Taking the Guesswork Out of Water Conservation

Thousands of years have passed since the Romans constructed their vast network of aqueducts to deliver water from remote rivers to fields and cities where it was needed.

Although the feat of constructing such aqueducts was impressive, the concept of getting water from its source to where it's needed was very simple. Since then, we have greatly refined water delivery methods. We have harnessed rivers with dams and piped water thousands of miles for use in cities and farms. From there, water is further propelled by pumps and computers to precise locations where it is needed. From rivers to tiny drip tubing, we control the delivery of water.

We have concentrated nearly all our energy and resources on getting water from one place to another with tremendous success. Now, some of these resources are being redirected to a more complicated yet equally important concept—turning the water off when a plant's needs have been met.

This has been Bill Pogue's mission for more than five years. Pogue. president of the Irrometer Company, knows it's only a matter of time before moisture sensing devices become an integral part of all large landscape irrigation systems.

"With rising labor, energy and water costs, irrigation system management has to improve," stresses Pogue. "No longer can we delegate operation and maintenance of valuable irrigation systems to seasonal or unskilled workers. Irrigation has become considerably more complex in the past ten years. As a result, training is an absolute necessity. Once a person is trained, he is more valuable to his employer and should be paid accordingly."

Landscape contractors and golf course superintendents have reacted slowly to rising water costs and water shortages in general. On many golf courses, maintaining lush, verdant turf has taken precedence over the cost of water. Recently, superintendents have begun to restrict irrigation in response to research proving that overwatering encourages diseases and weeds. Communities, after experiencing droughts, have encouraged golf courses to be more responsible about water conservation.

Typical moisture sensing "location." One "short" and one "longer" probe to monitor both the shallow and deep portions of the root system.

Municipalities and parks, however, have become extremely concerned about use. Their irrigation systems tend to be vast and located in many separate areas. The labor alone to keep huge systems functioning properly is expensive. Municipalities with limited tax bases will let some areas go without irrigation rather than pay rising water and labor costs. However, they have also been willing in many cases to invest funds in advanced irrigation controls to reduce labor costs in the long run.

For the most part, irrigation system operators have been guessing how long and how frequent irrigation cycles should be. Even the latest computerized irrigation systems are originally programmed according to guestimates. The first time an irrigation manager turns on his computer he faces a convenient, organized format of blanks. But, before the system will apply the first drop of water, he must fill in these blanks with estimates and data from his previous controller. Later, he can adjust the program based upon field observations. With 50 or more heads that refinement can be very time consuming.

Once all cycles are adjusted to average weather conditions, various sensors can be added to alert the computer to increase or decrease irrigation based upon weather conditions. For example, a rain-activated switch can signal the central controller to turn off irrigation in progress. Evaporation indicators can tell a central controller to irrigate more or less frequently. Data from a local or on-site weather station can be fed into some advanced computers to adjust irrigation cycles.

As water becomes more scarce and more costly, there is a definite trend today toward using sensing devices to turn water on or off. By the nature of their task, however, these devices are more complicated and require more knowledge to operate.

Only in the last 15 years have universities started research into the water needs of turf and ornamentals. Armed with the new information gleaned from this research, soil and plant scientists have developed formulas based on weather conditions, solar radiation, wind speed and evaporation rates to estimate how soil moisture levels are changing. Once fed into computerized irrigation controllers, these formulas adjust the amount of water applied.

One such system was established by Dr. Richard Snyder at the University of California, Davis. Called the California Irrigation Management System (CIMS), the project is now run by the state Department of Water Resources. Snyder always stresses that the estimated evapotranspiration (ET) rates generated by the CIMS need to be periodically adjusted and corrected based upon actual field measurements of soil moisture.

Pogue and others feel that moisture sensing devices are a more direct method of shutting down irrigation when plants have all the water they need. They feel these devices placed in the rootzone of key plants are bound to be more accurate than even highly sophisticated formulas designed to estimate what soil conditions are. They don't use the same methods to measure soil moisture levels, but they are all convinced these devices can detect a plant's water needs at any moment and can relay this message to a central location for adjustment of irrigation cycles.

Soil and plant scientists have been experimenting with soil moisture sensing devices for more than 60 years. Researchers at Cornell University and Iowa State University discovered that an enclosed tube of water with a porous ceramic tip on the bottom responded to different soil moisture levels like they theorized a plant's roots did. They knew that plant roots had to pull water away from soil particles. As the soil got drier, the roots had to pull harder to overcome the grip of the soil particles on the water.

When they added a vacuum gauge to measure the suction inside the tube, the researchers could assign a number to the wetness or dryness of the soil. The drier the soil was, the higher the gauge read. Since this was a measure of the tension of the water in the soil, they called the device a tensiometer.

Scientists in soil and plant laboratories were the first to use it. "With the tensiometer," Pogue points out, "researchers could compare plant performance under varying conditions knowing that soil moisture conditions were exactly the same for all plants being studied. In other words, they could eliminate water as a variable in their research."

It wasn't until 1951, when Irrometer began commercial production, that tensiometers became available to the landscape and agriculture industries. Citrus growers were the first to use them to a significant degree. Early tensiometers had to be checked individually by the irrigation manager before he would adjust the amount of water applied manually. If they were left unattended during extended dry periods, they could run dry. The water in the tensiometers had to be checked regularly.

Irrometer's tensiometer has been commercially available for more than 30 years,

Irrigation manager sets the switches on the moisture sensing devices for the desired moisture levels.

but its appeal is starting to broaden with rising water bills and a growing awareness of the problems caused by overwatering or underwatering turf and ornamentals. Irrometer has added a data collection unit to its tensiometer, making it more useful to turf and landscape managers.

Water Conservation Systems, Inc., makes a solid-state tensiometer called a Hydrovisor. Like Irrometer's tensiometer, it measures the suction required to remove water from the grip of soil particles. WCS president Ed Bramlett says it's this force that matters, not the percentage of moisture in the soil. Rather than measuring the suction through a porous ceramic tip, the Hydrovisor uses soil temperature information to calculate the availability of water in the soil.

The Hydroturf System from Hydrodyne measures the amount of free water between soil particles in the rootzone. Griswold Controls' Scanex also measures soil moisture content. All companies have reported water savings of 50 percent in systems where their devices have been used.

When electromechanical controllers were developed in the late '50s and early '60s, they opened new doors for moisture sensors. Electric valves in the field, linked to the controller with wires, would open and close according to instructions at times set on the controller clock. No longer did the landscape manager have to manually open valves located in many different locations and then wait or return to shut them off again. The electromechanical controller was quickly accepted as a big labor saver for the landscape industry.

Sensing a great opportunity, in 1961 the engineers at Irrometer linked a switching unit to its tensiometer. When the tensiometer detected a preset level of moisture in the soil, the switching unit would break the circuit between the valve and the controller shutting the water off. As the soil became drier and fell below another preset moisture level, the switching unit would reconnect the circuit and the signal from the controller to irrigate would again activate the valve.

"The manager could set the controllers in the field to cycle more frequently and the tensiometers would stop any cycle after soil moisture levels were adequate," said Pogue. This eliminated the need for the irrigation manager to read the tensiometers before adjusting the irrigation cycles. Still, the units would run dry if left unchecked during dry periods, says Pogue. Part of the problem was irrigation managers didn't understand how these moisture sensors worked, so the company began to hold water management seminars.

The advent of solid state controllers and, most recently, computerized centralized controllers, greatly expanded the number of stations a central controller could operate. Today, satellite controllers in various locations in the field can both receive instructions from a centralized computer as well as send appropriate information back. Now, a person sitting at a computer in an office can know what heads out of thousands in a system are operating and at what pressure. He can see by feedback from gauges in the field if there are leaks, malfunctioning valves or

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heads and if certain zones have all the water they need.

Soon, software for these computers will be able to take the feedback from the field and make adjustments to irrigation cycles automatically. In addition, satellite controllers in the field will be able to communicate with a central computer by radio or telephone lines. With so much new information and technology, it is easy to see a need for irrigation managers who understand these complex systems and can get the most out of them.

Moisture sensor manufacturers are taking advantage of this new capability. Utilizing computer software and two-way communication between field controllers and a central computer, Irrometer has solved two of its problems with tensiometers. Now, actual soil moisture readings from many tensiometers in the field can be seen on a control panel sitting next to the central computer. Without going into the field to check individual moisture sensors, the irrigation manager can adjust cycles without leaving his desk. It also allows him to carefully track his soil moisture trends and to spot problem areas long before they become serious.

The feedback capability also alerts a central computer when tensiometers have broken suction and are malfunctioning. "This eliminates the maintenance problem associated with tensiometers," says Pogue. "By using feedback from moisture sensors in the field, the long, dry periods that cause the units to break suction are eliminated. But, if they do malfunction, the irrigation manager will know right away without having to go into the field to find out."

The first major installation of a system combining tensiometers with a Motorola centralized computer is planned for the Sepulveda Basin Golf and Recreation Project in Los Angeles. Dave Megeath, the project manager for Motorola, says, "The whole key at this point is the software. Our software was compatible with Irrometer's so we didn't have to wait to develop programs to link the tensiometers with our MIR-3500 System."

The Sepulveda Basin complex includes two golf courses and a driving range, plus general landscaping. With long range plans to utilize reclaimed water, the moisture sensors will insure that control is maintained over the potential deep percolation of low quality water into the ground water supply.

"The park also wanted control of the irrigation system to be in one person's hands," Megeath adds. "Since there is such a variety of sites within the park, moisture sensors seemed like a good way to customize water needs for these areas. The two-way communication between the MIR-3500 and the tensiometers clinched the sale. The results in water and labor savings will be very interesting to see."

As manufacturers of other centralized computer irrigation systems develop the software to incorporate the tensiometers, their new capabilties can be realized in more systems. In the meantime, tensiometer systems can be installed in key problem areas for connection with computers at a future date. Pogue recommends two probes per site, one at a shallow depth and another at 3/4 of the depth of the root system. This will permit better control over deep penetration of water in various soil types.

A number of probes can be connected to a single switching unit. The switching units, when hooked to controllers set to cycle frequently, will maintain appropriate soil moisture levels and prevent the tensiometers from breaking suction. When the manager of a large irrigation system adds a centralized computer controller, or when the company who made an existing computer controller develops the necessary software, the tensiometers can be incorporated into an overall water management program.

Significant water and labor savings have been realized already by incorporating moisture sensing devices into large irrigation systems. As the value of water continues to rise and computer technology helps improve the reliability and accuracy of moisture sensors, they will become as important a part of an irrigation system as a source of water, satellite controller or valve.