there is significant variability in the PR or soil conditions etc., then an independent test will have to be performed for those systems as well. For even a relatively small commercial project, this process could easily take more than half of the workday.

Once you have defined how long the valve(s) must run to drive water down well into the root zone, and if there is a run time limitation to prevent run-off, you are ready to schedule the site.

Show Time
As I mentioned, the form of the irrigation schedule will likely appear pretty exotic to staff compared to traditional sites. For sites without turf, the controller should be set to irrigate *every night.* If there is turf, the evening before it is mowed obviously should be left off the schedule so you aren't leaving ruts all over the site.

Once the base irrigation schedule is in place, you must adjust the knob on the control module. Depending upon the system there will either be a scale of wet to dry or 1 to 12 or something of the sort. Regardless of the scale used, the point is to understand that the knob dictates how often the system will irrigate. Wet means it will run often, dry means it will go longer between irrigation events.

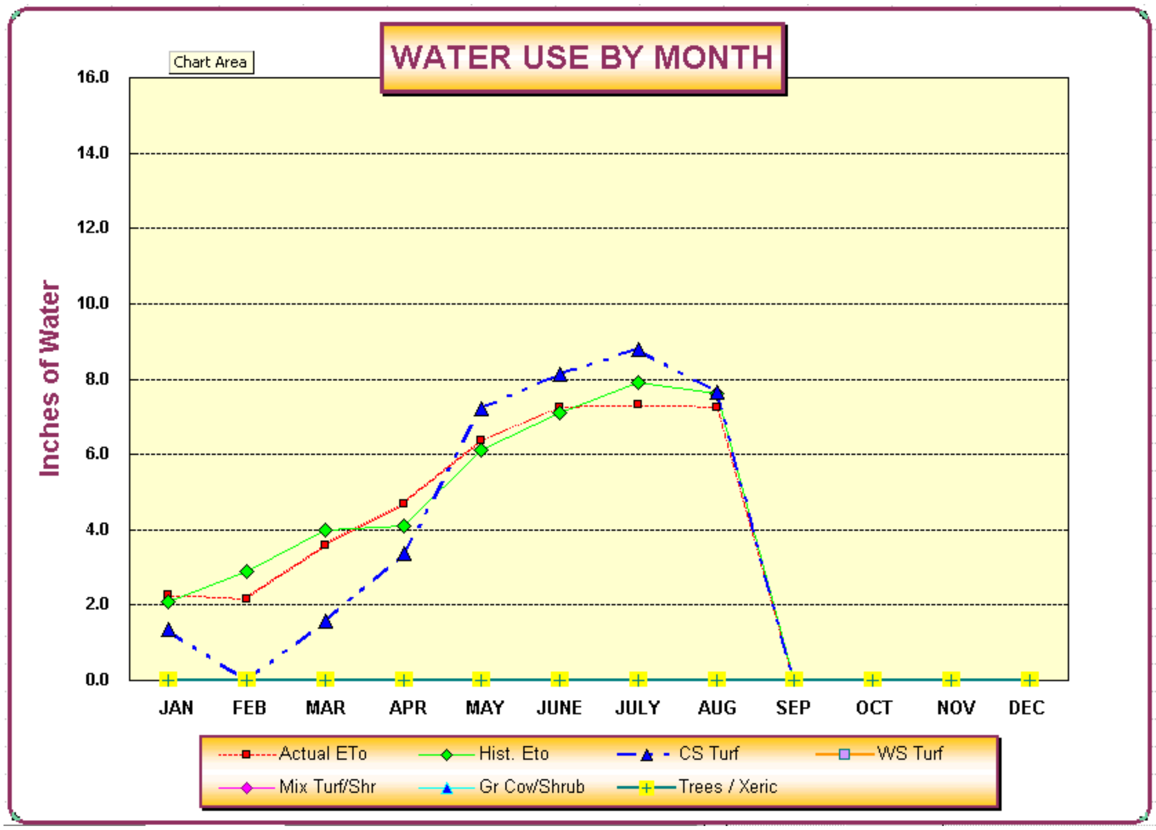
The goal is to continually try to stretch the interval by incrementally increasing how dry the soil should get before the sensor module allows irrigation to be applied. Obviously the season will influence this interval. If your making the switch to sensors in the summer proceed with caution, chose a setting near the 'wet' end of the scale. In the cooler months keep pushing the envelope to see if you get to a point where you see stress but the system isn't allowing irrigation to occur. That will usually define the highest setting you will ever want to run.

The key to success is to watch the site carefully the first two months. Don't panic at the first sign of stress; monitor consistently to see if stress worsens before succumbing to the impulse to dump water on it for a week.

Besides tuning the sensor module, you need to balance the applied irrigation between valves on the site. Some areas get reflected heat while others get none. Hopefully the sensor is your 'worst case' scenario, and other valves in the hydro zone require somewhat less water. By watching and probing the entire site, you soon will learn how to make subtle adjustments in the schedule (up the runtime here, cut it a little more there) until the site has a consistent look.

The next step is to begin monitoring water use at the site. That means reading the water meter each month, and comparing consumption with expected water use for the site. The WaterPerfect software incorporates such a feature. If you don't already know how, drop me an e-mail (brucec@moval.org) and I will send you the specifics of how it can be done. You need to know the area irrigated by each point of connection with a fair degree of accuracy, and what units your meter measures to complete the calculation.

The report card
Once you have determined how many inches of water your system applied, you can quickly grade the performance of the system in terms of plant need. If you've been in this business for very long you have probably heard of Reference Evapotranspiration (ETo). This ten-dollar term simply defines a value of expected water loss from a landscape based on the water use of a plot of well-watered tall fescue (probably) that is monitored by a weather station. Universally, ETo is reported in inches of water. This value is easily available for many parts of California through the California Irrigation Management Information System (CIMIS), operated by the State of California. For other parts of the country this data is becoming more common, but you may have to dig a little harder to find it.



Here's the utility of CIMIS, you gather the ETo value (inches) for last month, you calculate the applied inches your system applied last month, and viola; you have a ready made comparison that illustrates how well water has been managed at your site. Rarely will the values agree exactly, but if your site uses 100% or less of ETo, you can feel secure that the system is working well. What better way to illustrate your commitment to excellence than to have records that show how effectively your management program works. If on the other hand your site is consistently above 115% of ETo, you have some work to do.

The first area to check to find the waste is to carefully review the hardware, are there blown wiper seals, missing nozzles, cracked fittings, lateral breaks and/or stuck valve(s)? If so, these obviously kill system performance. Make sure the low and leaning heads are re-positioned so they can do the job. Replace or service clogged nozzles and really watch the system run. Do you have head-to-head coverage and operating pressure reasonably close to manufacturers recommendations? If not, you have some serious work ahead of you. You can't expect excellent results from a marginal (don't blame control hardware for poor maintenance practices) system.

Closing

In Moreno Valley we have automated nearly 30 sites with sensors and the results have been excellent. The key has been consistent monitoring of water use, and quickly reviewing system performance when water use jumps above typical levels. Sometimes a nozzle adjacent to the sensor gets clogged, or a shrub isn't trimmed quite soon enough and the spray pattern is blocked. The hardware itself has been to blame for erratic performance in only one case in the nearly three years we have been using the system. I am convinced that if system installation is thoughtfully planned, and post install observation is adequate, the chances for failure are quite low. This means monitoring the water use at the site must be done consistently. If it is, problems with the control system or the irrigation equipment in the ground can be identified quickly. In our pilot project, we experienced an average irrigation management labor savings of 35% over traditional methods where schedules were modified twice each month according to weather conditions.

Staff has gained a high degree of confidence in the sensor system, and will continue to expand the scope of tracts irrigated this way as budgets permit. I encourage anyone in the industry to learn more about this alternative to artistic irrigation scheduling. As water becomes a more highly valued commodity, it will become essential that those of us in the green industry be able to prove to the outside world that we know how to manage it wisely. Soil moisture sensing is one very straightforward method of achieving that goal.